

Best Available Techniques (BAT) Reference Document for the Slaughterhouses, Animal By- products and Edible Co-products Industries

*Industrial Emissions Directive
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(Integrated Pollution
Prevention and Control)*

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WORKING DRAFT IN PROGRESS

This document is one from the series of foreseen documents listed below (at the time of writing, not all documents have been drafted):

Reference Document on Best Available Techniques (BREF)	Code
Ceramic Manufacturing Industry	CER
Common Waste water and Waste Gas Treatment/Management Systems in the Chemical Sector	CWW
Common Waste Gas Treatment in the Chemical Sector	WGC
Emissions from Storage	EFS
Energy Efficiency	ENE
Ferrous Metals Processing Industry	FMP
Food, Drink and Milk Industries	FDM
Industrial Cooling Systems	ICS
Intensive Rearing of Poultry or Pigs	IRPP
Iron and Steel Production	IS
Large Combustion Plants	LCP
Large Volume Inorganic Chemicals – Ammonia, Acids and Fertilisers Industries	LVIC-AAF
Large Volume Inorganic Chemicals – Solids and Others Industry	LVIC-S
Large Volume Organic Chemical Industry	LVOC
Management of Waste from Extractive Industries	MWEI
Manufacture of Glass	GLS
Manufacture of Organic Fine Chemicals	OFC
Non-ferrous Metals Industries	NFM
Production of Cement, Lime and Magnesium Oxide	CLM
Production of Chlor-alkali	CAK
Production of Polymers	POL
Pulp and Paper Industry	PP
Production of Speciality Inorganic Chemicals	SIC
Production of Wood-based Panels	WBP
Refining of Mineral Oil and Gas	REF
<i>Slaughterhouses, Animal By-products and Edible Co-products Industries</i>	SA
Smitheries and Foundries Industry	SF
Surface Treatment of Metals and Plastics	STM
Surface Treatment Using Organic Solvents	STS
Tanning of Hides and Skins	TAN
Textiles Industry	TXT
Waste Incineration	WI
Waste Treatment	WT
Reference Document (REF)	
Economics and Cross-media Effects	ECM
Monitoring of Emissions to Air and Water from IED Installations	ROM

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EXECUTIVE SUMMARY

Introduction

The BAT (Best Available Techniques) Reference Document (BREF) entitled ‘Best Available Techniques in the Slaughterhouses and Animal By-products Industries’ reflects an information exchange carried out under Article 16(2) of Council Directive 96/61/EC (IPPC Directive). This executive summary describes the main findings, a summary of the principal BAT conclusions and the associated consumption and emission levels. It should be read in conjunction with the preface, which explains this document’s objectives; how it is intended to be used and legal terms. It can be read and understood as a standalone document but, as a summary, it does not present all the complexities of this full document. It is therefore not intended as a substitute for this full document as a tool in BAT decision making.

Scope

This BREF covers the industrial activities specified in Annex I, paragraphs 6.4.(a) and 6.5. of the Directive, i.e.

6.4.(a) Slaughterhouses with a carcase production capacity greater than 50 tonnes per day

and

6.5. Installations for the disposal or recycling of animal carcasses and animal waste with a treatment capacity exceeding 10 tonnes per day

Some processes are in this document because they are associated activities of 6.4.(a) even though on first examination they would more obviously be 6.5. activities, but they fall below that threshold.

For large animals, such as cattle, sheep and pigs, the “slaughter” activity is considered to end with the making of standard cuts and for poultry, with the production of a clean whole saleable carcase. In recent years there has been a change in the terminology used to describe outputs from slaughterhouses. The term “by product” is being used increasingly and it is widely used in this document. The word “waste” is only used when referring to disposal activities.

Animal by products activities covered include the treatments for entire bodies or parts of animals and those for products of animal origin. These activities include the treatments of animal by products both intended for and not intended for human consumption. A wide range of by products activities are covered. These include fat melting; rendering; fishmeal and fish oil production; bone processing; blood processing associated with slaughterhouses and to the degree where the blood becomes a material for use in the preparation of another product. The incineration of carcasses, parts thereof and animal meal and the burning of tallow, are covered principally as routes for disposal. Land spreading; land injection; biogas production; composting; the preservation of hides and skins for tannery use, in slaughterhouses and gelatine manufacture are also covered. Landfill is not covered, except when mentioned as a route for disposal.

General information (Chapter 1)

Slaughterhouses

The slaughtering industry throughout the EU is diverse with many different national characteristics. Some of these are due to different local end products, e.g. typical Italian cured products. Others depend on what market the products are destined for, e.g. longer shelf lives

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may be required for meat destined for export than that to be sent to the local market. These characteristics reportedly affect some of the choices made about what techniques are used in some slaughterhouses.

Trends in the industries can influence environmental issues by, e.g. changing the amounts of water consumed or the amount of waste produced. There appears to be a trend towards fewer slaughterhouses with increasing average throughputs. It is reported that this trend towards larger units has not resulted in lower consumption levels, but that it is easier and cheaper to solve environmental problems at large plants. The increasing concern about food safety can result in more waste being produced as parts of animals are discarded, such as following the BSE crisis and in increased cleaning and sterilisation, which incur associated consumption of water, energy and chemicals. There are other trends based on environmental driving forces, such as odour prevention. The cooling of blood and other by products, not only those parts destined for use, but also those destined for disposal is becoming more common. Refrigeration requires a considerable amount of energy, but does provide other advantages, such as better products and less air and water pollution.

Animal by products installations

In the past, animal by products provided a valuable source of slaughterhouse income, however, due to BSE, in recent years their value reduced substantially and much of the material which was previously used, is now disposed of as waste at a cost to the slaughterhouse operator.

The animal by products industry handles all of the raw materials that are not directly destined for human consumption. The use and disposal routes permitted are governed by the *Regulation (EC) No 1774/2002 of the European Parliament and of the Council of 3 October 2002 laying down health rules concerning animal by products not intended for human consumption*.

The continuing ban on the use of processed animal proteins in feed for animals farmed for food has led to the diversification of the animal by products industry into incineration and to research into alternative ways of disposing of by products and in particular TSE materials and SRM. The rendering industry still processes most of the animal by products not intended for human consumption although some are stored frozen, for future incineration.

Key environmental issues in slaughterhouses

The most significant environmental issues associated with slaughterhouse operations are typically water consumption, emissions of high organic strength liquids to water and the energy consumption associated with refrigeration and heating water. Blood has the highest COD strength of any liquid effluent arising from both large animal and poultry slaughterhouses and its collection, storage and handling is a key issue for assessment and control. At most slaughterhouses, the refrigeration plant is the biggest consumer of electricity. It can constitute 45–90 % of the total site load during the working day and almost 100 % during non production periods. Food and veterinary legislation requires potable water to be used in slaughterhouses, so there are virtually no opportunities for re-use of water. This has water consumption and contamination consequences and also energy consequences when the water is heated. The emission of odours from e.g. blood storage and handling and WWTPs, can be the most problematic day to day environmental issue. Noise from e.g. animal noises during unloading and marshalling and from compressors can also lead to local problems.

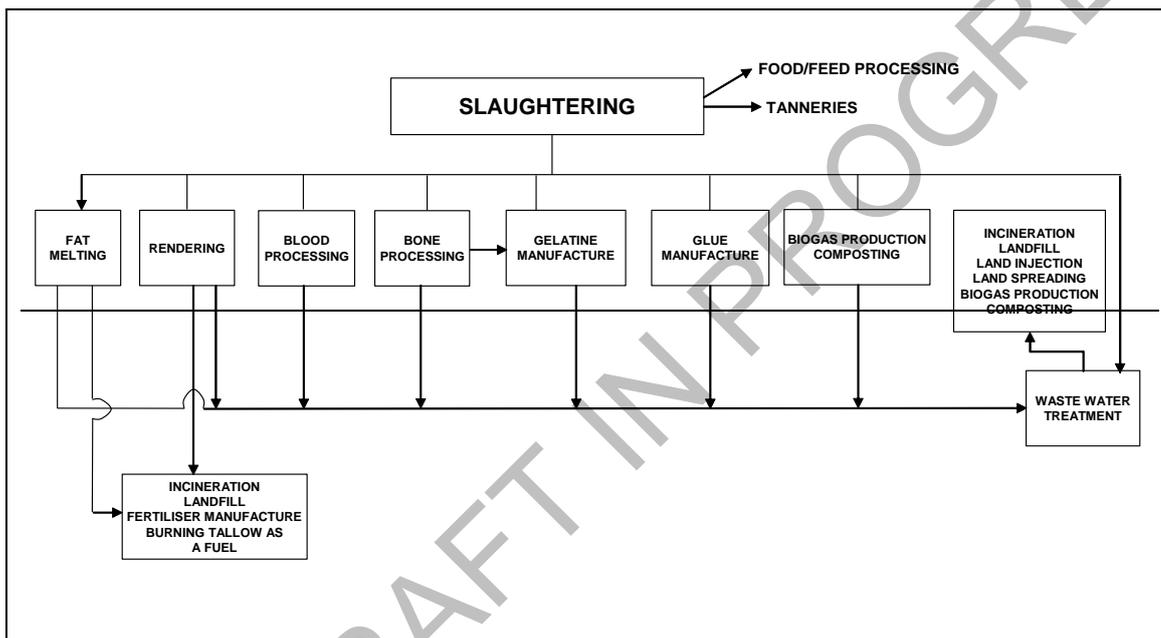
Key environmental issues in animal by products installations

All animal by products installations can potentially emit high organic strength liquids to water and cause significant local odour problems. If animal by products are not treated quickly after slaughter and before decomposition causes odour and/or quality problems and downstream waste water problems, they may be refrigerated to minimise decomposition. This consumes energy. Odour is a key environmental issue during rendering and fishmeal and fish oil production, even if fresh by products are treated. Energy consumption is also a key issue for those installations undertaking drying activities, i.e. fat melting, rendering, fishmeal and fish oil

production, blood processing, gelatine manufacture and glue manufacture. Emissions of the gaseous products of combustion to air, is an issue for incinerators. Infectivity associated with the destruction of TSE risk material is an issue for rendering plants and for incinerators. Infectivity associated with the destruction of pathogens has to be considered for composting and where the by product or waste produced by a treatment can be landfilled, land spread or land injected. Infestation by insects, rodents and birds can be an issue during animal by products storage and use. Water consumption is significant for gelatine manufacture.

Applied processes and techniques (Chapter 2)

The relationships between slaughterhouses and their downstream activities are illustrated in a very simplified and general form in the figure below.



Relationships between slaughterhouses and their downstream activities (summary)

Individual unit operations in slaughterhouses are described first. This section is divided between the slaughter of large animals and the slaughter of poultry. The processes at individual types of animal by products installations are then described. Some waste water treatment processes that are applied in the industries are then described, firstly for slaughterhouses and then for animal by products installations.

Current consumption and emission levels (Chapter 3)

The average live weights of animals and carcase weights vary considerably between Member States. Consumption and emission data has, to a large extent, been reported either “per tonne of carcase produced” or “per tonne of by product treated”. This reflects the terminology of the Directive and makes it easier to compare information from different sources. It also enables the relationships between the actual processes and consumption and emission levels to be examined, at the same time as avoiding misleading information based on, e.g. low concentrations, which may be achieved by the overconsumption of water.

Detailing the consumption and emission levels serves several purposes. Firstly, the ranges of levels for given processes and unit operations illustrate potential opportunities for improvement in environmental performance by those operating at the higher levels in the range. Secondly, the availability of data from unit operations also demonstrates that it is practicable to measure consumption and emission levels at that level and thus to monitor improvements. Thirdly, the information can also be used to identify priority unit operations which can be improved. Also,

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the availability of data at unit operation level makes it possible to compare techniques and determine BAT for those parts of processes where consumption and emission levels are significant and alternatives are available.

The data reported in the BREF illustrate a wide range of performances in the industries. For example, for pig slaughterhouses a total water consumption range of 1600–8300 litres per tonne of carcase produced is reported in Table 3.2. Water consumption levels, either in ranges or single values, were also provided for the following unit operations: loading and vehicle washing; lairage; slaughter; bleeding; scalding; hair and toenail removal; singeing; rind treatment; chilling; intestine washing and cleaning. Intestine washing was reported to use between 442–680 litres per tonne of carcase produced and to emit a BOD range of 0.98–3.25 kg per tonne of carcase and was therefore identified as a unit operation making a significant contribution to the pollution caused by the whole activity. Any contact between water and carcasses or animal by products leads to water contamination, which is one of the key environmental issues for slaughterhouses. The issue of reducing water consumption and water contamination, during intestine washing is addressed later in this document. Techniques are described and BAT is identified in Section 5.2.1.

Some of the data provided for slaughterhouses show the breakdown of how water and energy are consumed for different operations in an installation, as percentage values. This method of presenting data can be useful for identifying overall priorities, but it is less useful for monitoring improvements in a single operation because others may also change. For example, if less water is used for scalding then the percentage used in cleaning may rise even if the actual consumption does not. Nevertheless, this information has been useful, for confirming that cleaning as a major consumer of water and that refrigeration as a major consumer of energy, in slaughterhouses. The issue of minimising the consumption of water, and therefore the associated reduced contamination of waste water and the energy consumed to heat the water, has been addressed in this document. Unfortunately very little information has been received about reducing the energy consumed by chilling and refrigeration.

Drying operations at animal by products installations generally use most of the energy consumed. Information about consumption levels supports this. This issue has been addressed to some extent in the BREF and BAT has been identified for rendering.

Most of the information provided about odour is qualitative and the measurements received have been presented using several units, which has made quantitative comparison between the problems and potential solutions impossible. Nevertheless, odour associated with the storage and processing of animal by products is addressed from both the preventive and abatement perspectives and BAT have been identified.

Most of the consumption and emission data provided for slaughterhouses and animal by products installations relates to waste water, although unfortunately most of the data submissions were not accompanied by descriptions of the processes and throughput data or the waste water treatments applied. Nevertheless, sufficient information was received for the technical working group (TWG) to conclude that BAT is to subject the effluent from slaughterhouses and animal by products installations to a biological treatment process. BAT associated levels based on the expert judgment of the TWG are given in chapter 5 and are shown in the table below.

For incineration, data on air emissions and ash analysis is reported both in this chapter and in the chapter 4. The TWG has agreed to BAT associated levels and these are reported in chapter 5 and are shown in the table below.

For some animal by products activities, little or no consumption and emission level data was provided, however, qualitative information is included in the document.

The collection of data at the unit operation level, using comparable monitoring techniques and accompanied with detailed descriptions of the technique and the operating conditions, would be very useful for the revision of the BREF.

Techniques to consider in the determination of BAT (Chapter 4)

Chapter 4 contains the detailed information used by the TWG to determine BAT for the slaughterhouses and animal by products industries.

About 250 techniques are described. They are described under the standard headings Description, Achieved environmental benefits, Cross media effects, Operational data, Applicability, Economics, Driving force for implementation, Example plants and Reference literature. The TWG has aimed to include enough information to assess the applicability of the techniques in general or specific cases. The standard structure assists the comparison of techniques both qualitatively and quantitatively. The information in this chapter is essential to the determination of BAT.

Those techniques which the TWG has judged to be BAT, are also cross referenced from chapter 5. Permit writers and installation operators are thus directed to the discussion of the technique associated with the BAT conclusions, which can assist them when they are determining the BAT based conditions of IPPC permits.

This chapter includes both “process integrated” and “end of pipe” techniques, thus covering both pollution prevention and pollution control measures, respectively. Some of the techniques are very technical and others are good operating practices, including management techniques.

The chapter is structured so that techniques which are generally applicable to all slaughterhouses and animal by products installations are described first. These include general training, maintenance and operational good practice, considered as general techniques as they can be applied to virtually all activities. Others are more technical, but apply to the provision and use of utilities and services that are also applied in most industrial activities, such as providing lighting, or cleaning the installation. There are some techniques in this section which are more directly related to slaughterhouses and animal by products installations, including several dealing with the storage of animal by products and in particular the prevention of odour. Techniques associated with preventing the accidental release of large volumes of liquids and especially blood, are also included. General waste water treatment techniques are also included in this section.

Techniques which apply to all slaughterhouses are then described. These deal with issues such as the cleaning of lorries delivering live animals; minimisation of water consumption and contamination on slaughter lines; blood collection and the minimisation of water and energy use in knife sterilisation.

The next 2 main sections contain techniques dealing with the slaughter of large animals and poultry, respectively. These include viscera and hide treatments undertaken at large animal slaughterhouses. The techniques address potential consumption and emission issues at the unit operation level, i.e. they are inherently “process integrated” pollution prevention and control techniques. Some are technical and some are operational. Many of them address the key environmental issue of minimisation of water consumption and the associated contamination of waste water. In many cases there are energy considerations too, due to water being heated. They also address the minimisation of waste, e.g. associated with the trimming of hides.

The final section on slaughterhouses includes techniques for cleaning, waste water treatment and waste treatment. Throughout the chapter there is an ongoing theme about preventing waste water contamination and the segregation of by products to maximise their usability and minimise cross contamination and waste.

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When the animal by products industries are addressed there is an emphasis on minimising waste and odour problems. Where the individual processes are addressed one by one, techniques particular to the process in question are addressed, although in many cases the same environmental issues are discussed. For example, several of the techniques address energy saving for drying processes. Many of the techniques deal with “end-of-pipe” odour abatement and waste water treatment.

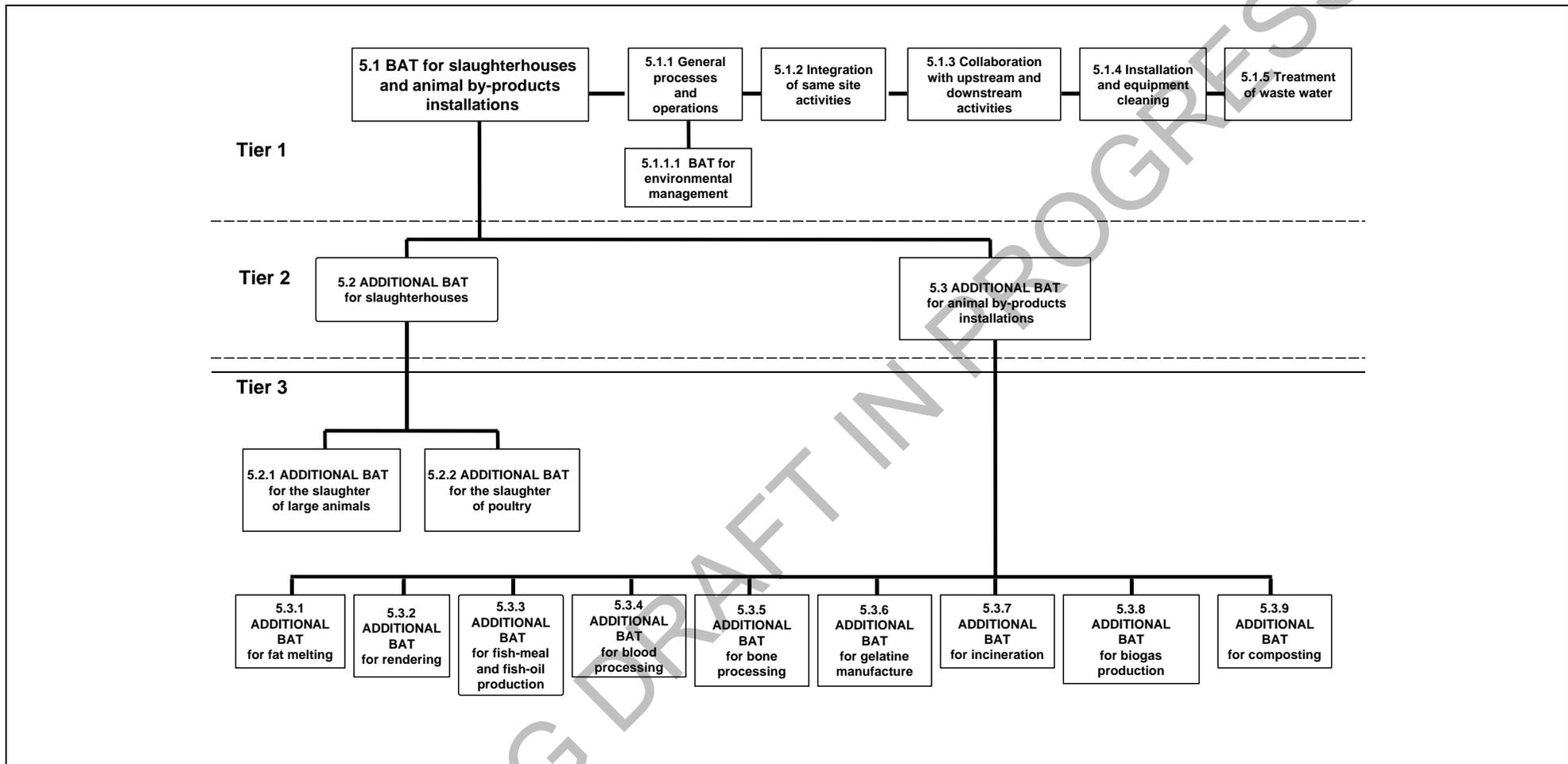
The section on the incineration of animal by products addresses those issues specific to the incineration of animal by products, starting from their delivery to the site. Techniques which have no special relevance to animal by products are not covered because they come within the scope of the “Waste Incineration” BREF. Issues such as flue gas treatment come within the scope of the “Waste Incineration” BREF whereas the main issues addressed by the techniques in this BREF are either directly or indirectly related to prevention of odour arising from animal by products and the destruction of TSE risk material.

Finally, 3 integrated same site activities are described and the environmental advantages of, e.g. reduced energy consumption by re-using heat and odour destruction by on-site incinerators are described.

Best available techniques (Chapter 5)

The way the BAT conclusions are presented in chapter 5 is shown in the figure below. In the figure, the BAT conclusions are presented in tiers. The top tier shows the Sections listing BAT for all slaughterhouses and animal by products installations; the second is divided between additional BAT for slaughterhouses and BAT for animal by products installations and the third is divided further showing the Sections listing additional BAT for individual types of slaughterhouse and animal by products installation.

The conclusions represent what the TWG considered to be BAT in a general sense for the slaughterhouses and animal by products industries based upon the information in chapter 4 and taking account of the Article 2(11) definition of “best available techniques” and the considerations listed in Annex IV to the Directive. This chapter does not set emission limit values but suggests emission levels that are associated with the use of BAT.



How the BAT conclusions are presented for slaughterhouses and animal by-products installations

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BAT addressing the main environmental issues for slaughterhouses and animal by products installations have been identified, to the extent that the information provided during the information exchange has allowed. The assessment of techniques is dependent on the information provided and assessed by the TWG. For many techniques there is only limited technical and economic data available. For some key environmental issues very little information was provided.

For slaughterhouses, the key environmental issues are generally water consumption; the emission of high organic strength liquids to water and the energy consumption associated with refrigeration and heating water. For animal by products installations, the main issues are related to the energy consumption associated with drying animal by products; the emission of high strength organic liquids to water; infectivity, especially related to the controlling, the handling and the destruction of TSE material and odour.

Measures to minimise consumption and emission levels are very much influenced by planning each process technically and operationally at each unit operation level. Some BAT therefore, relate to this.

Regulation (EC) No 1774/2002 of the European Parliament and of the Council of 3 October 2002 laying down health rules concerning animal by products not intended for human consumption specifies requirements for the handling, storage, transport and processing of animal by products and describes the disposal routes allowed for TSE risk material. Care has been taken to ensure that the BAT conclusions do not conflict with the requirements of this Regulation. Likewise care has been taken to ensure consistency with other legislation relating to, e.g. public health, food safety, animal welfare and health and safety at work. A great deal of the discussion about the BAT conclusions examined the potential impact of the use of techniques on these issues.

The following paragraphs summarise the key BAT conclusions relating to the most relevant environmental issues. During the discussion of the information exchanged by the TWG, many issues were raised and discussed. Only some of them are highlighted in this summary and it should not be read instead of the "Best available techniques" chapter, which should not be read in isolation from the rest of the BREF.

General management and operation

BAT options related to general management and operational techniques contribute to the overall minimisation of consumption and emission levels, by providing systems of work which encourage good practice and raise awareness. The BAT identified focus on issues such as using an environmental management system; providing training; using a planned maintenance programme; implementing energy, refrigeration, light and noise management systems; managing and minimising the quantities of water and detergents consumed and, in slaughterhouses, managing and monitoring the use of hot water.

Water consumption and the emission of high organic strength liquids in waste water

It is recognised that minimising water consumption and contamination has wide reaching environmental benefits, beyond just that. Increasing the volume of water used automatically affects the volume of waste water which has to be treated at either an on site or a municipal waste water treatment plant. The treatment of waste water consumes energy and sometimes chemicals and it can lead to odour problems. Every time water makes contact with a carcase or any animal by product, whether during production or cleaning, contaminants such as fats or blood are entrained and these increase the burden on the waste water treatment plant. In many cases the water used is hot, so energy will have been used to heat it. Also the fats can melt in hot water and then become more difficult to separate from the water.

The availability of water varies depending on factors such as climate, hydrogeology, other demands for its use and price. Whether consumption is considered to be a key environmental issue at site level may, therefore, vary. The Water Framework Directive requires that water

pricing policies provide adequate incentives for users to use water resources efficiently. The BREF identifies BAT to minimise water consumption.

Some examples of the type of BAT conclusions reached are included in the following list, although this is only a summary and there are more in the BAT chapter. BAT is to remove all running water hoses and repair dripping taps and toilets; fit and use drains with screens and/or traps to prevent solid material from entering the waste water; dry clean vehicles and installations before cleaning with a high pressure hoses fitted with hand operated triggers; use a squeegee for the initial cleaning of the blood collection trough; where the equipment is suitable, operate a cleaning in place system; avoid carcass washing and where this is not possible to minimise it, combined with clean slaughter techniques; re-use cold water within pig de hairing machines; re-use cooling water from pig singeing kilns; empty stomachs and small intestines dry; remove carcass washing equipment from poultry slaughter lines except after de feathering and evisceration and use recycled water, e.g. from the scalding tank, for the carriage of feathers.

Some of the techniques apply to all slaughterhouses and animal by products installations and others are applicable in e.g. only in large animal or only in poultry slaughterhouses. Many, but not all, of the techniques applicable to animal by products installations are waste water treatment techniques to clean water which has been contaminated by the process, e.g. during rendering; fishmeal and fish oil manufacture or gelatine manufacture. Waste water treatment techniques are listed.

Energy

Power generation has major global implications, due to the emissions of greenhouse gases from large combustion plants, so minimising energy consumption, including the use of hot water is a key issue to be addressed. Hygiene standards have always been paramount in slaughterhouses and to a great extent in animal by products installations producing food or pharmaceutical grade products. The Regulation (EC) No 1774/2002 of the European Parliament and of the Council of 3 October 2002 laying down health rules concerning animal by products not intended for human consumption has increased the emphasis on hygiene, at all animal by products installations, to protect the food and feed chain and to control the risk to public health. Some examples of the types of relevant BAT which have been identified include: dry clean installations and transport by products dry, followed by pressure cleaning using hoses fitted with hand operated triggers and where the use of hot water is necessary, using thermostatically controlled steam and water valves; insulating and covering knife sterilisers and insulating scalding tanks and the steam scalding of pigs and poultry.

In animal by products installations carrying out fat melting, rendering, fishmeal and fish oil production, blood processing, bone processing, gelatine manufacturing or glue making the majority of the energy consumed is generally associated with the drying process. For example 2/3 of the energy consumed in a rendering plant may be directly due to drying. Some examples of the types of BAT techniques identified include: rationalising and insulating steam and water pipework; removing water from blood, by steam coagulation, prior to rendering; for raw material throughputs less than 50000 t/yr, to use a single effect evaporator and for raw material throughputs greater than, or equal to 50000 t/yr, to use a multiple effect evaporator, to remove water from liquid mixtures and to concentrate plasma, prior to spray drying, using reverse osmosis, vacuum evaporation or by steam coagulation.

In slaughterhouses, in particular, refrigeration is a very large consumer of energy. It may also be significant where animal by products are kept in refrigerated storage prior to treatment at animal by products installations. Although this was identified as a key environmental issue, very little information was provided to assist with the determination of BAT. Some general BAT have been identified, including: implementing refrigeration management systems; operating controls over refrigeration plant running times; fitting and operating chill room door closing switches and recuperating heat from refrigeration plants.

Infectivity

Infectivity was identified as a key environmental issue, principally due to the concerns arising from the BSE crises regarding both animal health, especially with respect to the feed and food chain and human health after the links between TSE in animals and CJD, in humans were discovered. Control of the handling and treatment of confirmed TSE infected materials, those suspected of being infected and those arising from animals killed in the context of TSE eradication measures is regulated by *Regulation (EC) No 1774/2002 of the European Parliament and of the Council of 3 October 2002 laying down health rules concerning animal by products not intended for human consumption*.

The BREF contains BAT conclusions both directly and indirectly associated with the prevention of the spread of TSE and the destruction of TSE risk materials. These are particularly related to rendering and incineration. For example, BAT is to do the following: continuously collect by-products dry and segregated from each other, along the length of the slaughter line and throughout animal by-products treatment; optimise bleeding and the collection of blood; use sealed, storage, handling and charging facilities for animal by-products; enclose any buildings used for delivery storage, handling and processing of animal by-products; clean and disinfect delivery vehicles and equipment, after each delivery/use; reduce in size animal carcasses and parts of animal carcasses, before incineration; restrict feedstock to exactly that tested during trials; operate continuous incineration; operate an ash burnout chamber, where adequate combustion is not otherwise achievable, e.g. immediately downstream from rotary kilns; operate a monitoring regime for emissions, including a protocol for monitoring burnout, including biohazard from TSE prions, in ash; to achieve emission levels as low as reasonably practicable below those shown in the table below. This table includes BAT associated levels for total carbon and total protein, in ash.

Odour

Although odour is widely considered to be an issue of local nuisance, it can in reality be the most troublesome day to day environmental problem for slaughterhouses and animal by-products installations and so it has to be controlled. Typically it will be caused by the decomposition of animal by-products and this has other related environmental consequences, e.g. it reduces the usability of the animal by-products and hence increases waste. Also, the substances causing odour can cause problems during waste water treatment.

Odour has been considered in detail by the TWG and BAT has been identified to minimise odour and to destroy it when prevention has not been possible. The main conclusion was that animal by-products should be used or disposed of as soon as possible after the animal is slaughtered. Preservation techniques to prevent decomposition and to minimise the formation of malodorous substances and abatement techniques incur significant cross media effects, including energy consumption and often they require significant economic investment and running costs. Taking account of the cross media effects and their global implications and the economic factors, the TWG concluded that BAT is to implement some such techniques, but only if the animal by-products cannot be treated before the malodorous substances form, if the animal by-products are inherently malodorous or if the process is inherently malodorous.

Some examples of the BAT identified include: store animal by-products for short periods and possibly to refrigerate them; where it is not possible to treat blood or other animal by-products before their decomposition starts to cause odour problems and/or quality problems, refrigerating them as quickly as possible and for as short a time as possible, to minimise decomposition; where inherently malodorous substances are used or are produced during the treatment of animal by-products, to pass the low intensity/high volume gases through a biofilter. For rendering, when it has been impossible to use fresh raw materials and thereby to minimise the production of malodorous substances, BAT is to do either of the following: to, burn the non-condensable gases in an existing boiler and to pass the low intensity/high volume odours through a biofilter or to burn the whole vapour gases in a thermal oxidiser and to pass the low intensity/high volume odours through a biofilter. For fishmeal and fish oil production, BAT is to use fresh, (low total volatile nitrogen) feedstock and incinerate malodorous air, with heat

recovery. For incineration of animal by products, some examples of BAT include, to duct air from the installation and the pre-combustion equipment to combustion chambers, operate odour arrestment techniques, when the incinerator is not working, when odour prevention is not reasonably practicable and use a carbon filter for odour abatement, when incinerators are not operating.

Collaboration with upstream and downstream activities

The operations of those involved in the supply of animals to slaughterhouses, including the farmers and the hauliers, can have environmental consequences in the slaughterhouse. The suppliers of feedstock to animal by products installations and other downstream users can also influence the environmental impact of those installations. Their impact can be affected by the properties of the feedstock, e.g. the freshness, degree of separation of different materials and the specification.

BAT is to seek collaboration with upstream partners, to create a chain of environmental responsibility, to minimise pollution and to protect the environment as a whole. Several BAT are identified and most of these are associated with the delivery and feeding of animals or the storage of animal by products.

Sites with more than one activity

Several examples have been identified where sites with more than one activity can collaborate to minimise consumption and emission levels. BAT is to re-use heat and/or power produced in one activity in other activities and to share abatement techniques, where these are required, e.g. for waste water or odour treatment.

Three examples are listed in the BREF, but the principle can probably be applied to any same-site activities, of which there are many, for instance, slaughterhouses may, e.g. be on the same site as fat melting plants, rendering plants, blood processing plants, incinerators and composting plants.

It is also very common for slaughterhouses to have meat cutting plants and further processing plants on the same site. In such cases information from the "Food, drink and milk" BREF can be used to identify opportunities for collaboration.

The TWG also concluded that BAT is to export any heat and/or power produced which cannot be used on-site

BAT associated levels

BAT associated levels were identified for waste water treatment and for the incineration of animal by products.

The emission levels given below are generally considered to be appropriate for protecting the water environment and are indicative of the emission levels that would be achieved when applying those techniques generally considered to represent BAT. They do not necessarily represent levels currently achieved within the industry but are based on the expert judgment of the TWG.

Parameter	COD	BOD ₅	SS	Nitrogen (total)	Phosphorus (total)	FOG
Achievable emission level (mg/l)	25–125	10–40	5–60	15–40	2–5	2.6–15

Emission levels associated with BAT for minimising waste water emissions from slaughterhouses and animal by-products installations

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BAT for the incineration of animal by products, is to achieve emission levels as low as reasonably practicable below those shown in the table below:

Releases to air	Performance associated with BAT ⁽³⁾	
	Typical	Monitoring
SO ₂ (mg/m ³)	<30 ⁽²⁾	Continuous
HCl (mg/m ³)	<10 ⁽²⁾	Continuous
HF (mg/m ³)	n/a	
NO _x (mg/m ³)	<175 ⁽²⁾	Continuous
CO (mg/m ³)	<25 ⁽²⁾	Continuous
VOCs (mg/m ³)	<10 ⁽²⁾	Periodic
Dust (mg/m ³)	<10 ⁽²⁾	Continuous
Dioxins and furans (ng/m ³)	<0.1 ⁽⁴⁾	Periodic
Heavy metals total (Cd, Tl) (mg/m ³)	<0.05 ⁽⁵⁾	
Heavy metals (Hg) (mg/m ³)	<0.05 ⁽⁵⁾	
Heavy metals total (Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V) (mg/m ³)	<0.5 ⁽⁵⁾	
NH ₃ (mg/m ³)	<10	
Residence time ≥850 °C	3.5 s	
Oxygen (minimum after last injection)	9 %	Continuous
Pressure, Temperature, Water vapour; Volumetric flow		Continuous
Ash (total carbon)	<1 % ⁽⁶⁾	Periodic
Ash (total protein) (Aqueous extract) (mg/100g)	0.3 - 0.6	Periodic
⁽²⁾ Releases control "95 % percentile hourly average over 24 hours". Measurements at 273 K (temp.), 101.3 kPa (pressure) and 11 % O ₂ dry gas		
⁽³⁾ Actual performance results operating a dry flue gas cleaning system with bag filters and injected reagents		
Values measured over a sample period of a minimum of 6 hours and a maximum of 8 hours expressed as toxic equivalent in accordance with Annex 1 of the Waste Incineration Directive		
⁽⁵⁾ Values measured over a sample period of a minimum of 6 hours and a maximum of 8 hours		
⁽⁶⁾ Total organic carbon		
Note: Protein analysis is not relevant to the dedicated incineration of poultry by products		

Emission levels associated with the dedicated incineration of animal by products in either bubbling fluidised bed, circulating fluidised bed or rotary kiln incinerators

Emerging techniques (Chapter 6)

Chapter 6 includes 2 techniques that have not yet been commercially applied and are still in the research or development phase. They are "Bio refining of animal by products to produce soil improvers and fertilisers" and "Biotechnological treatment of animal by products in order to increase energetic valorisation". They have been included here to raise awareness for any future revision of this document.

Concluding remarks (Chapter 7)

Information provided

Many reports from industry and Member State authorities were used as sources of information in the drafting of this BREF and these were supplemented by information from individuals based on example plants. A great deal of information was received during and following site visits to slaughterhouses and animal by products installations in several Member States. The formal consultations on each draft of the document also prompted the provision of a huge

amount of information as well as providing the main opportunities for the TWG to verify the information already submitted.

Although over 350 pieces of information were provided, some significant gaps remain. Energy consumption is a key environmental issue in slaughterhouses, due to chilling and refrigerated storage and in many animal by products installations, especially during drying. In spite of this, very little data or information about energy saving techniques was submitted.

There is a lack of consistency in the data on the measurement of odour and the identification of the options for keeping odour streams separate for treatment. Prevention of odour is addressed, however, albeit qualitatively.

In general the consumption and emission data provided was not well explained in terms of operating conditions and analytical methods and its relationship with the techniques described was not always made clear. This is one of the reasons why there are very few associated BAT levels quoted. The TWG attempted to collect data “per tonne of carcase produced” and “per tonne of animal by product treated” for each unit operation, to allow direct comparisons to be made and to identify the areas with high consumption and emission levels, so that these could be addressed. Large gaps remain in this data.

Very little information was received about bone processing, glue manufacture, gasification of meat and bone meal, land spreading/injection, shellfish shell cleaning and the manufacture of fertiliser from animal meal. This may in some cases be due to local legislation prohibiting or restricting the application of animal by products to land and restrictions under the new *Regulation (EC) No 1774/2002 of the European Parliament and of the Council of 3 October 2002 laying down health rules concerning animal by products not intended for human consumption*.

Driving forces

The content of the BREF, as well as its time scale for preparation has been strongly influenced by issues such as food and feed safety concerns, e.g. arising from BSE; food hygiene and animal welfare. The focus has remained on the prevention and control of pollution, but care has been taken to ensure there is consistency with legislation and good practice associated with these other important drivers. The main legal driver has been the new *Regulation (EC) No 1774/2002 of the European Parliament and of the Council of 3 October 2002 laying down health rules concerning animal by products not intended for human consumption*.

Level of consensus

The conclusions of the BREF were agreed at the final TWG meeting and there are no split views.

Recommendations for future work

The gaps in the information indicate areas where future work could provide results which might assist in the identification of BAT when the BREF is revised, thereby helping operators and permit writers to protect the environment as a whole.

The lack of data “per tonne of carcase produced” and “per tonne of animal by product treated”, for each unit operation, could be addressed via the regulatory authorities and the various industry NGOs which represent the slaughterhouses and animal by products operators. They could encourage and co ordinate the increased measurement of consumption and emission levels at the unit operation level, including details on operating conditions; descriptions of techniques applied; sampling protocols; analytical methods and statistical presentation.

A great deal of the information provided about techniques was incomplete. The TWG decided that although there was insufficient information in these techniques to help with the determination of BAT, they should still be included in the document. The incomplete techniques

Executive Summary

are appended to chapter 7. They are included to provoke both the collection and provision of further information, when the BREF is revised.

Suggested topics for future R & D projects

The following topics might be considered for future research and development projects:

- 1 — minimisation of energy consumption associated with chilling and refrigerated storage
- 2 — minimisation of energy consumption associated with the drying of animal by products
- 3 — opportunities to use non-potable water at slaughterhouses, without compromising hygiene and food safety
- 4 — optimisation of the use of animal by products, to minimise waste and
- 5 — the development of benchmarking tools to improve the quality of future information exchanges and revisions of the BREF.

The EC is launching and supporting, through its RTD programmes, a series of projects dealing with clean technologies, emerging effluent treatment and recycling technologies and management strategies. Potentially these projects could provide a useful contribution to future BREF reviews. Readers are therefore invited to inform the EIPPCB of any research results which are relevant to the scope of this document (see also the preface of this document).

PREFACE

This chapter has been completely rewritten compared to the original SA BREF

1. Status of this document

Unless otherwise stated, references to ‘the Directive’ in this document refer to Directive 2010/75/EU of the European Parliament and the Council on industrial emissions (integrated pollution prevention and control) (Recast).

This document is a working draft of the European IPPC Bureau (of the Commission's Joint Research Centre). It is not an official publication of the European Union and does not necessarily reflect the position of the European Commission.

2. Participants in the information exchange

As required in Article 13(3) of the Directive, the Commission has established a forum to promote the exchange of information, which is composed of representatives from Member States, the industries concerned and non-governmental organisations promoting environmental protection (Commission Decision of 16 May 2011 establishing a forum for the exchange of information pursuant to Article 13 of the Directive 2010/75/EU on industrial emissions (2011/C 146/03), OJ C 146, 17.05.2011, p. 3).

Forum members have nominated technical experts constituting the technical working group (TWG) that was the main source of information for drafting this document. The work of the TWG was led by the European IPPC Bureau (of the Commission's Joint Research Centre).

3. Structure and contents of this document

- Chapter 1 provides general information on the SA sector in Europe and its key environmental issues (KEI).
- Chapter 1 provides information and data on generally applied processes and techniques, emission levels, techniques to consider for the determination of BAT across the SA sector. As much as possible information on general issues is included in this chapter to avoid repetitions.
- Chapter 3 provides information and data on applied processes and techniques, emission and consumption levels, techniques to consider for the determination of BAT for slaughterhouses. The chapter includes a general section and sections referring to specific animal species (cattle, pigs, chickens).
- Chapter 4 provides information and data on applied processes and techniques, emission and consumption levels, techniques to consider for the determination of BAT for installations processing animal by-products and/or edible co-products. The chapter includes a general section and sections referring to specific installations, i.e. rendering of animal by-products and/or edible co-products (rendering, fat melting, blood and feather processing), fishmeal and fish oil production, gelatine manufacturing.
- Chapter 5 presents the proposed BAT conclusions. These include associated emission levels, and other associated environmental performance levels, as stipulated in the BREF Guidance.
- Chapter 6 presents information on ‘emerging techniques’.
- Chapter 7 will be drafted at a later stage and will include the concluding remarks and recommendations for future work.

- Annex I (Chapter 8) gives general information about the data collection process, as well as the list of plants that took part in the data collection via questionnaire.
- Annex II (Chapter 9) gives examples of various processes flowcharts from installations that participated in the data collection.

4. Information sources and the derivation of BAT

This document is based on information collected from a number of sources, in particular through the TWG that was established specifically for the exchange of information under Article 13 of the Directive. The information has been collated and assessed by the European IPPC Bureau (of the Commission's Joint Research Centre) who led the work on determining BAT, guided by the principles of technical expertise, transparency and neutrality. The work of the TWG and all other contributors is gratefully acknowledged.

The BAT conclusions have been established through an iterative process involving the following steps:

- identification of the key environmental issues for the Slaughterhouses, and Animals By-products and Edible Co-products Industries;
- examination of the techniques most relevant to address these key issues;
- identification of the best environmental performance levels, on the basis of the available data in the European Union and worldwide;
- examination of the conditions under which these environmental performance levels were achieved, such as costs, cross-media effects, and the main driving forces involved in the implementation of the techniques;
- selection of the best available techniques (BAT), their associated emission levels (and other environmental performance levels) and the associated monitoring for this sector according to Article 3(10) of, and Annex III to, the Directive.

Expert judgement by the European IPPC Bureau and the TWG has played a key role in each of these steps and the way in which the information is presented here.

Where available, economic data have been given together with the descriptions of the techniques presented in *Techniques to consider in the determination of BAT* sections. These data give a rough indication of the magnitude of the costs and benefits. However, the actual costs and benefits of applying a technique may depend strongly on the specific situation of the installation concerned, which cannot be evaluated fully in this document. In the absence of data concerning costs, conclusions on the economic viability of techniques are drawn from observations on existing installations.

5. Review of BAT reference documents (BREFs)

BAT is a dynamic concept and so the review of BREFs is a continuing process. For example, new measures and techniques may emerge, science and technologies are continuously developing and new or emerging processes are being successfully introduced into the industries. In order to reflect such changes and their consequences for BAT, this document will be periodically reviewed and, if necessary, updated accordingly.

6. Contact information

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WORKING DRAFT IN PROGRESS

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WORKING DRAFT IN PROGRESS

SCOPE

This chapter has been completely rewritten compared to the original SA BREF

This BAT reference document (BREF) concerns the following activities specified in Annex I to Directive 2010/75/EU:

- 6.4. (a) Operating slaughterhouses with a carcass production capacity greater than 50 tonnes per day.
- 6.5. Disposal or recycling of animal carcasses or animal waste with a treatment capacity exceeding 10 tonnes per day.
- 6.11. Independently operated treatment of waste water not covered by Council Directive 91/271/EEC¹ when the main pollutant load originates from the activities covered by this document.

This document also covers:

- the processing of animal by-products and/or edible co-products (such as rendering and fat melting, feather processing, fishmeal and fish oil production, blood processing and gelatine manufacturing), covered by the activity description in points 6.4 (b) (i) and 6.5 of Annex I to Directive 2010/75/EU;
- the combustion of meat-and-bone meal and of animal fat;
- the combustion of malodorous gases including non-condensable gases (e.g. in thermal oxidisers or steam boilers);
- the preservation of hides and skins if directly associated with the activities covered by this reference document;
- the handling of casings and offal (viscera);
- the combined treatment of waste water from different origins provided that the main pollutant load originates from the activities covered by this document and that the waste water treatment is not covered by Council Directive 91/271/EEC².

This document does not address the following:

- On-site combustion plants, not covered by the above bullet points, generating hot gases that are not used for direct contact heating, drying or any other treatment of objects or materials. This may be covered by the BREF for Large Combustion Plants (LCP) or by Directive (EU) 2015/2193 of the European Parliament and of the Council³.
- The production of food after the making of standard cuts for large animals or of cuts for poultry. This may be covered by the BREF for Food, Drink and Milk Industries (FDM).

Other reference documents which could be relevant for the activities covered by this BREF include the following:

- Large Combustion Plants (LCP);
- Food, Drink and Milk Industries (FDM);

¹ Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment (OJ L 135, 30.5.1991, p. 40).

² Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment (OJ L 135, 30.5.1991, p. 40).

³ Directive (EU) 2015/2193 of the European Parliament and of the Council of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants (OJ L 313, 28.11.2015, p. 1).

Scope

- Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector (CWW);
- Waste Treatment (WT);
- Tanning of Hides and Skins (TAN);
- Monitoring of Emissions to Air and Water from IED Installations (ROM);
- Economics and Cross-Media Effects (ECM);
- Emissions from Storage (EFS);
- Energy Efficiency (ENE);
- Industrial Cooling Systems (ICS).

The scope of this document does not include matters that only concern safety in the workplace or the safety of products because these matters are not covered by the Directive. They are discussed only where they affect matters within the scope of the Directive.

WORKING DRAFT IN PROGRESS

1 GENERAL INFORMATION ABOUT THE SA SECTOR

1.1 Economic overview

Request to the TWG: Please provide updated information.

The FAO have forecast that global meat consumption will grow by 2 % per year, until the end of 2015. It has warned that the associated increase in trade and transport links required will raise the risks of the spread of animal diseases across borders. These trends are reported to have already started in the early 1980s, driven by population growth, rising incomes, urbanisation, changing diets and by the opening up of markets, particularly for poultry and pig meat.

It is predicted that most of this increase will occur in the developing world, where consumption is expected to grow by 2.7 % per year, compared to 0.6 % year in rich countries. The FAO has also stated that recent animal disease outbreaks in major meat exporting countries, such as BSE, had accelerated a shift in consumption away from red meat to poultry. The FAO predict a 2.9 % per year increase in demand for poultry meat until the end of 2015, and a 1.4 % increase in annual demand for beef.

According to the FAO, there are many hidden costs in animal disease epidemics. In total, 11.0 million animals were slaughtered in the Netherlands during the classical swine fever outbreak in 1997/98 and 6.24 million were killed in Great Britain during the FMD crisis in 2001.

The FAO report that The disposal of slaughtered carcasses has huge environmental implications; during the first six weeks of the UK FMD outbreak, the burning of carcasses released dioxins into the atmosphere amounting to some 18 percent of the UK's annual emissions, and Furthermore, the mass slaughter of animals resulted in the loss of bio diversity of native livestock populations, with some breeds left critically endangered following the UK FMD outbreak. [324, Brough D., 2002]

In 2000, EURA reported that the animal by products industry manufactures products with an annual value of greater than EUR 2.2 billion and that this represents a very significant source of income for the European agriculture industry. [24, EURA, 1997]

In the past few years the BSE crisis has meant that costs to slaughterhouses for disposal of their animal wastes have increased significantly. To keep costs to a minimum, most have sought to place contracts with the larger rendering companies offering economies of scale. Due to fierce competition, many rendering companies went bankrupt or were bought out by the larger companies. As a result there are now only two very large rendering companies left in the UK and about 20 smaller companies. [12, WS Atkins EA, 2000]

Costs have increased for the treatment and disposal of animal by products and this has been passed along the meat supply chain to the customer. [18, UKRA, 2000]. For example, in the UK before the BSE crisis many animal by products, including fallen stock were sold to rendering companies or collection charges were minimal. The European Commission prohibitions limiting the use and export of "processed animal proteins" from 1 January 2001 has led to additional storage and disposal costs [18, UKRA, 2000]. Rendering companies now impose significant charges for the collection of animal by products.

The numbers of cases of BSE in the UK has significantly exceeded those elsewhere in Europe and this has led to the UK and Ireland taking some preventive actions, which have had financial consequences, ahead of the other EU MSs. In the UK, prior to the BSE crisis, the value of the protein and fats produced by the rendering industry was GBP 150 million. In 2000, this had

fallen to nearer GBP 50 million. [17, UKRA, 2000]. In 1996, MAFF provided temporary financial support of GBP 100 million to prevent the collapse of the meat industry. In 1997/98, it provided a further GBP 59 million. [18, UKRA, 2000]

The action by the UK to prohibit the feeding of processed animal proteins to all livestock, not just ruminants and to ban exports to third countries before the rest of the EU, placed financial burdens on the meat industry there, exceeding those experienced elsewhere at that time.

In the UK, government support to the meat industry was withdrawn in 1998. Until cases of BSE were discovered in some MSs, for the first time, from December 2000 onwards, their market for animal meal was largely unaffected, although the feeding of processed animal proteins to ruminants had been banned. The other MSs then introduced legislation to quickly restrict their use further.

Each MS had its own financial arrangements for paying for rendering and for the subsequent disposal of animal meal. In Denmark, the co-operative system, whereby the farms, slaughterhouses and rendering plants are jointly owned, means that additional costs are passed to the customer and there is no government support. In Italy, France and the Netherlands the cost is passed to the customer. In Germany, support can be provided to rendering plants. In France, the government funds the collection, processing and disposal of SRM and all dead ruminants, pigs and poultry by imposing a customer tax on meat sales. This amounts to approximately GBP 59 million per year. [21, UKRA, 2000]

Compensation was temporarily made available to farmers unable to obtain the “trigger price”, i.e. a minimum market value, applicable to their MS, for beef and veal. The scheme was known as the “over thirty months scheme” (OTMS). The cost was divided between the European Commission, which paid 70 % and the MS, which paid 30 %. The OTMS was for cattle not eligible for intervention purchases, which were more than 30 months of age and which had all been tested negatively for BSE. The price paid to farmers for these animals, that were no longer available for human consumption, was fixed on the basis of the market price in the MSs, according to the quality category of the meat concerned. For those MSs without full testing capacity, the provisions of the “purchase for destruction scheme” remained in force until 30 June 2001, when the compulsory testing came into force. This was to avoid non-BSE tested meat from cattle over 30 months from entering the food chain.

The continuing ban on the use of processed animal proteins in feed for animals farmed for food has led to the diversification of the animal by products industry into incineration and to research into alternative ways of disposing of by products and in particular TSE materials and SRM. The rendering industry still processes most of the animal by products not intended for human consumption although some are stored frozen, for future incineration.

The economic cost of consumption and emissions

General considerations

The minimisation of consumption and emission levels, in many cases has direct financial benefits. These can be seen from, e.g. reduced energy costs and a decreased requirement to use “end of pipe” abatement techniques.

Some of the financial costs associated with the consumption of resources and emissions to air, water and land are easy to measure. The use of some resources, such as electricity, fuels and in some cases water, are measured, for payment purposes. At some installations measurements are made at unit operation level for monitoring and identifying possible areas for reducing consumption levels. Some emissions, including, e.g. solid wastes, are taken away for disposal, by waste contractors who are paid per unit load transported. Some animal by products which are now considered to be wastes were used in the past and in some countries were sold for

profit. The provision and maintenance of abatement equipment, e.g. the replacement of filter material, can also be quantified relatively easily.

Some of the insured and uninsured costs associated with cleaning up and repairing damage, to the plant and the environment, after an accident can be quantified.

To measure the full consumption and emission economic costs requires a focused effort. It must, e.g. take into account all of the man hours spent identifying, planning, sourcing, buying, installing, commissioning, operating, adjusting, maintaining, cleaning, repairing or transporting equipment for pollution abatement.

The costs associated with changing technological and operating techniques which improve environmental performance and have an effect on the process may be more difficult to calculate accurately, for various reasons, including the element of cost saving due to, e.g. the reduced consumption of electricity.

Some examples

Water

The cost of water depends on factors such as whether it is bought from an external source or abstracted directly at the installation and what pretreatment, such as softening, is required. The attitude to water usage varies considerably depending, to some extent, on its cost. Some users who have their own plentiful sources of water and abstraction facilities do not consider water to be a key environmental or economic issue.

The Water Framework Directive [180, EC, 2000] addresses this and sets out to ensure that all users value and pay for the water they use. This Directive introduces a principle of recovery of the costs of water services, including environmental and resource costs associated with any damage or negative impact on the aquatic environment, invoking in particular, the “polluter pays principle”. It requires that water pricing policies provide adequate incentives for users to use water resources efficiently. The attitude which encourages increased consumption of water because the supplier provides it at a lower unit cost if more is consumed, may cease to have foundation.

The link between water consumption and energy use is very important in the slaughterhouses and animal by products industries. Typically about half of the total water usage at a slaughterhouse is heated to between 40 and 60 °C and some is heated to 82 °C. In England and Wales in 1998, slaughterhouses reliant on local water authorities for their supply, typically paid GBP 0.70 (EUR 1.13)/m³. If the water requires softening before use, on-site water processing costs may increase the cost by a further GBP 0.30 (EUR 0.48)/m³. For every 10 °C increase in water temperature there is an additional cost of typically GBP 0.16 (0.26)/m³, if water is heated by gas, or GBP 0.47 (EUR 0.76)/m³, if water is heated by electricity (1998) [12, WS Atkins EA, 2000, 67, WS Atkins Environment/EA, 2000].

The user does not only have to pay for the consumption of water. The water used has to be treated before being discharged. Whether the treatment is done on-site or at a municipal WWTP the consumer will have to pay. The WWTP will have to be capable of treating both the volume and the pollutant load. Reducing both of these parameters will reduce the investment and operating costs for the WWTP. WWTPs, in common with other “end of pipe” techniques, only control emissions; they do not add other benefits to, e.g. productivity, which “process-integrated” techniques may do [327, EC, 2002].

In Denmark, most of the waste water treatment is undertaken at municipal sewers, with only the preliminary removal of solids using a 2 mm mesh being done at the slaughterhouse. The waste water is considered to be desirable for the denitrification process and surcharges are normally calculated according to the BOD levels. Water costs in 1998 were on average DKK 14–16/m³. “Green taxes” are levied on the final discharge plant. [134, Nordic States, 2001]

In Italy, most slaughterhouses abstract groundwater directly and treat it to drinking water standard. Several small slaughterhouses use the local authority supply. The cost of the water from the public network depends on the particular site and the volume. The average cost is EUR 0.80/m³. The cost of the abstraction and treatment of well water is about EUR 0.16–0.20/m³, depending on the depth. If softening is required, only for water that must be heated and for steam production, an additional cost of EUR 0.24/m³ must be paid. Heating water costs EUR 0.52/m³ for every 10 °C increase in temperature. The average cost of waste water treatment, including sludge disposal is EUR 0.5–0.7/m³. Some slaughterhouses discharge their waste waters to municipal sewers after a physico-chemical pretreatment at a cost of EUR 1–2/m³, plus EUR 0.35/m³ for treatment in WWTPs. [237, Italy, 2002]

All Finnish slaughterhouses discharge their waste water to municipal WWTPs. Some have their own pretreatment systems (flotation). There are no special “green taxes” on water consumption for slaughterhouses, but the water charge consists of a clean water cost and a waste water charge. The charges vary so much, from authority to authority, that quoting an average would be meaningless. [134, Nordic States, 2001]

Water costs at Swedish slaughterhouses are typically SEK 15–18/m³. This covers clean water use and the treatment of waste water at municipal WWTPs. Where slaughterhouses have their private water supplies, the costs are significantly lower.

Charges for water use and waste water discharge are based on the measured usage, although they consist of both a water charge and a discharge fee. Surcharges for particularly high levels of pollution are rarely used, but when applied they normally consist of an extra payment of 20 % over the standard charges. [134, Nordic States, 2001]

Energy

There is some information available about the relationship between economics and the environmental impact from the meat industry. In the simplest sense the annual energy costs paid by an installation may be compared to the annual profits made. This does not take full account of the environmental impact of the energy generation, e.g. the extraction of fuel and the building and operation of the power plant. It does, however, show that if energy use was reduced profits could be greater. An MLC survey of red meat sites in 1987 found that average profits were of the same magnitude as energy costs. The study concluded that there was considerable scope for profit improvement through increased operating efficiency. A UK survey in 1991 showed that in the red meat slaughtering industry, although electricity was less than 39 % of the total energy usage it accounted for 78 % of the energy costs [57, DoE, 1993]. Reduction in electricity use is therefore a worthwhile goal both environmentally and economically.

In Denmark, a “green tax” is levied on electricity supply. In 2000, the average cost of electricity for slaughterhouses was DKK 0.48/kWh. Denmark has a district heating system which is subject to “green taxes”. The average cost of heat energy in 2000 was DKK 0.165/kWh. [134, Nordic States, 2001]

In Italy, the average price of electricity is EUR 0.087/kWh. For natural gas, the average price is EUR 0.248/m³ gas, which is equivalent to EUR 0.03/kW thermal. [237, Italy, 2002]

In Finland, there is a “green tax” on electricity supply of FIM 0.026 (EUR 0.1)/kWh. The electricity cost varies, depending on the supplier, between FIM 0.22 and 0.37 (EUR 0.1 and 0.6)/kWh (electricity price + transfer cost + all taxes). The heating energy used by slaughterhouses is produced with light or heavy fuel oil. “Green taxes” are levied on these at a rate of FIM 0.40 (EUR 0.7)/l and FIM 0.34 (EUR 0.6)/l, respectively. [134, Nordic States, 2001]

In Sweden, industry is exempt from energy tax. The electricity cost is SEK 0.23–0.30/kWh. The cost of heat for process and room heating varies according to the method of production. Some slaughterhouses use wood chips from the forest industry, but fuel oil and gas oil are also

used. The cost is similar to the cost of electricity, unless it has been found profitable to invest in heat recuperation. [134, Nordic States, 2001]

The Norwegian meat industry pays on average NOK 0.265/kWh for electric power. For oil, the cost is about NOK 0.35/kWh or (NOK 3.50/l). About 65 % of the energy consumed is from electricity and the rest is from oil. The average energy cost is NOK 0.295/kWh. The Norwegian meat industry is exempt from electricity tax.

Food and veterinary legislation influences

There are other legal requirements and prohibitions, which must be considered when identifying “best available techniques” in the slaughterhouses and animal by products industries. There are specific requirements relating to, e.g. food safety and animal welfare.

Council Directive 91/497/EEC of 29 July 1991 amending and consolidating Directive 64/433/EEC on health problems affecting intra-Community trade in fresh meat to extend it to the production and marketing of fresh meat [169, EC, 1991] and *Council Directive 92/116/EEC of 17 December 1992 amending and updating Directive 71/118/EEC on health problems affecting trade in fresh poultrymeat* [223, EC, 1992] set out the main hygiene requirements for slaughterhouses. Some of these requirements have significant environmental consequences, in terms of, e.g. water and energy consumption.

There is legislation, which is also very relevant to the animal by products activities covered in this document, which has been taken into account, i.e. *Regulation (EC) No 1774/2002 of the European Parliament and of the Council of 3 October 2002 laying down health rules concerning animal by products not intended for human consumption* [287, EC, 2002].

Whereas other food, veterinary and animal welfare legislation influences the applied processes and techniques, e.g. with respect to water temperature requirements in slaughterhouses, ABP Regulation 1774/2002/EC goes further. It stipulates specific treatments requiring, e.g. materials to be heated to a certain temperature for a specified time. It states what uses and routes for disposal are permitted or required for animal by products not intended or not fit for human consumption. Where there is more than one process permitted under ABP Regulation 1774/2002/EC operators may decide which to follow due to market preferences, or economic considerations. Consequently, such decisions may differ either geographically or through time.

ABP Regulation 1774/2002/EC allows for currently unspecified processes to be approved for the use or disposal of animal by products not intended for human consumption and refers to procedures for such approval.

The objective of implementing ABP Regulation 1774/2002/EC, is to prevent animal by products derived from animals not fit for human consumption, following health inspection, from entering the feed chain and thereby presenting a risk to animal or public health. ABP Regulation 1774/2002/EC also applies to parts of slaughtered animals which are fit for human consumption, but are not intended for human consumption for commercial reasons.

Some of the materials processed by the animal by products industry are edible and are eaten by humans. Some of the activities covered in this document produce food for human consumption and care has been taken to ensure that nothing conflicts with relevant food safety legislation.

Until recently EU legislation covering the animal by products industry referred to the animal tissues not directly consumed by humans as “waste”. The current practice of using the term “by-product” for materials reserves the use of “waste” for by products disposed of as waste.

1.2 Key environmental issues

1.2.1 Emissions to water and to air

For emissions to water and to air, a key environmental issue (KEI) is caused by a process that emits a pollutant, for example, is measured and characterised by the monitoring of the pollutant, and there are techniques able to prevent and/or reduce the emissions of the given pollutant.

The approach used to determine the KEI is based on the following four criteria:

1. What is the environmental relevance of the pollutant?
2. What is the significance of the activity?
3. What is the potential for identifying new or additional techniques that would further significantly reduce pollution?
4. What is the potential for BAT-AELs that would significantly improve the level of environmental protection from current emission levels?

The key environmental issues (KEIs) were discussed during the kick-off meeting for the review of the SA BREF in June 2019. Based on the proposals made by the EIPPCB in the background paper and on the discussions which took place during the kick-off meeting for each pollutant, the technical working group (TWG) agreed to include in the review of the SA BREF the KEIs for emissions to water which are summarised in Table 1.1.

Table 1.1: KEIs for emissions to water included in the review of the SA BREF

(Groups of) Substance(s)	Type of discharge
Chemical oxygen demand (COD)	KEI for direct discharges only
Total organic carbon (TOC)	
Total suspended solids (TSS)	
Total nitrogen (TN)	
Total phosphorus (TP)	

Source: [199, COM 2019]

In addition, a number of conclusions were reached for some pollutants or parameters, as follows:

- To collect data on TSS for indirect discharges from slaughterhouses as contextual information.
- To collect information on sources of copper and zinc emissions from slaughterhouses and on techniques to reduce copper and zinc emissions.
- To collect data on direct and indirect emissions of copper and zinc from slaughterhouses.
- To collect information on sources of AOX emissions from SA installations and on techniques to reduce AOX emissions.
- To collect data on direct and indirect emissions of AOX from SA installations.
- To collect bulk information on the selection and use of less harmful detergents in SA installations.
- To collect bulk information on emissions of microorganisms resistant to antimicrobials from slaughterhouses as well as on techniques to reduce such emissions.
- To collect data on the following substances and parameters not as KEIs but as contextual information:
 - temperature (for direct discharges only);
 - BOD₅ or BOD₇ (for direct discharges only);
 - ammonium-N (for direct discharges only);
 - pH (for direct and indirect discharges);

- chloride (in slaughterhouses, in SA installations performing hide/skin salting and in gelatine manufacturing installations using bones, for both direct and indirect discharges);
- sulphide and sulphate (in slaughterhouses and rendering installations, for direct and indirect discharges);
- level of automation (for slaughterhouses).

The TWG agreed to include in the review of the SA BREF the KEIs for channelled emissions to air which are summarised in Table 1.2.

Table 1.2: KEIs for channelled emissions to air included in the review of the SA BREF

(Groups of) Substance(s)	Type of installation or process
Odour	All SA installations
H ₂ S	Rendering installations
HFC and HCFC	Slaughterhouses
Dust	<ul style="list-style-type: none"> • Installations processing animal by-products and/or edible co-products when thermal oxidation is used as an abatement technique. • Incineration of carcasses. • Combustion of meat-and-bone meal and animal fat. • Combustion of malodorous gases including non-condensable gases (e.g. in thermal oxidisers or steam boilers) in SA installations.
SO _x	
NO _x	
NH ₃	
TVOC	<ul style="list-style-type: none"> • Rendering installations. • Incineration of carcasses. • Combustion of meat-and-bone meal and animal fat. • Combustion of malodorous gases including non-condensable gases (e.g. in thermal oxidisers or steam boilers) in SA installations.
HCl	
Dioxins and furans	<ul style="list-style-type: none"> • Incineration of carcasses. • Combustion of meat-and-bone meal.
Hg	
Cd+Tl	
Sb+As+Pb+Cr+Co+Cu+Mn+Ni+V	
HF	<ul style="list-style-type: none"> • Incineration of carcasses.

Source: [199, COM 2019]

In addition, a number of conclusions were reached for some pollutants or parameters, as follows:

- To collect information on techniques to prevent and/or reduce diffuse odour emissions, including from waste water treatment plants.
- To collect information on the use of refrigerants without ozone depletion potential and with low global warming potential in slaughterhouses.
- To collect information on the consumption of refrigerants and techniques to prevent or reduce leakages in slaughterhouses through the questionnaires.
- To collect information on techniques to prevent or reduce dust emissions from installations processing animal by-products and/or edible co-products.
- Not to include dust as a KEI for slaughterhouses.
- Not to include NH₃ as a KEI for slaughterhouses.
- To include in the questionnaires CO emissions not as a KEI but as contextual information on the combustion efficiency of thermal oxidisers.
- To include in the questionnaires CO emissions from the incineration of carcasses not as a KEI but as contextual information on the combustion efficiency.

- To include in the questionnaires CO emissions not as a KEI but as contextual information on the combustion efficiency of:
 - the combustion of meat-and-bone meal and animal fat;
 - the combustion of malodorous gases including non-condensable gases (e.g. in thermal oxidisers or steam boilers) in SA installations.
- Not to include noise as a KEI for SA installations.
- To collect information on techniques to prevent or reduce noise emissions from SA installations.

1.2.2 Consumption of energy and water and amount of waste water discharged

The TWG members agreed at the kick-off meeting upon the need to collect energy consumption data from specific processes and contextual information necessary to assess these data, in addition to the collection of water consumption data and the amount of waste water discharged at installation level. The TWG concluded on a closed list of specific processes representing the major sources of energy consumption in SA installations, and the major sources of water consumption for installations processing animal by-products and/or edible co-products. A number of conclusions were reached for these topics [199, COM 2019]:

- To include energy consumption at installation level as a KEI for SA installations.
- To include energy consumption as a KEI in slaughterhouses for the following specific processes:
 - cooling through all types of systems (electricity);
 - pig and poultry scalding (heat);
 - pig singeing (heat);
 - production of hot water for cleaning and disinfection (heat).
- To include energy consumption as a KEI in installations processing animal by-products and/or edible co-products for the following specific processes:
 - drying (in rendering, fishmeal and fish oil production, blood processing and gelatine manufacturing installations);
 - waste gas treatment.
- To include water consumption and waste water discharge as KEIs for SA installations.
- To include water consumption as a KEI in slaughterhouses, in particular for the following specific processes:
 - cleaning of floors and equipment (all animals);
 - sterilisation of slaughtering tools;
 - vehicle washing (all animals);
 - pig and poultry scalding;
 - poultry defeathering.
- To include water consumption as a KEI in installations processing animal by-products and/or edible co-products for the following specific processes:
 - cleaning of floors and equipment;
 - boilers including when using conventional fuels;
 - vehicle washing.

Slaughterhouses

~~The most significant environmental issues associated with slaughterhouse operations are water consumption, emissions of high organic strength liquids to water and the energy consumption associated especially with refrigeration and heating water.~~

Air

~~Most emissions to air from slaughterhouses are water vapour from the boilers used to raise hot water and steam. There is also a potential for the release of refrigerant gases from chilling and~~

freezing plants and CO₂ from stunning equipment. These issues are common throughout much of the food and drink industry.

Dust emission arising during the unloading of poultry and the hanging of live birds on the slaughter line is a key environmental issue at poultry slaughterhouses [240, The Netherlands, 2002].

Water

The most significant environmental impact resulting from slaughterhouses is the emissions to water [177, EA SEPA and EHS, 2001]. This is related to the water consumption, which is the other major environmental issue [12, WS Atkins EA, 2000, 67, WS Atkins Environment/EA, 2000].

High water consumption and high BOD, COD and TSS concentrations arise during slaughter and carcass dressing. Solids break down, releasing colloidal and suspended fats and solids and leading to an increase in the BOD and COD. [177, EA SEPA and EHS, 2001]. Other key contaminants are nitrogen and phosphorus, e.g. from the breakdown of proteins; copper and zinc from, e.g. pig feed residues and chloride, from hides/skins salting. The consumption of water is partly governed by EU and MS meat legislation, which require fresh, potable water to be used for almost all washing and rinsing operations and which limit the scope for the re-use of water within the slaughterhouse.

The excessive use of water is not only an environmental and economic issue in itself, it also adds to the WWTP burden. Waste water may be fully or partially treated at a WWTP at the slaughterhouse. If the treatment is undertaken at a municipal WWTP, there is usually some pre-treatment done at the slaughterhouse. The contamination of waste water can be minimised by collecting by products and waste as close to the source as possible, and by preventing their contact with water. Minimising the water use in slaughter and carcass dressing can also reduce the actual contaminant load, by reducing the opportunities for the entrainment of organic matter such as fat or faeces. If by products are entrained in water, the opportunities for their re-use are limited. The opportunities for eliminating or reducing water use need to be explored at each unit operation of the process.

In any slaughterhouse, a major factor affecting water consumption is the amount of floor area used. For hygiene reasons, all process floor areas must be washed down at least once a day [99, EC, 1964]. Water consumption is, therefore, highly dependent on the layout of individual slaughterhouses and in poultry slaughterhouses will also depend on, e.g. the size of bird; the method of slaughter, carcass dressing, carcass cooling and the degree of automation. Large quantities of water are consumed in poultry slaughterhouses for evisceration, cleaning and washing operations. [67, WS Atkins Environment/EA, 2000, 177, EA SEPA and EHS, 2001]

Blood has the highest COD strength of any liquid effluent arising from both large animal and poultry slaughterhouses [12, WS Atkins EA, 2000, 67, WS Atkins Environment/EA, 2000]. The polluting potential of blood and the huge quantities which are handled and stored, therefore, make it a key environmental issue for assessment and control. The potential contamination of water needs to be considered from the process and from all potential sources ranging from small leaks to major technical and operational accidents.

In some countries, such as Denmark, Finland, Sweden and Norway the waste water from slaughterhouses is considered to be an important source of carbon for denitrification at municipal WWTPs, so only limited treatment is undertaken at the slaughterhouses. [134, Nordic States, 2001]

Energy

The majority of large animal slaughterhouses do not submeter their electricity consumption. The total consumption is measured by looking at utility bills. Some slaughterhouses do submeter energy consumption by process area and expect to make substantial cost savings

through monitoring and targeting programmes. [12, WS Atkins EA, 2000]. Most slaughterhouses have a stand by generator to enable partial operation of the plant if the power is interrupted. [12, WS Atkins EA, 2000]

At most slaughterhouses, the refrigeration plant is the biggest consumer of electricity. It constitutes 45–90 % of the total site load during the working day and almost 100 % during non-production periods. Refrigerated areas include chills, freezers and cold stores. It is common practice for each refrigerated room to be a self contained, direct expansion unit, which comprises a compressor, evaporator and condenser. Some larger sites have a centralised compressor and condenser plant [12, WS Atkins EA, 2000, 57, DoE, 1993]. The requirement to cool carcasses sets a legal duty for them to reach a maximum temperature of 7 °C before leaving the slaughterhouse and for offals not to exceed 3 °C [169, EC, 1991]. For a large animal, cooling may take 48 hours [239, Denmark, 2002]. Some exceptions to the rule for cooling carcasses before leaving the slaughterhouse have been reported in Italy, in integrated slaughterhouses and cutting plants producing typical Italian cured products. It is also reported that because smaller pieces are cooled, the energy required for cooling is less than that needed to cool whole or half carcasses. [237, Italy, 2002].

The use of energy to heat water is another key environmental issue. Oil and/or natural gas are the principal fuels used to produce hot water. Boiler water is usually softened before use. The requirement for hot water is split between basins and showers, pig scalding tanks (58–65 °C), washing down (60–65 °C), and implement sterilising baths (> 82 °C). [57, DoE, 1993]. Some slaughterhouses have their own laundry on site.

In pig slaughtering, either natural gas, LPG (principally propane), or oil burners are used for the direct flame singeing of carcasses. It is reported that singeing with oil burners can cause hygiene and quality problems [237, Italy, 2002].

On the slaughter line, hoists, cutters, hide pullers and saws are powered pneumatically or by electric motors. [57, DoE, 1993]

Odour

Odours emitted from blood storage and handling, slurry, occupied lairages and inedible offal storage are reported to be the most problematic. Yard areas, unwashed by products containers and WWTPs, including the initial screening of solids, are also reported to be potential problem areas. [285, Brindle J., 2001]

Noise

The main sources of pollution from noise and vibration are the animal noises during unloading and marshalling, vehicle movements, compressors, air conditioners and ventilation fans. [134, Nordic States, 2001]

Site restoration

Slaughterhouse activities are not expected to result in significant site restoration issues. Leakage from underground drainage pipes and tanks could possibly cause subsidence in the longer term, but there are unlikely to be any significant land or groundwater contamination issues. All materials, apart from the brine from hide/skin salting, which is discharged to the foul sewer from slaughterhouses, are readily biodegradable, including cleaning chemicals. [12, WS Atkins EA, 2000, 241, UK, 2002]

Non industry specific site restoration issues might arise from any leakage from fuel and oil storage tanks. [12, WS Atkins EA, 2000]

Animal by-products installations

General information about key environmental issues

Rendering

Water

The contamination of water, as well as foul water produced by the rendering process, is a key environmental issue [243, Clitravi – DMRI, 2002].

Energy

Significant amounts of energy are consumed, e.g. to produce steam for the process.

Odour

One of the key environmental issues associated with rendering is odour. Both the process and associated activities can give rise to objectionable odours. These are associated with the reception, handling and storage, transfer and preparation of raw material; the cooking process; handling and storage of processed product and the handling, storage, treatment and disposal of solids, liquid effluents and process gases. [241, UK, 2002]

The fresher the raw materials are, the fewer odour problems they will cause, either directly or during the rendering process. The odorous substances are characterised by some being insoluble in water and others being volatile in steam. They are detectable at low concentrations. The concentration and composition of the emitted substances can change suddenly during the production process. If the formation of these substances is not prevented then abatement techniques need to be capable of coping with these characteristics. This may possibly require the adoption of a variety of techniques. [49, VDI, 1996]

Infective matter

The raw materials of rendering are potential sources of infection, depending on their origin, age and state of preservation. This is particularly significant with respect to the destruction of TSE materials and SRM. Infectivity is, therefore, a key environmental issue [243, Clitravi – DMRI, 2002].

Fat melting

Energy

Energy consumption is an important issue during the melting process and at decanters, centrifuges and crushers [319, NL TWG, 2002].

Noise

Noise emissions from vehicles and refrigeration equipment can be significant [333, Netherlands TWG, 2003].

Fishmeal and fish-oil production

Water

Large quantities of seawater are used. The pollution from fishmeal factories stems from many different sources. The pollutants are often mixed with large quantities of seawater, which is used for cooling, in the processing plant. [155, Nordic Council of Ministers, 1997]

A number of compounds are formed during the bacteriological decomposition of the raw material before it is cooked. These compounds are volatile under the process conditions and they can pollute the marine environment, as well as generating odour problems in areas around the factories. The marine environment is also polluted as a result of product losses, including fishmeal, stickwater and a liquid known as evaporated stickwater, which contains approximately 40 % dried matter. The degree of bacteriological deterioration, the raw material quality and the concentration of volatile substances, especially ammonia and trimethylamine (TMA), in the raw material, are all related to each other.

Energy

Large quantities of energy are used for drying [155, Nordic Council of Ministers, 1997].

Odour

Odour from the raw material, the process and from the waste water treatment can be a significant problem. The volatile compounds that cause the odours arise from the degradation of the fish and freshness is, therefore, not just an important influence on the quality of the product, but also determines the odour emissions from a site.

Blood processing

Water

Liquid blood has a COD of about 400 g/l and a BOD of about 200 g/l. Congealed blood has a COD strength of about 900 g/l [12, WS Atkins EA, 2000] and it has a total nitrogen content of approximately 30 g/l. Preventing the accidental discharge of liquid blood or the spillage of dried blood by, e.g. explosion of the spray drier or tearing of packaging during storage or handling, needs to be treated as a priority.

The main requirement for water is for cleaning operations. Blood is about 82 % water, so emissions to water will include the water derived from the blood during the various separation techniques.

Energy

Energy consumption is significant, especially with respect to spray drying. If the blood is not processed quickly, then refrigerated storage is needed, which can also consume significant energy.

Odour

On a routine daily basis, odour problems can arise during the unloading of blood from the transport tanker [168, Sweeney L., 2001].

Noise

Spray driers are noisy.

Gelatine manufacturing

Water

The key environmental issues associated with gelatine manufacturing is the water consumption during the early stages of the extraction process and the associated waste water treatment.

Energy

Drying the product consumes significant amounts of energy.

Odour

Odour from the degreasing units of gelatine plants processing bones and pigskins and raw material delivery may be a key environmental issue [349, GME TWG members, 2003].

Glue manufacture

Energy

Drying the product consumes significant amounts of energy [244, Germany, 2002].

Odour

Odour from both the liming pit and from drying is a key environmental issue [244, Germany, 2002].

Dedicated incineration of animal meal

Air

Quantities of dioxins and furans of 0.2 and 0.3 ng/kg have been found in MBM samples in Ireland and Portugal, respectively [164, Nottrodt A., 2001] but these are likely to be destroyed by the incineration process. There is, however, a risk of dioxin formation during the incineration process, the degree of risk depending to some extent on the techniques used to operate the incinerator [65, EA, 1996]. Dust emissions may also arise from incomplete combustion.

Land

The loss of phosphorus through incinerating animal meal, instead of recovering the phosphorus from it for use as a fertiliser, is considered to be key environmental issue [239, Denmark, 2002].

Infectivity

If the animal meal production process prescribed in ABP Regulation 1774/2002/EC is followed, the potential risk from BSE pathogens should be insignificant. The incineration of properly produced animal meal should, therefore, require no additional protective measures regarding the TSE biohazard. The same should be true for animal meal imported within the conditions required by ABP Regulation 1774/2002/EC. If animal meal from an unreliable source is incinerated then there may be occupational health risks associated with potential contact or airborne exposure, so controls may be required.

There may be a risk of pests, vermin, bacteria and fungi being attracted by the large amounts of nutrients and moisture in the animal meal. If animal meal is stored in damp conditions, it will provide an ideal medium for these. If the storage temperature is allowed to exceed 40 °C, animal meal may heat up and spontaneously combust. Certain grades, or distributions of grades can carry a risk of explosion. [164, Nottrodt A., 2001]

Burning of tallow

Tallow is currently burned in boilers and this gives rise to emissions of CO₂ and NO_x. At the time of writing, the burning of tallow is not permitted in the EU, due to the fact that in ABP Regulation 1774/2002/EC, it is neither listed, nor has it been approved in accordance with the procedure referred to in Article 33(2) therein, after consultation of the appropriate scientific committee.

Dedicated incineration of carcasses

Air

Potential emissions to air commonly associated with the incineration of animal carcasses include particulate matter; hydrogen chloride; oxides of sulphur, nitrogen and carbon and organic compounds, such as dioxins. Chlorine can lead to hydrogen chloride production. There is a potential release of particulate matter from incomplete combustion.

Land

Potential emissions to land include dioxins, organic compounds, alkali metals and their oxides and alkaline earth metals and their oxides [65, EA, 1996].

The chlorine in the salt in carcasses means there is a potential for dioxin formation.

Infectivity

The raw materials are, depending on their origin, age and state of preservation, potential sources of infection. This is particularly significant, with respect to the destruction of TSE materials and SRM. Infectivity is, therefore, a key environmental issue [244, Germany, 2002]. The incineration of animal carcasses may give rise to a biohazard in the form of undestroyed organics released to air, water and land.

Odour

In common with all installations handling, storing or processing animal by products odour is a potential problem [65, EA, 1996].

Land spreading/injection

Air

If, e.g. manure from slaughterhouse lairages is spread on land then emissions to air of volatile substances, such as ammonia, may be an issue. The potential nutritional advantage to the soil is thereby lost. There may also be an odour problem.

Water

Surface water and groundwater contamination may occur from manure, slurry and/or sewage sludge, if they contain, e.g. pathogens, such as *Salmonella*, *E. coli 0157* and *Campylobacter* and metals. The residues from biogas production and compost should be free of pathogens as they should already have been destroyed during these processes.

Soil

Solids containing above about 4% fat or oil content, have been demonstrated to have a detrimental effect on plant growth. They are, therefore, considered to be unsuitable for land spreading [179, EA SEPA & EHS, 2001].

Odour

Odour is a key environmental issue [244, Germany, 2002].

Infectivity

If the deactivation of pathogens is inadequate there is a risk of land and groundwater contamination [244, Germany, 2002]. Soil contamination may occur from manure, slurry and/or sewage sludge, if they contain, e.g. pathogens, such as *Salmonella*, *E. coli 0157* and *Campylobacter* and metals. The residues from biogas production and compost should be free of pathogens as they should already have been destroyed during these processes.

Biogas production

Air

The main product of biogas production is methane. CH₄ is a “greenhouse gas”. In terms of its potential to cause damage, one molecule of CH₄ is 30 times more powerful than one of CO₂. Consequently, the requirement to prevent accidental release into the atmosphere is significant. There are also safety controls required, due to the fire and explosion hazard, which are also related to pollution prevention and control.

Odour

Odour may arise from raw materials and from the process.

Composting

Air

Key environmental issues include bioaerosols and dust.

Energy

Some consider it a key environmental issue that using animal by products for composting does not make use of their energy value [243, Clitravi DMRI, 2002].

Water

The risk of leachate contaminating soil and groundwater is a key environmental issue.

Odour

Odour results from the raw materials and during the composting process, especially during windrow composting.

Infectivity

If the deactivation of pathogens is inadequate there is a risk of land and groundwater contamination [244, Germany, 2002].

WORKING DRAFT IN PROGRESS

WORKING DRAFT IN PROGRESS

2 GENERAL PROCESSES AND TECHNIQUES ACROSS THE SA SECTOR

Activities described in this chapter

This chapter describes the slaughterhouses and animal by products activities covered by the BREF. The relationships between the activities downstream from the slaughterhouse are illustrated in a very simplified and general form in Figure. The final use or disposal route for many of the individual by products of slaughter and of the treatment of waste water from slaughterhouses and animal by products installations varies geographically and also from time to time. This depends on whether the by products are considered, within food and veterinary legislation, to be fit for use as food for humans, pet food or animal feed; on economic factors and on local/national traditions and preferences. Local/national tradition is a significant factor with respect to, e.g. the choice between the use of landfill, incineration and biogas alternatives and it may be determined by local legislation.



Figure: Relationships between slaughterhouses and downstream activities (summary)

The unit operations in slaughterhouses are described first in Section. This section is divided between the slaughter of large animals and the slaughter of poultry. Although many of the environmental issues are common to both, the actual processes differ significantly. The different processes at individual animal by products installations are then described in Section 4.2.3.3.1, in the following order: fat melting, rendering, fishmeal and fish oil processing, bone processing, blood processing gelatine manufacture, incineration, burning of tallow, land spreading/injection, biogas production and composting. Some waste water treatment processes that are applied in the industries are then described, firstly for slaughterhouses and then for animal by products installations.

2.1 Applied processes and techniques

2.1.1 Energy efficiency

In the SA sector, a number of common techniques are applied with the aim of reducing energy consumption. Most of these techniques are described in more detail in the ENE BREF [247, COM 2009].

2.1.2 Anaerobic digestion

Animal waste and material like digestive tract content is easily digested anaerobically and it gives a high yield of biogas. The process is complex. The carbon-containing material is degraded by micro-organisms, thereby releasing biogas, comprising mainly CH₄ and CO₂. The digestion can be either wet or dry. Wet digestion allows normal pumps and stirrers to be used. The biogas is energy-rich and the digestion residues can often be used as organic fertilisers and soil improvers. [200, Widell S., 2001] [80, Widell S. 2001]. It is also reported that the biogas production process changes nutrients to a form that is more readily absorbed by plants and that the spreading of biogas residues on land leads to fewer odour problems than spreading untreated manure [222, Gordon W., 2001] [98, Gordon W. 2001].

Biogas cannot be produced from pure animal material because the nitrogen content is too high. Animal waste must, therefore, be mixed with other organic matter to reduce the nitrogen content. In Denmark, approximately 75 % of the biomass resource for anaerobic digestion is animal manure, with the remainder mainly originating from food processing, including slaughterhouses, although some segregated domestic waste is also treated [152, Danish Institute of Agricultural and Fisheries Economics, 1999] [48, Danish Institute of Agricultural and Fisheries Economics 1999]. Animal by-products, manure and the sewage sludge from slaughterhouses can all be treated [148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001] [47, Finnish Environment Institute and Finnish Food and Drink Industries' Federation 2001].

Feedstock

The production of biogas from animal by-products is allowed for certain Category 2 materials and all Category 3 materials, as defined in ABP Regulation 1069/2009/1774/2002/EC, if they are treated, as specified therein. For certain Category 2 by-products, sterilisation under prescribed conditions is required before biogas production. The resulting animal meal can undergo a pasteurisation as prescribed and can be used in biogas production. Category 3 by-products must be subject to the same prescribed pasteurisation/hygenisation treatment. [287, EC, 2002] [204, EC 2009]. It is reported that the pasteurisation process assists the subsequent anaerobic digestion, especially with the digestion of fats.

It is reported that most meat and poultry by-products could be anaerobically digested in a biogas plant, with the exception of hard bone, which is considered to have too high an ash content. Provided that the material is sufficiently reduced in size, feathers, viscera, heads and feet, as well as liquid wastes such as blood and effluent sludge, could be used. [222, Gordon W., 2001] [98, Gordon W. 2001]

The treatment of manure, stomach and intestinal contents, bits of hide, waste blood and similar products in biogas installations is advocated in Sweden. [134, Nordic States, 2001] [38, Nordic 2001]

Biogas production from solid digested and partially digested by-products such as rumen and stomach contents, screenings and of solids-rich substrates such as rumen press water, flotation tailings, grease trap residues and the excrement and urine from the lairage, reportedly have a significant energy potential. [206, Tritt W. P. and Schuchardt F., 1992] [83, Tritt W. P. and Schuchardt F. 1992]. There are, however, problems associated with the control of the formation

of a floating scum, but these can be reduced by substitution with a wetter feedstock, e.g. pig slurry instead of rumen contents.

Loading and unloading

Odour can be minimised during the unloading of raw materials and the loading of solid products/by-products if undertaken in an enclosed area.

Production

A biogas production plant has reported the use of slaughterhouse by-products consisting of blood, stomachs and intestines, together with large quantities of process water. Previously, most of the process water was sent to a WWTP. To obtain a slower decomposition process, the materials are mixed with farmyard manure. Other forms of biological waste can also be used. All of the slaughterhouse by-products are pasteurised. After the heat treatment, the mix is allowed to decompose anaerobically. The bacteria culture converts the nutritious substrate to CH₄ and CO₂. [207, Linköping Gas AB, 1997] [84, Linköping Gas AB 1997]

A normal biogas composition is about 65 % CH₄ and 35 % CO₂, with small amounts of other gases. The biogas is saturated with moisture. CH₄ is the usable part of the biogas. In order for the CH₄ to be used as fuel, it has to be purified of CO₂, water vapour and small quantities of H₂S. [207, Linköping Gas AB, 1997] [84, Linköping Gas AB 1997]

If the biogas is to be used as fuel for vehicles, it has to be cleaned, to a CH₄ content of at least 95 %. The energy content is about 9 kWh/m³. When biogas is used as a fuel for vehicles, the gas is compressed to a pressure of 20 MPa. [207, Linköping Gas AB, 1997] [84, Linköping Gas AB 1997]

Electricity can be produced from biogas, which can be utilised for own consumption and, in some countries, it can be integrated into the national power grid.

Table 2.1 shows the reported composition of biogas produced from unspecified animal by-products.

Table 2.1: Reported biogas composition from the biodegradation of unspecified animal by-products

Component	Volume (%)
CH ₄	40 - 70
CO ₂	30 - 60
Other gases, including	1 - 5
H ₂	0 - 1
H ₂ S	0 - 3

Source: [144, Det Norske Veritas, 2001] [44, Det Norske Veritas 2001]

Energy generation of 300 kWh/t of ABP processed have been reported. This represents a CH₄ production of 400 m³/h. [144, Det Norske Veritas, 2001] [44, Det Norske Veritas 2001]

To measure the energy recovery figures for CH₄ biogas produced from animal by-products, the CH₄ generated must be converted into electricity via a gas engine, taking into account the associated engine efficiency. The energy output quoted for biogas is similar to that produced by rendering with the on-site combustion of animal meal and tallow. [144, Det Norske Veritas, 2001] [44, Det Norske Veritas 2001]

For each unit of electricity generated, 1.5 units of waste heat are produced, as hot water at over 80 °C. In Denmark, this is used to provide district heating. If the biogas plant is close to major users of heat, such as industrial facilities or large municipal buildings, it may be possible to derive significant income from the waste heat. In general, the closer the users are to the plant, the more attractive it is to pipe the hot water to them. [222, Gordon W., 2001] [98, Gordon W. 2001]

The solid digestion residue contains nitrogen, phosphorus and potassium and can be used as a fertiliser. It is checked regularly to ensure the absence of *Salmonella*.

Problems

There may be problems with damage to vessels, due to gravel etc. ingested by cattle. The vessels may be glass-lined to avoid leaks, due to the very corrosive nature of products. Leaks lead to pressure losses which can interfere with boilers using the biogas.

It has been reported that sulphur in the biogas can cause problems in gas generators and that it should be removed to lengthen the life of the generator. It has also been reported that the sulphur can be added to the digestion residue to improve its plant nutrient value. [222, Gordon W., 2001] [98, Gordon W. 2001]

Abatement

The exhaust air from ventilation may require odour abatement or it may be burned in a burner. A flare can be used to prevent biogas from being discharged to air in cases where the capacity of the plant is insufficient or where there is overproduction or stoppage in a downstream power production unit. A temperature of at least 1000 °C for at least 0.3 seconds in the burning zone guarantees low emissions, including odours. Abatement may also be required to remove H₂S.

Germany

The first large scale plant in Germany for the methanisation of fresh rumen and flotation tailings was an anaerobic reactor situated in a slaughterhouse in Hamburg [206, Tritt W. P. and Schuchardt F., 1992].

~~Current legislative requirements for animal by products to be pretreated or for the biogas residues to be treated reportedly make biogas production uneconomic [244, Germany, 2002].~~

Austria

~~An industrial plant for the methanisation of rumen contents is situated in Greinsfurt [206, Tritt W. P. and Schuchardt F., 1992].~~

Sweden

~~The treatment of manure, stomach and intestinal contents, bits of hides/skins, waste blood and similar products is carried out in biogas installations in Sweden. Some slaughterhouses have their own biogas installations, whereas some others have a share in a public unit [134, Nordic States, 2001].~~

~~There are 7 biogas plants specifically approved for the use of certain qualities of animal by-product as raw material, together with the use of other raw materials such as manure and products of vegetable origin. The in-reactor wet digestion technique is used.~~

United Kingdom

~~Full scale digestion plants were installed at several UK slaughterhouses in the 1990s, but operational difficulties and high costs discouraged more widespread application. Most of the original digestion plants have now shut down. [12, WS Atkins EA, 2000]. It has been reported that biogas production from animal by products is not currently commercially available within the UK. [144, Det Norske Veritas, 2001], although it is being reconsidered.~~

2.1.3 Cleaning processes

Processing equipment and production installations are cleaned and disinfected periodically to comply with legal hygiene requirements. The frequency can vary considerably depending on the products and the processes. The aim of cleaning and disinfection is to remove product remnants, other contaminants and microorganisms.

Before starting the cleaning process, equipment is emptied as much as possible. Cleaning and disinfection can be carried out in various ways. Traditionally, they have been carried out

manually. Cleaning-in-place (CIP), washing-in-place and cleaning-out-of-place are all expressions used for different forms of cleaning. Cleaning agents are delivered in a variety of ways, for example in bags, e.g. powdered cleaning agents, or in drums or bulk tankers. Many cleaning agents are potentially hazardous to the health and safety of the operator and systems can be provided to minimise the risk during storage, handling, use and disposal.

CIP is used especially for closed process equipment and tanks, whether stationary or small mobile processing units. The cleaning solution is pumped through the equipment and distributed by sprayers in vessels, tanks and reactors. The cleaning programme is mostly run automatically and applies the following steps; pre-rinse with water, circulation with a cleaning solution, intermediate rinse, disinfection, and final rinse with water. In automatic CIP systems, the final rinse water is often reused for pre-rinsing or may be recycled/reused in the process. In CIP, high temperatures of up to 90 °C are used, together with strong cleaning agents. CIP systems used for open systems like freezers are almost entirely automatic, except for some dry clean-up and opening of hatches. Temperatures for medium-pressure systems are normally below 50 °C and the pressure is 10 bar to 15 bar [206, Giner-Santonja et al. 2019].

Cleaning-out-of-place is used when several of the machine's components need to be dismantled, usually before the manual or automated cleaning of the machine is started. The dismantled components are cleaned separately outside the machine. Forming machines are one example of this. There are augers, pistons, valves, forming plates and seals which all have to be dismantled before cleaning the machine. High-pressure jet cleaning, using gels and foams, can be carried out manually or automatically. The appropriate cleaning method involves an appropriate combination of cleaning factors such as water, temperature of the cleaning solution, cleaning agents, i.e. chemicals, and mechanical forces. Only mild conditions, with regard to temperature and cleaning agents, can be used for manual cleaning.

High-pressure jet cleaning and foam cleaning are generally applied for open equipment, walls and floors. Water is sprayed onto the surface to be cleaned, usually at a pressure of about 40 bar to 65 bar. Cleaning agents are injected into the water, at moderate temperatures of up to 60 °C. An important part of the cleaning action takes place due to mechanical forces [206, Giner-Santonja et al. 2019].

In foam cleaning, a foaming cleaning solution is sprayed onto the surface to be cleaned. The foam adheres to the surface. It stays on the surface for about 5 to 15 minutes and is then rinsed away with water. Foaming can be carried out both manually and automatically. Gel cleaning is similar to foam cleaning.

2.1.3.1 Cleaning in slaughterhouses

For hygiene reasons, many slaughterhouse operators wash down process areas with hot water during breaks in production. All process equipment, containers, etc., must be cleaned and disinfected several times a day and after the day's work is finished in preparation for work starting again [169, EC, 1991] [57, COM 1991]. A typical cleaning routine at a slaughterhouse consists of the following steps.

Meat scraps, fat, etc. are squeegeed and shovelled up throughout the shift and collected for use/disposal according to ABP Regulation 1069/2009 ~~1774/2002/EC~~. In some slaughterhouses, the meat scraps are hosed to the catchpots, if present and drains. Some areas are also hosed down lightly at regular intervals during the shift. Hosing down uses water which becomes contaminated with solid material as well as FOG. At breaks in production, some drain catchpots are emptied into the waste bins. Each drainage point can have a grate cover and a catchpot, typically with a 4 mm mesh. Some slaughterhouses use a two-stage catchpot, comprising a coarse screen above a fine screen in an "inverted top hat" arrangement.

Typically, at the ends of shifts, all process areas are washed using low-pressure hoses and all drain catchpots are emptied into the waste skip. A dilute proprietary detergent is then applied as foam onto all surfaces. After about 20 minutes or so the surfaces are then rinsed with high-pressure hot water. In some slaughterhouses, a very dilute sanitising compound is sprayed on to all surfaces and left to dry. At many slaughterhouses, hooks, shackles, pans, etc., are cleaned *in situ* in a similar way.

Only food grade cleaning agents can be used. There is a wide variety of cleaning materials available. Some have traditional chemical formulations and others are based on biotechnology. Some are formulated for specific or difficult cleaning problems, whereas others are intended for general use.

Hygiene requirements prohibit the use of HPLV sprays in meat areas during processing operations, as the atomised water can lead to airborne contamination. They can, however, be used for cleaning at the end of production. Good hygiene is vital for food safety reasons and there are strict EU and MS legal requirements. Using too much water can, however, have negative hygiene consequences. For instance, a very humid environment combined with the constant movement of machinery and the close proximity of carcasses to each other on the slaughter-line can lead to the spread of contamination by direct splashing and aerosols.

When the use of cleaning agents is reviewed at slaughterhouses, it is often found that changing to a more appropriate cleaning agent can reduce the amount of chemical required and in some cases can also improve hygiene standards. It is not unusual to find that higher doses than required are being used, especially during manual dosing. Automated dosing, if correctly set, has the advantage of stopping overdosing. It also has health and safety advantages because it minimises both personal exposure to hazardous substances and manual handling. In any case, adequate operator training and supervision are essential. There are, therefore, often opportunities to reduce the environmental impact of cleaning agents by selecting/substituting and applying them correctly.

In many slaughterhouses, it is common practice for the personnel involved in cleaning to remove floor grates and to flush meat scraps directly down the drain, believing that a subsequent screen or catchpot will trap all solids. In fact, when these meat scraps enter the waste water stream they are subject to turbulence, pumping and mechanical screening. This breaks the meat down and releases high COD substances into solution, along with colloidal and suspended fats and solids. Subsequent waste water treatment, either on-site or at a municipal WWTP can then be expensive. The breakdown of suspended fats and solids is increased if the water is hot. A review of cleaning practices may also identify if there is an excessive use of energy to heat water and possibly unnecessarily high water consumption.

Care should be taken with the use of hypochlorites for cleaning slaughterhouses. According to a Danish research project, groundwater in the surroundings of installations was polluted with an AOX content between 60 µg/l and 150 µg/l. The elevated content is mainly detected in the groundwater due to infiltration of rainwater on the slaughterhouse site [256, Ensen et al. 2016].

2.1.3.2 Cleaning in installations processing animal by-products and/or edible co-products

To comply with regulatory hygiene standards, all process floor areas, equipment and containers must be washed down regularly, and vehicles must be washed inside and out before leaving the site after a delivery. There must also be facilities to allow for the disinfection of vehicle wheels and other parts of the vehicle when they leave the unclean areas of the site.

All cleaning facilities must be sited to ensure that stored product is not contaminated via waste water splash or run-off. The type of facilities used will depend on the situation and may include:

- steam cleaner;
- hand-held hose or automated cleaning system;
- chemical disinfection using an approved disinfectant.

Steam sterilisation may be used for routine cleaning and disinfection but there must be facilities to disinfect with approved chemicals when necessary. Wheel washes or manual disinfectant sprays are satisfactory.

These practices with the use of approved disinfectants are designed to ensure that there is no potential for disease to be spread in waste water derived from cleaning operations when treated waste water is discharged into the environment. Furthermore, disinfection of raw material handling areas, vehicles and equipment also minimises the potential for disease to be spread from the air extracted from buildings housing raw materials.

Cleaning can be resource-intensive – with significant water, energy and chemical consumption. Unlike slaughterhouses, cleaning is performed throughout the shift by site personnel rather than by specialist contractors [245, EFRA 2019].

2.1.4 Waste water treatments used at slaughterhouses and non-animal by-products installations

Slaughterhouse waste water treatment

Slaughterhouses are divided between those that treat their waste water on-site and discharge directly to the local water course and those that discharge their waste water to the local WWTP with the permission of their local sewerage company. The latter category carry out some pretreatment of the waste water on site, usually to at least screen solid materials, although they may also undertake other treatments.

Slaughterhouses must comply with the conditions specified in trade effluent discharge consents, either for direct discharge or discharge to the municipal plant, in line with legislative requirements. Some municipal WWTPs can use the slaughterhouse waste water synergistically with influent received from other sources to maximise the efficiency of the plant.

Effluent discharge consents normally include limits for TSS, COD, BOD, pH, ammoniaical nitrogen, total nitrogen, total phosphorus, free or emulsified grease, anionic synthetic detergents, daily flow and maximum weekly flow. They may also include sulphide concentrations, due to the potential for anaerobic decomposition of sludge. Discharge permits for slaughterhouses that carry out hide salting, may also include limits for chloride concentrations.

In Denmark, the waste water is generally only pretreated, by screening through a 2 mm mesh, after which it is normally considered desirable for the denitrification process in the local authority WWTPs. Surcharges are normally calculated according to the BOD levels and in some areas the nitrogen and phosphorus contents are taken into account.

In the Flemish part of Belgium, about 40 slaughterhouses discharge their waste water to municipal WWTPs. Filters and screens, grease traps and coagulants/flocculants are used. About 20 Flemish slaughterhouses have biological treatment plants which treat the water to a high enough standard to enable it to be discharged directly without further off-site treatment. [346, Belgian TWG member, 2003]

Most slaughterhouses in the Netherlands discharge their waste water to municipal WWTPs. Due to the relatively high treatment costs at municipal WWTPs, all slaughterhouses have

pretreatment systems, mostly consisting of rotary drum sieves and DAF, sometimes in combination with chemicals. Sometimes the slaughterhouses have a biological treatment installation. The treated effluent is almost suitable for direct discharge to surface water and is not considered a desirable commodity for the municipal WWTPs [240, The Netherlands, 2002].

In Austria, most slaughterhouses have systems for waste water treatment consisting of grate covers and catchpots, followed by activated sludge lagoons and fat separators. Large plants occasionally use rotary drum screens and flotation plants. [348, Austrian TWG member, 2003]

In Sweden, slaughterhouse waste water is considered to be an important source of carbon in the denitrification process at the municipal WWTP and mechanical screening is usually the only pretreatment required [134, Nordic States, 2001].

In Norway, the majority of slaughterhouses have fat traps with screens with 0.8–1 mm mesh and they either have their own biological or chemical cleaning units or they discharge to municipal WWTPs. [134, Nordic States, 2001]

Preventing animal material entering the waste water stream in the first place is the best way of minimising effluent loading. Some slaughterhouse managers have carefully assessed operations involving cutting and trimming and have designed or modified their installations and equipment to physically intercept animal by-products such as meat wastes and viscera before they enter the drains. Training personnel can bring benefits beyond just improving environmental performance. Cleaning up any dropped scraps during the processing time and emptying drain catchpots then replacing them before beginning to clean an area, does not just reduce the overall effluent load, it also reduces the risk of individuals slipping, one of the main causes of work related lost time accidents in the meat industry.

Good management of the selection and use of cleaning chemicals is essential to ensure that they do not kill the micro-organisms in the WWTP. [12, WS Atkins-EA, 2000] [4, WS Atkins-EA 2000], [67, WS Atkins Environment/EA, 2000] [24, WS Atkins-EA 2000]

The spillage of high strength organic liquids from overflow from the effluent treatment plant is potentially one of the most polluting events at slaughterhouses. To prevent overflowing and potential spillage into local water courses, effluent tanks can be fitted with high level alarms and devices to prevent automatic overflowing. Many DAF plants continuously monitor their effluent quality and automatically divert effluent to a stand-by storage if the DAF plant breaks down. [12, WS Atkins-EA, 2000] [4, WS Atkins-EA 2000]

Some slaughterhouse waste water treatment techniques are shown in Table.

Emission type Technology	Total suspended solids	Organics	Oils/fats/grease	Nitrates/ammonia	Phosphorus
Primary treatment					
Mechanical screening	Yes	Yes			
Fat separation	Yes	Yes	Yes	Yes	Yes
Equalisation/balance tanks					
Dissolved air flotation	Yes	Yes	Yes		
Dispersion flotation	Yes				
Mechanical flotation	Yes				
Coagulation/flocculation/precipitation		Yes	Yes	Yes	Yes
Sedimentation/filtration/flotation		Yes	Yes		
Secondary treatment					
Anaerobic treatment, followed by anoxic step		Yes			
Activated sludge/aeration lagoons	Yes	Yes		Yes	Yes

Extended aeration		Yes		Yes	
Nitrification/denitrification				Yes	
Tertiary treatment					
Filtration/coagulation/precipitation				Yes	Yes

Table: Summary of technologies for treating slaughterhouse waste water emissions [3, EPA, 1996, 163, German TWG Members, 2001] adapted

Primary slaughterhouse waste water treatment

Waste water solids are collected for use/disposal according to ABP Regulation 1774/2002/EC. For example, ABP Regulation 1774/2002/EC definition of Category 1 material, includes, amongst other things, *all animal material collected when treating waste water from Category 1 processing plants and other premises in which specified risk material is removed, including screenings, materials from desanding, grease and oil mixtures, sludge and materials removed from drains from those premises, unless such material contains no specified risk material or parts of such material* and of Category 2 material, includes, amongst other things, *all animal materials collected when treating waste water from slaughterhouses other than slaughterhouses covered by Article 4(1)(d) or from Category 2 processing plants, including screenings, materials from desanding, grease and oil mixtures, sludge and materials removed from drains from those premises.*

The mechanical stages in the waste water treatment are usually implemented before any mixing or equalisation takes place. Waste water from process areas at slaughterhouses is normally screened, to both remove organic debris such as hairs, some fats, tissue, meat scraps, paunch and gross solids and to avoid blockages in the WWTP. Apart from the by-products of actual slaughtering the waste water generally contains primary solids produced during transport, lairage and the washing of stomachs and intestines. These include, e.g. straw, faeces, urine and intestinal contents. Secondary solids e.g. sieve and rake material; fats and floating matter are produced during waste water and air treatment. Solids removal, e.g. by screening may, therefore, be required at the end of the WWTP, as well as at the beginning.

Screens can remove 10–15 % of the organic load. They may remove a large proportion of the visible particles [134, Nordic States, 2001].

In the rendering industry, sludge catchers, fat separators, sieves, micro-strainers and settlement tanks are normally used. Undissolved animal matter, such as fat and fat particles, meat residues, hair, bristles and mineral admixtures from the process water can be conveyed back into the production process. Fat separation can be difficult, as the animal fat in the waste water can exist in a very fine form. This is especially true if the water temperatures are high and when the waste water contains tensides. High pH values also impair the fat separation, due to saponification.

In some cases some soluble colloidal substances and phosphates are removed from the waste water by adding coagulation and flocculation chemicals, e.g. iron salts, aluminium salts and polyelectrolytes, to form precipitates [12, WS Atkins EA, 2000] [4, WS Atkins-EA 2000], [216, Metcalf and Eddy, 1991]-[92, Metcalf and Eddy 1991].

DAF can remove 15 % of the BOD load and 70 % of the suspended solids, without chemicals and 50–65 % of the BOD and 85–90 % of the suspended solids, with chemicals. [215, Durkan J., 2001]

Other flotation methods include dispersion flotation, which involves the injection of “dispersion water” produced with compressed air, or mechanical flotation, where the water is agitated to produce air bubbles.

The oils, fats and greases and other solids removed may be sent for rendering, if the fat content is high. Otherwise they may be sent for landspreading, if they have a high nutrient content. [215, Durkan J., 2001] [91, Durkan J. 2001]

~~The liquor may then be passed to a balance tank which is aerated with coarse bubbles/diffusers and surface aerators/venturis to keep the contents mixed and aerated. This removes 5 % of the BOD. [215, Durkan J., 2001]~~

Secondary slaughterhouse-waste water treatment

~~Some large slaughterhouses have installed biological treatment plants which convert soluble and colloidal materials into biosolids. These are usually activated sludge plants which, depending on their capacity, may be preceded by sedimentation or DAF.~~

Aerobic digestion – activated sludge

The aerobic digestion process using activated sludge involves the production of an activated mass of micro-organisms, capable of stabilising a waste aerobically in an aerated tank. During endogenous respiration bacterial cells react with oxygen to produce CO_2 , water, NO_x and energy.

The addition of oxygen to the system is essential to the process for several reasons, including the oxidation of the organic matter and nutrients and for maintaining good physical mixing.

The organic matter acts as the essential carbon source for the micro-organisms, but they also require inorganic nutrients for their growth. Aerobic digestion is an effective technique for slaughterhouse waste water treatment. It removes principal inorganic nutrients such as nitrogen, phosphorus and sulphur as well as minor nutrients such as copper and zinc. ~~In the case of nitrogen it oxidises ammonia nitrogen to nitrate nitrogen, thereby dealing with the oxygen demand. Further denitrification to nitrogen gas, under anoxic conditions is, however, required to remove the nitrogen. This involves a series of steps via the formation of NO and N_2O . The release of phosphorus also requires a subsequent anoxic step.~~

~~After a period of time a mixture of old and new cells, from the aerobic digester, is passed to a settling tank. Here the cells are separated from the treated waste water. The success of this settling/separation process is crucial to the overall success of the treatment. This relies on the good design and operation of the system and on the prevention of “bulking”. Bulking is controlled by preventing the excessive growth of the filamentous bacteria which would create bulky, loosely packed flocs which do not settle well and which lead to excessive BOD in the treated water. The presence of nitrogen and phosphorus in slaughterhouse waste water advantageously inhibit the growth of filamentous bacteria.~~

~~A portion of the settled cells is kept to maintain the biological activity of the system and the remaining activated sludge is dewatered and spread on land, used for biogas production, or incinerated. [216, Metcalf and Eddy, 1991]~~

~~In some slaughterhouses, an extended aeration is undertaken in the endogenous respiration phase. This requires a low organic loading and a long aeration time. Alternatively an oxidation ditch may be used. [12, WS Atkins EA, 2000]. This comprises a ring or oval shaped channel and is equipped with mechanical aeration devices. They typically operate in extended aeration mode with long detention times and solid retention times. [216, Metcalf and Eddy, 1991]. Secondary sedimentation tanks are used in most applications.~~

There are other available techniques for aerobic treatment, which use the same principle, e.g. the moving bed trickling filter, on which the sludge is coated on plastic spheres. The waste water flows over the spheres and the system reportedly also operates as an odour abatement technique. [240, The Netherlands, 2002] [106, The Netherlands 2002]

Anaerobic digestion

The anaerobic treatment of waste water is widely used, although it is favoured by some and not by others. Reported advantages include the considerable reduction of the concentration of impurities in the water, low excess sludge production, biologically stable excess sludge and the potential collection of the energy-rich biogas which is produced [206, Tritt W. P. and Schuchardt F., 1992] [83, Tritt W. P. and Schuchardt F. 1992]. Anaerobic treatment is especially suitable as a pretreatment for waste water which has a high organic load, prior to aerobic treatment.

Anaerobic biological degradation takes place in a three part process. In the first step, known as hydrolysis, enzymes transform high molecular mass compounds, such as lipids, proteins and nucleic acids into compounds suitable for use as a source of energy and cell carbon, such as fatty acids, amino acids. In the second step, known as acidogenesis or the acid stage, bacteria break these acids down further. In the third stage the, methanogenic stage, the intermediate compounds are broken down into CH_4 and CO_2 . [216, Metcalf and Eddy, 1991]. The CH_4 (biogas) produced can be used as an integral part of the heating system in the plant.

There are two main techniques used. For the standard rate process, the contents of the digester are unheated and unmixed and the detention time is 30–60 days. In the high rate process, the contents are heated and mixed completely and the detention time is typically 15 days or less. The optimum temperature for the process is 30–40 °C. The speed of this method and the short retention time makes the dimensions of the installation within reasonable size limits, even at slaughterhouses where the space is limited. Alternatively, a combination of both processes can be used, i.e. the “two stage” process. The primary function of the second stage is to separate the digested solids from the supernatant liquor. Additional digestion and gas production may also occur. The sludges from aerobic digestion are commonly anaerobically digested.

The bacteria involved are mutually beneficial. Some of the bacteria consume substances which would inhibit the growth of others. An environment which sustains this dynamic equilibrium is, therefore, essential. This requires the absence of dissolved oxygen and sulphides. The pH should range between 6.6–7.6. A sufficient amount of nutrients, such as nitrogen and phosphorus, are necessary to ensure the maintenance of the biological community. [216, Metcalf and Eddy, 1991]

The active micro organisms are inoculated at the waste water inlet and because the process is generally slow and the CH_4 conversion is significant, the amount of sludge that has to be disposed of is minimal. [216, Metcalf and Eddy, 1991]

Anaerobic degradation only converts the carbon-based impurities, measured as BOD levels. The nitrogen compounds are still left in the water after cleaning. [134, Nordie States, 2001] [38, Nordic 2001]. It is, therefore, considered by some, not to be a realistic option for the treatment of slaughterhouse waste water [240, The Netherlands, 2002] [106, The Netherlands 2002] and only suitable as a pretreatment prior to aerobic treatment. The process does, however, reduce the pathogenic content of the waste water [216, Metcalf and Eddy, 1991] [92, Metcalf and Eddy 1991].

Biosolids produced by the treatment plant may, e.g. be dewatered prior to landspreading as a soil conditioner or digested to yield biogas. Limitations on landspreading and land injection are leading to an increased trend towards the incineration of sludges [244, Germany, 2002] [110, Germany 2002]. Sludge storage, handling and spreading can lead to odour problems. As well as managing the usual operational issues related to activated sludge plants, such as the development of bulking sludges or carrying excessive biomass inventories, particular problems may be experienced with slaughterhouse effluents, which can cause the formation of biologically stable foam; or they may contain biocidal substances capable of inhibiting microbial activity. [12, WS Atkins EA, 2000] [4, WS Atkins-EA 2000]

Physico-chemical treatment

Physico-chemical methods, particularly flotation methods, are used for an extensive separation of the fat and solids. Flocculation agents are used as and when required. Fat retention can be done in fat traps with manual or automatic cleaning. If the fat is emulsified or contains stickwater from the edible fat rendering department, the separation can be very difficult. In such cases it is necessary to use chemical precipitation and flotation.

As with the fat separators, the efficiency degree of flotation plants is reduced by high temperatures and high pH values. Mechanical flotation using air supplied from especially developed submerged flotation aerators, is the method least susceptible to high pH values.

Stripping can be used for the treatment of the hot exhaust vapour condensates (EVCs). Due to low waste water volume flows, it can also be used for the main waste water stream. It is reported that any neutralisation of the stripping effluent is not done immediately after the stripping, but only after the reconvergence with the other waste water part streams.

The position of the stripping plant in the waste water treatment process is shown in Figure.

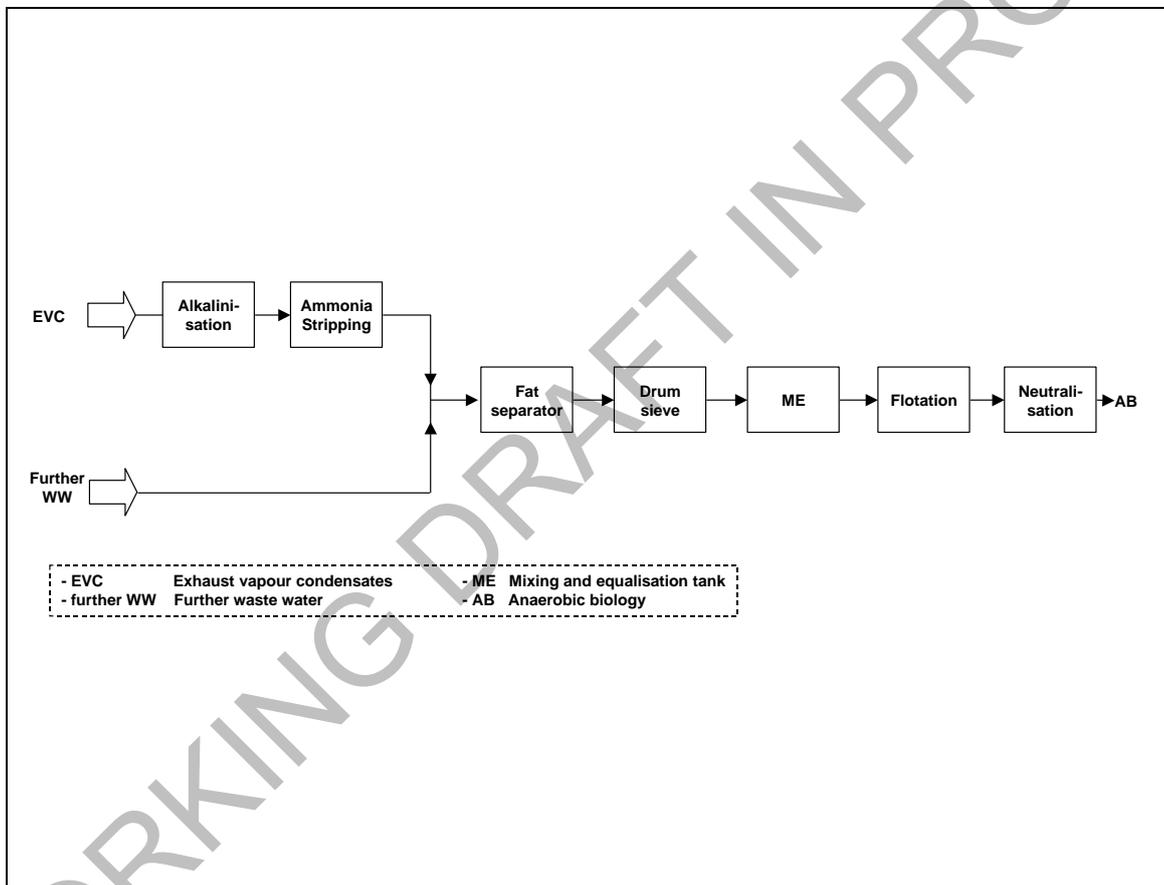


Figure: Block diagram of a mechanical/physical-chemical preliminary waste water plant [163, German TWG Members, 2001]

Tertiary slaughterhouse waste water treatment

Tertiary treatments, such as filtration, e.g. using sand filters, reed beds, coagulation, or precipitation, are sometimes used as a final cleaning step for the treated effluent, to reduce the BOD and suspended solids, prior to discharge to a water course.

The sludge produced may be used or disposed of in a variety of ways including the following: biogas production; composting, mixed with other biodegradable material, such as paunch and

blood; land injection; rendering followed by incineration and by direct incineration. The processing of sludge can cause odour problems, which are exacerbated by mixing and aerosol production. Energy is required to remove water, by, e.g. centrifugation or pressing. [168, Sweeney L., 2001] [56, Sweeney L. 2001]

Removal of nitrogen and phosphorus

Processes have been developed which combine the carbon oxidation, nitrification and denitrification steps in a single process. These processes have several advantages, including reducing the volume of air needed to achieve nitrification and BOD removal; elimination of the need for the addition of organic sources to provide carbon for denitrification and elimination of the need for intermediate clarifiers and return sludge systems required in a staged nitrification system. It has been reported that most of the systems can remove 60–80 % of the total nitrogen, although removal rates of 85–95 % have also been reported.

In the combined processes, the carbon in both the waste water and in the micro organisms after endogenous respiration during the aerobic treatment, is used to achieve denitrification. For denitrification, a series of alternating aerobic and anoxic stages, without intermediate settling, have been used. Anoxic zones can be created, e.g. in oxidation ditches, by controlling the oxygenation levels. The sequencing batch reactor is also suited to providing aerobic and anoxic periods during the operating cycle and can achieve a combination of carbon oxidation, nitrogen reduction and phosphorus removal. Phosphorus can be removed by coagulant addition or biologically without coagulant addition. If the sequence: fill, anaerobic, aerobic, anoxic, settlement and decant is followed then phosphorus release and BOD uptake will occur in the anaerobic stir phase, with a subsequent phosphorus uptake in the aerobic stir phase. By modifying the reaction times nitrification or nitrogen removal can also be achieved. Carbon from the endogenous respiration phase can be used in the anoxic phase to support denitrification. [216, Metcalf and Eddy, 1991]

Another option to reduce the ammoniacal nitrogen is ammonia conversion. The ammonia is conveyed with the exhaust vapours into a washing tower (converter) countercurrent to a nitrous solution and ammonium nitrate is formed. The ammonium nitrate is extracted from the filter tower when the desired concentration has been reached. The exhaust vapours freed from the ammonia are then condensed into acid exhaust vapours.

For the operation of such a converter, it is necessary that the exhaust vapours do not carry any solids. Cyclones or other suitable separation implements must, therefore, be installed before the converters.

Animal by-product installation waste water treatment

Rendering waste water treatment

See also Sections 0, 0 and 0.

Rendering plants produce waste water with a high organic load. The organic load from rendering a tonne of raw material is equivalent to that produced by 100 people/day. It also contains high levels of nitrogen and phosphorus. ABP Regulation 1774/2002/EC restricts the routes for the use and disposal of all animal material, as defined, collected from Category 1 and 2 processing plants. It also states *Waste water originating in the unclean sector must be treated to ensure, as far as is reasonably practicable, that no pathogens remain.*

Mechanical waste water treatment

Fat separators situated before the mixing and equalisation tanks need to be dimensioned for the maximum waste water production foreseeable. This maximum production occurs, for instance, during the exhaust vapour relaxation. Other issues such as temperature, the influence of rinsing and cleaning agents and the production of the different types and densities of fat need to be considered at the design stage.

In many plants, the fat separator is followed by additional strainer units with sieve apertures of 0.5–2 mm, for even more extensive solids separation.

Biological treatment

Aerobic part treatment can be used to remove some of the organic material and thereby reduce the BOD of the waste water. It is sometimes undertaken at installations, prior to further waste water treatment at a municipal WWTP.

The composition of waste water from the rendering industry makes it suitable for anaerobic pretreatment. It is, however, unsuitable for the total elimination of the organic load or the elimination of nitrogen. The presence of sulphides may also cause problems.

Anaerobic treatment is generally followed by aerobic treatment to remove nitrogen (and phosphorus) at the rendering site or at the municipal WWTP. Release of phosphorus occurs under anoxic conditions. Thus, biological phosphorus removal requires both anaerobic and aerobic reactors or zones within a reactor. [216, Metcalf and Eddy, 1991]. Anaerobic pretreatment of the waste water is suitable, especially for indirect discharge combined, with a physico-chemical nitrogen elimination.

Feathers – elimination of hydrogen sulphide

Fishmeal and fish oil manufacturing waste water treatment

One plant has reported that it uses DAF on site and then discharges its waste water to a local municipal WWTP.

Blood processing waste water treatment

A propriety WWTP has been described for a given blood processing plant. The first step is a physico-chemical treatment, during which polyamines and polyelectrolyte flocculants are added. This is followed by decanting the sludge to another tank. The clarified liquid is also transferred to another tank, where it is corrected for pH and anti-foaming agents are added. The liquid is then subject to a series of aerobic and anaerobic treatments. The WWTP is covered to prevent the release of NH_3 , from the breakdown of protein. The sludge is used in composting, due to its high protein content.

Gelatine manufacture waste water treatment

The water from the bone washing is cloudy and contains particles such as bone fragments, which are removed by screens. Solids are removed using sieves made from, e.g. a mechanical screen constructed from wedge wire. The solids are brushed off the screen into a skip, for disposal to landfill.

The liquid, which is highly organically contaminated [244, Germany, 2002], is delivered to a primary and secondary settlement tank, to allow separation of solids. Iron(III)chloride is injected with either H_2SO_4 or NaOH , depending on the pH, along with polyelectrolyte flocculant. The resultant liquor undergoes aerobic digestion using activated sludge. Nitrification and denitrification steps are also required [244, Germany, 2002]. A clarification step may be followed to remove the activated sludge. The resultant sludge is rich in nitrogen, phosphorus and calcium and is used for land injection and land spreading, possibly after mixing with other ingredients. Alternatively, the sludge may be used to produce biogas [349, GME TWG members, 2003].

2.2 Current consumption and emission levels

2.2.1 Emissions to water

2.2.1.1 Chemical oxygen demand (COD)

COD is commonly used to indirectly measure the amount of organic compounds in water by measuring the mass of oxygen needed for their total oxidation to carbon dioxide. The most widespread COD monitoring methods use dichromate as an oxidising agent and mercury salts to suppress the influence of inorganic chloride. COD has to be considered in relation to TSS since the TSS removal efficiency affects the performance achieved with respect to COD. For economic and environmental reasons, COD is being replaced to some extent by TOC.

Performance of reference installations

Often 24-hour composite samples are taken on a daily, weekly or monthly basis.

Figure 2.1 and Figure 2.2 show reported data (for the years 2016 to 2018) for COD emissions to water from slaughterhouses for direct discharges, as well as the applied abatement techniques.



Source: [264, TWG 2020].

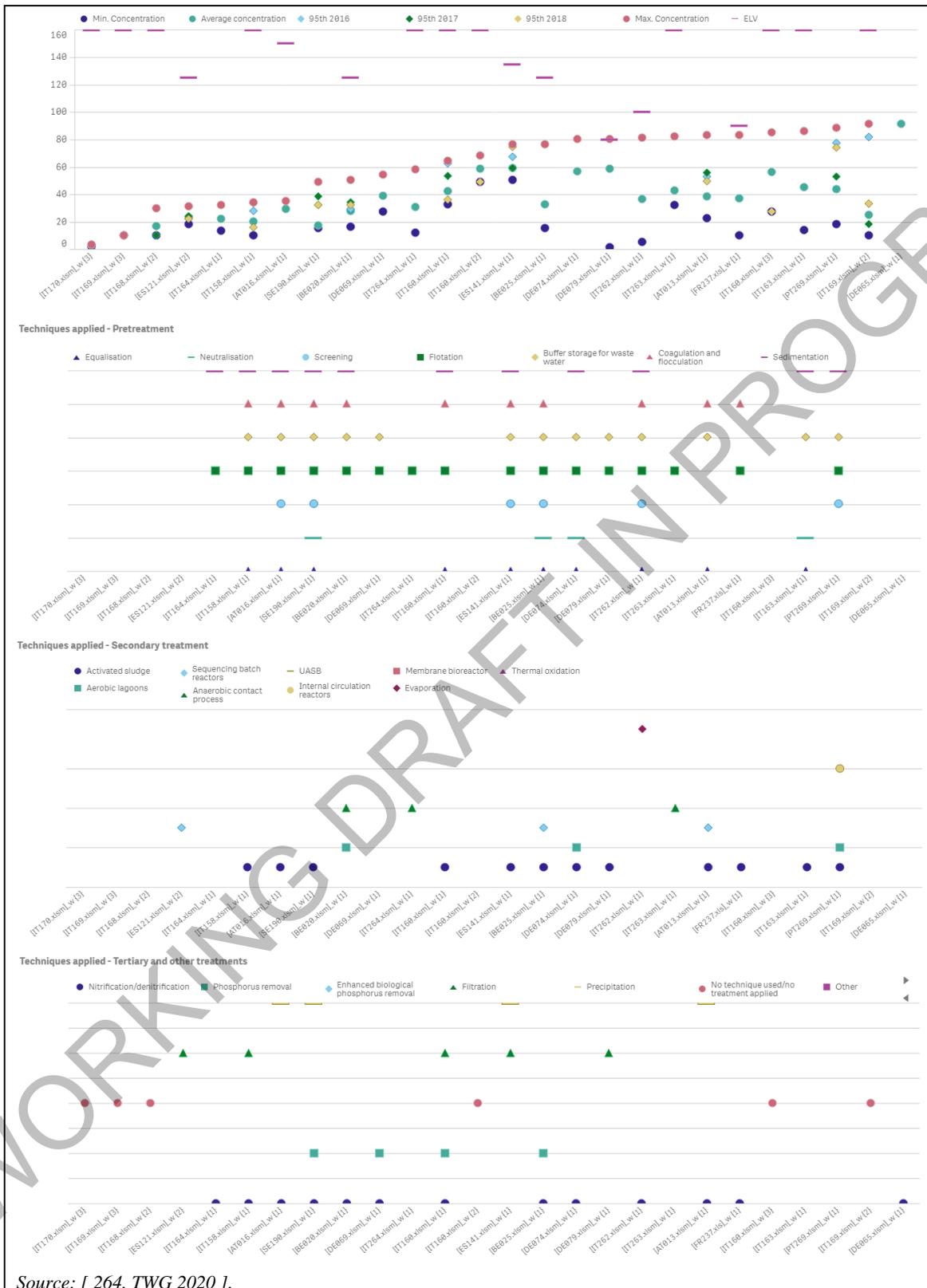
Figure 2.1: COD emissions to water (mg/l) from slaughterhouses (direct discharges) (Part 1 of 2)



Figure 2.2: COD emissions to water (mg/l) from slaughterhouses (direct discharges) (Part 2 of 2)

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Figure 2.3 and Figure 2.4 show reported data (for the years 2016 to 2018) for COD emissions to water from installations processing animal by-products and/or edible co-products for direct discharges, as well as the applied abatement techniques.



Source: [264, TWG 2020].

Figure 2.3: COD emissions to water (mg/l) from installations processing animal by-products and/or edible co-products (direct discharges) (Part 1 of 2)



Figure 2.4: COD emissions to water (mg/l) from installations processing animal by-products and/or edible co-products (direct discharges) (Part 2 of 2)

2.2.1.2 Total organic carbon (TOC)

Total organic carbon (TOC) analysis is used to directly measure the amount of organic compounds in water. The most widespread methods use a combustion chamber to completely oxidise the organic substances to carbon dioxide which is then measured by spectrometry. Inorganic carbon is not included in TOC. Identifying changes in the normal/expected TOC concentrations can be a good indicator of potential threats to a waste water treatment system. Various online TOC analysers exist. There is a tendency to replace COD with TOC for economic and ecological reasons.

Performance of reference installations

Often 24-hour composite or time-proportional samples are taken on a monthly basis.

Figure 2.5 shows reported data (for the years 2016 to 2018) for TOC emissions to water from SA installations for direct discharges, as well as the applied abatement techniques.

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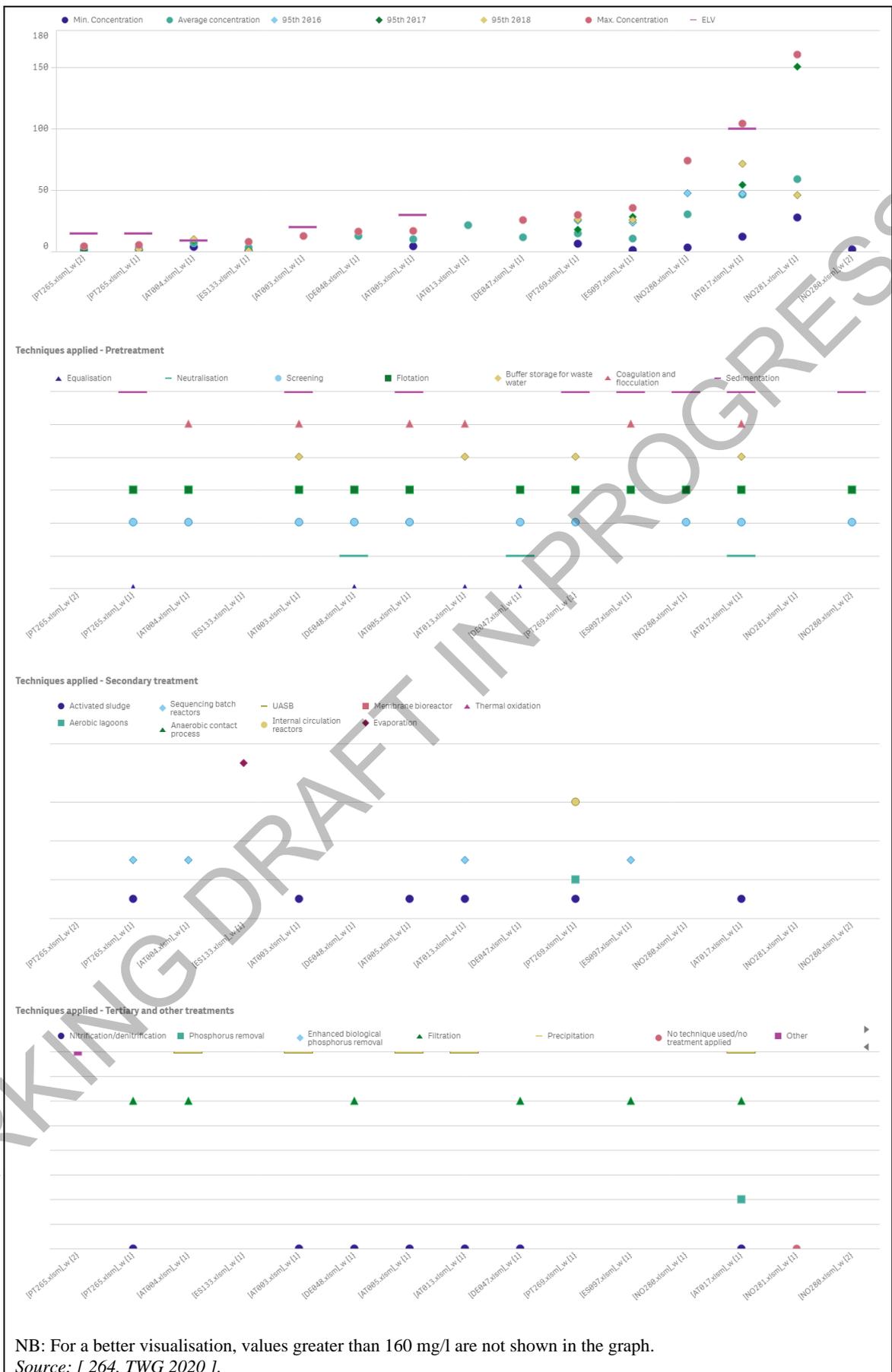


Figure 2.5: TOC emissions to water (mg/l) from SA installations (direct discharges)

2.2.1.3 Biochemical oxygen demand in 5 days (BOD₅)

BOD₅ measures the amount of dissolved oxygen required or consumed in 5 days at a constant temperature for the microbiological decomposition (oxidation) of organic material in water. The concentration in the effluent is generally a more pertinent parameter than the abatement efficiency.

The parameters COD and TOC can be determined more quickly than BOD₅. Furthermore, the use of BOD₅ as a parameter to describe the efficiency of biological treatment has some disadvantages such as:

- the monitoring method used is not very accurate considering reproducibility and methodology dependence (dilution method versus respirometer for example);
- the analytical result depends on the local conditions of the laboratory, such as the inoculum used for the test;
- the BOD₅ measurement does not allow for any prediction of the performance within the WWTP; it only provides an indication as to whether the waste water is easily degradable to a certain rate.

Performance of reference installations

Often 24-hour composite samples are taken on a weekly or monthly basis.

Figure 2.6 and Figure 2.7 show reported data (for the years 2016 to 2018) for BOD₅ emissions to water from SA installations for direct discharges, as well as the applied abatement techniques.

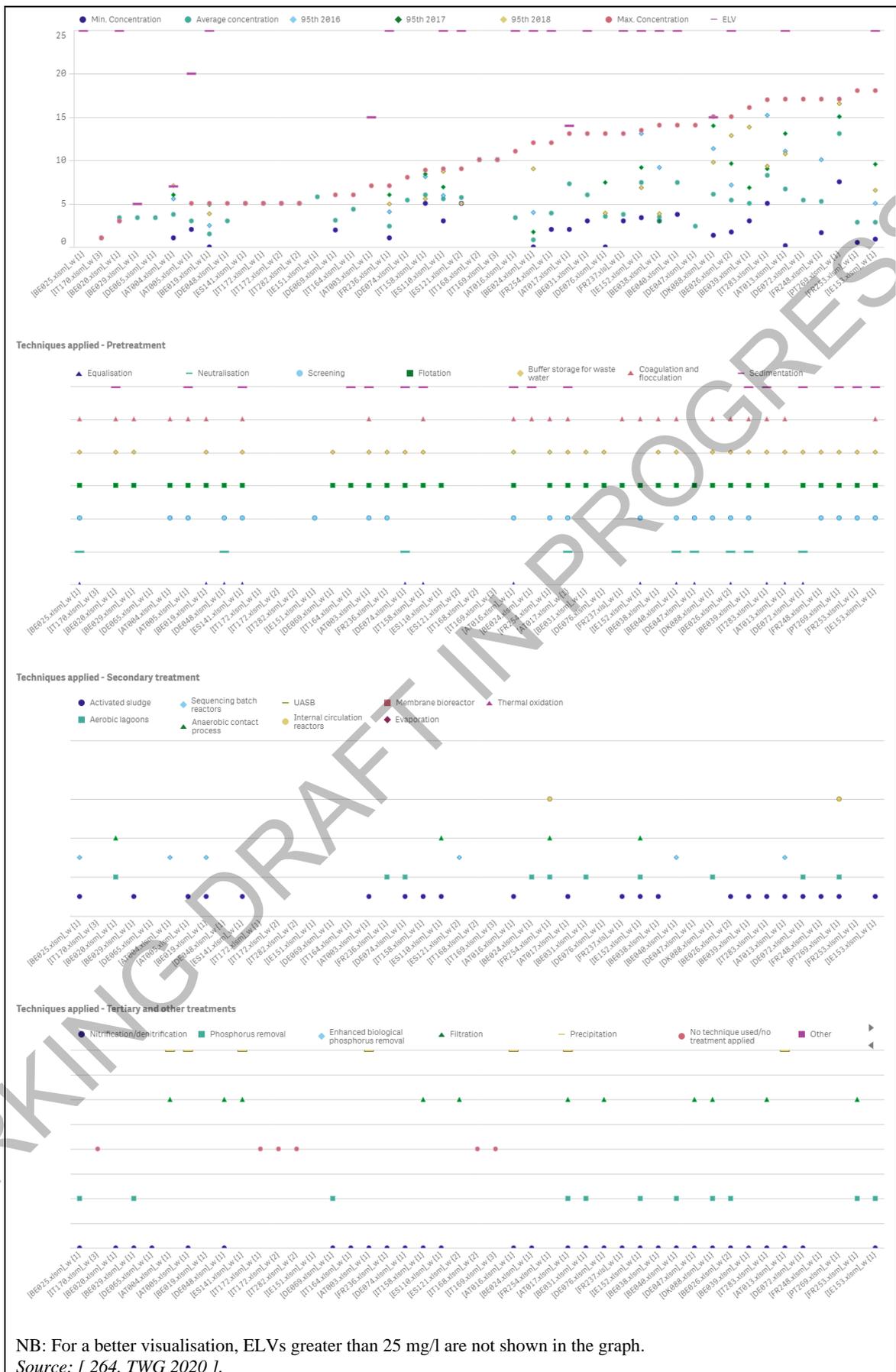


Figure 2.6: BOD5 emissions to water (mg/l) from SA installations (direct discharges) (Part 1 of 2)



Figure 2.7: BOD5 emissions to water (mg/l) from SA installations (direct discharges) (Part 2 of 2)

2.2.1.4 Total suspended solids (TSS)

There are some reasons to link the analysis of TSS with other parameters. If BOD/COD/TOC removal functions poorly, TSS emissions may be affected. Conversely, high TSS values can correlate with or cause high concentrations of other parameters, namely BOD, TOC or COD, total phosphorus and total nitrogen.

It is possible to have higher TSS values in the effluent than in the influent, for example due to the growth of biomass during biological treatment or due to the precipitation of compounds during physico-chemical treatment. In most cases, it therefore does not make sense to calculate abatement efficiencies for the WWTP.

Performance of reference installations

Often 24-hour composite samples are taken on a daily or monthly basis.

Figure 2.8 and Figure 2.9 show data (for the years 2016 to 2018) for TSS emissions to water from SA installations for direct discharges, as well as the applied abatement techniques.



NB: For a better visualisation, ELVs greater than 40 mg/l are not shown in the graph.

Source: [264, TWG 2020].

Figure 2.8: TSS emissions to water (mg/l) from SA installations (direct discharges) (Part 1 of 2)

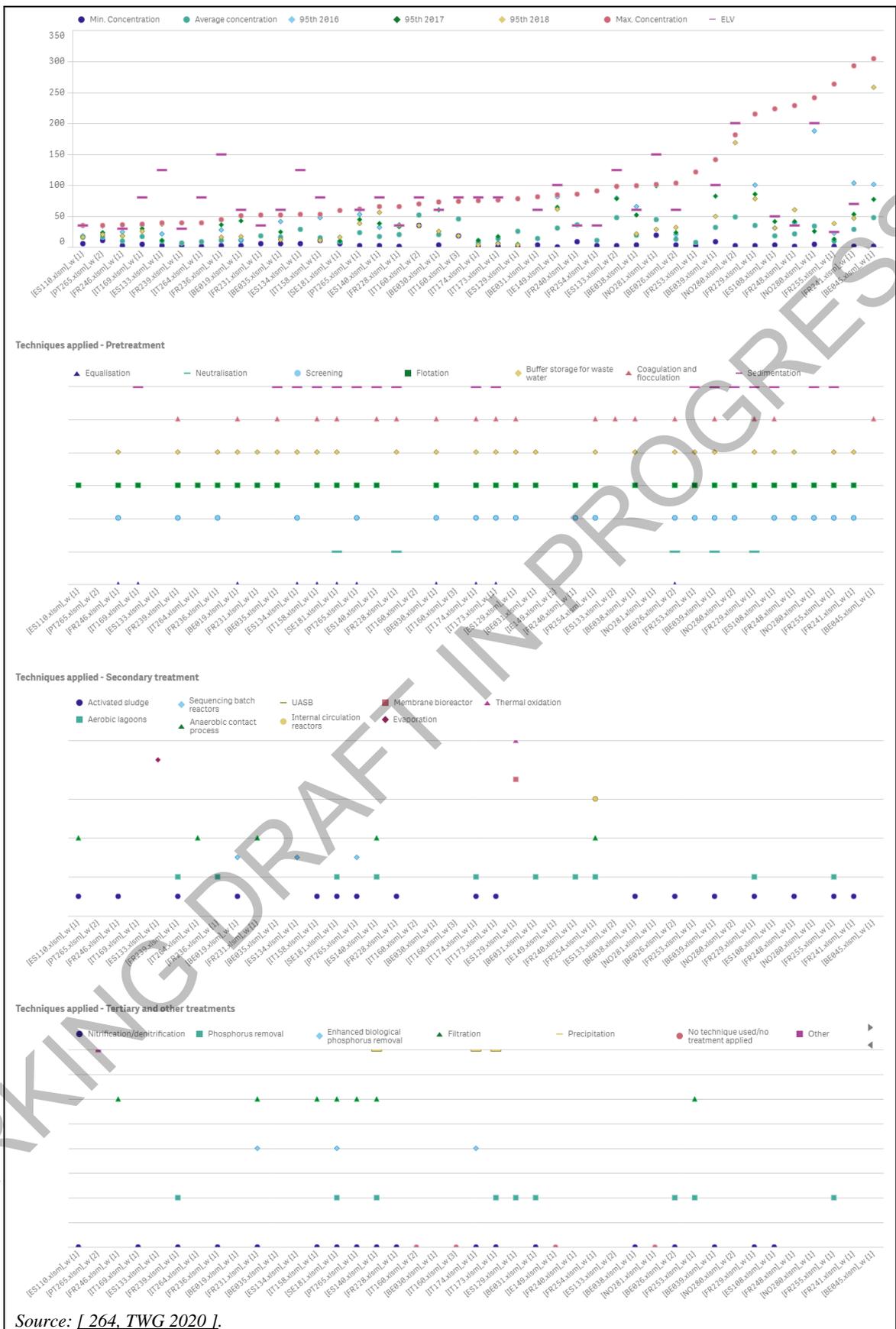


Figure 2.9: TSS emissions to water (mg/l) from SA installations (direct discharges) (Part 2 of 2)

2.2.1.5 Total nitrogen (Total N)

The parameter total nitrogen (Total N) includes free ammonia and ammonium (NH₄-N), nitrites (NO₂-N), nitrates (NO₃-N) and organic nitrogen compounds. Dissolved elementary nitrogen (N₂) is not included. Total N is frequently measured by combustion with subsequent analysis of nitrogen oxides via chemiluminescence (i.e. total nitrogen bound = TN_b, e.g. according to EN 12260), or by oxidation with peroxodisulphate with subsequent wet-chemical analysis of nitrate (Koroleff method, e.g. according to EN ISO 11905-1). Total N can also be determined by summing up the individual concentrations of total Kjeldahl nitrogen (TKN), NO₂-N and NO₃-N.

Performance of reference installations

Often 24-hour composite samples are taken on a weekly or monthly basis.

Figure 2.10 and Figure 2.11 show reported data (for the years 2016 to 2018) for Total N emissions to water from SA installations for direct discharges, as well as the applied abatement techniques.

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Figure 2.10: Total N emissions to water (mg/l) from SA installations (direct discharges) (Part 1 of 2)

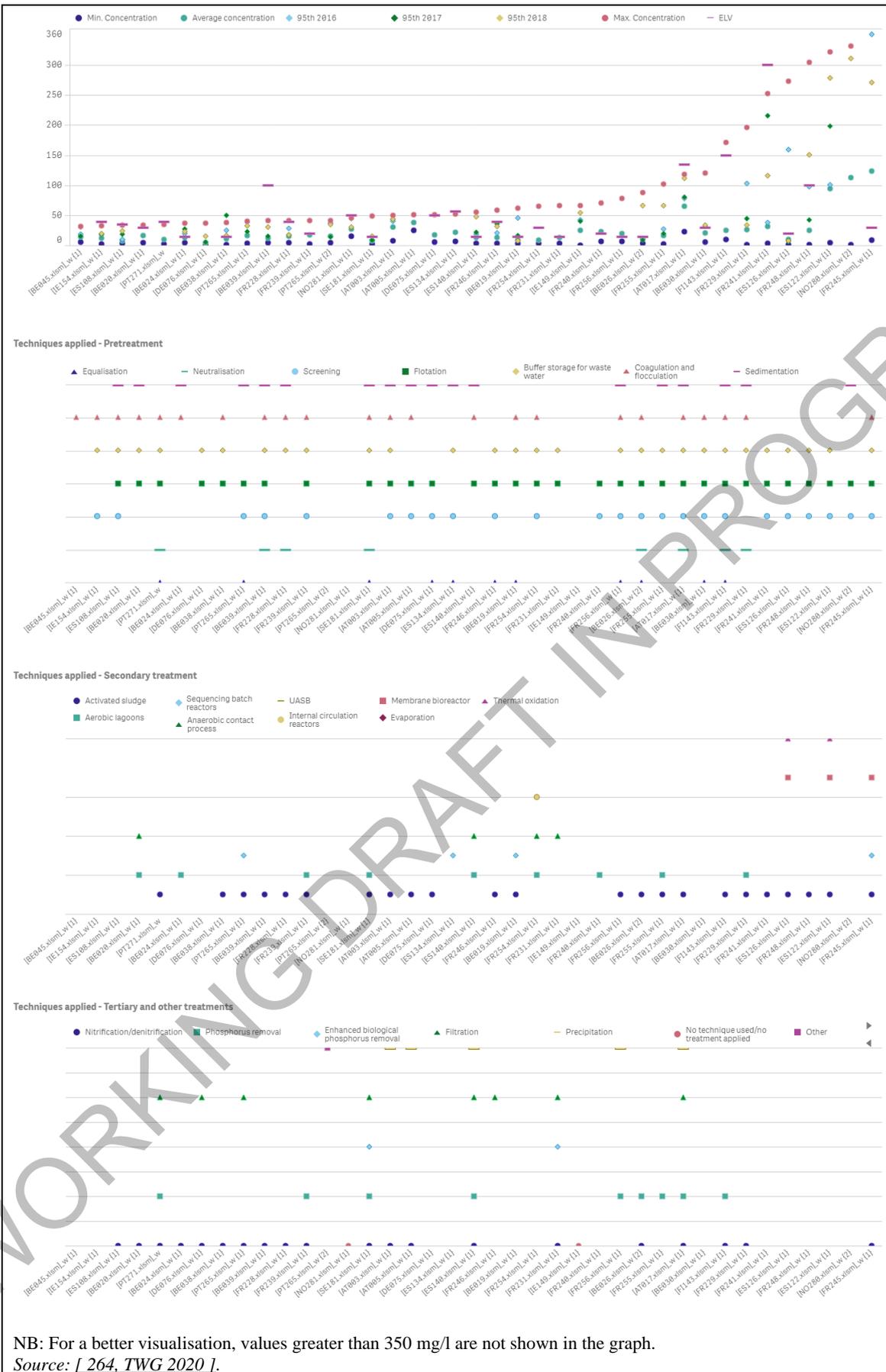


Figure 2.11: Total N emissions to water (mg/l) from SA installations (direct discharges) (Part 2 of 2)

2.2.1.6 Total phosphorus (Total P)

Phosphorus is present in waste water in inorganic and organic forms. The inorganic forms are orthophosphates (i.e. $\text{HPO}_4^{2-}/\text{H}_2\text{PO}_4^-$) and polyphosphates. Organically bound phosphorus is usually of minor importance. Polyphosphates can be used as a means of controlling corrosion. Phosphorus discharge has to be controlled in the same way as nitrogen discharge in order to avoid eutrophication of a surface water body. It was reported that, to avoid algal blooms in summer conditions, the critical level of inorganic phosphorus should be near 0.005 mg/l.

Performance of reference installations

Often 24-hour composite samples are taken on a weekly or monthly basis.

Figure 2.12, Figure 2.13 and Figure 2.14 show reported data (for the years 2016 to 2018) for Total P emissions to water from SA installations for direct discharges, as well as the applied abatement techniques.

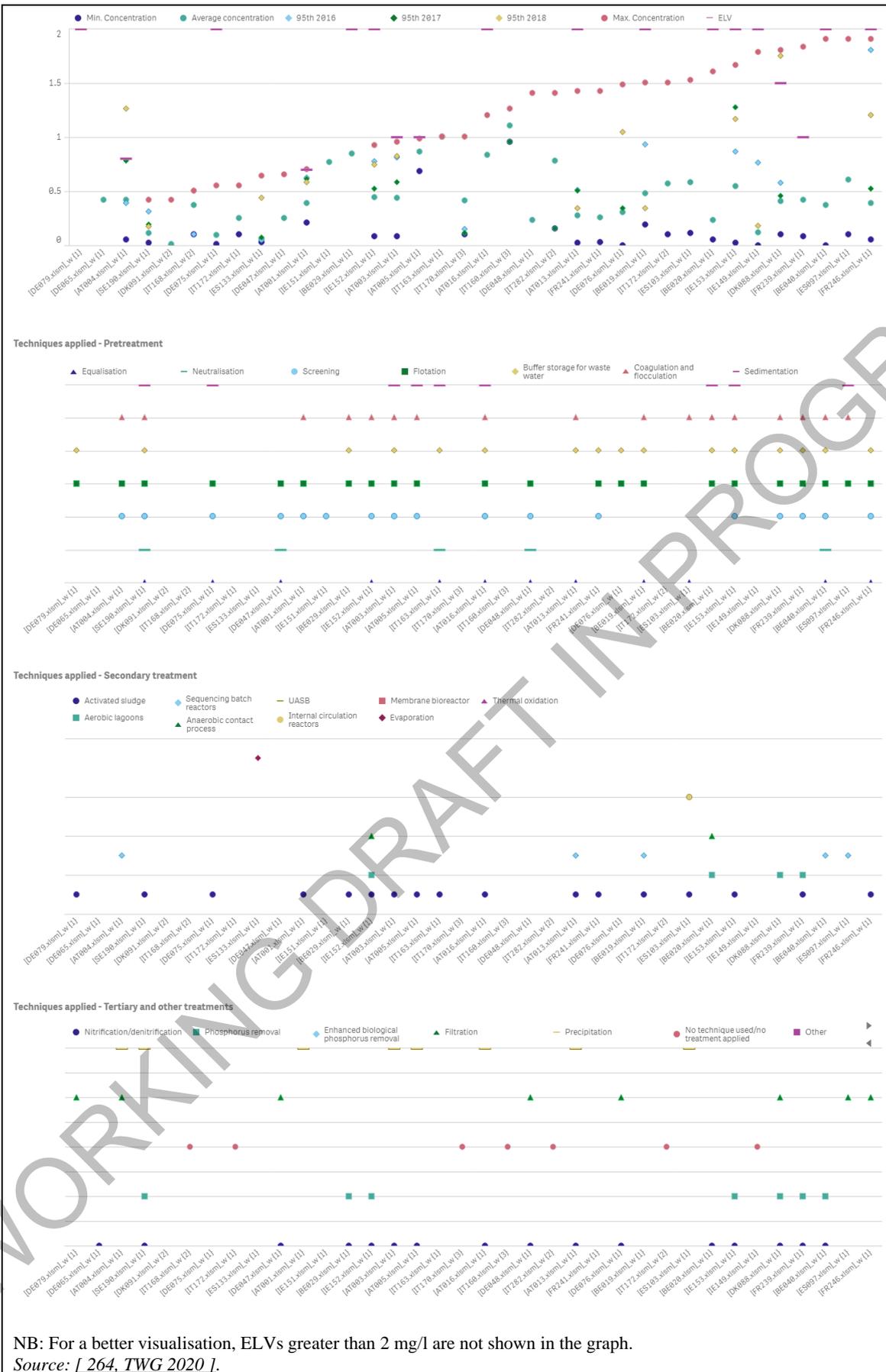


Figure 2.12: Total P emissions to water (mg/l) from SA installations (direct discharges) (Part 1 of 3)

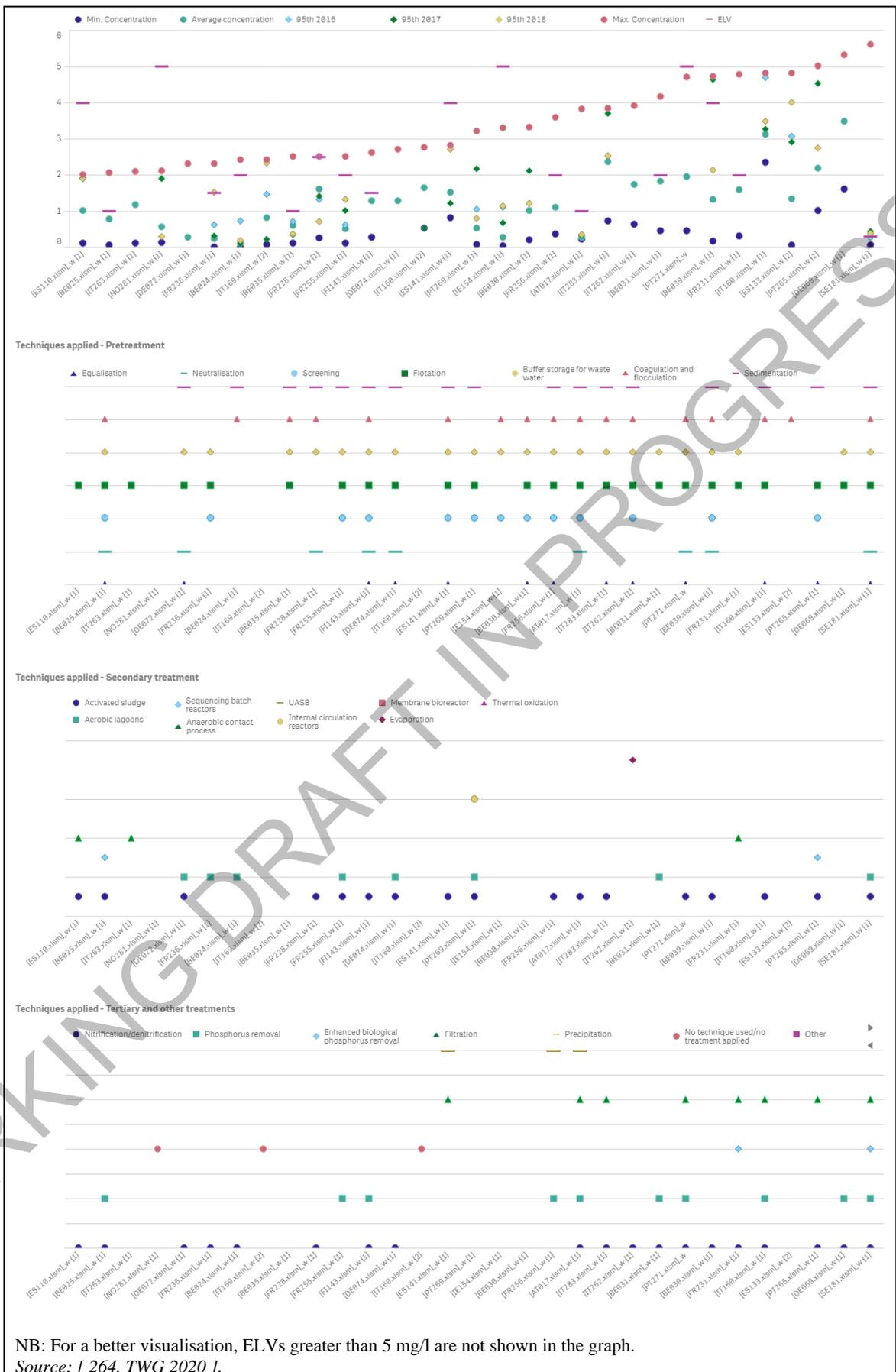


Figure 2.13: Total P emissions to water (mg/l) from SA installations (direct discharges) (Part 2 of 3)

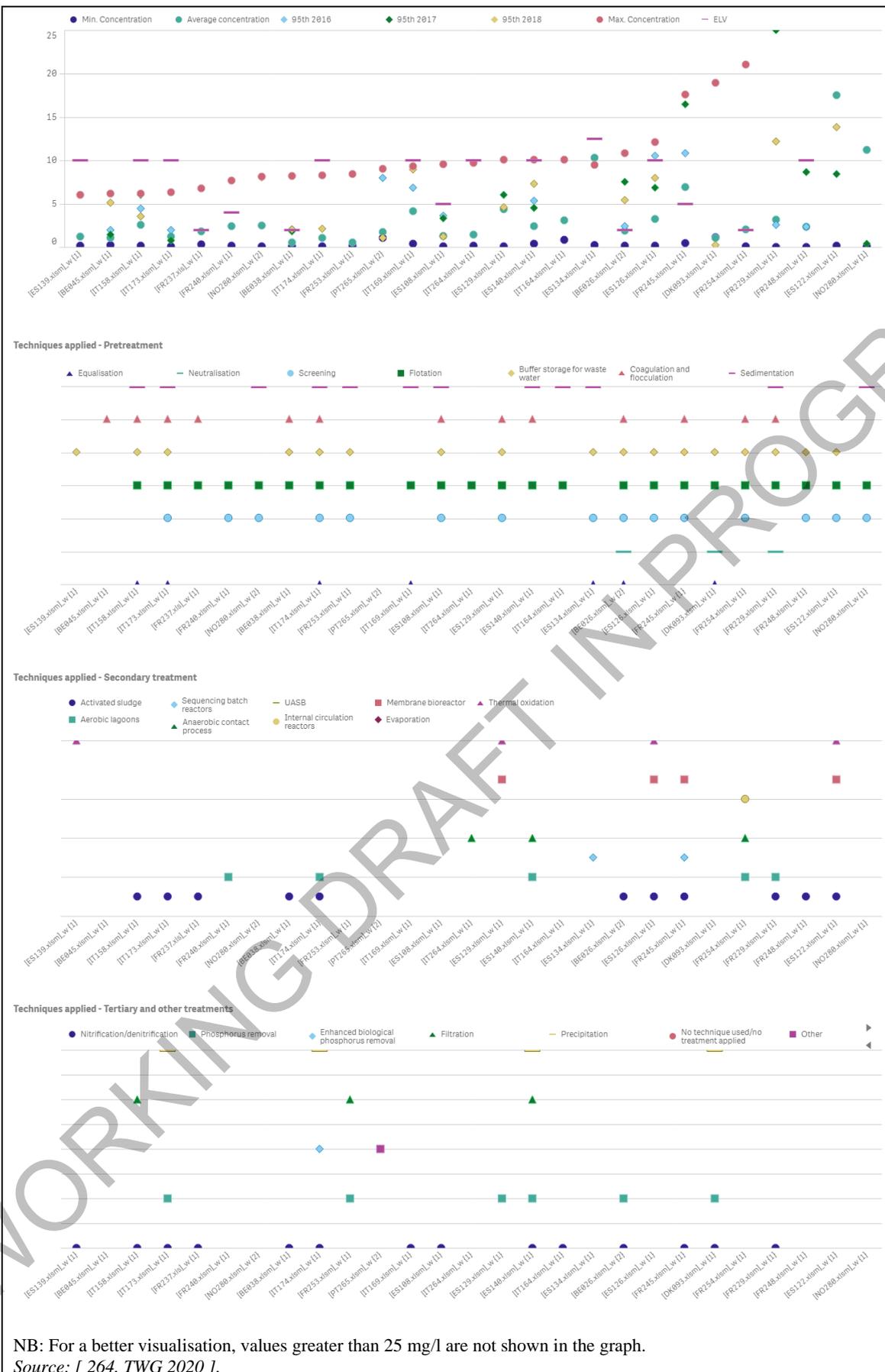


Figure 2.14: Total P emissions to water (mg/l) from SA installations (direct discharges) (Part 3 of 3)

2.2.1.7 Adsorbable organically bound halogens (AOX)

AOX is a sum parameter which indicates the overall level of organohalogen compounds (chlorine, bromine and iodine) in water samples. It is important as many organohalogen compounds are toxic (especially the fat-soluble chlorinated group – dioxins, furans and polychlorinated phenolic compounds) and/or persistent. However, as a sum parameter, AOX does not provide information on the chemical structure of organohalogen compounds present or on their toxicity. The AOX method has the advantage that it is a relatively simple measurement if it is compared with the alternative methods of measuring levels of individual compounds which are complex and require costly equipment.

Performance of reference installations

Often 24-hour composite samples are taken on a monthly or yearly basis.

Figure 2.15 shows reported data (for the years 2016 to 2018) for AOX emissions to water from SA installations for direct discharges, as well as the applied abatement techniques.



Figure 2.15: AOX emissions to water (mg/l) from SA installations (direct discharges)

Figure 2.16 shows reported data (for the years 2016 to 2018) for AOX emissions to water from SA installations for indirect discharges, as well as the applied abatement techniques.

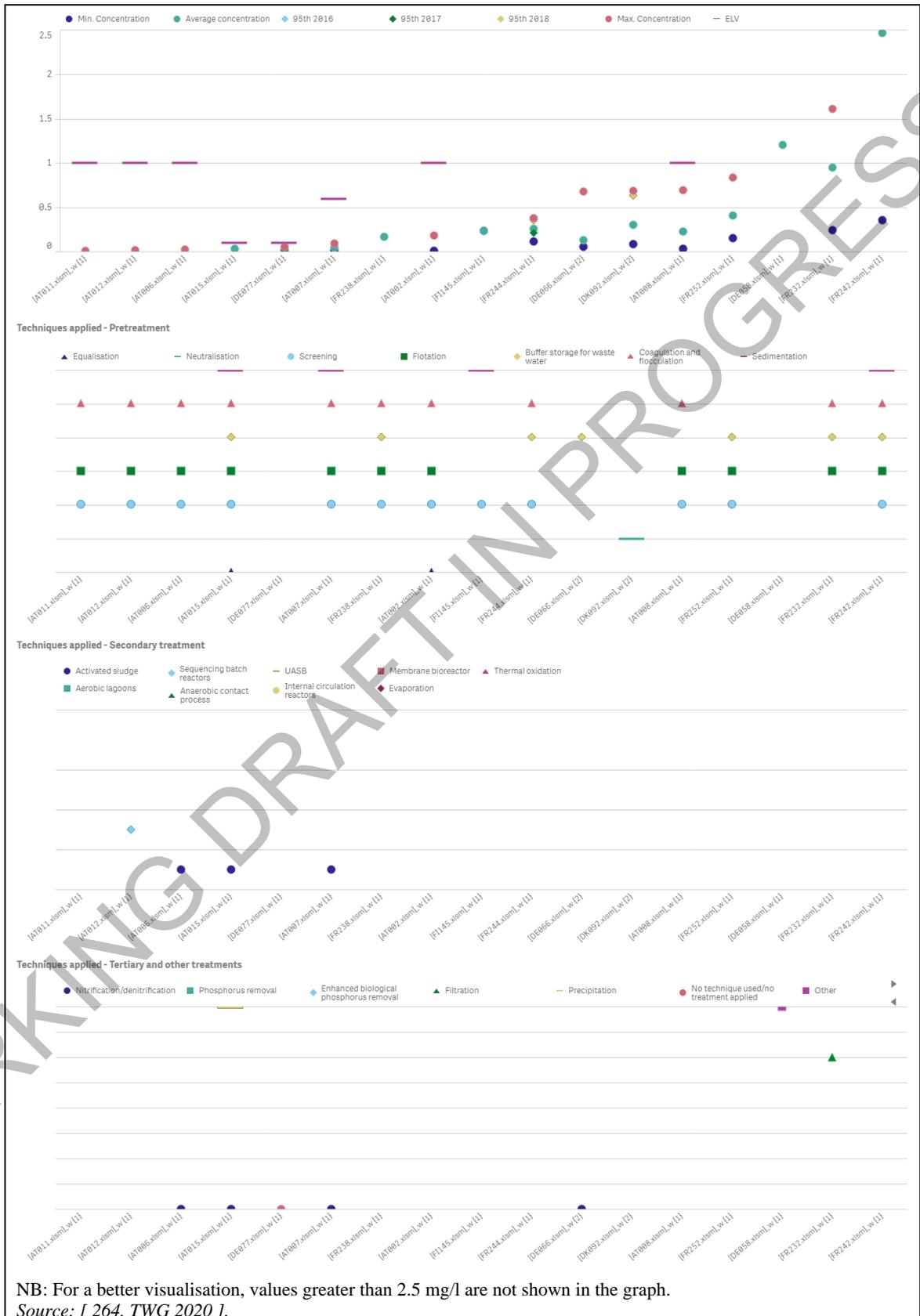


Figure 2.16: AOX emissions to water (mg/l) from SA installations (indirect discharges)

2.2.2 Emissions to air

2.2.2.1 Emissions to air from combustion of malodorous gases including non-condensable gases in an existing boilers

2.2.2.1.1 Dust

Figure 2.17 shows reported data (for the years 2016 to 2018) for channelled dust emissions to air from combustion of malodorous gases including non-condensable gases in existing boilers in SA installations. No correction for reported O₂ has been applied. Values have been reported at various O₂ contents.

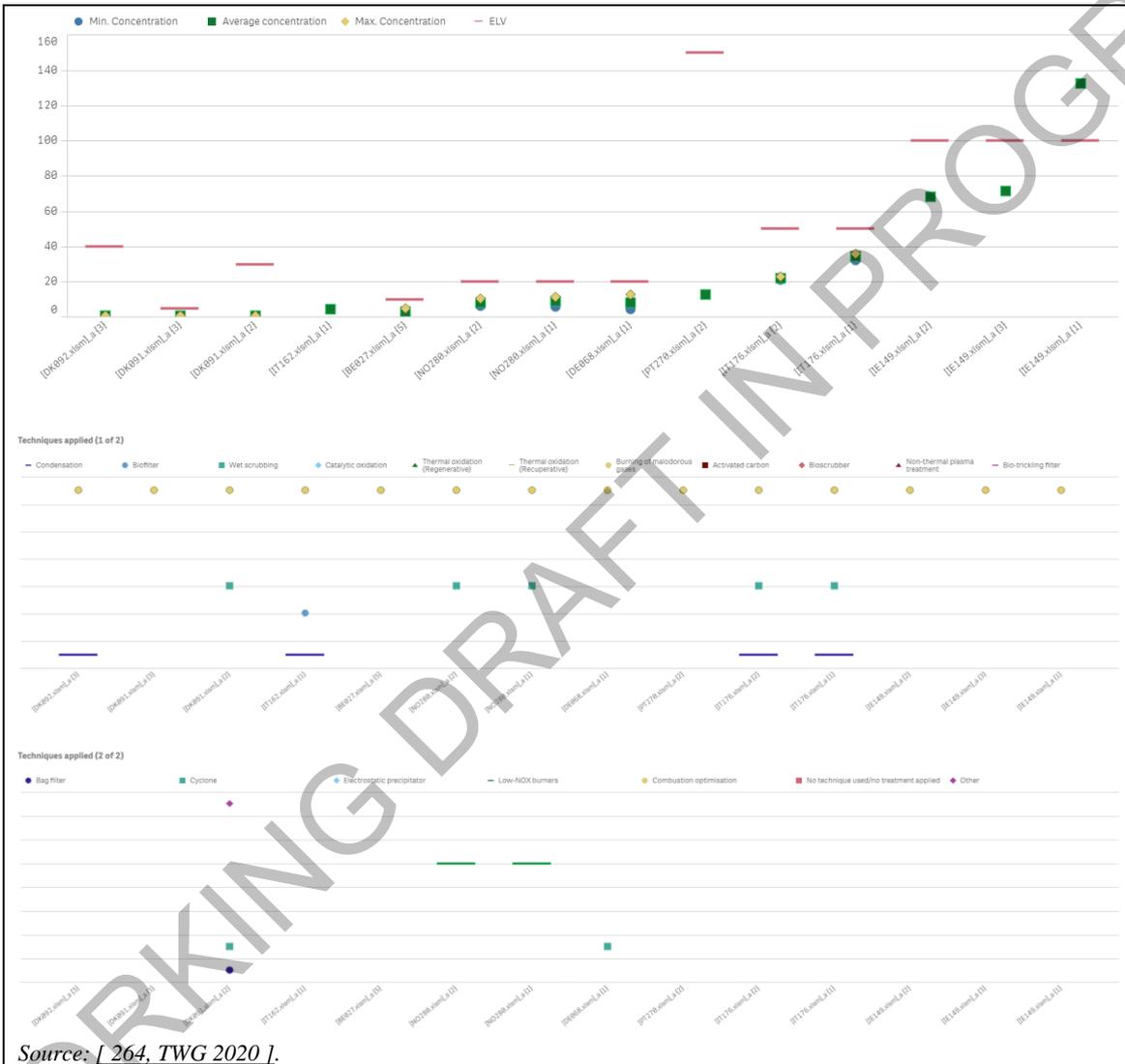


Figure 2.17: Dust emissions to air (mg/Nm³) from combustion of malodorous gases including non-condensable gases in existing boilers in SA installations

2.2.2.1.2 NO_x

Figure 2.18 shows reported data (for the years 2016 to 2018) for channelled NO_x emissions to air from combustion of malodorous gases including non-condensable gases in existing boilers in SA installations. No correction for reported O₂ has been applied. Values have been reported at various O₂ contents.

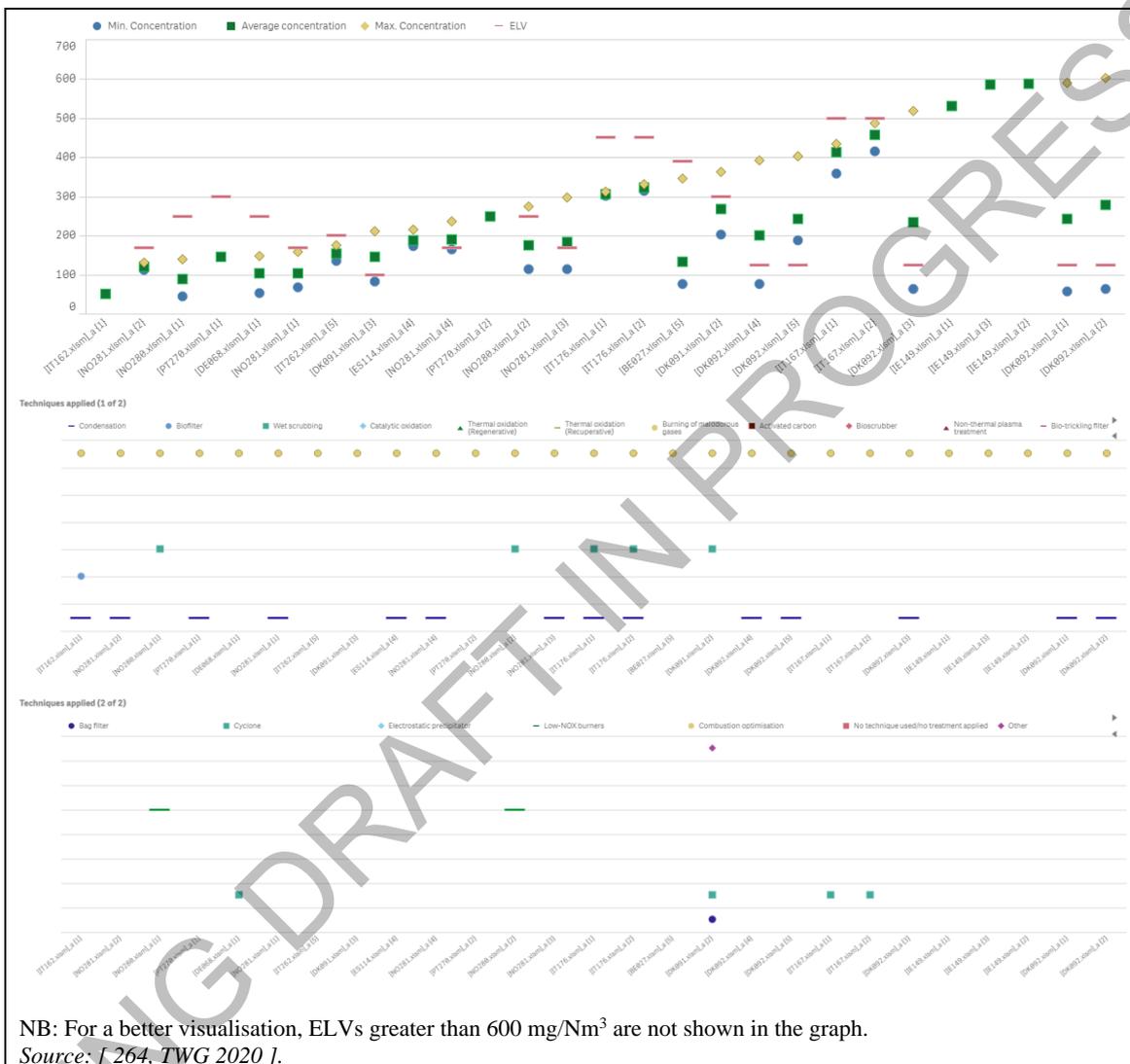


Figure 2.18: NO_x emissions to air (mg/Nm³) from combustion of malodorous gases including non-condensable gases in existing boilers in SA installations

2.2.2.1.3 SO_x

Figure 2.19 and Figure 2.20 show reported data (for the years 2016 to 2018) for channelled SO_x emissions to air from combustion of malodorous gases including non-condensable gases in existing boilers in SA installations. No correction for reported O₂ has been applied. Values have been reported at various O₂ contents.

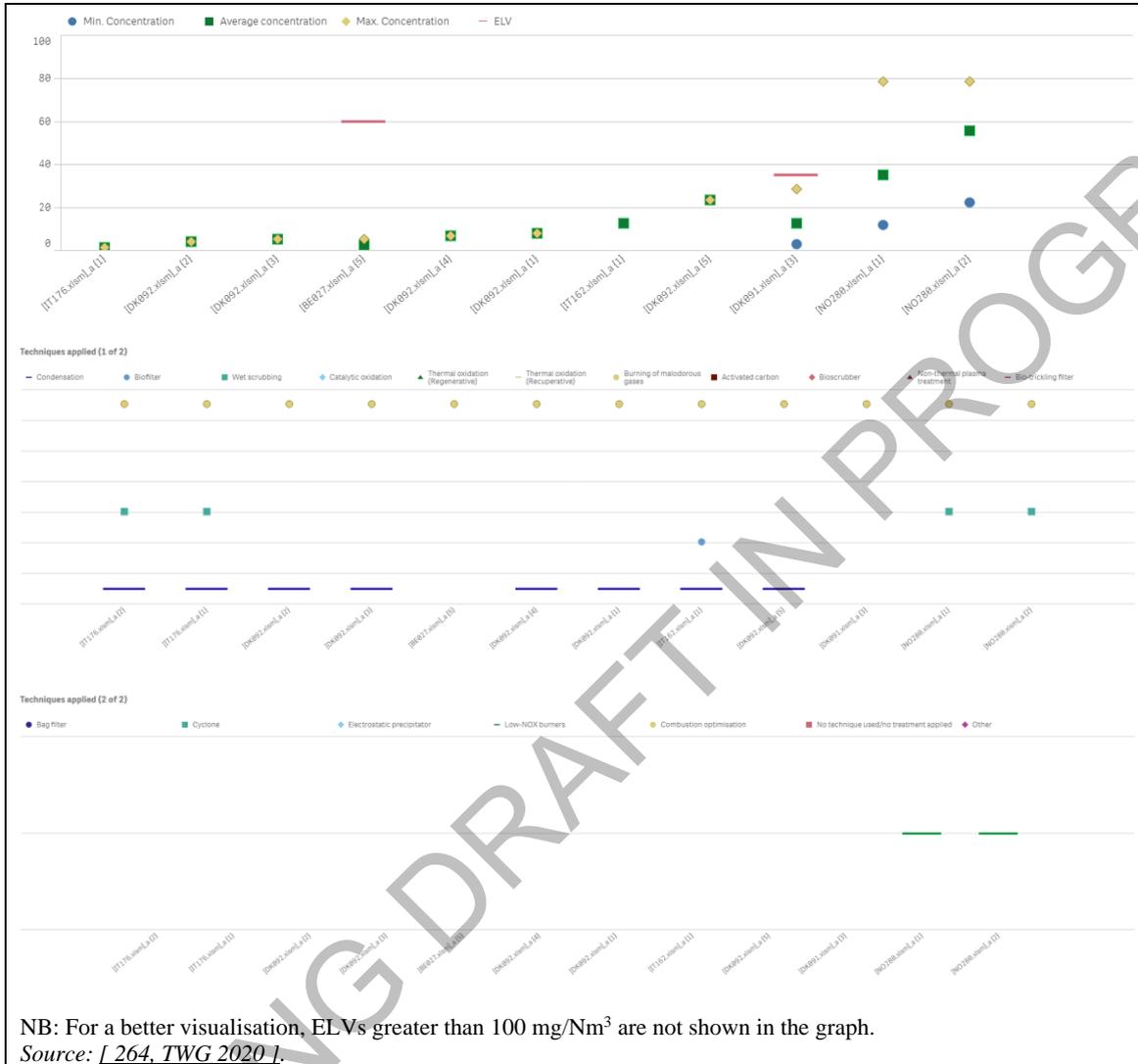


Figure 2.19: SO_x emissions to air (mg/Nm³) from combustion of malodorous gases including non-condensable gases in existing boilers in SA installations (Part 1 of 2)

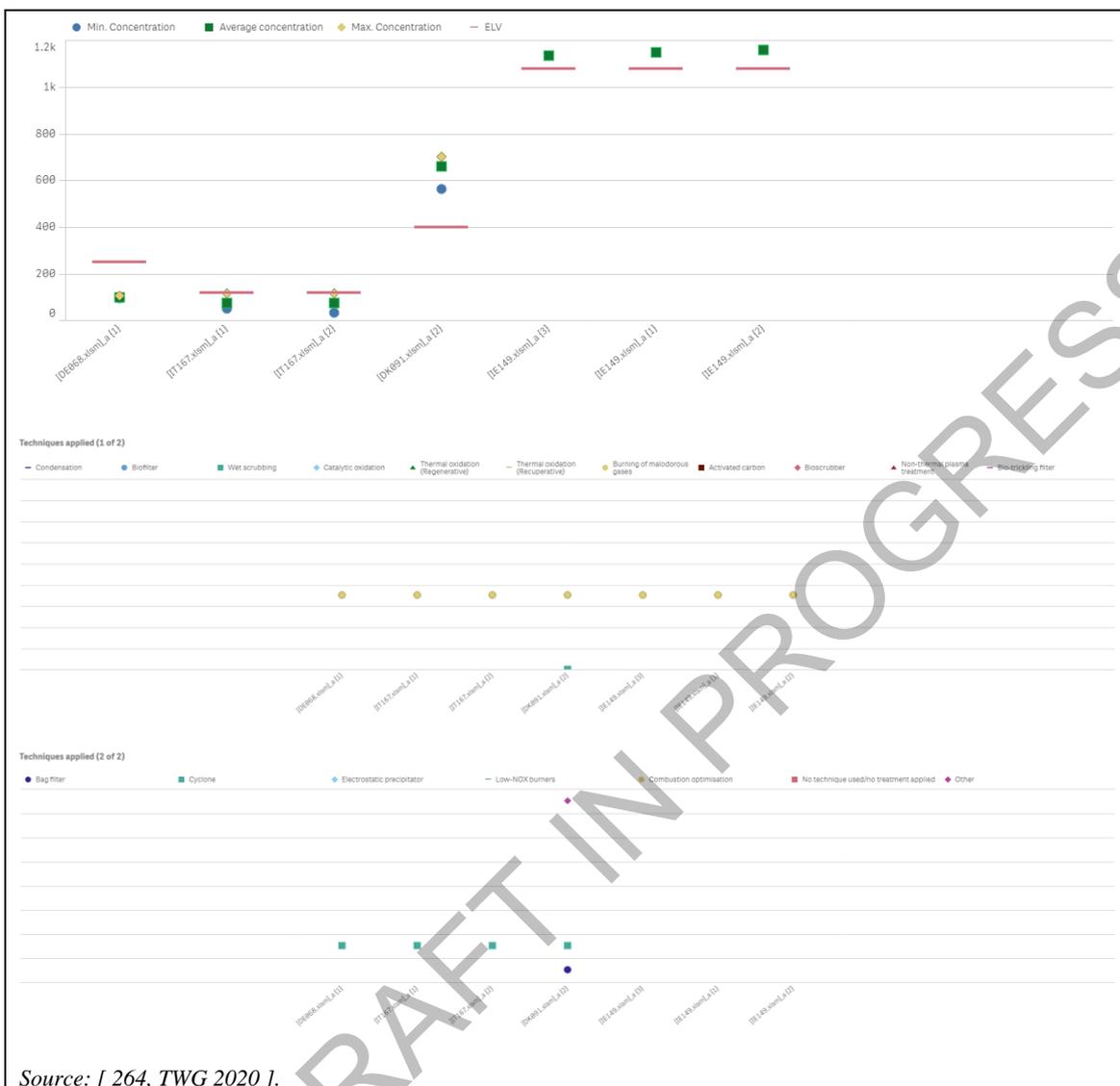


Figure 2.20: SO_x emissions to air (mg/Nm³) from combustion of malodorous gases including non-condensable gases in existing boilers in SA installations (Part 2 of 2)

2.2.2.1.4 CO

Figure 2.21 shows reported data (for the years 2016 to 2018) for channelled CO emissions to air from combustion of malodorous gases including non-condensable gases in existing boilers in SA installations. No correction for reported O₂ has been applied.

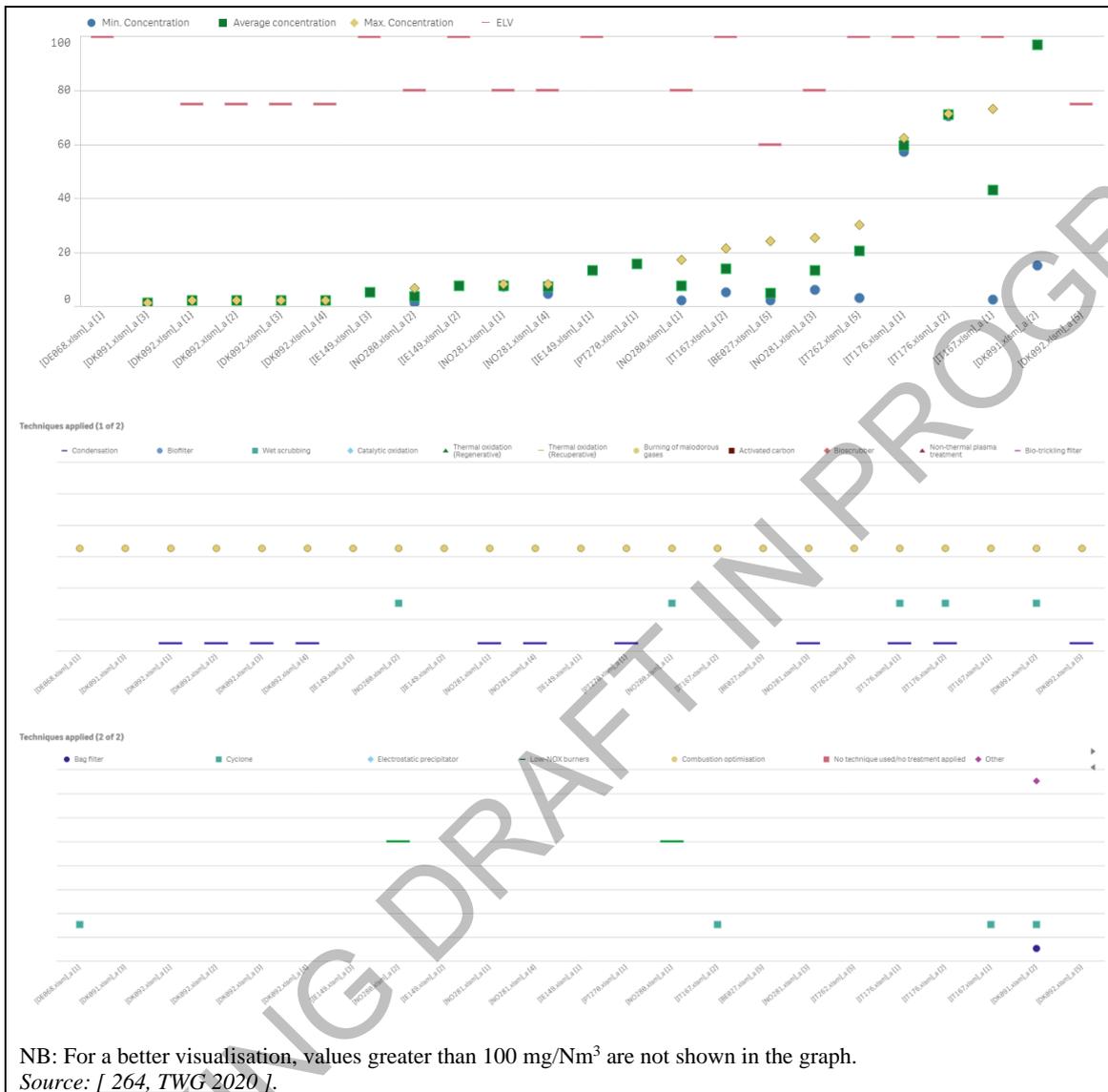


Figure 2.21: CO emissions to air (mg/Nm³) from combustion of malodorous gases including non-condensable gases in existing boilers in SA installations

2.2.2.2 Emissions to air from thermal oxidation

2.2.2.2.1 Dust

Figure 2.22 shows reported data (for the years 2016 to 2018) for channelled dust emissions to air from thermal oxidation in SA installations. No correction for reported O₂ has been applied. Values have been reported at various O₂ contents.

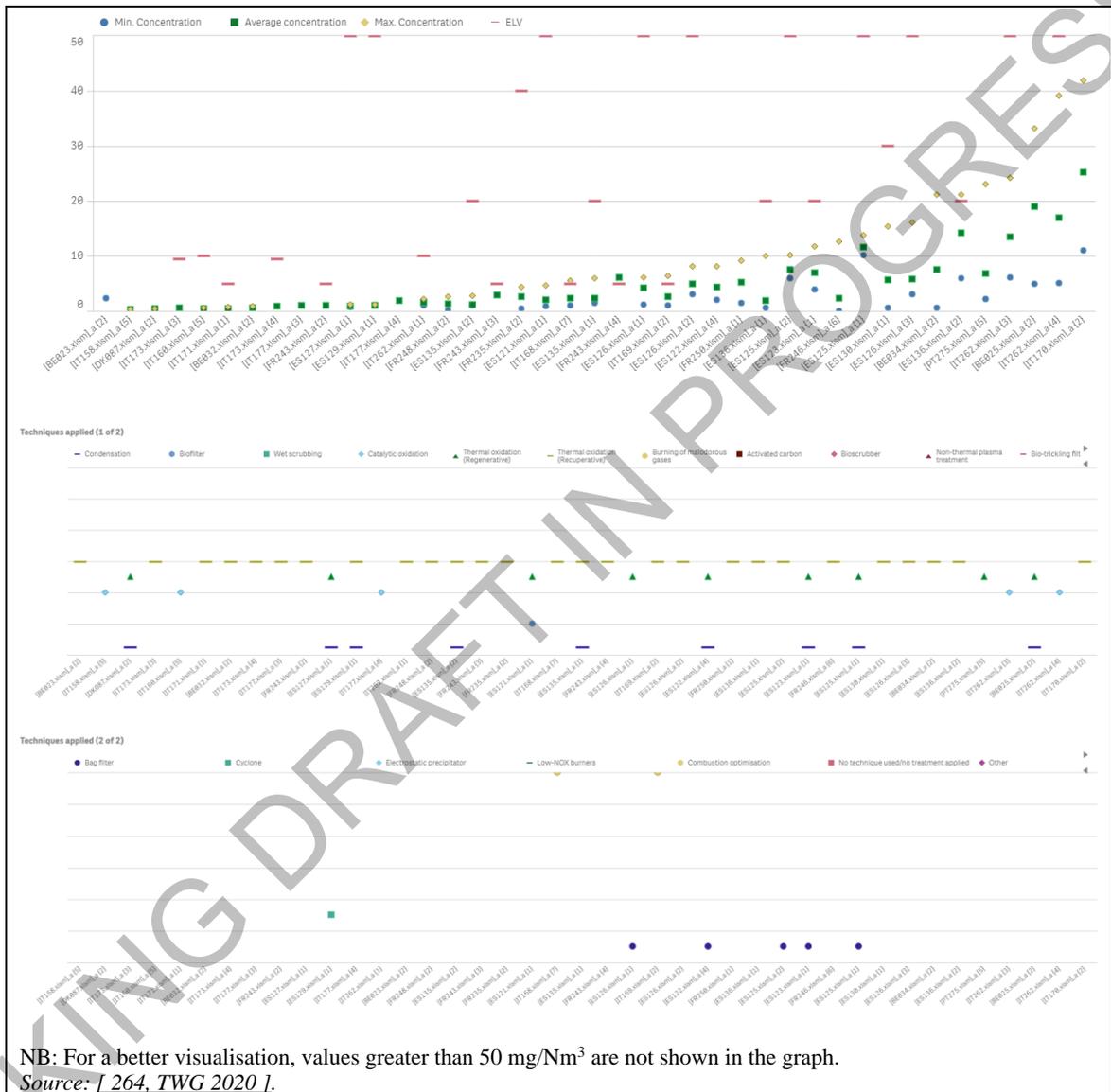


Figure 2.22: Dust emissions to air (mg/Nm³) from thermal oxidation in SA installations

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Figure 2.23 show reported data (for the years 2016 to 2018) for channelled dust emissions to air from thermal oxidation in SA installations. Values have been corrected to a reference O₂ level of 18 %.

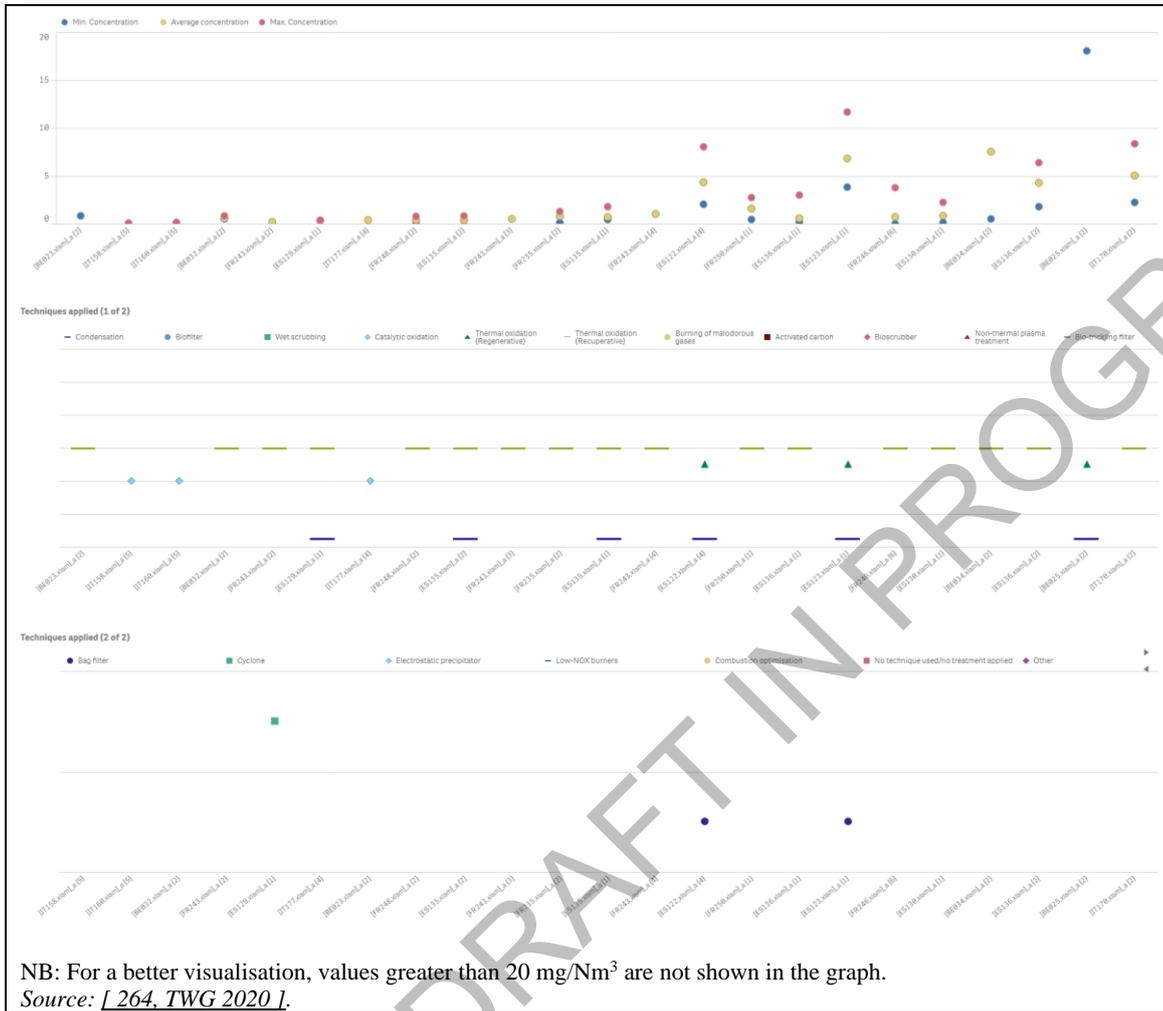


Figure 2.23: Dust emissions to air (mg/Nm³) from thermal oxidation in SA installations (values corrected to 18 % O₂)

2.2.2.2.2 NO_x

Figure 2.24 and Figure 2.25 show reported data (for the years 2016 to 2018) for channelled NO_x emissions to air from thermal oxidation in SA installations. No correction for reported O₂ has been applied. Values have been reported at various O₂ contents.

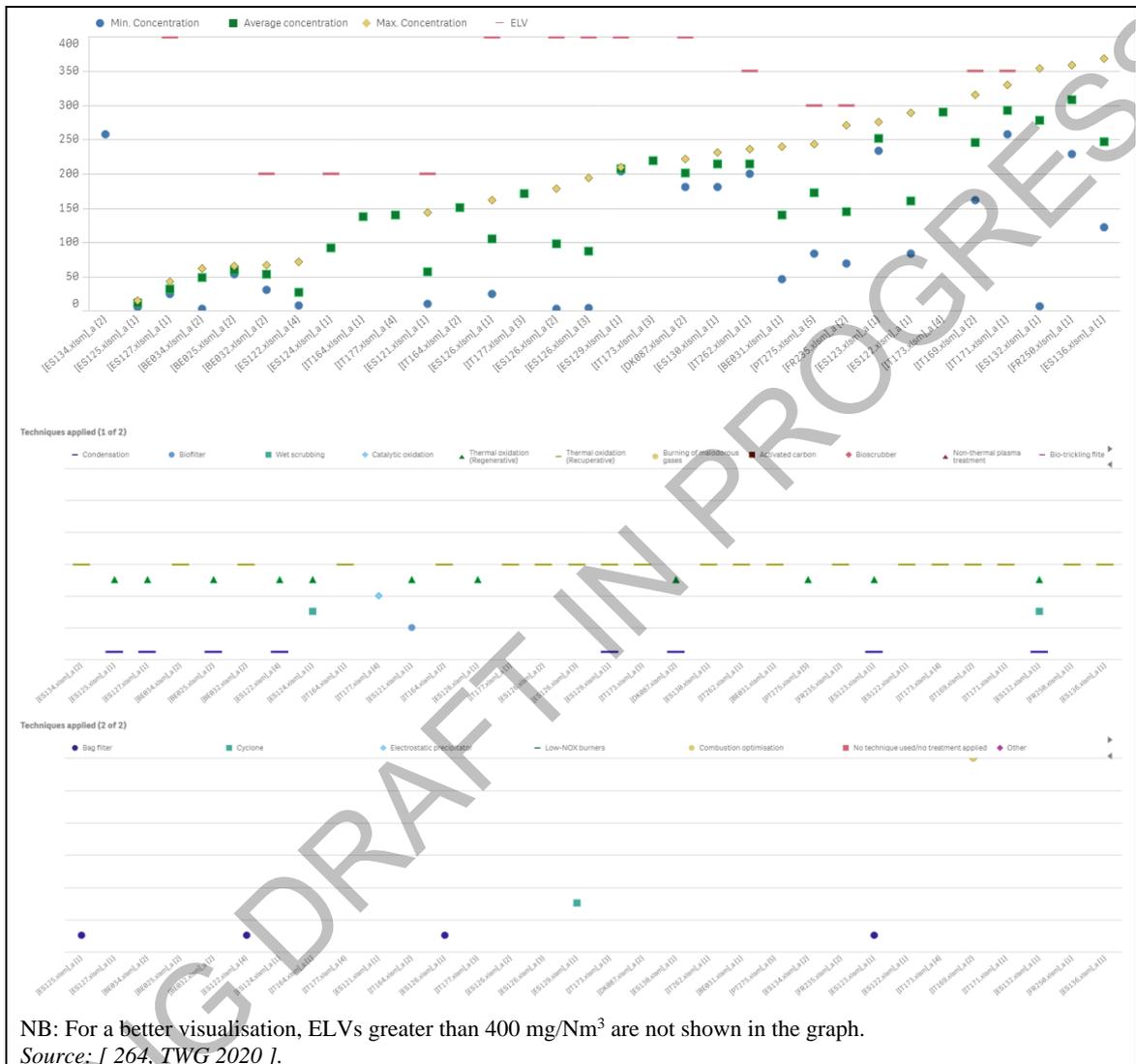
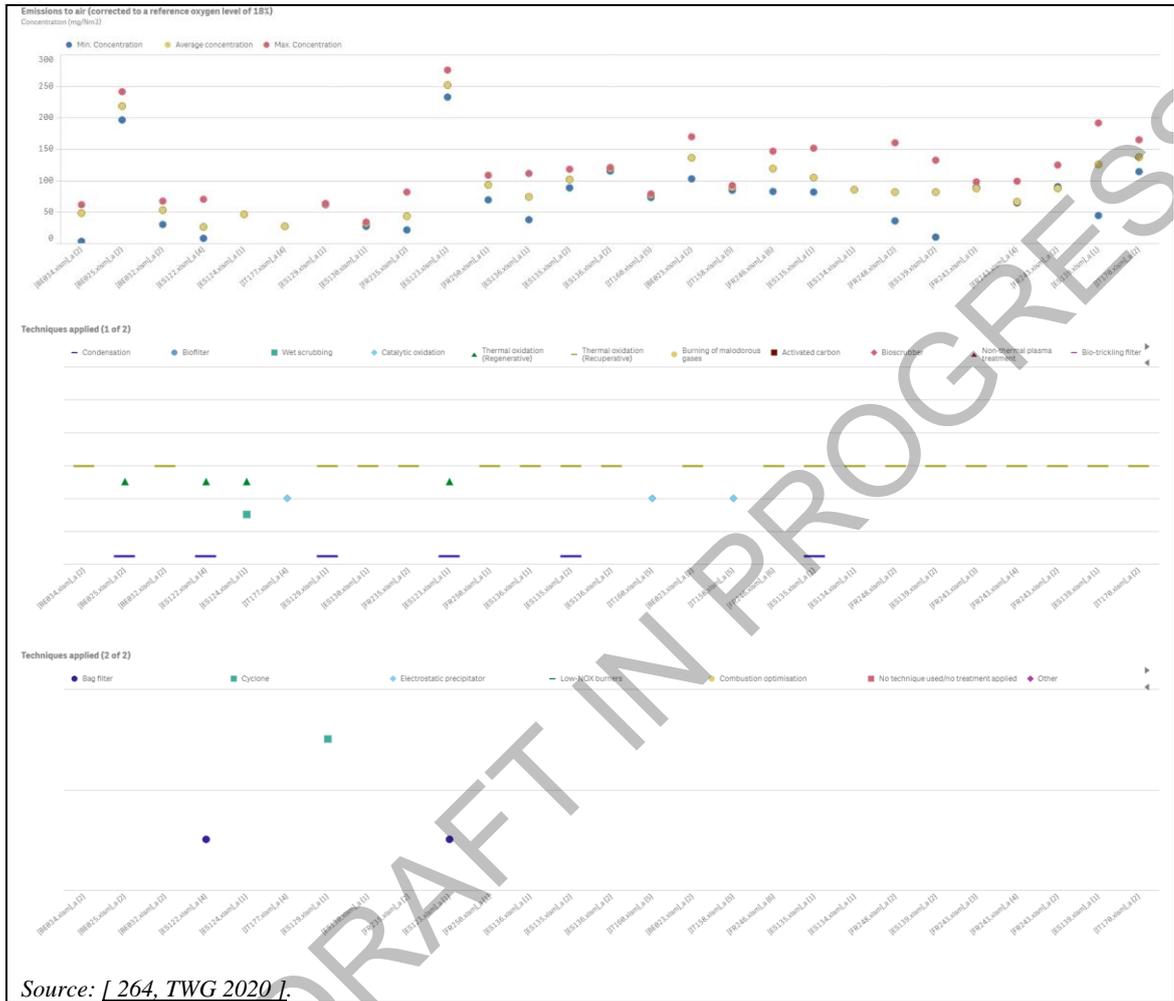


Figure 2.24: NO_x emissions to air (mg/Nm³) from thermal oxidation in SA installations (Part 1 of 2)



Figure 2.25: NO_x emissions to air (mg/Nm³) from thermal oxidation in SA installations (Part 2 of 2)

Figure 2.26 shows reported data (for the years 2016 to 2018) for channelled NO_x emissions to air from thermal oxidation in SA installations. Values have been corrected to a reference O₂ level of 18 %.



Source: [264, TWG 2020].

Figure 2.26: NO_x emissions to air (mg/Nm³) from thermal oxidation in SA installations (values corrected to 18 % O₂)

2.2.2.2.3 SO_x

Figure 2.27 and Figure 2.28 show reported data (for the years 2016 to 2018) for channelled SO_x emissions to air from thermal oxidation in SA installations. No correction for reported O₂ has been applied. Values have been reported at various O₂ contents.

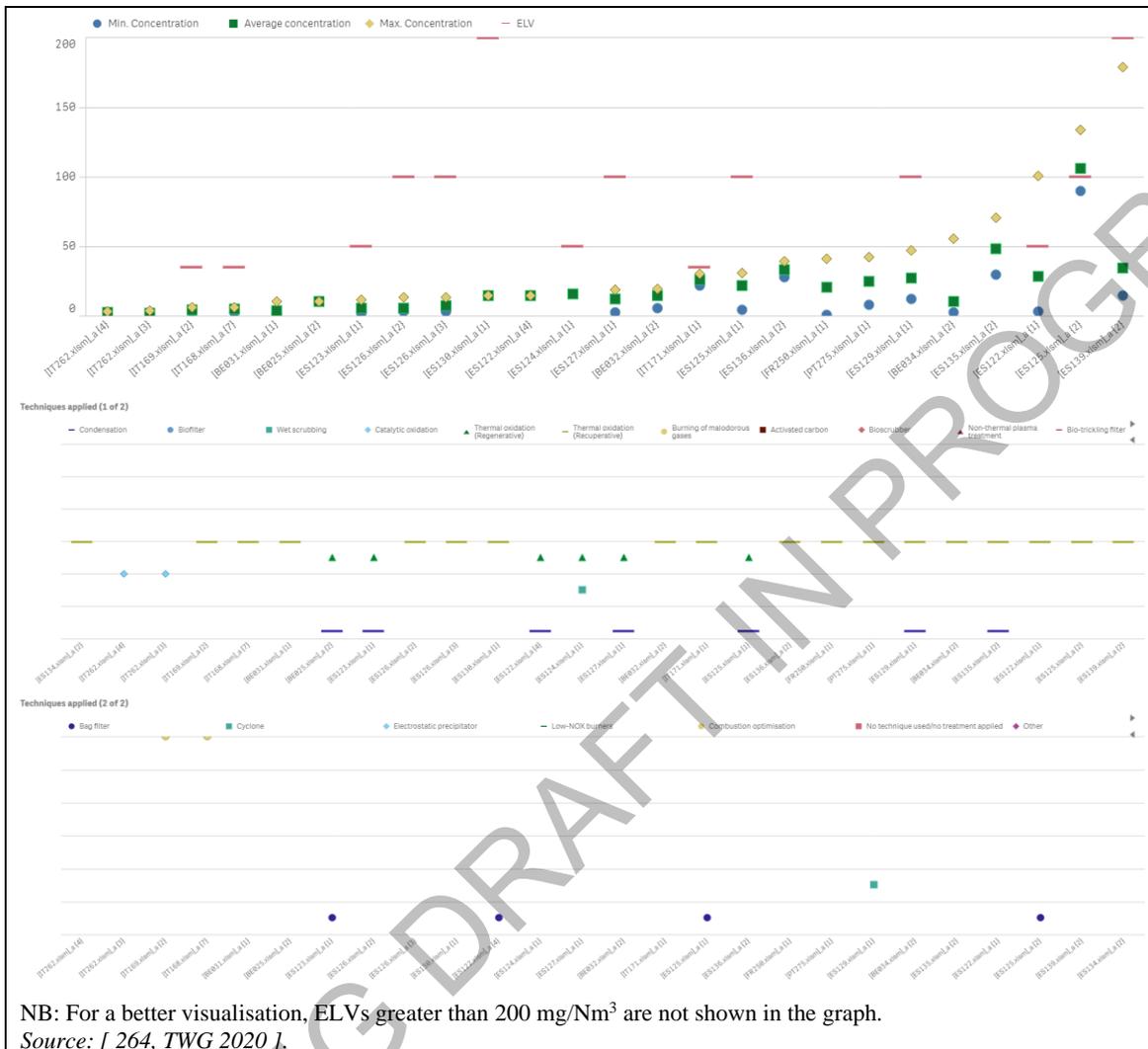
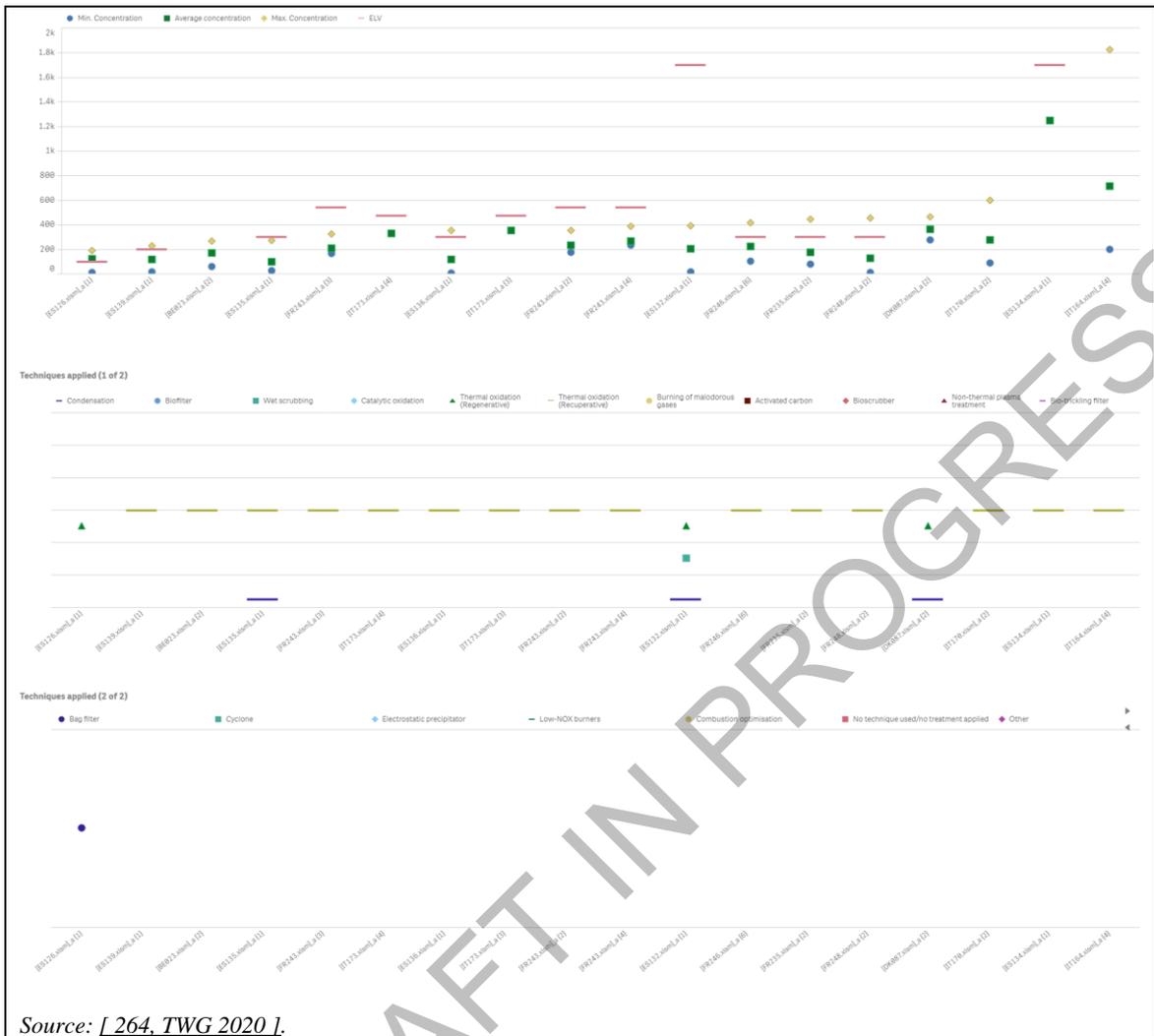


Figure 2.27: SO_x emissions to air (mg/Nm³) from thermal oxidation in SA installations (Part 1 of 2)

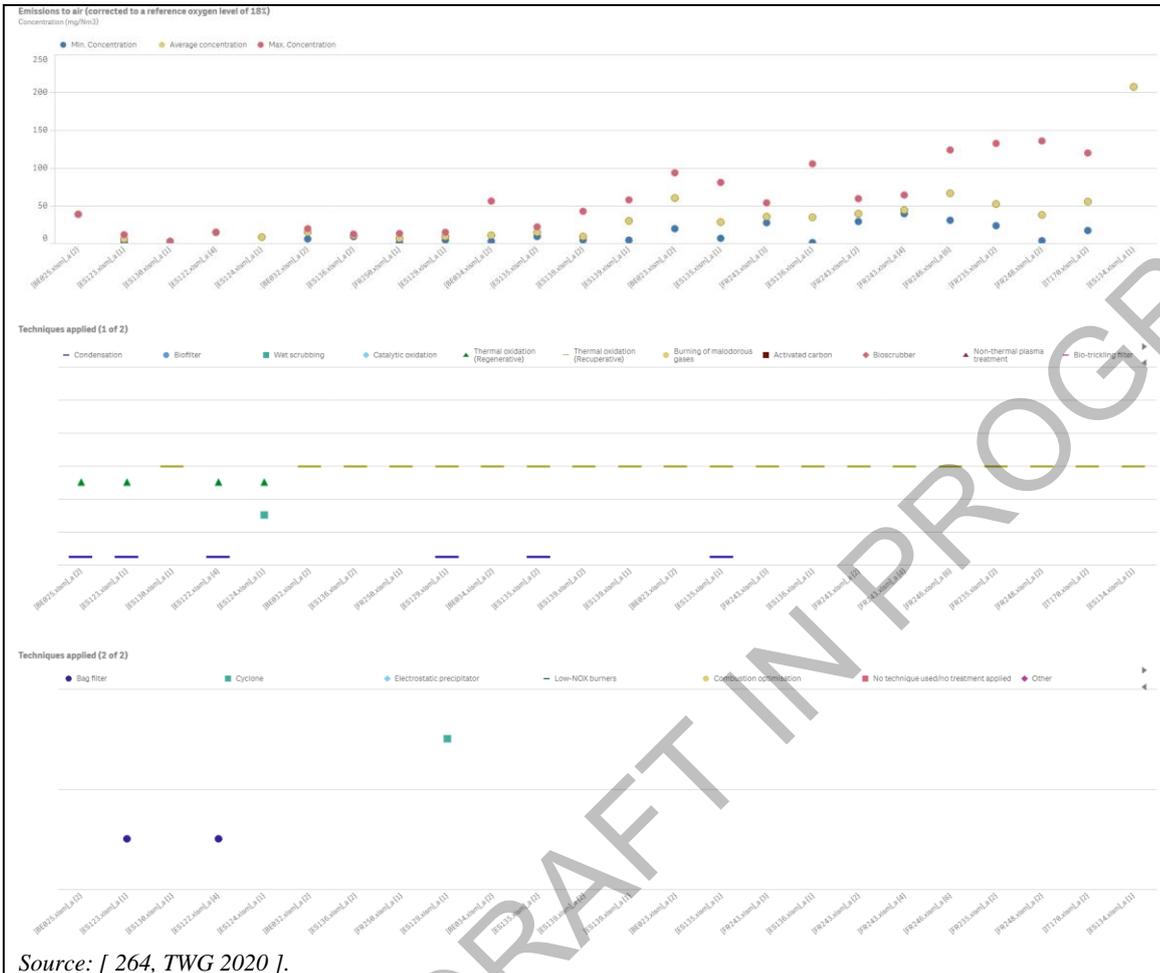


Source: [264, TWG 2020].

Figure 2.28: SO_x emissions to air (mg/Nm³) from thermal oxidation in SA installations (Part 2 of 2)

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Figure 2.29 shows reported data (for the years 2016 to 2018) for channelled SO_x emissions to air from thermal oxidation in SA installations. Values have been corrected to a reference O₂ level of 18%.



Source: [264, TWG 2020].

Figure 2.29: SO_x emissions to air (mg/Nm³) from thermal oxidation in SA installations (values corrected to 18 % O₂)

2.2.2.2.4 CO

Figure 2.30 shows reported data (for the years 2016 to 2018) for channelled CO emissions to air from thermal oxidation in SA installations. No correction for reported O₂ has been applied.

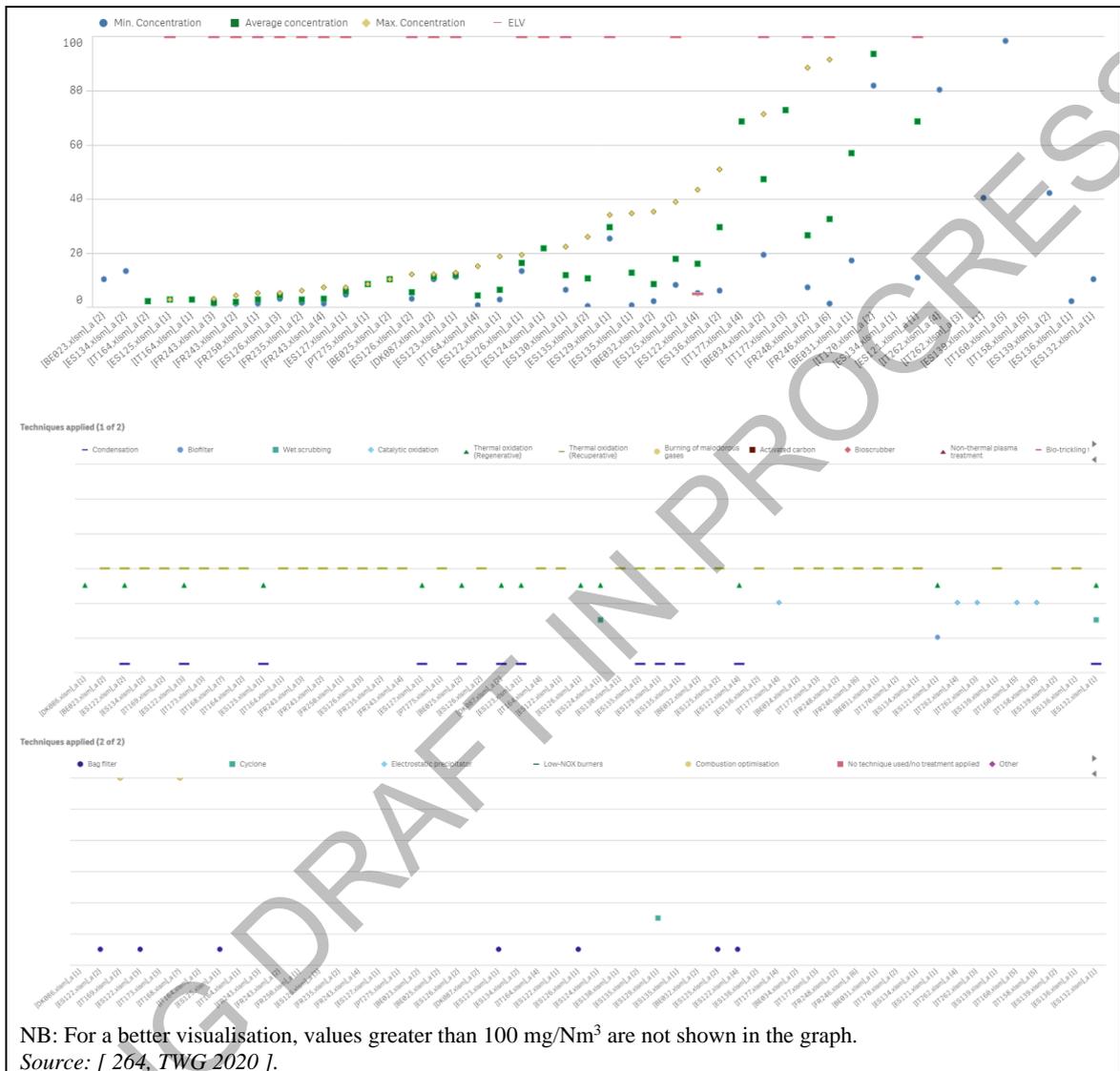


Figure 2.30: CO emissions to air (mg/Nm³) from thermal oxidation in SA installations

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Figure 2.31 shows reported data (for the years 2016 to 2018) for channelled CO emissions to air from thermal oxidation in SA installations. Values have been corrected to a reference O₂ level of 18 %.

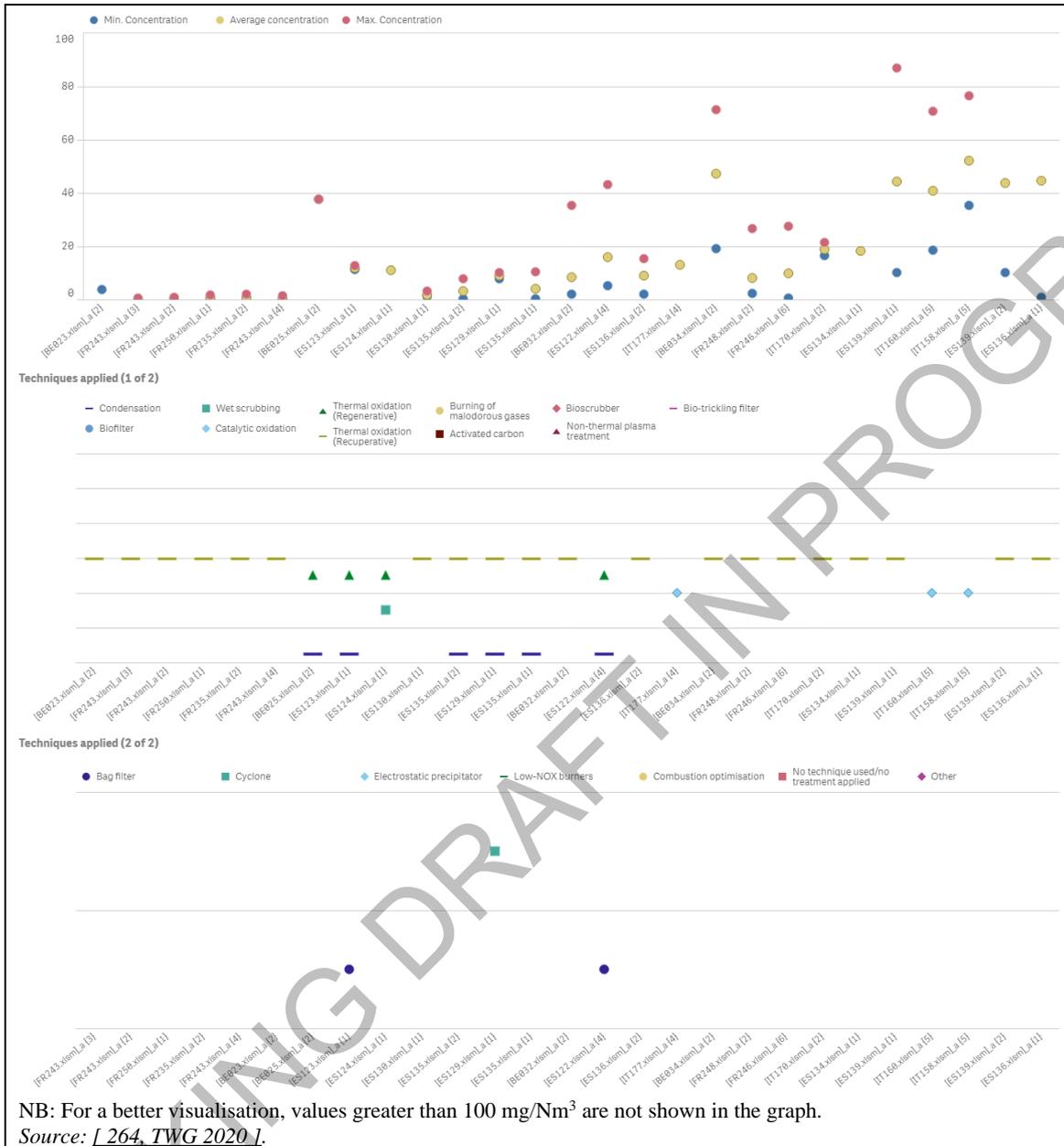


Figure 2.31: CO emissions to air (mg/Nm³) from thermal oxidation in SA installations (values corrected to 18 % O₂)

2.2.2.3 Emissions to air from combustion of animal fat and meat-and-bone meal (MBM)

2.2.2.3.1 Dust

Figure 2.32 shows reported data (for the years 2016 to 2018) for channelled dust emissions to air from combustion of animal fat from SA installations. Very little information has been reported for O₂ reference conditions.

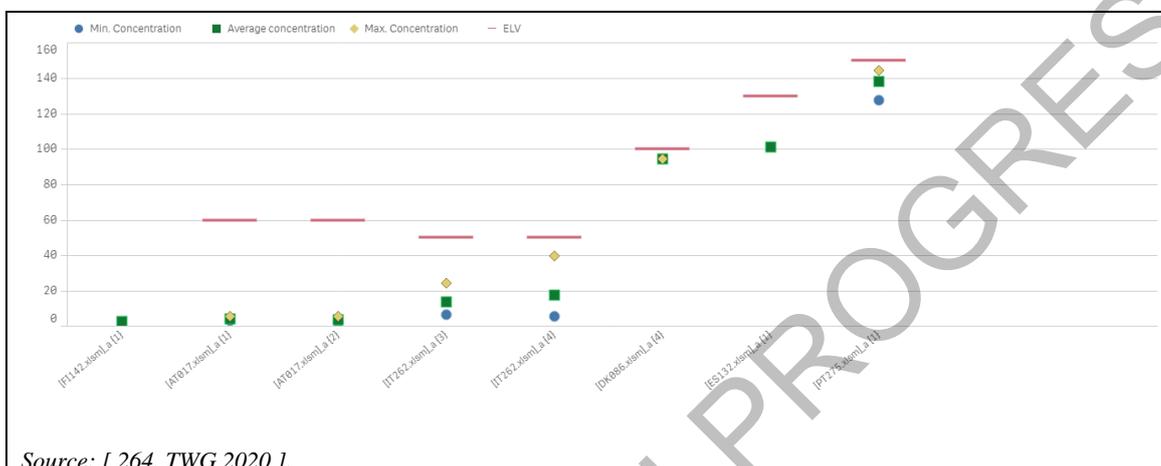


Figure 2.32: Dust emissions to air (mg/ Nm³) from combustion of animal fat in SA installations

Data from one emission point for dust emissions to air (with a maximum value of 143.7 mg/Nm³) from combustion of meat-and-bone meal have been reported.

2.2.2.3.2 NO_x

Figure 2.33 shows reported data (for the years 2016 to 2018) for channelled dust emissions to air from combustion of animal fat from SA installations. Very little information has been reported for O₂ reference conditions.

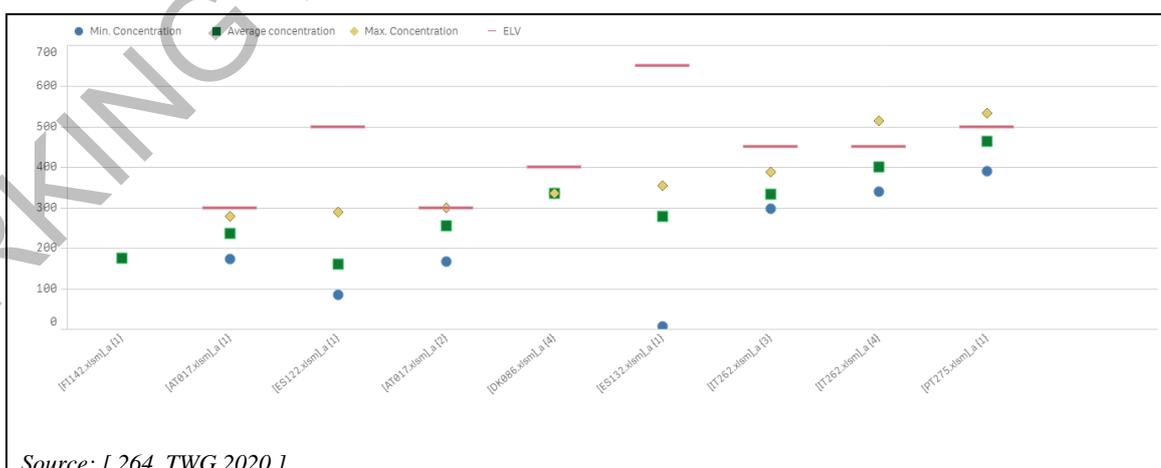


Figure 2.33: NO_x emissions to air (mg/Nm³) from combustion of animal fat in SA installations

Data from two emission points for NO_x emissions to air (with an average value of 144.7 mg/Nm³ and a maximum value of 530.4 mg/Nm³ respectively) from combustion of meat-and-bone meal have been reported.

2.2.2.3.3 SO_x

Figure 2.34 shows reported data (for the years 2016 to 2018) for channelled dust emissions to air from combustion of animal fat from SA installations. Very little information has been reported for O₂ reference conditions.

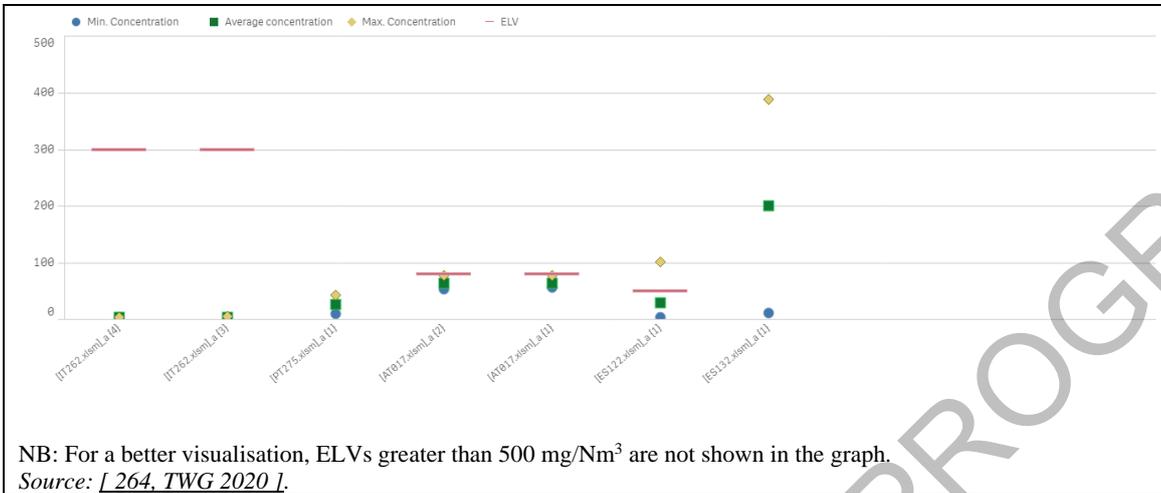


Figure 2.34: SO_x emissions to air (mg/Nm³) from combustion of animal fat in SA installations

Data from one emission point for SO_x emissions to air (with a maximum value of 42 mg/Nm³) from combustion of meat-and-bone meal have been reported.

2.2.2.3.4 CO

Figure 2.35 shows reported data (for the years 2016 to 2018) for channelled CO emissions to air from combustion of animal fat from SA installations. Very little information has been reported for O₂ reference conditions.

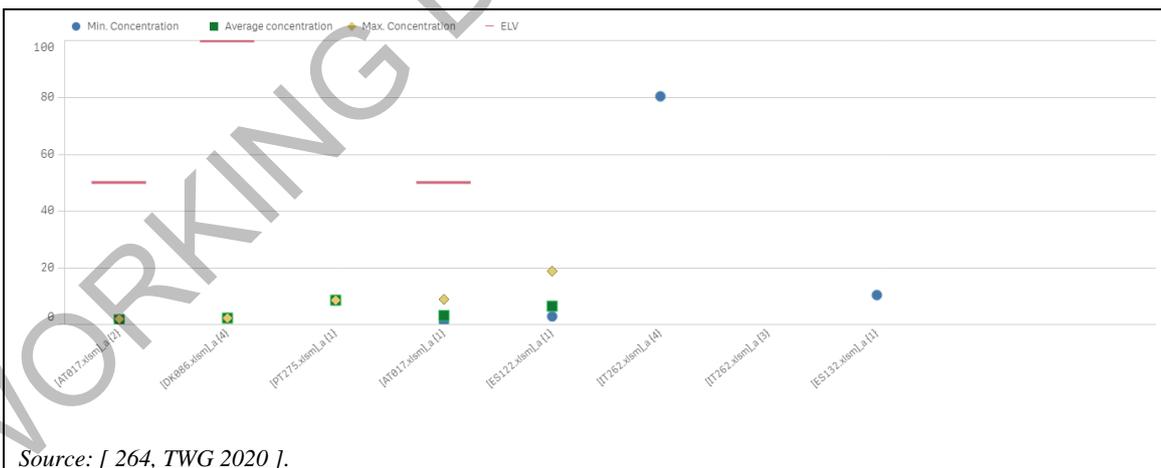


Figure 2.35: CO emissions to air (mg/Nm³) from combustion of animal fat in SA installations

Data from two emission point for CO emissions to air (with an average value of 15.7 mg/Nm³ and a maximum value of 8.4 mg/Nm³ respectively) from combustion of meat-and-bone meal have been reported.

2.3 Techniques to consider in the determination of BAT

This section describes techniques (or combinations thereof), and associated monitoring, considered to have the potential for achieving a high level of environmental protection in the activities within the scope of this document. The techniques described will include both the technology used and the way in which the installations are designed, built, maintained, operated and decommissioned.

It covers environmental management systems, process-integrated techniques and end-of-pipe measures. Waste prevention and management, including waste minimisation and recycling procedures are also considered, as well as techniques that reduce the consumption of raw materials, water and energy by optimising use and reuse. The techniques described also cover measures used to prevent or to limit the environmental consequences of accidents and incidents, as well as site remediation measures. They also cover measures taken to prevent or reduce emissions under other than normal operating conditions (such as start-up and shutdown operations, leaks, malfunctions, momentary stoppages and the definitive cessation of operations).

Annex III to the IED lists a number of criteria for determining BAT, and the information within this chapter will address these considerations. As far as possible, the standard structure in Table 2.2 is used to outline the information on each technique, to enable a comparison of techniques and the assessment against the definition of BAT in the Directive.

This chapter does not necessarily provide an exhaustive list of techniques which could be applied in the sector. Other techniques may exist, or may be developed, which could be considered in the determination of BAT for an individual installation.

Table 2.2: Information for each technique

Heading within the sections	Type of information included
Description	A brief description of the technique with a view to being used in the BAT conclusions.
Technical description	A more detailed and yet concise Technical description using, as appropriate, chemical or other equations, pictures, diagrams and flow charts.
Achieved environmental benefits	The main potential environmental benefits to be gained through implementing the technique (including reduced consumption of energy; reduced emissions to water, air and land; raw material savings; as well as production yield increases, reduced waste, etc.).
Environmental performance and operational data	Actual and installation-specific performance data (including emission levels, consumption levels—of raw materials, water, energy—and amounts of residues/wastes generated) from well-performing installations (with respect to the environment taken as a whole) applying the technique accompanied by the relevant contextual information. Any other useful information on the following items: <ul style="list-style-type: none"> • how to design, operate, maintain, control and decommission the technique; • emission monitoring issues related to the use of the technique; • sensitivity and durability of the technique; • issues regarding accident prevention.

	<p>Links between inputs (e.g. nature and quantity of raw material and fuel, energy, water) and outputs (emissions, residues/wastes, products) are highlighted, in particular where relevant to enhancing an understanding of different environmental impacts and their interaction, for example where trade-offs have been made between different outputs such that certain environmental performance levels cannot be achieved at the same time.</p> <p>Emission and consumption data are qualified as far as possible with details of relevant operating conditions (e.g. percentage of full capacity, fuel composition, bypassing of the (abatement) technique, inclusion or exclusion of other than normal operating conditions, reference conditions), sampling and analytical methods, and statistical presentation (e.g. short- and long-term averages, maxima, ranges and distributions).</p> <p>Information on conditions/circumstances hampering the use of the (abatement) technique at full capacity and/or necessitating full or partial bypassing of the (abatement) technique and measures taken to restore full (abatement) capacity.</p>
Cross-media effects	<p>Relevant negative effects on the environment due to implementing the technique, allowing comparison between techniques in order to assess the impact on the environment as a whole. This may include issues such as:</p> <ul style="list-style-type: none"> • consumption and nature of raw materials and water; • energy consumption and contribution to climate change; • stratospheric ozone depletion potential; • photochemical ozone creation potential; • acidification resulting from emissions to air; • presence of particulate matter in ambient air (including microparticles and metals); • eutrophication of land and water resulting from emissions to air or water; • oxygen depletion potential in water; • persistent/toxic/bioaccumulable components (including metals); • generation of residues/waste; • limitation of the ability to reuse or recycle residues/waste; • generation of noise and/or odour; • increased risk of accidents. <p>The Reference Document on Economics and Cross-media Effects (ECM) should be taken into account.</p>
Technical considerations relevant to applicability	<p>It is indicated whether the technique can be applied throughout the sector. Otherwise, the main general technical restrictions on the use of the technique within the sector are indicated. These may be:</p> <ul style="list-style-type: none"> • an indication of the type of installations or processes within the sector to which the technique cannot be applied; • constraints to implementation in certain generic cases, considering, e.g.: <ul style="list-style-type: none"> ○ whether it concerns a new or an existing installation, taking into account factors involved in retrofitting (e.g. space availability) and interactions with techniques already installed,

	<ul style="list-style-type: none"> ○ installation size, capacity or load factor, ○ quantity, type or quality of product manufactured, ○ type of fuel or raw material used, ○ animal welfare, ○ climatic conditions. <p>These restrictions are indicated together with the reasons for them.</p> <p>These restrictions are not meant to be a list of the possible local conditions that could affect the applicability of the technique for an individual installation.</p>
Economics	<p>Information on the costs (capital/investment, operating and maintenance including details on how these costs have been calculated/estimated) and any possible savings (e.g. reduced raw material or energy consumption, waste charges, reduced payback time compared to other techniques), or revenues or other benefits including details on how these have been calculated/estimated.</p> <p>Cost data are preferably given in euro (EUR). If a conversion is made from another currency, the data in the original currency and the year when the data were collected is indicated. The price/cost of the equipment or service is accompanied by the year it was purchased.</p> <p>Information on the market for the sector in order to put costs of techniques into context.</p> <p>Information relevant to both newly built, retrofitted and existing installations. This should allow assessment, where possible, of the economic viability of the technique for the sector concerned.</p> <p>Information on the cost-effectiveness of the technique (e.g. in EUR per mass of pollutant abated) and related assumptions for their calculation can be reported.</p> <p>The Reference Document on Economics and Cross-media Effects (ECM) and the Reference Document on the Monitoring of Emissions to Air and Water from IED Installations (ROM) are taken into account with regard to economic aspects and monitoring costs, respectively.</p>
Driving force for implementation	<p>Where applicable, specific local conditions, requirements (e.g. legislation, safety measures) or non-environmental triggers (e.g. increased yield, improved product quality, economic incentives – e.g. subsidies, tax breaks) which have driven or stimulated the implementation of the technique to date.</p> <p>This subsection should be very short using bullet point lists.</p>
Example plants	<p>Reference to an installation/plant(s) where the technique has been implemented and from which information has been collected and used in writing the section. An indication of the degree to which the technique is in use in the EU or worldwide.</p>
Reference literature	<p>Literature or other reference material (e.g. books, reports, studies) that was used in writing the section and that contains more detailed information on the technique. When the reference material consists of a large number of pages, reference will be made to the relevant page(s) or section(s).</p>

Chapter 2

In this document, techniques have been included in this chapter, whether or not they are considered in the determination of BAT.

The techniques described show that prevention can be achieved in many ways, such as using production techniques that pollute less than others; reducing material inputs; re-engineering the processes to reuse products, which have not met the customer's specifications for example; improving management practices; and substituting substances with less hazardous ones. This chapter provides information on both general and specific pollution prevention and control techniques that have been implemented on an industrial scale.

This chapter describes the techniques that are considered to be most relevant for determining BAT. This chapter should be seen as the background information for the conclusions on the determination of BAT presented in Chapter 5. Moreover, it does not include every technique applied in the slaughterhouses and animal by-products industries, even if the technique has been described in Chapter 2. Techniques that are generally seen as obsolete are not included.

This chapter covers "process integrated" techniques such as prevention, control, minimising consumption, re-use and recycling procedures. "End-of-pipe" techniques applied to waste water treatment, air pollution and odour control are also included.

Each technique is presented in the format given in Table. If the information has not been submitted under any of these categories, the relevant headings have been omitted.

Heading	Type of information included
Description	Brief technical description of the technique.
Achieved environmental benefits	Main environmental impact(s) addressed.
Cross-media effects	Side effects and disadvantages to other media caused by implementation.
Operational data	Performance data on emissions and consumption levels, including information from example plants. Any other useful information on operation, maintenance and control.
Applicability	Consideration of applicability in slaughterhouses and animal by-products industries; in new or existing plants; plant size, if relevant and factors involved in retrofitting, e.g. space availability.
Economics	Information on investment and operational costs and any savings, e.g. associated with reduced raw material consumption or waste charges. Values in currencies different than EUR have been converted if they are from countries which use the euro, otherwise the original currency and the year are quoted.
Driving force for implementation	Local conditions or requirements which have led to implementation. Information on reasons other than environmental ones for implementation, e.g. improvement in product quality, cost reduction, public health legislation or worker safety.
Example plants	Reference to the plants operating the technique in Europe and in the rest of the world.
Reference literature	Source(s) of information to the BREF.

Table : Format of information about techniques for consideration in the determination of BAT

Annex IV of the IPPC Directive lists considerations to be taken into account when determining best available techniques. The possible routes for recovery and recycling of by-products and waste are considered in this document. In recent years these routes have become increasingly regulated, largely due to BSE, culminating in ABP Regulation 1774/2002/EC [287, EC, 2002], develops and consolidates the level of regulation. Under this Regulation, some animal by-products, such as SRM, must be disposed of as waste.

The biodegradable nature of slaughterhouse by products has a direct influence on whether they can be recovered or recycled and on the overall impact of their emissions on the environment. There are more opportunities for recovery or recycling when the by products are fresh.

Some fresh animal by products, such as blood, have a distinctive smell, which can lead to problems or complaints if they are not handled properly. Emissions from by products can be prevented by storing, handling, processing and transferring materials within a suitable building; bunding tanks; using overground pipe lines and transfer lines; applying overfilling protection on bulk storage tanks and preventing rain ingress and wind entrapment [3, EPA, 1996].

Storing animal by products over prolonged periods at ambient temperature in the open air increases the risk of direct pollution from odour and leachate. As degradation increases, so does the likelihood of the by products needing to be disposed of as waste, as their usability significantly decreases. The environmental impacts of by products storage, such as odour and the need to dispose them as waste, may be lessened by storage in chill units or freezers. This will, however, incur energy use and the risk of refrigerant leaks. The immediate transfer of by products to an on-site or off-site animal by products installation for rapid processing could minimise their impact.

2.3.1 General environmental performance

2.3.1.1 Environmental management systems

Description

A formal system to demonstrate compliance with environmental objectives.

Technical description

The Directive defines 'techniques' (under the definition of best available techniques) as 'both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned'.

In this respect, an environmental management system (EMS) is a technique allowing operators of installations to address environmental issues in a systematic and demonstrable way. EMSs are most effective and efficient where they form an inherent part of the overall management and operation of an installation.

An EMS focuses the attention of the operator on the environmental performance of the installation; in particular through the application of clear operating procedures for both normal and other than normal operating conditions, and by setting out the associated lines of responsibility.

All effective EMSs incorporate the concept of continuous improvement, meaning that environmental management is an ongoing process, not a project which eventually comes to an end. There are various process designs, but most EMSs are based on the plan-do-check-act cycle (which is widely used in other company management contexts). The cycle is an iterative dynamic model, where the completion of one cycle flows into the beginning of the next (see Figure 2.36).

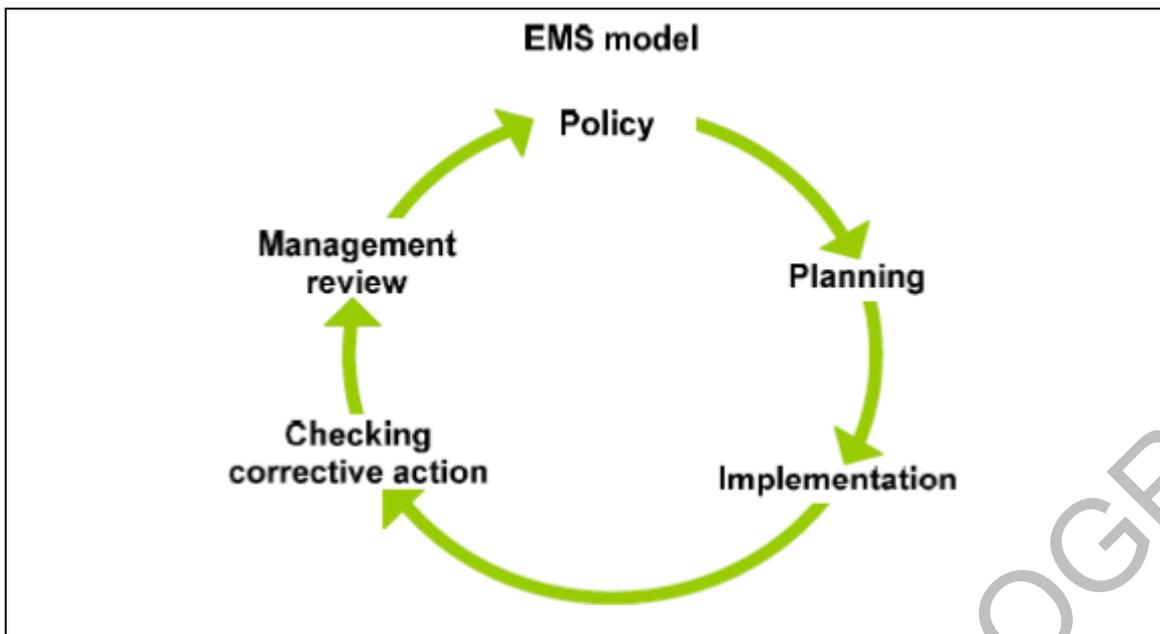


Figure 2.36: Continuous improvement in an EMS model

An EMS can take the form of a standardised or non-standardised (or customised) system. Implementation and adherence to an internationally accepted standardised system, such as EN ISO 14001:2015, can give higher credibility to the EMS especially when subjected to a properly performed external verification. The European Union eco-management and audit scheme (EMAS) according to Regulation (EC) No 1221/2009 provides additional credibility due to the interaction with the public through the environmental statement and the mechanism to ensure compliance with the applicable environmental legislation. However, non-standardised systems can, in principle, be equally effective provided that they are properly designed and implemented.

While both standardised systems (EN ISO 14001:2015 or EMAS) and non-standardised systems apply in principle to organisations, this document takes a narrower approach, not including all activities of an organisation, e.g. with regard to their products and services, due to the fact that the Directive only regulates installations.

An EMS can contain the following features:

- i. commitment, leadership, and accountability of the management, including senior management, for the implementation of an effective EMS;
- ii. an analysis that includes the determination of the organisation's context, the identification of the needs and expectations of interested parties, the identification of characteristics of the installation that are associated with possible risks for the environment (or human health) as well as of the applicable legal requirements relating to the environment;
- iii. development of an environmental policy that includes the continuous improvement of the environmental performance of the installation;
- iv. establishing objectives and performance indicators in relation to significant environmental aspects, including safeguarding compliance with applicable legal requirements;
- v. planning and implementing the necessary procedures and actions (including corrective and preventive actions where needed), to achieve the environmental objectives and avoid environmental risks;
- vi. determination of structures, roles and responsibilities in relation to environmental aspects and objectives and provision of the financial and human resources needed;

- vii. ensuring the necessary competence and awareness of staff whose work may affect the environmental performance of the installation (e.g. by providing information and training);
- viii. internal and external communication;
- ix. fostering employee involvement in good environmental management practices;
- x. Establishing and maintaining a management manual and written procedures to control activities with significant environmental impact as well as relevant records;
- xi. effective operational planning and process control;
- xii. implementation of appropriate maintenance programmes;
- xiii. emergency preparedness and response protocols, including the prevention and/or mitigation of the adverse (environmental) impacts of emergency situations;
- xiv. when (re)designing a (new) installation or a part thereof, consideration of its environmental impacts throughout its life, which includes construction, maintenance, operation and decommissioning;
- xv. implementation of a monitoring and measurement programme, if necessary, information can be found in the Reference Report on Monitoring of Emissions to Air and Water from IED Installations;
- xvi. application of sectoral benchmarking on a regular basis;
- xvii. periodic independent (as far as practicable) internal auditing and periodic independent external auditing in order to assess the environmental performance and to determine whether or not the EMS conforms to planned arrangements and has been properly implemented and maintained;
- xviii. evaluation of causes of nonconformities, implementation of corrective actions in response to nonconformities, review of the effectiveness of corrective actions, and determination of whether similar nonconformities exist or could potentially occur;
- xix. periodic review, by senior management, of the EMS and its continuing suitability, adequacy and effectiveness;
- xx. following and taking into account the development of cleaner techniques.

EMAS is an example of an EMS that includes the aforementioned features i. to xx.

Achieved environmental benefits

An EMS promotes and supports the continuous improvement of the environmental performance of the installation. If the installation already has a good overall environmental performance, an EMS helps the operator to maintain the high performance level.

Environmental performance and operational data

No information provided.

Cross-media effects

None reported. The systematic analysis of the initial environmental impacts and scope for improvements in the context of the EMS sets the basis for assessing the best solutions for all environmental media.

Technical considerations relevant to applicability

The components described above can typically be applied to all installations within the scope of this document. The level of detail and the degree of formalisation of the EMS will generally be related to the nature, scale and complexity of the installation, and the range of environmental impacts it may have.

Economics

It is difficult to determine accurately the costs and economic benefits of introducing and maintaining a good EMS. There are also economic benefits that are the result of using an EMS and these vary widely from sector to sector.

External costs relating to verification of the system can be estimated from guidance issued by the International Accreditation Forum [286, IAF 2010].

Driving force for implementation

The driving forces for the implementation of an EMS include:

- improved environmental performance;
- improved insight into the environmental aspects of the company which can be used to fulfil the environmental requirements of customers, regulatory authorities, banks, insurance companies or other stakeholders (e.g. people living or working in the vicinity of the installation);
- improved basis for decision-making;
- improved motivation of personnel (e.g. managers can have confidence that environmental impacts are controlled and employees can feel that they are working for an environmentally responsible company);
- additional opportunities for operational cost reduction and product quality improvement
- improved company image;
- reduced liability, insurance and non-compliance costs.

Example plants

EMSs are applied in a high number of installations throughout the EU. [287, COM 2021]

Reference literature

[286, IAF 2010], [288, COM 2009], [287, COM 2021]

Training provision

Description

Giving staff at all levels, from management to shop floor the necessary training and instruction in their duties can help to improve to control of processes and minimise consumption and emission levels and the risk of accidents. This may be undertaken with in house or external environmental advisers, but reliance should not be placed on them for ongoing environmental management of the process. Problems which can arise during start up, shut down, maintenance, abnormal conditions and non routine work should all be covered. Ongoing risk assessment of processes and work areas and the monitoring of compliance with identified standards and operating practices can then be undertaken by managers in partnership with shop floor employees.

Achieved environmental benefits

Reduced consumption and emission levels and reduced risks of accidents throughout the plant.

Operational data

Requires an investment of time by all personnel for the provision of information, instruction, training and supervision and the operation of an assessment programme, to identify training needs and the effectiveness of training.

Cross-media effects

None.

Applicability

Applicable in all installations.

Driving force for implementation

Routinely considering the environmental impacts can help to focus efforts to achieve lower consumption and emission levels, leading to cost savings and increasing the confidence of the regulatory authority.

Example plants

Many slaughterhouses and animal by products installations.

Reference literature

[47, DoE SO and WO, 1997]

2.3.1.2 Use of a planned maintenance programme**Description**

A maintenance programme is part of the environmental management system of the installation (see Section 2.3.1.1).

Technical description

The use of a planned maintenance programme, which involves changing parts and routinely checking the function of equipment can significantly reduce consumption and emission levels. This can involve the appointment of a competent individual with responsibility for managing maintenance in co-operation with operational managers. The maintenance manager's performance can also be monitored. Records of inspections, plans, permits and other relevant information can be used to monitor improvements and anticipate required actions, such as the replacement of parts.

Achieved environmental benefits

Reduced consumption and emission levels and reduced risks of accidents throughout the plant.

Environmental performance and operational data

Maintaining up-to-date plans of slaughterhouse drainage systems can aid the maintenance and operation of the applied waste water treatment. Management need to ensure that there are regular inspection programmes put in place to assess tank bunding, underground tanks and drain integrity and aboveground pipework. Surface water drains located next to skips containing SRM and other animal wastes can be connected to the effluent drainage system. A leak detection and repair programme can be used to save hot and cold water. Some examples of common causes of leaks include damaged pipeline connections; flanges and fittings; worn valves; flooded floats on water tanks, cistern valves and corroded pipework and tanks.

For a slaughterhouse killing 18 000 turkeys per day, equating to 38 birds per minute, the following potential water savings have been reported:

1 000 m³/yr with a financial saving of GBP 625/yr, for a ball valve repair on a scalding tank;
4 000 m³/yr with a financial saving of GBP 2 495/yr, for a ball valve repair on a tray wash and
1 000 m³/yr with a financial saving of GBP 625/yr for a ball valve repair on a pressure washer.
(Costs in 1999)

If managers ensure that equipment such as boilers, are adequately maintained to perform at their maximum combustion efficiency, then emissions to air will be minimised. In general, boilers should be capable of giving a smoke colour less than or equal to shade number 1 on the Ringelmann chart, except during periods of start-up. Such-start up periods should not normally exceed 30 minutes in any 24 hour period. In addition, if a policy of selecting those fuels with the minimal polluting potential is followed this will reduce emissions further. An example is the use of low sulphur fuel oil, i.e. containing less than 1 % sulphur, by weight.

Cross-media effects

None.

Technical considerations relevant to applicability

Applicable in all slaughterhouses and animal by-products installations.

Driving force for implementation

Reduced downtime due to breakdowns and accidents. Routinely considering the environmental impacts can help to focus the efforts to achieve lower consumption and emission levels, leading to cost savings and increasing the confidence of the regulatory authority.

Example plants

At least one poultry slaughterhouse in the UK.

Reference literature

[12, WS Atkins-EA, 2000] [4, WS Atkins-EA 2000], [63, ETBPP, 2000] [22, ETBPP 2000], [67, WS Atkins Environment/EA, 2000] [24, WS Atkins-EA 2000], [167, Greek Ministry for the Environment, 2001] [55, Greek Ministry for the Environment 2001], [214, AVEC, 2001], [90, AVEC 2001]

2.3.1.3 Chemicals management system

Description

The chemicals management system is part of the EMS (see Section 2.3.1.1) and is a set of technical and organisational measures to limit the impact of the use of chemicals on the environment.

Technical description

The chemicals management system (CMS) contains the following components:

- I. A policy to reduce the consumption and risks of process chemicals, including a procurement policy to select less harmful process chemicals and their suppliers with the aim of minimising the use and risks of hazardous substances and avoiding the procurement of an excess amount of process chemicals. The selection of process chemicals may consider:
 - a) their eliminability, their eco-toxicity and their potential to be released into the environment in order to reduce emissions to the environment;
 - b) the characterisation of the risks associated with the process chemicals, based on the chemicals' hazards statement, pathways through the plant, potential release and level of exposure;
 - c) the regular (e.g. annual) analysis of the potential for substitution to identify potentially new available and safer alternatives to the use of hazardous substances (e.g. use of other process chemicals with no or lower environmental impacts, see BAT 11 (a));
 - d) the anticipatory monitoring of regulatory changes related to hazardous chemicals and safeguarding compliance with applicable legal requirements.

The inventory of process chemicals (see BAT 2) may be used to support the selection of process chemicals.

- II. Goals and action plans to avoid or reduce the use and risks of hazardous substances.
- III. Development and implementation of procedures for the procurement, handling, storage, and use of process chemicals to prevent or reduce emissions to the environment.

Achieved environmental benefits

Reduction of the use of hazardous chemicals.

Environmental performance and operational data

Request to the TWG: Please provide information.
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Cross-media effects

None.

Technical considerations relevant to applicability

The level of detail of the CMS will generally be related to the nature, scale and complexity of the plant.

Economics

Request to the TWG: Please provide information.

Driving force for implementation

The driving forces for the implementation of a CMS include:

- improved environmental performance;
- compliance with regulations and/or certification schemes;
- optimised consumption of hazardous chemicals.

Example plants

Request to the TWG: Please provide information.

Reference literature

[246, COM 2019]

2.3.1.4 Set-up and implementation of an OTNOC management plan to reduce emissions during OTNOC

Description

A risk-based OTNOC management plan includes all of the following elements:

- identification of potential OTNOC (e.g. failure of equipment critical to the protection of the environment ('critical equipment')), of their root causes and of their potential consequences, and regular review and update of the list of identified OTNOC following the periodic assessment below;
- appropriate design of critical equipment (e.g. compartmentalisation of fabric filters);
- set-up and implementation of an inspection and preventive maintenance plan for critical equipment;
- monitoring (i.e. estimating or, where possible, measuring) and recording of emissions during OTNOC and of associated circumstances;
- periodic assessment of the emissions occurring during OTNOC (e.g. frequency of events, duration, amount of pollutants emitted) and implementation of corrective actions if necessary.

Technical description

When applying the processes described above, the SA plant may experience other than normal operating conditions (OTNOC). These OTNOC are very diverse and may cover conditions such as:

- start-up;
- shutdown;
- momentary stoppages;
- holding mode in heating furnaces;
- leaks (oils or acids);
- malfunction or breakdown of the abatement equipment or part of the equipment (e.g. fabric filters or ESPs);
- malfunction of instruments related to the process control or used for emission monitoring (such as instrumentation drift);
- testing of new apparatus;
- calibration of the monitoring system.

In order to reduce the frequency of the occurrence of OTNOC and to reduce emissions during OTNOC, a risk-based OTNOC management plan as part of the environmental management system (see Section 2.3.1.1) is put into place and may include the elements described in the description section above.

Achieved environmental benefits

Emissions associated with shutdown and start-up operations are in part avoided. Planning for and achieving a reduced number of shutdowns is likely to reduce the annual mass emission levels of any plant.

Environmental performance and operational data

Malfunctions in a waste gas treatment plant can result in a significant increase in emissions (e.g. dust). To prevent this, the following measures are put into place:

Preventive maintenance

Preventive maintenance is used to:

- ensure that maintenance requiring switching off emissions control equipment/systems (e.g. containment, extraction systems, off-gas treatment) is planned to take place when there are no emissions (e.g. shutdown times) or when emission levels are low;
- replacement of parts that require replacement on a regular basis is planned to take place before breakdowns are likely;
- ensure that parts that are essential to the normal running of emission control equipment are kept in stock, can be replaced or repaired rapidly with minimum call-off times;
- carry out routine and non-routine maintenance including maintenance of covers and pipe joints for oil/acid storage and delivery systems.

Regular maintenance checks

A maintenance schedule and record of all inspections and maintenance activities is kept and includes the following:

- visually check for leaking seals, flanges, valves, welds, tanks and vats;
- inspections by external experts where necessary;
- monitoring key equipment for problems such as vibration, emission leaks and planning repairs (as above);
- test programmes, e.g. pressure-test pipelines and tanks, calibration of metering and monitoring equipment;
- check the tightness of nuts and bolts;
- check for wear and tear on machinery, valves and bunds, over-heating bearings, etc.;
- recalibrate metering systems;
- ensure that extraction and abatement equipment is fully serviceable.

Unplanned maintenance

Process operators and maintenance staff identify and report leaks, broken equipment, fractured pipes, etc.

Cross-media effects

None.

Technical considerations relevant to applicability

Generally, there are no technical restrictions to the applicability of this technique.

Economics

Avoiding plant shutdowns can reduce costs at SA installations by:

- allowing continuous throughput and hence greater installation utilisation;
- decreasing furnace maintenance due to lower thermal stress on the process.

Driving force for implementation

- Reduces downtime.
- Maintains product quality and throughput.

Example plants

Widely used.

Reference literature

[205, COM 2019]

2.3.2 Techniques to increase resource efficiency**2.3.2.1 Anaerobic digestion****Description**

Treatment of biodegradable residues by microorganisms in the absence of oxygen, resulting in biogas and digestate. The biogas is used as a fuel, e.g. in a gas engine or in a boiler. The digestate may be used, e.g. as a soil improver, on site or off site.

Technical description

The treatment of biodegradable solids by anaerobic digestion is used to transform the organic matter contained in the residues into biogas (containing 70 % methane) and digestate. Anaerobic digestion is used to handle biodegradable solids very high in COD, and as a treatment process for sewage sludge after an aerobic waste water treatment.

The technique generally consists of the following steps:

- Anaerobic digestion: residues are directed to a sealed digester tank where anaerobic digestion takes place. This is a process by which microorganisms break down biodegradable material in the absence of oxygen, resulting in biogas and digestate.
- Biogas line: generated biogas is stored and at a later stage is dehumidified and used, e.g. in a cogenerator. It can also be used to produce heat, i.e. hot water in a boiler, combined electricity and heat in a CHP unit, as an alternative fuel in vehicles or as a substitute for natural gas after upgrading to biomethane. Some of the heat generated may be recycled in the SA process.
- Separation: the digestate is separated into solid and liquid fractions by centrifugation.
- Storage of the solid fraction of the digestate: the solid fraction of the digestate is stored for agricultural purposes (landspreading).

More detailed information on the process description, feed and output streams, biogas pretreatment techniques, and characteristics of the digestate is available in the WT BREF [265, Pinasseau et al. 2018]. A list of proven improvement techniques for anaerobic digestion of waste (e.g. micro anaerobic digestion, vertical flow dry) is described in the EC report 'Towards a better exploitation of the technical potential of waste to energy' [278, COM 2016].

Anaerobic co-digestion allows the operator to take advantage of the complementary nature of the different components of the waste. The mixture of both types of waste leads to more stable processes and a considerable increase in biogas production. The co-digestion allows the integration of the exploitation of organic waste in a given geographical area. Anaerobic digestion systems commonly used for the co-digestion of agro-industrial waste are called continuous stirred tank reactors.

Achieved environmental benefits

Waste generation and emissions to air are reduced (biogas is used for energy to replace fossil fuels). The recovery of by-products to produce digestate for agriculture conserves and recycles nutrients and reduces waste discharge and the use of chemical fertiliser.

Environmental performance and operational data

A biogas plant in a pig slaughterhouse in Austria is predominantly operated by fermenting accruing animal by-products (e.g. colon (large intestine)), and flotated fat and solids screened from the WWTP [198, Waxwender et al. 2016].

Anaerobic digestion of approximately 80 m³/d of sludge with a dry mass content of approximately 9 % produces roughly 5 000 m³/d of biogas [267, VDI 2020].

Biogas generated from digestion of WWTP sludge is used for the production of steam and hot water in a pig slaughterhouse (ES119). This allows for a reduction of 17 % in the consumption of natural gas and a reduction of 9 000 tonnes of CO₂/year [264, TWG 2020].

Emissions to water from anaerobic digestion in SA installations are not an environmental issue, given that the digestate is usually treated in the WWTP.

Cross-media effects

The nitrogen content of residues is not reduced after anaerobic digestion. Further waste water treatment of liquid digestate is usually required (e.g. membrane filtration).

Technical considerations relevant to applicability

The technique may not be applicable due to the quantity and/or nature of the residues. Digesters should be fed at a constant rate to operate properly. Due to the investment costs, a digester may not be applicable to installations with low amounts of residues.

Economics

An investment cost of EUR 3 500 000 has been reported, including an anaerobic biodigester plant, biogas cogenerator, centrifuge and a scrubber as the abatement system. The amount of electricity produced by the biogas cogenerator in a 6-month period was approximately 40 000 MWe. The amount of solid fraction of the digestate produced is about 3 500 tonnes/year. Savings of EUR 50 000/year have been reported due to the reduction of sludge considered as waste.

Driving force for implementation

Economic reasons are the main drivers for implementation, due to reduced energy consumption and waste generation.

Example plants

This technique is used in approximately 50 % of the slaughterhouses and in a few installations processing animal by-products and/or edible co-products [264, TWG 2020].

Reference literature

[198, Waxwender et al. 2016], [206, Giner-Santonja et al. 2019], [265, Pinasseau et al. 2018], [278, COM 2016], [264, TWG 2020], [267, VDI 2020]

Biogas production from slaughterhouse by-products

Description

Organic matter is degraded to CH₄ under anaerobic conditions. The releases to air, water, and land from the process can be well controlled.

Recent advances in anaerobic digestion technologies have made it possible to treat an increasing diversity of by-products and waste waters. Not only can slaughterhouse waste water undergo anaerobic treatment, but manure, slaughterhouse waste, including blood, fat, and the contents of stomachs and viscera and residues can also be treated.

The co-digestion of manure and slaughterhouse waste is sometimes undertaken with industrial organic wastes.

Achieved environmental benefits

CH₄ can be recovered and used in energy production, to replace fossil fuels and thereby to reduce CO₂ emissions. Most of the nutrients remain in the treated material and, as in composting, materials can be recovered for agricultural purposes.

Environmental performance and operational data

Cross-media effects

CH₄ and CO₂ produced during biogas production may be accidentally released to atmosphere, if adequate controls are not in place. CH₄ has a global warming potential 30 times greater than that of CO₂.

Applicability

Widely applicable. The application to pasture land of organic fertilisers and soil improvers, other than manure is prohibited by ABP Regulation 1774/2002/EC. The Regulation contains the definition "*Organic fertilisers*" and "*soil improvers*" mean materials of animal origin used to maintain or improve plant nutrition and the physical and chemical properties and biological activity of soils, either separately or together; they may include manure, digestive tract content, compost and digestion residues.

Economics

It is reported that a medium sized plant using 2000 tonnes per week of feedstock comprising 50 % poultry slaughterhouse by products and 50 % manure could generate approximately GBP 500 000/yr in gate fees at GBP 10/t and could sell around GBP 700 000 of electricity per year. Such a plant would cost GBP several million to construct. (2001 costs)

Driving force for implementation

Recovery of the energy content of animal by products and reduction of waste disposal costs.

Example plants

There are plants in Denmark and one plant treating the slaughterhouse waste, in Sweden.

Reference literature

[148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001, 222, Gordon W., 2001, 305, Porteous A., 2000]

Biogas from manure and fat containing waste

Technical description

Danish plants

The plants digest animal manure together with small amounts of fat containing waste, to produce biogas. The biogas is burned in a motor/generator unit (CHP unit), to produce CO₂-neutral energy. The energy is then sold directly to electricity networks and the heat produced as a consequence of cooling the motor, is used for on site heating, including in the biogas production process.

The plant comprises a highly efficient anaerobic digester unit; a biogas storage unit; a cleaning unit; a CHP production unit with a power interface with the local electricity utility and a heat accumulation tank.

An Italian plant

In an Italian plant 400–500 m³ manure and waste water sludge is mixed in a reactor vessel every day. Water, which has been heated to 90 °C using biogas, is added to maintain a temperature of 33 °C. The total volume of 8000 m³, of which 2400 m³ is added water, is mixed. After 15–20 days the mixture and CH₄ produced are pumped to a 4000 m³ reactor, for 10–15 days and from which the CH₄ is continuously bled to a 600 m³ gasholder. The gas is used to heat water and to generate energy at a rate of 250 kWh/m³ CH₄, in a 400 kW generator. At the example plant there is insufficient capacity to use all of the CH₄ produced and the excess is burned in a stack.

The residues are pumped from the base of the second reactor, mixed with polyelectrolyte and then, depending on the demand, spread directly on land or sent for composting.

Accidents are reportedly prevented by operator training and by prohibiting smoking and naked flames. The gas pipework and the gasometer water seal are inspected once every 3 months.

There are plans to modify the plant to substitute homogenised and pasteurised blood for approximately 18 % of the manure and to produce 30–40 % more CH₄, at a rate of 400 m³/h and to use all of this. There are also plans to pass the exhaust air, after pasteurisation, through a hot NaOH solution to remove NH₃, and then through a peat biofilter to remove malodorous substances. It is anticipated that the use of blood will increase the COD in the waste water from 1000 ppm to 2000 ppm and that the sludge will continue to be spread on land.

The CO₂ will be removed from the biogas, using water to produce H₂CO₃. Although the operators report that they do not expect the amount of H₂S produced to increase, it will be removed using FeCl₂.

German studies

German studies have been carried out on the treatment of certain wastes from fat separation or food processing in anaerobic treatment facilities at sewage treatment plants. The results for fat were considered to be “very good”, even improving the overall efficiency of the anaerobic process and producing a better yield of gas.

Achieved environmental benefits

Production of CO₂-neutral energy; the production of fertiliser from the digested manure, which can then replace chemical fertilisers; reduction of odour emissions from animal manure and the reduction of nitrogen leakage to the subsoil water.

The biogas production process favours the use of high moisture content feedstock. Other treatments use a lot of energy to remove water.

Cross-media effects

The CH₄ and CO₂ produced during biogas production may be accidentally released to atmosphere if adequate controls are not in place. Methane has a global warming potential 30 times greater than that of CO₂.

Environmental performance and operational data

Table shows actual and anticipated figures for biogas, heat and power production from manure and fat containing waste. It also shows the actual or anticipated energy and fuel savings resulting from the process.

Manure (m ³ /yr)	Fat containing waste (t/yr)	Biogas produced (or anticipated) (m ³ /yr)	Electricity produced (kWh/yr)	Heat produced (kWh/yr)	Electricity saved on site (kWh/yr)	Heating oil saved on site (kWh/yr)	Straw saved (t/yr)
14600	750	750000	1400000	1960000	542900	178000	
10950	550	520000	1430000	1716000	300000	80000	
4380	550	350000	1000000	1200000	150000		125

23000	800	1000000	2600000	3120000	430000	120000	
9125	850	750000	1650000	2310000	278907		
6570	550	536100	1533246	1839895	157223		
12000	900	831420	2377420	2853433	324000	72000	40

Table: Energy, heat and economic data for biogas/CHP units using (or planning to use) manure and fat-containing waste on Danish farms

Technical considerations relevant to applicability

The plants referred to in Table produce more than 75 % of the biogas from Danish farm biogas plants. The application to pasture land of organic fertilisers and soil improvers, other than manure is prohibited by ABP Regulation 1774/2002/EC. The Regulation contains the definition “Organic fertilisers” and “soil improvers” mean materials of animal origin used to maintain or improve plant nutrition and the physical and chemical properties and biological activity of soils, either separately or together; they may include manure, digestive tract content, compost and digestion residues.

Economics

Payback times for the Danish plants have been reported as 5–6 years. The costs of disposal are saved.

Driving force for implementation

Financial savings through electricity sales and hot water generation. Production of fertiliser from the biogas residues.

Example plants

In Denmark, more than 75 % of the biogas produced is from manure and fat-containing waste. There is at least one plant in Italy. There are power stations in the UK and Germany fired by biogas produced from manure.

Reference literature

[218, Dansk Biogas A/S, undated, 287, EC, 2002]

Landspreading of solid residues from biogas production

Technical description

The solid residues from biogas production may be applied as soil improvers.

Achieved environmental benefits

Utilisation of the nitrogen and phosphorus as an odourless sanitised fertiliser, in addition to the utilisation of the energy potential from slaughterhouse waste (gastro-intestinal contents, manure, material screened from waste water, fat from fat traps, sludge from sedimentation tanks and sludge from flotation tanks).

Cross-media effects

Iron, aluminium and manganese may be present and it may therefore be prudent to analyse for these.

Technical considerations relevant to applicability

The application to pasture land of organic fertilisers and soil improvers, other than manure, is prohibited by ABP Regulation 1774/2002/EC. The Regulation contains the definition “Organic fertilisers” and “soil improvers” mean materials of animal origin used to maintain or improve plant nutrition and the physical and chemical properties and biological activity of soils, either separately or together; they may include manure, digestive tract content, compost and digestion residues.

Economics

Cheaper than landfill or incineration.

Driving force for implementation

Recovery of the nutrients in the by-products after use of the energy content to produce biogas.

Example plants

The landspreading of biogas residues is practised in Denmark.

Reference literature

[134, Nordic States, 2001, 287, EC, 2002, 351, UK TWG Members, 2003]

Alkaline hydrolysis of animal carcasses and parts of animal carcasses at elevated temperature

See also Section.

Technical description

The heated alkaline hydrolysis process effectively digests and disposes of animal carcasses and reportedly inactivates BSE agents. The animal and microbial tissues are converted into a reportedly sterile, neutral aqueous solution, which, after cooling, is discharged to an anaerobic digestion process for further treatment. The anaerobic digestion produces CH₄ gas which can be used to generate electricity or steam.

Achieved environmental benefits

Destruction of microbial risk during alkaline hydrolysis. Energy production from anaerobic digestion.

Cross-media effects

Consumption of water, although it does not need to be potable and consumption of alkali, usually 50 % solutions of NaOH or KOH. A steam raising capacity is needed to heat water, at a rate of 1 kg steam/kg feedstock. Electricity is required at a rate of 17 kW for every 4.5 tonnes of feedstock.

Environmental performance and operational data

Alkaline hydrolysis at elevated temperature is undertaken in insulated, steam jacketed, stainless steel tissue digesters with lids which can either be manually or hydraulically clamped. The vessel contains a basket for the retention of bone remnants. The tissue digesters are manufactured in a range from 36 kg–4.56 t. Animal carcasses are generally treated without any prior size reduction, without any reported reduction in effectivity of the technique.

Raw material handling arrangements reportedly depend on the scale of operation and range from manual handling to systems of rails, conveyors and chutes.

For larger scale operations a series of digesters can be installed. The process operates at 150 °C, for 3 hours and > 400 kPa pressure. It is automated during the process cycle.

The process converts proteins, nucleic acids and lipids of all cells and tissues, as well as infectious micro-organisms, to a sterile aqueous solution of small peptides, amino acids, sugars and soaps. The alkali is consumed in the process, by generating the salts of the hydrolysis products. Ash comprising the mineral constituents of the bones and teeth of vertebrates, is produced and represents approximately 3 % of the weight of original carcass/tissue. This is easily crushed by hand and can reportedly be recovered as calcium phosphate powder.

A heat exchange for heating water can be built into the system design.

The digestion residue is discharged directly to the balance tank of the anaerobic digestion system. It has been suggested that the residues from anaerobic digestion could be used as

follows: crushed bone from non BSE risk animals as fertiliser, liquid residue from non BSE risk animals as fertiliser. The liquid residue from BSE risk animals could possibly be evaporated to minimise the solid residue and then be disposed of to landfill or by incineration, according to relevant legislation.

For an example digester of 4.5 t capacity, the following consumption and emission levels are reported:

To the 4.5 t of animal material, between 50–100 % equivalent weight of water, i.e. 2.25–4.5 t is added. The amount depends on the animal material. The addition of alkali to the tissue digester is 14 %, for NaOH and 21 % for KOH, of the weight of the animal carcass/tissue material to be processed. 4.5 kg of raw material requires 4.5 kg of steam. The electricity requirement is 11.1 kW/t of raw material.

Technical considerations relevant to applicability

At the time of writing, this technique is not permitted in the EU, due to the fact that in ABP Regulation 1774/2002/EC, it is neither listed, nor has it been approved in accordance with the procedure referred to in Article 33(2) therein, after consultation of the appropriate scientific committee.

The process is being marketed in the red and white meat and rendering industries, in preparation for potentially receiving approval under the procedures prescribed in ABP Regulation 1774/2002/EC, both in terms of BSE type risk and non-infected by product treatment and disposal, as an alternative to, e.g. landfill.

It can reportedly be applied to a range of plant sizes, from small to very large, with the installation of multiple units being appropriate for large scale operations, for which there is a reported economy of scale. The technique may be applied as an integrated system for on-site treatment and disposal, thereby saving on transport costs and environmental damage.

Economics

A 4.5 t capacity alkaline hydrolysis tissue digester is reported to be capable of processing 18 t of animal carcass waste material per 24 hour period. If it operates 7 days per week, 52 weeks per year, the annual throughput will, therefore, be 6570 t.

The capital investment cost for a 4.5 t capacity tissue digester is calculated at EUR 20.9/t of material processed, if the capital cost is assumed to be spread over 10 years, ignoring interest charges.

The operating cost for the tissue digester is calculated at EUR 41/t of material processed.

The capital and operating costs of combined alkaline hydrolysis and anaerobic digestion systems are to some extent offset by the income from energy generation.

Driving force for implementation

The need to destroy BSE agents, without the use of incineration. The pretreatment of waste prior to landfill, to satisfy the requirements of *Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste*.

Example plants

Alkaline hydrolysis is reportedly in full scale use in the US, for disposing of TSE infection risk sheep, elk and deer. Pharmaceutical research companies and medical/veterinary university research units have also installed tissue digesters for the disposal of animal and human material. They are in use in Canada for the disposal of TSE wastes. No plants are in operation in the EU, due to the current lack of approval of the technique as required by ABP Regulation 1774/2002/EC. Such approval is currently being sought.

The anaerobic digestion plants incorporated with this technique are currently applied in 100 full scale operational installations in Europe and Asia.

The combined technologies have not yet been installed on an integrated site.

Reference literature

[294, Waste Reduction Europe Ltd, 2002]

2.3.2.2 Separation of residues Fit and use floor drains with screens and/or traps to prevent solid material from entering the waste water

Description

Separation of residues, e.g. using positioned screens, flaps, catchpots, drip trays and troughs.

Technical description

Outputs, whether or not they are intended for use in the product, can be separated for optimised and easier use, reuse, recovery and recycling. This also reduces both the consumption and the contamination of water. It can be done either manually or mechanically. These outputs may include rejected raw materials, trimmings and off-specification product.

Accurately positioned, screens, flaps, drip trays and troughs can be used to contain individual materials separately. They can be fitted at processing, filling/packing and transfer lines and next to workstations, such as peeling, cutting and trimming benches. The position and design of a tray or trough for example, the means of preventing mixing with water and the transportation of the liquids or solids depend on the unit operation, the degree of segregation of different materials desired or required and their ultimate intended use, or disposal route.

A catchpot is a fine mesh basket placed over floor drains, to prevent solids from entering the drainage system and the WWTP. Catchpots can be locked in place to ensure that solids are not able to enter the WWTP during cleaning. If they are emptied after dry cleaning and locked in place again before wet cleaning, then entrainment of soluble materials and of particles can be avoided.

Examples of materials which can be collected and transported dry include bones and fat from deboning and trimming meat. These may or may not be intended for human consumption.

The initial screening of waste water may be achieved by fitting grates with small mesh sizes, or a combination bridge and screen, over floor drains.

Achieved environmental benefits

Reduced entrainment of solids in waste water and consequently reduced COD, BOD and TSS loadings at the WWTP. Depending on ABP Regulation 1774/2002/EC Category of the material, the solids may be used or disposed of in a variety of ways and there may be a requirement for a screen, with a mesh size not exceeding 6 mm.

Environmental performance and operational data

In many slaughterhouses and animal by-products installations, it is common practice for staff involved in clean-up operations to remove floor drain grates and flush solid materials, such as off cuts and meat scraps, directly down the drain. At present this may be done without thought, or in the belief that a subsequent screen or catchpot will trap all solids. However, when the solids enter the waste water stream they are subject to turbulence, pumping and mechanical screening, which breaks them down and releases high COD substances into solution, along with colloidal and suspended fats and solids. Subsequent waste water treatment and effluent disposal to the municipal WWTP can be expensive.

To reduce effluent loading, efforts can be made to keep the solids out of the waste water stream in the first place. For example, carcass dressing can be examined carefully for opportunities to intercept solid materials before they enter the drains. Similarly, cleaning staff can be encouraged to empty drain catchpots into a waste bin and replace them in the drainage point before using water to clean an area. This has the additional advantage that the solids are collected dry, so they both weigh less and are hence cheaper to transport and so that energy is not required to remove excess water.

Cross-media effects

Potential generation of odour if separated solids are not periodically collected and sent to their subsequent destination.

None.

Technical considerations relevant to applicability

Applicable in all slaughterhouses and animal by-products installations.

Economics

Inexpensive.

Driving force for implementation

Reduced load at the WWTP, associated cost savings and ABP Regulation 1069/2009 1774/2002/EC.

Example plants

Most slaughterhouses and animal by-products installations have drains with screens or traps fitted.

Reference literature

[12, WS Atkins-EA, 2000] [4, WS Atkins-EA 2000], [167, Greek Ministry for the Environment, 2001] [55, Greek Ministry for the Environment 2001], [206, Giner-Santonja et al. 2019]

2.3.2.3 Overfilling protection on bulk storage tanks, e.g. containing blood or tallow

Description

Level detection devices are implemented, which automatically detect the level of liquid in a vessel and send an audible and visual signal.

Technical description

Level detection devices can be fitted, which will automatically detect the level of liquid in a vessel and send an audible and visual signal, first to warn that the capacity is close to full and then, if no action is taken, to actually stop the tank from filling, e.g. by stopping the pump or diverting the flow.

Achieved environmental benefits

Reduced risk of accidental overfilling, which could otherwise lead, e.g. in the case of blood, to a massive increase in the COD of the waste water and a potential disabling of the on-site or municipal WWTP, or if the yard water soaks away without treatment, to potential major pollution of local water courses.

Environmental performance and operational data

Overfilling protection may automatically cut off the supply of further liquids, or it could comprise a system of audible and visual alarms, to which operators respond. The choice generally depends on the hazard associated with the substance being stored. Where the substance is hazardous to the environment and/or to personnel, automated systems are generally provided and maintained. This reduces the element of risk associated with human error.

For example, the spillage of blood is potentially one of the most environmentally harmful accidents that can happen in a slaughterhouse. The blood may escape to local water courses or cause problems in an on-site WWTP, due to shock loading. The risk of this can be reduced by installing a high level alarm on the blood tank, linked to an automatic cut-off device for the blood trough pumps. For example, a mechanism using a ballcock can be used. The ballcock hits an electrical switch which then operates a solenoid and activates a valve, which prevents further filling.

Cross-media effects

None reported.

Technical considerations relevant to applicability

Applicable in all slaughterhouses and animal by-products installations where bulk liquids are stored, which, if released to the environment, could cause significant pollution.

Economics

Inexpensive.

Driving force for implementation

Prevention of the accidental release of liquids hazardous to the environment.

Example plants

Overfilling protection on bulk storage tanks is in widespread use throughout the chemical industry and in industries where liquids that are hazardous to the environment, including to humans, are used, e.g. in the process or for cleaning.

Reference literature

[4, EPA, 1996] [2, EPA 1996], [148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001] [47, Finnish Environment Institute and Finnish Food and Drink Industries' Federation 2001], [244, Germany, 2002] [110, Germany 2002], [288, Durkan J., 2002] [138, Durkan J. 2002], [295, HSE, 1998] [144, HSE 1998]

2.3.2.4 Bunding of bulk storage tanks containing, e.g. blood or tallow

Description

A bund wall capable of holding at least 110 % of the volume of the largest storage tank within it and of adequate strength and integrity to contain the liquid stored is provided.

Technical description

A bund wall capable of holding at least 110 % of the volume of the largest storage tank within it and of adequate strength and integrity to contain the liquid stored can be provided. This is normally considered to be sufficient to contain the contents in the event of a catastrophic failure. A smaller capacity bund may be provided, if the liquid can be directed to a separate collection area. In this case diversion walls with a minimum height of 0.5 metres can prevent the bund from overfilling.

Achieved environmental benefits

Reduced risk of accidental leakage and spillage, which could otherwise lead, e.g. in the case of blood, to a massive increase in the COD of the waste water and potential disabling of the on-site or municipal WWTP, or if the yard water soaks away without treatment, overfilling could lead to potential major pollution of local water courses and land. A typical blood tank might hold 13 600 litres.

Environmental performance and operational data

A bund wall should incorporate a method of removing rainwater and the need for this should be assessed regularly and in particular always after rainfall. Rainwater should be removed to

ensure that the capacity of the bund is always sufficient to contain the contents of the tank, if it is required to do so. The integrity of the bund should be checked on a regular basis.

If bund walls exceed 0.6 metres in height, particular attention may be required to ensure their strength and a fixed means of escape may be required. Bund walls are usually positioned at least 1 metre away from a tank with a capacity of up to 100 m³ and 2 metres for larger tanks. Damage to bunds can be prevented by impact protection, such as crash barriers or bollards and by good traffic management.

Cross-media effects

None reported.

Technical considerations relevant to applicability

Applicable in all slaughterhouses and animal by-products installations where bulk liquids are stored, which if released to the environment could cause significant pollution.

Economics

Request to the TWG: Please provide information.
--

Driving force for implementation

To prevent the accidental release of liquids hazardous to the environment.

Example plants

Provision of bunding on bulk storage tanks is in widespread use throughout the chemical industry and in industries where liquids hazardous to the environment, including to humans are used, e.g. in the process or for cleaning.

Reference literature

[4, EPA, 1996] [2, EPA 1996], [295, HSE, 1998] [144, HSE 1998]

2.3.2.5 Double skin protection of bulk storage tanks, e.g. containing blood or tallow

Description

A double skinned wall is implemented on bulk storage tanks.

Technical description

A double skinned wall on bulk storage tanks provides some protection against a release of liquids through corrosion, wear or catastrophic damage.

Achieved environmental benefits

Reduced risk of accidental leakage and spillage, which could otherwise lead, e.g. in the case of blood, to a massive increase in the COD of the waste water and potential disabling of the on-site or municipal WWTP, or if the yard water soaks away without treatment, overflowing could lead to a potential major pollution of local water courses. A small degree of insulation from heat may be achieved, which may to a small extent reduce the rate of fermentation of blood and thereby slow down the formation of malodorous gases. A typical blood tank might hold 13 600 litres.

Environmental performance and operational data

Internal failures might remain undetected, so periodic inspections should be scheduled and undertaken. The monitoring system can use either vacuum or pressure to provide an alarm if one of the skins fails.

Cross-media effects

None.

Technical considerations relevant to applicability

Applicable in all slaughterhouses and animal by-products installations where bulk liquids are stored, which if released to the environment could cause significant pollution.

Economics

Request to the TWG: Please provide information.

Driving force for implementation

Reduced risk of spillage.

Example plants

Provision of double-skinned blood tanks is common practice.

Reference literature

[295, HSE, 1998] [144, HSE 1998]

MANAGEMENT OF SLAUGHTERHOUSES AND ANIMAL BY PRODUCTS INSTALLATIONS

For the optimum performance of each technique, it is necessary for all staff to be committed to its successful operation; from the managing director, managers, supervisors and shop floor workers through to the haulage contractor delivering the animals. This requires information, training, and demonstrating to all staff the results and economic consequences of how well or badly techniques are implemented. The “human factor” impinges on all techniques. For some techniques, to successfully minimise consumption and emission levels there is a greater reliance on the responsible actions of some individuals than for others. All employees must learn what is required of them and of the process. Staff motivation is, therefore, important, as is regular feedback about the results achieved by their actions. [134, Nordic States, 2001]. Specific responsibility may be allocated to competent individuals and their performance may be monitored.

If resources such as water and energy are used sparingly, their consumption will be minimised. The pollution of waste water can be minimised by removing any waste as near to the source as possible. If by products, such as blood, bits of meat, manure, stomach and intestinal contents are not intended to be treated together, they can be kept apart from each other and not deliberately mixed with water. The volume of waste can be minimised by measures such as, e.g. re using by products when possible. Consumption and emission levels can be measured; techniques can be identified to reduce both; results can be shared and techniques can be tried and tested. Action plans naming responsible individuals and setting time scales can be drawn up and monitored. Motivating and involving staff, as well as providing training and promoting a wider understanding of the process can encourage a positive attitude to the use of BAT. [134, Nordic States, 2001]

To, e.g. manage the minimisation of water and energy use, it is necessary to monitor their consumption and to record it continuously, not only in total, but also for individual unit operations, processes and departments. To achieve this, meters need to be installed at all significant places of consumption. They must be read regularly and the results analysed and used as feedback in continuous improvement efforts. [134, Nordic States, 2001]. Direct measurements may be required for regulatory purposes. Useful estimates of consumption and emission levels may also be obtained in advance of, or in some cases instead of, direct measurements. Estimates can be obtained from calculations based on the inputs and outputs, e.g. per weight of carcase produced; the weight of animal by products to be treated and the amount of water and energy used. Estimations by mass or energy balance will require some tracking of the material usage and the by product and waste production. Inconsistencies in these figures may introduce some inaccuracies in the estimates but, as a minimum, should make it possible to identify those areas where priority action is required to reduce consumption and

emission levels. Infrequent, non-routine and unplanned activities, including accidents, also need to be covered.

For direct measurements, it will only be possible to record the consumption during production, cleaning and quiet periods separately, if meters are read sufficiently often. Manual reading and reporting save capital costs from automatic systems but consume labour. Some companies find it worthwhile to install equipment for the automatic monitoring and recording of consumption. [134, Nordic States, 2001]. Further information about the measurement of consumption and emission levels is contained in the *Reference Document on The General Principles of Monitoring* [278, EC, 2002].

All processes and machines need to be examined and the following questions asked. How much water/energy is used? What is it used for? How much is required in order to achieve the desired result without impairing quality or hygiene? The answers to these questions can help to identify where water or energy savings can be made. In many cases it will be found that there is a large wastage of water, because the water actually used does not form part of the process. A typical example is that there is water for showering a product that does not actually hit the product or equipment to be cleaned. Such wasteful situations need to be rectified. [134, Nordic States, 2001]

Maintenance, including preventive maintenance, is important, e.g. the regular examination of blood storage facilities, to ensure that leakage is prevented [134, Nordic States, 2001]. Where significant interruption of the process could occur in the event of a breakdown, parts need to be routinely replaced as they approach the end of their expected lifetime. To minimise interruptions and downtimes, adequate supplies of all wearing and replacement parts for both process and treatment/abatement equipment need to be kept [49, VDI, 1996].

At installations where more than one activity is undertaken, there may be opportunities for an overall management of consumption and emission levels, to the benefit of one, or more, of the activities. This may be achieved, e.g. by using steam produced by one activity in another. The controllable characteristics of the feedstock for any process may affect the environmental performance of an installation. In such a case, the operator of the installation may make it a condition of the contract that the feedstock is supplied in the most suitable condition, for both quality and environmental performance.

Environmental management tools

Technical description

The best environmental performance is usually achieved by the installation of the best technology and its operation in the most effective and efficient manner. This is recognised by the IPPC Directive definition of 'techniques' as "*both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned*".

For IPPC installations an Environmental Management System (EMS) is a tool that operators can use to address these design, construction, maintenance, operation and decommissioning issues in a systematic, demonstrable way. An EMS includes the organisational structure, responsibilities, practices, procedures, processes and resources for developing, implementing, maintaining, reviewing and monitoring the environmental policy. Environmental Management Systems are most effective and efficient where they form an inherent part of the overall management and operation of an installation.

Within the European Union, many organisations have decided on a voluntary basis to implement environmental management systems based on EN ISO 14001:1996 or the EU Eco-management and audit scheme EMAS. EMAS includes the management system requirements of EN ISO 14001, but places additional emphasis on legal compliance, environmental performance and employee involvement; it also requires external verification of the management system and validation of a public environmental statement (in EN ISO 14001 self-declaration is an

alternative to external verification). There are also many organisations that have decided to put in place non-standardised EMSs.

~~While both standardised systems (EN ISO 14001:1996 and EMAS) and non-standardised (“customised”) systems in principle take the *organisation* as the entity, this document takes a more narrow approach, not including all activities of the organisation e.g. with regard to their products and services, due to the fact that the regulated entity under the IPPC Directive is the *installation* (as defined in Article 2).~~

~~An environmental management system (EMS) for an IPPC installation can contain the following components:~~

- ~~(a) definition of an environmental policy~~
- ~~(b) planning and establishing objectives and targets~~
- ~~(c) implementation and operation of procedures~~
- ~~(d) checking and corrective action~~
- ~~(e) management review~~
- ~~(f) preparation of a regular environmental statement~~
- ~~(g) validation by certification body or external EMS verifier~~
- ~~(h) design considerations for end-of-life plant decommissioning~~
- ~~(i) development of cleaner technologies~~
- ~~(j) benchmarking.~~

~~These features are explained in somewhat greater detail below. For detailed information on components (a) to (g), which are all included in EMAS, the reader is referred to the reference literature indicated below.~~

~~(a) Definition of an environmental policy~~

~~Top management are responsible for defining an environmental policy for an installation and ensuring that it:~~

- ~~— is appropriate to the nature, scale and environmental impacts of the activities~~
- ~~— includes a commitment to pollution prevention and control~~
- ~~— includes a commitment to comply with all relevant applicable environmental legislation and regulations, and with other requirements to which the organisation subscribes~~
- ~~— provides the framework for setting and reviewing environmental objectives and targets~~
- ~~— is documented and communicated to all employees~~
- ~~— is available to the public and all interested parties.~~

~~(b) Planning, i.e.:~~

- ~~— procedures to identify the environmental aspects of the installation, in order to determine those activities which have or can have significant impacts on the environment, and to keep this information up to date~~
- ~~— procedures to identify and have access to legal and other requirements to which the organisation subscribes and that are applicable to the environmental aspects of its activities~~
- ~~— establishing and reviewing documented environmental objectives and targets, taking into consideration the legal and other requirements and the views of interested parties~~
- ~~— establishing and regularly updating an environmental management programme, including designation of responsibility for achieving objectives and targets at each relevant function and level as well as the means and timeframe by which they are to be achieved.~~

(c) Implementation and operation of procedures

It is important to have systems in place to ensure that procedures are known, understood and complied with, therefore effective environmental management includes:

(i) Structure and responsibility

- defining, documenting and communicating roles, responsibilities and authorities, which includes appointing one specific management representative
- providing resources essential to the implementation and control of the environmental management system, including human resources and specialised skills, technology and financial resources.

(ii) Training, awareness and competence

- identifying training needs to ensure that all personnel whose work may significantly affect the environmental impacts of the activity have received appropriate training.

(iii) Communication

- establishing and maintaining procedures for internal communication between the various levels and functions of the installation, as well as procedures that foster a dialogue with external interested parties and procedures for receiving, documenting and, where reasonable, responding to relevant communication from external interested parties.

(iv) Employee involvement

- involving employees in the process aimed at achieving a high level of environmental performance by applying appropriate forms of participation such as the suggestion-book system or project based group works or environmental committees.

(v) Documentation

- establishing and maintaining up to date information, in paper or electronic form, to describe the core elements of the management system and their interaction and to provide direction to related documentation.

(vi) Efficient process control

- adequate control of processes under all modes of operation, i.e. preparation, start-up, routine operation, shutdown and abnormal conditions
- identifying the key performance indicators and methods for measuring and controlling these parameters (e.g. flow, pressure, temperature, composition and quantity)
- documenting and analysing abnormal operating conditions to identify the root causes and then addressing these to ensure that events do not recur (this can be facilitated by a 'no blame' culture where the identification of causes is more important than apportioning blame to individuals).

(vii) Maintenance programme

- establishing a structured programme for maintenance based on technical descriptions of the equipment, norms etc. as well as any equipment failures and consequences
- supporting the maintenance programme by appropriate record keeping systems and diagnostic testing
- clearly allocating responsibility for the planning and execution of maintenance.

(viii) Emergency preparedness and response

- establishing and maintaining procedures to identify the potential for and response to accidents and emergency situations, and for preventing and mitigating the environmental impacts that may be associated with them.

(d) Checking and corrective action, i.e.:

(i) Monitoring and measurement

- establishing and maintaining documented procedures to monitor and measure, on a regular basis, the key characteristics of operations and activities that can have a significant impact on the environment, including the recording of information for tracking performance, relevant operational controls and conformance with the installation's environmental objectives and targets (*see also the Reference document on Monitoring of Emissions*)
- establishing and maintaining a documented procedure for periodically evaluating compliance with relevant environmental legislation and regulations.

(ii) Corrective and preventive action

- establishing and maintaining procedures for defining responsibility and authority for handling and investigating non conformance with permit conditions, other legal requirements as well as objectives and targets, taking action to mitigate any impacts caused and for initiating and completing corrective and preventive action that are appropriate to the magnitude of the problem and commensurate with the environmental impact encountered.

(iii) Records

- establishing and maintaining procedures for the identification, maintenance and disposition of legible, identifiable and traceable environmental records, including training records and the results of audits and reviews.

(iv) Audit

- establishing and maintaining (a) programme(s) and procedures for periodic environmental management system audits that include discussions with personnel, inspection of operating conditions and equipment and reviewing of records and documentation and that results in a written report, to be carried out impartially and objectively by employees (internal audits) or external parties (external audits), covering the audit scope, frequency and methodologies, as well as the responsibilities and requirements for conducting audits and reporting results, in order to determine whether or not the environmental management system conforms to planned arrangements and has been properly implemented and maintained
- completing the audit or audit cycle, as appropriate, at intervals of no longer than three years, depending on the nature, scale and complexity of the activities, the significance of associated environmental impacts, the importance and urgency of the problems detected by previous audits and the history of environmental problems — more complex activities with a more significant environmental impact are audited more frequently
- having appropriate mechanisms in place to ensure that the audit results are followed up.

(v) Periodic evaluation of legal compliance

- reviewing compliance with the applicable environmental legislation and the conditions of the environmental permit(s) held by the installation
- documentation of the evaluation.

(e) Management review, i.e.:

- reviewing, by top management, at intervals that it determines, the environmental management system, to ensure its continuing suitability, adequacy and effectiveness
- ensuring that the necessary information is collected to allow management to carry out this evaluation
- documentation of the review.

(f) Preparation of a regular environmental statement:

- preparing an environmental statement that pays particular attention to the results achieved by the installation against its environmental objectives and targets. It is regularly produced — from once a year to less frequently depending on the significance of emissions, waste generation etc. It considers the information needs of relevant interested parties and it is publicly available (e.g. in electronic publications, libraries etc.);

When producing a statement, the operator may use relevant existing environmental performance indicators, making sure that the indicators chosen:

- i. — give an accurate appraisal of the installation's performance
- ii. — are understandable and unambiguous
- iii. — allow for year on year comparison to assess the development of the environmental performance of the installation
- iv. — allow for comparison with sector, national or regional benchmarks as appropriate
- v. — allow for comparison with regulatory requirements as appropriate.

(g) Validation by certification body or external EMS verifier:

- having the management system, audit procedure and environmental statement examined and validated by an accredited certification body or an external EMS verifier can, if carried out properly, enhance the credibility of the system.

(h) Design considerations for end-of-life plant decommissioning

- giving consideration to the environmental impact from the eventual decommissioning of the unit at the stage of designing a new plant, as forethought makes decommissioning easier, cleaner and cheaper
- decommissioning poses environmental risks for the contamination of land (and groundwater) and generates large quantities of solid waste. Preventive techniques are process specific but general considerations may include:
 - i. — avoiding underground structures
 - ii. — incorporating features that facilitate dismantling
 - iii. — choosing surface finishes that are easily decontaminated
 - iv. — using an equipment configuration that minimises trapped chemicals and facilitates drain down or washing
 - v. — designing flexible, self contained units that enable phased closure
 - vi. — using biodegradable and recyclable materials where possible.

(i) Development of cleaner technologies:

- environmental protection should be an inherent feature of any process design activities carried out by the operator, since techniques incorporated at the earliest possible design stage are both more effective and cheaper. Giving consideration to the development of cleaner technologies can for instance occur through R&D activities or studies. As an alternative to internal activities, arrangements can be made to keep abreast with — and where appropriate — commission work by other operators or research institutes active in the relevant field.

(j) Benchmarking, i.e.:

- carrying out systematic and regular comparisons with sector, national or regional benchmarks, including for energy efficiency and energy conservation activities, choice of input materials, emissions to air and discharges to water (using for example the European Pollutant Emission Register, EPER), consumption of water and generation of waste.

Standardised and non-standardised EMSs

An EMS can take the form of a standardised or non-standardised (“customised”) system. Implementation and adherence to an internationally accepted standardised system such as EN ISO 14001:1996 can give higher credibility to the EMS, especially when subject to a properly performed external verification. EMAS provides additional credibility due to the interaction with the public through the environmental statement and the mechanism to ensure compliance with the applicable environmental legislation. However, non-standardised systems can in principle be equally effective provided that they are properly designed and implemented.

Achieved environmental benefits

Implementation of and adherence to an EMS focuses the attention of the operator on the environmental performance of the installation. In particular, the maintenance of and compliance with clear operating procedures for both normal and abnormal situations and the associated lines of responsibility should ensure that the installation’s permit conditions and other environmental targets and objectives are met at all times.

Environmental management systems typically ensure the continuous improvement of the environmental performance of the installation. The poorer the starting point is, the more significant short-term improvements can be expected. If the installation already has a good overall environmental performance, the system helps the operator to maintain the high performance level.

Cross-media effects

Environmental management techniques are designed to address the overall environmental impact, which is consistent with the integrated approach of the IPPC Directive.

Environmental performance and operational data

No specific information reported.

Technical considerations relevant to applicability

The components described above can typically be applied to all IPPC installations. The scope (e.g. level of detail) and nature of the EMS (e.g. standardised or non-standardised) will generally be related to the nature, scale and complexity of the installation, and the range of environmental impacts it may have.

Economics

It is difficult to accurately determine the costs and economic benefits of introducing and maintaining a good EMS. A number of studies are presented below. However, these are just examples and their results are not entirely coherent. They might not be representative for all sectors across the EU and should thus be treated with caution.

A Swedish study carried out in 1999 surveyed all 360 ISO-certified and EMAS-registered companies in Sweden. With a response rate of 50 %, it concluded among other things that:

- the expenses for introducing and operating EMS are high but not unreasonably so, save in the case of very small companies. Expenses are expected to decrease in the future
- a higher degree of co-ordination and integration of EMS with other management systems is seen as a possible way to decrease costs
- half of all the environmental objectives and targets give payback within one year through cost savings and/or increased revenue
- the largest cost savings were made through decreased expenditure on energy, waste treatment and raw materials
- most of the companies think that their position on the market has been strengthened through the EMS. One third of the companies report increasing revenue due to EMS.

In some Member States reduced supervision fees are charged if the installation has a certification.

A number of studies⁴ show that there is an inverse relationship between company size and the cost of implementing an EMS. A similar inverse relationship exists for the payback period of invested capital. Both elements imply a less favourable cost-benefit relationship for implementing an EMS in SMEs compared to larger companies.

According to a Swiss study, the average cost for building and operating ISO 14001 can vary:

- for a company with between 1 and 49 employees: CHF 64000 (EUR 44000) for building the EMS and CHF 16000 (EUR 11000) per year for operating it
- for an industrial site with more than 250 employees: CHF 367000 (EUR 252000) for building the EMS and CHF 155000 (EUR 106000) per year for operating it.

These average figures do not necessarily represent the actual cost for a given industrial site because this cost is also highly dependent on the number of significant items (pollutants, energy consumption, ...) and on the complexity of the problems to be studied.

A recent German study (Schaltegger, Stefan and Wagner, Marcus, *Umweltmanagement in deutschen Unternehmen – der aktuelle Stand der Praxis*, February 2002, p. 106) shows the following costs for EMAS for different branches. It can be noted that these figures are much lower than those of the Swiss study quoted above. This is a confirmation of the difficulty to determine the costs of an EMS:

Costs for building (EUR):

- minimum 18750
- maximum 75000
- average 50000

Costs for validation (EUR):

- minimum 5000
- maximum 12500
- average 6000

A study by the German Institute of Entrepreneurs (Unternehmerinstitut/Arbeitsgemeinschaft Selbständiger Unternehmer UNI/ASU, 1997, *Umweltmanagementbefragung – Öko Audit in der mittelständischen Praxis – Evaluierung und Ansätze für eine Effizienzsteigerung von Umweltmanagementsystemen in der Praxis*, Bonn.) gives information about the average savings achieved for EMAS per year and the average payback time. For example, for implementation costs of EUR 80000 they found average savings of EUR 50000 per year, corresponding to a payback time of about one and a half years.

External costs relating to verification of the system can be estimated from guidance issued by the International Accreditation Forum (<http://www.iaf.nu>).

Driving forces for implementation

Environmental management systems can provide a number of advantages, for example:

- improved insight into the environmental aspects of the company
- improved basis for decision-making
- improved motivation of personnel
- additional opportunities for operational cost reduction and product quality improvement

⁴ (E.g. Dyllick and Hamschmidt (2000, 73) quoted in Klemisch H. and R. Holger, *Umweltmanagementsysteme in kleinen und mittleren Unternehmen – Befunde bisheriger Umsetzung*, KNI Papers 01/02, January 2002, p 15; Clausen J., M. Keil and M. Jungwirth, *The State of EMAS in the EU. Eco-Management as a Tool for Sustainable Development – Literature Study*, Institute for Ecological Economy Research (Berlin) and Ecologic – Institute for International and European Environmental Policy (Berlin), 2002, p 15.)

- improved environmental performance
- improved company image
- reduced liability, insurance and non-compliance costs
- increased attractiveness for employees, customers and investors
- increased trust of regulators, which could lead to reduced regulatory oversight
- improved relationship with environmental groups.

Example plants

The features described under (a) to (e) above are elements of EN ISO 14001:1996 and the European Community Eco Management and Audit Scheme (EMAS), whereas the features (f) and (g) are specific to EMAS. These two standardised systems are applied in a number of IPPC installations. As an example, there are 2 EMAS registered fishmeal and fish oil plants in Denmark and one EMAS registered turkey slaughtering and processing plant in the UK.

In the UK, the Environment Agency of England and Wales carried out a survey among IPC (the precursor to IPPC) regulated installations in 2001. It showed that 32 % of respondents were certified to ISO 14001 (corresponding to 21 % of all IPC installations) and 7 % were EMAS registered. All cement works in the UK (around 20) are certified to ISO 14001 and the majority are EMAS registered. In Ireland, where the establishment of an EMS (not necessarily of a standardised nature) is required in IPC licenses, an estimated 100 out of approximately 500 licensed installations have established an EMS according to ISO 14001, with the other 400 installations having opted for a non-standardised EMS.

Reference literature

Regulation (EC) No 761/2001 of the European parliament and of the council allowing voluntary participation by organisations in a Community eco-management and audit scheme (EMAS), OJ L 114, 24/4/2001, http://europa.eu.int/comm/environment/emas/index_en.htm

EN ISO 14001:1996, <http://www.iso.ch/iso/en/iso9000-14000/iso14000/iso14000index.html>;
<http://www.tc207.org>

2.3.2.6 Short and possibly cold storage Prevention of biological degradation of animal by-products and/or edible co-products

See also Section 2.3.8.2.7 for further information about the storage of blood and Section 3.3.2.5.1 for information about the storage preservation of hides/skins.

Description

Animal by-products and/or edible co-products are stored in closed vessels or rooms in slaughterhouses and animal by-products installations, for as short a time as possible, before further treatment. Raw materials intended for human consumption (e.g. fat, blood), feed material or pet food may require refrigeration.

Technical description

By-products destined for use or disposal can be stored in closed vessels or rooms in slaughterhouses and animal by-products SA installations, for as short a time as possible, before further treatment. Depending on the nature of the by-products, such as their inherent odour characteristics and how rapidly they biodegrade and create an odour nuisance, it may be prudent to also refrigerate them, particularly during warm weather and in hot climates.

Raw materials intended for human consumption (e.g. fat, blood) may also require refrigeration. A temperature not exceeding 5 °C, for solids and less than 10 °C, for blood has been reported as being necessary, to prevent odour problems. Cooling can take place, if necessary, at the slaughterhouse, in transit or at the animal by-products installation. This applies at both the slaughterhouse and the animal by-products installation. Although IPPC the IED does not apply to the transport of materials between installations, by implication it is good practice to control

the conditions of transport as these may have a very significant influence on, e.g. odour emissions at the by-products installation.

Commission Regulation ~~1774/2002/EC~~ (EU) No 142/2011 contains some requirements for temperature conditions for the collection and transportation of animal by-products *in sealed new packaging or covered leak-proof containers or vehicles* and for *the maintenance of an appropriate temperature throughout transport*. The cooling/cold storage of Category 3 materials destined for the production of feed material or pet food is not mandatory at slaughterhouse level if these are collected and processed within 24 hours (see also Section 4.3.2.1.2) [241, TWG 2019].

If raw materials are handled as fresh as possible, the quantity of compounds that end up in the waste water or the air can be reduced. For example, by cooling warm waste, such as soft waste from the slaughter-line and casing-cleaning department, the formation of air and water pollution can be reduced. Consequently, the energy consumption for waste water and air cleaning is also reduced.

There may be greater opportunities for animal by-products to be recovered or recycled if they remain fresh due to short storage times or refrigeration. For example, blood meal manufactured from refrigerated blood has a higher nutritional value than unrefrigerated blood and it can be fed to non-farmed animals, such as pets.

It may be appropriate to refrigerate animal by-products due to extreme operational difficulties, such as a long distance between the source of the materials, which makes quick treatment impossible. An additional or alternative reason may be high ambient temperatures, which cause materials to rapidly decompose and produce malodorous emissions. High temperatures may be seasonal in the north of Europe or permanent in countries with warmer climates.

Achieved environmental benefits

- Reduced biological and/or thermal decomposition, which consequently leads to lower COD, nitrogen and phosphorus levels in the waste water at the animal by-products installation.
- The formation and emission of odour-intensive substances at both the slaughterhouse and animal by-products installation is minimised. There are reduced emissions to air from the waste gas treatment system.
- There is also a reduced risk of infestation by insects, rodents and birds.

Environmental performance and operational data

To optimise the prevention of odour problems, without creating cross-media effects at either, or both, the slaughterhouse and the animal by-products installation requires co-operation between the operators of both. If the handling and storage of by-products at the slaughterhouse is not managed in such a way as to minimise odour problems beyond the actual storage time before despatch, the animal by-products installations will almost certainly have problems, even if they treat the animal by-products immediately. The odour problems associated with animal by-products do not only arise from storage before treatment. Putrescent and putrid animal by-products also produce more malodorous gaseous and liquid emissions during processing than do fresh feedstock. They consequently cause additional odour problems at WWTPs.

Where refrigeration is required, if the storage times are also kept as short as possible, then the refrigeration capacity and the energy consumption can also be minimised.

Table 2.3 shows the practice for the storage of animal by-products in the Flemish region of Belgium.

Table 2.3: Storage requirements for animal by-products in the Flemish region of Belgium

Animal by-product	Storage practice
Animal waste/material for destruction	Enclosed storage in a refrigerated room, awaiting daily removal
Pig hair (to be used)	Enclosed storage in a refrigerated room
Blood	Enclosed and refrigerated storage
Hides (after treatment)	Enclosed storage in a refrigerated room
Intestinal fat and mucus (for subsequent treatment)	Enclosed storage in a refrigerated room
Washed intestines (if unsalted)	Refrigerated storage
Washed intestines (if salted)	Enclosed storage
Dung, contents of stomachs, intestines and rumens	No stipulations in respect of enclosed storage, refrigerated storage or removal frequency
Sludge from grease trap	Enclosed storage (airtight packaging)
<i>Source: [215, COM 2005]</i>	

Cross-media effects

Energy consumption may be required for refrigeration, if by-products cannot be used or disposed of before malodorous substances are produced from them, especially in summer and in warm climates.

The early despatch of animal by-products can increase the numbers of journeys between the slaughterhouse and the animal by-products installations processing animal by-products and/or edible co-products, transporting smaller loads, and consequently lead to an increase in the environmental harm due to transport.

Technical considerations relevant to applicability

Applicable in all slaughterhouses and animal by-products installations processing animal by-products and/or edible co-products. There may be limitations on space in existing premises, unless the existing unrefrigerated space is used.

Cooling of animal by-products and edible co-products should be carefully assessed, since energy is again consumed for heating the cooled by-product at the installation processing animal by-products and/or edible co-products [241, TWG 2019].

Economics

For a slaughterhouse killing 600 pigs per hour, it has been reported that the cost of a tank for blood and refrigeration equipment is about EUR 65 000 – 70 000 (2001). It has been reported that for slaughterhouses producing animal by-products that do not have a commercial value, the investment in storage facilities is not a viable option. This may be the case if the by-products are treated or removed before they cause an odour nuisance.

There may be contractual arrangements affecting the price paid to slaughterhouses for raw materials, which depend on the quality of raw material provided, if the animal by-products are destined for further use. If the materials are destined for disposal, the cost of dealing with problems, such as odour due to material not being provided fresh, may be passed on to the slaughterhouse, so investment in early despatch or refrigerated storage may be cost effective.

Driving force for implementation

- Prevention of odour emissions.
- Requirements for temperature conditions in Commission Regulation (EU) No 142/2011.

In Denmark, the cooling of blood at slaughterhouses was introduced due to a demand from the environmental regulatory authorities, in order to reduce the odour emissions, during the handling and transporting of blood.

Example plants

This technique has been reported by approximately 20 % of the slaughterhouses and 15 % of the installations processing animal by-products and/or edible co-products participating in the SA data collection. For example, a turkey slaughterhouse (PL289) implemented refrigeration in the storage of blood [264, TWG 2020].

~~Several rendering plants in Germany. In the Flemish region of Belgium, virtually all stored animal by-products are kept under refrigeration.~~

Reference literature

[16, VDI 2008] [49, VDI 1996] [289, VDI 1996], [134, Nordic States 2001] [38, Nordic 2001], [238, UECBV 2002] [104, UECBV 2002], [244, Germany 2002] [110, Germany 2002], [241, TWG 2019] [259, EFPPA-EAPA 2020], [264, TWG 2020]

2.3.2.7 Use of animal fat as a fuel**Description**

Use of animal fat to replace fuel in boilers and/or thermal oxidisers.

Technical description

Animal fat can be used in boilers and thermal oxidisers as an alternative fuel to natural gas, diesel or fuel oil. Fuel oil is available in various sulphur grades (< 1 %, < 2 %, < 3 % and > 3 %). Tallow is essentially sulphur free. Boilers can be converted to burn tallow (animal fat) by replacing the burners. ~~Traditional uses for tallow have been restricted, as a consequence of the BSE crisis. The permitted uses and routes for disposal are defined by ABP Regulation 1774/2002/EC. In some circumstances, e.g. where there is not a readily accessible outlet for tallow, it could be convenient and/or cheap to burn it within the installation where it is produced, although this technique is currently not approved under ABP Regulation 1774/2002/EC.~~

Chapter IV of Annex IV to Commission Regulation (EU) No 142/2011 - Alternative Process Methods includes the combustion of animal fat in a thermal boiler process [201, COM 2011].

The fat fraction must be separated from the protein and in the case of fat of ruminant origin which is intended to be combusted in another plant, insoluble impurities in excess of 0.15 % by weight must be removed. The fat must then be vaporised in a steam-raising boiler and combusted at a temperature of at least 1 100 °C for at least 0.2 seconds, or processed using equivalent process parameters as authorised.

It is a commercial decision whether tallow is used as an on-site fuel or sold as a product and the permits of all EU ABP processors give scope to burn tallow in on-site boilers or thermal oxidisers.

Achieved environmental benefits

The need to consume fossil fuel is reduced. Also, because tallow is virtually sulphur free lower SO₂ emissions can be achieved and without the need for abatement that, e.g. sulphur-containing fuel oil requires. There is also reduced pollution associated with transport if the tallow is burned on the same site as it is produced.

Environmental performance and operational data

Two steam boilers are heated by animal fat in a rendering installation in Austria. General information and emissions from the steam boilers are presented in Table 2.4.

Table 2.4: Emissions to air from two steam boilers burning animal fat

Parameter	Steam boiler 1		Steam boiler 2	
	Rated thermal input (MW)	6.9		6
Start of operation	1993		1975	
Fuel	120–695 kg/h animal fat (natural gas for start-up only)		120–590 kg/h animal fat (natural gas for start-up only)	
Flue-gas cleaning	No secondary installations for emission reduction		No secondary installations for emission reduction	
Flue-gas temperature (°C)	226		257	
Pollutant (3 half-hour measurements)	Maximum	Average	Maximum	Average
Dust (mg/Nm ³ ; 11 % O ₂)	16	15	18	14
NO _x (mg/Nm ³ ; 11% O ₂)	145	138	147	146
CO (mg/Nm ³ ; 11% O ₂)	< 10	< 10	22	18
SO ₂ (mg/Nm ³ ; 11% O ₂)	< 9	< 9	< 9	< 9
Total C (mg/Nm ³ ; 11% O ₂)	< 5	< 5	< 5	< 5

Source: [198, Waxwender et al, 2016]

The modifications required to enable a boiler burning fuel oil to burn tallow are very minor. It has been reported that burners are available which enable a boiler to burn tallow, natural gas, diesel or oil. If an alternative use or disposal route is not readily available, e.g. due to the grade of tallow produced, or is not considered to be economically viable, then burning the tallow in a boiler has been reported to be an easy and economic option.

Cross-media effects

NO_x and CO emissions may be high depending on the combustion operating conditions.
None reported.

Technical considerations relevant to applicability

Generally applicable in installations processing animal by-products and/or edible co-products producing animal fat.

At the time of writing, this technique is not permitted in the EU, due to the fact that in ABP Regulation 1774/2002/EC, it is neither listed, nor has it been approved in accordance with the procedure referred to in Article 33(2) therein, after consultation of the appropriate scientific committee.

Economics

There will be an initial cost for modifications to the fuel supply system and the burners. The running costs for natural gas compared to fuel oil are unlikely to increase, although the fuel price may be higher. The fuel cost will depend on the market in any given MS at any time and it may be higher or lower than alternative fuels. Costs of the technique will depend mainly on the prevailing fuel prices.

Driving force for implementation

Economic savings due to the replacement of fuel with animal fat. Reduced SO₂ emissions.

Example plants

Combustion of animal fat has been reported in approximately 20 % of rendering installations of the SA data collection. For example, a rendering installation (IT262) uses animal fat as fuel for cogeneration [264, TWG 2020].

Numerous slaughterhouses, rendering plants and other animal by product (and non animal byproduct) installations throughout Europe.

Reference literature

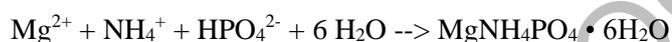
[167, Greek Ministry for the Environment, 2001, 265, EC, 2001] [55, Greek Ministry for the Environment 2001], [198, Waxwender et al. 2016], [201, COM 2011], [264, TWG 2020]

2.3.2.8 Phosphorus recovery as struvite**Description**

Phosphorus contained in waste water streams is recovered by precipitation in the form of struvite (magnesium ammonium phosphate).

Technical description

In the case of waste water containing high concentrations of phosphate, phosphorus can be recovered by precipitation of struvite. The reaction takes place by adding magnesium, at pH levels of 7.5 to 10. The result will be the formation of struvite (magnesium ammonium phosphate):



The most common technique for phosphorus recovery as struvite is carried out using waste water in stirred tank reactors, after anaerobic digestion. The waste water is usually aerated in a first tank (see Figure 2.37), which results in a pH increase due to CO₂ stripping. The process continues in a second reactor (where the magnesium chloride or magnesium oxide is mixed with the waste water) and a separation unit, where struvite is removed from the waste water, dewatered and dried. Recovered struvite has a crystal structure that is pure and can be reused as a fertiliser.

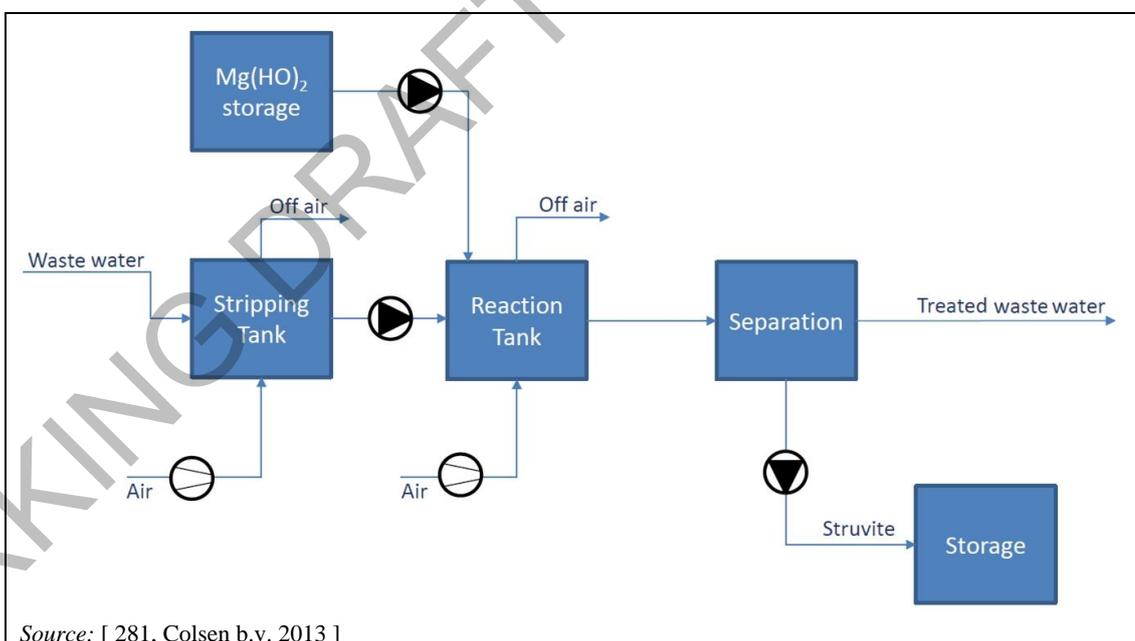


Figure 2.37: Flow diagram for one example of phosphorus recovery as struvite

Struvite can also be recovered from sewage liquors or sewage sludge digestate, with tens of installations operating at full scale worldwide, or from manure digestate or certain industry waste waters (semi-conductor industry, fertiliser industry, etc.) Other similar techniques exist at the development stage or operating at full scale for municipal waste waters or manures, recovering other phosphate salts (e.g. potassium struvite, brushite) or phosphoric acid which can be used in industry or converted to phosphate fertiliser products. For a general description of chemical precipitation, see Section 2.3.6.5.1.

Achieved environmental benefits

Reduced total phosphorus emission levels. Reduction of sludge production in the WWTP compared to chemical phosphorus precipitation. Recovery of phosphorus for other uses (e.g. as fertiliser).

The EU depends on imports for more than 90 % of its mined phosphorus. Phosphate rock and white phosphorus P₄ are both on the EU List of Critical Raw Materials.

Environmental performance and operational data

Request to the TWG: Please provide more information.

Average removal efficiencies of 80–90 % have been reported from the application of this technology in the food sector.. The effluent concentration that can be reached is no lower than 10–20 mg P-PO₄/l. When phosphate is recovered from the sewage sludge directly after anaerobic digestion, the risk of scaling problems in the remainder of the sludge line can be significantly reduced.

Cross-media effects

No information provided.

Technical considerations relevant to applicability

The technique is only applicable to waste water streams with a high total phosphorus content (e.g. above 50 mg/l) and a significant flow.

Economics

An investment cost of around EUR 983 000 for the treatment of 120 m³/h of waste water has been reported, for achieving an outlet P-PO₄ concentration of 20 ppm (inlet P-PO₄ concentration around 150 ppm) [206, Giner-Santonja et al. 2019]. The cost of recovery is lower compared to phosphorus removal by chemical precipitation using, for example, FeCl₃.

Phosphorus recovery as struvite can also result in a decrease in the costs for the treatment and disposal of sludge. There are potential revenues from selling the recovered struvite.

Driving force for implementation

In conventional waste water treatment plants, the remaining phosphorus is mainly eliminated by chemical precipitation with metal salts. However, large amounts of chemicals are required to obtain low emission levels (1 mg/l or 2 mg/l of TP), and large volumes of sludge are produced. Furthermore, metal phosphate salts, such as iron or aluminium, cannot be reused in agriculture because the iron or aluminium phosphates are not available for plants under normal pH conditions. Due to the presence of iron or aluminium (which are added to precipitate phosphates) and the increasing contamination of waste water sludge with heavy metals and toxic organic substances, its application in agriculture has become increasingly unpopular or has been phased out completely [282, Desmidt et al., 2015].

The recovered phosphate can be reused as a fertiliser, either directly or after further processing, improving the economic feasibility of the investment. For direct use as a fertiliser, the struvite produced has to be certified and recognised. Phosphorus recovery as struvite can help to prevent scaling problems in the WWTP.

Example plants

Request to the TWG: Please provide more information.

Potato processing and dairy installations [283, NuReSys 2016].

Reference literature

[206, Giner-Santonja et al. 2019], [281, Colsen b.v. 2013], [282, Desmidt et al., 2015], [283, NuReSys 2016]

2.3.2.9 Integrated site - slaughterhouse and rendering plant

Description

Operation of a rendering plant on a slaughterhouse site.

Technical description

A rendering plant may be operated on a slaughterhouse site. The by-products of the slaughter process and on-site waste water treatment may be treated on a continuous basis, thereby minimising the need for collection and transport, for use or disposal off-site, and the need for storage.

Achieved environmental benefits

Reduced energy consumption, reduced production of malodorous substances and reduced need for energy required for their treatment.

Environmental performance and operational data

Heat in the system can be recovered in the form of hot water and used, e.g. as cleaning water in the slaughterhouse.

The use of the tallow as a fuel, in theory could make the installation largely self-sufficient in terms of heating. At the time of writing, this is not permitted in the EU, due to the fact that in ABP Regulation 1774/2002/EC, it is neither listed, nor has it been approved in accordance with the procedure referred to in Article 33(2) therein, after consultation of the appropriate scientific committee.

Putrescible materials are used quickly, so there is minimal raw material degradation. The waste water treatment plant is not required to treat the products of decomposition and the odour problems associated with such treatment are thus avoided. The need for either a frequent collection service, or other means of preventing odour problems such as chilling is also avoided. There are consequent energy savings.

Category 1, 2 and 3 animal by-products can either be treated in separate rendering units or in combination, although mixtures containing Category 1 materials are deemed to be Category 1 and mixtures of Category 2 and 3 materials are deemed to be Category 2 and must be treated as such, as prescribed in ABP Regulation 1069/2009 1774/2002/EC.

Continuous rendering minimises the storage times and ensures that the existing boiler is available for the destruction of the non-condensable gases produced during rendering.

Cross-media effects

None in addition to those associated with slaughtering and rendering.

Technical considerations relevant to applicability

Applicable in all slaughterhouses SA installations.

Economics

The costs of separate collection and disposal of the various ABP Regulation 1774/2002/EC categories of animal by-products are saved. The investment and running costs of odour prevention and treatment techniques are minimised, during storage, processing and waste water treatment.

Payback periods of 2 - 3 years have been reported, for installing a rendering system in on a slaughterhouse site. The calculations included savings achieved by minimising the costs of collection, processing, cooling and concentration. They also took account of the value of saleable end-products, minus variable operating costs. Cost savings on transport, environmental protection and energy were also identified.

Driving force for implementation

Cost savings.

Example plants

Integrated slaughterhouses and rendering plants exist in 3 locations in Belgium, 1 in the Netherlands and 1 in France.

Reference literature

[321, RenCare nv, undated] [168, RenCare 2002]

Integrated site – slaughterhouse and animal carcass incinerator

See also the information about rotary kiln incinerators in 0. The information here concerns the integration of slaughtering with incineration.

Description

Slaughterhouses with a capacity over 50 t/d can have an on-site incinerator for the destruction of TSE and SRM material.

Achieved environmental benefits

Recovery of energy for internal use, e.g. for the production of steam or hot water for use in the slaughterhouse or for other associated activities on the site, such as blood processing and meat processing. Reduced time between slaughter and incineration, therefore, the by products are fresher and odour problems are potentially reduced. Rapid destruction of TSE confirmed, suspected or culled cases, fallen stock, dead on arrival animals and *ante mortem* condemned animals. Reduced packaging wastes. Reduced whole environmental impact associated with the transport of untreated SRM, from the risks associated with the SRM and from transport (transport between installations is outside the scope of the Directive).

Operational data

One case study incinerator, with a capacity of 1 t/h, is reportedly capable of destroying all of the SRM produced by a slaughterhouse killing 1 100 carcasses daily, five days a week. The heat recovered, using a reportedly under capacity boiler, raises 2 000 kg of steam per day.

Cross-media effects

None in addition to those associated with slaughtering and incineration.

Applicability

Applicable in slaughterhouses where there is sufficient space for an incinerator which can be adequately separated from the slaughterhouse to meet the requirements of ABP Regulation 1774/2002/EC.

Economies

This information concerns an incinerator on a cattle slaughterhouse site, for which some public funding was provided.

For an effective incinerator capacity of 0.5 t/h, i.e. 4380 kg/yr, an investment of EUR 2300000 has been reported. This has been quoted as being equivalent to EUR 0.525/kg. It has been estimated that the cost of a 1 tonne capacity incinerator would be more than twice the cost of a 0.5 t/h incinerator.

Payback, for the case study incinerator, is reported to be difficult to measure because of the public investment, but is estimated to be 4 years.

Driving force for implementation

Significant reduction in the amount of waste produced in the slaughterhouse requiring off-site treatment. Reduced risk of cross-contamination by different sources of materials destined for rendering to make animal meal.

Example plants

Two cattle slaughterhouses in Italy have on site rotary kiln incinerators for the direct and dedicated incineration of some of their SRM.

Reference literature

[269, Italian TWG Members, 2002]

Integrated site – rendering plant and animal meal incinerator

See also the information about BFB incinerators in 0. The information here concerns the integration of rendering with incineration.

Description

At an example site, a rendering plant and a BFB incinerator are situated on the same site. The rendering plant provides the feedstock for the incinerator. The incinerator is capable of burning malodorous gases from the rendering process, and the steam and electricity produced by the incinerator can be used for the rendering process.

Achieved environmental benefits

Integrating the rendering plant with the incinerator provides a convenient and reportedly effective means of destroying malodorous gases. These arise in rooms, storage vessels and from pretreatment and handling equipment and they include non condensable gases which have the most intense and offensive odours, which are produced during rendering. These malodorous gases would otherwise require an alternative means of destruction. To ensure that all of the malodorous non condensable gases are destroyed, the incinerator needs to be running all of the time when they are being produced. Many incinerators operate continuously.

The steam and electricity produced by the incineration process can be used directly in the rendering plant.

Off site transport is not regulated under IPPC, however, by removing the requirement to transfer animal meal from the rendering site to the incinerator the environmental impact associated with transport, which is usually carried out by road, is also removed.

Data was provided for what is reported to be a typical rendering plant with on-site incineration of MBM.

Operational data

Figure shows some consumption and emission data for rendering 1 tonne of animal by products and the subsequent on-site incineration of MBM.

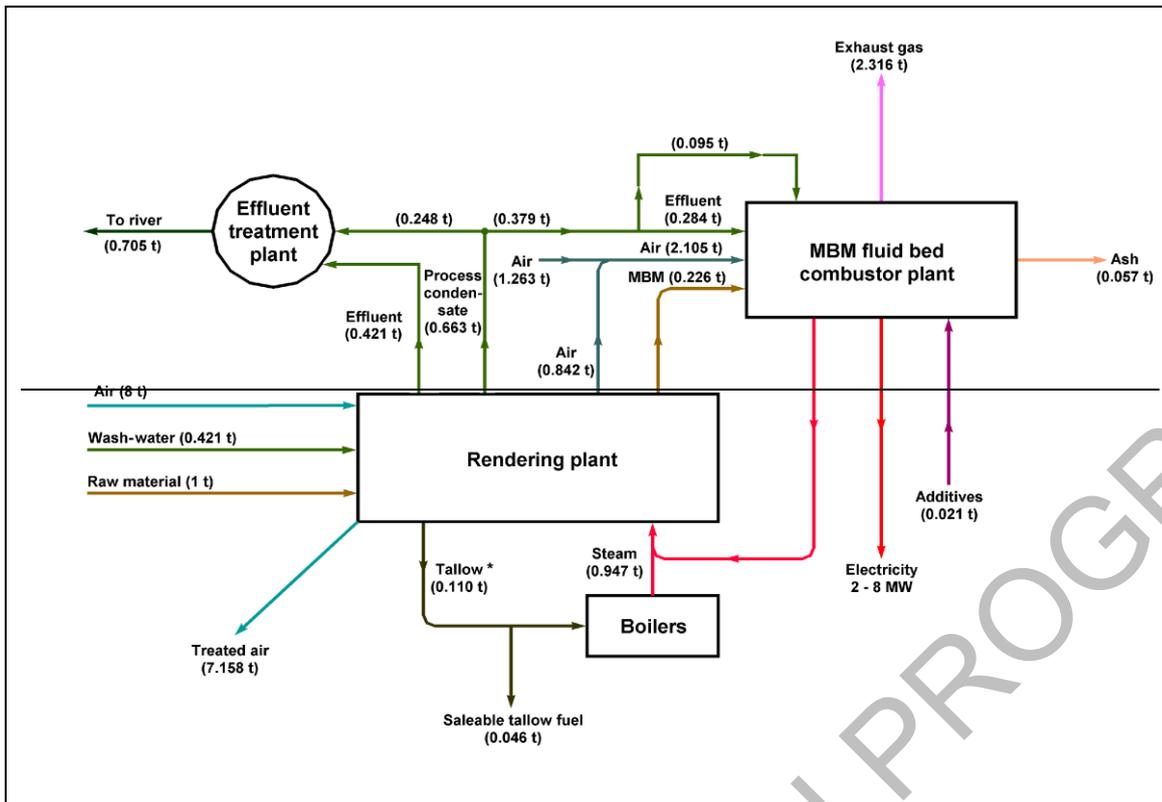


Figure: Consumption and emission data for rendering with on-site burning of MBM

[199, PDM Group and Wykes Engineering (Rushden) Ltd, 2000]—adapted

*At the time of writing, burning tallow in a boiler is not permitted in the EU, due to the fact that in ABP Regulation 1774/2002/EC, it is neither listed, nor has it been approved in accordance with the procedure referred to in Article 33(2) therein, after consultation of the appropriate scientific committee.

The malodorous air from rendering plant rooms can be used as the incinerator air supply, because the BFB temperature can also incinerate the malodorous compounds.

Cross-media effects

Only those associated with rendering and incineration. No additional cross-media effects due to the integration of the processes have been reported.

Applicability

Applicable in slaughterhouses where there is sufficient space for an incinerator and in particular where the animal meal being produced has to be incinerated or co-incinerated to comply with ABP Regulation 1774/2002/EC. The rendering treatments and Categories of material used to produce animal meal which must be incinerated are summarised in-

Driving force for implementation

The BSE crisis in the UK.

Example plants

There is at least one BFB incinerator burning MBM on the same site as a rendering plant in the UK.

Reference literature

[199, PDM Group and Wykes Engineering (Rushden) Ltd, 2000]

2.3.3 Monitoring

2.3.3.1 Overview

Real data are required on the precise effects of the activities of the industrial site on the environment. It is thus necessary to implement a planned, regular sampling and monitoring programme. The parameters monitored include:

- point sources' channelled, diffuse and fugitive emissions to the atmosphere, water or the sewer;
- wastes;
- contamination of land, water and air;
- use of water, fuels, energy, oxygen, nitrogen and other gases;
- discharge of thermal energy, noise, odour and dust;
- effects on specific parts of the environment and ecosystems;
- on-site accidents and near misses;
- staff injuries;
- transport accidents;
- complaints from community residents.

Monitoring, however, is not restricted to analytical measuring. It also includes regular maintenance, and visual and safety checks.

Parallel to this document, a Reference Report on Monitoring of Emissions to Air and Water from IED installations [258, Brinkmann et al. 2018] exists to which the reader is referred for further information.

2.3.3.2 Integrated monitoring system

Description

Integrated monitoring system, formed by a large amount of measuring equipment and permitting the tracking of the energy, gas and water consumption from input to points of consumption.

Technical description

An integrated monitoring system is formed by a large amount of measuring equipment and it permits the tracking of the energy, gas and water consumption from input to points of consumption. The system can obtain data from measuring equipment, such as calorimeters, electric watt-hour meters, gas meters and CO₂ meters.

Monitoring of water and energy consumption could include direct measurements, calculation or recording, e.g. using suitable meters or invoices. The monitoring is broken down at the most appropriate level (e.g. at process or plant/installation level) and considers any significant changes in the plant/installation.

This technique could also include a system of hardware and software for the automatic detection of electric energy and water consumption. It allows the constant monitoring of installation energy consumption (process consumption and utilities such as air compressors, air treatment units, refrigeration units and lighting), the detection of deviations and the estimation of the consumption reduction.

Achieved environmental benefits

Benefits include the control and measurement of water and energy consumption in an integrated way. This permits the main points of consumption and potential points of savings to be identified, consumption levels to be controlled, points of losses or incorrect functioning to be identified, and achieved savings to be measured.

Environmental performance and operational data

An example of monitoring is to control temperature, by dedicated measurement and correction.

Technical considerations relevant to applicability

The technique can be implemented in the overall operation of a SA installation.

Economics

Investment and operating costs generally depend on the type of measurement and the complexity of the installation.

Driving force for implementation

The implementation of this technique is stimulated by the potential economic savings, rise in yield and efficiency, and improvement of operating conditions.

Example plants

Various SA installations.

Reference literature

[206, Giner-Santonja et al. 2019]

2.3.3.3 Monitoring of influent and effluent waste water

Description

For relevant emissions to water, monitoring of key process parameters at key locations of a waste water treatment facility.

Technical description

Proper operation of a waste water treatment facility requires the monitoring and targeted adjustment of various process parameters in the influent and effluent of the facility. Monitoring of the relevant parameters can be accomplished by online measurements (that facilitate rapid intervention and control) or analytical results derived from waste water samples. Parameters to be monitored and the frequency of monitoring depend on the characteristics of the waste water to be treated, the final effluent discharge medium and the waste water treatment techniques used within the facility, based on an inventory of waste water streams. They may include, for instance, the waste water flow, pH, temperature, conductivity or BOD.

The monitoring is carried out at key locations, e.g. at the point where the emission leaves the installation and/or at the inlet and/or outlet to pretreatment and at the inlet to final treatment. Important parameters are monitored at the level of each waste water treatment technique of the facility to ensure the proper operation of the techniques and the subsequent treatment steps.

Achieved environmental benefits

Monitoring the influent and effluent waste water of a waste water treatment facility helps to maintain the proper operation of the facility and to detect accidental releases and thus helps to prevent any possible adverse environmental effects upon discharge of waste waters.

Environmental performance and operational data

No information provided.

Cross-media effects

Some equipment, chemicals and energy are required for carrying out monitoring. The COD measurement relies on the use of very toxic compounds (i.e. mercury and/or chromate).

Technical considerations relevant to applicability

Generally applicable.

Economics

The costs associated with monitoring the influent and effluent waste water of a WWTP relate to personnel and equipment used for sampling and measurement.

Driving force for implementation

The driving force is to ensure the proper operation of the WWTP and to ensure that the required quality of the effluent waste water from the WWTP is met and in line with the effluent discharge criteria.

Example plants

Monitoring of influent and effluent in a waste water treatment facility is applied in a number of installations throughout the EU.

Reference literature

[239, Brinkmann et al. 2016]

2.3.3.4 Monitoring of emissions to water**Description**

Proper operation of a waste treatment plant requires the monitoring and targeted adjustment of various process parameters in the effluent of the waste treatment plant.

Technical description

Monitoring of the relevant parameters can be accomplished by online measurements (that facilitate rapid intervention and control) or analytical results derived from waste water samples. Parameters to be monitored and the frequency of monitoring depend on the characteristics of the waste water, which are connected *inter alia* to the type of process, to the type of raw materials in the installation, and to the final effluent discharge medium.

The monitoring of emissions is carried out in accordance with EN standards or, if EN standards are not available, ISO, national or other international standards which ensure the provision of data of an equivalent scientific quality.

Achieved environmental benefits

Monitoring the waste water of a SA installation helps to maintain its proper operation and to detect accidental releases and thus helps to prevent any possible adverse environmental effects upon discharge of waste water.

Environmental performance and operational data

This information is detailed later in this document for each type of SA installation in the dedicated chapters (Chapters 3 and 4).

Cros-media effects

Some equipment, ancillary materials and energy are required for carrying out monitoring. The COD measurement relies on the use of very toxic compounds (i.e. mercury and/or chromate).

Technical considerations related to applicability

Generally applicable to all SA installations where there are emissions to water.

Economics

The costs associated with monitoring the effluent waste water of a SA installation relate to personnel and equipment used for sampling and measurement.

Driving force for implementation

Legislation on water pollution.

Example plants

See examples in Chapters 3 and 4.

Reference literature

[258, Brinkmann et al. 2018] , [239, Brinkmann et al. 2016]

2.3.3.5 Monitoring of channelled emissions to air

Description

Proper operation of a SA installation requires the monitoring and targeted adjustment of various process parameters in its channelled emissions to air.

Technical description

Monitoring of the relevant parameters can be accomplished by online measurements (which facilitate rapid intervention and control) or analytical results derived from air samples. Parameters to be monitored and the frequency of monitoring depend *inter alia* on the type of process and on the characteristics of the raw materials processed in the installation.

The monitoring of emissions is carried out in accordance with EN standards or, if EN standards are not available, ISO, national or other international standards which ensure the provision of data of an equivalent scientific quality.

Achieved environmental benefits

Monitoring the waste gas of a SA installation helps to maintain its proper operation and to detect accidental releases and thus helps to prevent any possible adverse environmental effects upon emission of waste gas.

Environmental performance and operational data

This information is detailed later in this document for each type of SA installation in the dedicated chapters (Chapters 3 and 4).

Cross-media effects

Some equipment, ancillary materials and energy are required for carrying out monitoring.

Technical considerations related to applicability

Generally applicable to all SA installations where there are channelled emissions to air.

Economics

The costs associated with monitoring the waste gas relate to personnel and equipment used for sampling and measurement.

Driving force for implementation

Legislation on air pollution.

Example plants

See examples in Chapters 3 and 4.

Reference literature

[258, Brinkmann et al. 2018] , [239, Brinkmann et al. 2016]

2.3.3.6 Odour monitoring

Description

Odour monitoring is carried out using analytical methods (i.e. physical and chemical analysis) or sensorial approaches. Sensorial analyses, being assigned to ‘human sensors’, are the cause of significant uncertainties.

Technical description

The techniques include:

- for odour concentration determination (expressed in OU_E/m^3 , to control limit values): dynamic olfactometry (measured according to the European standard EN 13725);
- for odour in ambient air: the grid method (according to the European standard EN 16841-1) or the plume method (according to the European standard EN 16841-2) to determine the odour exposure;
- for odour perception in the surrounding area (impact): odour surveys (see odour intensity mapping and odour wheels);
- electronic noses.

To determine the odour concentration, an air sample must be taken. The sampling techniques are similar to those used for measuring individual compounds.

Techniques for odour monitoring are described in [258, Brinkmann et al. 2018] and in [239, Brinkmann et al. 2016].

Achieved environmental benefits

The achieved environmental benefit is the minimisation of odorous emissions.

Environmental performance and operational data

See [258, Brinkmann et al. 2018] and [239, Brinkmann et al. 2016].

Cross-media effects

None.

Technical considerations related to applicability

Odour monitoring is applicable where an odour nuisance at sensitive receptors is expected and/or has been substantiated.

Economics

See [258, Brinkmann et al. 2018] and [239, Brinkmann et al. 2016].

Driving force for implementation

The driving forces for implementation include legislation and complaints occurring in the vicinity of the installation/site.

Example plants

See Chapters 3 and 4.

Reference literature

[239, Brinkmann et al. 2016], [258, Brinkmann et al. 2018]

2.3.3.7 Consumption and stream inventory/register

Description

The compilation of relevant basic data on water, energy and raw materials consumption as well as on the composition and quantity of waste water and waste gas streams – each one individually – is done in a consumption and stream inventory/register. The consumption and emitted streams are listed respective to their source, i.e. the process from which they originate. This is a key element in assessing the resource efficiency of the installation, the nature of the contaminants as well as the possibilities of reduction at the source.

Technical description

A consumption and stream inventory/register addresses the following aspects, if relevant to the particular local conditions:

- I. Information about the production process(es), including:
 - (a) simplified process flow sheets that show the origin of the emissions;
 - (b) descriptions of process-integrated techniques and waste water/waste gas treatment techniques to prevent or reduce emissions, including their performance (e.g. abatement efficiency).
- II. Information about energy consumption and usage.
- III. Information about water consumption and usage (e.g. flow diagrams and water mass balances).
- IV. Information about the quantity and characteristics of the waste water streams, such as:
 - (a) average values and variability of flow, pH and temperature;
 - (b) average concentration and mass flow values of relevant substances/parameters (e.g. COD/TOC, nitrogen species, phosphorus) and their variability.
- V. Information about the characteristics of the waste gas streams, such as:
 - (a) emission point(s);
 - (b) average values and variability of flow and temperature;
 - (c) average concentration and mass flow values of relevant substances/parameters (e.g. dust, TVOC, NO_x, SO_x) and their variability;
 - (d) presence of other substances that may affect the waste gas treatment system or plant safety (e.g. oxygen, water vapour, dust).
- VI. Information about the quantity and characteristics of the process chemicals used:
 - (a) the identity and the characteristics of process chemicals, including properties with adverse effects on the environment and/or human health;
 - (b) the quantities of process chemicals used and the location of their use.

Achieved environmental benefits

The reduction of emissions to water and/or air. Identification of relevant waste water/waste gas streams is a prerequisite for an efficient waste water/waste gas management and for the reduction of emissions by technical and management measures.

Environmental performance and operational data

Request to the TWG: Please provide information.

Cross-media effects

None.

Technical considerations related to applicability

The scope (e.g. level of detail) and nature of the inventory will generally be related to the nature, scale and complexity of the installation, and the range of environmental impacts it may have.

Economics

No information provided.

Driving force for implementation

Inventories/registers may be used to assess the implementation of BAT and may constitute basic information for authorities in order to set emission limit values.

Example plants

Stream inventories are applied in a number of installations throughout the EU.

Reference literature

[206, Giner-Santonja et al. 2019]

2.3.4 Techniques to increase energy efficiency**2.3.4.1 General processing techniques****2.3.4.1.1 Energy efficiency plan and energy audits****Description**

An energy efficiency plan entails defining and calculating the specific energy consumption of the activity (or activities), setting key performance indicators on an annual basis (for example for the specific energy consumption) and planning periodic improvement targets and related actions. The plan is adapted to the specificities of the installation.

Technical description

An energy efficiency plan and energy audits are part of the environmental management system (EMS) and include:

- energy flow diagrams;
- establishment of energy efficiency objectives;
- implementation of actions to achieve these objectives.

Energy audits are carried out at least annually to ensure that the objectives of the energy efficiency plan are met.

Management to achieve energy efficiency requires structured attention to energy with the objective of continuously reducing energy consumption and improving efficiency in production and utilities, and sustaining the achieved improvements at both company and site level. It provides a structure and a basis for the determination of the energy efficiency, defining possibilities for improvement and ensuring continuous improvement. All effective energy efficiency (and environmental) management standards, programmes and guides contain the notion of continuous improvement, meaning that energy management is a process, not a project which eventually comes to an end.

There are various process designs, but most management systems are based on the plan-do-check-act approach (which is widely used in other company management contexts). ISO 50001 is one of the more globally widespread standards for energy efficiency management systems.

More information on energy efficiency management systems can be found in the ENE BREF [247, COM 2009].

Some common techniques applicable to increase the energy efficiency of SA plants are as follows:

- a. Appraising the costs and benefits of different energy options.
- b. Monitoring energy flows (consumption and generation by source) and the targeting of areas for reductions (see also Section 2.3.4.1.2).
- c. Defining and calculating the specific energy consumption of the activity (or activities), and setting key performance indicators on an annual basis (e.g. MWh/tonne of carcass).
- d. Carrying out an energy survey to identify the opportunities for further energy savings.
- e. Optimising boilerhouses (reuse of condensed water, preheating of air supply, heat recovery in combustion gases) and optimising boiler design according to energy demand profile (see also the LCP BREF [266, Lecomte et al. 2017]).
- f. Using combined heat and power (CHP).
- g. Applying operating, maintenance and housekeeping measures to the most relevant energy-consuming systems such as:
 - air conditioning, process refrigeration and cooling systems (leaks, seals, temperature control, evaporator/condenser maintenance);
 - insulation of pipes, vessels and equipment (see also Section 2.3.4.1.9);
 - operation of motors and drives (e.g. high-efficiency motors);
 - compressed gas systems (leaks, procedures for use);
 - steam distribution systems (leaks, traps, insulation);
 - management of hot water systems (see also Section 2.3.4.2.3);
 - lubrication to avoid high friction losses (e.g. mist lubrication);
 - boiler maintenance, e.g. optimising excess air;
 - other maintenance relevant to the activities within the plant;
 - reviewing equipment requirements on a regular basis.
- h. Using techniques that reduce energy consumption and thereby reduce both direct (heat and emissions from on-site generation) and indirect (emissions from a remote power station) emissions. For example:
 - building insulation;
 - use of energy-efficient site lighting (see also Section 2.3.4.1.3);
 - efficient plant layout to reduce pumping distances;
 - variable speed drives;
 - optimisation of air conditioning systems (e.g. by sections or by direct conditioning of specific weaving machines for individual adaptation of volume and humidity);
 - ensuring equipment is switched off, if safe to do so, when not in use;

Achieved environmental benefits

See energy efficiency management systems in the ENE BREF [247, COM 2009].

Environmental performance and operational data

No information provided.

Cross-media effects

See energy efficiency management systems in the ENE BREF [247, COM 2009].

Technical considerations relevant to applicability

See energy efficiency management systems in the ENE BREF [247, COM 2009].

Economics

No information provided.

Driving force for implementation

The implementation of the energy management system allows the energy consumption of the installation to be monitored.

Example plants

This technique is widely applied. This technique has been reported in approximately 50 % of the installations participating in the SA data collection [264, TWG 2020].

Reference literature

[247, COM 2009], [264, TWG 2020]

2.3.4.1.2 Monitoring of energy consumption**Description**

Monitoring of energy consumption, as part of the energy efficiency plan (see Section 2.3.4.1.1).

Technical description

Monitoring comprises the establishment of a register of energy-consuming processes and of all single aggregates including air conditioning and lighting. If no energy consumption meters are installed, the power values of aggregates are registered together with the estimated mean consumption and running times. Consumption data are connected to cost data according to each energy source.

Achieved environmental benefits

Reduction of the environmental impact associated with energy production by identification of the main energy consumers and related efficient prioritisation of improvement measures as well as by awareness-raising and training of employees.

Environmental performance and operational data

For monitoring consumption, indicators are defined for the entire plant and for single processes, together with determined periods for data collection, e.g. energy consumption (gas, oil, etc.) per tonne of steam produced, electricity consumption for compressed air per tonne of product produced, electricity consumption of big aggregates per tonne of product produced, consumption of steam and electricity per processed good or group of goods, consumption of steam and electricity per processed good during dyeing and drying, gas consumption of the stenter frame per group of goods.

Consumption data are communicated to the workers in charge of the respective process, and training on reduction measures conducted.

Based on the latest up-to-date energy cost data, the economic viability of potential energy saving measures are regularly recalculated.

Cross-media effects

None identified.

Technical considerations relevant to applicability

Generally, there are no technical restrictions to the applicability of this technique.

Restrictions for the use of consumption meters may occur in existing installations if potential energy savings are expected to be low in relation to the meter installation costs.

Economics

Request to the TWG: Please provide information.

Driving force for implementation

Energy savings.

Example plants

This technique is widely applied.

Reference literature

[246, COM 2019]

Management and monitoring of hot water use

Technical description

The heating and pumped circulation of water at 82 °C can be stopped automatically when slaughter operations stop, after which time only cold water and water at 60 °C needs to be available, e.g. for cleaning purposes. In a large pig slaughterhouse in Denmark, it has been reported that the temperature of the water has been reduced from 60 to 50–55 °C and cleaning is carried out at 1.62 kPa, instead of at a higher pressure.

Achieved environmental benefits

The energy used to heat and pump water at unnecessarily high temperatures can be saved. Fats which have not been prevented from entering waste water, are easier to remove at lower temperatures.

Operational data

According to Danish reports, water at 60 °C gives the best cleaning result, due to its ability to remove fat. Using water at a lower temperature requires the use of either greater quantities or more aggressive cleaning agents. Higher temperatures could reduce the use of cleaning agents, but lead to an increased energy use.

Cross-media effects

If water is used at a higher temperature then the amount and/or aggressiveness of the cleaning chemicals used could be lessened, but on the downside more energy would be required to heat the water to the higher temperature. Below 60 °C, the opposite could be true.

Applicability

Applicable at all slaughterhouses.

Example plants

Cleaning using water at 60 °C is undertaken in Danish slaughterhouses. Cleaning using water at 50–55 °C, at 1.62 kPa is undertaken in at least one large pig slaughterhouse in Denmark.

Reference literature

[134, Nordic States, 2001, 243, Clitravi—DMRI, 2002]

Implement energy management systems

Description

Improving energy efficiency can lead to significant financial savings.

Achieved environmental benefits

Reduced energy use and potential reductions in other consumption and emission levels associated with some unit operations. For example, reduced hot water consumption can result in a lower consumption of both energy and water. Adopting a formal approach to assessing consumption and identifying areas for potential improvement can help identify areas which may otherwise be overlooked, e.g. in slaughterhouses a significant proportion of the overall energy consumption is from refrigeration outside slaughtering times.

Operational data

Formal methods which give a structured approach to assessing the current situation and introducing improved systems for managing ongoing improvements are available. One such method is summarised in Table. It provides a scoring system based on 6 performance criteria, which when analysed can be used to identify the organisations weak and strong points and what the priorities for improvement are. It includes reference to financial costs and savings, so it may be used to attract the attention of senior managers, for whom profitability of the organisation is likely to be a high priority. The scores obtained indicate the potential improvement for each criteria and they can be used to plan and prioritise improvements. The scoring system may be repeated periodically to monitor any improvements.

Improvements in each performance criteria may involve the provision of information, instruction and training to motivate change at all levels of the organisation.

Level	Performance criteria					
	Energy policy	Organising	Motivation	Information systems	Marketing	Investment
4	Energy policy, action plan and regular review with the commitment of top management	Energy management fully integrated into management structures. Clear delegation of responsibility	Formal and informal channels of communication regularly exploited	Comprehensive system that sets targets, monitors consumption, identifies faults, quantifies savings and provides budget tracking	Marketing the value of energy efficiency and the performance of energy management both within the organisation and outside it	Positive discrimination in favour of 'green' schemes with detailed investment appraisal of all new build and refurbishment opportunities
3	Formal energy policy but no active commitment from top management	Energy manager accountable to energy committee representing all users, chaired by a member of the managing board	Energy committee used as main channel together with direct contact with major users	Monitoring and targeting reports for individual premises based on submetering, but savings not reported effectively to users	Programme of staff awareness and regular publicity campaigns	Same payback criteria employed as for all other investments
2	Unadopted energy policy set by energy manager or senior departmental manager	Energy manager in post, reporting to ad hoc committee, but line management and authority are unclear	Contact with major users through ad hoc committee chaired by senior departmental manager	Monitoring and targeting reports based on supply meter data. Energy unit has ad hoc involvement in budget setting	Some ad hoc staff awareness training	Investment using short term payback criteria only
1	An unwritten set of guidelines	Energy management the part time responsibility of someone with only limited authority or influence	Informal contacts between engineer and a few users	Cost reporting based on invoice data. Engineer compiles reports for internal use within technical department	Informal contacts used to promote energy efficiency	Only low cost measures taken
0	No explicit policy	No energy management or formal delegation of responsibility	No contact between energy managers and users	No information system. No accounting for energy consumption	No promotion of energy efficiency	No investment in increasing energy efficiency in premises

Note—0 = poor and 4 = good

Table : Energy management matrix

Cross-media effects

None.

Applicability

Applicable in slaughterhouses and animal by products installations.

Economies

It is reported that improved energy management could reduce the amount of money spent on energy on a national basis in the UK, by 20 %. The money saved could then be used to, e.g. fund core activities, lower operating costs/raise profits, improve products or services, or to upgrade working conditions to reduce the organisations impact on the environment.

Driving force for implementation

Reduced energy consumption and consequent costs.

Reference literature

{300, ETSU, 1998}

Energy management at a red meat plant

This “technique” is summarised in a case study report of an energy and water saving project carried out at an installation where cattle and sheep are slaughtered. Some deboning of meat and rendering of by products is also undertaken at this site. The project incorporated several general techniques that may be considered for application in slaughterhouses and animal by products installations. Some of the individual techniques will be described under separate headings. The overall project is reported for three reasons: (1) It illustrates the method used to identify those unit operations which were high consumers and/or high emitters, where improvements could be made (2). It shows the importance of management commitment to such an initiative, in ensuring that it is implemented successfully (3). It also shows that for this commitment to exist, managers need to understand the issues and the potential benefits to be derived from investing in pollution prevention and control techniques. Note, however, that not all of the environmental and financial benefits were calculated for each individual technique introduced.

Technical description

An energy saving strategy was undertaken at a red meat plant using a computerised “Monitoring and Targeting” (M & T) system. The system continuously monitors oil; electricity; hot and cold water; temperatures in chill rooms and cold working areas; whether chill room doors are open or closed; whether the chiller plant is on or off; whether the boiler is on or off and the temperatures in the fat plant and by products plant. It is also used to obtain fuel and water consumption figures in specific areas of the installation.

Steam, hot water, cold water and electricity are individually metered in slaughter halls, deboning halls, the office block, fat plant and the by products plant. Targets for usage are set. This is reported to have been particularly successful for hot water usage. This success appears to be due to hot water usage being the most personally attributable service and this has reportedly led to a competitive spirit among the workforce, on a departmental basis.

The electricity, fuel oil and water consumption were linked to production levels, using a computer spreadsheet program. As a result senior managers became very interested in energy reduction. Investment was made in energy saving measures. The project's success was secured by the enthusiasm engendered in the shop floor employees. The technique helped to prove the effectiveness of the energy saving measures introduced and thereby encouraged further action. The continuous monitoring of fuel and water consumption enabled anomalous readings to be investigated and addressed, thereby avoiding excessive costs.

The main technical improvements made were as follows. Sterilisation tanks were installed for knives used in slaughtering and deboning. Hand and apron cleaning cubicles were installed. Steam, water and compressed air pipework was rationalised and insulated. Override electrical control panels were installed. Refrigeration plant time controls were installed, to take account of actual process requirements. Computer controlled isolation valves were installed for hot water

and steam supplies. A computerised system was introduced for setting off alarms when chill room doors and external loading doors were left open and for measuring the length of time they were left open.

Additional energy saving actions which could have been taken include the insulation of walls and roofs against heating and cooling. Around 25–40 % of heat is lost through the outside walls of a poorly insulated building. Good insulation can reduce such loss by up to 75 %.

Achieved environmental benefits

Reduced energy and water consumption.

Operational data

The installation described in the case study reported that the reduced use of fuel oil and electricity saved 6914 GJ and 820 GJ, respectively, per year. The reduction in emissions as a consequence of reduced fuel use at the installation was approximately 561 t of CO₂ and 9.7 t of SO₂ per year and due to reduced electricity use was approximately 164 t CO₂ and 2.8 t of SO₂ at the power station. A reduction in water usage from 116 000 m³ to 95 000 m³, i.e. 21 000 m³ per year was reported. This was also reflected in a reduced effluent discharge, although this cannot be quantified as it preceded the installation of a meter for monitoring effluent, which was installed after the case study measurements were made and after a new effluent plant was installed. The new effluent plant resulting in reduced COD and suspended solids in the discharge.

Cross-media effects

No negative environmental impacts were reported.

Applicability

Applicable at all slaughterhouses and animal by-products installations.

Economics

The implementation costs; annual actual energy and water savings; actual financial savings and payback time are shown in table.

Table: Summary of costs and savings associated with environmental improvements

	Date	Energy saving (GJ)	Water saving (m ³)	Financial saving (GBP)				Cost of implementation (GBP)	Payback period (years)
				Energy	Water	Effluent	Total		
Knife sterilisation tanks	Sep 91	2518	6435	5213	3185	1840	10238	6000	0.6
Conversion of electricity tariff to HV and bulk tariff	Oct 91 + Apr 93	-	-	53823	-	-	53823	43900	0.8
Hand and apron wash	Oct 91–Mar 92	2035	11700	4213	5792	3346	13351	17000	1.3
Rationalisation and insulation of steam, water and air pipework	Jul 92	474	-	982	-	-	982	1100	1.1
Override control panels	Aug 92	325	-	3612	-	-	3612	13000	3.6
Refrigeration plant time control	Apr 93	269	-	3563	-	-	3563	-	-
Isolation of steam and water services	Apr 93	1891	2700	3914	1335	770	6019	15000 ⁽²⁾	2.5
Computerised M&T system	Apr 93	-	-	-	-	-	-	60000 ⁽¹⁾	-
Chill room door closing control microswitches	Oct 91 + Jul 93	226	-	3000	-	-	3000	4100	1.4
Totals		7738	20835	78320	10312	5956	94588	160100	1.7

⁽¹⁾ The total cost of the overall M&T system and the isolation of steam and water services was GBP 75000; GBP 15000 was accounted for by the isolation of steam and water services, the remainder being the cost of the computerised M&T system.

⁽²⁾ Included in the computerised M&T system costs.

Economic data from 1993

Driving force for implementation

As the company's energy costs increased a method of systematically reducing them was sought and identified. The method was attractive because the reduced energy costs could be both measured and related to production levels.

Example plants

A cattle and sheep slaughterhouse in the UK.

Reference literature

[52, DoE 1994], [159, EC 2001], [347, German TWG members 2003]

2.3.4.1.3 Implementation of Lighting management system

Description

Ensure the application of an efficient lighting system in the installation.

Technical description

Existing fluorescent light fittings in rooms that are normally occupied, with either ineffective reflectors or without reflectors and using two fluorescent tubes can be reconstructed to incorporate a reflector and to use a single energy-saving tube. Energy can be saved without a reduction in the lighting efficiency.

In rooms which are not regularly occupied, such as packaging materials store and the hide room, the lighting can be sensor-controlled.

Achieved environmental benefits

Reduced energy and water consumption.

Environmental performance and operational data

Any requirements for emergency lighting, for health and safety or fire purposes cannot be compromised.

Cross-media effects

None.

Technical considerations relevant to applicability

Applicable in all slaughterhouses and animal by-products installations.

Driving force for implementation

Reduced energy consumption and associated costs.

Example plants

This technique has been reported in approximately 40 % of the installations participating in the SA data collection [264, TWG 2020].

~~At least one large Danish cattle slaughterhouse and a poultry slaughterhouse in the UK have introduced sensor operated lights in rooms which are not regularly occupied. A poultry slaughterhouse in the UK has installed reflectors fitted with a single energy saving tube.~~

Reference literature

[134, Nordic States, 2001] [38, Nordic 2001], [167, Greek Ministry for the Environment, 2001] [55, Greek Ministry for the Environment 2001], [243, Clitravi - DMRI, 2002] [190, Clitravi - DMRI 2003], [264, May G. E., 2001] [118, May G.E. 2001], [264, TWG 2020]

2.3.4.1.4 Heat recovery

Description

Use of heat exchangers and heat pumps to recover heat.

Technical description

The SA sector has plenty of examples of heat recovery. The most commonly used heat recovery methods are the following:

- direct usage: heat exchangers make use of heat as it is in the surplus stream;
- heat pumps upgrade the heat in relatively cold streams so that it can perform more useful work than could be achieved at its present temperature (i.e. an input of high-quality energy raises the energy quality of the waste/surplus heat).

Heat can be also recovered from the blowdown of a boiler.

Another example of heat recovery is related to air compressors. From 80 % to 90 % of the mechanical energy that is consumed by compressors in an air-compressed system is converted to thermal energy. This causes an increase in air temperature and for this reason a compressor cooling system is required. In this way, this heat can be recovered and reused. The heat output from air compressors can be crossed with water or air to transfer the heat and, then, the heat can be reused. Heating systems, the drying processes and heat feed to the steam boiler or oven burners are the main applications of the heated airstream. The applications of heated water streams are varied.

Achieved environmental benefits

Reduction of energy consumption.

Environmental performance and operational data

There are multiple ways of heat recovery reported in the questionnaires of the SA BREF data collection. Some examples are presented in Table 2.5.

Table 2.5: Various examples of heat recovery in the SA sector

Type of SA activity	Source of heat	Purpose of recovery	Example installations
Slaughterhouses	Refrigeration plants	Heating of washing and domestic water, avoiding condensation in slaughter room, defrosting cooling units, compressors, water for heating/cooling system	BE020, BE024, FR238, FR249, FR256, PL289, PT269, SE185, SE186
	Pig singeing exhaust gases	Cooling system Preheating of water	BE030, DE063, DE064, various Finnish pig slaughterhouses (see also Section 3.3.3.1.2)
	Hot water used for showering carcasses	Preheating of water	FR242
Rendering and fat-melting plants	Waste gas from cooking/drying process	Hot water for cleaning, scalding, district heating system	AT017, BE020, DE072, DE073, DE074, FI143
	Steam condenser	Heating fat and water	ES132
	Boiler	Heating of cleaning water, make-up water for steam boiler	BE020, BE025
	Condensate from steam circuit	Heating of cleaning water	ES139, FR241, IT262
	Thermal boiler linked to a thermal oxidiser	Steam for the rendering process	FR250
Fishmeal and fish oil plants	Drying of press cake, grax and evaporated stickwater in a falling film evaporator	Evaporate water from stickwater	A fishmeal and fish oil factory in Denmark (see also Section 4.4.4.1.1)
	Dryer, evaporator	Heating of raw material, evaporator, district heating	DE071, DK092, NO280, NO281
	Boiler	Boiler	FR245, [252, Spain 2020]

Source: [215, COM 2005], [252, Spain 2020], [264, TWG 2020]

Cross-media effects

No information provided.

Technical considerations relevant to applicability

Heat recovery opportunities are present in existing and new SA installations. As indicated in the ENE BREF [247, COM 2009], heat recovery is not applicable where there is no demand that matches the production curve.

Economics

See Table 2.5.

Driving force for implementation

Energy savings.

Example plants

Heat recovery is commonly reported in various SA sectors. This technique has been reported in approximately 50 % of the installations participating in the SA data collection [264, TWG 2020].

Reference literature

[215, COM 2005], [247, COM 2009], [252, Spain 2020], [264, TWG 2020]

2.3.4.1.5 Energy-efficient motors**Description**

Use of high-efficiency motors to minimise motor losses.

Technical description

Motor losses can be minimised by specifying higher efficiency motors where feasible. More information on energy-efficient motors can be found in the ENE BREF [247, COM 2009].

Achieved environmental benefits

Reduced energy consumption.

Environmental performance and operational data

See energy-efficient motors in the ENE BREF [247, COM 2009].

Cross-media effects

See energy-efficient motors in the ENE BREF [247, COM 2009].

Technical considerations relevant to applicability

Applicable where motors are used.

Economics

Reduced energy costs.

Driving force for implementation

Reduced energy costs.

Example plants

This technique has been reported in approximately 65 % of the installations participating in the SA data collection [264, TWG 2020].

Reference literature

[247, COM 2009]

2.3.4.1.6 Frequency converters on motors

For more information, consult the ENE BREF [247, COM 2009] and the FDM BREF [206, Giner-Santonja et al. 2019].

Description

Frequency converters (or variable speed drivers) regulate the speed of the impeller to the required output of the motor.

Technical description

Controlling the speed of the pump motor by frequency converters ensures that the speed of the impeller is exactly adapted to the required output of the pump, as are the power consumption and treatment of the liquid. More information on frequency converters (or variable speed drivers) can be found in the ENE BREF [247, COM 2009].

Achieved environmental benefits

Reduced energy consumption.

Environmental performance and operational data

The reduction of the power consumption depends on the capacity and number of pumps and motors. Generally, a 10 % reduction in the output of a pump corresponds to a 28 % reduction in the power consumption of the pump.

Cross-media effects

See variable speed drivers in the ENE BREF [247, COM 2009].

Technical considerations relevant to applicability

Frequency converters can be used with standard three-phase motors. They are available for both manual and automatic speed controls. They can be applied in existing and new installations for pumps, ventilation equipment and conveying systems. It is reported that frequency-converter-driven motors should not exceed 60 % of the total energy use of the installation because they can have an adverse effect on the electricity supply and can lead to technical problems.

Economics

The price of a 5.5 kW frequency converter is about EUR 600 [206, Giner-Santonja et al. 2019].

Driving force for implementation

Reduced consumption of electrical power in combination with a more gentle treatment of the product.

Example plants

This technique has been reported in approximately 55 % of the installations participating in the SA data collection [264, TWG 2020].

Reference literature

[206, Giner-Santonja et al. 2019], [247, COM 2009], [264, TWG 2020].

2.3.4.1.7 Process control systems

Description

Automation of a facility to switch off equipment when it is not needed.

Technical description

Automation of a manufacturing facility involves the design and construction of a process control system, requiring sensors, instruments, computers and the application of data processing. It is widely recognised that automation of manufacturing processes is important not only to improve product quality and workplace safety, but also to increase the efficiency of the process itself and contribute to energy efficiency. More information on process control systems can be found in the ENE BREF [247, COM 2009].

Achieved environmental benefits

Reduced energy consumption.

Environmental performance and operational data

See process control systems in the ENE BREF [247, COM 2009].

A cattle slaughterhouse (IE154) implemented carcass chill temperature controls. Temperature probes inserted into the carcass feed information back to a control module that controls the amount of cooling required to get the carcass to the core temperature required by food safety standards. The compressor is managed to reduce energy consumption down to 3 % of the total electricity consumption [264, TWG 2020].

Cross-media effects

See process control systems in the ENE BREF [247, COM 2009].

Technical considerations relevant to applicability

Widely applicable in the SA sector.

Economics

See process control systems in the ENE BREF [247, COM 2009].

The economic cost for installation of the probes in IE154 was EUR 50 000 across five carcass chillers. The main cost was due to PLC development to control the compressors. The electricity savings were EUR 19 800/year [264, TWG 2020].

Driving force for implementation

Reduced energy costs.

Example plants

This technique has been reported in approximately 50 % of the installations participating in the SA data collection [264, TWG 2020].

Reference literature

[206, Giner-Santonja et al. 2019], [247, COM 2009], [264, TWG 2020]

Isolation of steam and water services**Description**

Isolation valves installed in fluid supply pipework for steam, hot water (at 42 °C and 82 °C) and cold water linked to a computer time control of various areas resulted in a reduction in water losses. The system enabled leaks and taps left running during non-working hours to be identified and stopped. Preventing the wastage of heated water also saved energy.

Achieved environmental benefits

An annual water saving of 2 700 m³ and an energy saving of 1 891 GJ.

Cross-media effects

No negative environmental impacts were reported.

Applicability

Fully applicable.

Economics

The implementation costs; annual actual energy and water savings; actual financial savings and payback time are shown in:

Driving force for implementation

Increased energy costs and the identification of a method of systematically reducing these in way that could be both measured and related to production levels.

Example plants

A cattle and sheep slaughterhouse in the UK. Several rendering plants in Germany.

Reference literature

[52, DoE 1994], [244, Germany 2002]

2.3.4.1.8 Combined heat and power generation (CHP)

For more information, consult the ENE BREF [247, COM 2009] and the FDM BREF [206, Giner-Santonja et al. 2019]

Description

Use of a heat engine or power station to generate electricity and useful heat at the same time.

Technical description

Information on different cogeneration applications can be found in the ENE BREF [247, COM 2009].

Achieved environmental benefits

Reduced energy consumption and emissions to air, e.g. NO_x, CO₂ and SO₂.

Environmental performance and operational data

The energy efficiency of CHP plants can be as high as 90 %. This optimises the use of fossil fuels and reduces the production of CO₂. New CHP installations save at least 10 % of the fuel otherwise used in the separate production of heat and electricity. Furthermore, gas-fired CHP schemes can eliminate SO₂ emissions and NO_x can be controlled to comply with environmental legislation. Modern CHP equipment is likely to require less effort to operate and maintain than many older boiler systems, as it is equipped with automatic control and monitoring systems.

Economics

A decision on whether to implement CHP generation based on investigation of the economic aspects will take account of the price of gas and electricity. A balance of relatively expensive gas or other fuels and cheap electricity mitigates against the selection of CHP generation.

Cross-media effects

See cogeneration in the ENE BREF [247, COM 2009].

Technical considerations relevant to applicability

Widely applicable. The applicability of CHP very much depends on several technical aspects. A simple rule of thumb is that the site needs to have a simultaneous demand for heat and electricity for at least 4 000 hours a year.

Driving force for implementation

The introduction of measures and procedures to promote cogeneration installations is supported by Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency.

Example plants

This technique has been reported in 11 slaughterhouses and 6 installations processing animal by-products and/or edible co-products participating in the SA data collection [264, TWG 2020].

Reference literature

[206, Giner-Santonja et al. 2019], [247, COM 2009], [264, TWG 2020].

2.3.4.1.9 Insulation of pipes, vessels and equipment

Description

Insulation of pipes, vessels and equipment by selecting effective coating materials.

Technical description

Insulation of pipes, vessels and equipment such as ovens and freezers can minimise energy consumption. Insulation can be optimised by selecting effective coating materials that are thick and have low conductivity values and by using pipes, vessels and equipment that are insulated prior to installation. Pre-insulation has the advantage that the pipe supports are mounted outside the insulation coating instead of being directly connected for example. This reduces the heat loss through the mounts.

Insufficient insulation of pipework can lead to excessive heating of the surrounding process areas as well as the risk of burn injuries.

Some examples in the SA sector are the following:

- insulation of scalding tanks in pig and poultry slaughterhouses: The scalding tank can be insulated to reduce the heat loss through the sides and covered to reduce evaporation and heat loss from the water surface. The surface may be covered with plastic balls.
- insulation of bone de-fatting equipment in gelatine manufacturing: The bone de-fatting process emits heat in quantities sufficient to make the equipment and associated metalwork, such as walkways and handrails, hot to touch. The equipment can be insulated to minimise such heat losses and to reduce energy consumption.

Achieved environmental benefits

Reduced energy consumption and associated fuel consumption and emissions to air.

Environmental performance and operational data

Insulation of pipes and tanks can reduce the heat/cold loss by 82-86 %. Additionally, 25-30 % heat can be saved by using pre-insulated pipes instead of traditionally insulated ones.

For a scalding tank with a capacity to handle 210 pigs per hour, with the dimensions of: length approximately 43 meters, area of sides and bottom about 100 m² and surface area 22 m², the following data has been reported: heat loss of about 370 000 kJ (103 kWh) per hour, of which 53 % is lost through the sides and bottom and 47 %, from the surface. The heat loss can be reduced from 1.73 to 1.35 kWh per pig (from 22.5 kWh/t to 17.2 kWh/t of pig carcass) by applying insulation and covering of the scalding tank.

Cross-media effects

No information provided.

Technical considerations relevant to applicability

Applicable to all FDM installations, whether new or existing. Pre-insulated pipes are applicable in new installations and where pipework, vessels and equipment are replaced.

Economics

Insulation of a scalding tank used for about 360 pigs per hour costs EUR 55 000. There are conflicting reports about the applicability in existing slaughterhouses. One view is that the payback time for the insulation of tanks is 1 to 3 years. Another view states that existing scalding tanks can be insulated, but the cost will normally only be recouped in connection with the replacement or alteration of the system.

Driving force for implementation

Reduction in energy costs.

Example plants

This technique has been reported in approximately 45 % of the installations participating in the SA data collection [264, TWG 2020].

Reference literature

[57, DoE, 1993] [20, DoE 1993], [34, Nordic States, 2001] [38, Nordic 2001], [183, Pontoppidan O., 2001] [66, Pontoppidan O. 2001], [203, Denmark 2015], [206, Giner-Santonja et al. 2019], [264, TWG 2020].

Rationalisation and insulation of steam and water pipework

Description

Steam, water and compressed air are widely used in various unit operations during slaughter and animal by-product recycling and disposal. An example slaughterhouse with on-site rendering removed 80 metres of steam pipes and 80 metres of water and air pipework. The pipework was divided into zones so that maintenance could be carried out in one area in isolation, without affecting the whole installation. At the same time the steam and water pipework was insulated.

Achieved environmental benefits

There was an annual energy saving of 474 GJ.

Operational data

Additional benefits can be gained from eliminating leaks; regulating use and stopping misuse and by setting correct supply pressures.

Cross-media effects

None.

Applicability

Applicable in all slaughterhouses and animal by-products installations.

Driving force for implementation

Reduced energy consumption and associated costs.

Reference literature

[52, DoE, 1994]

Techniques for the prevention of spillage, which minimise the need for cleaning and waste water contamination are described elsewhere, e.g. in Sections and.

2.3.4.1.10 Combustion regulation and control

Description

Combustion regulation and control can be used to control boiler combustion by monitoring and controlling fuel flow, air flow, oxygen levels in the flue-gas and heat demand.

Technical description

Excess air can be minimised by adjusting the air flow rate in proportion to the fuel flow rate. This is greatly assisted by the automated measurement of the oxygen content in the flue-gases. Depending on how fast the heat demand of the process fluctuates, the excess air level can be manually set or automatically controlled. Too low an air level causes extinction of the flame, then re-ignition and backfire, causing damage to the installation. This improvement minimises the heat loss due to unburnt gases and to elements in solid wastes and residues from combustion, e.g. through the slag.

More information on optimisation of combustion and advanced control systems can be found in the ENE BREF [247, COM 2009] and the LCP BREF [266, Lecomte et al. 2017].

Achieved environmental benefits

Reduced energy consumption and emissions to air.

Environmental performance and operational data

There will be an initial set-up stage, with periodic recalibration of the automatic controls.

Cross-media effects

As excess air is reduced, unburnt components like carbonaceous particulates, carbon monoxide and hydrocarbons are formed and may exceed emission limit values. This limits the possibility of energy efficiency gain by reducing excess air. In practice, excess air is adjusted to values where emissions are below the limit value.

Technical considerations relevant to applicability

Generally, there are no technical restrictions to the applicability of this technique.

Economics

Request to TWG: Please provide information.

Driving force for implementation

Reduced energy costs.

Example plants

This technique has been reported in approximately 45 % of the installations participating in the SA data collection [264, TWG 2020].

Reference literature

[247, COM 2009], [264, TWG 2020], [266, Lecomte et al. 2017]

2.3.4.1.11 Pre-cleaning blood and meat juice contamination with cold water

Description

Application of cold water instead of hot water for pre-cleaning in areas where the dominant by-product is blood and meat juice.

Technical description

In areas where the dominant by-product is blood and meat juice, the initial pre-cleaning can be carried out with cold water. Hot water makes blood stick to the surfaces being cleaned. Hot water only needs to be used in areas with fatty waste.

Achieved environmental benefits

Reduced energy consumption for heating the water for the initial rinsing and for a subsequent cleaning, which would be required due to the adherence of materials to surfaces being cleaned. Reduced use of detergents and contamination of waste water by detergents.

Environmental performance and operational data

Request to the TWG: Please provide information.

Cross-media effects

Request to the TWG: Please provide information.

Technical considerations relevant to applicability

Applicable in all SA installations-slaughterhouses.

Economics

There is an immediate cost saving.

Driving force for implementation

Reduced energy costs.

Example plants

Request to the TWG: Please provide information.
--

Reference literature

[134, Nordic States 2001] [38, Nordic 2001], [167, Greek Ministry for the Environment 2001] [55, Greek Ministry for the Environment 2001]

2.3.4.2 Techniques related to steam systems

2.3.4.2.1 Preheating feed water (include the use of economisers)

For more information, consult standard and condensing economisers in the FDM BREF [206, Giner-Santonja et al. 2019].

Description

Heat exchanger which reduces steam boiler fuel requirements by transferring heat from the flue-gas to the incoming feed water.

Technical description

The economiser is already a very common and standard solution to recover energy in steam boilers and other heat sources. Very briefly, it is a heat exchanger located in the flue-gas of combustion, which can be useful for low-grade heat applications, such as water preheating.

Achieved environmental benefits

Reduced energy consumption.

Environmental performance and operational data

An economiser has to be designed and fitted according to the boiler design, and this will define its working range and conditions for maximum efficiency. Water preheating should be limited to avoid boiling, by ensuring a minimum flow through the economiser. Flue-gases should not be cooled below the condensation point, except in the case of a condensing economiser.

Cross-media effects

Only in the case of condensing economisers, a small amount of low pH waste water is generated, from the combustion water condensation.

Technical considerations relevant to applicability

Generally, there are no technical restrictions to the applicability of this technique.

Economics

Request to TWG: Please provide information.
--

Driving force for implementation

Reduced energy costs.

Example plants

This technique has been reported in approximately 45 % of the installations participating in the SA data collection [264, TWG 2020].

Reference literature

[206, Giner-Santonja et al. 2019], [264, TWG 2020]

2.3.4.2.2 Minimisation of the blowdown of boilers

For more information, consult the FDM BREF [206, Giner-Santonja et al. 2019].

Description

Measures such as pretreating the water, maximising the recovery of condensate, using an automated blowdown control system, or flashing the blowdown at medium or low pressure.

Technical description

The blowdown of a boiler is used to limit the accumulation of salts (e.g. chlorides, alkalis and silicic acid) and is therefore necessary to keep these parameters within prescribed limits. It is also used to remove the sludge deposits (e.g. calcium phosphates) and corrosion products (e.g. ferric oxides) from the boiler and to keep the water clear and colourless. Waste water at high pressure and temperature is always discharged, either for a set time or continuously. It is therefore preferable to restrict the blowdown as far as possible.

Achieved environmental benefits

- Reduced energy consumption.
- Reduced waste water generation.

Environmental performance and operational data

At a steam pressure of 10 bar, a fuel saving of 2.1 % can be achieved if the blowdown volume is reduced by 10 %.

Cross-media effects

Discharges of treatment chemicals, chemicals used in deioniser regeneration, etc.

Technical considerations relevant to applicability

Applicable where a boiler is used.

Economics

The payback of condensate return will depend on the condensate flow rates and temperature [206, Giner-Santonja et al. 2019].

Driving force for implementation

Reduced energy costs.

Example plants

This technique has been reported in approximately 40 % of the installations participating in the SA data collection [264, TWG 2020].

Reference literature

[206, Giner-Santonja et al. 2019], [264, TWG 2020].

2.3.4.2.3 Optimisation of steam distribution systems

Description

Implementation of a maintenance system to minimise leaks and selection of appropriate steam traps and insulation.

Technical description

The distribution system transports steam from the boiler to the various end-uses. Although distribution systems may appear to be passive, in reality these systems regulate the delivery of steam and respond to changing temperatures and pressure requirements. Consequently, proper performance of the distribution system requires careful design practices and effective maintenance. The piping should be properly sized, supported, insulated and configured with

adequate flexibility. Pressure-regulating devices such as pressure-reducing valves and backpressure turbines should be configured to provide a proper steam balance among the different steam headers. Additionally, the distribution system should be configured to allow adequate condensate drainage, which requires adequate drip leg capacity and proper steam trap selection.

Maintenance of the system is important, especially:

- to ensure that traps operate correctly;
- to ensure that insulation is installed and maintained;
- to ensure that leaks are detected and dealt with systematically by planned maintenance; this is assisted by leaks being reported by operators and dealt with promptly; leaks include air leaks on the suction side of pumps;
- for checking for and eliminating unused steam lines.

More information on optimising steam distribution systems can be found in the ENE BREF [247, COM 2009].

Achieved environmental benefits

Reduced energy consumption.

Environmental performance and operational data

See optimising steam distribution systems in the ENE BREF [247, COM 2009].

Cross-media effects

See optimising steam distribution systems in the ENE BREF [247, COM 2009].

Technical considerations relevant to applicability

Generally applicable.

Economics

See optimising steam distribution systems in the ENE BREF [247, COM 2009].

Driving force for implementation

Reduced economic costs.

Example plants

This technique has been reported in approximately 40 % of the installations participating in the SA data collection [264, TWG 2020].

Reference literature

[247, COM 2009], [264, TWG 2020].

2.3.4.2.4 Use of thermostatically controlled steam- and water-blending valves

See also Section 2.3.4.1.7.

Description

Use of thermostatically controlled steam- and water-blending valves that automatically control the water temperature.

Technical description

Thermostatically controlled steam- and water-blending valves that automatically control the water temperature can remove the risk of an untrained or over cautious operator setting water temperatures too high and consequently using excessive amounts of energy.

Achieved environmental benefits

Reduced energy consumption. Fats in the waste water, are easier to remove at lower temperatures.

Environmental performance and operational data

If hot water is provided by blending steam with cold water at the point of use, the water temperature is often controlled by manually adjusting the steam and water blending valves. Steam pressure and water pressure may vary throughout the day, so the temperature may also vary. To ensure that minimum temperature requirements, not necessarily required by law, for wash or rinse water are met, an operator may open steam valves enough so that the water always remains above a certain temperature. This leads to unnecessarily high temperatures when the steam pressure is high or the water pressure is low. If thermostatically controlled steam and water blending valves are used, they can automatically control the water temperature and remove the responsibility from the operator to judge the correct setting.

An energy savings calculation for lowering the water temperature for cleaning at one station by installing an automatic controlled steam and water blending valve is shown below.

This calculation assumes a starting water temperature of 100 °C and a flowrate of 83.3 l/min. The target cleaning water temperature is 60 °C. Gas is used in a steam boiler at a cost of USD 0.495/therm (i.e. USD 4.67/GJ). Assuming that the efficiency of the system is 70 % and the hose is used for 2 h/d, 250 d/yr. The calculated annual saving is USD 2 698 (Costs in 2000).

Another example shows the energy and cost savings when using water with an incoming water temperature of 16 °C and for lowering the temperature the water is heated to from 71 °C, to various lower temperatures. The example assumes a water use of 831 l/min, 6 h/d for 250 d/yr. Some examples of the savings are shown in Table 2.6.

Table 2.6: Annual energy and cost savings per hose from lowering the water temperature from 71 °C

New temperature setting (°C)	Energy savings (GJ/yr)	Cost savings using natural gas (USD)
68.3	7 793	580
60	31 160	2 340
51.9	54 528	4 090
46.1	70 104	5 260
32.2	10 9057	8 174
Cost of natural gas - USD 0.175/m ³ in 2000		
<i>Source: [122, Ockerman H.W. and Hansen C.L. 2000]</i>		

Cross-media effects

None.

Technical considerations relevant to applicability

Applicable in all slaughterhouses and animal by-products installations

Economics

The valves are reported to cost USD 450 – 700 (Costs in 2000) and the payback depends on the previous water temperature settings and the variation of the temperature above those settings.

Driving force for implementation

Reduced energy costs.

Example plants

This technique has been reported in approximately 20 % of the installations participating in the SA data collection [264, TWG 2020].

Reference literature

[268, Ockerman H. W. and Hansen C. L., 2000] [122, Ockerman H.W. and Hansen C.L. 2000], [264, TWG 2020].

2.3.4.3 Techniques related to compressed air

2.3.4.3.1 Reduction of compressed air system leaks

For more information, consult reduction of air leaks and optimisation of pressure settings in the FDM BREF [206, Giner-Santonja et al. 2019].

Description

Carrying out of leak prevention measures and periodic leak tests, and setting the pressure at the compressor at the maximum required and then regulating it at each individual application.

Technical description

Consumption losses during production downtime can be avoided by sectorisation of pressure (multiple changes to the pressure distribution). Several additional techniques can be implemented to optimise compressed air generation and use:

- replace pneumatic installations with electric ones;
- use a variable speed compressor;
- adjust the pressure level (more pressure is provided with a separate compressor);
- adapt the compressor to the need (flow/pressure).

Achieved environmental benefits

Reduced energy consumption and reduced noise, if large compressors run for shorter periods.

Environmental performance and operational data

Request to TWG: Please provide information.

Technical considerations relevant to applicability

Generally, there are no technical restrictions to the applicability of this technique.

Economics

Request to TWG: Please provide information.

Driving force for implementation

Reduced energy costs.

Example plants

This technique has been reported in approximately 55 % of the installations participating in the SA data collection [264, TWG 2020].

Reference literature

[206, Giner-Santonja et al. 2019], [264, TWG 2020].

2.3.5 Techniques to reduce water consumption

2.3.5.1 Management, design and operation techniques

2.3.5.1.1 Water management plan and water audits

Description

A water management plan and water audits are part of the environmental management system (EMS) and include:

- flow diagrams and a water mass balance of the plant;
- establishment of water efficiency objectives;
- implementation of water optimisation techniques (e.g. control of water usage, recycling, detection and repair of leaks, water level control in various tanks).

Water audits are carried out at least annually to increase the reliability of controls and to ensure that the objectives of the water management plan are met.

Achieved environmental benefits

Reduction of water consumption and waste water discharge.

Environmental performance and operational data

No information provided.

Cross-media effects

None reported.

Technical considerations relevant to applicability

The level of detail and nature of the water management plan and water audits will generally be related to the nature, scale and complexity of the plant.

Economics

- Staff time.
- Cost of any additional metering required.

Driving force for implementation

Cost reduction depending on pricing and availability of water.

Example plants

Frequently used in SA installations.

Reference literature

[279, Chronopoulos et al. 2020]

2.3.5.1.2 Water recycling and/or reuse

Description

Recycling or reuse of water streams (preceded or not by water treatment), e.g. for cleaning, washing, cooling or for the process itself.

Technical description

Recycling/reuse of water can be carried out either preceded or not preceded by water treatment. Examples are given for both options under Environmental performance and operational data below.

Achieved environmental benefits

- Reduction of water consumption (e.g. water of drinking water quality) by using water sources of a different quality.
- Reduction of emissions to water.
- The technique can also enable heat to be recovered (e.g. condensate return).

Environmental performance and operational data

There are multiple ways of reusing water reported in the questionnaires of the SA BREF data collection. Some examples are as follows:

- Use of cooling water and water from vacuum pumps: Water from cooling systems, which has not previously been in contact with the products, by-products or other substances and which is of drinking water quality, can be used in some applications.
- Recirculation of water within pig de-hairing machines (applicable in pig slaughterhouses, see Section 3.3.3.2.2).
- Reuse of cooling water from the singeing kiln (applicable in pig slaughterhouses, see Section 3.3.3.2.3).
- Reuse of crate washing water (applicable in poultry slaughterhouses, see Section 3.4.4.3.2).
- Use of recycled water, from scalding, for the carriage of feathers (applicable in poultry slaughterhouses, see Section 3.4.4.3.3)

Cross-media effects

Increase in recycling/reuse of water can result in an increase in energy and chemical consumption for treatment of water before recycling.

Technical considerations relevant to applicability

Water recycling/reuse opportunities are present in existing and new SA installations. Hygiene requirements may compromise the applicability of this technique, in particular for the meat sector.

Economics

No information provided.

Driving force for implementation

Reduced water consumption.

Example plants

Water recycling/reuse is commonly reported in the SA sector.

Reference literature

[206, Giner-Santonja et al. 2019]

2.3.5.1.3 Optimisation of water flow

Description

Use of various control devices, e.g. photocells, flow valves, thermostatic valves, to adjust the water flow.

Technical description

Flow measurement and control techniques can reduce water consumption and waste water generation in SA processing.

For example in slaughterhouses, sensors such as photocells can be fitted to detect carcasses and parts of carcasses and to supply water as required (see Section 3.2.3.2.1.2). The water supply can be turned off automatically between carcasses and during all breaks.

Moreover, in slaughterhouses, the periodic change of water in electrically heated knife sterilisers can be controlled by a timer (see Section 3.2.3.2.1.6).

In pig slaughterhouses, the water level control in the pig scalding tank can be controlled (see Section 3.3.3.2.4).

Another example of automation is related to cooling towers. Blowdown may be controlled by measurement of conductivity to detect when it is required.

Achieved environmental benefits

Reduced water consumption and associated energy use.

Environmental performance and operational data

In relation to the moving of intestines, water may be supplied to slides, intestine conveyors and intestine elevators, only when required. The required water quantity can be determined and the setting can then be locked.

Moreover, water usage can be minimised during rinsing of tongues and hearts. The rinsing of tongues, sweetbread and neck meat is sometimes done to remove blood splashes. Tongues can be rinsed without using running water. A timer control can be fitted to the water supply, to ensure that water is used in the required time only, or with intervals. Tongues can also be hung on a Christmas tree (multiple hook) or placed in a trolley with perforations and then rinsed lightly before being stored in a chill room. The rinsing of hearts can be done with a handheld shower head after hanging them on a rack. It can be limited to only rinsing away possible blood drips.

Cross-media effects

There are no cross-media effects associated with this technique.

Technical considerations relevant to applicability

Generally applicable.

Driving force for implementation

Reduced water consumption and associated costs.

Example plants

Widely applied in the SA sector.

Reference literature

[206, Giner-Santonja et al. 2019]

2.3.5.1.4 Use and optimisation of water nozzles and hoses

Description

Use of the correct number and position of nozzles; adjustment of the water pressure of nozzles and hoses.

Technical description

Where a supply of water is essential, e.g. to a slaughter line, it can be supplied through nozzles designed and positioned for each individual unit operation and cleaning operation. For cleaning operations, the water may be supplied to a series of hoses, e.g. a ring main. The water flow at each nozzle can be set by the management, for each individual application. The water pressure can be adjusted according to the unit operation/cleaning operation requiring the highest pressure and a suitable pressure regulator can be installed at each of the other unit operations/cleaning stations which require water.

Water nozzles are widely used in the SA sector, e.g. for washing and for cleaning the equipment during processing. Water consumption and waste water pollution minimisation can be carried out by correctly positioning and directing the nozzles. The use of presence-activated sensors and, most importantly, only installing them where required can ensure that water is only consumed where necessary.

In addition, water consumption can be optimised by monitoring and maintaining the water pressure of the water nozzles. Water pressure can be adjusted according to the unit operation requiring the highest pressure and a suitable pressure regulator can be installed at each of the other unit operations which require water.

A nozzle can be fitted with two mixing chambers. The first chamber has a conical shape where water is mixed with compressed air. This results in a very small droplet size. In the second chamber, the droplet/air mixture is expelled at very high speed, due to the pressure differential, through the mouth of the nozzle [270, IWC 2020].

Achieved environmental benefits

Reduced water consumption and waste water generation. Reduced waste water pollution, e.g. due to the reduction of the contact time between the food and water.

Environmental performance and operational data

Some examples of use and optimisation of nozzles in the SA sector are presented below:

Replace of irrigation pipes with flat jet nozzles

All irrigation pipes can be replaced with flat jet nozzles, which have considerably lower water consumption. Nozzles with diameters below 2 mm block frequently. In some installations it may be necessary to install a pressuriser to increase the water pressure. As an example, the water consumption for rind treatment has been reduced from approximately 100 litres per pig to 20 - 25 litres per pig (from 1 300 l/t to 260 - 325 l/t carcass) as a result of this and other techniques.

Saw sterilisation in a cabinet with automated hot water nozzles

Chest opening saws can be sterilised in a cabinet with nozzles supplying water at 82 °C, instead of in running water in a vat at the same temperature. The water supply can be turned on and off, as required. Reduced water consumption, by 130 - 195 l/t carcass has been reported

Use of nozzles instead of showers to flush out large intestines

When large intestines are flushed out, showers or nozzles are used to wet the surfaces to ensure that the intestines slide easily and are not damaged. Shower heads can be replaced by nozzles. Reduced water consumption, from 3.8 litres per pig intestine with a shower running continuously to 1.0 litre per pig intestine with a nozzle running only when the pipe is activated, has been reported.

Use spray nozzles in an evisceration line (poultry slaughterhouse)

An evisceration line with a total of 32 shower heads has a reported water use of approximately 600 l/h. Changing from domestic style shower heads, to an alternative form of spray nozzle, e.g. orifice plates, which have an estimated flowrate of 500 l/h, can save water. Additional savings may be achieved on new lines by reducing the number of shower heads.

Showering of pigs, using water saving, timer controlled nozzles

Pigs are showered during hot, dry periods, for animal welfare reasons. It helps to calm them and to prevent them from becoming stressed. The shower nozzles can be designed and installed so that they are only activated when there are pigs present. The flow and the operation time are controlled automatically. Showering also improves the environment for people entering the lairage, by reducing respirable and total dust levels.

Replace irrigation pipes at the top of de-hairing machines, with nozzles

In pig slaughterhouses, the irrigation pipes at the top of the de-hairer can be replaced with flat jet nozzles, which direct the flow of water at the pigs. At the same time, the spray to transport the hair away, can be moved to just under the pig, because the water in this area will no longer be sufficient by itself, for removing the hair. The water can be controlled so that it is only running when there is a pig in the machine. It is unnecessary to add water to the gambrelling table. The water use can be reduced from 16 litres per pig to 6 litres per pig (208 l/t carcass to 78 l/t carcass).

Control of water consumption for small and large intestine washing with the use of nozzles

The water supply for the small and large intestine lines can be strictly regulated and valves can be equipped with nozzles and automatic stop controls. Water consumption in a pig slaughterhouse has reportedly been reduced from 70 litres to 40 litres per gut set. On the small intestine line in a Danish pig slaughterhouse, water savings of 844 l/t carcass have been reported.

Post singeing showering with flat jet nozzles

In pig slaughterhouses, showering can be done with flat jet nozzles instead of shower heads. The water supply can be arranged so that water only flows when a carcass is present. The water consumption can be reduced from 3 000 – 4 000 l/h to approximately 400 l/h, depending on the throughput of carcasses per hour.

Use of nozzles instead of irrigation pipes for defeathering

It is possible to use nozzles instead of irrigation pipes, to supply water in the defeathering machine. They can also be used, supplemented with beater straps, for showering poultry after defeathering.

Cross-media effects

There are no cross-media effects associated with this technique.

Technical considerations relevant to applicability

Generally applicable.

Economics

The payback time for replacing shower heads with nozzles has been calculated to be approximately 6 months.

For a slaughterhouse killing 18 000 turkeys per day, i.e. 38 birds per minute, the reported potential water saving with the application of spray nozzles in the evisceration line is 8 000 m³/yr with a financial saving of GBP 5 000/yr. The cost quoted per shower head is GBP 15. (Costs in 1999.)

Driving force for implementation

Reduction of costs associated with savings in water consumption.

Example plants

Widely applied in the SA sector.

Reference literature

{134, Nordie States, 2001} [38, Nordic 2001], [134, Brindle J. 2002], AVEC, 2001 [90, AVEC 2001], {243, Clitravi - DMRI, 2002} [190, Clitravi - DMRI 2003], [206, Giner-Santonja et al. 2019], [270, IWC 2020]

2.3.5.1.5 Segregation of water streams ~~Separation of process and non-process water~~

Description

Water streams that do not need treatment (e.g. uncontaminated cooling water or uncontaminated run-off water) are segregated from waste water that has to undergo treatment, thus enabling uncontaminated water recycling.

Technical description

The drainage/sewerage system can be designed to separate waste water into different categories, to collect as much waste as possible and to treat the waste correctly. This technique should complement others which minimise the amount of materials entering the waste water and thus can help to optimise the re-use of water.

Rainwater and cooling water from the refrigeration system can be discharged in the same system, as they are usually not contaminated.

Waste water from lairage and from the cleaning of lorries can be collected in a second system, as it usually contains manure. Filtered material from this system can be used for biogas production or composting.

The waste water from the production and the casing department could be channelled separately. The treatment which the entrained material will have to undergo will depend on the Category assigned to it under ABP Regulation 1069/2009-1774/2002/EC.

Achieved environmental benefits

Reduced water contamination, by keeping clean water separate from dirty water and consequently also a reduced energy consumption associated with the waste water treatment.

Environmental performance and operational data

Request to the TWG: Please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

For existing installations, there might be technical and economic difficulties associated with the installation of a waste water separation/segregation system.

~~Only in new and substantially altered existing slaughterhouses.~~

Economics

High capital cost, however, this may be offset by the reduced running costs due to the lower requirement for waste water treatment, whether on-site, at municipal WWTPs or a combination of both.

Driving force for implementation

Reduction of long-term expenses for treating waste water and disposing of animal waste.

Example plants

Several animal by-products plants in Germany. Pig slaughterhouses in Denmark [203, Denmark 2015].

References to literature

[134, ~~Nordic States 2001~~] [38, Nordic 2001], [183, ~~Pontoppidan O. 2001~~] [66, Pontoppidan O. 2001], [244, ~~Germany 2002~~] [110, Germany 2002], [203, Denmark 2015], [206, Giner-Santonja et al. 2019]

2.3.5.1.6 Dry transport of by-products

Description

By-products and waste from the slaughter and animal by-products treatment processes are transported as dry as possible.

Technical description

By-products and waste from the slaughter and animal by-products treatment processes can be transported as dry as possible and all spillages cleaned up, by sweeping or by using a squeegee, prior to wet cleaning. This reduces the entrainment of organic matter into water, which would consequently have to be treated in either an on-site or municipal waste water treatment plant.

Achieved environmental benefits

Reduced water consumption and volume of waste water. Reduced entrainment of materials in waste water and, therefore, reduced COD and BOD levels. Increased potential for the recovery and recycling of substances generated in the process. Reduced use of energy needed to heat water. Reduced use of detergents.

Environmental performance and operational data

Some examples of dry transport methods include the transfer of feathers by screw conveyer and the transfer of offal not intended for human consumption by vacuum or compressed air. Transport in water is usually appropriate for by-products intended for human consumption, partly because of the cooling effect, although this still needs to be assessed on a case-by-case basis, because alternatively frequent despatch of batches, to cooled areas, may remove the need for such water consumption and the associated contamination.

See also Section.

Cross-media effects

None.

Technical considerations relevant to applicability

Applicable in all slaughterhouses and animal by-products SA installations.

Driving force for implementation

Reduced energy and water use, reduced need for waste water treatment and lower detergent use and expenditure.

Example plants

Several rendering plants in Germany.

Reference literature

[167, Greek Ministry for the Environment, 2001] [55, Greek Ministry for the Environment 2001], 244, Germany, 2002] [110, Germany 2002], 346, Belgian TWG member, 2003] [183, Belgium 2003]

Dedicated metering of water consumption

Description

By applying dedicated meters, water consumption can be measured at a specific unit operation level instead of only at the installation level. Areas of overconsumption due to technical and operational reasons can be identified and actions then taken to optimise the consumption. It has been suggested that frequent readings need to be taken at submetered unit operations and be logged once during every 10 minutes. The usefulness of such frequent measures depends on the complexity of the actual process and the unit operations and the size and frequency of the changes in water consumption.

Achieved environmental benefits

At one site, a comparison of actual water consumption with recommended values led to a reduction in consumption of 13 %. Consequently, the volume of waste water, which would have had to be treated was also reduced. Also, as 45 % of the water was heated to 60 °C, the energy consumption fell too.

Operational data

A case study plant prepared a map of its water usage. Meters were fitted and some pipework was modified to enable each area's water consumption to be measured individually. Hot and cold water consumption was measured separately. The map enabled areas where improvements could be made immediately to be highlighted, for instance, the washing-down of the lairage area with hot water stopped.

Target consumption rates were set. Suppliers of equipment were asked how much water each piece of equipment should optimally use. Flow meters were fitted and employees were instructed to maintain the pressure between preset minimum and maximum limits.

In the consultation with equipment suppliers, immediate saving potentials become apparent, e.g. it was discovered that some equipment had been fitted with 5 cm diameter intake pipes to account for the odd occasion when the water pressure suddenly drops, but for normal day-to-day operation 2.5 cm diameter intake pipes were adequate.

The training programme for new employees was updated to cover methods to minimise water consumption. This included reporting leaks, overflows and faulty valves and on the job training on the use of in-line flow meters.

Cross-media effects

None expected.

Applicability

Applicable in all slaughterhouses and animal by products installations.

Economics

In the case study installation, in 1999 the flow meters cost GBP 200–300 each. Modifying the pipework and installing 20 meters cost a total of GBP 30 000. This led to a reduction of around GBP 23 000/yr in the company's water and effluent bill. Information about the associated energy savings is unavailable.

By 2002, it was reported that there were submeters available at a cost of approximately EUR 30 each.

Driving force for implementation

To reduce water consumption and thereby to save money.

Example plants

At least one cattle and sheep slaughterhouse and one pig slaughterhouse in the UK.

Reference literature

[52, DoE, 1994, 63, ETBPP, 2000, 307, UK, 2002]

Use of cooling water and water from vacuum pumps

Description

Achieved environmental benefits

Reduced water consumption.

Operational data

The water from sources such as vacuum pumps may have been treated with chemicals to avoid corrosion or deposits.

Cross-media effects

None.

Technical considerations relevant to applicability

Will require veterinary approval before use in slaughterhouses, where the water must be of drinking water quality. It could then be used for washing yards and lairages.

Example plants

A small Danish poultry slaughterhouse uses cooling water from the anus drill to maintain the water level in the scalding tank.

Reference literature

[134, Nordic States, 2001, 167, Greek Ministry for the Environment, 2001, 238, UECBV, 2002, 349, GME TWG members, 2003]

Removal of running water hoses and the repair of dripping taps and toilets**Description**

Removal of running water hoses and the repair of dripping taps and toilets.

Achieved environmental benefits

The water losses listed in table can be saved.

Type and condition	Loss (l/h)	Loss (m ³ /yr)
<i>Leaking tap</i>		
- 10 drops per 10 second	0.7	6.1
- 30 drops per 10 second	2.1	18.4
- 1 mm run	9.0	79
- 1.5 mm run	18.0	158
<i>Water hose</i>		
- running fully open (250 days at 8 hours)		
- 1/2 inch (12.7 mm)	3000	6000
- 3/4 inch (19 mm)	5100	10000
<i>Toilet</i>		
- running so it can only be seen with careful observation		99
- running and can be clearly seen		195
- unrest on surface		495
- pouring		3000

Table: Water losses from leaking taps, running hoses and toilets

Operational data

A running 3/4 inch (19 mm) water hose results in an added consumption of 195 l/t during the period the water is running at a slaughter rate of 350 pigs per hour. At lower slaughter rates the figure increases proportionally.

If a slaughterhouse has 50 water supply positions, including wash hand basins etc., with dripping taps and 10 toilets with running water, the extra water consumption can easily amount to 5 000–6 000 m³ annually. This is equivalent to DKK 75 000–90 000 (2001) running straight into the sewer.

Chapter 2

Cross-media effects

None.

Applicability

Applicable in all installations.

Economics

This is a cost saving measure.

Driving force for implementation

To save water.

Example plants

A pig slaughterhouse in Denmark.

Reference literature

[134, Nordic States, 2001]

Replace irrigation pipes with flat jet nozzles

Description

Achieved environmental benefits

Reduced water consumption.

Operational data

Cross-media effects

None.

Applicability

Applicable in all slaughterhouses with rind treatment lines.

Economics

The estimated cost for nozzles is about EUR 500. The payback time is very short.

Driving force for implementation

Reduced water costs.

Reference literature

[134, Nordic States, 2001, 183, Pontoppidan O., 2001]

Saw sterilisation in a cabinet with automated hot water nozzles

Technical description

Achieved environmental benefits

Cross-media effects

None.

Technical considerations relevant to applicability

Applicable in all large animal slaughterhouses.

Driving force for implementation

Reduced water consumption and consequent energy use.

Reference literature

[134, Nordic States, 2001]

Supply of pressure-controlled water and via nozzles**Description****Achieved environmental benefits**

Reduced water consumption. Where heated water is used the overall energy consumption can be reduced.

Operational data

The pressure of the general process water can be adjusted for the process requiring the highest pressure, e.g. for slaughter equipment this has been quoted as 17 atmospheres (1.72 MPa). At the other processes a suitable pressure regulator can be installed.

Cross-media effects

None.

Applicability

Applicable in all slaughterhouses and animal by products installations, according to in-line, general operational and cleaning needs.

Driving force for implementation

Reduced water consumption.

Reference literature

[134, Nordic States, 2001]

Showering of pigs, using water saving, timer controlled nozzles**Description****Achieved environmental benefits**

Less water consumption than if manual or continuous showering is carried out.

Operational data

In one case study slaughterhouse, the water supply is timer controlled to supply water for two minutes each half hour.

Cross-media effects

Reduces dust by 60 %, whereas an electrostatic filter reduces both total and respirable dust by 40–45 %.

Applicability

All pig slaughterhouses.

Driving force for implementation

Less money spent on water.

Example plants

At least one pig slaughterhouse in Italy.

Reference literature

Control of water consumption for small and large intestine washing

Technical description

Achieved environmental benefits

Reduced water consumption and reduced water contamination.

Operational data

Cross-media effects

None.

Example plants

A slaughterhouse in Denmark.

Reference literature

[134, Nordic States, 2001]

Replace irrigation pipes at the top of de-hairing machines, with nozzles

Description

Achieved environmental benefits

Reduced water consumption.

Operational data

Cross-media effects

None.

Applicability

Applicable in all pig slaughterhouses.

Economics

Payback is almost immediate.

Driving force for implementation

Reduced water costs.

Reference literature

[134, Nordic States, 2001, 183, Pontoppidan O., 2001]

Post singeing showering with flat jet nozzles

Description

Achieved environmental benefits

Reduction in water consumption, of 65 l/t carcase.

Operational data

Cross-media effects

None.

Applicability

Applicable in all pig slaughterhouses.

Driving force for implementation

~~Reduced water consumption.~~

Reference literature

~~[134, Nordic States, 2001]~~

~~Use of nozzles instead of irrigation pipes~~

~~Technical description~~

~~Achieved environmental benefits~~

~~Reduced water consumption and more efficient washing.~~

~~Environmental performance and operational data~~

~~The water can be directed better with nozzles, so its consumption can be reduced.~~

Reference literature

[134, Nordic States, 2001, 243, Clitravi – DMRI, 2002]

2.3.5.2 Techniques related to cleaning

2.3.5.2.1 Dry cleaning

Description

Removal of as much residual material as possible from raw materials and equipment before they are cleaned with liquids, e.g. by using compressed air, vacuum systems or catchpots with a mesh cover.

Technical description

As much residual material as possible can be removed from raw materials, vessels and equipment before they are wet cleaned. This can be applied both during and at the end of the working period. All spillages can be cleaned up, by for example shovelling or vacuuming spilt material or by using a squeegee, prior to wet cleaning, rather than hosing them down the drain. This reduces the entrainment of material into water, which would consequently have to be treated in a WWTP. This is enhanced further by transporting materials such as ingredients, by-products and waste from processing as dry as possible.

Dry cleaning is facilitated by, for example, providing and using catchpots with a mesh cover, making sure suitable dry clean-up equipment is always readily available and providing convenient, secure receptacles for the collected waste (see Section 2.3.2.2). Catchpots may be locked in place to ensure that they are in position during cleaning. As well as manual dry cleaning of equipment and installations, other measures can be used, such as letting materials drain naturally, by gravity, into suitably located receptacles and by using pigging.

Dry cleaning can also be applied by [203, Denmark 2015]:

- using a rubber scraper to clean the blood line; it is only after a thorough scraping that cleaning with water begins;
- scraping transportation vehicles for live animals before cleaning with water.

Cleaning of the lairage in slaughterhouses can be done by collecting manure and bedding materials, before rinsing with water. In cases where the drains are connected to a urine/slurry container, they can be transferred to the sewerage system before rinsing starts to prevent overloading of the container. Cleaning with dry scraping, using a squeegee and a shovel is normally sufficient, although it should be followed by high-pressure rinsing at least once a week.

Moreover in slaughterhouses, manure and bedding can be scraped into a collection area before delivery vehicles is cleaned with water. The wash area is arranged so that as much manure as possible can be collected before the vehicle wash starts.

Achieved environmental benefits

- Reduced water consumption and volume of waste water.
- Reduced entrainment of materials in waste water and therefore reduced COD and BOD levels.
- Increased potential for the recovery and recycling of substances generated in the process.
- Reduced use of energy needed to heat water.
- Reduced use of detergents.

Environmental performance and operational data

Immediate removal may be necessary to safeguard hygiene and prevent microbiological risks.

In pig slaughterhouses using dry scraping, water consumption levels of 78 – 130 litres per tonne of pig carcass have been reported, compared to a maximum level of 300 litres elsewhere. At one major pig slaughterhouse in Denmark, the water consumption for cleaning vehicles is approximately 110 l/t, when using dry scraping. The time for the driver to carry out dry scraping followed by washing is practically the same as when wash only is carried out.

Cross-media effects

Increased solid waste.

Technical considerations relevant to applicability

Generally applicable.

Driving force for implementation

- Reduced energy and water use.
- Reduced need for waste water treatment.
- Lower detergent use and expenditure.

Example plants

Many installations apply some dry cleaning prior to wet cleaning.

Reference literature

[134, Nordic States, 2001] [38, Nordic 2001], [203, Denmark 2015], [206, Giner-Santonja et al. 2019]

2.3.5.2.2 High-pressure cleaning ~~Use of pressure cleaning throughout the installation~~

Description

Spraying of cleaning water at pressures ranging from 15 bar to 150 bar.

Technical description

In high-pressure cleaning, water is sprayed onto the surface to be cleaned at pressures ranging from 15 bar, which is considered to be low pressure, up to 150 bar, which is considered to be high pressure. A pressure of about 40-65 bar has also been described as high.

Cleaning agents are injected into the water, at moderate temperatures of up to 60 °C. An important part of the cleaning action is due to mechanical effects. Pressure cleaning reduces water and chemical consumption compared with mains hoses. It is important, however, that a pressure that is both safe and efficient is used. There is concern in the food industry about the hygiene implications of over-splash and aerosols associated with the use of high-pressure hoses.

High- and medium-pressure cleaners have the following advantages compared with low-pressure cleaners, i.e. water use is lower due to the mechanical cleaning action of the water jet; chemical use is lower because heavy soiling is removed by the action of the water jet and the reduction in water volume means that there is less of a breeding ground for bacteria. However, there can be concerns about the increased aerosol risks with higher water pressures.

Pressurised water can be used to wash the carcasses. If the pressure is kept below 1 MPa, this will reportedly avoid fat detachment and the consequent waste water contamination. A mixture of compressed air and water increases the pressure without using excess water.

Moreover, delivery lorries can be cleaned using a high-pressure trigger-operated adjustable water jet.

Achieved environmental benefits

A 75 % reduction in water consumption can be achieved. Consequently, the volume of waste water to be treated is also reduced. Also if the water used is heated, then there is an energy saving too.

Environmental performance and operational data

Notwithstanding the effects of e.g. temperature and cleaning agents, the effectiveness of cleaning using hoses varies depending on the flow of the water and the applied pressure. It has been reported that a pressure of 1.5 MPa and a flow of 60 l/min per nozzle gives a good result for cleaning trucks, compared to 0.3 MPa (3 bar) and 250 l/min, i.e. a 75 % water saving is possible for the same cleaning result.

The use of an adjustable high-pressure water pistol with a pressure of approximately 1.8 - 2.3 million Pa (18 - 25 atmospheres) can reportedly reduce the water consumption needed for washing lorries. The step-less control of the pressure and the range of the water jet makes it possible to remove dirt from both flat surfaces and corners. A saving of 130 l/t of carcass produced can be achieved due to the fact that the water flow stops when the trigger is released.

Cross-media effects

None foreseen.

Technical considerations relevant to applicability

May not be applicable to carcass washing due to hygiene requirements. Applicable in all slaughterhouses and animal by-products SA installations.

Economics

The direct economic benefit depends on the price of the water. An investment of EUR 50 - 250 per nozzle is necessary. If the existing pumps and water pipes are not fit for the desired pressure, then their replacement will increase the investment costs.

The cost of a pump system with two hoses is approximately DKK 35 000 (2001). If it is necessary to increase the water pressure before a pressure gun can be used, the reported cost is EUR 10 000 – 14 000. This reportedly covers the cost of installing high-pressure pumps for the cleaning of several lorries, normally 4, at a time. It also includes, amongst other things, piping and electrical works, hoses and spray-guns.

Driving force for implementation

Saving water and, therefore money.

Reference literature

[3, EPA, 1996] [1, EPA 1996], [240, The Netherlands, 2002] [106, The Netherlands 2002], [134, Nordic States, 2001] [38, Nordic 2001], 183, Pontoppidan O., 2001] [66, Pontoppidan O. 2001], [206, Giner-Santonja et al. 2019]

2.3.5.2.3 Optimisation of chemical dosing and water use in cleaning-in-place (CIP)

Description

The amounts of hot water and chemicals are optimised by measuring turbidity, conductivity, temperature and/or pH for example.

Technical description

CIP systems are cleaning systems that are incorporated into equipment and can be set to use only the required quantities of detergents and water at the correct temperature (and sometimes pressure) conditions, for that equipment and the substance it is being used for. Incorporation of a CIP system can be considered at the equipment design stage and installed by the manufacturer. Retrofitting a CIP system may be possible, but is potentially more difficult and expensive. CIP systems can be improved by incorporating the internal recycling of water and chemicals, optimising programmes, using water efficient spray devices and by removing product and gross soiling prior to cleaning. Equipment correctly designed for CIP cleaning should have spray balls located so that there are no “blind spots” in the cleaning process.

Design and operational features which increase the efficiency of the CIP system include:

- using a turbidity or conductivity detector to optimise both the recovery of material/product from water and the reuse of cleaning water during pre-rinsing;
- measuring pH to optimise chemical consumption.

Additional features to optimise CIP include the following:

- Dry product removal before the start of the wet cleaning cycle by, for example, gravity draining, pigging or using compressed air.
- Pre-rinsing using small quantities of water, which, in some circumstances, may be combined with either returning the pre-rinse water to the process for reuse or recovering it for disposal.
- Internal recycling of water and chemicals.
- Water-efficient spray devices.
- Correct selection of CIP detergents.
- Collection and reuse of CIP detergents: instead of discharging to waste water after each CIP, the detergents are collected in tanks to be reused; new detergent is fed continuously until the correct concentration is reached.
- Regeneration of caustic soda used in CIP. The pipes and tanks are flushed through with hot alkali as a first step, resulting in a liquid very high in organic matter. The used caustic soda is then passed through a process in which a clay-based reagent is used to separate the alkali from the solids which form a sludge.

It is common practice for the final rinse water to be reused, either for pre-rinsing, intermediate rinsing or the preparation of cleaning solutions. The aim of the final rinse is to remove the last traces of cleaning solutions from the cleaned equipment. Clean water is used and the rinsing water, which returns to the central CIP unit, is clean enough to be reused, instead of being discharged to the drain. The recovery of the final rinsing water requires a connection from the CIP return pipe to the pre-rinsing tank. A conductivity transmitter is used to divert the water, e.g. to the pre-rinsing tank.

Achieved environmental benefits

A reduction in the consumption of water, detergents and the energy needed to heat the water are achievable because it is possible to set the consumption levels, specifying the use of only that required for the surface area to be cleaned. It is possible to recover and re-use water and chemicals within the system.

Cross-media effects

Possible energy considerations associated with pumping the water and detergent.

Technical considerations relevant to applicability

Applicable in closed/sealed equipment through which liquids can be circulated, comprising, e.g. pipes and vessels.

Economics

The capital cost can be high but annual savings due to reduced hot water and chemical consumption are achieved.

The capital cost is high.

Driving force for implementation

Automation and ease of operation. Reduced requirement to dismantle and reassemble equipment.

Example plant

Commonly used in the SA sector

Reference literature

[61, ETBPP, 1998] [21, ETBPP 1998], [134, Nordic States, 2001] [38, Nordic 2001], [163, German TWG Members, 2004] [52, Germany 2001], [206, Giner-Santonja et al. 2019]

2.3.5.2.4 Low-pressure foam and/or gel cleaning**Description**

Use of low-pressure foam and/or gel instead of water to clean walls, floors and/or equipment surfaces.

Technical description

Low-pressure foam cleaning can be used instead of traditional manual cleaning with water hoses, brushes and manually dosed detergents. It can be used to clean walls, floors and equipment surfaces. A foam cleaner, such as an alkaline solution, is sprayed onto the surface to be cleaned. The foam adheres to the surface. It is left for about 10-20 minutes and is then rinsed away with water.

Low-pressure foam cleaning can either use a centralised ring main or decentralised individual units. Centralised systems supply pre-mixed cleaning solutions and pressurised water from a central unit and during cleaning they automatically change between foam spreading and rinsing.

Achieved environmental benefits

Reduced water, chemical and energy consumption compared to the use of traditional water hoses, brushes and manually dosed detergents.

Environmental performance and operational data

Cleaning with gels provides a longer contact time between the soiling and active detergent than foams, because of the tenacious nature of gels with surfaces, and there is greater accessibility to crevices as access is not inhibited by air bubbles. However, gels are transparent and difficult to see and may be inconsistent at high temperatures.

Reported advantages of using gels include increased contact time with soiled surfaces, which allows improved cleaning results to be achieved, even though less aggressive chemicals are used. The chemical constituents soften soiling, resulting in improved rinsing efficiency and cleaning. As gels are very easy to rinse, less water is used. Labour costs are also reduced because, compared with traditional methods, cleaning takes less time. Due to less aggressive chemicals being used, there is reduced wear and tear on machinery and reduced risk to the operator.

Gels are typically used for cleaning walls, ceilings, floors, equipment and containers. The chemical is sprayed onto the surface to be cleaned.

Technical considerations relevant to applicability

Applicable in new and existing installations, for cleaning floors, walls, vessels, containers, open equipment and conveyors.

Economics

Request to the TWG: Please provide information.
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Driving force for implementation

Better cleaning and the elimination of problems associated with high-pressure cleaning, e.g. spreading of aerosols containing dirt particles and bacteria.

Example plant

Commonly used in the SA sector.

Reference literature

[206, Giner-Santonja et al. 2019]

2.3.5.2.5 **Optimised design and construction of equipment and process areas** ~~**Design and construction of vehicles, equipment and premises for easy cleaning**~~

Description

The equipment and process areas are designed and constructed in a way that facilitates cleaning. When optimising the design and construction, hygiene requirements are taken into account.

Technical description

The hygienic design is a set of design and construction criteria that improve the cleanability of equipment and facilities, by avoiding critical points and dead zones where the product may be retained and cannot be removed properly using standard sanitation (cleaning and/or disinfection). The prefix 'eco' refers to additional design criteria intended to reduce the environmental impact during sanitation (i.e. spillage collection, reduction of pipelines, reuse of cleaning water in closed loops, etc.)

The main goal of hygienic design of equipment and facilities is hygiene, but it is also related to the reduction of the environmental impact of cleaning and disinfecting operations, requiring a lower input of water, energy and chemicals to achieve the same level of hygiene. In other words, from the hygienic point of view, equipment and premises are hygienically designed and constructed if they minimise the risk of contamination of food being processed.

From the environmental point of view, hygienically designed and constructed equipment and premises reduce the environmental impact of their sanitation. Eco-hygienic design of equipment and installations is presented as a preventive technique to reduce the environmental impact of sanitation of food production equipment while maintaining the hygienic results of sanitation.

At the global level, there are two recognised groups working on hygienic design criteria and standards:

- The European Hygienic Engineering & Design Group (EHEDG) has published several guidelines for hygienic design criteria that have become a reference for both equipment manufacturers and the food industry. These guidelines are online and are regularly updated and complemented by new documents in various languages.
- 3-A SSI is an independent US corporation dedicated to education and the mission to promote food safety through hygienic equipment design in the food, beverage and pharmaceutical industries (<http://www.techstreet.com/3a>).

All vehicles, handling and storage equipment and premises can be smooth, impervious and designed so as not to harbour solids and liquids. Floors can have a chemical resistant finish applied, to prevent damage being caused by the chemicals used for cleaning and disinfection. Floors can be sloped to holding pits.

Achieved environmental benefits

- Reduction in the consumption of water and its contamination by cleaning chemicals.
- Reduced odour emissions.

Environmental performance and operational data

Vehicles and equipment can be designed in such a way that eases, the movement and removal of materials, e.g. by ensuring that hoppers have sides which slope downwards, by avoiding angles where materials may stick or be difficult to dislodge and by ensuring that none of the equipment contains any “dead ends”. One way of achieving this is to follow the general principles described in CEN standard *prEN 1672-2:1997 rev Food processing machinery - Basic concepts - Part 2: Hygiene requirements* which is intended to assist compliance with *Directive 98/37/EC of the European Parliament and of the Council of 22 June 1998 on the approximation of the laws of the Member States relating to machinery*.

Cross-media effects

The construction phase of some eco-hygienically designed equipment could potentially entail an increase in material, energy or water use compared to construction of conventional equipment (i.e. extra polishing in order to reduce the roughness of the surface). However, any extra consumption required would be clearly negligible in comparison to the consumption of the near daily sanitation over the total life cycle of food processing equipment (lifetime 10-20 years).

Technical considerations relevant to applicability

Applicable in all slaughterhouses and animal by-products handling premises.

Economics

The increase in the market price of eco-hygienic certified equipment (with EHEDG certification) compared to their conventional equivalents could be below 5 %.

Driving force for implementation

Reduction of costs associated with savings in water and energy consumption. Ease of operation, including cleaning. Reduced odour emissions.

Example plants

Commonly used in the SA sector.

Reference literature

[206, Giner-Santonja et al. 2019] [~~6, EA, 1997~~] [3, Environment Agency 1997], [~~65, EA, 1996~~] [23, Environment Agency 1996]

2.3.5.2.6 Fitting of cleaning-hoses with hand-operated triggers

Description

Fitting of cleaning hoses with hand-operated triggers.

Technical description

Trigger control shutoffs can be fitted to cleaning hoses with no other modification, if a water heater is used to provide hot water. If a steam and water blending valve is used to provide hot water, it will be necessary to install check valves to prevent steam or water from entering the wrong line. Automatic shutoff valves are often sold with nozzles attached. Nozzles increase the water impact and decrease flow.

Achieved environmental benefits

Reduced water and energy consumption.

Environmental performance and operational data

The energy saved was calculated for running a hose that had been fitted with an automatic shutoff valve and nozzle, using water at a temperature of 71 °C. The flowrate before installation was 76 l/min and after installation was 57 l/min. The time the hose was running was 8 h/d before installation and 4 h/d afterwards. For a water cost of USD 0.21/m³, an annual water cost saving of USD 4 987 (costs in 2000) was calculated. An annual energy saving of 919 GJ has also been calculated.

For a slaughterhouse killing 18 000 turkeys per day, i.e. 38 birds per minute, the potential water saving is reported as 9 000 m³/yr with a financial saving of GBP 5 620/yr. The investment cost quoted per hose was GBP 70. (Costs in 1999)

Cross-media effects

None.

Technical considerations relevant to applicability

Applicable in all slaughterhouses and animal by-products SA installations.

Economics

If nozzles are installed without automatic shutoffs, the equipment costs are less than USD 10. An automatic trigger controlled shutoff with a nozzle costs approximately USD 90. (Costs in 2000). The payback is reported to be immediate.

Driving force for implementation

Reduced water and energy costs.

Example plants

A turkey slaughterhouse in the UK.

Reference literature

[3, EPA, 1996] [1, EPA 1996], [214, AVEC, 2001] [90, AVEC 2001], [268, Ockerman H. W. and Hansen C. L., 2000] [122, Ockerman H. W. and Hansen C.L. 2000]

2.3.5.2.7 Cleaning of equipment as soon as possible

Description

Cleaning is carried out as soon as possible after use of equipment to prevent wastes hardening.

Technical description

For additional information, consult the Sectoral Reference Document on Best Environmental Management Practices for the food and beverage manufacturing sector [280, COM 2017].

Achieved environmental benefits

Reduced water consumption and waste water pollution.

Environmental performance and operational data

No information provided.

Cross-media effects

No information provided.

Technical considerations relevant to applicability

Applicable to all installations where manual cleaning is carried out.

Economics

No information provided.

Driving force for implementation

Reduced cost of water and waste water treatment.

Example plants

This technique is widely applied in the SA sector.

Reference literature

[206, Giner-Santonja et al. 2019], [280, COM 2017]

2.3.6 Waste water treatment techniques**2.3.6.1 Preliminary, primary and general treatment****2.3.6.1.1 Screening of solids –sieves (type unspecified)****Description**

The use of a device with openings, generally of uniform size, to retain the coarse solids found in waste water.

Technical description

After solids are removed with process-integrated techniques and prevented from entering the waste water, e.g. using catchpots located at drainage points inside the installation, further solids can be removed from the waste water using screening. Large quantities of non-emulsified FOG can be removed if screening is carried out together with technical and operational measures to avoid clogging.

A screen is a device with openings, generally of uniform size, that is used to retain the coarse solids found in waste water. The screening element consists of parallel bars, rods or wires, grating or a wire mesh or perforated plate. The openings may be of any shape but are generally circular or rectangular slots. The spacing between bars for removing very coarse materials prior to finer screening may be 20-60 mm. To remove smaller particles, the spacing between bars generally does not exceed 5 mm. The openings in automatic screens range from 0.5 mm to 5 mm, with openings of 1-3 mm in widespread use. Smaller openings (1-1.5 mm) are reported to be less susceptible to blockage than larger ones (2-3 mm).

The most commonly used screening equipment at slaughterhouses includes the static wedge screen, inclined screw press and the rotary drum screen. These screens typically have a mesh size of about 3 mm. After screening, many large slaughterhouses SA installations use a DAF treatment plant to further treat their waste water prior to discharge. DAF uses very fine air bubbles to remove suspended solids. The suspended solids float to the top of the liquid and form foam, which is then skimmed off.

In the static wedge/curved screen the waste water is pumped, or flows by gravity, to the top of the screen and then runs down a slide constructed from profile bars. The liquid drains through the screen, with the solids being collected at the bottom for separate disposal. Some screens are vibrated to facilitate particle transport. Others have cleaning nozzles for rinsing the screen from the clean side. Curved screens are supplied with slots down to 0.25 mm.

The inclined screw press is basically a rotating screw, edged with brushes, which is located inside a cylindrical perforated screen. The whole assembly is then incorporated within a “U” shaped trough. The waste water is pumped or flows by gravity into the bottom of the trough and is moved up the cylindrical screen by the action of the rotating screw. The force of gravity and the action of the screw causes liquid to be extracted through the screen and the remaining solids are discharged from the top of the unit.

Rotary or drum screens receive the waste water at one end and discharge the solids at the other. The liquid is passed outward through the screen to a receiving box for forward transfer. The screen is usually cleaned by a continuous spray via external spray nozzles, which are inclined towards the solids discharge end. This type of screen is effective for streams containing a relatively high solids content. Microscreens mechanically separate solid particles from the waste water by means of microscopically fine fabrics. The most important operating parameter is the headloss, i.e. the loss of operating pressure, with the best separation results reported to be between 5 mbar and 10 mbar.

Aperture widths of 0.25 - 4 mm.

Achieved environmental benefits

- Reduced suspended solids, ~~particulate~~ BOD/COD emission levels.
- Reduced potential for the formation of malodorous gases.
- Reduced risk of odour emissions further downstream in the WWTP.

Environmental performance and operational data

Reduction rates of 50 - 90 % for the settleable solids and 10 - 40 % for the BOD₅. A BOD₅ reduction between 17 - 49 % has been reported for slaughterhouse waste water, when using a mesh size of 1 mm. It is reported that the performance can be increased significantly if the plant is operated efficiently.

If screening ~~sieving~~ is not undertaken, solids get trapped in the WWTP network, where they then rot, emit odours and cause problems for complete treatment of the waste water. If sieves and collection vessels are not enclosed there may be problems associated with freezing during winter and with odour and vermin in summer.

Cross-media effects

Odour may be emitted from the screenings.

Technical considerations relevant to applicability

Applicable in all ~~slaughterhouses and those animal by-products~~ SA installations which produce waste water.

Economics

No information provided.

Driving force for implementation

Reduced waste water treatment requirements. Sieving removes the need for and therefore the cost of additional waste water treatment. It reduces the volumes of sludge produced, which would otherwise require additional costs for disposal.

Example plants

Widely used in SA installations [198, Waxwender et al. 2016], [264, TWG 2020].

All slaughterhouses and many animal by-products installations, such as fat melting, rendering and gelatine plants.

Reference literature

[163, ~~German TWG Members, 2001~~] [52, Germany 2001], [244, ~~Germany, 2002~~] [110, Germany 2002] [198, Waxwender et al. 2016], [215, COM 2005], [206, Giner-Santonja et al. 2019], [264, TWG 2020]

Static wedge/curved screen**Technical description**

Figure shows a typical static wedge/curved screen. Figure shows the screening and solids removal in more detail.

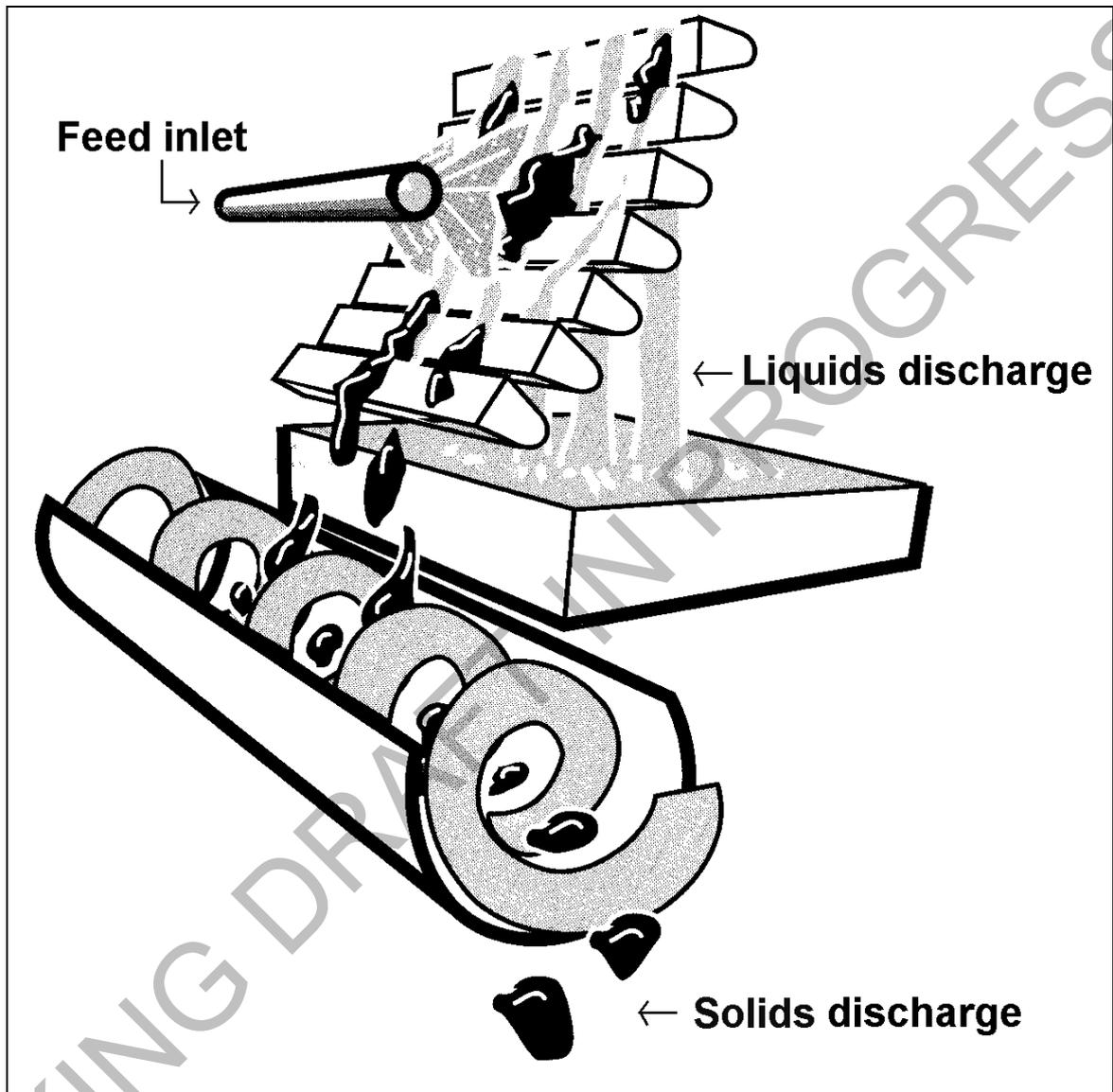


Figure: Curved screen
[134, Nordie States, 2001]

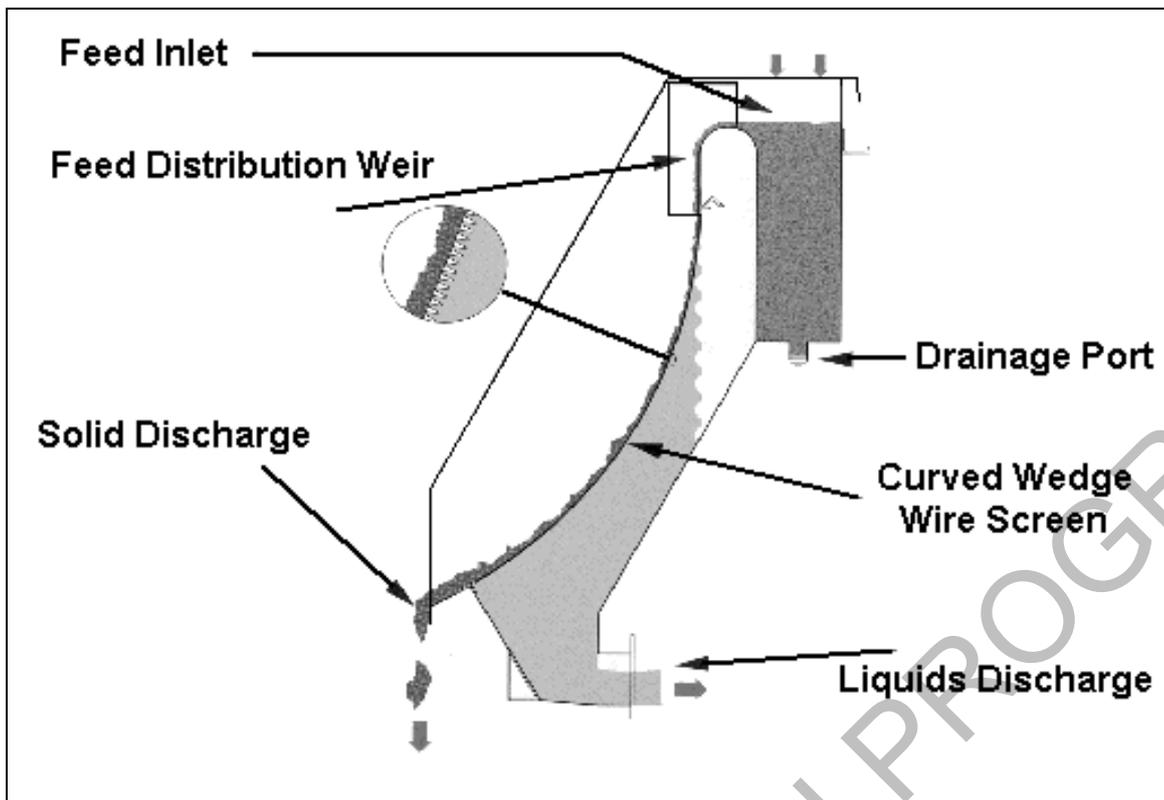


Figure: Static wedge screen
[12, WS Atkins-EA, 2000]

Achieved environmental benefits

A significant reduction in suspended solids and a small reduction in BOD of the waste water.

Cross-media effects

Water and detergents are consumed during cleaning.

Environmental performance and operational data

Static wedge screens require more maintenance than inclined screw press and rotary drum screens. In typical use, the static wedge screen can require cleaning up to three times a day using high pressure hoses to remove the build up of gross debris, and once a day with small amounts of cleaning chemicals, to dissolve any remaining fats.

Technical considerations relevant to applicability

Applicable in all slaughterhouses and animal by products installations which produce waste water which requires treatment.

Economics

Static wedge screens are generally cheaper than inclined screw press and rotary drum screens. The cost quoted in 2000 was GBP 10 000 – GBP 12 000. There are also maintenance costs associated with the regular cleaning requirement, which is necessary to prevent blinding and blocking of the mesh.

Example plants

At least one slaughterhouse in the UK.

Reference literature

[12, WS Atkins EA, 2000, 67, WS Atkins Environment/EA, 2000, 134, Nordic States, 2001, 236, ORGALIME, 2002, 243, Clitravi DMRI, 2002]

Inclined screw press

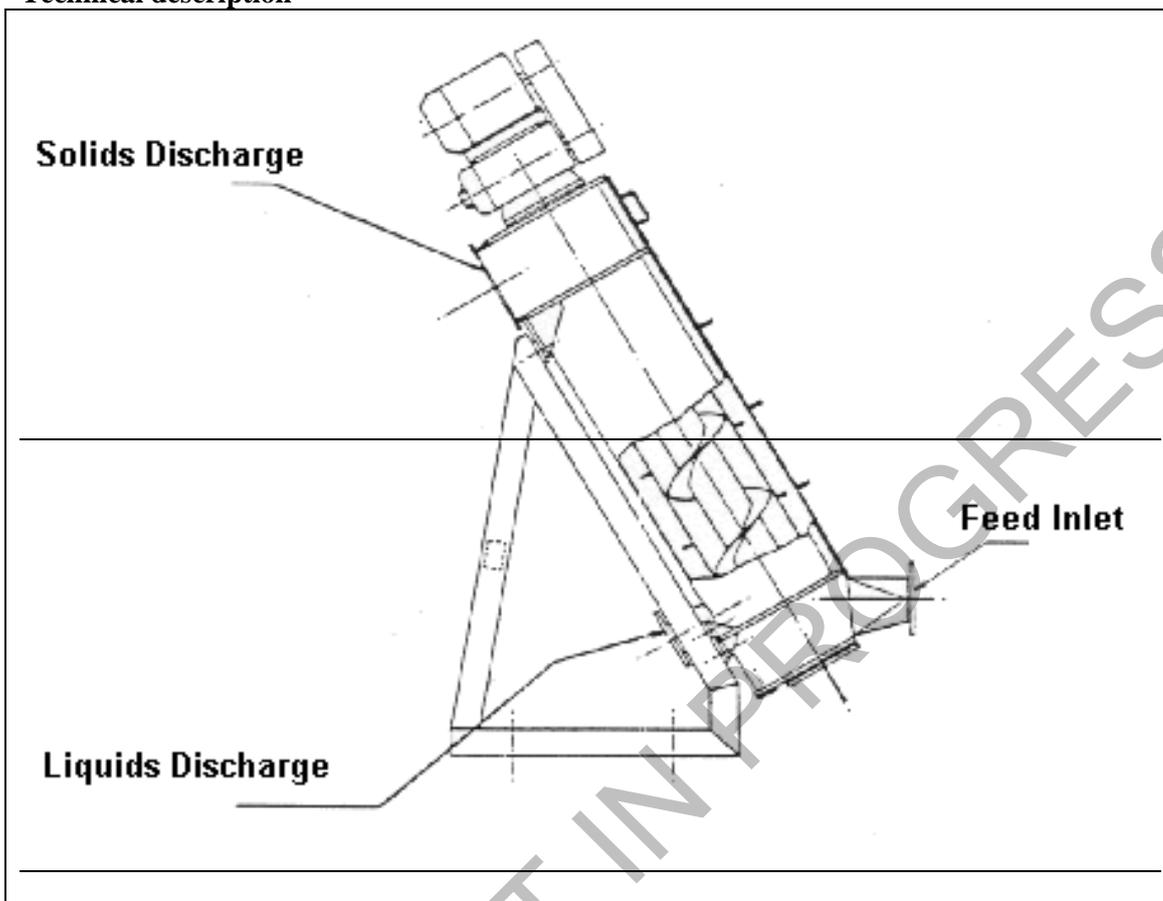
Technical description

Figure: Inclined screw press
[12, WS Atkins EA, 2000]

Achieved environmental benefits

Removal of particles and a small reduction in the BOD and suspended solids in the waste water.

Cross-media effects

There may be odour emissions, depending on, e.g. the age of the solids screened.

Environmental performance and operational data

The action of the screw brushes removes gross debris from the screen. Small amounts of cleaning chemicals are periodically used to dissolve any remaining fats which build up on the screen.

Technical considerations relevant to applicability

Applicable in all slaughterhouses and animal by products installations which produce waste water which requires treatment.

Economics

Inclined screw presses are generally more expensive to purchase than static wedge screens. The cost quoted in 2000 was GBP 12000.

Reference literature

[12, WS Atkins EA, 2000, 67, WS Atkins Environment/EA, 2000, 243, Clitavi DMRI, 2002]

Cylindrical screen

Technical description

The cylindrical screen comprises a rotating cylindrical drum constructed from perforated metal sheeting. The pore size in the sheeting can be as small as 1 mm. The waste water enters the drum and the liquid passes through the filter, with any particles being removed and discharged at one end, either as a result of being carried away by a screw or because of the oblique position of the cylinder. The cylindrical screen is suitable for removing materials which require tumbling to squeeze out residual liquid. The technique is illustrated in Figure.

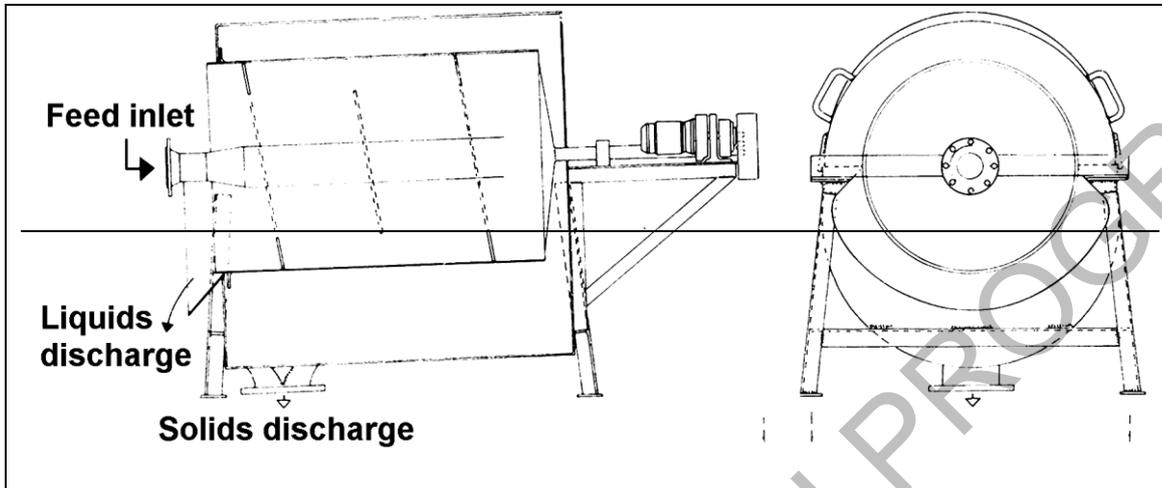


Figure: Cylindrical screen
[134, Nordic States, 2001]

Achieved environmental benefits

Removal of particles and a small reduction in the BOD and suspended solids in the waste water.

Cross-media effects

There may be odour emissions, depending on, e.g. the age of the solids screened.

Environmental performance and operational data

Screens with small holes need to be rinsed periodically from the outside. This may be achieved by a mechanical or spray system, to prevent blinding and clogging of the mesh.

Technical considerations relevant to applicability

Applicable in all slaughterhouses and animal by products installations which produce waste water which requires treatment.

Reference literature

[134, Nordic States, 2001]

Rotary drum screen

Technical description

There are a variety of rotary drum screens available. In some systems the effluent is loaded inside the drum, but more commonly the effluent flows over the external surface of the drum. Rotary drum screens have been reported to typically have a mesh size of between 3–4 mm, but in some cases this can be as small as 0.25 mm. In the rotary knife system the action of the drum lifts the solids from one side of the screen to the other, where they are then removed by a spring loaded scraper for collection into a skip, as shown in Figure. The screened liquid falls through the drum and is discharged to either an on-site or municipal WWTP.

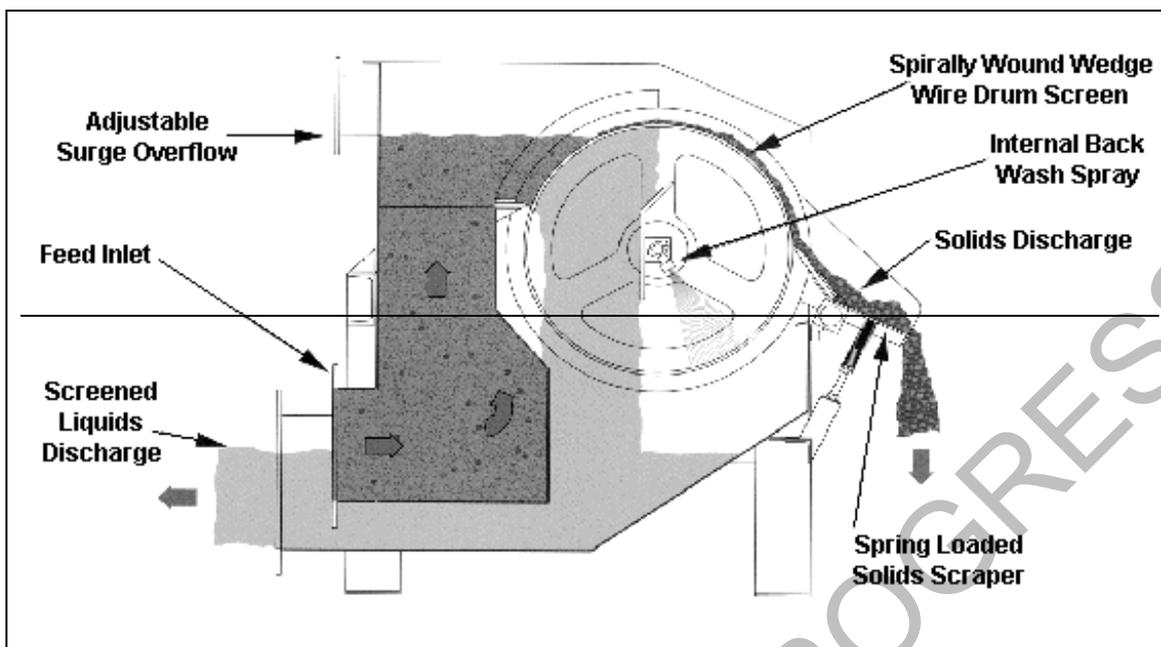


Figure: Example of a rotary drum screen
[12, WS Atkins-EA, 2000]

As well as ensuring that screening equipment is adequately maintained, it is essential to ensure that its screening capacity is capable of facilitating predictable variations in flowrates, whether on a day to day or a seasonal basis. At some pig slaughterhouses, there are problems when the scalding tank is emptied at the end of the working day and the waste water runs over the screen. This can remove meat scraps and debris out of the collection area. There may also be a problem in some slaughterhouses if surface water drains were routed to the waste water drainage system after the screening equipment was installed. This sometimes leads to screens being overrun during periods of heavy rainfall and meat scraps and debris being washed out of the collection area.

Achieved environmental benefits

The rotary drum screen reduces the contribution from solids to the waste water BOD level, although it does not remove the soluble fraction. It, therefore, only reduces the waste water treatment required. The proportion of the solid to the soluble fraction of the BOD depends on how the water use and the slaughter, carcass dressing and evisceration are managed in individual slaughterhouses. BOD reductions of 15–25% have been reported.

Cross-media effects

None reported.

Environmental performance and operational data

Internal back wash spray provides self-cleaning of the rotary drum screens, which generally require less maintenance than static wedge screens.

The equipment is virtually self-cleaning and is capable of working for many weeks unaided and with little or no maintenance.

The influent to be screened is introduced into a headbox which is designed to slow down the flow and distribute it. It then overflows a sealed weir onto the cylindrical screen, which rotates at 5–10 rpm. The solids are retained on the outside screen surface and removed by the doctor blade. In at least one type of rotary drum screen, the screened liquid then falls through the cylinder and passes through the bottom, from the inside to the outside. This action effectively backwashes the screen openings, so the portion of the cylinder screen to be fed is always clean. The backwash operation also avoids build up of, e.g. fatty solids inside the cylindrical screen.

Another type has a spray bar located inside the drum, which cleans the screen as the drum rotates, using water that has just been screened.

At least one type of rotary drum screen in current use is equipped with a patented high pressure inner washing system for periodic cleaning. The frequency of such cleaning, applied to remove grease, varies depending on the climate, with hot water being used to prevent blinding by grease solidification.

The solids produced are relatively dry, which is advantageous regardless of whether they are sent for rendering, incineration or composting.

The drum is generally constructed from high grade corrosion resistant material, which requires minimal maintenance. Wedge shaped wire is wrapped around a supporting structure to form a helical coil, leaving free spaces as small as 0.25 mm, depending on the users specification. The wire has a trapezoidal shape, specially designed to obtain a high specific flowrate by utilising a venturi effect.

The doctor blade removes the solids trapped on the surface of the screen. It is made of special corrosion proof material, e.g. copper and is considerably softer than the material used to make the cylinder. It is normally replaced once a year. Replacement takes a few minutes.

Correct sizing of the rotary drum to handle the volume of waste water anticipated is essential, as is the management of the rate of entry of effluent into the equipment. A number of rotary drum screens may even be constructed in series. Under sizing, or shock loading can cause the screen to overflow. The effect of this will vary depending on where the overflowing solids are then discharged. If yard water, including rainwater is collected separately from process water the solids can be discharged directly to the municipal WWTP. Shock loading can result during emptying of the scalding tank, especially if this coincides with hosing down during cleaning, as both are likely to occur at the end of a shift. Provision of a balance tank may, therefore, be required.

An example slaughterhouse killing 350 pigs per hour and producing 45.5 tonnes of carcasses and handling process water only in its WWTP, uses one rotary drum screen of diameter 90 cm and length 300 cm, with a mesh size of 0.75 mm, which is capable of handling a volume of 1 000 m³/h and 500 kg of suspended solids. The same slaughterhouse has a back up screen of diameter 70 cm and length 180 cm, capable of handling 420 m³/h of process water. The system has been in full successful operation for 8—10 years.

Technical considerations relevant to applicability

Applicable in all slaughterhouses and animal by products installations which produce waste water which requires treatment.

Economics

Rotary drum screens are typically between 2—3 times as expensive as static wedge screens, but they have the benefit of being self cleaning and generally require less maintenance and associated costs. The capital cost quoted in 2 000 was GBP 22 000—GBP 31 000.

Example plants

Slaughterhouses in Italy and the UK.

Reference literature

[12, WS Atkins EA, 2000, 67, WS Atkins Environment/EA, 2000, 279, Leoni C., 1979, 281, Savini F., 2002]

2.3.6.1.2 Oil and fat removal from waste water, using a fat trap

Description

A fat trap (or oil separator) is a plumbing device designed to intercept most greases before they enter the biological waste water treatment.

Technical description

Fat traps can capture fat, oil and grease that have been allowed to enter the waste water, by slowing down the flow of the water through the trap, which comprises a tank. If the water is hot, it is allowed to cool. As the water cools, the fat, oil and grease separate out and float to the top of the trap. The cooler water continues to flow out of the trap to the WWTP, while baffles contain the accumulated fat, oil and grease. The fat, oil and grease may be treated in a rendering plant.

The removal of the fat reduces corrosion and sedimentation in the receiving waste water pipelines and WWTPs and reduces the load requiring treatment.

Achieved environmental benefits

Removal of oil and fat from waste water.

Environmental performance and operational data

The size of the fat trap can vary depending on the amount of fat produced and on how often the fat trap is maintained. Fat traps may be located inside or outside the building. If they are located inside the building they tend to be smaller and they require more frequent maintenance. Traps that are located outside the building will operate differently in winter and summer and are more prone to clogging during cold weather.

If the separated fat remains in the fat trap for a long period it degrades and consequently its usability decreases and odour problems may occur during storage and processing, which can incur subsequent increased treatment costs. Automatic and continuous removal of the fats, using a scraper, can minimise these problems.

It is reported that at an example slaughterhouse, the waste water is fed into the tank via a vortex chamber. The light-weight fat, oil and grease particles go to the top of the tank and heavier material which cannot be diverted is dropped out of the bottom of the tank. The water phase then flows upwards via a submerged pipe and leaves the tank. The fat accumulated on the surface is then removed using a scraper, which guides it to a hopper and then into a storage tank. The sedimented material which accumulates in the bottom part of the tank can be removed by gravity or pump, either automatically or controlled.

It is reported that this enhanced type of mechanical fat separation guarantees on average a COD reduction of 50 % of the maximum possible COD reduction. The separation efficiency can be considerably increased if precipitants and coagulants are added. The process can be further enhanced by aeration. If a residence time of over four minutes is applied lighter materials are also retained in the sludge, reducing the settleable solids by up to 60 %.

Manual fat collection during the slaughter line reduced 35 % of the organic load in waste water in installation ES120 [264, TWG 2020].

Cross-media effects

The correct sizing of chambers is critical to ensure proper separation and to avoid the danger of washout during high or abnormal flows. Flow diversion may be needed if inflows suffer large fluctuations. Ease of emptying and regular maintenance is essential to prevent odour problems.

Installing fat traps within processing areas can cause food safety problems. Excessively hot water can cause fats to carry through and may melt precollected fat, so it should be avoided. The baffle material and ease of cleaning need to be considered.

Odour can be a major problem, particularly during emptying.

Technical considerations relevant to applicability

Applicable in all slaughterhouses and animal by-products SA installations.

Economics

The investment required is reportedly outweighed by the savings in waste water treatment costs and plant maintenance.

Driving force for implementation

Reduction in problems caused by fat in waste water pipelines and WWTPs and reduced loads requiring treatment.

Example plants

This technique is applied in virtually all slaughterhouses and animal by-products SA installations.

Reference literature

[344, Brechtelsbauer P., undated] [181, Brechtelsbauer P. 2003], [206, Giner-Santonja et al. 2019], [264, TWG 2020]

2.3.6.1.3 Equalisation Waste water equalisation tanks

Description

Balancing of flows and pollutant loads by using tanks or other management techniques.

Technical description

Storage and mixing tanks can be installed to equalise the enormous variations in the volume flow and in the concentration of the waste water.

Achieved environmental benefits

Enables downstream treatment techniques to operate at the optimum efficiency for minimising contaminated discharges to local water courses.

Environmental performance and operational data

The constant use of equalisation tanks, rather than their intermittent use when the flowrate exceeds a predetermined figure, is advantageous to the WWTP, since it ensures a more consistent effluent for treatment and minimises the problems that may otherwise be caused by shock loading, e.g. from cleaning chemicals which are used once each day. The effluent quality and thickening performance of secondary sedimentation tanks following biological treatment is reportedly improved through constant solids loading. It is reported that there are advantages to be gained from locating the equalisation tank after the primary treatment and before the biological treatment. If it is located before the primary settling tank, sufficient mixing must be provided to prevent the deposition of solids, concentration variations and odour problems. It is also reported that as general rule equalisation should take place after any fat has been removed from the waste water.

At one slaughterhouse, which reportedly successfully treats process and rainwater, an equalisation tank is located after the rotary screening equipment and before a flotation tank, where fat is skimmed off and sand is removed from the bottom of the tank. Another slaughterhouse reports that it has an equalisation tank capable of holding four days worth of liquid effluent. This can have advantages in terms of creating a homogeneous feed to the WWTP, but it can also lead to odour problems.

The tanks need to be sufficiently aerated to minimise the formation of noxious and malodorous gases. They may also need to be coated to protect the concrete from corrosion by fatty acids.

The tanks should be cleaned at regular intervals to prevent the build-up of solids and fat. The tanks should be agitated to prevent settlement of solids and potential overload of the WWTP.

Cross-media effects

None reported.

Technical considerations relevant to applicability

Applicable in all ~~slaughterhouses and animal by-products~~ SA installations where the flow rate and content of the waste water varies and where this may have a detrimental effect on the other WWTP processes.

Economics

The cost of constructing and operating an equalisation tank needs to be compared with the cost savings associated with the smooth running of the downstream treatment techniques.

Driving force for implementation

To present a virtually homogeneous feed to downstream WWTP processes.

Example plants

This technique is widely applied in SA installations [264, TWG 2020].

Equalisation tanks are used in slaughterhouses in Germany, Italy and the UK and in rendering plants in Germany.

Reference literature

[163, German TWG Members, 2001] [52, Germany 2001], [216, Metcalf and Eddy, 1991] [92, Metcalf and Eddy 1991], [244, Germany, 2002] [110, Germany 2002], [269, Italian TWG Members, 2002] [123, Italy 2002], [206, Giner-Santonja et al. 2019], [264, TWG 2020]

2.3.6.1.4 Buffer storage for waste water

Description

A buffer tank typically capable of receiving 2-3 hours of peak waste water flow.

Technical description

More detailed information on buffer storage is available in the CWW BREF [239, Brinkmann et al. 2016].

Achieved environmental benefits

Avoidance of uncontrolled and untreated discharges of waste water.

Environmental performance and operational data

Contingency measures can be provided to prevent accidental discharges from processes damaging the WWTP, due to receipt of a sudden high load. A buffer (or diversion) tank typically capable of receiving 2-3 hours of peak flow can be established. The waste water streams are monitored upstream of the WWTP so that they can be automatically sidetracked to the buffer system if necessary. The buffer tank is linked back to the equalisation tank (see Section 2.3.6.1.1) or primary treatment stage so that out-of-specification liquors can be gradually introduced back into the waste water stream. Alternatively, provision can be made to allow the disposal of the diversion tank contents off site. Buffer tanks are also applied where there is no separate drainage system for surface water and it could enter the on-site WWTP.

Cross-media effects

There are no cross-media effects associated with this technique.

Economics

Investment costs of EUR 150 000 have been reported for the installation of two buffer tanks (90 m³ each) including the measurement and control system [206, Giner-Santonja et al. 2019].

Driving force for implementation

Compliance with legal requirements to limit pollution to a receiving water body.

Technical considerations relevant to applicability

Lack of space and/or the layout of the waste water collection system in existing plants can limit the applicability.

Example plants

This technique is widely used in SA installations [264, TWG 2020].

Reference literature

[206, Giner-Santonja et al. 2019], [239, Brinkmann et al. 2016], [264, TWG 2020]

Provision of a waste water holding capacity in excess of routine requirements

Description

An emergency lagoon can be provided to intercept waste water which will exceed consent limits if it is discharged from the site. On-line monitoring of, e.g. ammonia, suspended solids and flow can be undertaken. If consent limits are exceeded the waste water can then be diverted to the lagoon and if necessary returned to the WWTP for further treatment.

The installation of mixing and equalisation tanks larger than those required for routine waste water treatment, as well as additional safety tanks, can enable plants to cope with emergencies, such as culls or occasional breakdowns. High volumes of waste water, which may also be highly loaded, can then be emptied slowly without exceeding the capacities of WWTPs.

Achieved environmental benefits

Prevention of discharge of untreated, insufficiently treated or excessive quantities of waste water to the local water course or municipal WWTP.

Cross-media effects

There may be odour problems.

Applicability

Applicable in all new slaughterhouses and animal by products SA installations. For existing installations, there may not be enough space to construct a lagoon.

Economics

There is an initial high cost incurred from providing the additional storage capacity, including paying for the space this requires. This has to be balanced against the cost of contaminating local water courses, damaging the operating conditions at the local municipal WWTP and the costs of exceeding discharge ELVs.

Example plants

A poultry slaughterhouse in the UK.

Reference literature

[163, German TWG Members, 2001, 243, Clittravi – DMRI, 2002, 248, Sorlini G., 2002, 264, May G. E., 2001]

2.3.6.2 Physico-chemical treatment

2.3.6.2.1 Chemical oxidation with ozone

Description

Chemical oxidation is the conversion of pollutants by chemical-oxidising agents other than oxygen/air or bacteria into similar but less harmful or hazardous compounds and/or to short-chained and more easily degradable or biodegradable organic components. Ozone (O₃) is one example of a chemical-oxidising agent applied.

Technical description

Since ozone is involved in the process, an ozone generator is part of the equipment, because ozone as an unstable compound cannot be stored or transported and has to be generated on site. After treatment, surplus ozone has to be eliminated, e.g. using a catalyst system based on manganese oxide.

In the example plants (DE047 and DE048), the ozone generator is a water-cooled tubular ozone generator with a vertical design, which is equipped with an electrode system. The PSU (power supply unit) consists of a medium-frequency converter, high-voltage transformer and control unit. The PSU produces the medium-frequency high voltage (1-1 000 Hz) required for ozone generation from the mains voltage fed in (3 x 400 V/50 Hz).

The heat loss resulting from ozone formation is very efficiently dissipated to the cooling water via the heat exchanger designed as a tube bundle.

The internal structure of ozone generators achieves the production of ozone from oxygen-containing gases according to the principle of 'silent electrical discharge' or non-thermal plasma. The ozone generation system is characterised by the exclusive use of inert materials such as stainless steel, borosilicate glass and polytetrafluoroethylene (PTFE), which ensure the long service life and insensitivity of the core component of the ozone generator.

Achieved environmental benefits

Reduction in AOX and COD emission levels.

Environmental performance and operational data

High ozone requirement of 8-15 g ozone per g of COD eliminated. A COD reduction of 3 mg/l for an ozone dosage of 40 g/m³ waste water is expected.

The AOX removal is strongly dependent on the composition of the cleaning chemicals used as well as the respective waste water composition.

Cross-media effects

Electricity consumption.

Technical considerations relevant to applicability

No technical considerations reported.

Economics

For the purpose of AOX reduction, the technique is considered a more economic option than the application of activated carbon.

Driving force for implementation

Compliance with legal requirements to limit pollution to a receiving water body.

Example plants

Plants DE047 and DE048.

Reference literature

[264, TWG 2020].

2.3.6.2.2 Evaporation

Description

The use of distillation to concentrate aqueous solutions of high-boiling substances for further use, processing or disposal (e.g. waste water incineration) by transferring water to the vapour phase. It is typically carried out in multistage units with increasing vacuum, to reduce the energy demand. The water vapours are condensed, to be reused or discharged as waste water.

There are many types of evaporators: natural circulation evaporators; short-tube vertical evaporators; basket-type evaporators; falling film evaporators; agitated thin film evaporators.

Achieved environmental benefits

Reduction in soluble contaminants.

Driving force for implementation

Compliance with legal requirements to limit pollution to a receiving water body.

Example plants

Plants DE051, ES133, IT262 and SE183.

Reference literature

[239, Brinkmann et al. 2016]

2.3.6.2.3 Precipitation

See Section 2.3.6.5.1.

2.3.6.3 Secondary treatment

2.3.6.3.1 Aerobic treatment

2.3.6.3.1.1 Activated sludge process

Description

A biological process where the microorganisms are maintained in suspension in the waste water and the whole mixture is mechanically aerated. The activated sludge mixture is sent to a separation facility from where the sludge is recycled to the aeration tank.

Technical description

The activated sludge technique produces an activated mass of microorganisms capable of stabilising a waste aerobically. The general arrangement of an activated sludge process for removing carbonaceous matter includes the following items:

- aeration tank where air (or oxygen or a combination of the two) is injected into the mixed liquor;
- settling tank (usually referred to as the final clarifier or secondary settling tank) to allow the biological flocs to settle, thus separating the biological sludge from the clear treated water.

Treatment of nitrogenous matter involves additional steps where the mixed liquor is left in an anoxic condition.

Achieved environmental benefits

Reduction in BOD, TOC or COD, phosphorus and nitrogen emission levels.

Environmental performance and operational data

After a given residence time, which can vary from several hours to in excess of 10 days, based on an organic loading rate or F/M ratio of about 0.1-0.15 kg BOD/kg of MLSS per day, the mixed suspension of microorganisms is passed to a sedimentation facility (see Section 2.3.6.5.2). The hydraulic retention time or sludge age and F/M ratio can all vary as a function of the raw waste water characteristics, e.g. composition, availability and degradability of organic substances, and the required final waste water quality. For example, nitrification occurs with lower (< 0.1 kg BOD/kg of MLSS per day) F/M ratios.

Cross-media effects

These include high energy consumption for aeration combined with mixing in the aeration tank. Volatile waste water content can be released into the atmosphere, giving rise to odour. Aerobic biological treatment produces a relatively large amount of excess activated sludge that needs to be disposed of.

Technical considerations relevant to applicability

The technique can be used to treat high- or low-BOD waste water, but will treat low-BOD water highly efficiently and cost-effectively.

Economics

The activated sludge technique provides a cost-effective treatment of soluble organic matter.

Driving force for implementation

Compliance with legal requirements to limit pollution to a receiving water body.

Example plants

This technique is widely used in SA installations.

Reference literature

[206, Giner-Santonja et al. 2019]

2.3.6.3.1.2 Sequencing batch reactors (SBR) in slaughterhouse waste water treatment

Description

The various stages of the activated sludge processes are all carried out within the same reactor.

Technical description

The sequencing batch reactor (SBR) process is an activated sludge process which treats waste water through a timed sequence of operations within one or more reactor tanks. The system allows equalisation, COD removal, nutrient removal and clarification to be achieved using a SBR. The cycle comprises a timed sequence of operations and is divided into the following main stages: filling, reaction, settling, discharging and idle.

Before the SBR treatment, the waste water needs to be screened using a 0.5 – 1 mm mesh and then degreased. If there is only one reactor, it is then collected in an equalisation tank prior to filling.

Filling stage: the SBR is filled with a quantity of waste water. The filling can be static, aerated, anoxic and/or anaerobic and adjusted to the particular waste water by simply modifying parameters in the control unit. This adaptability reportedly improves nutrient removal and prevents bulking problems. The filling velocity can also be controlled and this affects the effectiveness of the final settling stage.

Reaction stage: the reactor is mixed and aerated in sequence to optimise the final removal of COD and nitrogen. These can be controlled with dissolved oxygen or oxidation-reduction potential monitoring to ensure the desired efficiency with the minimum consumption.

Settling stage: the biomass is separated from the treated water by sedimentation in the reactor. The clarification is very effective since there is no countercurrent flow of the treated water. The length of the sedimentation period can be modified during operation to improve the clarification.

Discharging stage: the treated clarified liquid is discharged by a floating device at an appropriate height to ensure that neither settled solids nor floating debris are discharged. Finally, the settled biomass is pumped away from the bottom of the reactor, to prevent a build-up of excess sludge.

Idle stage: when there is no waste water to be treated, the SBR is switched to an idle phase. During this stage, it is not necessary to run the aeration systems at the same rate as during a normal cycle.

Another technique has been reported which is similar and which uses separate reactor vessels for aerobic, anoxic and anaerobic treatments.

Achieved environmental benefits

Reduction in BOD, TOC or COD, phosphorus and nitrogen emission levels.

Environmental performance and operational data

The COD and TN removal efficiency of a WWTP with a SBR in a pig slaughterhouse in Austria are reported to be 99.3 % and 95.8 % respectively, as a yearly average [198, Waxwender et al. 2016].

The COD reduction efficiency is reported to be as high as 95 %, thereby resulting in a low oxygen depletion potential in receiving waters. Compared to other waste water treatment processes, the energy consumption is reported to be low, as there is no need for recirculation between tanks, since all the operations are carried out in the same tank. There is no requirement to use chemicals and consequently there is no chemically contaminated sludge. The sludge can be used, e.g. in composting.

COD emission values of 22 mg/l have been reported from an SBR plant for a chicken slaughterhouse without total blood recovery. An achieved sludge waste value of 0.05 kg SS/kg COD has been reported.

As slaughterhouse waste water contains nitrogen and phosphorus there is an associated risk of the eutrophication of receiving waters. Emission levels as low as 0.2 mg/l of ammonium and < 1 mg/l of nitrates have been measured after SBR waste water treatment in chicken slaughterhouses, although it is reported that in practice the average levels in a plant with optimal operation is around 1 – 2 mg/l of ammonium and 5 – 15 mg/l of nitrates.

SBRs can alternate anoxic periods with aerobic periods, thereby removing nitrogen from the waste water. The length of the anoxic periods can be adjusted to create anaerobic conditions which facilitate up to about 40 % phosphorus removal.

It is reported that odour is not a problem if the biological reactor and the equalisation tank are well aerated.

It is reported that there is a low risk of accidents, since the plant works automatically and requires very little control by personnel.

It is reported that a de-foaming agent is the only chemical required and only during the first week of starting-up, due to blood in the waste water.

Table 2.7, Table 2.8 and Table 2.9 show data for a pilot plant and for three existing SBR WWTPs in poultry slaughterhouses.

Reference	Pilot plant (23 August 2001 – 2 August 2002)					
Waste water	Poultry slaughterhouse with < 85 % blood recovery					
Design	HRT = 3 days					
Pretreatments	Equalisation (HRT = 1 day) + 0.5 mm screening					
Net sludge production	0.1 kg SS/kg COD					
Parameters	pH	Conductivity (mS/cm)	COD (mg/l)	TKN (mg/l)	NH ₄ ⁺ (mg/l)	NO ₃ ⁻ (mg/l)
Inlet	6.5 – 8	3 – 4	3500	350		10
Outlet	7 – 8	3 – 4	< 125		< 5	< 20
Minimum value			17		0.4	8.4

Table: Operational data for a SBR at a poultry slaughterhouse pilot plant

Table 2.7: Operational data for a SBR at a 40 m³/d poultry slaughterhouse

Reference	Slaughterhouse A					
Waste water	Poultry slaughterhouse					
Flow	40 m ³ /d					
Design	HRT = 3 days					
Pretreatments	0.6 mm screening + degreasing DAF unit + aerated equalisation (HRT = 1.5d)					
Net sludge production	0.06 kg SS/Kg COD					
Parameters	pH	Conductivity (mS/cm)	COD (mg/l)	TKN (mg/l)	NH ₄ ⁺ (mg/l)	NO ₃ ⁻ (mg/l)
Inlet (equalisation tank)	7 - 8	3.0 - 4.5	2 800 – 4 200	300 – 475	–	5
Outlet	7 – 8	1.8 – 2.3	< 200	–	< 5	< 30
Minimum value	–	–	42	–	0.4	14.6
Source: [215, COM 2005]						

Table 2.8: Operational data for a SBR at a 100 m³/d poultry slaughterhouse

Reference	Slaughterhouse B					
Waste water	Poultry slaughterhouse					
Flow	100 m ³ /d					
Design	HRT = 2 days					
Pretreatments	1 mm screening + equalisation tank + DAF primary unit					
Net sludge production	SBR = 0.023 kg SS/kg COD Primary flotation approx. 4000 l/day at 4 % dryness					
Parameters	pH	Conductivity (mS/cm)	COD (mg/l)	TKN (mg/l)	NH ₄ ⁺ (mg/l)	NO ₃ ⁻ (mg/l)
Inlet (equalisation tank)	6.4 – 8.2	3.3 - 4.5	2 900 – 7 250	200	–	2.5
Outlet	6.8 – 8.5	2.5 – 3.5	< 100	–	< 25	< 10
Minimum value	–	–	22	–	0.2	0.8
Source: [215, COM 2005]						

Table 2.9: Operational data for a SBR at a 470 m³/d poultry slaughterhouse

Reference	Slaughterhouse C					
Waste water	Poultry slaughterhouse					
Flow	470 m ³ /d					
Design	HRT = 1.25 d x 2 SBR = 2.5 d					
Pretreatments	0.3 mm screening + degreasing DAF unit					
Net sludge production	0.21 kg SS/kg COD					
Parameters	pH	FOG (mg/l)	COD (mg/l)	TKN (mg/l)	NH ₄ ⁺ (mg/l)	NO ₃ ⁻ (mg/l)
Inlet (equalisation tank)	5.8 – 6.4	400 - 725	3 300 – 3 820	227	–	–
Outlet	6.1 – 7.4	1 – 35	< 150	–	< 20	< 5
Minimum value	–	0.8	93	–	0.4	< 1
<i>Source: [215, COM 2005]</i>						

The SBR is automated and controlled using a PLC. The main controls are for the cleaning of the screens and the degreasing units rather than for the operation of the technique. The operation of the SBR is monitored by the periodic measurement of V₃₀ values, i.e. by measuring the volume of a 1 litre sludge from the reactor after 30 minutes sedimentation time.

The cycle can be adjusted easily at the touch panel of the PLC and as required by the properties of the inlet waste water, e.g. if the COD:N changes or if there is a problem due to the appearance of filamentous bacteria, which create bulking.

The sludge is normally dried in a decanter, to achieve a 95 % reduction in volume.

SBRs are reported to require low maintenance secondary treatment, as they use less electromechanical equipment than other biological treatments.

Cross-media effects

These include energy consumption for aeration combined with mixing in the aeration tank. Aerobic biological treatment produces a relatively large amount of excess activated sludge that needs to be disposed of.

Most of the carbonaceous contamination ends up as CO₂ emissions, which eventually contribute to global warming. The nitrates output is higher than the input, because all of the TKN nitrifies into nitrates. This is compensated for by the TKN output being very much lower than the input.

Technical considerations relevant to applicability

Applicable in all SA installations slaughterhouses.

The technique is reported to have the advantages of not requiring much space and not requiring a clarification system (sedimentation or flotation units) or separate anoxic treatment for denitrification or phosphorus removal. It operates at a high solids concentration (MLVSS = 4 000 – 5 000 mg/l), so low volumes are required.

Economics

Investment costs

SBR is reported to be the cheapest secondary treatment, because the treatment can be carried out in one vessel. The reported selling prices of some slaughterhouse SBR treatment plants are shown in Table 2.10

Table 2.10: Reported selling prices of SBR treatment plants in 6 slaughterhouses

Name	Flow (m ³ /d)	COD effluent (mg/l)	Price not including VAT (EUR)	Observations
Slaughterhouse A	40	200	63 106	Civil works not included.
Slaughterhouse B	200	160	96 162	Civil works not included.
Slaughterhouse C	570	160	280 524	Civil works and sludge line included. Stainless steel tanks and centrifuge decanter sludge line.
Slaughterhouse D	1 500	*1 750	187 305	Civil works and sludge line included. Galvanised tanks and centrifuge decanter sludge line. Existing pretreatment.
Slaughterhouse E	160	160	75 685	Civil works not included.
Slaughterhouse F	200	160	110 115	Civil works partially included.

* COD value required by local permit, before treatment at a municipal WWTP
Source: [215, COM 2005]

Operational costs

The range of electrical costs reported is EUR 0.12 – 0.25/m³, for a EUR 0.06/kWh cost for electricity. There are no chemical reagent costs.

Driving force for implementation

The main driving force for the use of SBR in slaughterhouses is its capacity for removing nitrogen contents with a high efficiency and low investment and running costs. The technique is flexible and conditions such as the length and frequency of anoxic periods, filling velocity, settling time and anaerobic periods can be easily altered using a PLC. The technique does not require a lot of space.

Example plants

At least 3 poultry slaughterhouses in Spain, one ostrich slaughterhouse in Cyprus and several pig, poultry and cattle slaughterhouses in the Netherlands. There are plans for the technique to be installed in a pig slaughterhouse and a poultry slaughterhouse in Cyprus.

Reference literature

[302, Jimenéz Rodríguez J J. 2002] [151, Jimenéz R. 2002], [306, Hydrotech Water and Environmental Engineering Ltd 2001] [154, Hydrotech Water and Environmental Engineering Ltd 2001], [333, Netherlands TWG 2003] [177, The Netherlands 2003], [198, Waxwender et al. 2016], [206, Giner-Santonja et al. 2019]

2.3.6.3.1.3 Trickling filters ~~Moving bed trickling filter – for the treatment of air, water and air/water mixtures~~

Description

Waste water is distributed over a filter medium where biomass grows as a film.

Technical description

In fixed-film aerobic systems such as trickling filters, the biomass grows as a film on the surface of packaging media and the waste water is distributed so as to flow evenly across it. The trickling filter medium normally consists of rocks or various types of plastic. The treated liquid is collected under the media and passed to a settling tank from where part of the liquid can be recycled to dilute the pollutant load of the incoming waste water. Variations include alternating double filtration or permanent double filtration.

The moving bed trickling filter (MBTF) is a sludge-on-carrier aerobic biological filter for the treatment of waste water, waste gases and air and air/water mixtures. It is possible to treat waste water and air simultaneously.

The MBTF comprises a vertical cylindrical tank filled with plastic spheres. The spheres, which are made of durable material, act as a carrier material for micro-organisms. The waste water is fed into the filter at the top, whilst the air flows through the filter parallel or countercurrently to the water. Intensive mixing takes place in the filter and the contaminants in the water and air are broken down by the micro-organisms. A special feature is the fact that a number of the micro-organism-carrying spheres are periodically removed from the bottom of the filter and cleaned. The micro-organisms removed from the spheres are thickened to a compact sludge in the cone of the filter. The cleaned spheres are returned to the top of the filter. This unique integrated cleaning procedure makes it possible to control the amount of micro-organisms and makes clogging of the filter impossible.

The MBTF is shown in Figure 2.38.

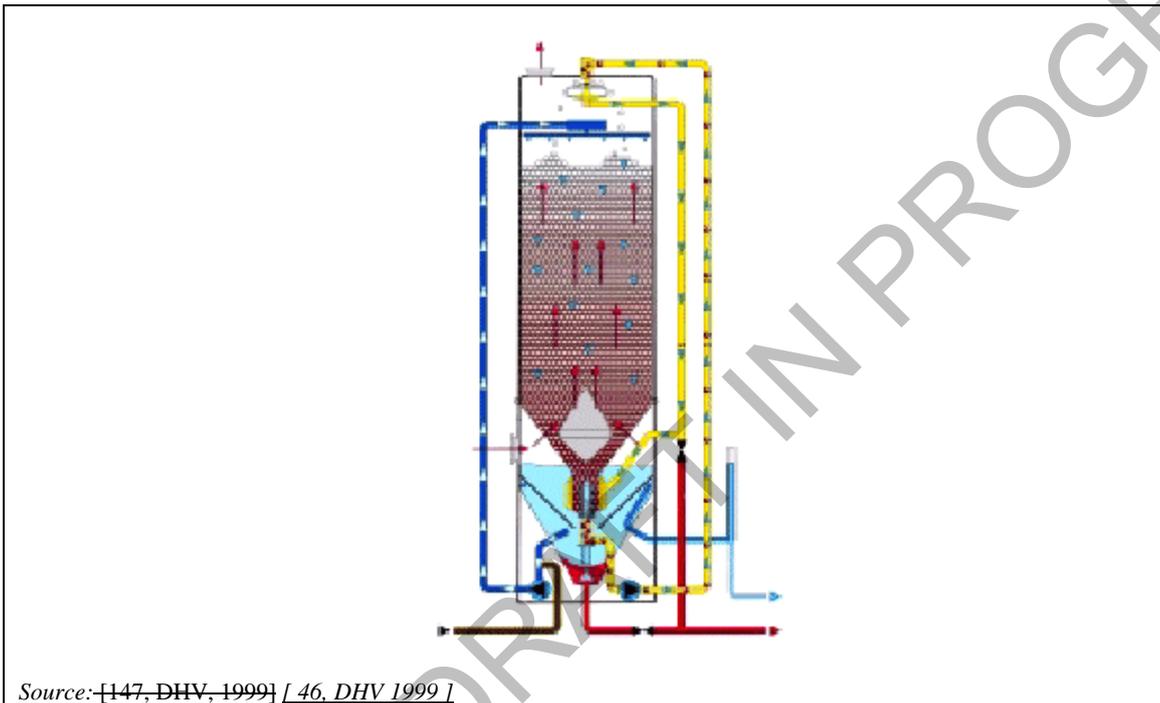


Figure 2.38: Diagram of a moving bed trickling filter designed to treat waste water and air emissions

Achieved environmental benefits

Low energy consumption. COD levels and nitrogen compounds are reportedly reduced by 90 % and 55 %, respectively.

Environmental performance and operational data

Compared to other systems for the treatment of air/gas or waste water, the MBTF is characterised by a high efficiency and a high capacity. Depending on the concentrations and flows, a reactor with a diameter of 4 metres could treat a waste gas flow of 30 000 Nm³/h of air while simultaneously treating 20 m³/h of waste water. For highly concentrated flows or with very strict effluent requirements other gas:liquid ratios are feasible.

MBTF has proven to be relatively insensitive to suspended solids and fats in the waste water stream. This often makes the use of coagulants or flocculants in the pretreatment unnecessary.

Cross-media effects

Potential odour nuisance.

Technical considerations relevant to applicability

Generally applicable

~~Applicable at slaughterhouses and animal by products installations.~~

Economics

Filter costs are compensated for by the reduced waste water charges. With combined treatments there is no need to invest in separate air/gas treatment techniques.

Example plants

A poultry slaughterhouse in the Netherlands.

Reference literature

[147, DHV 1999]-[46, DHV 1999], [240, The Netherlands 2002] [106, The Netherlands 2002], [206, Giner-Santonja et al. 2019]

2.3.6.3.2 Anaerobic treatment

2.3.6.3.2.1 Anaerobic contact process

Description

An anaerobic process where waste water is mixed with recycled sludge solids and then digested in a sealed reactor. The water/sludge mixture is separated externally.

Technical description

See the FDM BREF [206, Giner-Santonja et al. 2019].

Achieved environmental benefits

See the FDM BREF [206, Giner-Santonja et al. 2019].

Environmental performance and operational data

In a chicken slaughterhouse which also includes a rendering and a fat melting plant (BE020), the anaerobic contact process is applied. Maximum COD effluent values in the range of 29-34 mg/l are reported for the years 2016-2018.

Average COD effluent values in the range of 60 mg/l are reported in a cattle slaughterhouse (FR231).

Cross-media effects

See the FDM BREF [206, Giner-Santonja et al. 2019].

Technical considerations relevant to applicability

See the FDM BREF [206, Giner-Santonja et al. 2019].

Economics

Request to the TWG: Please provide more information.

See the FDM BREF [206, Giner-Santonja et al. 2019].

Driving force for implementation

See the FDM BREF [206, Giner-Santonja et al. 2019].

Example plants

Various SA installations.

Reference literature

[206, Giner-Santonja et al. 2019], [264, TWG 2020].

2.3.6.3.2.2 Internal circulation reactors

Description

Two UASB reactor compartments can be put on top of each other, one high-loaded and one low-loaded.

Technical description

See the FDM BREF [206, Giner-Santonja et al. 2019].

Achieved environmental benefits

See the FDM BREF [206, Giner-Santonja et al. 2019].

Environmental performance and operational data

One of the main advantages of the IC reactor is that it can undergo a certain amount of self-regulation, irrespective of the variations in incoming flows and loads. As the load increases, the quantity of methane generated also increases, and further increases the degree of recirculation and hence dilution of the incoming load.

In a pig slaughterhouse (ES103) average COD effluent values in the range of 17-90 mg/l are reported for the years 2016-2018.

Cross-media effects

See the FDM BREF [206, Giner-Santonja et al. 2019].

Technical considerations relevant to applicability

See the FDM BREF [206, Giner-Santonja et al. 2019].

Economics

Request to the TWG: Please provide more information.

See the FDM BREF [206, Giner-Santonja et al. 2019].

Driving force for implementation

See the FDM BREF [206, Giner-Santonja et al. 2019].

Example plants

Several SA installations.

Reference literature

[206, Giner-Santonja et al. 2019], [264, TWG 2020].

~~Anaerobic pretreatment using down-flow or up-flow reactors~~

~~**Technical description**~~

~~Passing waste water from slaughterhouses or rendering plants over fixed bed reactors supporting anaerobic micro-organisms on plastic rings or balls or on sintered glass, can act as a pretreatment technique to reduce the COD in waste water, prior to aerobic treatment. One particular technique operates in either a down flow or up flow operation, incorporating recirculation. However, the technique is unable to reduce either the COD or nitrogen content sufficiently for it to be more than just a pretreatment. It is reported to be capable of removing 73–76 % of COD in a rendering plant if 2 reactors are used, one operating in down flow mode and the other in up flow mode.~~

~~**Achieved environmental benefits**~~

Partial removal of some of the organic load from waste water, prior to further treatment on the site or at a municipal WWTP. It is reported that the biogas produced during the process contains more energy than the anaerobic plant needs to carry out the treatment.

Operational data

As a rule, almost 75 % of the COD during the down flow stage is soluble, while the remainder are solids. The dissolved COD is approximately 85 % volatile organic acids, especially ethanoic and propionic acid. Anaerobic micro organisms convert approximately 95 % of the in-flowing organic impurities into biogas and only 3–5 % into new biomass. Low volumes of biomass (excess sludge) are created during the acidification or methanation stage and these can be channelled into an aerobic biological purification stage. The biogas created is 60–85 % CH₄, which can be used for heating and power generation.

In an example rendering plant, the specific CH₄ production is reported to reach on average 0.32 m³/kg COD input. The biogas comprises 86–87 % CH₄ and 0.3–0.7 % H₂S. The high H₂S content in the crude gas has to be removed using a desulphurisation plant to prevent emissions and corrosion.

The actual volume load achievable depends on the specific surface, free space and the biomass concentration within the reactor. The reactor configuration, the environmental conditions within the reactor, such as the temperature and pH, as well as the substrate specific decomposition ability of the micro organisms are also important.

To treat waste water originating from rendering plants, a mesophilic method of operation at 35–37 °C is reported to be effective. A temperature of 32–42 °C can largely be maintained through the heating energy contained in the raw effluent. The residence time in the fixed bed reactor may be 11–30 h, depending on the biomass concentrations.

A prerequisite requirement for trouble free operation of fixed bed reactors is to ensure the removal of solid and lipophilic substances from the effluent, in order to avoid the accumulation of materials and blockages. The anaerobic process is relatively susceptible to failure from load fluctuations, so volume and concentration equalisation of the effluent is required. A mixing and equalisation tank with a stirring device can also facilitate gradual pre-acidification. The pH needs to be maintained around neutral, to prevent inhibition of the anaerobic mixed biocenosis. Stable CH₄ production takes place within a pH range of 6.8–7.8. The optimum pH for a separate pre-acidification process, depending on the substrate, is between 3.5–6.5.

To optimise the microbiological environmental conditions, necessary to free ammonia from the organic nitrogen compounds, an acidification dosage may be required, e.g. by the addition of hydrochloric acid or phosphoric acid. Depending on the effluent to be treated an additional dose of nutrients, e.g. phosphorus, may be required. A COD:N:P:S ratio of 800:5:1:0.5 is considered optimal. Toxicity problems may arise if there are higher ammonia or hydrogen sulphide contents. The inhibiting effects are determined by the pH, the substrate composition and the adaptation time of the micro organisms.

Table shows the results of anaerobic pretreatment at a rendering plant. Data are given for 2 months: February and July. It is not known to what extent the results of the treatment are due to the temperature of the anaerobic treatment or the difference in storage conditions of the raw material. The results are summarised in terms of the percentage change in each parameter. The starting loads were different.

Table: Influent and effluent data from an anaerobic waste water pretreatment plant

Parameter	February			July		
	Influent	Effluent	% increase or decrease	Influent	Effluent	% increase or decrease
pH value	7.5	7.8	-	7.9	8.2	-

Specific conductivity (mS/cm)	6.67	6.89	-	7.54	7.66	-
Filterable solids (mg/l)	1 115	532	-61.8	2642	1 011	-62
COD total (mg/l)	4 311	1 156	-73.2	9 414	2 208	-76.5
BOD ₅ total (mg/l)	3 433	534	-84.5	5 890	1 154	-80.4
Fat (mg/l)	370	90.8	-75.5	717	265	-63
NH ₄ -N (mg/l)	126	145	+15.1	185	208	+12.4
org. N (mg/l)	57.6	30.4	-47.2	80.2	59.4	-25.9
P total (mg/l)	8.7	8.6	-0.7	14.5	12.8	-12.1
Sulphide (mg/l)	24.1	8	-66.8	8.1	13.5	+65.2
Sulphate (mg/l)	39.5	11	-72.2	65.5	22.8	-65.2

It is reported that the biogas from the waste water produces more energy than that used during the waste water treatment. One kg COD produces 0.5 m³ of biogas. The heating value of one m³ of biogas is about 6.4 kWh. Using a block heat and power plant, 35 % of the 6.4 kWh can be used for the generation of electricity and 55 % in producing heat.

Cross-media effects

The ammonia content released from organic nitrogen combinations during anaerobic treatment exceed the nitrogen fixation through new biomass formation, so the level of ammoniacal nitrogen increases during the treatment.

Applicability

Applicable as a pretreatment in slaughterhouses and rendering plants, prior to aerobic treatment. Efficient removal of fat may make this step unnecessary in slaughterhouses, if the organic load is reduced sufficiently, as is the case in slaughterhouses in the Flemish region of Belgium.

Driving force for implementation

Significant removal of the COD in waste water and production of biogas.

Example plants

At least 2 rendering plants and one slaughterhouse in Germany.

Reference literature

[163, German TWG Members, 2001, 244, Germany, 2002, 346, Belgian TWG member, 2003]

2.3.6.3.3 Aerobic/anaerobic treatment

2.3.6.3.3.1 Membrane bioreactor

Description

A combination of activated sludge treatment and membrane filtration. Two variants are used: a) an external recirculation loop between the activated sludge tank and the membrane module; and b) immersion of the membrane module in the aerated activated sludge tank, where the effluent is filtered through a hollow fibre membrane, with the biomass remaining in the tank.

Technical description

See the FDM BREF [206, Giner-Santonja et al. 2019].

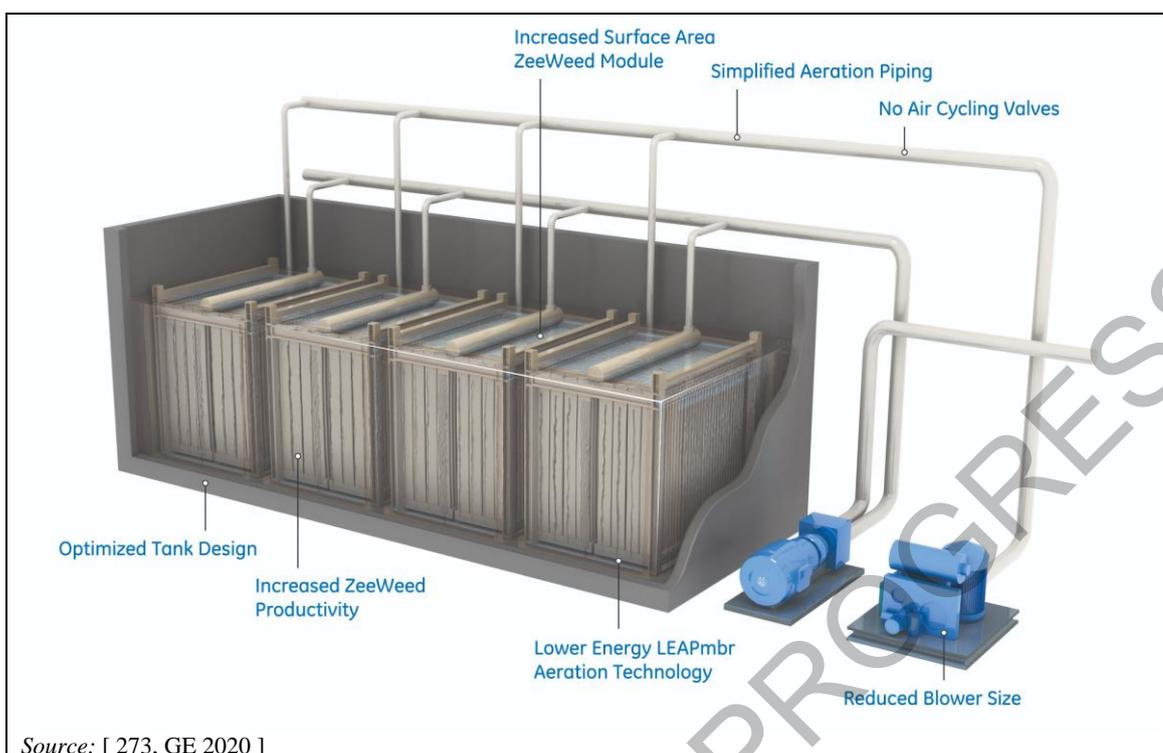


Figure 2.39: Scheme of a MBR

Achieved environmental benefits

See the FDM BREF [206, Giner-Santonja et al. 2019].

Environmental performance and operational data

A membrane bioreactor (MBR) provides highly efficient biomass separation, allowing the biomass concentration within the upstream reactor to be up to 10 times greater than the concentration normally attainable in a conventional suspended growth system. When using a MBR, no secondary sedimentation is required and very low COD and TSS emission levels can be achieved after treatment.

The operational data of a MBR operated in a turkey slaughterhouse are [272, Roudier et al. 2013]:

- TSS < 2 mg/l (50 mg/l before the ultrafiltration), abatement efficiency \approx 99.9 %;
- COD < 50 mg/l;
- BOD < 20 mg/l;
- Kjeldahl-N < 5 mg/l;
- Total nitrogen < 10 mg/l;
- Energy consumption = 4 – 6 kWh/m³;
- Working pressure of ultrafiltration membranes = 0.4 bar;
- Waste water flow = 1 200 m³/day.

Cross-media effects

See the FDM BREF [206, Giner-Santonja et al. 2019].

Technical considerations relevant to applicability

See the FDM BREF [206, Giner-Santonja et al. 2019].

Economics

See the FDM BREF [206, Giner-Santonja et al. 2019]. An investment of EUR 1 million to install an ultrafiltration membrane process was required in a turkey slaughterhouse [272, Roudier et al. 2013].

Driving force for implementation

See the FDM BREF [206, Giner-Santonja et al. 2019].

Example plants

Various SA installations.

Reference literature

[206, Giner-Santonja et al. 2019], [272, Roudier et al. 2013], [273, GE 2020]

2.3.6.4 Nitrogen removal

2.3.6.4.1 Nitrification and denitrification

Description

A two-step process that is typically incorporated into biological waste water treatment plants. The first step is the aerobic nitrification where microorganisms oxidise ammonium (NH_4^+) to the intermediate nitrite (NO_2^-), which is then further oxidised to nitrate (NO_3^-). In the subsequent anoxic denitrification step, microorganisms chemically reduce nitrate to nitrogen gas.

Technical description

A more detailed technical description of biological nitrification and denitrification can be found in the CWW BREF [239, Brinkmann et al. 2016].

Achieved environmental benefits

Nitrogen emission levels are reduced and energy is saved.

Environmental performance and operational data

This technique has the potential to achieve a high removal efficiency, a high process stability and reliability, relatively easy process control and space requirements.

Cross-media effects

Biological nitrification and denitrification imply the consumption of energy. In some cases, an external carbon source needs to be added.

Technical considerations relevant to applicability

Nitrification may not be applicable in the case of high chloride concentrations (e.g. above 10 g/l) and if the reduction of the chloride concentration prior to nitrification would not be justified by the environmental benefits. Moreover, the nitrification process may not be applicable when the temperature of the waste water is low (e.g. below 12 °C). This technique is not applicable when the final treatment does not include a biological treatment.

Economics

Investment costs of EUR 1 300 000 are reported for an aerobic treatment step for nitrification and denitrification in the FDM sector (treating around 1 500 m³/day of waste water, a COD load of around 1.0 t COD/day and a total nitrogen load of 150 t TN/day [206, Giner-Santonja et al. 2019].

Driving force for implementation

Member States' legislation to reduce eutrophication of fresh water.

Example plants

This technique is widely used in SA installations.

Reference literature

[206, Giner-Santonja et al. 2019], [239, Brinkmann et al. 2016]

2.3.6.4.2 Partial nitrification-anaerobic ammonium oxidation

Description

A biological process that converts ammonium and nitrite into nitrogen gas under anaerobic conditions. In waste water treatment, anaerobic ammonium oxidation is preceded by a partial nitrification (i.e. nitritation) that converts about half of the ammonium (NH_4^+) into nitrite (NO_2^-).

Technical description

The anaerobic ammonium oxidation process is used for nitrogen removal instead of the classic nitrification-denitrification process. This conversion is a shortcut in the natural nitrogen cycle where ammonium and nitrite are converted to nitrogen gas. In a first aerated step (preventing conditions for nitrate formation), ammonium is oxidised to nitrite; then the conversion of nitrite to nitrogen gas takes place in an anaerobic second step where the relevant bacteria are present.

As one oxidation step (nitrite→nitrate) is avoided by applying the partial nitrification-anaerobic ammonium oxidation process, less oxygen/air is used. Also, lower amounts of sludge are generated, in relation to the classic nitrification-denitrification process.

Achieved environmental benefits

Nitrogen emission levels are reduced and energy is saved.

Environmental performance and operational data

Request to the TWG: Please provide more information.

The conventional activated sludge treatment of waste water in a potato processing installation was retrofitted with a partial nitrification-anaerobic ammonium oxidation process in 2011. The applied process has a total nitrogen (TN) removal efficiency of around 90 %. Ammonium and nitrate are monitored in the aerated tank to optimise the oxygen supply. The organic load is also monitored and adjusted through recirculation of waste water.

Cross-media effects

Ammonium oxidation implies the consumption of energy to supply oxygen.

Technical considerations relevant to applicability

This technique is not applicable when the final treatment does not include a biological treatment. The technique may not be applicable when the temperature of waste water is low.

Economics

The operational costs of the WWTP can be reduced to around 60 % compared to a conventional nitrification/denitrification step.

Driving force for implementation

Member States' legislation to reduce eutrophication of fresh water.

Example plants

Request to the TWG: Please provide more information.

Various food installations.

Reference literature

[206, Giner-Santonja et al. 2019]

~~**Aerobic digestion combined with either intermittent or alternating denitrification under anoxic conditions**~~

Technical description

Biological nitrogen elimination is described in general terms in the “Common waste water and waste gas treatment/management systems in the chemical sector” BREF.

Aerobic digestion combined with either intermittent or alternating denitrification under anoxic conditions involves the simultaneous aerobic and anoxic treatment of waste water, either in separate tanks or in a single tank. The process is controlled by monitoring the concentrations of ammonia and nitrogen oxides. Consequently, a number of aeration devices are automatically switched on or off. For example, a single tank may be divided into aerobic and anoxic zones. During the alternating operational method, individual, sequentially arranged tanks are operated alternately on an aerobic or anoxic basis which coincides with the simultaneous transfer of effluent between tanks. During the intermittent operational method, the tanks are operated in parallel.

Achieved environmental benefits

Removal of nitrogen, BOD and COD compounds from high loaded waste water streams, which have not been excluded by other means.

Operational data

The technique is characterised by the removal of BOD without aeration, combined with the denitrification typically required for the waste water from slaughterhouses and animal by-products installations. This offers the advantage of minimising energy consumption. It has been reported that aeration can account for 60 % of energy consumption at WWTPs.

The aeration is achieved by diffusing the air through a very large number of fine holes, to ensure that there is enough oxygen in the waste water to undertake the nitrification required for the high nitrogen loads which are typical for the waste water from this industry.

In addition, the technique is characterised by high sludge ages, which also assist the denitrification process.

At one rendering plant where the treatment is applied, it is reported that the effluent is first subjected to fat separation, solids removal using cylindrical sieves, flotation, mixing and equalisation.

The treatment is then carried out in large volume, foil sealed earth basins. Aeration is carried out intermittently. Full nitrogen elimination, through simultaneous nitrification/denitrification, is reportedly achieved. The main part of the BOD and COD load can be removed without aeration. The introduction of air and the circulation of the biomass are achieved using 8 aerator chains. The aerator chains consist of 7 floating aerators, each connected to the others by means of air supply hoses. The air is introduced in the form of small bubbles, over the basin floor. The required quantity of air is made available through sliding vane rotary compressors. A compressor constantly runs on base load in order to ensure a specific minimum level of circulation of the activated sludge. The connection of further compressors is regulated by a timing programme and an automatic oxidation/reduction control. By varying the rate of oxygen introduced through different chains aerobic and anoxic zones are produced. The rate of oxygen fed through the chains is altered periodically, so that over time anoxic zones are intermittently created throughout the entire basin. The intermittent creation of aerated and anoxic zones is achieved by stopping the aeration process at 33 % of the aerators at any one time.

The sludge is removed and the effluent is subjected to further aeration and sedimentation.

Dimensional and operating data of the aerobic treatment stage, at this example plant, are shown in:

Parameters	Values
Total volumes, aeration tank	1 803 m ³

Inflow	100 m ³ /d
Mixed liquor suspended solids in the aeration tank	3.5 g/l
BOD load	346 kg BOD/d
NH ₄ -N load	90 kg NH ₄ -N/d
COD:N (ratio)	5.6:1
BOD volume load	0.19 kg BOD/(m ³ ·d)
N volume load	0.05 kg N/(m ³ ·d)
BOD sludge load	0.05 kg BOD/(kg TS·d)
N sludge load	0.015 kg N/(kg TS·d)
Excess sludge	66 kg/d
Age of sludge	95 d
Specific O ₂ consumption for BOD	2.09 kg O ₂ /kg BOD
Specific O ₂ consumption for N	1.91 kg O ₂ /kg BOD

Table: Dimensional and operating data of the aerobic treatment stage at a rendering plant

Table shows the effluent emission levels achieved in the plant described in during the period 1992 to 1996.

Parameters	Influent concentration	Effluent concentration		
		Average	Minimum	Maximum
BOD ₅ homogenised mg/l	3 460	3.1	1	8
COD homogenised mg/l	5 040	65.4	35	125
NH ₄ -N mg/l	900	10.0	0.3	29
NO ₃ -N mg/l		2.4	0.3	7.7
NO ₂ -N mg/l		1.8	0.7	4
P-total mg/l		1.8	0.3	4.3
AOX mg/l		0.015	<0.01	0.02

Table: Influent and effluent levels achieved during the period 1992–1996

Further information has been reported for another example rendering plant. The WWTP is reportedly designed with a processing capacity of 580 t/d of animal carcasses and designed for full nitrogen elimination, 2 tanks are operated in parallel with intermittent aeration. The process effluent is subject to fat separation and flotation, followed by mixing with non-process waste water. It is then treated in a clarification plant and an equalisation basin (1250 m³ with a reserve of 1750 m³). It is then divided between 2 basins, each of 6240 m³ capacity. The basins contain a total of 1300 metres length of tubes, each 1.365 metres long and perforated with fine holes, for air intake and 3 stirring devices. The basins are alternately supplied with air (aerated) or are simply stirred (anoxic) in a time ratio of approximately 2:1.

At a third example plant, a slaughterhouse, a WWTP treats effluent from the slaughterhouse, which has a tripe processing plant, in which intestines and stomachs are cleaned out and prepared for further processing. Stomach and intestinal contents, as well as blood are also handled.

The slaughterhouse has a capacity of 25 000 cattle per week, i.e. 5 000 per slaughter day. This produces 200 litres of effluent per slaughter unit, i.e. 623 l/t cattle carcase or 1 000 m³ per working day. It is reported that the daily load treated by the WWTP is BOD₅ 2020 kg, TKN 360 kg and 18 kg phosphorus. Two activation basins are used, alternating 1.5–2 hours denitrification with 1.5–2 hours nitrification. The times are controlled by monitoring NH₄-N, NO₃-N and O₂ and adjusting the pressure aeration rate.

Dimensional and operating data of the aerobic treatment stage of this plant are shown in-

Parameters	Values
------------	--------

Total volumes, aeration tank	7 000 m ³
Mixed-liquor suspended solids in the aeration tank	4–5.3 g/l
BOD load	2.020 kg BOD/d
TKN load	360 kg TKN/d
pH	6.8–7.2
BOD volume load	0.29 kg BOD/(m ³ d)
TKN volume load	0.051 kg TKN/(m ³ d)
BOD sludge load	0.072 kg BOD/(kg TS d)
P sludge load	0.00064 kg P/(kg TS d)
TKN sludge load	0.012 kg TKN/(kg TS d)
Excess sludge	66 kg/d
Age of sludge	30–40 d
Mixed-liquor suspended solids in return sludge	7–11 g/l

Table: Dimensional and operating data of the aerobic treatment stage at a slaughterhouse

Using this method, the maximum emission levels measured between 1995 and 1997 are shown in:

Parameters	Influent concentration	Emission levels (Maximum ever measured 1995–1997) (mg/l)
COD		47
BOD ₅	2020	7
N-tot		11
NH ₄ -N		3.7
P-tot	18	0.8

Table: Data from a waste water treatment plant of a slaughtering plant in Germany

This treatment was combined with sieves, equalisation and biofiltration prior to alternating denitrification and nitrification and sedimentation and filtering afterwards.

Cross-media effects

Odour problems may be caused. Energy is used, e.g. during aeration.

Applicability

Applicable in slaughterhouses and rendering plants.

Economics

The technique is considered to be economically advantageous as all of the processes can be undertaken in one tank.

Example plants

At least one slaughterhouse and 2 rendering plants in Germany.

Reference literature

[244, Germany, 2002, 341, EC, 2002]

2.3.6.5 Phosphorus removal

2.3.6.5.1 Precipitation

Description

Precipitation refers to the conversion of dissolved pollutants into insoluble compounds by adding chemical precipitants. The solid precipitates formed are subsequently separated by sedimentation, air flotation, or filtration. Multivalent metal ions (e.g. calcium, aluminium, iron) are used for phosphorus precipitation.

Technical description

Chemical precipitation of phosphorus is a frequently utilised method of phosphorus removal that can be carried out at different stages in a biological WWTP. Phosphorus precipitation is the transformation of the soluble phosphates present in the waste water to insoluble chemical compounds (salts) followed by the removal of these insoluble precipitates by sedimentation or filtration. The most commonly utilised chemicals contain lime, aluminium (mainly alum) and iron (mainly ferric chloride).

Achieved environmental benefits

Reduced phosphorus emission levels.

Environmental performance and operational data

In a pig slaughterhouse (AT004) precipitation is applied after treatment with SBR. Average Total P effluent values in the range of 0.20-0.62 mg/l are reported for the years 2016-2018.

In a geletine manufacturing installation (SE190) precipitation is applied after treatment with the activated sludge process. Maximum Total P effluent values in the range of 0.21-0.42 mg/l are reported for the years 2016-2018.

Cross-media effects

Generation of sludge and consumption of chemical precipitants. Metal phosphate salts, such as iron or aluminium, might not be used as fertilisers in agriculture because the iron or aluminium phosphates are not available for plants under normal pH conditions.

Economics

Request to the TWG: Please provide more information.

See the FDM BREF [206, Giner-Santonja et al. 2019].

Technical considerations relevant to applicability

Generally, there are no technical restrictions to the applicability of this technique.

Driving force for implementation

When phosphorus removal is applied before the biological treatment, a reduction of the energy costs of the WWTP can be achieved.

Example plants

This technique is widely used in SA installations.

Reference literature

[206, Giner-Santonja et al. 2019], [264, TWG 2020].

2.3.6.5.2 Enhanced biological phosphorus removal

Description

A combination of aerobic and anaerobic treatment to selectively enrich polyphosphate-accumulating microorganisms in the bacterial community within the activated sludge. These microorganisms take up more phosphorus than is required for normal growth.

Technical description

SA waste water may contain significant amounts of phosphorus if the cleaning agents used contain phosphate ingredients. Biological treatment methods can be used for phosphorus removal. These methods are based on stressing the microorganisms in the sludge so that they will take up more phosphorus than is required for normal cell growth. Two types of processes used for enhanced biological phosphorus removal (EBPR) are described:

- The proprietary A/O process for mainstream phosphorus removal is used for combined carbon oxidation and phosphorus removal from waste water. This process is a single-sludge suspended growth system that combines anaerobic and aerobic sections in sequence.
- In the proprietary phostrip process for side-stream phosphorus removal, a portion of the return activated sludge is diverted to an anaerobic phosphorus stripping tank.

Under certain operating conditions, more phosphorus than is needed may be taken up by the microorganisms, which is known as the luxury uptake. Under anaerobic conditions, the microorganisms break the high-energy bonds in internally accumulated polyphosphate, resulting in the release of phosphate and the consumption of organic matter in the form of volatile fatty acids (VFAs) or other easily biodegradable organic compounds. When the microorganisms are then put under aerobic conditions, they take up phosphate, forming internal polyphosphate molecules. This luxury uptake results in more phosphate being included in the cells than was released in the anaerobic zone, so the total phosphate concentration in the solution is reduced. When the microorganisms are wasted, the phosphate contained is also removed. A sufficient supply of VFAs is the key to removing phosphorus biologically.

EBPR can be accomplished in conjunction with treatment plants that nitrify and/or denitrify, with and without primary sedimentation. Where both nitrogen and phosphorus are to be removed, combined processes are used most commonly.

Achieved environmental benefits

Reduced phosphorus, BOD and TOC or COD emission levels.

Environmental performance and operational data

In a mainly pig slaughterhouse (SE181) biological phosphorus removal is applied after treatment with the activated sludge process and aerobic lagoons. 95th percentile Total P effluent values in the range of 0.26-0.42 mg/l are reported for the years 2016-2018.

Cross-media effects

Pumping is needed to send the waste water to further aerobic treatment.

Technical considerations relevant to applicability

Generally, there are no technical restrictions to the applicability of this technique.

Economics

Request to the TWG: Please provide more information.

See the FDM BREF [206, Giner-Santonja et al. 2019].

Driving force for implementation

To reduce the potential for eutrophication of fresh water.

Example plants

This technique has been reported in several SA installations.

Reference literature

[206, Giner-Santonja et al. 2019], [264, TWG 2020].

2.3.6.6 Final solids removal**2.3.6.6.1 Coagulation and flocculation****Description**

Coagulation and flocculation are used to separate suspended solids from waste water and are often carried out in successive steps. Coagulation is carried out by adding coagulants with charges opposite to those of the suspended solids. Flocculation is carried out by adding polymers, so that collisions of microfloc particles cause them to bond to produce larger flocs.

Technical description

When solid particles cannot be separated by simple gravitational means, e.g. when they are too small, their density is too close to that of water or when they form colloids/emulsions, coagulation and flocculation can be used. This technique converts the substances dissolved in the water into insoluble particles by means of a chemical reaction.

Their effect can be boosted by the addition of precipitation and flocculation agents before the waste water enters the flotation tank. Certain metal salts such as iron (III) sulphate, iron (III) chloride and aluminium sulphate, aluminium chloride and a number of polymers are used for precipitation and flocculation. The quantity and type of flocculation agents and flocculation aids can only be determined conclusively after semi-commercial trials or after the construction of a plant. It is reported that their use is not usually necessary. The application of sludge on agricultural land may be restricted after flocculation, due to metallic salt residues. For this reason, flotation without flocculation and precipitation agents can be selected for new designs, with the subsequent treatment steps dimensioned accordingly.

Achieved environmental benefits

Reduction of TSS, FOG and phosphorus emission levels.

Environmental performance and operational data

The effectiveness of coagulation and flocculation and selection of the coagulants depend upon understanding the interaction between the charge, size, shape and density of the particles to be separated. The final selection of the coagulant(s) should be made following thorough jar testing and plant-scale evaluation. Considerations must be given to the required effluent quality, effect on downstream treatment process performance, cost, method and cost of sludge handling and disposal, and overall net cost at the dose required for effective treatment.

Cross-media effects

Due to the addition of chemicals to the waste water, the dissolved solids/salt content may increase significantly and the solid waste produced might be difficult to reuse or dispose of. Another cross-media effect is the energy consumption for mixing.

Technical considerations relevant to applicability

Generally, there are no technical restrictions to the applicability of this technique.

Economics

This technique produces solid waste which is expensive to dispose of.

Driving force for implementation

Request to the TWG: Please provide information.
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Example plants

Various SA installations.

Reference literature

[206, Giner-Santonja et al. 2019]

2.3.6.6.2 Flotation plants

Description

The separation of solid or liquid particles from waste water by attaching them to fine gas bubbles, usually air. The buoyant particles accumulate at the water surface and are collected with skimmers.

Technical description

Flotation plants separate the fat and solids from the waste water. Usually they are installed after a coarse filter and a sand filter.

Achieving flotation of the solid particles requires the production of micro-bubbles. There are 3 methods for producing the bubbles. They are air flotation, i.e. aeration at atmospheric pressure; dissolved air flotation and mechanical flotation.

The basic mechanism of dissolved air flotation (DAF) is the introduction of small air bubbles into the waste water containing the suspended solids to be floated. The fine air bubbles attach themselves to the chemically conditioned particles and, as they rise to the surface, the solids float to the surface with them.

The air is dissolved under pressure, i.e. at 300-600 kPa (3-6 bar). The air is normally introduced into a recycled stream of treated waste water which has already passed through a DAF unit. This supersaturated mixture of air and waste water flows to a large flotation tank where the pressure is released, thereby generating numerous small air bubbles. Here they are accumulated, thickened and removed by mechanical skimming or suction withdrawal. Chemicals such as polymers, aluminium sulphate or ferric chloride can be used to enhance flocculation and, therefore, the adhesion of bubbles.

The floating material is removed by the use of chain conveyor scrapers.

Achieved environmental benefits

Reduction of COD, BOD, nitrogen and phosphorus in waste water and the production of sludge, after dewatering, for use in biogas manufacture. The cleaning efficiency depends on the equipment, the characteristics of the waste water and how it is operated. The solid materials may be recycled into an animal by-products installation, e.g. for composting, either on the same site, or elsewhere.

Environmental performance and operational data

In air flotation, air bubbles are formed by introducing the gas phase directly into the liquid phase through a revolving impeller or through diffusers. It is reported that aeration alone, at least for a short period, is not particularly effective in bringing about the flotation of solids.

For dissolved air flotation, air is injected while the water is under pressure. The dispersion water used, at 10 - 20 % of the flow, can be fresh water or waste water recirculated after flotation. The sludge may be scraped off the surface and sent off-site for land injection.

Table 2.11 and Table 2.12 give figures for the efficiencies of flotation plants.

Table 2.11: Purification performance of a flotation plant during production and cleaning

		Units	COD	BOD ₅	Fat	Total Kjeldahl Nitrogen	Phosphorus
Production	Influent	mg/l	1 000	498	104	36	10
	Effluent	mg/l	458	142	< 15	23	3.5
	Efficiency degree	%	54	71.5	> 86	36	65
Purification	Influent	mg/l	929	515	106	35	9.8
	Effluent	mg/l	530	237	< 15	32	5
	Efficiency degree	%	43	54	> 86	11	52

Source: [163, German TWG Members, 2001] [52, Germany 2001]

Table 2.12: Purification performance of a flotation plant using precipitation and flocculation agents

Pollutant	% reduction
BOD	70
Total N	55
Total P	70
Fat	85

Source: [134, Nordic States, 2001] [38, Nordic 2001]

Table 2.13 shows further operational data for a rendering plant with a flotation plant using submerged flotation aerators designed for this specific purpose.

Table 2.13: Influent/effluent data – for preliminary mechanical/physical-chemical waste water treatment after rendering

Parameter	Influent	Effluent	% decrease
pH	9.0 - 9.5	7.7 - 11	-
Filterable solids (mg/l)	1 530	570	2.7
COD total (mg/l)	5 024	3 416	32.0
Fat (mg/l)	1 590	199	87.5
NH ₄ -N (mg/l)	943	648	31.3
Organic-N (mg/l)	119	39	66.9

Source: [215, COM 2005]

Another report quotes typical COD strengths of slaughterhouse waste waters ranging from between 2 900 mg/l to 3 800 mg/l. These can be reduced by a DAF plant, to less than 600 mg/l, prior to trade effluent discharge. Suspended solids can be reduced from about 1 500 mg/l to less than 100 mg/l. [12, WS Atkins- EA, 2000] [4, WS Atkins-EA 2000]. The principal components of a DAF plant are shown in Figure 2.40.

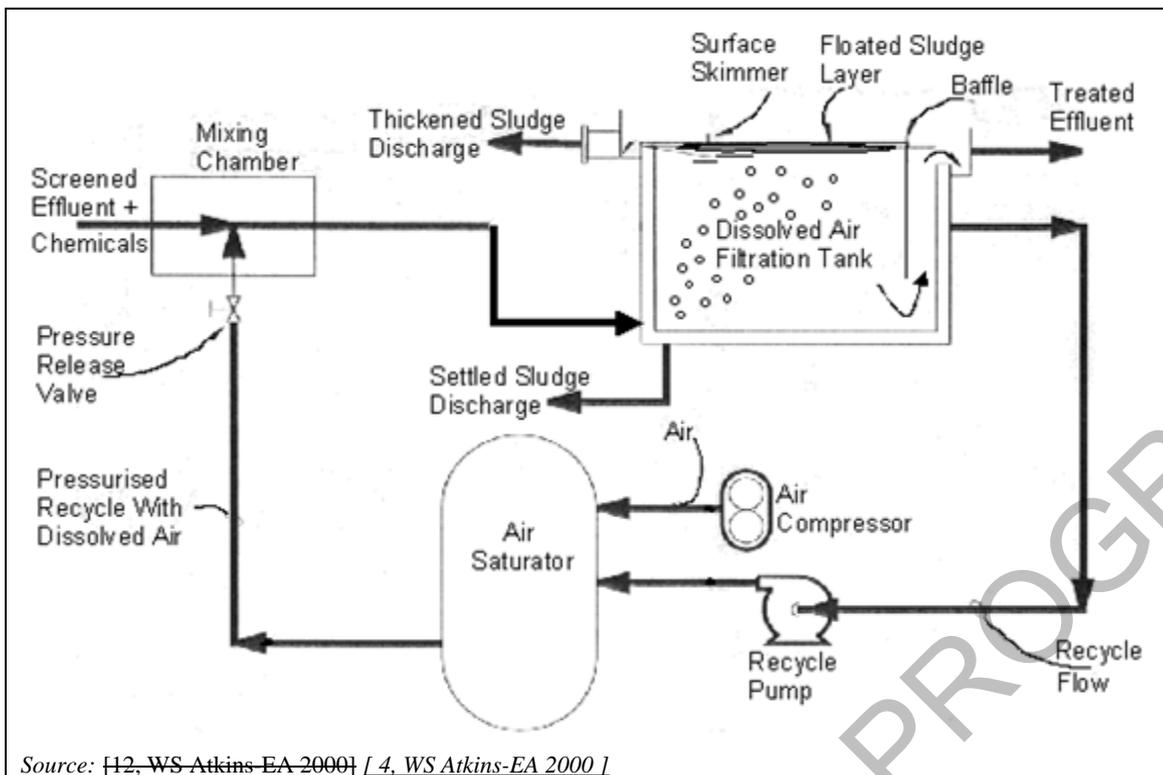


Figure 2.40: Principal components of dissolved air flotation

At a rendering plant using submerged aerators for flotation and a paddle to remove the floating material, with a flow of 15 m³/h and a volume of 12 m³ and surface area of 8 m², a 76 % reduction in fat content and a 42 % reduction in COD, are reported. An automatic spraying system controls the formation of foam.

At one German rendering plant the N-elimination from the high ammonia content of the waste water amounted to 10 %. At another, with higher initial ammonia levels, it amounted to approximately 30 - 40 %. This led to high ammonia levels in the air in the enclosed flotation area and occupational health risks to personnel entering the area.

High temperatures and pH values make fat separation difficult. Mechanical separation is reported to be the least sensitive to these parameters.

At an animal carcass disposal plant in Germany, flotation is undertaken using a mixing and equalising vessel designed for a constant effluent inflow of up to 8 m³/h. At this plant, a fat elimination rate of 50 % has been achieved. The COD (homogenised) is only reduced by 16 %, because the excess sludge from the biological treatment plant simultaneously reaches the flotation plant. This can lead to temporary overloading.

Cross-media effects

Often the dissolved air flotation water may use fresh water, thereby increasing the overall water consumption and increasing the quantity of water contaminated and thus requiring further waste water treatment.

Flotation plants are a potential source of odour problems. Iron III salts also aid odour reduction, because they remove H₂S [148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001] [47, Finnish Environment Institute and Finnish Food and Drink Industries' Federation 2001].

The presence of metallic salts from flocculation can prevent the sludge from subsequent biological treatment being applied to land.

Technical considerations relevant to applicability

Applicable in all slaughterhouses and animal by-products SA installations which produce waste water.

Economics

It has been reported that in many cases, the capital expenditure of a DAF plant is justified by reduced trade effluent costs.

Mechanical flotation is reported to incur lower investment and operating costs than other flotation techniques.

It has been reported that the investment cost for a flotation plant with a capacity of 60 m³/h is EUR 125 000 – 150 000 (2003).

Table 2.14 shows costs and maintenance requirements for a DAF plant treating 750 m³/d.

Table 2.14: Cost and maintenance requirements for DAF treatment - (750 m³/d effluent)

	Estimated capital cost	Typical maintenance requirements
Dissolved air flotation (DAF)	GBP 150 000	Up to 2 hours per day cleaning and maintenance may be required.
<i>Source: [67, WS Atkins Environment/EA, 2000] [24, WS Atkins-EA 2000]</i>		

Driving force for implementation

Reduction of COD, BOD, TSS, nitrogen and phosphorus in waste water.

Example plants

This technique is widely applied in SA installations [264, TWG 2020].

A poultry slaughterhouse in the UK. Slaughterhouses and rendering plants in Germany.

Reference literature

[134, Nordic States, 2001] [38, Nordic 2001], [163, German TWG Members, 2001] [52, Germany 2001], [244, Germany, 2002] [110, Germany 2002], [346, Belgian TWG member, 2003] [183, Belgium 2003], [206, Giner-Santonja et al. 2019], [264, TWG 2020]

Regularly conduct laboratory analysis of the effluent composition and maintain records**Technical description**

Regular laboratory analyses of effluent can form an important part of the management of waste water. Together with records of actual inputs, by composition and flow, the information can be used to determine how the WWTP can be operated to optimise the emission levels in the discharge to the local water courses or to the municipal WWTP.

Achieved environmental benefits

Assists with the management of the operation of the WWTP, to minimise emission levels.

Cross-media effects

None.

Technical considerations relevant to applicability

Applicable in all WWTPs.

Driving force for implementation

Compliance with ELVs.

Example plants

Several rendering plants in Germany.

Reference literature

[167, Greek Ministry for the Environment, 2001, 244, Germany, 2002]

2.3.6.7 Other general techniques applicable in slaughterhouses and animal by-products installations

2.3.6.7.1 Electrocoagulation

Description

Electrocoagulation is the process of applying an electrical charge to water and changing the particle surface charge, allowing suspended matter to form an agglomeration. Treating wastewater by electrocoagulation results in a reduction in water pollutants and replaces the chemical coagulation, biological treatment and the nitrogen and phosphorus removal step.

Technical description

Electric current passes through water in combination with highly charged polymeric metal hydroxide species. It uses a proprietary treatment chamber and electricity. An electrocoagulator (EC) reactor is made up of an electrolytic cell with a cathode and an anode, and consists of pairs of conductive metal plates (currently aluminium or iron) in parallel acting as monopolar electrodes (Figure 1). The main operation requirements are a direct current power source, a resistance box, and a multimeter [210, Chemicals 2019].

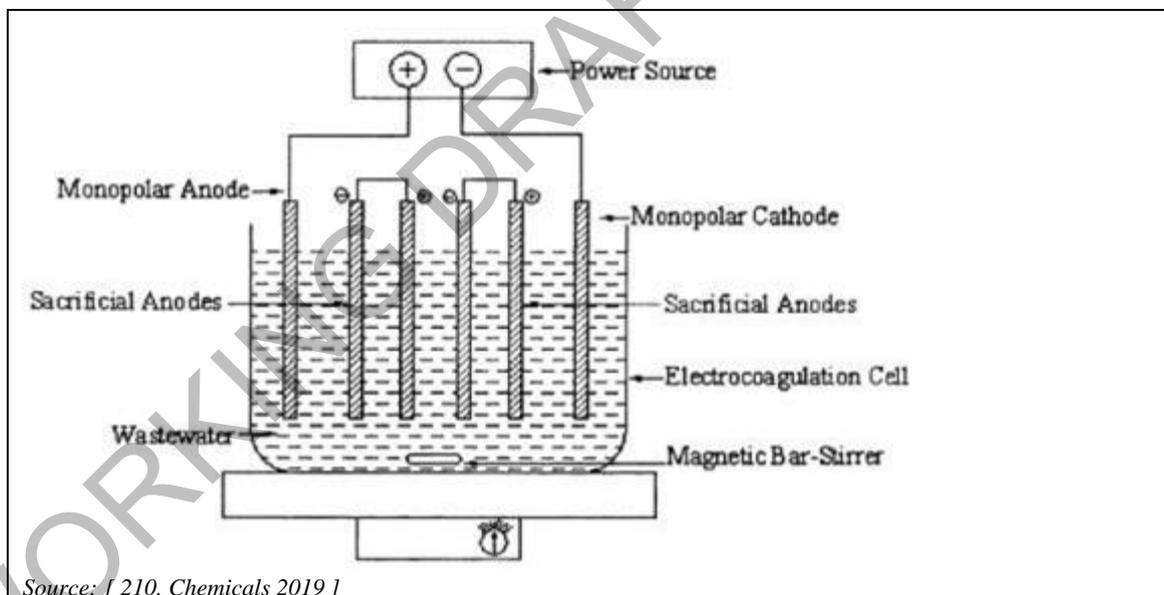
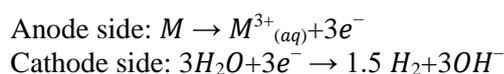


Figure 2.41: Overview of a electrocoagulation plant

Electrocoagulation is similar to chemical coagulation, except that there is *in-situ* generation of coagulant by the dissolution of the ‘sacrificial’ anode (conductive metal plates). When current is generated, hydroxide ions (OH⁻) are produced at the anode and hydrogen gas (H₂) at the cathode. Flocs will be formed due to the hydroxide ions and will settle the pollutant which is then easily removed by sedimentation. Gas bubbles are also formed and will entrain the lighter

pollutants to the surface and will be removed by flotation [211, Nwabanne et al. 2017]. The (simplified) reactions occurring at the electrodes are the following:



where M is the metal (i.e. Fe or Al).

Achieved environmental benefits

- Removal of the majority of organic pollutants (BOD, COD, TSS) and heavy metals.
- Lower sludge production.
- Recovery of metals [212, VITO 2019].

Environmental performance and operational data

Table 2.15 shows the removal efficiency of electrocoagulation (with iron and aluminium electrodes) in comparison with a general slaughterhouse waste water treatment (flotation plants (+ flocculants), biological treatment and removal of nitrogen and phosphorus). The majority of the contaminant removal efficiencies with EC are similar (except for COD, which is slightly lower).

Table 2.15: Removal efficiencies of electrocoagulation vs general slaughterhouse waste water treatment techniques

Parameter	Average concentration prior to treatment (mg/l) ⁽¹⁾	Electrocoagulation removal efficiency (%) ⁽²⁾		Slaughterhouse waste water treatment removal efficiency (%) ⁽³⁾
		Fe electrode	Al electrode	
COD	4 221	75	79	70 - 97
Oil grease	325	95	95	
Suspended solids	1 164	96	95	
TN	427	70 ⁽⁴⁾	78 ⁽⁴⁾	
TP	50	80 ⁽⁴⁾	90 ⁽⁴⁾	
Electricity consumption	-	10 kWh/m ³	8 kWh/m ³	- ⁽⁵⁾

NB:
⁽¹⁾ [213, Bustillo-Lecompte et al. 2016]
⁽²⁾ At optimal operating conditions of pH=6, operation time = 30 min, current density = 100 A/m² [214, Ozyonar et al. 2013].
⁽³⁾ [215, COM 2005]
⁽⁴⁾ At optimal operating conditions of pH=2, operation time = 25 min, current density 110 A/m² [216, Kazem et al. 2012].
⁽⁵⁾ Some electricity consumption is required to operate a conventional WWTP.

Cross-media effects

Higher usage of energy in comparison to traditional slaughterhouse waste water treatment. Electricity use is estimated between 8 kWh/m³ and 10 kWh/m³ for iron and aluminium electrodes respectively [214, Ozyonar et al. 2013].

Technical considerations relevant to applicability

The electrocoagulation process is simple, but the chemical reaction that can occur can be complex depending on the influent waste water composition. Laboratory tests are therefore required to determine the optimal operating conditions for a specific type of waste water [212, VITO 2019].

Economics

In general, average costs of electrocoagulation are equal to or higher than those of coagulation and flocculation. Typical operational expenses of electrocoagulation are at least 0.15 EUR/m³

for large installations ($> 1 \text{ m}^3/\text{h}$). These costs primarily consist of electricity use and, to a lesser degree, the replacement of electrodes [212, VITO 2019].

Little specific cost information is available due to the absence of large-scale plants in the slaughterhouse sector. For an installation with waste water volumes of $10 \text{ m}^3/\text{h}$, the investment cost would be around EUR 100 000 [217, MLA 2003]. The operational cost, principally driven by the current density, will mainly determine if this technology is cost-effective. At optimal working conditions, the operational cost is about $0.9 \text{ USD}/\text{m}^3$ and $2.75 \text{ USD}/\text{m}^3$ for iron and aluminium electrodes, respectively [214, Ozyonar et al. 2013].

Driving force for implementation

Replacement of three waste water treatment steps (chemical coagulation, biological treatment and the nutrients removal) by one step.

Example plants

Burrangong Meat Processors in NSW Australia [217, MLA 2003].

Reference literature

[212, VITO 2019], [213, Bustillo-Lecompte et al. 2016], [214, Ozyonar et al. 2013], [215, COM 2005], [216, Kazem et al. 2012], [217, MLA 2003]

Minimise liquid seepage and cover waste water treatment tanks

Description

The base and sides of waste water treatment tanks can be sealed to prevent leakage into the soil and groundwater and the tops may be covered and ventilated to minimise odour problems. Drainage systems can be provided underneath tanks, to collect any seepage that does occur in the event of an accident.

Achieved environmental benefits

Prevention of soil and groundwater contamination and minimisation of odour emissions.

Operational data

It is standard practice to line and seal the base and sides of tanks and to construct them on a base which will settle and not stress the tank materials or cause either small or catastrophic leaks. It is also standard practice to provide a drainage system beneath tanks to collect any liquid seepage that does occur and to feed it back into the WWTP.

The ventilated gases can be drawn to an odour abatement system, either specially provided for that purpose or which treats other malodorous gases arising from other activities on the site.

Cross-media effects

Energy will be required to power any ventilation equipment.

Applicability

Sealing of the base and sides, applicable in all waste water treatment tanks. Covering and ventilating tanks is applicable where odour problems may arise and are not otherwise prevented.

Driving force for implementation

Minimisation of the risk of soil and groundwater contamination and reduction in odour emissions.

Minimise liquid seepage and aerate waste water treatment tanks

Technical description

The base and sides of waste water treatment tanks can be sealed to prevent leakage into the soil and groundwater and the contents of the tank may be aerated to prevent the development of anaerobic conditions and a consequent production of malodorous gases.

Achieved environmental benefits

Prevention of soil and groundwater contamination and minimisation of odour emissions.

Operational data

It is standard practice to line and seal the base and sides of tanks and to construct them on a base which will settle and not stress the tank materials or cause either small or catastrophic leaks. It is also standard practice to provide a drainage system beneath tanks to collect any liquid seepage that does occur and to feed it back into the WWTP.

Cross-media effects

Energy will be required to mix the contents of the tank and perhaps to supply oxygen.

Applicability

Sealing of the base and sides is applicable in all waste water treatment tanks. Aeration is applicable when anaerobic conditions which are not actually necessary for the waste water treatment arise and create malodorous gases.

Driving force for implementation

Minimisation of the risk of soil and groundwater contamination and reduction in odour emissions.

Prevention of stagnant waste water

Technical description

The pipes associated with the drainage and the WWTP can be laid to have sufficient gradient to avoid the stagnation of waste water. This may be done for hygiene reasons, as e.g. stagnant slaughterhouse waste water will attract flies and rats. Odour problems can also be caused by anaerobic conditions in stagnant water in drainage systems.

Achieved environmental benefits

Reduced odour and vermin.

Cross-media effects

In existing plants which have insufficient gradient, energy may need to be used to pump the waste water.

Applicability

Applicable in all slaughterhouses and animal by products installations.

Economics

Not economically restrictive.

Example plants

Most slaughterhouses and animal by products installations which produce waste water.

Reference literature

[134, Nordic States, 2001, 244, Germany, 2002]

Treatment of slaughterhouse waste water at municipal WWTPs

Technical description

The degree of waste water treatment undertaken at the slaughterhouse before discharge to either a water course or to a municipal WWTP varies between installations and in some MSs is governed by local legislation or practice.

Instead of the slaughterhouse reducing the BOD level of its waste water to levels acceptable for discharge, it may, usually after primary treatment, be transferred to a local municipal WWTP. Gross solids are generally removed at the slaughterhouse and in the case of slaughterhouses handling Category 1 and 2 material, the sieved material is also deemed to be Category 1 and 2 material, as required by ABP Regulation 1774/2002/EC. Fats are also removed because these can cause serious problems with the operation of the biological treatment processes. The municipal WWTP must be designed to be able to treat the volume and load received from the slaughterhouse.

To run a waste water treatment plant with complete denitrification (nitrogen removal) it is necessary for sufficient carbon to be present. The ratio between carbon and nitrogen (the C:N ratio) of the incoming waste water normally needs to be a minimum of 5:1 for denitrification. Household waste water almost meets this requirement, but the inclusion of even only a small amount of badly compounded waste water, e.g. from industry, can disturb this ratio, with the result that complete denitrification is not obtained. Some plants add methanol or strong carbonaceous by products like treacle to the waste water. In towns with slaughterhouses, this type of problem seldom occurs because waste water from slaughterhouses contains easily degradable organic matter with a favourable C:N ratio.

In some countries, e.g. Denmark and the Flemish part of Belgium, taxes on waste water removal make it profitable for the slaughterhouse to pre-clean its waste water so that the tax they pay is reduced or discontinued. Pre-cleaning at the slaughterhouse is usually done by flotation. With flotation, the C:N ratio decreases to approximately 5:1. This results in lower waste water costs for the slaughterhouse since discontinuation of the tax they pay will normally fully make up for the expenses associated with running the flotation plant and for the return on investment in the new plant. The pre-cleaned waste water from the slaughterhouse still has a high enough C:N ratio that it can be completely denitrified, but the local authorities will now need the additional contribution of carbon to denitrify the rest of the waste water.

Achieved environmental benefits

Treatment of municipal waste without the need to add a carbon source.

Operational data

The slaughterhouse waste water contains high concentrations of nitrogen and phosphorus compounds. Discharge of this water to the municipal WWTP places extra burdens on it, which may require additional treatment techniques to be introduced, in order to achieve low concentrations of nitrogen and phosphorus in the final effluent.

Cross-media effects

Transferring untreated waste water to the municipal WWTP introduces a risk of accidental discharge between the slaughterhouse and the WWTP.

Applicability

Where the municipal WWTP is sufficiently close to the slaughterhouse and has the capacity and willingness to accept and treat the waste water.

Economics

Local arrangements determine how much the slaughterhouse has to pay.

Driving force for implementation

The slaughterhouse waste water may be a useful source of carbonaceous organic matter for the municipal WWTP. The slaughterhouse does not have to install or operate an on-site WWTP.

Example plants

Several Danish and German slaughterhouses.

Reference literature

[186, Pontoppidan O., 2001, 240, The Netherlands, 2002, 244, Germany, 2002, 277, EC, 1991]

2.3.7 Techniques to avoid the use of harmful substances**2.3.7.1 Proper selection of cleaning chemicals and/or disinfectants****Description**

Avoidance or minimisation of the use of cleaning chemicals and/or disinfectants that are harmful to the aquatic environment, in particular those that contain priority substances considered under Directive 2000/60/EC of the European Parliament and of the Council (Water Framework Directive). When selecting the cleaning chemicals and/or disinfectants, hygiene and food safety requirements are taken into account.

Technical description

Chemicals such as chlorine, quaternary ammonium compounds, bromine- or iodine-based products are routinely used to maintain the hygiene of SA sites. However, these are often potentially hazardous in combination with organic residues. For example, cleaning agents containing active chlorine can produce hazardous organic halogens and chlorinated hydrocarbons, which may impair or disturb waste water treatment. Moreover, to work safely and effectively, such chemicals typically require large volumes of water and often high temperatures. Then, when cleaning is complete, further treatment, with a significant associated environmental impact, is often needed to clean up any effluent.

Certain detergents, such as nonyl phenol ethoxylate (NPE) and alkylbenzene sulphonates (LAS) pose a high risk to the environment and can be avoided in all cleaning operations. NPE has been used as a cleaning agent in slaughterhouses and animal by-products installations. Nonylphenol is a metabolite of the nonylphenoethoxylate group. It is toxic to terrestrial and aquatic organisms, in which it has exhibits hormone-like effects.

Avoiding or minimising the production of harmful residues can include the following measures:

- use of less harmful cleaning chemicals (e.g. ozone);
- use of biochemical cleaning agents containing naturally occurring enzymes for cleaning and disinfection processes;
- reduction of the use of cleaning chemicals (e.g. EDTA, halogenated biocides, acids).

Sodium hypochlorite is frequently used in SA installations for cleaning and disinfection. Hypochlorites are classified as Aquatic Acute 1 and very toxic to aquatic life. Several studies have demonstrated the potential formation of hazardous halogenated by-products (e.g. chloroform, chlorinated acetic acids and trichloroacetyl groups [256, Ensen et al. 2016]) derived from the uses of hypochlorites in the presence of organic matter. Peracetic acid is the most suitable candidate to replace hypochlorites due to the lower production of organohalogen compounds and its high degradability. Peracetic acid breaks down into harmless acetic acid, oxygen and water. Products based on peracetic acid have the advantage of also being less corrosive than hypochlorite to metals, so they are very suitable for the disinfection of metallic surfaces. The main hazard of the substance as far as humans are concerned is the direct exposure, since it is corrosive. Information retrieved from the ECHA database indicates that peracetic acid is not genotoxic in rats and mice [255, Escudero 2015].

Although quaternary ammonium compounds are also effective substances for disinfection in the domestic and professional environments, little reliable evidence on their toxicity is available. Their use should be minimised as they could be harmful to the environment and health [255, Escudero 2015].

Ozone (O₃) in water solution can destroy the cell membrane of pathogens by oxidising the phospholipids and lipoproteins and has the advantage of itself quickly breaking down into harmless oxygen. Ozone is effective against a wide range of microbes including bacteria, yeasts, moulds, viruses and spores. The incorporation of ozone-rich water in CIP and other cleaning processes has the advantage over traditional disinfectants that no residues are left and the ozone is applied cold. This reduces the volume of water necessary to rinse detergents from the plant and the energy use associated with heating the water. Ozone can also be used in dry settings.

Using products with an EU Ecolabel is a voluntary commitment to a sustainable environment. From raw materials to production, packaging, distribution and disposal, EU Ecolabel products have been evaluated by independent experts to ensure that they meet the criteria that reduce their environmental impact. Detergents that meet the criteria of the European Ecolabel are readily biodegradable and are not toxic to the environment.

Achieved environmental benefits

- Reduction in consumption of cleaning agents and detergents.
- Reduced risk of groundwater AOX pollution in the surroundings of the installation, due to infiltration of contaminated run-off water [256, Ensen et al. 2016].

Cross-media effects

No information provided.

Technical considerations relevant to applicability

There are no technical restrictions to the applicability of this technique.

Economics

Request to the TWG: Please provide information.
--

Driving force for implementation

Use of less harmful substances.

Example plants

This technique is implemented in multiple SA installations.

Reference literature

[134, Nordic States, 2001] [38, Nordic 2001], [206, Giner-Santonja et al. 2019], [255, Escudero 2015], [256, Ensen et al. 2016]

2.3.7.2 Management of quantities of water and detergents consumption consumed

Description

Recording of the consumption of water and detergents on a daily basis to detect deviations from normal operation for its optimisation. This technique is part of the environmental management system of the installation (see Section 2.3.1.1).

Technical description

If the consumption of water, detergents and cleanliness can be recorded on a daily basis it is possible to detect deviations from normal operation and then to monitor and plan ongoing efforts to reduce the future consumption of both water and detergents without jeopardising hygiene.

Trials can also be undertaken, e.g. using less or no detergents; using water at different temperatures; using mechanical treatment, i.e. the use of “force” in the water pressure and using scouring sponges, brushes, etc.

Monitoring and controlling the required cleaning temperatures can enable the required cleaning standard to be achieved without the excessive use of cleaning agents.

Achieved environmental benefits

Potential reduced consumption of water and detergent and of the energy required to heat the water. The reduction potential depends on the cleaning requirements at each part of the installation or equipment to be cleaned.

Environmental performance and operational data

There are a small number of legal food and veterinary requirements which specify water consumption requirements. It is also recognised by veterinarians, operators and customers that water overuse can lead to cross contamination. Inadequate hygiene controls cause hygiene problems, which can result in product rejection or a shortened shelf life. Improvements in waterless cleaning techniques can be achieved, e.g. by using flow restrictions on the water supply and by regulating the water pressure from high-pressure wash to medium- and low-pressure for night and day cleaning, respectively. The frequency of wet cleaning can also be assessed with the objective of reducing the number of full wet cleans to one per day instead of one at every break, or as is the case in some slaughterhouses virtually constant wet cleaning, by someone who hoses down the slaughter hall approximately every 15 minutes.

Cross-media effects

None.

Technical considerations relevant to applicability

Applicable in all slaughterhouses and animal by products SA installations.

Economics

The technique results in reduced water and detergent costs.

Driving force for implementation

Reduced water and detergent costs.

Reference literature

[134, Nordic States, 2001] [38, Nordic 2001], [148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001] [47, Finnish Environment Institute and Finnish Food and Drink Industries' Federation 2001], [241, UK, 2002] [107, United Kingdom 2002]

2.3.7.3 Reuse of cleaning chemicals in cleaning-in-place

Collection and reuse of cleaning chemicals in cleaning-in-place (CIP). When reusing cleaning chemicals, hygiene and food safety requirements are taken into account.

See also Section 2.3.5.2.3.

2.3.7.4 Dry cleaning

See Section 2.3.5.2.1.

2.3.7.5 Optimised design and construction of equipment and process areas

See Section 2.3.5.2.5.

Selection of those detergents which cause the minimum impact on the environment

Description

Certain detergents, such as nonyl phenol ethoxylate (NPE) and alkylbenzene sulphonates (LAS) pose a high risk to the environment and can be avoided in all cleaning operations. NPE has been used as a cleaning agent in slaughterhouses and animal by products installations. Nonylphenol is a metabolite of the nonylphenoethoxylate group. It is toxic to terrestrial and aquatic organisms, in which it has exhibits hormone like effects. It will soon be banned for use as a cleaning agent in all but a few limited circumstances by Council Directive 2003/53/EC, amending for the 26th time Council Directive 76/769/EEC and will be prohibited from use in slaughterhouses and animal by products installations.

When choosing alternative detergents, it is necessary to first check that they can achieve an adequate level of hygiene and then to assess their potential environmental impact.

Achieved environmental benefits

Reduced damage to aquatic organisms.

Cross-media effects

These will depend on the alternative detergents chosen.

Applicability

Applicable in all slaughterhouses and animal by products installations.

Driving force for implementation

Nonyl phenols are "priority hazardous substances" highlighted for priority action under *Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.*

Reference literature

{134, Nordic States, 2001}

Avoid and reduce the use of cleaning and disinfection agents containing active chlorine

Description

Cleaning agents containing active chlorine can produce hazardous organic halogens and chlorinated hydrocarbons, which may impair or disturb the anaerobic treatment of floating matter in waste water. Substitutes for their use include, e.g. peracetic acid.

The consumption of all disinfectants can be reduced by applying an efficient cleaning before disinfection.

Achieved environmental benefits

Reduced emissions of hazardous organic halogens and chlorinated hydrocarbons, to water.

Operational data

The available substitutes for chlorine tend to be less efficient and more expensive.

Applicability

Applicable in all slaughterhouses and animal by products installations.

Economics

The available substitutes for chlorine tend to be more expensive.

Driving force for implementation

Reduced emissions of hazardous organic halogens and chlorinated hydrocarbons, which may interfere with the operation of WWTPs.

Reference literature

[163, German TWG Members, 2001]

Use of detergents using enzymes**Description**

Biochemical cleaning agents containing naturally occurring enzymes can be used for cleaning equipment, floors and walls and for disinfection.

Achieved environmental benefits

They are less harmful to the environment than some alternatives. They can be used at lower temperatures, so there are energy savings. They produce an effluent with a lower COD than other chemicals. They are non-corrosive.

Operational data

A major poultry processor tested a biochemical cleaning product in an area soiled with faeces, blood, urine, grease, fat and feathers, which was difficult to clean with NaOH. The biochemical cleaning product tested removed all traces of organic matter more efficiently. There was a reduction in odour and less damage to equipment. Less hot water was required.

Open handling and the use of detergents containing enzymes may result in unpredictable respiratory sensitisation in susceptible individuals.

Cross-media effects

There may be potential occupational health problems, as is the case with many traditional cleaning chemicals.

Applicability

Applicable in poultry slaughterhouses.

Driving force for implementation

The use of detergents containing enzymes instead of tensides, can reduce the problems associated with the use of the latter. Tensides can reduce the separation performance of fat separators and flotation plants.

Reference literature

[61, ETBPP, 1998, 163, German TWG Members, 2001]

2.3.8 Techniques to reduce emissions to air

2.3.8.1 Techniques applicable to a number of pollutants

2.3.8.1.1 Fuel choice

For more information, consult the LCP BREF [[266, Lecomte et al. 2017](#)].

Description

Switching from the combustion of one fuel to a less harmful one in terms of emissions (low sulphur, low ash content or better ash quality).

Technical description

The choice of fossil fuels with a lower content of potential pollution-generating compounds can lead to a significant reduction in emissions to air. In cases where supply is available, choosing or changing to a gaseous fuel may be a viable option. This will normally involve the use of fuels with a low ash content or low sulphur content.

Achieved environmental benefits

Better environmental profile, less emissions.

Technical considerations relevant to applicability

Generally applicable.

Reference literature

[[266, Lecomte et al. 2017](#)]

2.3.8.1.2 Combustion optimisation

For more information, consult the LCP BREF [[266, Lecomte et al. 2017](#)].

Description

Measures taken to maximise the efficiency of energy conversion, e.g. in the furnace/boiler, while minimising emissions. This is achieved by a combination of techniques including good design of the combustion equipment, optimisation of the temperature (e.g. efficient mixing of the fuel and combustion air) and the residence time in the combustion zone, and/or use of an advanced control system.

Technical description

The technique includes the good design of the furnace, combustion chambers, burners and associated devices and the regular planned maintenance of the combustion system according to suppliers' recommendations.

Achieved environmental benefits

Reduction of NO_x, N₂O, CO and other unburnt emissions to air in a balanced way.

Reference literature

[[266, Lecomte et al. 2017](#)].

2.3.8.1.3 Optimised thermal oxidation

Description

Optimisation of design and operation of thermal oxidation to promote the oxidation of organic compounds, as well as to reduce the generation of pollutants such as NO_x and CO.

Technical description

Optimisation of thermal oxidation can reduce the emissions of NO_x and CO. This is carried out by:

- optimising the design of the oxidiser:
 - residence time;
 - mixing of the flows (e.g. natural diffusion between turbulent streams, changes in flow direction);
 - combustion chamber;
- monitoring the combustion parameters:
 - oxygen content;
 - carbon monoxide concentration;
 - temperature;
- inspecting the burners regularly, and cleaning them when necessary.

When the oxidised VOCs contain sulphur and/or halogens, further emissions of sulphur dioxide and/or hydrogen halides might be expected. This might require an additional waste gas treatment after thermal oxidation (e.g. absorption), inspecting the burners regularly, and cleaning them when necessary.

Achieved environmental benefits

Reduction of NO_x and CO emissions to air.

Technical considerations relevant to applicability

Generally applicable.

Reference literature

[284, COM 2019]

2.3.8.1.4 Removal of high levels of dust, NO_x and SO_x precursors**Description**

Removal (if possible, for reuse) of high levels of dust, NO_x and SO_x precursors prior to combustion of malodorous gases, thermal oxidation, e.g. by absorption, adsorption or condensation.

Achieved environmental benefits

Reduction of dust, NO_x and SO_x emissions to air.

Technical considerations relevant to applicability

Generally applicable.

Reference literature

[197, Falcke et al. 2017]

2.3.8.2 Techniques mainly used to reduce organic and odour emissions**2.3.8.2.1 Odour management plan****Description**

An odour management plan (OMP) is part of the environmental management system (EMS) of the installation (see Section 2.3.1.1) and includes elements to prevent or reduce odorous nuisances.

Technical description

The OMP includes the following:

- A protocol containing actions and timelines.
- A protocol for conducting odour monitoring. It may be complemented by measurement/estimation of odour exposure (e.g. according to EN 16841-1 or -2) or estimation of odour impact.
- A protocol for response to identified odour incidents (including the management of complaints: identification of operations carried out, weather conditions such as temperature, wind direction, rainfall, communication with the authority and with complainant, etc.)
- An odour prevention and reduction programme designed to identify the source(s), to measure/estimate odour exposure, to characterise the contributions of the sources, and to implement prevention and/or reduction measures.

Since animals and materials of animal origin are handled in all SA installations, there are numerous potential sources for the formation of odours. Odour emissions can be caused by diffuse and fugitive sources (e.g. handling of animal by-products) or can derive from channelled release points of the installation (e.g. stack, biofilter). Due to the high number of possible diffuse emission sources, it is necessary to establish comprehensive measures in SA installations that help to prevent and minimise odour emissions.

The potential impact of malodorous emissions arising from the plant should be gauged from the nature, size and frequency of operation and the distance of neighbours from the plant. Identified sources of malodorous emissions can be further characterised by quantitative measurements of odour concentration, flow rate, temperature, humidity, chemical analysis and the pH.

Achieved environmental benefits

Prevention or reduction of the emissions of those odorous releases that may be offensive and detectable beyond the boundaries of the site.

Environmental performance and operational data

No information provided.

Cross-media effects

No information provided.

Technical considerations related to applicability

The technique is applicable to new and existing plants provided that an odour nuisance in residential or other sensitive areas (e.g. recreational areas, workplaces) is expected and/or has been reported.

Economics

No information provided.

Driving force for implementation

Reduction of number of complaints from the neighbourhood.

Example plants

Various SA plants in the the data collection..

Reference literature

[206, Giner-Santonja et al. 2019], [249, Giner Santonja et al. 2017]

Audit odour

Description

The individual sources of odour and factors which influence the rate and type of malodorous emissions are identified. All of the unit operations and the associated plant and buildings can be assessed for odour generation potential. The reception, handling, storage and preparation and the processing of raw material can be examined. The handling, storage and despatch of processed material, including separation into various products and solid, liquid and gaseous wastes can all be looked at separately. The potential impact of malodorous emissions arising from the plant should be gauged from the nature, size and frequency of operation and the distance of neighbours from the plant. In reported cases any detection of odour at the boundary fence is not acceptable. The effectiveness and appropriateness of existing odour abatement equipment and containment of emissions can be assessed.

Having identified sources of malodorous emissions these can be further characterised. Quantitative measurements may be required to determine the emission volume, flowrate, temperature, humidity, chemical analysis and the pH. A CEN standard *Air quality – Determination of odour concentration by dynamic olfactometry* [311, CEN, 2001] has become available during the late stages of the preparation of this document. Its availability may lead to more consistency in the measurement of odour concentration, within and between MSs. Much of the data currently available on odour concentrations is difficult to compare due to the diversity of the measurement techniques used to collect the data.

After emissions have been fully characterised the next step is to determine what further action, if any, is required. For example, it is necessary to look at ways of preventing the formation of malodorous substances and if this cannot be done to assess how best to contain and/or most appropriately treat the offending emissions, without incurring disproportionate cross-media effects.

Any odour abatement equipment should be selected according to the requirement of the relevant process and by taking into account the materials it will actually handle.

After installation, operator training and commissioning have been completed, the performance of the technique, including its operation and maintenance should be monitored and any further actions required can be taken as appropriate.

Achieved environmental benefits

Odour prevention and control:

Operational data

For an example rendering plant of 75 000 tonnes per year capacity, the following information was collected from an odour audit and the actions carried out (summary):

Sources of odour—offal intake area, main plant, finished goods area, tanker loading area, boiler outlet, carbon filter outlet, balance tank and aeration tanks.

Olfactometry—samples were taken from outlets and areas where it was identified that odours may arise. The odour concentrations (ou/m^3) and the odour emission rate were measured, to model the dispersion of odour from a given source.

Dispersion modelling—emissions from point, volume and area sources were calculated across simple and complex terrain, taking into account existing abatement techniques and meteorological and local climatological data.

Assessment of further needs to meet the conditions of an IPPC permit, which required that no odour nuisance occurs beyond the boundary fence because of the site operation.—odours detectable beyond the boundary fence, were detected from the offal intake area, the processing area, the finished goods area, the WWTP and from the carbon filter. The detectable odours emanated from open areas, open doors and a carbon filter which was being renewed regularly, but which was below specification.

~~*Additional action required* — ducting and ventilation of adequate dimensions to all new abatement plant; construction of an enclosed and negative pressure delivery building; a peat supported on shell biofilter, capable of treating 60000 m³/h of air from non-condensable gases from condensers, press areas, milling areas and cooling areas, process air from the drying and sterilising production area and air from the covered balance tank; refurbishment of the carbon filter area to treat the air from the material reception area.~~

~~*Post upgrade monitoring* — the modifications led to the conclusion that the odours emitted from the site would be unlikely to cause a nuisance to the people in the surrounding environment.~~

~~*Application for a permit to increase the capacity of the rendering plant to 125000 tonnes of raw material per year* — the odour audit was repeated and a decision was taken to prevent emissions from the additional throughput, by installing a thermal oxidiser to burn gases from all cookers, presses and sterilisers, as well as waste water, which was previously spread on land after treatment in the WWTP.~~

Cross-media effects

None.

Applicability

Applicable in all slaughterhouses and animal by products installations.

Driving force for implementation

Application for an IPPC permit.

Example plants

At least one rendering plant in Ireland.

Reference literature

[309, Sweeney L., 2002]

2.3.8.2.2 Prevention of biological degradation of animal by-products and/or edible co-products

See Section 2.3.2.6.

2.3.8.2.3 Regular cleaning and disinfection of installations and equipment

Description

Regular cleaning of installations and equipment where animal by-products are stored and processed.

Technical description

A regular, e.g. weekly, thorough cleaning of installations and equipment where animal by-products are handled will reduce the risk of diseases being spread by insects, rodents and birds and will help control the formation of malodorous substances.

Achieved environmental benefits

Reduced odour emissions. Insect, rodent and bird control.

Operational data

The following example of a cleaning routine has been reported at an installation incinerating animal carcasses and parts of carcasses, including SRM. First rinse, then apply an alkaline detergent, follow with another rinse, then disinfect with 2 % chlorine solution, for at least one hour. At the same installation, the enclosed storage, handling, grinding and charging equipment is cleaned periodically and usually before maintenance, by passing wood chips through the system and then incinerating them.

If raw material containers are emptied and washed frequently, e.g. daily, then decomposing and malodorous materials will not accumulate over long periods of time. Delays in the despatch of animal by-products from the slaughterhouse, together with the long distances travelled, without temperature control provide sufficient time for material to deteriorate and if storage, particularly badly controlled storage, continues on a site, even briefly, odour problems will be exacerbated. Even facilities with a quick turnover of clean material can generate odour problems, if good hygiene practices are not observed.

Cross-media effects

Detergents, including disinfectants are used. Water is consumed during the cleaning process, although the extent depends on the amount of dry cleaning carried out before water is used. There may be opportunities to re-use water from sources which have not been in contact with animals or animal by-products and from the WWTP, depending on the extent of treatment of the waste water and the final use of the by-product.

Applicability

Applicable at all installations, storing, handling and treating animal by-products, except perhaps where there is long-term storage of animal meal.

Example plants

Various SA plants in the the data collection.

Economics

Cheaper and more convenient than dealing with odour and infestation.

Driving force for implementation

Prevention of odour emissions. ~~ABP Regulation 1774/2002/EC. and infestation by insects, rodents and birds. Prevention of the spread of TSEs and in particular BSE.~~

Reference literature

[6, EA, 1997] [3, Environment Agency 1997], [82, EA, 1998] [27, EA 1998], [248, Sorlini G., 2002] [112, Sorlini G. 2002], [287, EC, 2002] [204, EC 2009]

Frequent cleaning of materials storage areas odour prevention

Description

Areas where by products, raw materials and waste are stored can be cleaned frequently. The cleaning programme can cover all structures, equipment and internal surfaces, material storage containers, drainage, yards and roadways.

~~ABP Regulation 1774/2002/EC prescribes minimum requirements at, e.g. storage installations, rendering plants, biogas plants and composting plants, for the establishment and documentation of cleaning procedures, for all parts of the premises, containers, receptacles and vehicles.~~

Achieved environmental benefits

~~The adoption of thorough cleaning and good housekeeping, as a routine reduces malodorous emissions.~~

Operational data

Cross-media effects

Applicability

~~Applicable in all slaughterhouses and animal by products installations.~~

Example plants

~~Several rendering plants in Germany.~~

Reference literature

{134, Nordie States, 2001, 163, German TWG Members, 2001, 241, UK, 2002, 244, Germany, 2002}

2.3.8.2.4 Cleaning and disinfection of vehicles and equipment used to transport and deliver animal by-products and/or edible co-products ~~Cleaning and disinfection of delivery vehicles and equipment after each delivery~~

Description

Transport vehicles and delivery equipment (e.g. containers) are cleaned and disinfected after being emptied, and at the end of each working day.

Technical description

After being emptied, and at the end of each working day, delivery vehicles and transport skips can be wet-cleaned and disinfected with calculated optimal amounts of sodium hydroxide or sodium hypochlorite. Wash-water can be collected and inactivated on the site, e.g. by being fed into the incinerator.

Achieved environmental benefits

Reduced odour and pest infestation.

Cross-media effects

Subsequent treatment of wash-water required, e.g. by incineration with associated emissions, or by waste water treatment also with associated problems. Sodium hypochlorite contains active chlorine. Disinfection with sodium hypochlorite, followed by incineration of the waste water provides a source of chlorine for emissions to air.

Driving force for implementation

Prevention of odour emissions.

~~The original driving force was lack of confidence in the sterilisation of animal meal received from numerous sources, some of them unknown. ABP Regulation 1069/2009 1774/2002/EC requires that vehicles and re-usable containers, and all re-usable items of equipment or appliances that come into contact with animal by products or processed products, must be: (a) cleaned, washed and disinfected after each use; (b) maintained in a clean condition; and (c) clean and dry before use.~~

Example plants

Various SA plants in the data collection.
~~At least 2 animal carcase incinerators in Italy.~~

Reference literature

{164, Nottrodt A., 2001} [53, Nottrodt 2001]

2.3.8.2.5 Dilution of odours by capture into one or more chimneys

Description

The malodorous air is collected from various sources and emitted through one or more chimney stacks.

Technical description

The malodorous air is collected from various sources into one or more high chimney stacks for emission, at a suitable height to ensure sufficient dilution and dispersion of the odour, taking into account the local prevailing climate conditions.

Achieved environmental benefits

Reduced perception of odour problems in the vicinity of the slaughterhouse or animal by-products installation. No additional by-products are produced.

Environmental performance and operational data

The determination of stack heights for odour control is uncertain and is less precise than for other polluting discharges, because the critical feature of the emission is its olfactory rather than its chemical characteristics. Sensitivity to odours is variable and subjective. Some form of pretreatment prior to release may be required, rather than relying solely on dilution and dispersion of a discharged emission. A wet rendering plant in Denmark emits an average of 333 000 Danish OU/s, from a 90 metres high chimney. 300 000 m³ of air is processed per hour. The plant reports emissions of 4 000 OU/m³. The air is passed through an activated sludge bioscrubber and a LECA biofilter before being directed to the chimney [243, Clitravi - DMRI, 2002] [190, Clitravi - DMRI 2003].

Cross-media effects

Reduced visual amenity due to the presence of the chimney(s). The production of the malodorous substance has not been prevented.

Energy consumption is increased. For Danish pig slaughterhouses, who have had to invest in central ventilation facilities with high chimneys, this has led to increased electricity consumption, amounting to between 0.11 kWh and 0.26 kWh per pig, with an average of 0.19 kWh per pig (calculated from data gathered from four pig slaughterhouses) [203, Denmark 2015].

Technical considerations relevant to applicability

Currently, this is the most common method employed at slaughterhouses. Pre-treatment is normally required for the types of odours produced at rendering plants.

Economics

Low cost technique.

Driving force for implementation

Odour reduction.

Example plants

A wet rendering plant and pig slaughterhouses in Denmark [203, Denmark 2015], [264, TWG 2020].

Reference literature

[203, Denmark 2015], [241, UK, 2002] [107, United Kingdom 2002], [243, Clitravi - DMRI, 2002] [190, Clitravi - DMRI 2003], [264, TWG 2020]

2.3.8.2.6 Enclosure of animal by-products and/or edible co-products during transport, loading/unloading and storage

Description

Loading/unloading areas are situated in enclosed ventilated buildings. Bunkers or other equipment for transport and storage of the animal by-products and/or edible co-products are used.

Technical description

ABP Regulation 1774/2002/EC states that 1. Animal by products and processed products must be collected and transported in sealed new packaging or covered leak proof containers or vehicles. 2. Vehicles and re-usable containers, and all re-usable items of equipment or appliances that come into contact with animal by products or processed products, must be: (a)

cleaned, washed and disinfected after each use; (b) maintained in a clean condition; and (c) clean and dry before use. 3. Re-usable containers must be dedicated to the carriage of a particular product to the extent necessary to avoid cross-contamination.

The transport of animals and animal by-products outside SA installations is outside the scope of the SA BREF. Directive and therefore their transport outside slaughterhouses and animal by-products installations is outside the scope of this document. However, whilst they remain in vehicles, whether within or outside the installation, problems associated with either spillage or leakage of any solid or liquid material or with odour, can be reduced by suitable vehicle design, construction and operation. Commission Regulation (EU) No 142/2011 sets requirements for collection and transport of ABP. The reception, off-loading and storage of animals and animal by-products can also be undertaken within an enclosed areas, in the case of animal by-products, operated under negative pressure, with extractive ventilation connected to a suitable odour abatement plant. If material is tipped from the delivery vehicle, the receiving hoppers can be covered and sealed after filling.

For loading/unloading, one technique that has been applied is the construction of a tunnel/covered area large enough to accommodate the biggest despatch/delivery vehicle likely to visit the site. Odours can be contained if the tunnel has doors at either end, which make a good seal with the walls and which can be opened and shut rapidly with the minimum of effort and inconvenience. If the doors are difficult to operate there is a high probability that they will fall into disuse. High-speed plastic roller-shutter doors, which are less susceptible to damage than metal doors, are commercially available. Ensuring the integrity of the tunnel and the unloading, storage, processing and packing areas can minimise the leakage of odours. Such tunnels can be used without significantly compromising the negative pressure maintained throughout the rest of the installation. For the unloading of animals, the enclosure can also reduce the risk of noise emissions to the surrounding neighbourhood. This is important as noise can be a major problem, especially when pigs are being unloaded.

Doors to areas where animals/animal by-products are loaded/unloaded, stored or treated, can be close fitting and kept closed other than to allow pedestrian access or the movement of materials. Self-closing personnel doors can be provided and fitted with alarms, which operate if the doors fail to close within a reasonable period of time based on access requirements.

Negative air pressure in rooms and the enclosure of WWTP balance tanks can also be implemented as a further measure to reduce odour emissions.

Achieved environmental benefits

Reduced odour production and emission is achieved during the loading/unloading, storage and subsequent treatment of animal by-products. The use of sealed and leak-proof containers also minimises water and soil contamination, from spillages and leaks and reduces the risk of infestation by insects, rodents and birds. Enclosure can also provide some temperature control, e.g. due to protection from direct sunlight and which can slow down the decomposition of the animal by-products. Noise emissions can also be reduced, e.g. during the unloading of pigs at slaughterhouses.

Environmental performance and operational data

Current practices in rendering plants are described in Section 4.3.2.1.2.

In one case study slaughterhouse using a tunnel with roller shutter doors, problems arose which prevented their use, mainly due to the ever increasing length of the lorries collecting by-products from the site, which have resulted in the loading tunnel now being too short.

By-products can be collected and stored in covered vessels. Difficulties caused by constant or intermittent feed can be solved by conveying the material into, e.g. hoppers or chutes, instead of dropping it directly into open skips. If the skips are placed outdoors, to ease their delivery and collection, the prevention of odour and vermin problems may be achieved by maintaining e.g.

conveyors and seals, to minimise both the need to open-up the equipment and the amount of downtime when it is not available for use.

Cross-media effects

Energy is consumed in providing the ventilation to maintain a negative pressure and when extracting malodorous air to abatement equipment.

Technical considerations relevant to applicability

Applicable in all slaughterhouses and animal by-products SA installations, whether the animal by-products are inherently malodorous or if they may become so before they are either treated or removed from the premises.

A drive-through tunnel has advantages from a health and safety point of view, e.g. it eliminates reversing and it is normally applicable at loading and unloading points in slaughterhouses and animal by-products installations. Where tipping from lorries is required, there may be more restrictions, especially in many existing installations, where the availability of space may be limited. Side tipping into hoppers constructed to the equivalent length of the lorry trailer units, or individual tipping units is required.

Economics

Request to the TWG: Please provide information.
--

Driving force for implementation

Driving forces include Regulation EC No 1069/2009 (the Animal by-products Regulation) 1774/2002/EC, odour control, noise reduction, hygiene and the risk of infection from animal by-products which are confirmed to be, or suspected of being, infected with transmissible diseases, such as TSE. The significance of these driving forces varies depending on the type of animal by-product and its intended use. For example, the prevention of the spread of BSE risk material by insects, rodents and birds to material intended for human consumption will make enclosure important.

Example plants

At least one pig slaughterhouse in Denmark has an enclosed area for the loading of animal by-products.

Several rendering plants in Germany have been reported to enclose materials during transport and storage and to ensure that doors are kept closed.

Reference literature

[16, VDI 2008] [49, VDI 1996] [289, VDI 1996] [134, Nordic States 2001] [38, Nordic 2001], [168, Sweeney L. 2001] [56, Sweeney L. 2001], [241, UK 2002] [107, United Kingdom 2002], [244, Germany 2002] [110, Germany 2002] [287, EC 2002] [204, EC 2009]

Transport blood in insulated containers

Description

In practice liquid blood is stored in a container incorporating an air valve to exhaust any gas which might possibly be produced internally. Completely eliminating oxygen from the storage is, therefore, not possible and as a consequence if a closed, but not sealed, blood container is not refrigerated the blood will ferment within a few hours of being collected, thus leading to odours being produced. However, it has been reported that the presence or absence of oxygen makes no difference and that low temperature transport/storage preserves the blood and minimises odour problems.

Achieved environmental benefits

Prevention of the formation of malodorous substances, by preventing rotting. By preventing rotting of the blood it is, more likely to be of a good enough quality to be used and therefore

will not need to be disposed of as waste. If it is already destined for disposal it may cause fewer odour problems during processing and during the subsequent waste water treatment.

Operational data

Transporting blood in insulated containers can prevent the temperature from rising by more than 2 °C during the transport.

Cross-media effects

None.

Applicability

Applicable during the transport of all blood, whether for use or disposal.

Driving force for implementation

Reduction of the decomposition of fresh blood, allowing it to remain usable for the production of “high” priced products. Otherwise quality will be so low that it may have to be disposed of as waste and at a cost.

Example plants

Several rendering plants in Germany.

Reference literature

[163, German TWG Members 2001], [244, Germany 2002], [271, Casanellas J. 2002]

2.3.8.2.7 Refrigeration/cooling of blood

See also Section for further information about the storage of animal by-products.

Description

Blood is cooled to a temperature below 10 °C.

Technical description

Blood which cannot be processed within a very short time can be cooled to a temperature below 10 °C, at the slaughterhouse immediately after collection (and also at the installation where the blood will be received). This can reduce odour problems and waste water pollution at the blood processing plant.

A pilot scale investigation gave the values shown in Table 2.16. These relate to emissions from rendering, after 30 hours storage of blood at 4 °C and 30 °C, respectively .

Table 2.16: Reduced emissions associated with cooling of blood prior to rendering

	4 °C	30 °C
Odour units per m³	1 000	60 000
ppm NH₃	200	675
ppm H₂S	200	300
<i>Source: [134, Nordic States, 2001] [38, Nordic 2001]</i>		

Achieved environmental benefits

Prevention of offensive odours from the liquid blood, caused by the degradation of the blood at both the slaughterhouse and the installation where the blood is used or disposed of. If the blood is rendered fresh, there will also be a lower level of emission of offensive odours and waste water contamination arising from the process.

Environmental performance and operational data

One company collects about 50 % of the total Spanish blood, for both processing and rendering. All of that blood is refrigerated at the slaughterhouses. Blood for plasma production is chilled at 4 °C and blood for rendering at 7 °C. The blood is refrigerated at the insistence of the blood processing/rendering company, to avoid its deterioration and subsequent bad odours at the slaughterhouses, during transport and at the processing/rendering plant. This requirement is contained in the contract between the blood processing/rendering company and the slaughterhouse, which also sets out, e.g. blood quality conditions, solid content, temperature and collection prices.

Of the remaining 50 % of Spanish blood, a further 10 % approximately is also refrigerated. Most of the 40 % which is not refrigerated is rendered on the slaughterhouse sites. Most of this blood is rendered at the slaughterhouse itself and if not it is usually coagulated in a tank, using steam. The clotted blood is rendered locally and the water goes to the WWTP of the slaughterhouse. There is a risk of odour production during these processes.

Reportedly, refrigeration is the only storage method which enables blood to be transported over long distances and for up to 5 days after being collected.

Approximately 15 % of mammalian blood is chilled prior to collection and processing, mainly to maintain the functionality of the plasma proteins for their use in pet foods.

It is reported that poultry blood is stored chilled, before being sent for further processing for disposal, e.g. rendering.

The blood is stored in closed containers fitted with an air valve, to allow the exhausting of any gas that may be produced. For this reason the European renders have asked all slaughterhouses to refrigerate their stored blood. It has been reported that if a closed, but not sealed, blood container is not refrigerated the blood will ferment within a few hours of collection and will become malodorous. It is thus recommended that blood should always be refrigerated, whether it is destined for blood processing or rendering. It has been said that maintenance of a low temperature is the single most significant factor in the prevention of odour problems.

The energy for chilling has been reported to be about 1.44 kWh/t of pig carcase. It has been reported that 30.5 kWh of electrical energy is required to cool one tonne of blood to ~ 5 °C.

It has been reported that the waste water pollution from the rendering of uncooled blood can be as high as 90 kg COD and 9 kg N per tonne of blood, compared to 20 kg COD and 2 kg N per tonne for cooled blood.

Cross-media effects

Energy consumption by the refrigeration plant.

Technical considerations relevant to applicability

In all slaughterhouses and animal by-products SA installations where blood is handled, treated or stored, except where the blood is being treated virtually immediately after bleeding. It is reported that whilst continuous refrigeration during collection is the best option, processing blood should at least be refrigerated within a maximum delay of one hour after slaughtering, and that the refrigeration of blood destined for rendering should not wait beyond the end of the slaughtering shift.

If blood is used for human food, the blood should be cooled accordingly. For lower value products, it is not standard practice to chill blood at source and road tankers and bulk storage tanks at the processing site are not refrigerated.

Economics

A refrigerated blood tank and associated equipment, with a capacity for a slaughter-line killing 600 pigs per hour costs about EUR 65 000 – 70 000.

A refrigeration cost of EUR 0.0025 per litre of blood (1997), i.e. EUR 0.11 for the blood produced by one tonne of pig carcase, has been quoted.

Driving force for implementation

Odour control at the slaughterhouse and the animal by-products installation.

Refrigeration for blood processing is primarily carried out for quality reasons, indeed one of the raw material quality checks is the smell of fresh blood.

Rendering companies reportedly ask, as a minimum requirement, that the blood be chilled. By-products companies charge more for degraded and malodorous materials, partly due to the additional environmental costs associated with odour control and waste water treatment and partly due to the fact that they have no value and have to be disposed of.

Demand from enforcement authorities to reduce odour during the handling and transportation of blood. Maximum allowable temperatures for blood are specified in EU Regulation 853/2004 on hygiene for food of animal origin [260, EC 2004].

Example plants

Blood is refrigerated to < 10 °C in Danish slaughterhouses, except when treatment is carried out very quickly after slaughter. It is also refrigerated in all Belgian, all German and approximately 55 % of Spanish slaughterhouses, whether it is destined for use or disposal. In France, it is always refrigerated in all slaughterhouses if it is destined for use but only if it is destined for disposal if it cannot be treated quickly after slaughter. In Ireland and the United Kingdom, it is refrigerated only if it is destined to be used and not to be disposed of as waste.

Reference literature

[134, Nordic States 2001] [38, Nordic 2001], [183, Pontoppidan O. 2001] [66, Pontoppidan O. 2001], [271, Casanellas J. 2002] [124, Casanellas J. 2002], [272, Woodgate S. 2002, [125, Woodgate S. 2002] [308, Hupkes H. 2002] [156, Hupkes H. 2002] [260, EC 2004]

2.3.8.2.8 Biofilter

Description

The waste gas stream is passed through a bed of organic material (such as peat, heather, compost, root, tree bark, compost, softwood and different kinds of combinations) or some inert material (such as clay, activated carbon, and polyurethane), where organic (and some inorganic) components are transformed by naturally occurring microorganisms into carbon dioxide, water, other metabolites and biomass.

Technical description

Successfully operated biofilter systems are commonly characterised by an open design, organic filter media and exhaust air conditioning in an upstream spray humidifier with a closed water circuit (with and without addition of chemicals). Generally, the plant consists of a preliminary unit where the exhaust air is pretreated.

Biofilters comprise an air distribution system and a carrier medium, often made from an organic material, which can support growing micro-organisms which feed on malodorous substances and thereby remove odours from the air. The malodorous substances must be caught on the micro-organism carrier, which, therefore, must have a sufficiently high surface area. As the micro-organisms also require water, the air needs to be kept moist.

Irrespective of the medium, it is important that the gases to be treated pass through the bed at the optimum flowrate. Conventional biofilters are configured as open surface filters (see Figure 2.42) with filter areas ranging between 75 m² and 3 000 m², depending on the waste gas flow to be treated. The residence time required to effectively abate an odour depends on the odour strength and which pollutants are present in the gas. For low intensity odours a residence time

of at least 30 seconds should be aimed for, rising to up to 60 seconds for very strong odours. To maintain bio-efficiency, and to maximise the biofilter performance it is necessary to control the humidity, pH, oxygen supply and nutrients. The temperature can also affect the overall performance and operation of the biofilter. Filter media temperatures below 5 °C have been measured in the cold season which goes hand in hand with a major deterioration in the odour abatement efficiency.

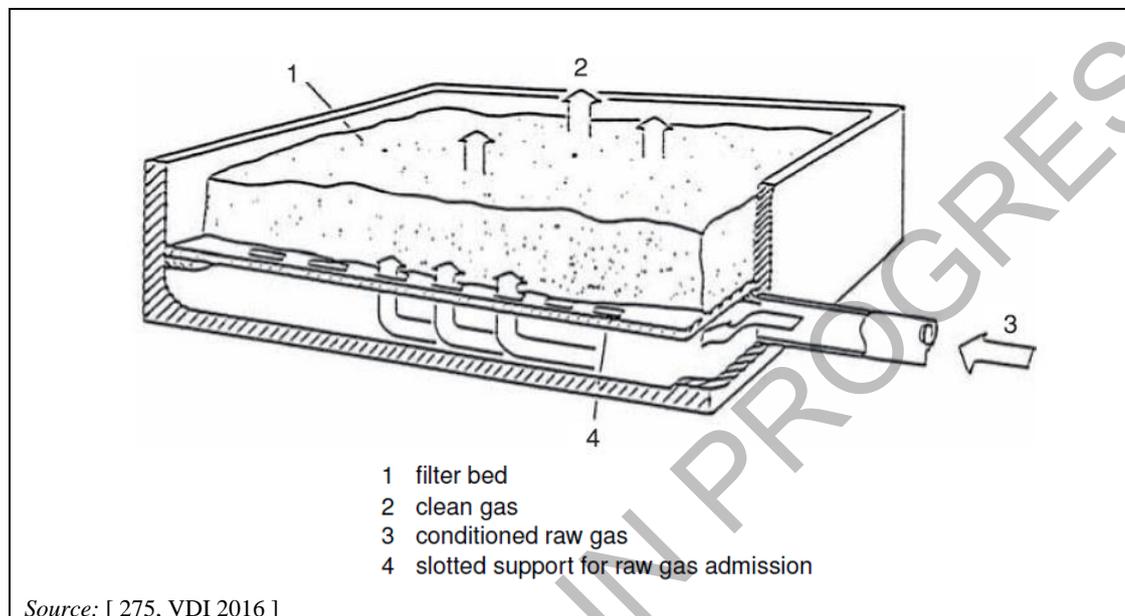


Figure 2.42: Scheme of an open surface biofilter

Sufficient water supply is essential to the function of the biodegradation processes. Moreover, the presence of water as a mass transfer agent is a basic prerequisite for all biodegradation processes. Depending on the type of filter media, a moisture content of between 40 % and 60 % is recommended. The moisture content can be maintained by an irrigation system. A high moisture content in the exhaust is beneficial for biofiltration because it reduces the amount of water required to irrigate the bed. The extracted air is drawn through a humidifier and drop-out pot to remove entrained particulate matter. Humidifiers are typically designed for a water-to-air ratio of 1 l/m³ to 10 l/m³ and a waste gas residence time of > 1 s at a flow velocity of < 3 m/s [275, VDI 2016]. The air is then ducted to the void beneath the biofilter, which is used to distribute the extracted air uniformly beneath the filter medium, before it passes upwards through it.

The biofilter typically consists of a treatment medium supported on concrete slats above a concrete base. The filter medium must not be allowed to compact, as this will cause a pressure drop across the bed and a loss of efficiency. Typical media include a pasteurised worm compost inoculated with a selected *Pseudomonas* culture, broken pallets, bark, light expanded clay aggregate (LECA), peat and heather supported on seashells and fixed earth of a defined particle size. Insufficient information has been provided to determine the relative performances of the various media for given odour sources and concentrations.

If air pollutants are present in high concentrations in individual exhaust air streams, these may have to be treated before being admitted to the biofilter. pH-relevant exhaust air components such as H₂S and NH₃ can be reduced by chemical scrubbing to a tolerable level of approximately 5 mg/m³ for the biofilter media and the microorganisms. Too high a concentration of these exhaust air constituents results in an acidification of the filter media and hence unfavourable environmental conditions for the microorganisms [16, VDI 2008]. To prevent a drop in the pH, the filter media is amended with lime in individual cases [275, VDI 2016].

Removal of pH-relevant components can be accomplished by scrubbers for instance. According to guideline VDI 2433, gas scrubbers using an acidic or alkaline scrubbing liquid, if required with oxidant addition, may be used for pH control. A properly designed chemical scrubber achieves high removal efficiencies for ammonia, hydrogen sulphide, mercaptans and fatty acids. However, the removal efficiency for odour compounds is normally limited to approximately 70 % [16, VDI 2008].

For monitoring the proper operation of biofilter systems, weekly, monthly or yearly monitoring measures can be implemented [264, TWG 2020]. Thus, it is convenient to carry out a visual inspection and sensory check (odour quality and hedonic tone) of the overall system daily. Releases of untreated air can be detected by the sense of smell and must be promptly eliminated. The typical odour of the exhaust air of a SA installation is no longer perceptible in the treated air exiting the biofilter.

The technology is simple and can be operated continuously without constant supervision/attention. Maintenance is simple. It generally just comprises annually loosening and refurbishing of the filter medium. A daily visual inspection of the filter medium allows the operator to detect any compaction or the development of preferential channelling of the effluent gas, or signs of erosion by the irrigation water, all of which can reduce abatement efficiency. The retaining walls may be inspected daily for any leaks and damage that could compromise their airtight integrity. Flooding of the subfloor plenum due to inadequate drainage or due to the water table rising may occur and is usually due to improper design or installation.

Biofilters are reported to be suitable for the separation of malodorous substances which result from organic and partly inorganic exhaust air components, such as nitrogen, phosphate, etc.

Achieved environmental benefits

Reduced odour emission. Used biofilter material may sometimes be used for soil improvement in gardening.

Environmental performance and operational data

Experience from operating practice indicates that satisfactory removal efficiencies are attained at specific space loadings of 0.5 million OU/(m³_{filter media} · h) to 1.5 million OU/(m³_{filter media} · h). For instance, for a normalised flow rate of 100 000 m³/h and a typical bed depth of approximately 1.8 m, the resulting filter area is around 1 100 m². With such a design, it can be expected that only the filter-specific odour will be perceptible on the biofilter exit side [16, VDI 2008].

To obtain a representative result for the entire area of the biofilter, samples must be collected at several locations with the aid of a sampling hood. The number of sampling locations is governed by the size of the area source and the base area of the sampling hood. Representative sampling of large area sources requires a large number of samples. For example, VDI 2590 requires a minimum of 30 samples for a biofilter with a surface area of 3 000 m² when using a sample hood with a base area of 1 m² [16, VDI 2008].

There is some disagreement about the average efficiency of biofilters. Generally, efficiency is above 90 % for the elimination of malodorous substances from the waste gases from rendering plants. This, however, depends on the composition of the feedstock, the inlet concentration, the flowrate, the number of hours in operation and maintenance of the biofilter.

The figures in Table 2.17 show the required biofilter surface areas designed by calculation. These were found to agree with the surfaces of existing unspecified biofilters installed in rendering plants, with various raw material throughput, which were actually controlling odour problems.

Table 2.17: Reference values for the size and rating of biofilters

Raw material throughput (t/h)	Required filtration area (m ²)	Volume flow (m ³ /h)
5	250	30 000
10	500	60 000
20	1 000	120 000
50	2 500	300 000

Source: [49, VDI 1996] [289, VDI 1996]

Operational data for a rendering plant using an unspecified biofilter medium is shown in Table 2.18.

Table 2.18: Emission reductions achieved using unspecified biofilters in a German rendering plant

Operational area	Exhaust air volume flow (m ³ /h)	Odour concentration in the raw gas *(OU/m ³)	Odour concentration in the clean gas *(OU/m ³)	Decrease in odour conc. *(%)
Production	58 000	-	226	-
WWTP	1 430	-	159	-
Production	109 107	-	197	-
WWTP	3 939	-	160	-
Biofilter 1	85 700	16 000	242	98.5
Biofilter 2	75 800	21 500	236	98.9
Entire plant	16 000	60 000	35 - 100	99.8

*A consistent unit for odour concentration has not been agreed, these figures are provided to give an indication of the effectiveness of a biofilter
Source: [163, German TWG Members, 2001] [52, Germany 2001]

In this case, the number of OUs, represents the volume of clean air/m³ required to dilute 1 m³ of malodorous air, to remove the smell down to the odour threshold, e.g. 80 000 OU requires 80 000 m³ of clean air to dilute 1 m³ of malodorous air to the odour threshold.

For pasteurised worm compost inoculated with a selected *Pseudomonas* culture, reduced odour emissions with an efficiency of approximately 95 – 98.4 % have been reported. This filter material is reported to be suitable for most types of ventilation air. This medium is used in an example fishmeal and fish oil processing plant. The malodorous emissions are extracted from the processing plant, including from places where the highest intensity odours are produced such as the cooker. Fish is processed at a rate of 15 t/h, producing condensate at a rate of 0.258 t/t fish, i.e. 3.87 t/h of exhaust vapour. 60 % goes to the WWTP and 40 % evaporates, to produce 1.55 t/h of exhaust vapour [215, COM 2005].

In the example plant, before the air is transferred to the biofilter it undergoes some initial purification by passing it through water. This separates out some fats and solids. The biofilter applied has a surface area of 800 m² handling air at a rate of 100000 m³/h, with a consequent surface load of 125 m³/h per square metre and an annual operating time of 500 h/yr. It works at full load for 60 % of the time and part load for the remainder. The filter bed height is approximately 0.8 metres and the residence time of the malodorous air is approximately 15 - 20 s. During this time, the malodorous organic components of the exhaust air are organically disintegrated by micro-organisms, which include bacteria and fungi. Individual components of the malodorous air have been measured and reductions in total carbon, ammonia and other nitrogen compounds detected [215, COM 2005].

Performance data for measurements taken during a limited sampling period at the example plant, during several hours of processing under similar conditions of, e.g. temperature and pressure, are shown in Table 2.19. A scrubber is also used to reduce the odour emissions further and condensed vapours are treated in a WWTP.

Table 2.19: Performance figures for a pasteurised worm compost biofilter in a fishmeal and fish oil processing plant

Measurement 1 (09.55 – 10.55)			Measurement 2 (10.40 – 11.10)			Measurement 3 (11.15 – 11.45)		
Before biofilter (OU)	After biofilter (OU)	% odour reduction	Before biofilter (OU)	After biofilter (OU)	% odour reduction	Before biofilter (OU)	After biofilter (OU)	% odour reduction
89 334	1 969	97.8	94 646	2 481	97.4	103 213	1 656	98.4
See above for the definition of OU, in this case								
Source: [215, COM 2005]								

In 2014, a chicken slaughterhouse in Austria reported odour emissions of 287 OU_E/m³ from a biofilter consisting of three closed bio-filters (container) which are connected in series. Overall, the bio-filter unit has a capacity of 25 000 m³/h and the filter medium is bark mulch [198, Waxwender et al. 2016].

Depending on its composition and the specific application, biodegradable filter media has a service life of about 1 to 5 years. Media mixtures containing elevated inert fractions may have a considerably longer service life. Frequently, the complete media bed is replaced when the performance of the biofilter declines. Here, on-site regeneration may be a more cost-effective alternative [275, VDI 2016].

Broken pallets can be used as a filter medium and it is reported that such spent filter material from a bone de-fatting plant is used as compost in gardens.

Bark can be used as a filter medium. One supplier of bark as a biofilter medium to a gelatine manufacturing plant, recommends that the bark is replaced every 3 or 4 years, but this is done annually by an example plant operator.

LECA is used as a filter medium in rendering plants. The supplier of the LECA recommends that it is periodically sterilised and re-inoculated with micro-organisms. One user with 2 plants reports that this has been unnecessary and that odour reduction efficiencies of 99 % have been achieved. A bioscrubber and chimney are also used as odour abatement in at least one of these plants.

Peat and heather supported on sea shells can also be used as a filter medium. The peat and heather provide the growing medium on which the micro-organisms grow. The shells support the medium, which would otherwise compact, thereby removing the need to periodically mix it to re-establish the growth of the micro-organisms.

Fired earth of a defined particle size is both self-supporting, i.e. it does not compact and does not biodegrade and it presents a surface area capable of supporting the biodegradation of malodorous emissions.

Cross-media effects

Spent filter media from biofilters can normally be used as a soil improver in landscaping applications which may, however, require a pH adjustment of the filter material by lime addition [16, VDI 2008]. The used biofilter can sometimes be used as compost, but most of the time it has to be disposed of as waste, e.g. by incineration as chemical waste.

Leachate which seeps through the biological filtration system and waste water generated from the blowdown requires waste water treatment.

Any leachate produced can contain organic residues of the filter material.

Energy is consumed during the transfer of the malodorous air to and through the biofilter. Filter bed dry-out should be counteracted by providing for additional irrigation of the filter media. The electricity consumption is 30 000 kWh/year for a biofilter of 78 m² installed in a pig slaughterhouse (FI146) to treat air from the WWTP [264, TWG 2020].

The biofilter may be an odour source. It has been reported that emissions of N₂O, which is a greenhouse gas, may be a problem.

All biofilters exhibit a specific odour which is of biogenic origin. The higher the microbial density of the biologically active media, the higher the biogenic odorant concentrations released will be [275, VDI 2016].

There may be problems due to noise from the fans used to transfer malodorous air to the biofilter.

There may be occupational health hazards associated with personnel entering the biofilter to visually inspect the filter medium and to water it. Remote watering systems may be provided.

Technical considerations relevant to applicability

Applicable in ~~slaughterhouses and animal by products~~ SA installations. Not suited to combustion gas treatment. It has been reported that peaks of malodorous non-condensable gases may not only pass through a biofilter without any significant reduction, but they may also be inhibitory to the biological activity in the medium. Biofilters are, therefore, considered to be suitable for high volume low odour intensity air streams only, as they do not achieve 100 % odour destruction.

The requirement for a large surface area may be prohibitive if space availability is limited. Small standard modules can, however, be used for local exhausts.

Economics

The initial capital costs and running costs are relatively low. Investment costs of EUR 5 000 – 20 000 for a biofilter treating 1 000 Nm³/h have been reported.

Pasteurised worm compost inoculated with a selected *Pseudomonas* culture.

For the fishmeal and fish oil processing case study above, the following costs have been quoted.

2 x 58 kW exhaust fans, operating for 3 000 h/yr x EUR 0.065/kWh	= EUR 22 620
2 x 23 kW exhaust fans, operating for 2 000 h/yr x EUR 0.065/kWh	= EUR 5 980
2 x circulating pumps for the scrubber	= EUR 4875
Treatment of 60 % of the condensate in the WWTP	= EUR 39 000
The filter material is changed every 4 years	= EUR 14 000/yr
Maintenance	= EUR 7 000/yr

Overall annual cost EUR 93 475

The electricity cost is EUR 3 000/year and the maintenance cost is EUR 500/year for a biofilter of 78 m² installed in a pig slaughterhouse (FI146) to treat air from the WWTP [264, TWG 2020].

Driving force for implementation

Reduction of odour emissions.

Example plants

Pasteurised worm compost inoculated with a selected *Pseudomonas* culture is used in a fishmeal and fish oil product plant in Germany, as reported above.

Broken pallets are used in at least one plant bone de-fatting plant.

Bark is used in at least one gelatine manufacturing plant.

LECA is used in at least 2 rendering plants in Denmark.

Reference literature

[16, VDI 2008] [49, VDI 1996] [289, VDI 1996], [134, Nordic States 2001] [38, Nordic 2001], [163, German TWG Members 2001] [52, Germany 2001], [241, UK 2002] [107, United Kingdom 2002], [242, Belgium 2002] [108, Belgium 2002], [243, Clitravi - DMRI 2002] [190, Clitravi - DMRI 2003], [244, Germany 2002] [110, Germany 2002], [198, Waxwender et al. 2016], [206, Giner-Santonja et al. 2019], [264, TWG 2020], [275, VDI 2016]

2.3.8.2.9 Adsorption Odour control using activated carbon filters

Description

Organic compounds are removed from a waste gas stream by retention on a solid surface (typically activated carbon).

Technical description

Adsorption is a unit process involving the capture of airborne components onto a fine particulate active surface. There are a number of possible active materials that are used for general applications, including zeolites, silicas, polymeric resins and activated carbon. The activated carbon is the most frequently chosen adsorbent within the SA sector and hence the term carbon adsorption is commonly used.

Carbon adsorption is a dynamic process in which vapour molecules impinge on the surface of the solid and remain there for a period of time before desorbing again into the vapour phase. An equilibrium is established between adsorption and desorption, i.e. a particular concentration of a compound on the carbon surface corresponds to a concentration or partial pressure of that compound in the gas phase.

Activated carbon has been used for odour abatement for many years. The effect is based on the very large specific surface area, in the form of micro-pores, which bind the odour molecules. The larger the molecules, the better the binding. Neither ammonia nor hydrogen peroxide are bound effectively. The efficiency for, e.g. hydrogen peroxide can, however, be improved by using specially prepared carbon. As the pores are filled, the efficiency falls and the carbon must be either replaced or regenerated.

Achieved environmental benefits

Reduced odour emission.

Environmental performance and operational data

The efficiency of new carbon preparations is 95 - 98 %, but it drops over time, so the average efficiency during the life cycle of the active carbon is considerably lower, possibly nearer to 80 %. Water, dust and fat aerosols can ruin an activated carbon filter. The relative humidity must therefore not exceed 80 - 90 % and particles must be effectively removed upstream of the filter.

The rendering installation FR243 reported an average air flow rate of 50 000 Nm³/h for the waste gas stream treated by activated carbon. Three fishmeal and fish oil installations reported a range of air flow rate between 3 720 Nm³/h and 12 310 Nm³/h [264, TWG 2020].

The rendering installation IT166 implemented a carbon filter in 2019 to deodorise the air vented from a finished product silo. Vents are activated during the loading of the silos to avoid overpressures. Measurement of the outlet air of the vents before the filter showed a concentration of odour about 19 500 OU_E/m³, and a concentration of 205 OU_E/m³ after the filter (99 % removal efficiency) [264, TWG 2020].

The activated carbon filter applied in a pig slaughterhouse to reduce odour emissions from the blood tank has a capacity of 36 000 m³/h [198, Waxwender et al. 2016].

For reducing odour emissions from the flotation unit and certain production steps, an activated carbon filter with a capacity of 4 250 m³/h was installed in a pig slaughterhouse [198, Waxwender et al. 2016].

Technical considerations relevant to applicability

The technique is applicable in all ~~slaughterhouses and animal by products~~ SA installations, providing the air is dry and does not contain dust or aerosols.

Economics

Can be expensive to maintain and replace.

Driving force for implementation

Reduced odour emissions.

Example plants

Used in slaughterhouses of pigs and cattle, in rendering plants of ABP category 1, in a fishmeal and fish oil installation [264, TWG 2020].

Many Danish slaughterhouses and rendering plants.

Reference literature

[134, Nordic States, 2001]-[38, Nordic 2001], 347, German TWG members, 2003] [184, Germany 2003], [198, Waxwender et al. 2016], [206, Giner-Santonja et al. 2019], [264, TWG 2020]

2.3.8.2.10 Condensation

Description

The removal of vapours of organic and inorganic compounds from a process off-gas or waste gas stream by reducing its temperature below its dew point so that the vapours liquefy.

Technical description

High intensity cooking vapours can be passed through a condenser(s) to separate condensable and non-condensable gases. Where this is done, the non-condensable gases are passed for further abatement and the condensate is either treated on-site in a waste water treatment plant or at an off-site plant for treatment.

The configuration of condensers / boiler and WWTP for treating cooking vapours has equal merits from an environmental perspective to treating them in a thermal oxidiser and the decision is normally dependent on whether a WWTP is available on site.

Condensate has very high chemical oxygen demand and ammonia concentration, so it must be fed into a WWTP in a controlled manner so as not to overload the plant. There is potential to recover energy from the high COD condensate by anaerobic treatment to produce methane for renewable energy purposes. However, this is dependent on the ammonia loading which could inhibit the AD process.

Condenser systems are an essential step if the primary abatement system consists of burning the non-condensable gases in multiple boiler(s). They may also provide back-up to primary combustion abatement plant such as thermal oxidisers. Under these circumstances the back-up condensers may feed into a boiler which operates as a secondary abatement system. In both scenarios, the cooking process can be stopped in a controlled manner if the primary abatement plant goes offline.

High efficiency condensers can increase condensing performance and the residual air may be suitable for abatement in a biofilter or chemical scrubber rather than using energy intensive

thermal oxidation. Chilled condenser units are in use in other Sectors and this technology may be an option for the EU ABP Sector to consider as an emerging technique.

Condensation is a technique that eliminates solvent vapours from a waste gas stream by reducing its temperature below its dew point.

Condensation is carried out by means of direct cooling (i.e. contact between gas and cooling liquid) or indirect cooling (i.e. cooling via a heat exchanger). Indirect condensation is preferred because direct condensation needs an additional separation stage. Recovery systems vary from simple, single condensers to more complex, multi-condenser systems designed to maximise energy and vapour recovery.

A more detailed technical description of condensation can be found in the CWW BREF [239, Brinkmann et al. 2016].

Achieved environmental benefits

Odour reduction.

Environmental performance and operational data

Condensation is typically applied in rendering plants where high-intensity cooking vapours are passed through a condenser(s) for condensable and non-condensable gases separation. Afterwards the non-condensable gases are passed for further abatement and the condensate is either treated on site in a waste water treatment plant or at an off-site plant.

A condensation unit is implemented in a rendering installation (IT163) after the combustion of malodorous gases in an existing boiler. It is a classical spiral condenser: the air from the burner enters the hot side and is cooled down by a glycol solution recirculating in the cold side in a closed loop. The hot air is cooled from around 200 °C to about 50 °C and in doing so water is condensed; the cold glycol enters the condenser and receives the heat from the air; the glycol, now hot, leaves the condenser and is sent to three air coolers installed on the roof. Here the heat is transferred from the glycol to the environment, and the now cooled glycol is sent again to the condenser, closing the loop (see Figure 2.43). The general operational parameters are [264, TWG 2020]:

- Condenser:
 - air mass flow rate: 14 000 kg/h;
 - air temperature in: 225 °C;
 - air temperature out: 65-55 °C;
 - glycol mass flow rate: 218 500 kg/h;
 - glycol temperature in: 40 °C;
 - glycol temperature out: 50 °C;
 - heat exchange capacity: 2 383 kW;
 - condensed water capacity: 2 393 kg/h.
- Glycol loop:
 - glycol solution: 16 %;
 - flow rate: 216 m³/h (or around 218 t/h);
 - dry cooler to cool down the the glycol solution.

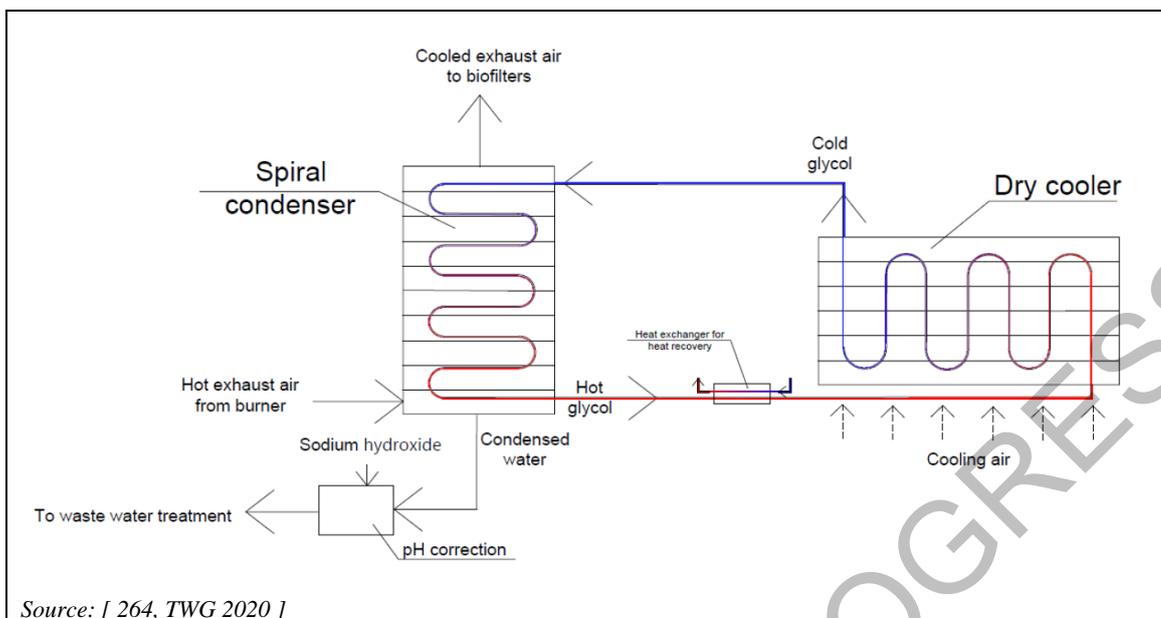


Figure 2.43: Scheme of a condensation unit

Technical considerations relevant to applicability

Generally, there are no technical restrictions to the applicability of this technique.

Cross-media effects

Production of waste water.

Economics

Condensation is usually a low-cost technique.

The economic costs associated with the condensation unit implemented in installation IT163 are EUR 97 850 for the spiral condenser; EUR 92 150 for the dry coolers; EUR 11 000 for the exhaust air extractor (from burner to condenser); and EUR 155 000 for the supporting structure for dry coolers and glycol loop pipes and pump [264, TWG 2020].

Driving force for implementation

Legislation related to odour emissions.

Example plants

IT163.

Reference literature

[239, Brinkmann et al. 2016], [264, TWG 2020]

2.3.8.2.11 Wet scrubber

Description

The removal of gaseous or particulate pollutants from a gas stream via mass transfer to a liquid solvent, often water or an aqueous solution. It may involve a chemical reaction (e.g. in an acid or alkaline scrubber). In some cases, the compounds may be recovered from the solvent.

Technical description

The concentration of malodorous substances in waste gases can be reduced by means of a waste gas scrubbing process using a scrubbing fluid (absorption agent). The absorption of a substance by the scrubbing fluid is a balance reaction which depends on the solubility and vapour pressure of the substance under the prevailing temperature and pressure conditions; the contact area; the

residence time and the ratio of the gas flowrate to the liquid flowrate. The process can be optimised by atomising the scrubbing fluid and by coating absorbers on support material to maximise the surface area exposed.

Water is frequently used as a preliminary scrubbing fluid to remove dust and droplets of fat, which could otherwise interfere with the activity of the absorbent, as well as to remove some of the nitrogenous compounds. The use of water alone, even in several stages, is not sufficient to reduce odour emissions to acceptable levels. Seawater can also be used for scrubbing of waste gas streams in fishmeal and fish oil plants.

While the addition of chemicals to the scrubbing liquid improves the removal of exhaust air constituents like ammonia, hydrogen sulphide, mercaptans and fatty acids, the removal efficiency for odour compounds normally remains limited to approximately 70%. It is, therefore, usually followed by exposure to acid or alkali oxidising streams.

Gas absorbers are essentially gas-liquid contacting devices where vapours and gases are absorbed from a contaminated exhaust stream into chemical solutions. This liquid phase is generally recirculated, with a small quantity being continually bled off and an equal amount of fresh reagent being added. Malodorous pollutants are absorbed into appropriate chemical solutions-oxidants.

An alternative or complementary technique to burning malodorous rendering gases is to pass the outlet air and water through a recirculating scrubber system. In this case, the scrubber water can be treated with a chemical oxidant to remove offensive contaminants, such as H₂S, mercaptans and ammonia-based compounds, such as amines. Chlorine dioxide is effective as a chemical oxidant for controlling decomposition products generated from rendering operations, i.e. products formed by the action of putrefactive bacteria on nitrogenous matter.

Wet scrubbers are frequently implemented as a pretreatment step before biofilters in rendering plants [198, Waxwender et al. 2016], [240, Karlis et al. 2019]. The scrubber effluents discharged to the waste water treatment plant should be monitored for a compatible pH.

Achieved environmental benefits

Odour reduction.

Environmental performance and operational data

For efficient and cost-effective absorber operation, the pH of the scrubbing liquid is always adjusted to either the acidic or alkaline range [267, VDI 2020].

A wet scrubber is composed of a vertical tower 18 m high with a first acid stage (use of H₂SO₄ to reduce the NH₄ content) and a second basic stage (use of NaClO) with capacity of 120 000 Nm³/h. The scrubber treats room air of a rendering activity (IT176) and some of the process air. During 2019, the electricity consumption was 7 kWh/tonne of raw material, the consumption of chemicals was 1.5 kg/tonne of raw material, and the consumption of fresh water was 0.04 m³/tonne of raw material [264, TWG 2020].

Cross-media effects

Waste water is generated. Generally in installations there is inadequate separating capacity and a lack of suitable means of feedback control for the metering of chemicals. In Germany, there have consequently been no new investments in chemical scrubbers for the past several years, not even for use in old plants.

The use of oxidants can lead to the formation of malodorous compounds and poor liquid effluent management and can create a secondary odour source.

Technical considerations relevant to applicability

Generally, there are no technical restrictions to the applicability of this technique.

Economics

The installation cost of a wet scrubber in a rendering plant (IT176) in 2018 was approximately EUR 800 000 [264, TWG 2020].

The cost effectiveness of absorbers is reduced, if the exhaust gas to be treated has a high moisture content, due to their preferential absorption of water vapour.

Driving force for implementation

Reduction of odour emissions.

Example plants

IT176.

Reference literature

[16, VDI 2008] [49, VDI, 1996] [289, VDI 1996], [241, UK, 2002] [107, United Kingdom 2002], [206, Giner-Santonja et al. 2019], [240, Karlis et al. 2019], [264, TWG 2020], [267, VDI 2020]

2.3.8.2.12 Bioscrubber**Description**

A packed tower filter with inert packing material which is normally continuously moistened by sprinkling water. Air pollutants are absorbed in the liquid phase and subsequently degraded by microorganisms settling on the filter elements.

Technical description

Biological scrubbers, also known as biotrickling filters, work through the microbial decomposition of air pollutants absorbed in the scrubbing medium. The absorbent is a scrubbing medium containing a high concentration of micro-organisms, such as activated sludge. The bioscrubber can be operated in several stages, using absorbents of different pH values to absorb components of differing chemical composition, thereby achieving decomposition to as great an extent as possible.

The micro-organisms can also be established as a filter film on built-in elements or on packing, i.e. trickle bed reactors.

Nutrients for the microbes are added to the absorbents in controlled quantities.

Achieved environmental benefits

Can reduce odour emissions by 70 - 80 %.

Environmental performance and operational data

The gas to be treated is passed countercurrent against a flow of water containing a population of microbes suitable for oxidising the malodorous pollutants. The treatment is undertaken within a "tower" containing a packing medium on which the microbial growth is supported. Bacteria from activated sewage sludge can be used to seed the packing. The water is circulated through the absorber and nutrients are added as required. The pH and nutrient balance are particularly important to prevent biomass from accumulating within the packing and causing a reduced circulation and flow and ultimately a blockage, if not periodically removed.

Fluctuations in the conditions of the airstreams can have a large impact on the performance.

The performances in Table 2.20 have been reported.

Table 2.20: Reported performance data for a biotrickling installation

Pollutant	Concentration at 15 – 40 °C and atmospheric pressure	Performance (% removal)
Volatile organic compounds	400 – 1 000 mg/m ³	80 – 95
Odour	> 20 000 OU/m ³	70 – 90
H ₂ S	50 – 200 mg/m ³	80 – 95
NH ₃	100 – 400 mg/m ³	80 – 95
Mercaptans	5 – 100 mg/m ³	70 – 90
Source: [215, COM 2005]		

Cross-media effects

The requirement for water and air to be circulated makes this abatement technique relatively energy intensive.

Sludge is produced which then needs to be thickened, dehydrated and removed. The waste water produced needs to be sluiced to prevent scaling and to prevent it from inhibiting microbiological activity.

Technical considerations relevant to applicability

Unsuitable for toxic and high concentrations of acidifying substances. The technique is not suitable for very poorly soluble components.

Economics

Investment costs of EUR 5 000 – 15 000 for a biofilter treating 1 000 Nm³/h have been reported. Running costs are relatively high, due to the energy requirements for the water circulation.

Driving force for implementation

- Reduction of odour emissions.
- Meeting H₂S emission requirements.

Example plants

A rendering plant in Denmark.

Reference literature

[241, UK, 2002] [107, United Kingdom 2002], [242, Belgium, 2002] [108, Belgium 2002], 266, Tauw, undated] [120, Tauw 2000], [206, Giner-Santonja et al. 2019], [267, VDI 2020]

~~Chlorine dioxide scrubber generated from sodium chlorite – odour abatement~~

~~Description~~

~~A technical sodium chlorite solution can be applied through a chlorine dioxide generation system.~~

~~Cross-media effects~~

~~Chlorinated amines and AOX can be formed.~~

~~Environmental performance and operational data~~

~~This technique is reported to be less efficient than burning the malodorous gases.~~

~~Chlorine dioxide is reported to be more attractive than chlorine, because it does not react with the ammonia and primary amines, instead only reacting with the malodorous secondary and tertiary amines.~~

Reference literature

[200, Widell S., 2001, 243, Clitravi – DMRI, 2002, 347, German TWG members, 2003, 348, Austrian TWG member, 2003, 350, EFPPA, 2003]

2.3.8.2.13 Thermal oxidation ~~ser for combustion of vapour, non-condensable gases and room air~~**Description**

The oxidation of combustible gases and odorants in a waste gas stream by heating the mixture of contaminants with air or oxygen to above its auto-ignition point in a combustion chamber and maintaining it at a high temperature long enough to complete its combustion to carbon dioxide and water.

Technical description

The direct combustion of malodorous gases can be undertaken for a few seconds at 850 °C. The running cost of doing this is high in terms of the energy consumption, so expensive heat-exchange systems need to be used to minimise this.

An example thermal oxidiser comprises a 3 unit system and consists of a combustion chamber, where the gases are heated to e.g. 950 °C; a retention chamber, where the temperature is maintained for the required time, e.g. 1 - 2 seconds and a steam boiler which uses the heated gases to produce steam, which can be used. The excess heat is passed through a heat-exchanger to preheat the air and vapour going into the combustion chamber.

The system deodorises the non-condensable gases and some process air and ventilation air. It can also treat the water evaporated from raw materials and then discharge the water into the air as clean water vapour. However, there will still be some water requiring treatment in a WWTP, e.g. the washing water, some of which will come from washing the oxidiser equipment, such as in-line filters.

Achieved environmental benefits

Reduced emissions of low volume/high intensity and high volume/low intensity odours to almost 100 % efficiency and the elimination of whole vapour, thus removing the need for it to be treated in the WWTP.

Environmental performance and operational data

Generally it is the concentrated process gases that are incinerated, particularly those containing non-condensable gases. Complete combustion must be achieved, as partially oxidised organic matter might still produce malodorous substances. The effective destruction of malodorous emissions is achieved by paying particular attention to the temperature in the combustion chamber, keeping it at 850 – 950 °C, with a residence time of 1 – 2 s and employing turbulence/mixing and sufficient oxygen.

The sizing of the combustion chamber is important. The combustion chamber length and design is determined by the length of the flame and the requirement to achieve the required residence time and effective mixing of the gas stream with combustion air. Process gases and vapours are extracted directly from the cooker and meal presses and conveyed, via stainless steel pipework, to a collector. Dropout pots situated within the pipework remove any air-entrained solid matter within the gas stream.

Room air from other malodorous areas may also be extracted, after first being filtered to remove entrained particulate matter. It may then be preheated by an economiser and used as combustion air within the combustion chamber. ~~See also Section, regarding the ducting of air from an incinerator installation in the incinerator.~~

Operation of the thermal oxidiser is managed by a PLC control system. Temperature is continuously measured in the combustion chamber and variable speed fans ensure balanced rates of combustion, extraction of process gases and steam production. There is a strong relationship between the thermal destruction requirement and the demand for steam. This includes steam venting arrangements at process shutdown and the provision of steam during periods of process start-up and downtime return.

During thermal oxidation, the objective is to completely oxidise the combustible gases. This leads to the production of pollutants such as CO₂, NO_x and possibly SO₂ and/or chlorides, plus water.

As the process destroys all of the odour from the cookers, including by destroying the non-condensable gases, the need to provide an alternative means of disposal or to treat a highly malodorous effluent is removed. If, in addition, waste water is also subject to a thermal destruction, the generation of liquid effluent is greatly reduced and even potentially removed.

The achievable emission release levels met by any installation are affected by baseline combustion conditions pertaining to the fuel being used and the character of the process gas needing to be destroyed. Additional levels of substances such as NO_x, arise from the destruction of substances present in the process air fed into the combustion chamber. The principal factor affecting the magnitude of NO_x releases is the level of NH₃ present in the process gases, which is directly related to the storage history of the raw material prior to the rendering. In order to minimise releases of ammonia and NO_x some degree of control over the raw material storage, handling and transfer at the source and at the animal by-products installation, can ensure that the materials are processed in as fresh a state as possible.

A waste heat recovery boiler integrally connected to the thermal oxidiser can use heat from the combustion gases to provide steam for use in the cooking/rendering operation.

There is some opposition to the use of this technique on the grounds of high energy consumption and capital expenditure, which may limit the feasibility of this technique to small quantities of air and/or heavily polluted air.

Case study

For a case study, a new plant was studied. It treats poultry offal in a continuous drier, followed by a screw press and a centrifuge for purification of the fat. It also hydrolyses feathers in a continuous hydrolyser, which is also used for sterilising/pressure cooking pig offal. A thermal oxidiser was installed and tested. The flue gas analysis showed that emissions were below the permitted levels. Odour emissions were not measured.

The plant has a potential throughput of 13 – 15 t/h of raw material. The operational data in Table 2.21 was reported:

Table 2.21: Operational data for a case study rendering plant using a thermal oxidiser

Maximum vapour flow	-	10 000 kg/h
Maximum non-condensable gases flow	1 930 m ³ /h	2 500 kg/h
Maximum combustion airflow (air to be deodorised)	10 800 m ³ /h	14 000 kg/h
Working temperature	-	900 °C
Residence time	-	> 1 s
Steam production*	-	11 500 kg/h, 12 Pa
* As a general rule, the amount of steam used to dry render a given raw material is 10 x x %, where x is the raw material water content, 10 x x kg of steam are used. For example, if the raw material contains 75 % water, then at least 750 kg of steam will be used.		
Source: [215, COM 2005]		

Cross-media effects

A feature of the combustion systems is that they produce the greenhouse gases CO₂ and NO_x and can give rise to SO_x emissions.

The amount of NO_x emitted may be high if the raw materials are not fresh, especially in warm weather if degradation is not first prevented, i.e. by the rapid treatment or preservation of raw materials by, e.g. cooling. The continuous measurement of NO_x may be required, to monitor the combustion conditions.

Fuel is required to run the thermal oxidiser.

Technical considerations relevant to applicability

The equipment suppliers have concluded that the system is most suited for conventional rendering systems which do not use waste heat evaporators or similar heat recovery systems.

Economics

The equipment suppliers have calculated investment and running costs for such a system built into various conventional systems. Their calculations are shown in ~~Table XX~~ Figure 2.44. The economy of the system is reported to be substantially improved if new investments in a conventional boiler, condensing unit and waste water treatment plant can thus be avoided.

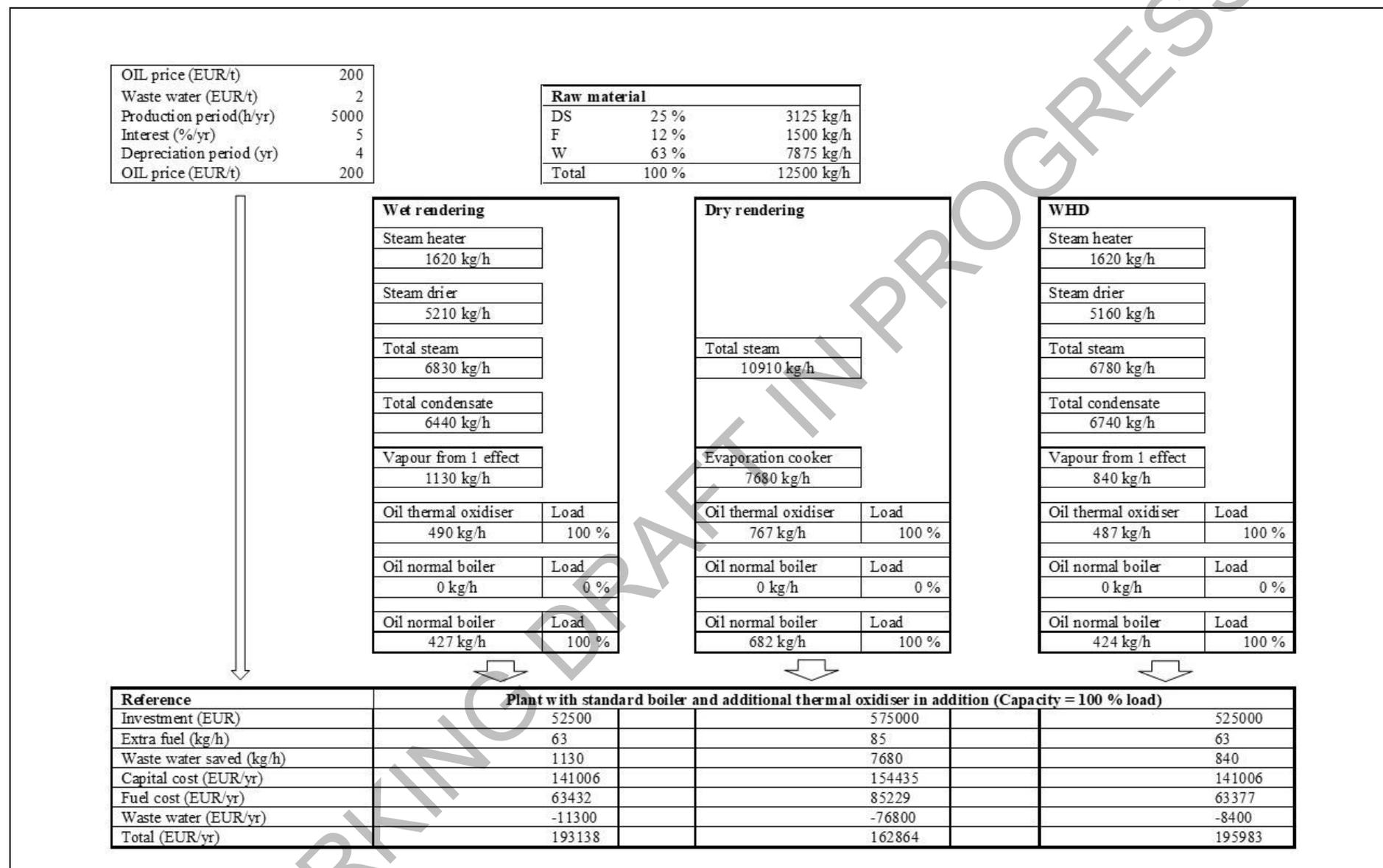
~~Table XX~~ Figure 2.44 shows comparative costs for 3 different rendering processes replacing their existing boiler with a thermal oxidation system. In each case the thermal oxidiser is designed to cope with the whole vapour, including the non-condensable gases and a proportion of room extraction air from the process and to provide 100 % of the steam required by the process. The information is referenced to a throughput of 12.5 t/h of raw material, comprising 25 % dry solids, 12 % fat and 63 % water.

The total cost given is the additional annualised cost of running the thermal oxidiser system compared with retaining the existing system of steam raising boiler, condenser system and waste water treatment system. It is made up of the elements shown in Table 2.22.

Table 2.22: Cost elements for replacing an existing boiler with a thermal oxidiser

Element name	Definition
Investment	The capital cost of the new thermal oxidiser
Extra fuel	The additional fuel required by the thermal oxidiser compared to that required by the existing boiler, to process those vapours that would not be processed by the boiler
Waste water saved	The amount of process vapour that is no longer condensed, but passes directly to the thermal oxidiser
Capital cost	The investment cost annualised over a 4 year period with an interest rate of 5 %
Fuel cost	The annualised cost of the extra fuel based on an oil price of EUR 200/t
Waste water	The savings in effluent treatment/disposal costs of the vapour that is no longer condensed, based on a waste water treatment cost of EUR 2/t

The use of recuperative or regenerative heat recovery systems can improve the efficiency of the process and reduce the running costs. The comparative costs of the thermal oxidation system can also be improved if its installation prevents the need to invest in new, or replacement, boiler plant, condensers or waste water treatment facilities.



[194, EURA, 2000]Source: [77, EURA 2000]

Figure 2.44: Consumption, emission and economic data for a thermal oxidiser for the combustion of vapour, non-condensable gases and room air in rendering

Driving force for implementation

Elimination of intense malodorous gases, especially the non-condensable gases produced during rendering.

Example plants

The technique is widely used in rendering plants [241, TWG 2019].

Rendering plants in Ireland, Spain and the UK.

Reference literature

[134, Nordic States, 2001] [38, Nordic 2001], [168, Sweeney L., 2001] [56, Sweeney L. 2001], [194, EURA, 2000,] [77, EURA 2000], [241, UK, 2002,] [107, United Kingdom 2002], [310, Oberthur R., 2002] [158, Oberthur R. 2002], [206, Giner-Santonja et al. 2019], [241, TWG 2019]

2.3.8.2.14 Burning Combustion of malodorous gases, including non-condensable gases, in an existing boiler**Description**

Malodorous gases, including non-condensable gases produced, ~~during rendering may be~~ are burned in an existing boiler in the installation.

Technical description

Steam collected from cookers, driers and evaporators is first passed through a cyclone, to separate out the solid material. It then passes through a heat-exchanger, in which the steam is cooled. The moist air is then dewatered. The water is discharged to a WWTP and the air containing the malodorous substances, including air from the premises, is finally burned.

In some cases, non-condensable gases from the process are burned in an existing boiler, the waste gas from the boiler is consequently condensed and the non-condensable gas passed through a biofilter [241, TWG 2019] [264, TWG 2020].

A rendering installation (IT163) uses a burner for steam generation and exhaust air treatment. The temperature set point in the burner permits a compromise between NO_x and CO emissions, with the former being strongly influenced by the animal by-products rendered. Due to the high nitrous content of the animal by-products being treated, a condensation unit was added to treat the waste gas from the burner. The condensation unit allows for better regulation of the temperature in the burner, so that lower CO emissions are generated. The NO_x compounds are transferred from the waste gas to the condensed water, while the air exiting the condensation unit is further treated in a biofilter. The condensed water is sent to the WWTP after pH regulation [264, TWG 2020].

Achieved environmental benefits

Reportedly highly efficient and if properly operated, as efficient at eliminating odours, including intense odours, as other burning methods.

Environmental performance and operational data

If the installation does not have a boiler capable of running continuously to burn the malodorous gases in places where there is a demand for abatement, an alternative treatment system may be required. The flowrate needs to be controlled to ensure complete combustion of the malodorous gases.

Cross-media effects

Fuel consumption is raised slightly, due to reduced boiler efficiency. It may be necessary to keep the boiler running during rendering, even when there is no demand for steam, otherwise

strong odours may escape, e.g. via a biofilter, which may be only capable of treating low intensity odours. Keeping the boiler running incurs an additional fuel use.

Indirectly fired hot air dryers are used in Norway as well as other countries to produce so-called LT meal, which is a high-quality low-temperature-dried fishmeal. The flue-gas from the combustion has too high a temperature for the operation of the dryers. A measure to reduce the temperature of the flue-gas is to operate the burner with a significantly higher excess of air than, for example, conventional steam boilers. Typical air excess in the burner of the indirect hot air dryer is 8-12 %, which is three to four times higher than in conventional steam boilers, resulting in higher formation of nitrogen oxides than from conventional boilers not burning nitrous gases [276, EU Fishmeal 2020].

Technical considerations relevant to applicability

Applicable to low-volume high-concentration odours generated in SA installations. Some boilers are designed for this purpose.

Economics

High running costs can be reduced by heat recovery. The running costs can be reduced if the inevitable reduction in boiler efficiency can be minimised and provided that the installation is properly designed and built to minimise the effects of the corrosive gases treated.

Driving force for implementation

Reduction in odour emissions.

Example plants

The technique is widely used [241, TWG 2019].

At least one rendering plant in the Netherlands and one in the UK.

Reference literature

[167, Biosphere Refineries Corporation 2002] [55, Greek Ministry for the Environment 2001], [200, Widell S., 2001] [80, Widell S. 2001], [243, Clitravi - DMRI, 2002] [190, Clitravi - DMRI 2003], [333, Netherlands TWG, 2003] [177, The Netherlands 2003] [241, TWG 2019], [264, TWG 2020], [276, EU Fishmeal 2020]

Ducting of air from the installation and the pre-combustion equipment to the combustion chamber

Technical description

Storage, handling and possibly size reduction equipment, can be sealed or maintained under negative pressure and the air extracted can then be used to provide oxygen for the incineration process. Air can also be ducted to the incinerator from the building in which the storage handling and grinding equipment are situated. The amount of air which can be fed to the combustion chamber will be limited to the optimum oxygen requirements for the incineration process. An odour assessment can help to identify the areas which are most likely to lead to odour emissions and these can be selected as the highest priority for capture of air, for incineration.

The amount of air which passes through the incinerator can also be controlled. Excess air fed into the incinerator adds an additional burden on the flue gas treatment equipment. The use of small storage buildings with small openings/air inlets increases the effectiveness of capturing malodorous air.

Achieved environmental benefits

Enclosure of the process combined with continuous extraction of the air in the storage and handling equipment reduces the risk of malodorous emissions from animal by products, which

may be stored for a number of days. In an example incinerator, the incinerator is situated on the same site as a slaughterhouse, where cattle are killed 5 days a week, from Monday to Friday. The incinerator operates continuously, so material fed into the incinerator on Monday may have been in storage for up to 3 days. Without the extraction of air from the storage, handling and grinding equipment, odour problems would almost certainly arise.

Cross-media effects

None.

Environmental performance and operational data

At one case study site, there are two air inlets at the top of the storage vessel. The air from the vessel, as well as that from the other handling and grinding equipment between the storage vessel and the furnace, is drawn into the furnace to provide oxygen for the combustion process. This is the only source of oxygen for combustion. The furnace is in continuous operation, so this method of providing oxygen for combustion maintains the negative pressure within the storage vessel and prevents malodorous air from escaping. The air inlets to the storage vessel are protected by grills, to prevent the access of rodents and birds.

When the incinerator is shut down, especially if this is unplanned, it may be necessary to extract malodorous air from the installation and equipment to alternative treatment systems. For planned shutdowns the receipt of feedstock may be temporarily stopped, e.g. to prevent odour emissions.

This technique is not restricted to incinerators and can be used for any site that has combustion equipment installed.

Technical considerations relevant to applicability

Applicable at all incinerators burning malodorous material and at other all installations with a combustion equipment.

Economics

There will be a cost for the ducting required to draw the air from inside the building and through the pre-combustion storage and handling equipment. The cost will depend on whether the installation has been designed so that the pre-combustion equipment is situated close to the incinerator or not. Some redesign and or sealing of air inlets at areas from where the air is extracted may also be required, to improve the effectiveness of the air capture.

Driving force for implementation

Odour reduction.

Example plants

This technique is widely used in incinerators and co-incinerators throughout Europe.

Reference literature

[269, Italian TWG Members, 2002, 350, EFPR, 2003]

2.3.8.3 Techniques to reduce dust emissions

2.3.8.3.1 Bag filter

For more information, please consult the FDM BREF [206, Giner-Santonja et al. 2019].

Description

Bag filters, often referred to as fabric filters, are constructed from porous woven or felted fabric through which gases are passed to remove particles. The use of a bag filter requires the selection of a fabric suitable for the characteristics of the waste gas and the maximum operating temperature.

Technical description

Bag filter or fabric filter systems work by passing air containing particulates through a filter medium which traps the particles as the air is forced through the filter media. The process takes place inside filter units which are placed in the flow of the air to be filtered. To maintain the efficiency of the filter media, they are cleaned at regular intervals either by being vigorously shaken or by a reverse jet of air being blown through them to release any material held on the filter - this material is then collected and reused in the production process. It is necessary to change the filter media regularly to ensure that they remain efficient and that there are no microbiological risks to the installation resulting from accumulation of material on the filter media.

Achieved environmental benefits

Reduction of dust emissions to air.

Environmental performance and operational data

Bag filters may reduce dust emissions to $< 5 \text{ mg/Nm}^3$.

Cross-media effects

Energy consumption. Bag filter material life is limited and creates another waste to dispose of.

Reference literature

[206, Giner-Santonja et al. 2019]

2.3.8.3.2 Cyclone

For more information, please consult the FDM BREF, [206, Giner-Santonja et al. 2019].

Description

Dust control system based on centrifugal force, whereby heavier particles are separated from the carrier gas.

Technical description

Cyclones use inertia to remove (generally large/coarse) particles from the gas stream by using centrifugal forces, usually within a conical chamber. They operate by creating a double vortex inside the cyclone body. The incoming gas is forced into circular motion down the cyclone near the inner surface of the cyclone tube. A high-speed rotating flow is established within a cylindrical or conical container called a cyclone. Larger (denser) particles in the rotating stream have too much inertia to follow the tight curve of the stream, and strike the outside wall, then fall to the bottom of the cyclone where they can be removed. At the bottom, the gas turns and spirals up through the centre of the tube and out of the top of the cyclone. Particles in the airstream are forced toward the cyclone walls by the centrifugal force of the spinning gas but are opposed by the fluid drag force of the gas travelling through and out of the cyclone. Large particles reach the cyclone wall and are collected in a bottom hopper, whereas small particles leave the cyclone with the exiting gas.

Achieved environmental benefits

Reduction of dust emissions to air.

Reference literature

[206, Giner-Santonja et al. 2019]

2.3.8.4 Techniques to reduce NO_x emissions

2.3.8.4.1 Low-NO_x burners

For more information, consult the LCP BREF [266, Lecomte et al. 2017].

Description

The technique is based on the principles of reducing peak flame temperatures; boiler burners are designed to delay but improve the combustion and increase the length of the flames, allowing the heat radiated during combustion to reduce peak temperatures. The air/fuel mixing reduces the availability of oxygen and reduces the peak flame temperature, thus retarding the conversion of fuel-bound nitrogen to NO_x and the formation of thermal NO_x, while maintaining high combustion efficiency. This may be associated with a modified design of the furnace combustion chamber.

Achieved environmental benefits

Reduced NO_x emissions to air.

Technical considerations relevant to applicability

Applicability to existing plants may be restricted by design and/or operational constraints.

Reference literature

[266, Lecomte et al. 2017]

Replacement of fuel oil with natural gas

Fuel oil is available in various sulphur grades (< 1 %, < 2 %, < 3 % and > 3 %). Natural gas is essentially sulphur free. If there is access to a natural gas supply, boilers can be converted to burn gas, e.g. by modifying the fuel supply system and replacing the burners. The use of natural gas is relatively easy to control and it does not require storage facilities.

Achieved environmental benefits

Due to natural gas being essentially sulphur free, lower SO₂ emissions can be achieved, without the need for abatement. The nitrogen content of natural gas is generally negligible, so fuel NO_x emissions are effectively zero.

Operational data

The combustion of natural gas is associated with SO_x emission levels lower than those associated with the combustion of coal, as shown in Table XX.

Natural gas produces less energy per unit mass than fuel oil.

Cross-media effects

No information provided.

Applicability

Applicable in all installations using boilers and which have access to a supply of natural gas.

Economics

There will be an initial cost for modifications to the fuel supply system and the burners. The running costs for using natural gas compared to fuel oil are unlikely to be higher, although the fuel may be more expensive. The fuel cost will depend on the market in any given MS at any time and it may be higher or lower than alternative fuels. The costs of the technique will depend mainly on the prevailing fuel prices.

Driving force for implementation

Reduced SO₂ emissions.

Reference literature

{167, Greek Ministry for the Environment, 2001, 265, EC, 2001, 349, GME TWG members, 2003}

2.3.9 Techniques to reduce noise emissions

2.3.9.1 Noise management plan

Description

A noise management plan is part of the environmental management system of the installation (see Section 2.3.1.1) and includes elements to prevent or reduce noise nuisances.

Technical description

Such a plan normally does the following:

- Describes the main sources of noise (including infrequent sources) and the nearest noise-sensitive locations. This description covers the following information for each main source of noise within the installation:
 - the source and its location on a scaled plan of the site;
 - whether the noise is continuous/intermittent, fixed or mobile;
 - the hours of operation;
 - a description of the noise, e.g. clatter, whine, hiss, screech, hum, bangs, clicks, thumps or has tonal elements;
 - its contribution to the overall site noise emission, e.g. categorised as high, medium or low unless supporting data are available.
- Also provides the above information for the operation of infrequent sources of noise (such as infrequently operated/seasonal operations, cleaning/maintenance activities, on-site deliveries/collections/transport or out-of-hours activities, emergency generators or pumps and alarm testing).
- Details the appropriate noise surveys, measurements, investigations (which can involve detailed assessments of sound power levels for individual plant items) or modelling that may be necessary for either new or existing installations taking into consideration the potential for noise problems.
- Describes a protocol for response to identified noise incidents, e.g. complaints.
- Contains appropriate actions to be undertaken and timelines.

Noise levels can be assessed and controlled to ensure that they do not cause annoyance to persons in the vicinity. This can be undertaken in co-operation with the regulatory authorities.

Significant stationary and mobile noise sources; those building and ground conditions which may influence noise emissions and the level and duration of each noise source can be mapped.

The consequences of noise from a planned increase in production; increased traffic to/from/at the plant; increased operational times for existing sources and from new stationary sources of noise can be evaluated.

Noise strain in the surroundings of the plant can be calculated. A plan to reduce the noise strain in the surroundings from stationary sources and mobile sources can be prepared.

Meetings with working groups which include the participation of the neighbours can be followed by subsequent implementation of noise reducing activities. Working groups can continue to meet and review noise prevention and control measures.

Achieved environmental benefits

Reduced noise emissions.

Environmental performance and operational data

The noise characteristics, e.g. the tone; its timing, its duration and its level, can all affect how annoying the noise is and can all be assessed to establish what controls are required.

Legislation controlling noise exposure in the workplace requires noise exposures to be controlled by means other than hearing protection, in the first instance. As a general rule, occupational noise assessments are required where the noise levels are such that people standing 2 metres apart have to raise their voices to be heard. Control of noise levels at source for occupational reasons may, therefore, significantly reduce environmental noise. Noise levels that annoy neighbours may, however, be both below occupational action levels at the ear of the person hearing the noise and/or may be high levels of noise which are not an occupational hazard due to the position, time or duration of the source of the noise.

In an example slaughterhouse, the following action was taken to combat a noise problem. A ventilating exhaust was changed; an awkwardly placed machine room was closed; the frequency control/speed of ventilators, e.g. at condensers was changed; condenser equipment was changed; heat recuperation from the cooling system was extended and selected sources of noise were shielded. For mobile sources internal traffic routes were altered and acoustic screens were erected. A dispensation allowing an increased noise level of +5 dB(A) was arranged for Monday mornings. The total noise emitted from the slaughterhouse was reduced by 12 - 13 dB(A).

It has been reported that most traffic noises arise from the way the vehicle is driven and that effective noise reduction measures include speed reduction and steady driving. Good planning before the installation is constructed can reduce noise emissions by design. This may include building structures such as embankments and walls and placing roads lower than surrounding land. Noise-reducing road surfaces can be applied, e.g. a mastic asphalt with chippings, is reportedly 2 dB(A) quieter than a rolled asphalt surface and 4 dB(A) quieter than a concrete surface. Open textured asphalt capping, known as “whispering asphalt”, can reportedly reduce noise levels by a further 3 dB(A), but has a much shorter lifetime than other road surfacing materials. It may be possible to construct the access and egress on the side facing away from, e.g. residential areas. The vehicle may also be adapted by, e.g. insulating HGV engines.

Fan noises can be transmitted over long distances, with the higher frequencies tending to die away faster. A roof-mounted fan may, therefore, be modified to produce higher-frequency noise. The connections between fans and ducts or housings can be made using elastic linkages, to minimise noise associated with vibrations.

Cross-media effects

None.

Technical considerations relevant to applicability

Applicable in all slaughterhouses and animal by-products installations.

A common-sense approach needs to be adopted in determining which sources to include. The ones which need to be considered are those which may have an environmental nuisance impact; for example, a small unit could cause an occupational noise issue in an enclosed space but would be unlikely to cause an environmental issue. Conversely, a large unit or a number of smaller units enclosed within a building could, for example, cause a nuisance only if the doors are left open. It also needs to be remembered that some noise, which is not particularly noticeable during the day, may become more noticeable at night.

The applicability is restricted to cases where a noise or vibration nuisance in sensitive areas is expected and/or has been reported.

Economics

Request to the TWG: Please provide information.
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Driving force for implementation

Good relations with neighbours and occupational health and safety.

Example plants

Request to the TWG: Please provide more information.

A Danish pig slaughterhouse.

Reference literature

[189, Pontoppidan O., 2001] [72, Pontoppidan O. 2001], [224, German TWG members, 2002] [100, Germany 2002], [296, EA, 2002] [145, Environment Agency 2002], [297, EA, 2002] [146, Environment Agency 2002], [265, Pinasseau et al. 2018]

2.3.9.2 Noise and vibration reduction at source and noise abatement

Description

Implementation of operational and maintenance techniques, as well as low-noise equipment and buildings.

Technical description

Techniques to reduce noise and vibration emissions include:

- appropriate location of equipment and buildings: noise levels can be reduced by increasing the distance between the emitter and the receiver, by using buildings as noise screens and by relocating buildings' exits or entrances;
- inspection and maintenance of equipment;
- use of low-noise equipment (e.g. compressor with a noise level < 85 dB(A), speed-controlled pumps and fans, direct drive motors);
- soundproofing of buildings to shelter any noisy operations including:
 - sound-absorbing walls and ceilings,
 - sound-isolating doors,
 - double-glazed windows;
- use of vibration or acoustic insulation, or vibration isolation;
- enclosure of noisy equipment;
- reduction of noise propagation by inserting appropriate obstacles such as protection walls, embankments, and buildings.

Achieved environmental benefits

Reduction of noise emissions.

Environmental performance and operational data

No information provided.

Cross-media effects

None.

Technical considerations relevant to applicability

For existing plants, the relocation of equipment and building exits or entrances may be restricted by a lack of space or excessive costs. Low-noise equipment can be installed when the old equipment is replaced. The use of other noise-reducing equipment is subject to space availability.

Economics

Request to the TWG: Please provide information.

Driving force for implementation

Environmental legislation.

Example plants

Request to the TWG: Please provide information.

Reference literature

[265, Pinasseau et al. 2018]

Reduced noise by roof extract fans – by routine maintenance

Technical description

Routine maintenance of roof fans reportedly resulted in a reduction of 10 dB(A).

Achieved environmental benefits

Reduced noise emissions, thus giving benefits to local residents, especially at night and weekends. For an example installation, the number of complaints about noise fell from approximately 6 per week to one in 4 months. An additional advantage reported, was the improved health and safety working environment for the employees.

Operational data

A noise survey was undertaken to determine the cause of complaints, to compare levels with standards and to advise on practical solutions to control emissions. There are 3 processing sites and a poultry rearing farm at the site. The facility operates 24 hours, 7 days per week. The survey was carried out over a 12 hour period from 15.00 to 03.00 hours.

Measurements were taken at specific predetermined positions on the site and at 3 fixed locations in the surrounding areas, as determined by the complaints.

Noise levels were recorded and compared with BS4142:1997, *Methods for rating industrial noise affecting mixed residential and industrial areas*. Measurements were taken using a CEL 573 sound level meter, set at a height of 1.5 m, for varying sample durations. Also a CEL 162 environmental noise analyser was set up in fields within 50 metres of complainant properties.

The survey indicated that the noise emissions for the site were 20 dB above the existing background noise level for the area in which the factory is situated.

The survey also identified specific sources of noise emissions. After assessment the consultants were able to recommend correction methods. As well as the effluent plant air blowers, there were emissions from refrigeration plant rooms, roof fans and lorries/trailers. The levels were greater in the tonal range of 250 to 500 hertz frequencies

Applicability

Applicable in premises with roof mounted fans.

Driving force for implementation

Regular environment meetings are held on the case study site, with representatives from the local parish council and the area environmental regulating officer. There is a register of complaints to which all incoming complaints are logged and actions taken. From these meetings and registered complaints it was decided to undertake a noise survey to try and locate any nuisance levels and to reduce these where required. The first survey to establish noise levels was undertaken in October 1999. Most of the complaints were from residents living near the further processing unit and those in a direct line with the main site and most related to the noise levels during the evenings.

Example plants

A poultry slaughterhouse in the UK.

Reference literature

{214, AVEC, 2001}

Reduced noise at balance lagoon blower

Technical description

Additional sound insulation was fitted to the effluent blower building.

Achieved environmental benefits

Reduced noise emissions.

Operational data

At an example plant, noise emissions were reduced by about 15 dB(A). The benefits were felt by local residents, especially at night and at weekends. The numbers of complaints about noise fell from approximately 6 per week to one in 4 months. An additional advantage reported, was the improved health and safety environment for the employees.

Loud tonal characteristics were reduced so that they are no longer significant and at approximately 10 metres from blower sheds, the blower noise is almost inaudible against the site background noise.

A noise survey was undertaken to determine the cause of complaints, to compare levels with standards and to advise on practical solutions for controlling emissions. There are 3 processing sites and a poultry rearing farm at the site. The facility operates 24 hours a day and 7 days per week. The survey was carried out over a 12 hour period from 15.00 to 03.00 hours.

Measurements were taken at specific predetermined positions on the site and at 3 fixed locations in the surrounding areas, as determined by the complainants.

The noise levels were recorded and compared with BS4142:1997, *Methods for rating industrial noise affecting mixed residential and industrial areas*. Measurements were taken using a CEL 573 sound level meter, set at a height of 1.5 m, over varying sample durations. A CEL 162 environmental noise analyser was set up in fields within 50 metres of complaint properties.

The survey indicated that the noise emissions for the site were 20 dB above the existing background noise level for the area in which the factory is situated.

It also identified specific sources of noise emissions. After assessment the consultants were able to recommend correction methods. As well as the effluent plant air blowers, there were emissions from refrigeration plant rooms, roof fans and lorries/trailers. The levels were greater in the tonal frequencies ranging between 250 and 500 hertz.

Cross-media effects

None.

Applicability

Applicable in installations which use a balance lagoon blower.

Driving force for implementation

Regular environment meetings are held at the case study site, with representatives from the local parish council and the area environmental regulating officer. There is a register of complaints in which all incoming complaints are logged together with the actions taken. From these meetings and registered complaints it was decided to undertake a noise survey to try and locate any nuisance levels and to reduce them where required. The first survey to establish noise levels was undertaken in October 1999. Most of the complaints were from residents living near

the further processing unit and those in a direct line with the main site and most related to noise levels during the evenings.

Example plants

A poultry slaughterhouse in the UK.

Reference literature

{214, AVEC, 2001}

Abatement of noise from refrigeration plants by the use of insulated doors

Technical description

In an example slaughterhouse, the large up and over roller shutter doors of the refrigeration plant rooms were exchanged for insulated design doors which give 21 dB insulation, in the 63 to 4 000 hertz frequency range. Where practical the doors are kept closed overnight and during the day.

Achieved environmental benefits

Reduced noise emissions, thus giving benefits to residents local to the site, especially at night and at weekends. The number of complaints about noise fell from approximately 6 per week to one in 4 months. An additional advantage was an improved health and safety working environment for the employees.

Energy is also saved, due to the reduction in heat loss.

Operational data

Safety requirements regarding ventilation need to be taken into account during the design and construction of refrigeration plant rooms.

A noise survey was undertaken to determine the cause of complaints, to compare levels with standards and to advise on practical solutions to control emissions. There are 3 processing sites and a poultry rearing farm at the site. The facility operates 24 hours a day and 7 days per week. The survey was carried out over a 12 hour period from 15.00 to 03.00 hours.

Measurements were taken at specific predetermined positions on the site and at 3 fixed locations in surrounding areas, determined by the complaints.

The noise levels were recorded and compared with BS4142:1997, *Methods for rating industrial noise affecting mixed residential and industrial areas*. Measurements were taken using a CEL 573 sound level meter set at a height of 1.5 m, over varying sample durations. A CEL 162 environmental noise analyser was set up in fields within 50 metres of complainant properties.

The survey indicated that the noise emissions for the site was 20 dB above the existing background noise level for the area in which the factory is situated.

It also indicated sources of noise emissions. After assessment the consultants were able to recommend correction methods. As well as the effluent plant air blowers, there were emissions from refrigeration plant rooms, roof fans and lorries/trailers. The levels were greater in the tonal range frequencies between 250 and 500 hertz.

Economics

The costs can be offset by energy savings.

Driving force for implementation

Regular environment meetings are held on the case study site, with representatives from the local parish council and the area environmental regulating officer. There is a register of complaints to which all incoming complaints are logged and actions taken. From these meetings and registered complaints it was decided to undertake a noise survey to try and locate any nuisance levels and reduce where required. The first survey to establish noise levels was

Chapter 2

undertaken October 1999. Most of the complaints were from residents living near the further processing unit and those in a direct line with the main site and most related to the noise levels during the evenings.

Example plants

A poultry slaughterhouse in the UK.

Reference literature

{214, AVEC, 2001}

WORKING DRAFT IN PROGRESS

3 SLAUGHTERHOUSES

3.1 General information for slaughterhouses

Request to the TWG: Please provide information.

The slaughtering industry in the European Union

The slaughtering industry throughout the EU is diverse with many different national characteristics. There does, however, appear to be a trend towards fewer slaughterhouses with increasing average throughputs. All MSs have to comply with common hygiene and structural standards [99, EC, 1964] [30, COM 1964], [169, EC, 1991] [57, COM 1991] and it is widely believed that this is the reason for the increased consolidation of slaughtering into fewer and larger installations [57, DoE, 1993] [20, DoE 1993], [127, MLC Economics, 1999] [35, MLC 1999].

Table shows the number of cattle, pigs, and sheep (including goats) slaughtered by species, for all MSs in 1998. To enable comparisons, the MLC has calculated total slaughter on the basis of GB cattle units. They have defined a GB cattle unit, as follows:

1 GB cattle unit = 1 cattle beast or 3 calves or 5 sheep or 2 pigs

(This differs from the definition given in Council Directive 91/497/EEC, which refers to livestock units as follows: bovines and solipeds = 1.0 livestock unit; pigs = 0.33 livestock units and sheep = 0.15 livestock units [169, EC, 1991]. Interestingly, this definition is used even though the average slaughter weights of some species vary significantly between MSs, sometimes by a factor as high as 100 %.)

	<u>Adult cattle</u>	<u>Calves</u>	<u>Sheep⁽⁺⁾</u>	<u>Pigs</u>	<u>Total expressed in GB cattle units</u>	<u>% change 1998/87⁽²⁾</u>
	<u>'000</u>	<u>'000</u>	<u>'000</u>	<u>'000</u>	<u>'000</u>	
<u>Belgium</u>	<u>612</u>	<u>311</u>	<u>203</u>	<u>11531</u>	<u>6523</u>	<u>+22</u>
<u>Luxembourg</u>	<u>21</u>	<u>3</u>	<u>-</u>	<u>129</u>	<u>87</u>	<u>-5</u>
<u>Denmark</u>	<u>615</u>	<u>50</u>	<u>66</u>	<u>20960</u>	<u>11125</u>	<u>+24</u>
<u>Germany</u>	<u>4126</u>	<u>485</u>	<u>2151</u>	<u>41352</u>	<u>25394</u>	<u>-</u>
<u>Greece</u>	<u>225</u>	<u>82</u>	<u>11993</u>	<u>2241</u>	<u>3772</u>	<u>-4</u>
<u>Spain</u>	<u>2331</u>	<u>133</u>	<u>21963</u>	<u>33428</u>	<u>23482</u>	<u>+64</u>
<u>France</u>	<u>3858</u>	<u>1984</u>	<u>8639</u>	<u>26567</u>	<u>19531</u>	<u>+9</u>
<u>Ireland</u>	<u>1899</u>	<u>7</u>	<u>4067</u>	<u>3339</u>	<u>4384</u>	<u>+40</u>
<u>Italy</u>	<u>3317</u>	<u>1099</u>	<u>7806</u>	<u>12571</u>	<u>11530</u>	<u>+3</u>
<u>Netherlands</u>	<u>1039</u>	<u>1373</u>	<u>650</u>	<u>19277</u>	<u>11266</u>	<u>+1</u>
<u>Austria</u>	<u>550</u>	<u>135</u>	<u>366</u>	<u>5359</u>	<u>3348</u>	<u>nc</u>
<u>Portugal</u>	<u>264</u>	<u>118</u>	<u>1271</u>	<u>4954</u>	<u>3034</u>	<u>+52</u>
<u>Finland</u>	<u>372</u>	<u>14</u>	<u>61</u>	<u>2195</u>	<u>1487</u>	<u>nc</u>
<u>Sweden</u>	<u>480</u>	<u>46</u>	<u>159</u>	<u>3962</u>	<u>2508</u>	<u>nc</u>
<u>United Kingdom</u>	<u>2297</u>	<u>32</u>	<u>18698</u>	<u>16286</u>	<u>14191</u>	<u>-6</u>
EU-15	22005	5872	78092	204151	141656	+12

⁽⁺⁾ — Includes goats
⁽²⁾ — Comparison made on the basis of GB cattle units (cattle beast or 3 calves or 5 sheep or 2 pigs)
nc — No comparison

Table: Numbers of cattle, sheep and pigs slaughtered in the EU in 1998
[127, MLC Economics, 1999]

Table shows that Germany accounted for the largest share of EU slaughter, i.e. 18 % of the total, followed by Spain with 17 % and then France with 14 %.

Between 1987 and 1998 the numbers of animals slaughtered in the EU, based on GB cattle units, rose by about 12 %. Most of the increase occurred in pig and to a lesser extent, sheep slaughtering. Overall, cattle and calf slaughter fell. Spain and Portugal were responsible for much of the increase. Both of these countries were new EU members in 1987, and since then their livestock industries have expanded rapidly. Spain has increased in all parts of the industry. In Portugal the increase has been greatest for pigs, with cattle slaughter actually falling in that period.

Although Germany slaughtered more animals than the other EU countries, its total in 1998 was more or less unchanged compared with its 1987 number. The Netherlands also showed little change. It had recently slaughtered fewer pigs, following the introduction of environmental measures to reduce the pig herd and problems with swine fever outbreaks. The drop in numbers of animals slaughtered in the UK was primarily due to fewer cattle being slaughtered because of BSE.

In 1999 the largest cattle slaughterhouse groups in the EU, comprised 4 companies in France and Germany, which together accounted for 11 % of the EU kill. Pig slaughtering was even more concentrated, being dominated by two large groups in Denmark, which between them slaughtered 8 % of the EU total. These two groups have since merged. France dominated the poultry slaughter industry, with its two largest groups accounting for 14 % of EU slaughter.

Some slaughterhouses have on-site animal by products processing activities. ABP Regulation 1774/2002/EC sets out the rules for preventing cross contamination. This is achieved by various requirements covering segregation, hygiene and record keeping.

Belgium

Pig slaughtering dominates the Belgian industry and accounts for practically all the expansion in slaughter in the period 1987 to 1998. However, the industry is fragmented and profitability is poor.

No company slaughters more than one million pigs per year. Several of the country's largest meat processing companies belong to international groups.

Of the EU accredited slaughterhouses in Belgium there are 21 for slaughtering pigs exclusively, 2 for cattle and/or calves exclusively and 42 for slaughtering poultry. In addition, there are 41 EU accredited slaughterhouses for slaughtering pigs and other animals, 46 that slaughter other animals in addition to cattle and/or calves and 80 poultry slaughterhouses with an annual slaughtering capacity of fewer than 150000 birds.

In Flanders, slaughterhouses are typically SMEs employing fewer than 50 people. Demand has been falling in recent years for beef and pork, but exports are increasing, mainly to other EU countries. [346, Belgian TWG member, 2003]

Denmark

The majority of pig and cattle slaughterhouses in Denmark are co-operatively owned. Pig slaughtering is dominant. The industry is very concentrated, due to a round of amalgamations and company take overs during the 1980s. The largest slaughter company operating in Denmark in 1997 had 12 slaughter units, accounting for around half the national kill. At this time, it was the largest pig slaughter group in the EU and ranked second or third in the world. It has since merged with the second largest company, which also previously ranked amongst the world's top ten.

The resultant company operates 5 cattle slaughterhouses and slaughters more than 60 % of Danish cattle. One cattle slaughterhouse also slaughters approximately 20000 lambs per year on

a separate line. The remaining sheep and lambs are slaughtered in a large number of plants. Previously one of these companies accounted for 38 % of cattle slaughter in Denmark and was ranked eighth in size in the EU. It operated out of both Denmark and the UK. Its market share is even greater now.

Generally, Danish poultry slaughterhouses are privately owned. Two companies each slaughter 40 % of the total national kill, i.e. about 25 million chickens each per year and six others slaughter between 9 and 13 million each.

Germany

Germany is the EU's largest slaughterer of both cattle and pigs. In 1987 there were estimated to be 350 slaughterhouses in West Germany alone. In 1995 there were 268 EU approved slaughterhouses. In 1997, there were 200 slaughterhouses employing more than 20 people. Several thousand more reportedly operate under the "Kleinbetrieb Regelung", i.e. slaughtering up to 20 GB units a week.

Germany's prime position within the EU is reflected in the fact that 3 of its companies are ranked high in terms of cattle slaughter, occupying the third, fourth and tenth positions for EU cattle slaughter. The company that is ranked tenth biggest for cattle slaughter is also the EU's third largest pig slaughterer. Germany also has the EU's eighth largest pig slaughtering company. Three of the largest companies are producer co-operatives.

An overview of the economic position of slaughterhouses in Germany is given in Table.

	Slaughtering and meat processing (excluding poultry)		
	1997	1998	1999
Number of companies	200	219	228
Staff per company	83	75	76
Staff total	16668	16459	17430
Turnover (DEM million) (exclusive of VAT)	14122.9	12532.1	12693.4
Turnover per company (DEM million)	70.4	57.2	55.7
Export ratio (%)	8.8	10.6	11.0

Table: Number of slaughterhouses (excluding poultry) in Germany, with turnover data for 1997–1999
[163, German TWG Members, 2001]

Spain

The numbers of cattle, sheep and particularly pigs slaughtered in Spain have all grown in the ten years to 1999, following the accession of Spain to the EU. One of the largest slaughter companies controls about 12 % of the Spanish market.

France

In the ten years between 1987 and 1997, the slaughter of cattle, calves and sheep all decreased in France but the numbers of pigs slaughtered rose. The number of slaughterhouses decreased from 602 in 1986 to 344 in 1997, but the average throughput size rose. One of the main characteristics of the French industry is the continuing importance of public slaughterhouses, even though practically all of the decline in slaughterhouse numbers has been in the public sector and their average throughput is lower than the private sector. They still account for more than half of the slaughterhouse numbers.

In 1997, there were 187 public slaughterhouses and 157 private slaughterhouses in France. Public slaughterhouses dominate in the smaller size group, whereas the private sector has more in the larger size group.

There has been a reduction in the number of slaughterhouses for all species, implying that the average throughput has increased across the board. The rise in the number of pigs slaughtered, however, means that pig slaughter has become particularly concentrated.

For cattle slaughter, France has the two largest groups in the EU, and between them they account for about half of the French national kill.

Ireland

The slaughtering of all species in Ireland grew between 1987 and 1997. This was carried out by a relatively small number of companies, many of which also own considerable business in the UK. The biggest player in cattle slaughter has an estimated 22 % of the total Irish kill and is also a substantial player in the UK.

There is a small number of major companies operating in cattle slaughter, where there is over-capacity. This has been influenced by a decline in cattle numbers and the gradual removal of intervention as a major market. In 1998, Forbairt, an Irish Government development agency, sponsored a rationalisation scheme. This was essentially an industry funded buy out scheme. By 1999 it had not resulted in any major re-structuring, reportedly due to a lack of interest from the industry in the amount of compensation that was being offered to reduce slaughter capacity.

One company in particular has a large interest in the Irish pig industry, controlling about 42 % of slaughter.

Italy

In the last twenty years there has been a gradual decrease in red meat slaughterhouses in Italy [161, Italy, 2001]. The slaughter industry is highly fragmented, particularly for pigs. In cattle slaughter, five groups account for about 39 % of the national total. The five leading pig slaughtering companies account for only 16 % of the national kill. None of these slaughter more than 500000 pigs a year.

All Italian pig slaughterhouses over the IPPC threshold kill pigs for typical Italian cured products, such as ham and salami. Only pigs with an average live weight higher than 160 kg and a minimum carcase weight of about 130 kg are killed. The main difference between Italian pig slaughterhouses and others is that all the carcasses are split to portions of maximum weight 15 kg, before cooling or chilling. [331, Italy, 2003]

Netherlands

In 1987, the Netherlands had the third highest pig kill in the EU, after Germany and France. In the early 1990s measures were introduced to reduce the number of pigs held, because of environmental concerns, but then in 1997, a swine fever epidemic led to the destruction of millions of animals. Pig slaughtering has, therefore, been cut significantly and this has in turn led to a reduction in the number of companies slaughtering pigs. In 1987, the number of slaughterhouses slaughtering more than 25000 pigs annually was 55. By 1997, this had fallen by half to 27. Since then it has dropped even further due to the slaughter capacity being concentrated in fewer and larger plants [240, The Netherlands, 2002].

By 1995, the problems of over-capacity in cattle and pig meat slaughter led to efforts, on behalf of the industry, for rationalisation by closing plant capacity. By 1997, it was estimated that 15 % of the capacity from the Dutch slaughter/processing industry, had been removed. At the same time two co-operatives in the meat industry were merged to form a new farmers company. This new company is a slaughtering, trading and meat processing business. It produces 650000 tonnes of pig meat each year from 6–7 million pigs, equivalent to 40 % of the Dutch kill and 35000 tonnes of cattle.

It is anticipated that the production of pigs, poultry and cattle may fall even further over the coming years due to a programme by the Dutch agriculture ministry to tackle phosphate pollution from the farming industry [170, ENDS Daily, 2001].

Austria

The biggest Austrian slaughter group slaughters 500000 pigs and 85000 head of cattle a year. Three companies process nearly 20 % of all Austrian meat products.

130 out of the 4900 cattle, pig and small ruminant slaughterhouses are EU approved. Slaughterhouses that are not EU approved operate under the "Kleinbetrieb Regelung", i.e. slaughtering up to 20 GB units a week. [348, Austrian TWG member, 2003]

UK

In Great Britain, between the years 1987/1988 and 1998/1999 the numbers of slaughterhouses decreased from 919 to 416. Over the same period the market share of slaughterhouses killing over 50000 GB cattle units per year increased from 59 % to 78 % and those killing more than 100000 rose from 30 % to 56 %. Concentration has increasingly taken place, especially in pig slaughtering, but also to a lesser extent in sheep slaughtering and less still in cattle slaughtering.

EU funding of red meat slaughterhouses in the late 1970s and early 1980s contributed to overcapacity. Low profit margins then led to cheap sales, resulting in low cost takeovers and mergers, many of which involved investment from Ireland. Capacity has to some extent been restricted as a consequence of new temperature requirements for fresh meat, which require filled refrigeration space and increased regulatory inspection, which has slowed down slaughter line speeds.

Conglomerates of medium sized slaughterhouses have been replaced by groups controlling large slaughterhouses, which are closely controlled by the main customers, i.e. supermarkets. Many of the top ten plants have also been investing in integrated slaughter, cutting, deboning and in some cases further processing plants.

Finland

Most of the large slaughterhouses in Finland are privately owned, although 77 % of pig slaughter and 65 % of cattle slaughter is carried out by co-operatives. Sheep slaughter is limited in Finland and is always done on the same slaughter lines as cattle. [134, Nordic States, 2001]

There are 10 slaughterhouses in Finland with a carcase production capacity greater than 50 tonnes per day. Together these slaughter about 83 % of the total in Finland. There are also a number of smaller slaughterhouses. The processes and the type of animals being slaughtered vary a lot. The main animals slaughtered are pigs, cattle, chicken, and turkeys. [148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001]

Sweden

One Swedish co-operative group dominates both the cattle and pig slaughter industries, accounting for 76 % of the country's cattle throughput and 79 % of the pig throughput. It is the EU's ninth largest cattle slaughter group and its seventh largest pig slaughter group. There is a slight trend towards private slaughterhouses and away from co-operatives [134, Nordic States, 2001].

Generally Swedish poultry slaughterhouses are privately owned. Their total production is 65 million chickens per year, 99 % of which are slaughtered by companies belonging to one organisation [134, Nordic States, 2001].

Norway

In Norway there is a low animal density, so most of the slaughterhouses are small compared to other countries. The supply market is divided between one producer owned company and a number of private slaughterhouse companies. The producer owned company owns a number of subsidiary slaughter companies, which together slaughter about 75 % of the total. The low

animal density also means that very few of the 55 or so slaughterhouses slaughter only a single species. [134, Nordie States, 2001]

The numbers of slaughterhouses, the numbers of animals slaughtered, the average live weights and average carcass weights for the MSs and some PACs are summarised in Table.

Country	Species	No of slaughterhouses	No of animals slaughtered each year	Average live-weight (kg)	Average carcass weight (kg)
Belgium [127, MLC Economics, 1999, 136, Derden A, 2001, 242, Belgium, 2002, 346, Belgian TWG member, 2003]	Cattle	48	923000	670	410
	Sheep		203000	42	21
	Pigs	62	11531000	120	93
	Poultry	42	276520055	2.15	1.4
Denmark [132, Thy-Christensen, 2001, 134, Nordie States, 2001]	Cattle	13	650000	450	250
	Sheep	1	74000		33
	Lambs				21
	Pigs	24	21000000	100	77
	Chickens	6	136600000	1.8	(chicken + giblets) 1.4
	Turkeys	1	1000000		9.9
	Ducks		1750000		
Germany [127, MLC Economics, 1999, 163, German TWG Members, 2001]	Cattle		4611000		321
	Sheep		2151000		20
	Pigs		41352000		92
Greece [127, MLC Economics, 1999]	Cattle		307000		
	Sheep		11993000		
	Pigs		2241000		
Spain [69, AINIA, 2000, 70, AINIA, 2000, 127, MLC Economics, 1999, 271, Casanellas J., 2002]	Cattle	128 (production cap > 50 t)	2464000		
	Sheep	included in cattle	21963000		
	Pigs	included in cattle	33428000		85
France [127, MLC Economics, 1999]	Cattle		5842000		
	Sheep		8639000		
	Pigs		26567000		
Luxembourg [127, MLC Economics, 1999]	Cattle		24000		
	Pigs		129000		
Netherlands [127, MLC Economics, 1999]	Cattle		2412000		
	Sheep		650000		
	Pigs		19277000		
Austria [348, Austrian TWG member, 2003]	Cattle		598445	638	339
	Sheep		83808	49	23
	Pigs		5274285	118	95
Portugal [127, MLC Economics, 1999]	Cattle		382000		
	Sheep		1271000		
	Pigs		4954000		
Ireland [127, MLC Economics, 1999, 215, Durkan J., 2001]	Cattle		1906000	330	
	Sheep		4067000		
	Pigs		3339000		
Italy [127, MLC Economics, 1999, 137, Leoni C., 2001, 248, Sorlini G., 2002]	Cattle		4416000		270
	Sheep		7806000		
	Pigs		12920465	143	130
Finland [127, MLC Economics, 1999, 134, Nordie States, 2001, 148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001]	Cattle	5	103000	470	260
	Sheep and goats		61000		16
	Pigs	3	756000	100	82
	Mixed species (named)	10	Cattle 270000 Pigs 1390000		255
	Chickens	4	43800000	1.9	1.4

Country	Species	No of slaughterhouses	No of animals slaughtered each year	Average live weight (kg)	Average carcass weight (kg)
Sweden [134, Nordic States, 2001]	Cattle	15	518000	530	290
	Sheep	10	187000		sheep 25
	Lambs				lambs 19
	Pigs	16	3900000	110	84
	Chickens	6	69300000	1.8	1.3
	Turkeys		200000	15	
	Ducks		57000		
	Geese		30000		
United Kingdom [12, WS Atkins EA, 2000, 67, WS Atkins Environment/EA, 2000, 127, MLC Economics, 1999]	Cattle	376	2329000		(England and Wales) 263
	Sheep	included in cattle	18698000		(England and Wales) 18
	Pigs	included in cattle	16282000		(England and Wales) 51
	Mixed species	included in cattle			
	Chickens	130	(England and Wales) 78000000		4
	Turkeys	included in chickens	(England and Wales) 24000000		5
Norway [134, Nordic States, 2001]	Cattle	55	353725		cattle 263 calves 81
	Sheep	included in cattle	1156065		18
	Pigs	included in cattle	1324571		80
	Mixed species	included in cattle			
Slovenia [143, Skodlar M., 2001]	Cattle	5	127128	484	261
	Sheep				
	Pigs				
	Mixed species	5	500000	104	82
	Chickens	2	21000000	2	1.5
	Turkeys	1	90000		
Czech Republic					
Hungary					
Malta					
Latvia [312, Latvia TWG, 2002]	Cattle		46248	300	140
	Sheep/goats		953	50	25
	Pigs		211211	100	60
	Horses		144		
	Rabbits		399		
	Poultry		3101222	2	1.2
	"Cattle" includes calves where calves are not reported separately "Sheep" includes goats where goats are not reported separately "Chickens" includes hens				

Table: Numbers of slaughterhouses, animals slaughtered and associated live/carcass weights in Europe (Sources listed in column 1)

Trends which may influence future resources in the slaughtering industry

The following view is a summary of information reported by the Nordic countries [134, Nordic States, 2001].

Main tendencies

There are some clear general tendencies, which may influence the future consumption of resources in the slaughtering industry. These are: the trend for larger and larger units; the

increasing demand for better food safety; the increasing focus on animal welfare; the growing requirements for good eating quality; the need to improve the working environment and the increasing level of processing required to produce ready-to-eat food.

Larger installations

Production is progressively being concentrated in fewer and larger plants. For individual plants, the larger units might, in theory, be expected to result in lower consumption per unit. However, in practice this is not the case. An analysis of the Norwegian and Danish meat and poultry slaughter plants has shown no significant difference between large and small plants. It is claimed that it is easier and cheaper, per unit, to solve environmental problems by odour abatement and waste water cleaning at large plants. There are some notable exceptions to this trend, towards larger plants e.g. in Austria the trend has been towards smaller slaughterhouses, due to stricter animal transport regulations and consumer pressure [348, Austrian TWG member, 2003].

Food safety

The occurrence of *Salmonella*, including the multiresistant strain DT 104; *Listeria*; VTEC (0157) and other microbiological contaminants in meat products, plus the BSE crisis, have created a strong focus on food safety. This has led to increased hygiene requirements at slaughterhouses and as a consequence a higher intensity of cleaning and sterilisation operations. This in turn leads to an increased consumption of water and energy. Increasing quantities of water at 82 °C are now consumed for the sterilisation of knives and other tools. Showering cabinets are now available for showering pig or cattle carcasses with hot water, typically using 40 litres per pig carcass. An increased use of such systems could result in a significant increase in water and energy consumption. Cleaning chemicals are also used in greater amounts [237, Italy, 2002, 240, The Netherlands, 2002].

Lower temperatures may be demanded where meat is handled and a safer and more effective cool chain from the slaughterhouse to the consumer may be required. All this could increase energy consumption. Increased hygiene requirements may also result in increased packaging and even new types of packaging [241, UK, 2002].

Prohibiting the feeding of “processed animal proteins” to farmed animals, i.e. those kept fattened or bred for the production of food, due to the BSE crisis has changed the concept of what is waste and what may have a further use. This may change further, in the future.

Animal welfare/ethics

Animal welfare issues influence stunning methods. Examination of the safety and ethics of feeding animal by products to animals has led to a reduction in the use of animal by products in animal feed and an increase in the amounts disposed of as waste.

Eating quality

The growing requirement for good eating quality is receiving increasing attention. In pig slaughter, for example, careful control of carcass chilling processes can improve the tenderness of meat. To decrease the frequency of PSE, it is important to chill warm pig carcasses as soon as possible after slaughter. It has been reported that the reduction of water consumption on the slaughter line, e.g. in de-hairing machines, after singeing and in scraping/polishing machines, has slowed down the temperature decrease in the carcasses on the slaughter line. It has, therefore, been suggested that carcasses should be showered with a large volume of cold water before being opened.

Working environment

To preserve the health of the employees and to attract sufficient good labour to the industry, it is necessary to avoid heavy lifting, repetitive working operations and arduous operations. This is leading to the automation of some tasks. If there is a lack of available labour, this will also speed up the introduction of automation. Automated equipment requires energy for its operation and in, e.g. Italy, there is a requirement for cleaning and sterilisation between each carcass, if the meat is destined for export to the US [237, Italy, 2002]. In any case the equipment must be

cleaned and sterilised several times a day and always at the end of each working day [99, EC, 1964] as a minimum, although it is actually recommended between each carcase. Efficient washing and sterilisation require training [241, UK, 2002], supervision and the maintenance of equipment [241, UK, 2002], as well as the use of considerable quantities of both cold and 82 °C water.

Improved lighting and ventilation in working areas also consumes energy. In many cases, the environment in the lairage will often have to be improved for both the staff and the animals by, e.g. increased ventilation to remove dust, and by the showering of pigs.

Processing

The degree of processing of meat products is increasing at the moment, due to the demand for products which can be prepared quickly and simply. This means that meat processors now carry out a higher level of processing and packaging, usually combined with chilling and freezing. Processing and packaging are not within the scope of this document, but they will be associated activities on many slaughterhouse sites.

Other considerations

The best possible utilisation of gut sets from pigs (those from ruminants are SRM), may be in conflict with the wish to reduce water consumption and pollution. There is a tendency not to clean intestines, or parts of the gut sets, if a reduction in water usage or pollution of the waste water is required. The cooling of blood for rendering is becoming more common and the cooling of other raw materials for rendering, e.g. those from the slaughter line, is being discussed. This demands a considerable amount of energy, but does provide other advantages, such as better products and less air and water pollution.

Changes in the EU agricultural support scheme could result in changes in capital availability/profitability in the meat industry. When there is only a limited amount of money available for capital investments, it has been forecast that there would be a tendency for it to be used for production improvements, rather than for environmental purposes, even when the latter have a short repayment period. It has also been anticipated that investments in environmental improvements will probably, to an increasing extent, be for odour and noise abatement, due to local community pressures. It is perceived that reducing odour problems leads to increases in energy consumption, e.g. to overcome the pressure drop in ducts, chimneys and filters and to move large volumes of air. Many cleaning systems also require the use of water and chemicals.

Technical characteristics of slaughterhouses

Large animal slaughterhouses can, in general, be classified into two groups. The first group carries out slaughterhouse operations only, i.e. they slaughter, dress and chill carcasses for sale to wholesalers. The second group does the same operations, but also operates cutting plants to produce specific meat cuts and portions, both on and off the bone. These are then packed as chilled or frozen meat for sale to wholesalers and retailers [57, DoE, 1993], or sent to processing plants [331, Italy, 2003]. Most poultry processors carry out slaughtering, cutting and portioning at the same site. There is a trend for slaughterhouses to expand to produce value-added products, such as diced meat and mince and to diversify into further processing. This requires large investments, which often only the bigger, multinational companies can make. [127, MLC Economics, 1999]. Concentration of the industry into fewer larger units may, therefore, further increase.

Where downstream activities and/or disposal or recycling of animal by products take place on the same premises as slaughtering, it will be possible to consider opportunities to reduce consumption and emission levels on the integrated site as a whole. This may require other BREFs in the IPPC series to be taken into account when determining BAT-based conditions for IPPC permits.

Many process lines are automated. Throughputs of, e.g. 80 cattle, 350 sheep and 300 pigs per hour are not uncommon. [57, DoE, 1993]. The throughput at a typical cattle or pig slaughterhouse is relatively constant throughout the year. For sheep slaughter, June and December are normally busy periods. [12, WS Atkins EA, 2000]. Easter is a peak period for lamb slaughter due to Islamic traditions.

Poultry slaughter is very highly mechanised. Slaughtering rates of 100 birds per minute are common. Throughput is typically constant throughout the year [67, WS Atkins Environment/EA, 2000].

In general, the anticipated lifetime of a slaughterhouse plant is about 25–40 years. Slaughterhouses must meet the criteria and standards set down in Council Directive 64/433/EEC [99, EC, 1964], as amended. These include specifications for process plant design, building finishes [12, WS Atkins EA, 2000] and hygiene considerations.

WORKING DRAFT IN PROGRESS

3.2 General processes and techniques for slaughterhouses

3.2.1 Applied processes and techniques for slaughterhouses

Figure shows an example of the main uses of water in a pig slaughterhouse and the waste water pretreatments associated with various unit operations.

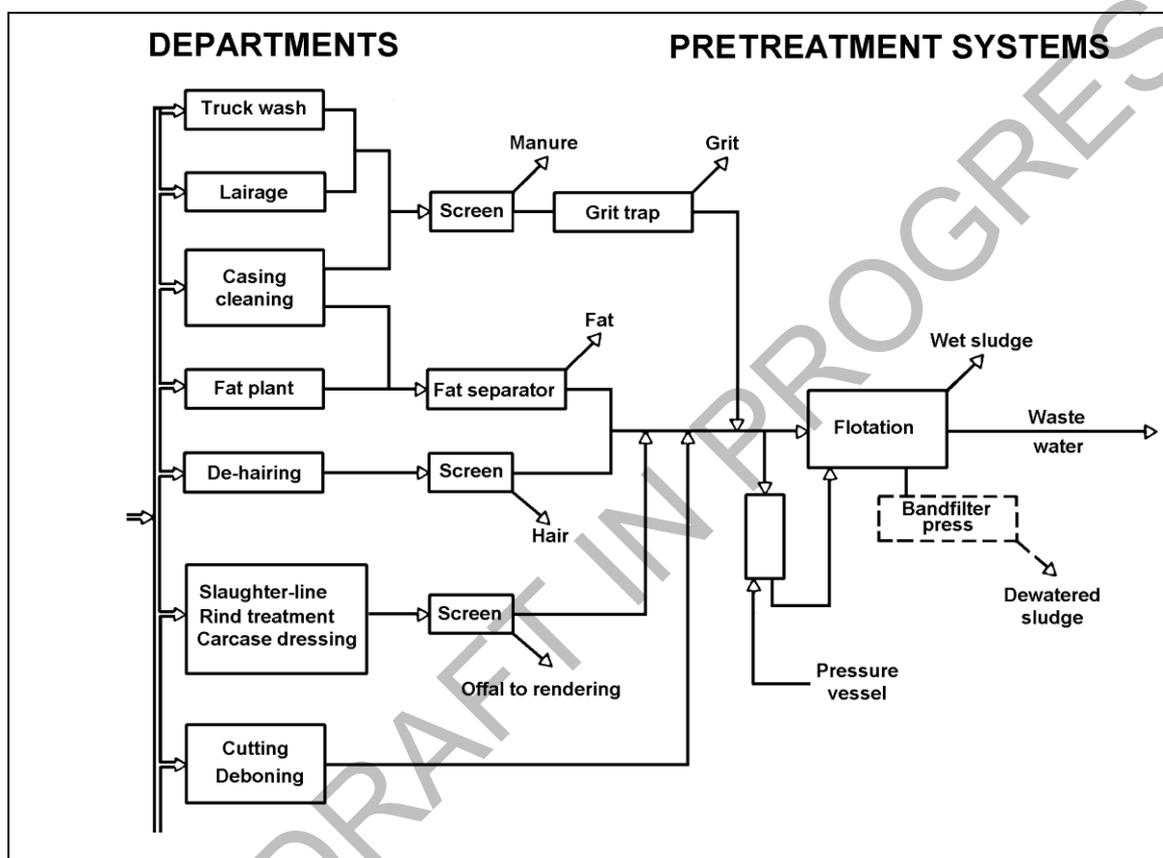


Figure : Waste water streams through a pig slaughterhouse
[134, Nordic States, 2001]

3.2.1.1 Chilling

The carcasses are chilled to reduce microbiological growth. To reduce the internal temperature to less than 7 °C, they are chilled in batch chillers with air temperatures between 0 °C and 4 °C. Typical chilling times are 24 – 48 hours for beef sides, 12 hours for lamb and 12 – 24 hours for pig carcasses. Pig carcasses can be chilled quickly in a chill tunnel for about 70 minutes at -20 °C, followed by temperature equalisation at about 5 °C for 16 hours. Alternatively, they may be batch chilled at -5 to -10 °C.

The carcasses may then be held in a chilled meat store to further condition the meat prior to despatch to cutting plants, wholesalers, or on to further processing. For cattle, the storage time varies depending on the degree of maturation required by the customer and may be up to 17 days.

The choice of cooling method has an impact on the hygienic quality. Product hygiene has an influence on how long the meat products can remain fresh and thus the distance the products can be exported (nationally, regionally or globally) [203, Denmark 2015].

Air-chilling is generally used where the carcasses are for sale fresh. Chilling can be carried out by batch in a chill room or by a continuous air blast method. Tests have shown that air-chilling can reduce the food contamination rate by up a third of that after immersion chilling. Immersion/spin chillers can be a big users of process water for chilling.

The need for carcasses to be showered prior to entering a chilling tunnel should be examined as not all slaughterhouses do it. Generally, following scalding, pig carcasses don't require further cleaning, although they are cooled with water after singeing.

If the carcasses need to be washed before chilling, it can be done with nozzles, rinsing the required areas only, i.e. the belly at the first skin incision, parts of the front legs and the neck. The water supply can be controlled to ensure that water flows, only when the carcasses are in the correct position in relation to the nozzles, or it can be controlled by handheld trigger-operated nozzles.

The washing of carcasses should not take place before they have been through the routine official veterinary inspection, because visible contamination may be washed away and make microbiological contamination difficult or impossible to detect.

Spin chillers have a higher water consumption than spray chillers. The cooling method is typically selected based on the products that one wants to produce; spray cooling is mostly used for fresh products, while spin chillers are used for frozen products [203, Denmark 2015].

Description of refrigeration technology [292, ETSU, 2000]

The refrigeration systems use a refrigerant to transfer heat from the carcasses to be cooled to ambient air (or sometimes water in the case of poultry). A simple refrigeration system comprises the following elements and is depicted in Figure 3.1:

- an evaporator, in which the refrigerant boils (or evaporates) at a temperature lower than the product by absorbing heat from the carcasses or standard cuts
- a compressor, which compresses the gas generated in the evaporator
- a condenser, in which the high pressure gas pumped by the compressor is liquefied (or condensed). During this process the refrigerant emits heat, usually to ambient air or water
- an expansion device, which reduces the pressure of the condensed liquid back down to the pressure of the evaporator
- a set of controls, such as a thermostat that switches the refrigeration system off when the required temperature has been reached, and switches the system on again when the product has reached its upper temperature limit. The differential between off and on must not be so low as to cycle the refrigeration compressor rapidly
- a high pressure cut off switch, which turns the compressor off when the pressure on the high pressure side of the system rises too high and a low pressure cut out, which shuts off the compressor if the suction pressure drops below a set limit (for example, due to loss of refrigerant from the system)
- compressor motor protection devices, which switch off the compressor if the electrical current rises too high.

The amount of heat a refrigeration system removes is measured in watts (W). The heat extraction rate will depend on the size of the system and the conditions under which it is operating.

To drive the system, energy, usually in the form of electrical power, has to be put in to the compressor's motor and to other motors for pumps, fans, etc. This is also measured in watts. The system is operating at optimum efficiency when the minimum input power achieves the maximum heat extraction. The expression used to describe the efficiency of a refrigeration system is the COSP (coefficient of system performance).

$$\text{COSP} = \frac{\text{Refrigeration capacity (watts)}}{\text{Total system power input (watts)}}$$

The COSP should not be confused with the commonly quoted COP (coefficient of performance), which relates to the power consumed by the compressor alone.

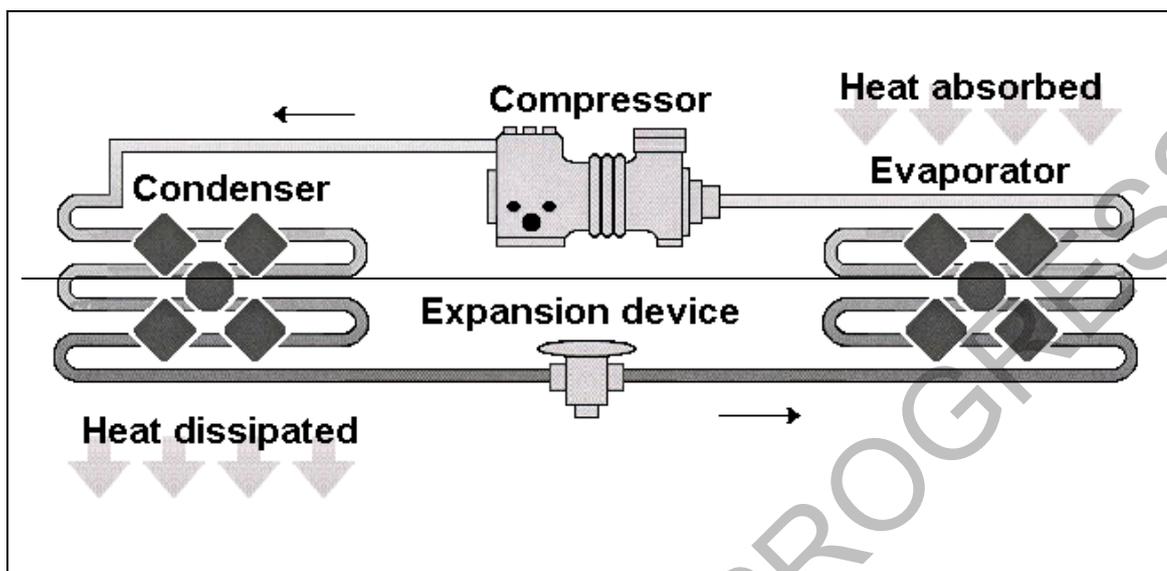


Figure: Schematic diagram of a simple refrigeration system

Refrigerants commonly used include ammonia; ethylene glycol and water; R404 and R22 (an HCFC). The refrigeration condensers may be water-cooled or air-cooled. Some slaughterhouse refrigeration units include heat recovery equipment to capture waste heat in the form of usable hot water.

Associated downstream activities – viscera and hide and skin treatments

3.2.1.2 Viscera Casings and offal treatment

The use of casings varies from country to country. Parts of cattle and sheep intestines are SRM [113, EC, 2000] [32, COM 2000] and these currently cannot be used for sausage casings. Pigs produce about 19 metres of intestine, which can be used for sausage casings. In Denmark, a large proportion of the intestines are used for edible products. In Norway, intestines are rendered.

If the intestines are destined for food use, after veterinary approval, the pancreas gland is cut off the intestine set. The intestine set is then conveyed to the casing cleaning area. It is then separated into the following parts: stomach, fat end (rectum), small intestine (duodenum, jejunum), large intestine (colon) and “blind” intestine (caecum). These are then cleaned and may be salted at the slaughterhouse or off-site.

If the intestines are to be rendered, the contents may be removed first, by, e.g. cutting followed by centrifugation. [134, Nordic States, 2001] [38, Nordic 2001]

The mucose membrane of the small intestine of pigs can be used for the pharmaceutical industry or in biogas production. [134, Nordic States, 2001] [38, Nordic 2001]

3.2.1.3 Composting**Raw materials**

By-products from slaughterhouses, e.g. lairage bedding, manure, stomach contents, intestinal contents, blood and feathers; from waste water treatment, e.g. screenings, flotation tailings and sludge; solid residues from biogas production; sludge from blood processing and sludge from WWTPs, can all be used in composting.

It has been reported that with the exception of manure from delivery vehicles and lairage no single material from a slaughterhouse fulfils the necessary conditions for optimum composting. Rumen and stomach contents contain vegetable structural materials, but have high water contents. Flotation tailings and fat from grease traps contain no structural substances. Composting is possible, e.g. after mechanical phase separation, or after mixing moisture sorbing and structural components with liquid or pasty sludges. [206, Tritt W. P. and Schuchardt F., 1992] [83, Tritt W. P. and Schuchardt F. 1992]. Composting is carried out using the rumen contents and sludge from slaughtering from at least one Italian slaughterhouse, [248, Sorlini G., 2002] [112, Sorlini G. 2002]. Although blood is liquid, when combined with, e.g. paunch, it can be pumped and composted in windrows. Other liquids, such as pig slurry, are also mixed with “dry” materials such as the sludge from WWTPs, for composting.

Fresh and anaerobically pretreated rumen or pig stomach contents dried to a dry matter content of $\geq 20\%$ can be composted without additives, with a bed depth of 1 m. For greater bed depths, the dry matter should be at least 22%. Anaerobic pretreatment can reduce the reaction time from 6 to 4 weeks. If strongly dehydrating machines, such as screw presses, are used to increase the dry matter to $\geq 35\%$, undehydrated flotation tailings and/or fat from the grease trap can be added. Experiments with dehydrated rumen content and flotation tailings, with dry matter contents of 37.6% and 8.8% respectively, have shown that compost can be prepared in 6 - 8 weeks. During composting the temperature reaches 70 °C, so decontamination is reportedly guaranteed [206, Tritt W. P. and Schuchardt F., 1992] [83, Tritt W. P. and Schuchardt F. 1992], although the pretreatment required under ABP Regulation 1774/2002/EC should control this.

Composting the solid residues from biogas production can minimise the requirement for capturing and treating the outlet air to remove odours given off as a result of the open handling of by-products and composting. If the biogas production is accompanied by a mechanical separation, e.g. pressing, then there are reported advantages of mass and volume reduction in the biogas plant. It has been reported that, taking into account the costs for disposal of solid slaughterhouse waste, the economic viability of an anaerobic plant in connection with composting could be easily achieved, even without the marketing of the composted material. [206, Tritt W. P. and Schuchardt F., 1992] [83, Tritt W. P. and Schuchardt F. 1992]

Receipt and storage

Odour problems may arise from the composting feedstock.

Process

The most important composting condition is that the raw materials should be appropriately mixed to provide the nutrients needed for microbial growth and activity, which includes a balanced supply of carbon and nitrogen. There should be sufficient moisture to permit biological activity without hindering aeration; oxygen should be at levels that support aerobic organisms and temperatures should encourage active microbial activity from thermophilic micro-organisms. [210, Environment Agency, 2001] [87, Environment Agency 2001]

Raw materials mixed to provide a C:N ratio of 25:1 - 30:1 are generally accepted as ideal for active composting, although ratios from 20:1 up to 40:1 can give good composting results. Low C:N ratios of below 20:1 allow the carbon to be fully utilised but without stabilising the nitrogen, which may be lost as NH₃ or N₂O. This can cause odour problems. [210, Environment Agency, 2001] [87, Environment Agency 2001]

Windrows

A windrow is a long pile of composting materials, usually shaped as an elongated triangular prism [176, The Composting Association, 2001] [61, The Composting Association 2001].

Windrows are constructed on a hard standing and drainage is provided to collect any leachate. Wind and rain protection are also provided to minimise air and water entrainment. Water is added to the windrows as and when required for the composting process. Rows reduce by at least one third of their starting size, mainly due to water losses.

The material being composted is turned sufficiently frequently to ensure the maximum sanitation and degradation of the total material and to keep the process fully aerobic [148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001] [47, Finnish Environment Institute and Finnish Food and Drink Industries' Federation 2001].

The windrow composting process is summarised in Figure 3.1.

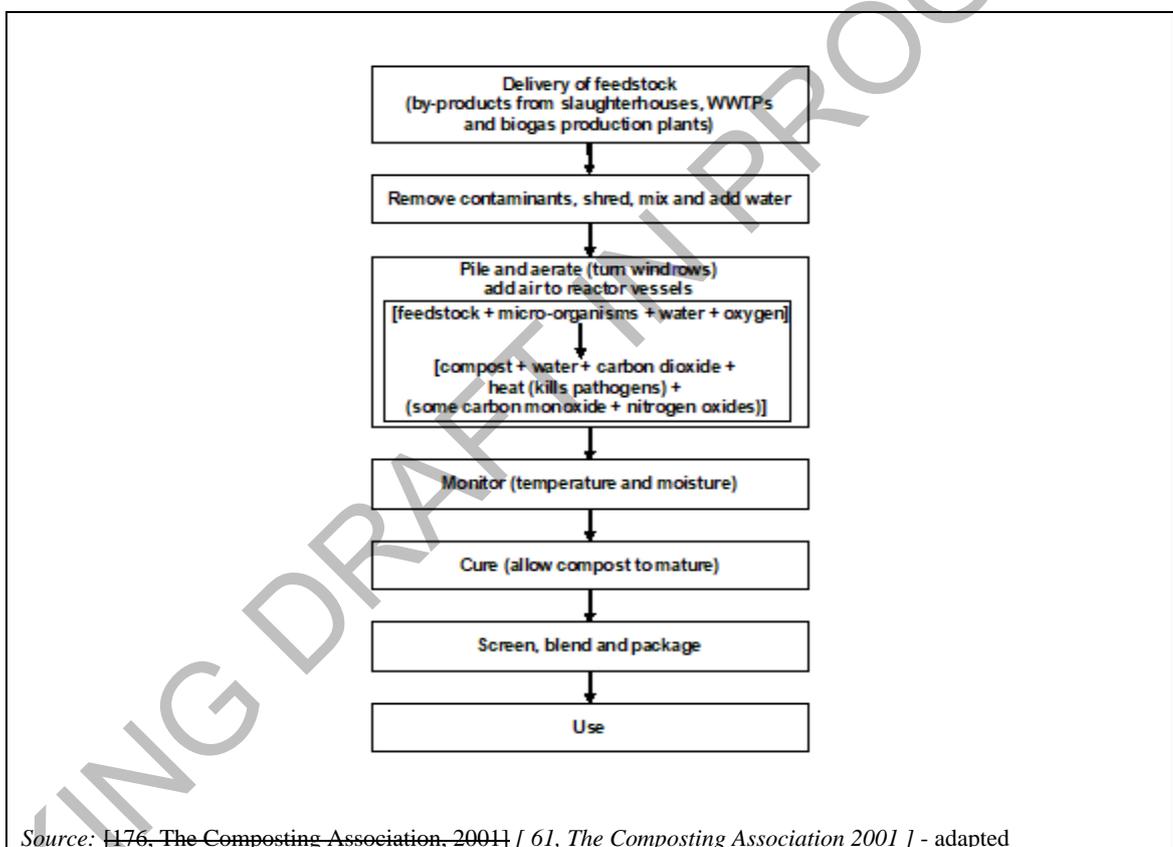


Figure 3.1: Flow chart showing the windrow composting process

In-vessel composting

In-vessel composting refers to a group of composting systems, such as bins or containers, agitated bays, silos, drums or tunnels and enclosed halls [210, Environment Agency, 2001] [87, Environment Agency 2001]. If composting is undertaken in reactors, the process, including the exchange of respiration gases and temperature, can be controlled better than if windrows are constructed. Consequently the starting materials can be decontaminated and the malodorous and ammonia-laden air can be captured and treated. [206, Tritt W. P. and Schuchardt F., 1992] [83, Tritt W. P. and Schuchardt F. 1992]. The ammonia-laden air is cooled to 38 - 45 °C, by taking more air in through a damper near the exhaust fan and then sending it to a biofilter, via a water scrubbing tower to remove dust. [209, The Composting Association, undated] [86, The Composting Association 2000]. For all year use of open systems, wind and rain protection are required. Regular turning is required during the high-temperature composting period, i.e. when

the temperature is $> 50\text{ }^{\circ}\text{C}$. [206, Tritt W. P. and Schuchardt F., 1992] [83, Tritt W. P. and Schuchardt F. 1992]. In any case, above $60\text{ }^{\circ}\text{C}$ the microbial activity appears to decrease. The principle of in-vessel systems is to supply air in such excess that it cools the compost, allowing much higher rates of microbial activity.

When supplied in high volumes, air can also help to maintain an open structure in the material. This stops the compost from compacting under its own weight and becoming anaerobic. The material being composted should be 20 % structural material to maintain the airflow through the compost mass.

A reactor vessel composting system is shown in Figure 3.2.

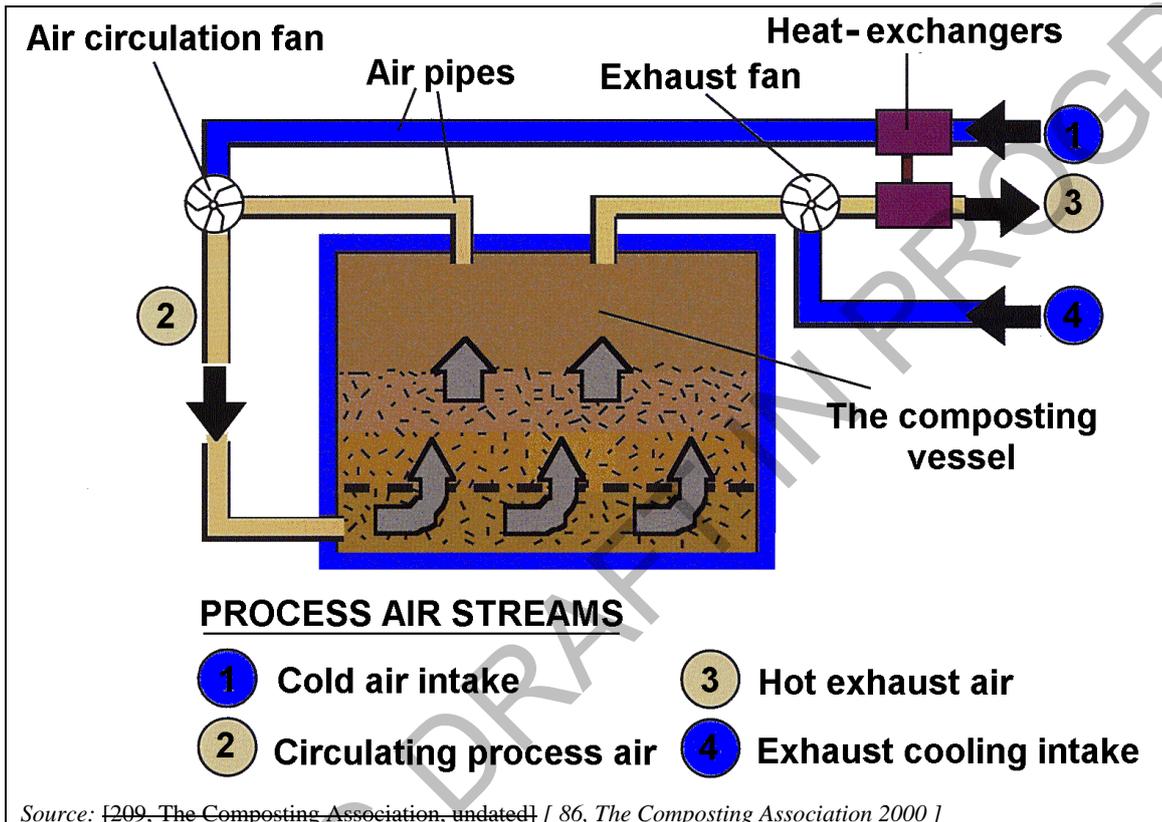


Figure 3.2: Diagram illustrating the in-vessel composting process

Maturation

This happens at mesophilic temperatures, i.e. within a range of $20 - 45\text{ }^{\circ}\text{C}$. The moisture evaporation, heat generation and oxygen consumption are all much lower than the active composting stage.

Product

Compost has been defined as *biodegradable municipal waste which has been aerobically processed to form a stable, granular material containing valuable organic matter and plant nutrients which, when applied to land, can improve the soil structure, enrich the nutrient content of the soil and enhance its biological activity.* [176, The Composting Association, 2001] [61, The Composting Association 2001]

It has been reported that until recently the potential benefits of composting animal by products have not been exploited, mostly due to a lack of knowledge about their compostability and the economic benefits of composting over some other uses and routes for disposal. It is possible that the composting of animal by products may increase in the future [206, Tritt W. P. and Schuchardt F., 1992]. On the other hand, the pretreatments required for certain by products,

before they can be composted and the restrictions on their use, which are required by ABP Regulation 1774/2002/EC, may limit any such expansion. ABP Regulation 1774/2002/EC bans the application of compost derived from animal by-products to pasture land [287, EC, 2002]. Opportunities remain for their use in landscaping, forestry, horticulture and land restoration [176, The Composting Association, 2001]. The growth or decline of the composting industry will depend, to some extent, on economic factors, such as the cost or profitability of alternative uses and disposal routes.

Germany

It has been reported that in 1986 rumen contents were composted by 9 slaughterhouses in the 11 Federal States of former West Germany [206, Tritt W. P. and Schuchardt F., 1992].

Finland

Composting is carried out in windrows or reactors. It is a common method for treating materials such as excrement and urine; the contents of stomachs and intestines and the solid products of waste water treatment, such as screenings, fat from grease traps, settlings, excess activated sludge and flotation tailings. The compost produced is then applied to land. [148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001]

Composting has been defined as *the controlled biological decomposition and stabilisation of organic substrates, under conditions that are predominately aerobic and that allow the development of thermophilic temperatures as a result of biologically produced heat. It results in a final product that has been sanitised and stabilised, is high in humic substances and can be beneficially applied to land.* [176, The Composting Association, 2001]. The composting of animal by-products and their application to land is controlled by ABP Regulation 1774/2002/EC and by Commission Regulation (EC) No 808/2003 of 12 May 2003 amending Regulation (EC) No 1774/2002 of the European Parliament and of the Council laying down health rules concerning animal by-products not intended for human consumption [356, EC, 2003]. Category 2 and Category 3 material may be composted, however, most Category 2 materials must be sterilised under specified temperature, time, pressure and size conditions first.

3.2.1.4 Storage of slaughterhouse by-products

The animal and public health rules laid down in ABP-Regulation EC No 1069/2009 (the Animal by-products Regulation) 1774/2002/EC cover, amongst other things, the storage of animal by-products.

Arrangements for the storage of animal by-products vary between premises. To some extent they depend on the nature and characteristics of the by-product and its intended use or disposal route. Generally, the storage of materials can be undertaken within an enclosed area, operated under negative pressure, provided with extractive ventilation connected to a suitable odour abatement plant. The decision whether to store by-products in such an enclosed and sometimes refrigerated space may depend on whether they are intended for sale or for disposal, at a cost. A major consideration in any case is whether unrefrigerated storage will result in odour problems. Some by-products, such as intestines are malodorous when fresh and others become so as they degrade. Malodorous materials can cause problems both during storage at slaughterhouses and during storage, handling, processing and disposal at animal by-products installations.

Some slaughterhouses store animal by-products in open containers in the open air and rely on frequent removal from the site, e.g. once or twice a day, to prevent odour problems from putrescible materials.

Some, but not all, slaughterhouses store blood and other non-process liquids, such as fuel oils, in double skinned tanks. Other hazardous substances commonly stored at slaughterhouses include cleaning and sanitising chemicals, effluent treatment chemicals, ethylene glycol, ammonia and other refrigerants. These may be stored in bulk storage tanks, IBCs, or dedicated drum storage areas.

There is a risk of spillage of these substances, especially during handing or transport around the site. Tanks and containers are often located in areas where there is a risk of them being damaged by moving vehicles [12, WS Atkins-EA, 2000] [4, WS Atkins-EA 2000]. In addition to the environmental risks, there are also health and safety risks associated, not only with the spillage of substances hazardous to health, but also from the vehicle/pedestrian interface. Management of site layout and use, in conjunction with hardware safeguards such as the provision of bunds and crash barriers around storage areas, can reduce the risk of accidents.

3.2.1.5 Level of process automation

During recent years there has been a technological development for meat processing but also for opening, evisceration and other slaughterhouse processes. Moreover, labour costs throughout Europe have led to varying degrees of implementation of the new equipment and the degree of automation of the slaughtering processes. Due to veterinarian and food safety requirements, the automated equipment must be sterilised by hot water between each unit operation. In turn, the degree of automation affects slaughterhouses' consumption of water and energy. Other important parameters for the degree of consumption of water and energy are the utilisation and handling of co-products and the number of work shifts before cleaning is important [202, Danish Technological Institute 2019].

In Denmark, slaughterhouses are generally divided into three categories, based on their level of process automation [203, Denmark 2015]. This categorisation is described in Table 3.1.

Table 3.1: Categorisation of slaughterhouses according to their process automation level

Type of slaughterhouse	Process automation level
Manual (traditional) type of slaughter - Small capacity	Manual slaughter with few or relatively simple tools. In Denmark, this is used only at the smallest slaughterhouses with an output of far less than 50 tonnes/day.
Mechanised slaughtering - Medium and high capacity	Slaughter with mechanical feeds and mechanised processes, particularly in connection with rind treatment of pigs. Mechanised slaughtering is typically used at medium-sized and large slaughterhouses - for example, Danish cattle slaughterhouses and smaller Danish pig slaughterhouses.
Automated slaughtering - High capacity	Slaughter with mechanical feeds and both mechanised and automated processes (robots). Mechanised and automated slaughtering are typically used in countries with high wages-costs and is only profitable to use in the largest slaughterhouses, for example: - Danish poultry slaughterhouses - Danish pig slaughterhouses

Source: [203, Denmark 2015]

Pig slaughterhouses in Germany present fully automated systems for bunging (removal of the anus), opening the complete carcass including breastbone, removing the toenails and splitting the carcass using fully automated saws or cleavers.

Due to their large hourly throughput, most poultry slaughter facilities in Germany use automated stunning and slaughtering systems [267, VDI 2020].

3.2.1.6 Antimicrobial resistance

Antimicrobials are medicines, mostly antibiotics, used to treat infections or disease in humans and animals. Antibiotics are active substances which impede the growth of and/or kill bacteria. With increasing antimicrobial use, antimicrobial resistance (AMR) has emerged. AMR is internationally recognised as a major societal challenge. It has been identified as a strategic risk facing the EU. It is one of the most serious problems facing modern healthcare delivery. If prudent use of existing antimicrobials and evidence-based infection prevention and control measures were universally implemented and assured, and if effective novel antimicrobials can be developed and swiftly brought to market, an AMR crisis might be averted [208, Ireland 2019].

Antibiotic-resistant bacteria (ARB) are considered to be bacteria which do not react especially sensitively to one antibiotic or several antibiotics, i.e. they are resistant to the impact of these substances. This means that their growth is no longer impeded by the antibiotic. Therefore, infections with such bacteria are more difficult to treat with the currently available antibiotics. The resistance of bacteria to antibiotics can be a naturally existing property or it can be a gained property. Bacteria can develop a resistance through mutation and through the transfer of genes from resistant bacteria. Documenting ARB in the environment occurs through the cultivation and characterisation of the bacteria [209, Germany 2018].

Antibiotic resistance genes are the area of genetic material (DNA) in which the capacity for antibiotic resistance is located. Documenting resistance genes in the environment occurs through molecular biological methods. When documenting resistance genes based on samples from the environment, it is not generally possible to determine whether they are resistance genes from environmental bacteria, pathogens or free DNA [209, Germany 2018].

Many of the antimicrobials used in the treatment of animals are the same drugs as those used in human medicine. A key area of concern is increasing AMR in a family of bacteria normally resident in the gut of humans and animals (*Enterobacteriaceae*). *Enterobacteriaceae* can be associated with some common and potentially serious infections such as cystitis and bloodstream infection. AMR in *Enterobacteriaceae* is severely limiting treatment options. No novel antimicrobial class effective against this family of bacteria has been brought to market in decades, although some enhancements of older antimicrobials have recently become available and may be valuable in some settings [208, Ireland 2019].

AMR is a growing worldwide concern – which incurs costs both financially and in mortality. It has been estimated that 671 689 infections with AMR bacteria in 2015 in the EU accounted for more than 30 000 deaths and 170 disability-adjusted life-years per 100 000 people (almost on a par with the combined estimate of influenza, tuberculosis and HIV). It is noteworthy that resistance of nearly all antimicrobials has been observed. AMR was named one of the three most important health threats of the 21st century by the World Health Organization in 2014 [250, Thornval 2019].

Of considerable clinical and publicly relevant importance in this respect are those ARB that have gained resistance, such as methicillin-resistant staphylococcus aureus (MRSA), extended spectrum β -lactamases (ESBL *E. coli*) or multi-resistant Gram-negative bacteria (MRGN). These develop especially in places where antibiotics are used because there they have a survival advantage. Hotspots for the occurrence of ARB therefore include hospitals and agricultural livestock keeping. From these hotspots, ARB are able to enter the environment via waste water or through the spreading of sewage sludge, slurry or fermentation residues [209, Germany 2018].

Further accumulation and spread of ARB can occur in the environment. With waste water, sewage sludge, slurry or fermentation residues from biogas plants, not only are ARB released into the environment, but also antibiotic substances, which exert a selection pressure on bacteria and are therefore able to foster the development of ARB. In this respect, even limited concentrations of antibiotic residues are sufficient to provide resistant bacteria in the

environment with a selection advantage compared to non-resistant bacteria. Additionally, the horizontal transfer of genes between bacteria species in waste water can be fostered by the high nutrient content and the high bacterial density in biofilms (a layer of mucus consisting of microorganisms which can also contain ARB and genes). In this respect, pathogens which were previously not resistant can also acquire resistance genes from bacteria [209, Germany 2018].

The technology used at municipal waste water treatment plants is not generally configured for eliminating micro-pollutants and therefore antibiotics. The processes for the reduction of antibiotic substances (e.g. low concentrations of ozone and activated carbon) are unable to effectively minimise bacteria (including ARB) in the waste water. If sewage sludge from waste water treatment plants is applied to soil, active substances can find their way onto fields and meadows [209, Germany 2018].

A considerable number of antibiotic substances have been found in slurry. In particular, the groups of tetracyclines, sulphonamides and trimethoprim are found in very high concentrations, sometimes of more than 100 mg/kg, especially in pig and poultry slurry, and, in individual cases, in cattle slurry as well [209, Germany 2018].

Slurry and fermentation residues also tend to be contaminated with ARB through excretions from animals that have been treated with antibiotics. It is therefore concerning that slurry and fermentation residues are not just contaminated with antibiotic mixtures, but also other pollutants such as zinc, copper and antimicrobial biocides which also support the formation of new combinations of these resistances in environmental bacteria [209, Germany 2018].

Guidelines for these measurements and analyses require urgent development so as to obtain harmonised results. The COD parameter serves the purpose of the documentation of the degradation efficiency and/or elimination performance of biological waste water treatment plants; with cumulative parameters, the AMR is not properly monitored [209, Germany 2018].

3.2.1.6.1 Methods for identifying AMR

According to the European Union Strategic Approach to Pharmaceuticals in the Environment (COM(2019) 128 final), the European Commission should ensure that the emission of pharmaceuticals to water is considered a possible KEI. This Strategic Approach is a component of the European One Health Action Plan against Antimicrobial Resistance (AMR) (COM/2017/0339 final), where there is a Commission commitment to support the development of technologies that enable efficient and rapid degradation of antimicrobials in waste water and the environment and reduce the spread of AMR. The European One Health Action Plan against AMR highlights the need for research into and the development of new tools for monitoring antimicrobials and microorganisms resistant to antimicrobials in the environment.

The traditional way of assaying AMR in bacteria is time-consuming and expensive per sample. This antimicrobial susceptibility testing (AST) is culture-based and requires a pure culture of the pathogen it is wished to identify. AST can be performed both phenotypically and genotypically. Phenotypic AST determines at which concentration of antibiotic the in vitro growth of bacteria is inhibited. As this method provides phenotypic resistance data, it can be beneficial in a clinical setting where an isolated strain can often be obtained. Genotypic AST must be validated by phenotypic ways in clinical settings, but by using molecular detection the resistance factors can be determined much faster. Usually, either amplification- or sequence-based methods are used to identify genetic mutations and/or resistance genes [250, Thornval 2019].

Current surveillance of AMR often focuses on a few pathogens only and mainly based on passive reporting of phenotypic laboratory results. Metagenomic techniques, using short-read next-generation sequencing data, benefit from the ability to quantify total AMR abundance, based on thousands of especially transmissible resistance genes in a single sample. Hendriksen

et al. proposed metagenomic analysis of waste water as an economically feasible approach for continuous global surveillance and prediction of AMR [251, Hendriksen et al. 2019].

A pilot study was conducted with the aim to find a protocol for DNA extraction of slaughterhouse waste water to use for metagenomic analysis to identify AMR determinants. This study applied the global sewage protocol proposed by [251, Hendriksen et al. 2019] and concluded that protocol to be a positive indication for monitoring AMR in waste water from slaughterhouses, although more research work is needed to validate that protocol [250, Thornval 2019].

3.2.2 Current consumption and emission levels across slaughterhouses

Before reporting the specific consumption and emission level data for the unit operations, some levels for the overall processes are reported here. The units used reflect the information made available and its purpose. The Directive refers to slaughterhouse production capacities in tonnes per day and animal by products installations with treatment capacities in tonnes per day. The average live and carcase weights reported from the various EU countries vary, as shown in Section.

Consumption and emission data has, to a large extent, been reported either per tonne of carcase produced or per tonne of by product treated. This reflects the terminology of the Directive and it makes it easy to compare information from different sources. The main driving force for using “per tonne of carcase produced” and “per tonne of by product treated”, is to closely examine the relationships between the actual processes and consumption and emission levels and to avoid misleading information based on, e.g. low concentrations, which are achieved by the overconsumption of water.

The actual consumption and emission levels reported in this chapter serve more than one purpose. Firstly, the ranges of levels for given processes and unit operations illustrate potential opportunities for improvement in environmental performance by those operating at the higher levels in the range. Secondly, the availability of data from unit operations also demonstrates that it is practicable to measure consumption and emission levels at that level. The information can also be used to identify priority unit operations which can be improved and to monitor the progress of improvements. The availability of data at unit operation level also makes it possible to compare techniques and determine BAT, for those parts of processes where consumption and emission levels are significant and alternatives are available.

Slaughterhouses – overall consumption and emission data at installation level

Analyses of data from Danish and Norwegian slaughterhouses examining the trend between the consumption of water and energy as a function of the total production of a plant have been undertaken. These compared levels either per tonne produced or per animal. They show a weak tendency towards a lower relative water and energy consumption as the plant size increases. A statistical analysis indicates a very large standard deviation, so only a subjective evaluation can be made. This shows that the relationship is not clear. [134, Nordie States, 2001]

Consumption and emission data for slaughterhouses are summarised in Table, Table, Table and Table.

All PER TONNE of CATTLE carcase	Water consumption (t)	Waste water (t)	Energy (TOTAL elec. + fuel) consumption (kWh)	Heat recovery (kWh)	BOD emission (kg)	COD emis. (kg)	Nitrogen emission (g)	Phosphorus emission (g)	Suspended solids emission (g)	Odour emission	Noise emission	Detergents (kg)	CO ₂ emission (kg)	SO ₂ emission (kg)	NO _x emission (kg)
	(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 27)	(6, 8, 9, 28)	(3, 4, 6, 12, 13)	(6)	(3, 4, 5, 12, 9, 11, 14)	(12, 9, 11, 14)	(4, 6, 12, 9, 14)	(3, 4, 6, 12, 9, 14)	(6, 14)	(5, 12)	(5, 12)	(12)	(12)	(12)	(12)
Unloading + vehicle wash	200–320				0.4					Yes	Yes				
Lairage	152–180				0.4–3.0			26.6–30.4		Yes	Yes				
Slaughter										Yes	Yes				
Bleeding										Yes					
Hide removal	5									Yes	Yes				
Head + hoof removal										Yes					
Evisceration										Yes					
Splitting					2.2						Yes				
Chilling											Yes				
Red and green offal treatment										Yes					
Intestine washing										Yes					
Tripe washing	500–2760									Yes					
Hide preservation/storage		≈5000													
Cleaning															
Air treatment															
Liquid effluent treatment															
Solid waste treatment															
Storage of by-product										Yes					
Total (including where individual data are not available)	1623–9000	1623–9000	90–1094	≤60	1.8–28	4–40	172–1840	24.8–260	11.2–15.9			≈0.2	0.12	75.6	0.16
Techniques which provide or derive benefit to or from other activities															

* per/day – irrespective of no. of hides **0.11 kg/t alkali, 0.03 kg/t acid, 0.04 kg/t disinfectant, 0.02 kg/t “post treatment”
 Ranges received – operating conditions, treatments and sampling methods neither described nor submitted
 References: (1) [12, WS Atkins EA, 2000]; (2) [63, ETBPP, 2000]; (3) [132, Thy Christensen, 2001]; (4) [134, Nordic States, 2001]; (5) [142, Derden A., 2001]; (6) [148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001]; (7) [163, German TWG Members, 2001]; (8) [215, Durkan J., 2001]; (9) [242, Belgium, 2002]; (10) [243, Clitravi – DMRI, 2002]; (11) [248, Sorlini G., 2002]; (12) [185, Pontoppidan O., 2001]; (13) [314, Viitasaari S., 2002]; (14) [315, Belgium, 2002]; (15) [316, Belgium, 2002]; (16) [317, Belgium, 2002]; (17) [318, Belgium, 2002]; (18) [319, Belgium, 2002]; (19) [320, Belgium, 2002]; (20) [321, Belgium, 2002]; (21) [322, Belgium, 2002]; (22) [323, Belgium, 2002]; (23) [324, Belgium, 2002]; (24) [325, Belgium, 2002]; (25) [326, Belgium, 2002]; (26) [327, Belgium, 2002]; (27) [346, Belgian TWG member, 2003]; (28) [353, Clitravi – DMRI, 2003]

Table : Consumption and emission data for cattle slaughter

All PER TONNE of PIG carcase	Water consumption (t)	Waste-water (t)	Energy (TOTAL electricity + fuel) consumption (kWh)	Heat recovery (kWh)	BOD emission (kg)	COD emission (kg)	Nitrogen emission (g)	Phosphorus emission (g)	Suspended solids emission (kg)	Odour emis.	Noise emis.	Detergents emission (kg)	CO ₂ (kg)		SO ₂ emis. (g)	NO _x (g)	Ammonia (kg)
													Stunning + dry ice (cooling)	Other (not stunning + dry ice)			
	(1, 2, 3, 4, 15, 16, 5, 6, 7, 17, 18, 9, 19)	(6, 7, 18, 9, 28)	(3, 4, 6, 17, 18, 9, 13)		(3, 4, 5, 17, 9, 14)	(7, 9, 14)	(3, 4, 6, 9, 14)	(3, 4, 6, 18, 9, 20, 14)	(6, 14)	(5, 18)	(5, 18)	(17)	(3, 4, 17)	(17, 18)	(17)	(17)	(17, 18)
Unloading + vehicle wash	78-290				0.3					Yes	Yes						
Lairage	130-300									Yes	Yes						0.01
Slaughter	10-50									Yes	Yes		1.3-2.9				
Bleeding	30-40				0.3					Yes	Yes						
Skin removal	520-1750									Yes							
Sealding	150-156		17-39		0.23- 0.26						Yes						
Hair + toenail removal	78-120				0.91-2.2					Yes	Yes						
Singeing	162-208		47-182	175						Yes	Yes			6-8			
Rind treatment	260-460				1.25- 2.21					Yes	Yes						
Evisceration										Yes							
Splitting				55	5.5					Yes	Yes						
Chilling	0-226										Yes						Yes
Red and green offal treatment											Yes						
Intestine washing	442-680	220-540			0.98-3.25	1.41-3.04				Yes							
Cleaning	325									Yes							
Air treatment																	
Liquid effluent treatment														5-6			Yes
Solid waste treatment																	
Storage of by-product													1.7				
Total (including where individual data are not available)	1600-8300	1600-6000	110-760		2.14-10	3.22-10	180- 2100	20-233	0.12-5.1	Yes	Yes	0.81	4.6-10	0.25	112	0.26	0.03-0.04
Techniques which provide or derive benefit to or from other activities																	

Ranges received—operating conditions, treatments and sampling methods neither described nor submitted
References: (1) [12, WS Atkins EA, 2000]; (2) [63, ETBPP, 2000]; (3) [132, Thy Christensen, 2001]; (4) [134, Nordic States, 2001]; (5) [142, Derden A., 2001];
(6) [148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001]; (7) [163, German TWG Members, 2001]; (9) [242, Belgium, 2002];
(13) [314, Viitasaari S., 2002]; (14) [315, Belgium, 2002]; (15) [136, Derden A., 2001]; (16) [137, Leoni C., 2001]; (17) [182, Pontoppidan O., 2001]; (18) [237, Italy, 2002];
(19); [322, Finnish TWG, 2002] (20) [274, Pontoppidan O., 2002], (28) [353, Clittravi—DMRI, 2003]

Table : Consumption and emission data for pig slaughter

Chapter 3

All PER TONNE of SHEEP carcase	Water consumption (t) (2, 4)	Waste water (t) (28)	Energy consumption (kWh) (4)	Heat recovery (kWh) (4)	BOD emission (kg) (4)	COD emission (kg) (4)	Nitrogen emission (g) (4)	Phosphorus emission (g) (4)	Suspended solids (g)	Odour emission	Noise emission	Detergents	CO ₂ emis. (kg)	SO ₂ emis. (kg)	NO _x emis. (kg)	Salt consumption (kg) (4)	Salt waste (kg) (4)
Unloading + vehicle wash																	
Lairage																	
Slaughter																	
Bleeding																	
Skin removal																	
Head udder + hoof removal																	
Evisceration			4-7		0.44												
Splitting																	
Chilling																	
Red and green offal treatment	1667																
Intestine washing																	
Skin preservation	278				0.33											94	39
Cleaning																	
Air treatment																	
Liquid effluent treatment																	
Solid waste treatment																	
Storage of by-product																	
Total (including where individual data are not available)	5556-8333	5556-8333	922-1839	0	8.89		1556	500									
Techniques which provide or derive benefit to or from other activities																	

Ranges received – operating conditions, treatments and sampling methods neither described nor submitted

References: (2) [63, ETBPP, 2000]; (4) [134, Nordic States, 2001], (28) [353, Clitravi – DMRI, 2003]

Table : Consumption and emission data for sheep slaughter

All PER TONNE of POULTRY carcase	Water consumption (t)	Waste water (t)	Energy (TOTAL elec. + fuel) consumption (kWh)	Heat recovery (kWh)	BOD emission (kg)	COD emis. (kg)	Nitrogen emission (g)	Phosphorus emission (g)	Suspended solids emission (g)	Odour emis.	Noise emis. (d(B)A) (at source)	Detergent	CO ₂ emis. (kg)	SO ₂ emis. (kg)	NO _x emis. (kg)	Solid waste emis. (kg)	By-product emis. (kg)	Wax
	(3, 4, 6, 21, 22, 9)	(6, 9, 28)	(3, 4, 6, 21, 22, 13)	(6)	(4, 21, 22, 9, 14)	(22, 9, 14)	(4, 6, 21, 22, 9, 14)	(4, 6, 21, 22, 9, 14)	(6, 22, 14)	(21)	(21, 22)					(22)	(22)	
Unloading + Vehicle/crate wash	19-3786									Yes	99							
Lairage	0-1039		5.4							Yes	91							
Stunning	0-22.8		1.1															
Bleeding	0		0.1								84					38.3		
Scalding	276-1000		34							Yes	93							
De-feathering	90-1429		7.5							Yes	93					52		
Evisceration	1300-2100		15								91					141	85	
Chilling	714-1700		20					15.1	157									
Cleaning	1973-2600		39															
Air treatment																		
Liquid effluent treatment	132		14		15.3	23.6		202	60.4	Yes	93							
Solid waste disposal or treatment																5.5		
Storage of by-product	1100																	
Utilities – please state																		
Maturation	1540		16			0.74		4.1	48									85
Total (including where individual data are not available)	5070-67400	5070-67400	152-860	≤ 220	2.43-43	4-41	560-4652	26.2-700	48-700									
Techniques which provide or derive benefit to or from other activities																		

Ranges received – operating conditions, treatments and sampling methods neither described nor submitted
References: (3) [132, Thy Christensen, 2001]; (4) [134, Nordic States, 2001]; (6) [148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001]; (9) [242, Belgium, 2002]; (13) [314, Viitasari S., 2002]; (14) [315, Belgium, 2002]; (21) [188, Pontoppidan O., 2001]; (22) [214, AVEC, 2001], (28) [353, Clittravi – DMRI, 2003]

Table: Consumption and emission data for poultry slaughter

Air

Reported emissions of CO₂, SO₂ and NO_x are shown in Table.

Substances emitted	Range of emissions per tonne of carcase (kg) (species and sources not specified)
CO ₂	22–200
SO ₂	0.45–1.1
NO _x	0.29–0.52

Table: The range of air emissions from 3 Finnish slaughterhouses [148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001]

Energy

Investigations in Norway have shown that slaughterhouses have an energy consumption even when no production takes place. Much of the energy is used for heating and operation of the refrigeration system. At a Norwegian slaughterhouse, the energy consumed during the sheep/lamb season was measured as 356 kWh/t sheep/lamb carcase and the annual average was calculated as 1256 kWh/t sheep/lamb carcase. This demonstrates the importance of implementing energy saving techniques, even outside the slaughtering times. [134, Nordic States, 2001]

In 1991, a study in the UK reported that the average specific electricity consumption (SEC) for large animal slaughterhouses carrying out slaughter, dressing, chilling and some freezing was 85 kWh/t carcase, with a range of 36–154 kWh/t carcase. Some cattle slaughterhouses have rendering plants so they consume more electricity [57, DoE, 1993]; this has, however, become less common.

Energy use is not only in the form of electricity. The 1991 UK study looked at other forms of energy as well and used the term “specific heating fuel consumption” (SHC), defined as “therms purchased to process one tonne of meat”, to standardise their measurement. 85 % of the sites involved in the study had SHCs below 15 therm/tonne carcase (440 kWh/t), with the average being 11 therm/tonne carcase (322 kWh/t). In Italy, pig slaughterhouses have a total energy consumption of 280–380 kWh/t carcase, of which 1/3 uses electricity and the remaining 2/3 thermal energy [237, Italy, 2002]. The information available suggests that generalisations cannot be made about which unit operations use electrical energy and which use other sources.

The 1991 study revealed that installations in Northern Ireland had higher SECs than those in Great Britain and this was attributed to the fact that all of the Northern Ireland installations were EC licensed. The higher consumption levels were attributed to the electricity consumption associated with the refrigeration requirements of the EC legislation. The best reported practice for slaughterhouses was 36 kWh/t carcase (although it should be noted that the temperature to which installations cooled their meat products was not investigated). The best SHC (0.2 therm/tonne, 5.86 kWh/t carcase) found was from a site using an anaerobic digestion plant to produce biogas from solid slaughterhouse waste. A small amount of fuel was required to supplement the on-site generated fuel. [57, DoE, 1993]. Since then all of the installations in the UK have been licensed.

At a pig slaughterhouse in Denmark, the sources of energy consumption shown in Table have been reported.

Energy source	%
Electricity	~35
Purchased heat	~50
Recouped heat	~15

Table : Sources of energy consumption at a large Danish pig slaughterhouse [134, Nordic States, 2001]

At a cattle slaughterhouse in Denmark, the sources of energy consumption shown in Table have been reported.

Energy source	%
Electricity	~40
Heat	~50
Recouped energy	~10

Table : Sources of energy consumption at a Danish cattle slaughterhouse [134, Nordic States, 2001]

The same Danish cattle slaughterhouse had an electricity consumption distribution, as shown in Table and heat consumption distribution, as shown in Table.

Where energy consumed	%
Refrigeration plant	~45
Compressed air	~10
Lighting	~10
Machines	~10
Ventilation	~5
Various	~20

Table: Distribution of electricity consumption in a Danish cattle slaughterhouse [134, Nordic States, 2001]

Where energy consumed	%
Room heating	13
Water heating, total	80
Water heating to 40 °C	5
Water heating to 60 °C	54
Water heating to 82 °C	21
Transmission loss	7

Table: Distribution of heat in a Danish cattle slaughterhouse [134, Nordic States, 2001] [38, Nordic 2001]

The figures in Table are similar to the German figures of 90 % of heat consumption attributed to water heating and 10 % to building heating [163, German TWG Members, 2001].

Most poultry slaughterhouses use cold and iced water, as well as water at 40, 60 and 82 °C. The distribution between the different types has been estimated as that shown in Table.

Temperatures of water consumed	%
Iced water	10–20
Cold water	~50
40 °C	10–15
60 °C	15–20
82 °C	~2

Table: Estimated distribution of water temperature requirements at Danish poultry slaughterhouses [134, Nordic States, 2001]

In poultry slaughterhouses in the Nordic countries 60 % of the energy consumed is from electricity and 40 % is from heat sources. The distribution of electricity consumption throughout the process has been reported as shown in Table.

Where energy consumed	%
Refrigeration	52
Machines	22
Pumps	10
Compressed air	8
Lighting	2
Ventilation	2
Other	4

Table: The distribution of energy consumption in poultry slaughterhouses in the Nordic countries [134, Nordic States, 2001]

In the Nordic countries, it is reported that hot water accounts for 85 % of heat consumption. The remaining 15 % is used for room heating. A considerable proportion of the energy consumption for water heating originates from recouped energy from refrigeration and compressed air machines. [134, Nordic States, 2001]

Water

Many slaughterhouses do not carry out any submetering of water or energy consumption, and are only aware of their total consumption from utility bills. Some have recently begun to submeter water and energy consumption by process area and expect to make substantial cost savings through monitoring and targeting programmes. The water balance for different process areas at a typical UK pig slaughterhouse is shown in Figure. It should be noted that the UK data do not include chilling. Data for water consumption in a typical Italian pig slaughterhouse are shown in Figure.

All slaughterhouses must have a pressurised supply of potable water within the meaning of Directive 80/778/EEC. A non potable water supply is authorised in exceptional cases for steam production, fire fighting and the cooling of refrigeration equipment, provided that the pipes installed for this purpose preclude the use of this water for other purposes and present no risk of contamination of fresh meat. Non potable water pipes must be clearly distinguished from those used for potable water. [169, EC, 1991, 223, EC, 1992]. This requirement for potable water to be used limits the opportunities for re-use of water.

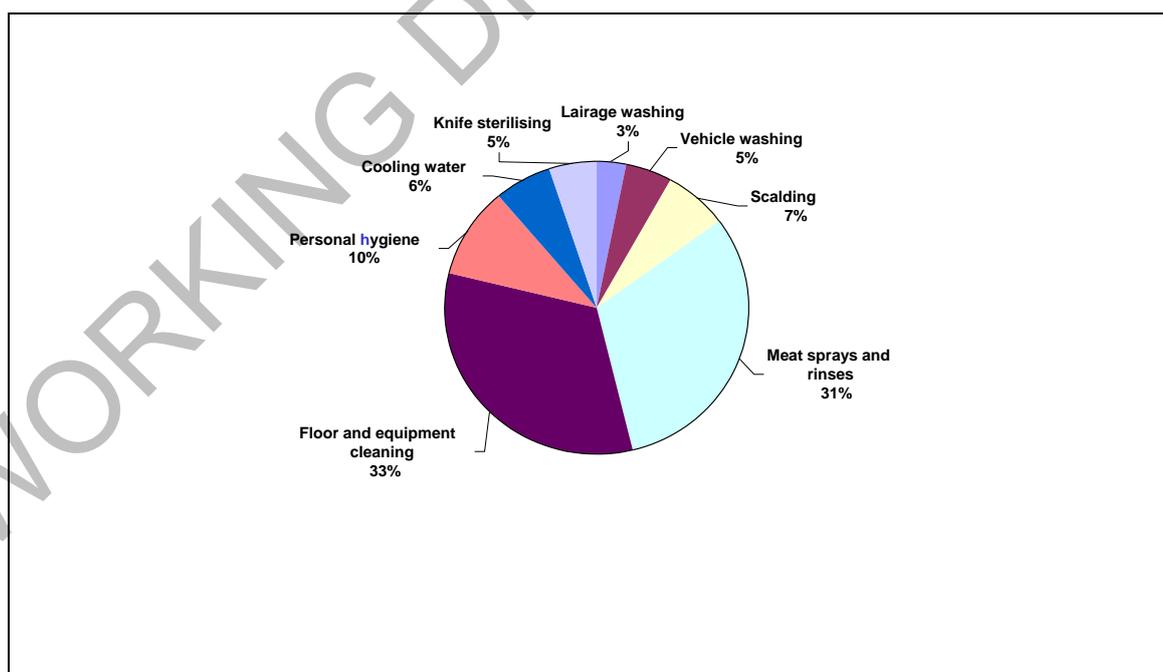


Figure: Typical water balance for areas in a UK pig slaughterhouse [12, WS Atkins- EA, 2000]

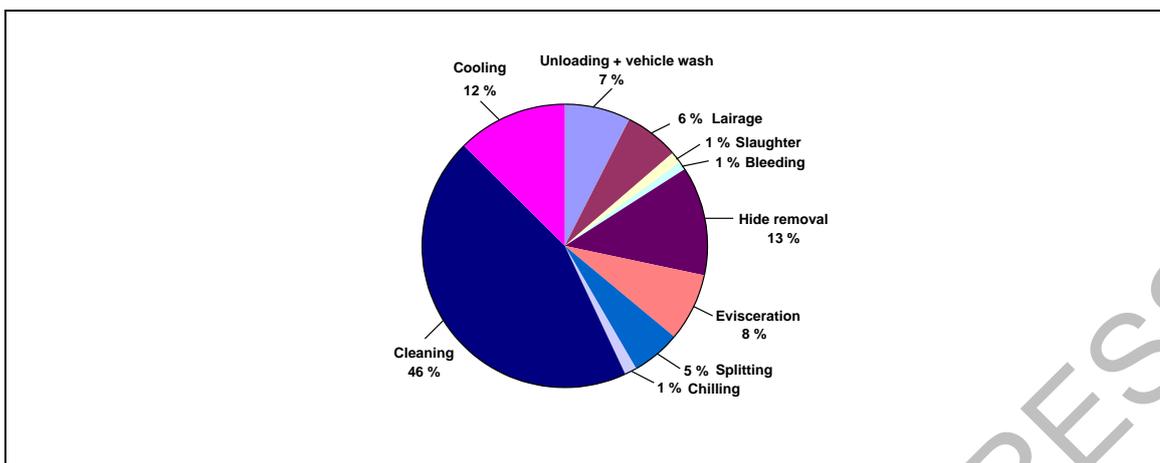


Figure: Data for water consumption in a typical Italian pig slaughterhouse

Where water consumption data has been collected for different groups of unit operations, comparison is not easy. If Figure is compared with Table, some similarities can be seen, e.g. for vehicle washing and lairage washing. There are some wide variations too, e.g. for cleaning. Although the percentages cannot be attributed to absolute consumption levels, they illustrate, by the fact that there are variations, that for some unit operations the techniques which consume the least water are not universally applied.

Where water consumed	%
Vehicle wash area	5 %
Lairage	5 %
Scalding tank	3 %
Rind treatment	10–15 %
Clean slaughter area	5–10 %
Cutting/deboning	5–10 %
Sterilisation (82 °C)	10–15 %
Casing cleaning department	20 %
Cleaning	15–20 %
Refrigeration system	5 %
Boiler house	2 %

Table: Estimated distribution of water consumption in some large Danish pig slaughterhouses [134, Nordic States, 2001]

It has been stated, that it is difficult to reduce water consumption significantly, due to veterinary demands. There is, however, no EU legal requirement for the washing of large animal carcasses, but it is general practice. Also, there is only a limited requirement for the washing of poultry carcasses, in a specified volume of water, between the evisceration and chilling [223, EC, 1992]. Many slaughterhouses exceed this requirement. It has been reported that in one Danish poultry slaughterhouse killing approximately 25 million birds per year, at a rate of approximately 9000 birds per hour, the demanded minimum consumption for “external and internal wash” and for chilling comprises approximately 56 % of the total water consumption. [134, Nordic States, 2001]. Cleaning and carcass washing can account for more than 80 % of the total water use and the effluent volume [63, ETBPP, 2000].

It has been demonstrated in Norway, that the water consumption for cleaning after completion of the slaughter process, is nearly the same whether 1 or 150 animals have been slaughtered. A dirty slaughter line must be cleaned, regardless of the number of animals processed. [134, Nordic States, 2001]. The water required for cleaning the plant, after completion of the slaughter process, may not differ much with respect to throughput, but it can be affected by the plant size. The other water consumption activities may also be more dependent on the throughput, e.g. vehicle washing, carcass washing and cleaning during the slaughter process.

The opportunity to reduce water consumption in some areas may be limited by hygiene and quality requirements. If these are genuinely excessive and both customers and regulators can be convinced of this, then a reduction may be possible. A comparison of actual water consumption with that recommended by equipment suppliers may identify opportunities for reducing consumption. Sub processes for which the water use often exceeds the actual need include cleaning, meat sprays and rinses, pig scalding, vehicle washing and lairage washing. [12, WS Atkins EA, 2000]

Table shows the estimated distribution of water pollution between individual processes in a cattle slaughterhouse.

Where water consumed	%
Vehicle wash and lairage	~5
Slaughter area	40–50
Casing cleaning including tripe wash	40–50

Table: Estimated distribution of waste water pollution in a Danish cattle slaughterhouse [134, Nordic States, 2001]

The increased automation of carcase dressing and the incorporation of washing at every stage, are increasing both water consumption and the amount of material such as fat, blood and faeces entering the waste water. This consequently requires WWTPs which are capable of treating high volumes of contaminated waste water.

Table shows the estimated distribution of water consumption between individual processes in a sheep slaughterhouse.

Where water consumed	%
Slaughter	~80
Cutting/deboning	~10
Casing cleaning	~10
Deboning is not within the scope of the BREF	

Table: Estimated distribution of water consumption in a Norwegian sheep slaughterhouse [134, Nordic States, 2001]

Table shows the estimated distribution of water consumption between individual processes in a number of poultry slaughterhouses.

Where water consumed	%
Scalding tank	6
Plucking	11
Internal/external wash	9
Chiller	14
Wash/cooling of viscera	9
Refrigeration condensers etc.	3
Box/rackwash	2
Cleaning during operation	18
Cleaning after operation	28

Table: Estimated distribution of water consumption in some Danish poultry slaughterhouses [134, Nordic States, 2001]

Table shows the distribution of water consumption reported for a Finnish slaughterhouse.

Use	The distribution of	Water consumption per
-----	---------------------	-----------------------

	water consumption % of total	tonne of carcase produced (t)
Water at 4 – 7 °C		
Cleaning of intestines	17.34	730
Slaughter	8.90	380
Lairage	1.30	60
Vehicle washing	0.03	<10
Cleaning of hides/skins and heads	3.09	130
Waste water treatment plant	0.11	<10
Refrigeration	0.24	10
Sanitation	0.31	10
Total water at 4 – 7 °C	30.59	1340
Water at 40 °C		
Slaughter	7.80	330
Cleaning	0.87	40
Various	15.39	650
Total water at 40 °C	24.06	1020
Water at 55 °C		
Cleaning of intestines	2.43	100
Cleaning	21.64	920
Various	0.75	30
Total water at 55 °C	24.82	1050
Water at 90 °C		
Slaughter	15.23	640
Cutting/deboning	3.77	160
Cleaning of intestines	1.53	60
Total water at 90 °C	20.53	860
Total water	100.00	4270

Table: The distribution of water consumption reported for a Finnish slaughterhouse [148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001]

It has been reported that blood and intestinal mucous are responsible for the greatest part of water contamination [206, Tritt W. P. and Schuchardt F., 1992].

Slaughterhouse waste water may contain disease causing agents and the high discharge temperatures of, e.g. scalding tanks make it a good breeding ground for germs. The rumen contents of healthy cattle have been found to contain rare *Salmonella* types. [206, Tritt W. P. and Schuchardt F., 1992]

3.2.2.1 Slaughterhouse cleaning - equipment and installation

The level of cleanliness achieved depends on a combination of several factors. These include the cleaning agents used, including the detergent reaction time; the water temperature for washing and rinsing and the mechanical treatment applied, e.g. the use of “force” in the water pressure and the use of scouring sponges and brushes. If one of these components is reduced, the others must be increased to achieve the same result.

If the water pressure is increased, the water consumption can be reduced. Enough water is still required, however, to contain the rinsed off dirt in suspension and to transport it to the floor drains. A high water pressure can also influence the working environment, by, e.g. causing increased noise, vibration and aerosol formation and it can damage electrical installations, machines and building materials. A pressure of approximately 2.53 MPa, i.e. a low-pressure cleaner, used with foam-borne detergents and rinsing water at 50 – 60 °C, is reported to be most widely used.

Significant resources are consumed during the cleaning but significant savings can be achieved. A slaughterhouse, where no special attention had previously been paid to the use of resources for cleaning achieved the following results shown in Table 3.2, without reducing the standard of cleanliness. Thorough instructions were given to cleaning staff into methods of environmentally correct cleaning, taking account of the use of detergents and water. This was combined with working time studies. As a result, the time used for preparation, pre-cleaning and removal of waste increased, but the total cleaning time was reduced.

Table 3.2: Reduced consumption of water and detergents achieved without loss of cleanliness

	Before	After
Water consumption	9.3 m ³	6.4 m ³
Detergent consumption	9.2 kg	3.0 kg

Source: [134, Nordic States, 2001] [38, Nordic 2001]

Alkaline detergents dissolve and break down proteins, fat, carbohydrates and other types of organic deposit. They can be corrosive, so an inhibitor is sometimes added. These detergents often contain sodium or potassium hydroxide. Their pH varies from approximately 8 to 13, depending on their composition and their degree of dilution for use.

Acid detergents are used to dissolve lime deposits. Nitric, hydrochloric, acetic and citric acids are commonly used. The pH is low and it varies according to the composition of the detergent. They are corrosive. They have some disinfectant properties.

Detergents contain a number of active ingredients, each with a specific function.

~~Tensides reduce the surface tension of the water and improve the wetting of surfaces. They produce micelles to facilitate fat emulsification. They include soaps and syndetes. Compounds used in the meat industry must be biodegradable in normal biological waste water cleaning. The tenside nonyl phenol ethoxylate (NPE) can be broken down to release its surfactant properties, but some stable compounds which are suspected toxins are produced and its use as a cleaning agent will soon be banned in all but limited applications, so it will not be available for use in slaughterhouses and animal by products installations, under the forthcoming 26th amendment of Council Directive 76/769/EEC, by Council Directive 2003/53/EC. Linear alkylbenzene sulphonates (LAS) also give rise to environmental problems. They are toxic towards organisms in an aquatic environment and cannot be broken down in anaerobic environments.~~

~~Complexing agents ensure that calcium and other minerals are not "bound" to soap or syndetes. In the past, sodium carbonate (washing soda) was used to bind calcium in the cleaning water. Today phosphates are mainly used, but other compounds such as phosphonates, EDTA, NTAA, citrates and gluconates are also used.~~

Disinfectants are used after cleaning to kill residual micro-organisms. The disinfectants commonly used include various chlorine compounds, e.g. sodium hypochlorite and chlorine dioxide. Hydrogen peroxide, peracetic acid, formaldehyde and quaternary ammonia compounds (QACs) are also used, all in aqueous solution. Ethanol is also used. Sodium hypochlorite is the most commonly used compound. With the exception of ethanol, disinfectants must be rinsed off after use.

The choice of detergent used has an effect on the waste water treatment. Some WWTPs have a system for removing phosphates. Others can handle EDTA, phosphonates or similar compounds. The quantity of calcium binder used will vary depending on how soft or hard the water is. Detergent residues may remain in the sludge from the waste water treatment. This may limit the options for disposal of the sludge. This needs to be considered when choosing the detergents.

A study at a Danish pig slaughterhouse showed the consumption of detergents given in Table 3.3. The quantity of detergents used at a slaughterhouse can be based on the surface area of the equipment and installation to be cleaned.

Table 3.3: Quantities of detergent used in Danish pig slaughterhouses

Detergent type	Use per slaughtered pig (g)	Use per tonne of pig carcass (g)
Acid detergents	11 (3 - 15)	143 (39 - 195)
Alkaline detergents	41 (18 - 48)	533 (234 - 623)
Neutral detergents	3 (estimate)	39 (estimate)
Disinfectants	15 (7 - 17)	195 (91 - 221)
Liquid paraffin	4 (1 - 5)	52 (13 - 64)
Total		962
<i>Source: [134, Nordic States, 2001] [38, Nordic 2001]</i>		

Sprays and rinses typically account for a high proportion of water consumption at slaughterhouses. Sprays and rinses typically consume about 24 % of the water used at poultry slaughterhouses and 30 % of that used at large animal slaughterhouses. Trigger operated spray nozzles, which control and direct the water, are commonly used to both reduce the water consumption and to provide adequate washing efficiency. Spray technologies have improved in recent years. The latest designs are less susceptible to blockage than those previously available. New designs are also available with improved water efficiency whilst maintaining, or often improving the washing effect. [12, WS Atkins-EA, 2000] [4, WS Atkins-EA 2000], [67, WS Atkins Environment/EA, 2000] [24, WS Atkins-EA 2000]

Cleaning is carried out after production with the use of hot water and detergents and, subsequently, disinfection takes place which often uses a strong oxidation agent, e.g. hypochlorite. The consumption of detergents and hypochlorite in Danish slaughterhouses is summarised in Table 3.4.

Table 3.4: Quantities of detergents and hypochlorite used in Danish slaughterhouses

Type of animal	Average consumption (minimum – maximum)	
	Detergents	Hypochlorite
Pig ⁽¹⁾	67.1 (31.7 – 123.9)	2.0 (0.4 – 6.8)
Cows ⁽²⁾	108.9 (59.8 – 201.9)	10.9 (3.7 – 35.8)
NB: Consumption data related to 3 financial years. (1) Data collected from 9 pig slaughterhouses. (2) Data collected from 4 cattle slaughterhouses. <i>Source: [203, Denmark 2015]</i>		

3.2.2.2 Emissions to water

Emissions to water from slaughterhouses can be divided into process emissions and emissions from spills and diffuse sources. The main emissions include organic material, which contributes to the BOD and COD levels and inorganic material such as ammonia and phosphorus. Sources of process emissions include the washing of vehicles, washing of carcasses, cleaning of the production area and associated downstream activities such as e.g. stomach, tripe and casings washing. [3, EPA, 1996] [1, EPA 1996]. Those operations which emit manure and partly digested feed are increasingly believed to be significant sources of phosphorus emissions [274, Pontoppidan O., 2002] [127, Pontoppidan O. 2002].

According to the INERIS report on hazardous substances in industrial waste water, the average emission level at the point of discharge of waste water of 195 slaughterhouses in France is 348 µg/l for zinc and 58 µg/l for copper [262, INERIS 2016].

Figure 3.3 shows reported data (for the years 2016 to 2018) for Cu emissions to water from slaughterhouses for direct discharges, as well as applied abatement techniques. The same information for indirect discharges is presented in Figure 3.4.

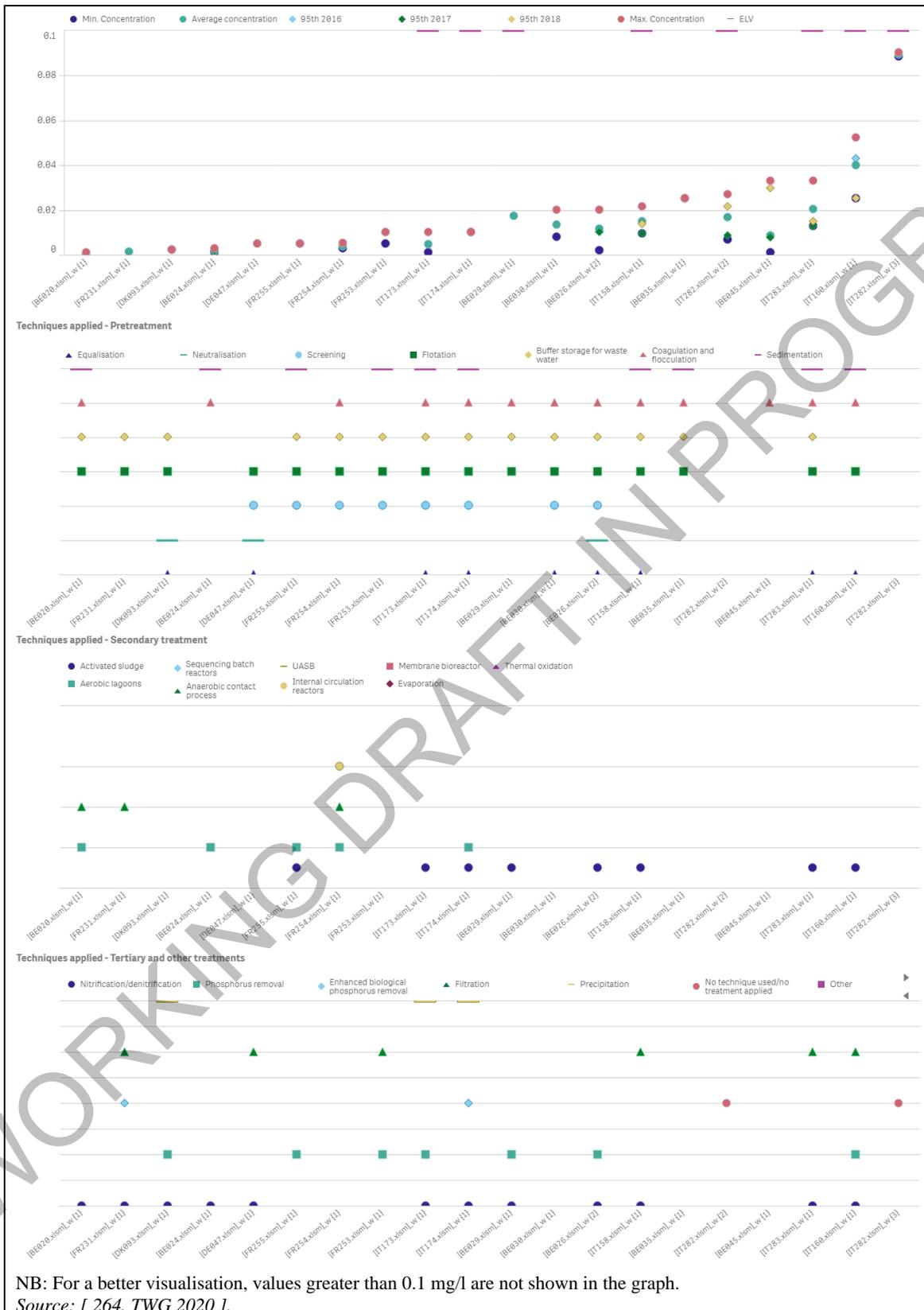


Figure 3.3: Cu emissions to water (mg/l) from slaughterhouses (direct discharges)

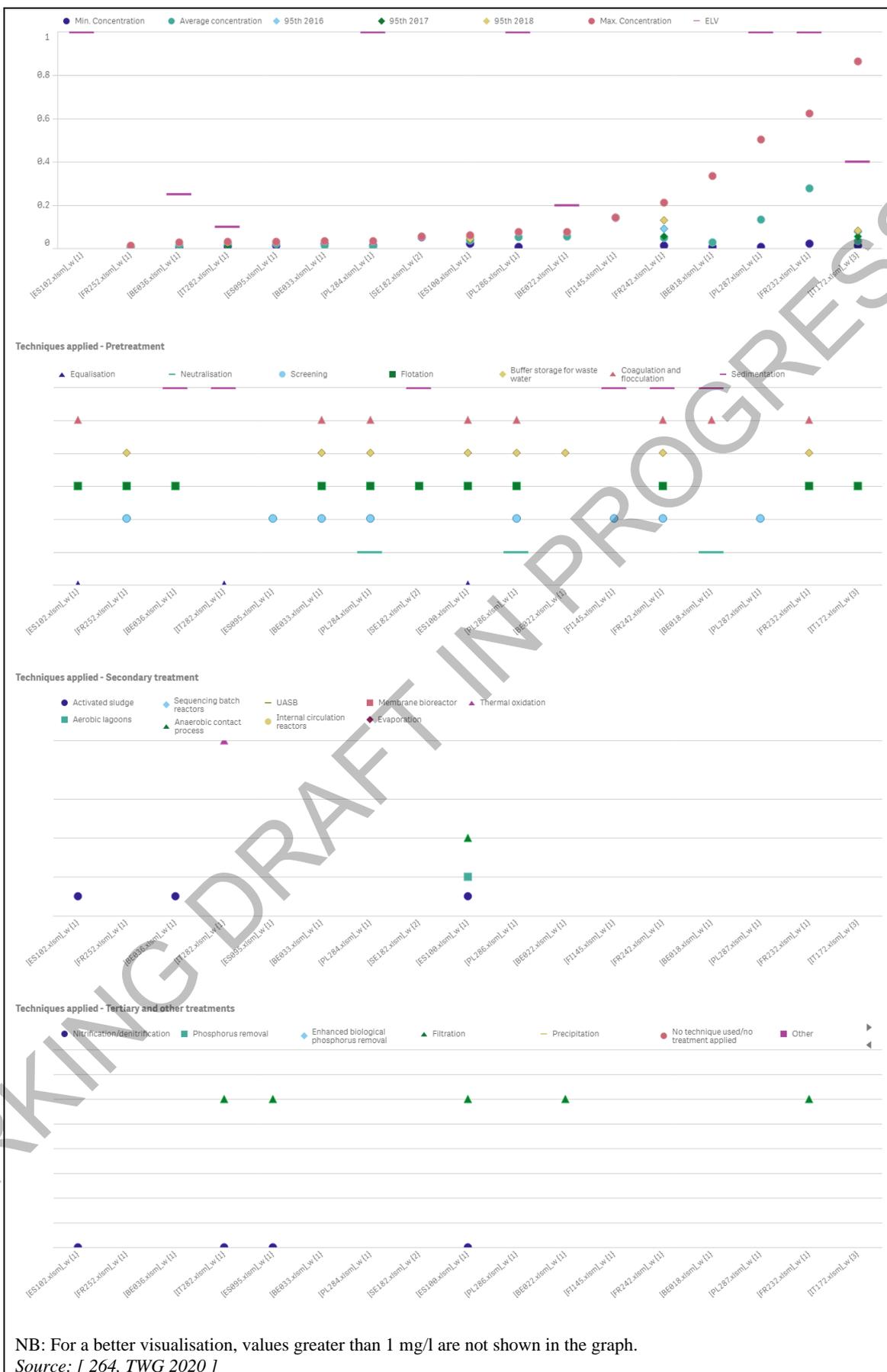


Figure 3.4: Cu emissions to water (mg/l) from slaughterhouses (indirect discharges)

Chapter 3

Figure 3.5 shows Zn emissions to water from slaughterhouses for direct discharges, as well as applied abatement techniques. The same information for indirect discharges is presented in Figure 3.6.

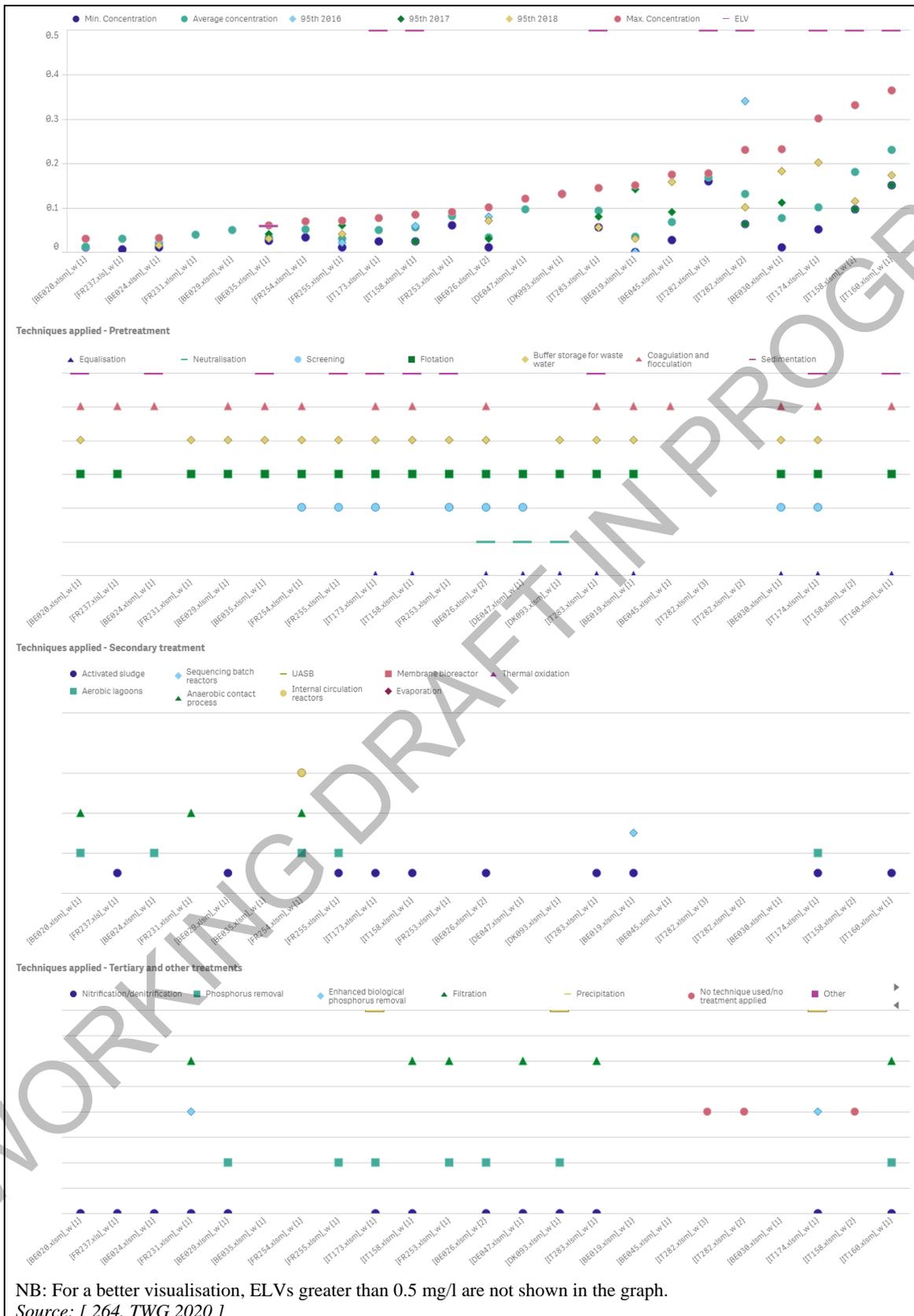
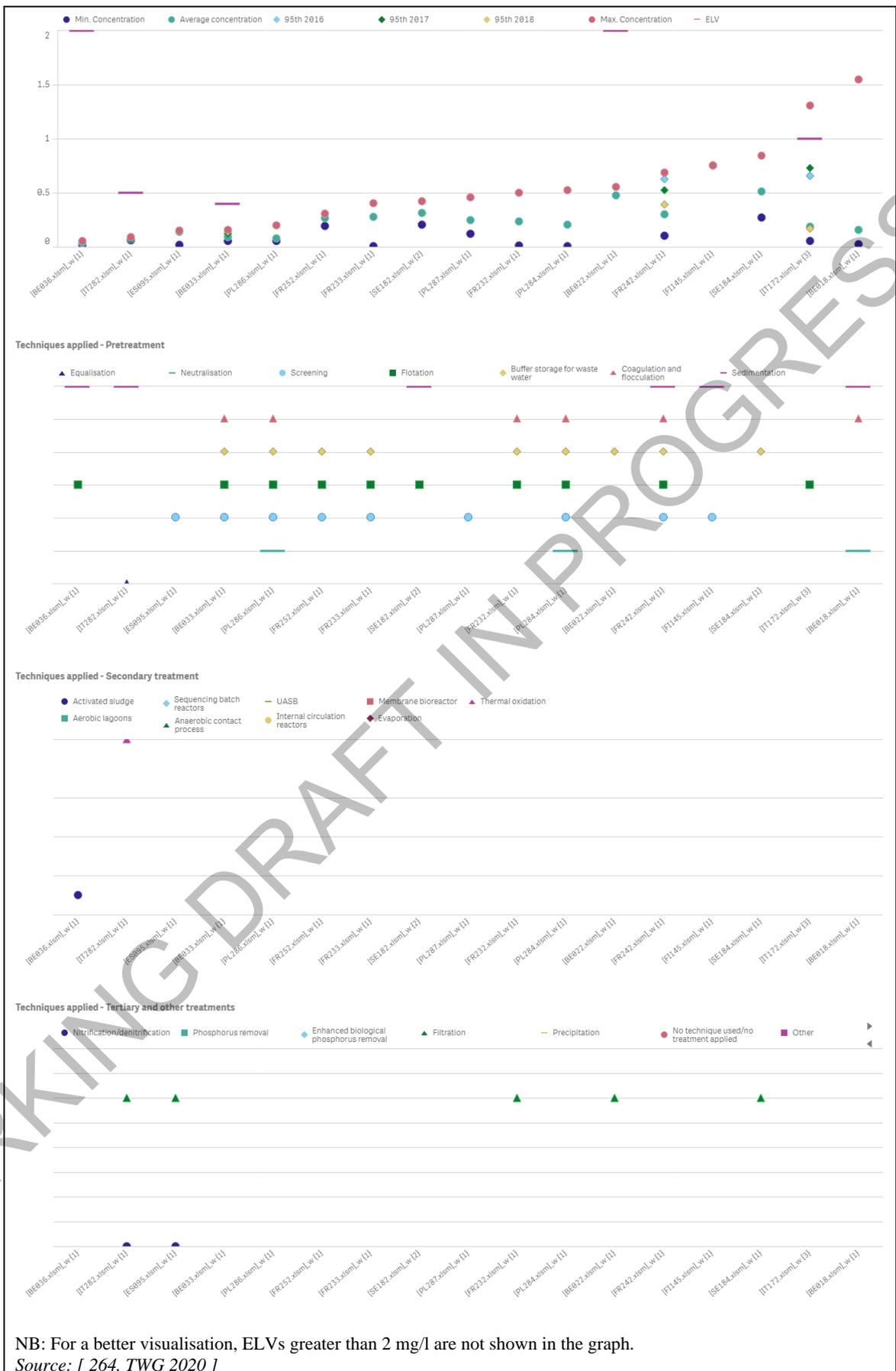


Figure 3.5: Zn emissions to water (mg/l) from slaughterhouses (direct discharges)



NB: For a better visualisation, ELVs greater than 2 mg/l are not shown in the graph.

Source: [264, TWG 2020]

Figure 3.6: Zn emissions to water (mg/l) from slaughterhouses (indirect discharges)

3.2.2.3 Emissions to air

Odour

For many slaughterhouses odour is the most significant air pollution issue in terms of day-to-day local prevention and control, particularly in built-up areas and in warm weather/climates. The odours are generally associated with the collection and storage of blood, gut contents, inedible offal, heads, feet, bones, meat scraps and SRM waste. Other potential sources are the use of macerator equipment to chop and wash inedible offal, inadequate effluent treatment plant maintenance and any blockage of drainage by meat and fat scraps.

Urine and manure odour from the slaughterhouse lairage areas can also cause minor nuisance in built-up areas, although the hygiene and welfare standards required at slaughterhouses can mitigate against significant odour from this source.

~~There is a very limited amount of emission level data available and a lack of consistency in the use of units. This makes it difficult to approach the issue of odour prevention and control in a quantitative way. CEN is developing a standard for measuring odour, i.e. prEN 13725:2001 – Air quality – Determination of odour concentration by dynamic olfactometry [31], CEN, 2001]. Its availability should make consistency easier to achieve, in the future.~~

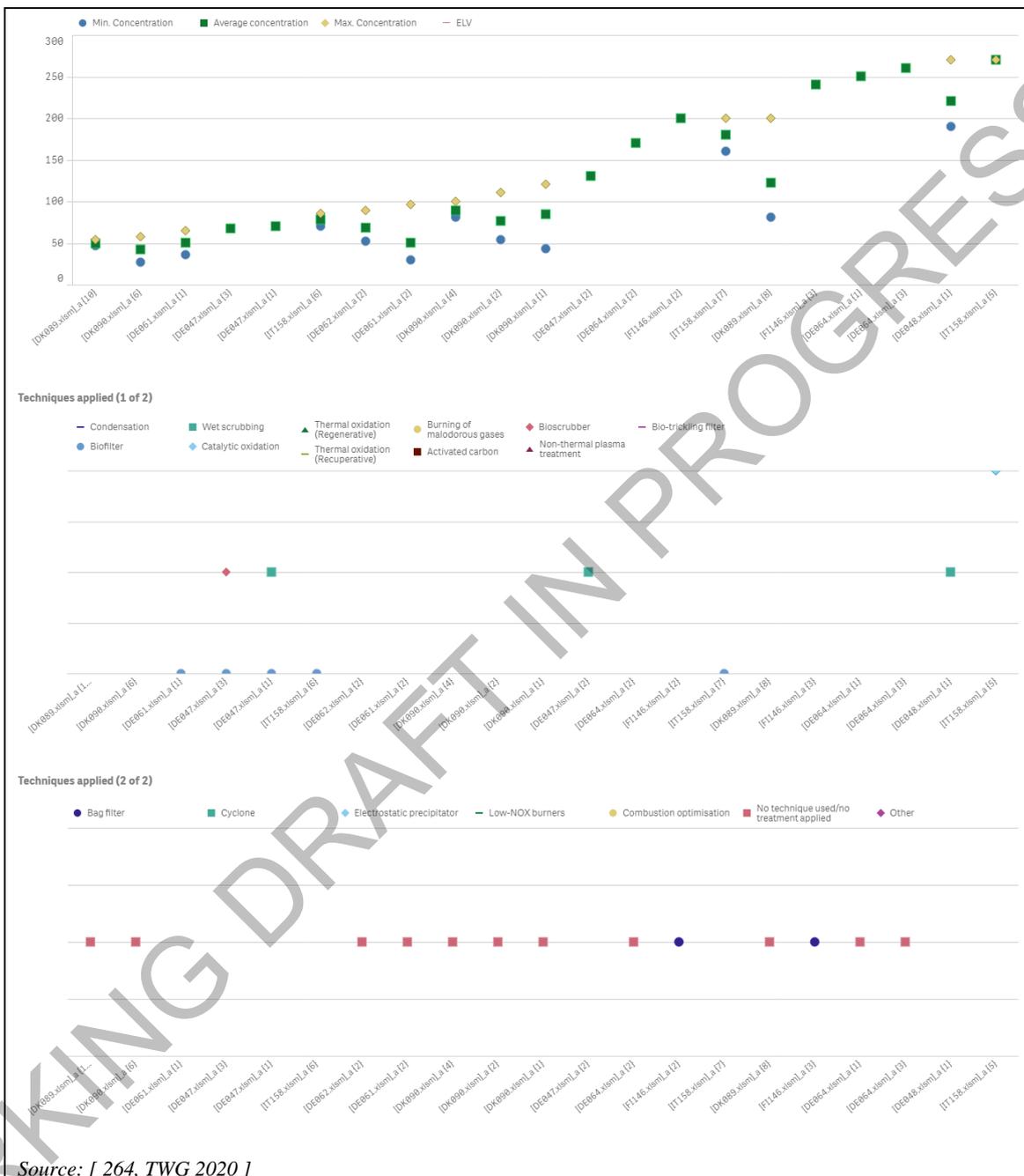
The collection and storage of slaughterhouse by-products, such as blood, gut contents, inedible offal, heads, feet, bones meat scraps and SRM waste cause some of the most significant day-to-day pollution problems, because of the odours they generate. Some by-products, such as gut contents, inherently have offensive odours. Others, such as blood, become offensive very rapidly. Freshly cut fat takes longer to degrade and cause odour problems. The existence and extent of odour emissions depends on what preventive and control measures are implemented, as well as the local weather and climate. Odour problems increase with exposure, time and temperature of storage. Odour emissions can be minimised and prevented.

To an extent, the emissions during storage depend on the process upstream of the storage, i.e. the whole collection and handling procedure. If, e.g. blood is collected directly into closed and sealed containers then emissions will be prevented whilst the container is closed, however the blood will ferment within a few hours after being collected and become malodorous. There is always an air valve in the storage container, to exhaust any gas which may be produced, so the escape of odours is possible. If blood cannot be processed immediately, refrigeration is the only reported way to prevent odour production [271, Casanellas J., 2002] [124, Casanellas J. 2002], although charcoal filters can reduce odour emissions.

If the storage time of by-products which do not have an offensive smell when fresh, is kept below the time in which they become offensive, the problem of odour emissions should be avoided. If the time from slaughter to animal by-product use or disposal is kept below the time for odours to be produced, then this will prevent problems both at the slaughterhouse and at the animal by-products installation. Fresher ingredients also produce higher quality products, e.g. from fat melting and fewer malodorous emissions, e.g. from rendering. For example, the fat collected after stomach washing, which is wet and has a high protein level, is subject to rapid decay and the production of organic acids, which make processing difficult and lead to high production costs [206, Tritt W. P. and Schuchardt F., 1992] [83, Tritt W. P. and Schuchardt F. 1992]. The processing of malodorous materials can also lead to odour problems at the WWTP.

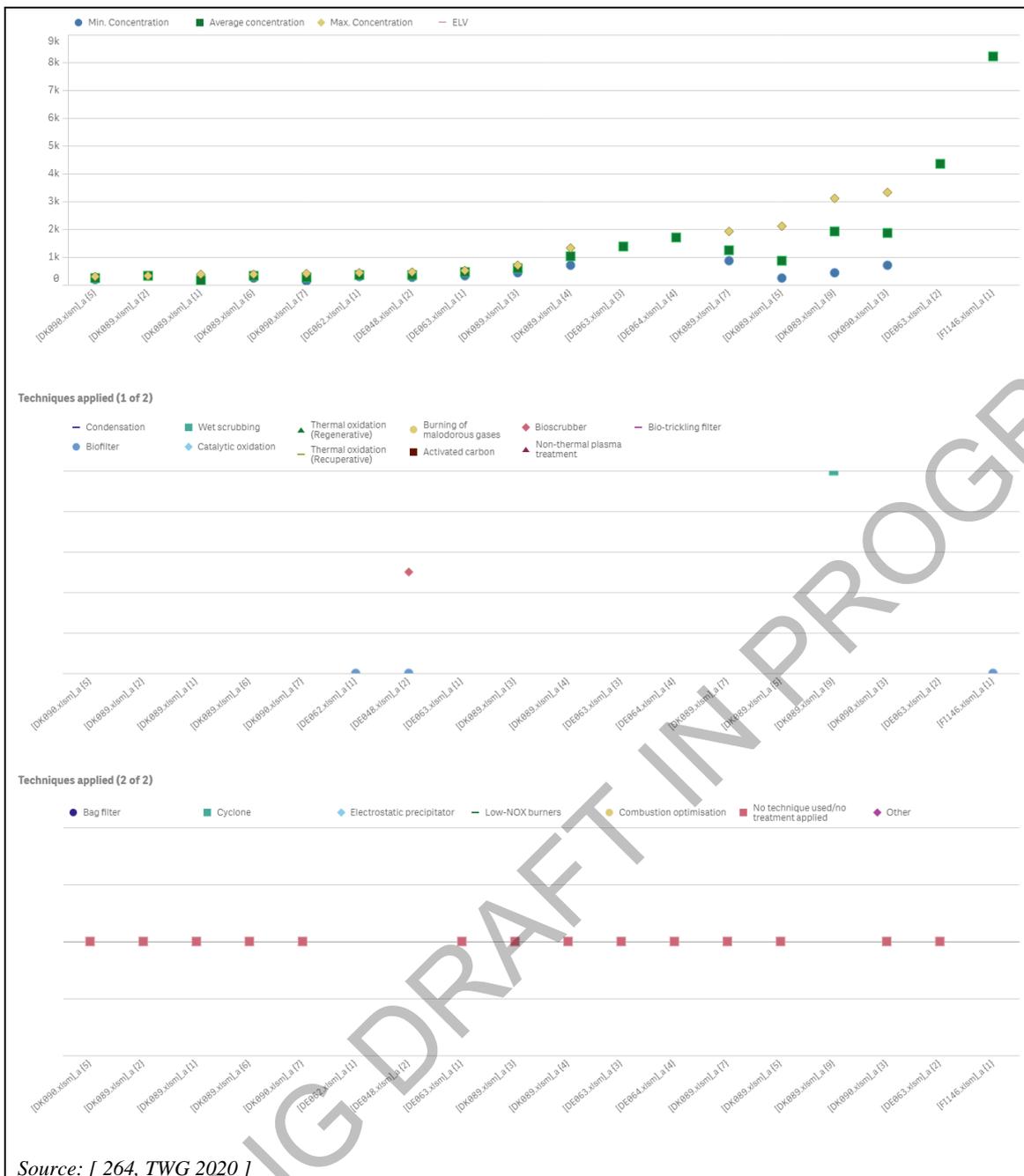
If by-products, which smell worse as they degrade, are refrigerated then odour emissions are reduced, but energy needs to be consumed to achieve this.

Figure 3.7 and Figure 3.8 show reported data for channelled emissions of odour, as well as the applied abatement techniques, from slaughterhouses. For the majority of emission points, no abatement technique is applied.



Source: [264, TWG 2020]

Figure 3.7: Odour emissions (OUE/Nm³) and abatement techniques from slaughterhouses (Part 1 of 2)



Source: [264, TWG 2020]

Figure 3.8: Odour emissions (OUE/Nm³) and abatement techniques from slaughterhouses (Part 2 of 2)

3.2.2.4 Refrigerant losses

According to the data reported, R717 (NH₃) is the most commonly used refrigerant, in about 52 % of the cases.

Figure 3.9 shows the reported R717 (NH₃) losses (%). The percentage of refrigerant losses refers to the total amount of refrigerants contained in the cooling systems.

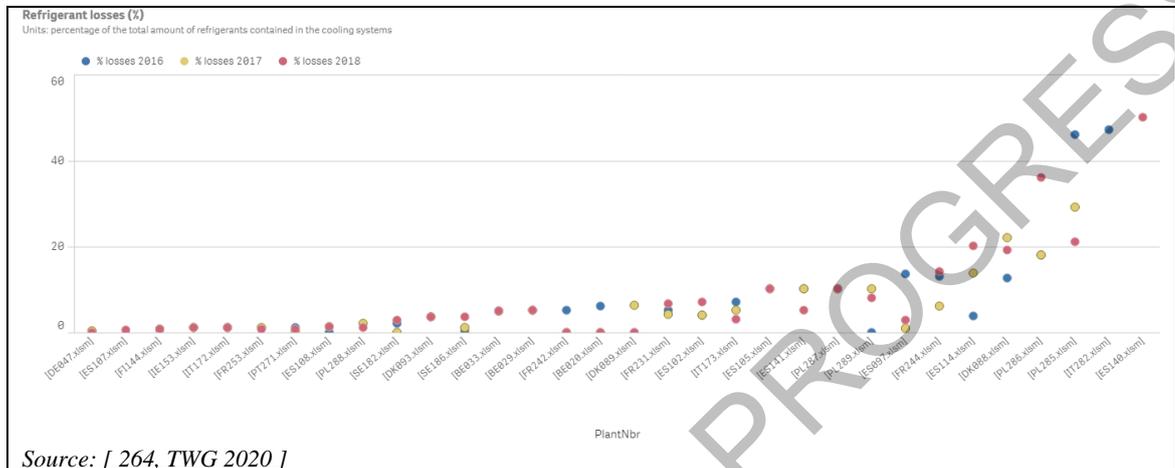


Figure 3.9: R717 (NH₃) losses (%)

The second most widely used refrigerant in the data reported (in about 23 % of the cases) was R404A. Figure 3.10 shows the reported R404A losses (%).

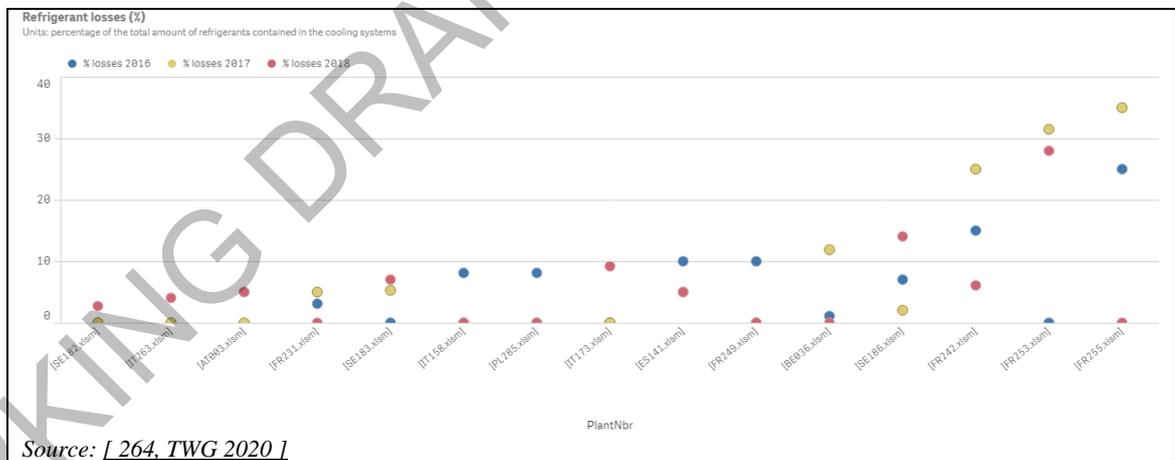


Figure 3.10: R404A losses (%)

3.2.2.5 Noise and vibration

Typical noise levels found during working hours and measured at the perimeter fence of a slaughterhouse or at the nearest buildings are 55 - 65 dB(A). Typical levels of 40 - 50 dB(A) and 35 - 45 dB(A) have been reported for the evening and night, respectively. These figures depend on the local conditions such as distance, shielding, reflection, operating time and the local attitude towards minimising unnecessary noise. [134, Nordic States, 2001] [38, Nordic 2001]

The main sources of noise and vibration are animal noises during unloading and marshalling to the slaughter-line; vehicle movements; compressors; air conditioners; ventilation fans and carcase splitting. Some of these sources are present 24 hours a day, whereas others coincide with intermittent activities such as animal deliveries or employee shift change-overs.

Solid waste

Examples of solid waste include lairage and vehicle wash solids; animal by products; sludge from WWTPs; clean and contaminated packaging; protective clothing and equipment. In the UK, WWTP solids are commonly sent to landfill. In Denmark, they are used in biogas production. Recent studies have revealed manure as the possible main source of phosphorus in solid waste and consequently in waste water too [274, Pontoppidan O., 2002].

Slaughterhouse waste water treatment

Water

A characteristic of slaughterhouse waste water is that it contains organic compounds which are easily broken down in a biological waste water plant. It does not contain persistent nitrogen, and the typical C:N ratio (BOD:total N) of 7.9:1 is advantageous. Salt from hide/skin preservation is difficult to remove and can cause corrosion damage in WWTPs [244, Germany, 2002].

The temperature of the waste water considerably affects the solubility of various pollutants and their microbial decomposition rate. The temperature of waste water in Finnish slaughterhouses is typically 25–35 °C. In general, biological processes perform faster at higher temperatures, whereas fat emulsification at higher temperatures causes substantial difficulties in fat removal by flotation, as well as in an activated sludge plant. [148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001]

Typical discharge levels are shown in Table.

Pollutant	Level achieved
BOD	< 10–75 mg/l
Suspended solid	< 30–60 mg/l
Total nitrogen	≤ 15–65 mg/l
Ammonia	10 mg/l
Phosphate	2 ppm

Table: Typical discharge levels from slaughterhouse WWTPs
[215, Durkan J., 2001, 240, The Netherlands, 2002, 346, Belgian TWG member, 2003]

The treatment of slaughterhouse waste water can achieve a high enough quality standard for it to be suitable for discharge to water courses, but the pathogenic risk renders it unsuitable for recirculation within the slaughterhouse. The recirculation of treated process water and wash-water is forbidden by veterinarians.

Odour

Odour problems may arise, e.g. where solids are screened and during sludge treatment.

Noise

Aerators associated with effluent treatment plants, which operate continuously, can produce significant noise impacts, particularly from badly maintained gearboxes and especially at night. [12, WS Atkins EA, 2000]

Biogas production

Air

There is a risk of an accidental release of CH₄, which is a greenhouse gas.

Water

The advantages associated with biogas production from slaughterhouse by products include: a reduction in the concentration of impurities in waste water, low excess sludge production and the production of a biologically stable excess sludge that can be used as a fertiliser [239, Denmark, 2002].

Land

The solid residues from biogas production from animal by products may be composted. The use of such compost is subject to the restrictions specified in ABP Regulation 1774/2002/EC.

Energy

For each unit of electricity generated from biogas, 1.5 units of heat may be produced as hot water at over 80 °C. The energy rich gas can be used, e.g. in slaughtering or animal by products production, as a substitute for conventional primary energy. Biogas is reported to make no net contribution to the greenhouse effect. [207, Linköping Gas AB, 1997]

Odour

Odour problems can arise from the storage and handling and processing of the raw materials and from the WWTP, if there is one.

Noise

Large scale mechanical equipment such as compressors, used to aerate the process fluid and filtration plant may be potential sources of noise pollution. [144, Det Norske Veritas, 2001]

3.2.3 Techniques to consider in the determination of BAT across slaughterhouses

3.2.3.1 Techniques to increase energy efficiency

Management and monitoring of compressed air use

See also Section .

Description

The main compressor for compressed air can be stopped at the end of the slaughter operations. A smaller compressor can then be used during cleaning operations. Inadequate maintenance of compressed air installations can lead to leaks developing and the consequent losses of large quantities of air. Losses of more than 30 % of the installed capacity can occur and losses of 20–25 % are common. With careful maintenance, losses due to leaks can be kept within 7–8 %. Tools operated by compressed air such as handsaws often determine the required pressure for the compressed air supplies. However, some tools are routinely operated at higher pressures than those required for the given task.

Achieved environmental benefits

By preventing leaks, the energy expended on producing unnecessary extra compressed air can potentially be reduced by 30 %. By reducing the pressure by 100 kPa, an energy saving of 6 % can be achieved.

Cross-media effects

None.

Applicability

Applicable in all slaughterhouses.

Economics

The technique will involve increased maintenance costs, but it is likely that these will be offset by the energy savings.

Driving force for implementation

Reduced energy use.

Reference literature

{134, Nordic States, 2001}

Management and monitoring of ventilation use

Technical description

Energy can be saved by ensuring that the filters in the ventilation system are kept clean. The pressure drop across clean filters is kept below 50 Pa. Filters can be changed at a pressure drop of approximately 100 Pa. The running time of ventilation systems can be managed. Installation of automated start and stop controls can be used to prevent unnecessary use of the system. For example, comfort ventilation might only be switched on under certain temperature conditions and only during the operation of those tasks which require it.

Achieved environmental benefits

The energy, otherwise wasted by forcing air across dirty filters and by the excessive use of the ventilation system, can be saved.

Cross-media effects

None.

Technical considerations relevant to applicability

Applicable in slaughterhouses where the air is cleaned using filters before entering any part of the installation.

Driving force for implementation

Reduced energy use and expense.

Reference literature

{134, Nordic States, 2001}

3.2.3.1.1 Techniques related to cooling/freezing

3.2.3.1.1.1 Implement Refrigeration management plan systems

Description

An energy efficiency plan is part of the environmental management system (see Section 2.3.1.1) and entails:

- information about the operating costs;
- operational measures such as inspection and maintenance of equipment, closing of doors when possible;
- equipment operation by experienced staff;
- monitoring of refrigerants consumption and leaks.

Technical description

It is reported that most refrigeration plants can be improved to save up to 20 % of their energy consumption. Surveying the plant can lead to the identification of technical and operational opportunities to improve energy efficiency and save money.

A plant can be reliable and still be inefficient. A plant designed and operated to be efficient, however, is inevitably more reliable; for instance, the compressor does not have to work so hard in an efficient plant, which makes it less prone to breakdown and therefore more reliable.

Increased energy efficiency can reportedly be improved by a combination of surveying the plant, adopting good housekeeping measures, and carrying out appropriate monitoring, maintenance and control.

~~Additional information is available in EN 378:2000 Refrigerating systems and heat pumps – Safety and environmental requirements Part 2 Design, construction, testing, marking and documentation; Part 3 Installation site and personal protection and Part 4 Operation, maintenance, repair and recovery.~~

Achieved environmental benefits

Reduced energy use. Reduced emissions of refrigerants, typically from small leaks and major accidents.

Environmental performance and operational data

Surveying the plant

Each component of the plant can be investigated separately, to measure/estimate its energy consumption and the associated operating costs. It may also be helpful to identify what exactly is being cooled.

The operating costs can be measured/estimated for each item of plant by either measuring the current to all meters and power consumers or, for less accurate results measuring the running times and combining these with the power rating information provided by the manufacturer. Other costs such as maintenance, refrigerant top-up, routine labour and water treatment can be included. This enables both energy and cost savings to be targeted and monitored.

Two types of cooling load can be identified: (1) product loads, i.e. the targets of the cooling and (2) parasitic loads, i.e. those not directly related to the product, e.g. heat generated by lights or motors in cooled spaces. This distinction is useful because the actions which can be taken to minimise the two types of load are different.

Good housekeeping

Good housekeeping by trained and aware personnel can lead to significant cost savings. Some examples of good housekeeping practice around the refrigeration plant and in cooled rooms, include the following:

Around the refrigeration plant

If condensers are not kept clean the condensing temperature increases. A 1 °C increase in condensing temperature can increase running costs by 2 - 4 %. The cooling capacity also drops and the required temperature may not be achieved. The warmer the air entering the condenser is, then the higher the condensing temperature will be. The condensers can be shaded, if necessary and warm air can be prevented from being recirculated. Anything obstructing the airflow can be removed.

Bubbles in the refrigerant sight-glass when the system operation is stable usually signify that the system is leaking. This is not only illegal and harmful to the environment, but it also increases the cost of running the system and the refrigerant then has to be replaced. Also, the system may not be able to provide the cooling required. Leaks thus need to be found and repaired before the system is recharged with refrigerant.

The oil level in the compressor sight-glass(es) can be checked regularly, as the compressor will be more likely to fail if the oil level is too low or too high. Neither refrigerant nor oil are used up during normal plant operation; refrigerant can only be lost because of a leak, whereas oil levels may vary because of a leak or if oil is trapped somewhere in the system

Running the plant hotter than necessary can reduce reliability and performance. The plant room can be ventilated, e.g. using an extractor fan that is switched on when the temperature gets too high.

Ensuring that the control settings for the plant are optimised, labelled and easy to find can encourage personnel to maintain efficient operating conditions.

In cooled rooms

An open door reportedly costs GBP 6/h for a freezer store and GBP 3/h for chilled storage, due to lost energy. Ice around a door indicates poor sealing, which also incurs a consequent increase in the heat load. This may mean that the system capacity cannot sustain the increased load and the store temperature may increase. Such problems may be repaired by ensuring that product is not left in the doorway and by repairing the sealing on the door. If a door has to be used regularly, strip curtains may be fitted and maintained.

Impeding the airflow over the cold store, by obstructing the evaporator airflow leads to a temperature increase throughout the store and consequently to the system consuming more power than necessary, or possibly not reaching the required temperature.

A defrost-on-demand system, which initiates a defrost when needed rather than by a timer has reportedly reduced power consumption by 30 %, in some applications. Evaporators that operate below 0 °C should be completely defrosted before ice starts to cover the fins. This may be every few hours or every few days. When the evaporator is iced-up the evaporating temperature drops. A 1 °C drop in evaporating temperature can increase the running costs by 2 - 4 %. The capacity also drops and the store may not get down to the required temperature. If the defrost elements are not working properly, then the frost build-up on the evaporator will worsen.

Other heat sources in the cold store, e.g. lights, forklift trucks, other motors and charging devices cost money due to the electricity they consume and again through running the refrigeration system to remove the heat they produce. Personnel also give off heat.

Ice formation on the floor and walls of a cold store indicate that a lot of air is entering the room, bringing with it moisture, which is condensing on the evaporator and the structure. It can also indicate a defrost problem.

Cold stores are often held at lower temperatures than necessary because of worries about failure. Having a cold store at a lower temperature than necessary makes failure more likely. A temperature 1 °C lower than necessary can reportedly add 2 - 4 % to the plant running cost.

In other areas

Refrigeration systems have to remove heat from many sources other than just the product or space intended to be cooled. These sources of heat can be minimised. Some common examples of heat sources are: pumps and fans that circulate cold air, chilled water or an anti-freeze solution. These deliver most of the power they consume as heat into the cooling load, so they need to be switched off when not required.

Cold refrigerant pipes between the evaporator and compressor, particularly the larger suction line pipes, pick up heat from their surroundings. These can be insulated and not run through hot areas.

Monitoring

Monitoring enables trends and developing faults to be detected, before they become a major and expensive problem, e.g. monitoring of refrigerant leaks.

Monitoring for very small plants

Even for small and simple plants, installing gauges to log suction and discharge pressures, daily or, at the very least, weekly can cost a few GBPs and save thousands of GBPs. Any change, such as a fall in suction pressure, indicates a problem, such as a refrigerant leak. If the discharge pressure rises and the ambient temperature does not then this may indicate a blocked condenser.

Maintaining a data log helps detect problems early and it helps the contractor to diagnose problems.

Monitoring for most plants

For most plant, more detailed monitoring may prove worthwhile. In some cases, a computerised monitoring system may be justifiable.

Maintenance schedules

Maintenance work will depend on the size and complexity of the plant, as well as on the components used. It has been reported that as a minimum, the following should be checked

- Compressors
 - oil level
 - suction and discharge pressures and temperatures
- Condensers
 - fans and pumps are working
 - fan guards are safe and secure
 - condenser is not blocked; clean condenser if necessary
- Gauges
 - for accuracy
- Receiver
 - if there is a liquid level sight glass or gauge, that it contains the right amount of refrigerant
- Evaporator
 - as for condensers, plus the degree of frost build-up
 - liquid-line sight-glass to see that it contains the right amount of refrigerant
- Safety and efficiency
 - all safety controls
 - control switches to ensure that they have not drifted from the optimum set-point
 - suction superheat to confirm that expansion valves are operating correctly
 - pressure vessels, e.g. liquid receivers, may legally need a written scheme of inspection to be carried out by a competent person (see the box on page 18)
- Others
 - no untoward vibration on any part of the system
 - pipework insulation is still in good condition
 - for leaks, e.g. of ozone depleting substances
 - insulation for damage, if you have a cold store or cabinet
 - cold store safety door releases.

At one example refrigeration plant, high condensing pressures were experienced, leading to increased energy usage and higher fuel bills. The condenser was cleaned, which solved the problem and a plan to replace the condenser was thus abandoned.

Control

It has been reported that keeping controls simple and getting settings right can be a big step towards making a refrigeration plant operate as efficiently as possible by, e.g. setting the thermostat to achieve the best energy efficiency for the plant without compromising reliability. Marking the normal readings on gauges helps the early detection of equipment malfunction. There are a number of low-cost controls that can be added to a plant, which give reportedly good results. Automatic controls can be used to switch off the refrigeration plant and/or lights when they are not required. Automatic switches or variable speed drives can be fitted to fans and pumps that circulate cold air, chilled water and anti-freeze solutions. Paybacks of one year or less have been reported. For plants with multiple condensers or cooling towers, these allow the minimum condensing temperature possible for the plant to be obtained and this allows cost saving advantages in cooler weather.

Case study

The refrigeration system at a small frozen and chilled food company eliminating CFCs replaced 9 old refrigeration units with a single integrated system. Energy efficiency features were incorporated. These included larger heat-exchangers, low power evaporator fans, efficient compressors, comprehensive instrumentation and heat recovery. The cold store insulation was improved and low energy lighting units were installed.

Cross-media effects

None.

Technical considerations relevant to applicability

Applicable in all slaughterhouses and those animal by products installations which have a refrigeration plant.

Economics

It has been reported that an investment made to save up to 20 % of energy normally has a payback time of well under two years.

The savings made in the case study plant are shown in Table 3.5. The total investment was GBP 30 000. The additional cost of the energy saving features was GBP 4 000 (1993). The payback period for the marginal cost of the energy saving features was 9 months.

Table 3.5: Summary of main energy saving features in a modified cold store

Modifications	% saving	Actual annual savings (GBP, 1999)	Annual energy savings (kWh)
Larger evaporator heat-exchangers	-	1 500	25 200
Low power evaporator fan	66	3 400	57 400
Efficient compressors	32	4 000	6 300
Low energy lighting	56	380	
Defrost use		440	
TOTAL site	23	Incomplete	Incomplete

Source: [299, ETSU, 1999] [148, ETSU 1999]

Driving force for implementation

Reduced energy costs.

Example plants

This technique has been reported in approximately 25 % of the slaughterhouses participating in the SA data collection [264, TWG 2020]. A chilled food distribution company in the UK.

Reference literature

[167, Greek Ministry for the Environment, 2001] [55, Greek Ministry for the Environment 2001], [292, ETSU, 2000] [141, ETSU 2000], [299, ETSU, 1999] [148, ETSU 1999], [264, TWG 2020]

3.2.3.1.1.2 Installation of groundwater cooling of refrigerant

Description

Groundwater is used to cool refrigerant gases.

Technical description

Groundwater can be used to cool refrigerant gases to reduce the amount of energy used.

Achieved environmental benefits

Reduced energy consumption.

Environmental performance and operational data

The refrigeration system can use 40 - 70 % of the electricity consumption of a slaughterhouse. Groundwater cooling has been introduced to cool the refrigerant and to reduce the condenser operating pressure from 1.22 kPa to the 0.81 kPa which is reported to be optimal from an energy saving point of view.

Cross-media effects

The technique can cause a rise in groundwater temperature. A system in Denmark has been closed down because of the resultant rising temperatures in neighbouring wells.

Technical considerations relevant to applicability

Applicable in situations where there are sufficient groundwater supplies to not cause a significant risk of raised groundwater temperatures.

Driving force for implementation

Reduced energy use.

Example plants

This is standard practice in poultry slaughterhouses [241, TWG 2019]. It is also used in at least one pig slaughterhouse in Denmark.

Reference literature

[134, Nordic States, 2001] [38, Nordic 2001], [269, Italian TWG Members, 2002] [123, Italy 2002] [241, TWG 2019]

*Use of backward bowed centrifugal fans***Technical description**

Many fans are of the centrifugal type with forward bowed blades. This type of fan is less efficient than the type with backward bowed blades.

Achieved environmental benefits

Reduced energy consumption.

Cross-media effects

None.

Technical considerations relevant to applicability

Applicable in ventilation and refrigeration systems.

Economics

Backward bowed fans are a little more expensive than those with forward bowed blades, but the extra cost will often be repaid in less than 2 years by the savings arising from the reduced energy consumption.

Driving force for implementation

Reduced energy use and expense.

Reference literature

[134, Nordic States, 2001]

*Heat recuperation from refrigeration plants***Description****Achieved environmental benefits**

Reduced energy consumption. The recouped heat can be used for preheating hot water. Reduced operation of the fan for the condenser results in less noise.

Cross-media effects

None.

Applicability

Applicable at all slaughterhouses.

Economics

Driving force for implementation

Reduced energy costs.

Reference literature

[134, Nordic States, 2001, 183, Pontoppidan O., 2001, 333, Netherlands TWG, 2003]

Control refrigeration plant running times

Description

Sequencing and time controls are used to set the refrigeration operations to match the process requirements.

Achieved environmental benefits

Reduced energy use.

Operational data

An annual energy saving of 269 GJ was reported in an example cattle and sheep slaughterhouse in the UK.

Cross-media effects

No negative environmental impacts were reported.

Applicability

Applicable in all slaughterhouses and animal by products installations which have a refrigeration plant.

Economics

The implementation costs; annual actual energy and water savings; actual financial savings and payback time are shown in:

Driving force for implementation

Increased energy costs and the identification of a method of systematically reducing these in way that could be both measured and related to production levels.

Example plants

A cattle and sheep slaughterhouse in the UK.

Reference literature

[52, DoE, 1994]

Use of binary ice as a cooling fluid (secondary refrigerant)

Description

Binary ice can be used as a refrigerant fluid. Binary ice may be described as “liquid ice”. It comprises ice crystals of 10–100 μm , in suspension in water, containing antifreeze. The antifreeze is either ethanol based and containing an anti-corrosion substance, or if the binary ice is for the immersion of food, common salt (sodium chloride).

Two technologies are described for the production of binary ice. The first which is shown in Figure is for small and medium capacity binary ice, i.e. 100–1000 kW. The numbers in the following text refer to Figure. The binary ice is generated with a special evaporator, called a binary ice generator (1), which is supplied with fluid by a pump (2), from a binary ice storage vessel (3). A conventional refrigeration plant (4), with a small refrigerant charge, is connected to the binary ice generator. “Natural” refrigerants such as water (not for freezing), air, carbon dioxide (still under development), ammonia and hydrocarbons can be used, as alternatives to chlorofluorohydrocarbons. A secondary pump (5) supplies binary ice at a given ice concentration into the main feed pipe (6), where pumps (7) (optional), supply binary ice to the

cooling loads (8). In the case of “zero load”, but on standby, the binary ice is kept circulating in the secondary loop (6) and (10) but is passed over valve (9), which opens as soon as the cooling loads are disengaged. The return pipe (10) transports the binary ice fluid, (with or without ice crystals) back to the storage vessel (3).

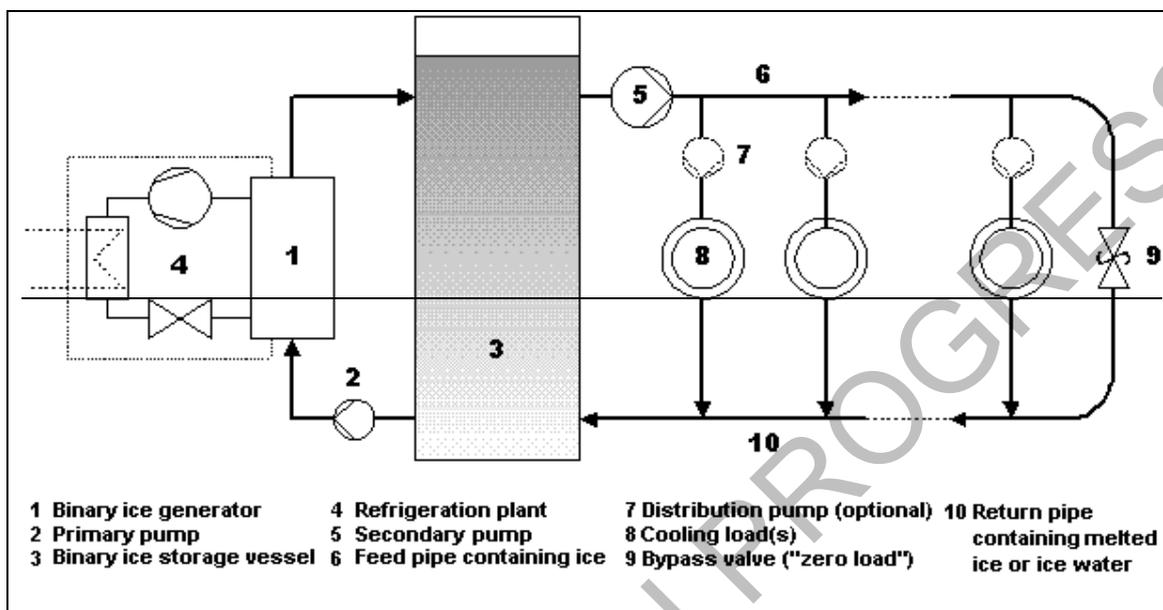


Figure : Binary ice system with a conventional refrigeration plant

Medium and large capacities of binary ice, i.e. 1000 kW – 1 MW, can also be produced with a refrigeration process with “water as refrigerant”. The technology is very similar as that shown in Figure, with the exception that the conventional refrigeration plant (4) is not necessary. A water vapour compressor and suitable vacuum conditions, for binary ice typically 500 Pa (5 mbar), cause the water to evaporate in an empty vessel (evaporator) and the compressor removes the water vapour, which is eventually condensed.

Achieved environmental benefits

Under comparable conditions, the coefficient of performance for binary ice is normally better than for conventional chilling and freezing plants, i.e. less power is consumed. Smaller refrigeration units are required, so fewer materials are needed and reportedly, because they do not have to be so chemically resistant they can be simpler and better suited for recycling. As the entire plant is not filled with potentially harmful refrigerants, the probability and severity of an accidental release is reduced. Unlike other refrigerants, binary ice made from water and alcohol can normally be released to the WWTP, with the permission of the regulator. The properties of an ice crystal’s rapid phase change reportedly ensure excellent heat transfer. The surface can, therefore, either be reduced or the binary ice can be “warmer”, which results in lower energy demand and less surface freezing. The product weight loss is consequently less and defrost may even be unnecessary for air chillers. Fluid coolers can reportedly also be 20 to 50 % smaller.

Operational data

Table compares the volumes of the refrigerants brine and binary ice required to achieve a 3 °C decrease in temperature.

Cooling process	Refrigerant	Comparable cooling ability for a given mass, to achieve a 3 °C decrease in temperature	Energy available for cooling (kJ/kg)
Chilling	Brine	1	11
	Binary ice of 10 % ice crystals	3.0	33
	Binary ice of 20 % ice crystals	6.0	66

Chapter 3

Freezing	Brine	4	11
	Binary ice of 10 % ice crystals	3.7	33
	Binary ice of 20 % ice crystals	7.3	66

Table: Comparison between the volumes of binary ice and brine required to achieve a 3 °C decrease in temperature

For example, 4 to 7 times more refrigerant has to be circulated if brine is used as a refrigerant, compared to binary ice. It has been reported that pipe diameters can be approximately 50 % smaller and the pumping power 70 % lower, for binary ice compared to brine. It is also reported that binary ice plants commonly run throughout 24 h/d, so only a small ice making machine and storage volume is required.

In an example slaughterhouse and meat processing plant, the slaughtered cattle and pig carcasses were chilled, prior to further processing. The following binary ice plant, with a total installed capacity of 424 kW was installed provide the cooling requirements:

Total area used	3800 m ²
Number of employees	40
Production per week	500 cattle and 2000 pigs
Refrigerant	Ammonia
Binary ice system	Trade name
Number of independent refrigeration plants	2
Compressors	Gram (reciprocating)
Additional features	Heat recovery
Cooling work per day	5500 kWh/d
Full load operating hours (maximum)	13 h/d
Installed refrigerating capacity (icemakers)	230 kW
Operating hours of the Binary Ice plant (hottest summer day)	24 h/d
Binary ice storage work	1600 kWh
Binary ice storage volume	34 m ³
Binary ice fluid corrosion inhibitor	Trade name
Maximum binary ice concentration in ice storage	> 50 %
Binary ice concentration in the pipework	12 %

Cross-media effects

None reported.

Applicability

Applicable in slaughterhouses.

Economics

For the slaughterhouse example referred to above, the service life was 15 years. With an interest rate of 7 % and a depreciation time of 10 years, the additional direct investment costs could reportedly be recovered in 2.2 years and the annual operating costs of the binary ice plant, including depreciation immediately recoverable. It is estimated that the payback time would be 10 to 15 years for typical Danish slaughterhouses.

It is reported that binary ice plants normally run at off-peak tariff or during times when there is a low overall electrical loading.

Driving force for implementation

The phase-out of ozone-depleting chlorofluorohydrocarbons under the "Montreal protocol" and the expected pressure to reduce the use of hydrochlorofluorohydrocarbons by the "Kyoto protocol".

Example plants

At least one slaughterhouse in Germany.

Reference literature

[360, German TWG members, 2003, 361, Pontoppidan O., 2003]

Chill room door closing microswitches

Description

In one example plant, 14 doors to chill rooms and external loading doors were frequently left open, thereby leading to considerable electricity wastage. Initially 3 sirens were installed and programmed to sound when the doors were left open for more than a permitted period. This encouraged personnel to close the doors. The next step was the fitting of microswitches to monitor and record the length of time the doors were left open.

Achieved environmental benefits

There was an annual energy saving of 226 GJ.

Cross-media effects

No negative environmental impacts were reported.

Applicability

Fully applicable.

Economics

The implementation costs; annual actual energy and water savings; actual financial savings and payback time are shown in.

Driving force for implementation

Increased energy costs and the identification of a method of systematically reducing these in a way that could be both measured and related to production levels.

Example plants

A cattle and sheep slaughterhouse in the UK.

Reference literature

[52, DoE, 1994]

3.2.3.2 Techniques to reduce water consumption

3.2.3.2.1 General techniques

3.2.3.2.1.1 Avoidance and minimising-minimisation of carcase rinsing, combined with using-use of clean slaughter techniques

Description

Skilled and careful slaughter is performed minimising the necessity to wash the carcase after inspection by a veterinarian.

Technical description

Skilled and careful slaughter, dressing and evisceration prevents and or minimises carcase contamination and thus improves product quality, whilst also minimising the necessity to wash the carcase after inspection by a veterinarian. Rinsing can be limited to the splitting cut, to remove bone dust from cattle, the chest cavity and the fore shanks.

Achieved environmental benefits

Reduced water consumption and contamination of water.

Environmental performance and operational data

With a manually controlled shower head, a cattle carcass may be rinsed with 8 - 10 litres of water (approximately 30 - 40 l/t).

In pig slaughterhouses, water consumption at the slaughter and bleeding unit operations have been quoted as 10 – 50 l/t and 30 – 40 l/t respectively, with the water being supplied constantly, regardless of carcass throughput.

Cross-media effects

None.

Technical considerations relevant to applicability

Carcass rinsing may not be applicable due to hygiene requirements. ~~Applicable at all cattle slaughterhouses.~~

If carcass washing is required, due to visual contamination by, e.g. hair or feathers, washing may be required. The use of water sprays mixed with compressed air can minimise the amount of water used.

Sheep can be 'safely' left unwashed, providing dressing practices are of a high standard, and the meat quality is generally better, i.e. nicer appearance, colour and improved keeping quality. Wet carcasses tend to go 'sticky' when chilled. Likewise if de-hairing of pigs and evisceration of poultry is done skilfully, washing can be avoided.

Manual washing may be preferable to automatic rinsing in cabinets, where the water consumption is often unnecessarily high. If the temperature of the water is kept to a minimum, i.e. cold water is used, fat uptake can be avoided. The use of water sprays mixed with compressed air can also lessen the amount of water used.

Economics

A spray gun costs EUR 200.

Driving force for implementation

Reduced water costs, improved product quality.

Example plants

Various slaughterhouses.

Reference literature

[134, ~~Nordic States, 2001~~] [38, ~~Nordic 2001~~], [183, ~~Pontoppidan O., 2001~~] [66, ~~Pontoppidan O. 2001~~], [217, ~~Brindle J., 2001~~] [93, ~~Brindle J. 2001~~], [284, ~~Leoni C., 2002~~]

3.2.3.2.1.2 ~~Apply~~ Application of automated water start/stop controls throughout the slaughter-line

See also Section 2.3.5.1.3.

Description

Sensors such as photocells are fitted to detect carcasses and parts of carcasses and to supply water as required.

Technical description

Sensors such as photocells can be fitted to detect carcasses and parts of carcasses and to supply water as required. Water supplies can be turned off automatically between carcasses and during all breaks.

Achieved environmental benefits

Reduced water consumption, reduced volumes of water requiring treatment and if the pressure is regulated reduced entrainment of biological matter and contamination. It has been predicted that the savings could be up to half of the total water use during production together with the water saved during cleaning periods, by ceasing the practice of allowing it to continue to run.

Environmental performance and operational data

Care taken during the selection, installation and maintenance of the photocells can make certain that they are reliable and their correct position ensures that carcasses are washed to the extent planned, even if they are swinging on the overhead rail, or vary in size.

Use of the technique pre-supposes that each carcasses needs to be cleaned and the technique does not distinguish between clean and dirty carcasses or dirty parts of carcasses.

If the slaughter-line is not working to its maximum capacity, the water savings are greater, if water is only supplied when there is a carcass present. This has been measured at slaughter and bleeding unit operations.

In pig slaughterhouses, water consumption at the slaughter and bleeding unit operations have been quoted as 10 – 50 l/t and 30 – 40 l/t respectively, where water has been supplied constantly, regardless of carcass throughput.

Cross-media effects

Energy to pump water could be saved if the need for carcass washing was removed. Water may be wasted if clean carcasses are washed.

Applicability

Equally applicable to new and existing slaughterhouses.

Economics

The cost of an automated water stop/start control has been reported to be USD 255. For a pig slaughterhouse the estimated annual saving in water use was 6060 m³.

Driving force for implementation

Reduced water costs.

Example plants

A pig slaughterhouse in the US.

Reference literature

[134, Nordie States, 2001] [38, Nordic 2001], [214, AVEC, 2001] [90, AVEC 2001], [243, Clitravi - DMRI, 2002] [190, Clitravi - DMRI 2003], [268, Oekerman H. W. and Hansen C. L., 2000] [122, Ockerman H.W. and Hansen C.L. 2000], [284, Leoni C., 2002]

3.2.3.2.1.3 Continuous, dry and segregated collection of by-products along the length of the slaughter-line

See also Section 3.2.3.4.1.1 and 3.2.3.3.1.

Description

Drip trays/troughs are positioned to collect liquids and solids.

Technical description

Depending on the position on the slaughter-line, drip trays/troughs can be positioned to collect liquids and solids. Drip trays/troughs can be provided for the collection of, e.g. dripping blood between the bleed hall and the scalding tank, on pig slaughter-lines; at head and hide removal

stations and for blood and mixtures of solids for rendering or other by-products, which are destined for further processing. The troughs can be linked by drains, pumps or suction devices to the relevant collection vessel. The position and design of the tray/trough and the means of preventing mixing with water and the transportation of the liquids or solids depend on the unit operation, the degree of segregation of different materials desired/required and their ultimate intended use, or disposal route. Examples of materials which can be collected and transported dry include offal not intended for human consumption and feathers. For materials destined for human consumption temperature control is particularly important and some slaughterhouses transport offals in water, due to the cooling effect. This can be avoided by transferring the materials to chills quickly after they are removed from the animal.

The amount of waste is particularly large for chest opening, pluck set removal and carcass splitting operations. It is, therefore, very important to install collection systems in these areas. The removal could be done with special suction installations or pumps. In one case study slaughterhouse, all of this waste was formerly washed into the sewerage system during interval cleaning. It was found to be possible to do all the initial cleaning dry, e.g. using shovels, squeegees or vacuum suction, thereby avoiding water usage during the working period. The initial cleaning at the end of the working period can also be done without using water.

Elsewhere, when rumen is removed it is immediately transferred by dedicated pneumatic tunnel to the “dirty zone”, where it is pressed by a hopper system and unloaded into a container for composting.

Achieved environmental benefits

Reduced water consumption and less entrainment of by-products in water. If by-products are collected efficiently, the volume of water required for cleaning is reduced and consequently less energy is used to heat the cleaning water. Less detergent is also required. The amount of waste water produced and its BOD, COD, nutrient and detergent levels and CO₂ emissions are all reduced.

The segregation of liquids and solids destined for use or destruction has several advantages. If sufficient separate collection systems are provided, it reduces cross contamination between different by-products. Segregation of the by-products can, therefore, reduce potential odour problems from materials which even when fresh emit the most offensive odours, i.e. by storing/removing them separately under controlled conditions, instead of having to control a greater volume of mixed by-products. It also reduces the use of water to transport the by-products and to clean the installation (the by-products are largely confined to the drip tray/trough). In addition, cleaning may be easier.

Also, by minimising cross-contamination, segregation enables individual by-products which can be used to be used, instead of being disposed of because they are mixed with materials which cannot be used. All materials can, therefore, be used or disposed of in the most appropriate way for them.

Environmental performance and operational data

At a Danish slaughterhouse, the amount of organic material collected per pig increased by 0.2 kg (2.6 kg/t pig carcass) after a trough was installed in the “clean slaughter-line”, i.e. where evisceration, splitting, weighing, cleaning and classification took place and wet suction was introduced. In addition, the pollution of the waste water was reduced by 0.52 – 0.65 kg BOD per tonne of pig carcass. Similar results would be expected using a squeegee/shovel, provided that correct procedures were consistently followed.

In another case study, the COD loading in the waste water was reduced. In a Norwegian slaughterhouse, the combination of fitting a double drain system in the bleed area and collection trays for blood under the scraping table and the evisceration area, together with a pump to the blood tank, reduced the total COD discharge by 22 %, i.e. by or more than 1.25 kg COD per tonne of pig carcass.

Some slaughterhouses use a long trough with a screw conveyor under the slaughter-line to eliminate the need for wet floor cleaning during working hours. The material can be swept or squeegeed to the screw conveyor, the mechanism of which should be inaccessible to the operator, for safety reasons.

The use of drip trays to prevent material from falling on the floor has health and safety advantages, since it can significantly reduce the risk of slipping accidents. It may also influence the downstream value and use of the by-product, if hygiene is an important consideration, e.g. if it is to be used in blood processing.

Cross-media effects

Some energy will still be required, e.g. to operate pumps, but that energy which would have been used to heat additional cleaning water can be saved.

Technical considerations relevant to applicability

Applicable at all slaughterhouses.

Economics

Each trough costs approximately EUR 300 per metre. If a pumping system is installed, the additional cost will be approximately EUR 3 000 – 4 000.

The payback period was calculated to be 8 months for a Danish slaughterhouse paying a surcharge on waste water and approximately 4 years when no surcharges are paid.

The payback time for the Norwegian example quoted above, was a little over 6 years. Waste water treatment costs are saved.

Driving force for implementation

Reduced waste water treatment and waste disposal and the associated reduced costs.

Example plants

At least one Danish and one Norwegian slaughterhouse.

The direct collection of rumen contents for composting is undertaken in at least two cattle slaughterhouses in Italy.

Reference literature

[134, Nordic States, 2001] [38, Nordic 2001], [167, Greek Ministry for the Environment, 2001] [55, Greek Ministry for the Environment 2001], [183, Pontoppidan O., 2001] [66, Pontoppidan O. 2001], [239, Denmark, 2002], [244, Germany, 2002] [110, Germany 2002], [248, Sorlini G., 2002] [112, Sorlini G. 2002]

3.2.3.2.1.4 Insulated and covered knife sterilisers

Description

Knife steriliser boxes, located along the length of the slaughter-line, are insulated and fitted with fixed covers.

Technical description

Knife steriliser boxes which are located throughout the length of the slaughter-line can be insulated and fitted with fixed covers, which have slots through which 2 knives can be placed with their blades immersed in water at 82 °C. The cover can be designed and made to suit the type of knife used at each workstation.

Achieved environmental benefits

Reduced water consumption and consequently reduced energy consumption.

Environmental performance and operational data

The water consumption measured in one uninsulated knife steriliser, with constantly running water has been reported as approximately 2 000 l/d. By insulating and covering the steriliser the heat loss can be reduced, so the frequency and volume of top-up water required is consequently also reduced.

Use of a 20 mm thickness of insulating material is reported to reduce the heat loss by 80 %, compared to an uninsulated steriliser, without a lid.

Cross-media effects

None reported.

Technical considerations relevant to applicability

Applicable at all work stations in all slaughterhouses.

Economics

Each steriliser costs approximately EUR 700 - 800. In Denmark, the payback time, for fitting new insulated steriliser boxes, has been estimated to be one year.

Driving force for implementation

Reduced water consumption and consequently reduced energy use.

Example plants

This technique is in use in at least two Danish slaughterhouses, one of which is slaughtering cattle and the other pigs.

Reference literature

[134, Nordic States, 2001] [38, Nordic 2001], [274, Pontoppidan O., 2002] [127, Pontoppidan O. 2002]

3.2.3.2.1.5 Knife sterilisation using low-pressure steam

Description

Water is heated by an injection of steam in a low-pressure steam steriliser, which is then used to sterilise knives.

Technical description

In a low-pressure steam steriliser the water is heated by an injection of steam. The water is changed manually, or controlled by a timer, as required. The water consumption is approximately 500 l/d, or less depending on how often the water is changed.

Achieved environmental benefits

Reduced energy use and reduced water consumption.

Environmental performance and operational data

Measurements in 1992 on knife sterilisers at Norwegian slaughterhouses showed an energy consumption of 500 kWh per day equal to 0.3 kWh per head (17 kWh/t of carcase). When the method of knife sterilisation was changed from hot water to steam, the energy consumption was reduced by 75 %, to 4.24 kWh/t of carcase.

The sterilisation is carried out at 150 kPa and after the sterilisation unit the steam pressure is reduced to 50 kPa.

The heat of condensation is used to maximum effect, which reduces the amount of water needed to maintain the sterilisation units at 82 °C.

It is reported that there is no significant risk to the operator from the steam and that the risk from the alternative, i.e. hot water, is greater because it is kept at 400 – 600 kPa.

Cross-media effects

None reported.

Technical considerations relevant to applicability

Applicable in all slaughterhouses.

Economics

Request to the TWG: Please provide information.

Driving force for implementation

Reduced energy use and water consumption.

Example plants

The technique is applied in the installation FR242 [264, TWG 2020].

The technique has been applied in Norwegian sheep/lamb slaughterhouses for many years.

Reference literature

[134, Nordic States, 2001] [38, Nordic 2001], [274, Pontoppidan O., 2002] [127, Pontoppidan O. 2002] [264, TWG 2020]

3.2.3.2.1.6 Periodic change of water in electrically heated knife sterilisers, controlled by a timer

See also Section 2.3.5.1.3.

Description

Disinfection and cleaning of the cutting tools is done with the application of sterilisers with heating elements and with electric heating of water.

Technical description

A number of large cutting tools are used on the clean slaughter-line. For hygiene reasons, they are cleaned and disinfected several times during the working day, at the end of the day's work and before being used when they have been soiled. In small slaughterhouses, it may be possible to abandon the hot (82 °C) water system if new sterilisers with heating elements are installed and if electric heating of water is installed for major equipment. This significantly reduces heat losses from the hot water system and gives better temperature control. Water consumption can be reduced by periodically changing the water in the sterilisers, using a timer control.

Achieved environmental benefits

Reduced water consumption. Less water at 82 °C is used and consequently, less energy is used to heat the water.

Environmental performance and operational data

The consumption of water at 82 °C, at the clean slaughter-line of a Danish slaughterhouse has been measured to be 24 litres per pig (312 l/t of carcass). The energy consumption for heating this volume of water is in the order of 2 kWh per pig (26 kWh/t of carcass). The consumption in one uninsulated knife steriliser with constantly running water in a Danish slaughterhouse has been measured to be approximately 2 000 l/d.

A periodic change of the water in the steriliser with timer control has been reported to reduce the water consumption to approximately 500 l/d.

Cross-media effects

None reported.

Technical considerations relevant to applicability

Applicable at all slaughterhouses.

Economics

The payback period has been reported to be between 6 months and 2 years.

Driving force for implementation

Reduction of water and energy costs.

Example plants

At least one Danish slaughterhouse.

Reference literature

[134, Nordic States, 2001] [38, Nordic 2001], [169, EC, 1991] [57, COM 1991], [183, Pontoppidan O., 2001] [66, Pontoppidan O. 2001]

Double-knife sterilisation tanks

Description

It has been reported that it is a legal requirement that deboning knives are sterilised between each animal. At an example site, 55 small stainless steel sterilisers, each with 2 tanks supplied with water at 82 °C were designed and installed. Knives are placed in the tanks between each usage and used in rotation to ensure sterilisation. Special flow valves allow only a very small flow to avoid water wastage.

Achieved environmental benefits

Savings are estimated at 1 l/min at each tank. An annual saving of 6 453 m³/yr has been reported.

Cross-media effects

No negative environmental impacts were reported.

Applicability

Fully applicable.

Economics

The implementation costs; actual annual energy and water savings; actual financial savings and payback time are shown in:

Driving force for implementation

Increased energy costs and the identification of a method of systematically reducing these in such a way that could be both measured and related to production levels.

Example plants

A cattle and sheep slaughterhouse in the UK.

Reference literature

[52, DoE, 1994, 129, McIlwaine N., 2001]

Use of cyclonic vacuum cleaners

Description

Table gives the specifications of two sizes of vacuum cleaner in use. They are used to remove blood and viscera from slaughterhouse floors prior to washing.

Table: Cyclonic vacuum cleaner specifications

	Large size	Medium^(†) size
Suction tool	Curved—with open front attached to rubberised, smooth-bore hose (7.6 cm diameter)	Open ended—attached to rubberised smooth-bore hose (5 cm diameter)
Ease of cleaning	60 litre stainless steel drum that can be lifted out	35 litre stainless steel drum that can be lifted out
Method of emptying drum contents	Rubberised, smooth-bore drain hose (10 cm diameter)	Tipping chassis
Approximate dimensions	1.1 m high by 0.6 m wide	0.9 m high by 0.5 m wide
Voltage	240 or 110 volts	240 or 110 volts
Approximate cost (2000)	GBP 800	GBP 650

^(†) Also available as a battery powered unit

Achieved environmental benefits

Reduced water contamination.

Operational data

In an example cattle slaughterhouse, a cyclonic vacuum cleaner was used to remove blood and offal from the slaughter hall floor areas, during the day, prior to wash downs. The separation between blood and cleaning water was also improved by constructional changes and a number of taps and showers were equipped with automatic switches and timers and the water flowrate was adjusted. These measures reduced the slaughterhouse's water consumption by 170 litres per animal, i.e. 680 l/t, which was equivalent to a 15 % saving in water use. The waste water COD was reduced by 0.4 kg, which was equivalent to a reduction of 7 %.

Cyclonic vacuum cleaners can be designed for easy emptying. If they are not emptied and cleaned regularly the risks of odour and infestation problems can increase.

Cross-media effects

Increased use of energy compared to simply hosing down, or using a squeegee.

Applicability

Applicable in all slaughterhouses.

Economics

The investments costs for medium and large cyclonic vacuum cleaners were GBP 650 and GBP 800, respectively in 2000.

Example plants

Several UK slaughterhouses and a Danish slaughterhouse.

Reference literature

{63, ETBPP, 2000}

Demand-controlled drinking water**Technical description**

The water supply can be demand controlled, to supply the required water ration for the animals at suitable intervals. The drinking water supply can be reduced by installing teats that can be opened directly by the animals. The use of teats instead of water troughs has the advantage that water is only supplied when the animals are drinking. Water troughs also require a system to be in place for periodic cleaning.

Achieved environmental benefits

Reduced water consumption.

Cross-media effects

None reported.

Technical considerations relevant to applicability

Applicable in all large animal slaughterhouses.

Driving force for implementation

Reduced water consumption and labour requirements for cleaning.

Reference literature

{331, Italy, 2003}

Dry collection of floor waste

Description

A general principle of modern slaughterhouse operations is to minimise the amount of water that is added to animal by products as they are collected and transported away for further processing or disposal. A lot of blood and waste falls on the floor, e.g. in the slaughter line. The washing of this into the WWTP or sewerage system, can be avoided during the working period, by carrying out all cleaning dry. Shovels, squeegees and vacuum suction can be used. The initial cleaning at the end of the working period can also be carried out without water.

Achieved environmental benefits

Reduced water consumption and consequently a reduced consumption of energy for the later removal of the water from by products in downstream processes, e.g. by evaporation. For recovery operations, inedible waste products such as clotted blood, bone dust and manure from the rumen and from lairages are best maintained in as dry a condition as possible.

Operational data

If meat scraps are washed directly down the drain, they enter the waste water stream and they are subject to turbulence, pumping and mechanical screening. This breaks the meat down and releases high COD substances into solution, along with colloidal and suspended fats and solids. Subsequent waste water treatment either on site or at a municipal WWTP can then be expensive. The breakdown of suspended fats and solids is increased if the water is hot.

In an example plant, it was shown that by using wet suction in the “clean slaughter line”, i.e. where evisceration, splitting, weighing, cleaning and classification takes place, the amount of organic waste collected in a slaughterhouse, increased by 0.2 to 0.8 kg/pig (2.6 to 10.4 kg/t of pig carcass). The pollution of the waste water decreased by 40–50 g BOD per pig (520–650 kg/t carcass).

For a slaughterhouse killing 18 000 turkeys per day, i.e. 38 birds per minute, the reported potential water savings were reported to be 18 000 m³/yr with a financial saving of GBP 11 240/yr. (Costs in 1999)

Cross-media effects

Increased energy use if wet suction is used.

Applicability

Applicable in all slaughterhouses.

Economics

The payback period for a Danish slaughterhouse was calculated as 8 months and 4 years respectively, depending on whether or not a surcharge is paid on the waste water.

Example plants

At least one Danish slaughterhouse.

Reference literature

[27, University of Guelph, undated, 134, Nordic States, 2001, 214, AVEC, 2001]

*Removal of unnecessary taps from the slaughter-line***Technical description**

Unnecessary taps can be disconnected from the slaughter line to encourage and facilitate the dry collection of waste. Only essential hand and protective clothing washing facilities remain.

Achieved environmental benefits

Both the volume and contaminant burdens of waste water are reduced. Avoiding contamination of the water removes the need to clean it afterwards. Contaminants dissolve or physically break down in water into smaller fragments, thereby making their removal increasingly difficult, whether by physical, chemical or biological means. This is particularly significant with blood, blood water, and stomach and intestinal contents from the casing department.

Environmental performance and operational data

Trigger operated hoses required for wet cleaning may be needed.

Technical considerations relevant to applicability

Applicable in all slaughterhouses.

Driving force for implementation

Reduced water consumption.

Reference literature

[134, Nordic States, 2001]

Use of wet suction of by products/waste collection prior to wet cleaning

See also Section.

Technical description

The initial pre-cleaning of delivery vehicles can be done using wet suction. Norwegian tests have shown that it is necessary to use a vacuum system with high suction power when the mixture of manure and bedding becomes dry. The time needed for pre-cleaning is not affected. The system can also be used in the lairage area and for the collection of blood residues and soft tissues.

Achieved environmental benefits

Reduction of both water consumption and the contamination of waste water, by blood, fat, manure and other animal by products. Water is still required for cleaning

Cross-media effects

Energy required for operation of the suction equipment. The storage of manure may cause odour problems.

Environmental performance and operational data

A central system, which removes the need for a mobile collection tank and trailing cables, may be advantageous in the slaughterhouse environment.

By using wet suction in the clean slaughter area, it has been reported that a pig slaughterhouse increased the amount of solid by product it collected by 40–50 g BOD per pig, i.e. from 2.6–10.4 kg/t of carcase.

Technical considerations relevant to applicability

Applicable in all slaughterhouses, for cleaning vehicles, the lairage, and the slaughter, dressing and evisceration areas.

Economics

The reported cost is in the order of NOK 170 000.

The payback time for the introduction of a wet suction system in the clean slaughter area of a Danish slaughterhouse has been calculated to be 8 months, where a surcharge on waste water is paid and approximately 4 years where it is not.

Driving force for implementation

Saving money through reduced waste water treatment requirements.

Example plants

At least one Danish pig slaughterhouse.

Reference literature

{134, Nordic States, 2001}

Hand and apron cleaning cubicles—default “water-off”

Technical description

A slaughterman is required to wash his hands several times during the working day and each time he resumes work following a break. It is generally accepted that it is good practice to use water at 42 °C. At some workstations apron washing is also required. At an example slaughterhouse, it was customary to do this using a variety of hose pipes and wash basins, using hot water which was left running during the entire working day. This resulted in an enormous waste of water and energy, as well as leading to poor general conditions.

The hose pipes and wash basins were replaced by cubicles fitted with shower heads operated by foot pedals. The system can be a “dead mans control” design, where if the pedal is not depressed the water flow stops automatically. Alternatively, the shower head can be operated by a photoelectric system, which detects the slaughterman’s presence and turns on the water, with the default being automatic stoppage of the water.

Achieved environmental benefits

At the case study installation, there was an estimated water saving of 2 l/min at each washing point. This gave a total water saving of 11700 m³/yr. Considering the requirement for this water to be heated to 42 °C, the reduction in energy use was 2035 GJ.

Cross-media effects

No negative environmental impacts were reported.

Technical considerations relevant to applicability

Applicable in all slaughterhouses.

Economics

The implementation costs; annual actual energy and water savings; actual financial savings and payback time are shown in.

Driving force for implementation

Increased energy costs and the identification of a method of systematically reducing these in such a way that could be both measured and related to production levels.

Example plants

A cattle and sheep slaughterhouse in the UK.

Reference literature

[52, DoE, 1994, 169, EC, 1991, 237, Italy, 2002, 243, Clitravi – DMRI, 2002]

Wash delivery lorries using a high-pressure trigger-operated pistol with an adjustable jet

Technical description

Delivery lorries can be cleaned using a high-pressure trigger-operated adjustable water jet.

Achieved environmental benefits

Reduced water consumption.

Cross-media effects

None, if combined with “Dry scraping of delivery vehicles, prior to washing”, see .

Environmental performance and operational data

Water consumption at a Danish slaughterhouse was reduced to 6 litres per pig (78 l/t) and 25 litres per head of cattle (100 l/t) when dry scraping was used prior to washing and a trigger-operated self-closing high-pressure pistol was used for the subsequent washing. The same source of information reported consumption rates of 10 l/pig and 80 l/head of cattle.

Technical considerations relevant to applicability

All slaughterhouses.

Economics

The reported capital cost in a pig slaughterhouse was recouped in approximately 6 months. The payback period reported in a slaughterhouse killing 40 000 head of cattle annually, was 4–5 years, this is longer than the pig example before due to its less frequent use.

Driving force for implementation

Reduced waste-water treatment costs.

Example plants

At least one Danish slaughterhouse.

Reference literature

Dry scraping of delivery vehicles, prior to washing

Technical description

At a major pig slaughterhouse in Denmark, the reception area for pigs has been equipped with a system for collecting manure and bedding. After unloading the pigs the driver of the delivery vehicle scrapes the manure and bedding on to a low level belt conveyor, which carries the material to a container. The unloading of pigs and dry scraping are monitored on a video camera. This together with instructions to the drivers, ensures that the procedure is followed and complied with. After dry scraping, the vehicle is cleaned with water.

Achieved environmental benefits

Both the water consumption and the pollution burden in the waste water are reduced. This includes removal of substances difficult to degrade, e.g. sawdust. Water is still required.

Manure may be used as a fertiliser.

Cross-media effects

None.

Environmental performance and operational data

Technical considerations relevant to applicability

Applicable in all slaughterhouses.

Driving force for implementation

Reduction of water consumption and COD levels in waste water.

Example plants

At least one major pig slaughterhouse in Denmark.

Reference literature

Dry cleaning of the lairage floor and periodically cleaning it with water

Technical description

Achieved environmental benefits

Reduced water consumption.

Cross-media effects

Infrequent wet cleaning can increase odour emissions.

Environmental performance and operational data

Based on Norwegian experiences in a cattle slaughterhouse, it is reported that dry scraping in a lairage where animals are kept overnight, can reduce the discharge by 700–800 g BOD and 7–8 g total P per animal (2.7–3.0 kg BOD/t and 26.6–30.4 g P/t).

In practice it can be difficult to ensure the required room/access to achieve this.

Technical considerations relevant to applicability

Applied in at least one Norwegian cattle slaughterhouse.

Economics

Inexpensive

Driving force for implementation

Reduced water consumption and waste water contamination.

Reference literature

{134, Nordic States, 2001}

Use pressurised water to wash the carcass

Technical description

Cross-media effects

Although solid fat may not be detached, there may be some entrainment of fat in suspension.

Environmental performance and operational data

High pressure operation may cause contamination by over splash, thereby spreading contamination instead of removing it. High volume/low pressure washing is more effective than high pressure/low volume washing for removing wool and hair.

Technical considerations relevant to applicability

Applicable in all slaughterhouses.

Reference literature

[167, Greek Ministry for the Environment, 2001]

3.2.3.2.2 Techniques relating to casings and offal treatment

~~See also techniques for fat separation from water after evisceration in Section.~~

3.2.3.2.2.1 Dry emptying of stomachs**Description**

Emptying of stomachs with the use of machines with no use of water, apart from the amount used to clean the knife for cutting the stomachs.

Technical description

The stomachs can be cut open in a machine. The contents fall into the base of the machine, from where they are pumped away for use in, e.g. biogas production or composting. Machines are available which can empty the stomachs without using water, apart from the amount used to clean the knife for cutting the stomachs.

Achieved environmental benefits

Reduced water consumption and consequently a reduced volume and BOD loading of waste water.

The stomachs can be used as human food, e.g. ox tripe, or for pet food.

Environmental performance and operational data

Modifying old machines from double rinse to single rinse halves the water consumption.

Cross-media effects

None.

Technical considerations relevant to applicability

For a Danish slaughterhouse, the capital cost for a new pig stomach emptying machine can be repaid in approximately 5 years. Applicability may, therefore, be limited to new or refurbished casing cleaning departments. Old stomach emptying machines with a double rinse can, however, be altered to single rinse machines, at low cost.

Economics

The cost, including for a new stomach machine is approximately EUR 28 000. The cost of modification of an old stomach machine is approximately EUR 16 000.

Driving force for implementation

Reduced water consumption and treatment costs.

Example plants

Slaughterhouses in Denmark [203, Denmark 2015].

Reference literature

[134, Nordic States, 2001] [38, Nordic 2001], [183, Pontoppidan O., 2001] [66, Pontoppidan O. 2001], [317, German TWG, 2002] [64, COM 2000] [203, Denmark 2015]

3.2.3.2.2.2 'Dry' collection of the contents of intestines

Description

Intestines are emptied by pulling them between a pair of rollers. The content is then collected in a tray and pumped to a container.

Technical description

The content of pigs' small intestines which are to be used as casings can be collected dry. The first stage in the cleaning involves emptying the intestines by pulling them over a pair of rollers. The content can then be collected in a tray and pumped to a container for manure, stomach content, etc. The edge must be kept wet to avoid damaging the intestines, but a minimum amount of water can be used in order to limit the dilution of the intestinal content. The wetting can be done with nozzles, and the water supply can be stopped when no intestines are present. The content of the small intestines is an easy flowing, slimy mass. It is, therefore, important to ensure that there is no drainage from the collection container.

Condemned intestines and their contents can be separated prior to rendering. The intestines are cut to enable them to be separated from their contents during centrifugation. In principle, the centrifugation can be done without the use of water, other than that required for cleaning the centrifuge. Water is, however, often added, to make the content so thin that it can be pumped with a simple pump system, to the manure silo. Selecting a suitable pump type and screw conveyor can eliminate the requirement for adding water.

Achieved environmental benefits

Reduced water consumption and consequently a reduced volume and BOD loading of waste water.

The intestines can be used for sausage casings or pet food.

Environmental performance and operational data

The importance of collecting the stomach and intestinal contents dry is illustrated by the high contribution to overall waste water contamination from wet emptied stomach and intestinal contents. , as reported in Section.

Cross-media effects

None.

Technical considerations relevant to applicability

Applicable in all pig slaughterhouses.

Economics

In a slaughterhouse slaughtering 400 - 600 pigs per hour, the cost will be approximately EUR 10 000 – 15 000 for collecting the stomach contents and EUR 20 000 for small intestine contents. If only one of the items is installed the cost will be higher.

Driving force for implementation

Reduction of pollution and its costs.

Example plants

Slaughterhouses in Denmark [203, Denmark 2015].

Reference literature

[134, Nordie States, 2001] [38, Nordic 2001], [183, Pontoppidan O., 2001]- [66, Pontoppidan O. 2001], [203, Denmark 2015]

3.2.3.2.2.3 Regulation and minimisation of water use for moving intestines

See Section 2.3.5.1.3.

Achieved environmental benefits

~~Reduced water consumption and reduced water entrainment of high BOD material, especially intestine contents.~~

~~The intestines can be used for sausage casings or pet food.~~

Cross-media effects

~~None.~~

Technical considerations relevant to applicability

~~Applicable in all slaughterhouses.~~

Economics

~~Reduced water consumption, therefore, lower expenditure for water and waste water treatment.~~

Driving force for implementation

~~Reduced water consumption.~~

Reference literature

~~[134, Nordic States, 2001]~~

~~Dry" emptying of pig intestines, which are not to be used for casings~~

Technical description**Achieved environmental benefits**

~~Reduced water consumption and consequently a reduced volume and BOD loading of waste water. The water used is warm so there are also energy savings.~~

~~The reduced water content of the condemned intestines also reduces the energy costs associated with driving off the water at the rendering plant.~~

~~The manure can be used as fertiliser, after gas production in a biogas plant.~~

Applicability

~~Applicable at all slaughterhouses where intestines are emptied.~~

Economics

~~For a Danish slaughterhouse, the payback period for the required capital cost is calculated to be approximately one year.~~

Driving force for implementation

~~Reduced water use and costs. The separation of the by products into intestine material and contents enables them to be put to different uses, depending on the current market.~~

Example plants

~~Applied in at least one Danish slaughterhouse.~~

Reference literature

~~[134, Nordic States, 2001, 183, Pontoppidan O., 2001]~~

~~Minimise water usage during rinsing of tongues and hearts~~

Technical description

Achieved environmental benefits

Reduced water consumption and contamination. Drums for washing tongues and other by-products have a very high water use. Up to 50 litres per head (192 l/t cattle carcass) have been measured.

The tongues and hearts can be used for human food or for pet food.

Cross-media effects

None.

Applicability

Applicable in all cattle slaughterhouses.

Driving force for implementation

Reduced water consumption and reduced waste water volume.

Reference literature

[134, Nordic States, 2001, 183, Pontoppidan O., 2001]

Air-chilling

Description

Air chilling is generally used where the carcasses are for sale fresh. Chilling can be carried out by batch in a chill room or by a continuous air blast method.

Achieved environmental benefits

Greatly reduced water consumption, compared to immersion/spin chilling or spray chilling. Tests have shown that air chilling can reduce the food contamination rate by up a third of that after immersion chilling. Food contamination caused by immersion chilling is not only intrinsic to the process, which involves the same birds passing through common water, but it depends on the effectiveness of the pre-chilling wash. During immersion chilling, carcasses take up water and in some MSs microbial contamination is controlled by chlorination, within potable water limits.

Likewise, preventing water contamination depends to some extent on how well the birds are prepared, e.g. to prevent heads and feet breaking off during chilling.

Operational data

Air chillers can be designed to accommodate up to 3 layers of birds. This can save energy and space.

Cross-media effects

The energy consumption is higher than that required for cooling water or for making ice for immersion/spin chilling, or water for spray chilling. The refrigeration plants operate continuously. The condensing units, compressors and cooling towers associated with refrigeration can be a source of noise.

Applicability

All chicken slaughterhouses producing fresh poultry meat.

Economics

Air chilling is more expensive than immersion/spin chilling.

Driving force for implementation

Food hygiene.

Example plants

Most chicken slaughterhouses.

Reference literature

[12, WS Atkins EA, 2000, 67, WS Atkins Environment/EA, 2000, 308, Hupkes H., 2002]

*Controlling the supply of water to the immersion/spin chiller***Description**

Immersion/spin chillers can be the biggest users of process water for chilling, compared to other methods.

The volume of water supplied can be controlled, so that the required amount is maintained and not exceeded. Supplying water only according to the number of slaughtered chickens can ensure this.

Achieved environmental benefits

Reduced water consumption, water contamination and waste water treatment. Reduced energy consumption for cooling water.

Operational data

For a slaughterhouse killing 18 000 turkeys per day, i.e. 38 birds per minute, the reported potential water saving is 16 000 m³/yr with a financial saving of GBP 9 995/yr. The cost quoted per spin chiller is GBP 200. (Costs in 1999)

Applicability

Applicable in all poultry slaughterhouses applying spin chilling.

Economics

The reported payback time is one month.

Driving force for implementation

Reduced water consumption and consequent cost savings for waste water treatment, within discharge volume limits.

Reference literature

[134, Nordie States, 2001, 214, AVEC, 2001]

NOT showering carcasses before they are chilled in a chilling tunnel

Description

The need for carcasses to be showered prior to entering a chilling tunnel should be examined as not all slaughterhouses do it. Generally, following scalding, pig carcasses don't require further cleaning, although they are cooled with water after singeing.

Achieved environmental benefits

Reduced water consumption.

Operational data

If the carcasses need to be washed before chilling, it can be done with nozzles, rinsing the required areas only, i.e. the belly at the first skin incision, parts of the front legs and the neck. The water supply can be controlled to ensure that water flows, only when the carcasses are in the correct position in relation to the nozzles, or it can be controlled by handheld trigger-operated nozzles.

The washing of carcasses should not take place before they have been through the routine official veterinary inspection, because visible contamination may be washed away and make microbiological contamination difficult or impossible to detect.

Cross-media effects

None.

Applicability

~~Applicable in all slaughterhouses. It is reported that this technique cannot be applied in Italy, when the carcasses are destined for the production of typical Italian cured products are cut prior to chilling.~~

Reference literature

[134, Nordic States, 2001, 237, Italy, 2002]

3.2.3.3 Techniques to reduce emissions to water

3.2.3.3.1 Optimisation of bleeding and blood collection

Description

The bleeding operation is optimised to ensure that the maximum quantity of blood is collected and contained at the bleed area.

Technical description

The bleeding operation can be optimised to ensure that the maximum quantity of blood is collected and contained at the bleed area. This reduces the requirement to manage dripping blood along the length of the slaughter-line.

For large animals, the use of hollow knives gives a lower yield of blood collection than the more traditional method of cutting the animal's throat to initiate bleeding, which is then assisted by the animal's heartbeat and by gravity. For pigs, the blood yield has been reported to be 75 - 80 %. In most cases the time for bleeding using a hollow knife is limited to 20 - 40 seconds, because of the speed of operation of the slaughter-line and because this is reported to be the time needed to collect the highest quality blood by this method. In practice, the bleeding time with the hollow knife can be extended, to maximise the hygienic collection of blood. The animals can subsequently be hung over a blood collection trough until the amount of blood dripping from the carcass is insignificant. The second "bleed" contains clots, so it is not food/pharmaceutical grade blood and it may be sent for, e.g. rendering, biogas production or composting. The use of the hollow knife method for the hygienic collection of blood from cattle has ceased in some countries, e.g. Denmark, because blood from ruminants is not used for human consumption, or animal feed, although it is still used in some other countries for human food and pet food.

Where the traditional method of bleeding is used, the time allowed for this may be calculated to optimise the blood collection. It has been reported that for cattle the optimum bleeding time is about 7 minutes and for pigs is 5 - 6 minutes.

It is reported that bleeding carousels can be supplied with bleeding alarms that sound if not enough blood has been drained out of the animal before it leaves the bleeding area. Bleeding carousels for hollow knife bleeding can be operated by one operator for up to 360 - 380 pigs/h, or 120 - 130 cattle/h. At higher capacities, 2 operators are required. It is also reported that during traditional bleeding, the knife disinfection required between each animal is often omitted by the operator, but that this is less likely when a bleeding carousel is used.

The hollow knife method is not relevant to poultry. The blood is not collected for food, feed or pharmaceutical use, although it can be fed to fur animals, otherwise it has to be disposed of. Nevertheless optimisation of the collection minimises the amount which ends up in the WWTP. It is reported that 90 seconds is normally sufficient time and that the blood is stored in chilled vessels to prevent odour problems.

Discussion can take place between blood plants and slaughterhouses regarding optimising blood collection for subsequent blood processing. Blood processors may stipulate that hollow knives and small drip trays are used to collect blood. Blood for rendering is usually collected in large trays or on the bleed hall floor, from where it drains away to collection tanks. Slaughterhouses sell blood to blood processing companies and renderers charge for its collection. The cost depends on the disposal method. ~~In the UK, collection for rendering can cost twice as much as for land injection, which was practised, but is now banned by ABP Regulation 1774/2002/EC.~~ In Italy, it costs approximately EUR 75 for the collection of one tonne of blood. The bleeding area can have drip troughs fitted above floor level, to minimise contamination. The troughs can have falls to facilitate wet suction and/or scraping of blood or coagulated blood lumps to the blood tank prior to cleaning. Some installations carry out both blood processing and rendering on the same site and the transport of blood for both activities may be easily facilitated. With the agreement of the company receiving the blood, the water from the initial washing can be collected in the blood tank.

The extension of blood collection times does not necessarily have to slow down production. A sufficient number of hollow knives can be provided in the carousel to ensure that there is enough time for the bleeding process, without a queue developing before bleeding or waiting time after bleeding. Likewise, for bleeding by the traditional cut to the throat, collection can be extended by a number of means. The bleeding trough can be extended in the bleed hall and a stainless steel collection trough/slide, which drains to the blood tank, can be installed which extends from the blood collection area all the way to the scalding tank or de-hiding area. In short bleed halls both the overhead rail, from which the carcasses are suspended and the bleeding trough can be designed to follow a circuitous route, which allows enough time for bleeding. The “circuitous route” option reportedly works well for sheep. The trough/slide can be movable, or detachable, as necessary.

Extending the blood collection facilities reduces the importance of training slaughtermen in methods to minimise drip loss along the line, e.g. not to manually shunt pigs towards the scalding tank prematurely.

Achieved environmental benefits

A higher proportion of blood is used in processes downstream of the slaughter and so consequently less ends up in the waste water, for treatment in either the on-site WWTP or the municipal WWTP. Blood contamination of water leads to elevated BOD, COD and nitrogen levels. If blood is allowed to drip along the length of the slaughter-line, it will drain into the WWTP, as well as potentially adding to the cleaning water consumption requirements for the plant and equipment.

In addition, the collection of blood with minimal water uptake increases the yield of usable blood and reduces the energy consumption, for treatments where the blood is dried. Otherwise energy has to be expended to handle and remove the water.

Environmental performance and operational data

The following blood yields have been quoted following the use of traditional bleeding methods. For cattle, 16 litres of blood can be collected in 1 minute, from a total of 18 l. In this case the kill speed is quite low and in 2 minutes practically all the blood could be collected, using a long tray. For pigs, 3.2 litres of blood can be collected in the first 40 seconds immediately after the slaughtering and 3.5 litres in 1 minute, of a total of potentially 3.8 litres.

A small slaughterhouse reportedly implemented several improvements, including increasing the bleeding time for cattle to 7 minutes; it collected and separated the blood for composting instead of dumping it in the local river; controlled inventories; reduced salt consumption and established a training programme. After less than one month, the company had reduced its water consumption by 15 %, the pollutant load in the waste water by 34 % and the consumption of salt by 60 %.

Cross-media effects

Blood processing causes less contamination of waste water than blood rendering, but the energy consumption for processing is at least twice as high as that for rendering blood.

Technical considerations relevant to applicability

The collection and separation of blood, instead of discharging it either to a river or to a WWTP, is applicable to all slaughterhouses. Some slaughterhouses discharge blood to their local WWTP or collect it in a tank and then send it by tanker to a WWTP which is designed to treat it.

The provision of an extended stainless steel collection trough/slide, is applicable in all slaughterhouses.

Economics

The payback time for the increased bleeding time, for composting the separated blood, controlling the inventories, reducing the salt consumption and establishing a training programme was less than one month.

The cost of the trough/slide is about EUR 300 per metre.

Driving force for implementation

The driving force for the increased bleeding time was the reduction of water consumption and high organic load in its waste water.

The driving force for provision of an extended stainless steel collection trough/slide was a reduction in waste water treatment cost.

Example plants

Extended stainless steel collection trough/slides are used in a small poultry slaughterhouse and a small pig slaughterhouse in Denmark.

Reference literature

[134, Nordie States, 2001] [38, Nordic 2001], [183, Pontoppidan O., 2001] [66, Pontoppidan O. 2001], [220, APC Europe, 2001] [96, APC Europe 2001], [248, Sorlini G., 2002] [112, Sorlini G. 2002], [260, EAPA, 2002] [116, EAPA 2002], 262, United Nations Environment Programme, 2002] [117, UNEP 2002], 271, Casanellas J., 2002] [124, Casanellas J. 2002], [283, Brindle J., 2002] [134, Brindle J. 2002], [284, Leoni C., 2002], [308, Hupkes H., 2002] [156, Hupkes H. 2002]

3.2.3.3.2 Use of a squeegee for initial cleaning of the blood collection trough

See also Section 2.3.5.2.1.

Description

A squeegee with an offset handle is to remove blood without using initial washdown water.

Technical description

A squeegee with an offset handle can be used to remove blood from the blood trough into the blood collection vessel without using initial washdown water.

Achieved environmental benefits

Reduced consumption of water for cleaning and reduced COD and BOD levels in the waste water. Increased potential for waste minimisation. Increased potential for recovery or recycling of blood. The water previously used in the initial wash down no longer had to be handled and heated in the blood recovery process.

Environmental performance and operational data

The system was reportedly introduced in an example pig slaughterhouse, to replace the practice of using 6 sprays along and above the bleed trough to wash some blood from the trough into the blood collection vessel. This reportedly removed 50 - 60 % of blood in the trough, but resulted in some water going to the blood collection vessel and the remainder of the blood going to the WWTP. The use of the squeegee reportedly enables 80 – 90 % of the blood on the trough to be recovered. For the example slaughterhouse, this resulted in the recovery of an additional 11.3 kg/d of blood, representing 2.3 kg BOD, which had previously been directed to the WWTP. The additional labour required was considered to be insignificant.

Cross-media effects

None.

Economics

Request to the TWG: Please provide information.

Technical considerations relevant to applicability

Applicable in all slaughterhouses.

Driving force for implementation

Reduction of water consumption, waste water production and waste water contamination.

Example plants

This technique is commonly used at UK slaughterhouses [241, TWG 2019]. ~~At least one pig slaughterhouse in the US.~~

Reference literature

~~[268, Ockerman H. W. and Hansen C. L., 2000]~~ [122, Ockerman H.W. and Hansen C.L. 2000]
[241, TWG 2019]

3.2.3.3.3 Double drain from the bleed hall**Description**

The bleed hall has a system with two drains, one to the collection tank and one to the sewer.

Technical description

The bleed hall can have a system with two drains, one to the collection tank and one to the sewer. The system is designed so that the drain to the collection tank is open during slaughtering and the drain to the sewer is closed. During cleaning the opposite is true. The maximum possible proportion of the blood can be collected without dilution with water. The discharged waste water can contain a minimum quantity of blood. Some systems incorporate an interlock system, which prevents slaughtering from starting if the drain to sewer or to a blood tanker is open.

Additionally, before hosing the bleed hall area, the blood can be scraped with a squeegee to the collection tank.

Achieved environmental benefits

Reduction of organic matter (BOD) and N in waste water. Collected blood can be used for manufacturing blood meal.

Environmental performance and operational data

Request to the TWG: Please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

Applicable in all slaughterhouses.

In existing plants, it will be necessary to change the floor gradient in the bleed hall and to install a collection tank for blood. The changes can usually be made within the existing available area.

Economics

The total cost for changing the floor drain is in the order of EUR 25 000 – 35 000.

Technical considerations relevant to applicability

Applicable in all slaughterhouses.

Driving force for implementation

The reduction of organic matter and nitrogen in waste water, thereby reducing the cost of waste water treatment and discharge.

Example plants

This technique is commonly used.

Reference literature References to literature

[134, Nordic States, 2001] [38, Nordic 2001], [183, Pontoppidan O., 2001] [66, Pontoppidan O. 2001], [317, German TWG, 2002] [64, COM 2000]

3.2.3.3.4 Cessation of feeding of animals 12 hours prior to slaughter

Description

Feeding of the animals is stopped 12 hours prior to slaughter.

Technical description

Stopping feeding the animals 12 hours prior to slaughter reduces the quantity of undigested contents in their stomachs. However, the animals are not necessarily under the control of the slaughterhouse 24 hours before slaughter, so the implementation of such a policy would require co-operation with the farmer and the haulier, taking care not to contravene any animal welfare requirements.

Achieved environmental benefits

Reduced manure, paunch and soiled bedding, which might otherwise increase the BOD of wash-water, from vehicles, the installation, the equipment and the animals and which will subsequently require waste water treatment. The risk of odour arising from the manure, paunch and soiled bedding could be reduced.

Environmental performance and operational data

Request to the TWG: Please provide information.

Council Directive 93/119/EC of 22 December 1993 on the protection of animals at the time of slaughter or killing states that Animals which are not taken directly upon arrival to the place of slaughter must have drinking water available to them from appropriate facilities at all times. Animals which have not been slaughtered within 12 hours of their arrival must be fed, and must subsequently be given moderate amounts of food at appropriate intervals.

Cross-media effects

None.

Economics

Request to the TWG: Please provide information.

Technical considerations relevant to applicability

May not be applicable due to animal welfare considerations [241, TWG 2019]. ~~Applicable in all slaughterhouses.~~

Driving force for implementation

Reduced manure production and consequently reduced waste water contamination. There are hygiene benefits too, due to the decreased risk of faecal contamination of hides and carcasses.

Example plants

This technique is commonly used.

Reference literature

~~[115, EC, 1993] [34, COM 1993], [167, Greek Ministry for the Environment, 2001] [55, Greek Ministry for the Environment 2001], [241, TWG 2019]~~

3.2.3.3.5 ~~Minimise~~ Minimisation of animals' time in the slaughterhouse to reduce manure production

Description

The time that animals are kept in the slaughterhouse is shortened, whilst respecting animal welfare considerations.

Technical description

Shortening the time that animals are kept in the slaughterhouse, whilst respecting animal welfare considerations, will reduce the amount of urine and faeces produced.

Achieved environmental benefits

Reduced manure, paunch and soiled bedding, which might otherwise increase the BOD of wash-water and require waste water treatment. These materials are, however, the raw materials for biogas manufacture and composting, so any produced need to be collected as dryly as possible and with minimum mixing with other wastes to be useful.

Environmental performance and operational data

The implementation of such a policy would require co-operation with the farmer and the haulier, taking care not to contravene any animal welfare requirements.

Cross-media effects

A reduction of the amount of manure or faeces produced in the lairage will mean that the stomach and intestinal contents of the slaughtered animal will be greater. These will then have to be collected during and after evisceration.

Economics

Request to the TWG: Please provide information.

Technical considerations relevant to applicability

Applicable in slaughterhouses where the delivery of animals can be managed to coincide with slaughter times, therefore, minimising the time the animals are kept in the lairage.

Driving force for implementation

Efficient operation of the slaughterhouse.

Example plants

This technique is commonly used.

Reference literature

~~[167, Greek Ministry for the Environment, 2001] [55, Greek Ministry for the Environment 2001]~~

Removal of chopping blades from a by-product washer

Description

The blades may be removed from an animal by product washer so that the manure is collected with the intestines, etc. and, e.g. sent for rendering.

Achieved environmental benefits

It allows the further recovery and recycling of substances. It also permits a substantial reduction in BOD, suspended solids, and other pollutants going to the WWTP. Reduced energy use for running the chopping blades and the WWTP.

Operational data

At a pig slaughterhouse, the by product washer drain was the largest contributor of pollution load from the kill floor. Intestines and large quantities of other solid materials were washed into the by product washer from various parts of the kill floor. Blades slashed the intestines, to enable the water to wash away the intestinal contents. The objective was to send the fat and meat solids for inedible rendering and the waste water to the WWTP. The separation of solids and liquid was inefficient, so large quantities of solids ended up in the WWTP, causing an extremely high load in terms of, e.g. BOD solids, grease, and other pollutants.

After the chopping blades were removed from the by product washer, the unit functioned only as a dewatering device. The large and small intestines and their contents remained intact and were sent to inedible rendering. This increased the quantity of meat scrap and material for rendering by an average of 3856 kg/d.

Table and Table show pollution and cost savings as a result of the removal of the washer blades.

	Pollution load (parts per thousand per week, by weight)		Net reduction (parts per thousand per week, by weight)	Total for plant (kg/day)
	Before change	After change		
Flow	No change	No change	-	-
BOD	2.70	0.6498	2.050	1337
SS	2.35	0.324	2.020	1318
Grease	2.83	0.255	2.625	1712
TKN	0.23	0.134	0.096	63
COD	6.80	1.581	5.219	3404

Table: Reduction in production shift waste water contamination, due to removal of the washer blades

	Pollution reduction	Saving (USD 2000)
Flow savings	None	None
BOD savings	334110 kg/yr	23518
SS savings	329540 kg/yr	19179
Total annual savings		42697
Cost of modification		275
Based on 250 d/yr; USD 1.48/m ³ ; USD 0.07/kg BOD; USD 0.06/kg SS—costs in 2000		

Table: Annual cost savings associated with removal of the washer blades

Cross-media effects

These depend on the use or disposal route for the by products. Additional pollution is associated with transport of the solids to the animal by products installation.

Applicability

Applicable in all slaughterhouses.

Economics

In the US, the value to the slaughterhouse for additional material going to rendering was USD 488.75/d. This accounted for additional income, because in spite of it being of lower quality the additional quantity was worth more. In the EU, if the material was sent for rendering there would be a cost to the slaughterhouse. There would, however, be savings in WWTP operation charges, due to the decreased load. Figures are not available to compare the costs and savings.

Driving force for implementation

Financial savings.

Example plants

A pig slaughterhouse in the US.

Reference literature

[268, Ockerman H. W. and Hansen C. L., 2000]

Addition of dry bedding to existing bedding, to soak up manure**Technical description**

The addition of bedding, whether as straw or paper, on existing bedding, can reduce the potential BOD levels in waste water.

Achieved environmental benefits

Reduced BOD levels in the waste water.

Cross-media effects

There may be increased odour problems, due to the reduced frequency of changing bedding.

Environmental performance and operational data

Bedding levels may be topped up over a period of up to one week and then removed for, e.g. use as compost, after which the floor may be washed down.

Technical considerations relevant to applicability

Applicable in all slaughterhouses where the animals require bedding.

Driving force for implementation

Reduced BOD levels in waste water.

Example plants

Some UK slaughterhouses.

Collection of the mucosa from small intestines (pigs)**Technical description**

Mucosa is the mucous membrane of the small intestine. It is removed during the cleaning process. It has a very high BOD and can be collected without being mixed into the waste water. Mucosa can be pressed out and then collected, by pumping it to a tank. The material is pulpy, so it is essential that the pump is reliable, to prevent blockages from occurring.

Achieved environmental benefits

Reduction of organic matter (BOD) in the waste water.

Mucosa can be used by the pharmaceutical industry, for manufacturing heparin or it can be rendered or used in biogas installations.

Cross-media effects

None.

Environmental performance and operational data

Approximately 1.8 kg of mucosa can be collected per pig (23 kg/t of carcass).

Economics

The cost for a pump and control system for pumping the material to the manure tank is approximately EUR 12 000–16 000.

If the material is to be used for the manufacture of heparin, it will be necessary to install a tank and equipment for preservation. The total cost will be then be about EUR 40 000.

Driving force for implementation

Reduction of organic pollution of waste water and the costs of treating or discharging it.

Reference literature

[134, Nordic States, 2001, 183, Pontoppidan O., 2001]

Use of a mechanised fat trap for removing fat from water

Technical description

The warm outlet from the cleaning of small intestines and the water from centrifuges contain high levels of fat and protein and can be pre-cleaned in an automatic fat removal unit, prior to discharge. Allowing the temperature to fall first and then adding flocculants maximises the fat and protein separation. Passing the fat through a sieve cleaned with cold pressurised water also prevents the fat from dissolving and makes its collection easier.

A mechanised fat trap is normally constructed as a rectangular or circular stainless steel tank. The water is retained in the tank until the fat is separated onto the surface, where a mechanical scraper system transfers it to a storage container.

Achieved environmental benefits

Reduction of BOD and N in waste water.

The fat can be used for rendering.

Cross-media effects

None.

Environmental performance and operational data

Figures of 80 % fat retention and collection of about 360 g of fat per pig (4675 g/t of carcass) have been reported.

Technical considerations relevant to applicability

Applicable in most slaughterhouses, since the fat trap does not require a lot of space.

Economics

A fat trap costs approximately EUR 35000–40000.

Driving force for implementation

Reduction of pollution and cost of waste water treatment and/or discharge.

Example plants

Several German rendering plants.

Reference literature

[134, Nordic States, 2001, 183, Pontoppidan O., 2001, 244, Germany, 2002]

Microbiological treatment of slaughterhouse waste

Technical description

A biological treatment system using a tailored microbial culture has been reported. Three waste streams from a slaughterhouse, i.e. wash-water, stomach contents and blood are combined and treated in a two-stage, aerobic digestion process. The technology is reportedly applicable to other wastes with a high blood and/or fat content.

The sludge produced by the digesters is dewatered on a belt press, to give a biomass with a commercial value as a fertiliser. Analysis of the biomass shows that it contains elevated levels of the major plant nutrients nitrogen, phosphorus, potassium, magnesium and sulphur.

Liquid from the belt press undergoes a final biological polishing and is either collected in a tanker for landspreading, or used for belt washing. The final effluent is reportedly suitable for yard washing, after veterinary approval.

This two-stage, biological system has been shown to be capable of treating high strength wastes with a COD content of over 100 g/l and of adapting to a wide range of pollutant loads.

The process is shown in the Figure.

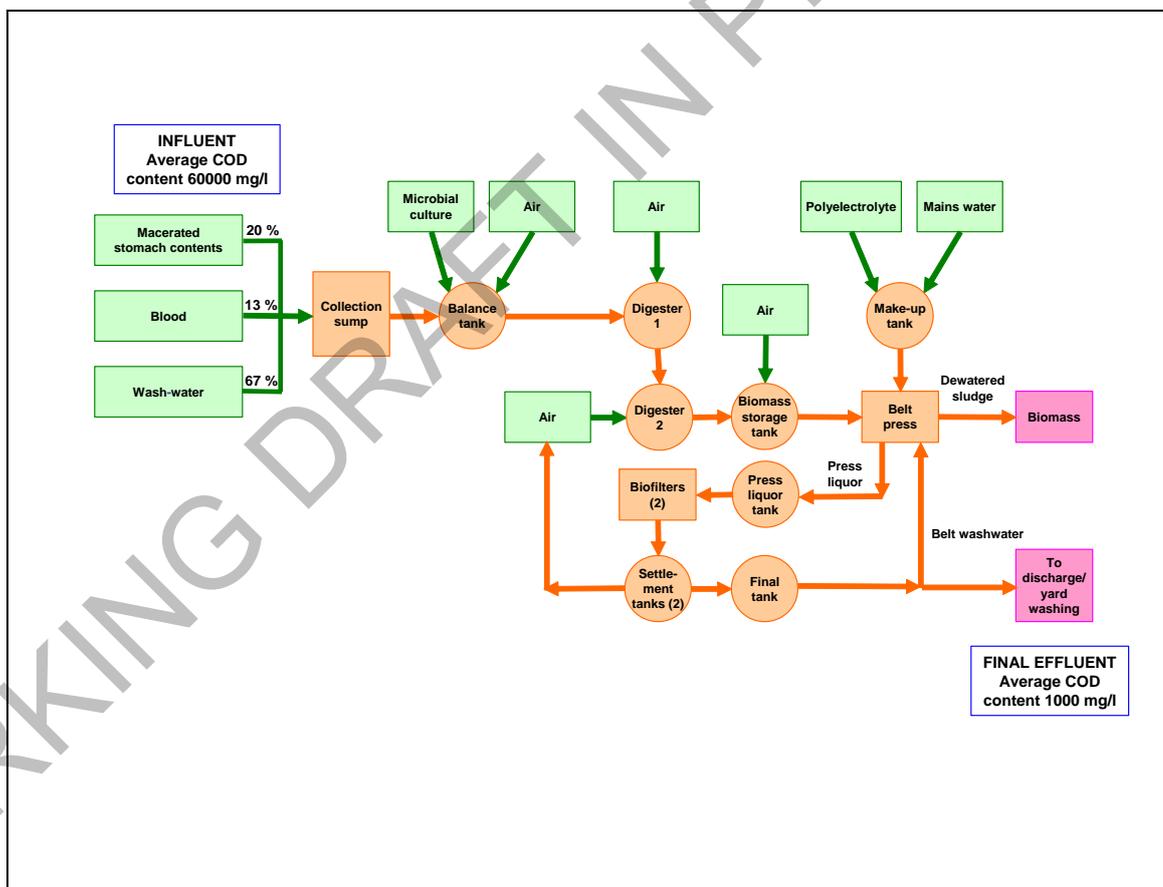


Figure : Schematic of the biological treatment process for high strength slaughterhouse wastes [56, ETBPP, 1997]

Achieved environmental benefits

Waste water treatment producing water and solids which can be used instead of needing to be disposed of. Although not within the scope of IPPC, environmental benefits from the reduced transportation of by products may be reported.

Cross-media effects

Some energy use for the operation of the process and odour from the biomass.

Environmental performance and operational data

The combined influent to the treatment plant consists of 67 % wash water, 20 % macerated stomach contents and 13 % blood. These waste streams vary in COD and suspended solids content owing to changes in slaughterhouse throughput and the type of animal slaughtered. The average COD content of the combined influent is 60 g/l, although levels of over 100 g/l can occur.

From the collection sump, the combined waste streams are pumped to a balance tank at a rate of approximately 45 m³/d. The balance tank, which is aerated, provides a buffer against extremely high pollutant loads entering the biological stage of the process and ensures a steady feed to the first digester. Dried microbial culture is regularly added to the balance tank. The modular design of the two-stage aerobic digestion process allows for operational flexibility and variable capacity. The process requires no external heating or cooling.

The sludge produced during the biological treatment process is dewatered in batches in a belt press, to which a proprietary polyelectrolyte is added to aid dewatering. The resulting biomass, which contains approximately 30 % dry solids, is discharged to a skip and stored on site prior to use or sale.

The average COD content of the final, treated effluent is 1 g/l, giving an average COD removal efficiency of greater than 98 %. With further polishing, lower levels have been achieved.

It has been reported that in Italy, COD levels have been reduced from 4000–7000 mg/l to <160 mg/l.

Technical considerations relevant to applicability

Applicable in all slaughterhouses.

Economics

The large volumes of waste with a high blood and fat content generated by slaughterhouses can be expensive to dispose of. At the time the case study was reported, stricter legislative controls were also expected to increase the costs of transporting and disposing of these wastes.

In 1996, the throughput of cattle, lambs and pigs at a slaughterhouse in the UK resulted in the production of nearly 11400 m³ of effluent with a high COD and suspended solids content. This high-strength waste had previously been tankered off site, for disposal by a specialist waste disposal contractor at an annual cost of over GBP 128000. Faced with rising waste disposal costs, a decision was taken to install a biological treatment system that would eliminate the need for expensive off site waste disposal and that would allow for increases in production capacity.

The benefits of this innovative biological treatment system include annual cost savings of over GBP 130 000 and the elimination of the need for off-site disposal of high-strength waste.

The commercial value of the biomass produced was estimated at GBP 50 per tonne. Based on the production of 10 tonnes per week, i.e. approximately 500 tonnes per year of biomass, the potential revenue from sales of the biomass was GBP 25 000 per year (1997). It has been reported that in Italy the spreading of biomass produced in a WWTP according to Council Directive 86/278/EEC costs approximately EUR 20/t.

In the example installation, prior to the installation of the biotechnology plant, the high-strength effluent was tankered off the site for 32 weeks of the year for disposal by a waste management contractor. This disposal method cost GBP 128 000 per year, i.e. GBP 17.7/m³ for 45 m³/d of effluent (1996 prices). For the remaining 18 weeks of the year, the waste was spread on land at the site, at an estimated cost of GBP 3 000 per year. The need to tanker high-strength waste off the site for disposal was thus eliminated.

With equipment costs of GBP 350 000 (1996 prices), the net cost savings of over GBP 130 000 per year led to a payback time of 2.7 years. This period would be significantly shorter if the cheaper option of landspreading had not been available, because it would have replaced a more expensive alternative.

At the time the case study was reported, municipal WWTPs were being upgraded to comply with the requirements of the Council Directive 91/271/EEC of 21 May 1991 concerning urban waste water treatment [277, EC, 1991]. This may have led to increased charges to the slaughterhouses for their waste water treatment. This new technology may, therefore, produce significant cost savings for slaughterhouses discharging effluent to sewer.

Table shows the annual operating costs, capital costs and savings for biological treatment at the slaughterhouse described in the case study.

	Costs, savings and payback (GBP)
Annual operating costs	
Microbial culture	-3200
Polyelectrolyte	-4380
Water	-1050
Specialist maintenance	-2500
Electricity	-9200
Labour ⁽¹⁾	-5000
Total annual operating costs⁽²⁾	-25330
Annual savings:	
Biomass value	-25000
Waste disposal	-131000
Total annual savings	-156000
Net annual cost savings	-130670
Total capital costs	-350000
Payback period	2.7 years
⁽¹⁾ — Estimate for one person working half a day, 5 days a week and for 50 weeks a year.	
⁽²⁾ — Based on treating 45 m ³ /day of effluent for 5 days a week and for 50 weeks a year.	

Table: Economic analysis of biotechnological treatment of slaughterhouse waste

Driving force for implementation

Rising costs for the off-site disposal of waste.

Example plants

One slaughterhouse in the UK and one in Belgium.

Reference literature

[56, ETBPP, 1997, 237, Italy, 2002, 248, Sorlini G., 2002, 346, Belgian TWG member, 2003]

3.2.3.4 Techniques to reduce emissions to air

3.2.3.4.1 Techniques mainly used to reduce organic/odour emissions

3.2.3.4.1.1 Segregated storage and handling of different kinds of animal by-products

Description

Animal by-products are collected, handled and stored separately or in categories, depending on their further use or disposal route and on the potential environmental consequences of mixing them.

Technical description

By-products can be collected, handled and stored separately or in categories (C1, C2 and C3), depending on their further use or disposal route and on the potential environmental consequences of mixing them. If, e.g. they are the same material but at different stages of degradation and one causes an odour problem, then mixing them would lead to an increased volume of malodorous material and make the whole volume less usable.

Achieved environmental benefits

Reduced odour emissions associated with the storage of malodorous by-products, both at the slaughterhouse and at animal by-products installations.

The segregation of liquids and solids destined for use or destruction offers several advantages. If sufficient separate storage systems are provided, it reduces cross contamination between different by-products. The segregation of by-products can reduce potential odour problems from those materials which even when fresh emit the most offensive odours. They can be stored or removed separately under controlled conditions. If by-products which require refrigeration are separated from those that do not, the refrigeration capacity required will be less.

Also, by minimising cross-contamination, segregation enables individual by-products to be used instead of disposed of. Each by-product can potentially be used or disposed in different ways.

Environmental performance and operational data

Request to the TWG: Please provide information.

Cross-media effects

Increased consumption of water and/or energy [241, TWG 2019].

Technical considerations relevant to applicability

Applicable in all slaughterhouses. Segregated by-products should be demanded by the market; otherwise, they can be processed together by an animal by-product installation [241, TWG 2019].

Economics

Request to the TWG: Please provide information.

Driving force for implementation

Odour control at the slaughterhouse. Reduced waste disposal costs.

Example plants

Request to the TWG: Please provide information.

Reference literature

[148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001]
[47, Finnish Environment Institute and Finnish Food and Drink Industries' Federation 2001],
[241, TWG 2019]

3.2.3.5 Techniques to minimise the environmental impact of the use of refrigerants

3.2.3.5.1 Use of refrigerants without ozone depletion potential and with low global warming potential

Description

Prevention of emissions of substances that deplete the ozone layer or have a high global warming potential by using alternative refrigerants, such as water, carbon dioxide or ammonia.

Technical description

Refrigerants are widely used in slaughterhouses in cooling, refrigeration and freezing operations. The interaction of halogen refrigerants with ozone in the air has resulted in the progressive prohibition of the placing on the market and use of ozone-depleting substances and of products and equipment containing those substances. These compounds are being substituted by other refrigerants such as carbon dioxide, ammonia, glycol or, in some cases, chilled water.

Hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), chlorine and ammonia are frequently used if the temperatures are below -10 °C. HCFCs have the disadvantage of depleting the ozone layer when released to the atmosphere. They also show considerable GWP. The use of HCFCs is generally prohibited [244, EC 2009]. HFCs have the disadvantage of possessing a much higher GWP than alternative refrigerants such as ammonia, carbon dioxide, chlorine and water. There are provisions aiming at containing, preventing and thereby reducing emissions of HFCs [243, EC 2014].

The leakage rate for industrial HFC refrigeration systems has been estimated at around 8 %, compared to > 20 % for HCFC-containing equipment. The HFC phase-out under the F-gas Regulation is being implemented by annual quantitative limits (quotas) on the placing on the EU market of HFCs by producers and importers. In 2018, EU-wide placing on the market of HFCs was 1 % below the overall market limit set by the quota system [248, EEA 2020].

Achieved environmental benefits

Reduced risk of ozone depletion and global warming.

Environmental performance and operational data

The use of substances that deplete the ozone layer can be prevented or minimised by:

- using substitutes for such substances;
- when ozone-depleting substances are used, using closed-circuit systems;
- enclosing systems in buildings;
- encapsulating parts of systems;
- creating a partial vacuum in the encapsulated space and preventing leaks in systems;
- collecting the substances during waste treatment;
- using optimised waste gas purification techniques;
- proper management of the recovered substances and the waste.

Ammonia (R717) has been used for industrial refrigeration for a long time. Ammonia refrigeration systems are more costly, especially in the low-capacity range. Since the year 2000, HCFC-22 has been replaced in new equipment by the HFC refrigerant R404A, first in Europe, then in other industrialised countries. In recent years, a number of cascade systems with ammonia and CO₂ have been installed in the food industry [242, COM 2011].

Cross-media effects

The risk of ammonia and glycol leaks, which can cause health and safety problems.

Technical considerations relevant to applicability

None.

Economics

Substitution of refrigerants is energy-efficient for industrial cooling systems. Examples of individual abatement costs for the alternative option ammonia (R717) are given in the preparatory study for a review of Regulation (EC) No 842/2006 on certain fluorinated GHG [242, COM 2011].

For a small system with 270 kW cooling capacity at three temperature levels:

- Cost of HFC system: EUR 425 000.
- Additional cost of similar NH₃ system: EUR 132 000 (+31 %).
- Electricity consumption: 1 800 000 kWh/year.
- NH₃: -27 % electricity consumption.
- Operation cost for F-gas system: EUR 100 000 per year.

For a large system with 5 MW cooling capacity:

- Cost of HFC system: EUR 6 million.
- Additional costs for similar NH₃ system: between 0 and 20%.
- Electricity consumption: between -10 % and -30 %.
- Operating cost for the large system: EUR 1 million per year.

Driving force for implementation

There are low-impact alternatives available in the FDM sector and promoted by Regulation (EU) No 517/2014. For some gases, e.g. HFOs (hydrofluoroolefins), there is no ban in Regulation (EU) No 517/2014 but only a reporting obligation. In addition, this Regulation's rules related to equipment aim to minimise leakage, not to prevent the use of all such gases. Moreover, the quota system refers to total tonnes of CO₂ equivalent and does not mention specific gases [243, EC 2014]

Example plants

This technique is implemented in multiple slaughterhouses.

Reference literature

[206, Giner-Santonja et al. 2019], [242, COM 2011], [243, EC 2014], [244, EC 2009], [248, EEA 2020]

3.2.3.5.2 Refrigeration management plan

See Section 3.2.3.1.1.1.

3.2.3.5.3 Preventive and corrective maintenance

Description

The correct operation of the refrigeration equipment is regularly reviewed and any deviations/malfunctions are corrected/fixed in a timely manner.

Technical description

A well-operated maintenance regime can ensure, for example, the prompt repair of leaks and faults which can lead to refrigerant losses. Examples of maintenance practices include:

- checking the refrigerant sight glass for bubbles; bubbles in the sight glass usually mean a system is leaking;
- finding the leaks and repairing them before the system is recharged with refrigerant;
- checking that the oil in the compressor sight glass(es) is at the right level; the compressor will be more likely to fail if the oil level is too low, or too high;
- inspection of pipes and valves.

If pipework is vibrating it is more likely to fracture, causing a major refrigerant leak. Provision of anti-vibration pipe mountings/arrangements and/or a length of flexible pipework can prevent this.

Achieved environmental benefits

Reduced risk of ozone depletion and global warming.

Environmental performance and operational data

A well-operated maintenance regime can ensure, for example, the prompt repair of leaks and faults which can lead to refrigerant losses. Simple modifications can often result in considerable reductions of refrigerant losses.

Cross-media effects

None reported.

Technical considerations relevant to applicability

None

Economics

Request to the TWG: Please provide information.
--

Driving force for implementation

- Reduced consumption of refrigerants.
- Legislation.

Example plants

This technique is implemented in multiple slaughterhouses.

Reference literature

[215, COM 2005], [264, TWG 2020].

3.2.3.5.4 Use of refrigerant leak detectors**Description**

A centralised alarm system is used in order to promptly identify refrigerant leaks.

Technical description

The detection systems/units can detect a wide range of refrigerant gases including R717 (NH₃) (R717), fluorinated refrigerants and R744 (CO₂). They include various sensor technologies to match the specific refrigerant and safety requirements of the refrigeration system, e.g. electrochemical, semiconductor, and infrared sensors.

Achieved environmental benefits

Reduced risk of ozone depletion and global warming.

Environmental performance and operational data

It is very important to carefully select the sensor location. The ease of access for maintenance should also be taken into account.

Cross-media effects

None reported.

Technical considerations relevant to applicability

None.

Economics

Request to the TWG: Please provide information.
--

Driving force for implementation

- Reduced consumption of refrigerants.
- Legislation.

Example plants

This technique is implemented in multiple slaughterhouses.

Reference literature

[264, TWG 2020]

Sufficient drainage capacity for windrow composting on a hard standing

Description

The site can be designed to prevent the ingress of rain to the windrow and to minimise the volume and load of leachate formed. Even with careful management of the addition of water, some leachate will be formed. An impermeable site surface, correctly sloped to drainage and with sufficient piping and drainage collection capacity to contain the maximum run off anticipated, can be provided. The drainage collection vessel can be separate from those collecting rainwater and other liquid effluents. The liquid may be recirculated to moisten the compost especially early in the process, when the composting is most active. If it is recirculated, it can be stored very close to the windrow.

Slopes with gradients as low as 1:200 have been reported to be sufficient for drainage, without causing problems with vehicle movement.

Achieved environmental benefits

Preventing contamination of water courses with leachate and run off, both of which potentially contain dissolved substances and suspended solids, which may cause pollution, or which will require waste water treatment. Leachate contains a higher concentration than run off, because it seeps through the pile. The leachate can be recirculated and used in the process.

Cross media effects

None.

Applicability

Applicable at all windrow composting sites.

Driving force for implementation

Prevention of leachate and run off polluting local water courses.

Example plants

Widely applied.

Reference literature

[176, The Composting Association, 2001]

Hard standing – concrete

Description

Concrete has been described as the strongest and most durable surface that can be used. The introduction of a layer of geotextile material gives the formation more strength, helps hold the sub base together and spreads the load on to the fill. Care needs to be taken when choosing the material between slabs to allow for the expansion and contraction and differential movement of the slabs.

Joints can be filled with material which permits expansion and contraction and prevents the passage of surface water or leachate down through the joint. Joint sealing compounds offer good adhesion to the concrete; flexibility without cracking; resistance to flow and temperature changes and are also durable and waterproof.

Achieved environmental benefits

Prevention of seepage of contaminated leachate and run-off into groundwater. Reduction in waste water contamination and treatment requirements.

Cross-media effects

None reported.

Operational data

Concrete is reported to be suitable for high volume sites on poor ground.

Economies

Rigid concrete pavement built over prepared sub-grade (e.g. soft clay/alluvium) has a reported cost of GBP 27–32 per square metre (2001).

Driving force for implementation

Prevention of leachate and run-off from polluting local water courses.

Reference literature

[176, The Composting Association, 2001, 210, Environment Agency, 2001]

*Hard standing - asphalt or macadams*Description

A dense bitumen macadam base course has been reported to give a high grade impermeable surface with a good wearing capacity. Bitumen macadams gain their strength from using an interlocking aggregate bound by bitumen.

Asphalt surfaces are not totally impermeable and some concerns have been expressed about their use. The temperatures reached by the composting material may affect the asphalt over time. The asphalt surface may become brittle and there may be a risk of contamination of the composting material.

Achieved environmental benefits

Reduction in seepage of contaminated leachate and run-off into groundwater. Reduction in waste water contamination and treatment requirements.

Cross-media effects

Asphalt surfaces are not totally impermeable.

Operational data

Asphalts and macadams are reported to be less durable and to have a higher permeability than concrete. Storage and delivery areas may need thicker layers or concrete to withstand the action of mechanical loading shovels.

The temperatures reached by the compost may make the asphalt brittle and there are fears that asphalt residues may contaminate the compost.

Economies

Flexible asphalt pavement built over prepared sub-grade, e.g. stiff clay soil, has a reported cost of GBP 15–20 per square metre (2001)

Driving force for implementation

Cheaper than concrete.

Reference literature

[176, The Composting Association, 2001]

Windrow composting of animal by-products

Description

A windrow is a long pile of composting materials, usually shaped as an elongated triangular prism. They are constructed on a hard standing and drainage is provided to collect any leachate. Water is added to the windrows as and when required for the composting process. Material being composted is turned sufficiently frequently to ensure the maximum sanitation and degradation of the total material and to keep the process fully aerobic.

Achieved environmental benefits

Furthering of recovery and recycling of the substances generated and used in the process and of waste, where appropriate.

Cross media effects

Odour emissions from decaying inherently malodorous and putrescent animal by products. ABP Regulation 1774/2002/EC requires most Category 2 materials to be sterilised under specified temperature, time, pressure and size conditions, before being composted. This requires energy.

Operational data

An example composting plant using slaughterhouse by products uses 50 % slaughter sludge and rumen contents mixed with 50 % wood, by volume, to improve the structure of the windrows. It is reported that that this mixture of products allows the production of good windrows which reach a core temperature of 70 °C during the bio-oxidation step. This process reportedly produces a good quality compost which could, however, benefit from the addition of more phosphorous.

Reportedly windrow composting may potentially carry, but not necessarily so, a greater risk of odour and pest problems than in vessel composting.

Applicability

The composting of animal by products in windrows is applicable for by products from slaughterhouses, e.g. lairage bedding, manure, stomach contents, intestinal contents, blood and feathers; from waste water treatment, e.g. screenings, flotation tailings and sludge; solid residues from biogas production; sludge from blood processing and sludge from WWTPs.

Economics

Composting plants dedicated exclusively to slaughterhouse by products are reported to be simpler and cheaper than traditional composting plants. The dedicated aspect represents an effective source separation. The dedicated plants do not tend to contain the plastic, glass, or other foreign bodies in the raw material that municipal wastes contain, so technologies for compost purification are not required. A dedicated composting plant for 30000 tonnes of biomass reportedly costs approximately EUR 3000000.

The investment, operational and maintenance costs for windrow composting are lower than those for in vessel composting. Windrow composting also requires greater levels of knowledge and skill and more labour than in vessel composting. It also requires a greater land area.

Driving force for implementation

Reduced disposal of slaughterhouse by products to landfill, as waste.

Example plants

There is at least one free standing plant in Italy and one on a slaughterhouse site in the UK.

Reference literature

[148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001, 176, The Composting Association, 2001, 210, Environment Agency, 2001, 269, Italian TWG Members, 2002]

3.3 Slaughter of large animals

3.3.1 Applied processes and techniques

Processing operations at slaughterhouses vary depending on the type of animal being slaughtered. The most significant difference is that for cattle and sheep the hide is removed. Pig skins are usually retained, although the bristles are removed and the surface of the skin is singed. Other differences relate to the difference in animal physiology and size. [12, WS Atkins-EA, 2000] [4, WS Atkins-EA 2000]

The slaughter process, although relatively labour intensive, is becoming increasingly automated. For instance, machinery is being developed to mechanise carcass dressing and this tends to incorporate automatic carcass washing at every stage. Up to 140 cattle and 600 pigs can be killed in an hour. Hundreds of cattle and thousands of pigs can, therefore, be killed in a slaughterhouse, on a daily basis.

3.3.1.1 General applied processes and techniques for all large animals

3.3.1.1.1 Animal reception and lairage

The animals are unloaded via ramps which should preferably be at the same level as the truck, have a non-slip surface and be sufficiently long to allow adult animals to be able to put all four hooves on. If unloading bridges are used, a direct connection can be made between the vehicle delivering large animals and the lairage. Looking after the animals' welfare reduces the risk of injury to them and subsequent waste, so it also has environmental advantages. [332, COTANCE, 2003] [176, COTANCE 2003]. After animals are unloaded the lorries are cleaned, for hygiene reasons. Most slaughterhouses have a dedicated vehicle wash area for this purpose. In some cases bedding, such as straw or sawdust is used. If so this is removed during vehicle washing after each delivery. The wash-water is discharged for waste water treatment and the manure and dirty bedding are collected.

Ideally animals should arrive at the slaughterhouse clean, although they may get dirty during the journey, e.g. from manure and washing upon arrival is an option. Washing the live animals can cause problems if there is not enough time for them to dry before they are slaughtered. Wet hides and skins can deteriorate more quickly than dry. [332, COTANCE, 2003] [176, COTANCE 2003]. There are conflicting views about the value of clipping. It has been encouraged to minimise the risk of both carcass contamination and operator exposure to *Escherichia coli* 0157.

The animals are often held in the lairage to allow them to recover from the stress of the journey. This improves the quality of meat by allowing adrenaline and glycogen levels to recover to normal levels. Pigs do not have sweat glands and are prone to heat stress during warm weather. To prevent this, they are kept cool by fine water sprays applied by shower arrangements in the lairage pens.

Most animals are retained for only a couple of hours before slaughtering, but some may be kept overnight to facilitate an early morning start. In general, farmers prefer their animals to be slaughtered on the day of arrival. Farmers are paid on the carcass weight of each dead animal, and many believe that this decreases if the animals are kept overnight.

A variety of lairage floor constructions are used. The most common are solid concrete floors; dimpled concrete floors, to allow animals adequate grip; or slatted concrete floors with under floor drainage to slurry tanks. For animal welfare reasons, slatted concrete floors are not generally used for sheep because their hooves can become trapped in the slats. Suspended mesh flooring is reported to work well in sheep lairages and like slatted floors they allow dirt to drop through and generate heat, which helps to dry the animals before they are slaughtered. Lairages for sheep/lambs are often simple and may have only a simple supported roof without walls.

Bedding is only used to a minor extent, but an official veterinary surgeon will insist that there is enough bedding to prevent the animals from getting dirty while in the lairage and/or there is sufficient dry bedding to dry off any wet animals. It is also generally used for overnight lairage. This is usually straw, but waste paper and sawdust are used at some installations. It has to be dry and of good quality. Lairages are normally cleaned by shovelling the solid manure and straw into a skip and then washing the lairage floor with HPLV hoses. In Italy, lairages are washed down and disinfected each time the lairage is emptied [~~331, Italy, 2003~~] [175, Italy 2003].

Straw and manure from delivery vehicles and lairages may be used as fertiliser, subject to public health legislation. Sheep/lambs may be sheared before slaughter, but this may reduce the value of the skin, because it removes the option of “doubleface” production, i.e. skins tanned with the wool on and it reduces the possibilities for recovering wool from the pelt.

Cattle that are dirty may have clumps of manure intertwined with their hair. This material is removed prior to slaughter. This is usually done by dry clipping the hair. At some slaughterhouses the animals are washed with a powerful hose. [~~288, Durkan J., 2002~~] [138, Durkan J. 2002]

3.3.1.1.2 Slaughter

Animals are taken from the lairage along a fenced or walled passageway constructed to allow them to walk in single file, or in small groups to where they are stunned and slaughtered.

Cattle are led one at a time into a stunning pen, which prevents the animal from moving and has a tiltable bottom and sides. The animal's head must be positioned in such a way that the stunning equipment can be applied and operated easily, accurately and for the appropriate time. The competent authority may authorise the use of head restraints. [~~115, EC, 1993~~] [34, COM 1993]. After stunning the animal collapses to the bottom of the pen, the operator then actuates a handle and the pen side opens allowing the animal to slide out onto a dedicated landing area on the slaughter hall floor.

Cattle are stunned before bleeding, normally using a captive bolt pistol activated by expanding gas either from an air compressor or a blank ammunition cartridge. The pistol is accurately located at a point on the midline of the skull, above the level of the brow ridges of the eye sockets. Bulls and boars, which have massive skulls, are sometimes shot with a rifle bullet. There are also some non-penetrative percussion pistols in use. One captive bolt pistol, known as the Hantover stunner, injects air as well, thus scrambling the brain. This can result in central nervous system material entering the blood stream. It is not used in Germany, Spain, Ireland or the UK [~~202, APC Europe, 2001~~] [96, APC Europe 2001].

Pithing during slaughter is prohibited under legislation, to prevent the transmission of TSE [~~173, EC, 2001~~] [59, COM 2001]. There is some resistance to the prohibition of pithing on slaughterman safety grounds [~~111, EC, 2001~~] [31, COM 2001]. Pithing involved the insertion of a long rod into the hole left by the captive bolt and reduced muscle contractions during carcass dressing. Paper and cloths used to clean the captive bolt are classed as SRM. Electrical stunning of cattle is undertaken in the US, Australia and New Zealand [~~332, COTANCE, 2003~~] [176, COTANCE 2003].

Sheep and pigs are also stunned before bleeding, using a captive bolt pistol or electrical tongs. The traditional stunning method for pigs involves applying scissor-like tongs or head plates with a current of at least 1.3 A, at a minimum voltage of 190 V, for about 5 s. For sheep, the current is normally at least 1 A. For pigs, in recent years the use of CO₂ baths has become more popular. The pig is exposed to two stages of gas, firstly a mixture of 30 % CO₂ to increase respiration and then a mixture of 70 - 82 % CO₂ (depending on the size of the pigs), to induce anaesthesia. The concentration of CO₂ for stunning pigs must be at least 70 % by volume [~~115, EC, 1993~~] [34, COM 1993].

The removal of as much blood as possible is important to maximise the quality of the meat. In many cases, animals such as pigs and sheep could be killed by electrocution, rather than being merely electrically stunned. In pigs, cardiac arrest does not affect the rate and extent of bleeding.

After stunning, the animals are hung by one or both of their hind legs on an overhead rail which carries the carcasses through the intermediate processes and into the chiller unit. Small multi-species slaughterhouses may have a common slaughtering and processing line, where the height of the workstation can be adjusted to match the height of the carcase. Large slaughterhouses typically operate separate slaughtering and processing lines for different species.

In at least one Danish slaughterhouse, the cattle are tipped from the stunning pen onto a table, where their neck arteries are then severed. The animal is then shackled and raised using an elevator platform to the hanging position, for bleeding.

During ritual slaughter, the restraint of bovine animals before slaughter using a mechanical method intended to avoid any pain, suffering or agitation and any injuries or contusions to the animals is obligatory [115, EC, 1993] [34, COM 1993].

The following welfare issues have been reported as crucial during the general slaughter process phase [285, EFSA 2019]:

- During the slaughter processes, animals may experience negative welfare consequences such as heat stress, cold stress, fatigue, prolonged thirst, prolonged hunger, impeded movement, restriction of movements, resting problems, social stress, pain, fear and distress.
- Consciousness is a prerequisite for the animal to experience pain, fear and distress. Therefore, animals that are ineffectively stunned, recover consciousness or those slaughtered without stunning will be exposed to the hazards and experience the related welfare consequences.
- During the slaughter processes, animals may be exposed to several hazards, which could have a cumulative effect on welfare consequences (e.g. water deprivation, insufficient space allowance, and an excessively high effective temperature will have a cumulative effect and exacerbate heat stress).
- Exposure to some hazards might persist during all processes and phases until the animal is rendered unconscious (e.g. food deprivation).
- Other hazards might be present only during one phase, but the welfare consequence might persist during the successive processes and phases until the animals are rendered unconscious (e.g. pain due to inappropriate handling).
- Most of the hazards are associated with lack of staff skills and training (inappropriate handling) and poor design, construction and maintenance of the premises. The lack of skills or lack of training of the staff working in the slaughterhouse is considered a serious welfare concern.
- The uncertainty analysis on the set of hazards for each process provided in this Opinion revealed that the experts were 95-99% certain that all listed hazards occur during slaughter of cattle. At the same time, the experts were 90-95% certain that at least one welfare-related hazard is missing in this assessment according to the three criteria described in the Interpretation of ToRs (95-99% considering the worldwide situation). This is due to the lack of documented evidence on all possible variations in the processes and methods being practised.

Some recommendations to address the previous welfare issues are the following [285, EFSA 2019]:

- Design, construction and maintenance of the premises and handling facilities should be based on understanding how cattle perceive their environment and meet their welfare requirements (e.g. thermal comfort, comfort for resting).

- Even in a well-designed and equipped slaughterhouse, training of staff is a key preventive measure to avoid hazards and mitigate welfare consequences: all processes of the slaughtering should be carried out by trained and skilled personnel. Staff should be trained to consider cattle as sentient beings, to have a good understanding of species-specific behaviour and to act accordingly during all processes.
- The welfare status (based on the welfare consequences) of the animal should be assessed at each phase of slaughtering to prevent and correct hazards and mitigate negative welfare consequences.

The following welfare issues have been reported as crucial during the stunning phase [[285, EFSA 2019](#)]:

- Consciousness is a prerequisite for the animals to experience pain, fear and distress. Therefore, animals that are not or ineffectively stunned or recover consciousness will be exposed to the hazards and related welfare consequences. Pain, fear and distress can be assessed indirectly by assessing the state of consciousness.
- Effective mechanical (excluding firearms) and electrical stunning methods require restraint of the body and the head that per se may impose additional pain and fear. These welfare consequences will persist during the restraining period until successful stunning.
- Ineffective captive bolt stunning is mostly due to the wrong shooting position and direction and inappropriate stunning parameters (bolt length, velocity, power, etc.)
- Inappropriate restraint of the head and lack of skilled operator can lead to the wrong shooting position and direction of the captive bolt.
- The pneumatically operated captive bolt guns are more effective than cartridge-powered guns, especially in heavy bulls.
- Non-penetrative captive bolt guns are less effective than penetrative captive bolt stunning methods.
- Ineffective electrical stunning is mostly due to wrong placement of the electrodes, poor electrical contact, excessively short exposure time, inappropriate electrical parameters.
- The duration of unconsciousness induced by head-only electrical stunning of cattle may not be sufficient to last until death occurs through bleeding.
- Irreversible stunning methods (e.g. head-to-body electrical stunning) have the animal welfare advantage of eliminating the risk of recovery of consciousness and associated pain, fear and distress.

Some recommendations to address the previous welfare issues are the following [[285, EFSA 2019](#)]:

- Optimum restraining of head and body is required to achieve effective stunning.
- Restraining methods or practices which cause severe pain and fear should not be used.
- Pain and fear associated with restraint should always be assessed by the use of ABMs.
- Animals should not be restrained if the operator is not ready to stun them immediately.
- Animals should not be stunned if the operator is not ready to bleed them immediately.
- To avoid animals recovering consciousness, irreversible stunning methods are recommended.
- When reversible stunning methods are used, bleeding should be applied without any delay to avoid recovery of consciousness.
- To monitor stunning method efficacy, the state of consciousness of the animals should be checked at each of the three key stages – i.e. after stunning, just prior to sticking and during bleeding.
- Animals ineffectively stunned or recovering consciousness should be stunned immediately with a backup method.
- The use of non-penetrative captive bolt guns for stunning cattle should be avoided due to higher incidence of ineffective stunning and shorter duration of unconsciousness when compared with penetrative captive bolt stunning.

3.3.1.1.3 Bleeding

EU animal welfare legislation dictates that bleeding must be started as soon as possible after stunning and be carried out in such a way so as to bring about rapid, profuse and complete bleeding [115, EC, 1993] [34, COM 1993]. In any event, it must be carried out before the animal regains consciousness. There are special provisions in the legislation which apply to slaughter according to certain religious rites. In the EU MSs, the religious authority on whose behalf slaughter is carried out is the competent authority for the application and monitoring of these provisions, operating under the responsibility of the official veterinarian. Otherwise, all animals that have been stunned must be bled, by incising at least one of the carotid arteries or the vessels from which they arise. After incision of the blood vessels, no further dressing procedures or any electrical stimulation may be performed on the animals before the bleeding has ended. Bleeding also aids the preservation of the meat, by removing a breeding ground for micro-organisms.

Carcases are bled over a trough or tank, to collect the blood. In some slaughterhouses the blood tanks are only large enough to hold the blood of a small number of animals, e.g. 10, to ensure that if one animal's blood is contaminated, or if a carcass is condemned after inspection by the veterinarian, only a small portion has to be disposed of.

The blood trough is normally fitted with a double drain, one opening for the blood to be pumped to a tanker for disposal and the other for wash-water. Removable plugs seal the openings when they are not in use. Some slaughterhouses have installed additional blood collection sumps at other parts of the process, such as at the legging platform where the back legs are skinned.

At cattle and pig slaughterhouses, some blood may be hygienically collected for human consumption, e.g. for black pudding or pharmaceutical use. Hygienic blood collection from pigs can be carried out by traditional bleeding, e.g. in small pans or a trough or by using hollow knives. The hollow knife is slightly broader than an ordinary knife and is double edged. The operator can hold the knife in place, or it can be fixed in position by a clamp or by a small hook fixed at its base. The blood runs from the hollow knife through the handle and a tube to a collection vessel. When bleeding is completed, the knife is placed back into its holding carousel for automatic cleaning and a clean knife is selected for the next animal. Bleeding/sticking knives can be washed, but not sterilised to the standards necessary to destroy all pathogenic organisms, especially TSE agents, in the interval between two kills [202, APC Europe, 2001] [96, APC Europe 2001]].

Typically, a total of between 2 - 4 litres of blood is collected from each pig and about 10 - 20 litres per head of cattle. After the collection of the initial flush of blood the animals are hung over a blood trough to collect the remainder of the free-flowing blood. Whilst the use of hollow knives is considered to be a very good system for obtaining high quality blood it gives a lower yield of blood collection at this stage on the slaughter-line and, therefore, increases the potential for blood to continue to drip from the carcass, leading to contamination of waste water later [220, APC Europe, 2001] [96, APC Europe 2001]. The lower yield is related to the back pressure associated with the use of the hollow knife and the time that the hollow knife is allowed to remain in the animal. In most cases the time is limited to 20 - 40 seconds because of the speed of operation of the slaughter-line. In practice, the hollow knives are only used in big slaughterhouses and only for the length of time required to obtain the quantity needed for the collection of food grade blood. In addition, it is not possible for the slaughterman to know whether the incision of the blood vessels has been accurate. [260, EAPA, 2002] [116, EAPA 2002]

Typically, the blood collected is pumped from the trough to a refrigerated tank/tanker where additives, e.g. citric acid or sodium citrate, are added to prevent coagulation. The addition of 100 ml of a 20 % solution of sodium citrate per pig may be added automatically using a flow-meter. Alternatively, the fibrin which binds blood clots together can be removed by stirring with a paddle. Plate heat-exchangers may also be used to chill the blood to a temperature of about 2 °C. The blood can be continually agitated in the tank [260, EAPA, 2002] [116, EAPA 2002].

In the UK, approximately 15 % of mammalian blood is chilled prior to collection and processing. The main reason for this is to maintain the functionality of the plasma proteins for, e.g. use in pet foods. The storage of blood above 10 °C is reported to quickly lead to odour problems.

Some UK slaughterhouses use an electrical conditioning process to improve the meat quality for cattle, pig and lamb carcasses. At one slaughterhouse pig carcasses are subjected to 600 V for 5 minutes on a carousel system. It is reported that bleeding with a hollow knife together with electrical stimulation, e.g. at 40 V for one minute, facilitates hide removal as well as improving the quality of hides and skins, due to earlier rigor mortis. It is reported that the pH of meat is reduced from 7.0 to 5.6 in 2 hours instead of 18 hours. There is some debate about whether it may also help to drain the blood from the carcass.

Blood has the highest COD strength of any liquid effluent arising from meat processing operations. Liquid blood has a COD of about 400 g/l and a BOD of about 200 g/l. The containment of blood is, therefore, one of the most important environmental controls at a slaughterhouse. The spillage of blood is potentially one of the most environmentally harmful accidents that can happen. Spillage from blood tanks has occurred when blood trough pumps have been left on overnight during floor cleaning, thereby causing the blood tank to overflow. The blood may escape to local water courses or cause problems in an on-site WWTP, due to shock loading. The risk of this can be reduced by installing a high level alarm on the blood tank, linked to an automatic cut-off device for the blood trough pumps. Here a ballcock hits an electrical switch and a solenoid activates a valve, which prevents any further addition—[288, Durkan J., 2002] [138, Durkan J. 2002].

During bleeding blood coagulates on the base/walls of the trough. This is either hosed down and washed directly to the WWTP or in some slaughterhouses it is collected by shovels, squeegees or by vacuum suction and as much as possible is pumped to a blood tanker. Such coagulated blood can be rendered, but cannot be used in blood processing. In most slaughterhouses, the blood trough is pitched and curved so that partially congealed blood can be directed into the drain and to the blood tanker. If the coagulated blood is collected first, a few litres of water can, usually with the permission of the renderer, be used to rinse blood into the blood tanker. The plug in the drain leading to the WWTP is then opened and the whole trough is washed down with water. Some slaughterhouses have traditionally allowed all or a significant proportion of the blood they collect to run to their WWTP. This has always been considered to be bad practice, due to the high COD and BOD and because it also removes the possibility of other routes for the use and/or disposal of blood being followed. ~~This route is not permitted under ABP Regulation 1774/2002/EC, which prescribes permitted routes for use and disposal, depending on the Category, as defined therein.~~

3.3.1.1.4 Hide and skin treatment removal

Whether hides/skins are salted or not may depend on customer requirements. If hides/skins can be delivered to a tannery and processed within 8 – 12 hours after slaughter they generally don't require any treatment at the slaughterhouse. They need to be chilled if they are to be processed within 5 – 8 days. For longer storage times, e.g. if they have to be transported overseas, then salting is reported to be the preferred option, due to the weight of ice and the energy consumption required for ice production and for refrigeration. [273, EC, 2001] [126, COM 2001]

If sheep/lamb skins and cattle hides are to be salted, they may be cooled first with cold water or chilled prior to being stacked flat and then salted, using sodium chloride, or alternatively they may be salted directly. After approximately 6 days they are packed with additional salt and stored or transported to tanneries for leather production. The hides and skins are normally stored in cool conditions, at about 4 °C.

If trimming is undertaken before salting is performed [276, Anão M., 2002] [128, Anão M. 2002], this reduces the amount of salt consumption, and there is a subsequent reduction in waste water contamination at the slaughterhouse and if the trimmings are used for the manufacture of gelatine, at the manufacturing installation too.

Salt in waste water is difficult to treat [332, COTANCE, 2003] [176, COTANCE 2003]. Specific treatments for preventing or controlling salt emissions via waste water have not been identified. It has been suggested that this may be due to a lack of awareness of salt emissions. Dilution and not treatment appears to be the mechanism by which harm to water courses and plant life is presently reduced.

The tanning industry reports that the washing of animals prior to slaughter is a questionable practice since animals should not be slaughtered in a wet condition for hygiene reasons. From the tanning industry point of view, it is much better that animals are kept clean on the farm and delivered in a clean condition to the slaughterhouse. [332, COTANCE, 2003] [176, COTANCE 2003]. Veterinarians require animals to be clean and dry to prevent carcase contamination during the slaughter and dressing operations. A CEN standard on hide and skin preparation in slaughterhouses is in preparation. Hides and skins are reportedly often sold with, e.g. legs, hooves and parts of heads still attached. It is claimed that tanneries do not have the variety of use and disposal routes for by-products available to them that slaughterhouses have. Fleshing is considered to be a skilled job, possibly not always appropriate to the slaughterhouse operation.

The tanning industry encourages chilling of hides/skins, but considers that salting cannot be phased out where the material is to be transported significant distances, so it encourages its careful execution, avoiding the use of excessive amounts of salt. Brining is not undertaken at slaughterhouses, although it is done at hide/skin markets or in tanneries. The routine use of biocides is considered to be unnecessary, if preservation is undertaken correctly but they may have a role to play, e.g. for storage or transport in hot climates [286, COTANCE, 2002] [137, COTANCE 2002]. Drying is not undertaken in Europe, but it is done in Africa. Icing is encouraged by the tanning industry. Irradiation is not known to take place at slaughterhouses. [286, COTANCE, 2002] [137, COTANCE 2002]. Table shows the treatment of hides and skins undertaken at slaughterhouses throughout Europe.

	Belgium	Denmark	Finland	France	Germany	Greece	Ireland ¹	Italy ⁵	Netherlands	Norway	Portugal ¹	Spain ¹	Sweden	UK ¹	Czech Republic
Washing	No ⁴	No		No	No		Yes (some)	Yes (10 %)	No	No	Yes	No	No	Yes (some) ²	Yes
Chilling	Yes (some)	Sometimes		Yes (2) bovine	No		Yes (some)	Yes (5 %)	No	No	No	No	Yes	Yes (20 %)	Yes
Trimming	Yes (bigger ones)	Sometimes		Yes (150)	Yes (South)		Yes ³	No	No	Yes	Yes (some)	Yes	Yes	Yes ³	Yes
Fleshing	No	No		No	No		No	No	No	No	No	No	No	No	Very little
Salting (sodium ehloride)	Yes (small)/ No (big)	Sometimes		Yes (100 – 150)	Yes	Yes	Yes (some)	Yes (95 %)	No	Yes	Yes	Yes	No	Yes (3 – 4)	Yes
Salting (potassium ehloride)	No	No		No	No		No	Yes (5 %)	No	No	No	Yes/No	No	No	No
Brining	No	No		Yes (few)	No	Yes	No	No	No	No	No	No	No	No	No
Biocide addition	No	No		Yes (100)	No	Yes	No	No	No	No	Yes (ovine/caprine) partly in bovine	No	No	No	No
Drying	No	No		Yes (10) caprine	No		No	No	No	No	No	No	No	No	No
Preservation in flake-ice	Yes (slowly)	Sometimes		Yes (50) bovine	Yes (in some smaller slaughterhouses)		Yes (some)	No	No	No	No	Partly	No	Yes	Very little
Preservation in flo-ice	No	No		No	No		No	No	No	No	No	No	No	No	No
Irradiation	No	No		Experimental – bovine	No		No	No	No	No	No	No	No	No	No

¹Unconfirmed

²If excessively dunged animals are rejected for slaughter

³On animals over 30 months trimming takes place at the slaughterhouses, on others at the hide/skin market

⁴Weak enforcement of health and safety recommendations

⁵None of these processes are undertaken at pig slaughterhouses

Numbers in brackets refer to the numbers of installations

Table: Treatment of hides and skins undertaken at slaughterhouses
[286, COTANCE, 2002, 323, Czech Republic TWG, 2002]

Machines to remove hide and skin typically pull the hide/skin from the carcass. Two chains are hooked to the hide/skin and are then wound onto a drum to pull the hide/skin. Some sheepskins are removed manually, but automated removal is also common. The hides and skins are supplied to tanneries for the production of leather goods. In some slaughterhouses, the hides and skins are salted to improve preservation, as described in Section.

Knives and similar tools, such as flaymasters, which are pneumatic tools with guards commonly used to minimise flay cuts, are used to remove animal hides and skins. These have a tendency to become contaminated with faecal material. Care is taken to ensure that dirty knives are not be used for any operations where the carcass meat has been exposed. They must be decontaminated first by removing any debris and then, e.g. dipping them in hot water at 82 °C for 10 seconds.

In some slaughterhouses, pig carcasses are skinned like cattle carcasses. Pigs are washed before the skin is removed using a hide-puller. The hide-puller is driven by a powerful motor or hydraulic piston and it pulls the skin off the carcass. The vertebral axis of the animal can be temporarily strengthened by brief electrical stimulation to tighten the muscles, otherwise some hide-pullers can cause a separation of the vertebrae, particularly in younger cattle. [27, University of Guelph, undated] [13, University of Guelph 2000]

After the hides/skins are removed, the carcasses are conveyed to the part of the slaughter-line known as the clean slaughter-line, for dressing and the hides/skins are taken to the hide/skin treatment area.

3.3.1.1.5 Evisceration

Evisceration involves manual removal of the respiratory, pulmonary and digestive organs. This is done by pulling out the bladder and the uterus, if it is present; the intestines and mesenteries; the rumen and other parts of the stomach; the liver and then, after cutting through the diaphragm, the plucks, i.e. the heart, lungs and trachea. The resulting offal is loaded into pans for inspection and transportation to the offal processing area. The heart, liver, kidneys and non-ruminant intestine may be sold for human consumption. At some pig slaughterhouses the pancreas may be sold to pharmaceutical companies to produce insulin. Some edible fats and trimmings may be rendered to produce lard and dripping.

Australia and New Zealand have recently developed large-scale automated systems for cattle and lamb evisceration, respectively. If successful, these systems are destined to have a dramatic impact on the meat industry, where labour costs in slaughtering have always been a major factor in locating slaughterhouses in relation to meat producing regions. [27, University of Guelph, undated] [13, University of Guelph 2000].

Offal, including the lungs and trachea for all animals and the first stomach for cattle and sheep, can be used in the production of pet food. For cattle and sheep, the first stomach is cut open on a table and the contents are removed using either a wet or dry process. In the wet process, it is cut open in a water flow to produce a slurry which is discharged over a screen and then pumped to a holding area. For veal cattle, less than one year old bulls and for cows, the first stomach contents weigh up to 10 kg, 40 kg and 50 kg, respectively [248, Sorlini G., 2002] [112, Sorlini G. 2002].

In the dry process, the first stomach is opened without water. The contents are removed manually and transported by a pneumatic system or screw conveyor to a collection point. First stomach contents are normally disposed of by spreading on agricultural land, subject to veterinary approval and the nutritional needs of the soil. Some companies use a piston compactor to reduce the volume of the contents for easier handling. After dry contents removal, the first stomach is washed in running or recirculated water.

The majority of slaughterhouses use a compressed air ring main to power equipment. In such cases, it is standard practice to use this to power a pneumatic system to blow the first stomach contents to the collection point. Compressed air at approximately 100 - 273 kPa (15 - 40 psi) can be used to blow paunch manure to the collection trailer. A piston compactor can be used to reduce the volume.

In some slaughterhouses macerator equipment is used to chop, wash and spin-dry the remaining offal prior to supply to the rendering company. This can reduce the offal volume by over 50 %.

It is not necessary to wash the carcasses in the evisceration area, although it is sometimes undertaken if there is contamination present from damaged viscera.

3.3.1.1.6 Splitting

After evisceration, the cattle, mature sheep (not lamb, because it is not necessary to remove the spinal cord as a TSE precaution) and pig carcasses are split along the spine using a saw. Water is sprayed onto the blade to remove any bone dust which is generated. The spinal cords of the cattle and mature sheep are then removed from the carcass and disposed of as SRM. Some slaughterhouses use a vacuum system which sucks the spinal cord material to the SRM waste skip. In other slaughterhouses, the spinal cord is removed manually and the cavity is cleaned using a steam spray/suction device. In Italian pig slaughterhouses on the same sites as cutting plants, the carcasses are cut into portions weighing a maximum of 15 kg, before chilling, for the production of typical Italian cured products [237, Italy, 2002] [103, Italy 2002].

In some slaughterhouses, the carcass is given a final rinse with low-pressure potable water before chilling or freezing. At every stage of production the meat is inspected visually to maintain quality standards.

For cattle which are known or suspected TSE sufferers at the time of slaughter, the carcasses are sawn in two, lengthways, ensuring that the spinal cord remains completely enclosed and intact and are sent for rendering followed by incineration or direct incineration.

If the correct diameter and thickness of saw blade is selected for the carcass-splitting saw and the blade is maintained sharp, then the noise levels will be reduced and less bone dust will end up in the waste water. Bone sawdust can cause a high phosphorus load in the waste water.

3.3.1.2 Additional applied processes and techniques for cattle slaughterhouses

A general scheme for the slaughtering of cattle is shown in Figure 3.11.

Pre-cooling in a tunnel (versus batch-cooling in a refrigeration room) can reduce cooling waste and improve the management of the cooling process, but has a higher energy consumption [203, Denmark 2015].

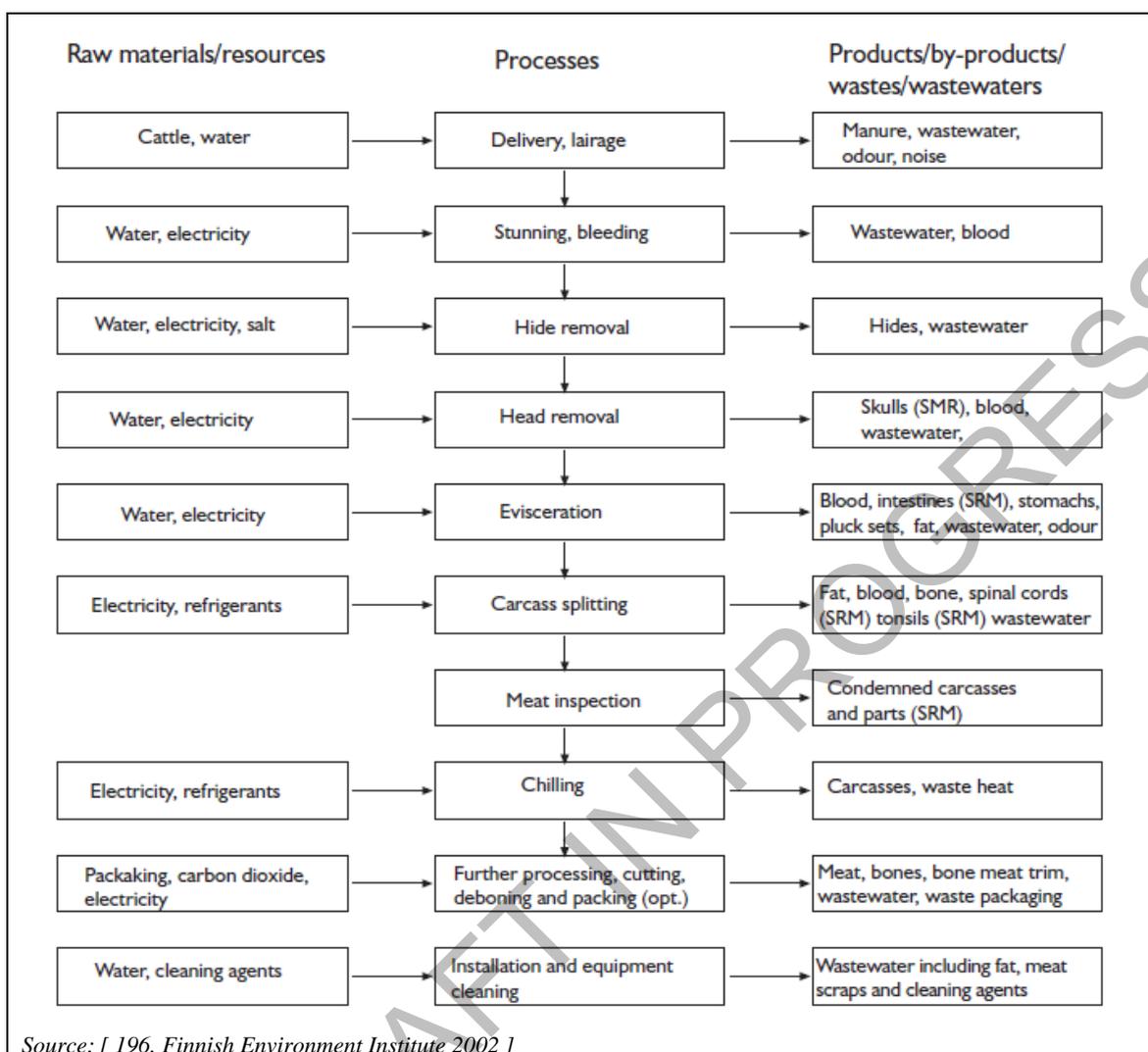


Figure 3.11: A typical flow scheme of cattle slaughtering

3.3.1.2.1 Head and hoof removal for cattle and sheep

After the bleeding of cattle and sheep, the animals' forelegs, tail and udder/testicles are manually removed using knives. At some cattle slaughterhouses, the operator cuts a slit in the neck to allow further blood to escape, before cutting the head off. The tongue and cheeks may also be removed for human consumption, except in certain MSs where cheeks are SRM [113, EC, 2000] [32, COM 2000]. Cattle and sheep heads are washed, inspected, then stained with the other SRM and disposed of.

Hooves are traditionally supplied for use in the manufacture of glue but may also be ground for use in pet food. They may also be used to produce horn meal fertiliser.

3.3.1.3 Additional applied processes and techniques for pig slaughterhouses

A general scheme for the slaughtering of pigs is shown in Figure 3.12.

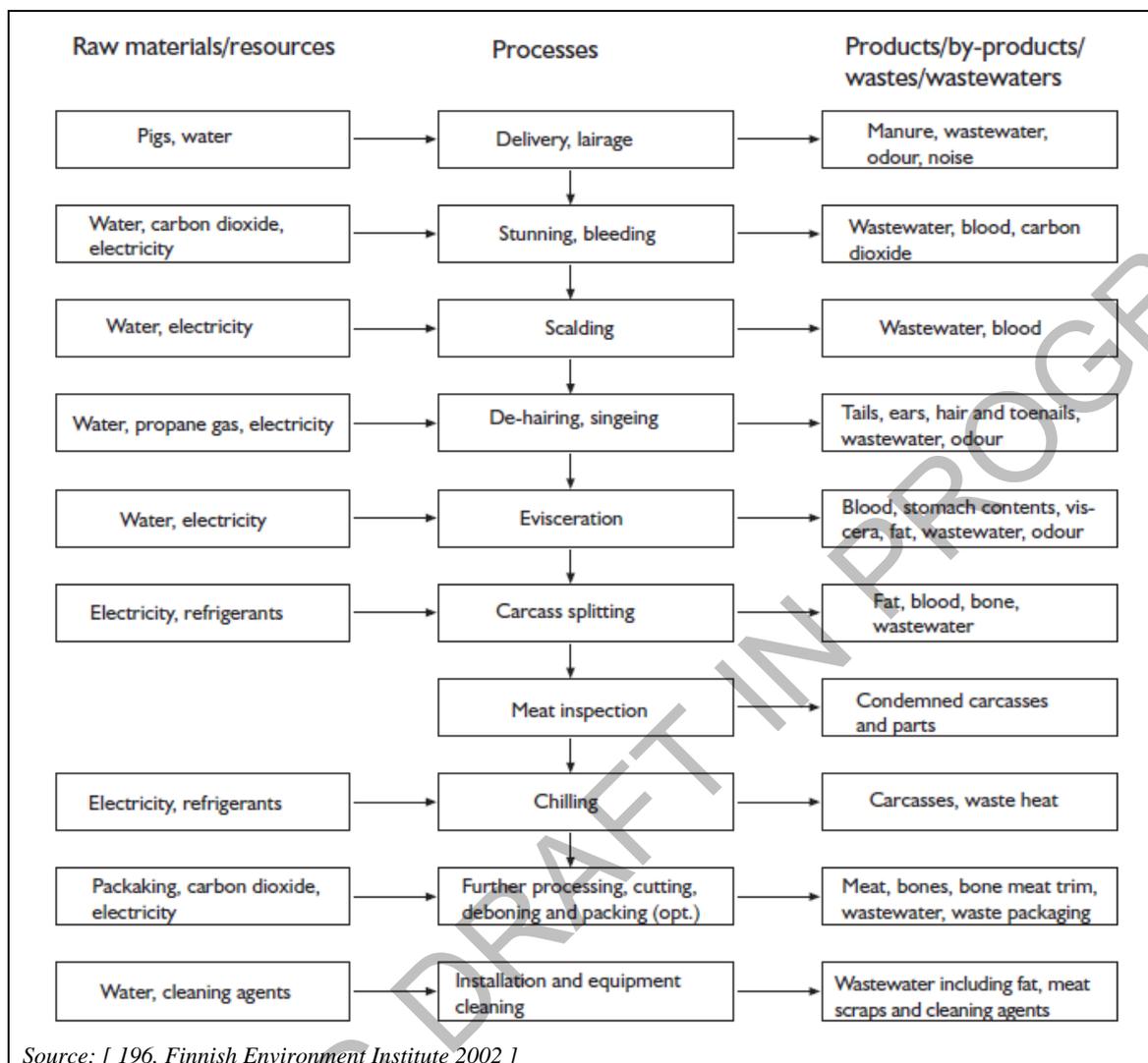


Figure 3.12: A typical flow scheme of pig slaughtering

3.3.1.3.1 Pig scalding

Pig carcasses are normally passed through a series of unit operations to remove the bristles. Traditionally the pig carcass is passed through a static or rotary scalding tank filled with water between 58 °C and 65 °C for 3 – 6 minutes to loosen the bristles and toenails. Under normal conditions, there is little or no heat penetration into the underlying flesh, so the meat quality is unaffected. Scalding at this temperature for longer than 6 minutes damages the skin. Lime salts or a depilatory agent, such as sodium borohydride, may be added to the water to facilitate loosening of the hair. A flap placed at the exit of the scalding tank can be used to collect and return water dripping from carcasses.

For a slaughterhouse processing about 100 pigs per hour, a typical static scalding tank would be about 4 metres long, 1.7 metres wide and 0.8 metres deep and would contain about 5500 litres of water. A typical rotary scalding tank may contain about 2500 litres of water and hold up to 14 carcasses at a time. Some large slaughterhouses use a conveyor system to drag the carcass through a longer tank with countercurrent water filtration and recycling. In Italy, because pigs are bigger, a typical scalding tank is longer, i.e. up to 10 metres long and it may contain 12 000 litres of water [237, Italy, 2002] [103, Italy 2002].

Steam heating is normally used to maintain the temperature in the scalding tank and continuous make-up water is required to balance drag-out, which drips onto the floor and into the de-hairing machine. The scalding process produces some steam and odour.

Debris and sludge builds up in the scalding tank during the day. It is common practice to empty the water and sludge directly into the site waste water drainage system at the end of production.

Alternative scalding methods may involve the use of either condensation or steam. Microbial contamination can be minimised by the use of steam [27, University of Guelph, undated] [13, University of Guelph 2000]. Condensation/steam scalding uses humidified air. The heat is transferred to the carcass surface through the condensation of steam. The heat and moisture are transferred to the scalding air by the atomisation of hot water in the circulating airflow. This process can maintain a constant temperature and 100 % humidity under varying loads, which is crucial for good scalding performance.

Figure 3.13 shows a generic pig slaughterhouse layout showing the processes from reception up to the cooling tunnel.

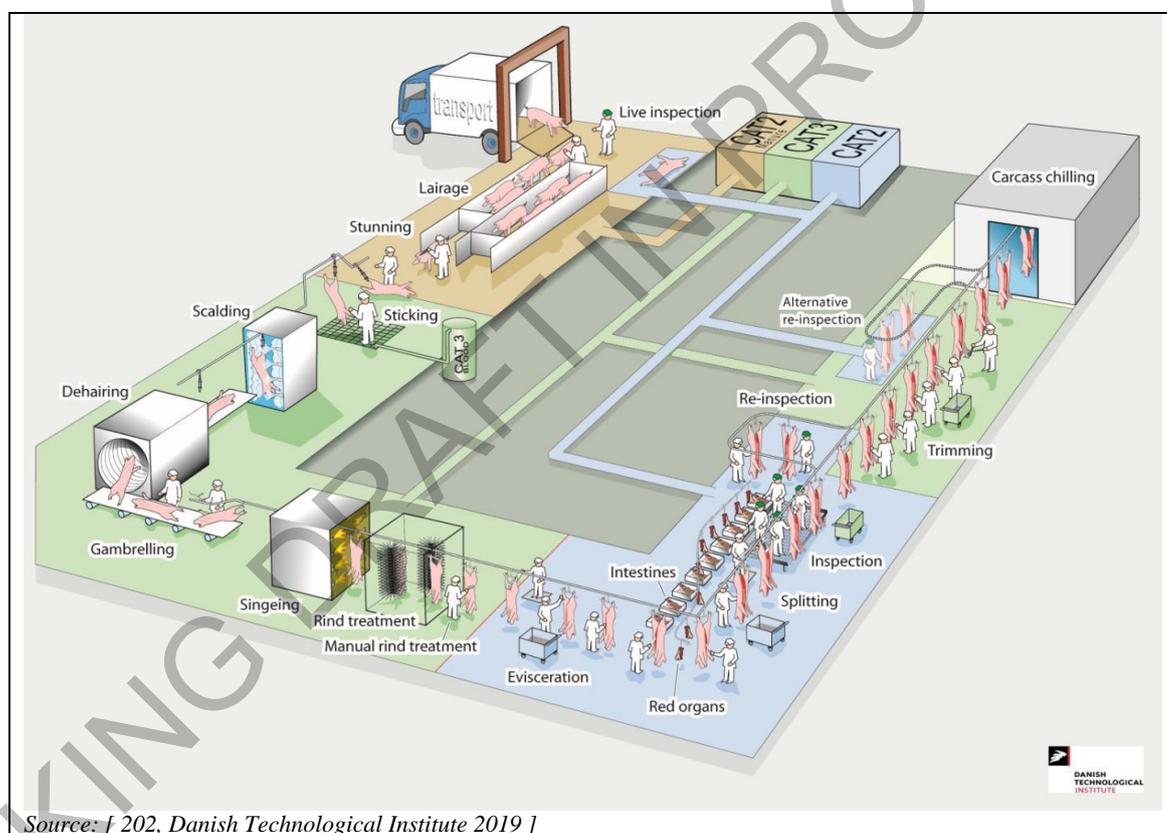


Figure 3.13: Generic pig slaughterhouse layout

3.3.1.3.2 Pig hair and toenail removal

An automatic de-hairing machine is used to remove bristles and toenails from pig carcasses. This comprises a number of rotating rubber flails, or similar, which brush or scrape the surface of the carcass.

In some de-hairing machines, the carcasses are tumbled two at a time horizontally between two sets of rubber flails, with a water spray from above to wash the hair out of the bottom of the machine. The water spray is used to flume hair and toenails to a primary screen. In some slaughterhouses, toenails are collected dry and sent for rendering. In Denmark and Ireland, hair and toenails are rendered [243, Clitravi - DMRI, 2002] [190, Clitravi - DMRI 2003], [288, Durkan J., 2002] [138, Durkan J. 2002].

In some slaughterhouses, the fluming water is recycled back to the de-hairing machine and the water is discharged to the site waste water drainage system once a day. In others, the water spray uses water from the once-through cooling system of the conveyor rail which is used to transport the pigs through the singeing unit.

3.3.1.3.3 Pig singeing

Pig carcasses are singed to remove residual hair which has not been removed by the de-hairer, to provide a firmer skin texture and to eliminate micro-organisms. Singeing units must only be fuelled with natural gas or fuels comparable to natural gas in terms of odour and other emissions [267, VDI 2020]. ~~The singeing unit commonly uses propane gas burners firing intermittently, usually for about 20 seconds in any minute, or alternatively oil burners, although this is becoming less common.~~ Propane is used in preference to natural gas because of the higher flame temperature, although natural gas is sometimes used if the slaughterhouse has an existing supply. Singeing should be optimised to reduce odour emissions and energy consumption (see Section 3.3.3.3.1).

~~A gas singeing unit may consist of 40 burners that are triggered to fire for 5 seconds as each carcass enters the unit. The singeing time, per carcass, can vary between 5 and 15 seconds, depending on the slaughter rate. The degree of singeing is controlled by the amount of energy supplied. Singeing temperatures are around 900–1000 °C. [12, WS Atkins EA, 2000, 134, Nordie States, 2001, 145, Filstrup P., 1976]~~

If the pig meat is to be used to make bacon, the carcass is given a “heavy singe”, by leaving the burners switched on continuously during the production run. This produces the rind. In some slaughterhouses, additional singeing may be carried out manually using portable gas burners. If a heavy singe has been applied the carcass undergoes rind treatment. If not, it is rinsed in cold water to cool the carcass.

If the meat is for the production of typical Italian cured products, a light singe is applied.

Singeing can also be carried out in an oven, which also has an impact on the finished product’s characteristics and product hygiene [203, Denmark 2015].

3.3.1.3.4 Rind treatment

After singeing, pig carcasses are passed through a black scraping machine to polish the skin and to remove singe hair and other debris. The polisher consists of sets of rotating rubber flails, similar to the de-hairing unit. At some slaughterhouses, additional carcass polishing may be carried out manually using handheld scrapers. Water is applied during rind treatment to cool the carcasses, soften the outer layer of skin and to rinse the bits of skin away.

The degree of the rind treatment, and thus the water consumption required for the rind treatment, depends on the selected degree of singeing - since the singed surface is removed during the process. The process is therefore dependent on the same choices that are made in connection with singeing in an oven or flaming [203, Denmark 2015].

3.3.1.3.5 Chilling of pig carcasses

The choice of cooling method has an impact on the hygienic quality. Product hygiene has an influence on how long the meat products can remain fresh and thus the distance the products can be exported. A comparison of the most commonly used chilling methods in Danish pig slaughterhouses is described here: batch chilling, water spray chilling and blast chilling [203, Denmark 2015].

Batch chilling

Batch chilling uses a chill room with rails or walking beams as the processing area. All batch chilling is separated from each other to avoid air infiltration between cells in operation and cells out of operation. Each cell has a capacity of 2 hours' production. Batch chilling uses air as transport media. A uniform air distribution, e.g. via socks with nozzles, will keep the heat transfer coefficient high. The combination of air velocity and air temperature determines the process time.

The advantage of using the batch chilling process is that chilling and equalisation of carcasses take place in the same room. The process is simple to establish and the cells could be loaded either manually or automatically.

If the air distribution is not uniform, it is disadvantageous to use the batch chilling process as it is impossible to get uniform equalised carcass temperatures. It is very important to ensure space around the carcasses. If some carcasses touch each other for example, this will prevent the heat transfer from the touching areas, which will become warm for a long time and thus increase the risk of damaging the meat quality (PSE and bacterial growth).

Another disadvantage is the development of condensation, caused by vapour from the carcasses, on building surfaces (primarily ceilings) and steel structures, especially in the first part of the cooling process, and therefore the risk of condensate dripping onto products.

Water spray chilling

By evaporative chilling – water spray chilling or mist cooling – water is applied to the carcass at the same time as it is swept over by air with moderate velocity and temperature. Evaporative chilling uses the thermophysical characteristic that an increase of the carcass surface water activity improves the overall heat transfer coefficient and reduces the evaporation of juice from the carcass. In practice, the process is built into a chilling tunnel with conveyor, evaporators and fans and up to 35 water spray cabinets for moistening the carcasses. Placement of the water spray cabinets depends on how fast the water activity on the surface decreases. As the carcass surface temperature is highest at the beginning of the process, the spraying cabinets are placed close to the first part of the tunnel.

The advantage of using water spray chilling is the low shrinkage and the high process temperature. The high process temperature reduces the energy consumption for compressor operations and reduces the capacity needed. At high process temperatures, it is possible to avoid surface freezing.

The disadvantage of using water spray chilling is that it is a very slow process, which needs huge tunnel dimensions. If the water activity is high on the carcass surface when it leaves the tunnel, this will cause an increased bacterial growth. The water consumption is high, and only usage of pure water of drinking quality is allowed. Purifying water with chloride compounds is not allowed in many countries. The wet surface increases the black bone problem.

Another disadvantage is the consumption of cleaning agents, water usage and manpower during the daily cleaning of the spray chilling process area. Besides this, requirements regarding the hygienic and cleanable design of the area are difficult to achieve in practice due to the complexity of the mechanical and structural system necessary. Insufficient cleaning increases the risk of listeria growth.

Blast chilling

Blast chilling uses the thermophysical characteristic that an increase of the boundary layer by a high air velocity at the carcass surface increases the heat transfer coefficient. This increases the carcass heat extraction and, together with a low air temperature, the surface temperature drops, which establishes maximum conductive heat transfer in the carcass. The blast chilling process is built into a tunnel with conveyor, evaporators and fans. The air velocity is high – 3 m/s to 4 m/s in the free cross-section.

The advantage of using blast chilling is the low shrinkage and the small tunnel dimensions. The low process temperature causes surface freezing, which improves the food safety, as surface freezing kills non-cold-permissive bacteria.

The disadvantage is a low process temperature, which increases the energy consumption for compressor operations and increases the capacity needed. The black bone problem caused by surface freezing can be eliminated by a short tempering zone at the end of the chilling process, which will cause the surface temperature to raise to equalisation room temperature.

Table 3.6: Comparison of chilling processes for pig carcass chilling

Subject	Batch chilling	Water spray chilling	Blast chilling
Chilling temperature (°C)	-3	-5	-24 – -12
Air velocity (m/s)	0.5–1	0.2–0.5	3–4
Chilling time (h)	7–9	3–4	1–1.5
Equalising time (h)	8–10	15–17	16–18
Total processing time (h)	18–20		
Weight loss (%)	1.6–1.8	1.0–1.2	
Mean equalised temperature (°C)	5		
Primal cut temperature prior to cutting	Slight difference	Uniform	
Risk of Pale Soft Exudative muscles	Slow temperature reduction. The temperature-dependent PSE level will not be reduced.		Fast temperature reduction. The temperature-dependent PSE level will be eliminated.
Risk of Pale Soft Exudative spots	It can be reduced by proper carcass spacing in the coolers.		Lower compared to processes with slow temperature reduction.
Drip loss (poor water-holding capacity)	The temperature-dependent drip loss: High level due to slow temperature reduction.		The temperature-dependent drip loss is eliminated due to fast temperature reduction.
Bacterial growth on carcass surface	Increased growth due to slow temperature reduction.	Increased growth due to wet surface and slow temperature reduction.	Reduction due to low temperature and fast temperature reduction.
Bacterial load	No surface freezing. <i>Camphylobacter</i> level unchanged.	No surface freezing: <i>Camphylobacter</i> level unchanged. Wet surroundings combined with insufficient cleaning increase the risk of <i>Listeria</i> contamination	Bacterial reduction due to surface freezing. Reduces the <i>Camphylobacter</i> level 1 log unit.
Discolouration of the back bones	No. Normally no risk due to chilling time, if the air distribution and temperature is uniform.	Yes. Risk of increased level. Can be reduced by drying the surface.	Yes. Risk of increased level. Can be reduced by a tempering zone before leaving the chilling zone.
Electricity consumption (kWh/pig)	1.0	1.6	2.0–2.9
Process area	Space for the kill of the day. Area index 100	Space for 4 hours kill + space for equalisation. Area index 180	Space for 1.5 hours kill + space for equalisation. Area index 105

Source: [203, Denmark 2015]

3.3.1.4 Additional applied processes and techniques for sheep slaughterhouses

Sheep and lambs are delivered by trucks to slaughterhouses and led to the lairage area. Hereafter they are stunned with a penetrating/non-penetrating captive bolt device or by electricity. Thereafter they are hung and stuck/cut so bleeding can occur. Approximately 1-2 kg of blood/head is relieved, which corresponds to 60 % of the total blood mass per animal. Afterwards their hide (for leather goods), stomach, intestines (for animal feed), and plucks (mainly for human consumption) are removed. In the end, approximately 21 kg/head slaughtered weight is showered with water to remove blood and fat residues and sent for cooling. Later they can be sold as an entire carcass, divided into halves or smaller parts [195, Nordic Council of Ministers 2016].

3.3.1.4.1 Head and hoof removal for sheep

Please see Section 3.3.1.2.1.

3.3.2 Current consumption and emission levels

~~Slaughter of large animals~~

~~Specific consumption and emission data for the sub processes of the large animal slaughter process are reported in this section.~~

3.3.2.1 General issues

3.3.2.1.1 Energy consumption

Chilling

Refrigeration systems affect the environment through the energy they consume and the effect they can have if refrigerants leak to atmosphere. Making the plant as energy efficient as possible will minimise its environmental impact. [292, ETSU, 2000] [141, ETSU 2000]

3.3.2.1.2 Water consumption

Animal reception and lairage

For hygiene reasons, animal delivery vehicles are washed down after each delivery. At most installations dedicated hose pipes are provided for this purpose. Most slaughterhouses do not charge for this water as they realise that the costs would be passed back to them in the form of increased delivery charges. HPLV hoses and spray guns can decrease water consumption, but their initial investment cost is greater than traditional hoses. It is reported that they are seldom used because delivery drivers do not generally treat them with care, e.g. they are left lying in the yard where vehicles drive over them. [12, WS Atkins-EA, 2000] [4, WS Atkins-EA 2000]. The use of hoses suspended from an inertia reel device, together with adequate training and supervision of drivers, may make their use more widespread and cost effective.

To reduce water wastage some large slaughterhouses have installed a metered water dispenser. Some meters take coins and others operate by inserting a token that is given to the driver on arrival. A driver can request an additional token if he is unable to finish cleaning his vehicle with the specified amount of water. The metered system has reportedly reduced water consumption. [12, WS Atkins-EA, 2000] [4, WS Atkins-EA 2000]

3.3.2.1.3 Noise

Animal reception and lairage

The lairage is one of the main sources of noise at slaughterhouses due to vehicle movements and animal noises during unloading. Cattle and sheep are generally fairly quiet, but pigs may be noisy, particularly during unloading and marshalling operations.

Splitting

Carcass splitting is one of the main sources of noise in a slaughterhouse. Noise levels of about 95dB(A) have been measured. Further noise is produced when the standard cuts are made. The sound may be detectable outside the building. In addition, the saw operator and anyone in the near vicinity has a significant risk of contracting noise induced hearing loss and health and safety legislation requires this risk to be minimised.

Chilling

The refrigeration plant is operated continuously and the condensing units, compressors and cooling towers associated with it can be a source of noise. Refrigerated trucks parked outside slaughterhouses can sometimes lead to noise problems if the refrigeration is powered from the truck engines. Many slaughterhouses provide mains power cables to power the refrigeration unit, thereby reducing the noise levels.

3.3.2.1.4 Emissions to water

Animal reception and lairage

Washing the vehicles and the lairage area can introduce organic material; inorganics, e.g. ammonia, phosphorus and solids; oils/fats/grease and solids into the waste water [~~3, EPA, 1996~~] [1, EPA 1996].

Lairage manure, urine and wash-water is high in nutrients and can be collected for agricultural use as a fertiliser, provided specific conditions are met. [~~12, WS Atkins EA, 2000~~] [4, WS Atkins-EA 2000]. At some slaughterhouses, clean water from other process areas, e.g. from chills and carcass refrigeration rooms, as well as cooling water and steam condensate, is used to provide a primary wash down of lairage areas [~~12, WS Atkins EA, 2000~~] [4, WS Atkins-EA 2000].

Bleeding

Blood collected for blood processing tends to be collected more carefully and hygienically than that destined for rendering, so less may contaminate the waste water at the bleeding stage of the process. Less stringent hygiene requirements apply to blood which can be rendered, so if it is collected from floors, the floors have to be washed and the waste water volume and contamination are consequently increased. Hollow knives used to collect blood for food or pharmaceutical use reduce spillage, but the back-pressure they cause means that they also capture less blood than when an animal's throat is cut and natural bleeding occurs. Hollow knives typically collect 75 % of a pig's blood. The remaining blood is then released later in the process and the degree of contamination it causes depends on the speed of the line and the blood collection arrangements along the line. Collection figures of 23 % along the line, for rendering, with the final 2 % going to the WWTP, have been reported. [~~220, APC Europe, 2001~~] [96, APC Europe 2001]

Blood has the highest COD strength of any liquid effluent arising from meat processing operations. Liquid blood has a COD of about 400 g/l and a BOD of about 200 g/l. Congealed blood has a COD strength of about 900 g/l. If the blood from a single cattle carcass was allowed to discharge directly to a water company sewerage system the COD effluent load would be equivalent to the total sewage produced by 50 people on an average day. [~~12, WS Atkins EA, 2000~~] [4, WS Atkins-EA 2000]. Blood has a total nitrogen content of approximately 30 g/l. It has been reported that retention of the blood is by far the most successful way of minimising

waste water contamination in a slaughterhouse [~~206, Tritt W. P. and Schuchardt F., 1992~~] [~~83, Tritt W. P. and Schuchardt F. 1992~~].

Even if blood is collected carefully, i.e. by positioning the animal over the collection pit for the duration of the sticking procedure and allowing enough time for completion of the bleeding before the carcass is moved on, it has been reported that there may be dripping blood losses of up to 0.5 litres per pig (5.4 l/t carcass) and 2 litres per head of cattle (6.2 l/t carcass). [~~163, German TWG Members, 2001~~] [~~52, Germany 2001~~]. Collecting the blood before the carcass moves away from the sticking area so that it does not drip as it moves down the slaughter-line adds time to the overall process. It has been reported that the additional time taken is compensated for, because the blood collected for processing has a value, otherwise there is a charge for its removal as waste.

It has been reported that 30.5 kWh/t of electrical energy is used to refrigerate raw blood to ~5 °C [~~272, Woodgate S., 2002~~] [~~125, Woodgate S. 2002~~].

Evisceration

The wet emptying of stomach and intestinal contents can contribute 20 % of the total BOD in screened waste water from a slaughterhouse and approximately 15 % of the nitrogen. [~~134, Nordic States, 2001~~] [~~38, Nordic 2001~~]. In Danish slaughterhouses, total water consumption levels between 800 and 1200 litres and 4.4 to 5.2 kg BOD per tonne of cattle carcass have been reported, for cleaning stomachs and intestines. It has been reported that in Germany 30 % of the total waste water and organic contamination originates from stomach washing [~~206, Tritt W. P. and Schuchardt F., 1992~~] [~~83, Tritt W. P. and Schuchardt F. 1992~~].

In those slaughterhouses where macerator equipment is used to chop, wash and spin-dry offal prior to supply to the rendering company, the resulting cost savings usually outweigh the increased energy and effluent costs. The cost benefits of this approach result from the reduced volumes of waste for disposal. If offal was cut and washed the tallow colouring during rendering would be reduced and its value could increase. Macerator equipment usually consists of hook-shaped blades set to counter rotate against themselves, or to rotate against fixed anvils. The cut offal is then washed in a rotating mesh drum. The equipment needs to be maintained regularly to optimise the speed and separation of the blades. If the blades are kept in good condition this will optimise the efficiency of the cutting operation and reduce the amount of waste offal, which goes on to become mixed with the wash-water. [~~12, WS Atkins EA, 2000~~] [~~4, WS Atkins-EA 2000~~]

The cleaning of secondary process areas where, e.g. stomach washing, tripe blanching and sausage skins are made can lead to emissions to water containing organic material; inorganics, i.e. phosphorus, ammonia and solids and oils, fats and grease [~~3, EPA, 1996~~] [~~1, EPA 1996~~].

The first stomach contents are about 75 % water, weigh about 15 – 20 g per head of cattle, and produce a slurry with a COD of over 100 g/l. [~~12, WS Atkins EA, 2000~~] [~~4, WS Atkins-EA 2000~~]

Evisceration processes are carried out dry, but water is used for rinsing, knife sterilisation, the sterilisation of other equipment and for cleaning. The removed parts and the carcasses are rinsed with water to remove blood and other impurities. The introduction of water not only increases water consumption and water contamination, but it also potentially masks microbiological contamination, by removing potential visible signs.

The fat contained in the waste water from slaughterhouses is mainly produced during evisceration [~~163, German TWG Members, 2001~~] [~~52, Germany 2001~~] and intestine washing.

The rumen contents (paunch) of fully grown cattle amount to 40 - 80 litres per head (wet) [~~163, German TWG Members, 2001~~] [~~52, Germany 2001~~].

Blood drips from the carcasses during evisceration.

Hide/skin treatment

Salting using sodium chloride is the most common method of hide and skin preservation. Excess salt which spills off the salting table or is dropped during hand salting may be swept up and re-used. If it is unacceptably contaminated it is normally disposed of, by incineration. Salinity can reduce the efficiency of the WWTP and unless there is a naturally saline water course for receipt of the treated waste water, the salt content can have adverse effects on plant growth. The presence of salts affects the plant growth by osmotic effects, due to the concentration of salt in soil water; the specific ion toxicity, caused by the concentration of an individual ion and the soil particle dispersion caused by high sodium and low salinity. Under these conditions, the plants expend more of their available energy on adjusting the salt concentration within the tissue to obtain water from the soil, so less is available for plant growth. [216, Metcalf and Eddy, 1991] [92, Metcalf and Eddy 1991]

Animal reception and lairage

There may be odour problems during animal delivery and storage.

3.3.2.2 Cattle slaughterhouses

This section presents data for installations exclusively slaughtering cattle.

3.3.2.2.1 Energy consumption

3.3.2.2.1.1 Specific net energy consumption in kWh/tonne of carcass

Figure 3.14 shows data in relation to total specific net energy consumption in terms of kWh/tonne of carcass at installation level as well as the applied techniques to reduce energy consumption.



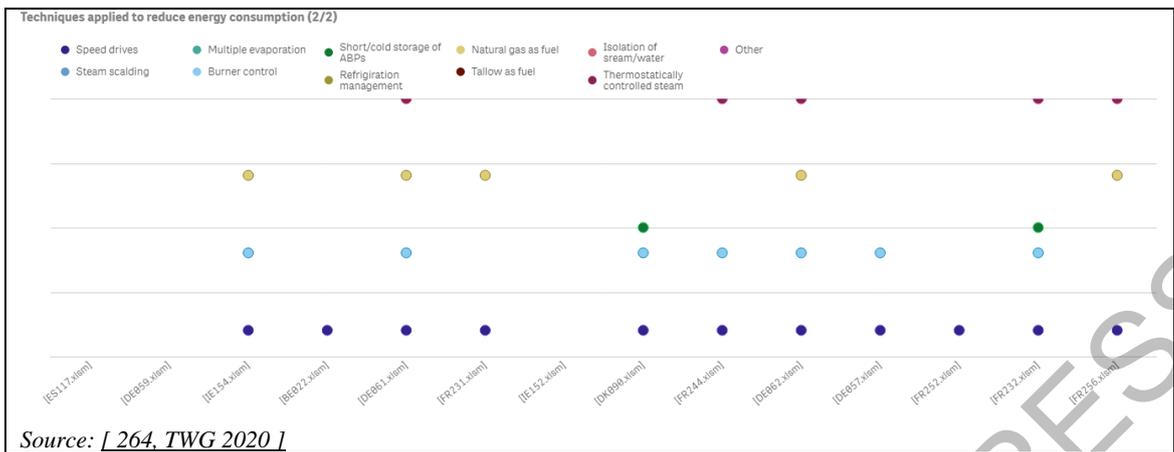


Figure 3.14: Specific energy consumption (kWh/t of carcass) and applied techniques to reduce energy consumption in cattle slaughterhouses (installation level)

Figure 3.15 shows data in relation to total specific net electricity and heat consumption in terms of kWh/tonne of carcass at installation level.

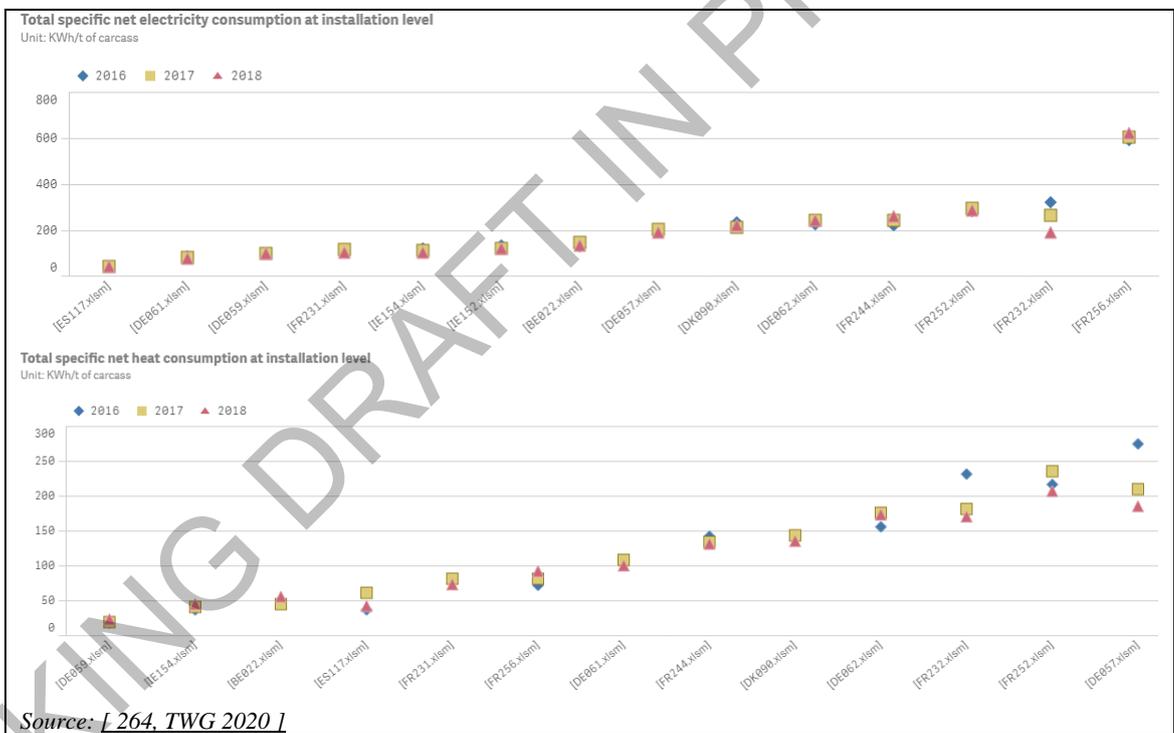


Figure 3.15: Specific electricity and heat consumption (kWh/tonne of carcass) in cattle slaughterhouses (installation level)

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Figure 3.16 and Figure 3.17 show the specific net energy consumption (in kWh/tonne of carcass) in various cattle slaughterhouse processes.

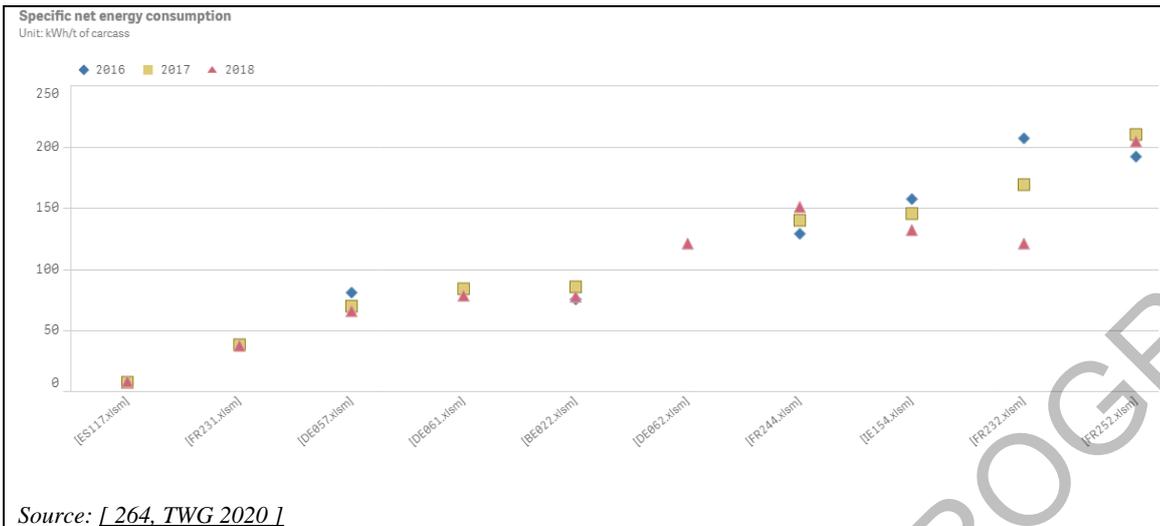


Figure 3.16: Specific energy consumption (kWh/tonne of carcass) in cattle slaughterhouses for cooling systems

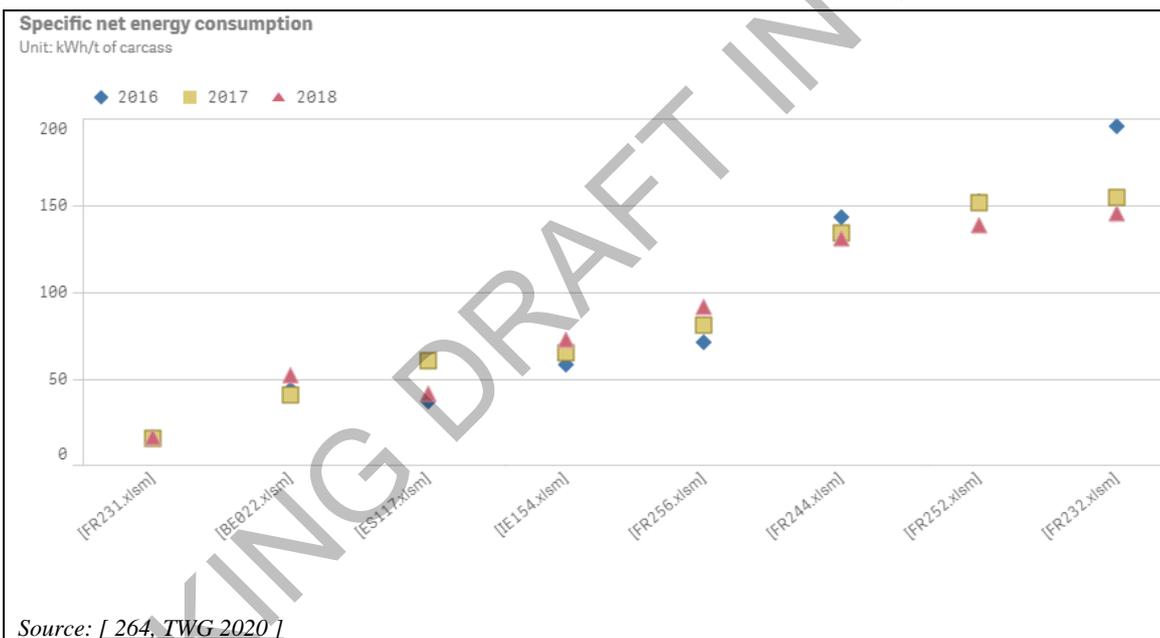


Figure 3.17: Specific energy consumption (kWh/tonne of carcass) in cattle slaughterhouses for production of hot water for cleaning and disinfection

3.3.2.2.1.2 Specific net energy consumption in kWh/animal

Figure 3.17 shows data in relation to total specific net energy consumption in terms of kWh/animal at installation level as well as the applied techniques to reduce energy consumption.



Figure 3.18: Specific energy consumption (kWh/animal) and applied techniques to reduce energy consumption in cattle slaughterhouses (installation level)

Figure 3.19 shows data in relation to total specific net electricity and heat consumption in terms of kWh/animal at installation level.



Figure 3.19: Specific electricity and heat consumption (kWh/animal) in cattle slaughterhouses (installation level)

Figure 3.20 and Figure 3.21 shows the specific net energy consumption (in kWh/animal) in various cattle slaughterhouse processes.

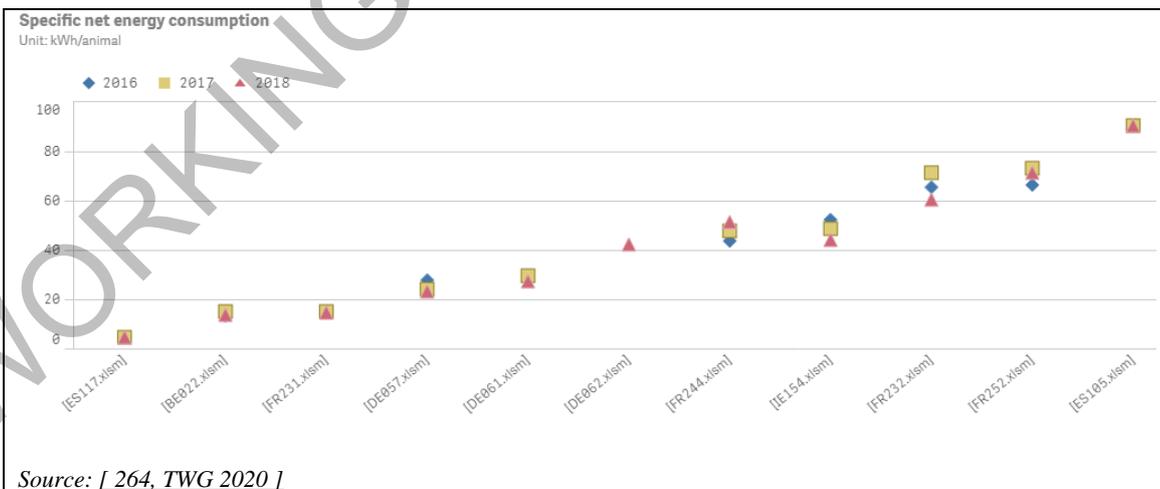


Figure 3.20: Specific energy consumption (kWh/animal) in cattle slaughterhouses for cooling systems

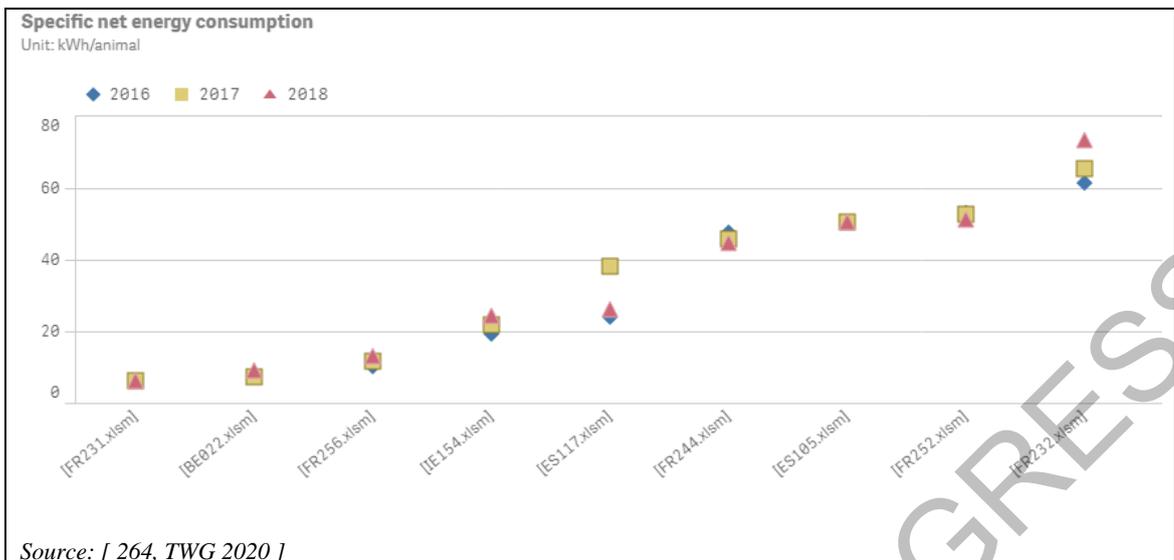


Figure 3.21: Specific energy consumption (kWh/animal) for production of hot water for cleaning and disinfection in cattle slaughterhouses

3.3.2.2.2 Water consumption

3.3.2.2.2.1 Specific net water consumption in m³/tonne of carcass

Figure 3.22 shows data in relation to total specific net water consumption in terms of m³/t of carcass at installation level.

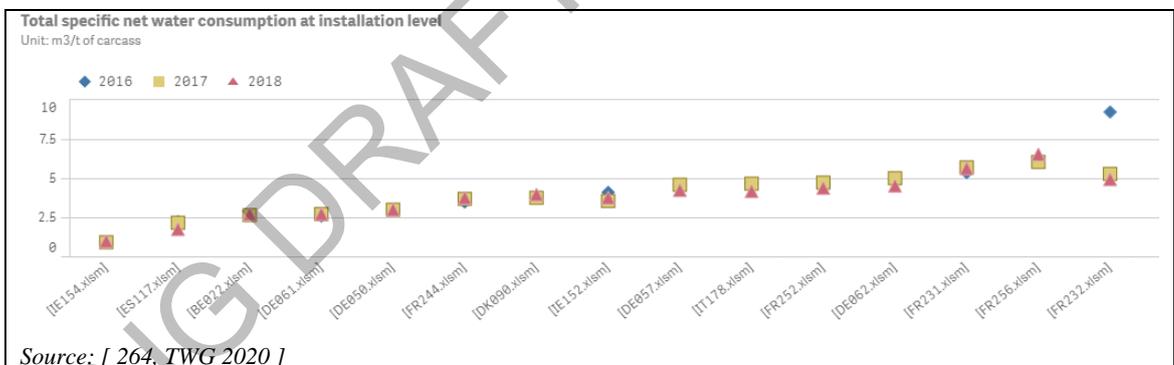


Figure 3.22: Specific water consumption (m³/tonne of carcass) in cattle slaughterhouses (installation level)

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Figure 3.23, Figure 3.24 and Figure 3.25 show the specific net water consumption (in m³/tonne of carcass) for several specific processes in cattle slaughterhouses.

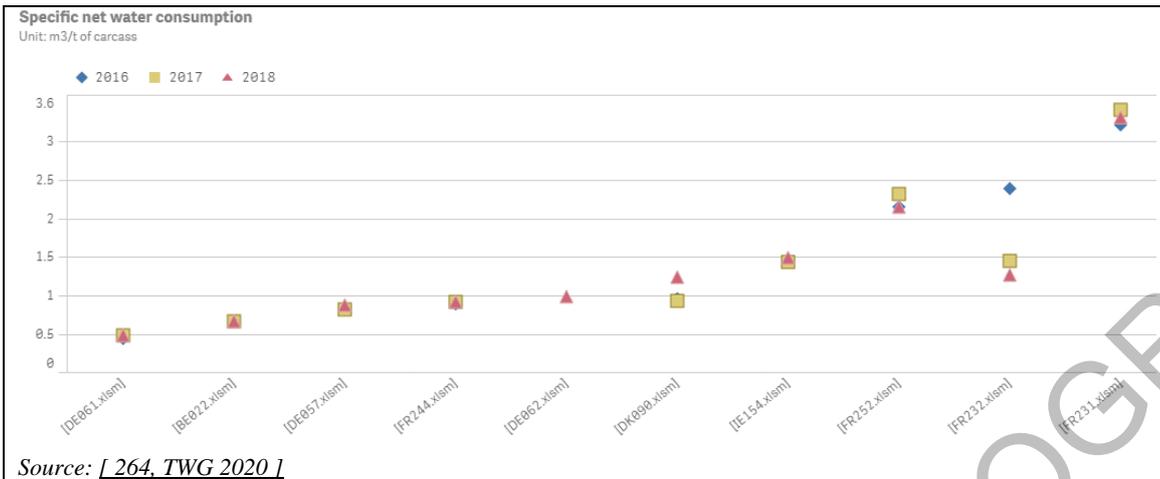


Figure 3.23: Specific water consumption (m³/tonne of carcass) for cleaning of floors/walls and equipment in cattle slaughterhouses

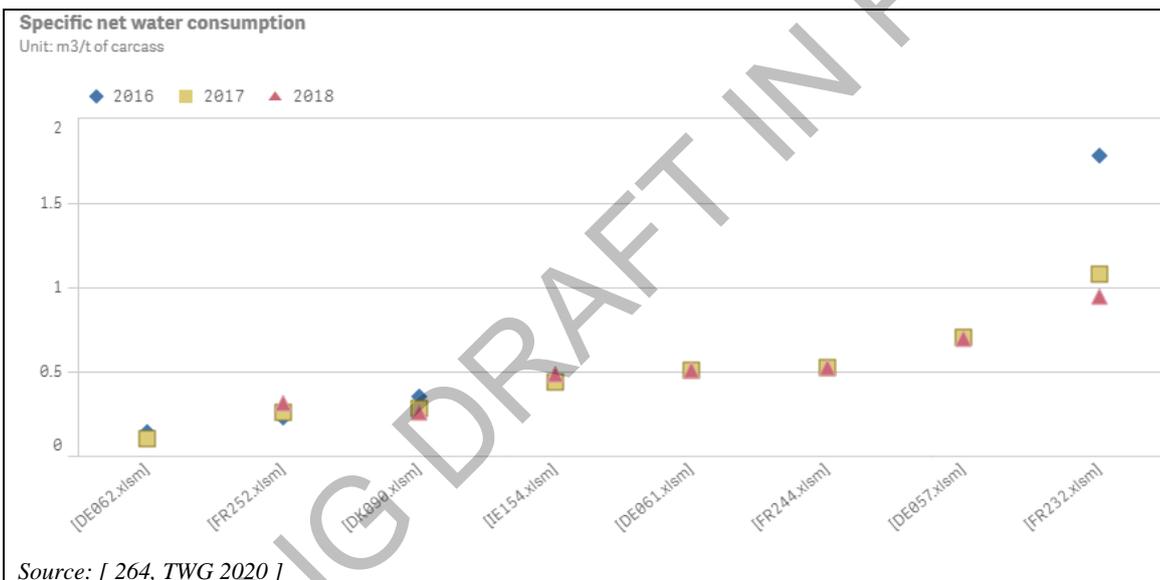


Figure 3.24: Specific water consumption (m³/tonne of carcass) for handling of casings and offal in cattle slaughterhouses

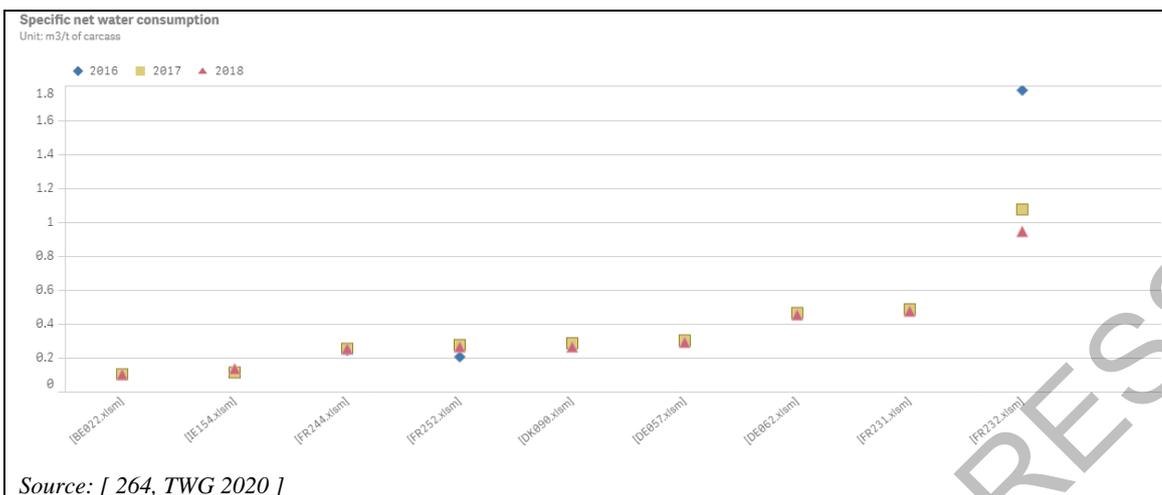


Figure 3.25: Specific water consumption (m³/tonne of carcass) for vehicle washing in cattle slaughterhouses

3.3.2.2.2 Specific net water consumption in m³/animal

Figure 3.26 shows data in relation to total specific net energy consumption in terms of m³/animal at installation level.

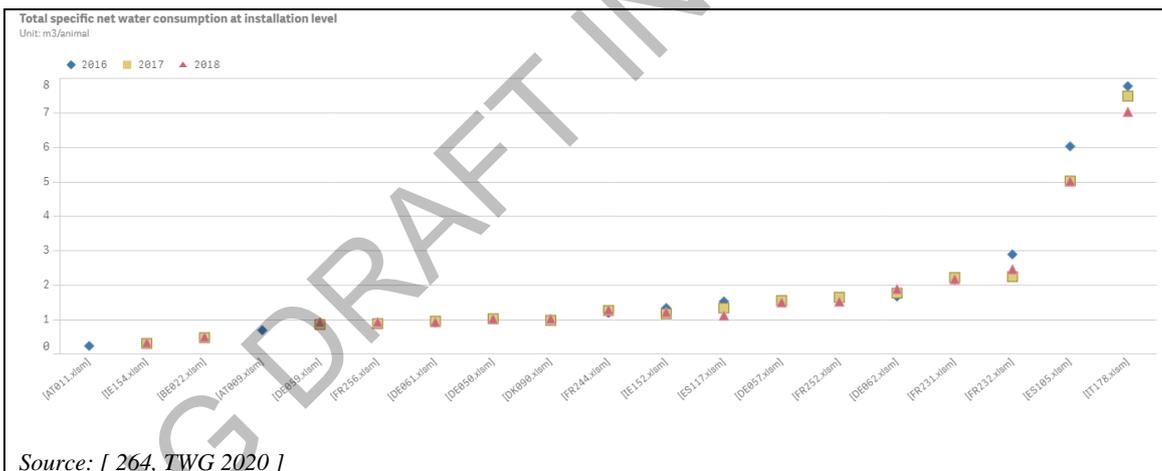


Figure 3.26: Specific water consumption (m³/animal) in cattle slaughterhouses (installation level)

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Figure 3.27, Figure 3.28 and Figure 3.29 show the specific net water consumption (in m³/animal) for several specific processes in cattle slaughterhouses.

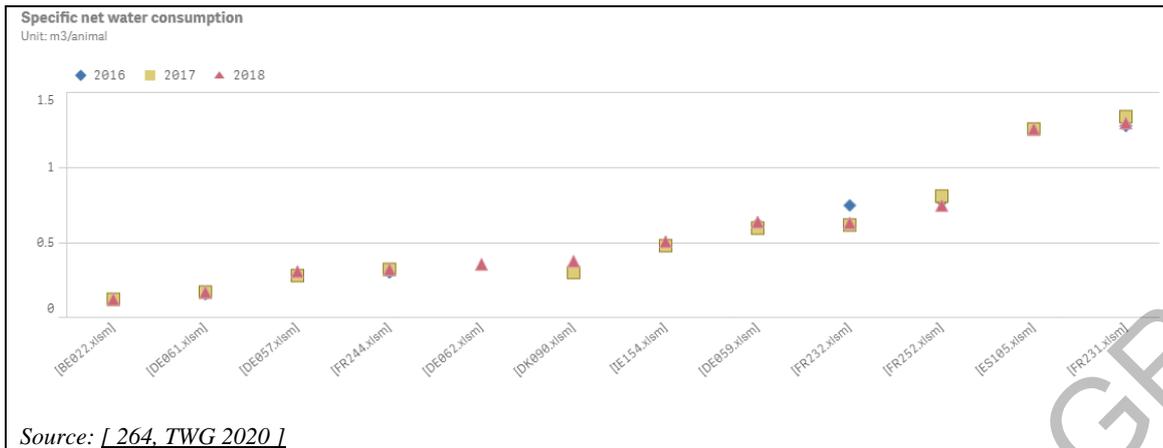


Figure 3.27: Specific water consumption (m³/animal) for cleaning of floors/walls and equipment in cattle slaughterhouses

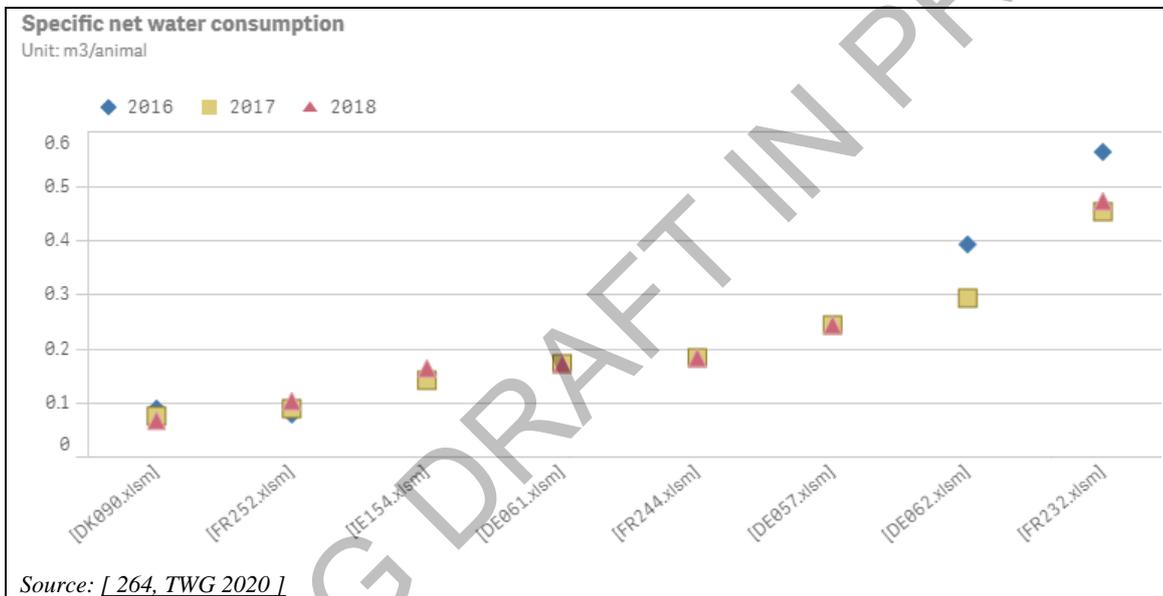


Figure 3.28: Specific water consumption (m³/animal) for handling of casings and offal in cattle slaughterhouses

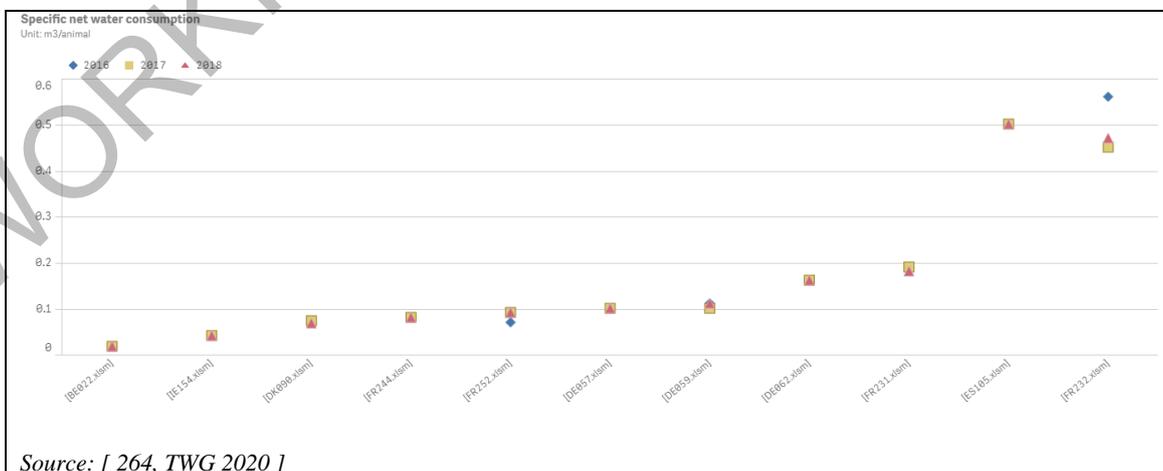


Figure 3.29: Specific water consumption (m³/animal) for vehicle washing in cattle slaughterhouses

3.3.2.2.3 Emissions to water

Figure 3.30 shows reported data on specific waste water discharges in m³/tonne of carcase from cattle slaughterhouses and all types of discharges, as well as the reported techniques to reduce water consumption.

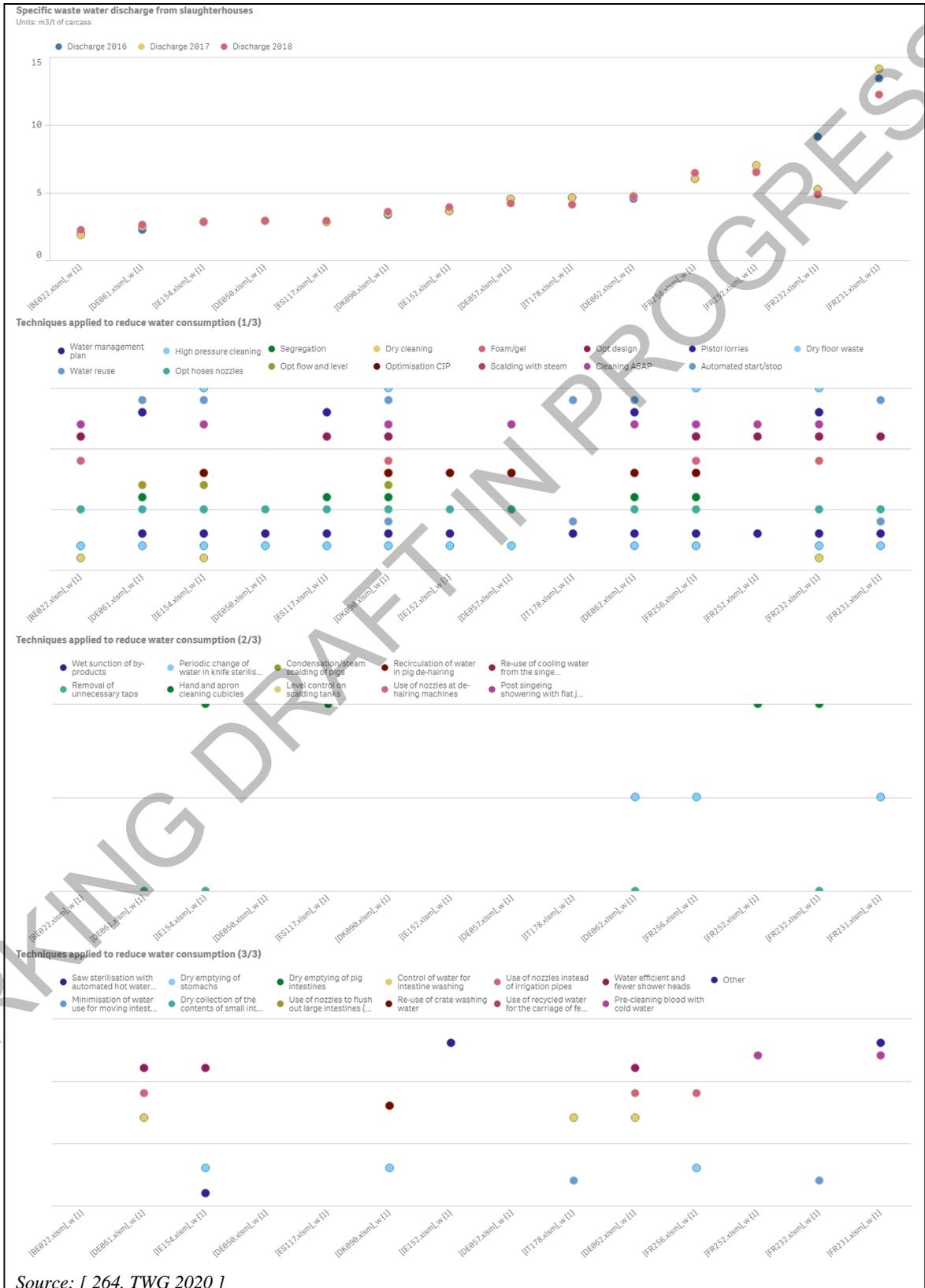


Figure 3.30: Specific waste water discharge (m³/tonne of carcase) in cattle slaughterhouses for all types of discharges and applied techniques to reduce water consumption

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Figure 3.31 shows reported data on specific waste water discharges in m³/animal from cattle slaughterhouses and all types of discharges, as well as the reported techniques to reduce water consumption

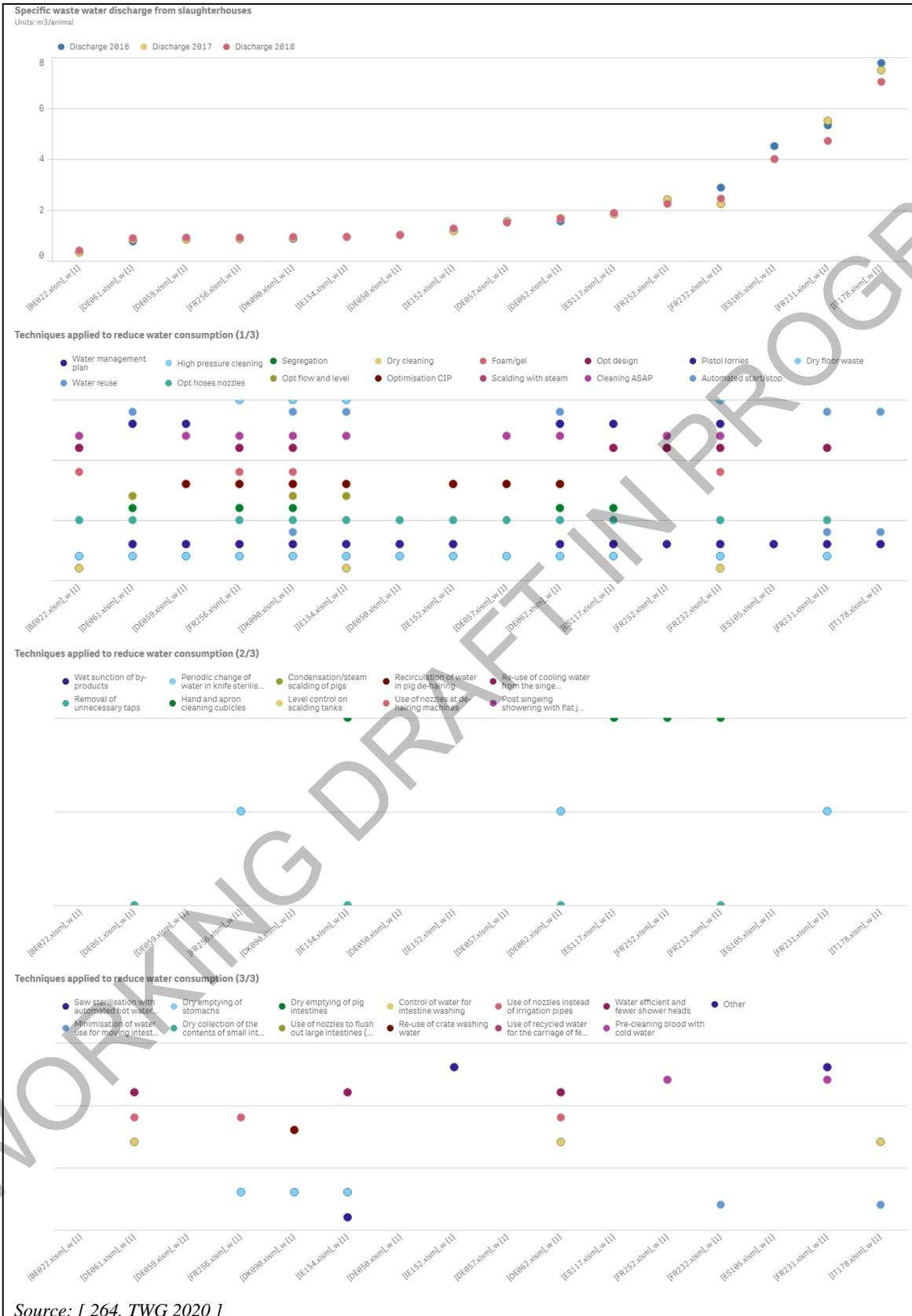


Figure 3.31: Specific waste water discharge (m³/animal) in cattle slaughterhouses for all types of discharges and reported techniques to reduce water consumption

Head and hoof removal for cattle ~~and sheep~~

Significant blood spillage occurs from the large blood vessels when the head is cut off. Rinsing the heads to remove blood, can as well as increasing water consumption and water contamination, spread impurities to other areas of the carcase. The need to rinse can, therefore, be limited by using correct slaughter procedures.

3.3.2.3 Pig slaughterhouses

This section presents data for installations exclusively slaughtering pigs.

3.3.2.3.1 Energy consumption

In many slaughterhouses there are opportunities to recover useable heat from the exhaust emission and opportunities to minimise heat losses during scalding. The condensation that occurs following evaporation can be removed by extraction.

3.3.2.3.1.1 Specific net energy consumption in kWh/tonne of carcase

Figure 3.32 shows data in relation to total specific net energy consumption in terms of kWh/tonne of carcase at installation level as well as the applied techniques to reduce energy consumption.

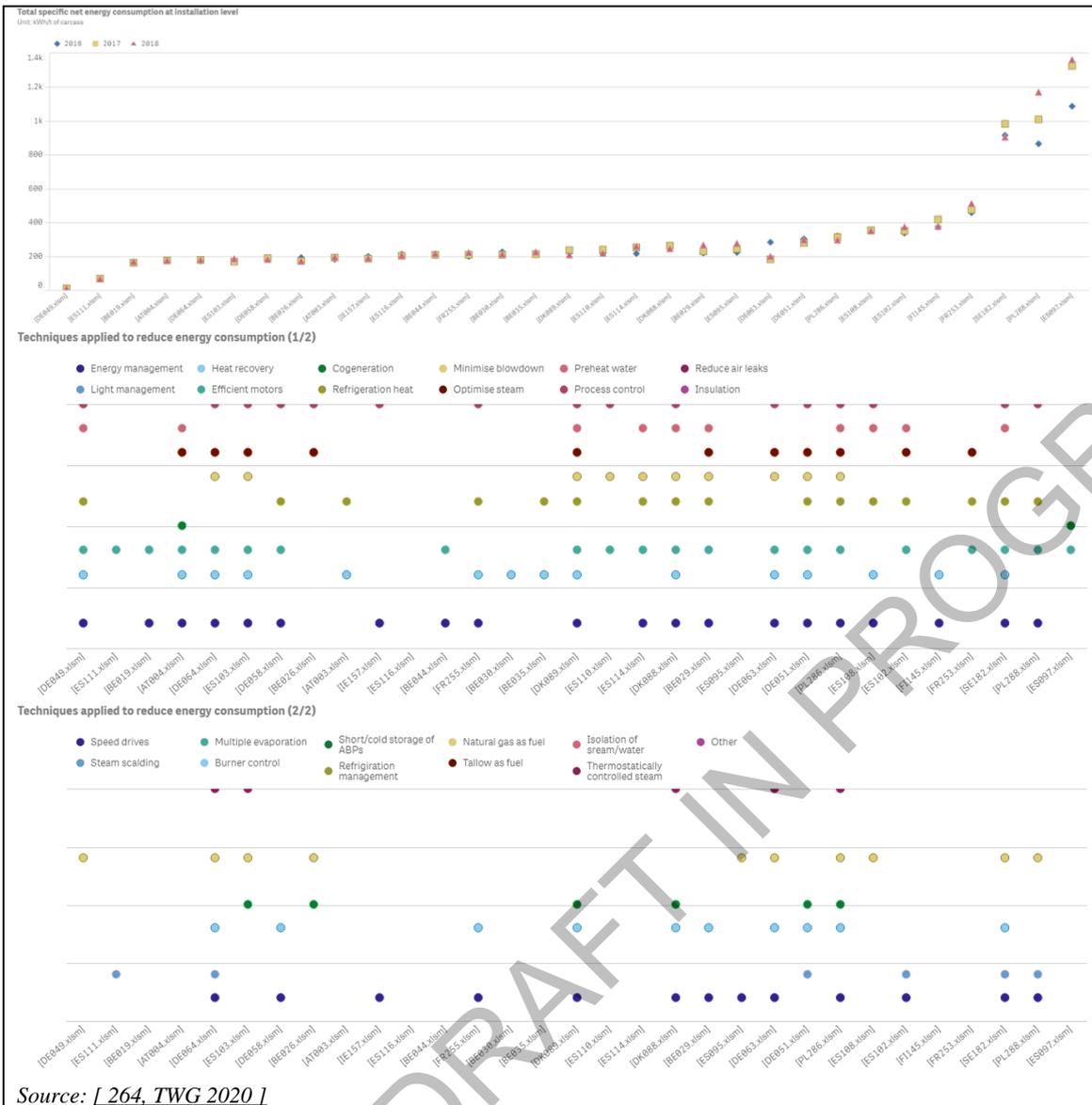
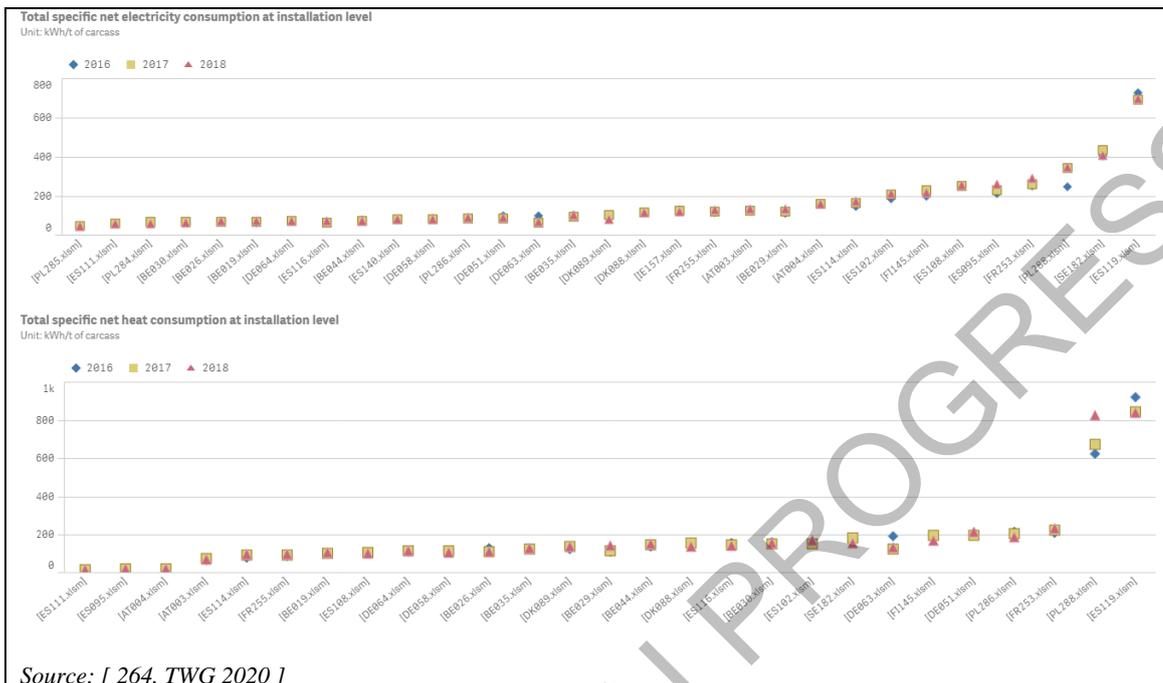


Figure 3.32: Specific energy consumption (kWh/t of carcase) and applied techniques to reduce energy consumption in pig slaughterhouses (installation level)

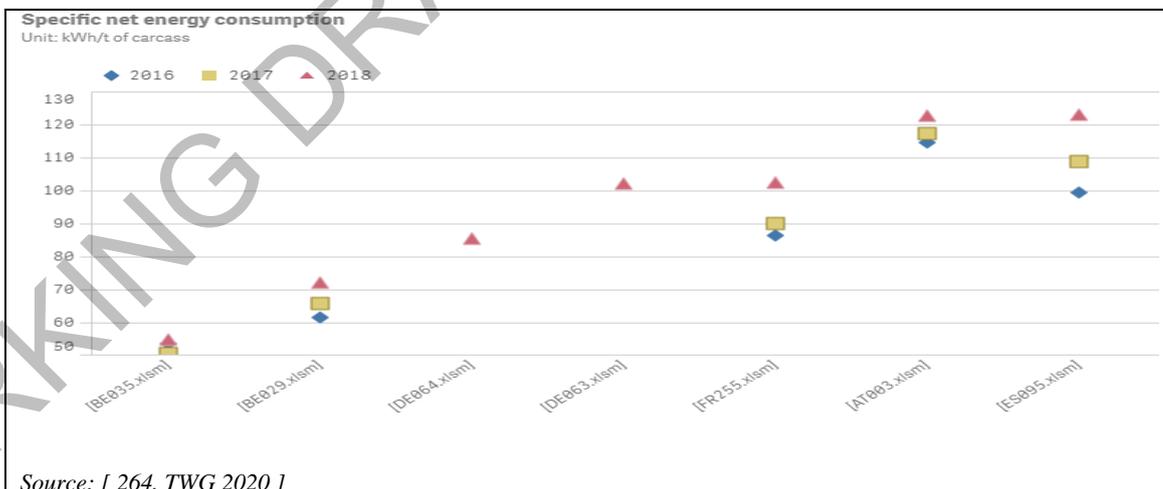
Figure 3.33 shows data in relation to total specific net electricity and heat consumption in terms of kWh/t of carcass at installation level.



Source: [264, TWG 2020]

Figure 3.33: Specific electricity and heat consumption (kWh/tonne of carcass) in pig slaughterhouses (installation level)

Figure 3.34, Figure 3.35, Figure 3.36 and Figure 3.37 show the specific net energy consumption (in kWh/tonne of carcass) in various pig slaughterhouse processes.



Source: [264, TWG 2020]

Figure 3.34: Specific energy consumption (kWh/tonne of carcass) for cooling systems in pig slaughterhouses

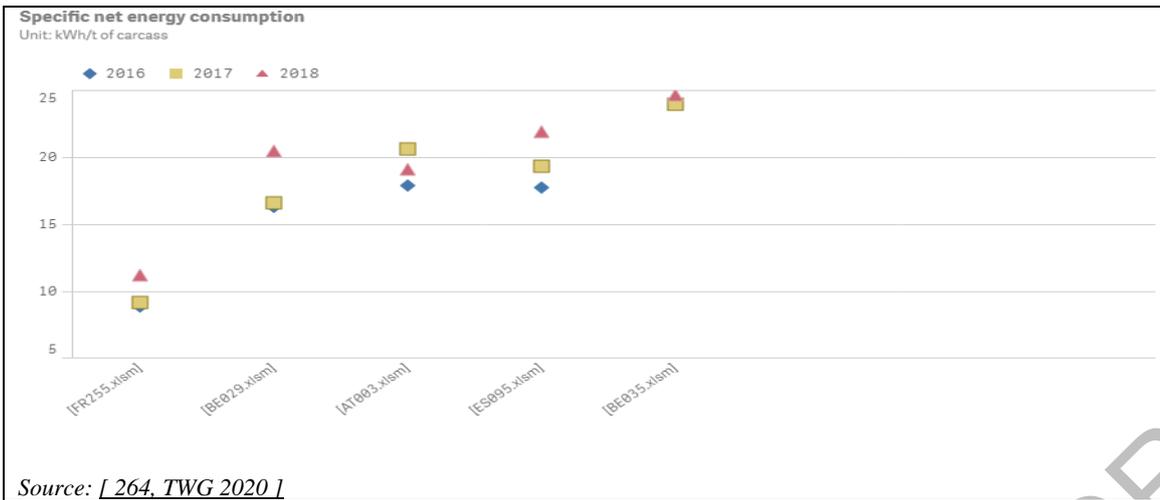


Figure 3.35: Specific energy consumption (kWh/tonne of carcase) for production of hot water for cleaning and disinfection in pig slaughterhouses

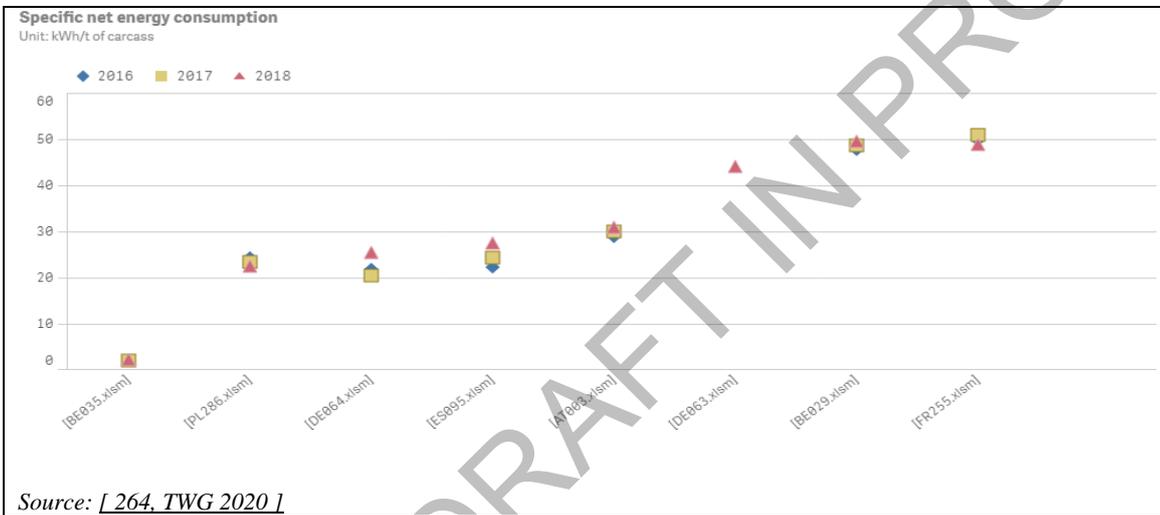


Figure 3.36: Specific energy consumption (kWh/tonne of carcase) for pig singeing in pig slaughterhouses

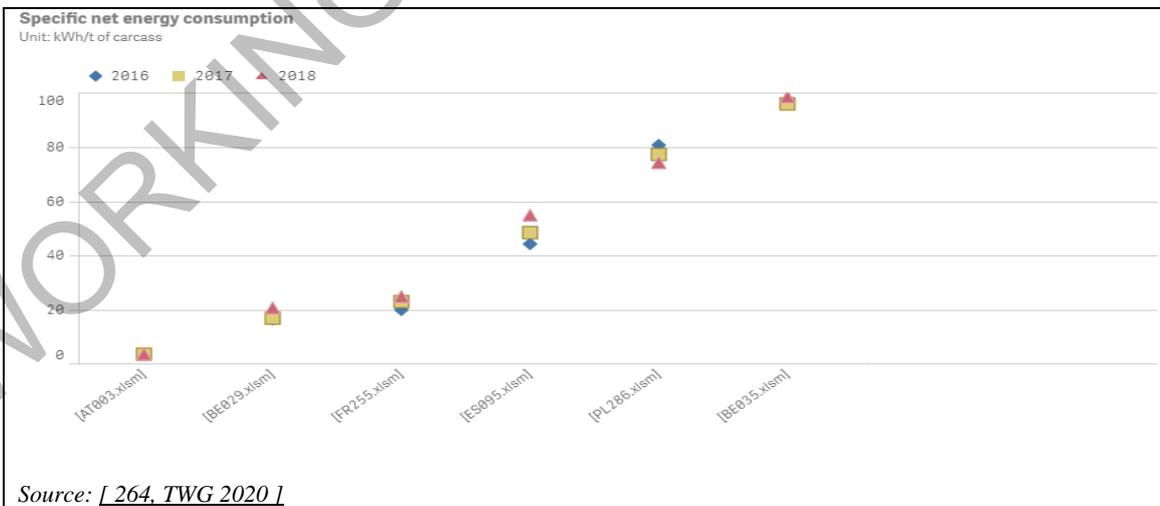


Figure 3.37: Specific energy consumption (kWh/tonne of carcase) for scalding in pig slaughterhouses

3.3.2.3.1.2 Specific net energy consumption in kWh/animal

Figure 3.38 shows data in relation to total specific net energy consumption in terms of kWh/animal at installation level as well as the applied techniques to reduce energy consumption.

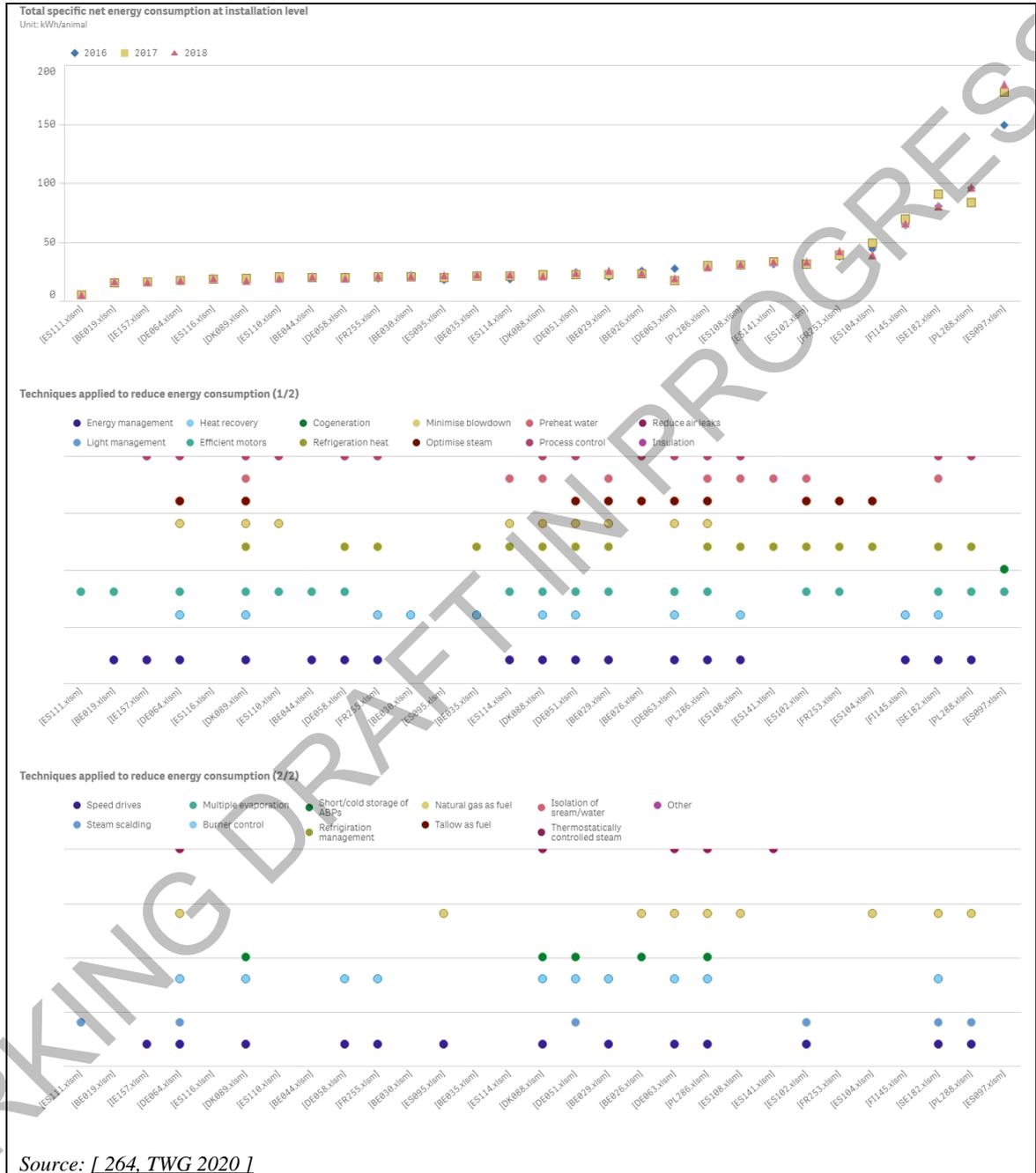
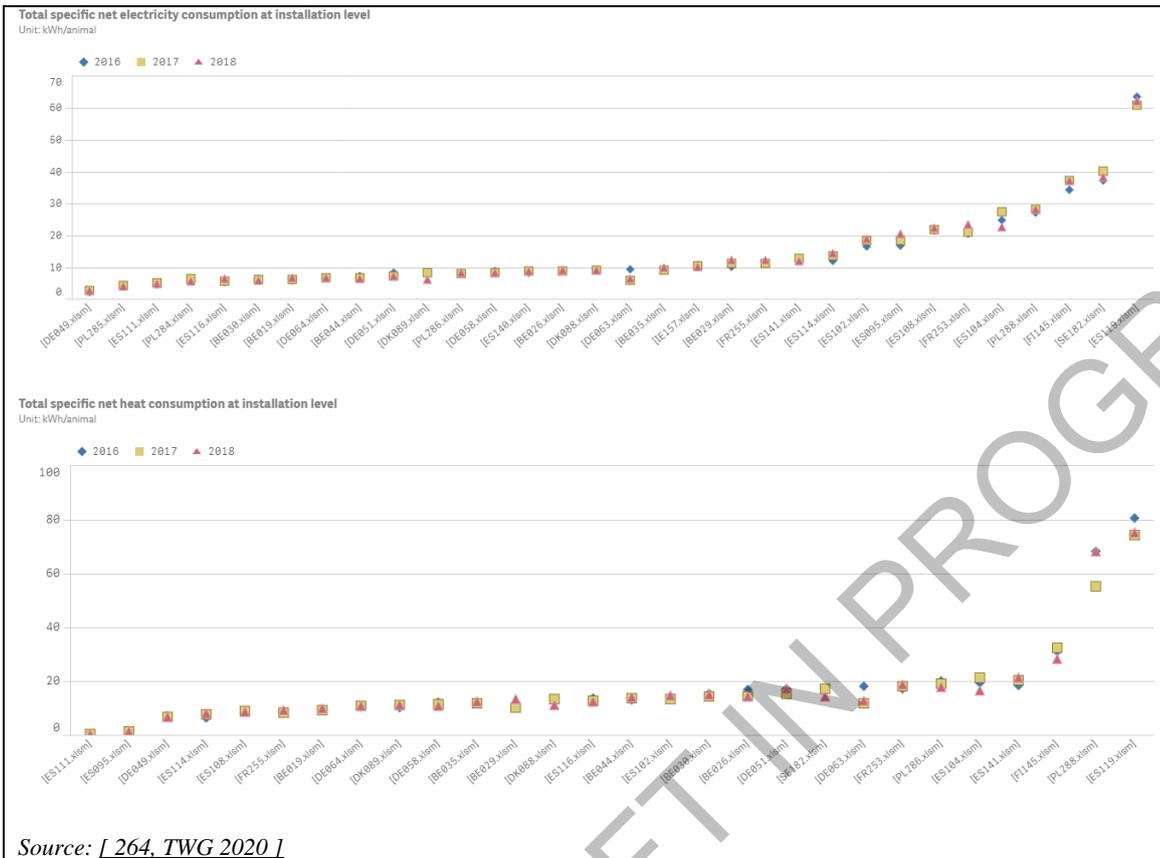


Figure 3.38: Specific energy consumption (kWh/animal) and applied techniques to reduce energy consumption in pig slaughterhouses (installation level)

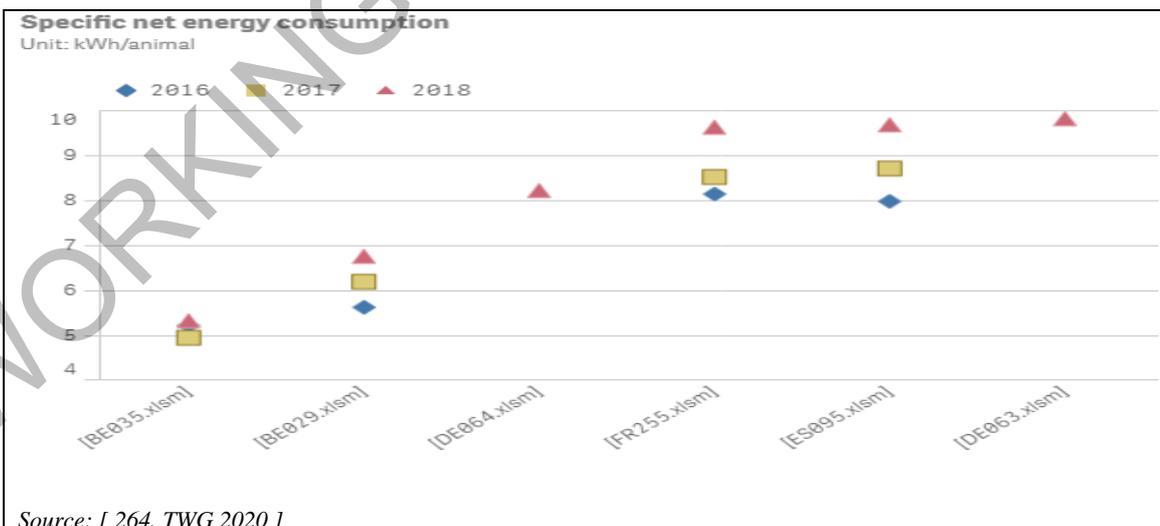
Figure 3.39 shows data in relation to total specific net electricity and heat consumption in terms of kWh/animal at installation level.



Source: [264, TWG 2020]

Figure 3.39: Specific electricity and heat consumption (kWh/animal) in pig slaughterhouses (installation level)

Figure 3.40, Figure 3.41, Figure 3.42 and Figure 3.43 show the specific net energy consumption (in kWh/animal) in various pig slaughterhouse processes.



Source: [264, TWG 2020]

Figure 3.40: Specific energy consumption (kWh/animal) for cooling systems in pig slaughterhouses

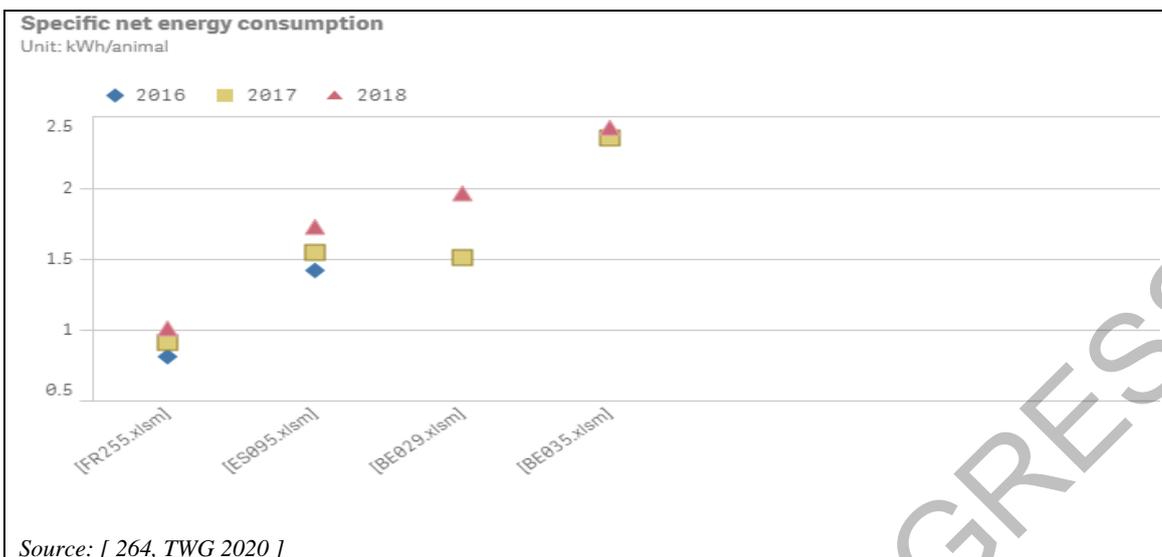


Figure 3.41: Specific energy consumption (kWh/animal) for production of hot water for cleaning and disinfection in pig slaughterhouses

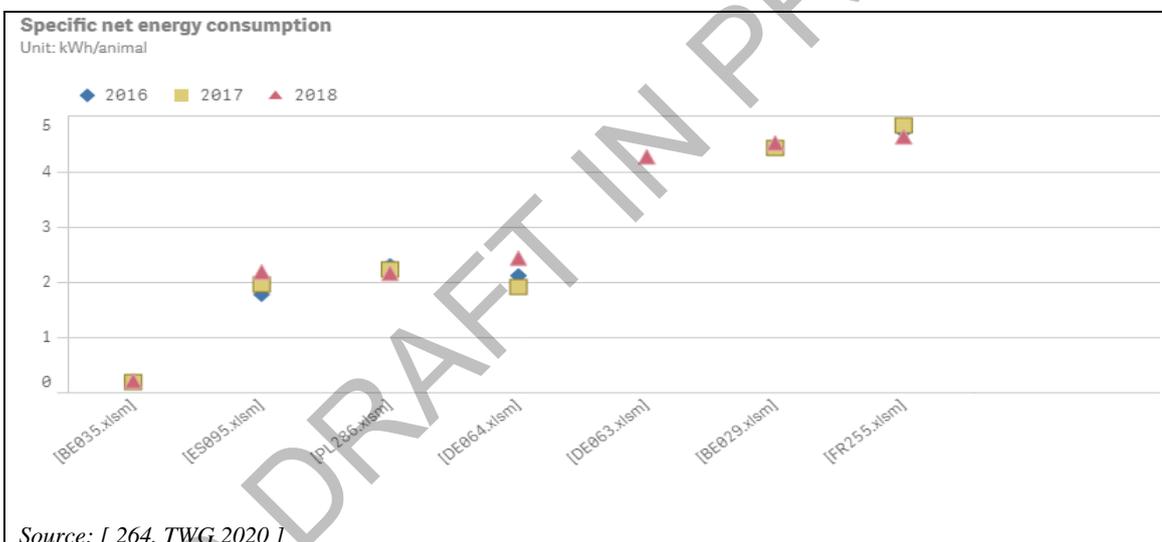


Figure 3.42: Specific energy consumption (kWh/animal) for pig singeing in pig slaughterhouses

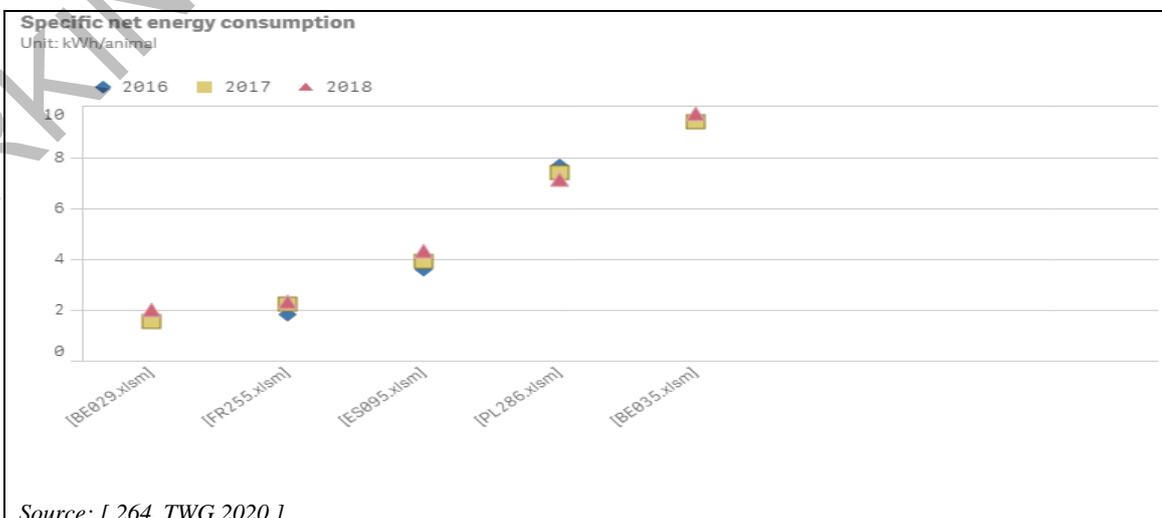


Figure 3.43: Specific energy consumption (kWh/animal) for scalding in pig slaughterhouses

3.3.2.3.2 Water consumption

Pig scalding

The scalding tanks are filled with water at the beginning of each day. They are kept at a temperature of approximately 60 °C throughout the day. Debris and sludge build up in the tanks during production. It is common practice in many slaughterhouses to empty the water and sludge directly into the site waste water drainage system at the end of each day. In some cases, the tank is refilled by leaving the water supply running until it is switched off by the cleaning staff, or the water is even left to run overnight, allowing excess water to spill over the tank into the drain. Some slaughterhouses have made considerable savings by installing a simple ball valve or other level sensing device to switch off the water supply when the scalding tank is full. [12, WS Atkins EA, 2000] [4, WS Atkins-EA 2000]

Hide and skin removal

The practice of de-hiding pigs is relatively rare, but where it is carried out, the pigs are machine washed and dried before the hides are removed. Limited figures for the de-hiding of pigs report that water is used at a rate of approximately 70 l/pig, for de-hiding. This includes thorough cleaning of the pigs in the lairage and after bleeding, to avoid contamination during the de-hiding process. [274, Pontoppidan O., 2002] [127, Pontoppidan O. 2002]

Dehairing

Use of appropriate amounts of water in the de-hairer improves the product hygiene. It is assessed that the optimal water consumption can vary between 3 litres and 12 litres per carcass. The product hygiene has an impact on the ability of the meat products to remain fresh and thus the distance to which they can be exported as fresh meat [203, Denmark 2015].

3.3.2.3.2.1 Specific net water consumption in m³/tonne of carcass

Figure 3.44 shows data in relation to total specific net water consumption in terms of m³/tonne of carcass at installation level.

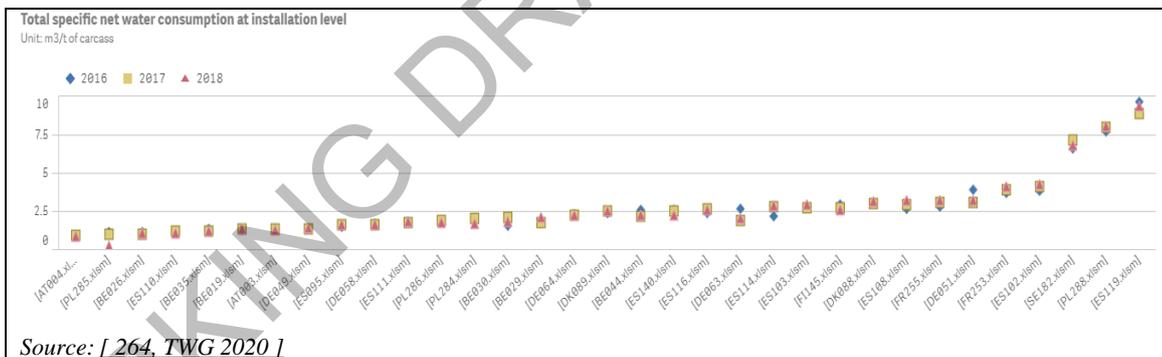


Figure 3.44: Specific water consumption (m³/tonne of carcass) in pig slaughterhouses (installation level)

Figure 3.45, Figure 3.46, Figure 3.47 and Figure 3.48 show the specific net water consumption (in m³/tonne of carcass) for several specific processes in pig slaughterhouses.

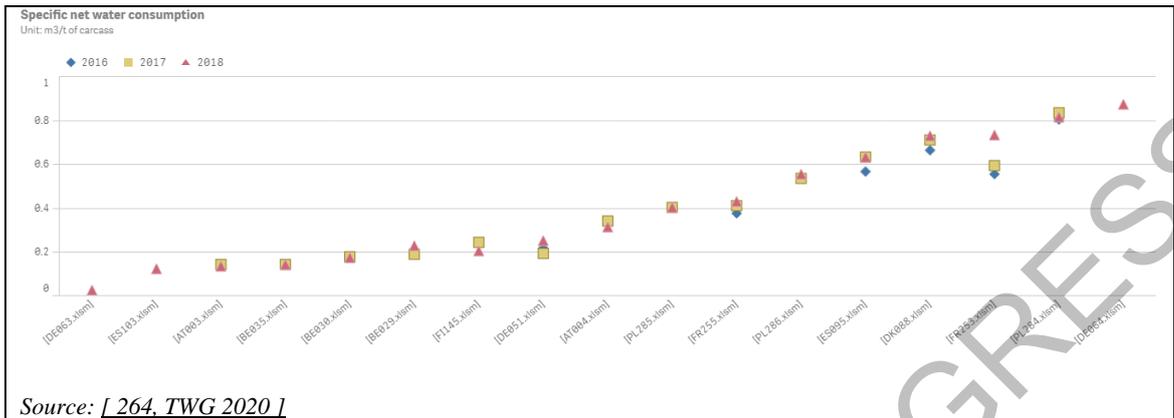


Figure 3.45: Specific water consumption (m³/tonne of carcass) for cleaning of floors/walls and equipment in pig slaughterhouses

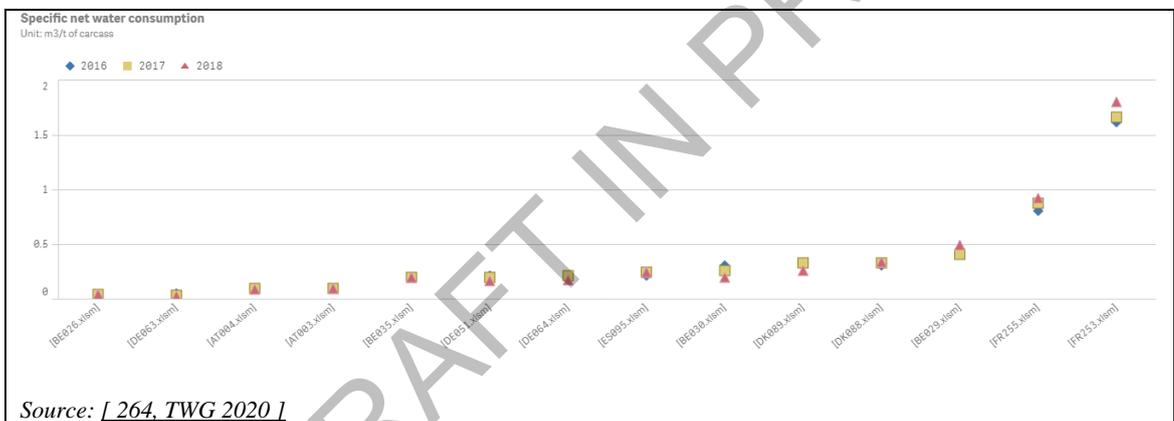


Figure 3.46: Specific water consumption (m³/tonne of carcass) for handling of casings and offal in pig slaughterhouses

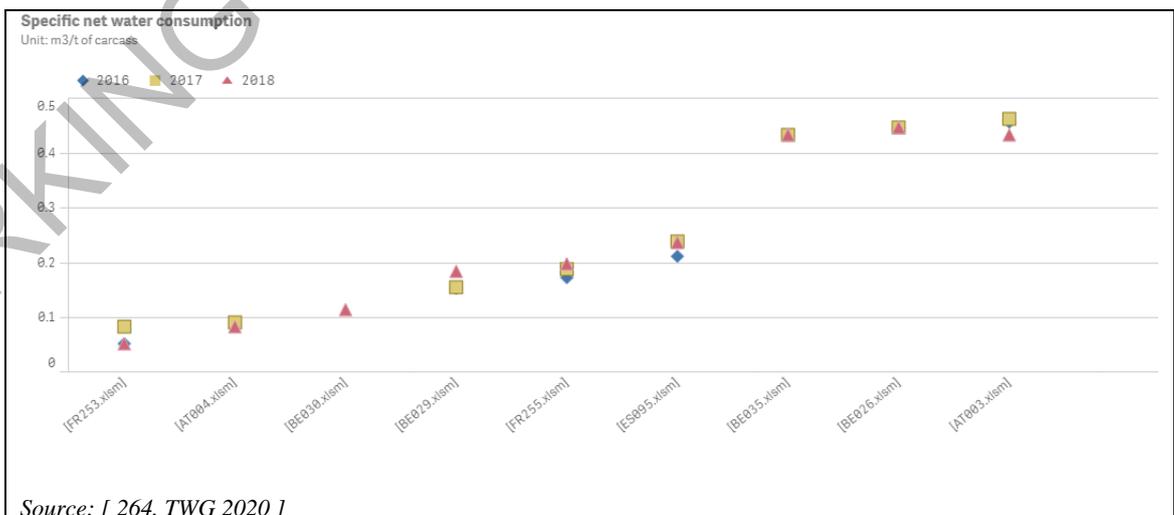


Figure 3.47: Specific water consumption (m³/tonne of carcass) for scalding in pig slaughterhouses

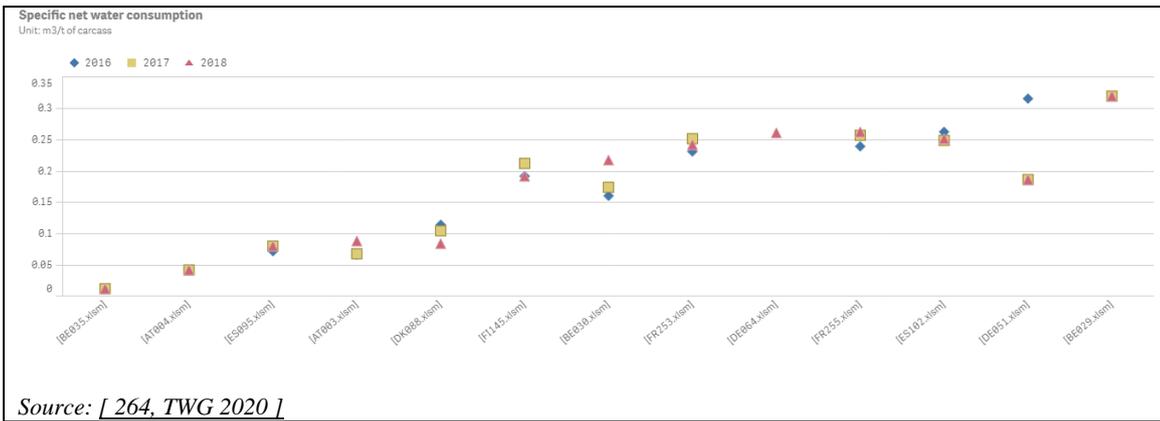


Figure 3.48: Specific water consumption (m³/tonne of carcass) for vehicle washing in pig slaughterhouses

3.3.2.3.2.2 Specific net water consumption in m³/animal

Figure 3.49 shows data in relation to total specific net energy consumption in terms of m³/animal at installation level.

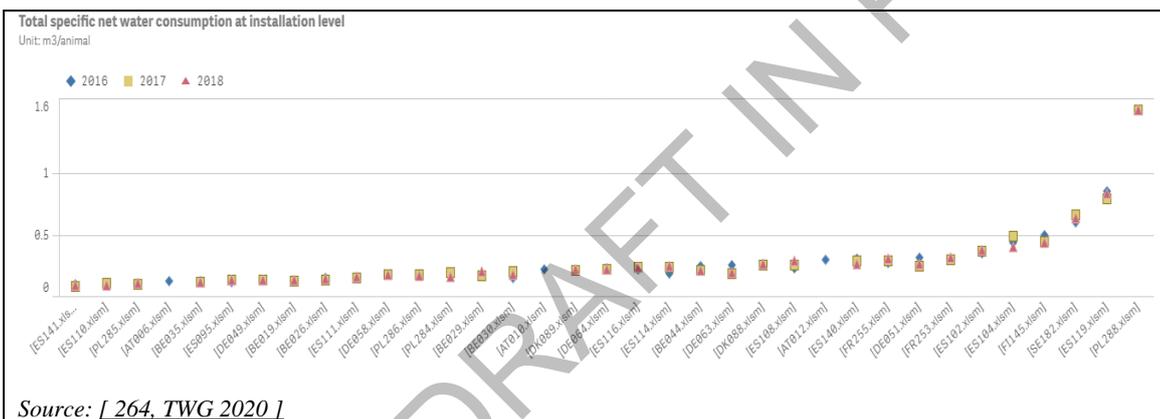


Figure 3.49: Specific water consumption (m³/animal) in pig slaughterhouses (installation level)

Figure 3.50, Figure 3.51, Figure 3.52 and Figure 3.53 show the specific net water consumption (in m³/animal) for several specific processes in pig slaughterhouses.

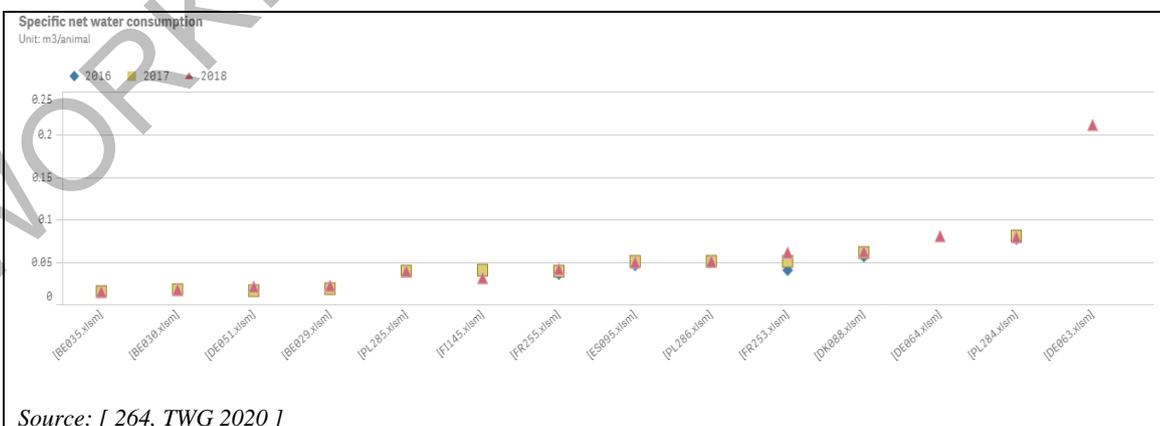


Figure 3.50: Specific water consumption (m³/animal) for cleaning of floors/walls and equipment in pig slaughterhouses

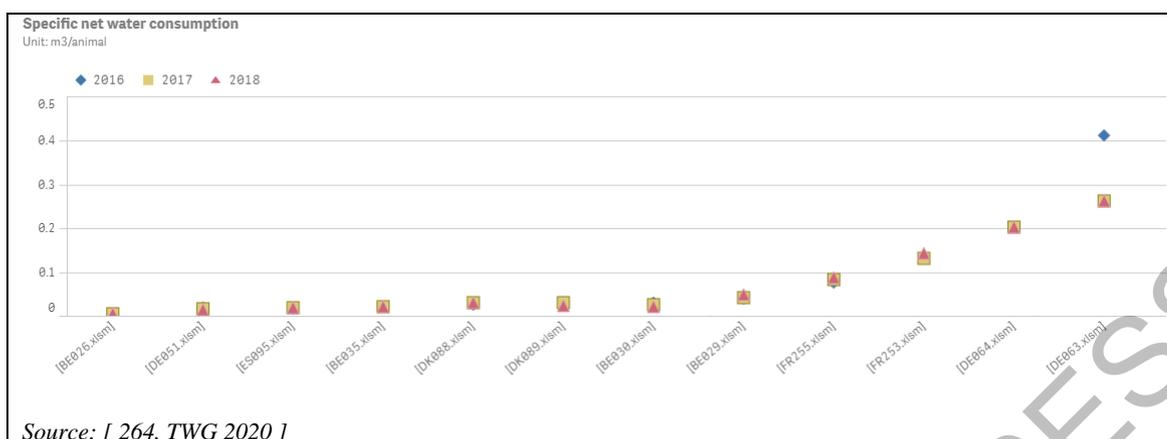


Figure 3.51: Specific water consumption (m³/animal) for handling of casings and offal in pig slaughterhouses

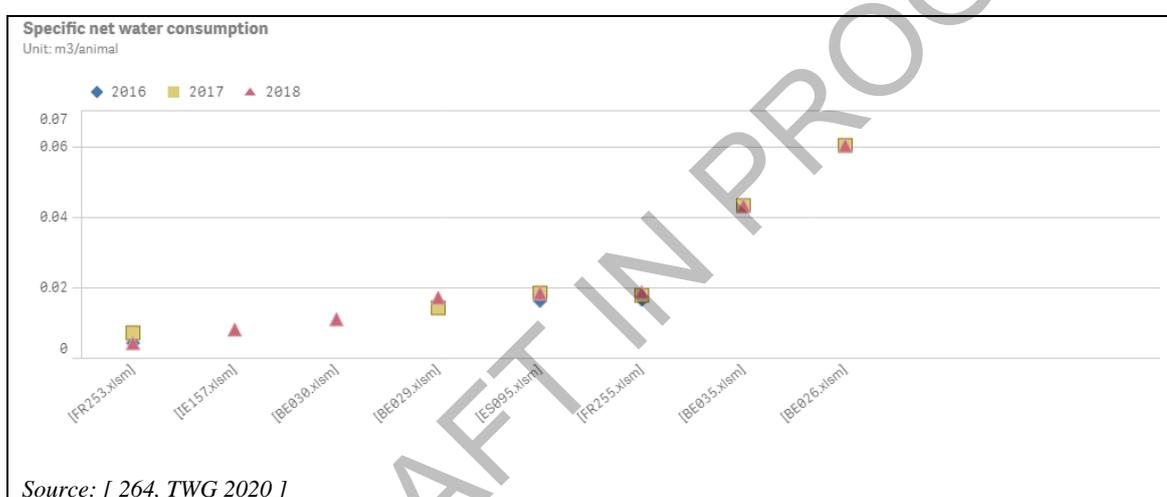


Figure 3.52: Specific water consumption (m³/animal) for scalding in pig slaughterhouses

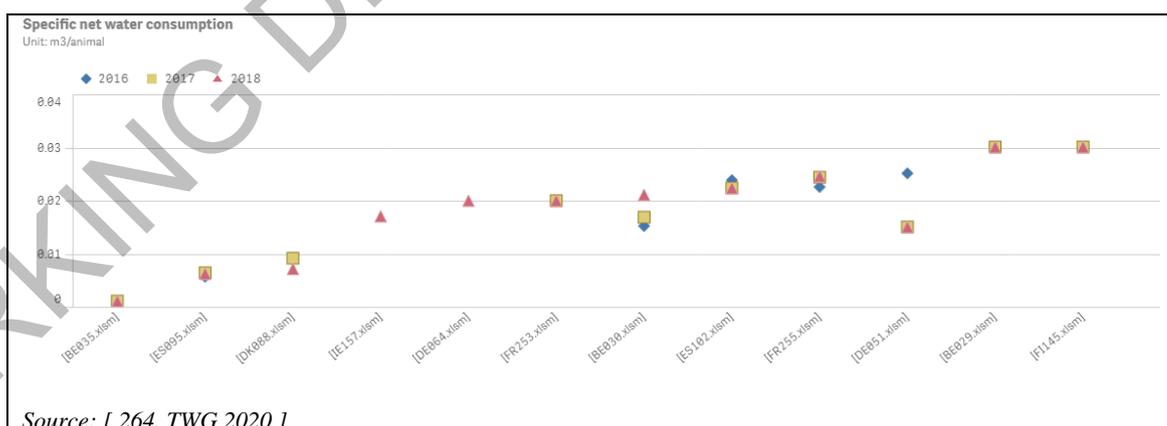


Figure 3.53: Specific water consumption (m³/animal) for vehicle washing in pig slaughterhouses

3.3.2.3.3 Emissions to water

Figure 3.54 shows reported data on specific waste water discharges in m³/tonne of carcase from pig slaughterhouses and all types of discharges, as well as the reported techniques to reduce water consumption.

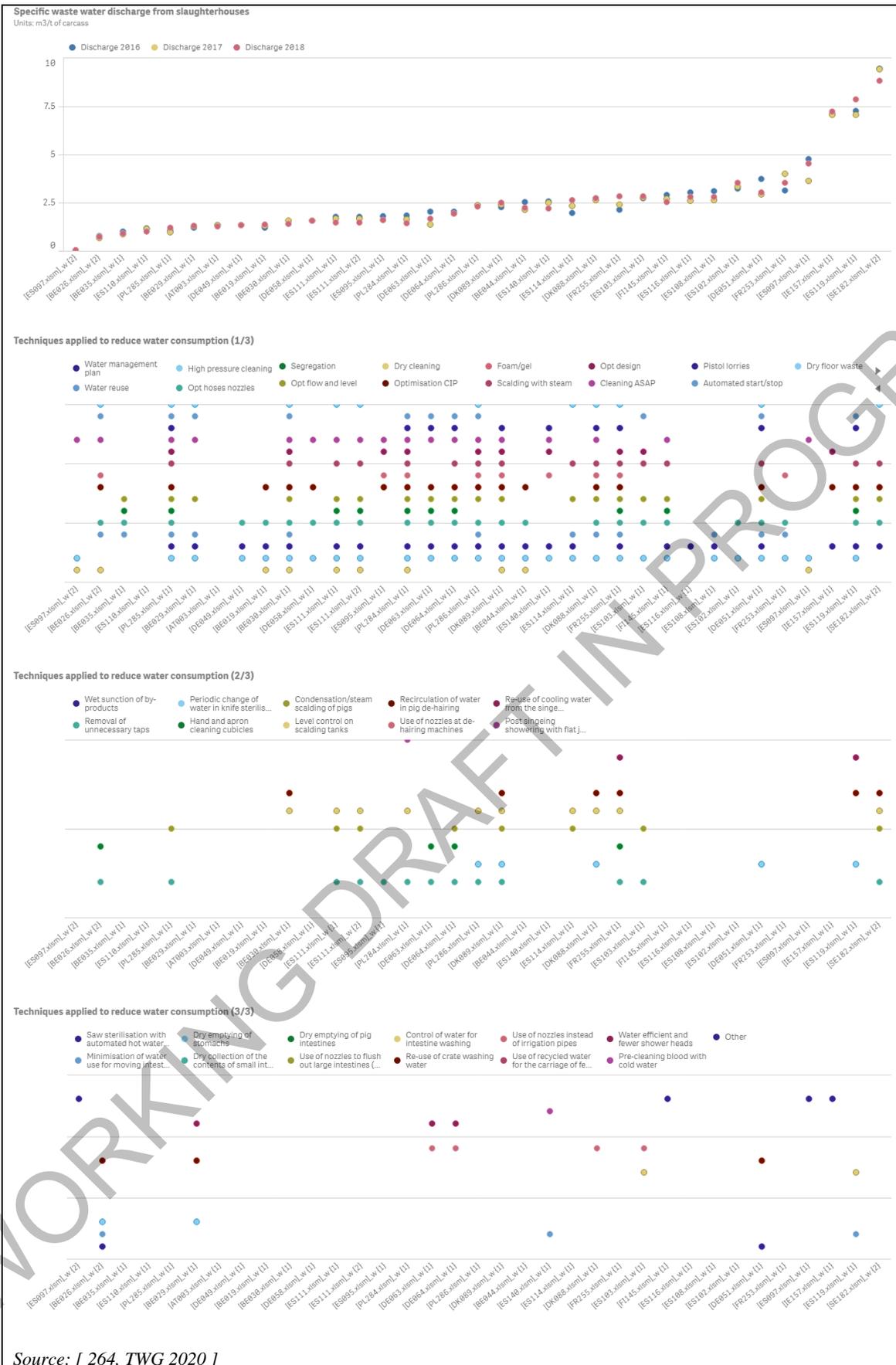


Figure 3.54: Specific waste water discharge (m³/tonne of carcass) in pig slaughterhouses for all types of discharges and reported techniques to reduce water consumption

Figure 3.55 shows reported data on specific waste water discharges in m³/animal from pig slaughterhouses and all types of discharges, as well as the reported techniques to reduce water consumption.



Figure 3.55: Specific waste water discharge (m³/animal) in pig slaughterhouses for all types of discharges and reported techniques to reduce water consumption

Animal reception and lairage

In Denmark and Sweden, data have been collected from some large pig slaughterhouses about the proportion of their water pollution which arises from the lairage/vehicle wash activities. In Denmark, it is estimated that 5 % of the pollution emitted came from these. In Sweden, the proportion was estimated to be 16 %. [134, Nordic States, 2001] [38, Nordic 2001]. With this information alone, it is not possible to comment on the difference because the overall Swedish figures included “cutting/deboning” (accounting for 7 %) and those from Denmark did not.

According to an analysis of semi-liquid manure from Danish pig farms the emission of copper and zinc from the slaughter process has been calculated/estimated. Some leaves the slaughterhouse in solid organic waste, i.e. manure and some in the waste water. The calculated/estimated levels are shown in Table 3.7.

Table 3.7: Calculated/estimated emissions of copper and zinc, from Danish slaughterhouses

	In solid organic waste (mg/t)	In waste water (mg/t or µg/l)	Total (mg/t)
Copper	0.4	0.6	1.0
Zinc	1.0	1.4	2.4

Source: [187, EFRA 2003]

Evisceration

In Denmark and Sweden, data have been collected from some large pig slaughterhouses about the proportion of their water pollution which arises from washing casings. In Danish slaughterhouses, it is estimated that 30 - 50 % of the pollution emitted comes from washing casings. In Sweden, the proportion was estimated to be 10 %. [134, Nordic States, 2001] [38, Nordic 2001]. Even allowing for the fact that the overall Swedish figures included “cutting/deboning” (accounting for 7 %) and those from Denmark did not, the difference is significant. The difference is explained by the fact that in Denmark approximately 100 % of stomachs, 100 % of small casings, 100 % of fat ends and 40 % of large casings are cleaned for human consumption. In Sweden the production is much lower. [274, Pontoppidan O., 2002] [127, Pontoppidan O. 2002]

Table 3.8 shows that de-sliming intestines makes a significant contribution to the overall pollutant load for waste water.

Table 3.8: Specific waste water amounts and pollutant loads with and without de-sliming of bowels

[163, German TWG Members, 2001] [52, Germany 2001]

	Examination days	Specific waste water amount	Specific pollutant loads					
			Settleable solids		BOD ₅		COD	
			(l per animal)	(l per animal)	(g DS per animal)	Without sediment (g per animal)	With sediment (g per animal)	without sediment (g per animal)
Pigs								
- with intestine de- sliming	7	100 - (250)	1 - 18	30 - 80	240 - 750	260 - 850	340 - (1080)	-
- without intestine de- sliming	19	58 - 254	0.2 - 1.9	8 - 65	60 - 366	70 - (430)	80 - 430	-

Calculated values are shown in brackets, i.e. extrapolated of 60:70 (measured) for 366 to calculate 430 (60/70 = 366/430)

Pig hair and toenail removal

At this stage of the process, blood is still dripping from the animal. The de-hairing process is wet, so the waste water COD loading may be raised significantly.

3.3.2.3.4 Emissions to airPig singeing

In most pig slaughterhouses, the singeing unit is exhausted directly to atmosphere, through a hood just above roof level. Sometimes, the exhaust may include an extraction fan. This emission is estimated to have a temperature of 600 – 800 °C. It also contains fine burnt hair dust. Some slaughterhouses recover useable heat from the exhaust emission. Due to the high flue temperatures, the equipment used to recover heat from singeing units requires storage, pumps and safety devices as well as a heat-exchanger. [12, WS Atkins EA, 2000] [4, WS Atkins-EA 2000]

If LPG is used to singe carcasses, approximately 19.6 l/t is consumed, for a light singe.

Water is used to cool the overhead rail and conveyor system. [134, Nordic States, 2001] [38, Nordic 2001]

The exhaust air has an odour of burnt hair. [134, Nordic States, 2001] [38, Nordic 2001]

Pig hair and toenail removal

The de-hairing of pig carcasses can cause minor odour problems [3, EPA, 1996] [1, EPA 1996].

Head and hoof removal for cattle and sheep

Significant blood spillage occurs from the large blood vessels when the head is cut off.

Rinsing the heads to remove blood, can as well as increasing water consumption and water contamination, spread impurities to other areas of the carcass. The need to rinse can, therefore, be limited by using correct slaughter procedures.

Pig hair and toenail removal

There is some mechanical noise and vibration from de-hairing machines, but this is not detectable outside the slaughterhouse buildings [12, WS Atkins EA, 2000].

Rind treatment

The main consumption and emission issues are associated with the water consumption and contamination.

Associated downstream activities - viscera and hide and skin treatments

Techniques to consider in the determination of BAT for all large animals slaughterhouses

3.3.2.4 Techniques to reduce waste

3.3.2.4.1 Trimming of all hide/skin material not destined for tanning immediately after removal from the animal

Description

Cutting away from the edges of hides and skins all unwanted material such as legs, tails, face, udders, testicles, etc. to give the raw material a better shape.

Technical description

Trimming consists of cutting away from the edges of hides and skins, all unwanted material such as legs, tails, face, udders, testicles, etc. to give the raw material a better shape.

This operation is performed manually, using the appropriate knives, ideally carrying it out as early as possible in the production process of hides and skins, to prevent material which is not intended for tanning from being processed unnecessarily. The operation is usually done in the slaughterhouse, although it is sometimes carried out in tanneries. Special knives can be used, depending on the appropriate standard for each type of hide or skin.

Achieved environmental benefits

The trimming of hides directly after hide removal optimises the alternative uses for trimmings, e.g. in pet food, gelatine or cosmetic production, thereby reducing waste production, both at the slaughterhouse and at the tannery. It also removes contaminants which could otherwise lead to the putrefaction of hides and skins.

It also minimises the consumption of substances used in the preservation processes, at both the slaughterhouse and the tannery. For example, at the slaughterhouse, if salt is used to preserve the hide, the amount used will be less. This also reduces the contamination of waste water by salt.

It is reported that trimming to ISO standards can give a 7 – 10 % reduction in the amount of waste produced in the leather industry.

There is a reduction in the amount of water and process chemicals used during tanning operations.

Odour problems are reduced due to the removal of putrescible trimmings.

Environmental performance and operational data

It is reported that approximately 120 kg/t of trimmings can be recovered from bovine hides at the slaughterhouse and that this can serve as a valuable raw material for other industries or for the production of biogas. Trimmings can be collected in batches, as appropriate, depending on their intended use. There are published standards for trimming hides and skins. Each batch can be monitored and records can be kept. If suppliers and buyers discuss the records regularly, they can plan continuous improvements in the operation of the technique.

It is reported that if fully trimmed hides and skins are delivered to the tannery, total water consumption there can be reduced by about 5 %. Total process chemicals are about 500 kg/t of hides or skins. The reduction in the consumption of substances used in tanning is directly proportional to the weight of the trimmed material. The contamination of waste water is also subsequently reduced.

The technique does not require any special equipment.

It is important that during hide or skin removal and trimming, damage is not caused which will lead to waste aggravated by the mechanical process during tanning.

If the animals are not washed and/or clipped before slaughter the trimming process may expose the operator to a risk of infection from, e.g. *Escherichia coli* 0157.

Cross-media effects

Additional waste may be produced at the slaughterhouse compared to the tannery. This may however have the advantage that it is not contaminated with those substances used for preservation or tanning and may consequently have a lower environmental impact.

Technical considerations relevant to applicability

Applicable in all large animal slaughterhouses where hide or skin removal is undertaken.

Economics

It is reported that no capital investment is required and that an average sized slaughterhouse can normally perform the technique without supplementary personnel. Some investment will be required for training.

Trimming may generate income of EUR 0.01/kg, if sold for further processing.

Driving force for implementation

The commercial driving forces are improved earnings from the sale of better shaped hides and skins and better by-product quality. Customer satisfaction is also improved.

The environmental driving forces are the improved waste management. There is a reduced waste of raw materials and consumption of process chemicals and water.

Example plants

Request to the TWG: Please provide information.
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Reference literature

[332, COTANCE, 2003] [176, COTANCE 2003]

3.3.2.5 Techniques to reduce emissions to water

3.3.2.5.1 Storage of hides/skins at 10-15 °C

Description

Hides and skins are stored at 10-15 °C, if they are processed within 8-12 hours.

Technical description

Hides and skins may be stored in hygienic conditions at 10-15 °C, in the short term, if they are processed within 8-12 hours.

Achieved environmental benefits

Compared to alternative preservation techniques, the use of salt and its subsequent contamination of waste water at the slaughterhouse and the tannery, as well as disposal of salt residues are avoided. The energy which would be required for refrigeration and/or ice making is also saved. Although it is not considered within IED IPPC, the environmental impact of long distance refrigerated transport, possibly with the added weight of ice can also be avoided.

Environmental performance and operational data

Hides and skins may be cooled by spreading them on a clean marble floor with the flesh side in contact with the cold floor, or by passing them through a tank of cooled water.

The opportunities for using untreated hides and skins stored between 10 – 15 °C are limited by the possibilities of processing them within 8 – 12 hours, which depends on the proximity of tanneries and their demand for hides/skins.

It has been reported that the quality and yield from fresh hides/skins is better than that from those that have been salted.

Cross-media effects

It has been reported that more biocides are needed when processing fresh hides and skins. This is because the cooling process takes several hours and bacterial growth may develop in this time.

Technical considerations relevant to applicability

Applicable where hides and skins can be processed within 8 – 12 hours.

Economics

Request to the TWG: Please provide information.

Driving force for implementation

There are reduced costs associated with the purchase of salt, careful addition of salt, ice making, refrigeration and transport.

Example plants

Request to the TWG: Please provide information.

Reference literature

[273, EC, 2004] [126, COM 2001]

3.3.2.5.2 Drum salting of hides and skins

Description

Hides and skins are taken from the slaughter-line directly to a drum, where clean salt that is free from, e.g. blood and rust is added.

Technical description

Hides and skins can be taken from the slaughter-line directly to a drum, similar to a concrete mixer, where clean salt that is free from, e.g. blood and rust is added.

Achieved environmental benefits

Water cooling is not required. The quantity of salt used is reduced by 30 - 50 %, compared to a salting table. All of the salt is used, compared to the addition of salt at a salting table which results in significant spillage, much of which inevitably ends up in the waste water. The hide/skin quality is at least as good as before. The need for energy use to chill the hide room is avoided.

Environmental performance and operational data

Hide/skin salting with this method can be done without water cooling, thereby saving 5 litres per head (278 l/t carcass). There was no residual salt, saving approximately 0.7 kg per head (0.039 t/t carcass). When salting large animal hides, an amount of salt equivalent to about 35 % of their weight is used. For example, for a hide weighing 28.5 kg, use 10 kg of salt. For sheepskins this ratio depends on whether the animals are sheared before slaughter, if not then an amount of salt equivalent to about 150 % of the skin weight, i.e. excluding the wool, is required.

Cross-media effects

Salt can reduce the efficiency of the WWTP and unless there is a naturally saline water course for receipt of the treated waste water the salt content can have adverse effects on plant growth.

Technical considerations relevant to applicability

Drum-salting has been implemented at the majority of Norwegian sheep/lamb slaughterhouses. For storage times longer than 8 days, e.g. if hides/skins have to be transported overseas, then

salting remains the preferred option, due to the weight of ice and the energy consumption required for ice production and for refrigeration.

Economics

Request to the TWG: Please provide information.

Driving force for implementation

Reduction in salinity of waste water treatment and associated problems with the efficiency of the WWTP.

Example plants

The majority of Norwegian sheep/lamb slaughterhouses.

Reference literature

[134, Nordic States, 2001] [38, Nordic 2001], [216, Metcalf and Eddy, 1991] [92, Metcalf and Eddy 1991], [273, EC, 2001] [126, COM 2001]

3.3.2.5.3 Drum salting of sheep/lamb skins with added boric acid

Description

Skins are taken from the slaughter-line directly to a drum, with addition of boric acid.

Technical description

Sheep/lamb skins can be taken from the slaughter-line directly to a drum, similar to a concrete mixer, where clean salt that is free from, e.g. blood and rust is added. The addition of boric acid prevents the growth of halophilic bacteria, known as "red heat".

Achieved environmental benefits

Water cooling is not required. The quantity of salt used is reduced by 30 - 50 %, compared to a salting table. All of the salt is used, compared to the addition of salt at a salting table which results in significant spillage and where much of the salt inevitably ends up in the waste water. The skin quality is at least as good as before. The need for energy use to chill the hide room is avoided.

Environmental performance and operational data

Skin salting with this method can be done without water cooling, thereby saving 5 litres per head (278 l/t carcass). There was no residual salt, saving approximately 0.7 kg per head (0.039 t/t carcass).

Cross-media effects

Salt can reduce the efficiency of the WWTP and unless there is a naturally saline water course for receipt of the treated waste water the salt content can have adverse effects on plant growth. A small amount of boric acid (1 - 2 %) may be added to the salt, although it is argued that if preservation is carried out properly the use of biocides should not be required. ~~Biocides are specifically mentioned in Annex III of the Directive.~~

Technical considerations relevant to applicability

Drum-salting has been implemented at the majority of Norwegian sheep/lamb slaughterhouses. For storage times longer than 8 days, e.g. if hides/skins have to be transported overseas, then salting remains the preferred option, due to the weight of ice and the energy consumption required for ice production and for refrigeration.

It has been reported that some tanneries in the UK have been unable to use boric acid because of limits on the amount they are permitted to discharge.

Economics

Request to the TWG: Please provide information.

Driving force for implementation

Reduction in salinity of waste water treatment and associated problems with the efficiency of the WWTP.

Example plants

Request to the TWG: Please provide information.

Reference literature

[134, Nordic States, 2001] [38, Nordic 2001], [216, Metcalf and Eddy, 1991] [92, Metcalf and Eddy 1991], [273, EC, 2001] [126, COM 2001], [332, COTANCE, 2003] [176, COTANCE 2003]

3.3.2.5.4 Dry collection of salt residues from hide, skin or fur preservation

Description

Salt residues from hide, skin and fur preservation are re-used or if they are excessively contaminated they are collected and disposed of dry.

Technical description

Salt residues from hide, skin and fur preservation can be re-used or if they are excessively contaminated they can be collected and disposed of dry. Excessive contaminated salt is disposed of by waste incineration.

Achieved environmental benefits

The quantity of salt used is reduced, so there is less contamination of the waste water.

Environmental performance and operational data

Techniques for the removal or recovery of salt from waste water in slaughterhouses have not been reported. High salinity can disrupt biological WWTPs and even after dilution, it may still cause corrosion damage. Prevention of waste water contamination appears, therefore, to be not only the preferred option, but actually the only option for controlling the salt content of waste water. It has been reported that techniques such as ion exchange and reverse osmosis are not suitable for salt removal from slaughterhouse waste water, both of which would produce concentrated brine. Brine can be naturally dried, in hot climates.

If dissolved salt is discharged to water courses it can have a significant environmental impact, especially for rivers with a low flowrate and during periods of low water levels. The high conductivity has an effect on the flora and fauna.

Dry collection may be achieved in vessels, such as trays and troughs, positioned beneath salting drums and tables, to collect overspill associated with, e.g. careless loading or spreading of salt. Floor spillages may have to be swept up, due to the corrosive properties of salt and the problems this may cause for a vacuum system.

Cross-media effects

None.

Technical considerations relevant to applicability

Applicable in all slaughterhouses where hides and/or skins are salted.

Economics

Inexpensive and in any case cheaper than the recovery of a disrupted WWTP. The costs are associated with the labour for handling the salt and payment for its disposal, if it cannot be re-used.

Driving force for implementation

Trouble-free waste water treatment.

Example plants

Request to the TWG: Please provide information.
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Reference literature

[163, German TWG Members, 2001] [52, Germany 2001], [273, EC, 2001] [126, COM 2001], [282, Palomino S., 2002] [133, Palomino S. 2002], [347, German TWG members, 2003] [184, Germany 2003]

3.3.2.5.5 Preservation of hides and skins by refrigeration**Description**

Cattle hides are washed and refrigerated.

Technical description

Cattle hides are washed and refrigerated at approximately 2 °C.

Achieved environmental benefits

The use of salt is avoided, so potential problems due to the salt at the slaughterhouse and the tannery are prevented. One problem with salt is that it can reduce the efficiency of the waste water treatment plant and unless there is a naturally saline water course for receipt of the treated waste water the salt content can have adverse effects on plant growth.

Environmental performance and operational data

Washing can lead to contamination and deterioration of the hides/skins.

Cross-media effects

Energy consumption for refrigeration. Washing hides/skins involves the consumption and contamination of water.

Technical considerations relevant to applicability

If the time between the de-hiding and the processing in the tannery is no more than 5 – 8 days, after draining the blood, it is possible to cool the hides/skins, to a temperature of 2 °C by refrigeration. The cooling chain must not be interrupted during transport and storage. If hides/skins can be delivered to a tannery and processed within 8 – 12 hours after slaughter then they generally don't require any treatment. They can be preserved satisfactorily by chilling, if they are to be processed within 5 - 8 days. For longer storage times, e.g. if they have to be transported overseas, then salting remains the preferred option, due to weight of ice and the energy consumption required for ice production and refrigeration.

Economics

The capital investment required for chilling units and cold stores exceeds that for one of the alternatives, i.e. ice making machinery.

It is, however, reported that investment in cooling equipment is not prohibitive and that, e.g. many hide markets and tanneries have invested in cooling systems with good results on quality and total cost.

Driving force for implementation

Reduction in salinity of waste water treatment and associated problems with the efficiency of the WWTP.

Example plants

The chilling of cattle hides and sheepskins is undertaken in some slaughterhouses in the UK. Nearly all slaughterhouses in Germany that manufacture leather from cow hides practise preservation by refrigeration. This is because the tanneries are within 300 km of the slaughterhouses, so the costs for refrigerated transport are not excessive.

Reference literature

[244, Germany, 2002] [110, Germany 2002], [273, EC, 2001] [126, COM 2001]

Preservation of hides and skins by cooling with flaked or crushed ice**Description**

Cattle hides are washed and then preserved in flaked ice at approximately 2 °C.

Achieved environmental benefits

The use of salt is avoided, so problems due to salt at the slaughterhouse and the tannery are prevented. Salt can reduce the efficiency of the waste water treatment plant and unless there is a naturally saline water course for receipt of the treated waste water the salt content can have adverse effects on plant growth.

Operational data

Washing can lead to contamination and deterioration of the hides/skins.

Cross-media effects

Energy and water consumption, for ice making. Washing hides/skins involves the consumption and contamination of water.

Applicability

If the time between de hidding and processing in the tannery is no more than 5–8 days, after draining the blood, it is possible to cool the hides/skins, to a temperature of 2 °C, using flaked or crushed ice. The cooling chain must not be interrupted during transport and storage. If hides and skins can be delivered to a tannery and processed within 8–12 hours after slaughter they generally don't require any treatment. They need to be chilled if they are processed within 5–8 days. For longer storage times, e.g. if they have to be transported overseas then salting remains the preferred option, due to the weight of ice and the energy consumption required for its production and for the refrigeration.

Economics

The capital investment required for ice making machinery is less than that required for chilling units and cold stores.

Reference literature

[273, EC, 2001]

Automation of the first part of the clean slaughter-line**Achieved environmental benefits**

None reported.

Operational data in relation to manual or semi manual process, e.g. when the operator uses some auxiliary equipment, such as a rectum loosener are shown in the following Tables.

Table: Operational data for automated splitting of pig breasts

Splitting of the breast	Units	Pre-automation	Automated process	Increase
Water	l/t	6.67	45.55	38.9
Electricity (1)	kWh/t	0.0	0.53	0.53
Heating (2)	kWh/t	0.67	1.34	0.67
Total energy (1 + 2)	kWh/t	0.67	1.87	1.2

Table : Operational data for automated splitting of pig carcasses

Splitting	Units	Pre-automation	Automated process	Increase
Water	l/t	Unknown	26.6	Unknown
Electricity (1)	kWh/t	Unknown	0.5	Unknown
Heating (2)	kWh/t	Unknown	1.3	Unknown
Total energy (1 + 2)	kWh/t	Unknown	1.8	Unknown

Table : Operational data for automated evisceration of pigs—existing slaughter line

Removal of plucks and viscera	Units	Pre-automation	Automated process	Increase
Water	l/t	0.0	39.9	39.9
Electricity (1)	kWh/t	0.0	0.13	0.13
Heating (2)	kWh/t	0.0	1.33	1.33
Total energy (1 + 2)	kWh/t	0.0	1.46	1.46

Table : Operational data for automated evisceration of pigs—new slaughter line

Removal of plucks and viscera	Units	Pre-automation	Automated process	Increase
Water	l/t	26.6	119.7	93.1
Electricity (1)	kWh/t	0.0	0.53	0.53
Heating (2)	kWh/t	0.67	2.67	2.00
Total energy (1 + 2)	kWh/t	0.67	3.20	2.53

Table : Operational data for removal of plucks and viscera

Removal of plucks and viscera	Units	Pre-automation	Automated process	Increase
Water	l/t	0.0	39.6	39.6
Electricity (1)	kWh/t	0.0	0.1	0.1
Heating (2)	kWh/t	0.0	1.3	1.3
Total energy (1 + 2)	kWh/t	0.0	1.5	1.5

Table: Operational data for automated back finning of pigs

	Units	Pre-automation	Automated process	Increase
Water	l/t	26.6	33.3	6.7
Electricity (1)	kWh/t	0.0	0.53	0.53
Heating (2)	kWh/t	0.67	1.34	0.67
Total energy (1 + 2)	kWh/t	0.67	1.87	1.2

Table: Expected effect of installing decontamination by spraying with hot water

	Units	Decontamination using hot water
Water	l/t	252.7
Electricity (1)	kWh/t	2.66
Heating (2)	kWh/t	33.25
Total energy (1 + 2)	kWh/t	35.91

Table: Operational data for rectum loosening pigs

Rectum loosening	Units	Pre-automation	Automated process	Increase
Water	l/t	13.3	39.9	26.6

Electricity (1)	kWh/t	0.0	0.53	0.53
Heating (2)	kWh/t	0.67	1.34	0.67
Total energy (1 + 2)	kWh/t	0.67	1.87	1.20

Some of the most physically demanding and “unpleasant” unit operations, such as carcass splitting and evisceration are automated.

Cross-media effects

Increased consumption of water, electricity and heat and consequently an increased volume of waste water. The additional wetting of carcasses and by products, sometimes with hot water, will entrain both solids and dissolved substances and will increase the COD, BOD and nitrogen loads in the waste water.

Applicability

Applicable in pig slaughterhouses.

Example plants

A few Danish slaughterhouses have implemented automation. All Danish pig slaughterhouses have implemented automated carcass splitting.

Reference literature

[184, Pontoppidan O., 2001, 243, Clitravi – DMRI, 2002]

3.3.3 Techniques to consider in the determination of BAT for pig slaughterhouses

3.3.3.1 Techniques to increase energy efficiency

3.3.3.1.1 Condensation/Steam scalding of pigs (vertical scalding)

Description

Scalding is performed with the use of steam instead of hot water.

Technical description

Scalding with steam is an alternative to scalding in hot water. This procedure operates using moist air heated to approximately 60 - 62 °C. The pig carcasses are conveyed through a tunnel. The moist air is extracted in the upper part of a tunnel by ventilators and circulated in exterior channels, where it is moistened and heated by steam. Ventilators then blow the hot moist air back into the lower section of the scalding tunnel. Air deflection plates guide the air over the carcasses, where some of it condenses and produces the scalding effect. The technique is illustrated in Figure 3.56.

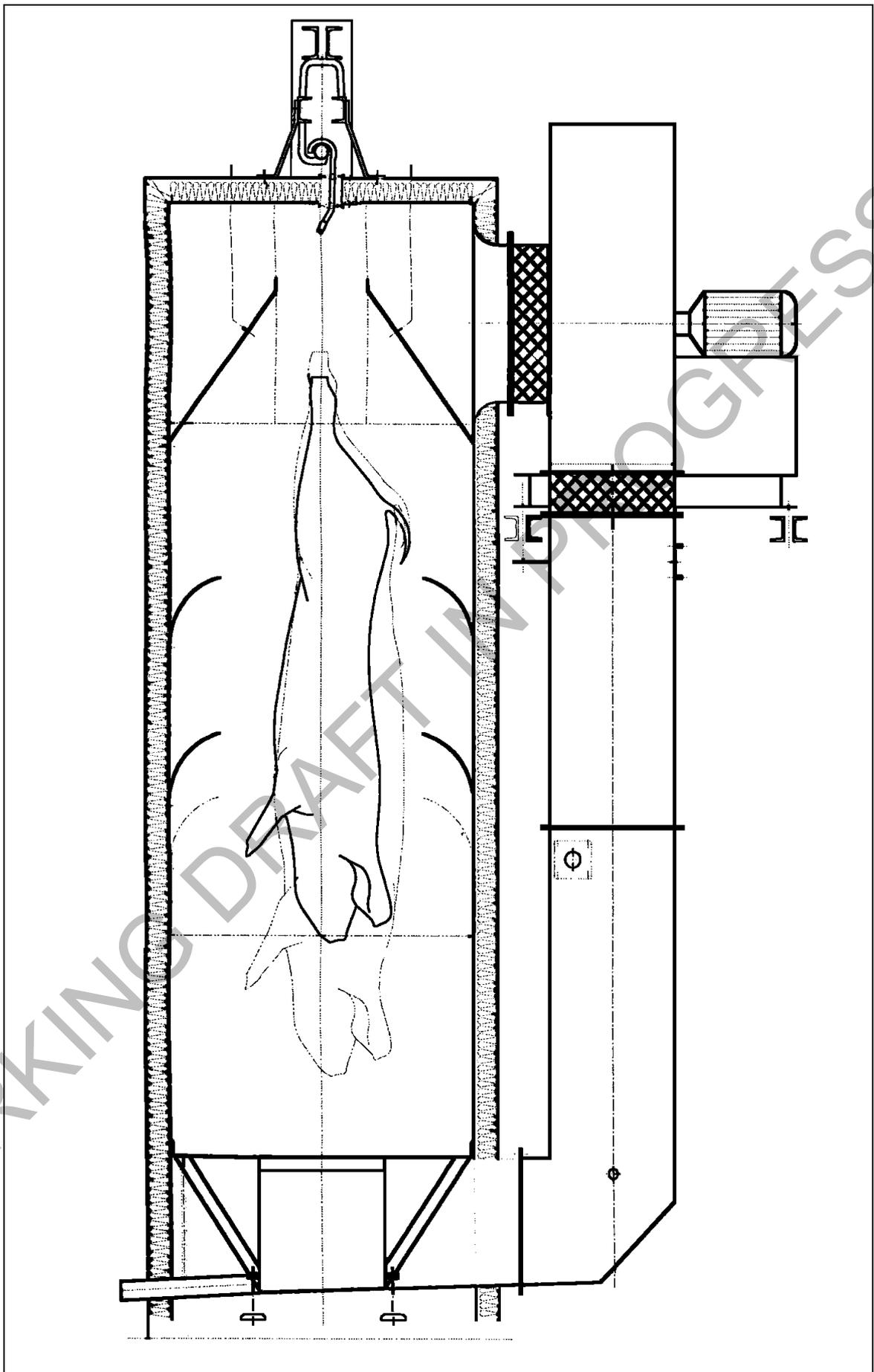


Figure 3.56: Outline of a condensation scalding tunnel
[163, German TWG Members, 2001] [52, Germany 2001]

Achieved environmental benefits

Reduced water and energy consumption. The lungs can be used.

Environmental performance and operational data

This process can be maintained at a constant temperature and 100 % humidity under varying loads, which is crucial for a good scalding performance.

The producers' information about consumption values of different scalding methods is listed in Table 3.9.

Table 3.9: Comparison of consumption data of different scalding methods (producers' information)

	Circulation method	Condensation/steam scalding method
Energy demand (Revolving pumps/ventilators)	4 x 7.5 kW x 8h/d = 240 kWh/d 240 kWh/d x 200 d/yr = 48 000 kWh/yr	4 x 5.5 kW x 8 h/d = 176 kWh/d 176 kWh/d x 200 d/yr = 35 200 kWh/yr
Heating demand (1 kWh = 3.6 MJ) (fuel oil: 1 kg = 1.2 l)	3 270 kWh/d x 200 d/yr = 654 000 kWh/yr 654 000 kWh/yr x 3.6 MJ/kWh = 2 354 400 MJ/yr 2 354 000 MJ/yr / 40 MJ/kg = 58 860 kg/yr 58 560 kg/yr x 1.2 l/kg = 70 632 l/yr fuel oil	2 020 kWh/d x 200 d/yr = 404 000 kWh/yr 404 000 kWh/yr x 3.6 MJ/kWh = 1 454 400 MJ/yr 1 454 400 MJ/yr / 40 MJ/kg = 36 360 kg/yr 36 360 kg/yr x 1.2 l/kg = 43 632 l/yr fuel oil
Water demand	14 000 l/d + 5 l/pig x 2 400 pigs/d = 26 000 l/d 26 000 l/d x 200 d/yr = 5 200 000 l/yr	0.7 l/pig x 2 400 pigs/d = 1 680 l/d 1 680 l/d x 200 d/yr = 336 000 l/yr

Source: [163, German TWG Members, 2001] [52, Germany 2001]

Operational consumption levels for “water circulation spray scalding” and “condensation/steam scalding” are shown in Table 3.10 for plants with a capacity of 350 pigs per hour or 600000 pigs per year.

Table 3.10: Comparison of actual consumption data of “water circulation spray scalding” and “condensation steam scalding”

	Water circulation spray scalding	Condensation/steam scalding
Energy demand	4 pumps x 5 kW x 8h x 255 days = 40 800 kWh/yr	4 ventilators x 4 kW x 8h x 255 days = 32 640 kWh/yr (0.0544 kWh/pig)
Heat consumption	To heat the water-bath	
	1 450 kWh x 255 days = 369 750 kWh	Not applicable
Water demand	To heat the pigs	
	3 116 kWh/pig x 600 000 = 1 869 600 kWh/yr	2.5 kWh/pig x 600 000 = 1 500 000 kWh/yr
Water demand	Daily water-bath	
	25 m ³ x 255 days = 6 375 m ³	Not applicable
	Leaking loss	
	11.625 l/pig x 600 000 = 69 75 m ³	1 l/pig x 600 000 = 600 m ³

Source: [163, German TWG Members, 2001] [52, Germany 2001]

Unpublished results from tests of steam scalding indicate that the water consumption can be reduced to 3–5 litres per pig (40–65 l/t pig carcase) and the energy consumption to approximately 0.4 kWh per pig (5.2 kWh/t pig carcase), for a slaughterhouse of unspecified throughput. These energy consumption levels are lower than those shown in Table, whereas the water consumption levels are higher, nevertheless they are both lower than the levels shown for water circulation spray scalding, also in Table. Table reports that both methods consume less water than using a scalding tank.

Table: Comparison of water consumption data for different scalding methods (producers' information)

	Scalding tank	Water circulation spray scalding	Condensation/steam scalding
Water consumption	8 440 000 l/yr	5 200 000 l/yr	336 000 l/yr

Cross-media effects

The carcasses will have to be washed prior to scalding. If there is any dirt on the skin, this will prevent the steam from contacting the skin and will result in poor scalding of the dirty part.

Technical considerations relevant to applicability

For outdoor living pigs, the bristles are harder and steam is not a suitable means to loosen bristles from this type of animals [241, TWG 2019].

It has been reported that measurements of hair and toenail loosening have shown that the scalding quality of the condensation/steam condensation system is comparable to that of a traditional scalding tank. Furthermore, condensation/steam has a number of advantages over a traditional scalding tank, i.e. hygiene, no water gets in the lungs or the sticking wound; it has a short start-up time and a reduced risk of over-scalding during stops on the slaughter line.

Economics

The replacement of an existing scalding tank system with a condensation/steam system is not considered to be profitable, based on the water and energy savings alone. The method is, however, considered to be applicable in connection with large alterations, extensions or new buildings.

Expensive.

Driving force for implementation

Reduction of water and energy costs.

Example plants

One pig slaughterhouse in Germany and several slaughterhouses in Denmark [203, Denmark 2015].

Reference literature

[12, WS Atkins-EA, 2000] [4, WS Atkins-EA 2000], [134, Nordic States, 2001] [38, Nordic 2001], [63, German TWG Members, 2001] [52, Germany 2001], [183, Pontoppidan O., 2001] [66, Pontoppidan O. 2001], [237, Italy, 2002] [103, Italy 2002], [243, Clittravi - DMRI, 2002] [190, Clittravi - DMRI 2003] [203, Denmark 2015] [241, TWG 2019]

3.3.3.1.2 Heat recovery from pig singeing exhaust gases, to preheat water

See also Section 2.3.4.1.4.

Description

The heat of the exhaust of the singeing unit is recovered to heat water

Technical description

In pig slaughterhouses, the heat of the exhaust of the singeing unit can be recovered to heat water, e.g. to maintain the scalding tank temperature.

Achieved environmental benefits

Reduced energy use to heat water for, e.g. scalding or cleaning and reduced odour, by stopping the direct emission of hot singeing gases.

Environmental performance and operational data

Temperatures in the singeing unit can be as high as 900 - 1000 °C and if heat is not recovered gases can be emitted at 600 - 800 °C. A heat recovery system, such as that shown in Figure 3.57, can be used to heat the water. In the case study shown in Figure 3.57, water is heated to 70 °C and is then used to clean the slaughterhouse.

After singeing, the exhaust contains approximately 58 % of the energy used to heat it. By installing a heat recuperation unit, 40 - 45 % of the applied energy can be recovered.

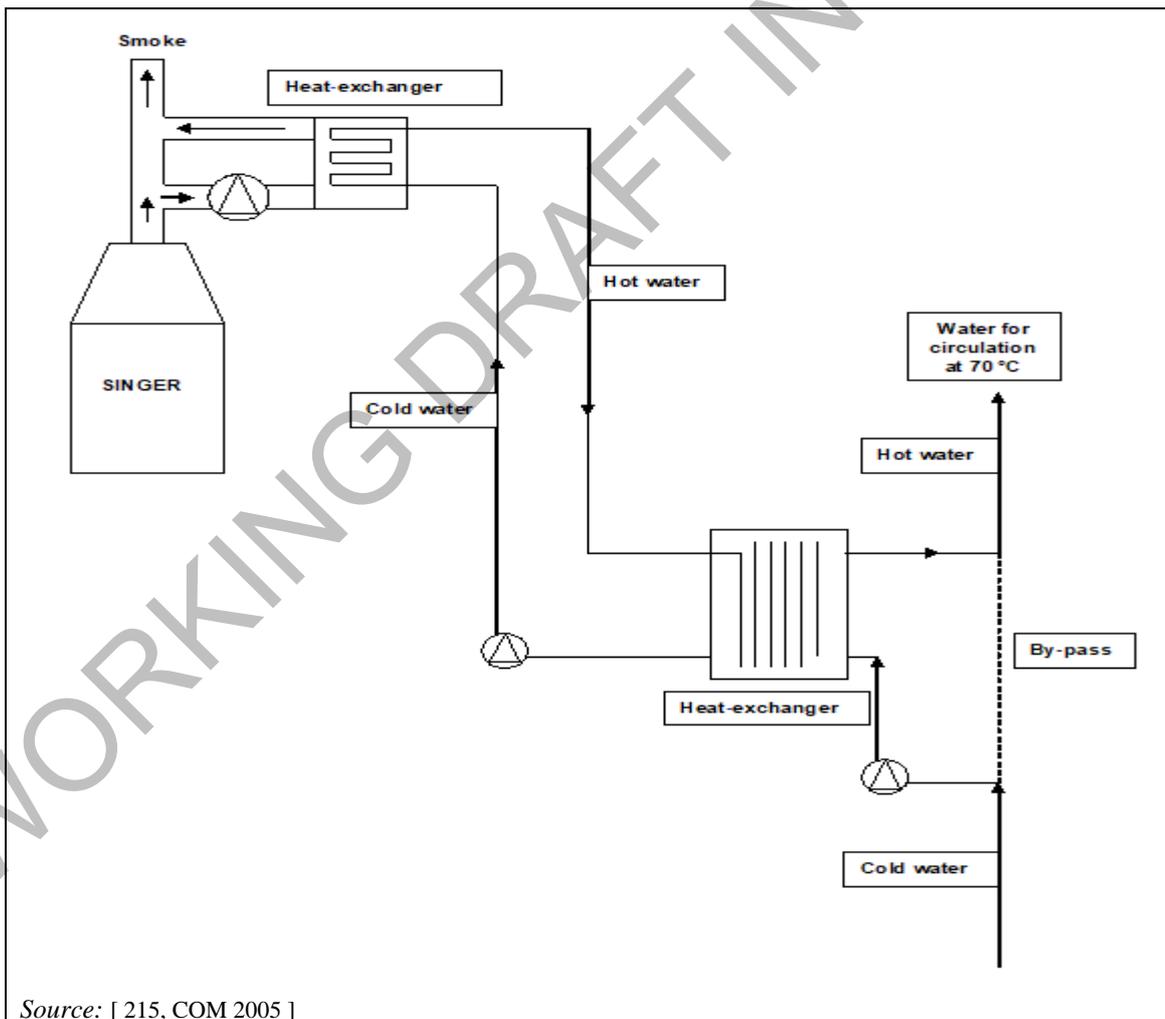


Figure 3.57: Heat recovery from pig singeing gases

Cross-media effects

None reported.

Technical considerations relevant to applicability

Applicable in all pig slaughterhouses.

Economics

Two differing reports state that, based on Danish conditions, the payback time is either approximately 6 months or 3 - 4 years. A payback time of 1 to 3 years is reported from the UK.

Driving force for implementation

Reduced energy costs.

Example plants

The technique is used in Finnish slaughterhouses and in at least one Italian pig slaughterhouse.

Reference literature

[57, DoE, 1993] [20, DoE 1993], [134, Nordic States, 2001][38, Nordic 2001], [148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001][47, Finnish Environment Institute and Finnish Food and Drink Industries' Federation 2001], [183, Pontoppidan O., 2001] [66, Pontoppidan O. 2001], [280, Savini F., 2002][131, Savini F. 2002]

Blast-chilling/shock-cooling tunnel - for chilling pigs**Description**

Blast-chilling uses the fact that an increase of the boundary layer air velocity at the carcass surface leads to an increase in the heat transfer coefficient. This increases the extraction of heat from the carcass. This, combined with a low air temperature, causes the surface temperature to drop. The blast chilling process is built into a tunnel with a conveyor, evaporators and fans. The air velocity is high, i.e. 3 - 4 m/s.

Operational data

The advantage of using blast chilling is the low shrinkage and the small tunnel dimensions. Low process temperatures cause surface freezing, which kills all non cold-tolerant bacteria and improves food safety. The black bone problem, which is a discolouration of the backbone due to incorrect chilling, can be caused by surface freezing. This can be eliminated by a short tempering zone at the end of the chilling process, which will cause the surface temperature to rise to the equalisation room temperature.

The temperatures in the shock-cooling tunnel lie between -15 °C and -20 °C. The contact time in the shock-cooling tunnel is 60 - 90 minutes. After leaving the shock-cooling tunnel, the carcasses are subjected to secondary cooling in an equalisation-cooling room until they have a core temperature of +7 °C.

Operational data for blast-chilling/shock-cooling and mist-cooling are compared in Table.

	Blast-chilling/shock-cooling	Water-spraying/mist-cooling
Weight loss after 24 hours	1.3 - 1.7 %	0.4 - 1.0 %
Temperature in the core of the ham after 18 hours	5.4 °C	5.8 °C
Surface freezing	On the entire surface	NONE
Bursting of small blood vessels	Often in the bones and in the fat	NONE
Bacteriological quality	Reduction by 2 log units	Increase by 2 log units
Air temperature in the cooling tunnel	-25 to -8 °C	+5 to -5 °C
Energy consumption	16.3 - 21.7 kWh/t carcass	6.5 - 13.0 kWh/t carcass

Water consumption	0 l/t carcase	Unknown
Maintenance and repair requirements	High	Very low
Cleaning frequency	2–4 times each month	Daily
Wall insulation	Thickness 160 mm	Thickness 80 mm
Space requirements (ratio)	1	2

Table : Consumption data for shock-cooling and mist-cooling
[163, German TWG Members, 2001, 342, Pontoppidan O., 2003]

For a slaughterhouse killing approximately 300 pigs/h, the installed cooling capacity of the shock-cooling tunnel is about 1 000 kW. The temperature of the ammonia refrigerant is –35 °C.

Cross-media effects

The low chilling temperature, increases the energy consumption of the compressor operation and also the capacity required.

Applicability

It is reported that this technique cannot be applied in Italy, when carcasses are destined for the production of typical Italian cured products and are cut beyond the standard cuts, before chilling.

Reference literature

[163, German TWG Members, 2001, 237, Italy, 2002]

Water-spraying/mist-cooling as a method of cooling pigs

Description

The entire surface of the split carcase is sprayed with water at the same time as it is swept over by air at moderate velocity and temperature. The cooling effect is achieved by evaporation of the spray water on the surface of the carcase. Fine droplets with a size of 10–100 µm are evaporated by the warmth of the carcasses. When these droplets evaporate, the carcase surfaces remain very moist and this prevents the meat from parching. As soon as the droplets are evaporated, the spraying is repeated until the desired cooling has been achieved. For this cyclical treatment, the pig halves are conveyed through water spraying cabins, which are installed in the cooling tunnel. During a cooling period of 3 hours the pig halves may, e.g. be conveyed through 30–35 cabins. In each cabin, the spraying with sterile water lasts only 1–3 seconds. As the carcase surface temperature is highest at the beginning of the process, the spraying cabinets are placed close together in the first part of the tunnel. The entire spraying time during a 3-hour cooling period, therefore, adds up to a treatment of 50–100 seconds.

Achieved environmental benefits

Consumption data for the shock-cooling technique and the water spray-cooling technique are compared in, within the shock-cooling technique information in Section.

Reduction in energy consumption for cooling and ventilation, compared to conventional cooling methods, which require cooler air and a greater airflow.

Operational data

It was anticipated that the weight loss would be 0.9 %, compared to 1.1 % for conventional cooling, and also that the reduction in the weight loss would have an environmental benefit, because the specific cooling energy for each carcase is lower than for conventional cooling. The energy efficiency would, therefore, be higher. However, in a slaughterhouse using this technique the anticipated reduction in weight loss did not occur, but there were energy savings. In a Dutch slaughterhouse each carcase required 1.5 kWh instead of 3.3 kWh.

At a processing volume of 1 million pigs/year, the annual electricity savings amount to 1 800 MWh/yr. This is equivalent to 510 000 m³ of natural gas, with a heating value of 31.65 MJ/m³, assuming an average power plant efficiency of 40 %.

Two advantages of using water spray chilling are the low carcase shrinkage and the high process temperature. At high process temperatures it is possible to avoid surface freezing.

Two disadvantages are that the process is very slow and it needs huge tunnel dimensions. If there is water on the carcase surface when it leaves the tunnel, it could cause an increased bacterial growth. Water consumption is high and it must be of drinking water standard. Purifying water with a chloride compound is not allowed in many countries. The wet surface increases the black bone problem.

Operational data for blast chilling/shock cooling and water spraying/mist cooling are compared in, in Section.

Cross-media effects

High water consumption.

Applicability

Applicable in all large animal slaughterhouses, although it may be difficult to retrofit the system in an existing slaughterhouse due to the large space requirements. It is reported that this technique cannot be applied in Italy, when carcasses are destined for the production of typical Italian cured products and are cut beyond the standard cuts, before chilling.

Economics

In the case study reported, the overall investment for the new tunnel amounted to NLG 1.8 million (1996). At an electricity price of NLG 0.142/kWh, the annual savings are NLG 256 000, which yields a payback period of about 7 years. (If the expected reduced cooling losses had taken place, this would have saved an additional NLG 452 000 and the payback period would have been 2.5 years.)

Example plants

The technique is reportedly used in several French slaughterhouses, at least one slaughterhouse in the Netherlands and at least one slaughterhouse in Germany.

Reference literature

[53, IEA OECD, 1996, 163, German TWG Members, 2001, 237, Italy, 2002]

Insulation and covering of pig scalding tanks

Description

Achieved environmental benefits

Energy savings are associated with preventing radiated heat losses and the loss of hot water. There is also a reduced water consumption.

In addition, less ventilation will be required, so less energy will be consumed.

The reduced evaporation will also result in less odour.

Operational data

Cross-media effects

None.

Applicability

Applicable in all new pig slaughterhouses. A cover can be installed on existing tanks and they can be insulated.

Economics

Driving force for implementation

Reduced energy costs.

Reference literature

3.3.3.2 Techniques to reduce water consumption

3.3.3.2.1 Condensation/steam scalding of pigs (vertical scalding)

See Section 3.3.3.1.1.

3.3.3.2.2 Recirculation of water within pig de-hairing machines

See also Section 2.3.5.1.2.

Description

The water used in pig de-hairing machines is recirculated, after it has been reheated by steam injection to the temperature required for de-hairing.

Technical description

The water used in pig de-hairing machines can be recirculated, after it has been reheated by steam injection to the temperature required for de-hairing. The water is collected in a tank, in which steam is injected to raise the temperature to that required. For food hygiene reasons the whole system is enclosed and the water collection and recirculation is carried out under hygienic conditions. The system is discharged, cleaned and disinfected at least once a day.

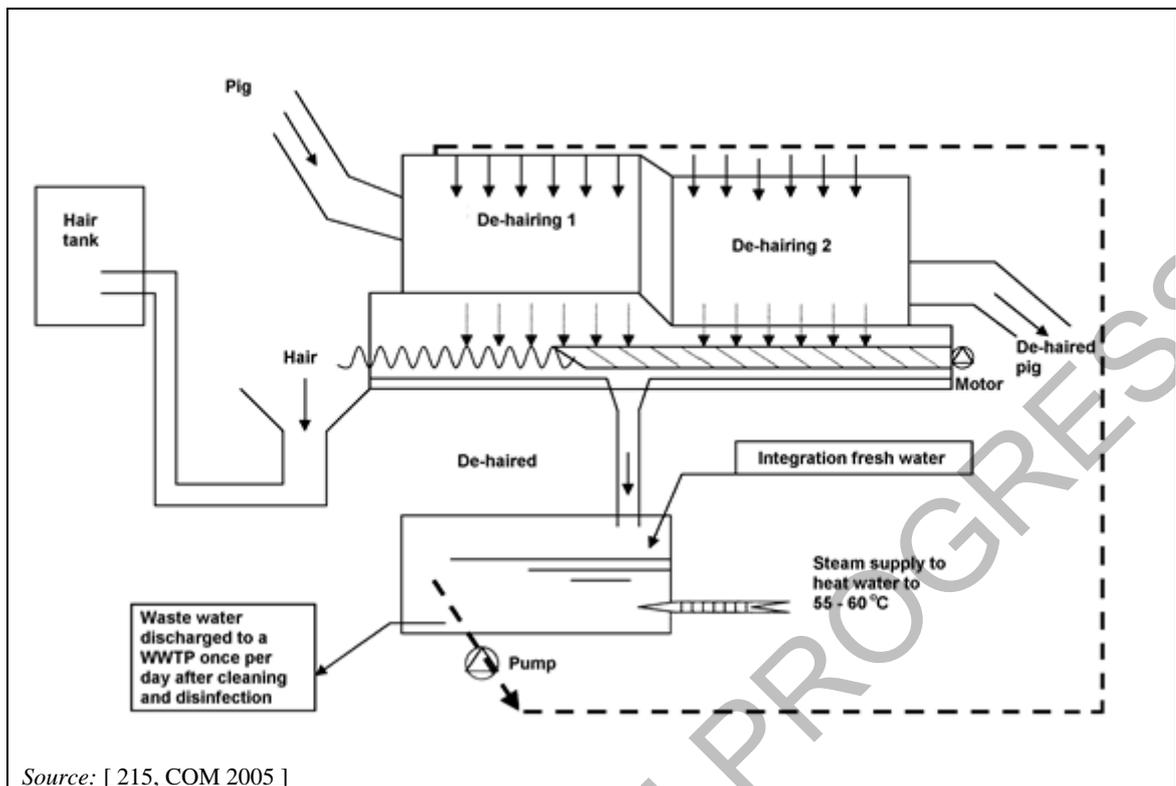
Achieved environmental benefits

Reduced water consumption and energy use.

Environmental performance and operational data

Water which is entrained with the pigs as they leave the system is replaced with fresh water. This has been reported to occur at a rate of 0.7 – 1 m³/h for a slaughterline producing carcasses at a rate of 55 – 60 t/h. Most of the water is heated from 50 – 55 °C to a de-hairing temperature of 55 – 60 °C. In the past the water was heated to 80 – 90 °C.

The operation is shown in Figure 3.58.



Source: [215, COM 2005]

Figure 3.58: Recirculation of water for de-hairing pigs

The use of cold water at temperatures less than 10 °C has been reported. The water has to be cooled, otherwise the temperature rises to 30 – 35 °C, due to the heat from the freshly slaughtered carcasses. Less energy is required to chill the carcasses later in the process and the risk of bacterial contamination is less in the colder water.

Cross-media effects

None reported.

Technical considerations relevant to applicability

Applicable in all pig slaughterhouses.

Economics

The costs of additional water are saved by recirculating the water. In the case where water was previously heated to 80 – 90 °C, the money which was required to both supply and heat that water is saved.

Driving force for implementation

Reduced water and energy costs.

Example plants

At least one pig slaughterhouse in Italy.

Reference literature

[269, Italian TWG Members, 2002] [123, Italy 2002], 347, German TWG members, 2003] [184, Germany 2003]

3.3.3.2.3 Re-use of cooling water from the singeing kiln

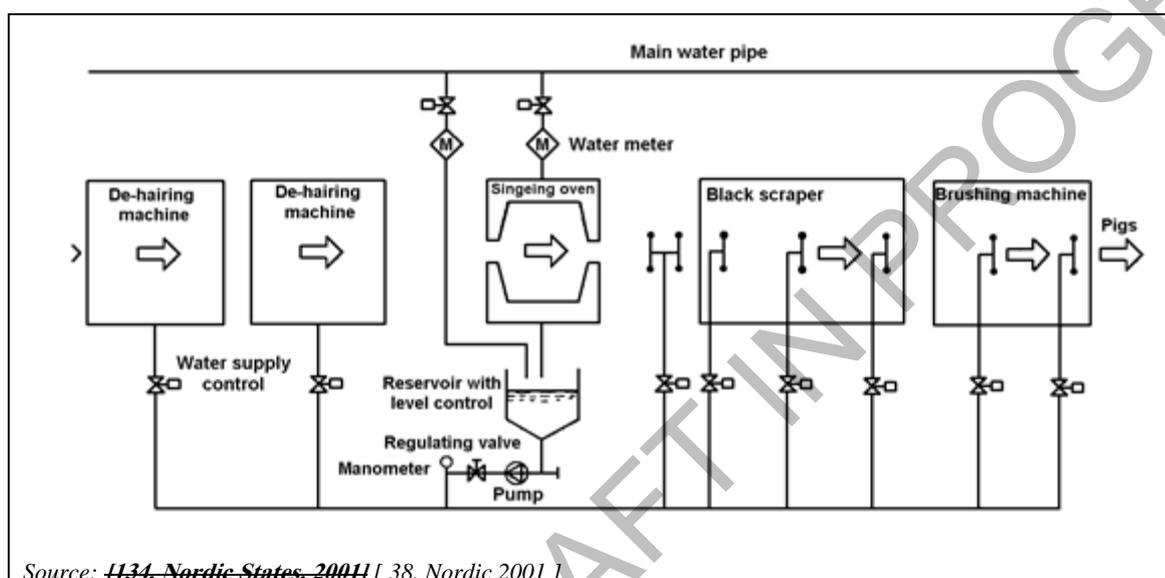
See also Section 2.3.5.1.2.

Description

Cooling water can be collected from the singeing kiln and distributed, for example to the scalding tank, post-singeing showering, or the scraping and polishing section.

Technical description

Cooling water can be collected from the singeing kiln and distributed to, e.g. the scalding tank, post-singeing showering, if used, or the scraping and polishing section. Additionally, instead of irrigation pipes, nozzles can be fitted and directed to the pigs. A schematic diagram of the system is shown in Figure 3.59. The water can also be used for cleaning.



Source: ~~[134, Nordic States, 2001]~~ [38, Nordic 2001]

Figure 3.59: The Grinsted system re-using cooling water from a singeing kiln

Achieved environmental benefits

Reduced water consumption, by 780 l/t of carcass.

Environmental performance and operational data

The system can reduce the water consumption from more than 100 litres per pig to 20 - 30 litres per pig (from more than 1 300 l/t to 260 - 390 l/t pig carcass).

Cross-media effects

None.

Technical considerations relevant to applicability

All slaughterhouses which currently use a particular very thorough surface treatment, which is considered to be necessary for carcasses to be used for bacon curing.

Economics

The capital cost for a Danish slaughterhouse has been calculated to be approximately DKK 210 000, giving a repayment period of less than 6 months.

Driving force for implementation

Reduced water costs.

Example plants

The system is used at all of the larger Danish pig slaughterhouses.

Reference literature

[134, Nordie States, 2001][38, Nordic 2001], 183, Pontoppidan O., 2001 [66, Pontoppidan O. 2001]

3.3.3.2.4 Water level control on pig scalding tanks**Description**

The spare distance from the water level to the top of the tank and to the overflow pipe can be sufficient to avoid overflow due to water displacement when the tank is filled with carcasses.

Achieved environmental benefits

Energy and water saving, by preventing the loss and need for replacement of water heated to approximately 60 °C.

Operational data

The control of the water level can be achieved through the fitting of an automatic level control, or by the operator filling the tank to a marked upper limit, in a tank that is sufficiently deep to contain sufficient water and the pig carcasses. Automation of the level control, if properly maintained, will remove the responsibility from the operator.

According to a Danish example, correct control of the water level can save approximately 5 m³/d.

Cross-media effects

None.

Applicability

Applicable at all pig slaughterhouses.

Economics

The capital cost is low and the payback is almost immediate.

Driving force for implementation

Reduced spending on water.

Example plants

At least one pig slaughterhouse in Denmark.

Reference literature

[134, Nordie States, 2001][38, Nordic 2001], 183, Pontoppidan O., 2001 [66, Pontoppidan O. 2001]

3.3.3.3 Techniques to reduce emissions to air**3.3.3.3.1 Reduction of the pig singeing time****Description**

The pig singeing time is reduced.

Technical description

The singeing unit exhaust will be virtually odour-free when the process is optimally controlled, i.e.:

- careful adjustment of the gas/air mixture;
- a reaction temperature of 600 °C to 700 °C;
- a residence time of 0.5 s to 1.0 s in the reaction zone.

Chapter 3

Solenoid switches may be installed which initiate the singeing flame only when a carcase is passing.

Achieved environmental benefits

Reduced odour emissions and fuel consumption.

Environmental performance and operational data

Request to TWG: Please provide information.

Cross-media effects

Request to TWG: Please provide information.

Technical considerations relevant to applicability

Generally applicable to pig singeing units.

Economics

Request to TWG: Please provide information.

Driving force for implementation

Odour control at the slaughterhouse.

Example plants

Request to TWG: Please provide information.

Reference literature

[267, VDI 2020]

3.4 Slaughter of poultry

3.4.1 General information about the sector

3.4.2 Applied processes and techniques

A general scheme for the slaughtering of poultry is shown in Figure 3.60.

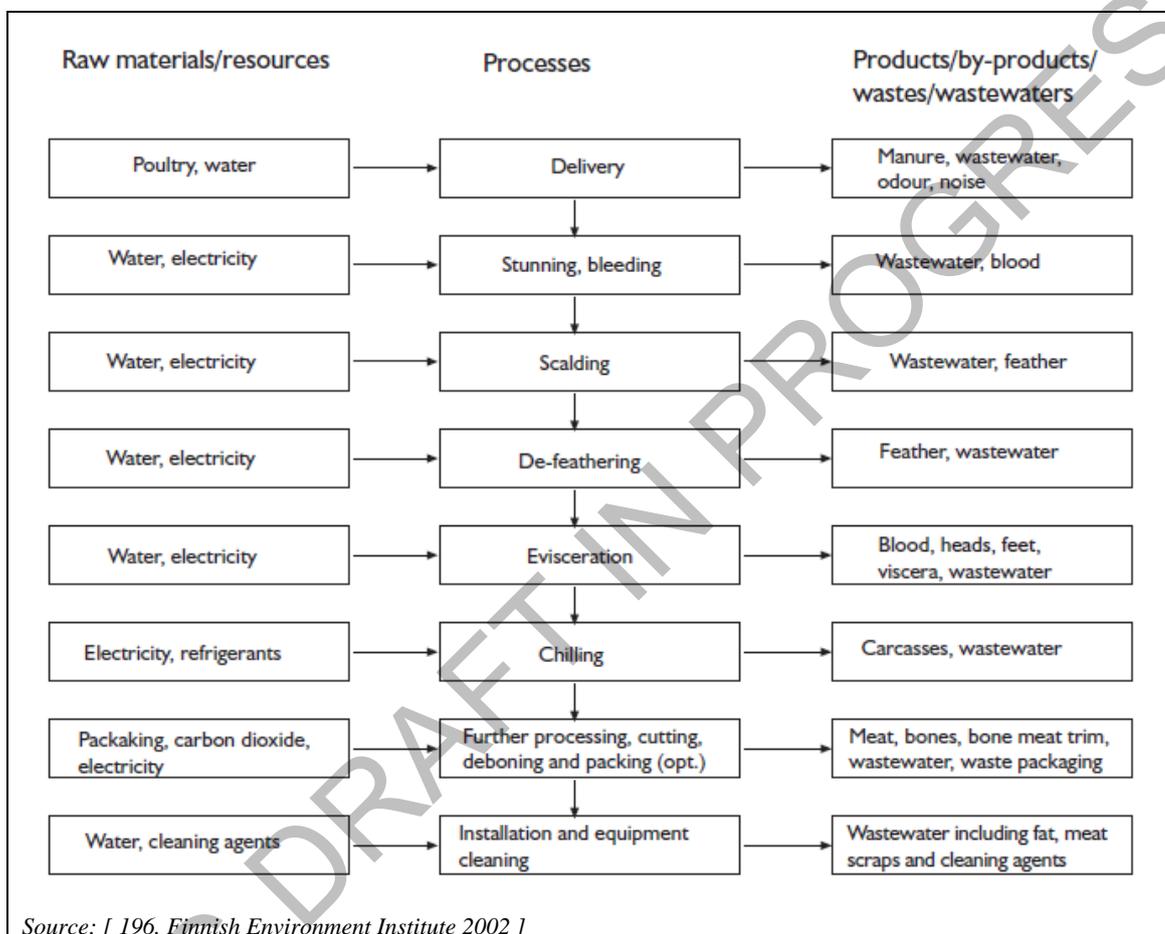


Figure 3.60: A typical flow scheme of poultry slaughtering

3.4.2.1 Reception of birds

It is essential that crates, modules and vehicles used to transport birds are thoroughly cleaned between collections, to reduce the spread of any infection which may be present. The poultry processor generally provides separate facilities for cleaning and disinfecting the crates, modules and vehicles, unless there are facilities available elsewhere at officially authorised facilities. [223, EC, 1992] [99, COM 1992]

The withdrawal of feed prior to loading the birds for transportation to slaughter can help reduce the level of faecal contamination during transportation and, therefore, can reduce the amount of effluent produced during cleaning operations. It can also reduce the amount of crop and intestinal tract contents.

In general, crate cleaning is a three-stage process, which offers considerable opportunities for re-using and recycling water. Many of the larger poultry processors have installed automated crate washing equipment to permit a thorough cleaning immediately following delivery of the birds. Other processors provide a variety of manual and semi-automatic cleaning facilities.

Due to the birds struggling and flapping their wings during unloading and hanging, a significant quantity of dust is produced in those areas. The dust is generally removed using exhaust ventilation and bag filters.

3.4.2.2 Stunning and bleeding

After the birds have had time to settle they are removed from their crates/modules and put onto the killing line. They are required to be stunned, before being killed, except in the case of slaughter according to religious rites [223, EC, 1992] [99, COM 1992]. They are hung upside down by their feet, using shackles on a conveyor which moves them towards the stunning equipment. A commonly used stunning system uses a water-bath (head only), which constitutes one electrode and a bar which comes into contact with the shackles and forms the other electrode. The bird is stunned as soon as the head comes into contact with the water. Other methods for stunning are available, mainly controlled atmosphere stunning and low-atmospheric-pressure stunning (see Section 3.4.4.1). Turkeys may be stunned using CO₂ [27, University of Guelph, undated] [13, University of Guelph 2000]. EFSA recommended the phasing out of electrical stunning methods on animal welfare grounds [269, COM 2012].

After stunning, the bird is bled for up to two minutes before being dressed. Bleeding may be initiated by an automatic circular knife system. The neck arteries of turkeys are sometimes cut using a handheld knife. Normal bleeding also occurs in poultry that have been killed by electrocution instead of being electrically stunned [27, University of Guelph, undated] [13, University of Guelph 2000].

Since poultry are bled whilst they are hanging from a moving conveyor, the majority of poultry slaughterers collect the blood in a tunnel or walled area. The cheapest option for the disposal of blood is to collect it separately. Efficient bleeding processes and maximum blood collection in the killing tunnel are therefore essential. Well designed blood tunnels need to be long enough and have high enough walls to capture all the spurting blood from freshly killed birds.

The blood trough is normally fitted with a double drain, one opening for the blood to be pumped to a tanker for disposal and the other for wash-water. Removable plugs seal the openings when they are not in use.

~~Blood has the highest COD strength of any liquid effluent arising from meat processing operations. Liquid blood has a COD of about 400 g/l and a BOD of about 200 g/l. The containment of blood is, therefore, one of the most important environmental controls at a slaughterhouse. The spillage of blood is potentially one of the most environmentally harmful accidents that can happen. The blood may escape to local water courses or cause problems in an on-site WWTP, due to shock loading. Spillage from blood tanks has occurred when blood trough pumps have been left on overnight during floor cleaning, thereby causing the blood tank to overflow. The risk of this can be reduced by installing a high level alarm on the blood tank, linked to an automatic cut off device for the blood trough pumps. Here a ballcock hits an electrical switch and a solenoid activates a valve, which prevents any further addition [288, Durkan J., 2002].~~

During bleeding blood coagulates on the base/walls of the trough. This is either hosed down and washed directly to the WWTP or in some slaughterhouses it is collected by shovels, squeegees or by vacuum suction and as much as possible is pumped to a blood tanker. This coagulated blood can be rendered, with the other poultry blood. In most slaughterhouses, the blood trough is pitched and curved so that partially congealed blood can be directed into the drain and to the blood tanker. If the coagulated blood is collected first, a few litres of water can, usually with the permission of the renderer, be used to rinse blood into the blood tanker. The plug in the drain leading to the WWTP is then opened and the whole trough is washed down with water.

Some slaughterhouses allow all or a significant proportion of the blood they collect to run to their WWTP. The WWTP in these cases needs to be capable of treating the high COD and BOD. This may incorporate the production of biogas. It is more usual for poultry blood to be sent for rendering [271, Casanellas J., 2002] [124, Casanellas J. 2002].

Excessive body movement of the slaughtered poultry may splatter blood on to the conveyor, out of the bleeding area and onto the feathers of adjoining birds, where it will be washed off in the scalding process. Ensuring that the birds are adequately stunned at slaughter will reduce such movements, allowing more efficient blood collection and reducing waste water effluent strength.

3.4.2.3 Scalding

After stunning and bleeding, the birds are immersed in a scalding tank to loosen the feathers to facilitate de-feathering. Scalding loosens the feathers by softening the feather follicles. The process can be performed by immersing the broilers in a long, hot water bath. It is usually a series of several baths in succession. When applying hot water scalding in a tank, there must be good water movement and a uniform water temperature to ensure that the heat penetrates well everywhere.

Birds destined to be sold frozen are usually 'hard scalded' at 56 - 58 °C. Carcasses to be air-chilled, for fresh sale, are most often 'soft scalded' at 50 - 52 °C to avoid damage to the cuticle and resultant skin discolouration. In the Nordic countries, chickens for freezing are scalded at approximately 58 – 60 °C and chickens for chilled distribution are scalded at approximately 50 - 51 °C [243, Clittravi - DMRI, 2002] [190, Clittravi - DMRI 2003].

As birds enter the scalding tank they may involuntarily defecate, leading to the accumulation of faecal materials in the water. In water, poultry faeces dissociate to form ammonium nitrate and uric acid which form a natural buffer which has the effect of maintaining the scalding tank at about pH 6, the point at which salmonellas are most heat resistant. In most cases, the scalding tanks are emptied into the wet feather flume at the end of the day shift.

3.4.2.4 De-feathering

Feathers are removed mechanically, immediately after scalding, by a series of on-line plucking machines. The machines comprise banks of counter-rotating stainless steel domes or discs, with rubber fingers mounted on them. Rubber flails mounted on inclined shafts are sometimes used for finishing. Any feathers remaining on the bird after mechanical plucking, including pin feathers, are removed by hand. In Finland, de-feathering may be performed by rubbing the scalded carcass with rotating rubber fingers and using pressurised water jets.

Continuous water sprays are usually incorporated within the machines for flushing out feathers. Feathers are commonly taken to a centralised collection point via a fast-flowing water channel located below the machine. The feathers may then be sent for rendering, composting, co-incineration with chicken litter in large combustion plants, or landfill, although the latter is becoming less available as an option [241, UK, 2002] [107, United Kingdom 2002]. Dry feather collection systems, using a conveyor belt in conjunction with a vacuum or compressed air arrangement are sometimes used, e.g. if the feathers are to be supplied to the feather/down industry.

After plucking, the surfaces of the chickens are cleaned by showering, possibly combined with beater straps. The chickens are then transferred from the unclean to the part of the slaughter-line to where the clean processes are carried out, known as the clean slaughter area. They are then inspected externally and the heads and feet are cut off. Some slaughterhouses have equipment for cleaning the feet for human consumption. The feet are cleaned with water at 80 °C. The equipment is only used when there is a viable market for this product.

For ducks, wax is used to remove the feathers. The ducks are dipped in a bath of hot wax and then passed through cool water sprays so that the wax hardens. The hardened wax, with the feathers attached, is either mechanically or hand stripped. The plucked carcasses are then spray-washed. The wax is melted and recycled.

3.4.2.5 Evisceration

After de-feathering and head and feet removal the birds are eviscerated, i.e. the internal organs are removed. In the majority of production sites, evisceration is carried out mechanically, but manual evisceration is still practised in some of the smaller companies. On automated lines, a cut is made around the vent, a spoon-shaped device is inserted into the opening and the viscera are withdrawn. Common practice is to allow the viscera to remain attached by their natural tissues and to hang them over the back of the carcass for post-mortem inspection. Some modern machinery holds the birds horizontally by the head and hocks so that when the viscera are removed from the body cavity they come out sideways and are placed on a tray beside the bird.

Hearts, necks, gizzards and livers can be transported with iced water to containers for collection, from the slaughter-line for storage and distribution, for either human consumption or pet food, depending on the market prices. This integrated transport and cooling system means that separate chilling of these organs is not required.

3.4.2.6 Chilling

After evisceration and inspection, fresh poultry meat must be cleaned immediately and chilled in accordance with hygiene requirements to a temperature not exceeding 4 °C. There are several designs of chilling equipment used; the most popular are immersion chillers, spray chillers, air-chillers, multistage chillers and combi chillers. Immersion chillers are applied in a very limited number of poultry plants. More than 70 % of the EU poultry slaughterhouses apply an air chilling system [241, TWG 2019].

Refrigeration plants operate continuously and the condensing units, compressors and cooling towers associated with them can be a source of noise. Refrigerated trucks parked outside slaughterhouses can sometimes lead to noise problems if the refrigeration is powered from the truck engines. Many slaughterhouses provide mains power cables to power the refrigeration unit, thereby reducing the noise levels.

~~Council Directive 92/116/EEC of 17 December 1992 amending and updating Directive 71/118/EEC on health problems affecting trade in fresh poultrymeat [223, EC, 1992] sets out the legal requirements. Poultry carcasses and parts must not be water chilled by simple immersion in a container of cold water. Water chilling must solely be used in a countercurrent chiller [355, AVEC, 2003]. Poultry meat to be subjected to an immersion chilling process must, immediately after evisceration, be thoroughly washed, both internally and externally, by spraying and then immersed without delay. The water must be potable and a minimum consumption per bird is specified in public health/food hygiene legislation [174, EC, 1880, 223, EC, 1992].~~

Immersion/spin chilling

~~Carcasses are chilled in a single water bath or in a series of water baths. They are moved through a countercurrent of water, so that they are constantly moving into cleaner water. The water needs to have a continuous and opposite flow to the direction of the bird. This is usually achieved by designing the system so that the outlet for the water is a weir at the bird input end. If there is more than one chiller, then the flow in the first stage has to be greater than in the previous and then progressively reduced through each stage. This system can lead to a build up of blood and carcass material in the water, depending on the effectiveness of the pre-chilling washing system and the countercurrent. The birds are passed through a series of water baths~~

filled with water at 0 - 1 °C. Flaked ice is added, e.g. at a rate of 6 tonnes per hour for a slaughterhouse killing 20 000 turkeys per day.

At present, immersion chilling is the least expensive method of chilling poultry. Carcasses take up water during chilling and in some MSs microbial contamination is controlled by chlorination of the water, within potable water limits. This is generally done using chlorine dioxide, even though it costs more than using chlorine. Immersion chilling has the highest legal limit of water uptake, i.e. 4.5 % [243, Clitravi - DMRI, 2002].

Spray chillers

These avoid the problems associated with the build-up of contamination in chiller tanks, but they can give rise to the spread of bacteria through aerosols. Spray chillers may also use high volumes of water, reportedly up to 1 litre of water per bird. Spray chilling has the lowest energy consumption.

Air-chillers

These are generally used when the carcasses are destined for sale fresh. Chilling is either carried out in batches in a chill room or by continuous air blast. Tests have shown that air-chilling can reduce the contamination rate by up to three times more than immersion chilling [67, WS Atkins Environment/EA, 2000] [24, WS Atkins-EA 2000].

Most chicken processors have now switched to air-chilling because this uses the least amount of water and extends the shelf-life of the product. Water chilling is, however, widely used by turkey processors in order to comply with USDA and UK hygiene requirements for rapid chilling of these larger carcasses. After spending about an hour in a countercurrent immersion chilling tank to reduce the carcass temperature, the turkeys are further chilled for 24 hours by loading 30 - 40 birds into 1m³ tanks filled with water at 0 - 1 °C and ice at -8 °C, to achieve the requirement for the water temperature of the final chiller to be less than 4 °C [67, WS Atkins Environment/EA, 2000] [24, WS Atkins-EA 2000], [246, AVEC, 2002] [111, AVEC 2002]. Air-chilling can cause dehydration of the carcass, but it helps to preserve the flavour of the poultry meat and can help the product command a premium price [27, University of Guelph, undated] [13, University of Guelph 2000].

Multistage chillers

In multistage tunnels, the cold room is subdivided into two or three sections - or stages - each with its own air velocity and air temperature. This system helps to bring down dehydration, subsequent yield loss and energy consumption. Spraying can be applied in the first section, even for products with epidermis.

Combi chiller

In a combined chilling tunnel, drag chilling is applied in the first phase of the chilling process. The products are immersed in a water bath while remaining hanging in the shackles of the overhead conveyor. A typical drag chilling line would comprise following phases:

- 6 minutes of drag chilling;
- 2 minutes of drip line;
- 2 minutes of drag chilling;
- 45-80 minutes of air chilling depending on bird weight and product end temperature.

The water bath used for drag chilling comprises long stainless steel tanks, optionally provided with a glycol coolant circuit. A separate glycol chilling system is required. Since the carcasses drag some water from the tank on leaving, the water bath is placed on the floor of the tunnel.

A multilayer air/combi chiller is a very efficient method of chilling compared with a single-layer air chilling system [241, TWG 2019].

Description of refrigeration technology (see Section 0)

3.4.2.7 Maturation

Where carcasses require maturation after chilling, further conditioning using a refrigeration medium (air, ice, water or other food-safe process) can be used which may continue the cooling process of the carcass or parts of carcasses. Council Directive 92/116/EEC of 17 December 1992 amending and updating Directive 71/118/EEC on health problems affecting trade in fresh poultrymeat allows maturation, after chilling, by water immersion in static slush ice tanks. Unlike water chilling they do not have to move through a countercurrent of water. [355, AVEC, 2003] [192, AVEC 2003]. The birds are immersed in stainless steel tanks in water and ice, to cool them to 1 °C. They are then stored in a room with temperature control at 0 - 1 °C for up to 24 hours. [214, AVEC, 2001] [90, AVEC 2001]

3.4.3 Current consumption and emission levels

Slaughter of poultry

Specific consumption and emission data for the sub-processes of the poultry slaughter process are reported in this section.

Dust is emitted from the birds' feathers during unloading and hanging [316, May G., 2002].

Scalding is undertaken at temperatures between 50 and 58 °C. The accumulation of faecal materials in the water has the effect of maintaining the scalding tank at about pH 6, the point at which salmonellas are most heat resistant.

As the viscera are kept with the carcass, for post mortem inspection, there shouldn't be elevated BOD and COD levels at the evisceration station.

The birds are washed in potable water, which in some MSs is chlorinated. In, e.g. the UK, the washing is undertaken with water chlorinated with, e.g. chlorine dioxide, at a concentration approved for potable water [241, UK, 2002].

Immersion/spin chilling can lead to a build up of blood and carcass material in the chilled countercurrent of water. The pre chilling wash, which may be manual or automatic, should remove any particulate matter and any blood from inside the cavity and blood residue from the outside. Depending on the effectiveness of the original bleeding, some additional bleeding may occur in the chiller. If there is more than one chiller in a line, this will occur in the first chiller. The water flow can be increased to the first chiller to aid dilution. If tails and/or necks are left on the bird these may sometimes become separated from the bird because during processing they are partly cut through. The use of automated processes and the fact that the birds are not a uniform shape or size also makes the prevention of contamination more difficult. The conditions applied for chilling, including, e.g. the volume of water required per bird, are prescribed in law and depend on the number of tanks and the weight of the carcass [223, EC, 1992]. Table summarises the requirements for water, excluding that used for first filling the tanks.

Table : Summary of water requirements for immersion chilling of poultry

Carcass weight (kg)	Pre-chill wash	Immersion chilling	
	Minimum water volume (l)	Minimum total flow (l)	Minimum flow last tank, if several (l)
≤ 2.5	1.5	2.5	1
2.5 - 5	2.5	4	1.5
≥ 5	3.5	6	2

Source: [223, EC, 1992]

Spray chillers avoid the problems associated with the build up of contamination in chiller tanks, but they can give rise to the spread of bacteria through aerosols. They use up to 1 litre of water per bird. Air chilling can reduce the contamination rate of the birds by up to three times more

than immersion chilling and it uses less water. [67, WS Atkins Environment/EA, 2000, 134, Nordic States, 2001]

~~Most chicken processors have switched to air chilling as this uses the least amount of water. Water chilling is, however, widely used by turkey processors in order to comply with hygiene requirements for the rapid chilling of these larger carcasses. After about an hour in a countercurrent immersion chilling tank, to reduce the turkey carcass temperature to less than 4 °C, the turkeys are further chilled for 24 hours by loading 30–40 birds into 1m³ tanks filled with water and ice at 2 °C. [67, WS Atkins Environment/EA, 2000]~~

In some MSs microbial contamination is controlled by chlorination, within potable water limits.

3.4.3.1 Chicken slaughterhouses

This section presents data for installations exclusively slaughtering chickens.

3.4.3.1.1 Energy consumption

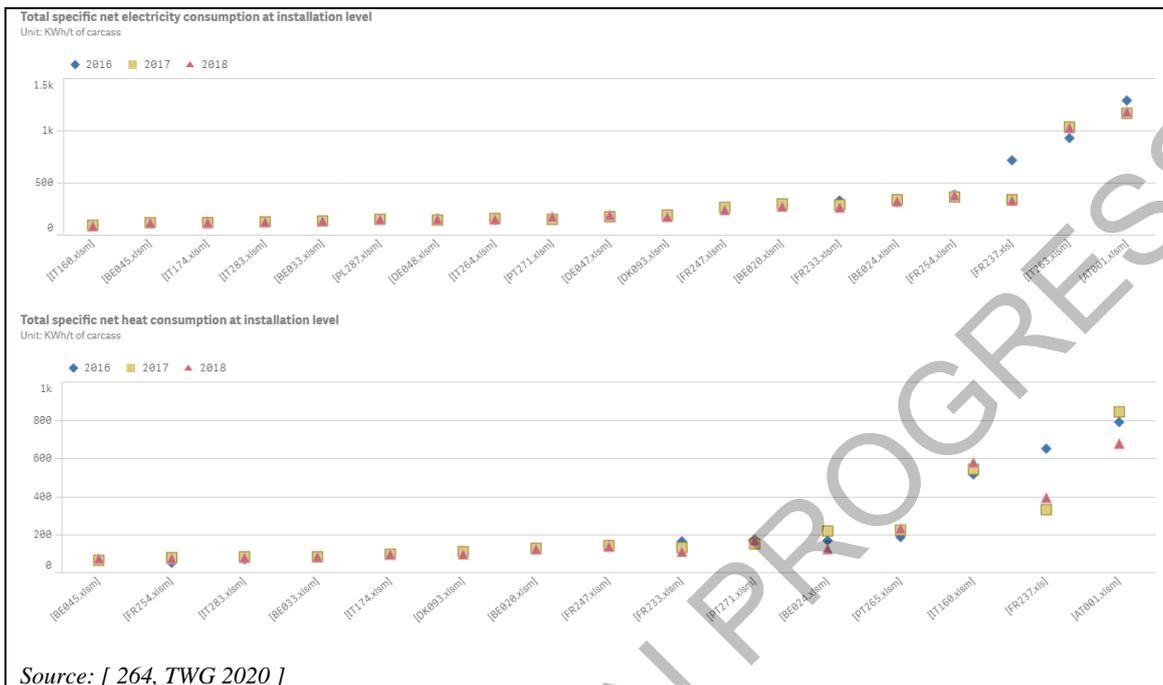
3.4.3.1.1.1 Specific net energy consumption in kWh/tonne of carcass

Figure 3.61 shows data in relation to total specific net energy consumption in terms of kWh/tonne of carcass at installation level as well as the applied techniques to reduce energy consumption.



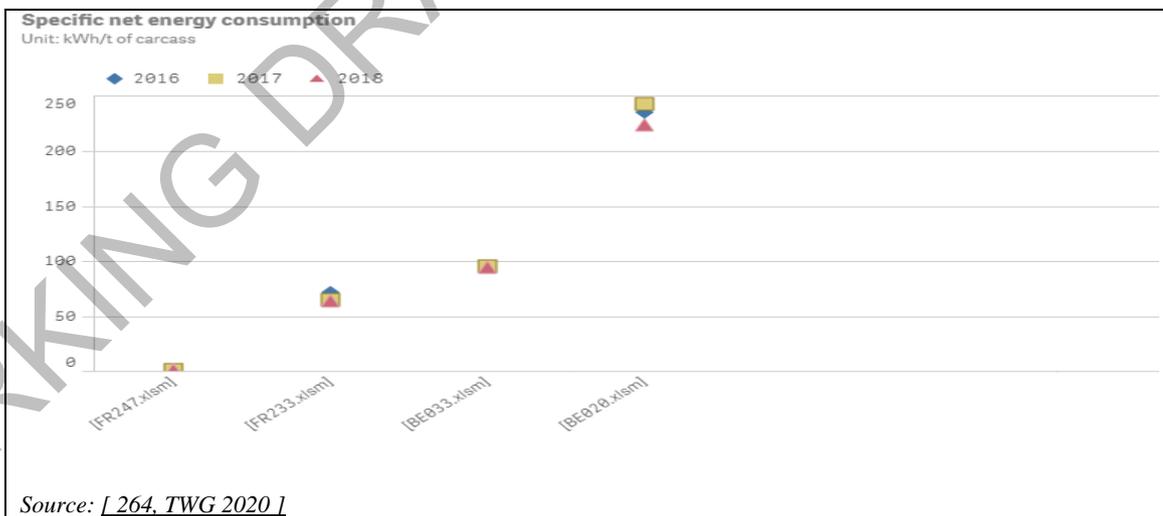
Figure 3.61: Specific energy consumption (kWh/t of carcass) and applied techniques to reduce energy consumption in chicken slaughterhouses (installation level)

Figure 3.62 shows data in relation to total specific net electricity and heat consumption in terms of kWh/t of carcass at installation level.



Source: [264, TWG 2020]
Figure 3.62: Specific electricity and heat consumption (kWh/tonne of carcass) in chicken slaughterhouses (installation level)

Figure 3.63 shows the specific net energy consumption (in kWh/tonne of carcass) for the cooling systems process.



Source: [264, TWG 2020]
Figure 3.63: Specific energy consumption (kWh/tonne of carcass) for cooling systems in chicken slaughterhouses

3.4.3.1.1.2 Specific net energy consumption in kWh/animal

Figure 3.64 shows data in relation to total specific net energy consumption in terms of kWh/animal at installation level as well as the applied techniques to reduce energy consumption.

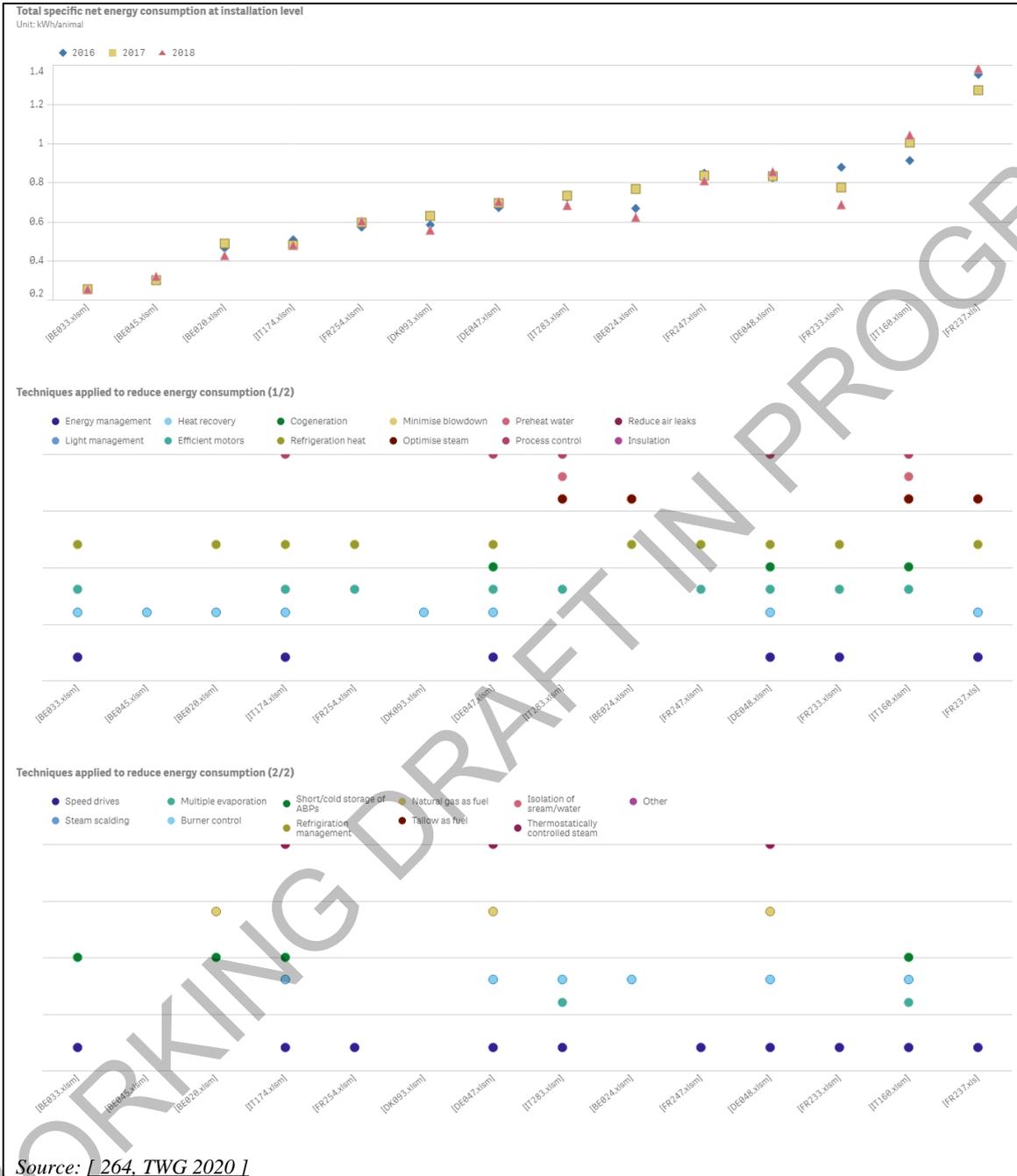


Figure 3.64: Specific energy consumption (kWh/animal) and applied techniques to reduce energy consumption in chicken slaughterhouses (installation level)

3.4.3.1.2 Water consumption

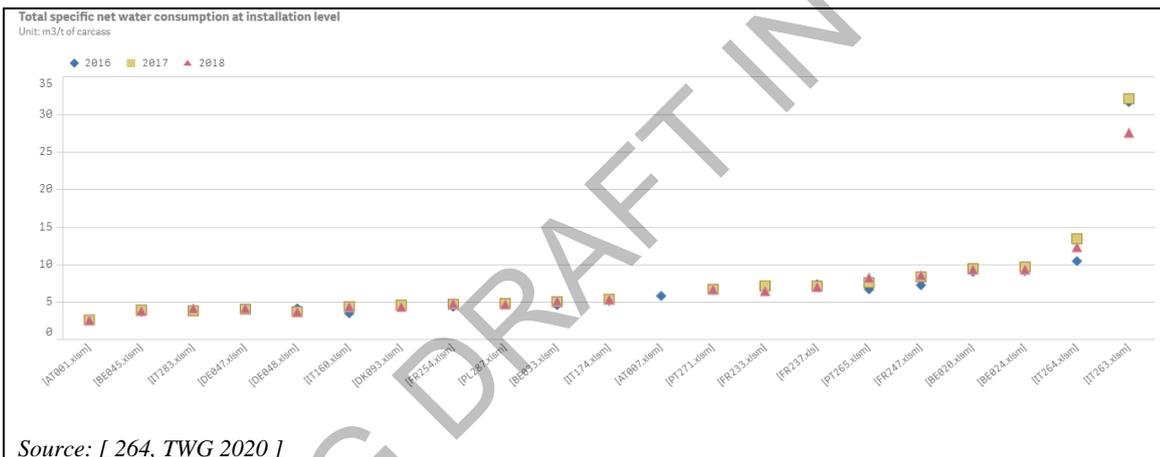
Cold or hot potable water is used to wash crates. Detergents are added because crates are a potential source of microbiological risk from, e.g. *Salmonella*. The strength of detergent used depends on the species of poultry. High strength detergent is used for turkeys.

Water is virtually always used to wash the birds and transport away the feathers. The wet transportation of feathers creates a potential for water contamination. It also adds moisture to the feathers, which naturally hold a lot of water. This increases the energy required to transport them during further processing. It also increases the amount of energy required to drive off moisture during rendering and the amount of condensate produced. If the feathers are landfilled the additional moisture may also create leachate problems.

The birds are washed in potable water, which in some MSs is chlorinated. In, e.g. the UK, the washing is undertaken with water chlorinated with, e.g. chlorine dioxide, at a concentration approved for potable water [241, UK, 2002] [107, United Kingdom 2002].

3.4.3.1.2.1 Specific net water consumption in m³/tonne of carcass

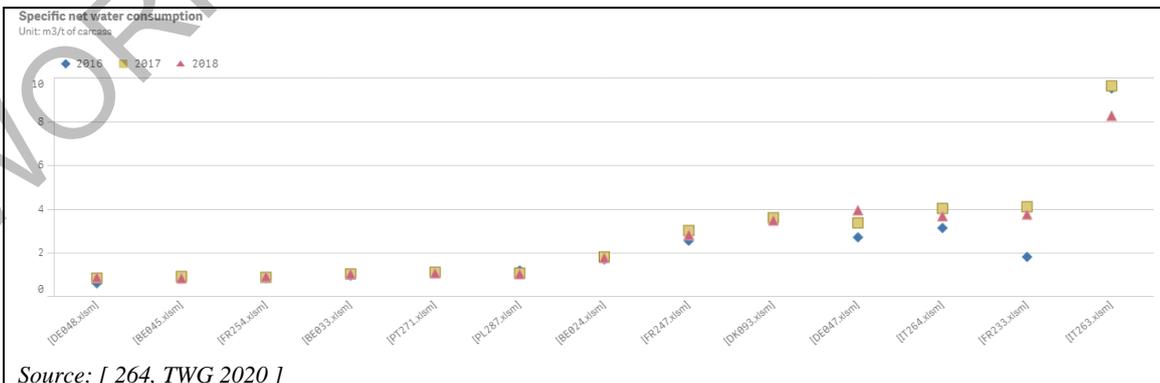
Figure 3.67 shows data in relation to total specific net water consumption in terms of m³/t of carcass at installation level.



Source: [264, TWG 2020]

Figure 3.67: Specific water consumption (m³/tonne of carcass) for chicken slaughterhouses (installation level)

Figure 3.68, Figure 3.69 and Figure 3.70 shows the specific net water consumption (in m³/tonne of carcass) for various processes in chicken slaughterhouses.



Source: [264, TWG 2020]

Figure 3.68: Specific water consumption (m³/tonne of carcass) for cleaning of floors/walls and equipment in chicken slaughterhouses

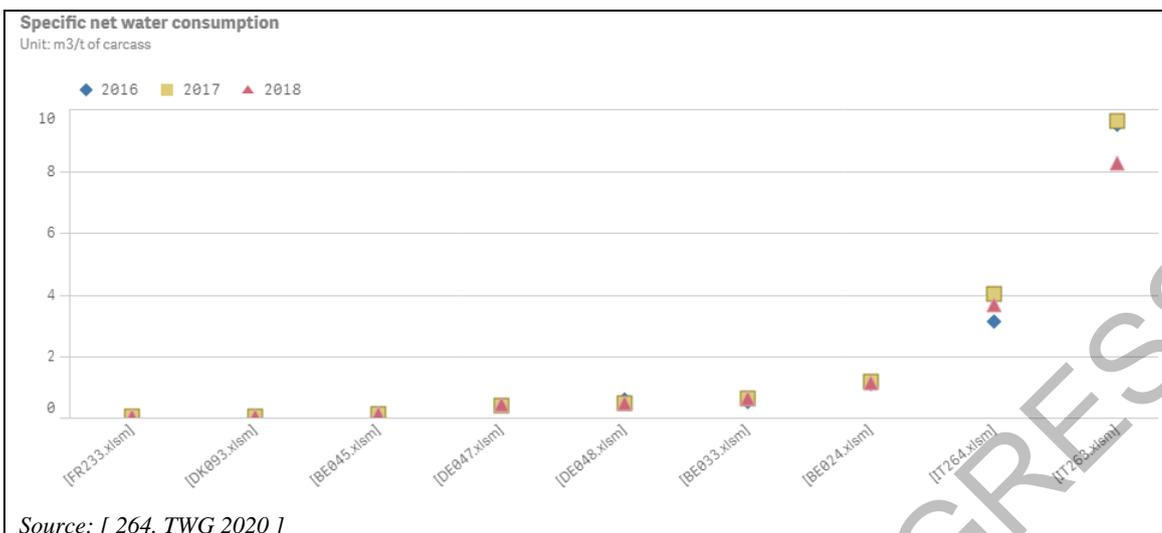


Figure 3.69: Specific water consumption (m³/tonne of carcass) for defeathering in chicken slaughterhouses

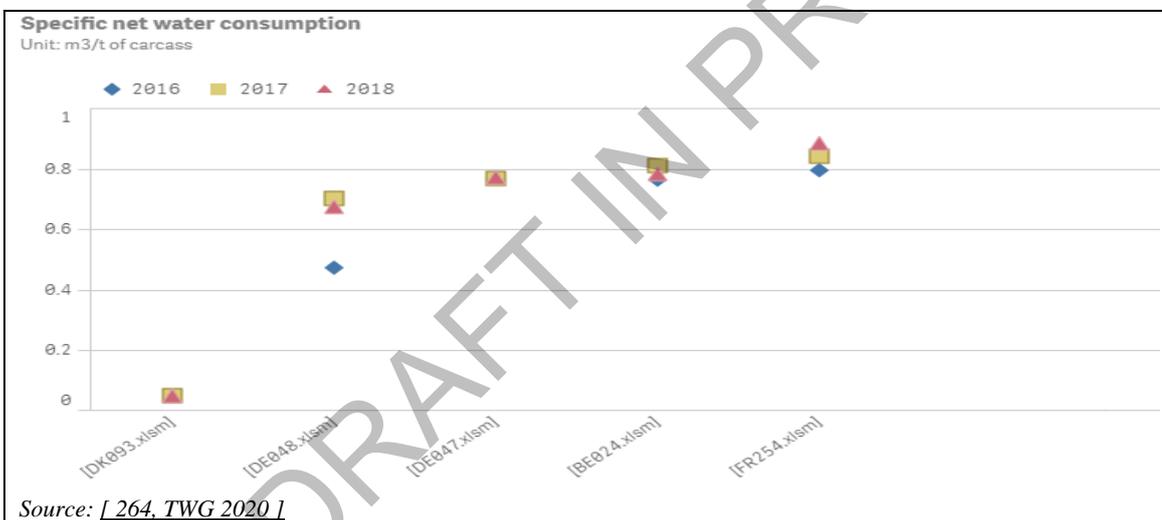


Figure 3.70: Specific water consumption (m³/tonne of carcass) for handling of casings and offal in chicken slaughterhouses

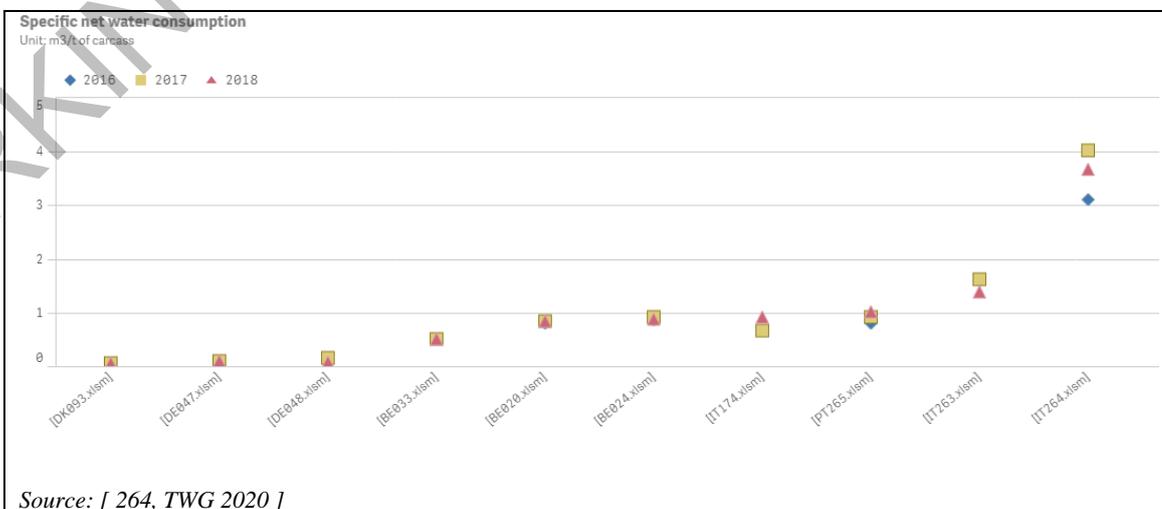


Figure 3.71: Specific water consumption (m³/tonne of carcass) for vehicle washing in chicken slaughterhouses

Chapter 3

3.4.3.1.2.2 Specific net water consumption in m³/animal

Figure 3.72 shows data in relation to total specific net energy consumption in terms of m³/animal at installation level.

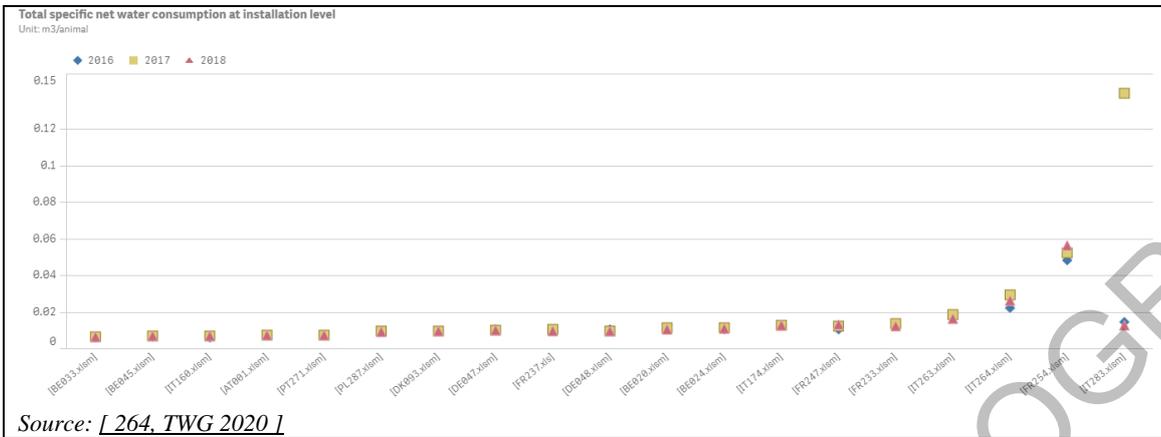


Figure 3.72: Specific water consumption (m³/animal) for chicken slaughterhouses (installation level)

Figure 3.73, Figure 3.74, Figure 3.75 and Figure 3.76 show the specific net water consumption (in m³/animal) for various processes in chicken slaughterhouses.



Figure 3.73: Specific water consumption (m³/animal) for for cleaning of floors/walls and equipment in chicken slaughterhouses

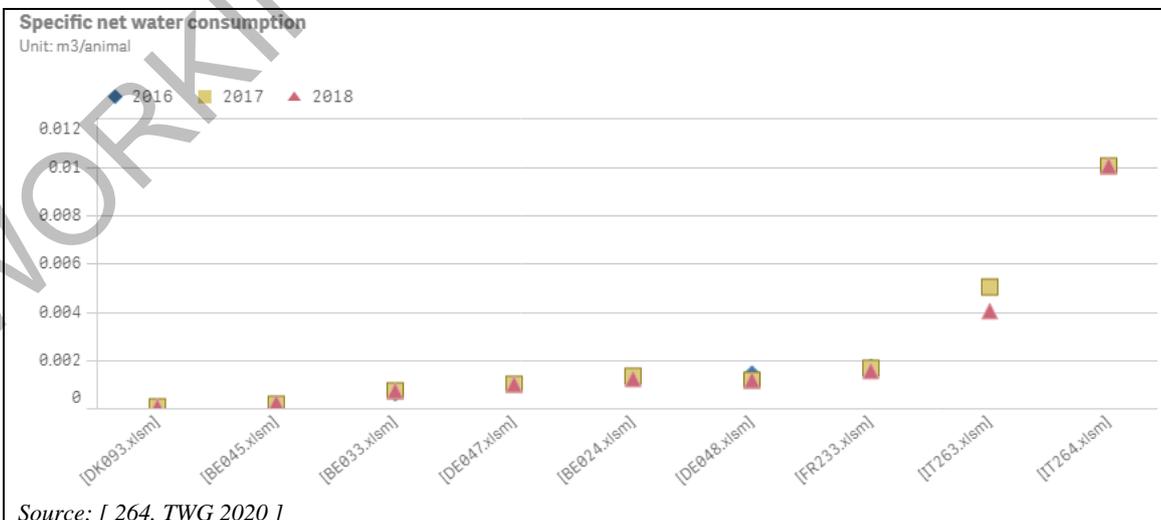


Figure 3.74: Specific energy consumption (m³/animal) for defeathering in chicken slaughterhouses

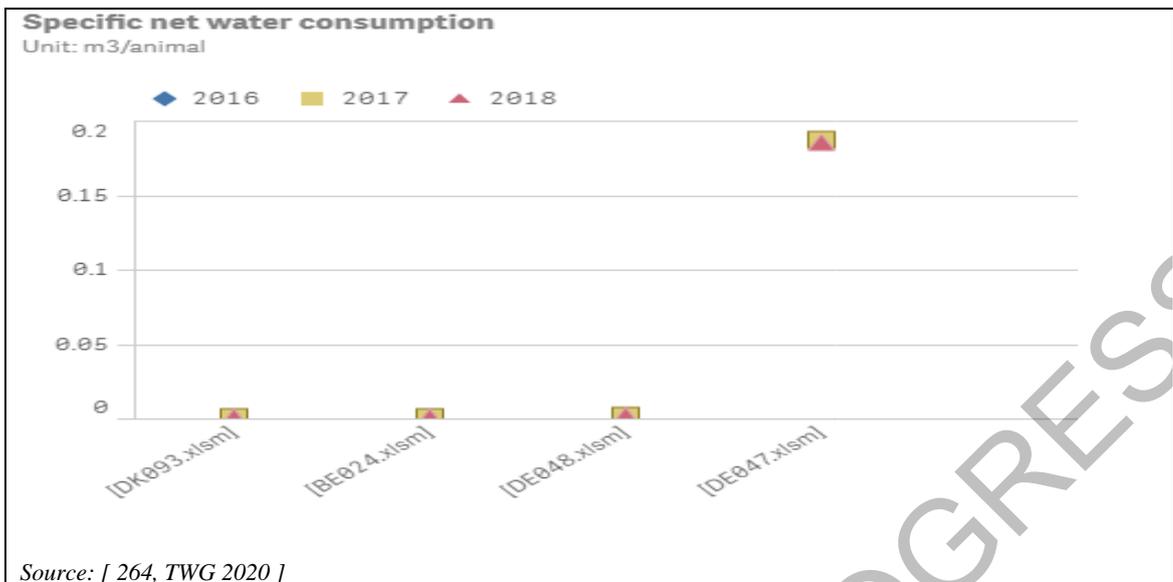


Figure 3.75: Specific water consumption (m³/animal) for handling of casings and offal in chicken slaughterhouses

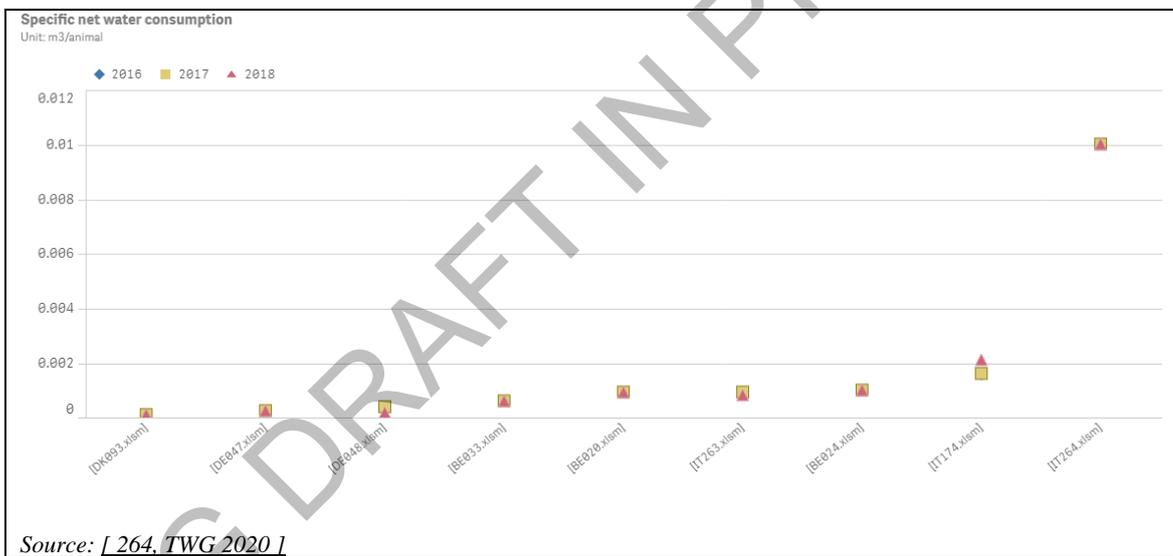


Figure 3.76: Specific water consumption (m³/animal) for vehicle washing in chicken slaughterhouses

3.4.3.2 Emissions to water

Figure 3.77 shows reported data on specific waste water discharges in m³/tonne of carcass from chicken slaughterhouses and all types of discharges, as well as the applied techniques to reduce water consumption.



Figure 3.77: Specific waste water discharge (m³/tonne of carcass) in chicken slaughterhouses for all types of discharges and applied techniques to reduce water consumption

Figure 3.78 shows reported data on specific waste water discharges in m³/animal from chicken slaughterhouses and all types of discharges, as well as the applied techniques to reduce water consumption.



Figure 3.78: Specific waste water discharge (m³/animal) in chicken slaughterhouses for all types of discharges and applied techniques to reduce water consumption

Blood has the highest COD strength of any liquid effluent arising from poultry slaughter operations. Poultry blood has a COD strength of about 400 g/l, which would lead to a doubling of the effluent strength at a typical poultry slaughterhouse if it was allowed to enter the waste water stream.

3.4.4 Techniques to consider in the determination of BAT

3.4.4.1 General environmental performance

3.4.4.1.1 Low-atmospheric-pressure stunning

Description

Birds are rendered unconscious from a lack of oxygen by the use of reduced oxygen tension.

Technical description

During the slaughter process, chickens are frequently stunned before being killed using an electrical water bath (electrical stunning) and, more recently, through controlled atmosphere stunning (CAS) by using inert gas mixtures. Low-atmospheric-pressure stunning (LAPS) is an alternative technique using reduced oxygen tension to render the birds unconscious from a lack of oxygen [218, Vizzier-Thaxton et al. 2010].

Lower pressure is achieved through slow decompression of the air in a sealed chamber using a vacuum pump (Figure 3.79). Birds are placed in the chamber and rendered unconscious by a gradual reduction of oxygen, leading to a progressive deprivation of adequate oxygen supply to the birds' organs. The loss of consciousness is therefore gradual, as with CAS, and potentially painless because no air is trapped within the body cavities [219, The Poultry Site 2019].



Source: [219, The Poultry Site 2019]

Figure 3.79: Low-atmospheric-pressure stunning system

The LAPS system works as follows [220, COM 2012]:

- standard transport modules are put onto a rail by forklift and led to the vacuum chambers;
- the transport modules enter one of the chambers at a time;
- the chamber is sealed, and air is gradually extracted over a 4-minute period, causing anoxia;
- the unconscious birds are then tipped out and shackled.

Achieved environmental benefits

LAPS offers various advantages over traditional electric water baths:

- Reduced unusable waste streams (losses in the water bath due to fractures and bleeding).
- Reduced dust production due to wing flapping.
- Reduced water use and consequently waste water production.
- Improved hygiene as the birds do not defecate on themselves.

Environmental performance and operational data

Compared to the traditional electric water bath, the LAPS system obtains (data for a specific case of 12 000 birds/hour, [220, COM 2012]) > 80 % reduction of water use at the stunning stage (this relates to a saving of 10 950 m³/year of water).

Cross-media effects

Increased energy use with LAPS compared to the traditional electric water bath (13-16 kW compared to 0.5-1.5 kW for a capacity of 12 000 birds/hour).

Technical considerations relevant to applicability

None.

Economics

Table 3.11 shows an estimate of the costs for the different stunning systems which can be used in a bird slaughterhouse, with a capacity of 12 000 birds/hour. The overall cost per bird of LAPS is about 5 % higher than traditional water baths.

Table 3.11: Economic differences of stunning procedures (water bath/head only, CAS, LAPS)

Cost factor	Water bath/head only	CAS	LAPS
Installation cost (EUR)	370 000	308 300	500 000
Maintenance (% of installation cost)	3.00	6.90	2.40
Labour for reception and hanging (hours/day)	96	90	90
Water for stunning and cleaning (m ³ /day)	0.96	3.5	3.5 (max)
Electricity (kWh/day)	9.6	127	1,136
Gas used	-	3.1 tonnes/day	-
Other labour (hours/day)	0.5	5	5
EU average cost per bird (EUR/bird)	0.02521	0.03495	0.02641
Cost per bird including labour, water, electricity (EUR/bird)	0.04151	0.05105	0.04367
<i>Source: [220, COM 2012]</i>			

Driving force for implementation

During this procedure the birds are in darkness, which could therefore reduce the stress of the stunning procedure. Different studies suggest that there are no pain-inducing effects of the LAPS systems [221, McKeegan et al. 2013]. However, the European Food Safety Authority conducted a review of several documents presented by the EC and concluded that ‘it is unclear from the submitted documents [...] that LAPS induced unconsciousness and death without causing avoidable pain’ [222, EFSA 2014]. More research on the physiological responses of poultry to LAPS is therefore suggested.

This system offers the advantage for the workers of not having to handle and shackle live birds because they are stunned directly in their transport containers.

Example plants

OK Foods of Fort Smith, Arkansas (USA). They produce 318 tonnes of meat per week.

Reference literature

[218, Vizzier-Thaxton et al. 2010], [219, The Poultry Site 2019], [220, COM 2012], [221, McKeegan et al. 2013], [222, EFSA 2014]

3.4.4.1.2 Controlled atmosphere stunning Using inert gases for poultry stunning

Description

Inert gases (e.g. argon, nitrogen) are used for stunning/killing chickens and turkeys, whilst they are in their in transport containers or unloaded on a conveyor belt.

Technical description

There are two commonly used CAS systems:

1. The birds are unloaded separately or the drawers with broilers are unloaded on a conveyor belt and then transported through the multistage gas stunner.
2. The birds are stunned in the container/drawer which enters the cabinet, and the gas mixture enters the closed cabinet. The birds are stunned according to a multistage process.

After the multistage gas stunning, the animals are irreversibly stunned and are shackled manually in the slaughter line.

Mixtures of (a) argon, nitrogen or other inert gases, or any mixture of these gases, in atmospheric air with a maximum 2 % oxygen by volume or (b) any mixture of argon, nitrogen, or other inert gases with atmospheric air and CO₂ provided that the CO₂ concentration does not exceed 30 % by volume and the oxygen concentration does not exceed 2 % by volume, can be used.

Achieved environmental benefits

- Reduced dust emissions during unloading, hanging and bleeding. It has also been reported that improved quality and yield have led to a reduced by-product destined for disposal as waste. The increase in yield in turn leads to a tendency to store more of the slaughterhouse output, in conditions which will not cause spillage or odour problems.
- Reduced energy consumption due to reduced refrigeration time and space requirements, since it is no longer necessary to mature the carcasses. Reduced water use, and consequently waste water production.

Environmental performance and operational data

The specific energy consumption is 3-10 W/kg bird. The specific gas (argon, CO₂ and/or O₂) consumption is 5-20 l/bird [241, TWG 2019].

A reduction in dust levels, from 11.1 – 29.6 mg/m³ to 9.0 mg/m³, has been reported.

A proprietary system has 12 draws per module, each with a capacity of around 24 broiler chickens per draw, giving a total of 288 birds per module. A typical poultry processing line operates at 8 000 birds per hour, thereby killing around 70 000 birds per line, per day.

The system is reported to have the following advantages. It does not impede blood loss, therefore, residual blood in the carcase meat is low. In comparison with electrical stunning, it reduces the number of birds with broken bones and the number of broken bones per bird; this is important as broken wish and collarbones frequently cause haemorrhaging in breast fillets and

tender loins. It greatly reduces the incidence of haemorrhaging, not associated with broken bones, in the breast and leg muscles and this improves the yield and the value of products.

Research during 2001 indicated that the adoption of a gas mixture consisting of 80 % by volume nitrogen and 20 % by volume argon, is considered to be better than the carbon dioxide-argon mixture from bird welfare and meat quality points of views.

Cross-media effects

The reduced energy consumption, due to reduced refrigeration requirements may be offset by installations using a nitrogen separation plant for processing atmospheric air.

Technical considerations relevant to applicability

Applicable in poultry slaughterhouses. CAS systems require more space than water bath systems.

Economics

See Table 3.11.

At a cost of GBP 1 200 per module (1995), the maximum investment on modules alone works out to be around GBP 288 000. To this module cost, around GBP 200 000 must be added for the standard plant handling equipment plus approximately a further GBP 200 000 for the stunning equipment. Total equipment costs for a complete installation on one processing line are therefore estimated to be about GBP 700 000.

Slaughterhouses using the system from 1995–1999, used a mixture of 30 % CO₂ and 60 % argon in air (leaving 8 % nitrogen and 2 % oxygen from residual air). Carbon dioxide and argon were stored in separate silos at the processing plant and mixed prior to supply into the stunning unit. Changing the gas silos to store nitrogen and argon led to additional costs.

The stunning unit is designed and built to accommodate gases which are heavier than air, and to minimise the gas loss. Maintaining 25–30 % CO₂ and 1.5–2.0 % residual oxygen in argon in the unit, at a throughput rate of 7 000 birds per hour, the gas consumption is estimated to be 17 litres of mixed gas per bird. In 1995, based on UK prices, the cost of stunning with this mixture was estimated to be between GBP 0.8–1.0 per 100 birds. The implementation of a mixture of 80 % nitrogen and 20 % argon in 2001, is estimated to have reduced the cost to between GBP 0.3–0.5 per 100 birds.

Driving force for implementation

The main driving force is reported to be animal welfare.

Some of the major welfare concerns associated with the water-bath electrical stunning systems, which reportedly cause stress, trauma and pain, are removed. These include, e.g. removing birds from their transport containers; shackling; conveying birds upside-down on a shackle line; giving birds an electric shock before being stunned (pre-stun shocks); cutting the necks of birds which miss being stunned adequately, due to wing flapping at the entrance to the water-bath stunners and the recovery of consciousness during bleeding due to inadequate stunning and/or an inappropriate neck cutting procedure.

Example plants

Approximately 15–20 % of the poultry slaughterhouses in the EU have a CAS system installed [270, IWC 2020].

There are at least 4 companies in the UK using a predominantly nitrogen-based gas mixture for killing chickens and turkeys.

Reference literature

[253, Raj A. B. M., 2002] [115, Raj A.B.M. 2002], [270, IWC 2020]

3.4.4.1.3 Electrical water bath stunning (head only)

Description

The birds are hung by their feet and only their heads are immersed in the water. An electric current is led to the water.

Technical description

The birds are hung in the shackles of the overhead conveyor by their feet, are led through the bath, in which only their heads are immersed. In the water bath, an electrode is placed which is connected to the control unit. The other electrode is formed by a stainless-steel shackle guide that touches the shackles which are placed above the bath. In this way, an electric current is led from the electrode to the water, through the head and body of the bird to the feet, from the feet to the shackle.

Achieved environmental benefits

Reduced energy consumption compared to CAS and LAPS systems.

Environmental performance and operational data

The specific energy consumption is 0.1-0.5 W/kg bird. The specific water consumption is 0.05-0.11 l/bird [241, TWG 2019].

Cross-media effects

Dust emissions occur during shackling and stunning of birds.

Technical considerations relevant to applicability

Applicable in poultry slaughterhouses. EFSA recommended the phasing out of electrical stunning methods on animal welfare grounds [270, IWC 2020].

Economics

See Table 3.11.

Driving force for implementation

Request to the TWG: Please provide information.

Example plants

This technique is widely applied in the EU poultry slaughterhouses.

Reference literature

[241, TWG 2019], [270, IWC 2020]

3.4.4.2 Techniques to increase energy efficiency

3.4.4.2.1 Steam scalding of poultry

Description

Poultry is scalded whilst hanging by being passed through steam.

Technical description

Poultry can be scalded whilst hanging by being passed through steam.

Achieved environmental benefits

Steam scalding of poultry can reportedly reduce both energy and water consumption by ~~at least 25 %~~, compared to scalding using hot water.

Example plants

Request to the TWG: Please provide information.

Steam scalding of poultry is used at one Danish turkey slaughterhouse.

Reference literature

[243, Clitravi—DMRI, 2002]

3.4.4.2.2 Jet stream scalding

Description

Water jets are applied at the bottom of the scalding tank and the flow of warm water arising from the jet is oriented so that it is brought into contact with the poultry skin. The poultry skin is contacted with scalding water only, without any air bubbles.

Technical description

The bird is led through the scalding tank hanging vertically by its legs from the shackle of the overhead conveyor. In the scalding tank, the bird is immersed in a warm water bath. At the bottom side, the scalding tank is provided with upwardly directed nozzles. These nozzles generate a vertically upwards directed flow of scald water. At the top side, the scalding tank is provided with reversing guides. These guides direct the stream of scald water downwards over the chicken. Thus a spiralled stream of scald water is obtained. This results in an effective heat transfer to the skin of the chicken and a homogeneous temperature distribution of the scalding water. After some time, the follicles are weakened. At the end of the scalding tank the feathers can be easily removed by mechanical rubber fingers.

The jet stream scalding tank applies water jets below the surface of the scalding tank, creating a down flow of warm water directly on the skin of the poultry. The poultry skin is contacted with scalding water only, without any air bubbles. As a result, there is hardly any exchange between scalding water and the air above it and this limits the loss of energy to the room in which the scalding tank is placed. Moreover, emissions of ammonia are absent as well.

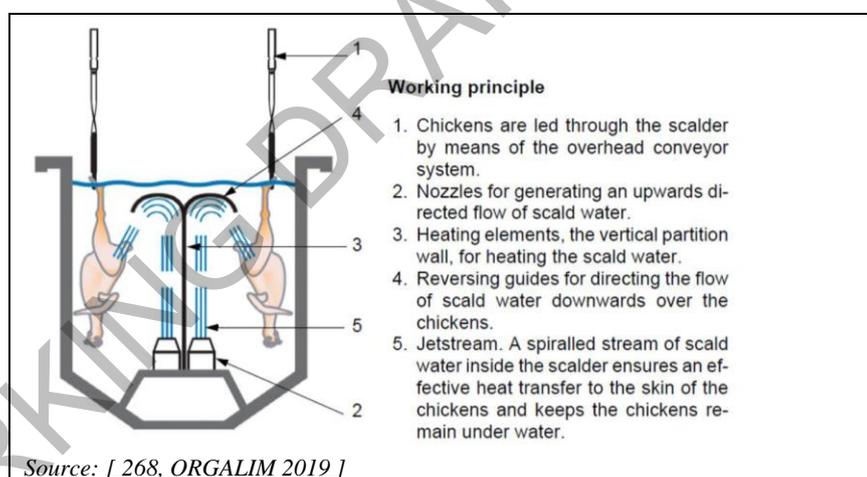


Figure 3.80: Working principles of jet stream scalding

Achieved environmental benefits

- Reduced energy consumption.
- No ammonia emissions are released from the scalding tank.

Environmental performance and operational data

The energy saving compared with jacuzzi-type scalding including canopy is approximately 30 %. The energy consumption is 81 kJ/bird, and the water consumption is between 0.2 l/bird and 0.4 l/bird.

Cross-media effects

None.

Technical considerations relevant to applicability

Applicable in poultry slaughterhouses.

Economics

The investment level and cost of ownership are comparable with other types of scalding solutions.

Driving force for implementation

- Increasing the slaughter capacity or line speed of the plant.
- Replacement of current scalding system because of decreased performance.

Example plants

There are more than 200 jet stream scalders installed in poultry processing plants worldwide and more than 60 jet stream scalders installed spread over small, medium and large poultry processing plants in the EU.

Reference literature

[268, ORGALIM 2019]

Insulation of scalding tanks

Description

Insulation of the scalding tank in poultry slaughterhouses can reduce heat loss by approximately 0.5 kW/m² of surface.

Achieved environmental benefits

Reduced energy consumption.

Cross-media effects

None.

Applicability

When a company has to replace an old scalding tank, the new one could be insulated.

Economics

The payback period for insulating an existing tank in poultry slaughterhouses is estimated to be approximately 10 years.

Reference literature

[134, Nordie States, 2001]

3.4.4.3 Techniques to reduce water consumption

3.4.4.3.1 Steam scalding of poultry

See Section 3.4.4.2.1.

3.4.4.3.2 Re-use of crate washing water

See also Section 2.3.5.1.2.

Description

Water from the final wash is reused for the early stages. Any large debris is filtered out and top-up water is added to maintain water levels in the system.

Technical description

The system is designed to make the most economical use of water by adding clean water from the final wash to the early stages. Any gross debris are filtered-out and top-up water is added to maintain water levels in the system.

Crate washing water can also be reused to transport feathers down to the offal plant [241, TWG 2019].

Achieved environmental benefits

- Reduced water consumption.
- Reduced detergent use.

Environmental performance and operational data

The crates are removed from their transport container and passed to the bird unloading stage. After emptying they are washed. The transport container goes to a separate washing system, after which it rejoins the cleaned crate for replacement on to the lorry.

Crate washing is achieved by the use of potable water at ambient temperature. The crate passes through a spray wash section. The water passes over a wire wedge screen and is then returned to a collection bath, for recirculation. A float operated water make up system maintains a constant water supply to the system. After leaving the washer the crate is immersed in a dip tank and travels approximately 6 m, after which it is raised into a final spray washer. The overflow from the washer feeds into the immersion section and also into the first wash.

The last stage is a final rinse using clean water plus a quaternary amine compound detergent/disinfectant. This is added by an automated dosing system at a concentration of 15 mg of chemical per litre of water volume used.

The transport container passes to an inline spray booth and the water is recirculated via a wire wedge screen to remove gross debris. Clean water is added to maintain the water level and this is controlled by a float valve. Detergent/disinfectant is added at a rate of 0.5 l/h.

The clean crates are assembled in the transport containers. Before leaving the system for reloading on the vehicle they are rinsed again in clean water dosed at a concentration of 15 mg of detergent/disinfectant per litre of water volume used.

In an example slaughterhouse, the system was installed in a new building. The water consumption increased by an average of 400 – 450 m³ per 5 day week. This led to an equivalent increase in the amount of water being processed in the WWTP over a 7 day period and the slaughterhouse requiring an increase in its volume consent, from the environmental regulatory authority.

Cross-media effects

Significant increases in water consumption.

Technical considerations relevant to applicability

Applicable in poultry slaughterhouses.

Economics

Request to the TWG: Please provide information.
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Driving force for implementation

In an example company, all of the water consumed on a given site is purchased from a local supply company and treated in an on-site WWTP, before being discharged to a river. The discharge volume is set by the regulatory authority. When the live bird handling system was installed, it was necessary to limit the increase in water to enable the installation to operate within the consent limits.

The system was also introduced for bird welfare reasons, i.e. to prevent potential contamination/diseases being transported between farms and factories.

Disinfecting the crates and transport containers reduces the spread of food poisoning organisms between the birds and the human population, which can be carried on the trays.

Example plants

At least one poultry slaughterhouse in the UK.

Reference literature

~~[291, Rodgers K., 2002]~~ [140, Rodgers K. 2002] [241, TWG 2019]

3.4.4.3.3 Use of recycled water, e.g. from scalding, for the carriage of feathers

See also Section 2.3.5.1.2.

Technical description

The feathers are collected in a trough under the plucking machine. They are then transported with recirculated water to a screen with water passing through it, before they are collected.

Systems in use in the UK include a water flume system for removing the feathers from the plucking. After the feathers have been screened out, this water is reused in the feather flume. This is topped up with fresh water used during the plucking process. There will be an overflow of water from the scald tank which runs into the feather flume [241, TWG 2019].

To limit the water loss from the scalding tank, drip trays carrying part at the water dripping from scalded chickens back to the tank can be fitted after the tank.

Achieved environmental benefits

Reduced water consumption.

Cross-media effects

None.

Technical considerations relevant to applicability

Applicable in all poultry slaughterhouses.

Reference literature

~~[134, Nordic States, 2001]~~ [38, Nordic 2001] [241, TWG 2019]

Water efficient and fewer shower heads**Technical description****Achieved environmental benefits**

Reduced water consumption, reduced waste water volume for treatment and reduced entrainment of, e.g. blood and fat in the waste water.

Cross-media effects

None.

Environmental performance and operational data**Technical considerations relevant to applicability**

Applicable in all poultry slaughterhouses.

Economics

Combined with other projects a payback time of 1 month was reported.

Driving force for implementation

Reduced water consumption and consequent cost savings for waste water treatment, within permitted discharge volume limits.

Example plants

A turkey slaughterhouse in the UK.

Reference literature**Reduction of water consumption in poultry slaughter****Technical description**

Water consumption can be reduced in a number of different ways. For instance, unnecessary water sprays can be removed. Manual cleaning procedures can be improved, by increasing dry cleaning, e.g. by removing solid materials and absorbing liquid spillages. The water supply flowrate can be restricted. Medium pressure washing can be carried out at night. Low pressure washing can be carried out during the day, when required, i.e. within a cleaning schedule which replaces cleaning at every break in the process with one substantial clean per day.

Council Directive 92/116/EEC of 17 December 1992 amending and updating Directive 71/118/EEC on health problems affecting trade in fresh poultrymeat requires carcase washing after evisceration.

Achieved environmental benefits

Reduced water consumption and reduced water contamination. Minimisation of water contact with the carcasses reduces the entrainment of organic matter, such as fat and this in turn reduces the BOD levels in the waste water. A reduced uptake of faecal material may also minimise phosphorus levels in the waste water.

Environmental performance and operational data

Reduced water consumption, from 10–11 litres to 7–8 litres per carcase can be achieved by optimisation of manual and automated cleaning. It is reported that this will not compromise microbiological standards.

In an example poultry slaughterhouse, the number of carcase washing sprays on a poultry slaughter line has been reduced to a minimum, i.e. to only after de-feathering and evisceration, without any increase in microbial contamination.

The operator could see no need for additional sprays, in particular, for between the scalding tanks.

With chickens, the reported reduction is from 2500–2750 l/t reduced to 1750–2000 l/t. For turkeys the reported reduction is from 2000–2200 l/t reduced to 1400–1600 l/t. These figures are much lower than the total water consumption levels reported in Table.

Technical considerations relevant to applicability

Poultry processing.

Driving force for implementation

To meet the volumetric flow limit on an effluent discharge permit.

Example plants

A UK poultry slaughterhouse.

Reference literature

[241, UK, 2002]

Dust abatement at bird reception, unloading and hanging stations – fabric filters

Technical description

During the unloading and hanging of birds up to and during slaughter and bleeding, high airborne dust levels are generated from the feathers. This is caused by the movements of the birds, especially by their flapping wings. The dust levels can be abated by the use of exhaust ventilation. The dust can be collected in a fabric filter. The air may be collected using either local exhaust ventilation or by general ventilation, although the former is more effective. The airstream is passed into a large chamber and through a filter fabric. When the airstream passes through the filter fabric, the dust particles are trapped in the fabric. As more particles are trapped, they in turn trap other particles from the airstream. Separation is carried out by sieve action, direct collision or attraction. The filter fabric can be fitted in various configurations, such as bags or screens. Compressed air or mechanical vibration is used to remove the separated dust from the fabric. The dust drops to the bottom of the chamber and is removed.

Achieved environmental benefits

Reduced dust emissions to air.

Cross-media effects

Captured dust has to be disposed of as waste.

Environmental performance and operational data

An emission level of 5 mg/Nm³ can be achieved from starting levels of the order of g/Nm³. Dust bags have to be disposed of and replaced approximately every 5 years.

Technical considerations relevant to applicability

Applicable in all poultry slaughterhouses.

Economics

A fabric filter requires an investment of EUR 1 000–4 500/1 000 Nm³/h, depending on the housing design. Operating costs are approximately EUR 2 800/1 000 Nm³/h each year.

Driving force for implementation

Primarily occupational health at the hanging station, but also reduction of dust emissions to the environment, particularly in residential areas.

Reference literature

[333, Netherlands TWG, 2003]

Dust abatement at bird reception, unloading and hanging stations – wet scrubber**Technical description**

During the unloading and hanging of birds up to and during slaughter and bleeding, high airborne dust levels are generated from the feathers. This is caused by movement of the birds, especially by their flapping wings. The dust levels can be abated by the use of exhaust ventilation. The air may be collected using either local exhaust ventilation or by general ventilation, although the former is more effective. The dust can be collected in a wet scrubber. The exhausted airstream is passed through a water spray to ensure intimate contact with the scrubbing water, causing the dust particles to be trapped in the droplets. For increased efficiency, the gases can be passed through a venturi collar in which water is atomised, either with the flow or as a counter flow. The increased efficiency is achieved due to the high speeds in the venturi collar and the intensive contact between the gas stream and the water mist. Alternatively a mist may be created by internal static vanes.

Achieved environmental benefits

Reduced dust and odour emissions to air.

Cross-media effects

Using a scrubber requires water and energy. The sludge produced from the dust in water, has to be concentrated and disposed of as waste.

Environmental performance and operational data

It is reported that dust emissions can be reduced by 99 % and that the average efficiency is 50–90 %.

Scrubbers can be used for air flows of up to 100 000 Nm³/h.

Technical considerations relevant to applicability

Applicable in all poultry slaughterhouses.

Economics

A scrubber requires an investment of about EUR 5 000/1 000 Nm³/h at a capacity level of 10 000 Nm³. Operating costs are approximately EUR 2 600/1 000 Nm³/h each year.

Driving force for implementation

Primarily, occupational health at the hanging station, but also reduction of dust emissions to the environment, particularly in residential areas.

Reference literature

{333, Netherlands TWG, 2003}

Dust abatement at bird reception, unloading and hanging stations – washable metal mesh**Technical description**

During the unloading and hanging of birds up to and during slaughter and bleeding, high airborne dust levels are generated from the feathers. This is caused by movement of the birds, especially by their flapping wings. The dust levels can be abated by the use of exhaust ventilation. The air may be collected using either local exhaust ventilation or by general ventilation, although the former is more effective. The dust can be collected using a washable metal mesh inserted in extract ventilation ducts.

Achieved environmental benefits

Reduced dust and odour emissions to air.

Cross-media effects

Using an extractor requires energy. The washings have to be disposed of as waste.

Environmental performance and operational data

In an example plant, the extract system is mounted at ground level with grills to prevent large material being drawn into the duct before it is collected in a 1 m³ tank/low velocity zone, via an internal baffle plate and a washable metal mesh filter. It is reported that the system is linked to an air intake providing a minimum of 30 air changes per hour and that either disposable cartridge filters or washable metal mesh filters need to be fitted to the air inlet.

Technical considerations relevant to applicability

Applicable in all poultry slaughterhouses.

Driving force for implementation

Primarily, occupational health at the hanging station, but also reduction of dust emissions to the environment, particularly in residential areas.

Reference literature

{336, BPME, 2003}

WORKING DRAFT IN PROGRESS

4 INSTALLATIONS PROCESSING ANIMAL BY-PRODUCTS AND/OR EDIBLE CO-PRODUCTS

4.1 General information for installations processing animal by-products and/or edible co-products

The animal by-products industry in the European Union

Introduction to the animal by-products industry

Animal by products from slaughterhouses are sometimes known in the industry as the 'fifth quarter'. They include edible materials such as tongue, edible offal, edible fats and casings, as well as hides/skins and other non food materials. In previous decades, these by products provided a valuable source of slaughterhouse income. In recent years, especially because of BSE, the value of the fifth quarter materials has reduced substantially and much of the material previously used is now disposed of as waste. [12, WS Atkins EA, 2000]

Installations processing animal by-products and/or edible co-products is a term used in this document to refer to the installations other than slaughterhouses covered by the scope of the SA BREF. Installations processing animal by-products and/or edible co-products [199, COM 2019]:

- are included in the scope of the SA BREF under under IED Annex I point 6.5 or 6.4 (b) activities;
- refer to the the processing of animal by-products and/or edible co-products, such as rendering and fat melting, feather processing, blood processing, fishmeal and fish oil production, and gelatine manufacturing;
- include other SA activities such as combustion of meat-and-bone meal and of animal fat, incineration of carcasses, anaerobic digestion and composting.

The animal by-products industry handles:

- all of the raw materials that are declared as not fit ~~not directly destined~~ for human consumption;
- ~~and some~~ raw materials that are ~~destined for eventual~~ fit for human consumption, but are not destined to human consumption for commercial reasons.

Both decisions are irreversible. It is not allowed to produce any edible co-products from animal by-products (ABP) [259, EFRA-EAPA 2020]. The permitted use and disposal routes of animal by-products are governed by the ABP Regulation 1069/2009 [204, EC 2009] 1774/2002/EC. ABP are defined in this EU regulation as 'entire bodies or parts of animals, products of animal origin or other products obtained from animals, which are not intended for human consumption (...)'. After processing the animal by-products, the ~~raw materials~~ products may have several applications, e.g. food and feed, cosmetics, medicinal products and medical devices, technical products, fertilisers and many others.

Edible co-products, also called food grade products means products fit for human consumption and destined for human consumption. Therefore all processing steps, i.e. collection, transport, processing and delivery fall under the EU Regulation 853/2004 on hygiene for food of animal origin [260, EC 2004]. All edible co-products must come from ante-mortem inspected healthy animals and must have passed also a post mortem inspection to be declared fit for human consumption.

Edible co-products can be received from slaughterhouses (blood), cutting plants (fat, bones, rind) and tanneries (split). The main examples of edible co-products are:

- gelatine / collagen;
- blood products like plasma and haemoglobin,
- fat, like lard (pig fat), tallow or beef dripping and poultry fat.

Fats like lard and tallow are mainly a food ingredient for human consumption, while blood products and gelatine are used as functional proteins. Food grade products can also be used for purposes outside the food chain, like feed for technical applications, e.g. fat in feed or soaps, blood products in feed, or gelatine in pharmacy and technical applications like glue or wall paper [259, EFPRA-EAPA 2020].

Products from slaughterhouses like blood or animal fat can be either food grade products or animal by-products (or non-food grade products). It is very difficult to distinguish visually between edible co-products and animal by-products. It is therefore important to know what “legal status” they have, according to the inspection. The processes are in principle very similar, although it is important to know that some food grade plants cool the raw material transport and storage which can increase the energy consumption. The hygiene requirement for processing edible co-products are stricter, and thus the consumption of disinfectants and/or chemical agents can be higher than for the processing of ABP.

Table 4.1 shows an overview of relevant animal by-products and the volumes generated per cattle and pig animal.

Table 4.1: Animal by-products (including products intended for human consumption)

Type of ABP	Cattle (kg/animal)	Pigs (kg/animal)
Blood (including food-grade blood)	15–20	3.5–5.0
Paunch and stomach contents	55	0,5
Gut contents	15	2,8
Skin	40	–
Bristles and hoofs/toenails	–	0.4–0.9
Shanks with hooves, horns	11	–
Internal fat tissue	35	1.5
Internal organs	90	10

Source: [267, VDI 2020]

Many of the animal by-products used and disposed of are derived from healthy animals which have been slaughtered in slaughterhouses and whose carcasses have been found fit for human consumption following ante and post mortem inspection. [349, GME TWG members, 2003]. Due to food and feed safety concerns an increased proportion of such animal by products are disposed of as waste.

Hides and skins are sold to the leather industry. Edible offal and fats are sold for direct use or inclusion in processed products. Inedible offal and fats are usually processed to produce animal meal and tallow. Some edible fats and trimmings are processed to produce lard and dripping [57, DoE, 1993]. The first flush of blood, e.g. from pigs, may be collected, for use as food, animal feed or pharmaceuticals.

Of the 47 million tonnes of animals slaughtered for meat production in Europe every year, 17 million tonnes, minus hides, skins and bones for gelatine production, are handled by the animal by products industry. About 14–15 million tonnes [13, UKRA, undated, 24, EURA, 1997] are processed by renderers and fat melters. As society becomes more affluent and eating habits change the proportion of an animal eaten directly is less than ever before. The amount of

by product available for processing is, therefore, increasing. [24, EURA, 1997]. About half the tallow and animal fats produced are used by the oleochemical industries as raw materials for a wide variety of chemicals, which are then used in soaps, cosmetics, pharmaceuticals, detergents and a large range of industrial products, e.g. from paint to car tyres. Oils and fats produced by fat melters are used in the food industry, e.g. in baking and food processing; frying and margarine production. [24, EURA, 1997]

Considerable numbers of carcasses are also left to rot or are illegally dumped. [20, UKRA, 2000]. The burial of fallen animals is illegal in the Netherlands, Denmark, Germany and France. Authorised burial is allowed in Italy and Spain. In the UK, the burial of carcasses is allowed if DEFRA guidelines are followed and in line with EU rules implemented through national legislation.

In November 1991, the use of MBM produced from specified bovine offals as a fertiliser was banned in the UK [19, UKRA, 2000].

Until the BSE crisis, a high proportion of the solid end products of rendering, i.e. the protein fraction, were important ingredients of animal feed. Feeding MBM to cattle, sheep or goats has now been banned within the EU since 1 July 1994. Since December 2002, the feeding of “processed animal proteins” to farmed animals, kept fattened or bred for the production of food, was prohibited, pending a total re-evaluation of Community legislation in MSs [88, EC, 2000]. The restrictions have led to an increased proportion of solid material being disposed of to landfill and by incineration. MBM has an energy content of about two thirds that of coal, so energy can be recovered, as heat and/or power. The limits placed on the traditional uses for animal by products have led to further alternative uses and to new routes for disposal being researched and developed. [22, UKRA, 2000]. These include, e.g. the combustion of MBM as an ancillary fuel for cement production [22, UKRA, 2000]; the burning of tallow as a fuel [22, UKRA, 2000]; biogas production [22, UKRA, 2000, 287, EC, 2002]; composting [287, EC, 2002]; biodiesel production [22, UKRA, 2000]; the use of MBM as fertiliser for non grazing land [22, UKRA, 2000] and the use of fat as a fuel in turbines and engines [22, UKRA, 2000]. These alternatives are at various stages of development and under environmental and economic evaluation.

The ban remains in place at the time of writing.

4.2 General processes and technique across installations processing animal by-products and/or edible co-products

4.2.1 Applied processes and techniques across installations processing animal by-products and/or edible co-products

4.2.1.1 Odour treatment in installations processing animal by-products and/or edible co-products

Decomposition commences as soon as the animal is slaughtered. During the period from the time of death to the commencement of ABP processing rendering, temperature in particular, affects the rate of decomposition. Much of the material to be processed is wet in nature and this adds to the creation of ideal conditions for rapid putrefaction. Undue delays before ABP processing rendering in conjunction with inadequate temperature control, therefore, have a direct effect on the state of decomposition and on the consequent severity of any odours. [241, UK, 2002] [107, United Kingdom 2002]. The biological and/or thermal decomposition of raw materials leads to the formation of odour-intensive substances, such as ammonia and amines; sulphur compounds, such as hydrogen sulphide, mercaptans, and other sulphides; saturated and unsaturated low-boiling fatty acids; aldehydes; ketones and other organic compounds. Synergistic effects can increase the odour intensity of the mixture as a whole.

Odour in installations processing animal by-products and/or edible co-products can arise from different sources, e.g. the raw materials, the process, the by-products, or the waste water treatment. Many of these installations are required to abate malodorous gases with a control strategy which is installation-specific.

Several considerations should be considered prior to selecting treatment possibilities:

- The freshness of raw material, to consider storage or refrigeration before processing, mainly in summer time with high temperatures. The use of fresh raw material can be a problem in terms of reaching suppliers located far from the plant. In the case of long distances, not only would a correct design of process line with a totally enclosed rendering line be highly recommended, but also some previous pretreatment of the raw material to avoid bad smells could be considered.
- The separation steps, for example if viscera are separated from skins, bones, etc. the process can be easily optimised in terms of odour streams segregation.
- The volume of raw materials treated is also a variable to consider, because it has an influence on the amount of gases generated.

The separation of high and low odour-concentrated gases is important to facilitate their treatment. Low concentrated gases coming from milling or conveyors can be easily treated compared to gases from cooking, pressing or drying.

The absence of citizen complaints in uninhabited areas reduces the pressure to undertake effective steps to minimise the odours. Therefore, the design for an odour treatment is plant-specific; it should be based on an in-depth analysis of the source and the emission points, considering the possibilities and the limitations of the abatement systems.

In this context, different systems could be applied to reduce odours. Table 4.2 summarises the main techniques to treat odours with their advantages and disadvantages. For example, [254, Pendashteh et al. 2015] suggest the use of absorption methods in a fishmeal and fish oil installation, such as a wet scrubber followed by oxidative scrubber systems which allows a removal efficiency of trimethylamine and trace sulphur compounds of 97 % and 100 %, respectively.

Combustion methods can also be applied. High-temperature combustion can achieve 99 % odour elimination; however, the energy consumption to reach 750 °C is important. Another solution can be to apply catalytic combustion using platinum as a catalyser. The temperatures used in catalytic oxidation are much lower (350-400 °C) than in high-temperature combustion. Catalytic oxidation can be applied for installations with low hydrocarbon concentrations in waste gases, but the cost of the catalyst process is also relatively high. For plants with less odour problems, mainly due to location, volume processed, etc., adsorption by active carbon can be considered, but the price of active carbon can be relevant.

Biological systems for odour treatment are being applied. These biofilters or bio-scrubbers should guarantee microorganism maintenance since they absorb the problematic odour compounds of the treated gases and allow their biological decomposition. The low cost and simple technology are the main advantages of these systems, which, however, may present difficulties for treating highly polluted streams or due to their important demand of space.

Table 4.2: Main techniques for odour treatment in installations processing animal by-products and/or edible co-products

Technology	Advantages	Disadvantages
Absorption	<ul style="list-style-type: none"> - Low CAPEX - Low OPEX - Treatment of highly polluted gases 	<ul style="list-style-type: none"> - Sometimes further purification steps are necessary - Possible corrosion in installations
Adsorption	<ul style="list-style-type: none"> - Recovery of adsorbed compounds - Useful in low contaminated streams 	<ul style="list-style-type: none"> - Adsorbent regeneration - Possible secondary emissions
Catalytic combustion	<ul style="list-style-type: none"> - High effectiveness - Possibility to eliminate gases with a broad range of odour compounds - Useful for highly and less polluted gases 	<ul style="list-style-type: none"> - High operating costs - High energy consumption
Thermal combustion	<ul style="list-style-type: none"> - High effectiveness - Useful for highly polluted gases 	<ul style="list-style-type: none"> - High energy demand - High CAPEX
Biological treatment	<ul style="list-style-type: none"> - Low CAPEX - Low OPEX - Useful for less polluted gases 	<ul style="list-style-type: none"> - Components should be biodegradable - Large surface area for installation - Problems with biomass generated
<i>Source: [252, Spain 2020]</i>		

4.2.1.2 Combustion of meat-and-bone meal

Fats may be used as an alternative to conventional primary energy sources such as fuel oil and natural gas to fuel the steam generator units of the processing plants.

Meat-and-bone meal (MBM) is brown in colour, weighs approximately 600 kg/m³ and has an intense sweet odour. It is a highly calorific, easily flammable fuel. [164, Nottrodt A., 2001] [53, Nottrodt 2001]. The incineration of MBM, in particular has, therefore, developed into a relatively large scale activity since the use of animal proteins in animal feed was banned.

Commission Regulation (EU) No 2020/735 amending Commission Regulation (EU) No 142/2011 provide rules concerning combustion plants in which MBM is used as a fuel for combustion, including emission limits and monitoring requirements. The emission limits and monitoring requirements applying to combustion plants using poultry manure as a fuel should also apply to combustion plants with a total rated thermal input not exceeding 50 MW using MBM as a fuel in order to meet the relevant environmental standards [274, COM 2020].

~~Some MSs co-incinerate MBM and other animal meals in municipal waste incinerators, hazardous waste incinerators, sewage sludge incinerators, coal fired power stations, cement works, gasification plants and residue incinerators in paper plants. [164, Nottrodt A., 2001].~~

Information in this section has been provided as background, although co-incineration and mixed waste incineration are not described or evaluated further in this BREF.

Germany

The first case of BSE in Germany was confirmed on 26 November 2000. This led to a ban on the use of processed animal proteins as animal feeds for livestock, e.g. pigs and poultry, with effect from 1 December 2000. This was followed by a ban on all uses and the requirement to dispose of processed animal proteins as waste by incineration. The development of dedicated incineration plants was not considered to be economically viable due to the relative uncertainty about future feedstock availability in the long term. The possibility of siting an incinerator at a rendering plant and recovering the energy through CHP has been raised. [164, Nottrodt A., 2001]

The relative treatment prices for incinerating animal meal and other wastes and the higher calorific value of animal meal, have reportedly stopped plants operating at almost full capacity from actively pursuing animal meal incineration, for economic reasons. They can make more money by incinerating lower calorific value wastes. The prices vary for hazardous waste incinerators, sewage sludge incinerators, power plants and cement works. [164, Nottrodt A., 2001]

Gasification of both animal meal and tallow has been tried successfully. [164, Nottrodt A., 2001]

France

France produces approximately 850000 tonnes of MBM and approximately 150000 tonnes of tallow annually. Approximately 130000 tonnes of MBM and 40000 tonnes of tallow are from SRM and are co-incinerated by the cement industry.

It is planned that the remaining MBM will also be incinerated in cement works and power stations.

Animal meal from BSE infected animals are disposed of in hazardous waste incineration plants.

In 2001, 400000 tonnes of MBM were either stored in warehouses or sent to landfill. [164, Nottrodt A., 2001]

Italy

The dedicated incineration of carcasses and parts of carcasses has recently been developed and implemented in Italy.

United Kingdom

The UK has a tradition of burning single carcasses in small, mainly on farm, incinerators. It is currently the only MS with dedicated incineration plants for animal meal. Three dedicated animal meal incinerators have been operating at 2 sites since the late 1990s. At one site there are 2 incinerators, each with a capacity 3.5 t/h and at the other location there is a single incinerator, which has a capacity of 7.5 t/h [199, PDM Group and Wykes Engineering (Rushden) Ltd, 2000]. Together the 3 incinerators incinerate a total of 60000 t/yr. A further dedicated animal meal incinerator, with a capacity of 60000 t/yr, came into operation in April 2001.

All of the UK's purpose-built dedicated animal meal incinerators are fluidised beds.

Since 1999 a power plant previously running on chicken manure has been adapted and now runs on animal meal exclusively. It burns 85000 tonnes of animal meal every year. It is a stoker-fired furnace. It does not burn animal meal derived from SRM.

In addition to animal meal incineration, approximately 3000 cattle carcasses are incinerated directly every year in incinerators with capacities < 50 kg/h. It is estimated that there may be

between 2000 and 2600 of these incinerators for burning animal carcasses presently in use in the UK [227, ADAS, 2001].

Most of the following information is taken from UK guidance [82, EA, 1998]. Other sources are cited.

The collection and disposal of certain animal by-products may be subject to the requirements of the Council Directive 91/689/EEC of 12 December 1991 on hazardous waste, concerning the prevention of infection.

Bubbling fluidised bed incinerator

Animal meal can be incinerated in fluidised bed incinerators, as these are suitable for reasonably homogeneous materials. BFB incinerators are used for incinerating animal meal in the UK. A fluidised bed incinerator is normally a single stage process. It consists of a refractory-lined shell. The chamber contains a granulated bed consisting of an inert material such as sand or limestone. In at least one plant the granulated bed comprises ash from the incineration of animal meal. The granulated bed is supported on a distribution plate and fluidised air or another gas which is blown up through the plate. Ancillary equipment includes a fuel burner, a waste feed mechanism and possibly an after-burner chamber. BFB incinerators have the advantage of having a simple construction with no moving parts, so maintenance requirements are minimal. The granulated bed provides continuous attrition of the burning material, removing the char as it forms and exposing fresh material for combustion. This assists with increasing the speed and completeness of combustion.

Description of animal meal

Animal meal can be incinerated on the rendering site where it is produced, it can be sent directly from the rendering plant to the incinerator, or it may be kept in an intermediate store. It may be in the form of true meal, i.e. finely ground. In most cases, however, the grinding stage which would have been undertaken during animal feed preparation, will have been omitted. Normally it will comprise lumps of up to 50 mm down to dust and this can cause problems with both handling and combustion. Sometimes MBM is delivered in pellets [164, Nottrodt A., 2001] [53, Nottrodt 2001]. The variability of MBM composition is shown in Table 4.3 and Table 4.4. The variability in supply may affect the combustion process and the emission levels.

Table 4.3: Fat, moisture and ash composition of meat and bone meal

Constituent	Intervention Board Analyses	Other analyses
Fat (%)	10 - 14	8.4 - 28.6
Moisture (%)	5 - 10	1.7 - 14.3
Ash (%)	25 - 30	12.8 - 30.7
Details of raw materials unknown Source: [82, EA, 1998] [27, EA 1998.]		

Table 4.4: Composition of meat and bone meal

Substance and source	Units	MBM analysis	MBM sample	MBM sample	MBM sample ⁽¹⁾	MBM Cat 1 (OTMS)	MBM Cat 3	Feather meal
		Bavaria	Ireland	Portugal	UK			
Net calorific value	MJ/kg	18.0	15.7	17.8	16.13	19.1	14.4	21.2
Water	%	4.6	18.9	2.2	7.53	4.5	3.3	5.0
Ash	%	22.03	29.4	23.6	31.0	15.0	31.7	2.9
Nitrogen	%	7.65	5.8	10.6	7.3	9.0	6.2	13.2
Sulphur total	%	0.62	0.5	0.4	0.33	0.57	0.32	2.5
Hydrogen	%	5.86	7.7	6.9	5.07	6.1	4.4	8.1
Carbon	%	40.83	37.2	47.3	36.3	45.7	32.7	50.8
⁽¹⁾ Origin unknown Details of raw materials unknown Source: [164, Nottrodt A., 2001] [53, Nottrodt 2001], [293, Smith T., 2002] [142, Smith T. 2002.]								

Only ground animal meal with a water content of under 5 % and a fat content of under 14 % can be transported pneumatically. There are reports of problems arising with fat contents above 10 %. There is rarely less than 10 % fat in MBM, so pneumatic transport is more practical for lower-fat bone meal and blood meal. [164, Nottrodt A., 2001] [53, Nottrodt 2001]

Rotary kiln or fluidised bed furnaces are used for the dedicated combustion of MBM because they can handle the finely divided material.

Tallow may in some cases be incinerated as a support fuel. It burns readily and cleanly and has a very low sulphur content.

Delivery, storage and handling

Animal meal is delivered in bulk tipper lorries or in skips. Tankers can be used for ground animal meal with a water content less than 5 % by weight and a maximum fat content of 10 - 13 % by weight. It can also be delivered packaged, e.g. in 25 kg or 50 kg sacks [164, Nottrodt A., 2001] [53, Nottrodt 2001]. It is then transferred to an unloading hopper, either mechanically via conveyors/augurs, or pneumatically. This takes place in enclosed buildings to avoid problems of possible wind dispersion of dusty material. The transfer and handling equipment may also be fully enclosed to avoid the spread of dust. Some animal meal will break down and become dusty, whilst that left at the bottom of stockpiles for long periods becomes compacted into large lumps which will have to be broken up sufficiently for handling and effective combustion. Tallow is likely to require heated storage.

Opinions vary about the potential problems associated with the storage of animal meal. The delivery of MBM in quantities which ensure that it is processed and incinerated on the day of delivery will minimise storage times and reportedly avoid problems with pests and vermin; spontaneous overheating and combustion and will avoid compaction and hardening over time. [164, Nottrodt A., 2001] [53, Nottrodt 2001]. It is reported elsewhere, that unless there is already a specific problem with old or damp animal meal, storage times do not cause a problem [65, EA, 1996] [23, Environment Agency 1996].

Charging the incinerator

The reported systems for charging incinerators are all continuous, usually by screw conveyor. Pumping can also be used for transferring and charging pasty material. In BFB incinerators, the material is injected into the combustion zone.

The incineration process

Residence time in the furnace should be controllable and must be long enough to ensure good burnout. This can be measured by the carbon content of the ash. For materials incinerated to destroy TSE risk material, the concentration of amino acids in ash is used to monitor the effectiveness of the destruction of proteins. The supply of air to different combustion zones also has to be controllable.

~~The circumstances when animal meal has to be incinerated are prescribed in ABP Regulation 1774/2002/EC and the conditions for incinerating it are specified in WID Council Directive 2000/76/EC.~~

Ash handling and storage

As with the incineration of animal carcasses and parts of carcasses, the use of enclosed handling systems without using brushes or compressed air can minimise dust emissions. This assists compliance with both occupational health and environmental controls.

Gasification of meat and bone meal

MBM has a significant calorific value and one option for incinerating it is by gasification to produce "syngas", which can then be burned or used in methanol production. The conditions for incinerating it are specified in WID Council Directive 2000/76/EC. Heat and/or power can be generated during the process. MBM can be gasified without a support fossil fuel. The following

information is largely taken from equipment supply literature [196, Therma CCT, 2000] [78, Therma CCT 2000], other sources are cited.

There are optimum MBM characteristics for the gasification process, so the source and pretreatment affect the efficiency of the process. The optimal characteristics are shown in Table 4.5.

Table 4.5: Optimum MBM composition (% mass dry) for gasification and thermal oxidation

Chemical composition	%
Carbohydrate	18
Ash	25
Protein	40
Moisture	3
Fat	14

Source: [215, COM 2005]

The gasification process involves partial combustion in a reduced oxygen environment. The MBM is fed by a vertical screw conveyor to a ring shaped combustion chamber, where process room air is added at sub-stoichiometric quantities compared to the fuel load at a temperature of 1300 - 1500 °C. The fuel is recirculated back to the gasifier, in the form of partially carbonised material. Syngas is the product of the low oxygen combustion process. The syngas has a lower heating value of 4605 kJ/m³(NTP) [194, EURA, 2000] [77, EURA 2000]. The gasification process is endothermic and the syngas is thereby cooled to between 680 °C and 850 °C.

The syngas then passes through a cyclone and a heat-exchanger to cool it further to 500 - 550 °C, for combustion in a thermal oxidiser and boiler.

The typical chemical composition of the syngas produced is shown in Table 4.6.

Table 4.6: Typical chemical composition of syngas produced by the gasification of MBM

Chemical composition	%
CO	18 - 24
H ₂	15 - 22
CO ₂	10 - 14
CH ₄	1 - 4
N ₂	45

Source: [215, COM 2005]

The syngas can then be burned in a thermal oxidiser or boiler, to produce steam. The combined system can incinerate MBM; burn air, vapour and non-condensables, from rendering and produce steam. Ash residues containing some carbon are produced. [194, EURA, 2000] [77, EURA 2000]

Burning of tallow

Many boilers have been designed to burn fuel oil, natural gas or tallow, depending on what is available, however, this method of treatment of tallow is not allowed under ABP Regulation 1774/2002/EC, at the time of writing. ABP Regulation 1774/2002/EC requires incineration or co-incineration of Category 1 tallow and allows other specified treatments of "rendered fats", from Category 2 and Category 3 material.

Landfill and land spreading/injection

Animal by products which are landfilled include animal meal, feathers, gelatine shavings and WWTP solid residues. The requirements of the Landfill Directive must be met [352, EC, 1999].

ABP Regulation 1774/2002/EC bans the application to pasture land of organic fertilisers and soil improvers, other than manure and consequently limits the opportunities for the land spreading of animal by products, including compost. It also sets out the limitations on what animal by products can be used in the manufacture of compost and what pretreatments they require. [287, EC, 2002]

In the UK, a code of practice on water protection has been published by DEFRA and the Scottish Executive. It includes guidance on the land application of non agriculturally derived wastes. Its objective is to describe management practices which can be adopted and which if vigorously followed should avoid, or at least minimise, the risk of causing pollution from agricultural practices. In Scotland, the use of untreated blood and gut contents has recently been prohibited, to prevent odour problems and possible health risks. Under the new rules, the total addition of nitrogen, phosphorus, potassium, magnesium, sulphur and trace elements being spread should not exceed the needs of the planned crop.

In Ireland, a “Code of Practice” has been established for land spreading, to ensure that it is undertaken with due regard to the pollution risks and taking into account the nutrient requirements of the land. During high rainfall months material destined for land spreading must be stored. Primary sludge from DAF plants is also deemed unsuitable due to its high fat content, which impairs drainage. [168, Sweeney L., 2001]

The land spreading of animal by products is not permitted in Germany, on anti epidemic and hygiene grounds [244, Germany, 2002].

In the Netherlands, manure from animal reception and lairage can be used within agriculture, within legal restrictions to regulate the application of nutrients to the soil. The concentrations of heavy metals in the sludge from WWTPs, have to comply with the limits for use as soil improvers in agriculture. [240, The Netherlands, 2002]

4.2.1.3 Incineration of carcasses

Incineration is a high temperature oxidation, which converts materials into gaseous products and solid residues with a high degree of volume reduction. It is possible to incinerate a wide diversity of materials, including a variety of animal by-products.

High temperature oxidative technologies can destroy organic material, including infectious agents. ABP Regulation 1774/2002/EC sets out the incineration requirements for materials it defines as Category 1, from animals suspected of being infected by a TSE, or in which a TSE has been officially confirmed as being present, or from an animal killed in the context of TSE eradication measures. ABP Regulation 1774/2002/EC requires incineration to be in accordance with WID Council Directive 2000/76/EC, where it applies and sets out specific requirements where it does not apply.

Rotary kiln or fluidised bed incinerators tend to be used for the incineration of animal by-products. Liquids and finely divided materials are placed within the combustion zone so that they are destroyed after passing through the furnace only once. If a grate furnace is used there is a higher risk of run-out and pooling, especially when carcasses and parts of carcasses are heated, causing fat to liquefy and drip through the openings in the grate. The particle sizes of animal meal may also be small enough to fall through the grate openings. A technically and operationally reliable and well maintained system for conveying material which has passed through the grate back to the combustion zone, is therefore, a prerequisite for this type of equipment.

~~Both WID Council Directive 2000/76/EC and ABP Regulation 1774/2002/EC require the residues to be *minimised in their amount and harmfulness* and to be *recycled, where appropriate*. Most ash residues are currently disposed of to landfill, subject to protein destruction requirements. Ash is also used by the construction industry, e.g. in road building. Other routes for use and disposal are currently being assessed.~~

Description of animal carcasses and parts of animal carcasses

Carcasses containing up to 70 % moisture and up to 5 % incombustible solids have a heating value of approximately 5815 kJ/kg [29, US Environmental Protection Agency, 1997] [14, EPA 1997]. Other figures, based on a limited experience of large-scale carcass incineration quote calorific values in the order of 10000 - 12000 kJ/kg for whole carcasses, 11000 - 13000 kJ/kg for quartered meat [6, EA, 1997] [3, Environment Agency 1997] and 12000 – 15000 kJ/kg for SRM, comprising skulls, intestines and vertebral columns [248, Sorlini G., 2002] [112, Sorlini G. 2002].

Animal carcasses are incinerated in fixed hearth incinerators in the UK. Other combustion technologies which have been reported to be suitable include pulsed hearth, rotary kiln and semi-pyrolitic incinerators [65, EA, 1996] [23, Environment Agency 1996], [144, Det Norske Veritas, 2001] [44, Det Norske Veritas 2001]. Promising trials using bubbling fluidised bed incinerators to dispose of crushed animal carcasses have been reported. [200, Widell S., 2001] [80, Widell S. 2001]. The incinerators are described below. BFB incinerators are described under Section 4.2.1.2, as the technique is more widely used for incinerating animal meal.

Fixed hearth incinerator

A fixed hearth incinerator operates as follows. A ram loader pushes the carcasses into a primary chamber where they are over-fired with primary air and/or with burners, depending on whether combustion is self-sustaining. Proper mixing of the material on the hearth can be difficult and requires careful adjustment of the feed and ash removal rates. Achieving constant burnout is difficult. The skill and training of the operator are particularly important.

A secondary chamber with an injection of supplementary fuel and secondary air is essential.

Semi-pyrolitic incinerators

This technology is described more a control method than a specific configuration of incineration. A primary chamber operates at less than the stoichiometric air requirement for complete combustion and a secondary chamber operates under excess air conditions. The material is dried, heated and pyrolised in the primary chamber, releasing moisture and volatile components. The gas is driven off and then burned in the secondary chamber which is supported by a supplementary fuel burner.

This method of combustion is reported to ensure a controlled burn with both relatively low releases of VOCs and CO. Also, the low combustion airflow results in a low entrainment of particulate borne pollutants.

Stepped hearth

Stepped hearth incinerators comprise a series of concrete steps, typically three, with embedded air channels. The materials are moved from step to step by a series of rams. The first step is a drying stage, with sub-stoichiometric oxygen conditions, during which most volatile compounds are released and burned above the grate in the combustion chamber. The remaining, less volatile material is pushed onto the next step, where the main combustion takes place. The third step is the burnout stage, before the ash is discharged into a final ash burnout chamber, which incorporates air injection and agitation. Material can take eight hours to pass through the hearths and a further eight hours in the burnout chamber. This depends, to an extent, on the feed rate, which will also determine the supplementary fuel requirements.

The steps between the hearths provide good agitation as the waste tumbles down the step, however, this also produces surges of unincinerated material, so good secondary combustion and residence time is important.

Pulsed hearth incinerator

Pulsed hearth incinerators use the pulsed movement of one or more refractory hearths to move the waste and ash through the incinerator. The hearths, which are stepped at each side to form a “U” shape, are suspended from four external supports. The smooth hearth can handle difficult wastes without the risk of jamming and there are no moving mechanical parts exposed to burning material or hot gases. There may, however, be problems achieving the good burnout of solid wastes. [65, EA, 1996] [23, Environment Agency 1996].

Rotary kiln incinerator

Incineration in a rotary kiln is normally a two stage process, which takes place in a primary combustion chamber and a secondary combustion chamber. The kiln is a cylindrical shell lined with a refractory substance. It is inclined downwards from the feed end and rotates slowly about its cylindrical axis. The rotation moves the waste through the kiln with a tumbling action, thus exposing fresh surfaces to heat and oxygen. Structures may be added within the kiln, to aid turbulence and to slow the passage of liquid wastes. The residence time of material incinerated in the kiln can be changed by adjusting its rotational speed.

Rotary kilns can operate at very high temperatures. Careful attention needs to be paid to the rotating kiln and the endplates, to prevent the leakage of gases and unburnt waste. The tumbling of waste may generate fine particles.

Commissioning

Commissioning tests carried out for new plants and existing installations planning to incinerate a different fuel from that for which it is authorised for or would normally incinerate, enable checks to be made about whether the desired results are achieved.

Delivery, storage and handling

Unloading, storage and handling can be done in totally enclosed buildings and equipment. There may be a risk of theft of meat which is unfit for human consumption, so security need to be applied.

Charging the incinerator

For batch processes, carcasses are generally fed into the incinerator intermittently, by front loader vehicles, ram-feed or manually. Opening of the doors for loading can allow considerable ingress of cold air which may upset combustion conditions and increase emissions. Fans capable of responding to changes in furnace pressure during charging, to avoid the escape of fumes or excess airflows may, therefore, be used. Large drops in temperature, e.g. during charging of batch incinerators, can be avoided by using charging systems which incorporate airlocks. Continuously operating incinerators are generally fed from enclosed handling and sometimes pretreatment and charging systems. Control of air and consequently combustion is easier with continuously operating systems.

The incineration process

Residence time in the furnace has to be long enough to ensure good burnout, as measured by the total organic carbon content and it needs to be controllable. The supply of air to different combustion zones also has to be controllable. ~~Minimum conditions of 850 °C combustion gas temperature, with a gas residence time of 2 seconds are specified in ABP Regulation 1774/2002/EC [287, EC, 2002], for animal carcasses, which are excluded from the scope of WID Council Directive 2000/76/EC [195, EC, 2000]. WID Council Directive 2000/76/EC sets similar conditions, for all other animal by products, including parts of carcasses, although it also allows the competent authority to lay down different conditions, provided the requirements of that Directive are met.~~

With most furnace designs, the minimisation of primary air will both minimise NO_x production as well as the velocities which lead to the entrainment of particles. An adequate distribution of air and fuel on the bed will prevent the formation of hot zones and thereby reduce the volatilisation of material, which could otherwise lead to the formation of heavy metal oxides and alkali metal salts in the fly ash. Combustion zones may be separate chambers or, as in the case of BFB incinerators, they may simply be areas within the same chamber where primary and secondary air are introduced.

Water cooling of grates may be an alternative to providing excess air in grates to control metal temperatures. This can also improve primary air control and hence combustion.

Ash handling and storage

Enclosed handling systems avoiding the use of brushes or compressed air minimise dust emissions and, therefore, assist compliance with both occupational health and environmental controls.

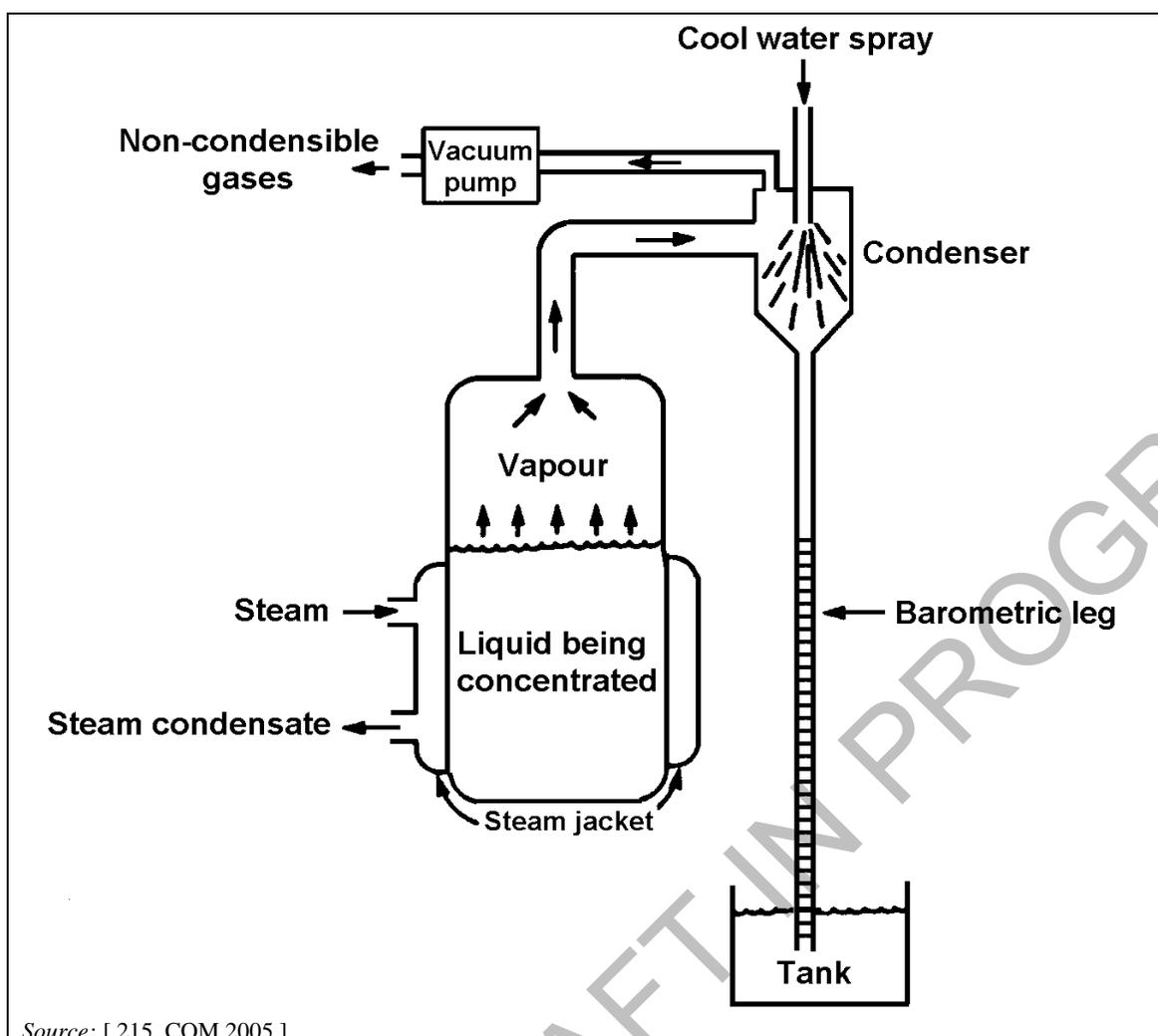
Cleaning

One rotary kiln incinerator operating continuously and its enclosed equipment upstream of the rotary kiln, i.e. the storage, handling, grinding and charging mechanisms, is cleaned by feeding wood chips through the system periodically, usually before maintenance and then incinerating them in the incinerator. This incinerator is dedicated to the destruction of SRM comprising cattle heads and vertebral columns.

4.2.1.4 Evaporation

Evaporators are used in several SA installations, e.g. rendering systems, fat melting, fishmeal production, to remove water from liquid mixtures. They usually operate at relatively low temperatures and this prevents scorching of the animal by-product being treated. Removing water by evaporation is an energy-intensive process, and low-pressure evaporators are more efficient at this than open kettles or other systems operating at atmospheric pressure. At 50.7 kPa (0.5 atmospheres), water boils at 81.5 °C. Evaporators can be made to operate at much lower pressures than 50.7 kPa, therefore, vapour just above 100 °C can be used as the heat source for the evaporators [122, Ockerman H.W. and Hansen C.L. 2000].

Figure 4.1 illustrates a single-effect evaporator and a typical method of operation. The condensation of live steam or cooker/drier vapour in the steam jacket provides the heat source to drive the evaporator. Vapour produced from the liquid being evaporated is condensed by the cool water sprayed into the condenser chamber. Water leaving the condenser flows through a barometric leg into an open tank. The water level in the barometric leg is higher than that in the open tank so it creates a vacuum within the evaporator, approximately equal to 74 mm Hg (9.87 kPa) per metre of water in the barometric leg. A pump may be used in place of the barometric leg to maintain the vacuum. The function of the vacuum pump is to remove non-condensable gases, such as air, from the evaporator.



Source: [215, COM 2005]

Figure 4.1: Single effect evaporator

Single effect evaporator

Description

Achieved environmental benefits

Reduced energy use for evaporation, i.e. by re-use of the heat from the evaporated water.

Operational data

Cross-media effects

None.

Applicability

Applicable in fat melting, rendering and fishmeal production.

Driving force for implementation

Reduced energy costs.

Example plants

Low temperature rendering systems in the US.

Reference literature

{268, Oeckerman H. W. and Hansen C. L., 2000}

4.2.1.5 Emissions to water

Several installations have no on-site waste water treatment plant (WWTP). These installations either evaporate waste water in the cookers or discharge directly to the sewer or tanker it off site for treatment [245, EFPRA 2019].

4.2.2 Current consumption and emission levels across installations processing animal by-products and/or edible co-products

4.2.2.1 Combustion of animal fat

Two steam boilers are heated by animal fat in a rendering installation in Austria. General information and emissions from the steam boilers are presented in Table 4.7.

Table 4.7: Emissions to air from two steam boilers burning animal fat

Parameter	Steam boiler 1		Steam boiler 2	
	Maximum	Average	Maximum	Average
Rated thermal input (MW)	6.9		6	
Start of operation	1993		1975	
Fuel	120-695 kg/h animal fat (natural gas for start-up only)		120-590 kg/h animal fat (natural gas for start-up only)	
Flue-gas cleaning	No secondary installations for emission reduction		No secondary installations for emission reduction	
Flue-gas temperature (°C)	226		257	
Pollutant (3 half-hour measurements)	Maximum	Average	Maximum	Average
Dust (mg/Nm ³ ; 11 % O ₂)	16	15	18	14
NO _x (mg/Nm ³ ; 11% O ₂)	145	138	147	146
CO (mg/Nm ³ ; 11% O ₂)	< 10	< 10	22	18
SO ₂ (mg/Nm ³ ; 11% O ₂)	< 9	< 9	< 9	< 9
Total C (mg/Nm ³ ; 11% O ₂)	< 5	< 5	< 5	< 5

Source: [198, Waxwender et al. 2016]

Dedicated incineration of carcasses, parts of carcasses and meat and bone meal

The incineration has potential global and local environmental impacts.

Incineration of substances which must be disposed of as waste provides an alternative to landfilling. When incineration is combined with energy recovery it can reduce the consumption of fossil fuels and the emissions associated with their combustion. Opportunities exist for the recovery of energy in the form of both heat and power and this is now a legal requirement where WID Council Directive 2000/76/EC applies [195, EC, 2000].

WID Council Directive 2000/76/EC [195, EC, 2000] requires the control and monitoring of emissions of specified substances from incineration plants and sets ELVs and methods to ensure compliance is monitored.

Odour may arise from raw material handling; flue and scrubber gas emissions, if there is poor combustion and poor dispersion, especially if there is a condensing vapour plume; from ash handling and from WWTPs.

Compared to incinerators which do not have dedicated feedstocks, animal by products incinerators and particularly those used for the combustion of animal meal, as opposed to raw

material, have the advantage of being able to closely control their feedstock composition and feed rate, and hence the combustion conditions. Better combustion control can result in reduced flue gas treatment requirements. [293, Smith T., 2002]

Dedicated incineration of carcasses and parts of carcasses

Chlorine present in the salt in carcasses means there is a potential for dioxin formation and can also lead to HCl production. There is a potential release of particulate matter from incomplete combustion.

The emission levels in Table have been reported for animal carcass incinerators operating in 1996 [65, EA, 1996], i.e. before WID Council Directive 2000/76/EC came into force.

Substance	Emission (mg/m ³)
NO _x	350 (average emission)
Dust	14–180 mg/m ³ (limited scrubbing)
SO ₂	50 mg/m ³ (limited scrubbing)
HCl	30 mg/m ³ maximum (minimum not reported) (limited scrubbing)

Table Achieved emission levels from animal carcass incineration, before WID Council Directive 2000/76/EC [65, EA, 1996]

Table shows some direct air emissions reported from an animal carcass incinerator.

Parameter	Emission level (kg pollutant per tonne of animal carcass incinerated)
CO ₂	<2500
SO ₂	0.566
Dust	1.5
HCl	2.25
NO _x	<2.5
CO	<2.5

Table : Direct air emissions from an animal carcass incinerator (no energy recovery) [144, Det Norske Veritas, 2001]

The run-out and pooling of liquid may be a problem during the combustion of carcasses or parts of carcasses. It is less likely to be a problem during the combustion of animal meal, but it can occur. If it is not taken into account during the design, installation, commissioning, operation and maintenance of the incinerator it may be difficult to achieve good combustion. This is of particular concern when TSE or suspected TSE materials are being incinerated, because the objective to destroy the prion might not be achieved, resulting in potential pollution and public health risks. Complete combustion should ensure the reduction of microbiological risk and prevention of the formation of liquid organic and aqueous wastes.

Dedicated incineration of animal meal

Meat meal has an energy value of approximately 14.4 MJ/kg [318, EPEA Internationale Umweltforschung GmbH, 2000].

There is a potential for harmful emissions. The prevention of the formation and emission of dioxin requires particular attention. Typical chlorine contents of UK animal meal are reported to be in the range 0.4–0.6%. This is high enough to lead to the formation or re-formation of dioxins if the correct combustion and cooling conditions are not maintained. Dioxin emissions

are, therefore, reported to be principally dependent on the plant design and operation rather than the composition of the animal meal [293, Smith T., 2002]. Dioxins are monitored regularly and more frequently at the incinerator commissioning stage [272, Woodgate S., 2002].

It has been reported that due to the high fat content of MBM, *no particular dust emissions* were registered during unloading [164, Nottrodt A., 2001].

Some reported advantages of fluidised bed incineration include a high combustion efficiency, with uniform temperatures, which make residence time calculations more reliable. Temperatures are reported to be low enough to prevent elevated NO_x emissions. The furnace design is simple and without moving parts. The fluidised bed material provides a continuous attrition of the burning material, removing the layer of char and thereby exposing fresh material for combustion. This assists both the rate of combustion and the burnout.

High levels of phosphorus in animal meal lower the melting point of the ash, which can give rise to problems. It has been suggested that the high phosphorus content of animal meal may impair catalytic denitrification. [164, Nottrodt A., 2001]

Table shows raw emission data for the incineration of MBM in a BFB incinerator.

Substance	Emission before FGT (g/t MBM incinerated)	Emission after FGT (g/t MBM incinerated)	Emission after FGT (mg/Nm ³)	WID Council Directive 2000/76/EC ELV daily (mg/Nm ³)	WID Council Directive 2000/76/EC ELV half hourly (97%) (mg/m ³)	WID-Council Directive 2000/76/EC Average value measured over 6-8 hours	Flue-gas treatment required
VOC	80	80	8	10	10	not applicable	No
HCl	800	80	8	10	10	not applicable	Yes
HF	no info.	no info.	no info.	1	2	not applicable	?
SO ₂	1600	160	16	50	50	not applicable	Yes
NO/NO _x	1750	1750	175	200	200	not applicable	No
CO	250	250	25	not applicable	not applicable	not applicable	No
Dioxins + furans	no info.	no info.	no info.	not applicable	not applicable	0.1 ng/m ³	?

The data are reported in Normal units, i.e. (mg/Nm³ at 0 °C, 11 % O₂, dry gas)
 Typical figure of 12000 kg dry flue gas per tonne MBM (corrected to 11 % oxygen) is used

Table: Raw emission data for the incineration of MBM in a BFB incinerator
 [325, Smith T., 2002]

Table shows consumption and emission data for an installation incinerating 50000 tonnes of MBM per year.

Parameter	Value
Water consumed	365 kg/t MBM
Electricity used	166 kWh/t MBM
Heat/fuel used	5 kWh/t MBM
BOD	0 g/t MBM
COD	0 g/t MBM
Phosphorus	unknown
Odour	< 25 OU via final exhaust
Noise	90 dB(A) max @ source
Detergents	identify
SO ₂	240 g/t MBM
CO ₂	1.9 t/t MBM
NO _x	1.2 kg/t MBM

H ₂ S	nil
HCl	120 g/t MBM
VOCs	not measured
Dust	40 g/t MBM
Condensate (effluent)	0 kg/t MBM
Non-cond. gas	0 kg/t MBM
Suspended solids in effluent	0 kg/t MBM
SRM	n/a
Others	
Steam produced	4955 kg/t MBM
Chemicals exhaust gas treatment	30 kg/t MBM
Chemicals boiler	0.01 kg/t MBM
Treated air for odour control	9679 kg/t MBM
Boiler emissions to atmosphere	10509 kg/t MBM
CO	400 g/t MBM
Effluent ammonia	0 g/t MBM
MBM/Meal to landfill	n/a
Waste-controlled	100 g/t MBM
Waste filter medium	n/a
Waste effluent sludge	0 kg/t MBM
Waste effluent	0 kg/t MBM
Waste scrap	40 g/t MBM
Waste oil	n/a
Raw material handled total	n/a
Dioxins	
Nitrates	
Water vapour in exhaust	
The meal comprised 98.5% dry matter and was burned as received	

Table: Consumption and emission data from an installation incinerating 50000 t/yr MBM [193, Woodgate S., 2001]

Table shows some direct air emissions reported from an MBM incinerator.

Parameter	Emission value (kg pollutant per tonne of MBM incinerated)
CO ₂	?
SO ₂	1.5
Dust	0.89
HCl	0.45
NO _x	10
CO	6.5

Table: Direct air emissions from incinerating MBM (no energy recovery) [144, Det Norske Veritas, 2001]

Table shows the range of amino acid residues reported in fly ashes from BFB incinerators.

	nmole amino acid/ g sample	µg amino acid/ g sample	mg amino nitrogen/ 100 g sample	mg protein/ 100g sample
Total	44.04—222.55	6.15—30.54	0.06—0.33	0.36—2.09

Table: Total amino acid residues reported in fly ashes from BFB incinerators incinerating MBM [199, PDM Group and Wykes Engineering (Rushden) Ltd, 2000, 250, James R., 2002]

Burning of tallow

Odour problems may arise during tallow loading and unloading [168, Sweeney L., 2001].

Table shows some emission data for the burning of tallow in a heavy fuel oil burner and Table shows an analysis of the animal fat burned.

Burning tallow (from rendering plant) in a heavy oil Boiler (5.6 MW, no abatement techniques)				
	UNITS			
Boiler capacity	MW	1.95	2.5	3.19
Fuel		Tallow	Tallow	Tallow
Temperature, combustion gas	°C	206	217.9	244.5
Volume flow, combustion gas	m ³ /s	1.63	2.02	2.81
Volume flow, combustion gas (dry)	Nm ³ /s	0.83	1.04	1.32
Vapour concentration in combustion gas	%	9.7	10.1	10.2
Air coefficient		1.43	1.38	1.36
Boiler efficiency	%	89.2	88.8	87.4
Combustion gas (dry)				
O ₂	%	6.3	5.7	5.5
CO ₂	%	10.2	10.5	10.8
CO	%	0.0001	0.0002	0.0003
CO	ppm	0.8	2.2	2.9
CO concentration	mg/Nm ³	1	2.7	3.6
CO, reduced to O ₂ concentration 3 %	mg/Nm ³	1.3	3.2	4.2
CO emission	mg/MJ	0.4	0.9	1.2
CO emission	g/s	0.001	0.003	0.005
SO ₂	ppm	7.5	7	6.8
SO ₂	mg/Nm ³	21.8	20.6	20
SO ₂ reduced to O ₂ concentration 3 %	mg/Nm ³	26.7	24.3	23.2
SO ₂ emission	mg/MJ	7.7	7	6.7
SO ₂ emission	g/s	0.018	0.021	0.026
SO ₂ (as S)	g/s	0.009	0.011	0.013
NO _x	ppm	214.8	223.3	197.5
NO _x (as NO ₂)	mg/Nm ³	440.4	457.8	404.9
NO _x , reduced to O ₂ concentration 3 %	mg/Nm ³	539.9	539.1	470.6
NO _x emission	mg/MJ	155.1	154.9	135.2
NO _x emission	g/s	0.367	0.476	0.535
Dust	mg/Nm ³	35		29
Dust, reduced to O ₂ concentration 3 %	mg/Nm ³	44		34
Dust emission	mg/MJ	12.6		9.8
Dust emission	g/s	0.029		0.038

Table: Emission data from burning animal fat in a heavy fuel boiler [166, Nykänen K., 2001]

It is reported that emissions not exceeding 200 mg/m³ for NO_x and 10mg/m³ for total have been achieved for the burning of tallow [244, Germany, 2002].

ANALYSIS OF ANIMAL FAT		
	Units	Quantity
H ₂ O	%	<0.2
Caloric value	MJ/kg	36–39.8
Viscosity	mm ² /s	12.4
Flash point	°C	> 250
Sulphur (S)	mg/kg	110
Density (50°C)	kg/m ³	890.1
Ash	%	0.05
Al	mg/kg	<1
Ba	mg/kg	2
Ca	mg/kg	17
Cr	mg/kg	<1
Cu	mg/kg	2

Fe	mg/kg	26
Mg	mg/kg	5
Mn	mg/kg	4
Na	mg/kg	34
Ni	mg/kg	4
P	mg/kg	110
Pb	mg/kg	<1
Si	mg/kg	8
V	mg/kg	2
Zn	mg/kg	3

Table: Analysis of animal fat
[166, Nykänen K., 2001] – adapted

Animal by-products installation waste water treatment plants

Water

A characteristic of waste water from animal by products is that it contains organic and ammonium compounds, sometimes in high concentrations. These can be broken down in a biological waste water plant.

The high temperatures associated with waste water from animal by products installations, affects the solubility of various pollutants and their microbial decomposition rate. In general, biological processes perform faster at higher temperatures, but this can make fat removal difficult.

Odour

Odour problems may arise, e.g. where malodorous raw materials have been treated and during sludge treatment.

Noise

Aerators associated with effluent treatment plants, which operate continuously, can produce significant noise impacts, particularly from badly maintained gearboxes and especially at night. [12, WS Atkins EA, 2000]. The noise from fans taking malodorous air from the WWTP can also be a problem.

4.2.3 Techniques to consider in the determination of BAT across installations processing animal by-products and/or edible co-products

4.2.3.1 Techniques to increase energy efficiency

4.2.3.1.1 Multistage effect evaporators

Description

Evaporators used to remove water from liquid mixtures generated for example in fat melting, rendering, fishmeal and fish oil production are multistage, where steam is introduced in a series of successive vessels, each one exhibiting a lower temperature and pressure than the previous one.

Technical description

Multiple-effect evaporators are used in, e.g. fat melters, rendering systems, fishmeal factories and gelatine plants, to remove water from liquid mixtures. In rendering, raw materials typically contain about 60 % water. Multiple-effect evaporators operate at relatively low temperatures and this prevents scorching of the animal by-products being treated. Removing water by evaporation is an energy-intensive process, and low-pressure evaporators are more efficient at

this than open kettles or other systems operating at atmospheric pressure. At 50.7 kPa (0.5 atmospheres), water boils at 81.5 °C. Evaporators can be made to operate at much lower pressures than 50.7 kPa, therefore, vapour just above 100 °C can be used as the heat source for the evaporators.

An effective use of the evaporative heat can be achieved in a multiple-effect evaporator. After the separation of the raw materials into a solid and a liquid phase in a continuous system, by either pressing, centrifugation, or a combination of both, the liquid phase can be dried in a multiple-effect evaporator. The heating-medium is the steam raised from the drying of the solid phase and from the evaporation in the other stages of the vacuum drier. The Atlas process of mechanical dewatering is an example of such a process. The heat consumption in this process is 400 - 450 kWh/t of raw materials.

Achieved environmental benefits

Reduced energy use for evaporation, i.e. by re-use of the heat from the evaporated water.

Environmental performance and operational data

A multiple-effect evaporator is shown in Figure 4.2. In theory, the efficiency of evaporation can be almost doubled by each doubling of effects, i.e. twice as much liquid can be evaporated per quantity of live steam or vapour consumed in the steam jacket. In a multiple-effect evaporator system, vapour from an effect is condensed in the steam jacket of a succeeding effect. This is possible because the succeeding effect will be operated at a lower pressure and thus a lower temperature.

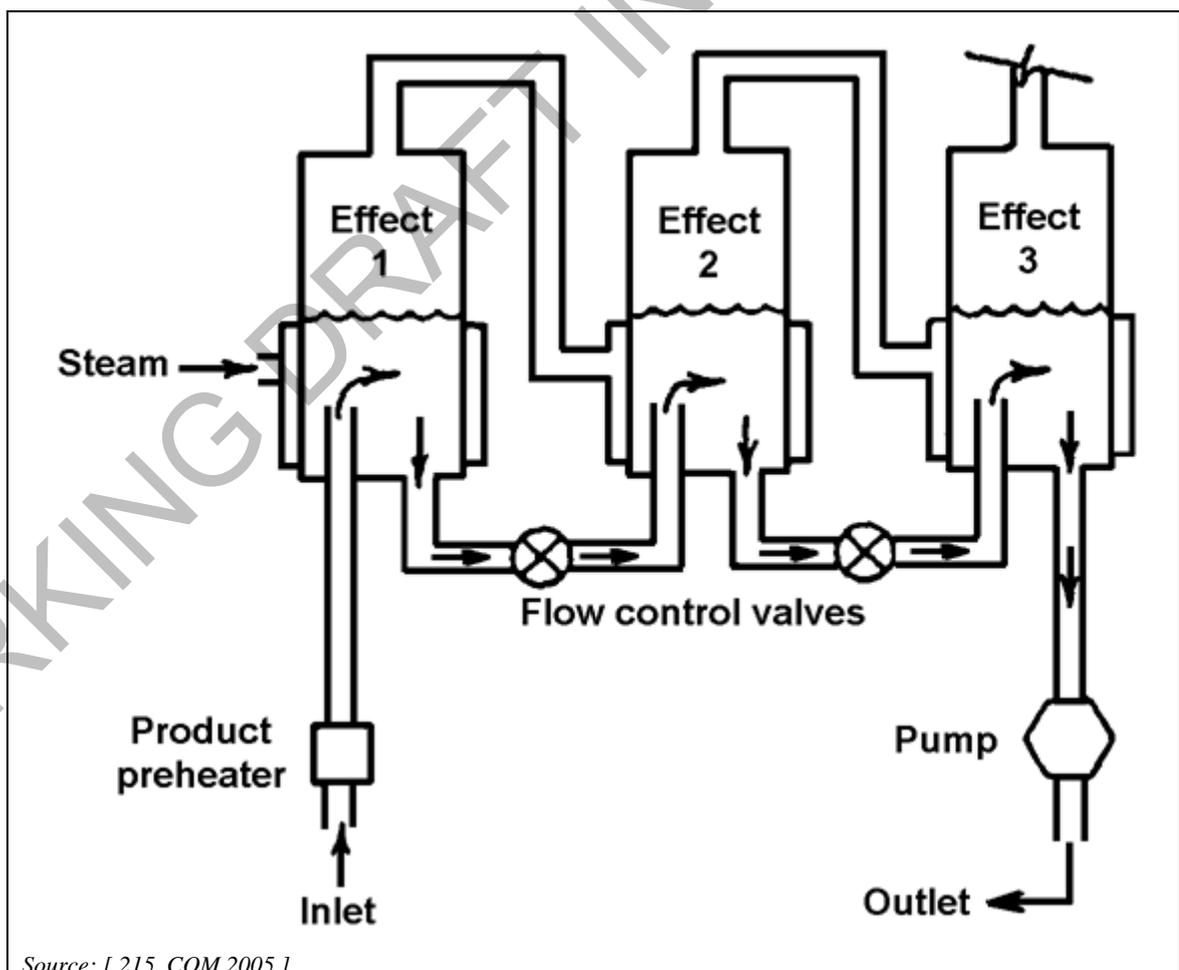


Figure 4.2: Multiple-effect evaporator

The efficiency of evaporators can be improved by providing more heat transfer surface than that given by simply jacketing the boiling chamber. The evaporators often consist of vertical tube bundles with the heating medium on the outside of the tubes and the product boiling on the inside. Product is either moved up through the tubes, i.e. in what is described as a “rising film”, or down-ward through the tubes, in which case the evaporator is called a “falling film” evaporator. The product is fed into these evaporators in such a way and at such a flowrate that facilitates the formation of a thin film covering the inside of the tubes. This results in high heat transfer coefficients and a tremendous amount of water can be boiled off within a relatively small area of equipment.

Other possibilities are rising film evaporators, which can be used as pre-heaters or preconcentrators, mechanical vapour recompression evaporators, or forced circulator evaporators, or combinations of some of them. The selection of the evaporator type is dependent on the viscosity of the liquid. High-viscosity liquids (e.g. stickwater in fishmeal and fish oil production) should be treated in forced circulator evaporators, which are highly energetically demanding, but if low-viscosity material is treated a falling film evaporator should be enough [252, Spain 2020].

Another sustainable option for trying to reduce the energetic consumption, and also potentially reduce the carbon footprint linked to this consumption, is to combine the evaporation step with a membrane process as a ‘pre-concentration’ stage. Their use in conjunction with evaporation will allow reduction of the water volume to be treated in the evaporator and also, depending on the membrane and pore size, will increase the water for reuse [252, Spain 2020].

Cross-media effects

None.

Technical considerations relevant to applicability

Applicable in fat melting, rendering, fishmeal production and gelatine manufacturing treating more than 50 000 – 100 000 tonnes per year.

Economics

The capital cost of such continuous installations is reportedly higher than that of conventional systems and they are reported to be only suited for plants with a relatively high level of raw material supplies, i.e. more than 50 000 – 100 000 t/yr.

The use of membrane technology combined with an evaporation step can reduce the operating costs by around 75 % compared with a five-stage multi-effect evaporator using thermal vapour. [253, Jevons et al. 2010].

Driving force for implementation

Reduced energy consumption and consequently reduced costs.

Example plants

~~All rendering plants in Denmark.~~ This technique has been reported in approximately 25 % of installations processing animal by-products and/or edible co-products in the SA data collection [264, TWG 2020].

Four-stage multi-effect evaporators are common in onshore fishmeal and fish oil plants in northern Europe [252, Spain 2020].

Reference literature

[249, GME, 2002] [113, GME 2002], [268, Ockerman H. W. and Hansen C. L., 2000] [122, Ockerman H.W. and Hansen C.L. 2000] [252, Spain 2020], [253, Jevons et al. 2010], [264, TWG 2020]

Biological waste water treatment using overpressure in conjunction with ultrafiltration

Technical description

The effluent, from an example animal carcase rendering plant, is initially treated by means of pressure relaxation flotation and subsequently by means of aerobic biological purification.

The effluent passes over a rotary drum screen and then to a type of pressure relaxation flotation, during which fats and lipophilic substances are largely separated out. This is done without the use of chemicals, so that the substances can be recycled back into the rendering process together with the coarse material from the rotary drum screen.

The mechanically treated effluent then undergoes an aerobic biological treatment, which is reportedly well suited for the treatment of heavily laden effluent. The solids are separated using a bag filter and the effluent is pumped to a series of 3 "activation reactors". Activation takes place at 300 kPa, thus facilitating oxygen use. The biological treatment consists of a denitrification reactor phase, followed by 2 subsequent nitrification reactor phases. Carbon compounds (BOD₅, COD) and nitrogen compounds (N org.; NH₄-N; NO₃-N; NO₂-N) are biologically converted into biomass, CO₂, N₂ and H₂O. Phosphoric acid and caustic soda are provided for the micro organisms. The plant has a cooling tower, through which heat is removed from the system. The temperature in the activation reactors, is maintained at a level of 35–37 °C.

The process reportedly has a high operational stability, even if the effluent conditions change. In contrast to conventional biological effluent purification processes, the separation of bacterial matter from the purified liquid takes place by means of membrane filtration during an ultrafiltration process. Solids down to a particle size of 0.05 µm can be removed. Bacteria and hazardous substances adsorbed in the activated sludge are retained within the system. The formation of bulking sludge in the bioreactor can be controlled through the use of membranes.

The process is characterised by a comparatively low increase in sludge, resulting in a high sludge age being achieved, which significantly promotes the adaptation of the micro organisms to the effluent. In this closed system, a biomass concentration is achieved which resembles that of a conventional activation plant.

The sludge concentrate retained in the ultrafiltration unit is continuously channelled back into the activation reactor as residue. The flowrate of the residue aids mixing. Mixing in the reactor is also assisted by the injection of air into the system.

After biological purification, the effluent is channelled into a municipal sedimentation plant. The effluent can be used for scrubbing the exhaust air from the system. The water is then passed through the biological treatment process again and the exhaust air is treated in a biofilter.

The technique is summarised in Figure.

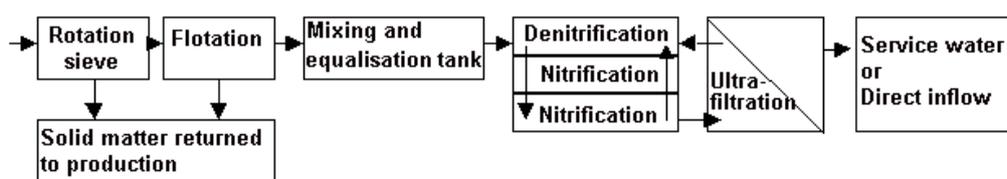


Figure : Flow diagram of biological waste water treatment using overpressure in conjunction with ultrafiltration

Achieved environmental benefits

The biological treatment reportedly achieves a COD reduction of greater than 97 % and a nitrogen reduction of greater than 90 %.

Cross-media effects

Odour emissions require abatement. In an example installation, a biofilter is used. Noise is emitted from pumps and compressors.

Environmental performance and operational data

Cleaning chemicals such as citric acid, nitric acid and caustic soda are used for cleaning membranes, thereby avoiding the use of complexing agents. The cleaning chemicals are channelled back into the biological treatment plant.

On average, the energy consumption for the plant is 40 kWh/m³.

The average annual water consumption for the cooling tower and for cleaning the membrane unit is approximately 1800 m³.

The excess sludge from the biological treatment has an organic content of over 90 % and it can be transported into the digestion tower of a municipal sedimentation plant or to a biogas plant. At a dry matter content of approx. 18–20 g/l the volume of sludge produced is in the region of 1500 m³/yr. The ultrafiltration unit can concentrate the excess sludge down to a dry matter content of approximately 35–38 g/l, thereby reducing the disposal volumes. It is possible to reduce the sludge disposal volume by as much as 50 % of the produced excess sludge volume.

The pumps and the compressors for supplying the air are the main sources of noise at the plant. The plant room noise level is reported to be 80–85 dB(A); dropping to < 45 dB(A) at a distance of 50 metres.

Technical considerations relevant to applicability

Applicable for waste water which contains a high organic load, such as that from rendering plants. The breaks for maintenance and cleaning represent only 5 % of the operating time. The process has particularly low space requirements compared to other WWTPs. As a result, it is possible to reduce construction costs substantially.

Economics

The operational costs for effluent treatment are approximately EUR 8.20/m³ of effluent or EUR 7.38/t of processed raw material.

The low space requirements, compared to other WWTPs, mean that construction costs are relatively low.

Driving force for implementation

Compact plant technology, minimal space requirements, high operational reliability, high availability, safe compliance with restrictive discharge parameters and low personnel expenditure through fully automated operation.

Example plants

An animal carcass rendering plant in Germany. Some data are shown in Table and Table

Month	2001 financial year Monthly averages processed raw materials (t)	Water volume (m ³)	Specific water volume (m ³ /t)
January	2339.8	2295	0.981
February	2309.2	1966	0.851
March	3195.3	2267	0.709
April	5065.1	3050	0.602
May	5458.5	2341	0.429
June	2359.5	2146	0.910
July	2331.2	2384	1.023
August	2804.7	1489	0.531
September	2689.5	2852	1.060

October	2735.2	2549	0.932
November	2942.4	1909	0.649
December	2579.0	1870	0.725
Average	3067.5	2260	0.784
Total	36809.4	27118	

Table : Effluent production during the 2001 financial year

Month	Effluent concentrations						
	Monthly averages						
	Inflow		Outflow				
	COD (mg/l)	NH ₄ -N (mg/l)	COD (mg/l)	NH ₄ -N (mg/l)	NO ₃ -N (mg/l)	NO ₂ -N (mg/l)	P-total (mg/l)
January	4935	995	55	5.0	45	3.0	0.15
February	4136	975	58	4.5	48	4.2	0.20
March	4832	838	65	2.2	52	5.3	0.30
April	7490	1067	75	3.8	50	6.5	0.20
May	8000	1015	68	3.2	43	5.8	0.25
June	8650	1250	72	3.8	46	8.2	0.32
July	11750	1540	75	4.2	56	9.3	0.34
August	6700	1311	71	4.6	53	8.4	0.45
September	6200	1137	68	4.3	68	7.6	0.30
October	5720	917	55	4.8	65	5.8	0.35
November	3800	802	58	4.1	63	5.2	0.45
December	4445	1012	61	3.8	58	5.3	0.25
Average	6388	1072	65	4.0	54	6.2	0.30

Table : Average effluent concentrations

Reference literature

{301, German TWG, 2002}

4.2.3.2 Techniques to reduce emissions to water

4.2.3.2.1 Use of fresh refrigerated raw materials

Description

Raw materials are handled as fresh as possible.

Technical description

If raw materials are handled as fresh as possible, the quantity of compounds that end up in the waste water or the air can be reduced. For example, by cooling warm waste, such as soft waste from the slaughter-line and casing-cleaning department, the formation of air and water pollution can be reduced. Consequently, the energy consumption for waste water and air cleaning is also reduced.

If it is not possible for the processing to take place within the time it takes for odour problems to develop after slaughter or intermediate treatment, materials may be refrigerated. Cooling can take place, if necessary, at the slaughterhouse, in transit or at the animal by-products installation. The refrigeration period may be kept to a minimum, sufficient to simply prevent odour/quality problems without delaying treatment of the animal by-products. Good co-operation between the operators of the slaughterhouse, the haulier and the animal by-products installation minimises the need for refrigeration and the time required, if refrigeration is needed at all.

Achieved environmental benefits

Reduced COD, BOD, sediments, nitrates and phosphate in waste water and reduced odour emissions from storage and processing.

Environmental performance and operational data

It may be appropriate to refrigerate animal by-products due to extreme operational difficulties, such as a long distance between the source of the materials, which makes quick treatment impossible. An additional or alternative reason may be high ambient temperatures, which cause materials to rapidly decompose and produce malodorous emissions. High temperatures may be seasonal in the north of Europe or permanent in countries with warmer climates.

A British investigation showed that the COD levels in rendering condensate from completely fresh raw materials, raw materials stored in winter and raw materials stored in summer was 2.7, 10 and 50 g/l, respectively.

A German study comparing waste water contamination in summer and winter illustrates the effect that the storage temperature for raw materials can have on the contamination loads of waste water, see Table 4.8.

~~Reported contamination data for waste water from a rendering plant are shown in. The data illustrate the significant effect of the warehouse storage temperature for raw materials on the waste water contamination loads.~~

Table 4.8: Data for untreated waste water in a rendering plant seasonal differences

Parameter	Maximum (summer)	Minimum (winter)	Annual average values
Quantity of waste water			0.9 – 1.6 m ³ /t
Temperature			18 – 35 °C
COD	8 – 20 kg/t	0.5 – 3.8 kg/t	3 – 10 kg/t
BOD ₅	3 – 12 kg/t	0.3 – 2.3 kg/t	1.6 – 5 kg/t
Sediments	1 – 55 mg/t	≤ 1 mg/t	0.3 – 8 mg/t
Nitrogen (NH ₄ -N)	1.3 – 2.7 kg/t	0.1 – 0.7 kg/t	0.6 – 1 kg/t
pH value			6 – 9.7 ⁽¹⁾
AOX ⁽²⁾	25 – 30 µg/l	< 10 – 24 µg/l	15 – 39 µg/l
⁽¹⁾ Range reported over the period of one year			
⁽²⁾ At sewage plant outlet, not crude waste water			
Source: [49, VDI, 1996] [289, VDI 1996]			

Cross-media effects

An increased energy consumption if refrigeration is necessary.

Technical considerations relevant to applicability

Applicable at all animal by-products installations where there is a risk of odour emissions which are likely to cause offence and that cannot be prevented without the use of refrigeration.

Economics

Request to the TWG: Please provide information.

Driving force for implementation

By-products companies charge more for degraded and malodorous materials, partly due to the additional environmental costs associated with odour control and waste water treatment and partly due to the fact that they have no value and have to be disposed of. This, therefore, provides the incentive for the slaughterhouse to keep the storage of by-products to as short a time as possible and even where further treatment is not possible, but before degradation and the formation of malodorous substances occurs, to refrigerate them.

Example plants

Six rendering plants in Germany.

Reference literature

[134, Nordic States, 2001] [38, Nordic 2001], [244, Germany, 2002] [110, Germany 2002], 272, Woodgate S., 2002] [125, Woodgate S. 2002]

4.2.3.3 Techniques to reduce emissions to air**4.2.3.3.1 Enclosure of Enclosing buildings for the delivery, storage, handling and processing of animal by-products****Description**

Unloading, storage and handling of animal by-products are undertaken in enclosed buildings with lockable, self-closing doors. Extracted air is ducted to an odour abatement system.

Technical description

Unloading, storage and handling can be undertaken in totally enclosed equipment (see Section 4) and in buildings with lockable, self-closing doors, which can be insect rodent and bird proof. The building can incorporate extraction fans through filters to prevent any dust generated from escaping and to minimise local odour problems. Material can be delivered in bulk tipper lorries and transferred directly to an unloading hopper, within an enclosed area (see Section 2.3.8.2.6). Extracted air is usually treated by an odour abatement system. can be burned in the incinerator to reduce odour emissions.

Hoppers can provide a storage method, which is relatively easy to control and may be combined with automated, fully enclosed, transfer and handling equipment. Material can be delivered in, e.g. bulk tipper lorries and transferred directly to an unloading hopper, either mechanically via conveyors/augers or pneumatically.

Achieved environmental benefits

Reduction of airborne dust and odour emissions. A reduction in the risk of spreading potential biohazards by insects, rodents and birds.

Environmental performance and operational data

Some animal meal will break down and become dusty, but that left at the bottom of stockpiles for long periods can become compacted into large lumps which will have to be broken up sufficiently for handling and for effective combustion.

Cross-media effects

None.

Technical considerations relevant to applicability

Applicable at all installations processing animal by-products and/or edible co-products.

Economics

Request to the TWG: Please provide information.

Driving force for implementation

Environmental regulator permits.

Example plants

Various installations.

Reference literature

[82, EA, 1998] [27, EA 1998]

4.2.3.3.2 Maintenance of negative pressure in storage, handling and processing areas

Description

Materials are stored in hoppers or on open floors in buildings which are well sealed and kept under a slight negative pressure.

Technical description

Material can be stored in hoppers or on open floors in buildings which are well sealed and kept under a slight negative pressure, whilst ensuring that the air is changed sufficiently frequently for the health and welfare of personnel. Storage times can also be kept to a minimum.

The process building can be subdivided internally into functional areas, by using full-height, solid walls, to control and manage air movement. All buildings can be designed and constructed so that they are well sealed to separate different processing areas, such as the raw material reception, storage, cooling and end-product storage areas. The ventilation provided can be capable of maintaining negative pressure and preventing an uncontrolled escape of malodorous air to outdoors. The areas from which ventilation is provided can be connected to suitable odour abatement plant.

Achieved environmental benefits

Reduced odour and dust emissions.

Environmental performance and operational data

Request to the TWG: Please provide information.

Cross-media effects

Energy is used to move large volumes of air. There may be cross-media effects associated with the odour abatement plant.

Technical considerations relevant to applicability

Applicable at all slaughterhouses and animal by-products installations where malodorous animal by-products are handled.

Economics

Request to the TWG: Please provide information.

Driving force for implementation

Prevention of odour emissions, beyond the site boundary.

Example plants

A rendering plant and a fat melting plant in the UK. Two animal carcase incinerators in Italy. A slaughterhouse and several rendering plants in Germany.

Reference literature

[47, DoE SO and WO 1997] [15, DoE SO and WO 1997], [164, Nottrodt A., 2001] [53, Nottrodt 2001], [241, UK, 2002] [107, United Kingdom 2002], [248, Sorlini G., 2002] [112, Sorlini G. 2002]

4.2.3.3.3 Use of fresh refrigerated raw materials

See Section 4.2.3.2.1 and also Section 2.3.2.6.

Sealed storage, handling and charging of animal by-products

Description

The storage, handling and possibly size reduction equipment, can be sealed or maintained under negative pressure and the air extracted can either be used to provide oxygen in a combustion process, such as incineration, see Section , or can be directed to an odour abatement system.

Achieved environmental benefits

Animal by products installations can use fully enclosed feed systems to minimise biological risk and fugitive emissions, e.g. of malodorous substances.

Operational data

In an example incinerator, carcases and parts of carcases are tipped into a hopper, from which they are immediately transferred to a storage vessel which has been designed and constructed to hold the maximum quantity of material likely to be delivered to the site.

A cover may be provided for the initial hopper into which the animal by products are tipped, as they are received from the slaughterhouse, to reduce odour emissions. If the animal by products are received fresh and are not inherently malodorous, e.g. if the incinerator is on the same site as the slaughterhouse, the material comprises fresh condemned carcases and bones and the material is then fed into the storage vessel immediately, a cover may not serve an odour reduction purpose, but it may reduce problems arising from, birds and vermin.

Storage hoppers are covered and sealed. The final feed to the continuously running rotary kiln furnace is always sealed by a fully charged screw conveyor.

Cross-media effects

None.

Applicability

Applicable in all animal by products installations where the materials can be stored, handled and treated in enclosed equipment and where odour and vermin problems may arise. This may include, e.g. in fat melting, rendering, fishmeal and fish oil processing, blood processing, bone processing, gelatine manufacturing, incineration and biogas production.

Economics

It is inexpensive to seal equipment upstream of the incinerator, to prevent air ingress during charging.

Driving force for implementation

Enclosure of raw materials reduces vermin and odour problems.

Example plants

Sealed handling, including hopper charging of whole carcases and parts of carcases is undertaken at least two animal carcases/parts of animal carcase incinerators in Italy.

Reference literature

[6, EA, 1997, 269, Italian TWG Members, 2002, 293, Smith T., 2002]

Monitoring regime for emissions, including a protocol for monitoring burnout, including biohazard from TSE prions, in ash

Technical description

A monitoring regime can be used to measure the actual environmental performance of an animal by products incinerator, to both establish the achievable performance and to monitor compliance with emission limit values. As a minimum, the monitoring regime should meet the requirements of WID Council Directive 2000/76/EC, notwithstanding the possibility that the achievable emission levels may be significantly lower than those required by the legislation.

Further information on monitoring is available in the “Reference Document on The General Principles of Monitoring”.

Both WID Council Directive 2000/76/EC and ABP Regulation 1774/2002/EC require that the residues *shall be minimised in their amount and harmfulness*. A protocol for monitoring burnout, including biohazard from TSE prions in ash after animal by product incineration, can be used to double check that all of the procedures and safeguards in use are operating correctly. The *Monitoring protocol—ash and particulate testing methods and frequency (for analysis of carbon, nitrogen and amino acid content)* and the *Environment Agency—Bovine trials group, Notes on sampling of ash* are reproduced in Section 0.

An incinerator burning SRM in Italy measures organic nitrogen in ash, as a way of monitoring prion destruction. The residual nitrogen is measured at 105 °C. The detection limit is 0.5 g nitrogen/100 g ash.

Continuous monitors should have battery back up to ensure that they can still record in the event of a power failure.

Achieved environmental benefits

By monitoring emissions the effectiveness of the chosen incineration equipment and associated processes, including “end of pipe” techniques, can be checked to see whether they are effectively preventing or controlling emissions to the environment as a whole. Underperformances can thereby be detected and rectified.

Cross-media effects

None.

Environmental performance and operational data

None.

Technical considerations relevant to applicability

The monitoring of emissions to air is applicable in all incinerators, including those burning animal by products. A protocol and regime for monitoring burnout, is also required and this should include a means of checking for any residual biohazard associated with TSE prions in ash.

Driving force for implementation

The legislative requirements of WID Council Directive 2000/76/EC and ABP Regulation 1774/2002/EC and the destruction of TSE prions.

Example plants

Virtually all incinerators are required by WID Council Directive 2000/76/EC, to monitor their emissions and those that are excluded from that particular legislation, do so to meet the permitting requirements of environmental regulators.

Reference literature

{6, EA, 1997, 82, EA, 1998, 278, EC, 2002}

Bio-refining of animal by-products to produce soil improvers and fertilisers

Technical description

The technique is a bio-refining treatment of biological waste materials which sterilises pathogenic agents. Animal carcasses and parts of carcasses can be processed with organic fibrous material to produce sterile plant and animal nutrient products, such as fertilisers and soil conditioners.

The organic waste material is mixed with a finely divided organic fibrous material to provide a reaction mixture. The absorbent organic fibrous material is selected from cellulose containing material and lignin containing material not exceeding about 40 % moisture by weight, or cellulose packaging materials, straw, hay, moss and mixtures thereof.

Ammonium nitrate, an oxidising agent, is added to give an animal by product: NH_4NO_3 in a weight ratio of 1:10–1:30. The reaction mixture is heated in a hyperbaric reactor vessel at elevated pressure and temperature, for enough time to create saturated steam and to hydrolyse the absorbent organic fibrous material and to produce a substantially denatured product containing inactivated pathogenic agents. The denatured product is dehydrated in a hyperbaric reactor vessel, to produce a free flowing solid. The moisture content of the solid is approximately 10 %. Controls are provided to prevent malodorous compounds from being released to the atmosphere.

The mixture is maintained at 180–200 °C and 1000–1380 kPa for 20–40 minutes.

The vapour is released from the hyperbaric reactor vessel into a condenser. The denatured vapour can be recovered and condensed for use in crop irrigation or for the production of liquid fertiliser.

Achieved environmental benefits

It has been reported that the technique can inactivate pathogens, including TSE prions. It can also increase opportunities for the recovery and recycling of animal by products.

Cross-media effects

Energy is consumed during heating and in the generation of high pressure.

Environmental performance and operational data

The construction materials of the equipment are not critical, as long the required operations can be adequately carried out. Any type of size reduction device may be used. The hyperbaric reactor vessel may be of any suitable size and shape as long as the required steam pressure and temperature ranges are maintained.

For example, a site may install a two vessel system with a capacity to process 20000 t/yr of animal by products. Multiple systems can be installed at one site to process larger volumes of material.

Technical considerations relevant to applicability

At the time of writing, this technique is not permitted in the EU, due to the fact that in ABP Regulation 1774/2002/EC, it is neither listed, nor has it been approved in accordance with the procedure referred to in Article 33(2) therein, after consultation of the appropriate scientific committee.

Reference literature

[320, Biosphere Refineries Corporation, 2002]

Biotechnological treatment of animal by-products in order to increase energetic valorisation

Technical description

Animal meal is sorted by grain size. It is then treated with a liquid containing active micro-organisms (non pathogenic bacteria), a feeding solution and water. The bacterial compound is selected for its ability to degrade animal and vegetable fat, proteins and starch. Approximately 1 litre is required per cubic metre of animal meal.

An enzymatic reaction is activated by the micro organisms. This substantially reduces the fat content. This causes the calorific value of the material to increase.

Once the process has started, it is assisted by mechanical or manual stirring. The time needed for the process is approximately 15–20 days. The reaction conditions are between 20–27 °C in semi-darkness.

Achieved environmental benefits

Reduced fat content

Cross-media effects

Mercury and arsenic loss during the process has been reported, but not accounted for.

Technical considerations relevant to applicability

At the time of writing, this technique is not permitted in the EU, due to the fact that in ABP Regulation 1774/2002/EC, it is neither listed, nor has it been approved in accordance with the procedure referred to in Article 33(2) therein, after consultation of the appropriate scientific committee.

It is reported that the simplicity of the treatment could make it possible to apply the process either at the end of the rendering process or before incineration.

Economics

The initial investment would be limited to the purchase of cochlea treatment tanks and stirring blades. The main operational cost would be the purchase of the biotechnological solution.

Driving force for implementation

The application of biotechnical processes for agricultural and environmental emergencies is continuously growing. The operations reportedly prefer the use of natural rather than artificially produced micro-organisms, in order to avoid the risk of genetic pollution which might be difficult to control.

Studies underway show the possibility of achieving a higher net calorific value with one simple treatment.

By the end of 2003, the process could be considered as an industrial technique usable for the treatment and transformation of animal by-products to increase their calorific value.

Example plants

None yet because the technique is still under development.

Reference literature

[326, Italian TWG Members, 2002]

4.3 Rendering of animal by-products and/or edible co-products (rendering, fat melting, blood and feather processing)

4.3.1 General information

European renderers turn animal by-products (ABP) and edible co-products from slaughterhouses and farms into different products, according to the risk they pose. Around 12 million tonnes of material/year posing a low risk (animal parts not used for human consumption generated in slaughterhouses) are processed into edible fats, animal feed, pet food, oleochemicals and fertiliser. A total of 5 million tonnes of material/year posing a high risk (fallen stock from farms and specified risk material from slaughterhouses) are processed into meat-and-bone meal and biodiesel [200, EFPPRA 2019].

Fat melting plants that are members of EFPPRA reported the processing of 335 000 tonnes of Category 3 fat, and 550 000 tonnes of food-grade fat during 2018 [259, EFPPRA-EAPA 2020].

Blood products are processed either under food hygiene regulation or animal by-product regulation. The blood itself must have passed both the ante- and post-mortem inspection of the competent veterinary authority.

Food-grade blood is gained under strict hygiene rules (Regulation 853/2004) which allow no contamination, only when it is considered as fit for human consumption after the post-mortem inspection. The blood is cooled and an anti-coagulant is added [259, EFPPRA-EAPA 2020].

Table 4.9 presents the different blood inspection patterns for different blood uses.

Table 4.9: Different inspection patterns for blood uses

Blood uses	Ante-mortem inspection only	Ante- and post-mortem inspection Blood not fit for human consumption	Ante- and post-mortem inspection Blood fit for human consumption
Blood meal Category 3	+	+	+
Blood products Category 3	–	+	+
Blood products Food-grade	–	–	+

Source: [259, EFPPRA-EAPA 2020]

Full blood powder is made from ante- and post-mortem inspected blood. The process is the same as for blood meal production, but the approval of the competent authority is for blood products. The separation of blood products generates two products, i.e. plasma and haemoglobin, as can be seen in Table 4.10.

Table 4.10: Classification of different blood products

Blood category	Type of process	
	Coagulation	Separation
Blood meal / Category 3	+	–
Blood powder / Category 3	+	–
Plasma, Haemoglobin / Category 3	–	+
Food-grade blood products Plasma, Haemoglobin	–	+

Source: [259, EFPPRA-EAPA 2020]

Data for blood processing lines located in 19 EU Member States, Switzerland and Norway are presented in Table 4.11.

Table 4.11: Data for blood processing lines in EFPRAs plants

Blood product	Number of lines in 2018	Processed blood in 2018 (tonnes)
Blood meal / Category 3	32	700 000
Blood products / Category 3	11	585 000
Blood products / Food-grade	5	

NB: Blood processing lines located in EFPRAs members' plants. Data from non-EFPRAs members (e.g. fat melting lines in slaughterhouses) are excluded from this table. The volumes for edible and non-edible blood products are collected together and cannot be distinguished.
 Source: [259, EFPRAs-EAPA 2020]

Belgium

There are 5 rendering plants in Belgium processing Category 1, 2 and 3 animal by products, either individually or mixed together [346, Belgian TWG member, 2003].

Denmark

Denmark has one rendering company which has 5 plants. The company is co-operatively owned by the slaughterhouses. In 2000/2001, it processed 750000 tonnes of animal by products. All SRM is processed in one of the plants. [239, Denmark, 2002]

Germany

In 2000, the rendering plants operating in Germany disposed of a total of approximately 2.6 million tonnes of raw material. The number of companies in Germany, the raw material amounts they processed and their products in 2001 are reported in Table.

Number of companies	Processed amount (t)	Meat meal (t)	Meat and bone meal (t)	Blood meal (t)	Animal fat (t)
63	2600000	460000	214000	21000	310000

Table: Raw material processed in the German meat meal industry (2001)
 [163, German TWG Members, 2001]

Finland

In Finland, approximately 200 million kg of animal derived by products are generated annually. About 170 million kg, including slaughterhouse waste and waste from fur animal production, is considered to be low risk material. High risk material and SRM, from slaughterhouse waste and dead farm animals, each contribute about 15 million kg to the total animal by product treatment industry.

There are two rendering plants in Finland approved for the treatment and the disposal and/or further recovery of the high risk material and SRM. There are 14 plants with a treatment capacity greater than 10 tonnes per day, for the recycling of the low risk material for further recovery as fur animal feed. Finland is among the biggest fur animal producers in the world, using an annual 370 million kg of fur animal feed, more than half of which are by products from the meat and fish industry. [148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001]

United Kingdom

In 2000, it was reported that 1.25 million tonnes of animal by products were collected annually from UK red meat slaughterhouses to be incinerated or rendered and then landfilled [12, WS Atkins EA, 2000], from a total of 1.75 million tonnes from cattle, sheep, pigs and poultry [13, UKRA, undated].

Slovenia

Slovenia has 3 rendering plants with a treatment capacity exceeding 10 tonnes per day [219, Skodlar M., 2002].

Fat meltingBelgium

There are 3 installations in Belgium producing fat for human consumption [242, Belgium, 2002].

There are 11 blood processing plants in the EU. They process a total of 300000 million tonnes of blood every year.

There is one plant in each of Belgium, Denmark, Spain, France, the Netherlands, Italy and Sweden and 2 in both Germany and the UK. [271, Casanellas J., 2002]. In addition to these dedicated sites there are others which are associated activities of slaughterhouses.

4.3.2 Applied processes and techniques**4.3.2.1 Rendering of carcasses and waste****4.3.2.1.1 General**

Although this section describes Rendering, the reader's attention is drawn to the fact that this activity is as previously stated in Section 0, is similar in many ways to fat melting and some of the equipment described is identical for both processes. The feedstocks differ and consequently the conditions for separating the fat, water and solids fractions vary accordingly. The raw materials used in rendering are frequently waste and are in practice have often been allowed to degrade so they cause more odour problems during storage and processing and require techniques for the treatment of odour and of high BOD waste water.

The term "processing" in ABP Regulation 1774/2002/EC [287, EC, 2002] is used to describe operations traditionally referred to as "rendering".

The rendering process uses animal by-products and edible co-products such as ~~The by-products include~~ carcasses, parts of carcasses, heads, feet, offal, excess fat, excess meat, hides, skins, feathers and bones. ~~from meat production.~~ These originate from, e.g. slaughterhouses, meat processing plants, butcher's shops, supermarkets and livestock rearing facilities. For example, about 10 – 11 % of a pig is rendered [148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001] [47, Finnish Environment Institute and Finnish Food and Drink Industries' Federation 2001]. In Germany, an average of 35 % of the live weight of all species is treated by inedible rendering [347, German TWG members, 2003] [184, Germany 2003]. The type of raw material in each rendering plant varies. Some plants specialise in individual species, e.g. producing just poultry meal and fats.

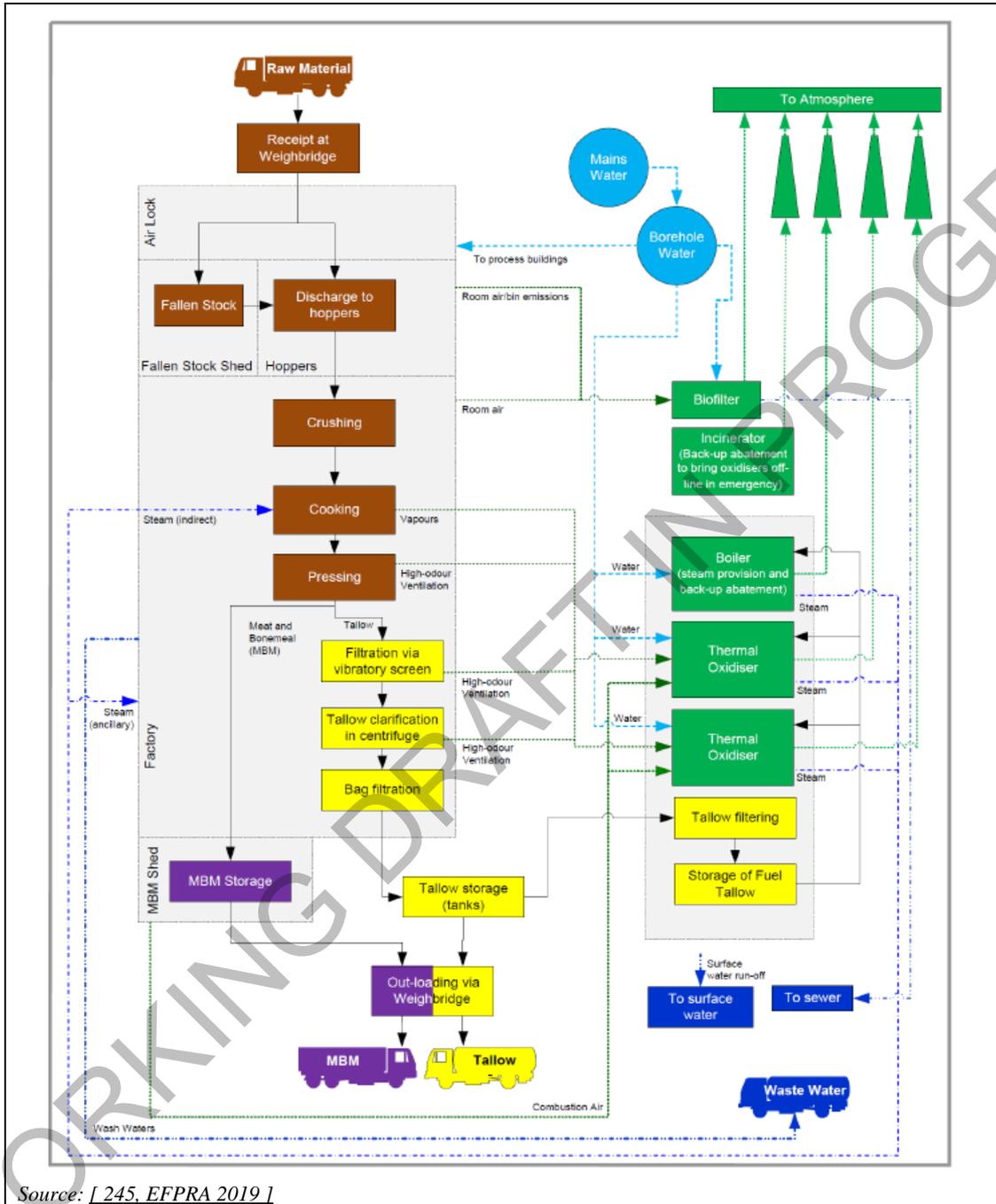
Rendering essentially consists of a combination of some of the following processes [245, EFRA 2019]:

- receipt and handling of raw material;
- sizing of the material;
- phase separation;
- drying/cooking to separate material into separate phases:
 - protein (meat-and-bone meal (MBM) or processed animal protein);
 - fat (tallow);
 - water vapour;
- pressing of the MBM to separate excess tallow;

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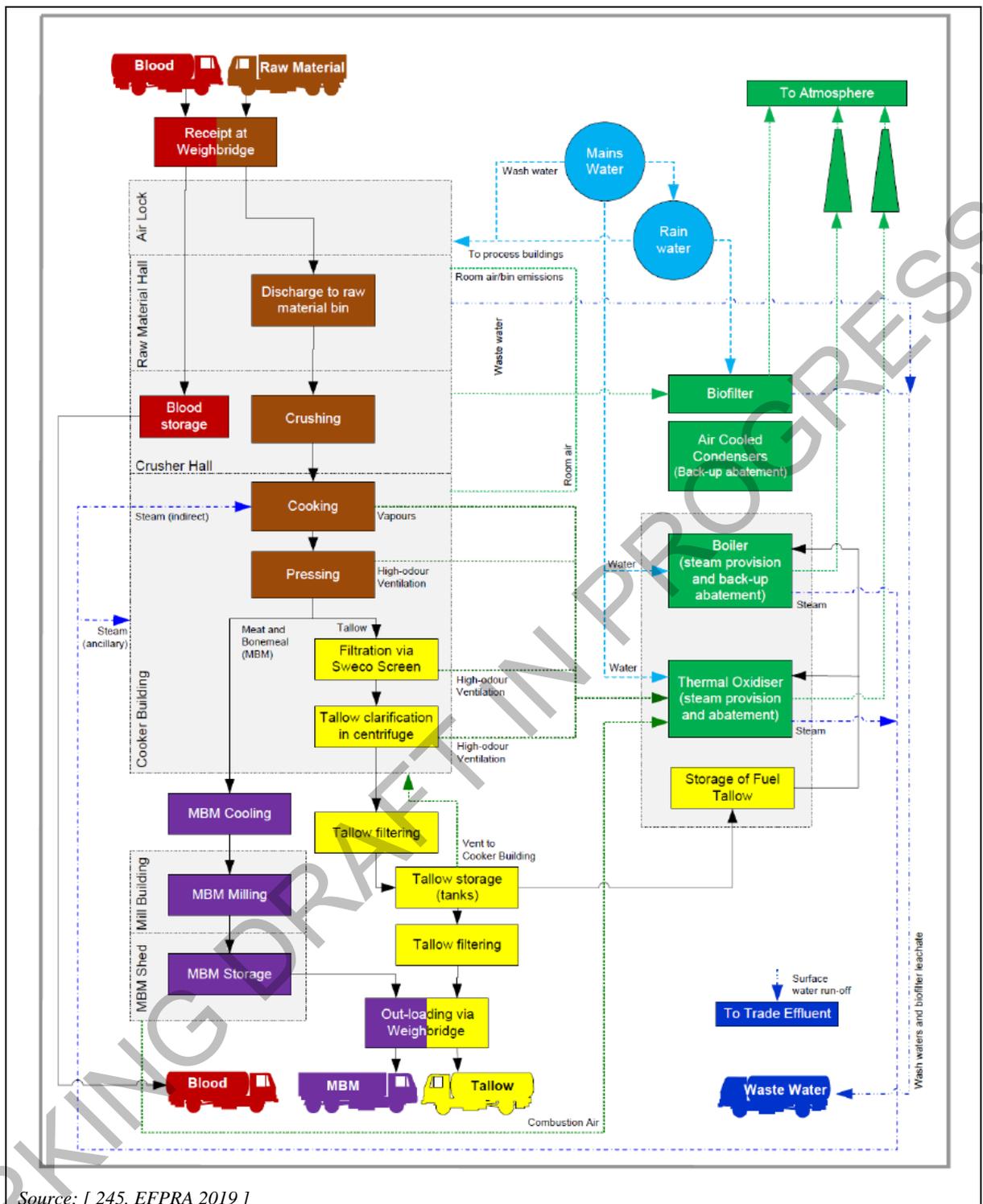
- filtering and centrifuging the tallow to remove fines;
- milling;
- storage and handling of products and intermediates.

Example process configurations are shown in Figure 4.3 and Figure 4.4.



Source: [245, EFPA 2019]

Figure 4.3: Example of a Category 1 rendering plant flow diagram



Source: [245, EFPA 2019]

Figure 4.4: Example of a Category 3 rendering plant flow diagram

The rendering processes can be ‘dry’ or ‘wet’. In the dry rendering process, steam is confined in a jacket that surrounds the rendering tank (containing the material being rendered). In the wet rendering process, steam or boiling water is injected into the rendering tank, along with the material being rendered.

The rendering process comprises a number of processing stages, as follows, although the order may vary between installations. The raw material is received at the installation and stored. Preparing the raw material for rendering generally involves size reduction, to meet the

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~~requirements of ABP Regulation 1774/2002/EC. The material is then heated under pressure to kill micro organisms and to remove moisture. The liquefied fat and the solid protein are separated by centrifugation and/or pressing. The solid product may then be ground into a powder to make animal protein meal, such as MBM or feather meal. The final products are transferred to storage and despatch [241, UK, 2002]. The waste solids, liquids and gases are then treated and disposed of, possibly with some intermediate storage. For certain materials, the conditions under which sterilisation must be carried out are prescribed in ABP Regulation 1774/2002/EC.~~

Chapter III of Annex IV to Commission Regulation No 142/2011 implementing ABP Regulation 1069/2009 ~~1774/2002/EC~~ specifies the operating conditions of the processing methods required for rendering animal by-products not intended for human consumption. These vary depending on the risk associated with the materials. The risks are divided into Category 1, 2 or 3 materials, which are defined. The conditions include, e.g. requirements for the segregation of slaughterhouses from animal by-products processing premises; separation of clean and unclean areas; adequate capacity of specified services and size reduction equipment. It also states general hygiene requirements and details operating conditions, including particle size, temperature, time and pressure [201, COM 2011], [204, EC 2009]. ~~These are summarised in Table.~~

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METHOD	Maximum particle size (mm)	Simultaneous temperature & time (°C) — (min)		Pressure requirement	Batch	Continuous	ABP Regulation 1774/2002/EC Category 1 TSE confirmed suspected & for eradication	ABP Regulation 1774/2002/EC Category 1 (except TSE)	ABP Regulation 1774/2002/EC Category 2	ABP Regulation 1774/2002/EC Category 3
							(if not directly incinerated)	(if not directly incinerated)	(if not directly incinerated)	(if not directly incinerated)
1 (sterilisation)	50	≥ 133	20	Yes ⁽⁴⁾	Yes	Yes	Yes then incinerate or co-incinerate	Yes then incinerate, co-incinerate or landfill	Any one of these methods MUST be used, but the subsequent required/allowed routes for use or disposal of the outputs are prescribed in ABP Regulation 1774/2002/EC.	Any one of these methods MAY be used and the subsequent allowed routes for disposal of the outputs are prescribed in ABP Regulation 1774/2002/EC.
2	150	≥ 100 ≥ 110 ≥ 120	125 120 50	No	Yes	Yes	Yes then incinerate or co-incinerate	Yes then incinerate, co-incinerate or landfill		
3	30	≥ 100 ≥ 110 ≥ 120	95 55 13	No	Yes	Yes	Yes then incinerate or co-incinerate	Yes then incinerate, co-incinerate or landfill		
4	30	≥ 100 ≥ 110 ≥ 120	16 13 3	No	Yes	Yes	Yes then incinerate or co-incinerate	Yes then incinerate, co-incinerate or landfill		
5	20	≥ 80 ≥ 100	120 60	No	Yes	Yes	Yes then incinerate or co-incinerate	Yes then incinerate, co-incinerate or landfill		
⁽⁴⁾ — 3 bar (300 kPa) pressure produced by saturated steam, i.e. all air is evacuated and replaced by steam in the whole sterilisation chamber — Co incineration and mixed waste incineration are not within the scope of this document										

Table: Summary of rendering processes allowed under ABP Regulation 1774/2002/EC — for detailed information on what is required, permitted and prohibited, see the legislation

The operating conditions and the sequence of unit operations may vary due to the nature of the raw material or the desired properties of the product, as long as the requirements of ABP Regulation 1069/2009 1774/2002/EC are also met.

The higher the fat-free solids content of the raw material, the larger will be the quantity of animal meal produced. The more bone in the raw material, the less protein the meal will contain, since bone has a lower protein content than meat or soft offal. If the raw material has a high bone content, the product will have a high mineral content. The average yield of fat and meal from a rendering plant will be about 35 – 45 % of the quantity of raw material fed into the plant. Examples of some extreme raw material contents include, e.g. pure meat which can contain up to 75 % water; cleaned bone from a deboning department, which can contain 45 % solid and very fatty material which can contain 95 % fat. Further information can be found in [16, VDI 2008] is given in Table.

The composition of the product to some extent dictates its suitability for further use or disposal. The feedstock can be any part of the animal and may comprise a single substance, such as feathers or blood, or may be a mixture. During the years before the BSE crisis there was a trend towards rendering various parts of the animal separately for specific customer requirements. This may have changed with the ban on the use of meal in animal feed and with the consequent use of the rendering process as part of the disposal route for a large proportion of animal by-products. The feeding of processed animal proteins to farmed animals which are kept, fattened or bred for the production of food is, at present, prohibited, with limited exceptions, by the 2000/766/EC Council Decision of 4 December 2000 concerning certain protection measures with regard to transmissible spongiform encephalopathies and the feeding of animal protein [88, EC, 2000].

Raw material Finished products Condensate (Waste water)	Quantity kg	Proteins		Mineral matter		Fat		Water	
		%	kg	%	kg	%	kg	%	kg
Animal carcasses	1000	15	149	4	38	12	118	68	683
Animal meal	240	62	149	16	38	12	29	5	12
Animal fat	90	0	0	0	0	99	89	1	1
Condensate	670	0	0	0	0	0	0	100	670
Slaughterhouse waste (red meat)	1000	9	90	2	20	14	137	74	739
Animal meal	150	60	90	13	20	12	18	5	8
Animal fat	120	0	0	0	0	99	119	1	1
Condensate	730	0	0	0	0	0	0	100	730
Bones	470	40	188	40	188	12	56	5	24
Bone meal	470	40	188	40	188	12	56	5	24
Animal fat	90	0	0	0	0	99	89	1	1
Condensate	440	0	0	0	0	0	0	100	440
Blood	1000	12	123	1	7	0	3	87	867
Blood meal	140	88	123	5	7	2	3	5	7
Condensate	860	0	0	0	0	0	0	100	860
Bristles	1000	28	255	1	6	2	21	72	718
Bristle meal	300	85	255	2	6	7	21	6	18
Condensate	700	0	0	0	0	0	0	100	700
Poultry waste	1000	12	124	2	21	18	181	66	663
Poultry meal	190	65	124	11	21	12	23	6	11
Animal fat	160	0	0	0	0	99	158	1	2
Condensate	650	0	0	0	0	0	0	100	650
Feathers	1000	28	281	1	7	2	23	69	690
Feather meal	330	85	281	2	7	7	23	6	20
Condensate	670	0	0	0	0	0	0	100	670

The sum of protein, mineral matter, fat and water portions need not be 100 %, as there are other ingredients in the substances mentioned, e.g. starch, nucleic acid and raw fibres. The figures serve only as a guide, as they depend on the actual composition of the raw material)

Table: Typical product quantities after rendering 1000 kg of various slaughterhouse by-products [49, VDI, 1996]

4.3.2.1.2 Raw material reception, handling and tipping

Overview

The freshness of ABP arriving at the site influences the nature and degree of odour associated with the material. Decomposition commences after the slaughter or death of the animal and materials continue to degrade over time, increasing both the offensive odour and the liquid fraction of the material. This is an issue that should be addressed so material is as fresh as possible and easier to handle and process at the rendering facility.

The rules for the chilling of ABP for processing into feed are specified in paragraph 1 of Section 2 of Annex VIII to Commission Regulation No 142/2011:

1. The transport of animal by-products destined for the production of feed material or raw pet food must take place at an appropriate temperature, in the case of animal by-products from meat and meat products which have been destined for purposes other than human consumption, at a maximum of 7 °C, unless they are used for feeding purposes in accordance with Chapter I of Annex II, in order to avoid any risk to animal or public health.
2. Unprocessed Category 3 material destined for the production of feed material or pet food must be stored and transported chilled, frozen or ensiled, unless it is processed within 24 hours after collection or after the end of storage in chilled or frozen form, if the subsequent transport takes place in means of transport in which the storage temperature is maintained.

As degradation increases, the likelihood of an odour problem increases, and even small odour releases are likely to be noticeable. Highly odorous raw material also puts a greater loading on the odour abatement equipment serving the rendering processing stages. Furthermore, an increase in the liquid fraction will increase pressure on trailer joints and seals and increases the likelihood of leaks and spillages, which can, in turn, lead to odour escape.

Processing material of a similar consistency is important for product quality and for odour control, particularly where abatement technologies other than thermal oxidation are employed. Highly odorous material may overload the abatement system and cause emission of odour. The blending of raw materials of variable moisture content helps to achieve a feedstock of a suitable consistency. The factor influencing the degree of freshness, and therefore the odour potential is the timely collection of the raw material in accordance with the ABP Regulation. The effect of these factors is seen in the different odour potential of different categories of raw material as shown in Table 4.12.

Table 4.12: Contrast between Category 1 or 2 and Category 3 raw material

	Category 1 or 2 raw material	Category 3 raw material
Origin	Can originate from slaughterhouses (SRM material), fallen livestock, dead animals from zoos and other sources.	Mostly ABP from slaughterhouses, meat processors, food manufacturing and retail outlets.
Collection frequency	Collection frequency varies, usually 1-2 days but sometimes up to several days after death of animal.	Regularly collected from the sites of origin.
Control	The renderer has less control on the freshness of the raw material.	Category 3 derived products have more value so raw material freshness is important to maintain the product quality.
Material freshness	Raw material is usually more decomposed and odorous when it arrives at the rendering site.	Raw material is relatively fresh in comparison to some Category 1 materials.

Source: [245, EFPA 2019]

The main consumption and emissions associated with raw material reception, handling and tipping are listed in Table 4.13.

Table 4.13: Consumption and emissions associated with raw material reception, handling and tipping

Description		Used by / Arising from
Consumption	Water	Cleaning of vehicles, equipment and infrastructure
	Energy	Provision of hot water for cleaning; operation of air extraction and odour abatement systems
	Chemicals	Cleaning
Emission	Odour	Raw material conveyed in vehicles and stored reception buildings
	Waste water	Cleaning of vehicles, equipment and infrastructure

Source: [245, EFPA 2019]

Refrigeration and freezing

Where chilling is required by the ABP Regulation, this is undertaken either at the slaughterhouse and or in the transport vehicle, which is refrigerated. This includes high-value products such as offal for raw pet food and blood.

In Mediterranean regions, ABP are occasionally transported in chilled vehicles, even if this is not mandatory under the ABP Regulation. Elsewhere in the cooler EU regions, it is not standard practice to transport ABP in chilled transport unless it is a requirement of the ABP Regulation.

Some of the larger EU pig farms have considered installing refrigerated pits but doing this at all EU farms would be a huge task and would be financially prohibitive in most cases. Similarly, refrigeration of animal by-products at the point of slaughter would also be required to cover the whole supply chain to the rendering facility. This is not standard practice.

Receipt at site

Operators are responsible for ensuring that raw material is processed as quickly as possible and prioritised where necessary. Contingencies should deal with highly odorous material and this may include exceptional circumstances such as transport delays or difficulties associated with bringing material from geographically remote areas.

Storage awaiting tipping

The aim is always to process material as quickly as possible after arrival at the site and to limit the opportunity for odour egress from trailers and skips up to the point of tipping.

Where space is available, raw material trailers or skips are moved indoors on arrival at the site. When space is not available, they may be parked outside. The following controls are commonly used to minimise odour emissions whilst awaiting tipping:

- trailers and skips remain covered until tipping;
- contingencies are in place to divert material to another site within 24 hours if a delay persists.

Access doors to raw material reception

At many sites, vehicle trailers are driven inside the raw material buildings through fast-acting vehicle access doors, activated by sensors as trailers approach. The doors automatically close a short time after the vehicle passes through. Door sensors can inadvertently open doors if they malfunction or are triggered by other means.

Manual controls for operating vehicle access doors are preferred by some operators who report that automated doors can be problematic, causing odour releases when they malfunction and fail to close. Odour control can be ensured if manual procedures are well managed so that vehicle access doors are kept closed during tipping and at all other times apart from vehicular access.

Personnel access raw material reception areas via dedicated personnel doors which are kept closed between use, either by procedural requirements or by using self-closing devices. It is not common practice for vehicle or personnel access doors to be alarmed if they are left open, when the methods described here are sufficient for door control. Even with good door controls, some air escape is inevitable due to air turbulence caused when a large vehicle passes into or out of a building.

Building airlock arrangements

Some sites have a physical airlock on raw material reception buildings, with a timed delay between the outer and inner doors opening and closing. A controlled ingress of air sweeps through the airlock and is drawn into the extraction ducting to the odour abatement system. Physical airlocks require sufficient space in front of the raw material building and this prevents their installation at some existing sites.

Some sites use an alternative arrangement and have vehicle access doors interlocked with the raw material hopper lids so both cannot be open simultaneously. Air extraction from around or inside the hoppers is fed into an odour abatement system. Where automatic doors are not in place, the opening and closure of manual doors is controlled procedurally.

Another alternative used at some sites is an air curtain across the access door to replace the need for an airlock. At most sites, the extraction of the building air to an odour abatement system minimises the fugitive escape of odours from the buildings.

Tipping location

At most rendering plants, raw material is tipped directly into hoppers. Some plants unload raw materials onto the building floor and then tip them into hoppers using a bucket loader machine. This allows materials to be blended to achieve a consistent feedstock to meet the desired product specifications.

Fallen stock is usually tipped onto the floor, often in a separate reception area, awaiting sampling for TSE controls or skin removal. Occasionally, raw material is tipped onto the floor for physical inspection of suspect batches to remove foreign objects and prevent physical damage to the processing plant.

Cleaning after tipping

After raw materials are tipped, the trailers or skips are cleaned and disinfected and vehicles are not allowed to leave the site until they have been cleaned and disinfected. Trailer covers are inspected for damage when the vehicles are cleaned.

The building floors are cleaned and any spilt materials are scraped or shovelled back into raw material bins. Trailer, skip and floor washing water runs into internal waste water drains.

4.3.2.1.3 Raw material processing

Overview

Rendering can be carried out as either a batch or continuous process and there are varying configurations for both. In the EU, continuous cooking is used at all the EU sites where rendering is undertaken on a large scale and batch cooker/steriliser-type systems tend to be used in feather and blood processing plants and for other category materials. Batch processing is also used at smaller-scale rendering facilities at slaughterhouses where the throughput is lower.

The cookers use large amounts of energy to evaporate the moisture from the raw material. Cooker exhaust gases are intensely odorous and must be abated to destroy the odour. This is another very energy-intensive step.

Some sites remove the condensable fraction before thermal oxidation and treat the condensate in a waste water treatment plant. Sites without a waste water treatment plant cannot do this and the uncondensed gases are treated by thermal oxidation or condensate is treated off site.

The cooking room building can become very hot and odorous due to fugitive releases from the presses and cookers if equipment is poorly enclosed. The air from within buildings is often extracted to an odour abatement system. There are seven EU-approved processing methods that can be used to process ABP. These are specified in Table 4.14.

Table 4.14: Processing methods according to Commission Regulation No 142/2011

Name	Category of ABP	Maximum particle size	Core temperature	Time at core temperature	Special details
Method 1 (pressure sterilisation)	1, 2 and 3	50 mm	133 °C	20 minutes without interruption	Maintain minimum pressure of 3 bar (2 bar above normal atmospheric pressure), by removing all air from the sterilisation chamber and replacing with steam.
Method 2	1, 2 and 3	150 mm	120 °C and 110 °C	50 minutes 120 minutes	Process material in batches, one after another. Do not feed more material into the cooker while one batch is processing.
			and 100 °C	125 minutes	
Method 3	1, 2 and 3	30 mm	120 °C	13 minutes	
			110 °C	55 minutes	
			100 °C	95 minutes	
Method 4	1, 2 and 3	30 mm	130 °C	3 minutes	Add fat before heating
			and 120 °C	8 minutes	
			and 110 °C	13 minutes	
			and 100 °C	16 minutes	
Method 5	1, 2 and 3	20 mm	100 °C	60 minutes	Before processing heat until ABP coagulate (begin to solidify). Then press so that fat and water are removed. Treat the leftover solid material.
			and 80 °C	120 minutes	
Method 6 (for aquatic ABP) preservation method	3	50 mm	90 °C	60 minutes	Mix with formic acid to pH 4.0 or lower and store for 24 hours before further treatment
		or 30 mm	70 °C	60 minutes	
<p>Method 7 – Category 3 only Operators can also use other methods to process ABP if the local regulator grants permission. This is known as Method 7. Flexibility in temperature and cooking time is restricted by regulations and varies by customer country. Method 7 is the only way to deviate from these and offers an opportunity to save energy by using lower cooking temperatures and shorter cooking times. However, the method must be validated to prove pathogen destruction.</p> <p>NB: For methods where more than one time and temperature combination is required, time spent at the higher temperature also counts towards the lower temperature. For example, in Method 5, the 60 minutes spent at 100 °C count towards the 120 minutes that must be spent at 80 °C.</p> <p>Source: [245, EFRA 2019]</p>					

There is a balance between energy costs, processing time and ensuring the product quality is achieved. The digestible protein content and palatability of meal can vary with the cooking temperature for example. The method can also be chosen based on the feed safety criteria.

Tallow produced from rendered Category 1 and 2 materials must be sterilised (Method 1) if it is to be used for biodiesel production. Tallow for combustion must be sterilised unless it is used on the site where it is made and the import of unsterilised tallow to Europe remains forbidden. The main consumption and emissions associated with raw material processing are listed in Table 4.15.

Table 4.15: Consumption and emissions associated with raw material processing

Description		Used by/arising from
Consumption	Water	Cleaning of equipment and infrastructure, steam supply, cooling towers
	Energy	Used to heat cookers, drive motors, operate building air extraction systems and odour abatement plant, and to heat water for cleaning
	Chemicals	Cleaning, odour abatement
Emission	Air	Combustion plant emissions and odour abatement plant emissions
	Odour	Cooker exhaust gases, separation equipment and process buildings
	Waste water	Cleaning of vehicles and infrastructure, condensate
Source: [245, EFPA 2019]		

Size reduction

Before it can be processed, any ABP material must be crushed into small pieces with a particle size between 20 mm and 150 mm (the exact size limit is different for each of the approved methods; see Table 4.14). For Method 7, this is specified upon validation.

The raw material is generally fed via screw conveyors or pumped via closed pipes from the hoppers into a mechanical crusher. The material is sometimes passed over a metal detector to remove any metal before entering the crusher.

The equipment used to crush the material may vary, e.g. mincers, cutters or breakers. The equipment is set up to ensure that material larger than the maximum size allowed for the specified processing method cannot pass through. Motors and drives serving this equipment are large energy users.

Heat processing – cooking or drying

Crushed raw material is fed into the cookers and heated to the specified temperature for the required residence time. This evaporates the moisture and melts the fat. Where pressure sterilisation is required the pressure is maintained at a minimum of 3 bar by removing all air from the sterilisation chamber and replacing it with steam. This part of the process is conventionally termed cooking but some refer to it as drying.

The cooker design and operating parameters will depend upon whether it is a batch or continuous process and whether pressure sterilisation is included. However, most cookers are heated by steam, fed into a jacket surrounding the material. Other heating methods are used at some sites.

A validated throughput of material per hour is set to ensure compliance with the regulatory method. Some sites use a constant raw material feed rate and vary the steam feed while others use a steady steam rate and vary the raw material feed. The cooker exhaust gases are drawn into ducting leading to the odour abatement system for intense odours.

Separation of cooked material

The cooked material, a mixture of oil (tallow) and solids (meal), is known as greaves. The solid meal material is referred to as meat and bone meal (MBM) for Category 1 and 2 material or processed animal protein (PAP) for Category 3.

The greaves are removed from the cooker via a variable feed screw conveyor and some sites pass them over a metal detector. The oil is drained from the meal in a screw conveyor with a

perforated plate screen or through a two-phase decantation and the remaining oil is extracted using presses.

Solid material is then pressed and the remaining oil removed. Any spillages or residues are commonly fed back through the cooker. The meal is transferred via screw conveyors to the milling area for further processing. Fine particles remaining in the oil are removed by centrifuge in the oil processing stage (see tallow processing and storage) and/or through gravity sedimentation.

Processing equipment is designed and maintained to contain odours from the handling of hot processed material. Good enclosure of equipment is important and air extraction points are located at essential inspection points and openings to draw odorous air into the intense odour abatement system.

Meal processing and storage

The meal is hot and odorous when it comes off the presses and is sometimes cooled before it is transported for direct dispatch or to the milling plant. Air cooling and water cooling are commonly used. Some sites cool the meal with building air from the meal dispatch area and then abate odour and dust in this air. Other sites use water jackets on conveyors for cooling.

Where material is stockpiled awaiting milling, it is important to recognise and address the potential for temperature build-up and spontaneous combustion. Thermal imaging and temperature probe monitoring are used at some sites to monitor temperature build-up and material can be spread out to cool if necessary.

Where meal is transported around the site, it is moved in covered containers or trailers to contain dust and odour. In the milling plant, the meal is passed over a metal detector and fed into hammer mills where the cake is broken down into smaller pieces. The material is passed over screens to achieve the desired particle size, followed by homogenisation to finished product specifications.

The product is either packed into bags or screw-fed into silos awaiting distribution. Category 1 and 2 MBM is often stockpiled inside product stores on the floor while awaiting distribution.

Dust from the meal milling operations is contained by enclosure of conveyors and screw feeds or collected in dust arrestors such as bag filters or cyclones. Dusty operations are potential explosion risks and good housekeeping is required to keep dust levels down and explosion risk assessments can be required.

Meal stores and milling areas have the potential to contribute to odour emissions, which need to be contained and may need to be abated.

Tallow processing and storage

Fine particles are removed from the oil/fat using centrifuges (decanters/separators) and/or through gravity sedimentation and the oil/fat is then pumped to bulk storage tanks. Filter aid is sometimes used to produce very low solids content.

Most tallow solidifies at ambient temperatures so the storage tanks and road tankers are mostly trace-heated with steam and are controlled to the optimum range using temperature gauges. Tallow is either distributed from the site in road tankers or used as a fuel in the on-site combustion plant.

Spillages of tallow will quickly solidify but could enter nearby drains so tallow tanks are either bunded or boarded up or operating and emergency procedures are used to contain and clean up any spillages and prevent them entering the drainage system or damaging the waste water treatment plant.

The preparation of the materials to be rendered and some examples of the numerous rendering methods in use, which illustrate the main principles, are described below.

Pretreatment and pre-breaking

The qualities of animal meal and tallow produced by rendering animal by-products will depend on the type of raw material, the storage time and temperature before rendering and the rendering process itself.

Traditionally there was a requirement to keep the FFA low. To do this, the raw material must be treated as soon as possible after removal from the animal; excessively high storage temperatures must be avoided; the raw material must not come into contact with the contents of the paunch and intestines and pre-cutting of the raw material should be carried out just before the heat treatment is started. These conditions make good environmental sense too because, by minimising the degree of breakdown of the materials to be rendered, they reduce odour and waste water problems.

Manual de-hiding/skinning may be undertaken at rendering plants.

Whole carcasses and parts of carcasses are mechanically reduced in size before rendering. ABP Regulation 1774/2002/EC specifies maximum particle size limits for by-products being rendered. These depend on which Category they are as defined in ABP Regulation 1774/2002/EC and their intended route for use or disposal. The size limits are shown in .

Sterilisation

ABP Regulation 1774/2002/EC prescribes the circumstances under which sterilisation, i.e. Method 1 from Annex V, Chapter III, is required. The conditions that must be achieved are summarised in . Examples of batch and continuous sterilisation are described. The sterilisation process may be applied as the whole process or as a pre or post process phase. The by-products, which have been reduced in size to no greater than 50 mm, are sterilised at 133 °C, for at least 20 minutes without interruption at a pressure (absolute) of at least 3 bar (300 kPa) produced by saturated steam.

Batch sterilisation

A horizontally lying cooker with a steam jacket and stirrer, known as a dry rendering cooker, may be used. One example of this type of equipment can handle batches of up to 15 tonnes of by-product. The stirring implements are made up of classical heated dry melting implements. They can simultaneously serve as driers and stirrers and are mainly used in smaller plants with lower throughputs. The sterilisation and drying time is 3–5 hours with a batch of about 1.5–10 tonnes. [163, German TWG Members, 2001]

Continuous sterilisation

Current continuous sterilisers consist of a system of preheaters, heaters, and a holding device. These can be constructed horizontally in series, or vertically as a compact system. The raw material is conveyed from the loading equipment, where fat may be mixed into it, into a piston pump, which presses the material at high pressure through the entire system. In the preheaters, which consist of a cylindrical container containing heated pipes, the raw material is heated to approximately 75–80 °C, using the exhaust vapour from the sterilisation. In a second stage, i.e. the heater stage, the material is brought to a temperature of (133 °C) through the indirect supply of steam. The heater is also a heat exchanger containing heated pipes. The third stage is the holding device, which must be sized for the maximum throughput volume. The pressure of 3 bar (300 kPa) is guaranteed by the pressure keeping system installed at the end of the holding device, which only opens at a pressure of 3 bar (300 kPa). The mixing of the raw material is ensured within the pipe system. After discharge of the sterilised material, the exhaust vapour steam is separated in a cyclone and used again for the preheating.

Some rendering systems

A large number of rendering systems are used in different EU countries, all based on similar principles. The combinations of the various unit processes are numerous. Some examples of the more commonly used systems are listed in Table and described in the following paragraphs.

System	Energy use ⁽⁴⁾ (kg oil/tonne by-product treated)	Pressure cook		Fat (% remaining in animal meal)
		Before	After	
Batch dry rendering/fat melting	55–60	No		12–15
Continuous drying in recycled fat	approx. 55	No	Yes	10–15
Wet pressing or other separation, evaporation, drying in fat, pressing	40–45	No	Yes	10–15
Separation, evaporation, drying in natural fat	approx. 55	No	Yes	8–10
Cooking and drying in added fat in multiple-effect evaporator, pressing	35–40	No	Yes	10–15
Wet pressing, separation, multiple-effect evaporation, drying without fat	35–40		No	8–9
⁽⁴⁾ Energy in kWh not submitted				

Table: Commonly used rendering and fat melting systems [289, EFPPA, 2002]

Batch dry rendering

The sequence of treatments can vary between installations, but the principles are the same.

The conventional batch dry rendering method is shown in and is basically the same equipment as used in the batch fat melting process. The cooker, which is charged with a batch of raw material, consists of a horizontal jacketed vessel which is indirectly heated by steam. An agitator, which is often of a hollow design and indirectly heated by steam, is used to mix the contents and to provide quick and even heating. The jacket and agitator may both be supplied with steam at a pressure of approximately 6–7 Pa.

The cooking period takes about 2.5 hours, during which the contents are heated, sterilised and most of the water is evaporated, i.e. down to a water content of 8–10%. The remaining contents of the cooker are then discharged into a percolator, which is a tank equipped with a strainer at the bottom for draining the free fat. The solid residue from the percolator, which still contains about 30–35% fat, is then de-fatted down to the desired fat content by means of a screw press (expeller), a pusher centrifuge, or a basket centrifuge. Alternatively, the material can be discharged to a solvent extraction plant, although this technique is being used less and less. Table shows the relative efficiencies of different types of separation equipment. The fat recovered is purified separately.

Equipment used	Fat content (%) (from a starting level of 30–35%)
Expeller	10–13
Pusher	12–15
Basket centrifuge	12–17
Solvent extraction	2–8

Table: Relative efficiencies of fat removal at the end of the batch dry rendering process [145, Filstrup P., 1976]

The fat drained from the percolator and from the de-fatting equipment contains a certain amount of fines. It can be clarified in a separator.

Continuous drying in added fat

The raw materials are reduced to a maximum particle size of 50 mm. They are then sterilised either immediately, in a batch cooker or a continuous pressure cooking vessel, or after drying and separation in a batch cooker with injection of live steam. Cooking and drying take place in a continuous drier with recycled fat. The dried material is drained and pressed to expel fat. The process has a high energy consumption but the plant is compact and the system well established. [289, EFPPRA, 2002]

Pressing, evaporation, drying in fat and pressing

The raw materials are reduced to particle sizes between 20–30 mm and then pressure cooked. They are then pressed in a screw press to separate the solids from the liquids, i.e. the fat and stickwater. The press cake is dried in a continuously operating disc drier. The liquid is evaporated in a multiple-effect vacuum evaporator and the concentrate is mixed up with the press cake. Evaporation and drying thus takes place in the fat phase and the fat is expelled afterwards, in a press. The energy consumption is low and the meal has a high fat content. [289, EFPPRA, 2002]

Separation, evaporation and drying in natural fat

The raw materials are reduced to particle sizes between 25–50 mm and pressure cooked. Coarse bones may be removed by screening. Solids, stickwater and fat are separated in a tricanter. Fat is further purified and stickwater is concentrated in a vacuum evaporator. The concentrate is mixed up with the solid phase and dried in a continuous drier. The fat content in meal is low. The drying for raw materials with high bone content can be difficult and recirculation of the meal may be necessary [289, EFPPRA, 2002].

Cooking and multiple-effect evaporation in added fat, pressing

The raw materials are finely minced and fluidised with recirculated fat. The resulting slurry is evaporated in multiple-effect vacuum evaporators, i.e. vertical tube heat exchangers, with flash chambers, using live steam and waste steam from the process. Fat is separated in expellers. The pressure cooking cycle can be applied before or after drying and may be continuous. The system has a low energy consumption and is used, e.g. in Belgium, Germany, the Netherlands and the UK [289, EFPPRA, 2002].

Pressing, separation, vacuum evaporation, drying without fat

Raw materials are reduced to particle sizes less than 20 mm, coagulated and pressed in a double screw press. The press cake is dried in a disc drier, which is heated indirectly by live steam. The liquid phase is separated in a tricanter into fat, stickwater and sludge. The fat is purified and sterilised and the stickwater is evaporated in a multiple-effect vacuum evaporator using waste steam from the process. The concentrated liquid is mixed into the press cake for drying. The resulting meal is pressure sterilised by live steam. The system has a low energy consumption. The residual fat in the meal is less than 10 %. The system is mainly used in Denmark, Ireland and Italy. [289, EFPPRA, 2002]

4.3.2.2 Fat melting

Fat serves in the body as an energy deposit and as isolation under the skin and protects the organs in the abdominal cavity. Raw fat is unique in its composition: fat, protein, water. Contrary to hard tissue like bones, hooves and horns, fat is just weak material, which can be easily downsized and melted. Fat itself is also a known energy/heat carrier which supports the melting of raw fat. Therefore fat melting can be carried out very gently at 80-110 °C. Too high temperatures can degrade the fat in composition and colour [259, EFPR-EEPA 2020].

Although this section describes fat melting, the reader's attention is drawn to the fact that This activity-Fat melting is similar in many ways to rendering and some of the equipment described is identical for both processes. The feedstocks differ and consequently the conditions for separating the fat, water and solids fractions vary accordingly. The product of fat melting is generally for food use, so feedstocks are required to be fresh and consequently cause less odour problems during storage and processing.

Two methods of fat melting have been reported: ~~batch-wet~~ fat melting with direct steam and ~~batch-dry~~ fat melting with indirect steam ~~and continuous wet fat melting~~. The method used affects the quality of fat produced. The most important quality demands are: low content of free fatty acids (FFA); low water content; good keeping qualities; low peroxide value; neutral taste, flavour and colour and high solidification point. Extended storage and processing times adversely affect both quality and environmental standards. Unfresh raw materials may cause odour problems and add to the waste water pollution burden.

Under certain conditions, fat undergoes two important chemical changes, i.e. hydrolysis and oxidation. Hydrolysis is a chemical reaction between fat and water, through which free glycerides and FFAs are formed. The compounds formed during oxidation give the product a rancid taste.

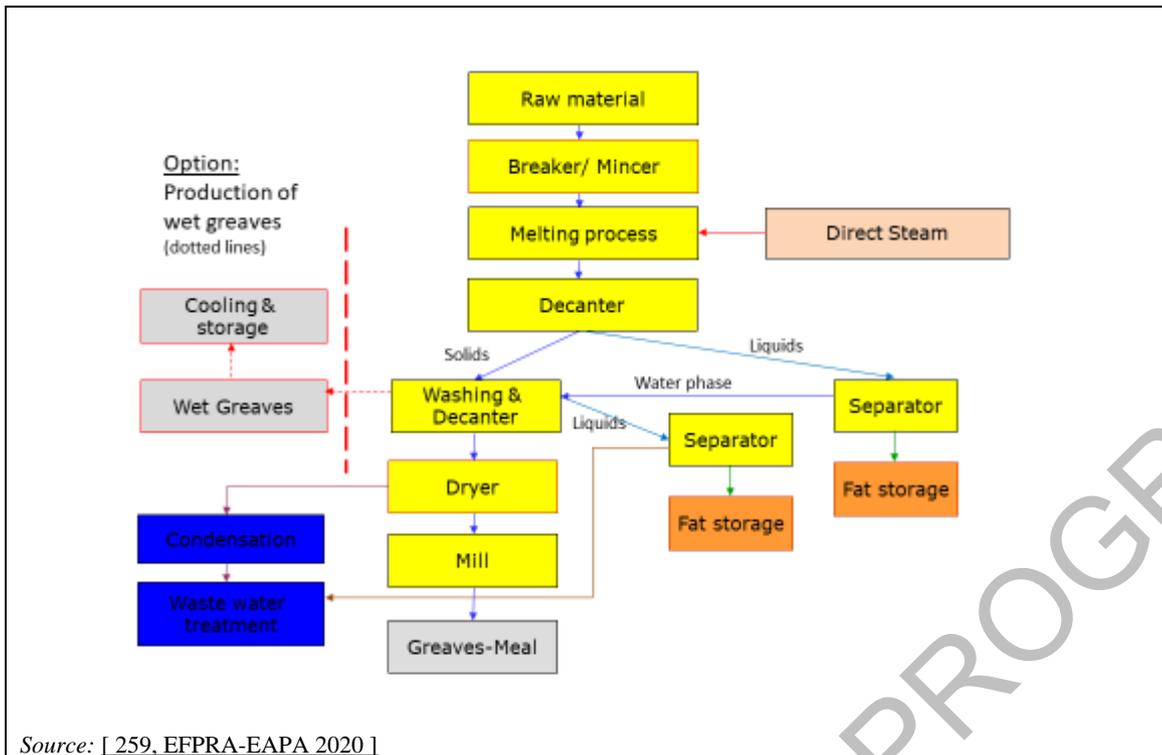
The handling and storage of the raw material before processing and the type of processing carried out determine the FFA and the peroxide value. The FFA content increases with the duration of storage and treatment, especially any time at raised temperatures. To avoid this, the constituents need to be separated quickly. To achieve a low water content the fat may be purified in a separator. The water content of the fatty raw material normally ranges between 6 - 25 %.

Sometimes food-grade fat melting plants do not sell the product as edible greaves/greaves meals. They are then considered as Category 3. This does not change the approval as the main product is edible fat. The whole process runs under food hygiene rules and supervision. It is the economic decision of the operator to produce food- or feed-grade greaves.

4.3.2.2.1 Melting with direct steam ~~Batch-wet~~ fat melting

After size reduction, the fat tissue is melted with direct steam which is jetted into the raw material. Very often this is done in a continuous process, in a so-called melting tube. A decanter separates the melted material into solids and liquids, which are fats and water. They are separated in a separator. The fat might undergo further cleaning steps. The water is used to wash the solid phase again to remove further fat from the greaves in another decanter. The liquid phase is again separated in a decanter into fat and water. The water goes to the WWTP. The fat is cleaned and stored. The solid part of the decantation is then either sold as wet greaves after cooling (very rare) or dried into a greaves meal. The evaporated water is condensed and goes to the WWTP [259, EFPR-EEPA 2020].

An overview of the process is shown in Figure 4.5.



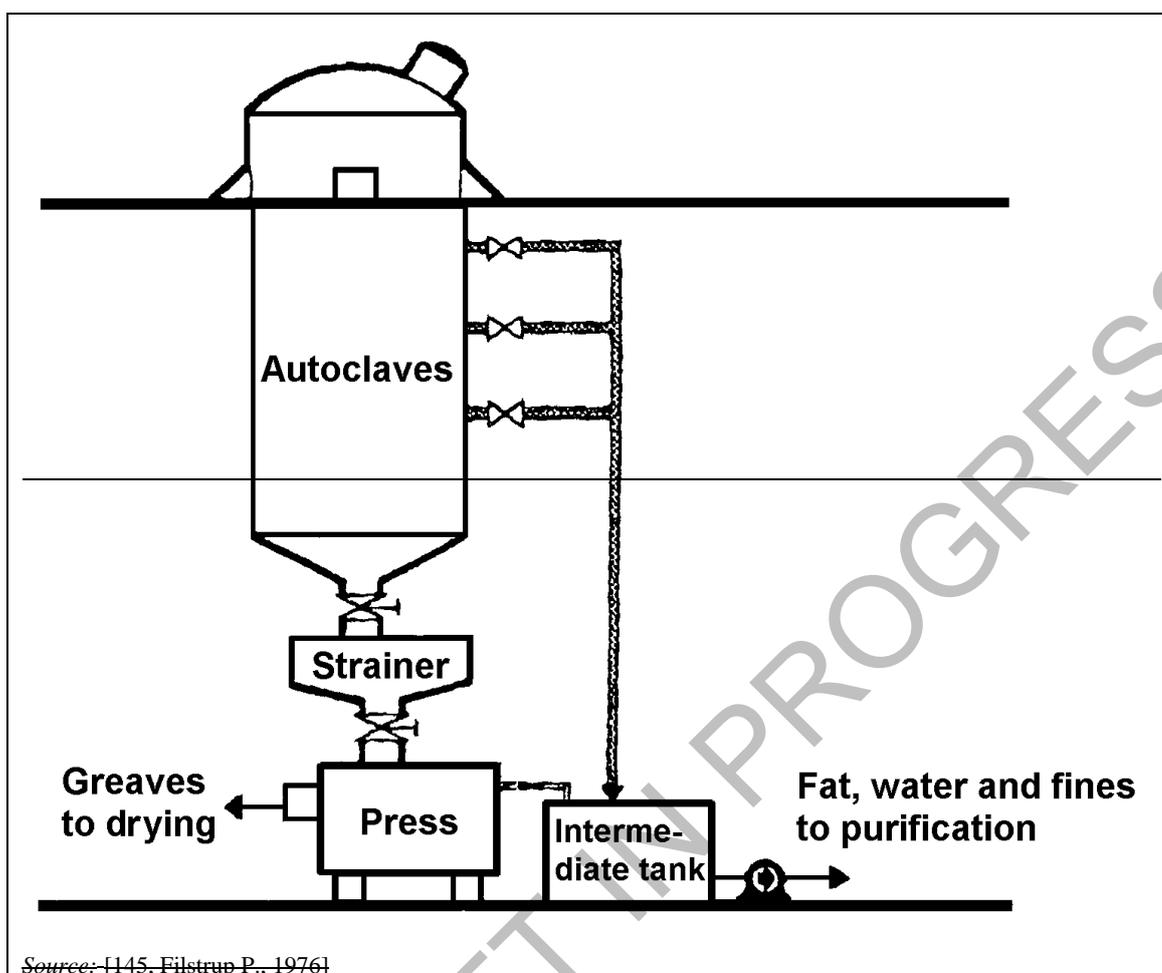
Source: [259, EFRA-EAPA 2020.]

Figure 4.5: Fat melting with the use of direct steam

Batch wet fat melting is the oldest method of fat melting. An autoclave is filled with pre-cut raw material and is then closed. Live steam is then injected into the raw material at a pressure corresponding to a saturation temperature of about 140 °C. To minimise the heating time, the cooking vessels are not too large and are equipped with agitators. Since the method is wet a good separator needs to be used, to ensure the final water content is below the required level.

After a heat treatment lasting 3–4 hours, depending on the size of the autoclave and the nature of the raw material, the pressure is slowly reduced to atmospheric pressure, in order to avoid emulsification. After a settling period, the free fat is drained from the autoclave to an intermediate tank, and the moist greaves are pressed and then dried. The fat collected is allowed to settle or is separated.

The batch wet fat melting/rendering is illustrated in Figure.



Source: [145, Filstrup P., 1976]

Figure: The batch wet fat melting system with autoclaves

Continuous processing combines mechanical and thermal treatments in order to minimise the processing time. The raw material is first passed through a mincer. It is then conveyed to an airtight section, where it is heated in two stages to about 60 °C and 90 °C respectively, in a matter of a few minutes.

The continuous wet fat melting is illustrated in Figure.

The heated material is then separated in a decanter centrifuge, especially designed for the continuous removal of solids from a liquid. The solids, known as greaves, leave the plant at this point. The liquid, now consisting mainly of fat, but also containing some water and fines, is subjected to a final purification. In this stage, it is separated into three phases. The “fines” are automatically discharged from the purifier at preset intervals.

The final purified fat flows through a plate heat exchanger, in which it is cooled down to about 40 °C before leaving the plant.

The direct injection of steam makes the processing time very short, displaces the air and minimises oxidation of the product. It has been reported that there is no rise in the FFA content or peroxide value in fat processed by continuous wet fat melting with direct steam. Continuous wet fat melting with direct steam takes less time and space than either batch wet fat melting with direct steam or batch dry fat melting with indirect steam. The fat yield is, however, lower than the batch method because the effluent water and the greaves contain more of the fat.

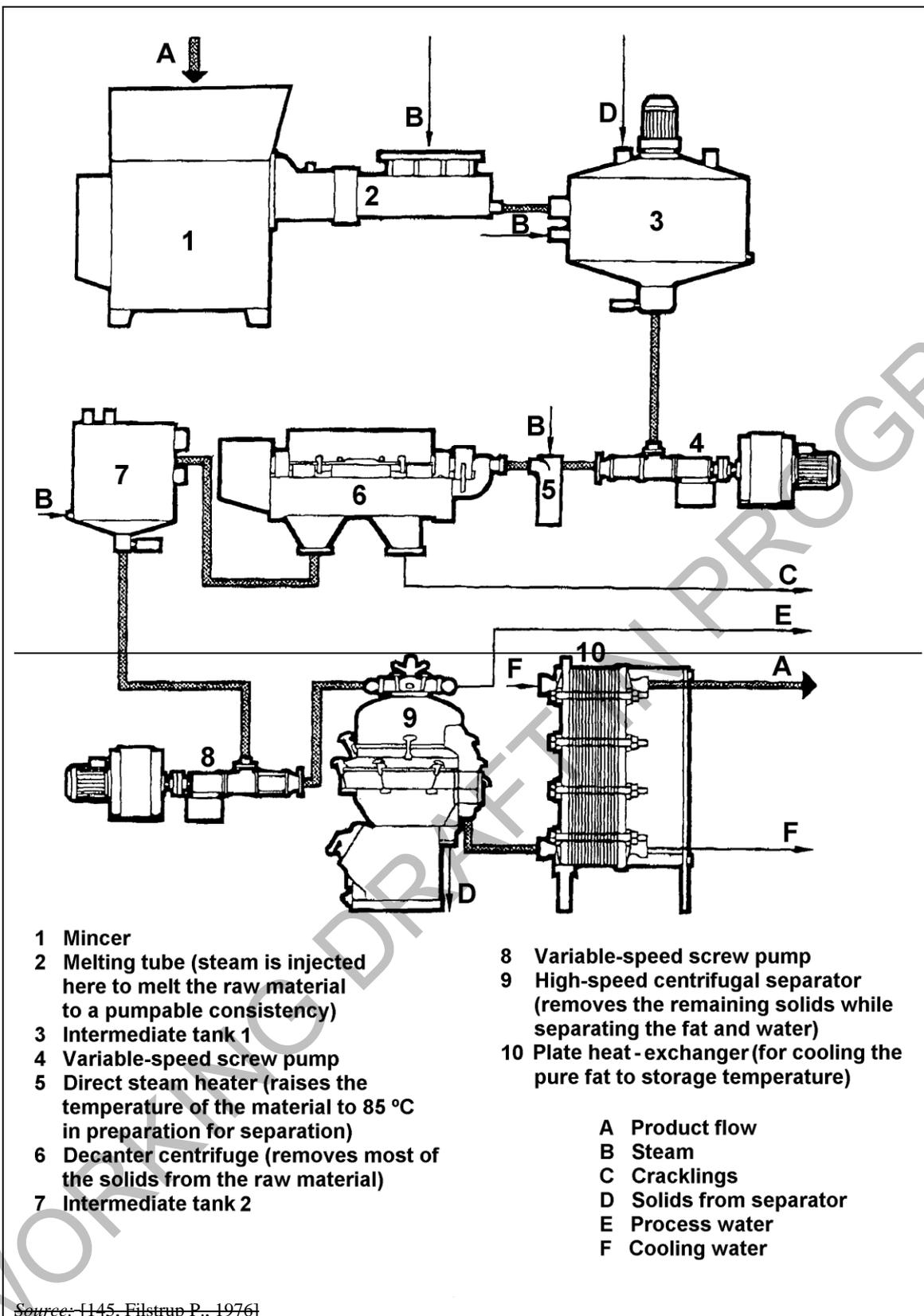


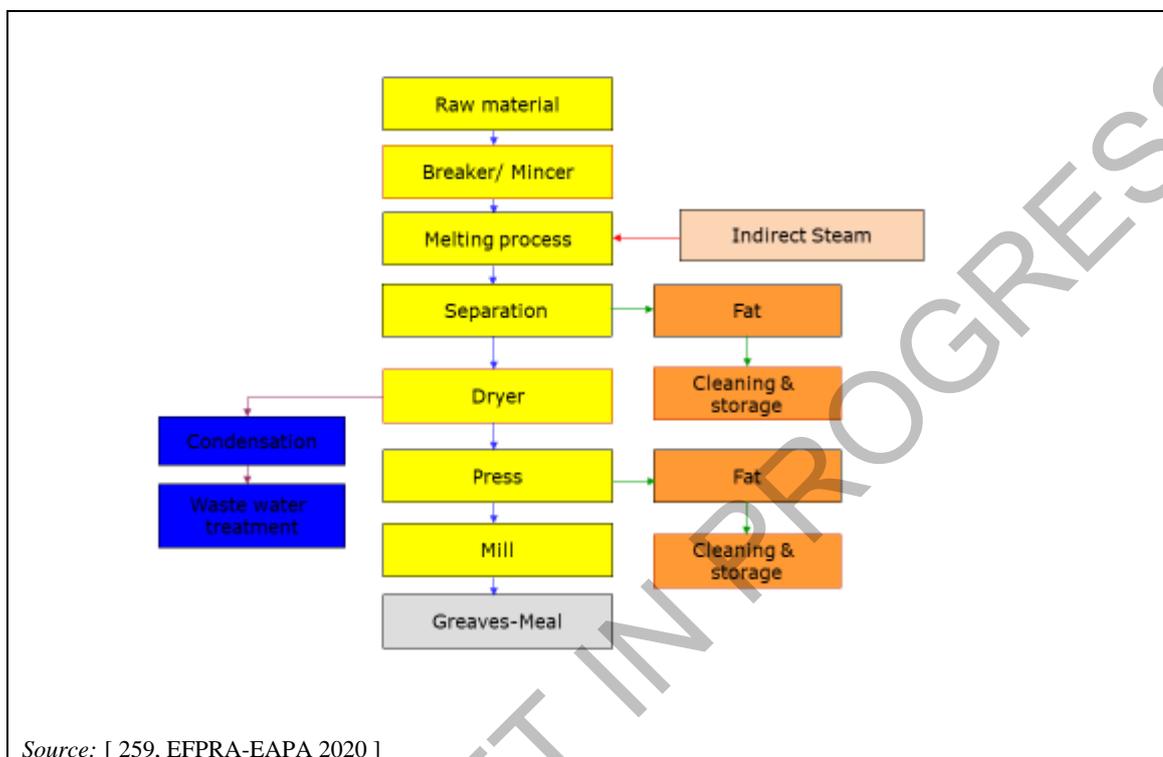
Figure: The continuous low-temperature wet fat melting system

4.3.2.2.2 Melting with indirect steam Batch-dry fat melting

After size reduction, the fat tissue is melted with indirect steam in a jacketed steam cooker, very often in a batch cooker. Then the fat is separated by a decanter, cleaned and stored. The other phase is dried, the water is evaporated, condensed and sent to the WWTP. The dried solids still

contain fat, which is removed in a press. That fat is also cleaned and stored. The remaining press cakes are milled into greaves meal [259, EFPA-EAPA 2020].

An overview of the process is shown in Figure 4.6.



Source: [259, EFPA-EAPA 2020]

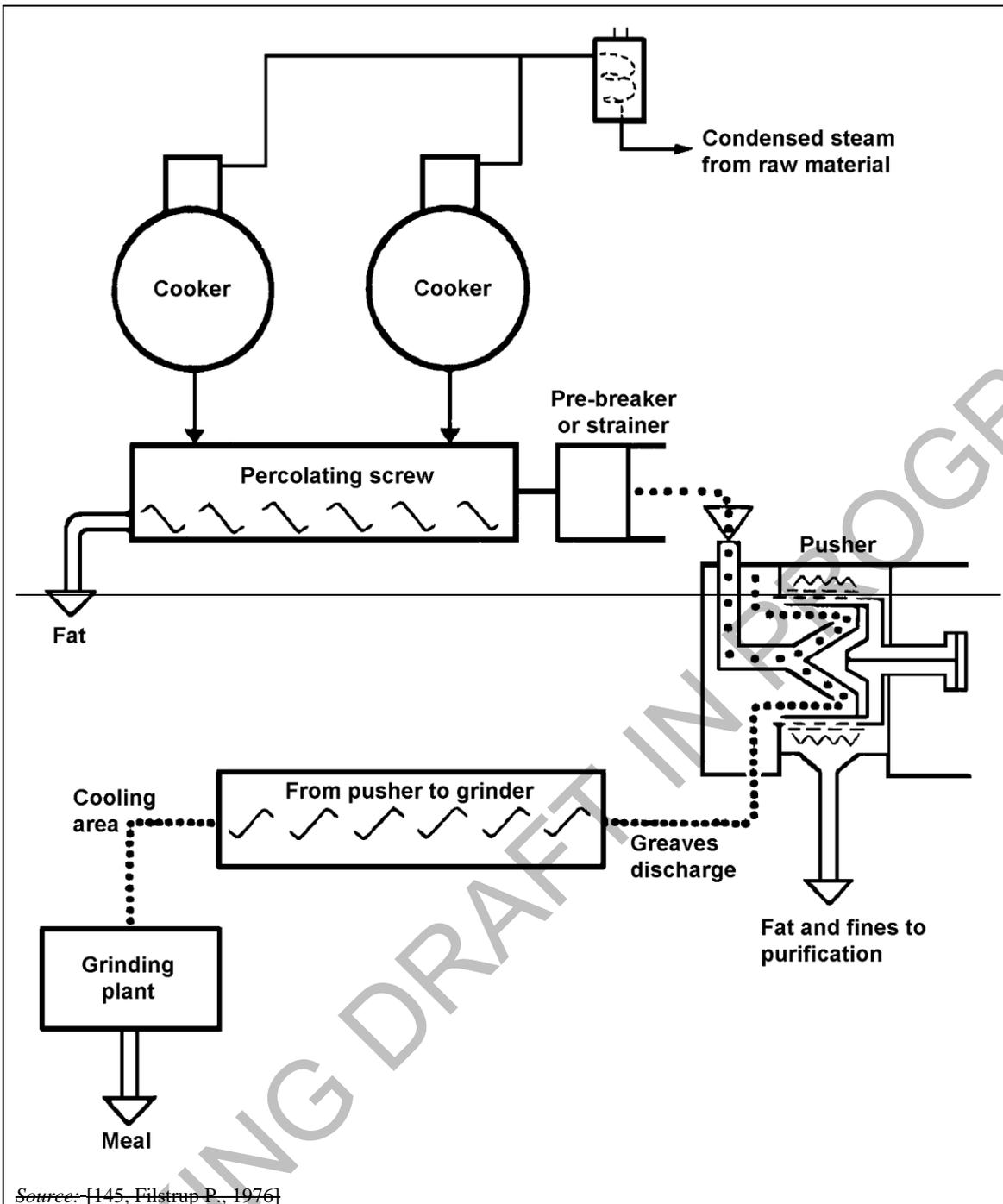
Figure 4.6: Fat melting with the use of indirect steam

Batch dry fat melting employs indirect heating. The melting vessel is steam jacketed and often also has a steam heated agitator. The operating pressure can vary from slightly above atmospheric to a vacuum. The latter will require a shorter processing time because the water is evaporated at a lower temperature.

The material is agitated during heat treatment and good heat transfer is obtained. It is, therefore, possible to use lower temperatures than for wet fat melting with the use of direct steam and to still liberate the fat in one batch within a shorter period of 1.5 - 2 hours. ~~The water in the raw material is removed by evaporation.~~ It is important that the heating process is stopped before all the water is evaporated, otherwise the product will be discoloured.

After discharge into a percolator, the free fat is drained to an intermediate tank. The greaves are then pressed or centrifuged, and then milled. As with wet fat melting, the liberated fat is either allowed to settle or is centrifugally separated before packaging.

A batch dry fat melting/rendering process is illustrated in Figure.



Source: [145, Filstrup P., 1976]

Figure : The conventional batch dry fat melting/rendering method

Fat melting with the use of indirect steam requires less space and time than wet fat melting with the use of direct steam. Due to the process being dry, the fat yielded will not be equally neutral in taste, flavour, or colour, even if the cooking cycle has been carried out correctly. The slightly roasted taste of the fat is a desirable feature in some countries. Compared to processing with the use of direct steam (wet processing), an advantage is that all of the water is removed by evaporation and there is less waste water contamination, because water is not added to the raw material which would then need to be subsequently removed. The evaporated water will, however, contain some volatile substances released during the drying process. There is a disadvantage, in that certain discolouring elements, which would otherwise have been extracted with the water, now remain in the fat.

Continuous wet fat melting

The combinations of techniques in use are numerous. Some further examples also used in rendering are described briefly in Section and Table. Their relationship with the quality of fat produced is shown in Table.

System	Quality of fat produced
Batch dry rendering/fat melting	
Continuous drying in recycled fat	Low quality fat
Wet pressing or other separation, evaporation, drying in fat, pressing	Fair quality fat
Separation, evaporation, drying in natural fat	Drying difficult with pressure cooking before
Cooking and drying in added fat in multiple effect evaporator, pressing	Fair quality fat
Wet pressing, separation, multiple-effect evaporation, drying without fat	Good quality fat

Table : The relationship between rendering/fat melting system and the quality of fat produced [289, EFPPRA, 2002]

4.3.2.3 Blood processing**4.3.2.3.1 Blood processing – blood meal**

Blood is a liquid whose dry matter content is dependent on the method of collection at the slaughterhouse, the species and the dosage of anti-oxidants/anti-clotting agents. The dry matter content is 10-12 % for poultry blood and 15-20 % for pigs and cattle blood. That means that 80-90 % of blood is water and has to be removed to receive a dry and stable product.

Blood contains functional proteins like albumin, immunoglobulin or fibrinogen. Those proteins are highly digestible and contain valuable amino acids. Their functionality and digestibility can be degraded or destroyed if the raw material is not properly cooled and treated or when the drying method and conditions are too harsh. The high functionality of the proteins leads to a lot of applications in the meat industry; the immunoglobulin G is specifically relevant for the diets of very young animals. A high digestibility of valuable proteins means a high body retention and therefore a reduced excretion, which protects the environment by not wasting energy and resources. This explains why mild and careful drying techniques are used [259, EFPPRA-EAPA 2020].

Blood from slaughterhouses is mostly sent to animal by-product processors where it is treated in several ways. Some ABP processors treat blood in the rendering process while others treat blood in a separate plant to either sterilise it for landspreading or to produce a blood meal. Slaughterhouses send blood for processing into food products such as black pudding or it can be spray-dried into pet food or made into plasma/haemoglobin.

Overview

The quality or freshness of blood and feather supplies is important for manufacturing blood and feather meals. Non-fresh material will cause significant odours during processing and handling and will affect the product quality.

Chilling blood at source extends the shelf life and minimises odour potential and blood suppliers often store blood in refrigerated tanks while awaiting collection for specialised uses. For lower-value products, it is not standard practice to chill blood at source and road tankers and bulk storage tanks at the processing site are not refrigerated.

Blood spillages are a risk and relatively common, either at the slaughterhouse during collection or at the processing site during offloading. Process water from feathers or blood water phase is also highly polluting. Failure to contain spillages on site can cause severe water pollution, either directly or by overloading the waste water treatment plant.

Minimising the degradation of blood in storage helps to control odours and product quality. The energy and odour issues associated with blood and feather processing are essentially the same as for rendering.

Receipt and storage

Blood is regularly received from the slaughterhouse, normally at the end of the day's slaughter, and is usually received in covered trailers and the same controls are applied as for raw materials related to rendering.

The blood is usually delivered to the processing site by road tanker, weighed and sent for unloading. The blood tanker is connected to the delivery lines and the blood is filtered into the storage tanks to remove unwanted material such as feathers.

Blood treatment by rendering

Most operators process blood through the rendering lines by feeding it in with other raw materials. Due to the high water content of blood, energy consumption is high and cooking temperatures can be affected by excess moisture. This is managed by controlling the feed and mixing with other raw material. Some sites preheat blood in a coagulator to overcome process fouling and this can reduce energy consumption in the cooking stage.

Blood sterilisation

Some operators sterilise blood before transfer off site for further processing or for application to land as fertiliser in accordance with the ABP Regulation. Blood is pumped from the bulk storage tanks, macerated and pumped into a coagulator where heat and pressure are applied to sterilise it.

Blood meal manufacture

An overview of the process is shown in Figure 4.7. Blood is pumped from the storage tanks into a coagulator and steam is injected to split the blood into water phase and solids. The coagulator is not always used as the sterilisation stage and sometimes the bloodmeal is sterilised and the water phase is sent to the WWTP without an official Method 1-7 sterilisation.

The coagulated blood is fed to a decanter to separate the solids from the water phase. The blood water phase is stored in tanks and fed to the waste water treatment plant or tankered off site for treatment. The solids are conveyed to a dryer and the dried meal (sterilised to comply with the requirements of the ABP Regulation approved method) is cooled, milled and discharged into bags at a bagging station or stored loose in bulk. Dust in the milling and bagging areas is contained in the equipment and with dust arrestors.

The process equipment is fully enclosed and all process waste gases are treated in an odour abatement unit. Despite this, buildings where blood processing is undertaken have the potential to contribute to fugitive odour emissions so the air may need to be extracted to an odour abatement system.

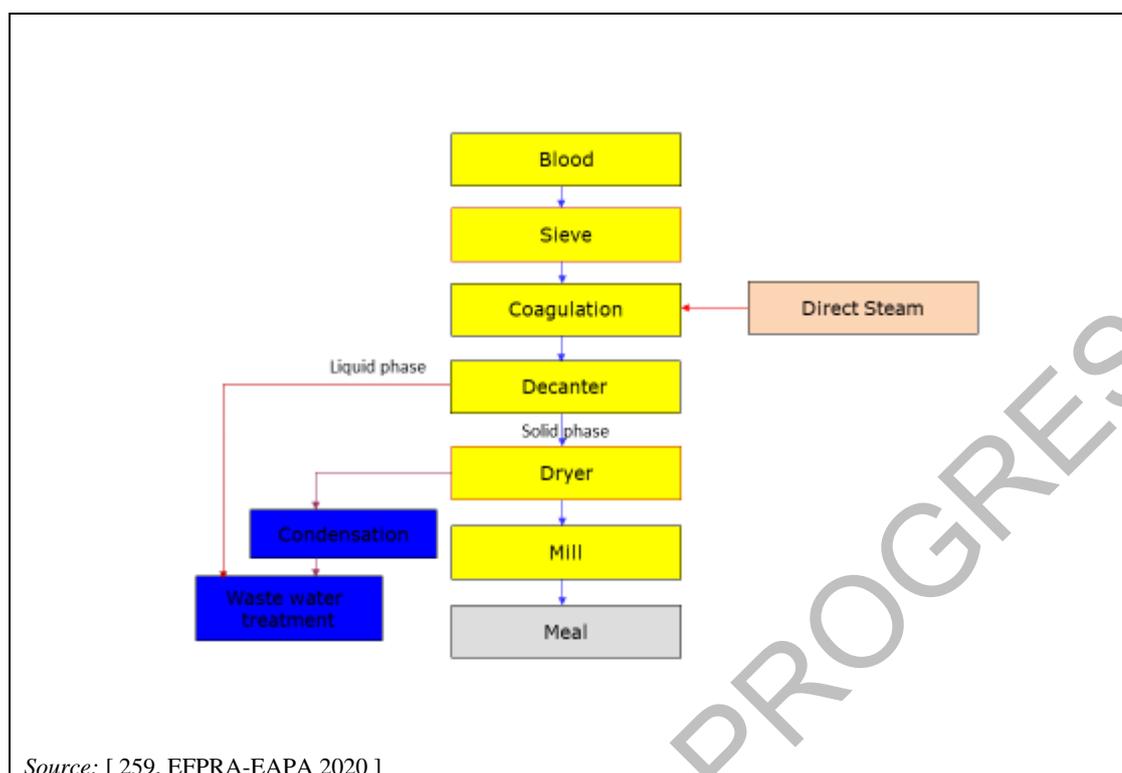


Figure 4.7: Typical process flow for a blood meal plant

4.3.2.3.2 Blood processing - plasma and haemoglobin dried red cell production

Blood processing uses blood from animals which have been passed as fit for human consumption by an official veterinarian, after a post mortem inspection.

Blood contains easily assimilated iron, when used for human food or pet food. Blood proteins have a high nutritional value and a high water binding capacity in processed products. The red blood cells burst if water is added to blood. If they are kept intact, red blood cells can be removed by centrifugation, in order to prepare plasma. Plasma is a yellow liquid, rather like egg white, which may be dried to a powder for food use. [27, University of Guelph, undated]

This process intends to keep the valuable properties of the two products, the plasma and the haemoglobin. This already begins at the slaughterhouse where the blood's autolysis is reduced by cooling, and the blood's clotting is reduced by adding anti-coagulants.

The blood is controlled on freshness and deterioration upon receipt at the blood processing plant. The process starts with the separation of the solid (containing red cells) and the liquid phase (containing plasma). The haemoglobin is obtained by spray-drying after separation. The plasma, which contains most of the water, is concentrated first and then spray-dried. Only very careful drying can minimise the thermal destruction of the plasma and preserve its functionality.

An overview of the process is given in Figure 4.8.

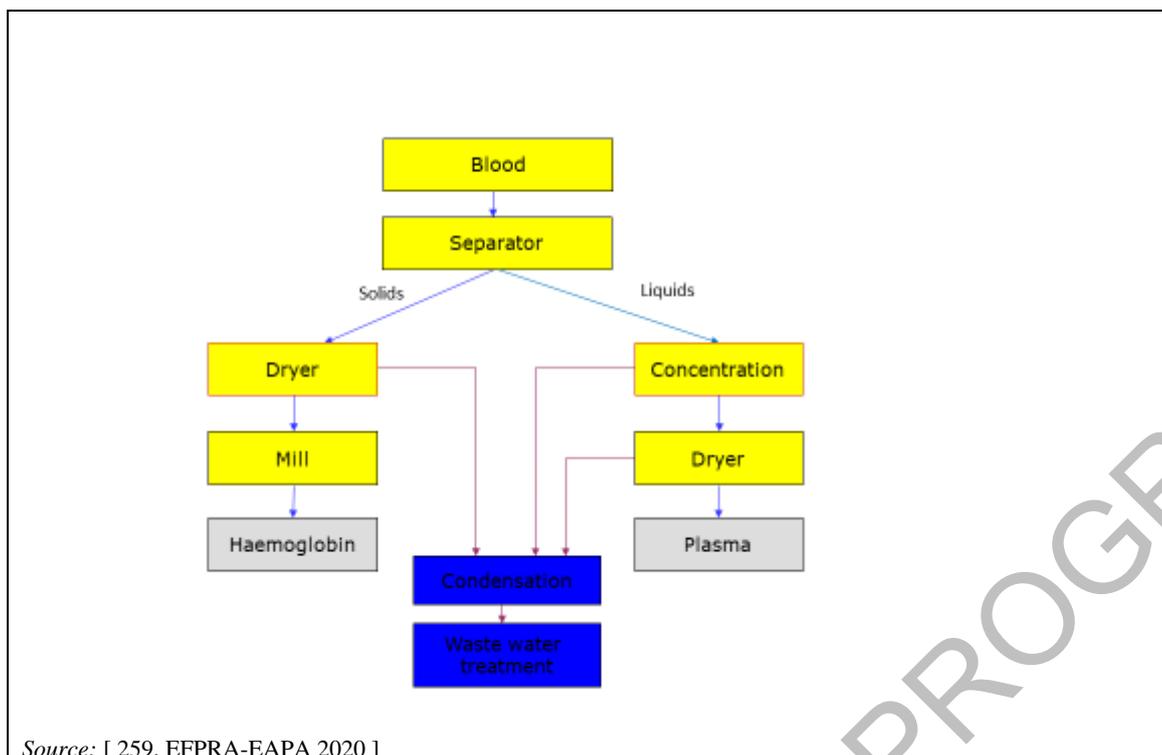


Figure 4.8: Overview of the blood processing to obtain plasma and haemoglobin

Blood collection

At the slaughterhouse, following hoisting, the stunned beast is stuck with a sticking knife at the lower end of the neck. This severs the major blood vessels, including at least one of the carotid arteries and jugular veins. Blood gushes from the stick hole to drain into a tank, canal or collection trough that receives the blood from multiple animals. For the collection of blood for the preparation of spray dried plasma, it should not be allowed to clot. To prevent this, blood is mixed with a solution of sodium citrate and/or sodium phosphate. Collections can be made singly but this is generally not practical for large numbers of animals. Thus it is usually pooled at the point of collection.

Filtering and centrifugation

The blood is filtered at the slaughterhouse and at the manufacturing plant. Following filtration, it is centrifuged to separate the plasma from the blood cells. This is done either at the slaughterhouse or at the processing plant. These two processes also assist in removing gross particles. If there is infectivity present, it will mostly be in the cellular fraction. Plasma would not necessarily be free of infectivity but it would be likely to be significantly reduced by separation of the cells. Following centrifugation there are 3 further filtration steps. Subsequent equipment is dedicated either to plasma or to cells.

Plasma production

The plasma yield is collected in a refrigerated stainless steel storage tank and chilled to 4 °C. At this point the plasma from various sources is allowed to mix in the storage tank. One tank may hold the blood from 1 500 – 8 000 pigs or 350 - 750 adult cattle. Cattle and pig plasma may be mixed. [202, APC Europe, 2001] [96, APC Europe 2001]]

The plasma received from the slaughterhouse contains approximately 8 % solids. These are removed by reverse osmosis and/or nano-filtration. This also concentrates the plasma, removing water and minerals, as well as the anticoagulant. The filters remove particles down to a 1 nm diameter. The purified plasma is then machine-homogenised and pressurised, in preparation for spray drying.

Alternatively, the plasma may be concentrated by vacuum evaporation. This technique involves the removal of the water from the plasma, under vacuum at $< 40\text{ }^{\circ}\text{C}$.

The spray drying involves the injection of the plasma into a heated drying chamber, at high pressure to form very fine droplets of 10 - 200 μm diameter, using a high-pressure nozzle. The type of nozzle used depends on the configuration of the drying chamber and on the flow of heated air. The drying chamber is the part of the system where the tiny plasma droplets contact the heated air and hence which the drying process takes place.

When the droplets encounter a stream of heated air the moisture quickly evaporates to form a dry powder. It is important that the drops are uniformly sized and are produced at a consistent rate, so that all the particles are exposed to the same temperature conditions. Specially designed and engineered nozzles are used to achieve this.

The air circulating through the drying chamber is atmospheric air, finely filtered and warmed by passing through a steam heater or an indirect gas heater. A centrifugal ventilator moves the heated air into the circulation system. The inlet temperature at one installation is reported to be $240\text{ }^{\circ}\text{C}$. The minimum contact time is 15 seconds at that same installation. It may be up to 30 seconds in other plants. The outlet temperature is $90\text{ }^{\circ}\text{C}$.

The plasma fraction is then bagged and stored. It has a moisture content of $< 10\%$. It is used in pet food and piglet feed. [201, APC Europe, 2000] [81, APC Europe 2001]. Plasma can currently be used by the meat industry, e.g. in cooked ham and cooked sausages and for pet food production [271, Casanellas J., 2002] [124, Casanellas J. 2002].

The process is illustrated in Figure 4.9.

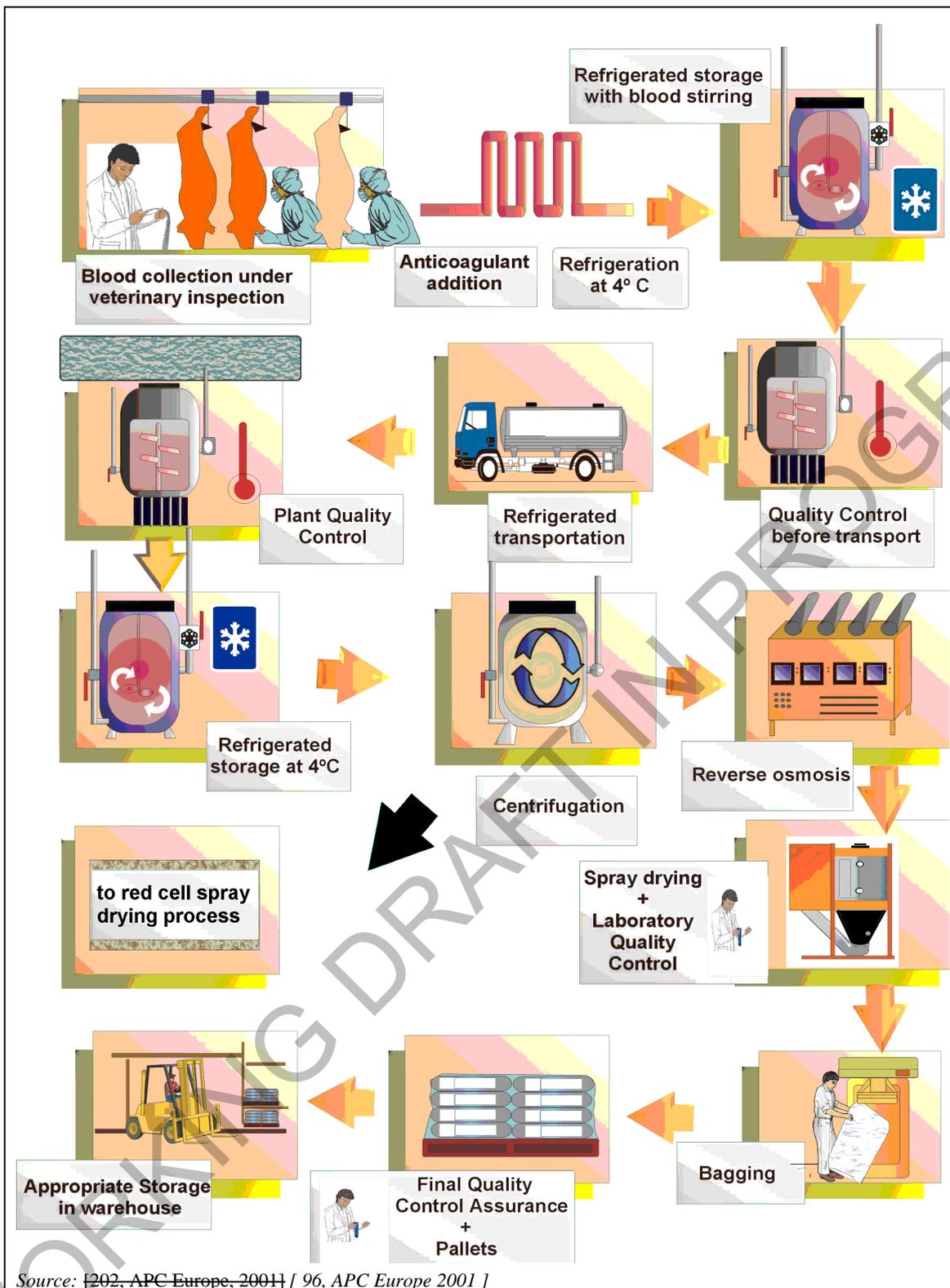


Figure 4.9: Spray dried plasma manufacturing process

Red-cell production

The red-cell fraction is pumped under high pressure, spray dried, bagged and stored, in the same way as previously described for the plasma, except that because the red cell fraction already comprises 30 % solids, it is not necessary to concentrate it prior to drying. The temperature for spray drying the red cells is higher than that for plasma, i.e. > 250 °C. The process is illustrated in Figure. The dried red blood cells are used as a natural pigment in the meat industry, pet food, animal feed and for fertilisers.

Waste disposal

Solid and liquid waste is produced during the spray drying process. The solid waste is largely biological waste from filtration, osmosis and cleaning. All of the biological waste is suspended in water. It is filtered and the waste water then undergoes biological degradation at a WWTP. The waste water contains solids, detergent and disinfectants from cleaning vehicles and equipment, such as centrifuges. The solids are incinerated or landfilled. The sludge from the WWTP is rich in protein and can be composted with other materials.

4.3.2.4 Feather processing

Receipt and storage

Feathers and bristles are collected regularly from the slaughterhouse, usually at the end of the day's slaughter. Feathers are usually received in covered trailers and the same controls are applied as for raw materials related to rendering.

Feather and hair/bristle processing

Feathers or hair/bristles are treated separately in a dedicated plant to manufacture a meal product. There are several feather and hair/bristle meal plants in the sector. These materials generally require different process equipment to rendering. The principles are the same, i.e. the application of heat to evaporate moisture and/or a pressure step if required by the ABP Regulation. An example process flow diagram for a feather meal plant is shown in Figure 4.10. Feather and hair/bristles are sometimes processed into hydrolysed proteins in a similar manner.

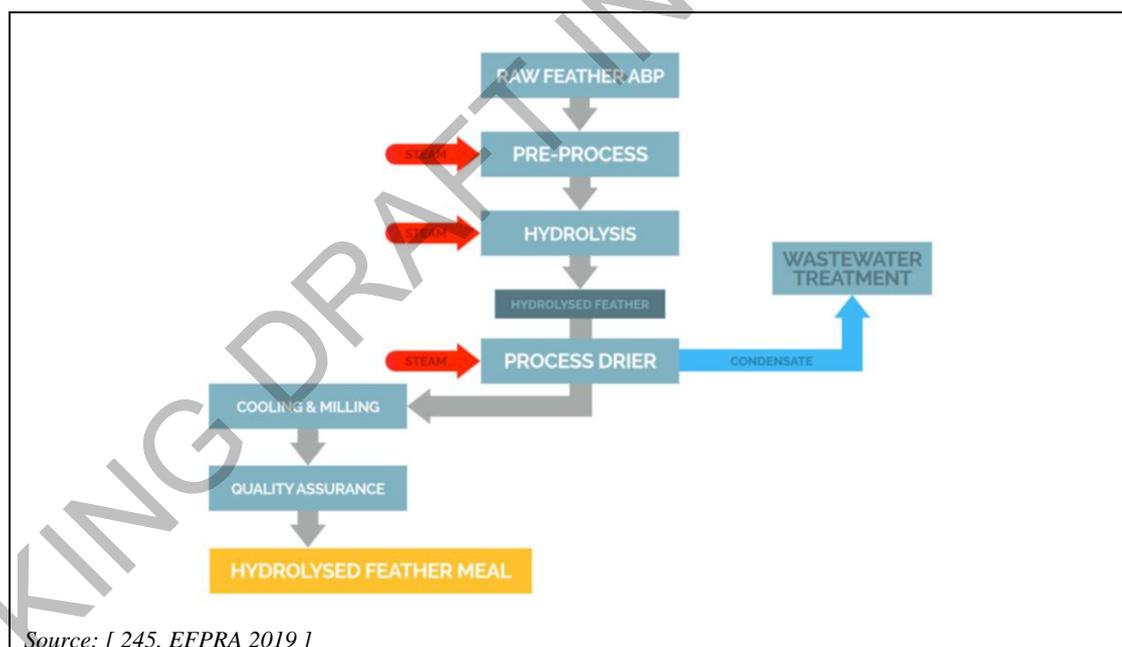


Figure 4.10: Typical process flow for a feather meal plant

Feather and hair/bristle meal manufacture

The raw material handling stages are essentially the same as for rendering. Feathers or hair/bristles are fed from raw material hoppers via conveyors into the hydrolyser which fluidises and hydrolyses them by applying steam and pressure at the regulatory approved method rate. Single-pass hydrolysers provide heating and fluidising of the feather or hair/bristle substrate at elevated temperatures while mixing to effect uniform hydrolysis. The sterilisation can take place in the hydrolysis stage or in the drying stage.

The hydrolysed material is distributed as a feed or fertiliser product for example. Alternatively, it can be further processed by pressing (pressed feathers have approximately 62 % water

content) and then drying into meal. The dried material is milled to the desired product specifications before packing or bulk distribution.

Feather water from the press is collected and is either tankered away and injected into land or reprocessed via an evaporative condenser and fed back into the dryer to recover more product. The process equipment is usually fully enclosed and all process waste gases are treated in an odour abatement unit.

Rendering of Feathers and pig hair

The first stage of feathers rendering and pig hair is hydrolysis, to release keratin. Keratin is an indigestible protein. The hydrolysed protein is then dried, to produce a digestible high protein meal. Before the ban on the use of certain animal proteins in animal feed this could be sold separately, but it was normally mixed with other types of meal and used as a protein concentrate.

Pig hair and feathers are treated separately, as the conditions (temperature/time) for a suitable hydrolysis of the two products are different. A more powerful heat treatment is required to “open” pig hair.

The processes can be carried out in batches in dry rendering cookers, where the keratin containing material is exposed to high temperature (135–145 °C) and pressure for 30–60 minutes. The pressure is then released and the product is dried and milled. This can eliminate the need for mechanical dewatering.

Special rendering equipment is also available for the continuous hydrolysis of feathers and/or hair. The material is transported in small batches to a compression chamber, where it is preheated and then to the hydrolysis unit, where it is treated with direct steam under suitable pressure conditions for a shorter period (normally 10–15 minutes). The hydrolysed material leaves the reactor at the bottom. Part of the water is then removed in a decanter. An evaporative unit is used for the concentration of the liquid phase. The dewatered product is dried separately or with other rendering products. [134, Nordic States, 2001]

The process for rendering feathers and pig hair is summarised in Figure.

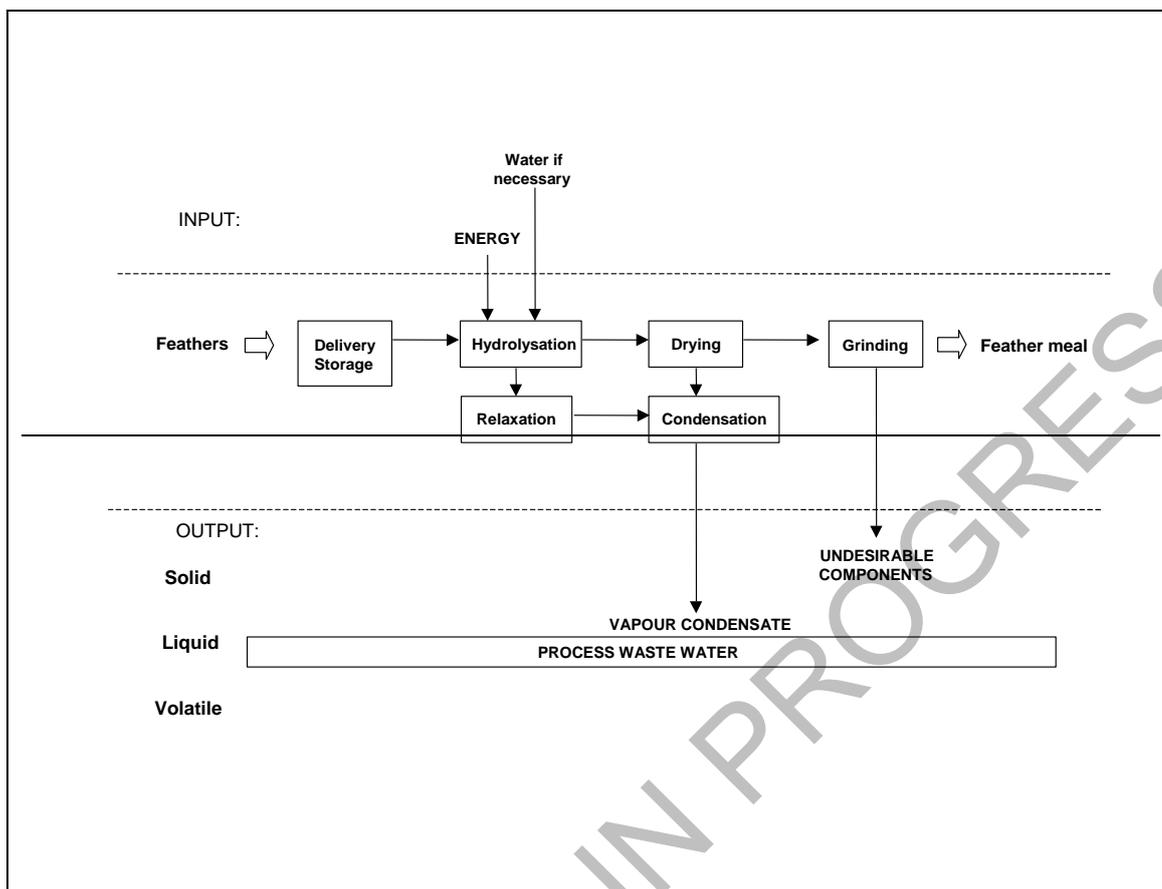


Figure: Flow diagram for the rendering of feathers and hair
[163, German TWG Members, 2001]

Feathers (and hair) processing produce high sulphide emissions in the waste water. The removal of H_2S is, therefore, important as the sulphide can impair the activated sludge activity and thus the biological waste water treatment process. [163, German TWG Members, 2001]

For waste water with high sulphide concentrations, for instance the part streams from the feathers processing, another preliminary treatment target is the reduction of the H_2S concentrations. Contents from about 80–100 mg/l of sulphide will impair the activated sludge biocoenosis and thus the subsequent biological treatment process. Hydrogen peroxide may be used for the treatment of sulphide containing waste water. To oxidise 1 kg sulphide stoichiometrically, about 13 litres of 30 % hydrogen peroxide are needed. The reaction time is about 10 minutes. [163, German TWG Members, 2001]

Bone processing

The flow chart in Figure summarises bone processing.

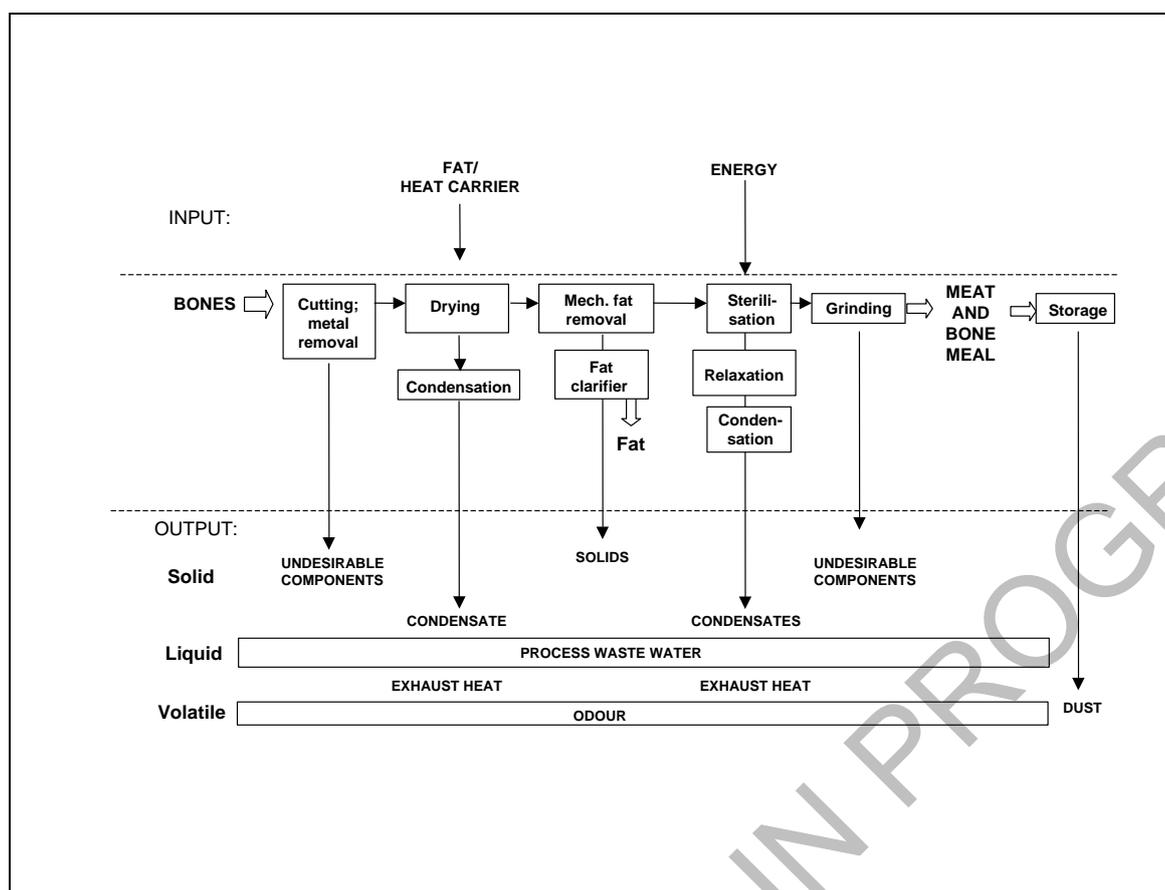


Figure : Flow diagram for bone processing
 [163, German TWG Members, 2001]

4.3.2.5 Odour abatement systems

4.3.2.5.1 General concepts

The malodorous emissions arise from gaseous emissions. These include highly concentrated process gases and vapours from the cooking operation and associated ductwork transferring the gases to the odour abatement plant. Odour emissions also arise from discharges from cookers, presses and/or centrifuges receiving hot rendered material for separation and hot separated materials en route to storage. Other sources include the displacement of malodorous air from the tallow storage tanks; the cleaning of process equipment; fugitive emissions from process buildings and the operation of an odour arrestment plant beyond its design specification. They also arise from liquid effluents, including the following: accumulated liquid at the base of the raw material transport containment and on-site storage hoppers; material spillages and floor washings; cooler condensate; the by-products of abatement techniques and treatment/effluent holding tanks. The storage and handling of animal meal and tallow can also cause odour problems. [241, UK, 2002] [107, United Kingdom 2002]

The proteins and enzymes in ABP undergo thermal and chemical decomposition over time and can produce a range of compounds which may include [245, EFPR 2019]:

- sulphurous compounds, e.g. hydrogen sulphide, mercaptans and organic sulphides;
- nitrogenous compounds, e.g. ammonia, amines and amides;
- oxygenated compounds, e.g. ketones, esters, alcohols, aldehydes and acids;
- aliphatic and aromatic compounds, e.g. oils and fats.

Many of these compounds, such as hydrogen sulphide and mercaptans, have very low odour thresholds and can be readily detected by human receptors, even when present in very low

concentrations in the environment. Most people are likely to find such odours very offensive and the degree of offensiveness will vary with the intensity of the odour. Exposure to these odours for even a short period may lead to the human receptor making a complaint.

Cooker operating temperatures are specified by the approved cooking method and maintaining the cookers within the approved range, i.e. avoiding cooking at higher temperatures, will minimise odour generation.

The control of odour is best achieved by a hierarchy of full containment in well-sealed process equipment, with local exhaust ventilation to primary abatement, typically thermal oxidation with or without pretreatment in condensers (but other techniques are used and suitable). Treating this smaller volume of concentrated odorous air in primary abatement is easier and cheaper than dealing with large volumes of lower-intensity odour.

However, some odour release into the buildings is inevitable, particularly the raw material reception buildings, and therefore some room air extraction is necessary. Odorous building air is usually extracted into ducting leading into an odour abatement unit using a series of fans. The ongoing energy costs associated with extracting building air and its abatement are high.

In addition, air is often drawn into buildings, particularly raw material buildings, to provide cooling and to remove noxious hydrogen sulphide and ammonia gases to control workplace safety. This may be passive or dynamic but either way it increases the volume of air that requires treatment for odour removal, adding to the energy consumption of the fans.

The main issues to be considered in the design of an effective odour control system include the following [245, EFPA 2019]:

- Equipment must be well sealed to prevent the release of high-intensity odour and excessive heat to buildings.
- Where point sources of odour are connected to abatement systems, the ventilation system should be designed to minimise the air volumes handled, i.e. low flow / high concentration. However, the local extraction rates must be high enough for efficient capture at the place where the odour is generated.
- During process or abatement plant interruptions, such as cooker faults, a controlled shutdown should be instigated and backup abatement systems employed if necessary. Removal of the heat to the cooker will reduce the temperature of the material inside the cooker and halt the production of non-condensable gases. This can prevent the build-up of odorous gases and potential fugitive releases into the building. Excess steam should be directed to other process applications where possible and only vented to atmosphere in an emergency.
- Where backup odour abatement systems are in place they should be immediately available in case the primary abatement unit goes offline.
- The air extraction systems should be checked and maintained regularly to ensure that sufficient air changes per hour are achieved. A well-balanced, effective extraction system should ensure there is minimal escape of air from the building.

4.3.2.5.2 Condensers

Malodorous emissions which arise from the processing of animal by-products develop and are emitted from a variety of sources. Concentrated emissions, such as vapours and non-condensable gaseous products, are emitted directly from cookers. These are captured directly from cookers and/or by the extraction equipment over presses.

In a typical rendering odour abatement system, high-intensity cooking vapours are passed through a condenser(s) to separate condensable and non-condensable gases. The vapour from cookers and meal presses can be extracted and ducted to an air-cooled condenser for example.

Drop-out pots situated within the ducting, upstream of the condensers, remove solid material entrained in the gas stream. The condensers reduce the temperature of the extracted vapour stream and condense out the aqueous fraction and some organic compounds. Where this is done, the non-condensable gases are passed for further abatement (e.g. thermal oxidation) and the condensate is either treated on site in a waste water treatment plant or at an off-site plant [[245, EFRA 2019](#)].

High-efficiency condensers (chilled water condensers / glycol systems) can increase condensing performance and the residual air may be suitable for abatement in a biofilter or chemical scrubber rather than using energy-intensive thermal oxidation.

See also Section 2.3.8.2.10.

4.3.2.5.3 Thermal oxidation

Highly odorous cooking vapours can be effectively destroyed by thermal oxidation with high odour removal efficiencies. The gases can be extracted into the combustion chamber of a thermal oxidiser or passed through a condenser to remove the condensable fraction and the non-condensable gases passed to the combustion chamber of a boiler or incinerator.

Where an oxidiser is also used for process steam production, it is important that there are controls in place to prevent the reduction or loss of incineration capacity when the process steam demand falls. This is also true for boilers. These will usually comprise diversional controls to other process areas or to atmosphere and will prevent spikes of high-intensity odour overloading secondary systems. Standby or alternative systems should be separate from the process demands to maintain treatment capacity in abnormal circumstances.

It is important in facilities using a condenser-boiler configuration that the temperature within the boiler combustion zone is maintained to ensure adequate destruction of the odorous emissions. In some cases (start-up/shutdown), this may lead to steam release until the minimum temperature is achieved to avoid incomplete odour destruction in the boilers [[245, EFRA 2019](#)].

See also Section 2.3.8.2.13.

4.3.2.5.4 Biofilters

Biofilters are normally used for abating lower-intensity odours such as extracted building air. They are a form of biological treatment which is achieved by the metabolism of organic compounds to non-odorous products - a biological oxidation process which consumes carbon (from organic contaminants in the gas stream) and oxygen, giving rise to carbon dioxide, water and biomass. Intermediate products may be acidic.

The bacteria require a continual feed of organic material and are therefore most effective when treating a consistent air stream. They will hibernate during periods where no foul air is being supplied and if such periods extend for several days, bacteria die-off may occur or the pick-up in performance will take time. Bacteria also struggle to deal with spikes of intense odours, e.g. during extreme conditions such as sudden very hot or very cold weather or shock loading with high-intensity inlet air, and such periods may cause bacterial die-off and a marked reduction in the treatment capacity of the biofilter until bacteria recover. Recovery may require reseeded.

Biofilters usually have concrete walls or walls made from wooden slats covered with plastic and have concrete slats over a void space (plenum chamber). The filter media are housed above a plastic mesh sheet covering the slats to prevent the media falling through the slats and blocking the drainage outlets. The odorous air is pretreated, drawn through a humidifier unit or water

scrubber by large fans where high-pressure water is sprayed directly into the flow of the air to remove any solid particles. The air is then forced underneath the biofilter and it passes up through the media where the bacteria break down the odorous compounds. Leachate collects in chambers under the beds and is sent to an on-site waste water treatment plant or off site for treatment [245, EFRA 2019].

See also Section 2.3.8.2.8.

4.3.2.5.5 Chemical scrubbers

Chemical scrubbers are an alternative or addition to biofilters and are a good option where limited space is available. They are mostly used for abating lower-level odours such as extracted building air but can be used for treating more odorous process air, either as a standby system or as the primary treatment.

Multi-stage scrubbing is usually specified for the more complex odour streams from animal by-product processors and is often combined with an initial venturi scrubber for dust removal and a final polishing dry media filter for insoluble VOC removal.

The incoming gas stream to be treated is met by an opposing stream of neutralising reagent, which falls from spray nozzles in the different sections of the scrubber. The sections below the spray nozzles are packed with a medium, usually plastic, designed to give a maximum surface area of contact between the reagent and the gas stream to ensure the maximum abatement is achieved [245, EFRA 2019].

See also Section 2.3.8.2.11.

4.3.2.6 Sludge management options

Sludge from a biological WWTP can be managed on site or off site, depending on the market demands around the rendering plant.

Sludge categorised as Category 1 can be reused in the meal processing line. This technique requires the separation of process and other waste water streams (e.g. from sanitary facilities, canteens, social rooms, offices, etc.) in order to reuse excess sewage sludge and filter material from the WWTP in the production of animal by-products [198, Waxwender et al. 2016].

Sludge from the WWTP can also be dried by recovering heat from the installation; the dried sludge can be sent off site for combustion and recovery of phosphorus from the ashes [271, Karlis et al. 2020].

Sludge generated from waste water that has been in contact with Category 1 material can be treated as Category 1 ABP and sent to ultrafiltration. The liquid phase ($\approx 35\%$ of waste water generated) is reused in the installation for cleaning, truck washing, steam production and cleaning of the reverse osmosis systems for boilers; the solid phase can be sent off site to incineration [240, Karlis et al. 2019].

4.3.3 Current emission and consumption levels

4.3.3.1 Energy consumption

4.3.3.1.1 Dry rendering installations

Data from installations applying only dry rendering of animal by-products and/or edible co-products (rendering, fat melting, blood and feather processing) are presented in this section.

Figure 4.11 shows data on total specific net energy consumption in terms of kWh/tonne of raw material at installation level, as well as the applied techniques to reduce energy consumption.

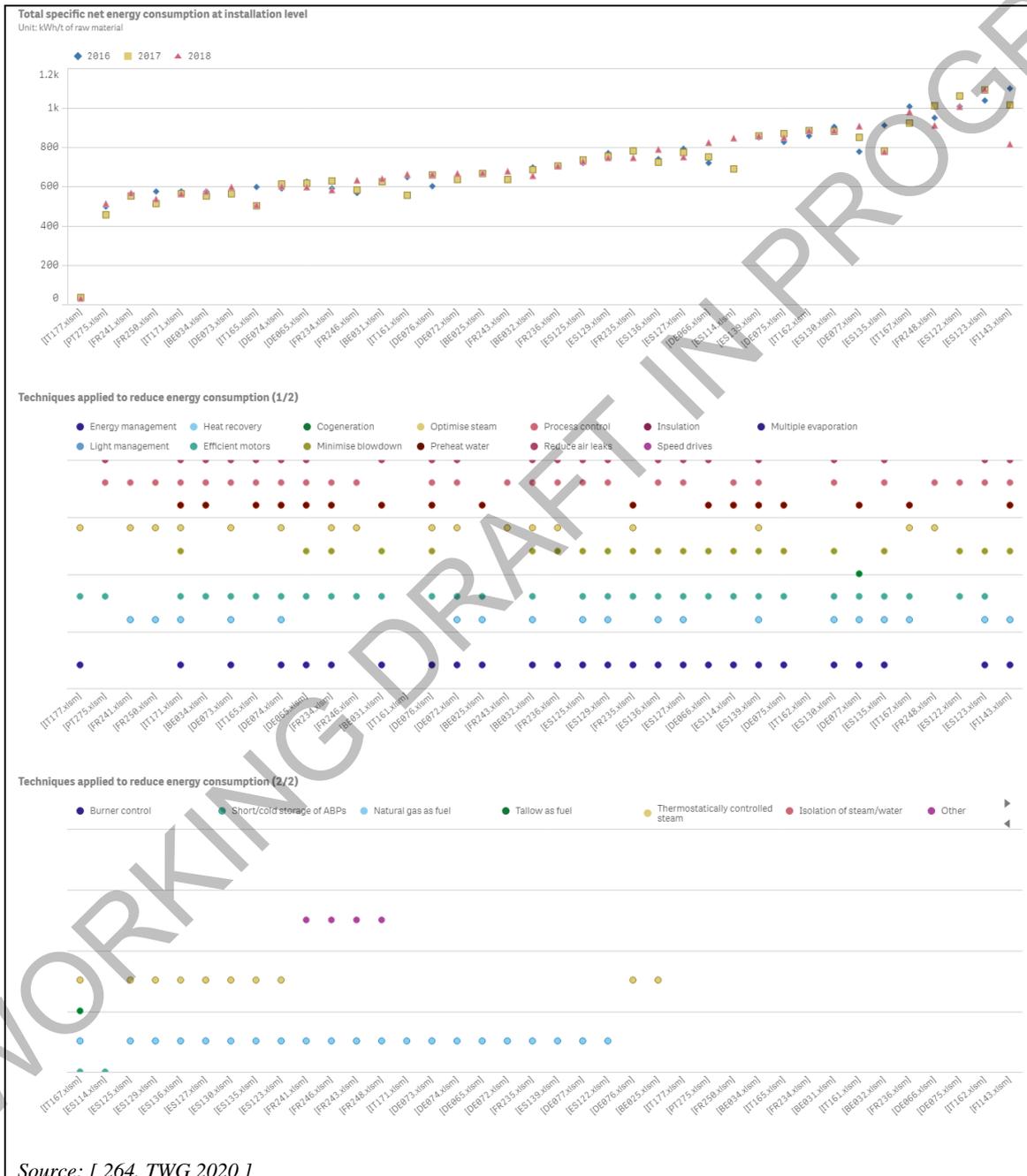


Figure 4.11: Specific energy consumption (kWh/tonne of raw material) and applied techniques to reduce energy consumption in dry rendering of animal by-products and/or edible co-products (installation level)

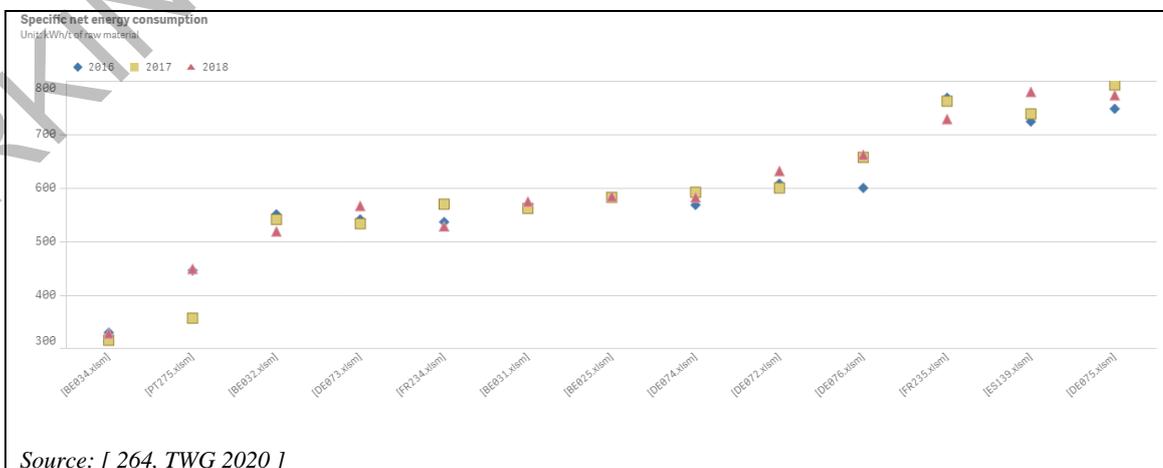
Figure 4.12 shows data on total specific net electricity and heat consumption in terms of kWh/tonne of raw material at installation level.



Source: [264, TWG 2020]

Figure 4.12: Specific electricity and heat consumption (kWh/tonne of raw material) in dry rendering of animal by-products and/or edible co-products (installation level)

Figure 4.13 and Figure 4.14 show the specific net energy consumption (in kWh/tonne of raw material) in some processes in dry rendering (rendering, fat melting, blood and feather processing) of animal by-products and/or edible co-products.



Source: [264, TWG 2020]

Figure 4.13: Specific energy consumption (kWh/tonne of raw material) for drying and cooking/sterilisation in dry rendering of animal by-products and/or edible co-products

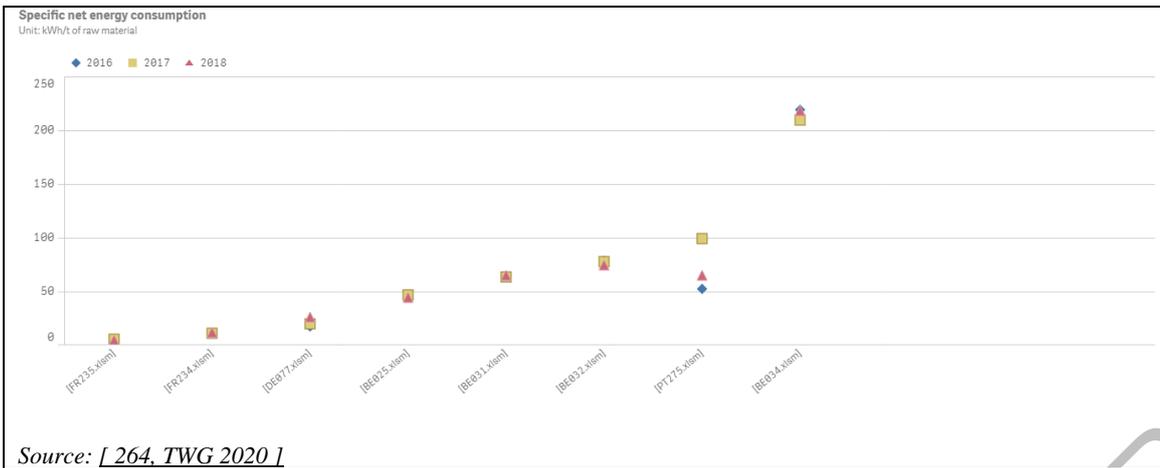
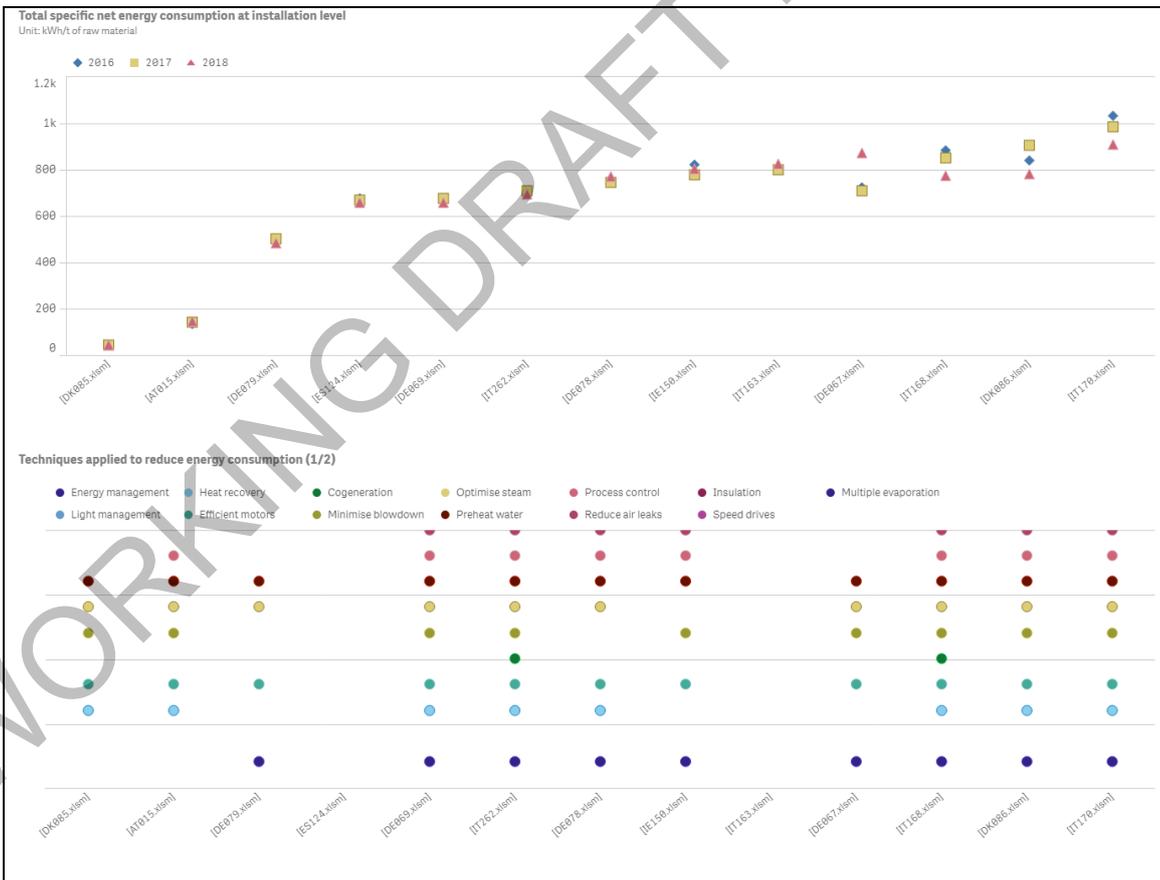


Figure 4.14: Specific energy consumption (kWh/tonne of raw material) for waste gas treatment in dry rendering of animal by-products and/or edible co-products

4.3.3.1.2 Wet rendering installations

Data from installations applying only wet rendering of animal by-products and/or edible co-products (rendering, fat melting, blood and feather processing) are presented in this section.

Figure 4.15 shows data on total specific net energy consumption in terms of kWh/tonne of raw material at installation level, as well as the applied techniques to reduce energy consumption.



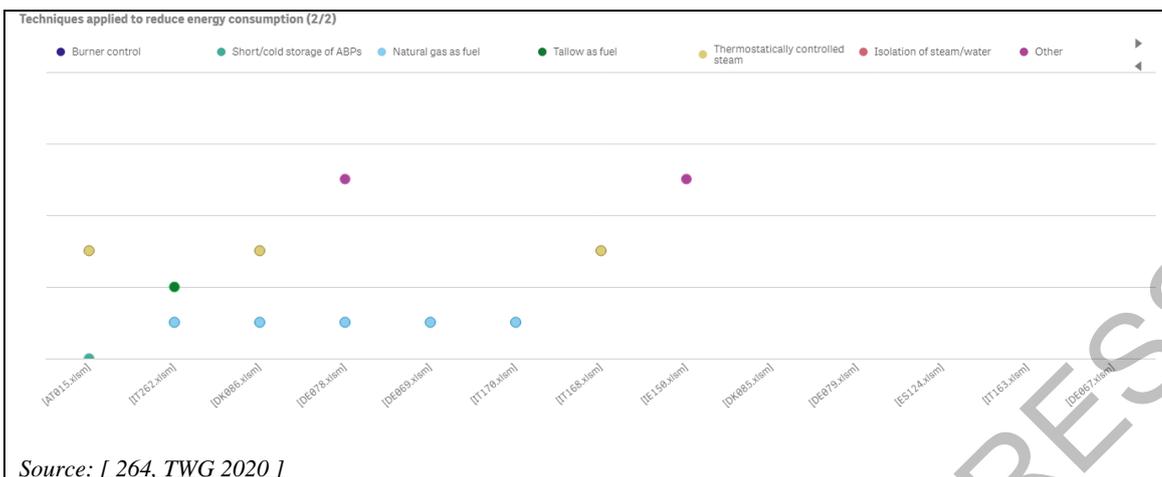


Figure 4.15: Specific energy consumption (kWh/tonne of raw material) in wet rendering of animal by-products and/or edible co-products (installation level)

Figure 4.35 shows data on total specific net electricity and heat consumption in terms of kWh/tonne of raw material at installation level.



Figure 4.16: Specific electricity and heat consumption (kWh/tonne of raw material) in wet rendering of animal by-products and/or edible co-products (installation level)

The energy and heat consumption for this process has been reported as shown in Table.

Electricity consumption	approximately 75 kWh per tonne of raw material
Heat consumption	approximately 775 kWh per tonne of raw material
Excluding odour abatement and waste water treatment (approximately an additional 20 kWh) Feedstock unspecified	

Table : Energy consumption for a dry rendering process
[134, Nordic States, 2001]

Details of the energy consumption for a plant using the “Atlas” rendering process are given in Table.

The plant processes 310000 tonnes of raw materials per year, using the Atlas wet rendering process. Meal and fat are sterilised at the end of the process. Pig hair is hydrolysed in a continuous process and decanted. The grax is mixed with the press cake, before drying and the liquid phase is mixed with the stickwater from the Atlas system for final processing. A minor part of the concentrate is separately spray dried.

Energy consumption	Process	heat energy kWh	% of total heat	electricity kWh	% of total electricity
In-process	Grinding, coagulation, pressing	83	17.0	13.1	16.5
	Drying	250	51.3	8.4	10.6
	Meal sterilisation	43	8.8	1.6	2.0
	Heating of press liquid	22	4.5	1.9	2.4
	Vacuum evaporation	11	2.3	5.0	6.3
	Fat treatment	14	2.9	0.6	0.8
	Heating of concentrate	9	1.8	0.6	0.8
	Milling plant			6.6	8.3
	Spray drying	47	9.7	9.5	12.0
	Hydrolysis of hair	3	0.6	1.1	1.4
		Total – process	482	99	48.5
For secondary purposes	Odour abatement			10.3	13.0
	Cooling towers			5.6	7.1
	Waste water cleaning			7.1	8.9
	Compressed air			1.4	1.8
	Water boring and preparation			0.1	0.1
	Other common systems			5.8	7.3
	Heating of buildings, hot water	0.5	0.1	0.6	0.6
	Heating of buildings, heated by waste energy	4.4	0.9		
	Total – secondary uses	4.9	1	30.9	39
	Total energy consumption	487	100	79.4	100

Table: Energy consumption for a plant using the “Atlas” rendering process
[221, Hansen P.I., 2001]

Drying consumes about 2/3 of the energy demand of a rendering plant. [163, German TWG Members, 2001]. The most efficient means of saving energy in rendering is to utilise heat from the evaporated water. This can be achieved by simple heat exchange, e.g. using a multiple-effect evaporator. [243, Clitravi – DMRI, 2002, 271, Casanellas J., 2002]

The figures reported from Finland are shown in Table. The total energy consumption is higher than that reported from the Nordic States.

It is difficult to meaningfully compare consumption and emission data without full details of the process. Rendering techniques vary between the wet and dry process, but also, e.g. depending on whether sterilisation is undertaken as a separate step or incorporated into the cooking/drying

process and on whether presses or centrifuges or a combination of both are used to separate the tallow meal and residual water.

Electricity consumption	65–72 kWh per tonne of raw material
Heat consumption	850–910 kWh per tonne of raw material
Heat recovery	≤170 kWh per tonne of raw material

Table: Energy consumption data from Finnish rendering plants
[148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001]

Table shows the comparison of energy consumption for 2 rendering systems, i.e. System 1—The Atlas rendering system (continuous, defatted, with post sterilisation) and System 2—Pre-sterilisation, followed by continuous drying in added fat and pressing in a screw press.

System	Raw materials processed (t/yr)	Total heat energy (kWh/t)	Electricity for process (kWh/t)	Electricity for environmental measures (kWh/t)	Total electricity (kWh/t)
1	310000	487	55	24	79
1	175000	456	77	14	91
2	65000	986	54	14	68

System 1—Atlas rendering system (continuous, defatted, with post sterilisation)
System 2—Pre-sterilisation, followed by continuous drying in added fat and pressing in a screw press

Table: Comparison of two types of rendering systems
[221, Hansen P.I., 2001]

Table summarises some energy consumption and emission data for rendering plants. It does not state whether the installations were undertaking wet or dry rendering or, give details about the rest of the process, such as what separation techniques were used. The data applies to UK installations where, unlike other countries, separate high pressure sterilisation is not carried out.

Energy (kWh/t of carcase or part of)	Minimum	Average	Maximum
Electricity consumed (in)	45.70	84.70	120
Electricity generated (out) ⁽⁴⁾		130	
Heat consumed (in)	440	690	906
Heat recuperated/produced (out)	71.40	111	163

⁽⁴⁾ Data for energy generated from on-site CHP facility
— Type of process and feedstock unspecified

Table: Summary of energy data from rendering plants
[144, Det Norske Veritas, 2001]

The most efficient means of saving energy in rendering is reportedly to use heat from the evaporated water. This can be done using, e.g. heat exchangers or multiple effect evaporators.

4.3.3.2 Water consumption

Figure 4.17 and Figure 4.18 show reported data on specific water consumption in m³/tonne of raw material from rendering of animal by-products and/or edible co-products (rendering, fat melting, blood and feather processing) at installation level.

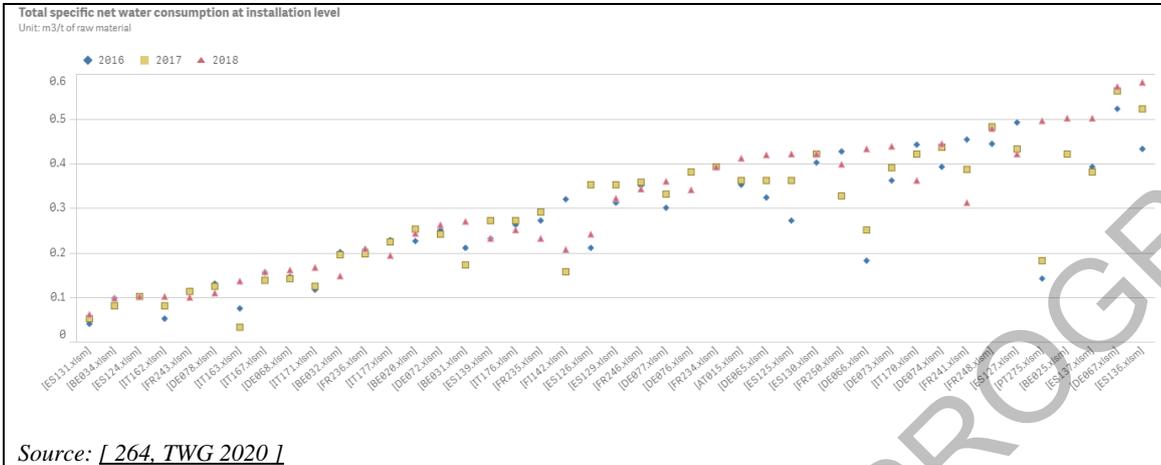


Figure 4.17: Specific water consumption (m³/tonne of raw material) in rendering of animal by-products and/or edible co-products (installation level) (Part 1 of 2)

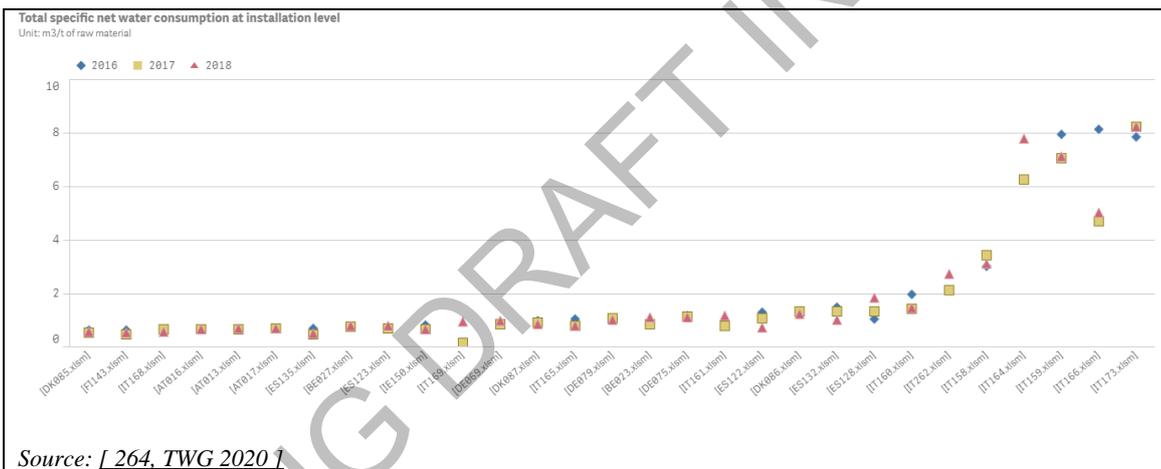


Figure 4.18: Specific water consumption (m³/tonne of raw material) in rendering of animal by-products and/or edible co-products (installation level) (Part 2 of 2)

Figure 4.19, Figure 4.20 and Figure 4.21 show the specific net water consumption (in m³/tonne of raw material) for several specific processes in rendering of animal by-products (rendering, fat melting, blood and feather processing).

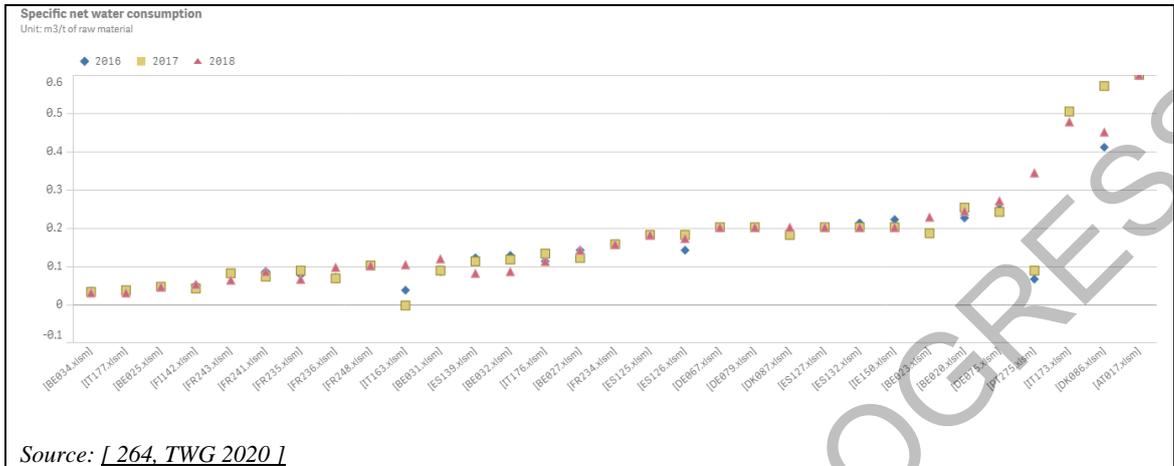


Figure 4.19: Specific water consumption (m³/tonne of raw material) for boilers in rendering of animal by-products and/or edible co-products

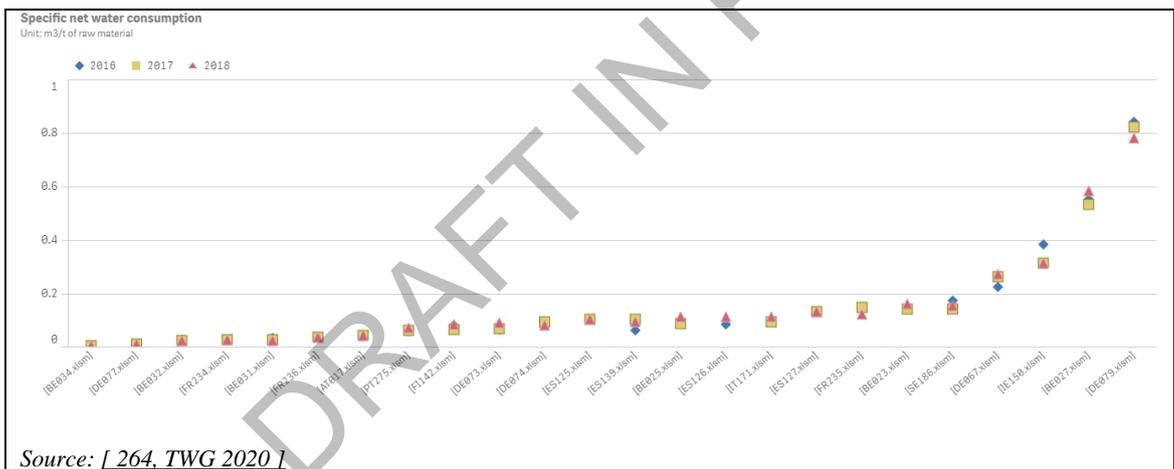


Figure 4.20: Specific water consumption (m³/tonne of raw material) for cleaning of floors/walls and equipment in rendering of animal by-products and/or edible co-products

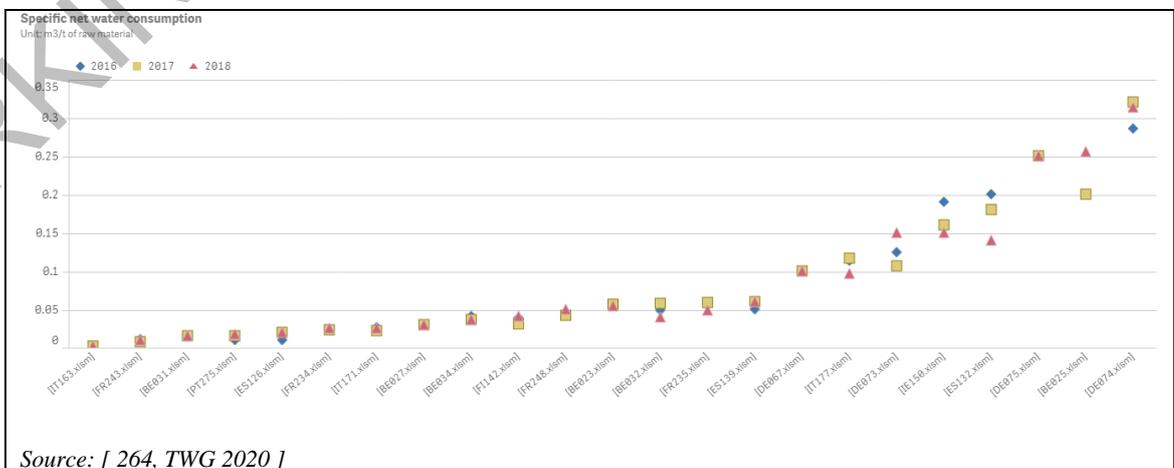


Figure 4.21: Specific water consumption (m³/tonne of raw material) for vehicle washing in rendering of animal by-products and/or edible co-products (rendering, fat melting, blood and feather processing)

The water consumption from unspecified rendering processes has been reported to be 500–1000 l/t of raw materials. Consumption is divided as follows: condensers consume 200–500 l/t; boilers 150–200 l/t and cleaning 200–300 l/t. [134, Nordic States, 2001]. In Finland the reported water consumption is 440–510 l/t, with about 30–40 % consumed by boilers [148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001].

4.3.3.3 Emissions to water

Figure 4.22 and Figure 4.23 show reported data on specific waste water discharges in m³/tonne of raw material from rendering (rendering, fat melting, blood and feather processing) of animal by-products and/or edible co-products and all types of discharges. The applied techniques for reducing water consumption are also shown.

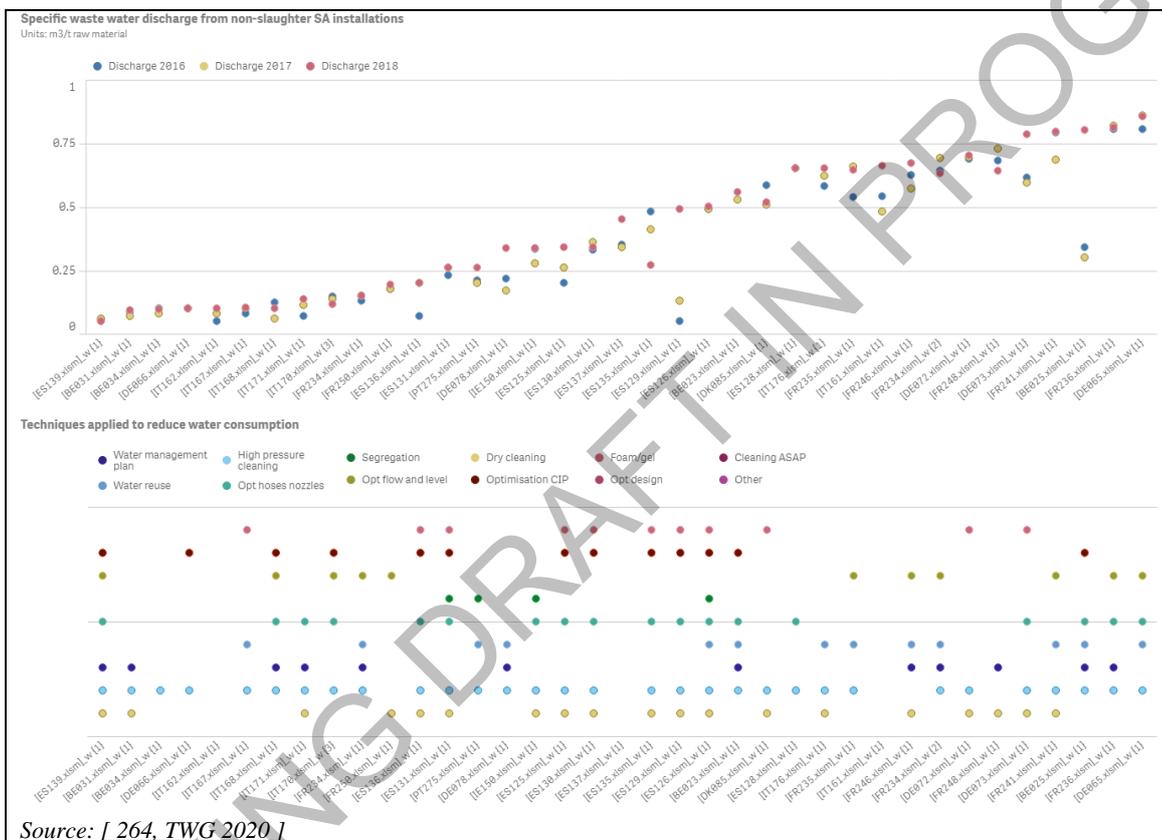


Figure 4.22: Specific waste water discharge (m³/tonne of raw material) and applied techniques for reducing water consumption in rendering of animal by-products and/or edible co-products for all types of discharges (Part 1 of 2)

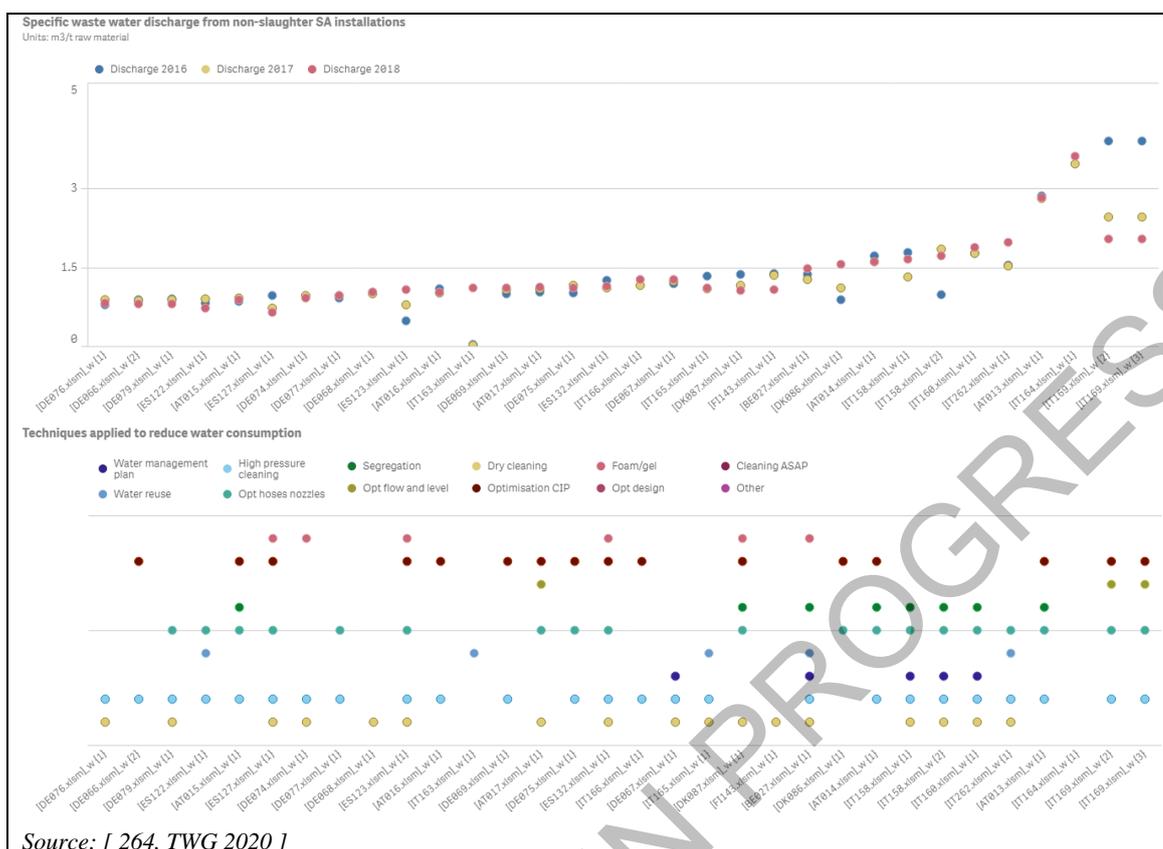


Figure 4.23: Specific waste water discharge (m³/tonne of raw material) and applied techniques for reducing water consumption in rendering of animal by-products and/or edible co-products for all types of discharges (Part 2 of 2)

For every tonne of raw materials used 1 000 – 1 500 litres of waste water is produced, including approximately 600 litres in the form of condensate, i.e. water evaporated from the raw materials. The waste water comprises the following: production waste water; rinsing water from the vehicles and raw material storage; the water fraction from mechanical blood separation; vapour condensate from sterilisation and drying and from abatement techniques, such as seeping water from a biofilter. [163, German TWG Members, 2004] [52, Germany 2001]. The composition varies a lot depending on the process and the freshness of the feedstock. On average, one tonne of raw material is reported to produce 5 kg of COD, 600 g of nitrogen [134, Nordic States, 2004] [38, Nordic 2001] and 1.65 kg of solids [144, Det Norske Veritas, 2001] [44, Det Norske Veritas 2001], before waste water treatment.

50 - 90 % of the waste water contamination originates from the vapour condensate. If wet rendering is undertaken, there will be a higher volume of contaminated waste water produced. Breakdown products of degradation of the raw material are conveyed into the waste water through the vapours from sterilisation and drying of the material. The amount of water pollutants expelled during processing is less for fresh animal by-products than for raw materials that have been allowed to decompose. [163, German TWG Members, 2004] [52, Germany 2001]

The main components among the pollutants are: organic acids, particularly acetic acid; propionic acid; butyric acid and iso-butyric acid but also valeric acid, isocaproic acid and others. They also include ammonia, aliphatic amines, aldehydes, ketones, mercaptans and hydrogen sulphide. [49, VDI, 1996]

Waste water from the cleaning of the “clean side” of the process has a considerably lower load than that from the “unclean side”. This does not increase proportionately with the size of the plant. Waste water from the exhaust air treatment comprises waste water from the process

exhaust air and from the room exhaust air. The treatment can be done together or separately. The waste water from the process exhaust air treatment can be highly loaded with organic components, up to 25 g/l COD; mercaptans ≤ 2 g/l; hydrogen sulphide ≤ 800 mg/l; ammonium nitrogen ≤ 400 mg/l; volatile oils, phenols, aldehydes and others. [163, German TWG Members, 2001] [52, Germany 2001]

Waste water from the lorry cleaning may contain mineral oil, solids and possibly cleaning agents [163, German TWG Members, 2001] [52, Germany 2001].

De-sludging waste water from the evaporators has hardly any organic load, but it may contain phosphorus compounds from any conditioning agents used. It can also have high pH-values, which need to be neutralised. There is also waste water from the de-sludging of the cooling water recirculation. [163, German TWG Members, 2001] [52, Germany 2001]

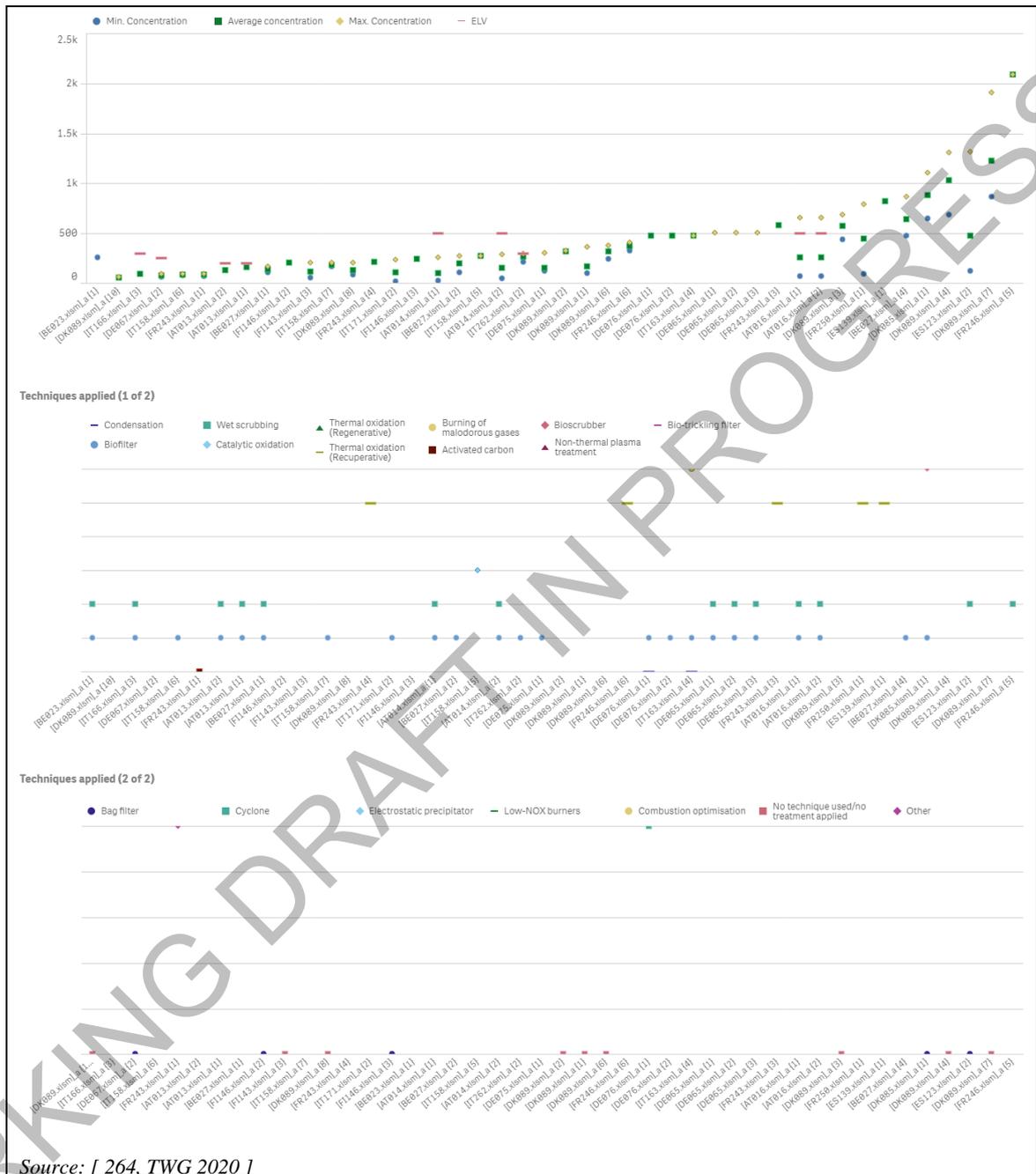
4.3.3.4 Emissions to air

Odour

~~Measurements have shown that average odour concentrations (German) can be 80–800 kOU/kg of raw material. [49, VDI, 1996]. Odour emissions of 108 to 1 010 odour units (Danish) per tonne of raw materials have been reported. [134, Nordic States, 2001]~~

Malodorous compounds may be organic or inorganic. High odour strength is not necessarily associated with high chemical concentrations. Where emissions of different odour intensity are produced within the process, the odour streams may be kept separate and treated by appropriate odour abatement plant. It is possible to build in a facility to ensure that in the event of an odour abatement plant malfunction or breakdown, malodorous air is diverted to an alternative suitable odour arrestment plant. [241, UK, 2002] [107, United Kingdom 2002]

Figure 4.24 and Figure 4.25 show reported data (for the years 2016 to 2018) for channelled emissions of odour, as well as the applied abatement techniques, from rendering, fat melting, blood and/or feather processing.



Source: [264, TWG 2020]

Figure 4.24: Odour emissions (OU_E/Nm³) and abatement techniques from rendering, fat melting, blood and/or feather processing (Part 1 of 2)

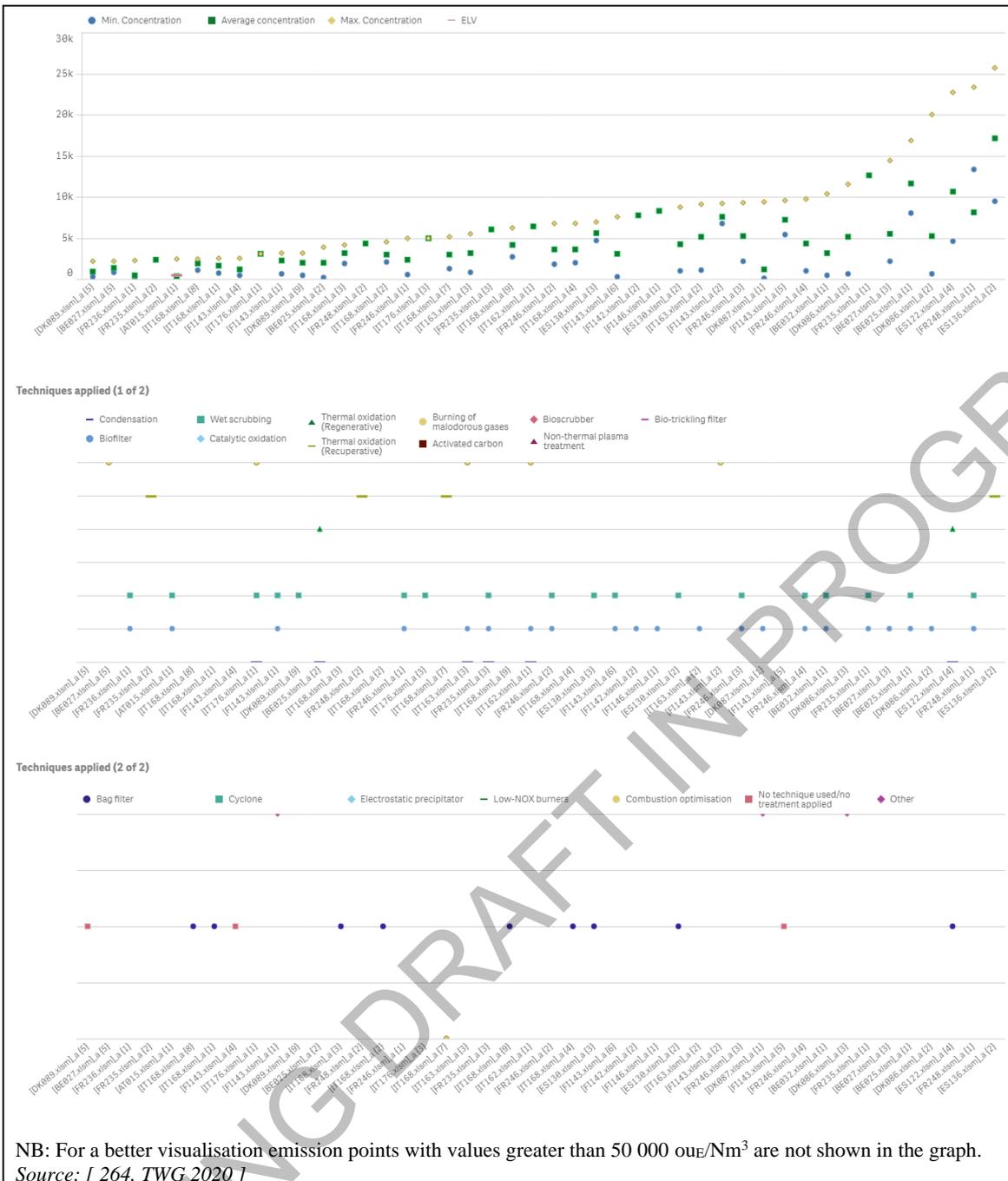


Figure 4.25: Odour emissions (OU_E/Nm^3) and abatement techniques from rendering, fat melting, blood and/or feather processing (Part 2 of 2)

The liquid condensate is pumped to a holding tank, pending on site treatment or disposal or is discharged direct to the WWTP. [241, UK, 2002]. Some non-condensable gases remain. The non-condensable gases and the condensate liquor have a particularly strong and offensive odour. If the odour is not destroyed at source, it can cause problems from within the installation and, for liquor, at the WWTP too. Odour problems may be exacerbated by stirring at the WWTP.

Diluted emissions include “room air”, which has a high air volume low pollutant concentration.

Considerations associated with the abatement of malodorous process gases include variations in flow; variations in the concentration of pollutants; the formation of corrosive condensate in pipework and in cold parts of the plant; oxygen content in the flow to be treated and the necessity for very high odour reduction performances. The choice of the odour abatement

method will depend on the chemical composition of the gases to be treated. Capture and segregation of odours from various sources and unit operations reduces the volume of malodorous gases that might otherwise require treatment. Segregation also ensures that, where appropriate, different techniques can be provided for different emissions and tailored to take into account cross-media issues such as energy consumption and solid waste disposal. [241, UK, 2002]

Feathers and hair consist mainly of keratin, a protein with a very high sulphur content. To “open” it and make it digestible, a number of very stable sulphur links in the keratin have to be broken. This results in a release of volatile sulphur compounds, including H₂S, mercaptans and a number of organic disulphides. These compounds can be found in the non condensable gases from hydrolysis and drying. In addition, ordinary breakdown products from proteins, such as ammonia and amines, will occur. Emissions of non-condensable gases have been measured as up to 1.5 million odour units per m³.

Reported emissions of CO₂, SO₂, NO_x and dust are shown in Table.

Substances emitted	Range of emissions per tonne of unspecified animal by-product treated (kg)
CO ₂	10.2–146
SO ₂	1.2–1.6
NO _x	0.51–0.59
Dust	0.19–0.21

Table: The range of air emissions from two Finnish rendering plants
[148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001]

TVOC

Figure 4.26 and Figure 4.27 show reported data (for the years 2016 to 2018) for channelled TVOC emissions to air, as well as the applied abatement techniques, from rendering, fat melting, blood and/or feather processing.

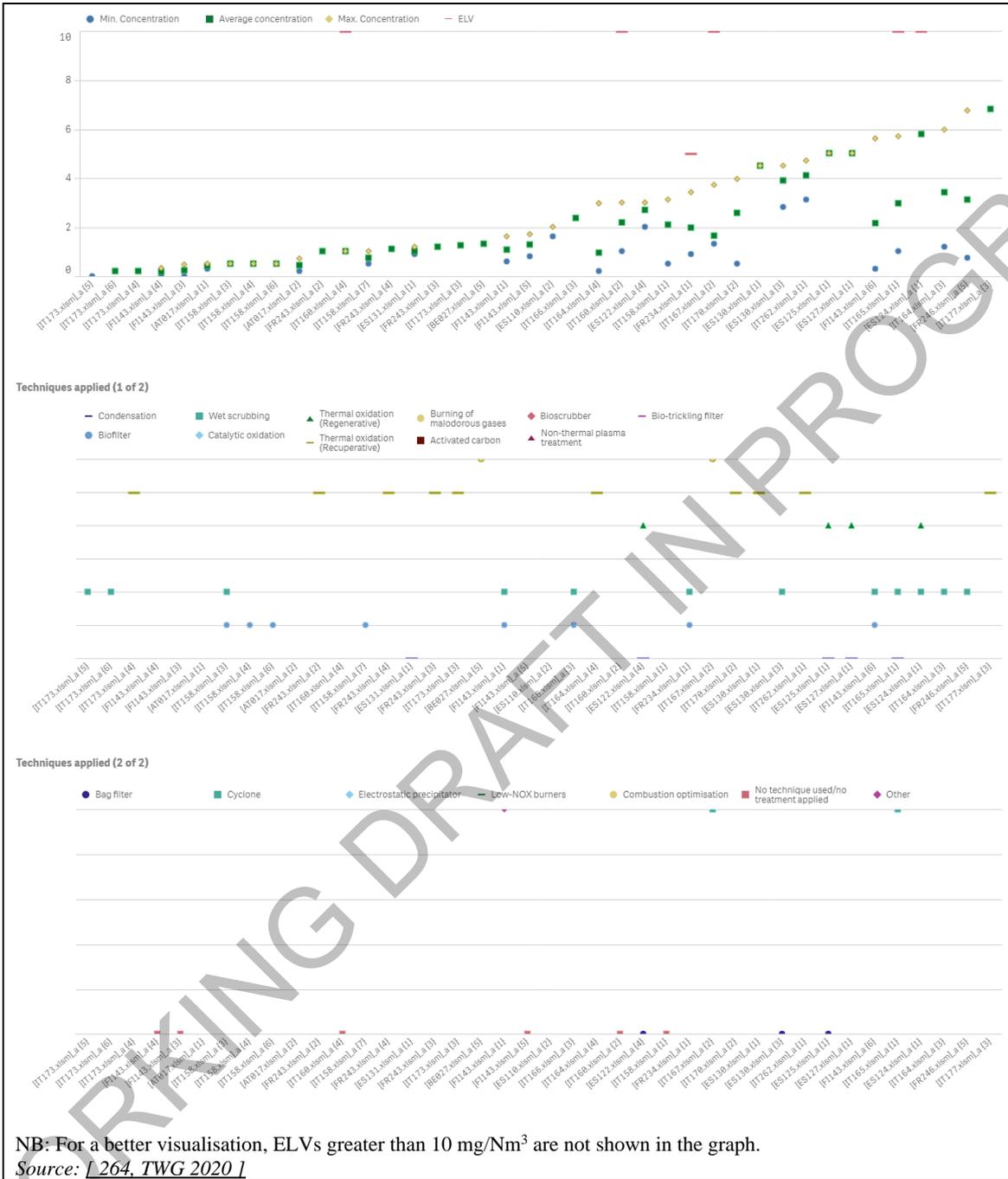


Figure 4.26: TVOC emissions to air (mg/Nm³) and abatement techniques from rendering, fat melting, blood and/or feather processing (Part 1 of 2)

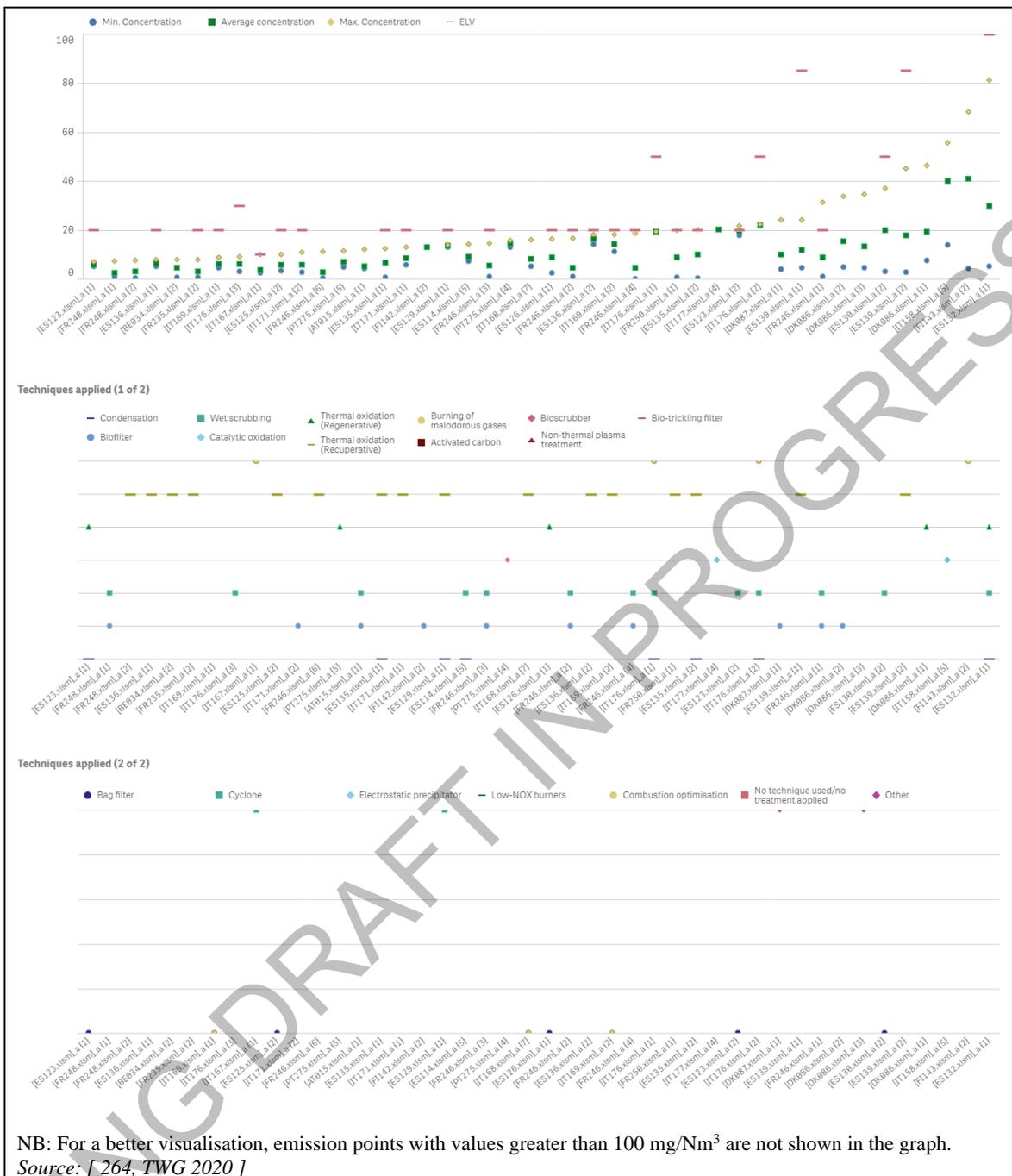


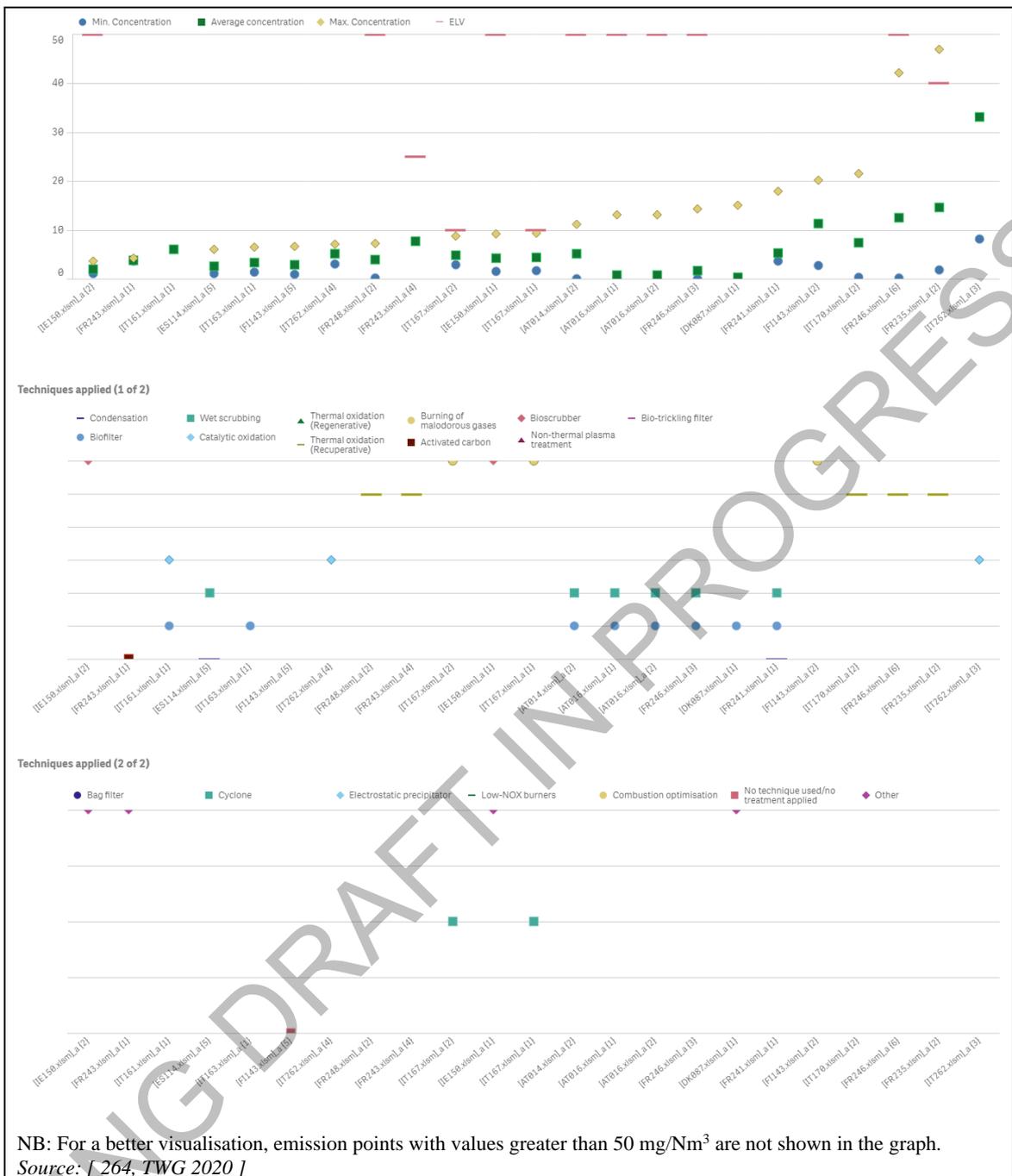
Figure 4.27: TVOC emissions to air (mg/Nm³) and abatement techniques from rendering, fat melting, blood and/or feather processing (Part 2 of 2)

NH₃

Figure 4.28 and Figure 4.29 show reported data (for the years 2016 to 2018) for channelled NH₃ emissions to air, as well as the applied abatement techniques, from rendering, fat melting, blood and/or feather processing.



Figure 4.28: NH₃ emissions to air (mg/Nm³) and abatement techniques for rendering, fat melting and blood processing (Part 1 of 2)



NB: For a better visualisation, emission points with values greater than 50 mg/Nm³ are not shown in the graph.

Source: [264, TWG 2020]

Figure 4.29: NH₃ emissions to air (mg/Nm³) and abatement techniques from rendering, fat melting, blood and/or feather processing (Part 2 of 2)

H₂S

Figure 4.30 and Figure 4.31 show reported data (for the years 2016 to 2018) for channelled H₂S emissions to air, as well as the applied abatement techniques, from rendering, fat melting, blood and/or feather processing.



Figure 4.30: H₂S emissions to air (mg/Nm³) and abatement techniques from rendering, fat melting, blood and/or feather processing (Part 1 of 2)

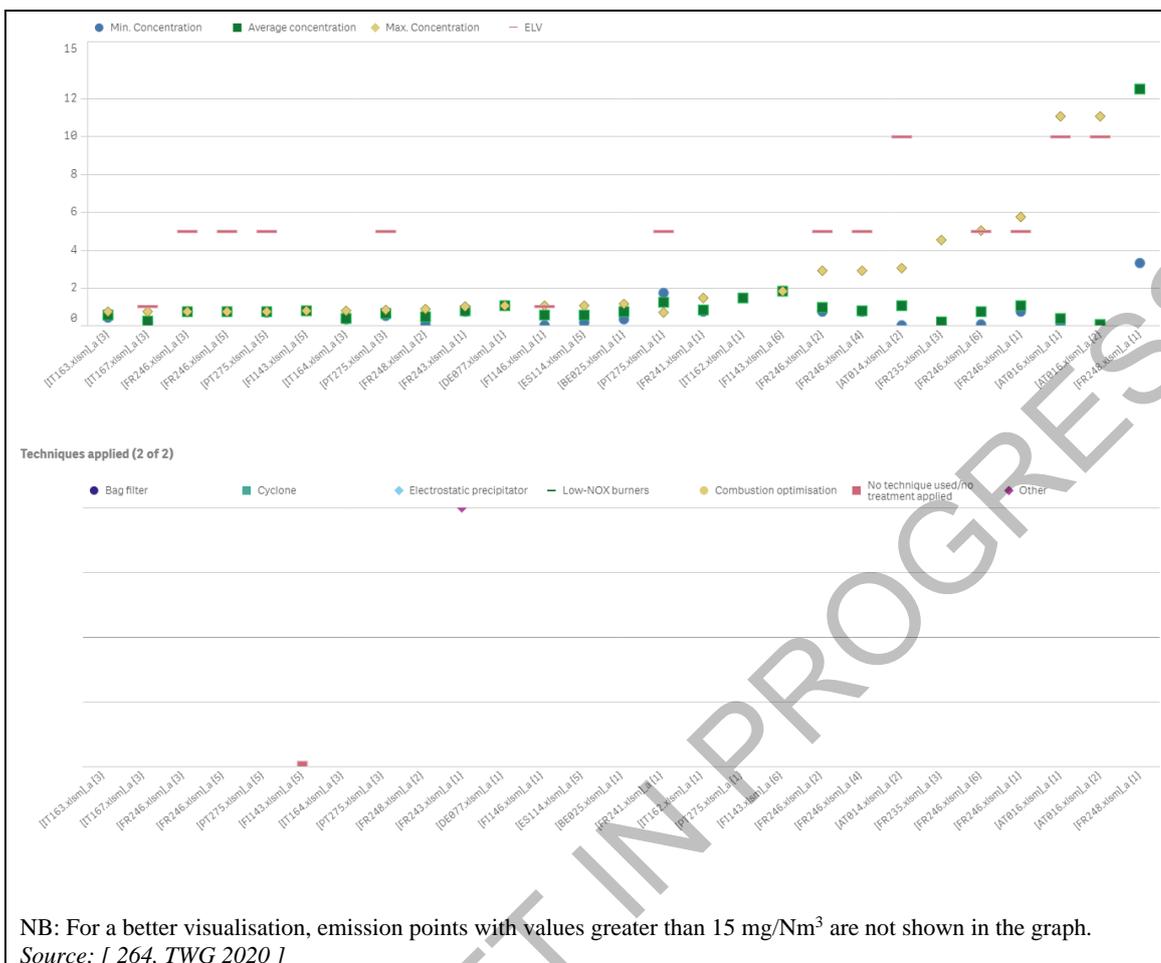


Figure 4.31: H₂S emissions to air (mg/Nm³) and abatement techniques from rendering, fat melting, blood and/or feather processing (Part 2 of 2)

4.3.3.5 Noise and vibration

New plants are usually constructed on the outskirts of towns, at least 1 km from residential areas. The reference noise levels of 60 dB(A) during the day and 45 dB(A) during the night can reportedly be achieved, without particular noise reducing measures. In existing installations close to residential areas significant noise emissions can occur. Some reported sources of noise problems are induced fans, scrubbing towers, filtration equipment and conveyors. [144, Det Norske Veritas, 2001] [44, Det Norske Veritas 2001]

Land

Leakage from drainage pipes and tanks could cause emissions to soil. The bulk storage of fuels and other chemicals, if not properly managed, pose a risk of accidental spillages and leaks, which could potentially result in contamination of the soil and groundwater. [148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001]

Site restoration

Activities associated with rendering installations are not expected to require significant site restoration work [148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001].

Data

Table shows consumption and emission data for 4 dry rendering plants.

Consumption	
-------------	--

Water consumed	1590 kg/t
Electricity used	83 kWh/t
Heat/fuel used	698 kWh/t
Emission	
BOD	1630 g/t (estimated as 67 % of COD)
COD	2440 g/t
Phosphorus	unknown
Odour	< 200 OU per treatment stream
Noise	90 dB(A) max at source
Detergents	
SO ₂	40 g/t
CO ₂	132 kg/t
NO _x	390 g/t
H ₂ S	nil
HCl	10 g/t
VOCs	not measured
Dust	10 g/t (boiler exhaust only)
Condensate (effluent)	1513 kg/t (as effluent to sewer/river)
Non condensable gases	285 kg/t
Suspended solids in effluent	400 g/t
SRM	145 kg/t
Others	
Steam produced	890 kg/t
Chemicals environment air	2.80 kg/t
Chemicals environment effluent	0.65 kg/t
Chemicals environment effluent oxygen	2.46 kg/t
Chemicals product	1.43 kg/t
Chemicals other	0.76 kg/t
Treated air for odour control	9510 kg/t
Boiler exhaust	789 kg/t
CO	30 g/t
Effluent ammonia	390 g/t
MBM/Meal to landfill	126 kg/t
Waste controlled	960 g/t
Waste filter medium	1420 g/t
Waste effluent sludge	12 kg/t
Waste effluent	13 kg/t
Waste scrap	210 g/t
Waste oil	60 g/t
Raw material handled total	1.17 t/t raw processed
Dioxins	
Nitrates	

Table: Average consumption and emission data per tonne of raw material treated – four dry rendering plants processing 515000 t/yr [192, Woodgate S., 2001]

Table and Table show consumption and emission data for the dry rendering of unspecified feedstock and blood, respectively.

Figure shows consumption and emission data for an example rendering plant. The plant operates a batch process to “Method 1” described in ABP Regulation 1774/2002/EC. The wet slurry is then dried in a continuous disc drier. In the drier, the temperature increases from 100 °C to about 130 °C. The plant has an ammonia conversion unit, where the volatile ammonia is removed from the evaporation vapours. The exhaust vapours are then condensed into acetic vapours. A solution of ammonium nitrate and urea of 28% (AHL 28) urea can be produced, by adding urea.

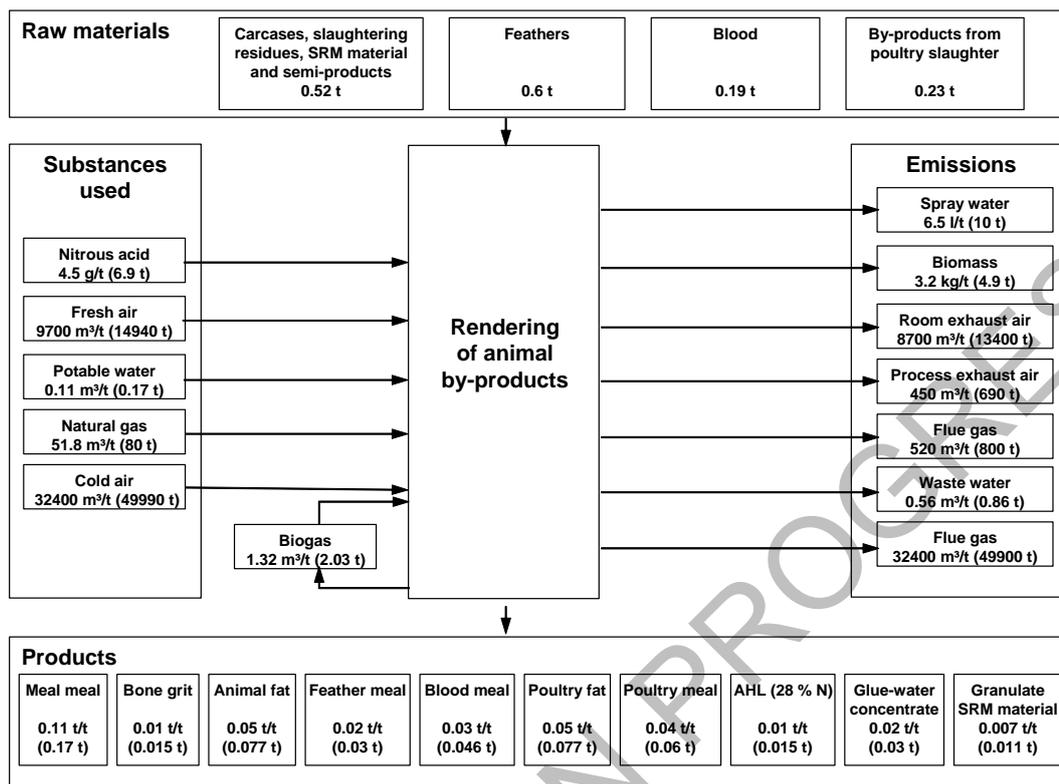


Figure : Consumption and emission levels for an example rendering plant [354, German TWG, 2003]

4.3.4 Techniques to consider in the determination of BAT

Size reduction of animal carcasses and parts of animal carcasses before rendering

See also Section .

Description

ABP Regulation 1774/2002/EC prescribes the maximum particle sizes for rendering animal by-products. Depending on the process to which the materials will be subject and based on their Category and further processing destination, the size varies between 20–150 mm. Size reduction can also yield processing advantages, e.g. increased weight capacity and throughput performance. Very finely ground raw material can be pumped through closed pipelines.

Achieved environmental benefits

Less energy for complete processing of smaller particles than for whole carcasses or large particles.

Operational data

With good mixing the increased surface area can make complete processing easier. It is reported that pre-cutting of the raw material should be carried out just before treatment is started, to minimise any decomposition and associated quality and odour problems.

Grinders equipped with knives or crushing teeth are used. They often represent critical points during processing, because they are particularly prone to wear and tear, so maintenance is important.

Cross-media effects

Energy is consumed in the size reduction operation

Applicability

Applicable in all plants rendering solid animal by products.

Example plants

Six German rendering plants.

Reference literature

[244, Germany, 2002]

4.3.4.1 Techniques to reduce emissions to water

4.3.4.1.1 Use of H₂O₂ to remove H₂S from waste water in feather rendering plants

Description

For waste water with high sulphide concentrations, e.g. from feathers processing, the reduction of the H₂S concentration is a high priority. Concentrations from about 80 - 100 mg/l of sulphide will impair the activated sludge biocoenosis and thus the biological treatment process in the downstream biological stage.

Hydrogen peroxide can be added to the waste water to oxidise the sulphide into SO₂ which is then removed with NaOH.

Environmental performance and operational data

To oxidise 1 kg of sulphide stoichiometrically, approximately 13 litres of 30 % hydrogen peroxide are needed. The reaction takes approximately 10 minutes. If surplus hydrogen peroxide is used the reaction time will be less, e.g. at a 50 % surplus the reaction takes approximately 5 minutes.

Example plants

A German rendering plant.

Reference literature

[163, German TWG Members, 2001] [52, Germany 2001], [244, Germany, 2002] [110, Germany 2002] [241, TWG 2019]

4.3.4.2 Techniques to reduce emissions to air

4.3.4.2.1 Ammonia stripping of exhaust vapour condensates from rendering

Technical description

The following example of a stripping plant for the exhaust air treatment in a biofilter describes the purification performance. The stripping plant consists of two columns which are dimensioned as follows:

Influent to the stripping plant:	75 m ³ /d
Filling body height:	~8 m
Throughput of column 1:	2 100 l/h
Throughput of column 2:	3 000 l/h
Column entry temperature:	~60 °C
Recirculating air stream:	5 100 Nm ³ /h
NaOH demand:	~5 k/kg (nitrogen eliminated)
Ammonium nitrogen (influent):	~2 000 mg/l
Guaranteed value (effluent):	150 mg/l

The exhaust vapour condensate, which is at a temperature of 60 - 80 °C, is conveyed into a container of 3 m³ volume. To prevent the emergence of foams, a defoaming agent, on a silicone base, is dosed onto the stripping input pipeline, which feeds the columns. The pH value is raised by the addition of NaOH. Air saturated with steam is fed countercurrently from the press room at a temperature of approximately 30 °C and with a waste water:air ratio of 1:1000. Neutralisation of the effluent does not occur immediately after the stripping, but only after the reconvergence with the other waste water part-streams. The exhaust air from the stripping is then conveyed through a biofilter system at a maximum rate of 122 400 m³/d. The reported alternative routes for disposal of the ammonia-laden air are incineration, catalytic oxidation and acid absorption.

Achieved environmental benefits

Removal of NH₃ from exhaust vapour condensates.

Environmental performance and operational data

Table 4.16 shows performance data for a winter and a summer month.

Table 4.16: Data of a stripping plant for ammonium (average values - daily mixed samples)

Parameter	February			July		
	Influent	Effluent	% increase/ decrease	Influent	Effluent	% increase/ decrease
pH value	7.6	12.1		5.7	12.5	
Specific Conductivity (mS/cm)	3.67	8.45		6.08	14.8	
COD total (mg/l)	6 168	5 553	- 10	14 016	12 780	- 9
NH ₄ -N (mg/l)	647	64.3	- 90	931	95.4	- 90

Cross-media effects

These depend on how the exhaust air is treated.

Example plants

At least 2 rendering plants in Germany.

Reference literature

[163, German TWG Members, 2001] [52, Germany 2001], [244, Germany, 2002] [110, Germany 2002]

4.3.4.2.2 Ammoniacal-N removal from rendering condensate by ammonia conversion

Description

Ammoniacal nitrogen can be removed from exhaust vapour condensates (EVCs) by ammonia conversion. Ammonia is conveyed with the EVCs into a washing tower (converter) in a countercurrent to a nitrous solution of 50 - 60 % strength. These react producing a solution of ammonium nitrate. The concentrated ammonium nitrate solution is pumped through a filter tower in the converter. The ammonium nitrate is extracted from the tower when the desired concentration has been reached. The exhaust vapours, now freed of ammonia, are then condensed in a condenser into acid exhaust vapours.

By adding urea, the ammonium nitrate solution gained in this way can be turned into a 28 % ammonium-nitrate urea solution, which can be used in agriculture as a high nitrogen ratio fertiliser.

Chapter 4

For the operation of such a converter, it is a requirement that the exhaust vapours do not carry any solids. Cyclones or other suitable means of separation must therefore be installed upstream of the converters. Volatile carbon acids in the exhaust vapours are mainly caused by high temperatures (> 130 °C) during the drying process.

Achieved environmental benefits

Removal of ammoniacal nitrogen from the condensates produced from rendering.

Example plants

At least 3 rendering plants in Germany.

Reference literature

[163, German TWG Members, 2001] [52, Germany 2001], [244, Germany, 2002] [110, Germany 2002]

4.3.4.2.3 Back venting of blood tanks during unloading

See also Section 2.3.8.2.9.

Technical description

An activated carbon filter is used in the blood tank to treat the exhaust gas, mainly when blood is transferred to trucks.

Achieved environmental benefits

Reduced odour emissions.

Environmental performance and operational data

Odour levels of 8 million odour units inside blood tanks have been reported [241, UK, 2002] [107, United Kingdom 2002].

Cross-media effects

None reported.

Technical considerations relevant to applicability

Generally applicable to blood tanks, in particular when sensitive receptors are close to the installation.

Economics

Request to the TWG: Please provide information.
--

Driving force for implementation

Prevention of odour emissions, beyond the site boundary.

Example plants

The Süddeutsche Truthahn AG site in Ampfing (Germany) [271, Karlis et al. 2020].

Reference literature

[271, Karlis et al. 2020]

Removal of water from blood, by steam coagulation, prior to rendering or spray drying

Description

Blood contains more than 800 kg of water per tonne, i.e. approximately 80 %. A lot of energy is required to remove this. To minimise the amount of energy required to remove the water,

during, e.g. rendering or spray drying, a proportion of this can be done in advance, using steam coagulation. This is common practice in the majority of plants.

The blood is coagulated by direct steam injection. The coagulated blood is then separated in a decanter, in which the blood is separated into a grax containing 50–55 % water and blood water containing 70–75 % of the original water content. The blood water is treated in the WWTP. The grax is sterilised and finally dried in a dry rendering cooker or another drier, such as a spray drier. Alternatively, the blood can be mixed with other raw materials and processed with them.

Achieved environmental benefits

Reduced energy consumption.

Operational data

The energy consumption in an energy saving installation has been measured to be approximately 60 kg fuel oil and approximately 120 kWh electricity per tonne raw materials. Of the electricity consumption, 72 kWh are used for the processes and 48 kWh, for air and waste water cleaning.

The energy consumption can be reduced from 700–800 kWh/t of blood to 350–400 kWh/t, depending on the type of drier used.

The water consumption has been measured as 2 000–2 300 litres of water per tonne of raw materials. Of this 600–700 litres are used for condensation and 200–250 litres are used in the boilers.

2 000 litres of waste water is produced per tonne of raw materials. 700–800 litres of this is water condensed from the raw materials. This contains a number of dissolved compounds. To a large extent, the waste water composition depends on the freshness of the processed blood and on the process itself. Discharge figures of the order of 5–6 kg BOD, 0.6–0.8 kg N and 0.20–0.25 kg P per tonne raw materials, have been reported.

Cross-media effects

The heat treatment of protein leads to the formation of a number of malodorous compounds, such as ammonia, amines and sulphur containing compounds.

Applicability

If only small quantities of blood have to be processed, the investment in energy saving equipment is not profitable.

Driving force for implementation

Reduced energy consumption.

Example plants

Very widely applied.

Reference literature

[134, Nordic States, 2001, 243, Clitravi—DMRI, 2002, 244, Germany, 2002]

Concentration of plasma, prior to spray drying—reverse osmosis

Description

Liquid blood plasma contains a very low proportion of solids, i.e. around 8 % and a high proportion of water, which means that it requires a lot of energy for direct drying. Reverse osmosis concentrates the initial liquid plasma by filtering its water through a set of membranes until the solid content reaches 24–28 %.

Achieved environmental benefits

Reduced energy consumption.

Operational data

The concentration process, by reverse osmosis, removes approximately 75 % of the initial water contained in the liquid plasma.

Cross-media effects

Electricity consumption.

Applicability

Applicable to any liquid plasma.

Economics

The final drying cost of the liquid plasma is reduced by 75 %. Cleaning and maintenance of the filtering membranes is expensive.

Driving force for implementation

Reduced energy costs.

Reference literature

[271, Casanellas J., 2002]

Concentration of plasma, prior to spray drying – vacuum evaporation

Description

Liquid blood plasma contains a very low proportion of solids, i.e. around 8 % and a high proportion of water, which means that it requires a lot of energy for direct drying. Evaporation under vacuum concentrates the initial liquid plasma by filtering its water through a set of membranes until the solid content reaches 24 – 28 %.

Achieved environmental benefits

Reduced energy consumption.

Operational data

The vacuum evaporation process removes approximately 75 % of the initial water contained in the liquid plasma.

Cross-media effects

Steam production and use of cooling water to condense the evaporated water from the liquid plasma.

Applicability

Applicable to any liquid plasma.

Economics

The cost of drying the liquid plasma is reduced by 75 %.

Driving force for implementation

Reduced energy cost.

Reference literature

[271, Casanellas J., 2002]

Totally enclosed rendering line

Description

The transfer of materials throughout the entire processing line, including the conveyance of process gases and liquid effluents, can be undertaken within totally enclosed and sealed handling systems designed, constructed and maintained to prevent leakages from occurring. If occasional access is required, e.g. to remove tramp metal from a magnet positioned at the beginning of the line, then a hinged cover interlocked to the mechanism can be provided.

Achieved environmental benefits

Reduced liquid and solid leakage and reduced emissions to air, including odour.

Cross-media effects

None.

Applicability

Applicable at all rendering plants.

Economics

Inexpensive.

Driving force for implementation

Reduced odour.

Reference literature

[49, VDI, 1996]

Rendering of feathers and pig hair

Table shows consumption and emission data for the rendering of feathers and pig hair.

Chapter 4

All PER-TONNE of FEATHER/HAIR rendered	Water cons. (t) (25)	Waste water (t) (7, 28)	Energy cons. (kWh) (4, 25)	BOD emission (kg) (7, 25)	COD emission (kg) (7, 25)	Suspended solids emission (kg) (7, 25)	Nitrogen emission (g) (7)	Phosphorus emission (g) (7)	Odour emission (4, 25)	Noise emis. (d(B(A)) (25)	Detergents	CO ₂ emis. (kg) (25)	SO ₂ emis. (kg) (25)	NO _x emis. (kg) (25)	CO emis. (g) (25)
Unloading + vehicle wash															
Storage/chilling															
Screening/separation															
Mixing/infeed															
Cooking		400–700	165												
Drying			700–800												
Grinding and milling															
Separation															
Fat settlement															
Fat filtering															
Meal packaging															
Condensation															
Boilers															
Cleaning															
Air treatment															
Liquid effluent treatment															
Solid waste treatment															
Storage of by-product															
Storage of waste for disposal															
Total (including where individual data are not available)	1590	1590	814	0.2–8	0.33–12	0.83–2.2	100–2700	<100	1.5 million *OU/m ³ \$ <200 OU/ treatment sys.	90 at source		183	0.630	0.3	70
Techniques which provide or derive benefit to or from other activities															

* Danish odour units — \$??odour units
Ranges received — operating conditions, treatments and sampling methods neither described nor submitted
References: (4) [134, Nordic States, 2001]; (7) [163, German TWG Members, 2001]; (25) [191, Woodgate S., 2001]; (28) [353, Clitravi — DMRI, 2003]

Table: Consumption and emission data for feather/hair rendering

At a feather rendering plant in the UK, H₂S, mercaptans, amines, amides and chlorides such as HCl are monitored in air emissions.

About 1.0 kg/pig of hair produced is rendered [148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001].

Continuous rendering of, e.g. fresh raw feathers and hair

Description

The processing of feathers and hair in as fresh a state as possible can minimise emissions to air and waste water. Hydrolysis in a continuous installation using direct steam, followed by mechanical dewatering in a decanter and evaporation of the liquid phase from the decanter in a multiple-effect evaporator can save significant heat energy.

Achieved environmental benefits

Potential savings of 40–50% of the heat energy for the process, if large amounts of raw materials are available and a waste steam evaporator is used.

Reduced storage times can lead to reduced odour emissions from storage, processing and waste water treatment.

Operational data

This technique requires a large amount of raw materials and access to a waste steam evaporator.

Cross-media effects

Additional journeys may be required between the slaughterhouse and the rendering plant to ensure that the feathers are rendered in as fresh a state as possible, hence transport may involve part loads and consequently the environmental impact of transport may be higher than if only full loads are transported.

Applicability

Applicable where there is a feather feedrate of at least 2 t/h and usually no more than 5 t/h. Continuous rendering is also applicable for other animal by products destined for rendering if their feedrates match the capacity of a continuous rendering plant, i.e. synchronised slaughter and rendering.

Driving force for implementation

By products companies charge more for degraded and malodorous materials, partly due to the additional environmental costs associated with odour control and waste water treatment and partly due to the fact that they have no value and have to be disposed of. This, therefore, provides the incentive for the slaughterhouse to store by products for as short as time as possible. Where further treatment is not possible, before degradation and the formation of malodorous substances occurs, they may be refrigerated, to minimise degradation.

Reference literature

[134, Nordic States, 2001, 272, Woodgate S., 2002]

4.4 Fishmeal and fish oil production

4.4.1 General information about the sector

On a global level in 2017, Europe produced 16 % of the world's fishmeal and 23 % of the world's fish oil. There are 29 fishmeal and fish oil installations in Europe [207, EUfishmeal 2019]. Fishmeal and fish oil are fish-based marine proteins and oils provide a balanced amount of all essential amino acids, minerals, phospholipids and omega-3 fatty acids (DHA and EPA).

The production of fishmeal and fish oil is based on fresh landings of small, oily, short-lived fish species such as Blue Whiting, Capelin, Sand Eel, Norway Pout and Sprat which are subject to international quotas. Furthermore, a significant amount of the raw material is by-products (trimmings) from the fish processing or filleting industry. The filleting industry utilises between 40 % and 60 % of a herring or a mackerel and the remaining part of the raw material is, to the extent that is possible, transported and processed by fishmeal and fish oil factories. Several of the fishmeal and fish oil factories in Europe produce only from trimmings, while the rest are produce both from fresh landings and trimmings. The conditions and production processes of fishmeal and fish oil differ fundamentally from the fish processing industry.

It is expected that more by-products will be used in the coming years in the fishmeal and fish oil industry. The quality of the end product can vary in terms of lower protein content and increase of minerals (ash) and small amino acids (e.g. glycine, proline, hydroxyproline) in comparison with products obtained from fresh fish [252, Spain 2020].

The following information is largely from the Nordic countries, [155, Nordic Council of Ministers, 1997], other sources are cited, when appropriate.

The raw material of the fishmeal industry is mainly small sized fish species which cannot be sold for human consumption. They are caught for use in the processing of fishmeal and fish oil. In many areas, a substantial part of the raw material consists of fish waste left over from filleting or other processes.

When processing pelagic fish species such as herring and mackerel, which are landed ungutted, the filleting industry can only utilise 50 % of the landed raw material. The remaining part of the raw material is offal, which the industry then has to sell or dispose of in some way.

Fishmeal is used as a protein supplement in agriculture, especially in pig and chicken production. Small quantities are used for mink feed. Its use in aquaculture feed is the most profitable, with producers buying considerable quantities of fish oil.

Without fishmeal and fish oil, the large scale Scandinavian production of salmon and trout would not be possible. Competition from Peru and Chile in the market for standard fishmeals, makes it difficult for European producers to achieve reasonable prices, due to the far higher production costs in Europe.

A substantial amount of pollution is caused by poor quality raw material. Pollution can be considerably reduced by improving the raw material quality. It is technically feasible to increase the fishmeal yield and reduce pollution by improving the quality of the raw material. Technical, environmental and economic conditions vary greatly from plant to plant.

Some fishmeal factories, in the Nordic countries, can influence investments in equipment for improving raw material quality. Some of the factories are owned by fishermen co-operatives. The factory operators can influence raw material quality through the purchase terms of the raw material, at delivery. A sufficiently large price differentiation seems to result in considerable improvements in raw material quality. A decrease in quality can also occur during the storage of raw material. Improved management of the storage tanks has reportedly resulted in an improvement in the quality of the raw material supplied to the cookers.

Improvement of the quality of the raw material not only reduces pollution. It also increases the fishmeal yield and makes it possible to produce high priced and specialised products. These products require a certain quality of raw material, i.e. the TVN content must not exceed a certain value.

Table summarises the EU fishmeal and fish oil production for 2001.

	Number of Factories	Year	Fishmeal (t/yr)	Fish oil (t/yr)
Denmark	4	2001	300000	80000
Germany	1	2001	15000	6000
Spain	2	2001	40000	6000
France	2	2001	10000	2000
Ireland	1	2001	25000	6000
Sweden	1	2001	12000	5000
United Kingdom	32	2001	46000	14000
TOTAL			448000	119000

Table: EU Fishmeal and fish oil production in 2001
[303, Minck F., 2002]

Denmark

Denmark produces about 5 % of the world's fishmeal and 8 % of the fish oil. There are 3 companies, with one being one of the world's largest fishmeal and fish oil producing companies, producing approximately 215000 tonnes of fishmeal per year, i.e. 67 % of Denmark's output. The process uses fish which are caught specifically for the production of fishmeal and fish oil, mainly from species which are not caught for direct consumption, e.g. sand eels, and it also uses by products from fish processing, such as offal. Sand eels make up 60 % of the raw material. 60 % of the catch is caught between April and July. The total fishmeal production in Denmark was 300000 tonnes in 2001.

United Kingdom

The UK produces about 0.25 % of the world's fishmeal and fish oil. Fish by products are used.

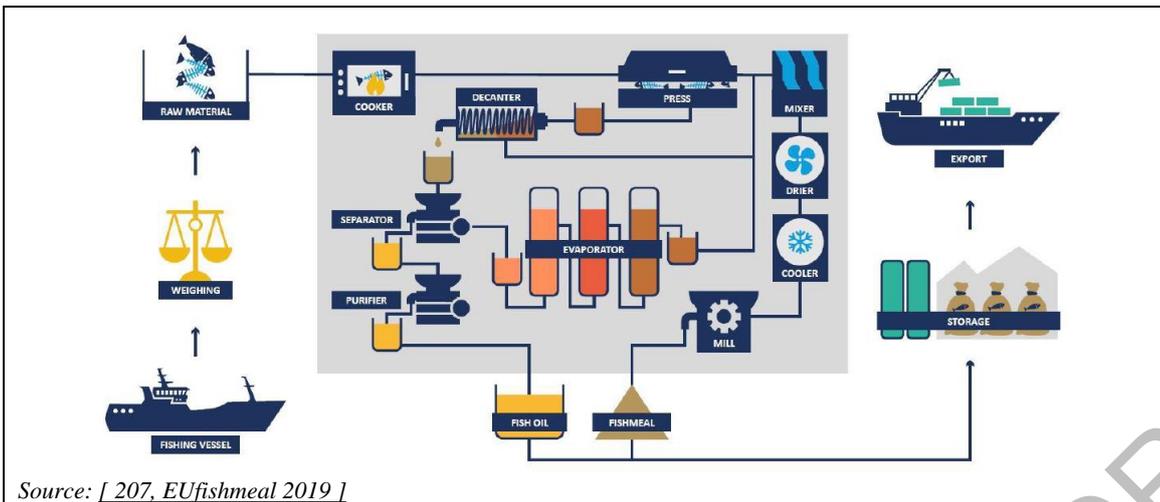
4.4.2 Applied processes and techniques

In principle, The fishmeal process is the removal of oil and water from the raw material and the separation of the material into 3 fractions, i.e. oil, meal and water. The water fraction is disposed of, normally to sea. The process is characterised by the continuous processing of very large quantities of raw material. Production normally takes place 24 hours a day, using large quantities of energy and seawater and with a minimum of manual labour.

The raw material is basically composed of three major fractions: solids (fat-free dry matter), oil and water. During the production process, these three fractions are separated from each other. The processing of the raw material into meal and oil takes place in fully automatic closed systems from beginning to final product(s).

The raw materials used in the production of fishmeal and fish oil go through a process that consists of boiling, separation, evaporation, drying, cooling and milling, as shown in Figure 4.32.

The fishmeal and fish oil production process may be summarised as follows, with Figure 4.32 illustrating the raw material, intermediate material and final product process order.



Source: [207, EUfishmeal 2019]

Figure 4.32: Processing steps of fishmeal and fish oil production

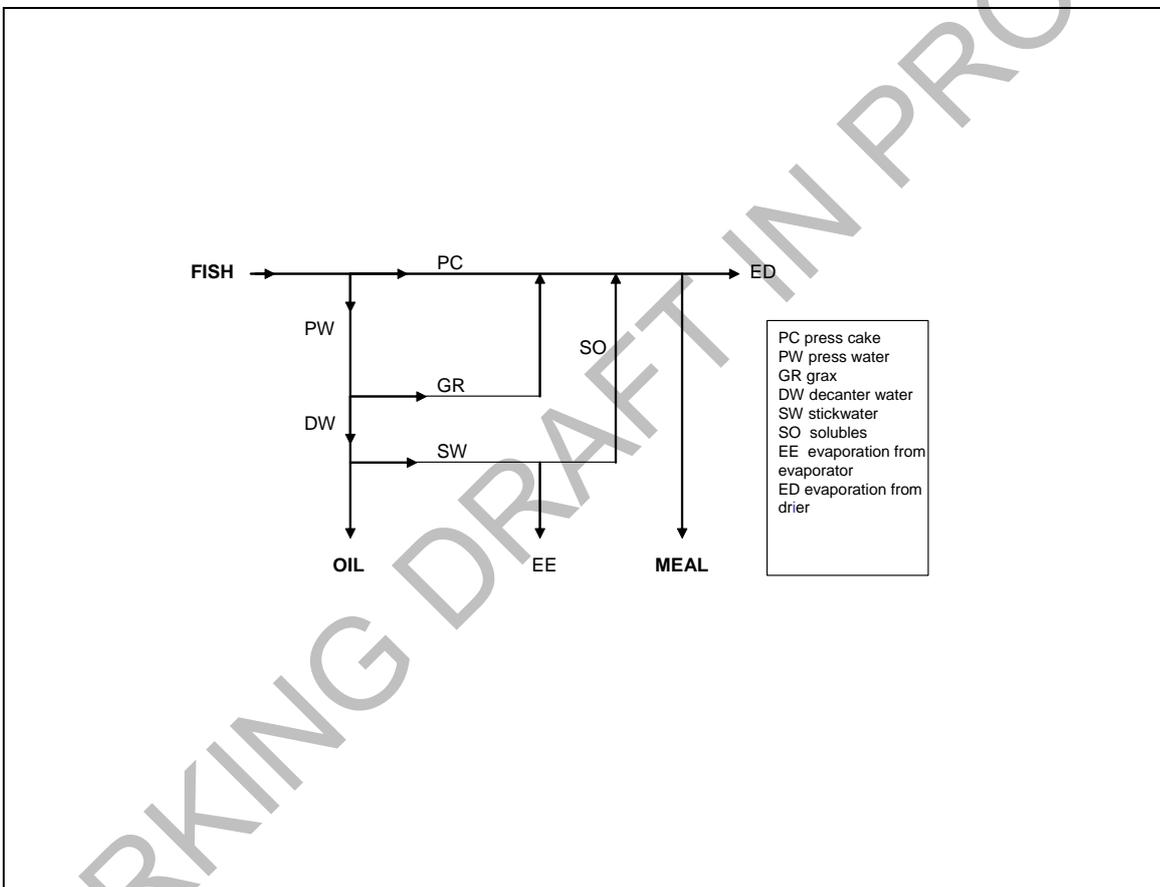


Figure: Material flow in fishmeal and fish oil production [140, Minek F., 2001]

The raw materials delivered to fishmeal and fish oil factories are composed of direct landings from fishing vessels, trimmings/by-products from the fish processing industry and trimmings/by-products from the aquaculture industry. To optimise the quality of the final product, most of the fish supplied directly from fishing vessels is maintained in a chilled condition from the time it is caught until it is offloaded from the vessel. The parameter used to measure the freshness of the raw material is total volatile nitrogen (TVN). TVN is used as a quality parameter and process control and used in the contract with the supplier, as it relates to the quality of the end-product. Hence there is an industry-driven financial incentive to keep TVN levels as low as possible.

A feature of the trimmings/by-product raw material is the remoteness of locations from which the material originates, which can make maintaining the quality of the raw material difficult as it is delivered to the plant in smaller consignments.

Raw material intake differs a little all over Europe as it depends on how the raw material arrives. It can be both by screw conveyers, lamella pumps, tipped from containers, bins, skips, bulkers or trucks or by pumping with water directly from the vessels. Common for all factories is that raw material is unloaded into enclosed hoppers or tanks.

After the raw material is unloaded and stored in a buffer silo, the raw material is fed into a cooker. The raw material is heated to 90-95 °C, which sterilises the fish, coagulates the proteins and disrupts the cell membranes, to facilitate the separation of the soluble fraction and the oil from the dry matter. The cooking temperature is controlled automatically to ensure correct cooking. This is done according to the veterinary requirements.

The cooked raw material is fed to a screw press, where much of the liquid is squeezed out to produce a liquid phase and a solid phase when using a two-phase decanter, and in the case of a three-phase decanter, there is also an oil phase. Strainers are used before pressing to make optimal working conditions for the presses. Efficient pressing gives low fat levels in the product.

The press water is separated further in a decanter. The press water contains most of the oil from the fish and dissolved proteins, salts and fine particles. The liquid from the decanter is sent to separators, where the oil is removed and subsequently stored for export. A two-step separation is used for the extraction of fish oil: 1) extraction of oil from the soluble fraction by means of a first separator; 2) polishing of extracted fish oil by means of a second separator. All solids separated by this process are recovered.

The liquid that remains after the removal of the oil is the stickwater. This is fed to evaporators, where it is concentrated before being blended with the press cake during the drying stage. The stickwater contains both dissolved and undissolved proteins, residual oil, minerals and vitamins. To concentrate the stickwater and achieve a high concentration of dry matter, large quantities of water are removed by evaporation, which requires energy, and the resultant condensate has to be discharged. The industry currently uses various devices for evaporation and having an evaporator significantly reduces the environmental impacts of waste water on the receiving environment.

The purpose of the drying process is to convert the wet mixture of the press cake, decanter sludge and concentrated stickwater into a dry fishmeal. In practice, this means drying to a moisture content below 12 %, which generally may be considered low enough to inhibit microbial activity. This drying is done by heating the material to a temperature where the rate of evaporation of the water is considered satisfactory in order to avoid reduction of quality, especially of the protein.

The typical drying processes are indirect steam drying, vacuum drying, hot air drying and spray-drying. Some plants may use more than one drying process. Good practice applied to the drying process involves sealing of equipment to avoid uncontrolled excess air ingress, control/removal of vapour steam and maintaining equipment under vacuum. After drying, the fishmeal is cooled by air. Air for cooling is treated to reduce odour emissions.

The fishmeal is ground to a specific particle size using hammer mills. After the milling, the meal is stored for export either as meal or pelletised. Air from the grinding/milling is treated to reduce odour emissions.

To remove undesirable substances, the oil producing factories may pass the oil through a carbon-filter press. A scrubbing tower collects air and surplus vapour from the dryers and the heat exchanger and air suction vapour from the processing plant.

Raw material

The raw material can be whole marine fish caught in the sea, or parts of fish from the filleting industry.

Unloading

If the fish are specifically caught for fishmeal and fish oil processing, they are unloaded from the fishing vessels and weighed. During unloading, fish samples of 300–500 kg, i.e. 70–100 spot samples, are taken and analysed to determine the quality of the raw material. Freshness is extremely important to the final product quality. The parameter used to measure freshness is the total volatile nitrogen (TVN). This is the nitrogen created by the degradation of protein in the raw material. Ideally, the raw material should be fresh and dry. It often contains melt water from ice used to conserve the fish.

Raw material buffer silo

The raw material is stored in a silo, which has enough capacity for 16–24 hours. The unloading capacity is greater than the production capacity because the plants cannot control the delivery times of the vessels, so production takes place 24 hours a day. Unloading tends to take place during the day. The buffer silos have to be empty when offloading starts the next day, to maintain a fresh throughput.

Cooker

Fish are 70–75 % water. They are indirect steam cooked for 20 minutes in their own water at 90–100 °C. The protein coagulates and it is this which forms the press cake.

Press

The cooked fish are pressed for 15 minutes, in a screw press to produce a liquid phase, known as press water and a solid phase known as press cake. The press water contains some dry matter and solid matter, known as fines. The press cake is 50 % dry matter.

Decanter

The press water is separated further, in a decanter, to produce decanter water and another solid phase, known as grax.

Centrifuge

The decanter water is separated further in a centrifuge to produce fish oil and a liquid containing dissolved dry matter and small amounts of suspended solids, known as stickwater. Approximately 20 % of the fishmeal is in the stickwater.

Evaporator

The stickwater is concentrated by evaporation in an evaporator, for 30 minutes, into a liquid containing approximately 40 % dried matter, i.e. evaporated stickwater. Seawater is used as cooling water in the evaporators.

Drier

The press cake and grax and evaporated stickwater are mixed and dried for 1–2 hours to produce fishmeal. The driers used in fishmeal factories are nowadays almost exclusively the indirect steam heated type. Heat is transferred to the drying material by hollow, rotating discs mounted on a horizontal axle. Older types of directly fired drum driers are being replaced, and other drying methods such as spray drying are only used for relatively small quantities of special meal types. [155, Nordic Council of Ministers, 1997]. The removal of oil from the meal is, in some cases, becoming increasingly important due to increased levels of dioxins detected in the fish and fears about the risks to human health associated with these.

Fishmeal consisting of press cake, decanter sludge (grax) and evaporated stickwater is called “whole meal”. Depending on the drying temperature, the meal is called “normally dried meal” or “low temperature dried meal” (LT meal). The latter is dried in vacuum driers. By far the largest part of the fishmeal produced is whole meal of many different types and qualities. In

addition, many special meals are produced, based on one or several of the intermediate products of the fishmeal factories. These have names such as press cake meal and evaporated stickwater meal. [155, Nordic Council of Ministers, 1997]

Meal cooler

The fishmeal is air cooled in a meal cooler. This protects the quality and makes grinding possible.

Grinder

The fishmeal is ground to a specific particle size using hammer mills.

Oil finishing/purification

The fish oil from the centrifuge is washed with hot water in another centrifuge, then settled and stored. If necessary it may be passed through a carbon filter press to remove traces of dioxins. The spent carbon is incinerated in a hazardous waste incinerator.

Storage

Fishmeal and fish oil can be stored for at least one year in storage houses and in tanks.

Example plant

Figure shows a simplified schematic diagram of the production process in a large fishmeal factory. This overview shows only the most important mass flows.

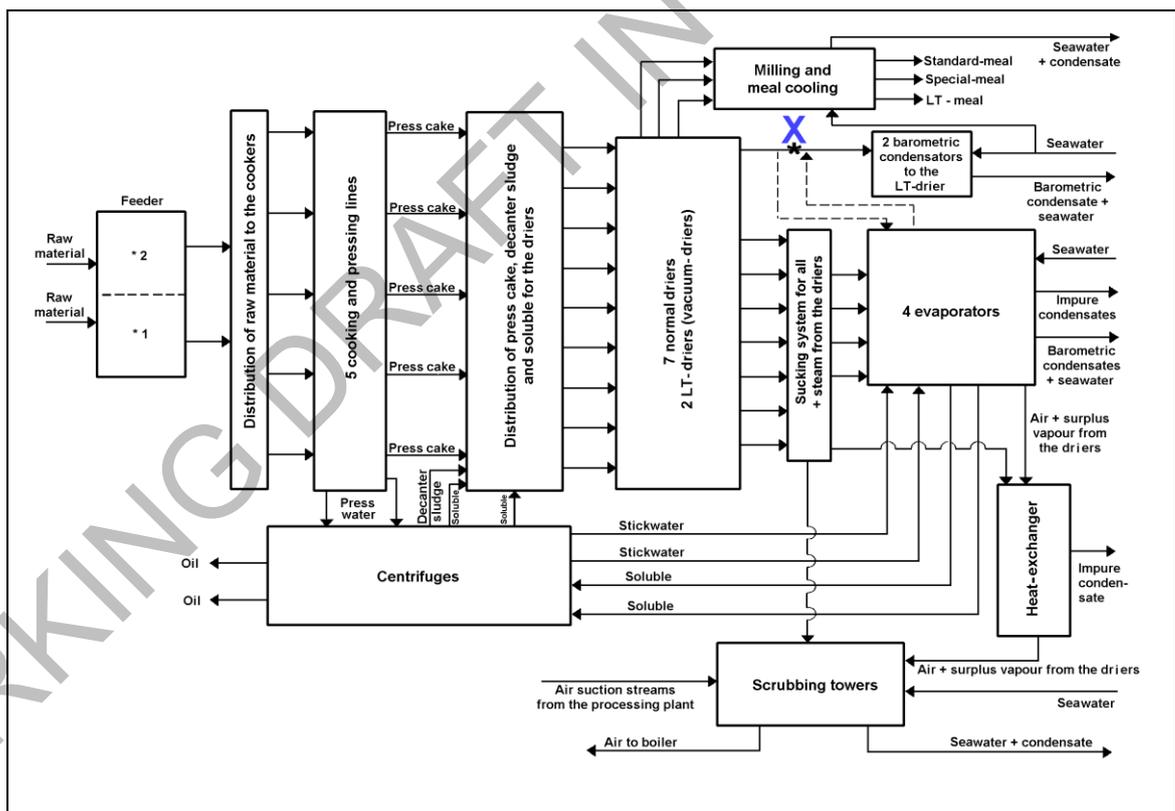


Figure : Schematic diagram of the production process in a large Danish fishmeal factory [155, Nordic Council of Ministers, 1997]

shows how production can be divided into two completely separate units through which different raw material qualities and meal types can be processed simultaneously. The buffer tanks for press liquor, stickwater and evaporated stickwater, the blood water intake, the blood water processing unit and the newest special fishmeal production unit are not shown.

An energy exchange valve has been mounted at point “X”, so that stage 1 of the surplus heat evaporator can be supplied with energy, i.e. surplus steam, from the two LT driers (vacuum driers), and the remaining steam can be conducted to the barometric condensers. Alternatively, the heat evaporator can be supplied with surplus steam from the normal driers, which work at atmospheric pressure.

When the factory represented in the schematic diagram produces surplus heat, it is conducted through the heat exchanger to a district heating system, if required. Only a few fishmeal factories supply heat in this way. During operation, a surplus of condensate is continuously produced at the primary side of the heat exchanger. This surplus is channelled away. The heat exchanger can also receive heat from other sources of condensate, but this is not shown on the figure, to preserve clarity.

4.4.3 Current emission and consumption levels

4.4.3.1 Energy consumption

Energy is used for offloading, cooling, cooking ~~preserving~~, separating, evaporating and drying. Fishmeal plants do not refrigerate the raw materials, but the fishermen add ice directly to the fish at sea, and the plants also receive fishery by-products as frozen or iced products from the filleting industry.

Figure 4.33 shows data in relation to total specific net energy consumption in terms of kWh/tonne of raw material at installation level, as well as the applied techniques to reduce energy consumption.

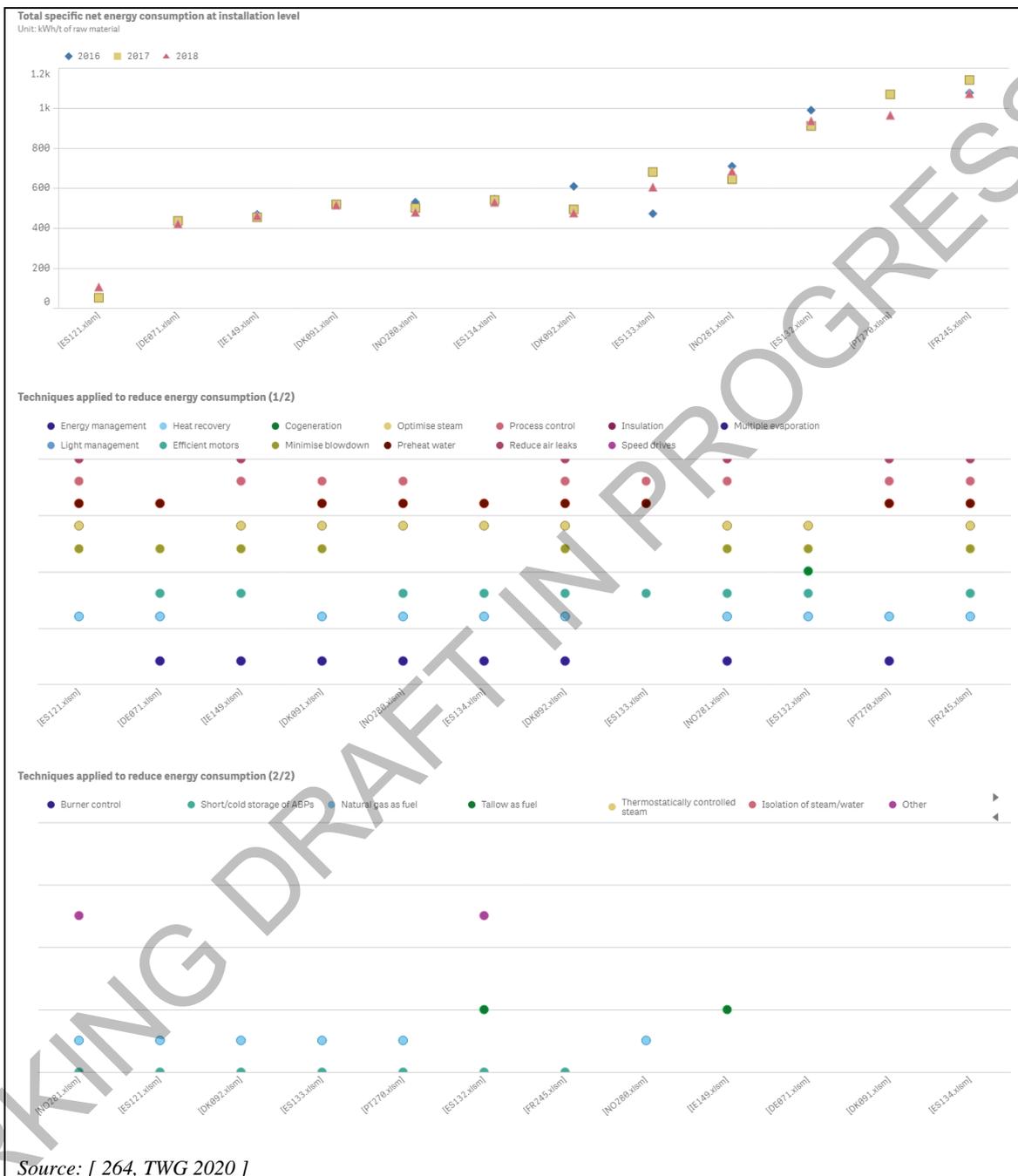
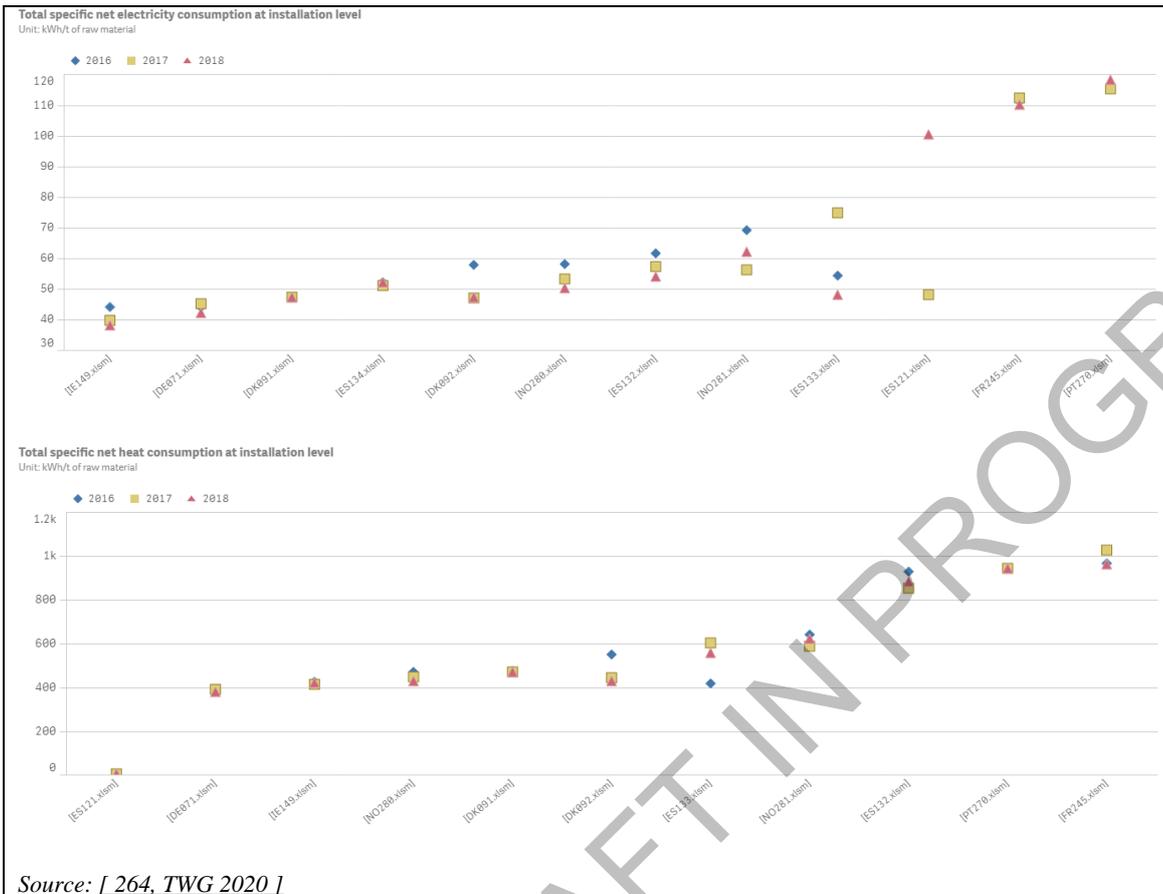


Figure 4.33: Specific energy consumption (kWh/tonne of raw material) and applied techniques to reduce energy consumption in fishmeal and fish oil production (installation level)

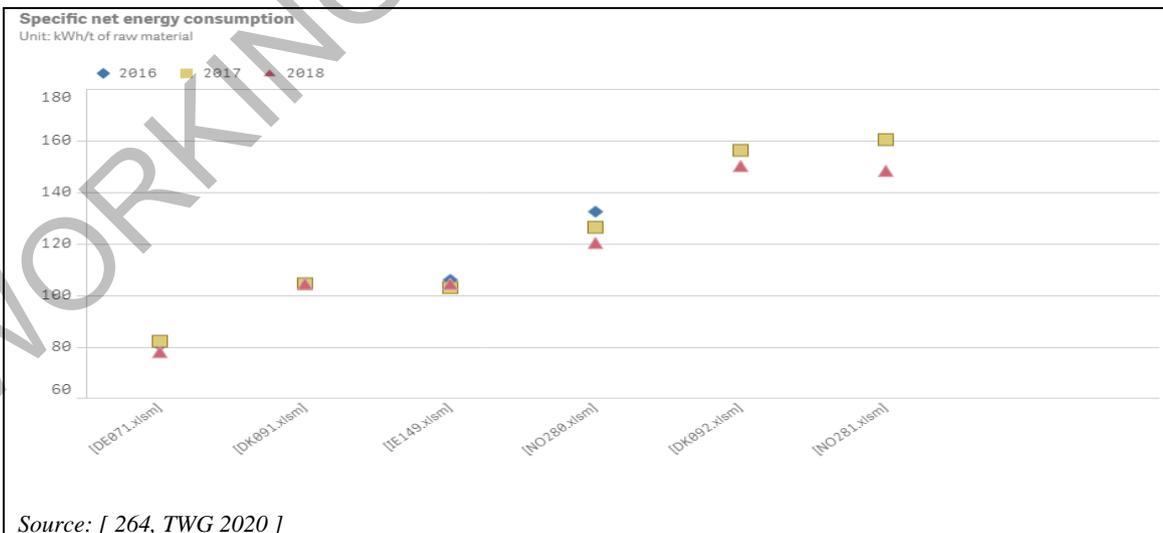
Figure 4.34 shows data in relation to total specific net electricity and heat consumption in terms of kWh/tonne of raw material at installation level.



Source: [264, TWG 2020]

Figure 4.34: Specific electricity and heat consumption (kWh/tonne of raw material) in fishmeal and fish oil production (installation level)

Figure 4.35 and Figure 4.36 show the specific net energy consumption (in kWh/tonne of raw material) in some processes in fishmeal and fish oil production.



Source: [264, TWG 2020]

Figure 4.35: Specific energy consumption (kWh/tonne of raw material) for cooking/sterilisation in fishmeal and fish oil production

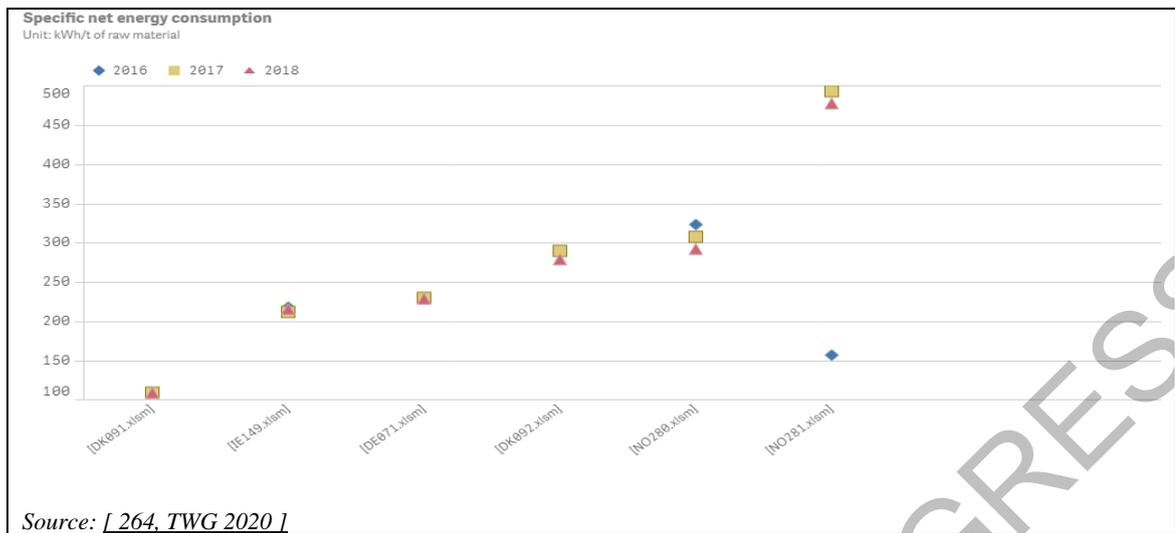


Figure 4.36: Specific energy consumption (kWh/tonne of raw material) for drying in fishmeal and fish oil production

Table shows consumption and emission levels reported for fishmeal and fish oil manufacturing.

All PER TONNE of fish-treated	Fresh water cons. (t)	Seawater cons. (t)	Energy cons. (kWh)			BOD emis. (kg)	Total N emis. (g)	Total P emis. (g)	CO ₂ (kg)		SO ₂ emis. (kg)	Suspended solids emission (kg)	NO _x Emission (kg)		*DMA emission (g)	**TMA emission (g)	Dioxin (ng/m ³)— emission calculated maximum emission for 700000 t of fish/yr (26)	Odour emission For 250 tonnes of fish/hour (26)	Noise emis.	
			Energy cons. (kWh) (TOTAL)	Electricity cons. (kWh)	Heat (natural gas) (kWh)				Electricity cons. (26)	Natural gas cons. (26)			Electricity cons. (26)	Fuel cons. (26)						
Unloading			4	4																
Storage in buffer silo																				
Cooking			138.2	0.2	138															
Pressing			1.9	1.9																
Decanting			42.7	0.7	42															
Centrifugation			1.1	1.1																
Evaporation			45.0	5.0	40															
Drying			158.5	10.5	148															
Meal cooling			1.2	1.2																
Grinding																				
Meal storage																				
Oil storage																				
Pumping seawater			3.0	3.0																
Pumping waste water			1.1	1.1																
Other pumping			1.0	1.0																
Steam production			52.6	4.6	46															
Incineration			0.5	0.5																
Room ventilation			0.2	0.2																
Compressing air			1.2	1.2																
Suction air from machinery			0.5	0.5																
Scrubbing (chemical)			0.5	0.5																
Pelletising fishmeal			4.2	4.2																
Residual			5.8	5.8																
Total (including where individual data are not available)	290	14888	464.8	50.8	414				0.0181	0.0849	0.0279	0.014	0.1698	0.426	0.6-3	10-25	0.003	555000 O.U./s		

Ranges received—operating conditions, treatments and sampling methods neither described nor submitted

*DMA = Dimethylamine **TMA = Trimethylamine

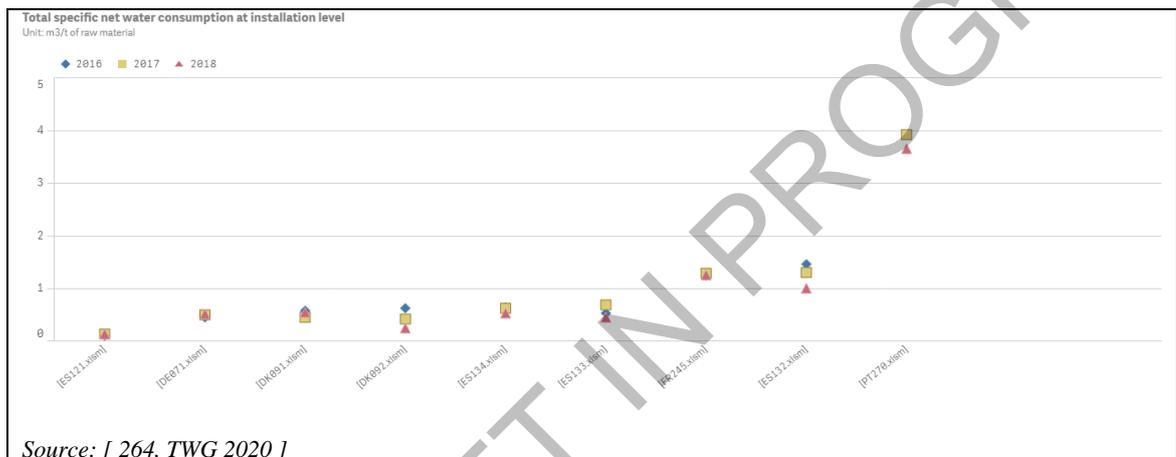
References: (26) [212, Nielsen E.W., 2001]

Table : Consumption and emission data reported from fishmeal and fish oil manufacturing plants

4.4.3.2 Water consumption

Fresh water is used in the boiling process, in the separators and to clean machinery and tanks through the cleaning-in-place (CIP) method. However, a number of installations use condensates as rinsing water for CIP. Seawater is used for cooling of waste water from the evaporators and other equipment which requires cooling. Seawater can be also used for cooling, scrubbing and condensing to liquid within the fishmeal production process and is also generally used directly for cooling excess air from meal cooling. Seawater is by far the biggest part of water consumption. However, local conditions mean that a few installations do not have access to seawater.

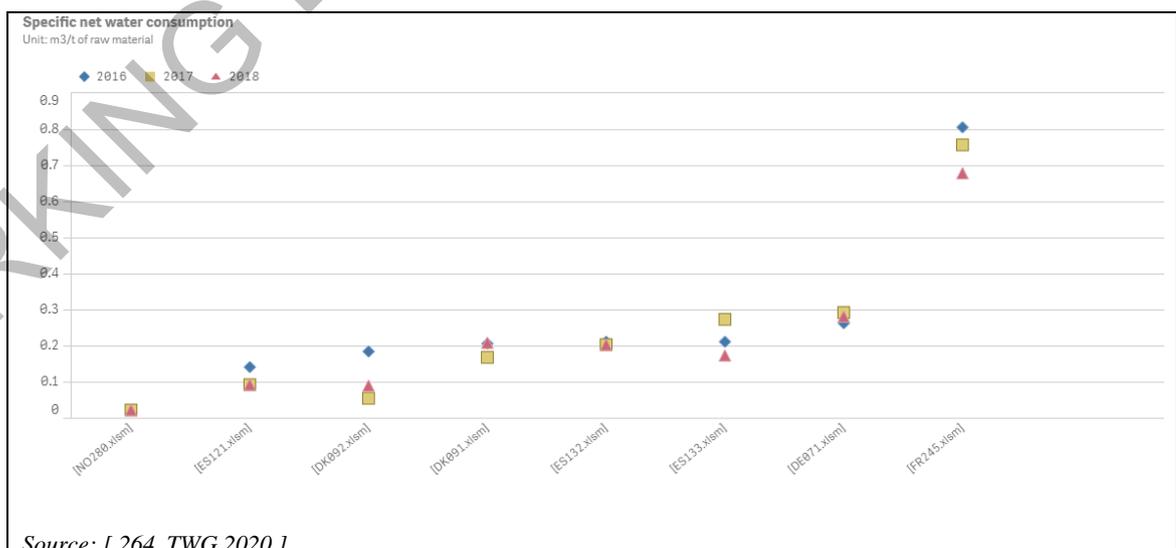
Figure 4.37 shows data in relation to total specific net water consumption in terms of m^3/tonne of raw material at installation level.



Source: [264, TWG 2020]

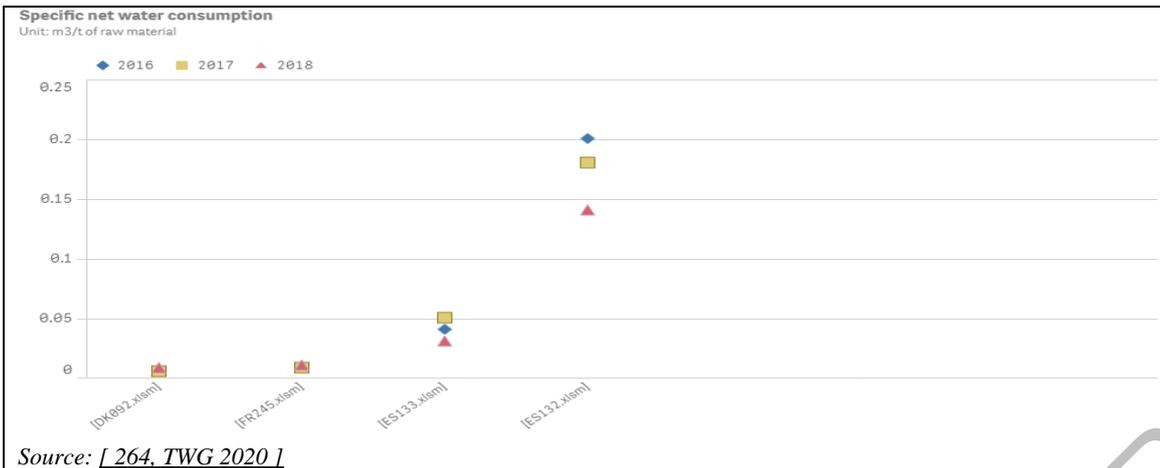
Figure 4.37: Specific water consumption (m^3/tonne of raw material) in fishmeal and fish oil production (installation level)

Figure 4.38 and Figure 4.39 show the specific net water consumption (in m^3/tonne of raw material) for several specific processes in in fishmeal and fish oil production.



Source: [264, TWG 2020]

Figure 4.38: Specific water consumption (m^3/tonne of raw material) for boilers in fishmeal and fish oil production



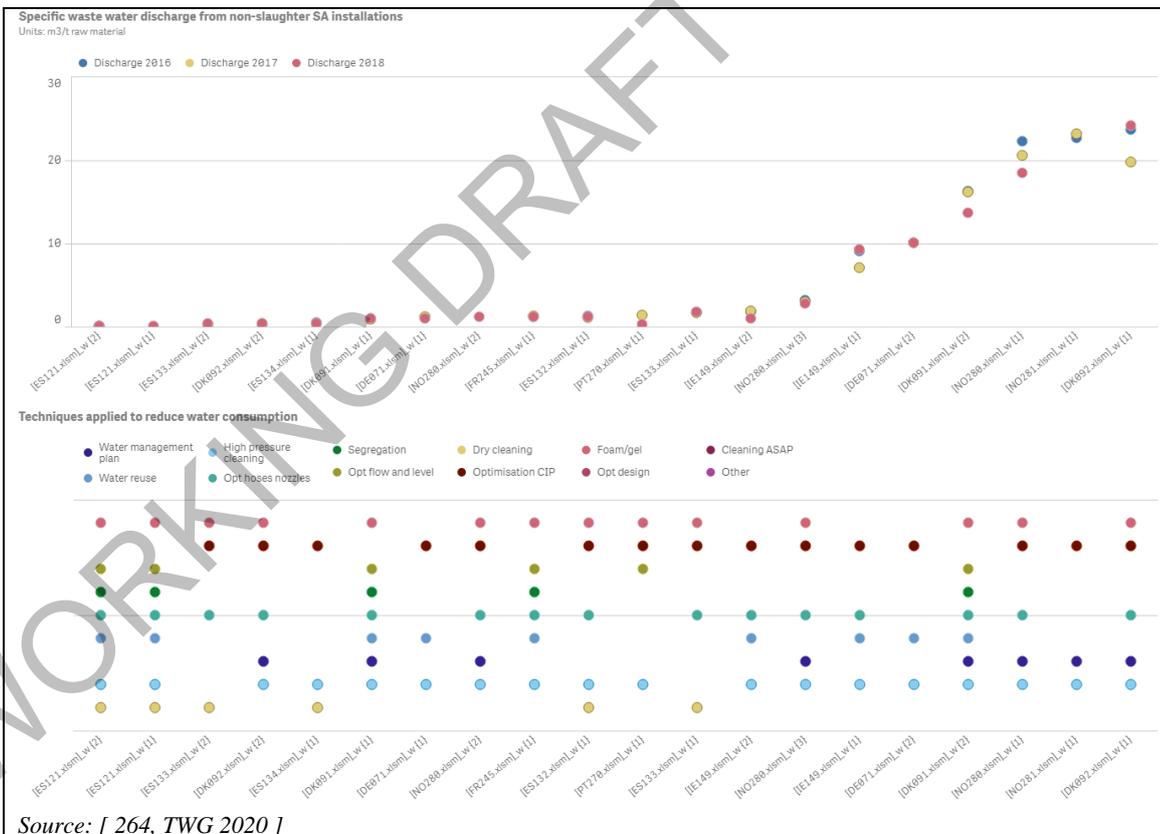
Source: [264, TWG 2020]

Figure 4.39: Specific water consumption (m³/tonne of raw material) for vehicle washing in fishmeal and fish oil production

4.4.3.3 Emissions to water

The total waste water discharge of fishmeal and fish oil installations is generated from several processes, the water content extracted from the raw material and seawater used in scrubbing and cooling processes.

Figure 4.40 shows reported data on specific waste water discharges in m³/tonne of raw material from fishmeal and fish oil production and all types of discharges. The applied techniques for reducing water consumption are also shown.



Source: [264, TWG 2020]

Figure 4.40: Specific waste water discharge (m³/tonne of raw material) and applied techniques for reducing water consumption in fishmeal and fish oil production for all types of discharges

Waste water contains organic matter, suspended solids, nitrogen, phosphorus, dimethylamine and trimethylamine. Sodium hydroxide and sulphuric acid are used as detergents.

Seawater is used as a cooling water in the scrubbers and in evaporators and for scrubbing the air before incineration-

The consumption of fresh or potable water and its subsequent discharge have been considered to play such a minor role that the issue was only recently investigated, due to the introduction of green taxes. An examination showed that the consumption of fresh water for use in the boiler was considerable in one factory, while in another factory a considerable amount of fresh water was used for cooling the hydraulics. A great deal of fresh water is also used for the cleaning of process equipment, although impure condensate from the fishmeal process is generally also used for this purpose. For example, impure condensate can be used as rinsing water for the automatic CIP of the falling film evaporators. [155, Nordic Council of Ministers, 1997]

Table shows emissions per tonne of processed raw material, from a Danish fishmeal factory. There are very large variations in the emissions, as a result of lost product, e.g. stickwater, evaporated stickwater and meal. Minimum and maximum values are shown, together with the average values.

Table: Emissions per tonne of processed raw material from a Danish fishmeal factory

	BOD (kg/t)	Total-P (kg P/t)	Volatile-N (kg N/t)	Kjeldahl-N (kg N/t)
Average	2.1	0.023	0.45	0.59
Maximum	8.9	0.241	1.15	1.75
Minimum	0.5	0.000	0.21	0.25
The results are based on measurements of average emissions per hour during a total of 61 hours. In practice, the emission of Kjeldahl N is equivalent to the total nitrogen emission. Source: [155, Nordic Council of Ministers, 1997]				

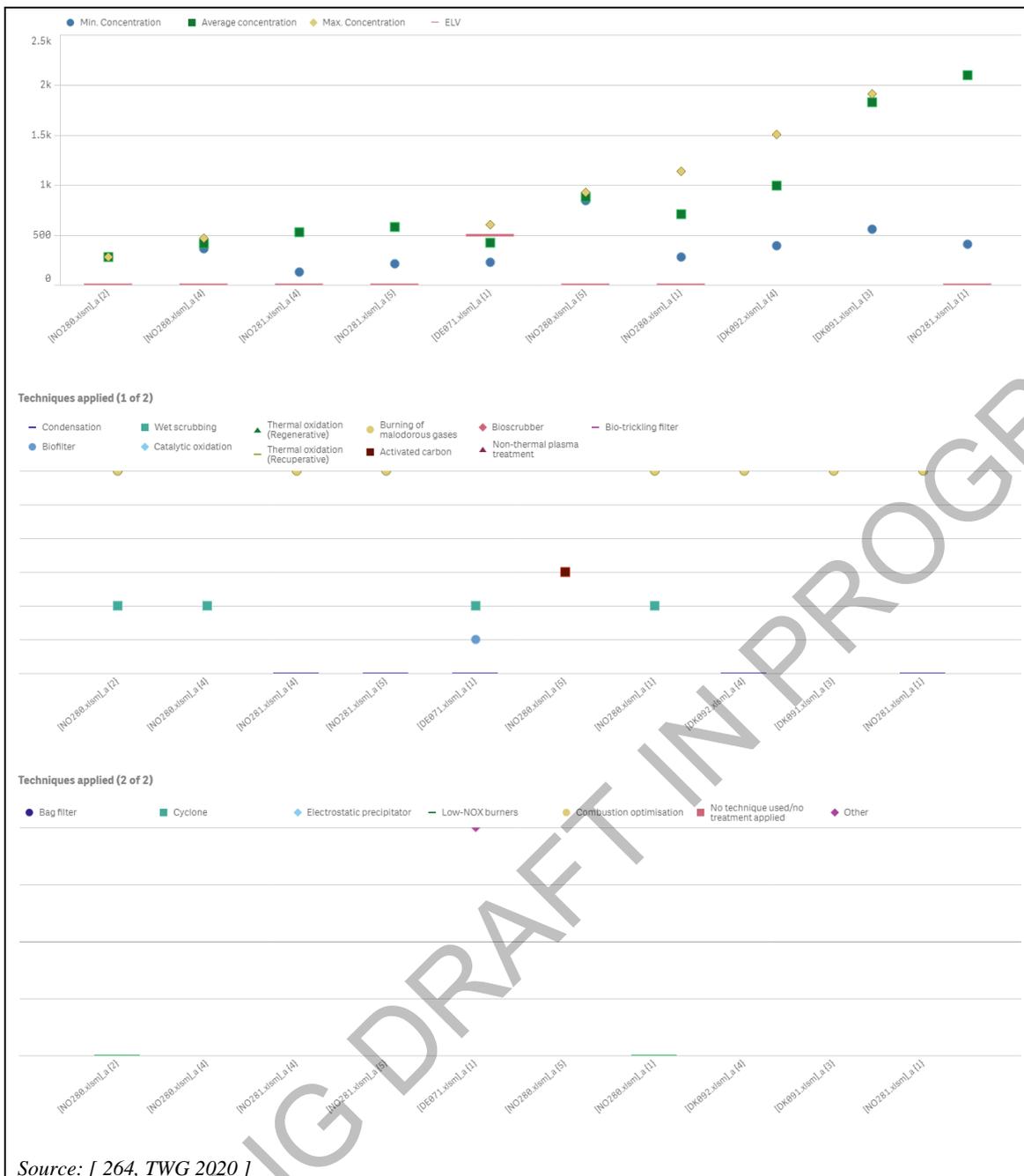
4.4.3.4 Emissions to air

Air emissions contain dimethylamine, trimethylamine and some hydrogen sulphide.

Odour

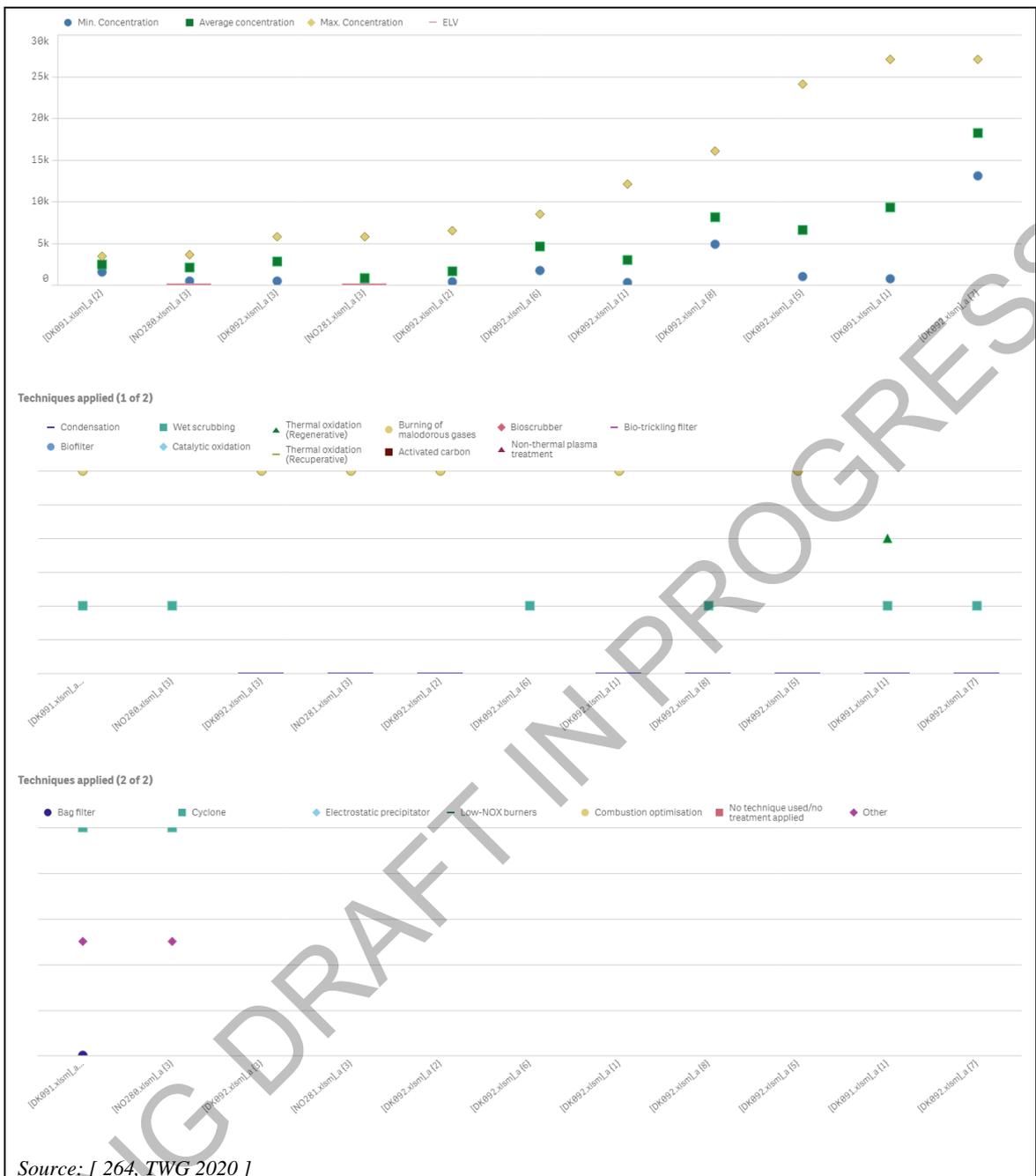
Malodorous air is produced during offloading, drying and from production rooms. It is caused by ammonia and amines in the air and water.

Figure 4.41 and Figure 4.42 show reported data (for the years 2016 to 2018) for channelled emissions of odour, as well as the applied abatement techniques, from fishmeal and fish oil production.



Source: [264, TWG 2020]

Figure 4.41: Odour emissions (OUE/Nm³) and abatement techniques from fishmeal and fish oil production (Part 1 of 2)



Source: [264, TWG 2020]

Figure 4.42: Odour emissions (OUE/Nm³) and abatement techniques from fishmeal and fish oil production (Part 2 of 2)

TVOC

Figure 4.43 shows reported data (for the years 2016 to 2018) for channelled TVOC emissions to air, as well as the applied abatement techniques, from fishmeal and fish oil production.

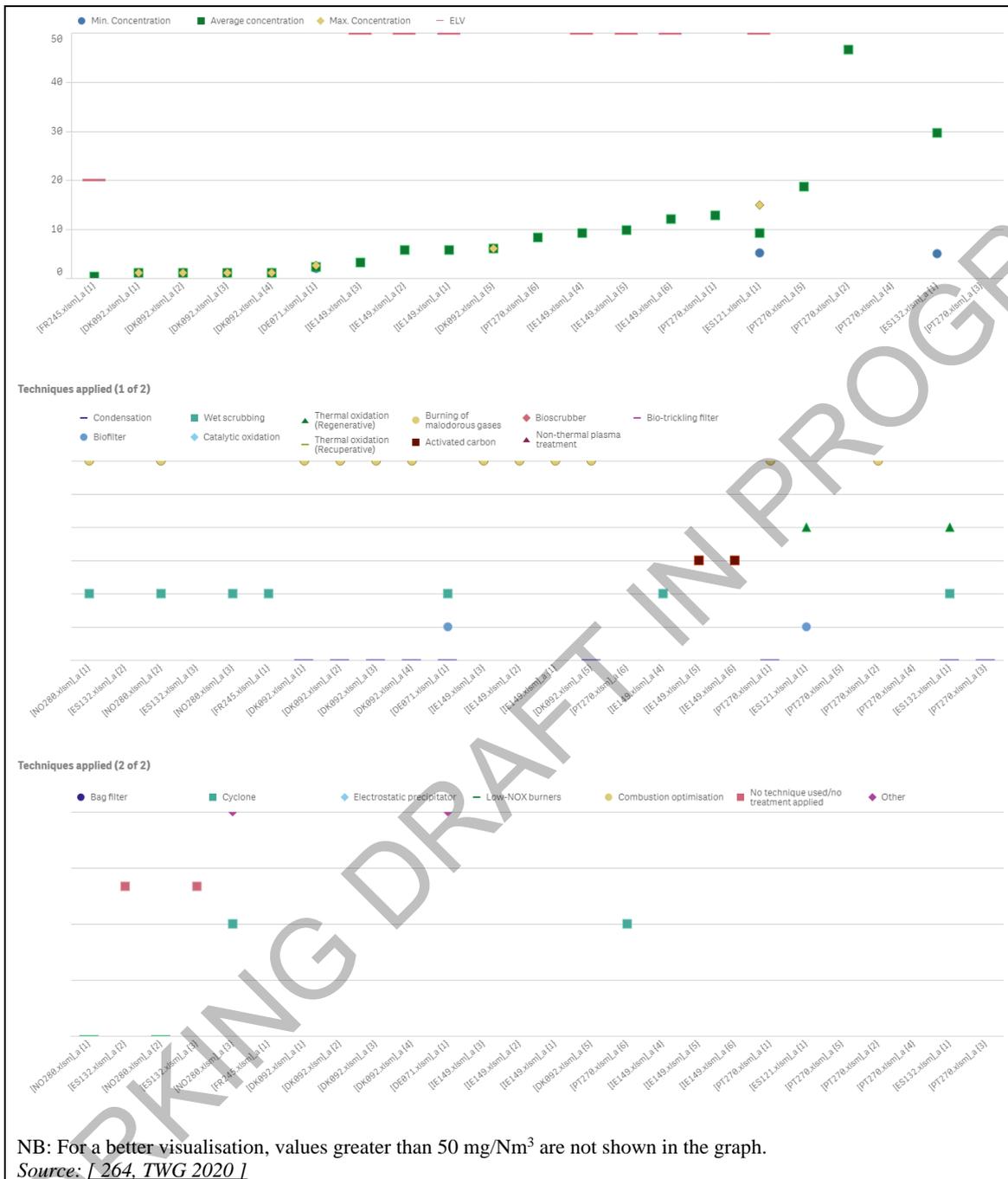


Figure 4.43: TVOC emissions to air (mg/Nm³) and abatement techniques from fishmeal and fish oil production

NH₃

Figure 4.44 shows reported data (for the years 2016 to 2018) for channelled NH₃ emissions to air, as well as the applied abatement techniques, from fishmeal and fish oil production. The reported data refer mostly to emission points from two installations.

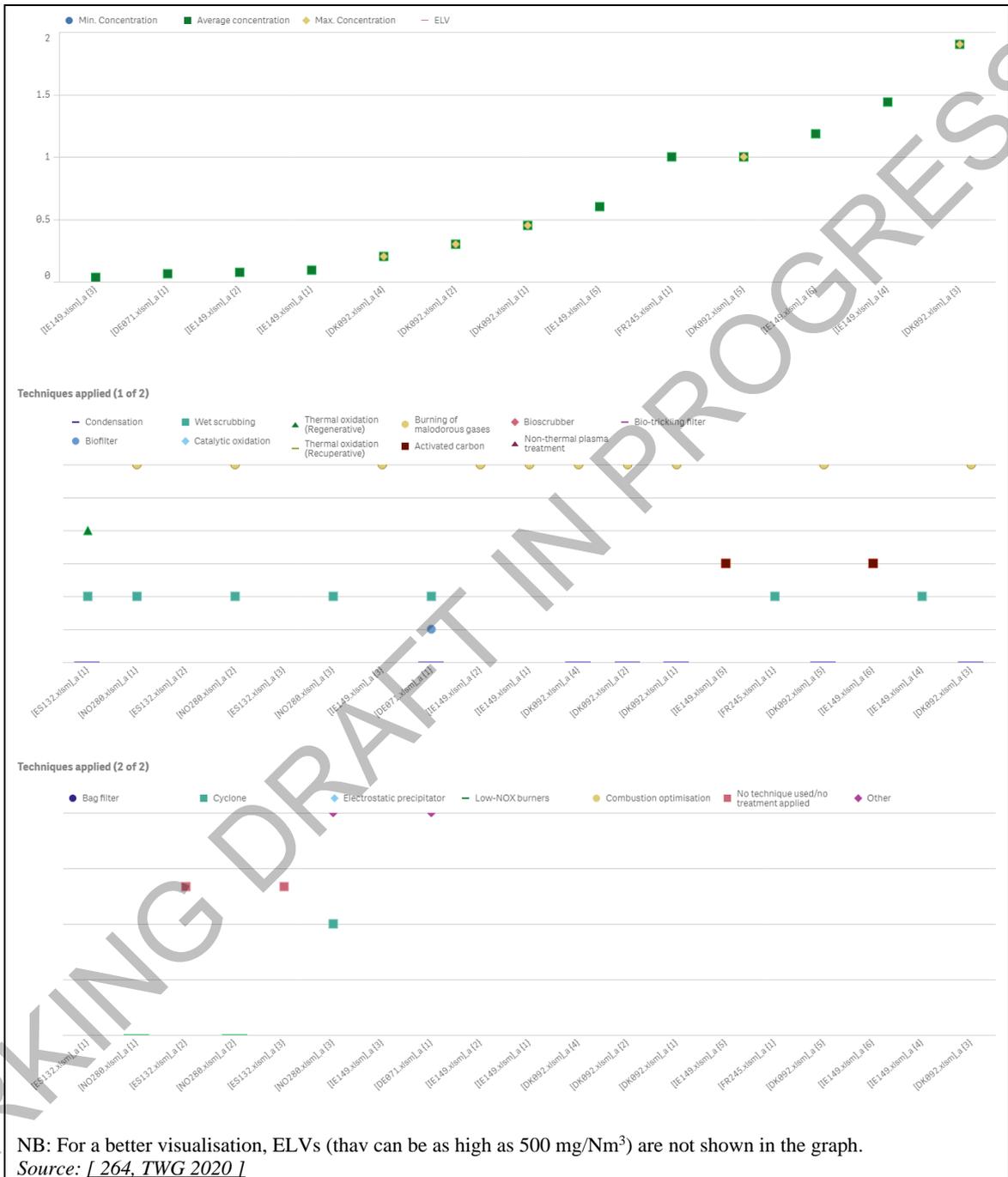


Figure 4.44: NH₃ emissions to air (mg/Nm³) and abatement techniques from fishmeal and fish oil production

4.4.3.5 Noise

Offloading is a noisy operation, due to the use of pumps. The use of submersible fish pumps, such as those used on fish farms, causes less noise. These have the additional advantage of being less damaging to the fish. Their disadvantage is that they need a lot of water and this has to be treated as waste water. [267, IFFO, 2002] [121, IFFO 2002]

~~Solid waste~~

~~The carbon filter press used to remove dioxins from fish oil in the oil finishing/purification process is disposed of as a hazardous waste, by incineration.~~

4.4.4 Techniques to consider in the determination of BAT

4.4.4.1 Techniques to increase energy efficiency

4.4.4.1.1 Use of heat from vapour from drying fishmeal in a falling film evaporator, to concentrate stickwater

See also Section 2.3.4.1.4.

Description

The waste heat from the drying of press cake, grax and evaporated stickwater is used in a falling film evaporator, for the concentration of stickwater, to form evaporated stickwater.

Technical description

The waste heat from the drying of press cake, grax and evaporated stickwater can be used in a falling film evaporator, for the concentration of stickwater, to form evaporated stickwater.

In the installation which reported this technique, the specification for the air/vapour mix from the drier is a temperature of at least 87 °C and for the mix to be saturated with vapour. A 1:1 mix of air:vapour gives an acceptable energy source with suitable heat transfer properties.

Figure 4.45 and Figure 4.46 are schematic representations of two different evaporator types. The evaporator shown in Figure 4.45 is an older self-circulating evaporator, where the stickwater/evaporated stickwater circulates up through the heat-exchanger as a result of heating and vapour formation. This circulation is not shown in the figure. It shows the main steam and liquid flows. The seawater flow through the barometric condenser is typically in the order of 200 m³/h, while the evaporation rate is about 5 to 20 m³/h. The self-circulating evaporator is heated with steam from the factory boiler. This is a very common evaporator type in the fishmeal industry. This type of evaporator typically contains very large quantities of liquid and uses high temperatures in its first stage, where boiling temperatures of 120 – 130 °C are normal. The large quantities of liquid lead to long average retention times and this, together with the high boiling temperatures, causes the stickwater/evaporated stickwater to be exposed to a severe heat load.

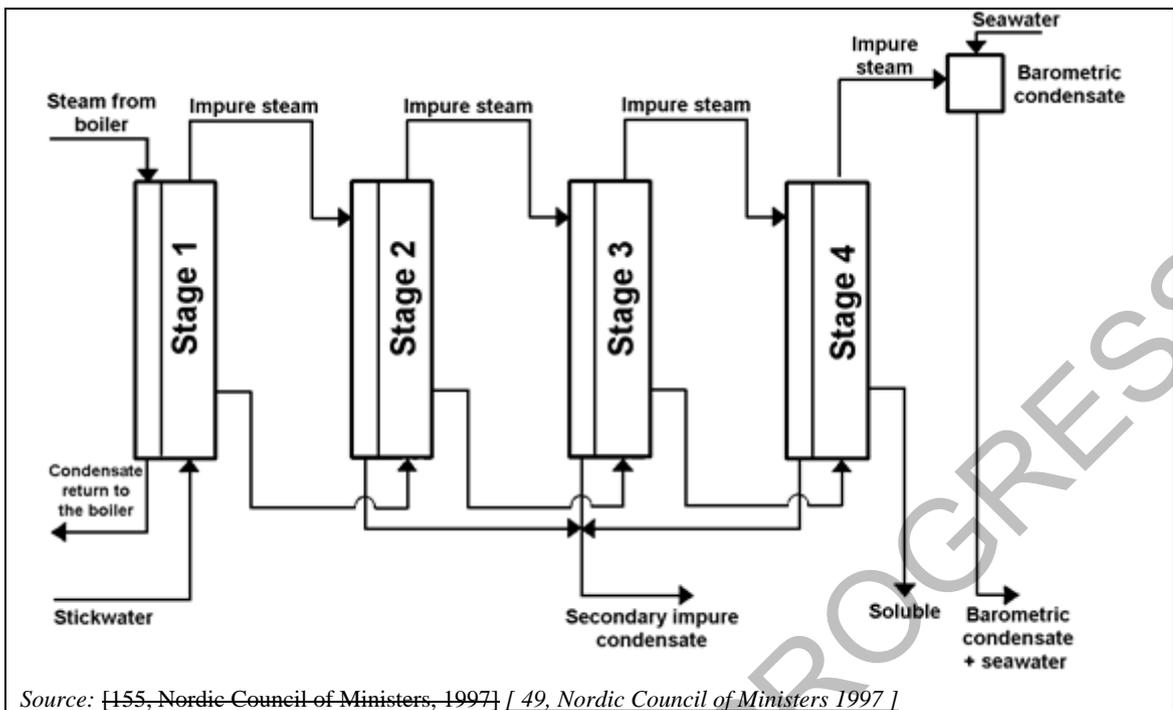


Figure 4.45: Schematic representation of a 4-stage self-circulating evaporator

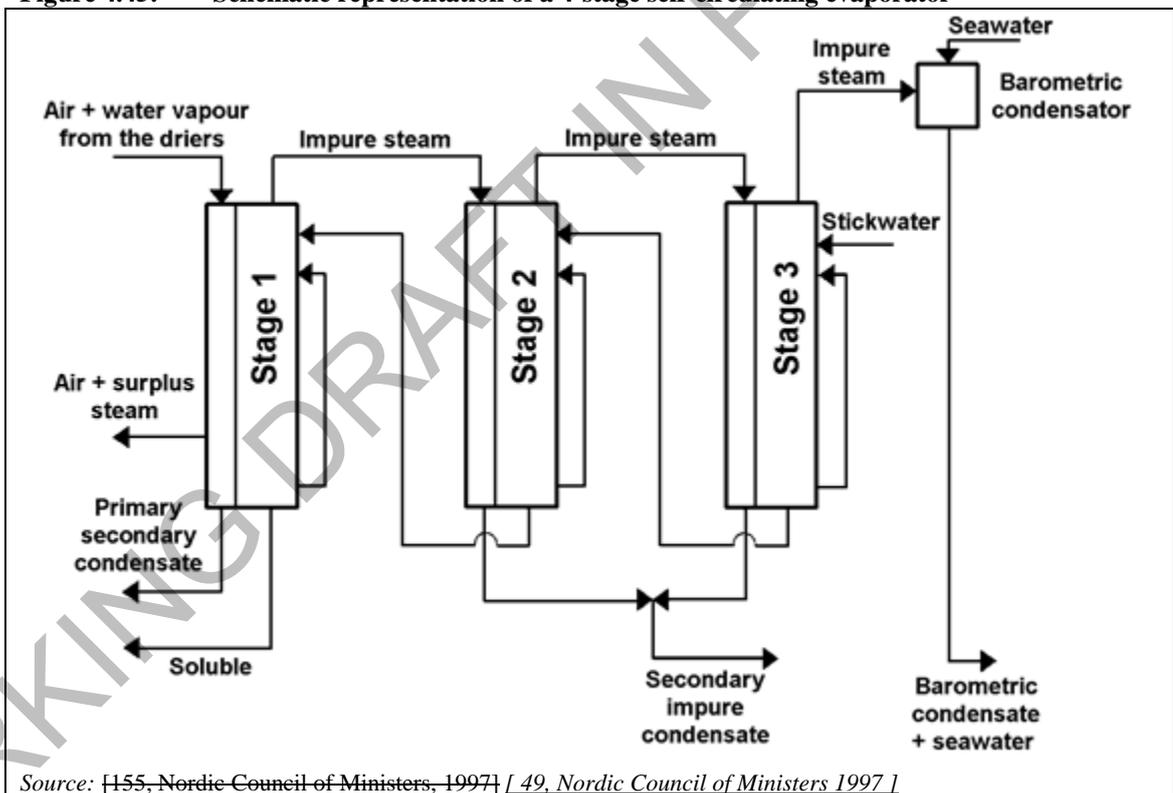


Figure 4.46: Schematic representation of a falling film surplus heat evaporator

The evaporator shown in Figure 4.46 is a falling film evaporator. It shows the main steam and liquid flows. The seawater flow through the barometric condenser is typically around 250 m³/h, while the evaporation rate is about 10 to 30 m³/h. The stickwater/evaporated stickwater is recirculated and then pumped to the top of the heat-exchanger. Here, the liquid is dispersed into a large number of tubes where it runs as a film down the inner walls of the tubes to the bottom of the heat-exchanger. Part of the liquid evaporates. At the bottom of the evaporator, the liquid and vapour mixture is separated. This evaporator type is typically heated with surplus steam from the driers but it can also be heated with steam from the boiler. The evaporator typically

contains very small quantities of liquid and this results in short average retention times. Normally, relatively low temperatures, typically 55 – 60 °C in stage 1 and 40 - 50 °C in the last stage, are used when the evaporator is supplied with surplus vapour from the normal atmospheric pressure driers. The product is submitted to a much lower temperature in this type of evaporator than in the self-circulating evaporator, so it has a better quality.

In the falling film evaporator, a correlation has been reported between the performance of the evaporator and the amount of carry-over in the impure condensate. It is, therefore, possible to reduce carry-over by controlling the output of the evaporator. The carry-over reported at moderate output from a falling film evaporator is reported to be slightly lower than the best results from a self-circulating evaporator. No severe boiling-over was observed from the falling film evaporator.

A self-circulating evaporator, in relation to a falling film evaporator, contains very large quantities of stickwater and evaporated stickwater which remain in the evaporator during temporary stoppages. As stickwater and evaporated stickwater are very unstable, even very short stoppages can result in changes in the product great enough to have a negative effect on the discharge from the evaporating process on restarting the evaporator.

The large volume of the self-circulating evaporator requires very large amounts of water and NaOH for cleaning, which subsequently leads to large amounts of waste water.

It is claimed that use of falling film evaporators in the evaporating process of the fishmeal industry improves the product, as well as reducing the environmental impact. The quality of evaporated stickwater from a falling film evaporator is reported to be considerably higher than that of evaporated stickwater from a self-circulating evaporator, due to the much lower temperatures to which the product is submitted in the falling film evaporator.

Achieved environmental benefits

Reduced energy consumption, due to using the vapour from the drier and by operating at lower temperatures. Less water contamination by product loss and cleaning substances than when a self-circulating evaporator is used.

Environmental performance and operational data

The secondary impure condensate received little contamination due to boiling-over from the self-circulating evaporator, until unidentified technical problems occurred in the evaporator. In spite of this, the results of a statistical analysis suggest that the phosphorus content had a significant influence on the degree of pollution in the condensate. A similar effect was not seen for the secondary impure condensate of the falling film evaporator, even though it often contained as much phosphorus as the samples from the self-circulating evaporator.

The quality of the evaporated stickwater from a falling film evaporator is considerably higher than that of evaporated stickwater from a self-circulating evaporator, because of the much lower temperatures to which the product is submitted in the latter. The fishmeal extracted from the press cake, grax and evaporated stickwater, is also consequently of a higher quality.

Cross-media effects

Seawater is discharged at approximately 10 - 15 °C.

Technical considerations relevant to applicability

Not applicable in all fishmeal and fish oil factories with mechanical vapour recompression evaporators [241, TWG 2019].

Economics

Request to the TWG: Please provide information.
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Driving force for implementation

Reduced energy consumption and improved product quality.

Example plants

A fishmeal and fish oil factory in Denmark.

Reference literature

[155, Nordic Council of Ministers, 1997] [49, Nordic Council of Ministers 1997], [213, Nielsen E.W., 2001] [89, Nielsen E.W. 2001], [241, TWG 2019]

Washing of air with condensate instead of with seawater**Description**

At one installation it was found that when condensate air was washed with seawater, it was unsuitable for treatment in a WWTP (in the installation reported, this would have been a municipal WWTP) and was discharged back to the sea, still containing the contaminants from the condensate.

The system was changed so that the air was washed/scrubbed with condensate and could consequently be directed to the WWTP. The operators of the installation chose to send a proportion of the effluent to the WWTP, thereby reducing the BOD, nitrogen and phosphorus emissions to the sea.

Achieved environmental benefits

Reduced emissions of nitrogen, phosphorus and BOD to sea. Reduced consumption of seawater.

Operational data

Table and Table show actual reductions in emissions of nitrogen, phosphorus and BOD to sea made possible by substituting condensate for seawater in an air scrubber. This made treatment of the scrubbing liquor in a WWTP an option.

Recipient	N (g/t fish)	P (g/t fish)	BOD (g/t fish)
Sea	137 (160)	0.68 (2)	131 (230)
WWTP	213 (condensate)	1.04 (condensate)	838 (condensate)
	25 (flotation)	5.59 (flotation)	137 (flotation)
Total	375	7.31	1106

Table: Contamination loads in waste water from a fishmeal/fish oil factory, before substitution of seawater by condensate in an air scrubber

Recipient	g/t fish						Condensate (m ³ /t fish)	
	Before	After	Before	After	Before	After	Before	After
	N	N	P	P	BOD	BOD		
Sea	137	19	0.68	0.62	131	53	0.230	0.185
WWTP	238	356	6.63	6.69	975	1053	0.770	0.815

Table: Reductions in emissions to sea from a fishmeal/fish oil factory, due to substitution of seawater by condensate in an air scrubber

Cross-media effects

Additional waste water treatment required.

Reference literature

[212, Nielsen E.W., 2001]

4.4.4.2 Techniques to reduce emissions to air

4.4.4.2.1 Use of fresh low total volatile nitrogen (TVN) feedstock

See also Section 2.3.2.6.

Description

Minimisation of the TVN of the feedstock by storing the fish in the fishing vessels at low enough temperatures and for the shortest time possible.

Technical description

A feature of the trimmings/by-product raw material is the remoteness of locations from which the material originates, which can make maintaining the quality of the raw material difficult as it is delivered to the plant in smaller consignments.

Fish can deteriorate under the anaerobic conditions present during storage on the fishing vessel and in the raw material silos in the factory. The deterioration causes the formation of a large number of strong-smelling compounds. Besides NH_3 , TMA and other volatile basic compounds, various volatile sulphur compounds, such as mercaptans and the highly toxic and strong-smelling H_2S gas, are formed.

Achieved environmental benefits

Reduced nitrogen and sulphide content and consequently reduced odour emissions during storage, processing and waste water treatment.

Environmental performance and operational data

A decrease in raw material quality (increase in TVN) results in a considerable increase in the levels of the nitrogen compounds evolved. It is reported that statistical analysis shows that even with low concentrations of phosphorus, e.g. from over-boiling, much larger increases in condensate nitrogen levels were recorded than expected from just a consideration of the nitrogen and phosphorus content of the stickwater and evaporated stickwater.

Several investigations have been carried out on the deterioration of the raw material and on odour emissions from fishmeal factories. The investigations included examinations of the odour emitted during the unloading, transport, storage and processing of industrial fish in relation to the freshness/quality of the raw material. Plots of the raw material TVN contents against time give almost straight lines which have a strong dependence on the storage temperature. Several investigations have shown that the rate of TVN formation roughly doubles for each 6°C temperature rise.

Investigations indicate that H_2S formation starts at a raw material TVN content of approximately 50 - 100 mg N/100 g of fish. H_2S is released from the fish during mechanical handling. It has been shown that at both 6°C and 12°C an exponential decrease in the H_2S content (the released amount) takes place. It has also been shown that extending the storage by 4 to 5 days results in roughly a tenfold increase in odour, irrespective of the temperature.

To summarise, the results of the odour measurements show that the higher the storage temperature, the faster the odour development and the stronger and more unpleasant the odour is, at an equal odour concentration. That is, odour formed at high temperature has a more powerful and worse smell than the same "odour quantity" formed at low temperature.

Minimising the TVN at the fishmeal and fish oil processor installation, therefore, depends on the fish being stored in the fishing vessels at low enough temperatures and for the shortest time possible, to minimise degradation and the formation of strong and intensively malodorous substances.

Fishmeal and fish oil processors do not generally refrigerate raw materials, but ice is added on the fishing vessels. The amount depends on the temperature of the seawater and on how long the

fish have to be stored in the boat before landing. In the late summer period, up to 25 % ice can be added to the fish; in the winter 10 % is considered to be sufficient. On average 15 % ice is added to all fish caught. To cool the fish down to 0 °C, ice is added at a ratio of 1.25 %, by weight of fish caught. For example, if the temperature of the fish is 4 °C, then $4 \times 1.25 \% = 5 \%$, by weight of ice is added, i.e. 5 t ice/100t fish. If the temperature is 16 °C then $16 \times 1.25 = 20$ t ice/100 t fish is added. If the fish has to be stored for longer than 1 – 2 days then more ice is required to keep the temperature down to 0 °C. The energy consumption for producing 1 tonne of ice is 60 kWh. The average energy consumption per tonne of industrial fish by adding 0.15 tonne of ice would be 9 kWh. The addition of ice to the fish means that more energy must be used to remove the water, which in turn has to be treated in a WWTP.

The use of fresh raw material, leads to the production of a higher quality product, as well as a reduction in odour and waste water treatment problems.

It is reported that it is not possible to totally avoid odours, even by using fresh materials, so the use of abatement techniques will always have to be considered.

Cross-media effects

None reported.

Technical considerations relevant to applicability

Applicable in all fishmeal and fish oil processing plants.

Economics

There are economic advantages associated with the production of a higher quality product from fresher, i.e. lower TVN, raw material.

Driving force for implementation

Reduced odour problems during storage, processing and waste water treatment and improved product quality.

TVN is used as a quality parameter and process control and used in the contract with the supplier, as it relates to the quality of the end-product.

Example plants

The 3 largest Danish fishmeal factories.

Reference literature

[155, Nordic Council of Ministers, 1997] [49, Nordic Council of Ministers 1997], [303, Minck F., 2002] [152, Minck F. 2002], [241, TWG 2019]

4.4.4.2.2 Incineration of malodorous air, with heat recovery

See also Section 2.3.8.2.13.

Technical description

An installation has been described where 80 000 m³/h of air is incinerated in each of 3 incinerators. The majority of the air is from the press cake, grax and evaporated stickwater drier. Other sources include air from offloading, which contributes about 5000m³/h. The air is passed through a scrubber before it is incinerated and the liquid effluent from the scrubber is treated in a WWTP.

Achieved environmental benefits

Odour abatement by 99.5 %.

Environmental performance and operational data

It is reported that it is impossible to avoid malodorous air during the production of fishmeal and fish oil, even if fresh ingredients are used. Malodorous emissions are produced during drying and evaporation. Those associated with the raw material can be reduced if the fish is processed fresh.

The inlet air is passed through one of 3 ceramic heat-exchangers at 40 - 50 °C and the outlet air is passed through one of the other 2, at a temperature of 90 - 100 °C. The air is forced through the incinerator by suction. The direction of the flow is changed about every 30 seconds, so that all 3 heat-exchangers operate in the cycle.

When the plant is running at a maximum fish throughput capacity, i.e. 250 t/h fish, the driers generate 50 t of dry air and 50 t of water vapour. Most of the water vapour condenses in the waste heat evaporator.

The incineration conditions are 850 °C for 1 second.

Non-condensable gases can reportedly be destroyed by increasing the temperature of the ceramic incinerator. It has been stated that using scrubbers with seawater will only reduce the odour problem by 50 %.

Cross-media effects

High energy consumption, i.e. 1 m³ of natural gas per tonne of fish treated. It is reported that 90 - 95 % of the heat is recovered and used to heat air.

Technical considerations relevant to applicability

Applicable in fishmeal and fish oil processing factories where odour problems cannot be eliminated.

Economics

The investment costs are reported to be EUR 10 000 – 15 000/1000 m³/hr.

Driving force for implementation

Odour reduction.

Example plants

A fishmeal and fish oil factory in Denmark.

Reference literature

[212, Nielsen E.W., 2001] [88, Nielsen E.W. 2001], [213, Nielsen E.W., 2001] [89, Nielsen E.W. 2001], [303, Minck F., 2002] [152, Minck F. 2002], [333, Netherlands TWG, 2003] [177, The Netherlands 2003]

4.5 Gelatine manufacturing

4.5.1 General information about the sector

The gelatine industry is represented by the Gelatine Manufacturers of Europe Association, which has 11 members and 21 gelatine production units, i.e. 2 in Belgium, 3 in France, 6 in Germany, 2 in Italy, 2 in Spain, 1 in the UK, 1 in Sweden, 3 in the Netherlands and 1 in Slovakia. In addition to these gelatine plants, there are 3 bone degreasing plants in France, Germany and the Netherlands, delivering bone chips to the gelatine plants (thus considered as part of the gelatine manufacturing). In the year 2018, they produced around 135 000 tonnes of gelatine (including hydrolysed collagen). The industry employs approximately 2 500-3 000 people. There are two other gelatine production units in the EU operated by non-GME members in Spain and in Poland, and 2 other bone degreasing plants in France and Ireland [263, GME 2019].

~~The gelatine industry is represented by the Gelatine Manufacturers of Europe Association (GME), which has 9 members and 18 production units, i.e. 2 in Belgium, 3 in France, 7 in Germany, 2 in Italy, 2 in Spain, 1 in the UK and 1 in Sweden. In the year 2001, they produced 117000 tonnes of gelatine. The industry employs approximately 3600 people. There are 3 other production units in the EU operated by non-GME members, i.e. 1 in the Netherlands, 1 in Germany and 1 in Spain. [349, GME TWG members, 2003]~~

4.5.2 Applied processes and techniques

Gelatine is natural, soluble protein, gelling or non-gelling, obtained by the partial hydrolysis of collagen produced from bones, hides and skins, tendons and sinews of animals (including fish and poultry). [85, EC, 1999]. ~~The raw materials used comprise bones, fresh or frozen hides, pig skins and fish skins. The use of hides and skins submitted to tanning processes is prohibited for the production of gelatine intended for human consumption [85, EC, 1999]. ABP Regulation 1774/2002/EC requires all material destined for gelatine production to be Category 3 material, as defined therein.~~

The edible raw materials intended for the manufacturing of gelatine and collagen peptides are sourced from [277, GME 2020]:

- pigskin (conventional and organic – as by-product from the meat industry);
- bovine hide - as by-product from the leather industry;
- bovine bone – as by-product from the meat industry;
- pig bones – as by-product from the meat industry;
- fish skin – as by-product from fish products.

All raw materials are fit for human consumption and have been approved ante- and post-mortem by veterinarian authorities. Several sites in Europe are producing gelatine from more than one type of raw material.

Gelatine is used in a diverse selection of industries (e.g. food industry, pharmaceutical industry, photographic industry) and products (e.g. powder gelatine, leaf gelatine, technical gelatine). The majority of gelatine produced is edible and pharmaceutical gelatine. It is also used in the photographic industry, in both films and paper. Technical gelatine is used, e.g. in cosmetics and micro-encapsulation (carbon paper).

The production of edible gelatine and collagen peptides should comply with European legal requirements, e.g. on rules for food of animal origin, microbiological requirements or medicinal products for human use.

Meat meal and some bone meal is produced from the removal of residual flesh from the bones. Tallow is used in pet food and as rolling oil in the ferrous metal finishing industry.

Gelatine waste shavings are landfilled in the UK.

Sludge from the waste water treatment after both the pretreatment of bones and gelatine production is may be used for landspreading injection, according to soil requirements. The sludge may need to be mixed with other substrates.

4.5.2.1 Description of the main gelatine manufacturing processes

There are several processes for the production of gelatine and/or collagen peptides. These depend to some extent on the raw materials used, although after the de-fatting and demineralisation of bones and the acid treatment of pig skins, the gelatine extraction steps in some of the processes using bones hides and pig skins are very similar. The main gelatine manufacturing processes are summarised in Figure 4.47 and the individual process steps are described below.

Flow diagrams for the manufacturing of gelatine produced from pig skins, hides, bones and fish skins are shown in Figure 4.49, Figure 4.50, Figure 4.51, Figure 4.52 and Figure 4.53.

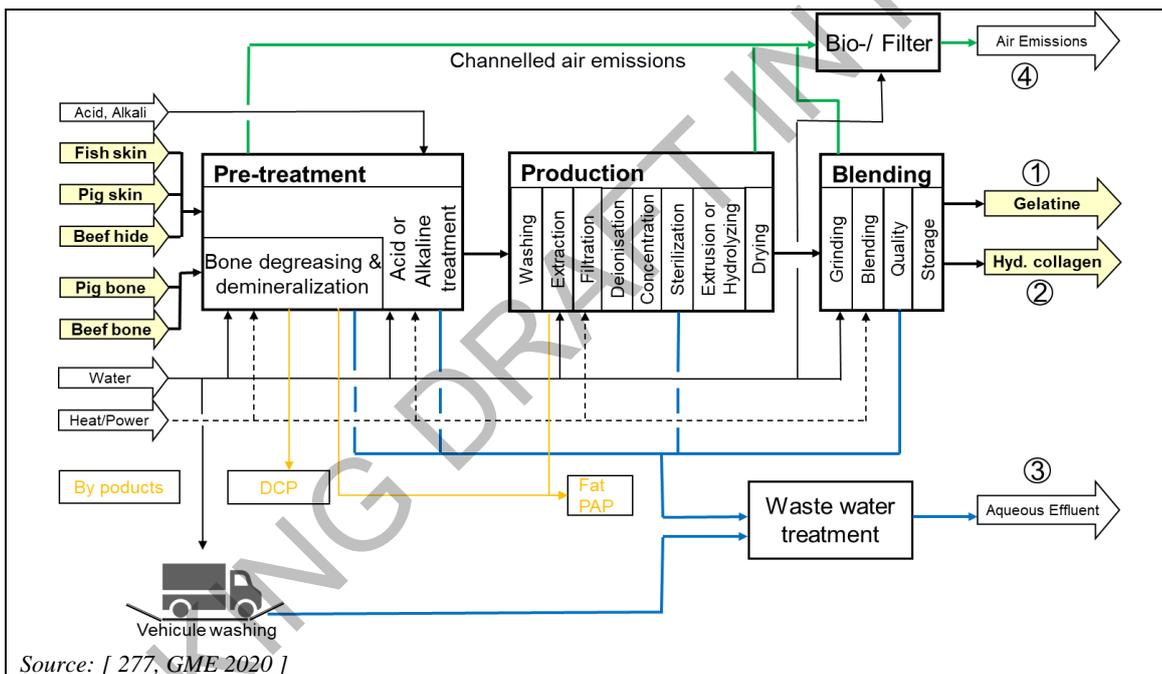


Figure 4.47: Production of gelatine and/or collagen peptides (installation level)

The unit operations for the processes for each of the eight types of gelatine produced are shown in and then again individually in to inclusive. As can be seen from, many of the unit operations are common to several and, in some cases, all of the processes. Techniques which minimise consumption and emission levels at such unit operations may, therefore, be widely applicable throughout the gelatine manufacturing industry.

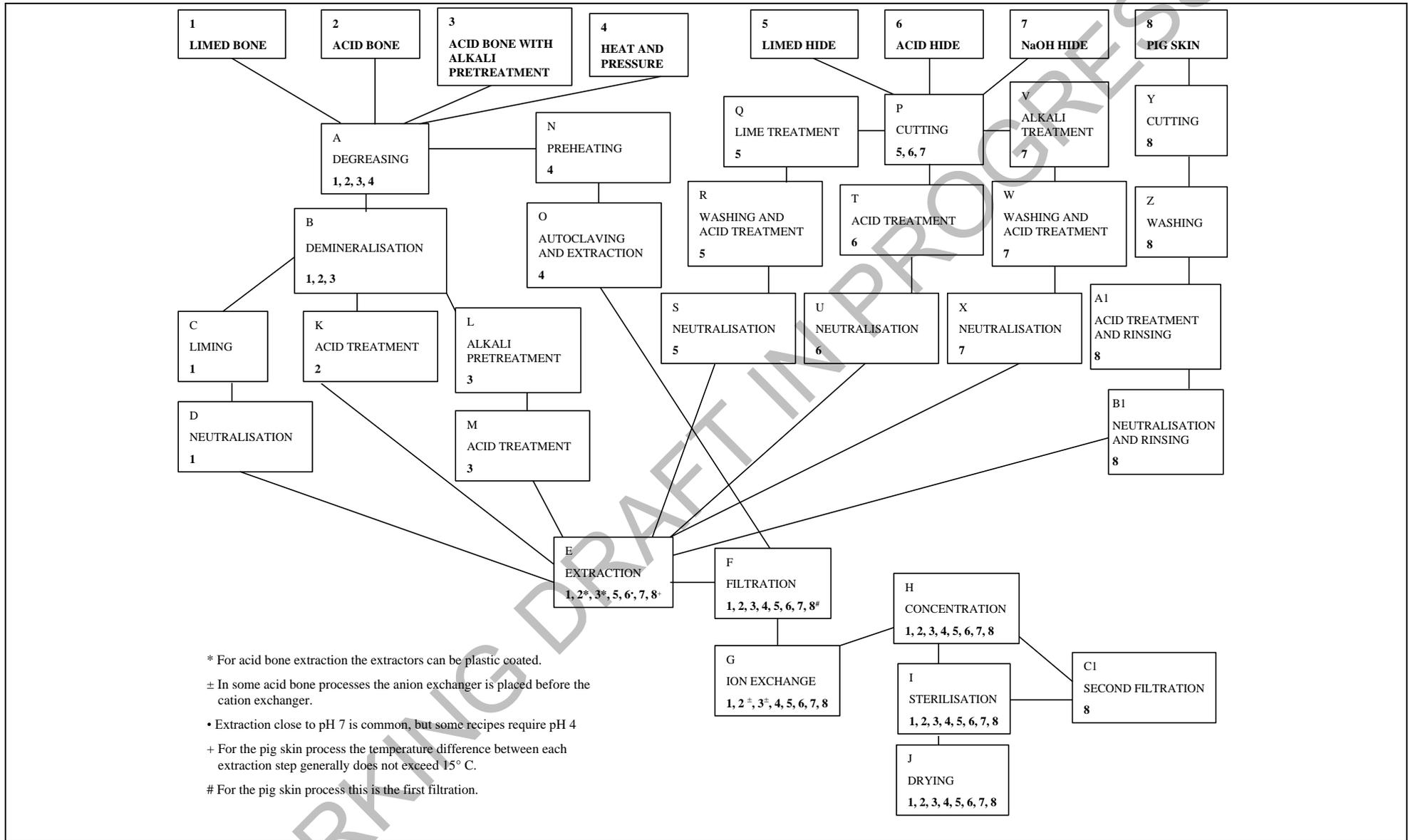


Figure: The main gelatine manufacturing processes
 [249, GME, 2002]
 See also Figure to Figure, inclusive

The unit operations are described next.

A Degreasing

The untreated bones contain a large amount of meat, soft tissue and fat, which has to be removed. A typical example of the composition of a batch of fresh bones is: 46 % water, 15 % fat, 19 % protein and 20 % minerals.

The bones are crushed in a pre-breaker to a maximum particle size of 20 mm diameter, before being degreased, using hot water, at a temperature of 75 - 90 °C, for 15 - 30 minutes. A continuous process has been reported, using a steam jacketed and steam-heated screw conveyor. The turbulent action of the hot water and the sliding and rubbing of the crushed bone loosens the meat and other soft tissue from the bone. The contents of the degreasing vessel are separated to give hard bone, sinew (soft bone) and liquids containing tallow and water.

The hard bone may be washed using hot water, to give a final moisture content of around 10 %. The sinew may be pressed to remove fat and water before being dried with the hard bone to give a final moisture content of 14 %. Drying at 85 °C takes 45 minutes. [~~208, Croda Colloids Ltd, undated~~] [85, Croda Colloids Ltd 2000]

Alternatively the sinew and liquid stream may be separated into a liquid stream containing tallow and water using a decanter or tricanter system and the sinew stream can then be dried in a rotating disc drier, to give a moisture content well below 10 %. The product temperature reached in the drier is about 110 °C, for at least 45 minutes. [~~249, GME, 2002~~] [113, GME 2002]

The dried bone and sinew are sieved at 2 mm and 5 mm to give bone meal (< 2 mm fraction), intermediate bone pieces (2 - 5 mm fraction) and degreased gelatine bone/sinew (> 5 mm fraction).

The tallow/water mix is separated using centrifuges to give purified tallow and process water. The liquids are maintained at a temperature of 85 °C for 30 minutes during separation.

Fine solids removed from the liquid during separation, together with fine solids from the pressing of the sinew are combined and dried to give a moisture content typically < 10 %. The product temperature achieved in the drier is around 110 °C for at least 45 minutes.

Cyclones are used to remove the air and to separate the fines from the larger particles destined for the gelatine manufacturing.

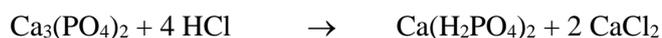
Bone chips are graded by density, using a hydrocyclone, because high-density bones require more processing than low-density bones, both to demineralise and to extract the gelatine. They are then dried in a band oven, with a starting air temperature of around 350 °C and an exit temperature of 150 °C. The chips are only in contact with the hot air for a short time and they are also cooled by the evaporation of the water, so their temperature will not normally exceed 85 °C. The drying time varies from 20 – 60 minutes. The dried bones are then classified by size, firstly using rotating or vibrating sieves, normally at 2 – 5 mm and then using a densimetry table, which comprises an inclined screen with an upward air-draught on to which the bone chips are dropped.

The amount of dried degreased bone chips obtained from 1 kg of bone is usually about 200 g.

If hides or skins are used this pretreatment stage is not required.

B Demineralisation

The demineralisation process is the removal of the inorganic component, which comprises mainly natural phosphates and calcium carbonate. The defatted bones are placed in a strong HCl solution at pH 1 - 2, where the tricalcium phosphate is converted into the soluble monocalcium salt, which is run-off in solution, for later conversion to dicalcium phosphate, soluble calcium chloride and CO₂. The chemical reaction with HCl is shown.



For 1000 kg of degreased bone, containing 8 % water and of which 63 % comprises 7 % CaCO_3 and 56 % $\text{Ca}_3(\text{PO}_4)_2$, approximately 7700 litres of 4 % HCl is required, for complete conversion.

The solid residue, which is known as ossein, is used in gelatine manufacturing. The ossein production process may take several days depending on the nature, size and density of the raw material. Several pits, e.g. six, sit in series, containing ossein, at various stages in the process. Fresh HCl at a concentration of 3.5 %, is added to the pit containing the ossein which has been treated for the longest time. After approximately 24 hours, this acid is pumped to the pit containing the second oldest ossein, whilst the acid from this is pumped to the pit containing the third oldest ossein. The process continues by this batch countercurrent action. In this way the “newest” liquor, with the highest acid concentration and the lowest concentration of monocalcium salt is extracting the salt from the ossein with the lowest available yield. The “oldest” liquor, with the lowest acid concentration, i.e. about 0.5 %, is extracting the salt from the ossein which has the most salt to give up. The process can be helped by air agitation. The process is illustrated in Figure 4.48.

Each reactor tank in the process typically contains a batch of 20 – 50 tonnes of bone chips, but smaller tanks may also be used. The tank height may be about 7 metres and the diameter about 3.5 metres. New reactors are usually made from plastic coated steel. For a system with 4 reactor vessels, 200 tonnes of degreased bone chips can be treated in 4 days, in 4 batches of 50 tonnes. To demineralise these, approximately 1540 cubic metres of 4 % HCl is required. For an installation operating at an efficiency of approximately 90 %, this requirement increases to approximately 1710 cubic metres in four days or about 17.8 m³ /h.

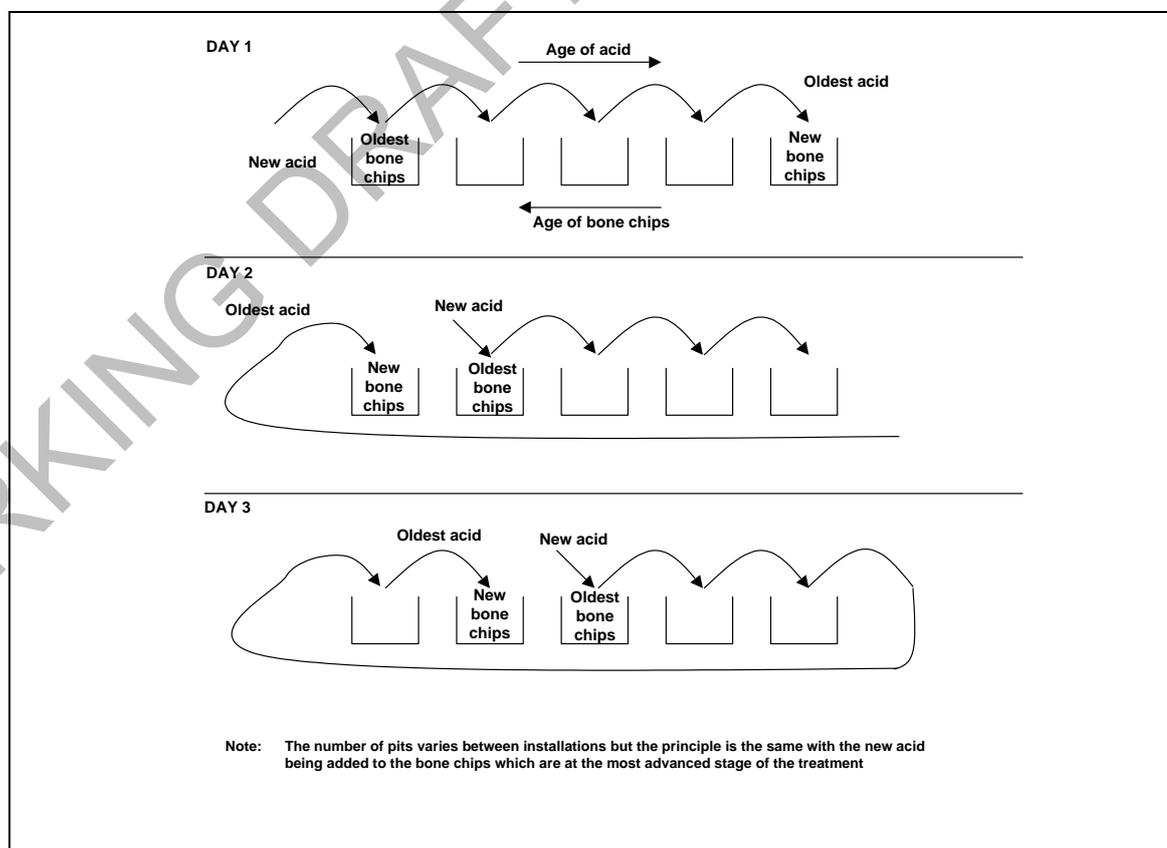


Figure 4.48: Flow diagram for the demineralisation of bone to produce ossein for gelatine manufacturing

C Liming

Liming is usually done in large concrete pits that can contain the ossein from one batch of demineralised bone chips. The ossein is submerged in a solution of supersaturated lime to purify and condition the collagen, to promote its hydrolysis. The pH during this process is approximately 12.5, i.e. the pH of fresh made lime solution. The supersaturated lime solution is refreshed regularly to compensate for its consumption during the process. Air is blown through regularly, to prevent local drops in the pH level.

After the last decanting of the lime the ossein is washed by filling the lime pit with about the same amount of water as the weight of the original bone chips and leaving it in for some time before running it off. The ossein is then washed a second time by agitating it with approximately the same amount of water, after which it is pumped in a stream of water to the neutralisation installation. The washings contain lime and can be used to neutralise the acid used in the early process, otherwise consumption of another alkali would be required for this.

A typical liming process schedule is shown in Table 4.17, the number of days varies between installations and can be as high as 90, depending on the quality of the bone chips, the average temperature of the lime and the desired physical properties of the gelatine. The frequency of refreshing the lime, the frequency and the time of blowing air into the pit and the number of times the ossein is washed, with or without agitation, also varies between installations and batches.

Table 4.17: Typical liming process schedule

Day	Adding fresh lime	Decanting	Pumping air	Washing
1	X			
2	X	X		
3			X	
4	X	X		
8			X	
9	X	X		
12			X	
15			X	
17	X	X		
21			X	
25			X	
27	X	X		
31			X	
35			X	
37	X	X		
41			X	
43			X	
46		X		X

D Neutralisation

The washed limed ossein still contains lime and has a high pH in the centre of the particles. It is treated with dilute acid to neutralise and remove the lime, and to change the pH to pH 4.5 – 7. The batch of ossein is submerged in at least as much water as the original weight of the bone chips from which the ossein was made. The ossein is stirred and the acid is added. The pH is measured continuously and can be used to control the flow of acid. When the pH remains constant for several hours within the desired pH range without acid being added, the ossein is considered to be neutralised. The acid water is then run-off and the ossein is washed with at least five times its own weight of fresh water, whilst remaining submerged. The neutralisation can be done in one or more stirred tanks in the extraction vessel. The installation is usually made of stainless steel or plastic coated steel.

E Extraction

The gelatine is extracted from the neutralised ossein, pretreated hides or pig skins, with hot water. This involves about 5 steps, at progressively higher temperatures, usually with no more than 10 °C difference between steps and typically ranging between 50 - 60 °C and 100 °C. The gelatine concentration of the extract is normally 3 - 8 %.

The water can be added cold and then heated, or already heated. The ossein in the extractors may be stirred carefully in the warm water or the water may be circulated over the ossein bed. This is continued until a concentration of about 5 % gelatine, is reached. The extract is then drained and the process is repeated, usually at a higher temperature. When drained, the extract usually passes through a sieve or a mesh to prevent large particles getting into the pipework. The final extraction is stopped when, while extracting at 100 °C, the concentration of gelatine does not reach 3 %, or when no ossein is left. The amount of water required is at least the amount needed to submerge the ossein or pig skins, plus the amount to fill the pipes, pumps and heat-exchangers. For ossein coming from 50 tonnes of bone chips, the amount of gelatine in each extract is between 1500 kg and 4000 kg. The installations are normally made of stainless steel.

F Filtration

The extract is filtered to remove any insoluble particles. The filtration can be done in one or more steps. The filter medium is generally diatomaceous earth or cellulose, although cotton may also be used. If diatomaceous earth is used, a filter aid, usually composed of the same kind of diatomaceous earth as the filter, is added to the gelatine solution, to prevent blocking by continuously building up the filter layer. When using cellulose, pulp pads of about 5 cm thickness can be used. Often the filtration is done in two steps, the diatomaceous earth filter being followed by a filter that uses commercially available cellulose filter pads, which are about 1 cm thick. The extract may pass a cloth filter bag first, to remove residual coarse particles. During filtration the temperature of the solution is kept at 55 - 60 °C.

The filtration equipment is usually of the same type as that used in several branches of the food industry and is readily available. The diatomaceous earth filtration can be either pressure or vacuum operated. For pressure operated filtration, the filter bed is in a closed vessel which is pressurised. When the maximum pressure is reached, the filter meshes are automatically cleaned and covered with new filter aid. For vacuum filtration, the filter is usually a rotating drum filter with the filter layer on the outside of the drum. The extract is sucked into the inside of the drum. With this kind of filter, the filter aid and the layer is automatically scraped off, so the filter continuously has a fresh surface.

G Ion exchange

The filtered extract is passed through an ion exchange resin to remove all the dissolved salts from the solution. The solution normally first passes the cation column and then the anion column. Most installations consist of two cation columns and two anion columns. One of each is in use at any one time, while the other two are either regenerating or are on standby. Modern installations have an automatic control system that diverts the flow to the standby column as soon as the column in use reduces in effectiveness, at the same time starting the automatic regeneration procedure for the exhausted column. Older installations are less automated. The cation and anion exchangers are regenerated with approximately 5 % HCl and 5 % NaOH and both are rinsed using de-ionised water. An example column size is 1.57 metres in diameter and 1.75 metres high. The flow through such a column is about 7 m³/h. During the ion exchange the temperature of the solution is generally kept at 55 - 60 °C. The installations are made of synthetic material or of plastic coated steel.

H Concentration

After the solution comes from the ion exchangers the next step is to concentrate it. Different designs of evaporators can be used for this. This facilitates the removal of water at relatively low temperatures. In multiple-effect vacuum evaporators, the vapour extracted from the first effect is used to heat the second and that from the second is used to heat the third. The heating

and cooling is undertaken very quickly so that the product is not damaged. Figure 4.2 shows a schematic diagram of a multiple-effect evaporator. At this stage in the process the solution is about 20 - 30 % gelatine. The equipment is made of stainless steel.

I Sterilisation

The concentrated gelatine solution is sterilised either by direct steam injection, such that the temperature is raised to 138 - 140 °C, or by operating the final effect, known as a finisher, at a temperature of about 120 - 140 °C. The increase in temperature is achieved by injecting steam from another source. If direct steam injection is used, the solution is kept at this temperature for at least 4 seconds whilst maintaining a pressure of at least 4 bar (400 kPa). The temperature of the gelatine is measured and monitored continuously. The sterilising equipment is made of stainless steel.

J Drying

The sterilised concentrated gelatine solution is pumped through a heat-exchanger and cooled to a temperature of less than 30 °C, to form a gel. The gel is extruded through a perforated sheet to form thin threads. A small pivoting conveyor belt is used to deposit the threads on to a large metal wire conveyor belt, which runs through a segmented drying tunnel. In the drying tunnel, the gel is dried with clean purified pre-dried warm air. Each subsequent segment of the tunnel has a higher temperature, ranging from 25 - 30 °C to 50 - 60 °C. The drying takes up to 6 hours. The heat for the drier may be recovered heat from the hot water from the evaporator. When the gel enters the drying tunnel it contains about 80 % water. The dried gelatine usually contains about 11 % water, although this may vary between 9 - 15 %. After drying, the gelatine is crushed and packed for intermediate storage. The dried threads are ground and bagged. Each batch is labelled for traceability. Various grades are blended to meet individual customer requirements. The equipment that comes into contact with the gelatine is usually made of stainless steel, but in some cases it is synthetic material.

K Acid treatment

After the demineralisation process the tank containing the ossein is filled again, with the same amount of water as the original weight of the bone chips, and is left to stand in it for about 0.5 - 1 day. The ossein still contains sufficient acid to keep the pH below 2. The liquid is then removed and the ossein is washed again, one or more times, to obtain a pH of about 2.5 or above. It is then transferred to the extractors, in a stream of water.

L Alkali pretreatment

Following demineralisation, the ossein is soaked twice in water, each "soak" lasts one hour and uses an equal volume of water to ossein. After each "soak", the water is drained away. The ossein is further washed by stirring for 10 minutes with an equal volume of water to ossein and then drained.

One volume of 0.3 N NaOH (pH > 13) is added to the ossein and allowed to stand for 2 hours, with occasional agitation. The pH is monitored, recorded and maintained above pH 13.0 by the addition of NaOH solution, as required.

After the alkaline "soak", the solution is drained and the ossein is washed twice. Each wash lasts for 15 minutes and uses an equal volume of water to ossein. Finally, the ossein is washed for 10 minutes with twice the volume of water to ossein.

M Acid treatment

1.2 times the volume of water compared to ossein are added to the alkali-pretreated ossein and by means of small additions of 1 N HCl, a pH of 2 is maintained for up to 6 hours, with occasional agitation.

The ossein is then washed a number of times, each wash using an equal volume of water to ossein, for at least 2 hours, until the pH is 2.5 or above.

N Preheating

An autoclave of about 6800 litres is filled with 2300 kg of degreased bone chips. It is preheated for 10 minutes by blowing steam at 1.7 bar (170 kPa) and 115 °C through it, from bottom to top.

O Autoclaving and extraction

The bone chips are pressurised and extracted in eight steps.

i - After preheating the exhaust is closed and the autoclave is pressurised and heated from the bottom with steam at a minimum of 300 kPa and 133 - 135 °C for at least 23 minutes. The autoclave is depressurised in 4 – 5 minutes and then 1500 litres of water is sprayed over the bone chips to extract the gelatine. The water is pumped out during the extraction. The pumping is continued for 12 minutes after the spraying is stopped.

ii - The autoclave is pressurised again for 20 minutes, with steam at 300 kPa and 133 - 135 °C, after which it is depressurised and the gelatine is extracted as described in step i.

iii - The autoclave is pressurised for 20 minutes with steam at 300 kPa and 133 - 135 °C, after which the autoclave is depressurised in 4 to 5 minutes. The autoclave is filled with 1500 litres of water at 10 °C, which is left in the autoclave for 20 minutes and then forced out with steam under pressure. After the third autoclaving and extraction, the extract is not pumped out but forced out with steam.

iv - The bone chips are autoclaved and extracted as in step ii. Instead of water the bone chips are, however, extracted with the extracts coming from steps 5 – 8 of the previous batch.

v and vi - The chips are autoclaved and extracted as in step ii. Parts of the extracts are saved for use as extraction liquid for this batch and the next batch.

vii and viii - The chips are autoclaved and extracted as in step iii. The bone chips are left to drain for 20 minutes and the liquid is pressed out by steam. All of the extract is saved for use in the extractions of the next batch.

P Cutting

The hide splits are cut and then washed with water.

Q Lime treatment

Slaked lime ($\text{Ca}(\text{OH})_2$) is added until the relative density of the solution is 1.5 - 3° Bé. The treatment takes 6 – 11 weeks. During the liming process, the lime solution is controlled, by refreshing the lime and regularly blowing air through the solution, to maintain this relative density and a pH of approximately 12.5.

R Washing and acid treatment

When the lime treatment is finished, the raw material is washed in water in order to obtain a pH of 9 - 10. Acid is then added until a pH of 1.9 – 2.0, is obtained. During this time the pH is kept at 2.4 for 2 – 3 hours. Depending on the recipe, some alternative pH ranges or durations may be maintained, but the principle of washing and acid treatment is always the same.

S Neutralisation

The excess of acid is removed by washing with water until a slightly acid to neutral pH of, e.g. 5.5 – 6.5, is obtained.

T Acid treatment

HCl, or another acid, is added until the pH of the solution is 1 - 3. These conditions are kept for 24 – 48 hours, by adding more acid, if necessary.

U Neutralisation

The excess acid is removed by washing with water to reach a typical pH of 5.3 – 6.0, but a pH of 2.5 – 4.0 is also possible.

V Alkali treatment

NaOH solution is added to the washed hide splits, to a concentration of 0.6 - 1.4 %. The alkaline soak takes a minimum of 10 days. During the process, the pH is approximately 12.5 or higher. Finally air is regularly blown through the solution.

W Washing and acid treatment

When the caustic treatment is finished, the raw material is washed in water until a pH of about 10 is achieved. An acid solution is then added to neutralise the solution.

X Neutralisation

The excess acid is removed by washing with water, until a slightly acid, but close to neutral pH of approximately 5.5 – 7.5, is obtained.

Y Cutting

The pig skins are cut into pieces of about 10 x 10 cm, in a special cutting machine.

Z Washing

The pig skin pieces are washed in a tank, to remove external fat, before demineralisation.

A1 Acid treatment and rinsing

The pig skin pieces are acidulated, in a tank, with dilute H₂SO₄ or HCl to a pH of about 1.8, for at least 5 hours. The acid solution is then removed and the pig skin pieces are then rinsed.

B1 Neutralisation and rinsing

The tank is filled with an alkaline solution of e.g. ammonia, to neutralise the pig skin pieces. The solution is then removed and the neutralised pig skins are rinsed, to reach a pH suitable for extraction of the gelatine. The pH may vary according to customer specification. The treated pig skins are then transferred to the extraction tanks.

C1 Second filtration

A second filtration is made to remove any remaining particles. The filter medium is usually a cloth bag which is able to remove coarse particles.

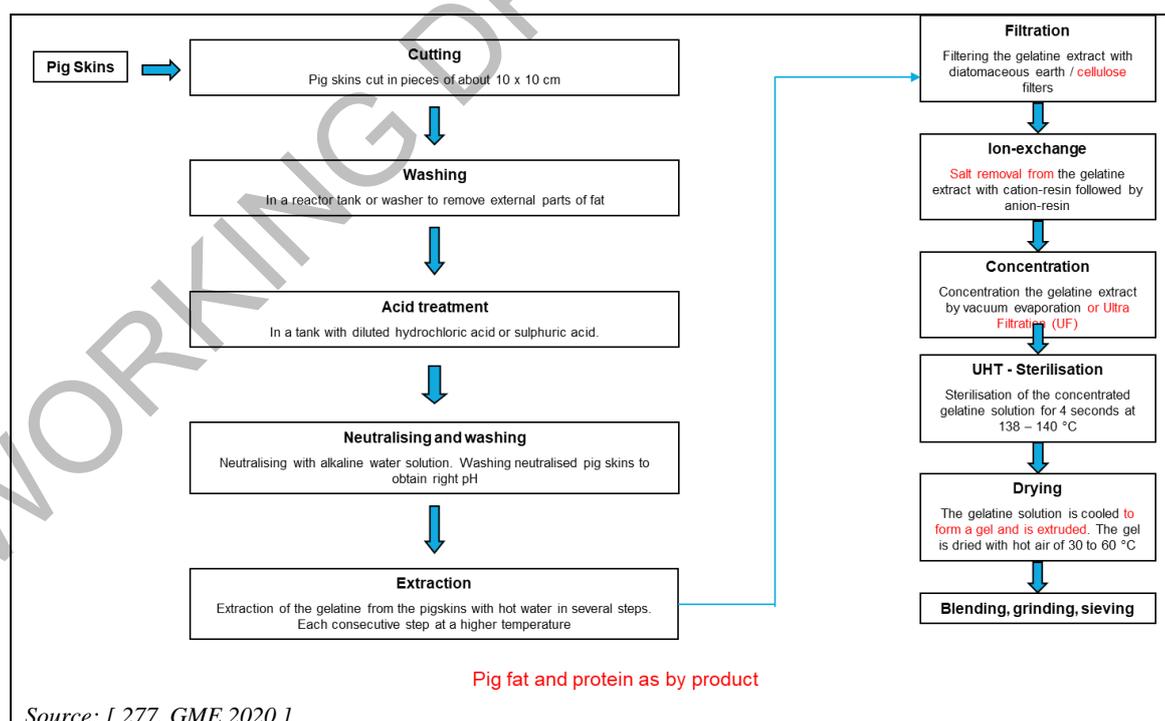


Figure 4.49: Production of gelatine from pig skins

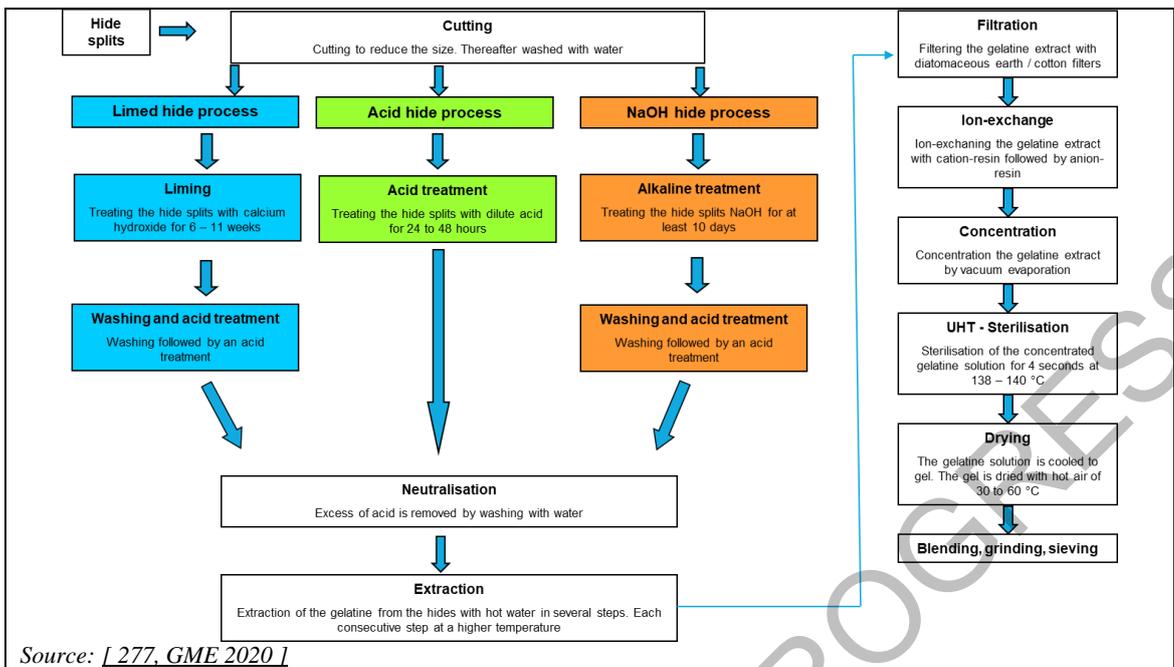


Figure 4.50: Production of gelatine from hides

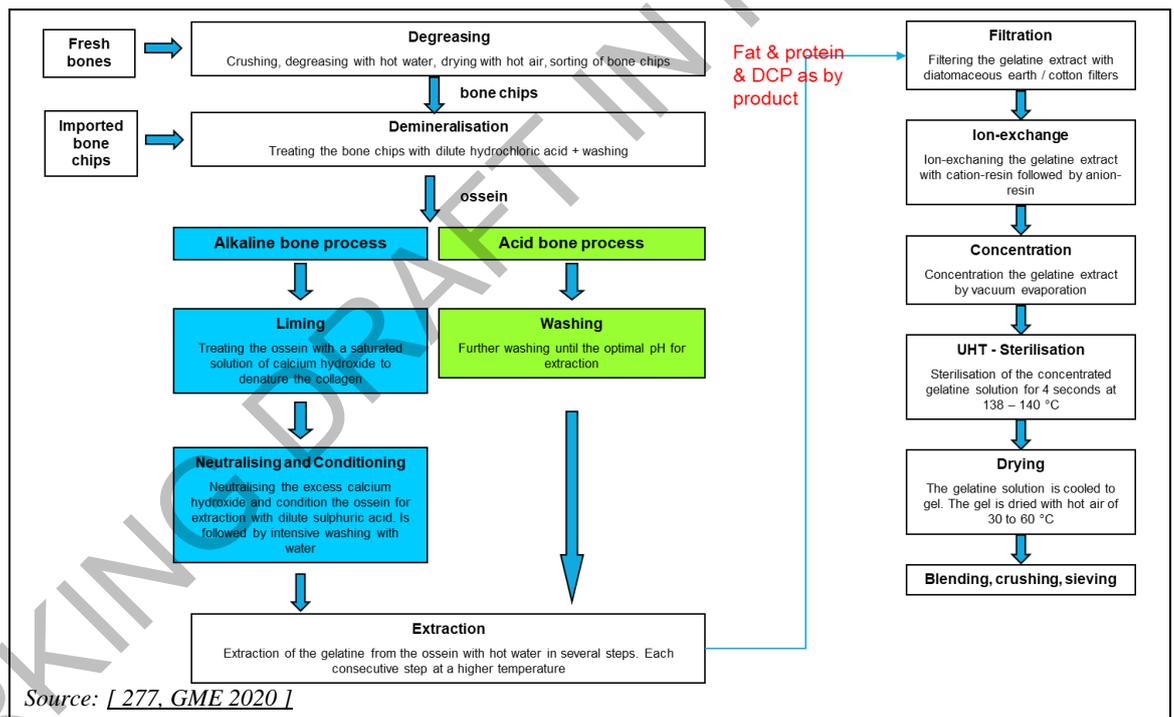


Figure 4.51: Production of gelatine from bones

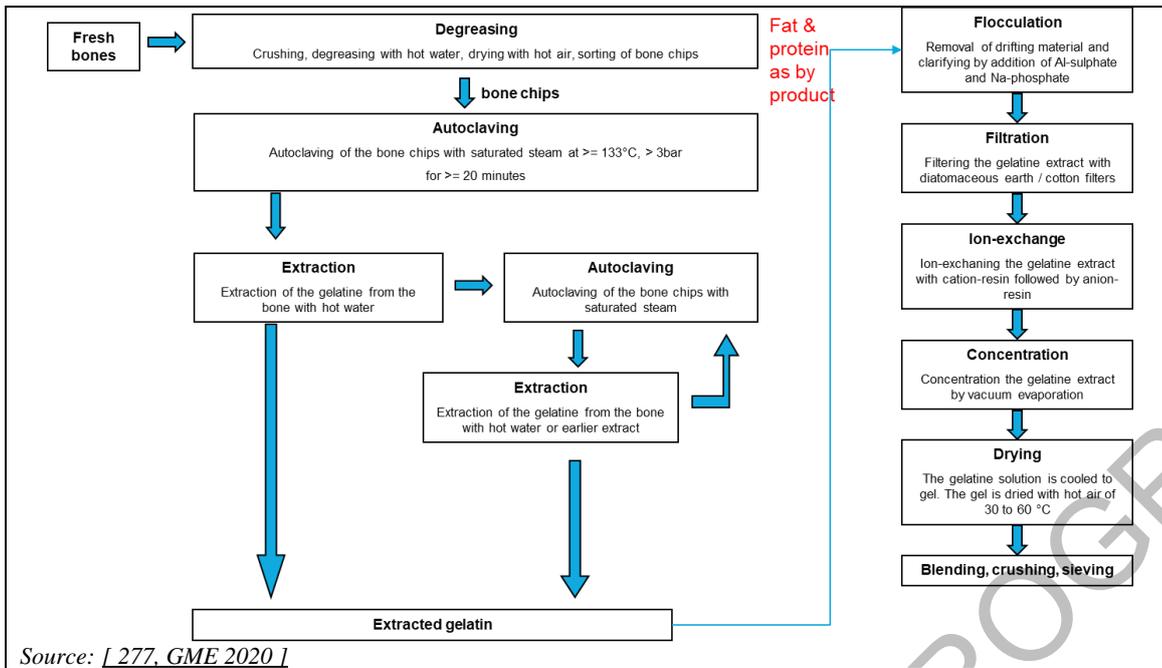


Figure 4.52: Production of gelatine from bones – heat and pressure processes

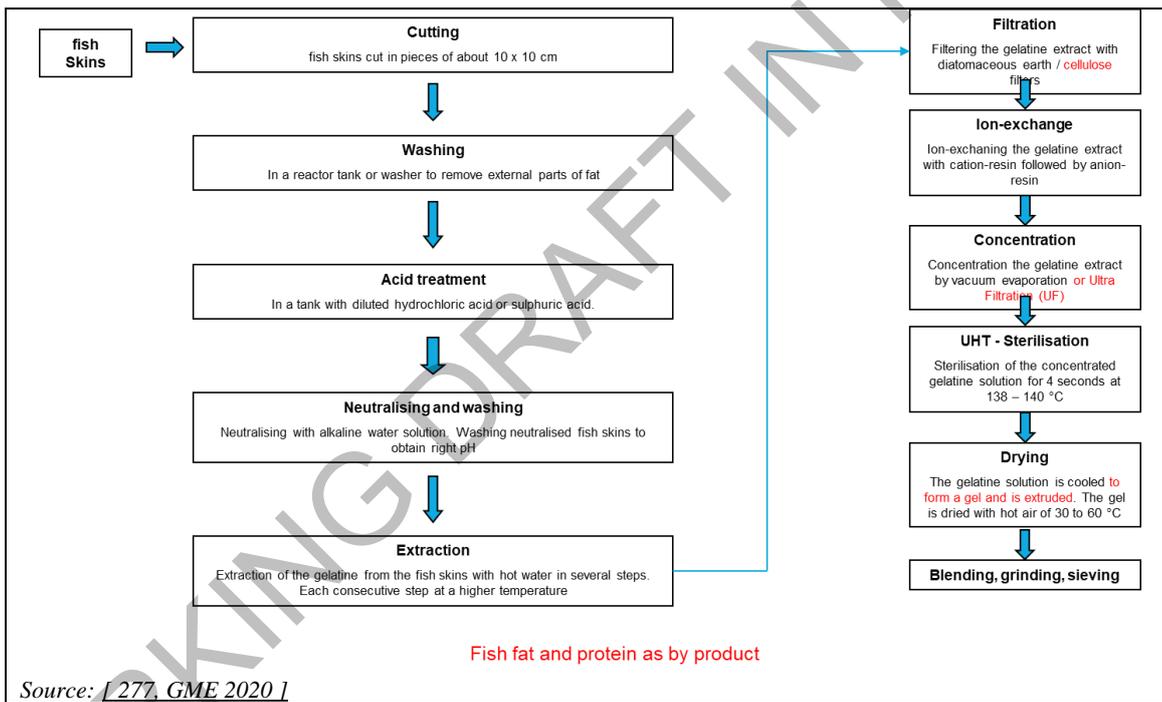
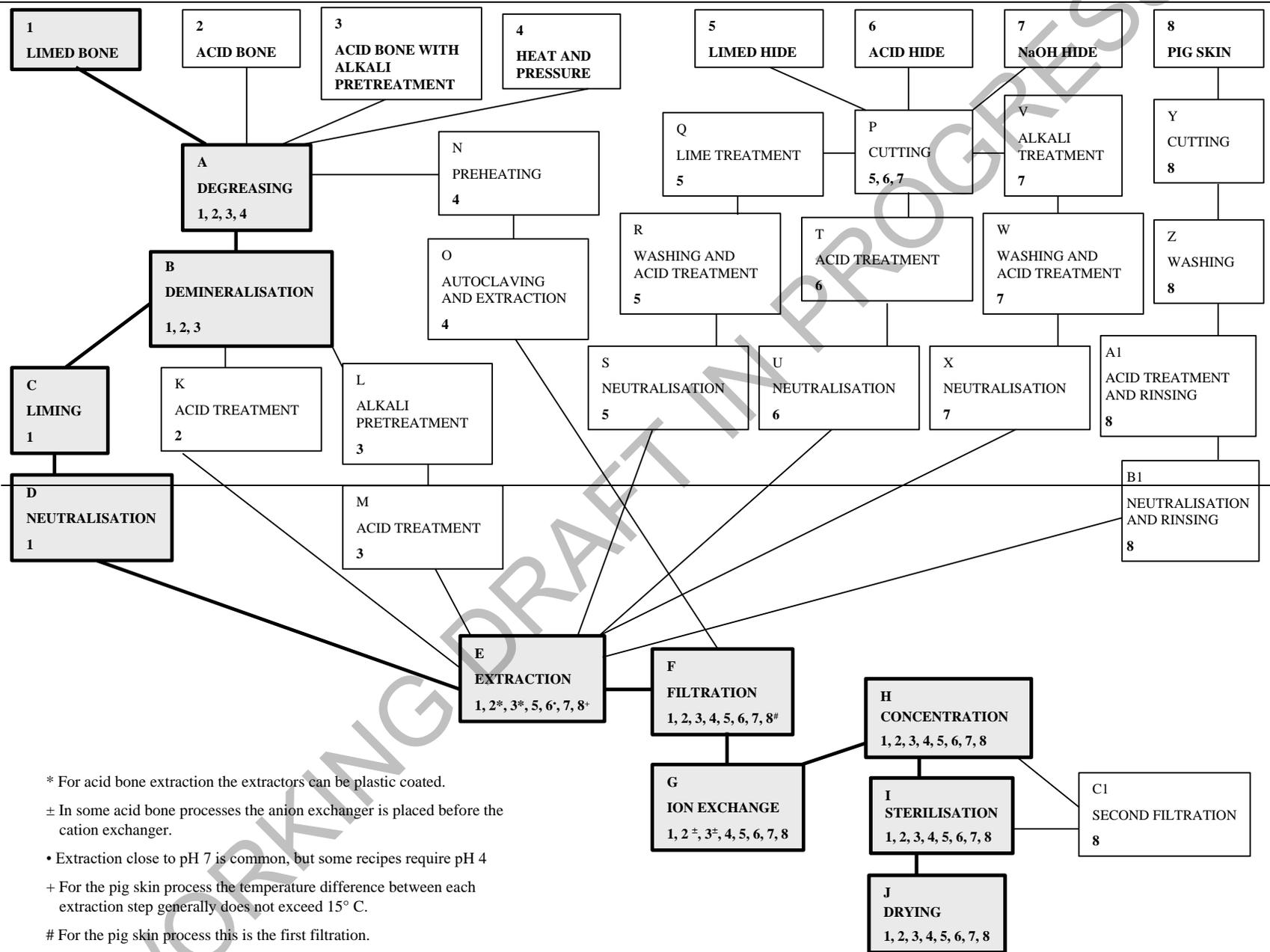


Figure 4.53: Production of gelatine from fish skins

BONE GELATINE**1 — Limed bone process**

The limed bone gelatine process is shown in Figure.

WORKING DRAFT IN PROGRESS

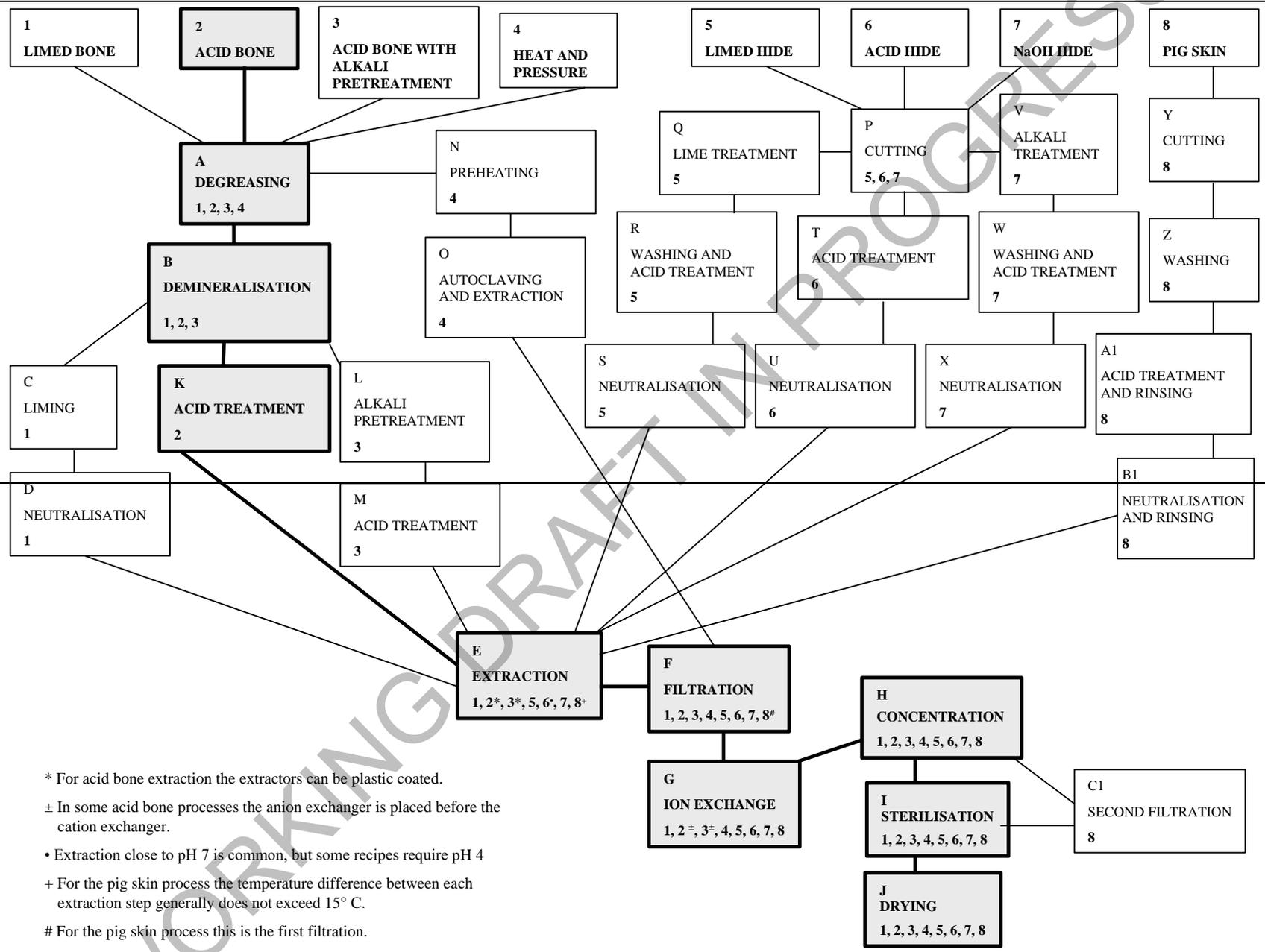


- * For acid bone extraction the extractors can be plastic coated.
- ± In some acid bone processes the anion exchanger is placed before the cation exchanger.
- Extraction close to pH 7 is common, but some recipes require pH 4
- + For the pig skin process the temperature difference between each extraction step generally does not exceed 15° C.
- # For the pig skin process this is the first filtration.

~~Figure: The limed bone gelatine manufacturing process~~

~~2 — Acid bone process~~

The acid bone gelatine manufacturing process is shown in.

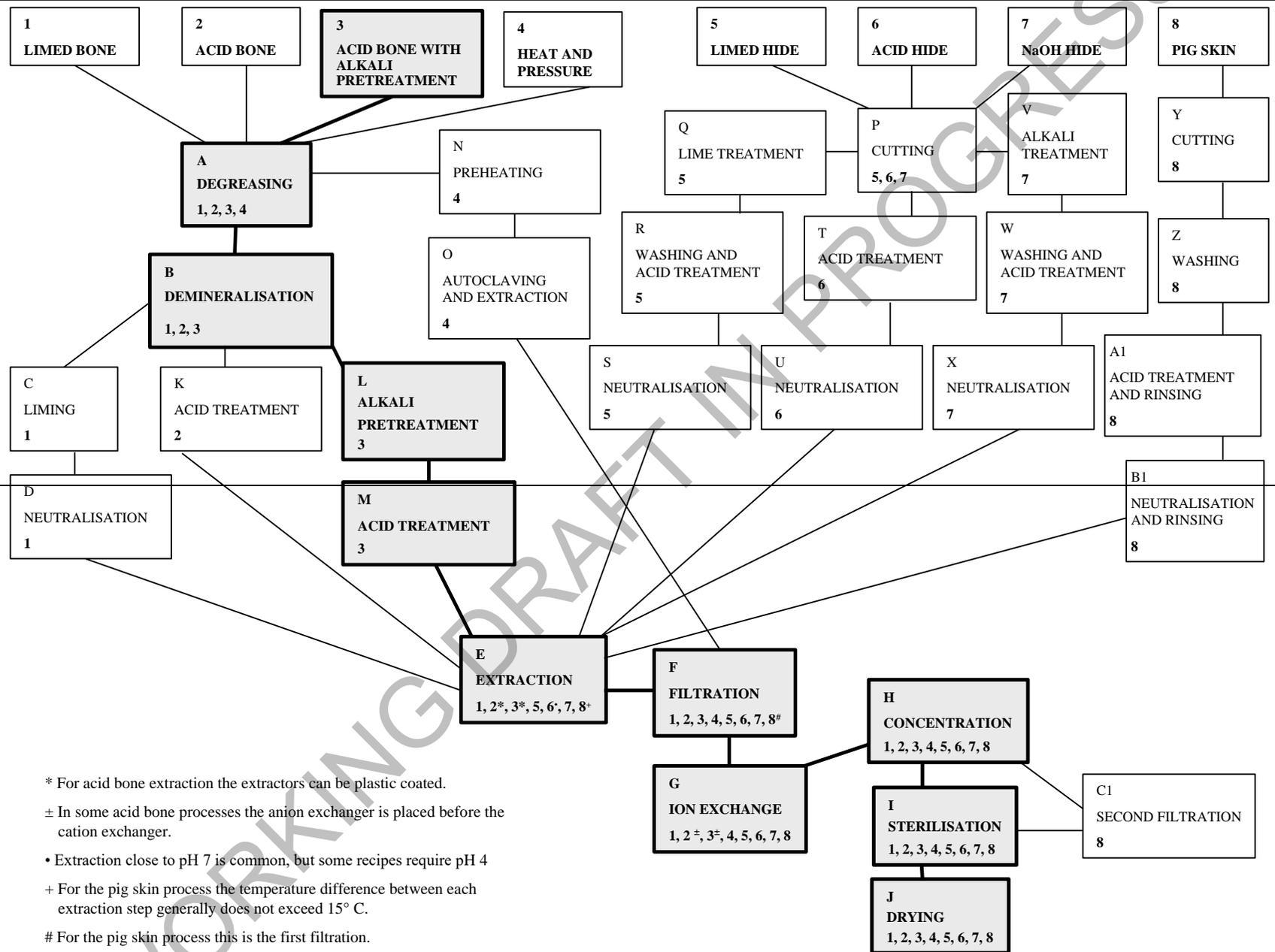


* For acid bone extraction the extractors can be plastic coated.
 ± In some acid bone processes the anion exchanger is placed before the cation exchanger.
 • Extraction close to pH 7 is common, but some recipes require pH 4
 + For the pig skin process the temperature difference between each extraction step generally does not exceed 15° C.
 # For the pig skin process this is the first filtration.

~~Figure: The acid bone gelatine manufacturing process~~
~~3 — Acid bone process with alkali pretreatment~~

The acid bone gelatine manufacturing process with alkaline pretreatment is shown in Figure.

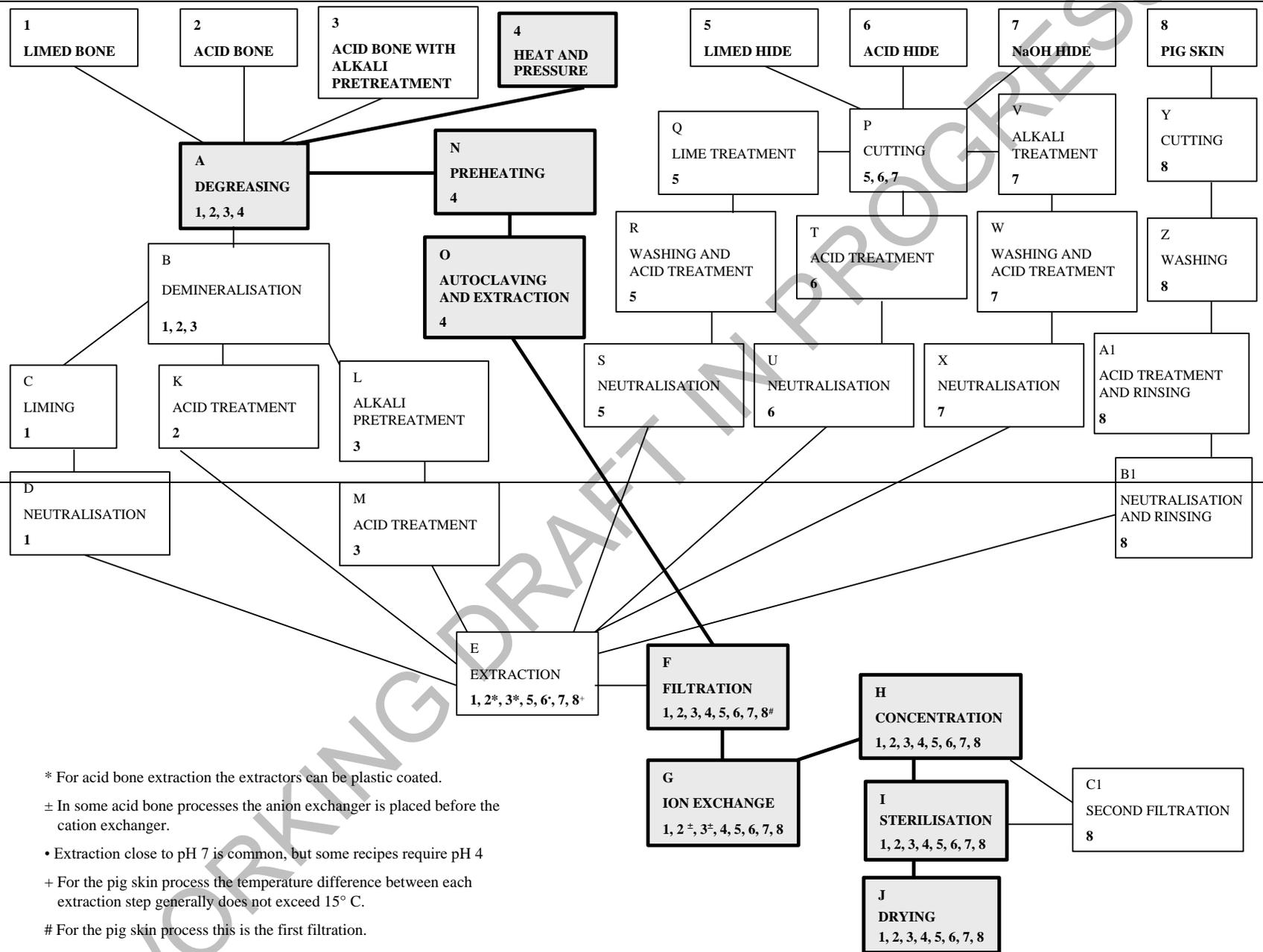
WORKING DRAFT IN PROGRESS



- * For acid bone extraction the extractors can be plastic coated.
- ± In some acid bone processes the anion exchanger is placed before the cation exchanger.
- Extraction close to pH 7 is common, but some recipes require pH 4
- + For the pig skin process the temperature difference between each extraction step generally does not exceed 15° C.
- # For the pig skin process this is the first filtration.

~~Figure: The acid bone gelatine manufacturing process with alkaline pretreatment~~
~~4 — HEAT AND PRESSURE PROCESS~~

The heat and pressure gelatine manufacturing process is shown in Figure.



* For acid bone extraction the extractors can be plastic coated.
 ± In some acid bone processes the anion exchanger is placed before the cation exchanger.
 • Extraction close to pH 7 is common, but some recipes require pH 4
 + For the pig skin process the temperature difference between each extraction step generally does not exceed 15° C.
 # For the pig skin process this is the first filtration.

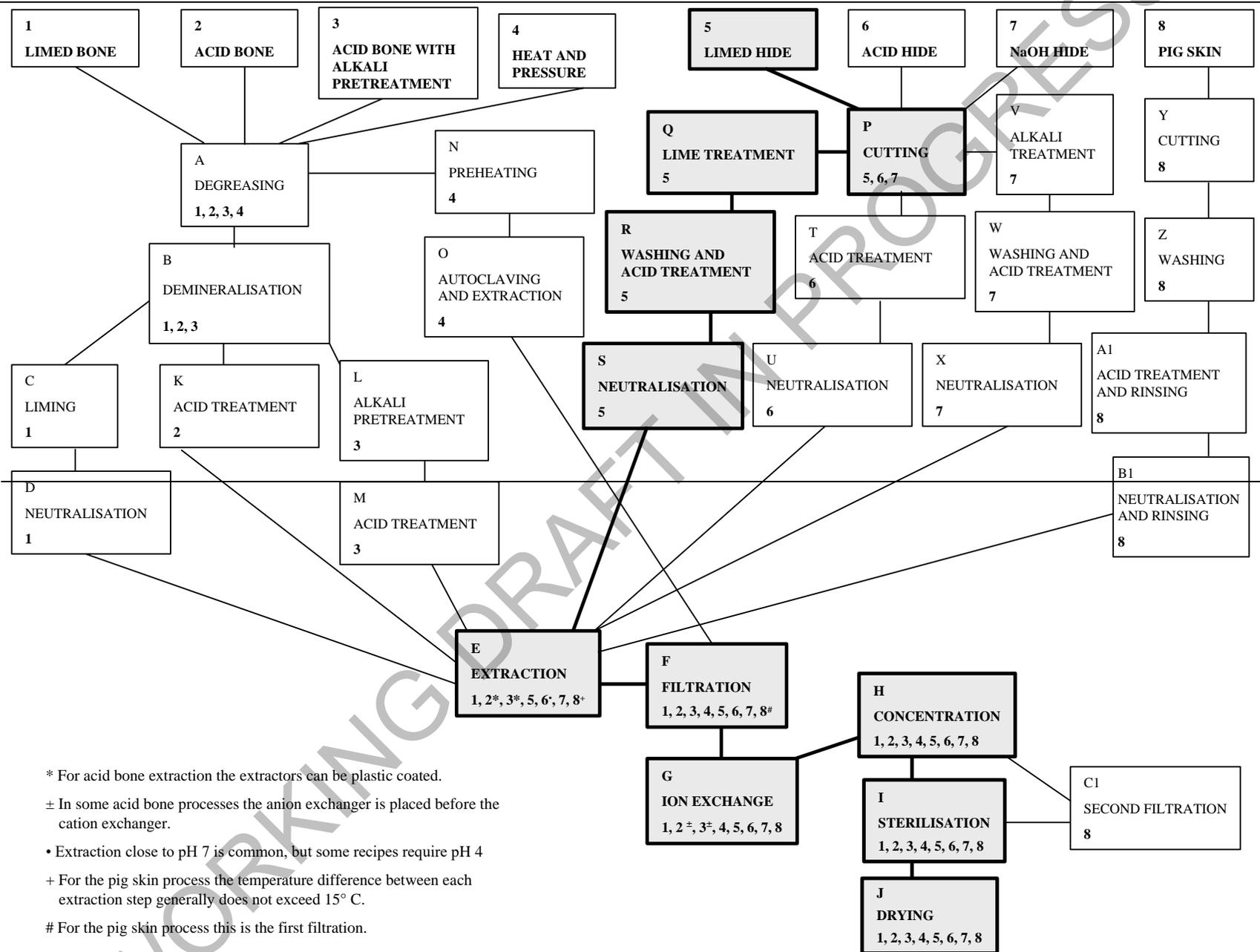
Figure: The heat and pressure gelatine manufacturing process

HIDE GELATINE

Limed hide process

The limed hide gelatine manufacturing process is shown in Figure.

WORKING DRAFT IN PROGRESS

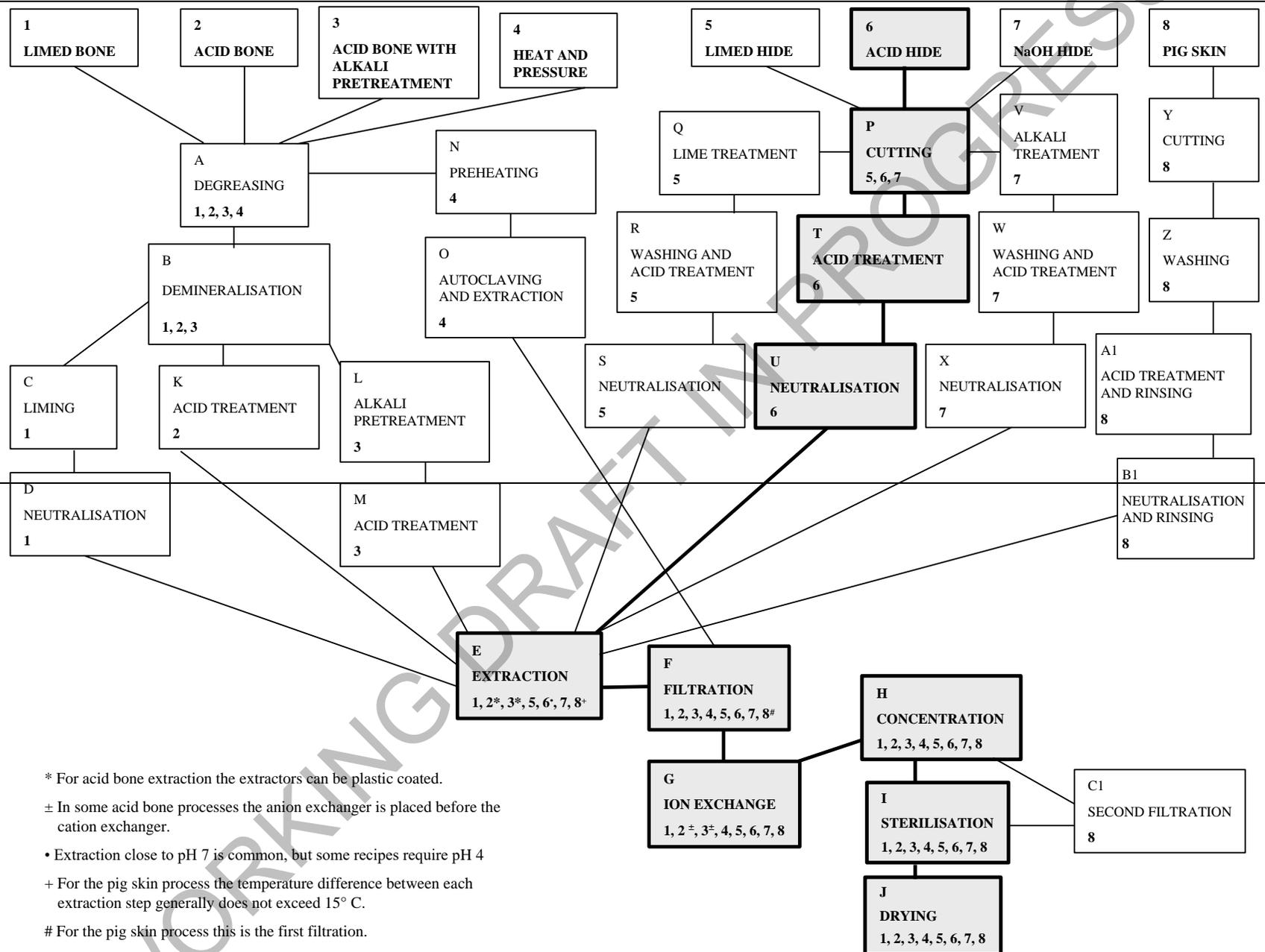


- * For acid bone extraction the extractors can be plastic coated.
- ± In some acid bone processes the anion exchanger is placed before the cation exchanger.
- Extraction close to pH 7 is common, but some recipes require pH 4
- + For the pig skin process the temperature difference between each extraction step generally does not exceed 15° C.
- # For the pig skin process this is the first filtration.

Figure: The limed hide gelatine manufacturing process

6 — Acid hide process

The acid hide gelatine manufacturing process is shown in Figure.



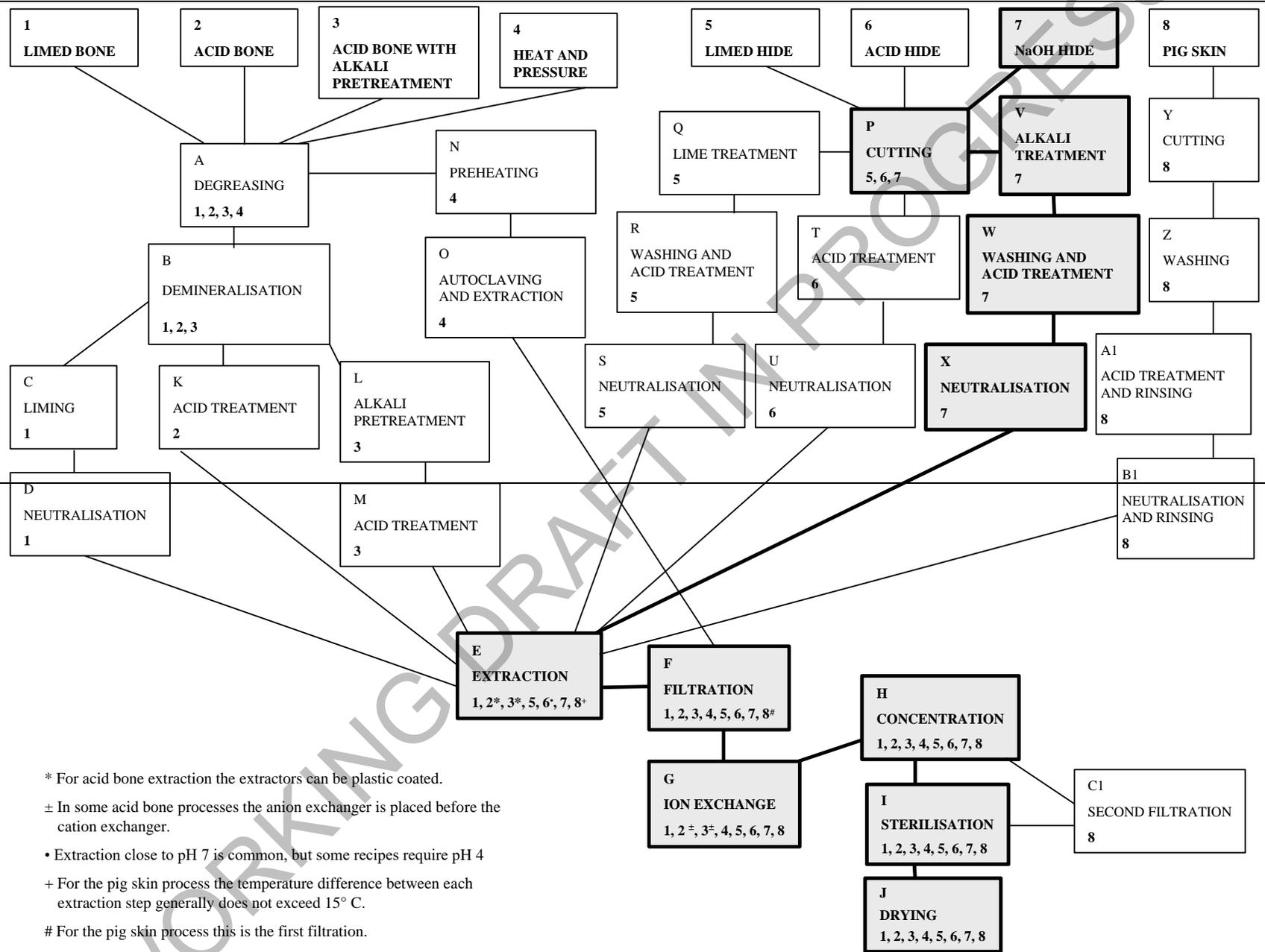
* For acid bone extraction the extractors can be plastic coated.
 ± In some acid bone processes the anion exchanger is placed before the cation exchanger.
 • Extraction close to pH 7 is common, but some recipes require pH 4
 + For the pig skin process the temperature difference between each extraction step generally does not exceed 15° C.
 # For the pig skin process this is the first filtration.

~~Figure: The acid hide gelatine manufacturing process~~

~~7 Sodium hydroxide hide process~~

~~The sodium hydroxide hide gelatine manufacturing process is shown in Figure.~~

WORKING DRAFT IN PROGRESS

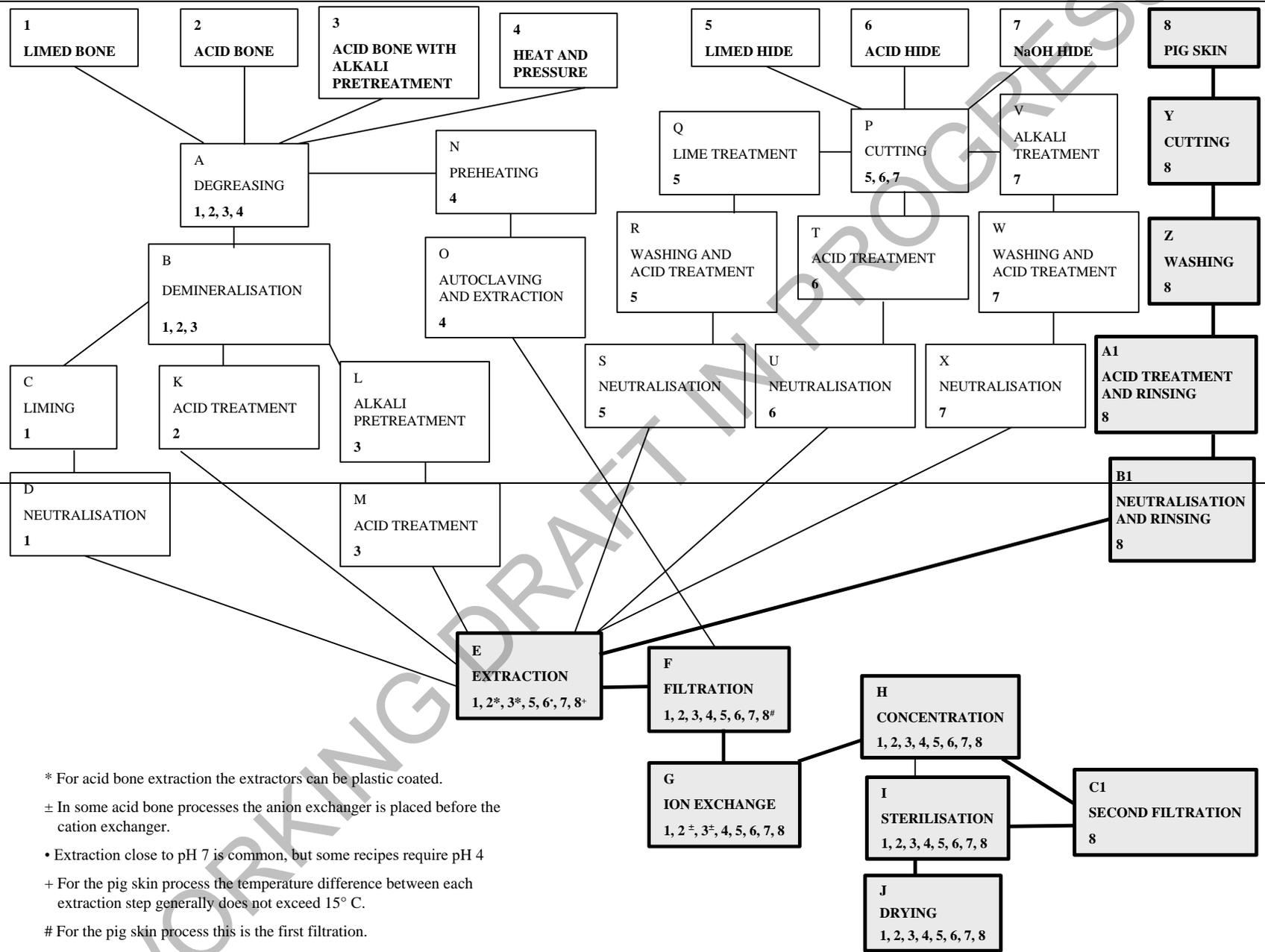


* For acid bone extraction the extractors can be plastic coated.
 ± In some acid bone processes the anion exchanger is placed before the cation exchanger.
 • Extraction close to pH 7 is common, but some recipes require pH 4
 + For the pig skin process the temperature difference between each extraction step generally does not exceed 15° C.
 # For the pig skin process this is the first filtration.

Figure: The sodium hydroxide gelatine manufacturing process

8 — Pig skin process

Pig skins, whether they are fresh or frozen, contain a large amount of fat. A typical example of the composition of a batch of pig skins is: 56 % water, 25 % fat, 18 % protein and 1 % minerals. There are 4 treatment steps, before gelatine extraction. The pig skin gelatine manufacturing process is shown in Figure.



* For acid bone extraction the extractors can be plastic coated.
 ± In some acid bone processes the anion exchanger is placed before the cation exchanger.
 • Extraction close to pH 7 is common, but some recipes require pH 4
 + For the pig skin process the temperature difference between each extraction step generally does not exceed 15° C.
 # For the pig skin process this is the first filtration.

Figure: The pig skin gelatine manufacturing process

WORKING DRAFT IN PROGRESS

4.5.2.2 Dicalcium phosphate manufacture from the gelatine manufacture demineralisation liquor

Dicalcium phosphate is used for ceramics manufacture and in fertilisers.

The liquor containing the spent acid and the water soluble monocalcium phosphate is treated with lime ($\text{Ca}(\text{OH})_2$) to extract the dicalcium phosphate. After precipitation and decanting, the precipitate is centrifuged or filtered, washed with water and dried with hot air.

Precipitation and decanting

Lime ($\text{Ca}(\text{OH})_2$) slurry is added in a controlled manner and the pH is monitored. In an example installation, a tank of 75 cubic metres capacity is filled with 35 cubic metres of spent acid, containing monocalcium phosphate, at about pH 1.5 and 10 cubic metres of filtrate after the precipitation of dicalcium phosphate. The pH of the liquid is measured continuously. During powerful stirring, a solution of saturated lime is added quickly until pH 3.5 is reached. Then the addition of the lime is slowed down so that the pH rises to 5.5 in not less than 4 hours after the start of the addition. The suspension contains about 5 % solid matter. The chemical reaction is shown below.



The suspension is pumped to a decanter while stirring is continued, to maintain a suspension. In the decanter, the suspension is separated and pumped to a tank, where the pH is adjusted. The suspension contains about 20 % solid matter at this stage.

Calcium chloride (CaCl_2) is produced in the supernatant liquid, after dicalcium phosphate settles. It is treated in a WWTP.

Adjusting pH, filtration and washing

The tank containing the 20 % suspension is stirred to keep the solid matter suspended. The pH is measured continuously. A 4 % HCl solution is added to the suspension at a rate which ensures that the pH is maintained at about 5 for about 6.5 hours.

Stirring is continued, to keep the solid matter in suspension, while the mixture is pumped to a filtration installation. Either a centrifugal filter, a rotating vacuum filter or a vacuum conveyer belt filter is used. The filtrate is pumped back to the reactor tanks. The residue on the filter is washed with water and then sucked dry until the residue contains approximately 80 % dry matter. The dry matter is scraped off the filter and transported to a drier.

Drying

The dicalcium phosphate is dried with air of at least 70 °C in either a rotating drier or a ring drier, until it contains less than 3 % water. The air is then filtered.

The product is then packaged in bags or bulk tankers.

Associated activity - lime production

Production of the lime from quicklime (CaO) may in some cases be an associated site activity. Quicklime reacts vigorously with water to produce slaked lime.

Glue manufacture

The manufacturing process for hide glue is the same as that for food gelatine [244, Germany, 2002].

4.5.3 Current emission and consumption levels

4.5.3.1 Energy consumption

The drying process is a high energy consumer in the pretreatment of bones. A great deal of heat is emitted from the rendering vessel, which it is reported cannot be insulated due to expansion and contraction caused by the temperatures reached. Meal driers use and emit heat, and are insulated. There may be techniques available to recoup the high heat losses from this process.

Energy consumption is also high during drying of gelatine.

De-fatting is a high-energy process which emits sufficient heat to make the metal handrails in the processing room hot to touch.

Figure 4.54 shows data in relation to total specific net energy consumption in terms of kWh/tonne of raw material at installation level., as well as the applied techniques to reduce energy consumption.

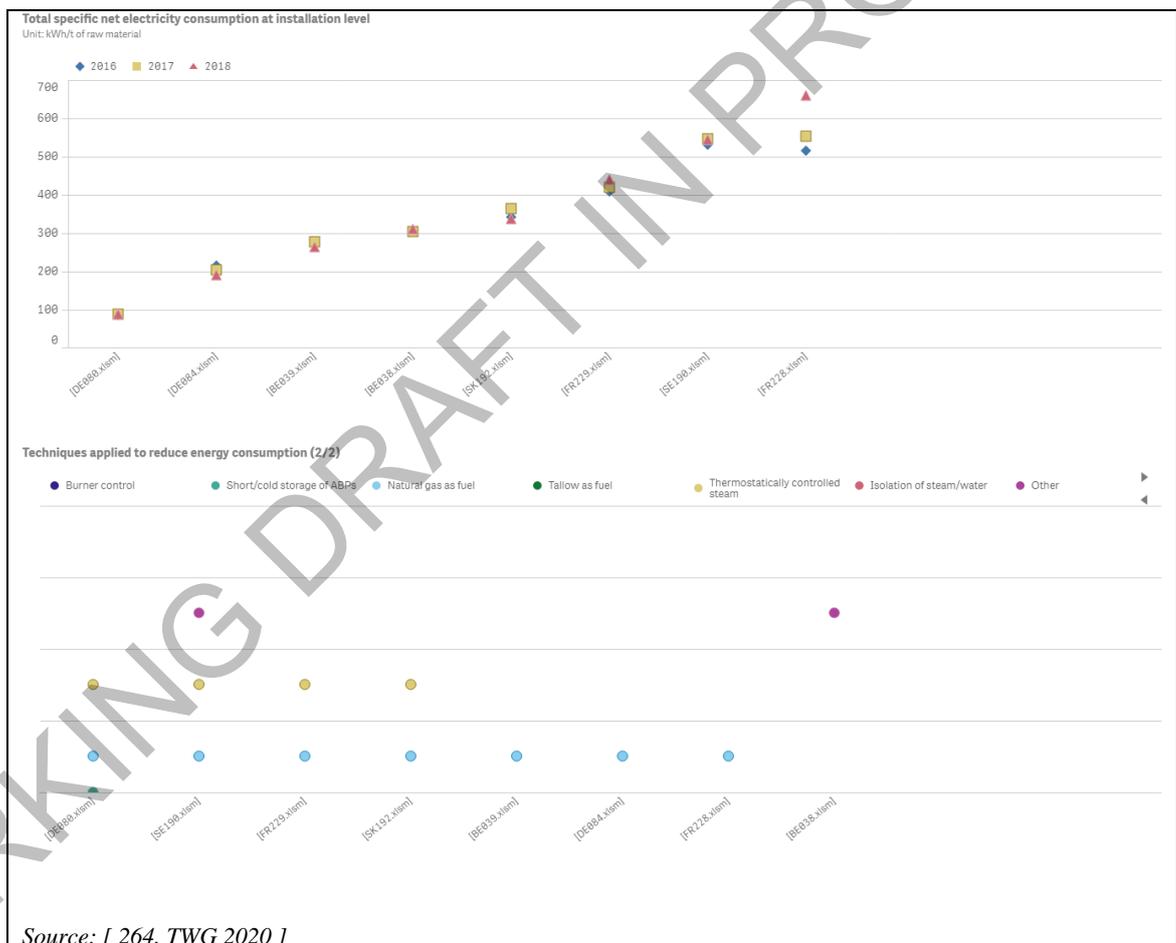


Figure 4.54: Specific energy consumption (kWh/tonne of raw material) and applied techniques to reduce energy consumption in gelatine manufacturing (installation level)

Figure 4.55 shows data in relation to total specific net electricity and heat consumption in terms of kWh/tonne of raw material at installation level.

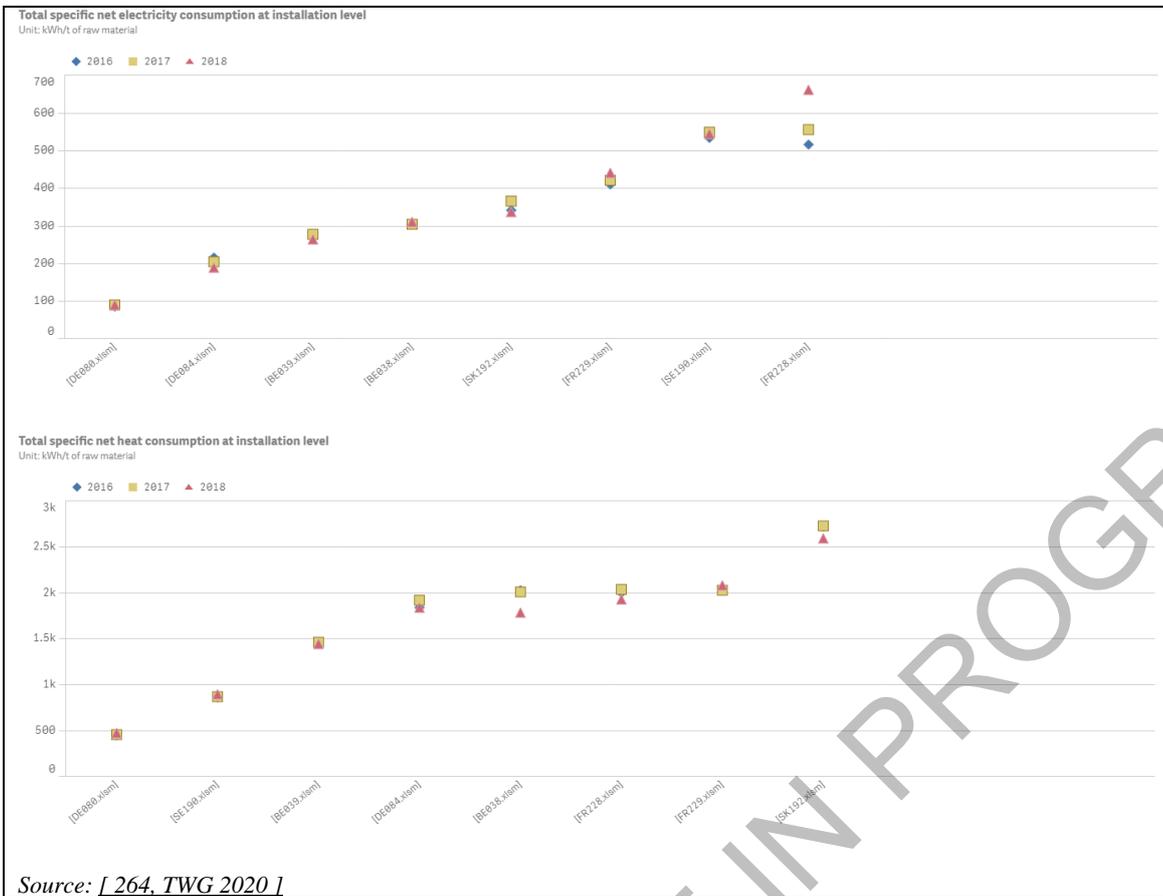


Figure 4.55: Specific electricity and heat consumption (kWh/tonne of raw material) in gelatine manufacturing (installation level)

Figure 4.56 shows the specific net energy consumption (in kWh/tonne of raw material) for the drying process in gelatine manufacturing.

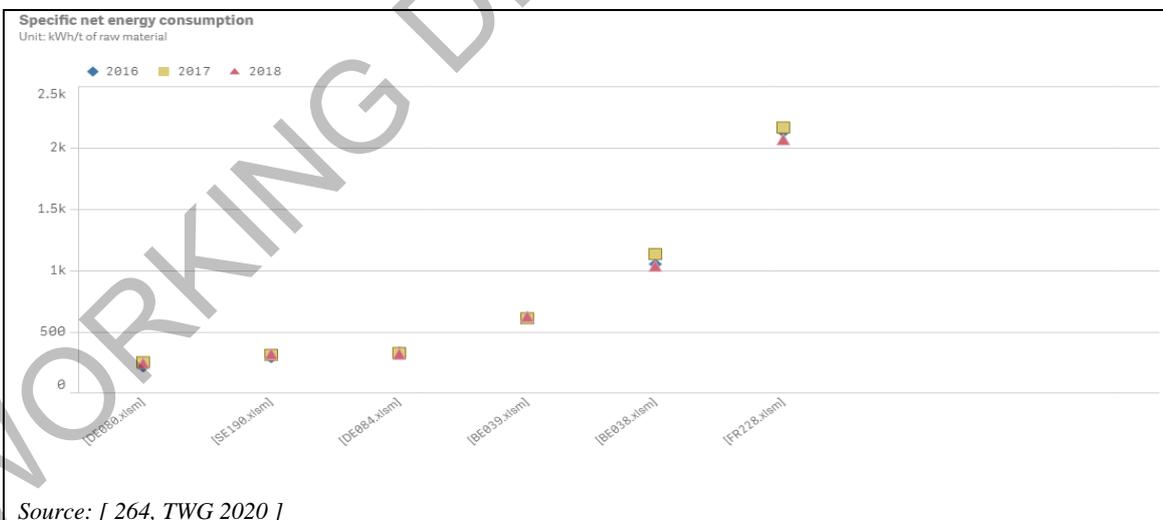


Figure 4.56: Specific energy consumption (kWh/tonne of raw material) for drying in gelatine manufacturing

4.5.3.2 Water consumption

Thousands of m³ of water can be used daily for charging the defatted bones, hides, skins, etc., depending on the throughput of the individual plant and the degree of recycling undertaken. This water then has to be treated before it can be discharged from the WWTP.

Figure 4.57 shows data in relation to total specific net water consumption in terms of m³/tonne of raw material at installation level.

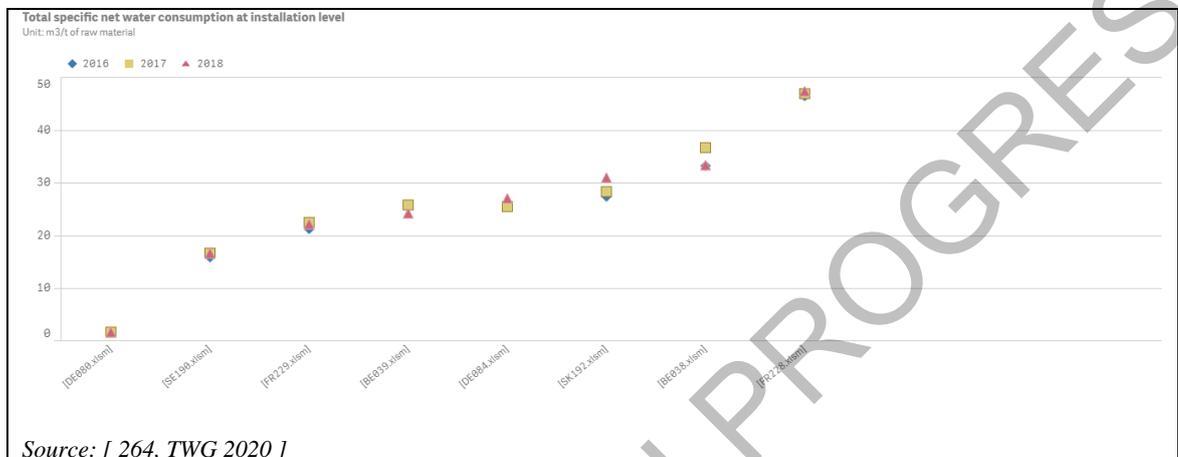


Figure 4.57: Specific water consumption (m³/tonne of raw material) in gelatine manufacturing (installation level)

Figure 4.58 shows the specific net water consumption (in m³/tonne of raw material) for boilers in gelatine manufacturing.

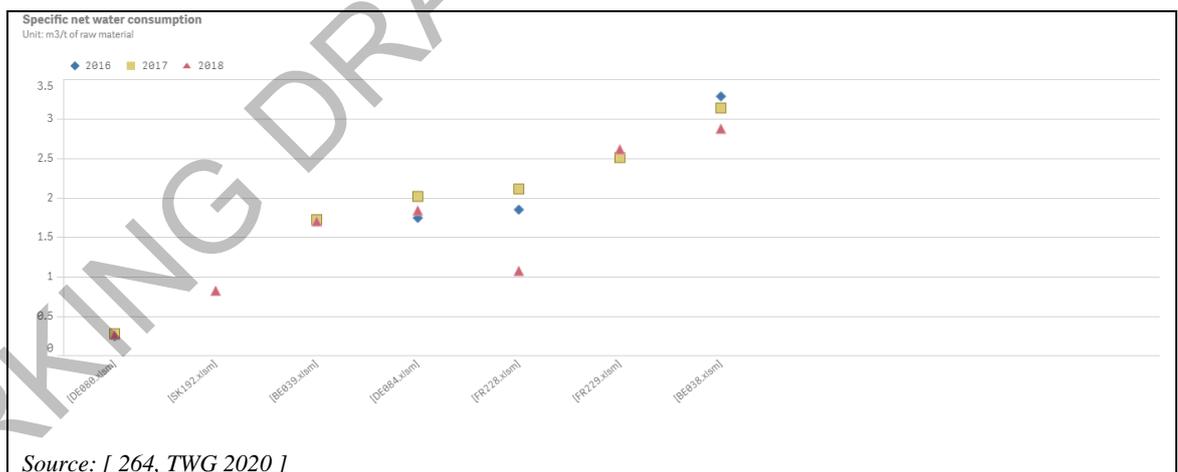


Figure 4.58: Specific water consumption (m³/tonne of raw material) for boilers in gelatine manufacturing

4.5.3.3 Emissions to water

Figure 4.59 shows reported data on specific waste water discharges in m³/tonne of raw material from gelatine manufacturing and all types of discharges. The applied techniques for reducing water consumption are also shown.



Figure 4.59: Specific waste water discharge (m³/tonne of raw material) and applied techniques for reducing water consumption in gelatine manufacturing for all types of discharges

The alkali and acid hydrolysis processes produce contaminated acid and alkali solutions respectively. Lime hydrolysis produces a soapy lime solution. Both processes are followed by thorough washing, which uses thousands of m³ of water which then have to be treated in the WWTP.

Waste water from gelatine manufacturing has a high BOD. If a plant has its own WWTP, then biological treatment, incorporating nitrification and denitrification steps is required, due to the high protein levels. It can also be treated in municipal WWTPs. The chloride content of waste water is high due to its salt content.

Table shows discharge limits for several gelatine manufacturing installations with on-site WWTPs and direct discharge to receiving waters.

	Individual maximum regulatory emission limits for gelatine manufacturing				
	COD (mg/l)	BOD (mg/l)	SS (mg/l)	Total-N (mg/l)	Total-P (mg/l)
Belgium factory A	600	100		100	10
Belgium factory B	200	30	100	130	3
Germany factory A	110	25		30	2
Spain factory A	140		50		20
France factory A	125	30	35	60	10
France factory B	125	30	35	50	2
Italy factory A	150	40		40	10
Sweden factory A	70			60	1

Limits are only valid for those factories who have a direct discharge

Table: Waste water emission limits for individual gelatine factories
[345, GME, 2003]

Delivery of lime

The continuous monitoring of stacks and silos is reported to be carried out at a gelatine manufacturing plant. Dust emissions are reportedly zero, except during loading, when they are 20–40 mg/m³.

Dicalcium phosphate

Filters are used in dicalcium phosphate silos to reduce dust emissions. There may be dust emissions from the dicalcium phosphate drier and the lime silo and stack.

Pretreatment of bones

Phosphorus may be a waste water issue.

There may be odour problems from the storage of hides and/or fish skins.

4.5.3.4 Emissions to air

Data for odour emissions to air have been reported from only two points of release. The maximum concentrations reported were 70 OU_E/Nm³ (using a biofilter) and 5 990 OU_E/Nm³ (no abatement technique used), respectively [264, TWG 2020].

4.5.4 Techniques to consider in the determination of BAT

4.5.4.1 Techniques to increase resource efficiency

4.5.4.1.1 Landspreading of sludge from gelatine and leather glue manufacture

Technical description

The sludge from waste water treatment from gelatine and leather glue manufacture is reported to be an excellent fertiliser and soil improver. It can be applied to agriculturally utilised soil, both as a wet sludge or it can be thickened and pressed.

Achieved environmental benefits

Application of the by-products of gelatine production as fertiliser, when suitable agricultural land is available. The sludge contains calcium, nitrogen and phosphorus.

Cross-media effects

Iron, aluminium and manganese may be present and it may therefore be prudent to analyse for these.

Technical considerations relevant to applicability

Applicable when soil requirements match the nutrient level of the sludge.

Economics

Cheaper than paying for landfill.

Example plants

Sludge from all gelatine and leather glue manufacturing WWTPs in Germany.

Reference literature

[244, Germany, 2002] [110, Germany 2002], 351, UK TWG Members, 2003] [188, United Kingdom 2003]

Insulation of bone de-fatting equipment

Description

Achieved environmental benefits

Reduced energy consumption.

Cross-media effects

None.

Applicability

Applicable in all gelatine manufacturing plants.

Driving force for implementation

Employee comfort.

Example plants

A gelatine manufacturing plant in Belgium.

Animal by-products installations

Continuous and segregated collection of by-products throughout animal by-products treatment

See for a description of another technique also applicable in animal by-products installations.

Land spreading/injection

See also Section.

Techniques for the land spreading of manure are described in the *Reference Document on Best Available Techniques for Intensive Rearing of Poultry and Pigs* [304, EC, 2002].

Techniques to consider in the determination of BAT - Dedicated incineration of carcasses, parts of carcasses and animal meal

See also Sections.

Enclosing buildings for the delivery, storage, handling and processing of animal by-products

Description

Unloading, storage and handling can be undertaken in totally enclosed equipment (see Section 0) and in buildings with lockable, self-closing doors, which can be insect rodent and bird proof. The building can incorporate extraction fans through filters to prevent any dust generated from escaping and to minimise local odour problems. Material can be delivered in bulk tipper lorries and transferred directly to an unloading hopper, within an enclosed area (see Section 2.3.8.2.6). Extracted air can be burned in the incinerator to reduce odour emissions.

Achieved environmental benefits

Reduction of airborne dust and odour emissions. A reduction in the risk of spreading potential biohazards by insects, rodents and birds.

Cross media effects

None.

Operational data

Some animal meal will break down and become dusty, but that left at the bottom of stockpiles for long periods can become compacted into large lumps which will have to be broken up sufficiently for handling and for effective combustion.

Applicability

Applicable at all installations.

Driving force for implementation

Environmental regulator permits.

Reference literature

[82, EA, 1998]

Cleaning and disinfection of delivery vehicles and equipment after each deliveryDescription

After being emptied, and at the end of each working day, delivery vehicles and transport skips can be wet cleaned and disinfected with calculated optimal amounts of sodium hydroxide or sodium hypochlorite. Wash water can be collected and inactivated on the site, e.g. by being fed into the incinerator.

Achieved environmental benefits

Reduced odour and pest infestation.

Cross media effects

Subsequent treatment of wash water required, e.g. by incineration with associated emissions, or by waste water treatment also with associated problems. Sodium hypochlorite contains active chlorine. Disinfection with sodium hypochlorite, followed by incineration of the waste water provides a source of chlorine for emissions to air.

Driving force for implementation

The original driving force was lack of confidence in the sterilisation of animal meal received from numerous sources, some of them unknown. ABP Regulation 1774/2002/EC requires that *vehicles and re-usable containers, and all re-usable items of equipment or appliances that come into contact with animal by products or processed products, must be: (a) cleaned, washed and disinfected after each use; (b) maintained in a clean condition; and (c) clean and dry before use.*

Reference literature

[164, Nottrodt A., 2001]

Carrying carcasses (not dragging)Description

Carcasses can be carried, preferably enclosed to prevent floor contamination. Individual small carcasses may be transported in wheeled bins with hinged lids.

Achieved environmental benefits

Reduced requirement for washing with water and consequently reduced waste water treatment requirements. Reduced potential for odour from the material which would be spread throughout the installation by the dragging action.

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Cross-media effects

None.

Operational data

Small quantities of carcasses and parts of carcasses can easily be transported in closed sealable bins. Larger quantities can be moved in sealable covered skips or tipper lorries and then tipped directly into feed hoppers at the incineration installation. It has been reported that carriage is very easy, even when the incinerator is on the same site as the slaughterhouse. It is possibly easier than dragging.

Applicability

Applicable to all installations handling carcasses and parts of carcasses.

Economics

Inexpensive.

Driving force for implementation

Efficiency in the movement of carcasses and parts of carcasses and prevention of contact between personnel and carcasses, especially in the case of the carcasses of diseased animals, including those from TSE confirmed or suspected animals.

Example plants

At least two slaughterhouses with on-site incinerators in Italy.

Reference literature

[65, EA, 1996, 269, Italian TWG Members, 2002]

Size reduction of animal carcasses and parts of animal carcasses before incineration

See also Section.

Description

Animal carcasses and parts of carcasses may be reduced in size to increase the surface area and to facilitate burning, particularly in an incinerator which operates in such a way that the material is suspended or regularly turned.

Achieved environmental benefits

Reducing the size of the material fed to the incinerator helps to stabilise combustion conditions which, in turn, has the following main benefits. The improved burnout that is achieved aids the destruction of organic material indicative of potential the potential presence of TSE, and improves the overall solid residue quality. There are reduced peak and overall CO emissions; reduced production of combustion related pollutants, e.g. VOCs, NO_x, dioxins and furans. There is a reduced requirement for support fuels.

Cross-media effects

Energy is consumed in the size reduction operation. There may also be increased odour emissions. The additional use of water and cleaning and disinfection agents is required.

Operational data

An example plant reported that their success in achieving good combustion of SRM, comprising cattle heads and vertebral columns, was due to the fact that they grind all material to a maximum diameter of 30 mm. Trials involving grinding the material twice did not yield any significant advantage, so a one grinding cycle is now undertaken.

The same plant reported “autothermic” conditions during the continuous incineration of parts of carcasses, at a rate of 5 t/h, but nevertheless it uses CH₄ at rate of 12 m³/h to maintain the furnace temperature, as a precaution against inconsistencies in the calorific value of the feedstock. The feedstock comprises cattle heads and vertebral columns. It is reported that considerably less CH₄ is used than would otherwise have been used to heat water in the co-located slaughterhouse if the incinerator had not been there.

Grinders equipped with knives or crushing teeth are used. They often represent critical points during processing, because they are particularly prone to wear and tear, so maintenance is important.

Size reduction may increase the risk of odour problems particularly if the equipment is not part of an enclosed and exhausted continuous system. Additional cleaning and disinfection is required.

Applicability

Applicable in all incinerators burning animal carcasses and parts of animal carcasses.

Driving force for implementation

Good combustion of the feedstock, which in the case study plant is SRM.

Example plants

At least two incinerators in Italy, burning animal carcasses and parts of animal carcasses.

Reference literature

[269, Italian TWG Members, 2002]

Restriction of feedstock to exactly that tested during trials

Description

Animal meal varies in terms of its calorific value, particle size range, fat and moisture content. Calculations can clearly take the type of material to be burned into account to ensure that only material which has been demonstrated to burn successfully in the trials is burned. In practice this may include a range of feedstocks, with a variety of fat:moisture:ash contents and calorific values. Permits can specify this in their authorisation conditions.

Achieved environmental benefits

Operation of the incinerator and any flue gas treatment techniques only within their design constraints, as demonstrated during trials, thereby minimising consumption and emission levels.

Cross media effects

None.

Applicability

Applicable to all incinerators.

Driving force for implementation

Trouble free incineration, within the design constraints of the incinerator and its associated flue gas treatment techniques. Minimal consumption and emission levels.

Reference literature

[82, EA, 1998]

Agreeing the fat:moisture:ash content of animal meal, with the renderer

Description

If the fat:moisture:ash content of animal meal is agreed with the renderer supplying the incinerator, the conditions can be set for the optimum combustion of a consistent feedstock.

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This can be done within the constraints of ABP Regulation 1774/2002/EC and WID Council Directive 2000/76/EC. Calculations can clearly take the type of material to be burned into account to ensure that only material which has been demonstrated to burn successfully in the trials is burned. In practice this may include a range of feedstocks, with a variety of fat:moisture:ash contents and calorific values.

Achieved environmental benefits

Consistent and controlled incineration reduces emissions and does not place variable burdens on the flue gas treatment equipment.

Cross media effects

None.

Operational data

Compared to incinerators which do not have dedicated feedstocks, animal by products incinerators and particularly those used for the combustion of MBM, as opposed to raw material, have the advantage of being able to closely control feedstock composition and feed rate, and hence combustion conditions.

Driving force for implementation

The incinerator should not be used for the combustion of materials which have not been subject to trials first and which have been included in the authorisation permit from the environmental regulatory authority. A known and consistent feedstock helps to facilitate trouble free incineration.

Reference literature

{293, Smith T., 2002}

Agreeing a specification with the renderer, regarding receipt of material manufactured to the optimal physical characteristics for incineration and associated handling and storage

Description

Co-operation between renderers and incinerator operators can take account of the risks associated with handling animal meal and the facilities available at both sites, especially for existing premises. Agreements can be made, e.g. about whether the meal should be delivered to the incinerator in tankers or bags, or whether it should be ground or pelletised.

Achieved environmental benefits

Reduced dust emissions at rendering installations and at incinerators.

Cross media effects

If meal needs to be ground, this will require the use of energy at either the rendering installation or at the incinerator.

Driving force for implementation

Reduced dust emissions.

Reference literature

{164, Nottrodt A., 2001}

Handling and burning of animal meal as pellets

Description

Animal meal can be received, handled, stored and burned in pellet form.

Achieved environmental benefits

Reduction of airborne dust and odour emissions, at the pre-combustion stages.

Cross-media effects

Energy consumption of pelletising process.

Reference literature

[164, Nottrodt A., 2001]

Handling and burning of packaged MBMDescription

Animal meal can be received, handled, stored and burned packaged, e.g. within sealed sacks. For instance, meal may be supplied in, e.g. bags, with the intention that it is burned in those bags, e.g. for occupational health reasons to minimise exposure to material infected or suspected to be infected with TSE or to minimise exposure to dust. If so, the potential environmental impact of burning the packaging should be assessed and also taken into account.

Achieved environmental benefits

Reduction of airborne dust and odour emissions.

Cross-media effects

If the packaging material is not carefully selected, e.g. to avoid PVC, environmental harm may be caused by its combustion. See also Section 0. Dust emissions may increase during handling, if material is received unpackaged, unless alternative arrangements have been made to control them.

Applicability

Some rendering plants used to put animal meal in bags for distribution as animal feed, before its use in feed was banned.

Reference literature

[164, Nottrodt A., 2001]

Avoid receipt of material for incineration in PVC packagingDescription

Conditions can be stipulated by incinerator operators, demanding that material for incineration is not supplied in PVC packaging.

Achieved environmental benefits

Reduced emissions of hydrogen chloride and consequently reduced consumption of reagents for HCl control and also reduced residue accumulation from flue gas treatment.

Cross-media effects

Dust emissions may increase during handling, if material is received unpackaged, unless alternative arrangements have been made to control them.

Applicability

Applicable in all animal by products incinerators.

Driving force for implementation

Reduced hydrogen chloride emissions, reagent consumption and flue gas treatment residue production.

Reference literature

{6, EA, 1997, 65, EA, 1996, 82, EA, 1998, 164, Nottrodt A., 2001}

~~Auger feed of parts of carcasses or animal meal~~

Description

~~A closed mechanical feed system which avoids the opening of the furnace during charging will prevent emissions from the furnace, the ingress of excess air and cooling. Material can be passed through a pre-breaker or shredder and then fed into the furnace using an auger.~~

Achieved environmental benefits

~~Reduced odour emissions. Reduced emissions from the furnace and reduced ingress of air, thereby potentially reducing NO_x production. Reduced fuel consumption to maintain the temperature of the combustion chamber. Improved combustion stability and control.~~

Cross media effects

~~Energy used by the feed system.~~

Applicability

~~Widely applied in the continuous incineration of animal by products and other materials.~~

Driving force for implementation

~~Maintenance of a consistent continuous feed to the incinerator and consequent stable incineration conditions, which the operator can control easily, possibly without supplementary fuel and which do not exceed the capacities of the flue gas treatment plant. Compliance with WID Council Directive 2000/76/EC will also lead to a system of closed feedstock loading.~~

Example plants

~~Widely applied in the continuous incineration of animal by products and other materials.~~

Reference literature

{6, EA, 1997, 82, EA, 1998}

~~Pumping of parts of carcasses or animal meal~~

Description

~~A closed mechanical feed system which avoids the opening of the furnace during charging will prevent emissions from the furnace, the ingress of excess air and cooling. Material can be passed through a pre-breaker or shredder and then, if it is sufficiently moist, pumped into the furnace.~~

Achieved environmental benefits

~~Reduced odour emissions. Reduced emissions from the furnace and reduced ingress of air, thereby potentially reducing NO_x production. Reduced fuel consumption to maintain the temperature of the combustion chamber. Improved combustion stability and control.~~

Cross media effects

~~Energy used by the feed system.~~

Applicability

~~Widely applied in the continuous incineration of pasty materials.~~

Driving force for implementation

~~Maintenance of a consistent continuous feed to the incinerator and consequent stable incineration conditions, which the operator can easily control, possibly without supplementary~~

fuel, and which do not exceed the capacities of the flue gas treatment plant. Compliance with WID Council Directive 2000/76/EC will also lead to a system of closed feedstock loading.

Example plants

Widely applied in the continuous incineration of pasty materials.

Incineration of incinerator waste water

Description

Waste water from the incineration installation and from the washing of delivery vehicles can be incinerated. The organic content of the waste water can be destroyed by incineration and the water can be evaporated.

Achieved environmental benefits

Destruction of pathogens. Reduced sewer disposal.

Cross media effects

Increased energy may be required to support combustion when the additional moisture load from the waste water is significant and combustion is not self supporting. If sodium hypochlorite is used as a disinfectant there may be increased hydrogen chloride emissions from the incinerator.

Operational data

In an example incinerator burning SRM, all water used for the cleaning of storage and handling facilities is collected in a tank and then automatically dosed to the incinerator at a rate proportionate to the material being incinerated. The water can be used to control combustion temperatures.

If increased energy is required to incinerate the waste water, this may provide an incentive to manage the use of water and to encourage reduced wastage.

ABP Regulation 1774/2002/EC sets requirements for the collection of animal material when treating waste water from Category 1 and Category 2 processing plants and other premises in which specified risk material is removed. Incineration of the water ensures that the animal materials are incinerated too, if they are not collected separately, e.g. in sieves and gratings.

Applicability

Applicable in all animal by products incinerators.

Economies

There may be additional costs if extra fuel is required to assist combustion. There may also be savings if the need for waste water treatment is removed.

Driving force for implementation

Confidence that all TSE risk material is destroyed. For a site dedicated to incineration, a WWTP would not be required.

Example plants

At least two slaughterhouses in Italy burning SRM incinerate all their waste water in this manner.

Reference literature

[6, EA, 1997, 82, EA, 1998, 269, Italian TWG Members, 2002]

Sealed storage, handling and charging of animal by-products to incinerators

Description

Hoppers can provide a storage method, which is relatively easy to control and which may be combined with automated, fully enclosed, transfer and handling equipment. Material can be delivered in, e.g. bulk tipper lorries and transferred directly to an unloading hopper, either mechanically via conveyors/augers or pneumatically.

The storage, handling and possibly size reduction equipment, can be sealed or maintained under negative pressure and the air extracted can be used to provide oxygen for the incineration process, see Section.

Animal by products can be introduced to the furnace without the entrainment of ambient air if the feed mechanism is designed so that it is always filled with the next batch of feedstock or the next quantity that will be drawn into the furnace. Examples of charging mechanisms include a screw conveyor feeding directly into the combustion chamber; feeding into a chute, which feeds into the combustion chamber, either directly or via either a ram mechanism, or a conveyor or by pumping.

Achieved environmental benefits

Plants burning animal meal are able to use fully enclosed feed systems to minimise biological risk and fugitive emissions. The same feed systems are able to closely control the composition and mass flowrate of the feedstock to ensure that stable combustion conditions are maintained. Sealing the process also reduces the risk of malodorous emissions from animal by products, which may be stored for a number of days. In an example incinerator, on the same site as a slaughterhouse, the slaughterhouse slaughters cattle 5 days a week, from Monday to Friday, but the incinerator operates continuously, so material fed into the incinerator on Monday may have been in storage for up to 3 days, during which time the animal by products can degrade and become malodorous.

Sealed charging of animal by products contributes to providing very stable and controllable combustion conditions, due to the stable air supply and the temperature profiles. Preventing air from entering the furnace via the charging system is reported to be effective in reducing emissions from the furnace, e.g. by reducing the potential for the production of NO_x . It is also claimed that it reduces fuel consumption, by preventing the ingress of cold air, which would otherwise lead to a need for additional fuel use to maintain the temperature of the combustion chamber.

Cross-media effects

None.

Operational data

In an example incinerator, carcasses and parts of carcasses are tipped into a hopper, from which they are immediately transferred to a storage vessel which has been designed and constructed to hold the maximum quantity of material likely to be delivered to the site.

A cover may be provided for the initial hopper into which the animal by products are tipped when they are received from the slaughterhouse, to reduce odour emissions. If the animal by products are received fresh and are not inherently malodorous, e.g. if the incinerator is on the same site as the slaughterhouse, then typically the material will comprise fresh condemned carcasses and bones. If this material is fed into the storage vessel immediately, the cover may not serve an odour reduction purpose but it will still reduce problems arising from birds and vermin.

Storage hoppers are covered and sealed. The final feed to the continuously running rotary kiln furnace is always sealed by a fully charged screw conveyor or chute or pumped supply.

Applicability

Applicable in all incinerators burning animal by products, whether they be carcasses, parts of carcasses or animal meal.

Economies

There is a relatively low cost associated with sealing equipment upstream of the incinerator, to prevent air ingress during charging.

Driving force for implementation

Ease of operation; maintenance of stable combustion conditions and maintenance of autothermic conditions, by preventing air from entering at ambient temperature and thereby avoiding the requirement for supplementary fuel to maintain combustion temperatures. The enclosure of raw materials can also reduce odour problems.

Example plants

Sealed hopper charging of whole carcasses and parts of carcasses is undertaken in at least two animal carcasses/parts of animal carcass incinerators in Italy.

Reference literature

[6, EA, 1997, 65, EA, 1996, 269, Italian TWG Members, 2002, 293, Smith T., 2002]

Ducting of air from the installation and the pre-combustion equipment to the combustion chamber

Description

Storage, handling and possibly size reduction equipment, can be sealed or maintained under negative pressure and the air extracted can then be used to provide oxygen for the incineration process. Air can also be ducted to the incinerator from the building in which the storage handling and grinding equipment are situated. The amount of air which can be fed to the combustion chamber will be limited to the optimum oxygen requirements for the incineration process. An odour assessment can help to identify the areas which are most likely to lead to odour emissions and these can be selected as the highest priority for capture of air, for incineration.

The amount of air which passes through the incinerator can also be controlled. Excess air fed into the incinerator adds an additional burden on the flue gas treatment equipment. The use of small storage buildings with small openings/air inlets increases the effectiveness of capturing malodorous air.

Achieved environmental benefits

Enclosure of the process combined with continuous extraction of the air in the storage and handling equipment reduces the risk of malodorous emissions from animal by products, which may be stored for a number of days. In an example incinerator, the incinerator is situated on the same site as a slaughterhouse, where cattle are killed 5 days a week, from Monday to Friday. The incinerator operates continuously, so material fed into the incinerator on Monday may have been in storage for up to 3 days. Without the extraction of air from the storage, handling and grinding equipment, odour problems would almost certainly arise.

Cross-media effects

None.

Operational data

At one case study site, there are two air inlets at the top of the storage vessel. The air from the vessel, as well as that from the other handling and grinding equipment between the storage vessel and the furnace, is drawn into the furnace to provide oxygen for the combustion process. This is the only source of oxygen for combustion. The furnace is in continuous operation, so this method of providing oxygen for combustion maintains the negative pressure within the storage vessel and prevents malodorous air from escaping. The air inlets to the storage vessel are protected by grills, to prevent the access of rodents and birds.

When the incinerator is shut down, especially if this is unplanned, it may be necessary to extract malodorous air from the installation and equipment to alternative treatment systems. For planned shutdowns the receipt of feedstock may be temporarily stopped, e.g. to prevent odour emissions.

This technique is not restricted to incinerators and can be used for any site that has combustion equipment installed.

Applicability

Applicable at all incinerators burning malodorous material and at other installations with combustion equipment.

Economics

There will be a cost for the ducting required to draw the air from inside the building and through the pre-combustion storage and handling equipment. The cost will depend on whether the installation has been designed so that the pre-combustion equipment is situated close to the incinerator or not. Some redesign and/or sealing of air inlets at areas from where the air is extracted may also be required, to improve the effectiveness of the air capture.

Driving force for implementation

Odour reduction.

Example plants

This technique is widely used in incinerators and co-incinerators throughout Europe.

Reference literature

{269, Italian TWG Members, 2002, 350, EFPPA, 2003}

Combustion temperatures alarmed and interlocked to charging mechanisms

Description

The maintenance of adequate combustion temperatures at all times when animal by products are in the furnace is one of the conditions required to ensure good combustion and for materials potentially infected with TSEs, the destruction of the prion.

~~WID Council Directive 2000/76/EC requires, amongst other things, the following *Each line of the incineration plant shall be equipped with at least one auxiliary burner. This burner must be switched on automatically when the temperature of the combustion gases after the last injection of combustion air falls below 850 °C or 1100 °C as the case may be. It shall also be used during plant start up and shut down operations in order to ensure that the temperature of 850 °C or 1100 °C as the case may be is maintained at all times during these operations and as long as unburned waste is in the combustion chamber.*~~

~~ABP Regulation 1774/2002/EC requires *Incineration or co-incineration plants must be designed, equipped, built and operated in such a way that the gas resulting from the process is raised in a controlled and homogeneous fashion, even under the most unfavourable conditions, to a temperature of 850 °C, as measured near the inner wall or at another representative point of the combustion chamber as authorised by the competent authority, for two seconds. and that Each line of high capacity incineration plants must be equipped with at least one auxiliary burner. This burner must be switched on automatically when the temperature of the combustion gases after the last injection of combustion air falls below 850 °C. It must also be used during plant start up and shut down operations to ensure that the temperature of 850 °C is maintained at all times during these operations and as long as unburned material is in the combustion chamber.*~~

The combustion temperatures can be interlocked to the incinerator charging mechanism, to ensure that if the temperature falls charging is automatically halted.

Gas temperatures in the primary combustion zone and at the point of exit from the secondary combustion chamber can be continuously monitored and recorded. Audible and visual alarms can be triggered when the temperature falls below the minimum specified. The charging of the system can be interlocked with the temperature at the exit from the secondary combustion chamber.

The term “zone” in this context is described as “the volume after the last injection of combustion air where adequate turbulent conditions exist”. For example, it may be the space above the freeboard in a fluidised bed combustor, or a secondary chamber in the case of a rotary furnace”.

Achieved environmental benefits

Maintaining combustion temperatures ensures the good combustion of gases and therefore reduces emissions of products of incomplete combustion.

Cross media effects

The operation of auxiliary burners increases fuel consumption.

Operational data

The maintenance of stable temperatures together with constant flowrate and consistent material composition creates stable combustion conditions and reduced emissions to air.

Stable temperatures reduce the amount of damage to the combustion chamber, due to thermal expansion and contraction. This in turn reduces the amount of downtime for maintenance and repair.

Applicability

Applied in virtually all incinerators.

Economics

Reduced maintenance requirements and minimal downtime lead to reduced costs.

Driving force for implementation

Legislative requirements, i.e. *Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste* and *ABP Regulation 1774/2002/EC*.

Example plants

Virtually all incinerators.

Reference literature

{6, EA, 1997, 82, EA, 1998}

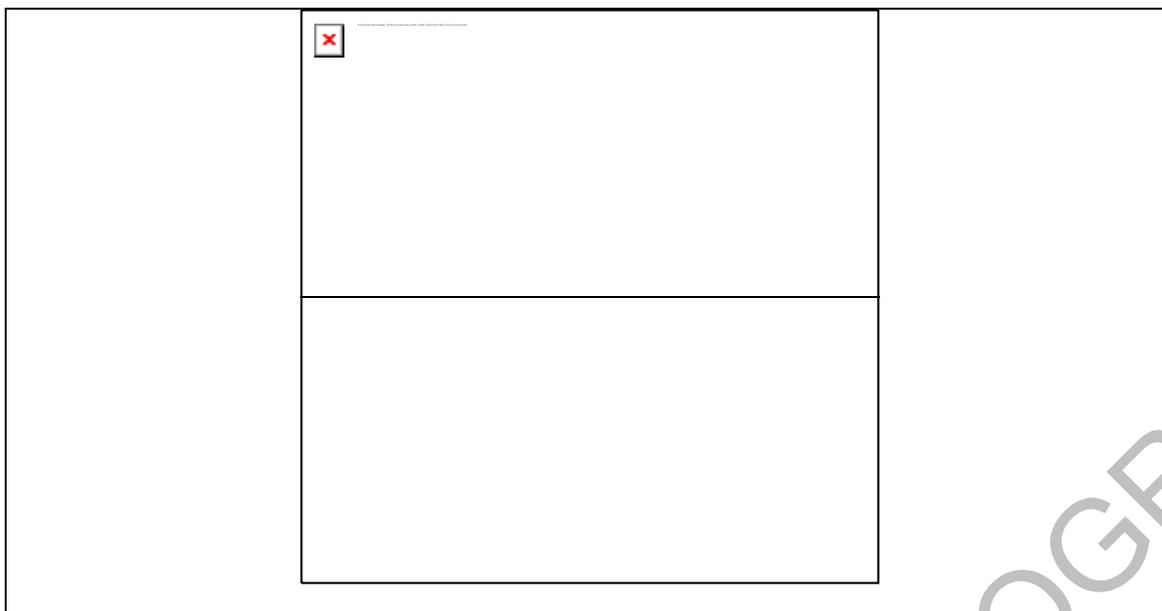
Bubbling fluidised bed (BFB) incineration of animal by-products

Description

The disposal of crushed animal carcasses and animal meal as waste, by incineration, can be undertaken in a BFB incinerator.

The furnace may be sensitive to the size, fat content and moisture content of the feedstock, so pretreatment may be important. Fluidised bed furnaces are usually designed with the gas residence time built into the top of a single furnace instead of in a secondary chamber.

The process, showing incineration of MBM, is summarised in Figure.



**Figure : 40 MW twin-stream MBM fluid bed combustion facility
[199, PDM Group and Wykes Engineering (Rushden) Ltd, 2000]**

The MBM is taken from storage, or directly from a rendering plant and ground to an optimum size for burning.

Conditioning liquor is then added to the MBM, to make a sludge, to ensure that the MBM does not flash off before it is properly combusted. The conditioning liquid may be water and/or it may include effluent from rendering, which comprises waste water and liquid condensate. The amount added will depend on the condition (fat:moisture:ash) of the MBM. If too much water is added the MBM fuses and builds up on the incinerator wall.

The velocity of the combustion air through a preheated bed of inert particles causes the bed to fluidise and gives the appearance of a boiling liquid. At a pre-determined bed temperature the MBM is fed into the top of the BFB at a controlled rate. Due to the fluidising motion the MBM particles are evenly distributed throughout the bed and are rapidly combusted.

Achieved environmental benefits

For untreated animal by products, the following environmental benefits have been reported. Reduced microbiological risks due to good combustion. This has in part been achieved by preventing the formation of liquid organic and aqueous wastes and by preventing run-out and the pooling of liquid (fat and water), during combustion. This in turn improves the potential for the residues to be recycled. Both WID Council Directive 2000/76/EC and ABP Regulation 1774/2002/EC require the residues to be *minimised in their amount and harmfulness* and to be *recycled, where appropriate*.

Low CO emissions have also been reported and considering the high N content in animal carcasses, low NO_x emissions were reportedly achieved. The NO_x emissions were reported to be lower than for the wood chips they replaced in the trial described under "Operational data" below.

It has been reported that consultant experts in incinerators involved in a project where 60 % of the feed was minced animal by products, have sufficient evidence to believe that a BFB incinerator specifically built for the incineration of animal waste will be able to incinerate 100 % animal waste and that such incinerators could work autothermically [298, Widell S., 2002].

~~For MBM, the following environmental benefits have been reported. Destruction of TSE risk materials has been claimed, by destroying proteins and producing an inert inorganic ash suitable for disposal to landfill. The ash is also reported to have a potential commercial use. Emissions of gases and dust are reported to be within the limits prescribed in WID Council Directive 2000/76/EC. When the MBM starts burning it becomes self-combusting, so supplementary fuels are not required.~~

~~The conditioning liquid added to the MBM, to make a sludge before incineration, may include effluent from rendering, which comprises waste water and liquid condensate, which would otherwise have to be treated using another technique.~~

~~BFB incinerators reportedly operate at temperatures at which a proportion of acid gases such as SO₂ and HCl can be absorbed into the alkaline bed material, i.e. the bone ash.~~

~~For both animal carcasses and animal meal incineration, the heat generated can be used to produce electricity, hot water or steam and these can be used either in on site associated activities, or off site. Malodorous process gases and air can be burned, at no additional cost. The granulated bed provides continuous attrition of the burning material, removing the char as it forms and exposing fresh material for combustion. This assists with increasing the speed and completeness of combustion.~~

Cross media effects

~~Emissions to air SO₂, HCl, NO_x and CO and additional energy use due to the requirement for the destruction of protein to destroy BSE prions and to fluidise the bed.~~

Operational data

~~The technique is more established for the dedicated incineration of animal meal than untreated carcasses and parts of carcasses, nevertheless it has been demonstrated to be effective in the treatment of carcasses if they are reduced in size before incineration.~~

~~**Trials have been carried out for the incineration of animal carcasses**, including one where wood chips were replaced with animal waste material, mainly consisting of fallen stock crushed into a pulp. There was no addition or removal of contents, such as water and no pretreatment was undertaken. A 10–11 MW BFB incinerator was used. As the feedstock was intended to be injected continuously into the boiler, a nozzle was developed which could inject the material in a proper way. An optimal particle size of the material was crucial for a proper injection. The technical staff responsible for the trial claimed that a substitution of up to 100 % is technically possible using a BFB boiler specifically designed for animal fuel combustion, taking into consideration the humidity of the fuel.~~

~~The suspension of the finely divided material in the fluidised bed allows it to be burned without run-out and pooling of liquid, which could result in insufficient combustion and the requirement for the material to be returned to the incinerator.~~

~~**In an example plant burning MBM**, the BFB bed is constantly fed and topped up by ash produced by the incineration process. To avoid it becoming too heavy the excess is removed. The air from the fluidising fan pushes the fines upwards and the heavier bed ash particles drop down. These are inorganic bone particles and they are transferred to store, pending disposal to landfill.~~

~~Malodorous air from storage areas and handling equipment can be used as an oxygen source. The BFB incineration temperature can also destroy the malodorous compounds.~~

~~CaCO₃, in the form of limestone, can be added to the BFB, to reduce the emission levels of NO_x, SO_x and HCl.~~

The hot gas generated in the combustion process is transferred into a specially designed waste heat recovery boiler. The waste heat from an installation burning 4750 tonnes per week in 2 incinerators is used to produce steam with a pressure of 4.5 million Pa (45 bar). Alternatively, it can produce 17 tonnes of steam per hour and 3.5 MW of electricity, or alternatively again it can be used exclusively for power generation, i.e. to generate 7 MW of electricity.

The hot gas carries minute particles of entrained ash from the BFB. Some of this ash will deposit on the outside of the vertical boiler tubes, within which water evaporation is taking place. A specially designed system periodically blows off this “fly ash” into a collecting hopper.

The fly ash laden air is then passed through sodium bicarbonate, to neutralise the flue gases and to remove HCl and SO₂.

The fly ash content of the air is then reduced using special texture membrane filters which reduce the emitted dust levels to less than 10 mg/m³. The filter banks self clean automatically and the resultant fly ash, which has the consistency of talcum powder, is collected and transferred to storage. The ash is then mixed with sodium bicarbonate and water and sent for landfill.

In line continuous computerised emission monitoring equipment, with fail safe alarms, is fitted between the filters and the final exhaust stack.

Several dedicated MBM incinerators operate in the UK. Emission data both before and after flue gas treatment are shown in. Further data are given in.

Table shows the reported performance of the example plant incinerator compared with those prescribed in WID Council Directive 2000/76/EC [195, EC, 2000].

Releases to air		Performance associated with BAT ⁽³⁾	
		Typical	Monitoring
SO ₂	(mg/m ³)	<30 ⁽²⁾	Continuous
HCl	(mg/m ³)	<10 ⁽²⁾	Continuous
HF	(mg/m ³)	n/a	
NO _x	(mg/m ³)	<175 ⁽²⁾	Continuous
CO	(mg/m ³)	<25 ⁽²⁾	Continuous
VOCs	(mg/m ³)	<10 ⁽²⁾	Periodic
Dust	(mg/m ³)	<10 ⁽²⁾	Continuous
Dioxins and furans	(ng/m ³)	<0.1 ⁽⁴⁾	Periodic
Heavy metals total (Cd, Tl)	(mg/m ³)	<0.05 ⁽⁵⁾	
Heavy metals (Hg)	(mg/m ³)	<0.05 ⁽⁵⁾	
Heavy metals total (Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V)	(mg/m ³)	<0.5 ⁽⁵⁾	
NH ₃	(mg/m ³)	<10	
Residence time	≥ 850 °C	3.5 s	
Oxygen	(minimum after last injection)	9%	Continuous
Pressure, Temperature, Water vapour; Volumetric flow			Continuous
Ash – (total carbon)		<1% ⁽⁶⁾	Periodic
Ash – (total protein) (Aqueous extract) (mg/100g)		0.3–0.6	Periodic

⁽²⁾— Releases control — “95 % percentile hourly average over 24 hours”. Measurements at 273 K (temp.), 101.3 kPa (pressure) and 11 % O₂ dry gas

⁽³⁾— Actual performance results operating a dry flue gas cleaning system with bag filters and injected reagents

⁽⁴⁾— Values measured over a sample period of a minimum of 6 hours and a maximum of 8 hours expressed as toxic equivalents in accordance with Annex 1 of the Waste Incineration Directive

⁽⁵⁾— Values measured over a sample period of a minimum of 6 hours and a maximum of 8 hours

(6) — Total organic carbon

Note: Protein analysis is not relevant to the dedicated incineration of poultry by products

Table: Emission levels associated with the dedicated incineration of MBM in a fluidised bed incinerator

[199, PDM Group and Wykes Engineering (Rushden) Ltd, 2000] (adapted)

Some examples of the results of analyses of fly ash and bed ash, for amino acid concentrations are shown in Table and Table.

Amino Acid	nanomole amino acid/g sample	µg amino acid/g sample	mg amino nitrogen/100g sample	mg protein/100g sample
Aspartic acid	2.78	0.37	0.004	0.02
Glutamic acid	Trace < 2.1	Trace < 0.31	Trace < 0.003	Trace < 0.018
Serine	Trace < 2.3	Trace < 0.25	Trace < 0.003	Trace < 0.020
Glycine	3.94	0.30	0.01	0.03
Histidine	ND < 0.4	ND < 0.06	ND < 0.002	ND < 0.011
Arginine	ND < 3.2	ND < 0.56	ND < 0.018	ND < 0.113
Threonine	ND < 2.4	ND < 0.28	ND < 0.003	ND < 0.021
Alanine	Trace < 3.3	Trace < 0.29	Trace < 0.005	Trace < 0.029
Proline	Trace < 1.1	Trace < 0.12	Trace < 0.001	Trace < 0.009
Tyrosine	ND < 2.0	ND < 0.37	ND < 0.003	ND < 0.018
Valine	Trace < 1.8	Trace < 0.21	Trace < 0.003	ND < 0.016
Methionine	ND < 2.3	ND < 0.35	ND < 0.003	ND < 0.020
Isoleucine	2.80	0.37	0.004	0.02
Leucine	2.54	0.33	0.004	0.02
Phenalanaline	28.98	4.79	0.04	0.25
Lysine	ND < 2.7	ND < 0.39	ND < 0.007	ND < 0.047
Total	41.04	6.15	0.06	0.36

Table : Analysis of fly ash from BFB incineration of MBM for amino acids
[199, PDM Group and Wykes Engineering (Rushden) Ltd, 2000]

Amino Acid	nanomole amino acid/g sample	µg amino acid/g sample	mg amino nitrogen/100g sample	mg protein/100g sample
Aspartic acid	4.62	0.62	0.01	0.04
Glutamic acid	Trace < 2.1	Trace < 0.31	Trace < 0.003	Trace < 0.018
Serine	5.36	0.56	0.01	0.05
Glycine	9.22	0.69	0.01	0.08
Histidine	0.97	0.15	0.004	0.03
Arginine	Trace < 3.2	Trace < 0.56	Trace < 0.018	Trace < 0.113
Threonine	Trace < 2.4	Trace < 0.28	Trace < 0.003	Trace < 0.021
Alanine	3.58	0.32	0.01	0.03
Proline	2.64	0.30	0.004	0.02
Tyrosine	ND < 2.0	ND < 0.37	ND < 0.003	ND < 0.018
Valine	2.47	0.29	0.003	0.02
Methionine	Trace < 2.3	Trace < 0.35	Trace < 0.003	Trace < 0.020
Isoleucine	2.22	0.29	0.003	0.02
Leucine	3.38	0.44	0.005	0.03
Phenalanaline	27.23	4.50	0.04	0.24
Lysine	4.26	0.62	0.01	0.07
Total	65.94	8.79	0.10	0.63

Table : Analysis of bed ash from BFB incineration of MBM for amino acids
[199, PDM Group and Wykes Engineering (Rushden) Ltd, 2000]

Applicability

BFB incinerators can be used to burn animal carcasses, if the feedstock is reduced in size to enable it to be injected into the fluidised bed, suspended and burned. They can also be used to burn animal meal.

Driving force for implementation

ABP Regulation 1774/2002/EC and consequently WID Council Directive 2000/76/EC.

Example plants

Several BFB incinerators dedicated to the incineration of MBM operate in the UK.

Reference literature

[82, EA, 1998, 164, Nottrodt A., 2001, 199, PDM Group and Wykes Engineering (Rushden) Ltd, 2000, 200, Widell S., 2001, 325, Smith T., 2002]

Circulating fluidised bed incineration of animal by-products

Description

In circulating fluidised beds, the feedstock is introduced to the fluidised bed, together with recirculated bed material, from the cyclone at the exit of the combustion chamber. High air velocities carry the granulated bed material and the feedstock up through the combustion zone to the top of the combustion chamber, i.e. the freeboard. The material then passes through a hot cyclonic collector. Hot gases pass through the cyclone and the majority of solids drop to the bottom of the cyclone and are reinjected into the bed of the furnace. Uncirculated flue gases pass to heat recovery and flue gas treatment processes.

The feedstock is introduced between the cyclone and the reactor bed, via a screw conveyor, from a holding silo. No atomisers or special nozzles are required to introduce the waste. A combustion air fan provides air to the bed for fluidisation and combustion. The furnace draft is maintained by an induced draft fan downstream of the cyclone.

The retention time of the material in the furnace is controlled by controlling the discharge from the ash cooler. Not all of the cyclone bottom ash is recirculated. Some is removed via an ash conveyor. The speed of this conveyor determines the rate of removal of material, so decreasing the speed increases the retention time. This feature can, in appropriate circumstances, allow lower combustion temperatures, with consequent lower supplementary fuel requirements and less refractory damage and maintenance.

Achieved environmental benefits

For animal meal, it has been claimed that TSE risk materials can be destroyed, by destroying proteins. The heat generated can be used to produce electricity, hot water or steam, which can be used either in on-site associated activities, or off-site.

Cross-media effects

Emissions of SO₂, HCl, NO_x and CO to air and additional energy use due to the requirement for the destruction of protein to destroy BSE prions and to fluidise the bed.

Operational data

At an example plant, a trial was undertaken using 100% animal meal, with a calorific value in the range 17–21 MJ/kg, a thermal load of approximately 9–12 MW and a throughput performance of 1550 to 2550 kg/h. It is reported that if in the same fluidisation bed, the throughput was changed to 2500–7500 kg/h, then a thermal output of 4.8–9.7 MW would be achieved.

The incineration in the circulating fluidised bed was carried out at a minimum temperature of 850 °C. The gas residence time was controlled to approximately 4 s, by setting the ash removal rate. The measuring system for testing the prescribed minimum dwell time of 2 s and the

temperature requirements was located between the two return cyclone separators specifically, between the top of the furnace head and the inlet to the boiler.

The hot flue gases were directed from the cyclone, where they were separated from the heavier solid matter. SNCR was used for NO_x removal, by injecting urea into the flue gas stream between the return cyclone and the waste heat boiler, at a temperature of > 850 °C. The boiler was used for heat recovery. Further cooling plus inorganic chlorine and sulphur dioxide removal was achieved using a scrubber containing calcium hydroxide in suspension. Carbon was injected to remove dioxins, furans and heavy metals. A fibrous filter was used for dust removal. Prions were not detected in the ash and it was therefore deduced that the proteins had been destroyed.

The achieved emission levels from this trial with 100 % animal meal incineration are illustrated in Table.

Parameter	Average annual measured levels (mg/m ³)	WID Council Directive 2000/76/EC limits	
		Daily average value (mg/m ³)	Half-hourly average value (mg/m ³)
Total dust	0.34	10	30
Gaseous and vaporous organic substances, expressed as total organic carbon	0.032	10	20
Hydrogen chloride (HCl)	2.83	10	60
Sulphur dioxide (SO ₂)	24.22	50	200
Nitrogen monoxide (NO) and nitrogen dioxide (NO ₂), expressed as nitrogen dioxide ⁺	120.13	200	400
CO*	17.95		
Hg and its compounds, indicated as Hg	0.0004	0.03	0.05 average determined through relevant sampling

⁺Until 1 January 2007 and without prejudice to relevant Community legislation the emission limit value for NO_x does not apply to plants only incinerating hazardous waste.

*The following emission limit values of carbon monoxide (CO) concentrations shall not be exceeded in the combustion gases (excluding the start up and shut down phase):
 –50 milligrams/m³ of combustion gas determined as daily average value;
 –150 milligrams/m³ of combustion gas of at least 95 % of all measurements determined as 10 minute average values or 100 mg/m³ of combustion gas of all measurements determined as half hourly average values taken in any 24 hour period.
 Exemptions may be authorised by the competent authority for incineration plants using fluidised bed technology, provided that the permit foresees an emission limit value for carbon monoxide (CO) of not more than 100 mg/m³ as an hourly average value.

Table: Emissions incinerating 100 % animal meal in a circulating fluidised bed

Example plants

A trial dedicated to the incineration of 100 % animal meal was carried out at one circulating fluidised bed incinerator in Germany.

Reference literature

[244, Germany, 2002, 334, Brunner C. R., 1996]

Rotary kiln incinerator design

Description

Incineration in a rotary kiln is normally a 2 stage process, consisting of a kiln and a secondary combustion chamber. The kiln is a cylindrical shell lined with a refractory substance, which is inclined downwards from the feed end and rotates slowly about its cylindrical axis. The rotation moves the material through the kiln with a tumbling action, so as to expose fresh surfaces to heat and oxygen. Structures may be added within the kiln, to aid turbulence and to slow the passage of liquid wastes.

If a rotary kiln furnace incorporates structures which slow down the passage of liquids along the inclined structure then run out, which could result in incomplete combustion, should not arise. Nevertheless it is normal practice to provide a burnout chamber to ensure that combustion is sufficiently complete.

Achieved environmental benefits

Conversion of "problematic" waste animal by products into useful energy.

The opportunity to co-incinerate offensive liquid waste products and effluents.

Adequate combustion reduces microbiological risk and prevents the formation of liquid organic and aqueous wastes, by preventing run out and the pooling of liquid (fat and water) during combustion. This in turn improves the potential for the residues to be recycled. Both WID and ABP Regulation 1774/2002/EC require the residues to be *minimised in their amount and harmfulness* and to be *recycled, where appropriate*.

Cross media effects

Emissions to air and energy consumption to turn the kiln.

Operational data

Air velocity, which depends on the fans, burners and furnace diameter and rotational speed is important for minimising dust emissions and to achieving good burnout. The furnace length needs to be long enough to minimise the load on the secondary chamber, which in turn should be designed to ensure adequate turbulence.

Table shows the analysis of ashes from a rotary kiln incinerator dedicated to the incineration of SRM comprising cattle heads and vertebral columns.

Analysis	Value	Units	Detection limit	Method
Total solid	78.6	g/100g		
Dry matter	78.2	g/100g		
Total volatile solid (organic substances)	< DL	g/100g	0.5	
Heavy metals:				
As	0.181	mg/kg		ICP/MS
Cd	< DL	mg/kg	0.05	ICP/MS
Cr	2.04	mg/kg		ICP/MS
Fe	171	mg/kg		ICP/MS
Mn	2.29	mg/kg		ICP/MS
Hg	< DL	mg/kg	0.05	ICP/MS
Ni	2.54	mg/kg		ICP/MS
Pb	0.962	mg/kg		ICP/MS
Cu	2.46	mg/kg		ICP/MS
Zn	2.47	mg/kg		ICP/MS

Table: Analysis of ashes from a rotary kiln incinerator dedicated to the incineration of SRM comprising cattle heads and vertebral columns

Applicability

Rotary kilns are suitable for the incineration of animal carcasses, parts of animal carcasses and animal meal.

Economics

This information concerns an incinerator on a cattle slaughterhouse site, for which some public funding was provided.

For an effective incinerator capacity of 0.5 t/h, i.e. 4380 kg/yr, an investment of EUR 2300000 has been reported. This has been quoted as being equivalent to EUR 0.525/kg. It has been estimated that the cost of a 1 tonne capacity incinerator would be more than twice the cost of a 0.5 t/h incinerator.

Payback, for the case study incinerator, is reported to be difficult to measure because of public investment, but is estimated to be 4 years.

Driving force for implementation

ABP Regulation 1774/2002/EC and consequently WID Council Directive 2000/76/EC.

Example plants

At least 2 carcass incinerators at 2 cattle slaughterhouses in Italy.

Reference literature

[82, EA, 1998, 248, Sorlini G., 2002, 269, Italian TWG Members, 2002]

Continuous incineration

Description

Continuous incineration involves the continuous operation of an incinerator without the repeated heating and cooling associated with batch processes.

Achieved environmental benefits

The main environmental benefit of continuous incineration is that it avoids the emission peaks associated with start up and shutdown. When a combustion temperature is reached and maintained with a steady supply of feedstock, the emissions to air are more uniform. Consequently, the emissions per tonne of feedstock are lower. Abatement equipment can be designed and run to lower emissions, with a consequent lower energy use and chemical consumption. Less supplementary fuel is required for continuous incineration than for batch incineration, since the feedstock continues to act as a fuel to maintain the combustion temperature. For batch incineration, as the feedstock is consumed additional fuel is required to complete the combustion process.

Continuous incineration may provide a faster disposal route for animal by products and may reduce odour problems associated with the storage and handling of putrescent materials. Incineration before malodorous substances are formed may be achievable, e.g. at incinerators located on the same site as slaughterhouses.

A method of treating malodorous air, i.e. the incinerator, is always available, except when the incinerator is stopped for, e.g. maintenance.

Cross media effects

None reported, compared with batch processes.

Operational data

Maintenance problems associated with damage to the equipment, e.g. the refractory lining of the incineration chamber, caused by frequent heating and cooling during batch incineration are avoided.

Applicability

Applicable when sizing new incinerators to process anticipated feedstock throughputs. Existing incinerators may maximise their inputs of animal by products required to be incinerated to achieve their full capacity and to run on a continuous basis.

Economics

Reduced maintenance costs.

Driving force for implementation

Reduced emissions, increased stability of operation and reduced maintenance time and expense.

Example plants

Numerous incinerators burning a wide variety of feedstocks, including rotary kilns burning animal carcasses and BFB incinerators burning MBM.

Provision of an ash burnout chamber

Description

Burnout of solid waste is important to ensure the destruction of microbiological hazards and dioxins. It also prevents biological attack of the ash afterwards, e.g. in a landfill site. Adequate combustion also assists in ensuring that the residues *shall be minimised in their amount and harmfulness*, thus increasing their potential for recycling, where appropriate, which is a requirement of both WID Council Directive 2000/76/EC and ABP Regulation 1774/2002/EC.

Achieved environmental benefits

Reduced biohazard risk from, e.g. TSE prions.

Cross media effects

None.

Operational data

The requirement for an ash burnout chamber will depend on the reliability of the main combustion zone in achieving adequate combustion for the designated throughput. They are usually provided as part of the rotary kiln incinerator system and are not generally required as part of BFB incinerators.

A "loss on ignition" test involving taking an ash sample, heating it to combustion temperature in the presence of air and measuring the weight loss can be used to monitor good performance.

Applicability

Applicable in all incinerators where reliable combustion cannot be achieved in the main combustion zone.

Driving force for implementation

Compliance with WID Council Directive 2000/76/EC and ABP Regulation 1774/2002/EC.

Reference literature

{65, EA, 1996}

Automated continuous de-ashing

Description

De-ashing can be enclosed and automatic for continuous systems. The combustion zone, therefore, is then reserved for the adequate incineration of the feedstock. The sealed system prevents the ingress of air during de-ashing and thereby allows continued stable combustion

conditions to be maintained. This results in reduced emissions to air and/or, a lower requirement for flue gas treatment systems.

Achieved environmental benefits

Minimal airborne dust emissions.

Cross media effects

Energy consumption associated with the operation of the automated de-ashing system.

Operational data

A screw conveyor can transfer the ash directly to a covered collection vessel. An example continuously operating rotary kiln furnace has a screw conveyor fitted to remove ash, which has first been cooled by quenching.

Applicability

Applicable at all continuous incinerators.

Driving force for implementation

Occupational health and reduced airborne dust emissions.

Reference literature

{82, EA, 1998}

Vacuum cleaning of ash – not sweeping

Description

The vacuum collection of ash, during de-ashing or cleaning up spillages, can be done using a high efficiency particle filter, instead of sweeping and can prevent dust from becoming airborne.

Achieved environmental benefits

Reduced dust emissions.

Cross media effects

Energy consumption associated with the operation of the vacuum system.

Operational data

If the material is adequately burned out and allowed to cool and all de-ashing operations are enclosed and made directly into an enclosed transport skip this will reduce the risk of dust becoming airborne. Forced cooling causes dust to become airborne.

Applicability

Applicable in batch incinerators.

Driving force for implementation

Possibly occupational health and reduced airborne dust.

Reference literature

{6, EA, 1997, 82, EA, 1998}

Wet quenching of ash

Description

Collecting ash, in a quench bath, or passing it through a quenching spray can prevent dust from becoming airborne.

Achieved environmental benefits

Reduced dust emissions.

Cross media effects

Increased water consumption.

Operational data

Dust quenching sprays can be designed and operated so that they moisten and agglomerate the surface of the ash without causing a run-off or leachate problem. They can use non-potable water. Alternatively, the ash can be collected in a quenching bath.

Wet ash can be held at an intermediate point to ensure that it is fully drained before it is transferred to the vessel which will be used to transfer it from the site. This will prevent the water from draining during transportation or at the place it is finally disposed of. The water which is drained can be returned to the quenching system.

Applicability

Applicable in all incinerators.

Driving force for implementation

Possibly occupational health and reduced airborne dust.

Reference literature

{65, EA, 1996}

Monitoring regime for emissions, including a protocol for monitoring burnout, including biohazard from TSE prions, in ash

Description

A monitoring regime can be used to measure the actual environmental performance of an animal by products incinerator, to both establish the achievable performance and to monitor compliance with emission limit values. As a minimum, the monitoring regime should meet the requirements of WID Council Directive 2000/76/EC, notwithstanding the possibility that the achievable emission levels may be significantly lower than those required by the legislation.

Further information on monitoring is available in the "Reference Document on The General Principles of Monitoring".

Both WID Council Directive 2000/76/EC and ABP Regulation 1774/2002/EC require that the residues *shall be minimised in their amount and harmfulness*. A protocol for monitoring burnout, including biohazard from TSE prions in ash after animal by product incineration, can be used to double check that all of the procedures and safeguards in use are operating correctly. The *Monitoring protocol – ash and particulate testing methods and frequency (for analysis of carbon, nitrogen and amino acid content)* and the *Environment Agency – Bovine trials group, Notes on sampling of ash* are reproduced in Section 0.

An incinerator burning SRM in Italy measures organic nitrogen in ash, as a way of monitoring prion destruction. The residual nitrogen is measured at 105 °C. The detection limit is 0.5 g nitrogen/100 g ash.

Continuous monitors should have battery back-up to ensure that they can still record in the event of a power failure.

Achieved environmental benefits

By monitoring emissions the effectiveness of the chosen incineration equipment and associated processes, including "end of pipe" techniques, can be checked to see whether they are effectively preventing or controlling emissions to the environment as a whole. Underperformances can thereby be detected and rectified.

Cross media effects

None.

Operational data

None.

Applicability

The monitoring of emissions to air is applicable in all incinerators, including those burning animal by products. A protocol and regime for monitoring burnout, is also required and this should include a means of checking for any residual biohazard associated with TSE prions in ash.

Driving force for implementation

The legislative requirements of WID Council Directive 2000/76/EC and ABP Regulation 1774/2002/EC and the destruction of TSE prions.

Example plants

Virtually all incinerators are required by WID Council Directive 2000/76/EC, to monitor their emissions and those that are excluded from that particular legislation, do so to meet the permitting requirements of environmental regulators.

Reference literature

[6, EA, 1997, 82, EA, 1998, 278, EC, 2002]

Regular cleaning and disinfection of installations and equipment

Description

A regular, e.g. weekly, thorough cleaning of installations and equipment where animal by products are handled will reduce the risk of diseases being spread by insects, rodents and birds and will help control the formation of malodorous substances.

Achieved environmental benefits

Reduced odour emissions. Insect, rodent and bird control.

Cross media effects

Detergents, including disinfectants are used.

Operational data

The following example of a cleaning routine has been reported at an installation incinerating animal carcasses and parts of carcasses, including SRM. First rinse, then apply an alkaline detergent, follow with another rinse, then disinfect with 2 % chlorine solution, for at least one hour. At the same installation, the enclosed storage, handling, grinding and charging equipment is cleaned periodically and usually before maintenance, by passing wood chips through the system and then incinerating them.

Applicability

Applicable at all installations, storing, handling and treating animal by products, except perhaps where there is long term storage of animal meal.

Economies

Cheaper and more convenient than dealing with odour and infestation.

Driving force for implementation

ABP Regulation 1774/2002/EC. Prevention of odour and infestation by insects, rodents and birds. Prevention of the spread of TSEs and in particular BSE.

Example plants

At least 2 animal carcase incinerators in Italy.

Reference literature

[6, EA, 1997, 82, EA, 1998, 248, Sorlini G., 2002, 287, EC, 2002]

Operation of odour arrestment techniques when the incinerator is not working

Description

Technical or operational odour controls can be provided to prevent odour emissions at times when the incinerator is not working and is consequently unavailable for odour destruction using malodorous air as furnace air.

For planned shutdowns, materials destined for incineration may, depending on, e.g. the refrigerated storage capacity at the incinerator, be directed to other incinerators or if suitable facilities exist at the slaughterhouse or animal by products installation, they may be stored there. For incinerators operating on a batch system, the downtime is generally more frequent and longer than for continuously operating incinerators.

If it is foreseeable that putrescent materials will be stored when the incinerator is not available for the combustion of malodorous air. Alternative odour abatement plant, such as biofilters, chemical scrubbers or carbon filters may be provided. Shock loading on a chemical scrubber would produce inefficient treatment during the initial stages, so this may not be a suitable technique for intermittent use. The energy used to transfer air to such equipment would replace that used to transfer it to the incinerator.

For breakdowns, arrangements for the use of alternative operational or technical means for preventing odour emissions can be put place, in case the problem cannot be rectified immediately by a readily available supply of spare parts and labour.

Achieved environmental benefits

Reduced odour emissions.

Cross media effects

Any cross media effects will depend on the action taken, e.g. there may be an energy use for refrigeration of any putrescent materials.

Applicability

Applicable in all incinerators burning inherently malodorous and/or putrescent materials.

Driving force for implementation

Reduced odour emissions.

Reference literature

[65, EA, 1996]

Biofilter for odour abatement when the incinerator is not operating

Description

Odours may be produced when the incinerator is not operating and available for odour abatement. The use of a biofilter may be effective for controlling low intensity odours from inherently malodorous and/or putrescent materials. Further information is available in Section 2.3.8.2.8.

Achieved environmental benefits

Odour abatement.

Applicability

Biofilters require a high surface area.

Reference literature

[65, EA, 1996]

Carbon filter for odour abatement when the incinerator is not operating

Description

Carbon filters can be used for odour abatement, especially when the total quantity of organic compounds is small. However, they can lead to a significant solid waste, which has to be disposed of. If it cannot be recovered it may be burned in the incinerator. This destroys the malodorous compounds and recovers the energy content of the carbon.

Achieved environmental benefits

Odour abatement.

Cross media effects

There may be energy consumed during the regeneration of the carbon.

Operational data

Carbon filters can be sized according to the needs of the installation and do not require a large ground space. They are not especially sensitive to intermittent use, or shock loading, so they are relatively easy to use effectively at short notice.

Applicability

Applicable in all incinerators burning inherently malodorous and/or putrescent material.

Driving force for implementation

Reduction of odour emissions.

Reference literature

{65, EA, 1996}

Re-use of heat during biogas production

Technical description

Heat exchangers can be used to extract heat from the material leaving the digester and this can be used to warm the incoming material.

Achieved environmental benefits

Reduced energy use to heat the raw materials for biogas production or pasteurisation.

Cross media effects

None.

Environmental performance and operational data

If the material is Category 3 material as defined in ABP Regulation 1774/2002/EC, the incoming material needs to have a maximum particle size of 12 mm and needs to be heated for pasteurisation at 70 °C, for 60 min. For the actual anaerobic digestion, the by products are heated to a temperature approximately in the range 33–37 °C. The heat from the materials leaving the pasteurisation plant or the digester can be used to warm the incoming material.

Technical considerations relevant to applicability

Applicable in all biogas production plants.

Driving force for implementation

Reduced energy use.

Reference literature

{222, Gordon W., 2001}

WORKING DRAFT IN PROGRESS

5 BEST AVAILABLE TECHNIQUES (BAT) CONCLUSIONS FOR THE SLAUGHTERHOUSES, ANIMAL BY-PRODUCTS AND EDIBLE CO-PRODUCTS INDUSTRIES

This chapter has been completely rewritten compared to the original SA BREF

SCOPE

These BAT conclusions concern the following activities specified in Annex I to Directive 2010/75/EU:

- 6.4. (a) Operating slaughterhouses with a carcass production capacity greater than 50 tonnes per day.
- 6.5. Disposal or recycling of animal carcasses or animal waste with a treatment capacity exceeding 10 tonnes per day.
- 6.11. Independently operated treatment of waste water not covered by Directive 91/271/EEC¹, provided that the main pollutant load originates from the activities covered by these BAT conclusions.

These BAT conclusions also cover the following:

- the processing of animal by-products and/or edible co-products (such as rendering and fat melting, feather processing, fishmeal and fish oil production, blood processing and gelatine manufacturing) covered by the activity description in points 6.4 (b) (i) and/or 6.5 of Annex I to Directive 2010/75/EU;
- the combustion of meat-and-bone meal and/or animal fat;
- the combustion of malodorous gases including non-condensable gases (e.g. in thermal oxidisers or steam boilers);
- the preservation of hides and skins if directly associated with the activities covered by these BAT conclusions;
- the handling of casings and offal (viscera);
- the combined treatment of waste water from different origins, provided that the main pollutant load originates from the activities covered by these BAT conclusions and that the waste water treatment is not covered by Directive 91/271/EEC².

These BAT conclusions do not address the following:

- On-site combustion plants, not covered by the above bullet points, generating hot gases that are not used for direct contact heating, drying or any other treatment of objects or materials. These may be covered by the BAT conclusions for Large Combustion Plants (LCP) or by Directive (EU) 2015/2193 of the European Parliament and of the Council³.

¹ Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment (OJ L 135, 30.5.1991, p. 40).

² Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment (OJ L 135, 30.5.1991, p. 40).

³ Directive (EU) 2015/2193 of the European Parliament and of the Council of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants (OJ L 313, 28.11.2015, p. 1).

- The production of food after the making of standard cuts for large animals or of cuts for poultry. This may be covered by the BAT conclusions for Food, Drink and Milk Industries (FDM).

Other BAT conclusions and reference documents which could be relevant for the activities covered by these BAT conclusions include the following:

- Large Combustion Plants (LCP);
- Food, Drink and Milk Industries (FDM);
- Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector (CWW);
- Waste Treatment (WT);
- Tanning of Hides and Skins (TAN);
- Monitoring of Emissions to Air and Water from IED Installations (ROM);
- Economics and Cross-Media Effects (ECM);
- Emissions from Storage (EFS);
- Energy Efficiency (ENE);
- Industrial Cooling Systems (ICS).

These BAT conclusions apply without prejudice to other relevant legislation, e.g. on hygiene or food/feed safety.

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DEFINITIONS

For the purposes of these BAT conclusions, the following definitions apply:

Term used	Definition
Animal by-products	As defined in Regulation (EC) No 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and repealing Regulation (EC) No 1774/2002 (Animal by-products Regulation).
Channelled emissions	Emissions of pollutants to air through any kind of duct, pipe, stack, etc.
Direct discharge	Discharge to a receiving water body without further downstream waste water treatment.
Edible co-products	Food-grade products intended for human consumption.
Existing plant	A plant that is not a new plant.
FDM activities	Activities covered by the BAT conclusions for the Food, Drink and Milk Industries.
FDM products	Products associated with activities covered by the BAT conclusions for the Food, Drink and Milk Industries.
Indirect discharge	Discharge which is not a direct discharge.
New plant	A plant first permitted at the site of the installation following the publication of these BAT conclusions or a complete replacement of a plant following the publication of these BAT conclusions.
Sensitive receptor	Areas which need special protection, such as: <ul style="list-style-type: none"> — residential areas; — areas where human activities are carried out (e.g. neighbouring workplaces, schools, day-care centres, recreational areas, hospitals or nursing homes).

Term used	Pollutants and parameters
AOX	Adsorbable organically bound halogens, expressed as Cl, include adsorbable organically bound chlorine, bromine and iodine.
Biochemical oxygen demand (BOD _n)	Amount of oxygen needed for the biochemical oxidation of the organic matter to carbon dioxide in <i>n</i> days (<i>n</i> is typically 5 or 7). BOD is an indicator for the mass concentration of biodegradable organic compounds.
Chemical oxygen demand (COD)	Amount of oxygen needed for the total chemical oxidation of the organic matter to carbon dioxide using dichromate. COD is an indicator for the mass concentration of organic compounds.
CO	Carbon monoxide.
Copper (Cu)	Copper, expressed as Cu, includes all inorganic and organic copper compounds, dissolved or bound to particles.
Dust	Total particulate matter (in air).
H ₂ S	Hydrogen sulphide.
Odour concentration	Number of European Odour Units (OU _E) in one cubic metre at standard conditions measured by dynamic olfactometry according to EN 13725.
NO _x	The sum of nitrogen monoxide (NO) and nitrogen dioxide (NO ₂), expressed as NO ₂ .
SO _x	The sum of sulphur dioxide (SO ₂), sulphur trioxide (SO ₃), and sulphuric acid aerosols, expressed as SO ₂ .
Total nitrogen (Total N)	Total nitrogen, expressed as N, includes free ammonia and ammonium nitrogen (NH ₄ -N), nitrite nitrogen (NO ₂ -N), nitrate nitrogen (NO ₃ -N) and organically bound nitrogen.
Total organic carbon (TOC)	Total organic carbon (in water), expressed as C, includes all organic compounds.

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Total phosphorus (Total P)	Total phosphorus, expressed as P, includes all inorganic and organic phosphorus compounds, dissolved or bound to particles.
Total suspended solids (TSS)	Mass concentration of all suspended solids (in water), measured via filtration through glass fibre filters and gravimetry.
Total volatile organic carbon (TVOC)	Total volatile organic carbon (in air), expressed as C.
Zinc (Zn)	Zinc, expressed as Zn, includes all inorganic and organic zinc compounds, dissolved or bound to particles.

ACRONYMS

For the purposes of these BAT conclusions, the following acronyms apply:

Acronym	Definition
ABP	Animal by-products
CIP	Cleaning-in-place
CMS	Chemicals management system
EMS	Environmental management system
FDM	Food, drink and milk
OTNOC	Other than normal operating conditions

GENERAL CONSIDERATIONS

Best Available Techniques

The techniques listed and described in these BAT conclusions are neither prescriptive nor exhaustive. Other techniques may be used that ensure at least an equivalent level of environmental protection.

Unless otherwise stated, the BAT conclusions are generally applicable.

BAT-AELs and indicative emission level for emissions to air

Unless otherwise stated, emission levels associated with the best available techniques (BAT-AELs) for emissions to air given in these BAT conclusions refer to concentrations (mass of emitted substances per volume of waste gas) expressed in mg/Nm³, under the following standard conditions: dry gas at a temperature of 273.15 K and a pressure of 101.3 kPa.

The reference oxygen levels used to express BAT-AELs and the indicative emission level in these BAT conclusions are shown in the table below.

Substance/Parameter	Emission points	Reference oxygen level (O _R)
Dust, NO _x , SO _x , CO	Combustion of malodorous gases including non-condensable gases in thermal oxidisers	18 dry vol-%
Odour concentration, H ₂ S, NH ₃ , TVOC	All other emission points	No correction for the oxygen level

For the cases where a reference oxygen level is given, the equation for calculating the emission concentration at the reference oxygen level is:

$$E_R = \frac{21 - O_R}{21 - O_M} \times E_M$$

where: E_R: emission concentration at the reference oxygen level O_R;
 O_R: reference oxygen level in vol-%;
 E_M: measured emission concentration;
 O_M: measured oxygen level in vol-%.

The equation above does not apply in combustion process(es) when additional air intake for safety reasons brings the oxygen level in the waste gas very close to 21 vol-%. In this case, the emission concentration at the reference oxygen level of 18 dry vol-% is calculated differently, e.g. by normalising on the basis of the carbon dioxide generated by the combustion.

For averaging periods of BAT-AELs and the indicative emission level for emissions to air, the following definition applies.

Averaging period	Definition
Average over the sampling period	Average value of three consecutive samplings/measurements of at least 30 minutes each ⁽¹⁾ .
⁽¹⁾ For any parameter where, due to sampling or analytical limitations, a 30-minute sampling/measurement is inappropriate, a more suitable measurement period may be employed (e.g. for the odour concentration).	

When the waste gases of two or more sources (e.g. dryers) are discharged through a common stack, the BAT-AEL and the indicative emission level apply to the combined discharge from the stack.

Emission levels associated with the best available techniques (BAT-AELs) for refrigerant losses

The BAT-AELs for refrigerant losses refer to yearly averages and are expressed as a percentage (%) of the total amount of refrigerant contained in the cooling system(s). The losses for a specific refrigerant in 1 year are equal to the amount of that refrigerant consumed by the installation in 1 year (i.e. the yearly amount of the specific refrigerant used to refill the cooling system(s)).

Emission levels associated with the best available techniques (BAT-AELs) for emissions to water

Unless otherwise stated, emission levels associated with the best available techniques (BAT-AELs) for emissions to water given in these BAT conclusions refer to concentrations (mass of emitted substances per volume of water), expressed in mg/l.

Averaging periods associated with the BAT-AELs refer to either of the following two cases:

- In the case of continuous discharge, daily average values, i.e. 24-hour flow-proportional composite samples. Time-proportional composite samples can be used provided that sufficient flow stability is demonstrated. Alternatively, spot samples may be taken, provided that the effluent is appropriately mixed and homogeneous.
- In the case of batch discharge, average values over the release duration taken as flow-proportional composite samples, or, provided that the effluent is appropriately mixed and homogeneous, a spot sample taken before discharge.

In the case of total organic carbon (TOC) and chemical oxygen demand (COD), the calculation of the average abatement efficiency referred to in these BAT conclusions (see Table 5.1) is based on the influent and effluent load of the waste water treatment plant.

The BAT-AELs for emissions to water apply at the point where the emission leaves the installation.

Other environmental performance levels

Specific waste water discharge levels associated with the best available techniques (BAT-AEPLs)

The environmental performance levels related to specific waste water discharge refer to yearly averages and are calculated using the following equation:

$$\text{specific waste water discharge} = \frac{\text{waste water discharge}}{\text{activity}}$$

where: waste water discharge is the total amount of waste water discharged (as direct discharge, indirect discharge and/or land spreading) by the specific processes concerned, expressed in m³/year, excluding any cooling water and run-off water that is discharged separately.

Activity is the total amount of products or raw materials processed, expressed in:

- tonnes of carcass/year or animals/year for slaughterhouses;
- tonnes of raw materials/year for installations processing animal by-products and/or edible co-products.

Raw material is any material entering the plant.

The carcass weight depends on the animal species under consideration:

- Pigs: the weight of the slaughtered pig's cold body, either whole or divided in half along the mid-line, after being bled and eviscerated and after removal of the tongue, bristles, hooves, genitalia, flare fat, kidneys and diaphragm.
- Cattle: the weight of the slaughtered animal's cold body after being skinned, bled and eviscerated, and after removal of the external genitalia, limbs, head, tail, kidneys and kidney fats, and the udder.
- Sheep and goats: the weight of the slaughtered animal's cold body after having been skinned, bled and eviscerated, and after removal of the head, feet, tail and genital organs. Kidneys and kidney fats are included in the carcass weight.
- Poultry: the weight of the cold body of the slaughtered farmyard poultry after being bled, plucked and eviscerated. The weight includes poultry offal (viscera), with the exception of foie gras.
- Other animal species: the weight of the slaughtered animal's cold body.

Total specific net energy consumption levels associated with the best available techniques (BAT-AEPLs)

The environmental performance levels related to specific energy consumption refer to yearly averages and are calculated using the following equation:

$$\text{specific net energy consumption} = \frac{\text{final net energy consumption}}{\text{activity}}$$

where: final net energy consumption is the total amount of energy consumed (excluding the recovered energy) by the installation (in the form of heat and electricity), expressed in kWh/year.

Activity is the total amount of products or raw materials processed, expressed in:

- tonnes of carcass/year or animals/year for slaughterhouses;
- tonnes of raw materials/year for installations processing animal by-products and/or edible co-products.

Raw material is any material entering the plant.

The carcass weight depends on the animal species under consideration (see General consideration for BAT-AEPLs for specific waste water discharge).

Unless otherwise stated, the calculation of the energy consumption for slaughterhouses may include the energy consumed by FDM activities.

5.1 General BAT conclusions

5.1.1 Overall environmental performance

BAT 1. In order to improve the overall environmental performance, BAT is to elaborate and implement an environmental management system (EMS) that incorporates all of the following features:

- i. commitment, leadership, and accountability of the management, including senior management, for the implementation of an effective EMS;
- ii. an analysis that includes the determination of the organisation's context, the identification of the needs and expectations of interested parties, the identification of characteristics of the installation that are associated with possible risks for the environment (or human health) as well as of the applicable legal requirements relating to the environment;
- iii. development of an environmental policy that includes the continuous improvement of the environmental performance of the installation;
- iv. establishing objectives and performance indicators in relation to significant environmental aspects, including safeguarding compliance with applicable legal requirements;
- v. planning, and implementing the necessary procedures and actions (including corrective and preventive actions where needed), to achieve the environmental objectives and avoid environmental risks;
- vi. determination of structures, roles and responsibilities in relation to environmental aspects and objectives and provision of the financial and human resources needed;
- vii. ensuring the necessary competence and awareness of staff whose work may affect the environmental performance of the installation (e.g. by providing information and training);
- viii. internal and external communication;
- ix. fostering employee involvement in good environmental management practices;
- x. establishing and maintaining a management manual and written procedures to control activities with significant environmental impact as well as relevant records;
- xi. effective operational planning and process control;
- xii. implementation of appropriate maintenance programmes;
- xiii. emergency preparedness and response protocols, including the prevention and/or mitigation of the adverse (environmental) impacts of emergency situations;
- xiv. when (re)designing a (new) installation or a part thereof, consideration of its environmental impacts throughout its life, which includes construction, maintenance, operation and decommissioning;
- xv. implementation of a monitoring and measurement programme; if necessary, information can be found in the Reference Report on Monitoring of Emissions to Air and Water from IED Installations;
- xvi. application of sectoral benchmarking on a regular basis;
- xvii. periodic independent (as far as practicable) internal auditing and periodic independent external auditing in order to assess the environmental performance and to determine whether or not the EMS conforms to planned arrangements and has been properly implemented and maintained;
- xviii. evaluation of causes of nonconformities, implementation of corrective actions in response to nonconformities, review of the effectiveness of corrective actions, and determination of whether similar nonconformities exist or could potentially occur;
- xix. periodic review, by senior management, of the EMS and its continuing suitability, adequacy and effectiveness;
- xx. following and taking into account the development of cleaner techniques.

Specifically for slaughterhouses as well as the processing of animal by-products and/or edible co-products, BAT is also to incorporate the following features in the EMS:

- xxi. an odour management plan (see BAT 18);
- xxii. an inventory of water, energy and raw materials consumption and of waste water and waste gas streams (see BAT 2);
- xxiii. a chemicals management system (see BAT 3);
- xxiv. an energy efficiency plan (see BAT 9a);
- xxv. a water management plan (see BAT 10a);
- xxvi. a noise management plan (see BAT 16);
- xxvii. an OTNOC management plan (see BAT 4).

Specifically for slaughterhouses, BAT is also to incorporate the following features in the EMS:

- xxviii. a refrigeration management plan (see BAT 20).

Note

Regulation (EC) No 1221/2009 establishes the European Union eco-management and audit scheme (EMAS), which is an example of an EMS consistent with this BAT.

Applicability

The level of detail and the degree of formalisation of the EMS will generally be related to the nature, scale and complexity of the installation, and the range of environmental impacts it may have.

[This BAT conclusion is based on information given in Section 2.3.1.1]

BAT 2. In order to improve the overall environmental performance, BAT is to establish, maintain and regularly review (including when a significant change occurs) an inventory of water, energy and process chemicals consumption as well as of waste water and waste gas streams, as part of the environmental management system (see BAT 1) that incorporates all of the following features:

- I. Information about the production process(es), including:
 - (a) simplified process flow sheets that show the origin of the emissions;
 - (b) descriptions of process-integrated techniques and waste water/waste gas treatment techniques to prevent or reduce emissions, including their performance (e.g. abatement efficiency).
- II. Information about energy consumption and usage.
- III. Information about water consumption and usage (e.g. flow diagrams and water mass balances).
- IV. Information about the quantity and characteristics of the waste water streams, such as:
 - (c) average values and variability of flow, pH and temperature;
 - (d) average concentration and mass flow values of relevant substances/parameters (e.g. COD/TOC, nitrogen species, phosphorus) and their variability.
- V. Information about the characteristics of the waste gas streams, such as:
 - (e) emission point(s);

- (f) average values and variability of flow and temperature;
- (g) average concentration and mass flow values of relevant substances/parameters (e.g. dust, TVOC, NO_x, SO_x) and their variability;
- (h) presence of other substances that may affect the waste gas treatment system or plant safety (e.g. oxygen, water vapour, dust).

VI. information about the quantity and characteristics of the process chemicals used:

- (a) the identity and the characteristics of process chemicals, including properties with adverse effects on the environment and/or human health;
- (b) the quantities of process chemicals used and the location of their use.

Applicability

The scope (e.g. level of detail) and nature of the inventory will generally be related to the nature, scale and complexity of the installation, and the range of environmental impacts it may have.

[This BAT conclusion is based on information given in Section 2.3.3.7]

BAT 3. In order to improve the overall environmental performance, BAT is to elaborate and implement a chemicals management system (CMS) as part of the EMS (see BAT 1) that incorporates all of the following features:

- I. A policy to reduce the consumption and risks of process chemicals, including a procurement policy to select less harmful process chemicals and their suppliers with the aim of minimising the use and risks of hazardous substances and avoiding the procurement of an excess amount of process chemicals. The selection of process chemicals may consider:
 - (a) their eliminability, their ecotoxicity and their potential to be released into the environment in order to reduce emissions to the environment;
 - (b) the characterisation of the risks associated with the process chemicals, based on the chemicals' hazards statement, pathways through the plant, potential release and level of exposure;
 - (c) the regular (e.g. annual) analysis of the potential for substitution to identify potentially new available and safer alternatives to the use of hazardous substances (e.g. use of other process chemicals with no or lower environmental impacts, see BAT 11 (a));
 - (d) the anticipatory monitoring of regulatory changes related to hazardous chemicals and safeguarding compliance with applicable legal requirements.

The inventory of process chemicals (see BAT 2) may be used to support the selection of process chemicals.

- II. Goals and action plans to avoid or reduce the use and risks of hazardous substances.
- III. Development and implementation of procedures for the procurement, handling, storage, and use of process chemicals to prevent or reduce emissions to the environment.

Applicability

The level of detail of the CMS will generally be related to the nature, scale and complexity of the plant.

[This BAT conclusion is based on information given in Section 2.1.3.4]

BAT 4. In order to reduce the frequency of the occurrence of OTNOC and to reduce emissions during OTNOC, BAT is to set up and implement a risk-based OTNOC management plan as part of the EMS (see BAT 1) that includes all of the following elements:

- i. identification of potential OTNOC (e.g. failure of equipment critical to the protection of the environment ('critical equipment')), of their root causes and of their potential consequences, and regular review and update of the list of identified OTNOC following the periodic assessment below;
- ii. appropriate design of critical equipment (e.g. waste water treatment plant);
- iii. set-up and implementation of an inspection and preventive maintenance plan for critical equipment (see BAT 1 xii.);
- iv. monitoring (i.e. estimating or, where possible, measuring) and recording of emissions during OTNOC and of associated circumstances;
- v. periodic assessment of the emissions occurring during OTNOC (e.g. frequency of events, duration, amount of pollutants emitted) and implementation of corrective actions if necessary;
- vi. regular review and update of the list of identified OTNOC under point i. following the periodic assessment of point v;
- vii. regular testing of backup systems.

[This BAT conclusion is based on information given in Section 2.1.3.5]

5.1.2 Monitoring

BAT 5. For waste water streams identified by the inventory of inputs and outputs (see BAT 2), BAT is to monitor key process parameters (e.g. continuous monitoring of waste water flow, pH and temperature) at key locations (e.g. the inlet and outlet of the pretreatment, the inlet to the final treatment, the point where the emission leaves the installation).

[This BAT conclusion is based on information given in Section 2.3.3.3]

BAT 6. BAT is to monitor at least once per year:

- the yearly consumption of water and energy;
- the yearly amount of waste water generated.

Description

Monitoring preferentially includes direct measurements. Calculations or recording, e.g. using suitable meters or invoices, can also be used. The monitoring is broken down to process level and captures any significant changes in the processes.

[This BAT conclusion is based on information given in Sections 2.3.3.2, 2.3.3.3 and 2.3.4.1.2]

BAT 7. BAT is to monitor emissions to water with at least the frequency given below and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.

Substance/parameter	Activities	Standard(s)	Minimum monitoring frequency ⁽¹⁾	Monitoring associated with
Adsorbable organically bound halogens (AOX) ⁽²⁾	All activities	EN ISO 9562	Once every 3 months	BAT 14
Biochemical oxygen demand (BOD _n) ⁽³⁾		Various EN standards available (e.g. EN 1899-1, EN ISO 5815-1)	Once every month	
Chemical oxygen demand (COD) ⁽³⁾ ⁽⁵⁾		No EN standard available	Once every week	
Total nitrogen (TN) ⁽³⁾		Various EN standards available (e.g. EN 12260, EN ISO 11905-1)		
Total organic carbon (TOC) ⁽³⁾ ⁽⁴⁾		EN 1484		
Total phosphorus (TP) ⁽³⁾		Various EN standards available (e.g. EN ISO 6878, EN ISO 156811 and -2, EN ISO 11885)		
Total suspended solids (TSS) ⁽³⁾		EN 872		
Copper (Cu) ⁽²⁾ ⁽⁵⁾	Slaughterhouses	Various EN standards available (e.g. EN ISO 11885, EN ISO 17294-2 or EN ISO 15586)	Once every 6 months	
Zinc (Zn) ⁽²⁾ ⁽⁵⁾				
Chloride (Cl ⁻) ⁽²⁾ ⁽⁵⁾	<ul style="list-style-type: none"> • Slaughterhouses • Hide/skin salting • Gelatine manufacturing using bones 	Various EN standards available (e.g. EN ISO 103041, EN ISO 15682)	Once every month	—
<p>⁽¹⁾ In the case of batch discharge less frequent than the minimum monitoring frequency, monitoring is carried out once per batch.</p> <p>⁽²⁾ In the case of an indirect discharge to a receiving water body, the monitoring frequency may be reduced to once every year for Cu and Zn and once every 6 months for AOX and Cl⁻, if the downstream waste water treatment plant is designed and equipped appropriately to abate the pollutants concerned.</p> <p>⁽³⁾ The monitoring only applies in the case of a direct discharge to a receiving water body.</p> <p>⁽⁴⁾ Either COD or TOC is monitored. TOC monitoring is the preferred option because it does not rely on the use of very toxic compounds.</p> <p>⁽⁵⁾ The monitoring only applies when the substance/parameter concerned is identified as relevant in the waste water stream based on the inventory of inputs and outputs mentioned in BAT 2.</p>				

[This BAT conclusion is based on information given in Section 2.3.3.4]

BAT 8. BAT is to monitor channelled emissions to air with at least the frequency given below and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.

Substance/Parameter	Activities	Standard(s)	Minimum monitoring frequency ⁽¹⁾	Monitoring associated with
Odour concentration	All activities	EN 13725	Once every year	BAT 25
TVOC	Rendering, fat melting, blood and/or feather processing	EN 12619		
	Fishmeal and fish oil production			
	Gelatine manufacturing			
NH ₃	Rendering, fat melting, blood and/or feather processing	EN ISO 21877		
	Fishmeal and fish oil production			
	Gelatine manufacturing			
H ₂ S	Rendering, fat melting, blood and/or feather processing	No EN standard available		
Dust	Combustion of malodorous gases including non-condensable gases in thermal oxidisers	EN 13284-1		BAT 15
NO _x		EN 14792		
SO _x		EN 14791		
CO		EN 15058		
⁽¹⁾ To the extent possible, the measurements are carried out at the highest expected emission state under normal operating conditions.				

[This BAT conclusion is based on information given in Section 2.3.3.5]

5.1.3 Energy efficiency

BAT 9. In order to increase energy efficiency, BAT is to use technique (a) and an appropriate combination of the general energy-saving techniques listed in technique (b) below.

	Technique	Description	Applicability
a	Energy efficiency plan and energy audits	An energy efficiency plan is part of the environmental management system (see BAT 1) and entails defining and calculating the specific energy consumption of the activity (or activities), setting key performance indicators on an annual basis (for example for the specific energy consumption) and planning periodic improvement targets and related actions. Energy audits are carried out at least once every year to ensure that the objectives of the energy management plan are met.	The level of detail of the energy efficiency plan and of the energy audits will generally be related to the nature, scale and complexity of the plant.
b	Use of general energy-saving techniques	This includes: <ul style="list-style-type: none"> - implementation of lighting management systems; - heat recovery with heat exchangers and/or heat pumps; - energy-efficient motors; - frequency converters on motors; - process control systems; - combined heat and power generation (cogeneration); - insulation of pipes, vessels and equipment; - combustion regulation and control; - preheating feed water (including the use of economisers); - minimisation of the blowdown of boilers; - optimisation of steam distribution systems; - reduction of compressed air system leaks. 	Applicability of cogeneration to existing plants may be restricted by a suitable heat demand.

Further sector-specific techniques to increase energy efficiency are given in Section 5.2 and Section 5.3 of these BAT conclusions.

[This BAT conclusion is based on information given in Section 2.3.4]

5.1.4 Water consumption and waste water generation

BAT 10. In order to reduce water consumption and the amount of waste water generated, BAT is to use techniques (a) and (b) and one or a combination of the techniques (c) to (k) given below.

Technique	Description	Applicability	
<i>Management, design and operation techniques</i>			
a	Water management plan and water audits	A water management plan and water audits are part of the environmental management system (see BAT 1) and include: <ul style="list-style-type: none"> • flow diagrams and water mass balances of the plant and processes as part of the inventory of inputs and outputs mentioned in BAT 2; • establishment of water efficiency objectives; • implementation of water optimisation techniques (e.g. control of water usage, reuse/recycling, detection and repair of leaks). Water audits are carried out at least once every year to ensure that the objectives of the water management plan are met.	The level of detail and nature of the water management plan and of the water audits will generally be related to the nature, scale and complexity of the plant.
b	Segregation of water streams	Water streams that do not need treatment (e.g. uncontaminated cooling water or uncontaminated run-off water) are segregated from waste water that has to undergo treatment, thus enabling uncontaminated water recycling.	Applicability to existing plants may be restricted by the layout of the water collection system and the lack of space for temporary storage tanks.
c	Water recycling and/or reuse	Recycling and/or reuse of water streams (preceded or not by water treatment), e.g. for cleaning, washing, cooling or for the process itself.	May not be applicable due to hygiene and safety requirements.
d	Optimisation of water flow	Use of control devices, e.g. photocells, flow valves, thermostatic valves, to automatically adjust the water flow to the amount needed and avoid unnecessarily high water flow.	Generally applicable.
e	Use and optimisation of water nozzles and hoses	Use of correct number and position of nozzles; adjustment of water pressure of nozzles and hoses.	
<i>Techniques related to cleaning operations</i>			
f	Dry cleaning	Removal of as much residual material as possible from raw materials and equipment, e.g. by using compressed air, vacuum systems or catchpots with a mesh cover.	Generally applicable.
g	High-pressure cleaning	Spraying of cleaning water at pressures ranging from 15 bar to 150 bar.	May not be applicable due to health and safety requirements.
h	Optimisation of chemical dosing and water use in cleaning-in-place (CIP)	The amounts of hot water and chemicals are optimised by measuring turbidity, conductivity, temperature and/or pH for example.	Generally applicable.
i	Low-pressure foam and/or gel cleaning	Use of low-pressure foam and/or gel to clean walls, floors and/or equipment surfaces.	
j	Optimised design and	The equipment and process areas are	

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	construction of equipment and process areas	designed and constructed in a way that facilitates cleaning. When optimising the design and construction, hygiene requirements are taken into account.	
k	Cleaning of equipment as soon as possible	Cleaning is applied as soon as possible after use of equipment to prevent hardening of residual material.	

Further sector-specific techniques to reduce water consumption and the volume of waste water discharged are given in Section 2 and Section 3 of these BAT conclusions.

[This BAT conclusion is based on information given in Section 2.3.5]

5.1.5 Harmful substances

BAT 11. In order to prevent or, where that is not practicable, to reduce the use of harmful substances, e.g. in cleaning and disinfection, BAT is to use one or a combination of the techniques given below.

Technique		Description	Applicability
a	Proper selection of cleaning chemicals and/or disinfectants	Avoidance or minimisation of the use of cleaning chemicals and/or disinfectants that are harmful to the aquatic environment, in particular those that contain priority substances considered under the Water Framework Directive 2000/60/EC of the European Parliament and of the Council ⁸ . When selecting the cleaning chemicals and/or disinfectants, hygiene and food safety requirements are taken into account. This technique is part of the CMS (see BAT 3).	Generally applicable.
b	Reuse of cleaning chemicals in cleaning-in-place (CIP)	Collection and reuse of cleaning chemicals in CIP. When reusing cleaning chemicals, hygiene and food safety requirements are taken into account.	
c	Dry cleaning	See BAT 7 (f).	
d	Optimised design and construction of equipment and process areas	See BAT 7 (j).	

[This BAT conclusion is based on information given in Section 2.3.7]

⁸ Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (OJ L327, 22.12.2000, p. 1).

5.1.6 Resource efficiency

BAT 12. In order to increase resource efficiency, BAT is to use one or a combination of the techniques given below.

Technique	Description	Applicability
a Anaerobic digestion	Treatment of biodegradable residues by microorganisms in the absence of oxygen, resulting in biogas and digestate. The biogas is used as a fuel, e.g. in a gas engine or in a boiler. The digestate may be used, e.g. as a soil improver, on site or off site.	May not be applicable due to the quantity and/or nature of the residues.
b Prevention of biological degradation of animal by-products and/or edible co-products	Animal by-products and/or edible co-products are stored in closed vessels or rooms in slaughterhouses and animal by-products installations, for as short a time as possible, before further treatment. Raw materials intended for human consumption (e.g. fat, blood), feed material or pet food may require refrigeration.	Generally applicable.
c Recycling/recovery of separated residues	Residues are separated, e.g. using accurately positioned screens, flaps, catchpots, drip trays and troughs for recycling and recovery.	
d Use of animal fat as a fuel	Use of animal fat to replace fossil fuel in boilers and/or thermal oxidisers.	Only applicable to rendering, fat melting, blood and/or feather processing.
e Phosphorus recovery as struvite	Phosphorus contained in waste water streams is recovered by precipitation in the form of struvite (magnesium ammonium phosphate).	Only applicable to waste water streams with a high total phosphorus content (e.g. above 50 mg/l) and a significant flow.

[This BAT conclusion is based on information given in Section 2.3.2]

5.1.7 Emissions to water

BAT 13. In order to prevent uncontrolled emissions to water, BAT is to provide an appropriate buffer storage capacity for generated waste water.

Description

The appropriate buffer storage capacity is determined by a risk assessment (taking into account the nature of the pollutant(s), the effects of these pollutants on further waste water treatment, the receiving environment, the amount of waste water generated, etc.).

The waste water from this buffer storage is discharged after appropriate measures are taken (e.g. monitoring, treatment, reuse).

Applicability

For existing plants, the technique may not be applicable due to lack of space and/or due to the layout of the waste water collection system.

[This BAT conclusion is based on information given in Section 2.3.6.1.4]

BAT 14. In order to reduce emissions to water, BAT is to use an appropriate combination of the techniques given below.

	Technique ⁽¹⁾	Typical pollutants targeted	Applicability
Preliminary, primary and general treatment			
a	Equalisation	All pollutants	Generally applicable.
b	Neutralisation	Acids, alkalis	
c	Physical separation, e.g. screens, sieves, grit separators, fat separators, or primary settlement tanks	Gross solids, suspended solids, oil/grease	
Physico-chemical treatment, e.g.			
d	Precipitation	Precipitable dissolved non-biodegradable or inhibitory pollutants, e.g. metals	Generally applicable
e	Evaporation	Soluble pollutants	
f	Chemical oxidation with ozone	Reducible dissolved non-biodegradable or inhibitory pollutants, e.g. AOX	
Aerobic and/or anaerobic treatment (secondary treatment)			
g	Aerobic and/or anaerobic treatment (secondary treatment), e.g. activated sludge process, aerobic lagoon, anaerobic contact process, membrane bioreactor	Biodegradable organic compounds	Generally applicable.
Nitrogen removal			
h	Nitrification and/or denitrification	Total nitrogen, ammonium/ammonia	Nitrification may not be applicable in the case of high chloride concentrations (e.g. above 10 g/l). Nitrification may not be applicable when the temperature of the waste water is low (e.g. below 12 °C).
Phosphorus removal			
i	Precipitation	Total phosphorus	Generally applicable.
j	Enhanced biological phosphorus removal		
Final solids removal			
k	Coagulation and flocculation	Suspended solids and particulate-bound non-biodegradable or inhibitory pollutants	Generally applicable.
l	Sedimentation		
m	Filtration (e.g. sand filtration, microfiltration, ultrafiltration)		
n	Flotation		
⁽¹⁾ The descriptions of the techniques are given in Section 5.4.1.			

The BAT-AELs apply at the point where the emission leaves the installation.

Table 5.1: BAT-associated emission levels (BAT-AELs) for direct discharges to a receiving water body

Parameter		Unit	BAT-AEL ⁽¹⁾ ⁽²⁾
Chemical oxygen demand (COD) ⁽³⁾ ⁽⁴⁾		mg/l	25–100 ⁽³⁾
Total organic carbon (TOC) ⁽³⁾			7–35
Total suspended solids (TSS)			4–40 ⁽⁵⁾
Total nitrogen (Total N)			2–25 ⁽⁶⁾
Total phosphorus (Total P)			0.25–2.5
Adsorbable organically bound halogens (AOX)			0.02–0.3
Metals / metalloids	Copper (Cu)		0.01–0.2 ⁽⁷⁾
	Zinc (Zn)		0.05–0.5 ⁽⁷⁾

⁽¹⁾ The averaging periods are defined in the General considerations.
⁽²⁾ No BAT-AEL applies for biochemical oxygen demand (BOD). As an indication, the yearly average BOD₅ level in the effluent from a biological waste water treatment plant will generally be ≤ 20 mg/l.
⁽³⁾ Either the BAT-AEL for COD or the BAT-AEL for TOC applies. The BAT-AEL for TOC is the preferred option because TOC monitoring does not rely on the use of very toxic compounds.
⁽⁴⁾ The upper end of the BAT-AEL range is 120 mg/l for installations processing animal by-products and/or edible co-products, only if the abatement efficiency is ≥ 95 % as a yearly average or as an average over the production period.
⁽⁵⁾ The lower end of the BAT-AEL range is typically achieved when using filtration (e.g. sand filtration, microfiltration, membrane bioreactor).
⁽⁶⁾ The BAT-AEL may not apply when the temperature of the waste water is low (e.g. below 12 °C) for prolonged periods.
⁽⁷⁾ The BAT-AEL applies only to slaughterhouses.

The associated monitoring is given in BAT 7.

Table 5.2: BAT-associated emission levels (BAT-AELs) for indirect discharges to a receiving water body

Substance/Parameter		Unit	BAT-AEL ⁽¹⁾ ⁽²⁾
Adsorbable organically bound halogens (AOX)		mg/l	0.02–0.3
Metals / metalloids	Copper (Cu)		0.01–0.2 ⁽³⁾
	Zinc (Zn)		0.05–0.5 ⁽³⁾

⁽¹⁾ The averaging periods are defined in the General considerations.
⁽²⁾ The BAT-AELs may not apply if the downstream waste water treatment plant is designed and equipped appropriately to abate the pollutants concerned, provided this does not lead to a higher level of pollution in the environment.
⁽³⁾ The BAT-AEL applies only to slaughterhouses.

The associated monitoring is given in BAT 7.

[This BAT conclusion is based on information given in Section 2.2.1 and 2.3.6]

5.1.8 Emissions to air

BAT 15. In order to reduce emissions to air of CO, dust, NO_x and SO_x from the combustion of malodorous gases (e.g. in thermal oxidisers or steam boilers) including non-condensable gases, BAT is to pretreat the waste gases using technique (a) when necessary, and to use one or a combination of techniques (b) to (d) given below.

	Technique	Description	Main compounds targeted	Applicability
a	Removal of high levels of dust, NO _x and SO _x precursors	Removal (if possible, for reuse) of high levels of dust, NO _x and SO _x precursors prior to combustion of malodorous gases or thermal oxidation, e.g. by absorption, adsorption or condensation.	Dust, NO _x , SO _x	Generally applicable.
b	Fuel choice	Switching from the combustion of one fuel to a less harmful one in terms of emissions (e.g. low sulphur content, low nitrogen content, low ash content or better ash quality).	Dust, NO _x , SO _x	
c	Low-NO _x burner	The technique is based on the principles of reducing peak flame temperatures; boiler burners are designed to delay but improve the combustion and increase the length of the flames, allowing the heat radiated during combustion to reduce peak temperatures. The air/fuel mixing reduces the availability of oxygen and reduces the peak flame temperature, thus retarding the conversion of fuel-bound nitrogen to NO _x and the formation of thermal NO _x , while maintaining high combustion efficiency. This may be associated with a modified design of the furnace combustion chamber.	NO _x	Applicability to existing plants may be restricted by design and/or operational constraints.
d	Optimised thermal oxidation	Optimisation of design and operation of thermal oxidation to promote the oxidation of organic compounds, as well as to reduce the generation of pollutants such as NO _x and CO.	CO, NO _x	Generally applicable.

Table 5.3: BAT-associated emission levels (BAT-AELs) for channelled emissions to air of dust, NO_x and SO_x from the combustion of malodorous gases including non-condensable gases in thermal oxidisers

Substance/Parameter	Unit	BAT-AEL (average over the sampling period)
Dust	mg/Nm ³	0.3–3
NO _x		40–95
SO _x		2–19

The associated monitoring is given in BAT 8.

Table 5.4: Indicative emission level for channelled CO emissions to air from the combustion of malodorous gases including non-condensable gases in thermal oxidisers

Substance/Parameter	Unit	Indicative emission level (average over the sampling period)
CO	mg/Nm ³	3–30

The associated monitoring is given in BAT 8.

[This BAT conclusion is based on information given in Section 2.2.2 and 2.3.8]

5.1.9 Noise

BAT 16. In order to prevent or, where that is not practicable, to reduce noise emissions, BAT is to set up, implement and regularly review a noise management plan, as part of the environmental management system (see BAT 1), that includes all of the following elements:

- a protocol containing actions and timelines;
- a protocol for conducting noise emissions monitoring;
- a protocol for response to identified noise events, e.g. complaints;
- a noise reduction programme designed to identify the source(s), to measure/estimate noise, to characterise the contributions of the sources and to implement prevention and/or reduction measures.

Applicability

BAT 16 is only applicable to cases where a noise nuisance at sensitive receptors is expected and/or has been substantiated.

[This BAT conclusion is based on information given in Section 2.3.9.1]

BAT 17. In order to prevent or, where that is not practicable, to reduce noise emissions, BAT is to use one or a combination of the techniques given below.

Technique		Description	Applicability
a	Appropriate location of equipment and buildings	Increasing the distance between the emitter and the receiver, by using buildings as noise screens and by relocating equipment and/or buildings' exits or entrances.	For existing plants, the relocation of equipment and buildings' exits or entrances may not be applicable due to lack of space and/or excessive costs.
b	Operational measures	These include: <ol style="list-style-type: none"> inspection and maintenance of equipment; closing of doors and windows of enclosed areas, if possible; equipment operation by experienced staff; avoidance of noisy activities at night, if possible; provisions for noise control, e.g. during maintenance activities. 	Generally applicable.
c	Low-noise equipment	This includes low-noise compressors, pumps and fans.	
d	Noise control equipment	This includes: <ol style="list-style-type: none"> noise reducers; insulation of equipment; enclosure of noisy equipment; soundproofing of buildings. 	May not be applicable to existing plants due to lack of space.
e	Noise abatement	Inserting obstacles between emitters and receivers (e.g. protection walls, embankments).	Generally applicable.

[This BAT conclusion is based on information given in Section 2.3.9.2]

5.1.10 Odour

BAT 18. In order to prevent or, where that is not practicable, to reduce odour emissions, BAT is to set up, implement and regularly review an odour management plan, as part of the environmental management system (see BAT 1), that includes all of the following elements:

- A protocol containing actions and timelines.
- A protocol for conducting odour monitoring. It may be complemented by measurement/estimation of odour exposure or estimation of odour impact.
- A protocol for response to identified odour incidents, e.g. complaints.
- An odour prevention and reduction programme designed to identify the source(s); to measure/estimate odour exposure; to characterise the contributions of the sources; and to implement prevention and/or reduction measures.

Applicability

BAT 18 is only applicable to cases where an odour nuisance at sensitive receptors is expected and/or has been substantiated.

[This BAT conclusion is based on information given in Section 2.3.8.1.2]

BAT 19. In order to prevent or, where that is not practicable, to reduce odour emissions, BAT is to use all of the techniques given below.

Technique		Description	Applicability
a.	Regular cleaning of installations and equipment	Regular cleaning of installations and equipment where animal by-products and/or edible co-products are stored and processed.	Generally applicable.
b.	Cleaning and disinfection of vehicles and equipment used to transport and deliver animal by-products and/or edible co-products	Transport vehicles and delivery equipment (e.g. containers) are cleaned and disinfected after being emptied, and at the end of each working day.	
c.	Enclose animal by-products and/or edible co-products during transport, loading/unloading and storage	Loading/unloading areas are situated in enclosed ventilated buildings. Use of bunkers or other equipment for transport and storage of the animal by-products and/or edible co-products.	
d.	Prevention of biological degradation of animal by-products and/or edible co-products	See BAT 12b above	

BAT-AELs for channelled emissions to air of odour: see Table 5.10, Table 5.11 and Table 5.12.

[This BAT conclusion is based on information given in Section 2.3.8.2]

5.2 BAT conclusions for slaughterhouses

The BAT conclusions presented in this section apply to slaughterhouses. They apply in addition to the general BAT conclusions given in Section 5.1.

5.2.1 Energy efficiency

BAT 20. In order to increase energy efficiency, BAT is to use an appropriate combination of the techniques specified in BAT 9 and of the techniques given below.

Technique		Description	Applicability
a	Refrigeration management plan	<p>A refrigeration management plan is part of the environmental management system (see BAT 1) and entails:</p> <ul style="list-style-type: none"> • monitoring of energy consumption; • operational measures such as inspection and maintenance of equipment, closing of doors when possible; equipment operation by experienced staff; • monitoring of refrigerants consumption and leaks. 	Generally applicable.
b	Steam scalding	Scalding is performed with the use of steam instead of hot water.	Only applicable to the slaughtering of pigs or poultry.
c	Jet stream scalding	Water jets are applied at the bottom of the scalding tank, and the flow of warm water arising from the jet is oriented so that it is brought into contact with the poultry skin. The poultry skin is contacted with scalding water only, without any air bubbles.	Only applicable to the slaughtering of poultry.

Table 5.5: BAT-associated environmental performance levels (BAT-AEPLs) for specific energy consumption in slaughterhouses

Type of animal	Type of installation	Unit ⁽¹⁾	Specific energy consumption (yearly average)
Cattle	Installations excluding the energy consumed by FDM activities	kWh/tonne of carcass	116–240
		kWh/animal	30–80
	Installations including the energy consumed by FDM activities	kWh/tonne of carcass	116–415
		kWh/animal	30–150
Pig	All installations	kWh/tonne of carcass	65–370 ⁽²⁾
		kWh/animal	4–35 ⁽²⁾
Chicken		kWh/tonne of carcass	170–490 ⁽²⁾
		kWh/animal	0.25–0.90 ⁽²⁾
⁽¹⁾ Either the BAT-AEPL expressed in kWh/tonne of carcass or the BAT-AEPL expressed in kWh/animal applies. ⁽²⁾ The BAT-AEPL range may not be applicable to installations producing more than 50 % convenience products (i.e. meat products processed further than simple meat cuts, e.g. marinated products, sausages) as a proportion of the total weight of the FDM products.			

[This BAT conclusion is based on information given in Sections 3.2.3.5.2, 3.3.2, 3.4.3 and 3.4.4.2]

5.2.2 Water consumption and waste water generation

BAT 21. In order to reduce water consumption and the amount of waste water generated, BAT is to use an appropriate combination of the techniques specified in BAT 10 and of the techniques given below.

	Technique	Description	Applicability
a	Dry emptying of stomachs	Stomachs are emptied by using machines without water.	Generally applicable.
b	Dry collection of the contents of intestines	Intestines are emptied by pulling them between a pair of rollers. Their content is collected in a tray and pumped to a container.	
c	Steam scalding	See BAT 20b.	Only applicable to the slaughtering of pigs or poultry.

Table 5.6: BAT-associated environmental performance levels (BAT-AEPLs) for specific waste water discharge

Type of animal	Type of installation	Unit ⁽¹⁾	Specific waste water discharge (yearly average)
Cattle	Installations excluding the water used by FDM activities	m ³ /tonne of carcass	1.85–3.90
		m ³ /animal	0.30–1.30
	Installations including the water used by FDM activities	m ³ /tonne of carcass	1.85–5.25
		m ³ /animal	0.30–2.45
Pig	All installations	m ³ /tonne of carcass	0.65–3.50
		m ³ /animal	0.07–0.30
Chicken		m ³ /tonne of carcass	1.45–6.30
		m ³ /animal	0.002–0.013
⁽¹⁾ Either the BAT-AEPL expressed in m ³ /tonne of carcass or the BAT-AEPL expressed in m ³ /animal applies.			

[This BAT conclusion is based on information given in Sections 3.2.3.2, 3.3.3.2 and 3.4.4.3]

5.2.3 Use of refrigerants

BAT 22. In order to prevent emissions of ozone-depleting substances and of substances with a high global warming potential from cooling and freezing, BAT is to use refrigerants without ozone depletion potential and with a low global warming potential.

Description

Suitable refrigerants include water, carbon dioxide or ammonia.

[This BAT conclusion is based on information given in Section 3.2.3.5.1]

BAT 23. In order to prevent or, where that is not practicable, to reduce refrigerant losses, BAT is to use one or a combination of the techniques given below.

Technique		Description	Applicability
a	Refrigeration management plan	See BAT 20(a).	Generally applicable.
b	Preventive and corrective maintenance	The correct operation of the refrigeration equipment is regularly reviewed and any deviations/malfunctions are corrected/fixed in a timely manner.	
c	Use of refrigerant leak detectors	A centralised alarm system is used in order to promptly identify refrigerant leaks.	

Table 5.7: BAT-associated emission levels (BAT-AELs) for refrigerant losses

Type of refrigerant	Unit	BAT-AEL (yearly average)
R717	Percentage (%) of the total amount of refrigerant contained in the cooling system(s)	<1-5
R404A		1-5

[This BAT conclusion is based on information given in Section 3.2.2.4 and 3.2.3.5]

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5.3 BAT conclusions for installations processing animal by-products and/or edible co-products

The BAT conclusions presented in this section apply to installations processing animal by-products and/or edible co-products. They apply in addition to the general BAT conclusions given in Section 5.1.

5.3.1 Energy efficiency

BAT 24. In order to increase energy efficiency, BAT is to use an appropriate combination of the techniques specified in BAT 9 and of the technique given below.

Technique		Description	Applicability
a	Multistage evaporators	Evaporators used to remove water from liquid mixtures generated for example in fat melting, rendering, fishmeal and fish oil production are multistage, where steam is introduced in a series of successive vessels, each one exhibiting a lower temperature and pressure than the previous one.	Generally applicable.

Table 5.8: BAT-associated environmental performance levels (BAT-AEPLs) for specific energy consumption in installations processing animal by-products and/or edible co-products

Type of installation/process(es)	Unit	Type of process	Specific energy consumption (yearly average)
Rendering, fat melting, blood and/or feather processing	kWh/tonne of raw material	Dry rendering	450–1 010
		Wet rendering	40–780
Fishmeal and fish oil production		—	420–710
Gelatine manufacturing			1 380–2 110 ⁽¹⁾ ⁽²⁾

⁽¹⁾ The specific energy consumption level does not apply to stand-alone bone degreasing installations.
⁽²⁾ The upper end of the BAT-AEPL range is 2 580 kWh/tonne of raw material for installations applying hot air drying.

[This BAT conclusion is based on information given in Sections 4.2.3.1, 4.3.3, 4.4.3, 4.5.3 and 4.3.4.1]

5.3.2 Water consumption and waste water generation

Table 5.9: BAT-associated environmental performance levels (BAT-AEPLs) for specific waste water discharge

Type of installation/process(es)	Unit	Specific waste water discharge (yearly average)
Rendering, fat melting, blood and/or feather processing	m ³ /tonne of raw material	0.05–1.55
Fishmeal and fish oil production		0.20–1.25
Gelatine manufacturing		16.5–27 ⁽¹⁾
⁽¹⁾ The specific waste water discharge level does not apply to stand-alone bone degreasing installations.		

[This BAT conclusion is based on information given in Sections 4.3.3, 4.4.3 and 4.5.3]

5.3.3 Emissions to air

BAT 25. In order to reduce emissions to air of organic compounds and malodorous compounds, including H₂S and NH₃, BAT is to use one or a combination of the techniques given below.

Technique		Description
a.	Condensation	See Section 5.4.2. The technique is used together with one or a combination of techniques (b) to (g) for the treatment of non-condensable gases. See Section 5.4.2.
b.	Adsorption	
c.	Biofilter	
d.	Combustion of malodorous gases, including non-condensable gases, in a boiler	
e.	Thermal oxidation	
f.	Wet scrubber	
g.	Bioscrubber	

Table 5.10: BAT-associated emission levels (BAT-AELs) for channelled emissions to air of odour, organic compounds, NH₃ and H₂S from rendering, fat melting, blood and/or feather processing

Substance/Parameter	Unit	BAT-AEL
Odour concentration	OU _E /Nm ³	60–1 300
TVOC	mg/Nm ³	0.5–16
NH ₃		0.01–3.2
H ₂ S		0.01–1

The associated monitoring is given in BAT 8.

Table 5.11: BAT-associated emission levels (BAT-AELs) for channelled emissions to air of odour, organic compounds and NH₃ from fishmeal and fish oil production

Parameter	Unit	BAT-AEL
Odour concentration	OU _E /Nm ³	120–1 150
TVOC	mg/Nm ³	1–14
NH ₃		0.01–3.2

The associated monitoring is given in BAT 8.

Table 5.12: BAT-associated emission levels (BAT-AELs) for channelled emissions to air of odour, organic compounds and NH₃ from gelatine manufacturing

Parameter	Unit	BAT-AEL
Odour concentration	OU _E /Nm ³	60–1 300
TVOC	mg/Nm ³	0.5–16
NH ₃		0.01–3.2

The associated monitoring is given in BAT 8.

[This BAT conclusion is based on information given in Sections 2.3.8, 4.3.3 and 4.4.3]

5.4 Description of techniques

5.4.1 Emissions to water

Technique	Description
Activated sludge process	A biological process in which the microorganisms are maintained in suspension in the waste water and the whole mixture is mechanically aerated. The activated sludge mixture is sent to a separation facility from where the sludge is recycled to the aeration tank.
Aerobic lagoon	Shallow earthen basins for the biological treatment of waste water, the content of which is periodically mixed to allow oxygen to enter the liquid through atmospheric diffusion.
Anaerobic contact process	An anaerobic process in which waste water is mixed with recycled sludge and then digested in a sealed reactor. The water/sludge mixture is separated externally.
Chemical oxidation with the use of ozone	Chemical oxidation is the conversion of pollutants by chemical-oxidising agents other than oxygen/air or bacteria into similar but less harmful or hazardous compounds and/or to short-chained and more easily degradable or biodegradable organic components. Ozone is one example of a chemical-oxidising agent applied.
Coagulation and flocculation	Coagulation and flocculation are used to separate suspended solids from waste water and are often carried out in successive steps. Coagulation is carried out by adding coagulants with charges opposite to those of the suspended solids. Flocculation is carried out by adding polymers, so that collisions of microfloc particles cause them to bond to produce larger flocs.
Equalisation	Balancing of flows and pollutant loads by using tanks or other management techniques.
Enhanced biological phosphorus removal	A combination of aerobic and anaerobic treatment to selectively enrich polyphosphate-accumulating microorganisms in the bacterial community within the activated sludge. These microorganisms take up more phosphorus than is required for normal growth.
Evaporation	The use of distillation to concentrate aqueous solutions of high-boiling substances for further use, processing or disposal (e.g. waste water incineration) by transferring water to the vapour phase. It is typically carried out in multistage units with increasing vacuum, to reduce the energy demand. The water vapours are condensed, to be reused or discharged as waste water.
Filtration	The separation of solids from waste water by passing it through a porous medium, e.g. sand filtration, microfiltration and ultrafiltration.
Flotation	The separation of solid or liquid particles from waste water by attaching them to fine gas bubbles, usually air. The buoyant particles accumulate at the water surface and are collected with skimmers.
Membrane bioreactor	A combination of activated sludge treatment and membrane filtration. Two variants are used: a) an external recirculation loop between the activated sludge tank and the membrane module; and b) immersion of the membrane module in the aerated activated sludge tank, where the effluent is filtered through a hollow fibre membrane, with the biomass remaining in the tank.
Neutralisation	The adjustment of the pH of waste water to a neutral level (approximately 7) by the addition of chemicals. Sodium hydroxide (NaOH) or calcium hydroxide (Ca(OH) ₂) is generally used to increase the pH, whereas sulphuric acid (H ₂ SO ₄), hydrochloric acid (HCl) or carbon dioxide (CO ₂) is generally used to decrease the pH. The precipitation of some substances may occur during neutralisation.

Technique	Description
Nitrification and/or denitrification	A two-step process that is typically incorporated into biological waste water treatment plants. The first step is the aerobic nitrification where microorganisms oxidise ammonium (NH_4^+) to the intermediate nitrite (NO_2^-), which is then further oxidised to nitrate (NO_3^-). In the subsequent anoxic denitrification step, microorganisms chemically reduce nitrate to nitrogen gas.
Precipitation	The conversion of dissolved pollutants into insoluble compounds by adding chemical precipitants. The solid precipitates formed are subsequently separated by sedimentation, air flotation, or filtration. Multivalent metal ions (e.g. calcium, aluminium, iron) are used for phosphorus precipitation.
Sedimentation	The separation of suspended particles by gravitational settling.

5.4.2 Emissions to air

Technique	Description
Adsorption	Organic compounds are removed from a waste gas stream by retention on a solid surface (typically activated carbon).
Bag filter	Bag filters, often referred to as fabric filters, are constructed from porous woven or felted fabric through which gases are passed to remove particles. The use of a bag filter requires the selection of a fabric suitable for the characteristics of the waste gas and the maximum operating temperature.
Biofilter	The waste gas stream is passed through a bed of organic material (such as peat, heather, compost, root, tree bark, softwood and different combinations) or some inert material (such as clay, activated carbon, and polyurethane), where it is biologically oxidised by naturally occurring microorganisms into carbon dioxide, water, inorganic salts and biomass. A biofilter is designed considering the type(s) of waste input. An appropriate bed material, e.g. in terms of water retention capacity, bulk density, porosity, structural integrity, is selected. Also important are an appropriate height and surface area of the filter bed. The biofilter is connected to a suitable ventilation and air circulation system in order to ensure a uniform air distribution through the bed and a sufficient residence time of the waste gas inside the bed.
Bioscrubber	A packed tower filter with inert packing material which is normally continuously moistened by sprinkling water. Air pollutants are absorbed in the liquid phase and subsequently degraded by microorganisms settling on the filter elements.
Burning of malodorous gases, including non-condensable gases, in a boiler	Malodorous gases, including non-condensable gases, are burned in a boiler in the installation.
Condensation	The removal of vapours of organic and inorganic compounds from a process off-gas or waste gas stream by reducing its temperature below its dew point so that the vapours liquefy.
Thermal oxidation	The oxidation of combustible gases and odorants in a waste gas stream by heating the mixture of contaminants with air or oxygen to above its auto-ignition point in a combustion chamber and maintaining it at a high temperature long enough to complete its combustion to carbon dioxide and water.
Wet scrubber	The removal of gaseous or particulate pollutants from a gas stream via mass transfer to a liquid solvent, often water or an aqueous solution. It may involve a chemical reaction (e.g. in an acid or alkaline scrubber). In some cases, the compounds may be recovered from the solvent.

6 EMERGING TECHNIQUES

Article 3(14) of Directive 2010/75/EU defines an ‘emerging technique’ as a ‘novel technique for an industrial activity that, if commercially developed, could provide either a higher general level of protection of the environment or at least the same level of protection of the environment and higher cost savings than existing best available techniques’. This chapter contains those techniques that may appear in the near future and that may be applicable to slaughterhouses and installations processing animal by-products and/or edible co-products.

6.1 General

6.1.1 Microalgal heterotrophic bioreactors

Technical description

Microalgal heterotrophic bioreactors convert organic matter, nitrogen and phosphorus in waste water into biomass suitable for energy production (e.g. biodiesel). SA waste water has a high pollution load and the high concentration of organic matter in the right ratios (ideal C/N and N/P ratio), combined with the absence of toxic compounds or growth inhibitors, makes it a suitable environment for heterotrophic microalgal cultivation. The core of the process is the conversion of COD, N-TKN and P-PO₄³⁻ into microalgal biomass. Inside the bioreactor, the heterotrophic microalgal cultivation is driven by sunlight and CO₂, and produces microalgal biomass composed of lipids, fatty acids, proteins, and pigments. As illustrated in Figure 6.1, after the production of biomass, there is no separation of the streams. The right-hand side of Figure 6.1 indicates the composition of biomass. The analysis of the biomass is done after processing in a decanter, a belt filter, and a drum dryer to separate the different streams.

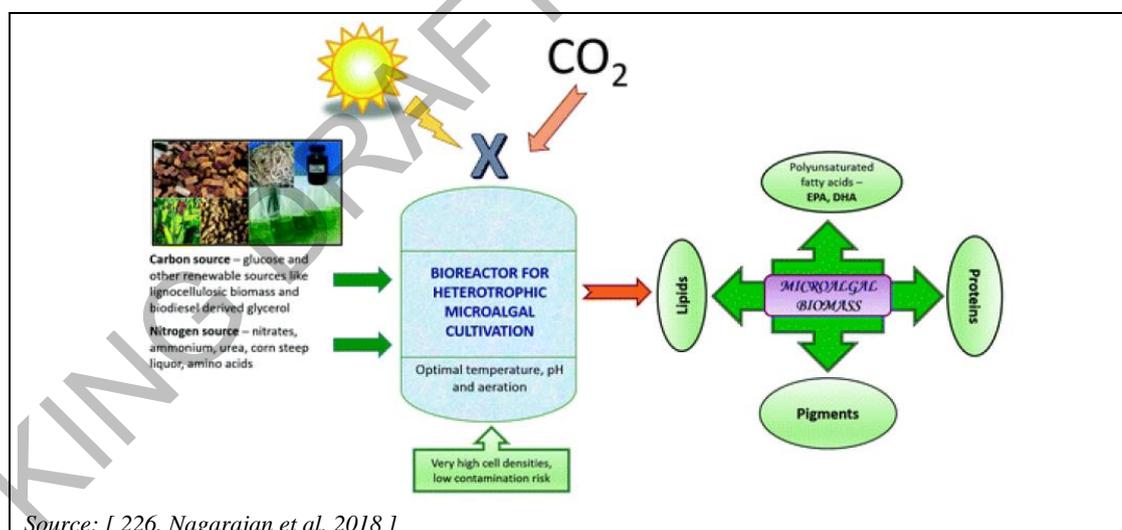


Figure 6.1: Process of heterotrophic microalgal cultivation

The chemical composition of microalgal sludge is as follows: protein (32 %), lipids (15 %), carbohydrates (16 %), minerals (22 %) and moisture (15 %). Sludge with this composition qualifies as a potential source of single-cell proteins and oils to feed biorefineries.

Achieved environmental benefits

- Requires low energy input.
- Contribute to the partial removal of nitrogen and phosphorus from waste water.

Environmental performance and operational data

The study [227, Santos et al. 2017], where poultry and swine slaughterhouse waste water was treated, showed removal efficiencies of 97.6 %, 85.5 % and 92.4 % for COD, N-TKN and P-PO₄³⁻, respectively. In addition, a microalgal sludge productivity of 0.27 kg/m³/d was observed.

Technical considerations relevant to applicability

The maintenance of a monoculture of heterotrophic microalgae is expensive and technically difficult to operate at full scale [228, Jacob-Lopes et al. 2013].

Economics

Economic data were available from a bench-scale facility, and were extrapolated to estimate the costs of an industrial scale with a capacity of 16 000 m³/day. The economic analysis demonstrated a cost of USD 2.66/m³ of treated industrial waste water, and, as a consequence of this process, the production cost of microalgal sludge was USD 0.03/kg of dehydrated biomass [227, Santos et al. 2017].

Driving force for implementation

Microalgal sludge is a rich biomass that can be used for animal feeding and bioenergy production.

Example plants

A pilot algal system has been installed in a multispecies slaughterhouse (pigs, cattle, sheep and goats) in Salteras (Spain) covered by the SA BREF scope, consisting of a 400 m² main algal pond and two 9 m² inoculation ponds for maintaining the inoculum culture. All ponds have a fully automated control system measuring the input and output parameters of the water substrate. The biomass produced is harvested by sedimentation and dissolved air flotation. A CO₂ diffuser is employed to optimise CO₂ dispersion into the algal ponds. This algal system has been developed in the context of the Water2Return project funded by the European Commission [261, Water2Return 2019].

Reference literature

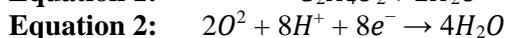
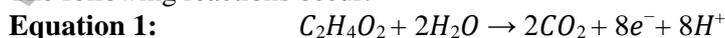
[226, Nagarajan et al. 2018], [227, Santos et al. 2017], [228, Jacob-Lopes et al. 2013], [232, COM 2019], [261, Water2Return 2019]

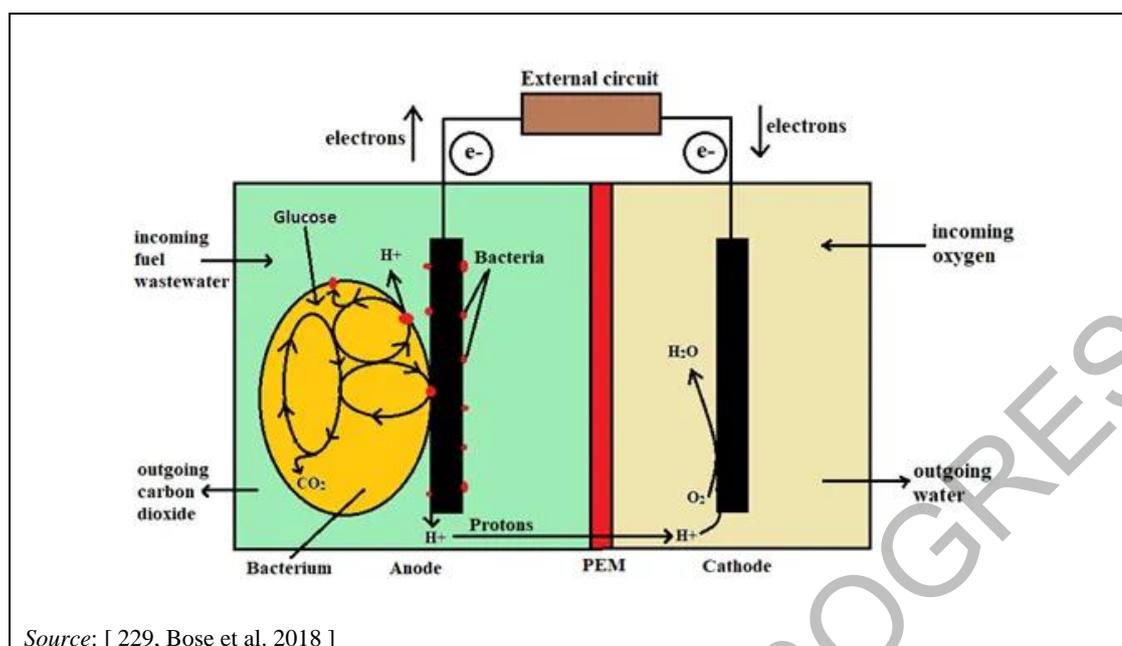
6.1.2 Microbial fuel cells

Technical description

Microbial fuel cells (MFCs) are devices that use bacteria as a catalyst for converting organic matter into electricity. A microbial fuel cell usually consists of two chambers: one anaerobic anodic chamber (left side in Figure 6.2) and one aerobic cathodic chamber (right side in Figure 6.2), separated by ion-conducting separators (Proton Exchange Membrane, PEM). Bacteria which are capable of extracellular electron transfer – called electricigens – will oxidise substrates in the anode chamber and generate electrons (e⁻) and protons (H⁺) which will flow to the anode (see Equation 1). Electrons will move to the cathode via an external circuit and generate electricity, while the protons will transfer via the PEM. In the cathode chamber (usually made of platinum), electrons, protons and O₂ will then combine to form water (see Equation 2) [230, Ismail et al. 2016].

The following reactions occur:





Source: [229, Bose et al. 2018]

Figure 6.2: Schematic diagram of microbial fuel cells with PEM

Achieved environmental benefits

- Renewable energy production.
- Reduction of COD, BOD, TSS and total nitrogen content in waste water.

Environmental performance and operational data

The maximum power density generated is around 700 MW/m². Reductions of concentration of waste water pollutants in a slaughterhouse are shown in Table 6.1.

Table 6.1: Reduction of concentration of waste water pollutants after treatment by MFC

Waste parameter	water	Before MFC treatment (mg/l)	After MFC treatment ⁽¹⁾ (mg/l)	Reduction (%)
COD		9 350	1 079	-88
BOD		2 600	895	-66
TSS		3 250	1 824	-44
Ammonia		1.2	0.48	-60
Phosphate		480	739	+54 ⁽²⁾
Total nitrogen		1.05	0.42	-60

Source: [231, Akaluka et al. 2016]

⁽¹⁾ Using 0.1 M potassium ferricyanide as catholyte.

⁽²⁾ Low redox potential could lead to release of inorganic phosphate from organic matter.

A possible explanation for the increase in phosphate concentration may be that the low redox potential in the anode cells leads to a release of inorganic phosphate from organic matter [232, COM 2019].

Cross-media effects

- Mining and usage of precious metals such as copper, graphite, zinc and platinum for the production of efficient cathodes.
- Metals are wasted in the use of cathodes.

Technical considerations relevant to applicability

Studies from have shown that scaling up causes a decreased power output [233, Chaturvedi et al. 2016]. Because electrodes' size increases, the distance between the electrodes changes

disproportionally and renders the MFC bulkier and less efficient. This is a major drawback for its large-scale commercialisation potential. There are also parameters which have to be adjusted such as size and shape of electrodes, electrode material, device configuration, which can make the implementation of this treatment method difficult in practice.

Economics

Electrodes are known to be expensive since these are not produced industrially yet and the material with which they are made (graphite, copper, zinc, platinum) is not cheap. The membranes separating the two chambers are usually made of nylon, which is also costly.

Driving force for implementation

Electricity production from contaminants specifically found in slaughterhouse waste water.

Reference literature

[229, Bose et al. 2018], [230, Ismail et al. 2016], [231, Akaluka et al. 2016], [232, COM 2019], [233, Chaturvedi et al. 2016]

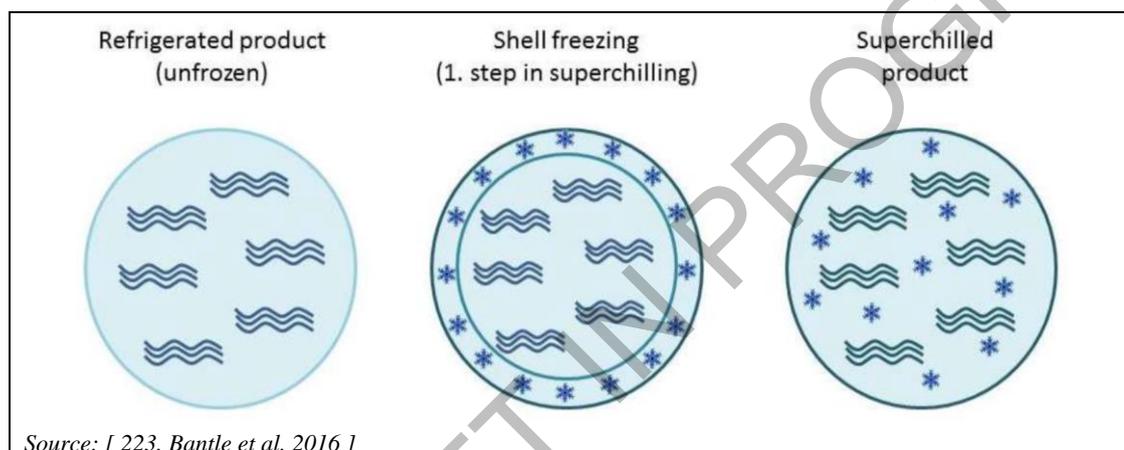
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6.2 Emerging techniques for slaughterhouses

6.2.1 Superchilling

Technical description

This is a cooling technique characterised by a product temperature which is lowered to just below its freezing point. Superchilling technology combines the favourable effect of low temperatures with the conversion of some water into ice, making it less prone to deteriorative processes. At the surface, ice is formed and will absorb heat from the interior of the meat until it eventually reaches equilibrium. Superchilling gives the meat an internal ice reservoir, so that there is no need for external ice around the product during storage or transportation for short periods. To put it into perspective, superchilling is positioned between refrigeration (conventional chilling) and freezing.



Source: [223, Bantle et al. 2016]

Figure 6.3: The different steps in superchilling

There are various superchilling technologies, each with their own advantages and limitations. The most common techniques are mechanical, cryogenic and impingement freezing [224, Kaale et al. 2011].

Mechanical freezing: This involves using a traditional circulating refrigerant such as carbon dioxide or ammonia to achieve a temperature reduction by heat exchange from air to the food product. They usually take the form of belt freezers to freeze foods, have lower operational costs than cryogenic freezers, but require longer processing times due to low heat transfer coefficients.

Cryogenic freezing: This involves immersing or spraying the food directly with carbon dioxide or liquid nitrogen. This offers shorter freezing times compared to conventional air freezing because of the large temperature differences between the food and the cryogen (-78°C for carbon dioxide as a solid or -196°C for liquid nitrogen). There may however be some distortion of the shape of the product due to the cryogenic process.

Impingement freezing: This involves using thousands of high-velocity impingement air jets to direct air towards the bottom and top surfaces of a product. Products are placed on conveyor belts, and the high-velocity air passes through the conveyor upwards and downwards, and blasts away the boundary layer of air which holds heat around the product, increasing heat transfer rates compared to traditional mechanical freezers.

Superchilling remains a grey area in terms of international legislation because superchilled food is neither chilled nor frozen. Superchilled meat is not defined within EU legislation. Only chilled ($< 4^{\circ}\text{C}$ for poultry meat), frozen $< -12^{\circ}\text{C}$ and deep-frozen ($< -18^{\circ}\text{C}$) are defined. The

operational temperatures of superchilling are just below the freezing temperature of the products: e.g. -2 °C for pork roasts, -3.5 °C for cured loin, -1.1 °C for pork legs

Achieved environmental benefits

Lower energy consumption compared to freezing.

Environmental performance and operational data

The energy consumption required for superchilling represents approximately one third of the energy needed for traditional freezing. Refrigerant consumption is higher than 1 kg N₂ per kg of processed product [224, Kaale et al. 2011].

Selecting optimal process conditions (temperature, velocity of the conveyor belt and holding time in the superchilling unit) to achieve the longest shelf life without compromising product quality is relevant. Also, controlling the amount of ice formation seems to be critical.

Technical considerations relevant to applicability

The influence of this technique on the microbiological quality of the meat is very important and needs to be investigated.

Driving force for implementation

- Relatively short implementation period in existing production lines [223, Bantle et al. 2016].
- Prolongs the shelf life for a meat product by 1.4 to 4 times compared to conventional meat-chilling methods [225, Bonou et al. 2016].

Example plants

Two processing lines for superchilling of fish and meat products have been implemented in the Norwegian food industry [223, Bantle et al. 2016].

Reference literature

[223, Bantle et al. 2016], [224, Kaale et al. 2011], [225, Bonou et al. 2016], [232, COM 2019]

6.3 Emerging techniques for installations processing animal by-products and/or edible co-products

6.3.1 Hydrothermal liquefaction

Technical description

Hydrothermal liquefaction (HTL) is a biomass decomposition and valorisation method, comparable to gasification and pyrolysis. It is a process that uses hot (300-400 °C), pressurised condensed water (40-200 bar) to convert biomass into a thermally stable oil product, also known as biocrude, which can then be thermocatalytically upgraded to hydrocarbon fuel blendstocks, as illustrated in Figure 6.4.

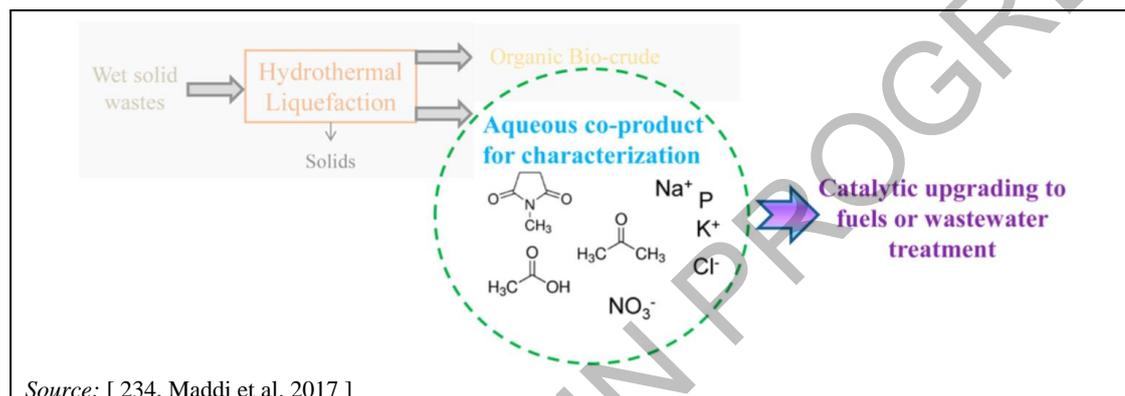


Figure 6.4: Flow of the hydrothermal liquefaction process

HTL accelerates the natural decomposition of organic matter to generate high-added-value hydrocarbons (biocrude oil) from a relatively wet biomass in the presence of a catalyst and hydrogen in a few minutes. A typical product may contain 10-73 wt-% biocrude oil, 8-20 wt-% gas, and 0.2-0.5 wt-% char. This biocrude oil produced contains less oxygen than bio-oil produced by pyrolysis. Researchers from the University of Alicante demonstrated in a lab-scale experiment that animal by-products can be used as raw material for the production of biocrude oil [235, García Cortés 2020].

Achieved environmental benefits

Advantages of this technique over traditional pyrolysis are:

- less energy consumption (because there is no need to dry the sample);
- better separation between the bio-oil and the water phase;
- bio-oil has lower O₂, sulphur and water content compared to pyrolysis oil.

In the specific case of using algal biomass as input [236, Gollakota et al. 2018], the environmental benefits are the following:

- reduced waste disposal;
- energy efficiency of 85-90 %;
- treatment of all biomasses from different origins (e.g. slaughterhouse waste can be added to the waste of a dairy production plant).

Cross-media effects

Nitrogen compounds are problematic for hydrotreatment catalysts and their presence in the bio-oil causes NO_x emissions.

Technical considerations relevant to applicability

Continuous reactors are required, while the majority of the knowledge is based on batch reactors. The thick walls of the pressure vessels together with a high feed viscosity result in low heat transfer efficiency. High-pressure (> 20 MPa) slurry feed pumps are not readily available. The chemistry of HTL is difficult to understand; therefore, it can be very challenging to use complex biomass, as is the case of slaughterhouse waste [237, Lee et al. 2016].

Economics

For a HTL plant with a feed rate of 7.9 l/h, the capital cost is around US 36 million. The biocrude production is estimated at 4.1 million Gasoline Gallon Equivalent (GGE)/year with a minimum selling price of USD 2.35/GGE biocrude (minimum revenue of USD 9.6 million/year) [238, Snowden-Swan et al. 2017]. This simulation is based on a mixture of waste water. There are no data available for the HTL method for slaughterhouse waste water because there are no large-scale plants in operation at the time of writing.

Reference literature

[232, COM 2019], [235, García Cortés 2020], [236, Gollakota et al. 2018], [237, Lee et al. 2016], [238, Snowden-Swan et al. 2017]

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7 CONCLUDING REMARKS

This chapter will be completed after the Final TWG Meeting
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~~Techniques not included in Chapter 4, “Techniques to consider in the determination of BAT”, due to lack of sufficient information~~

~~General techniques applicable in slaughterhouses and animal by-products installations~~

~~Hoses can be fitted with flat-jet spray nozzles~~

~~**Technical description**~~

~~Hoses can be fitted with spray nozzles with a pressure of 2.5 – 3 MPa (25 – 30 bar). A spray of up to 60° provides wide coverage and a sweeping effect. Dry cleaning can be undertaken first and drains can be filled with meshes and traps to prevent stray solids from entering the waste water.~~

~~**Achieved environmental benefits**~~

~~Reduced water consumption.~~

~~**Cross-media effects**~~

~~None.~~

~~**Reference literature**~~

~~[167, Greek Ministry for the Environment, 2001]~~

~~**Fat/sludge collector**~~

~~**Technical description**~~

~~A concrete pit covered with a lid made from planks or steel plates can be provided to as a collection vessel. The waste water flows in via an antechamber. The waste water stays in the pit for sufficient time to allow heavy particles to sediment and fat to collect on the surface. The outlet is placed midway between the base and top. This method removes significant impurities from the waste water if the retention period is sufficient and the pit is emptied regularly with a sludge suction system.~~

~~**Achieved environmental benefits**~~

~~Removal of fat from waste water.~~

~~**Cross-media effects**~~

~~If the water often stands in the pit overnight, this can result in anaerobic conditions and both the waste water and the sludge can produce unpleasant odours.~~

~~**Reference literature**~~

~~[134, Nordic States, 2001]~~

~~**Fat cleaning**~~

~~**Example plants**~~

~~Several rendering plants in Germany.~~

Reference literature

[244, Germany, 2002]

Conductivity controlled blowdown on cooling towers

Technical description

Blowdown may be controlled by measurement of conductivity to detect when it is required. This can replace either a timed automatic blowdown control, to release water to drain for 2–3 minutes every 0.5–1 hour each day or a constant flow to drain.

Achieved environmental benefits

Reduced water consumption.

Reference literature

[214, AVEC, 2001]

Design of refrigeration space to minimise energy consumption

Technical description

Dimensions of cold rooms can be designed to prevent unnecessary cooling of empty spaces. When doors are opened the cooled air can be rapidly replaced by warm air and this slows down the carcass cooling process and consumes more energy.

Achieved environmental benefits

Reduced energy consumption

Example plants

At least one cattle/sheep slaughterhouse in the UK.

Energy saving motors

Technical description

An electronic start up control of the motor prevents the high switch on current consumption that, depending of the type of burden, can amount to several times the nominal current consumption of the motor.

Achieved environmental benefits

Reduced energy use.

Example plants

A poultry slaughterhouse in the UK. Several rendering plants in Germany.

Reference literature

[244, Germany, 2002]

Heat recovery

Technical description

Heat can be recovered in rendering plants and used in the rendering process, for other on-site activities or for off-site activities, such as district heating. The recovered heat can be used for space heating, feedstock heating and water heating.

Achieved environmental benefits

Reduced energy use.

Reference literature

[148, Finnish Environment Institute and Finnish Food and Drink Industries' Federation, 2001]

Airlock provision between the indoor loading/unloading area and outdoors

Technical description

A tunnel large enough to accommodate the biggest despatch/delivery vehicle can be constructed. Odours can be contained if the tunnel has doors at either end, which make a good seal with the walls and which can be opened and shut rapidly with minimum effort and inconvenience. If the doors are difficult to operate they may fall into disuse. High speed plastic roller shutter doors, which are less susceptible to damage than metal doors, are available. The integrity of the tunnel and the unloading, storage, processing and packing areas should prevent leakage of odours and the use of the tunnel should not compromise the negative pressure maintained in the rest of the installation.

Achieved environmental benefits

Minimisation of emission of odour to the surrounding neighbourhood.

Driving force for implementation

Odour control and hygiene. The significance of hygiene may vary depending on the type of animal by product and its intended use. For example, the scattering of BSE risk material by birds and rodents and the prevention of contamination of material intended for human consumption will make enclosure important.

Example plants

Six rendering plants in Germany.

Reference literature

[168, Sweeney L., 2001, 244, Germany, 2002]

Ozone

Technical description

Ozone is a powerful oxidising agent and can remove odour in a number of cases. Good results have been reported after tests on air from lairages. Ozone can be produced by a high voltage generator or by using a UV tube.

Achieved environmental benefits

Reduced odour emission, with a reported efficiency often above 90 %.

Technical considerations relevant to applicability

Ozone odour control systems are less effective when dealing with high humidity air streams, e.g. the vent from a scalding tank room.

Use of low rpm fans for air conditioning

Example plants

Slaughterhouses in Denmark

Separation of metals

Concluding remarks

Example plants

Several rendering plants in Germany.

Reference literature

{244, Germany, 2002}

General techniques applicable in slaughterhouses

Control of water supply, by, e.g. department or unit operation

Technical description

The water supply to each part of the machine line can be controlled to switch off, when no carcasses are present.

Achieved environmental benefits

Reduction of water consumption.

Cross-media effects

None.

Technical considerations relevant to applicability

Applicable at all large slaughterhouses.

Economics

Short payback time.

Driving force for implementation

Reduction of water costs.

Reference literature

{134, Nordic States, 2001, 183, Pontoppidan O., 2001}

Air-cooling of vacuum pumps instead of water-cooling

Reference literature

{134, Nordic States, 2001}

Once a day knife washing – multiple knife supply at work stations

Technical description

Slaughter knives can be washed and sterilised once a day and the number of clean knives required during each shift, brought to each work station in the slaughter line. For those operations where the knife does not need to be cleaned between each animal, e.g. where there is faecal contamination, a new knife may be selected as and when required. This may be combined with centralised knife sharpening.

Example plants

At least one cattle slaughterhouse in Italy.

Reference literature

{269, Italian TWG Members, 2002}

Use of a hot dry airline to sterilise knives

Example plants

UK retail sector.

Use of an autoclave to sterilise knives (off-line, e.g. between shifts)

Automatic magnetic valve controlled water sprays

Achieved environmental benefits

Water consumption reduced, due to the flow being interrupted when there are no carcasses on the line, such as during lunch breaks.

Reference literature

{134, Nordic States, 2001}

Recuperation/recovery of energy

Technical description

Energy/heat can be regained from refrigeration installations, compressed air, singeing kilns. The recouped energy can be used for heating of water and room heating.

Achieved environmental benefits

In a pig slaughterhouse in Denmark there has been heat recuperation of 39 kWh/t of carcase.

Example plants

At least one pig slaughterhouse in Denmark.

Reference literature

{134, Nordic States, 2001}

Slaughter of large animals

Collect water used to clean aprons and boots

Technical description

The quality of blood intended for human consumption will be reduced if it is diluted by water used to clean aprons and boots.

Cross-media effects

Additional contamination of waste water by blood.

Technical considerations relevant to applicability

Applicable in large animal slaughterhouses.

Reference literature

{346, Belgian TWG member, 2003}

Lairage

Re-use of water to wash vehicles

Technical description

Concluding remarks

Cooling water from the refrigeration plant and vacuum pumps can be collected and re-used for washing vehicles. Veterinary approval must be obtained before use. It is also possible to use water from the rinsing of filters in water works, after sedimentation of ochre.

Achieved environmental benefits

Less water consumption.

Technical considerations relevant to applicability

Totally applicable

Reference literature

{63, ETBPP, 2000, 134, Nordic States, 2001}

Pig delivery planned for times least sensitive for noise

Reference literature

{134, Nordic States, 2001}

Unloading using unloading bridges

Technical description

If unloading bridges are used, a direct connection can be made between the vehicle delivering large animals and the lairage.

Technical considerations relevant to applicability

Applicable in large animal slaughterhouses.

Reference literature

{346, Belgian TWG member, 2003}

Use of slatted lairage floors

Technical description

Slatted concrete floors laid to falls of 1 in 60 with drainage beneath to a slurry tank.

Achieved environmental benefits

Reduced water consumption for wash-down and less entrainment of manure and urine in waste water.

Re-use of water to wash the lairage floor (pigs)

Technical description

Cooling water from the refrigeration plant and vacuum pumps can be collected and re-used for washing vehicles. Veterinary approval must be obtained before use. It is also possible to use water from the rinsing of the filters in water works, after sedimentation of ochre.

Example plants

Three slaughterhouses in Germany.

Reference literature

{134, Nordic States, 2001, 244, Germany, 2002}

Collection of urine, for use as a fertiliser

Technical description

Urine can be collected either through slatted or sloping floors.

Achieved environmental benefits

Reduces contamination of waste water by nitrogen from, e.g. ammonia, urea, uric acid and proteins.

Urine can be used as a fertiliser, in suitable land, where the addition of liquid will not lead to ground or surface water contamination.

Reference literature

[134, Nordic States, 2001]

Washing animals before slaughter**Technical description**

Animals can be washed before slaughter.

Achieved environmental benefits

Reduced water consumption and entrainment of fat, blood and manure, due to the reduced requirement for carcase washing along the slaughter line and during carcase dressing.

Cross-media effects

Additional water consumption and contamination, between the lairage and the stunning pen.

Reference literature

[288, Durkan J., 2002]

Slaughter**Drive pigs to the stunning pen, as quietly as possible****Technical description**

If pigs are driven to the stunning pen as quietly as is possible, this can reduce squealing and prevent stress to the animals.

Technical considerations relevant to applicability

Applicable in pig slaughterhouses.

Reference literature

[346, Belgian TWG member, 2003]

Carbon dioxide stunning of pigs**Technical description**

Pigs may be stunned and in some cases killed by exposure to CO₂, prior to bleeding.

Environmental performance and operational data

The pigs are lowered into a chamber containing 85 % CO₂ for 45 seconds. They may be stunned in batches of e.g. 12 at a time or individually in a *pater noster* lift.

Technical considerations relevant to applicability

Applicable in pig slaughterhouses.

Hide and skin removal

Concluding remarks

Pneumatic removal of hides and skins

Technical description

The carcass is removed pneumatically after receiving an electric stimulus, to stop the back breaking.

Technical considerations relevant to applicability

Applicable in cattle slaughterhouses.

Example plants

At least one cattle slaughterhouse in Italy.

Reference literature

{269, Italian TWG Members, 2002}

Pig scalding

Design of pig scalding tank, to ease emptying and cleaning

Technical description

The scalding tank may be designed with good falls to the bottom drain from all positions.

Achieved environmental benefits

The ease of emptying and cleaning of the tank minimises the total water consumption and the discharged waste water volume.

Reference literature

{134, Nordic States, 2001}

Reducing water carried out of scalding tanks

Technical description

A flap placed at the exit of the scalding tank can be used to collect and return water dripping from carcasses.

Achieved environmental benefits

Reduced water consumption and energy use to heat the water.

Reference literature

{346, Belgian TWG member, 2003}

Stopping the water supply to the scalding tank during breaks in production

Environmental performance and operational data

For a slaughterhouse killing 18000 turkeys per day, i.e. 38 birds per minute the reported potential water saving is 3650 m³/yr with a financial saving of GBP 2280/yr. (Costs in 1999)

Reference literature

{214, AVEC, 2001}

Heat recovery from tank water

Economics

The payback time is considered to be 1 to 3 years.

Reference literature

[57, DoE, 1993]

Use of a scalding tank with a steep base

Technical description

Use of a scalding tank which has a steep gradient towards the outlet can reduce cleaning water consumption.

Achieved environmental benefits

Reduced water consumption during cleaning.

Cross-media effects

The increased volume of the tank required to have a steep base may increase the water consumption required during the use of the tank.

Reference literature

[330, AWARENET, 2002]

Pig hair and toenail removal

Control of the water supply to de-hairing machines

Technical description

Water supplied to the de-hairing machines can be controlled, to ensure that it is only supplied when there are carcasses in the machine.

Achieved environmental benefits

Reduced water consumption.

Reference literature

[134, Nordic States, 2001]

Pig singeing

Reduce the pig singeing time

Technical description

The singeing time of a pig can be reduced if it is supplied to the singeing furnace dry.

Achieved environmental benefits

Reduced fuel consumption.

Reference literature

[346, Belgian TWG member, 2003]

Efficient use and design of singe pipes

Technical description

Singeing should only be to the extent necessary for the product. Bacon production requires a heavy singe, whereas pig meat destined for ham and other butcher cuts require minimum singeing.

Concluding remarks

Reference literature

{57, DoE, 1993}

Install switches which initiate the singeing flame only when a carcass is present

Technical description

The flame in the carcass singeing kiln can be ignited only when a carcass is present. A continuous supply of air can be combined with an intermittent supply of gas, to produce a flame, activated by a carcass entering the singeing furnace. It is reported that there are no adverse bacteriological effects. Solenoid switches may be installed which initiate the singeing flame only when a carcass is passing.

Achieved environmental benefits

Reduced gas consumption.

Reference literature

{330, AWARENET, 2002, 346, Belgian TWG member, 2003}

Insulate the singeing oven

Technical description

Singeing ovens can be insulated.

Achieved environmental benefits

Reduced energy consumption.

Reference literature

{330, AWARENET, 2002}

Evisceration

Move viscera by conveyor

Technical description

Viscera may be removed from the slaughter line by conveyor in individual receptacles.

Reference literature

{269, Italian TWG Members, 2002}

Use of fat separators

Technical description

At locations, where it is possible to concentrate volumes of fat, such as evisceration points, where there are high fat emissions, it is possible to reduce the fat content in the production water by using fat separators. They can, e.g. be installed at the discharges from the evisceration units.

Achieved environmental benefits

Reduced BOD in the waste water. The retained fat can be used for the production of technical fats.

Environmental performance and operational data

If the temperature of the effluent exceeds 30 °C, the efficiency of fat separation is significantly reduced.

Reference literature

[244, Germany, 2002]

Splitting

Optimise the use of the carcass splitting saw

Technical description

If the correct diameter and thickness of saw blade is selected for the carcass splitting saw and the blade is maintained sharp, then the noise levels will be reduced and less bone dust will end up in the waste water. Bone sawdust can cause a high phosphorus load in the waste water.

Achieved environmental benefits

Reduced noise levels and a lower phosphorus contamination of waste water.

Technical considerations relevant to applicability

Applicable in large animal slaughterhouses.

Reference literature

[346, Belgian TWG member, 2003]

Chilling

Batch chilling

Technical description

Batch chilling uses a chill room with rails or walking beams as in the processing area. Each batch chill is separate, to prevent air from filtering between operating cells and those out of use. Each cell has a capacity for 2 hours of production. Batch chilling uses air as transport media. A uniform air distribution, e.g. via socks with nozzles, keeps the heat transfer coefficient high. The combination of air velocity and air temperature determines the time it takes to chill a carcass.

Environmental performance and operational data

The advantage by using the batch chilling process is that chilling and equalization of carcasses take place in same room. The process is simple to establish. The chills can be loaded either manually or automatically.

The disadvantage of using batch chilling is that if the air distribution is not uniform, it is impossible to get uniform equalised carcass temperatures. It is very important that there is free space around the carcasses. If, e.g. some carcasses touch each other, this will prevent the heat transfer from the contact points. These will warm up and this may reduce the meat, by damaging the PSE and causing bacterial growth.

Downstream activities

Water control at rumen washing machine

Technical description

The supply of water at a drum washing machine for washing rumen, can be controlled by a magnetic valve connected to the motor of the drum. This can ensure that water is only used when the drum is operating.

Concluding remarks

Achieved environmental benefits

Measurements have shown that this can reduce the water consumption by 10–30 %.
The washed rumen can be used for pet food or mink feed.

Reference literature

{134, Nordic States, 2001}

Removal and use/disposal of water from the “dry” intestine contents

Technical description

If the intestinal contents are pressed, the liquid has a very high BOD and N content. It may not be sent to the municipal sewer, depending on what the local discharge consents allow. It may be treated in an on-site WWTP.

Dry removal of gut manure

Technical description

Compressed air at approximately 100–273 kPa (15–40 psi) can be used to blow paunch manure to the collection trailer. A piston compactor can be used to reduce the volume.

Achieved environmental benefits

Reduced water contamination.

Reference literature

{63, ETBPP, 2000}

Re-use of finish water from casing washing

Technical description

Finish water is the last batch of cold water used for the cleaning of the small intestines. The Danish State Veterinary Services have given approval, under certain conditions, for this water to be used to flush the contents out of large intestines and fat ends.

Achieved environmental benefits

Reduced water consumption.

Technical considerations relevant to applicability

For larger Danish slaughterhouses (with two slaughter lines), the payback time for the capital cost is 2 to 4 years.

Example plants

Re-use of finish water from cleaning of the small intestines (from pigs) is used at one Danish slaughterhouse, for emptying large casings and fat ends, with the approval of the Danish State Veterinary Services.

Reference literature

{134, Nordic States, 2001, 274, Pontoppidan O., 2002}

Minimise noise on the intestine mucus machine

Technical description

A silencer can be provided on pneumatically operated mucus removal machines.

Achieved environmental benefits

Reduced noise levels.

Reference literature

[346, Belgian TWG member, 2003]

Chilling of red and green offals, using ice

Technical description

Red and green offals can be chilled using ice instead of running water. The ice is often already required for storage and during transport.

Achieved environmental benefits

Reduced water consumption and consequent reduced volume and BOD loading of waste water.

Reference literature

[134, Nordic States, 2001]

Slaughter of poultry

Reception of birds

Multi-stage crate washing units

Technical description

Washing units for the racks and boxes used to transport the birds, can be multi-stage installations. The water used for initial rinsing and cleaning is recirculated over, e.g. wedge wire screens and only the last rinse done with clean water. The water from the last rinse can be used to supplement the water for the earlier stages.

Achieved environmental benefits

Reduced water consumption. Reduced use of detergents.

Cross-media effects

None reported.

Reference literature

[134, Nordic States, 2001]

Collection of materials screened off crate washing machines

Technical description

Crate washing units can incorporate a system for collection of solids, to ensure that they are removed from the waste water, before it is sent to either the on-site, or municipal WWTP.

Achieved environmental benefits

Reduced suspended solids and BOD in the waste water.

Reference literature

[134, Nordic States, 2001]

Sealing of the crate washing machines

Technical description

Concluding remarks

The outer cabinet of the crate washing machines can be sealed to prevent leakage of water and evaporation.

Achieved environmental benefits

Reduced water consumption and consequently reduced energy consumption, for heating water.

Reference literature

{134, Nordic States, 2001}

Poultry scalding

Limitation of water loss from the scalding tank

Technical description

The total water loss from the scalding tank can be limited to less than one litre per chicken (714 l/t of chicken carcase). To limit the water loss to this level, drip trays carrying part of the water dripping from scalded chickens back to the tank can be fitted after the tank.

Achieved environmental benefits

Reduced water consumption and consequently reduced energy consumption, to heat water.

Cross-media effects

None.

Reference literature

{134, Nordic States, 2001}

De-feathering

Transport of heads and feet using a vacuum system

Technical description

Transport of feathers can be done without using water, e.g. with a vacuum system.

Achieved environmental benefits

Reduced water consumption and reduced entrainment of organic matter in water. Reduced energy consumption to remove water from the heads and feet, during rendering or in preparation for landfill.

Cross-media effects

Energy is required to operate the vacuum system.

Reference literature

{134, Nordic States, 2001}

Evisceration

Dual water supply system

Technical description

The water supply to the slaughter equipment can be separated into two systems, one for "lubricating water", which is supplied only when the conveyor system is operating and one for "process water", which is supplied only when there are chickens in the appropriate machine.

Achieved environmental benefits

Reduced water consumption.

Reference literature

[134, Nordic States, 2001]

Integrated transport and cooling of red offal from poultry slaughter

Technical description

Hearts, necks, gizzards and livers are transported with iced water to containers for collection, from the slaughter line for storage and distribution, for either human consumption or pet food, depending on the market prices. This integrated transport and cooling system means that separate chilling of these organs is not required.

Achieved environmental benefits

Reduced energy consumption, i.e. avoiding the need for additional chilling.

Example plants

At least one large Danish poultry slaughterhouse.

Reference literature

[134, Nordic States, 2001]

Reduce water flow at knife wash points

Environmental performance and operational data

For a slaughterhouse killing 18000 turkeys per day, i.e. 38 birds per minute the reported potential water saving is 12500 m³/yr with a financial saving of GBP 7800/yr. (Costs in 1999)

Reference literature

[214, AVEC, 2001]

Reduced water flow in mini-chiller

Technical description

The manual control for the flow of water through the mini-chiller places reliance on the operator to set the flow when the valve is switched on. The flowrate could be permanently set at the minimum required.

Environmental performance and operational data

For a slaughterhouse killing 18000 turkeys per day, i.e. 38 birds minute the reported potential water saving is 1800 m³/yr with a financial saving of GBP 1125/yr. (Costs in 1999)

Reference literature

[214, AVEC, 2001]

Slaughterhouse cleaning

Large tray and box washing units

Technical description

Large washing units, e.g. for large quantities of trays and boxes, can be designed to optimise washing procedure, with respect to water, detergent and energy consumption. The unit may be designed to soak, pre-wash, wash, drip-off, rinse, disinfect and dry. The water consumption per unit will increase if one or more stages are left out.

Achieved environmental benefits

Concluding remarks

Reduced consumption of water, detergent and energy to heat water.

Reference literature

{134, Nordic States, 2001}

High-pressure cleaning

Technical description

Use of high pressure cleaning at 8.11 million Pa instead of 1.82 million–2.03 million Pa has been reported to have resulted in reduced water consumption.

Achieved environmental benefits

Reduced water consumption from approximately 750 litres to 500 litres per tonne of carcase.

Example plants

A small Danish pig slaughterhouse.

Reference literature

{134, Nordic States, 2001}

Monitor contamination removal

Technical description

Monitoring the contamination removal can assist in optimising the cleaning process, e.g. by using less water and causing less chemical, physical and/or biological pollution.

Achieved environmental benefits

Reduced water consumption and less chemical, physical and/or biological pollution.

Reference literature

{346, Belgian TWG member, 2003}

Waste water treatment

Trough screen

Technical description

The waste water is led to a trough shaped vessel where the half cylinder shaped screen is kept clean by brushes rotating from the centre of the cylinder, on arms. The particles are pushed over the edge of the trough and collected in a container. The typical pore size is 2 mm. Figure shows a trough screen.

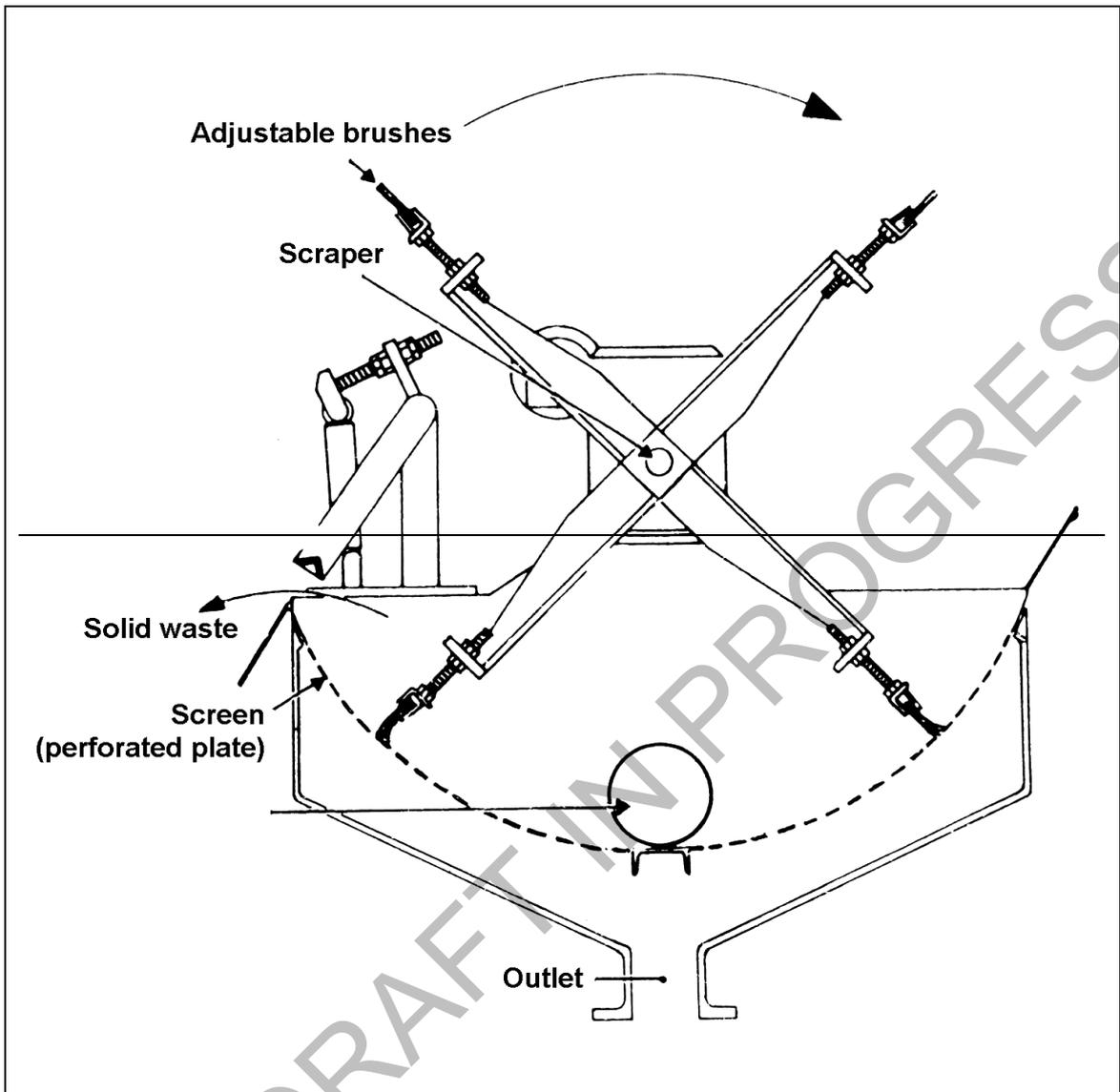


Figure 7.1: Trough screen – cross section
 [134, Nordic States, 2001]

Reference literature
 [134, Nordic States, 2001]

Rendering

Provide sufficient production capacity

Example plants

Several rendering plants in Germany.

Reference literature
 [244, Germany, 2002]

Discontinuous sterilisation using a “strainer basket boiling apparatus”

Technical description

A strainer basket boiling apparatus is a rotary cylindrical screen of mesh diameter approximately 15–18 mm, installed into a horizontal cylindrical cooker. During sterilisation, a

Concluding remarks

pulpy mass is produced, which is pressed out through the rotary screen within the cooker. Foreign matter is trapped inside the rotary screen and can be cleared from time to time.

Environmental performance and operational data

For a load of 8 tonnes, the total sterilisation time is approximately 1.0–1.5 hours.

Driving force for implementation

The technique is reported to be easily implemented at small plants.

Reference literature

[244, Germany, 2002]

Discontinuous sterilisation using a sieve disc-drier

Technical description

The sieve disc cooker is horizontally mounted and contains a stirrer. The casing and the stirring device are both heated. During sterilisation, a pulpy mass is produced, which is pressed out through the permanently installed sieve, or a sieve that rotates with the stirring device, within the cooker.

Environmental performance and operational data

The processing time for sterilisation is approximately one hour. The combination of the effects of the intensive mixing and the heated stirring device, enables cookers with capacities of up to 15 tonnes to be used.

Driving force for implementation

The technique is reported to be easily implemented at small plants.

Example plants

Several rendering plants in Germany.

Reference literature

[244, Germany, 2002]

Rendering, with periodic mixing

Technical description

Continuous driers with and without addition of fat, suspension driers, disc driers and grinder-driers can all be constructed with mixing paddles incorporated which can be operated periodically. For continuous drying, double-wall cylindrical cookers with a built-in stirrer are used. The shaft of the stirrer is heated. The material is removed from the end of the drier using a screw conveyor.

Reference literature

[244, Germany, 2002]

Rendering, with a disc drier

Technical description

The disc drier comprises a horizontal cooker with tightly packed discs, which can be heated and a stirrer.

Environmental performance and operational data

Capacities can be up to 8 tonnes per hour, if the raw material has a high fat content or 4 tonnes per hour if it has a low fat content.

Reference literature

[244, Germany, 2002]

~~Recirculation of solid residues from pre-treatment into the raw material (if there is no feed production)~~

Example plants

Several rendering plants in Germany.

Reference literature

[244, Germany, 2002]

~~Recirculation of excess sludge into the raw material (if there is no feed production)~~

Example plants

Several rendering plants in Germany.

Reference literature

[244, Germany, 2002]

~~Air-cooling of condensate, instead of water-cooling~~

Technical description

The large quantities of vapours produced during cooking and those from meal presses, can be extracted and ducted to air-cooled condensers.

Achieved environmental benefits

Reduced water consumption. Reduced water contamination because the contents of the condensate cannot be transferred into the cooling water.

Example plants

Several rendering plants in Germany.

Reference literature

[163, German TWG Members, 2001, 244, Germany, 2002]

~~Use of a decanter system~~

Technical description

The meal can be dried using a decanter system instead of a drier.

Achieved environmental benefits

The energy consumption can be halved.

Environmental performance and operational data

The energy consumption for drying can be reduced from 700–800 kWh per tonne raw materials to 350–400 kWh per tonne, depending on the type of drier.

Example plants

Several rendering plants in Germany.

Concluding remarks

Reference literature

{134, Nordic States, 2001, 244, Germany, 2002}

Centrifuge blood

Example plants

Several rendering plants in Germany.

Reference literature

{244, Germany, 2002}

Disinfection chute for vehicles and footwear

Example plants

Several rendering plants in Germany.

Reference literature

{244, Germany, 2002}

Sludge traps, settling tanks and oil/petrol separators for waste water from vehicle cleaning

Example plants

Several rendering plants in Germany.

Reference literature

{244, Germany, 2002}

Grease traps and oil traps (DIN 4040)

Example plants

Several rendering plants in Germany.

Reference literature

{244, Germany, 2002}

Cover all tanks to enable air treatment

Example plants

One rendering plant in Germany.

Reference literature

{244, Germany, 2002}

Enclosure of WWTP balance tanks and ducting air stream to odour treatment

Reference literature

{163, German TWG Members, 2001}

Dosing of nutrients, acids and alkalis

Example plants

Two rendering plants in Germany.

Reference literature

[244, Germany, 2002]

Thermal disinfection of cleaning water – dedicated water heating unit**Technical description**

The cleaning water from the raw material delivery storage and handling vehicles and equipment can be thermally disinfected. It is heated to 100 °C, for at least 30 minutes. The thermal treatment is generally done in batches.

Prior to thermal treatment the solids are frequently separated using sedimentation tanks, sieves and fat separators with sludge catchers, or by flotation plants.

Example plants

Several German rendering plants.

Reference literature

[163, German TWG Members, 2001] [52, Germany 2001], [244, Germany, 2002] [110, Germany 2002]

Neutralisation tanks**Technical description**

Neutralisation stages can be provided as part of the waste water treatment process, e.g. when high pH values result from ammonia stripping or extremely low pH values result from ammonia conversion. The case for neutralisation needs to be carefully considered because it causes salinisation, which can be problematic to the WWTP.

Environmental performance and operational data

At an example rendering plant the neutralisation process using 31 % hydrochloric acid leads to an increase in conductivity of 17 to 33 %. The pH value of the effluent was approximately 10 at the inflow and 7.5 at the outflow.

Example plants

Two German rendering plants.

Reference literature

[244, Germany, 2002]

Fishmeal and fish oil production**Vacuum unloading of fish from fishing vessels****Technical description**

Fish can be unloaded using a vacuum instead of air or water.

Achieved environmental benefits

Reduced air and water contamination and odour, all of which have to be treated afterwards.

Technical considerations relevant to applicability

The lay out of the vessels has to be suitable, so it may be difficult to apply where old unsuitable fishing fleets are in use.

Product loss audit and control

Technical description

Reduction of product loss, with a reduction in the emissions from production, demands a knowledge of how and when the product loss occurs and the size of the loss in the different sections of the process. For pollution reduction through investments in cleaner technologies, it is an absolute necessity to relate product loss, and thereby pollution, to the relevant process equipment.

Achieved environmental benefits

Reduced emissions to water.

Reference literature

[155, Nordic Council of Ministers, 1997]

Controlled cooking – preventing over-boiling

Achieved environmental benefits

Reduced phosphorus emissions.

Reference literature

[155, Nordic Council of Ministers, 1997]

Indirect cooling of vapour from production of evaporated stickwater, using seawater

Technical description

Instead of following the common practice of spraying seawater into the vapour air mix to cool it, the vapour can be indirectly cooled using seawater. The condensed vapour is then treated in a WWTP and heat is recovered from the seawater.

Achieved environmental benefits

Avoiding contamination of seawater and the subsequent treatment it requires, or pollution it causes.

Cross-media effects

High energy consumption to pump seawater.

Vacuum drying at 65 °C

Achieved environmental benefits

Re-use of heat from the meal drying process.

Economics

The fishmeal produced from vacuum drying is of a higher quality than that from traditional drying and it can be sold for 10 % more.

Reference literature

[213, Nielsen E.W., 2001]

Drying by heating

Technical description

The capacity of traditional drying equipment is greater than that for the equivalent vacuum drying equipment.

Stripping plant to remove volatile nitrogen from water

Reference literature

[213, Nielsen E.W., 2001]

Use of a decanter instead of a press and decanter

Technical description

A large decanter can be used instead of a press and decanter, to produce the press cake and grax.

Control of suction on the drier

Achieved environmental benefits

Odour reduction.

Reference literature

[155, Nordic Council of Ministers, 1997]

High-pressure removal of burned products instead of using NaOH

Achieved environmental benefits

Reduced nitrogen levels in waste water.

Cross-media effects

Increased use of water.

Reference literature

[155, Nordic Council of Ministers, 1997]

Waste water treatment of certain fractions of the impure condensate

Achieved environmental benefits

Reduced seawater contamination.

Reference literature

[155, Nordic Council of Ministers, 1997]

Blood processing

Back venting of tankers during unloading

Technical description

An activated charcoal filter can be provided.

Achieved environmental benefits

Odour reduction

Gelatine manufacturing

Neutralisation of acid waste waters by alkaline waste waters

Technical description

The washings from liming pits contain lime and can be used to neutralise the acid used in other parts of the process, e.g. during demineralisation.

Achieved environmental benefits

The washings can be used instead of caustic, which would have to be acquired for the purpose.

Economics

An example plant reported a 2-year payback time.

Example plants

A gelatine manufacturing plant in the UK.

Re-use of heat from evaporators

Technical description

Hot water from evaporators in gelatine production can be used to heat driers and the condensate can be used to manufacture steam.

Achieved environmental benefits

Reduced energy use.

Driving force for implementation

Reduced energy consumption and consequent reduced financial cost.

Example plants

A gelatine manufacturing plant.

Incineration

Initial cleaning of vehicles and equipment, by dry vacuuming

Technical considerations relevant to applicability

Applicable to animal meal delivery.

Reference literature

[82, EA, 1998]

Monitoring amino compounds in salt fractions recovered in wash-water

Reference literature

[164, Nottrodt A., 2001]

Burning of tallow

Back-venting of tankers during unloading

Achieved environmental benefits

Odour reduction.

Composting

~~In-vessel composting of animal by-products~~

~~Technical description~~

~~Achieved environmental benefits~~

~~In-vessel systems potentially provide optimal conditions for odour control, as they are enclosed systems and also offer a higher degree of process control than open systems.~~

~~Reference literature~~

~~{210, Environment Agency, 2001}~~

~~Use of a high carbon source to prevent pungent ammonia odours~~

~~Technical description~~

~~Adding a high carbon source, such as co-composting with a paper sludge can combat any pungent NH₃-odours.~~

~~Reference literature~~

~~{210, Environment Agency, 2001}~~

~~Avoiding dusty activities on windy days~~

~~Technical description~~

~~Formation or turning of windrows or piles, screening and shredding will cause dust problem if the natural is dry and there are windy weather/climate conditions.~~

~~Reference literature~~

~~{210, Environment Agency, 2001}~~

Integrated same-site activities

Combining gasification of MBM with thermal oxidation on a rendering site

~~Achieved environmental benefits~~

~~Reduction of odour from the rendering process, including removal of strong odours produced from non-condensable gases and process room odours. Re-use of heat to produce steam for use in the rendering process and the consequent reduction in fossil fuel use. Reduced fossil fuel usage to transport the MBM to another site for destruction. The high gasification temperatures produces a clean dust free fuel, for which passing through a cyclone is sufficient for purification prior to thermal oxidation.~~

~~Environmental performance and operational data~~

~~The suppliers of gasification equipment report the following efficiency, for a 6 MW thermal gasification plant.~~

~~Fuel data~~

~~MBM lower heating value — 3000 kcal/kg = 12.552 MJ/kg~~

~~MBM flowrate — 1720 kg/h = 0.478 kg/s~~

~~Power_{thermal} = 12.552 x 0.478 ~ 6000 kW~~

~~Syngas data~~

~~Syngas lower heating value — 1100 kcal/kg = 4.602 MJ/kg~~

~~Syngas flowrate — 3086 kg/h = 0.857 kg/s~~

~~Power_{thermal} = 4.602 x 0.857 ~ 3944 kW (3947 kW quoted)~~

Concluding remarks

Assuming a thermal efficiency of 92 % an the resultant $\text{Power}_{\text{effective}} = 92 \% \text{ of } 3944 = 3628 \text{ kW}$ (3632 kW quoted)

Boiler data

Assuming a thermal efficiency of 90 % they calculate a $\text{Power}_{\text{thermal global}} = 3268/3944 = 83 \%$.

Reference literature

[196, Therma CCT, 2000]

The EC is launching and supporting, through its RTD programmes, a series of projects dealing with clean technologies, emerging effluent treatment and recycling technologies and management strategies. Potentially these projects could provide a useful contribution to future BREF reviews. Readers are therefore invited to inform the EIPPCB of any research results which are relevant to the scope of this document (see also the preface of this document).

WORKING DRAFT IN PROGRESS

8 ANNEX I: SA DATA COLLECTION

8.1 The data collection process

The SA data collection process followed the decisions taken at the kick-off meeting for the review of the SA BREF and consisted of the following steps:

- starting from 28 January 2020, the questionnaire template was distributed to the installations taking part in the data collection;
- the installations filled in the questionnaire;
- the Member States' representatives checked the quality and the completeness of the filled-in questionnaires;
- until 30 June 2020, TWG members posted the filled-in questionnaires on BATIS;
- several data updates were provided by Member States' representatives during the SA BREF review.

Data from the filled-in questionnaires were extracted using an Excel macro and compiled into a general data file. The general data file was loaded onto Qlik Sense to create different data visualisation sets. Additional Qlik data cleaning operations were implemented to render the format of the data reported adequate.

8.2 Distribution of SA installations

A total of 207 filled-in questionnaires were submitted, by installations located in 14 Member States (MS) and 1 EEA country. The distribution of SA installations by country is shown in Figure 8.1.

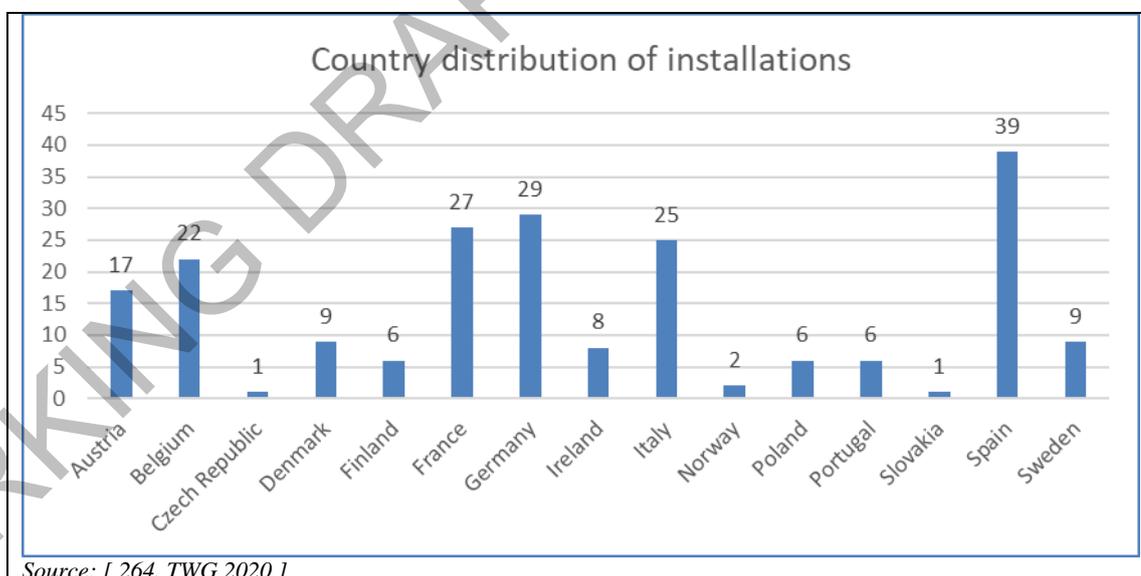


Figure 8.1: Country distribution of the participating SA installations

Figure 8.2 shows the number of SA installations by type of IED activities carried out.

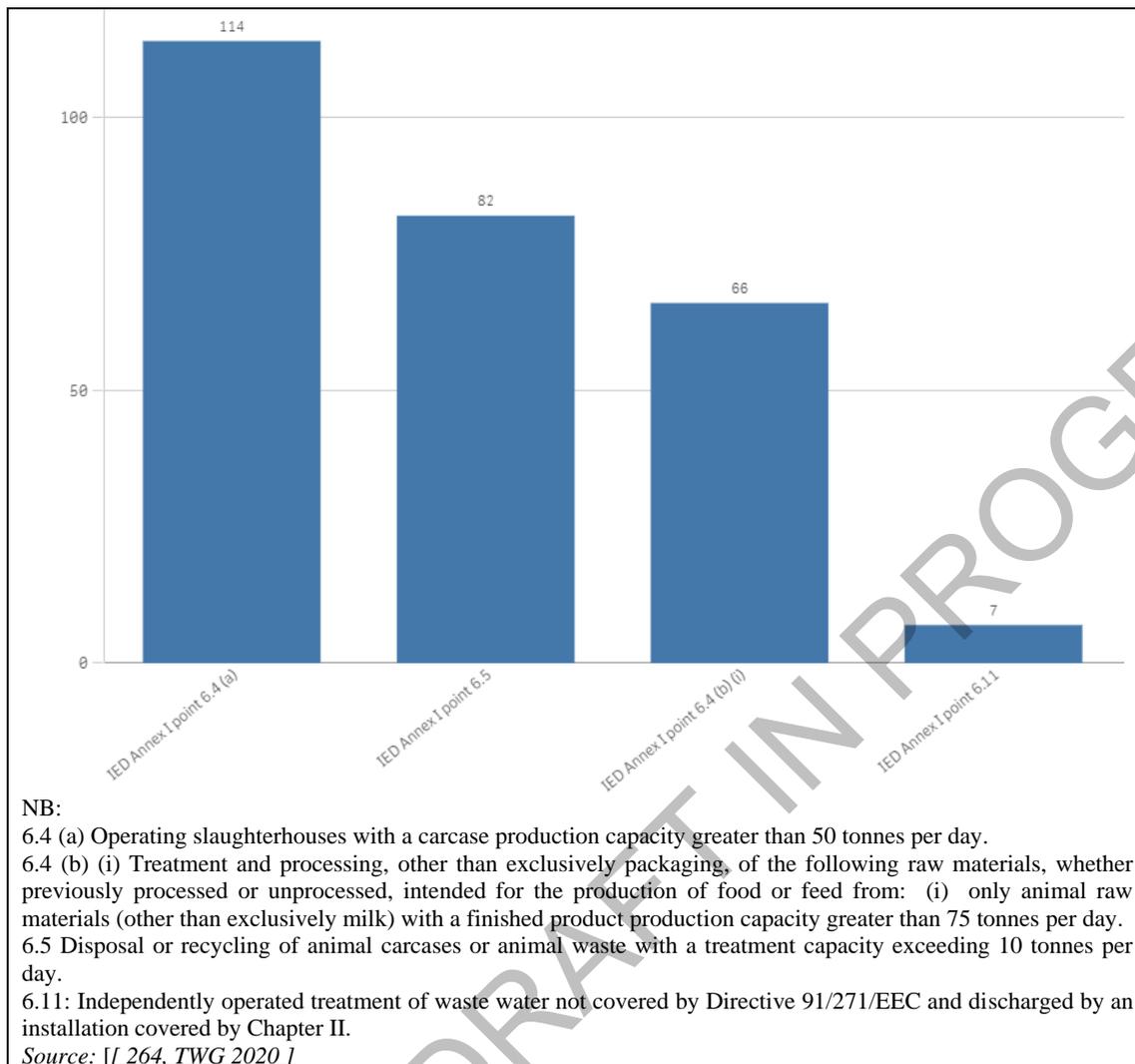
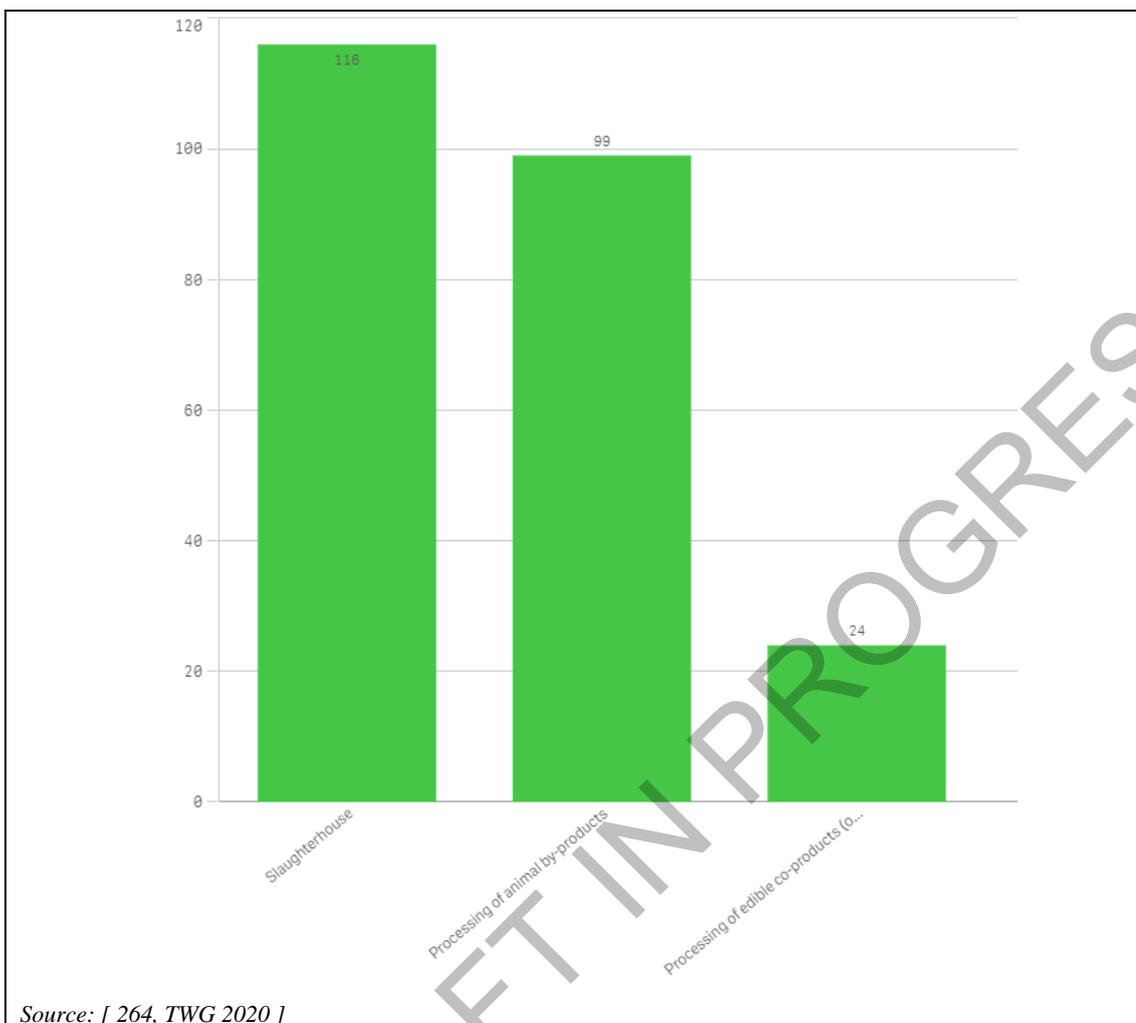


Figure 8.2: Number of SA installations by type of IED activities carried out

The processes carried out at the participating installations are shown in Figure 8.3. The types of activities processing animal by-products and/or edible co-products are shown in Figure 8.4.



Source: [264, TWG 2020]

Figure 8.3: Different types of processes

Out of 116 slaughterhouses, 34 also perform activities processing animal by-products and/or edible co-products.

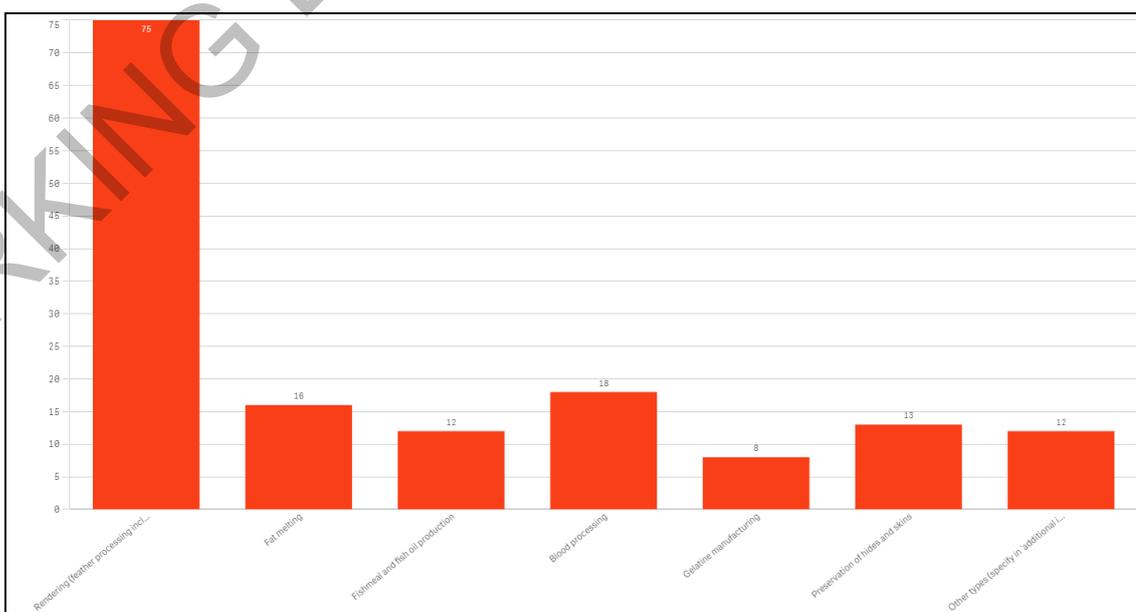


Figure 8.4: Distribution by type of activities processing animal by-products and/or edible co-products

8.3 List of installations that participated in the SA data collection

Country	Code	Installation / Site name	Town	Main sector	Type(s) of slaughtered animal (in the case of a slaughterhouse)	Type of animal by-product and/or edible co-product processing installation	Raw materials (for installations processing animal by-products and/or edible co-products)
AT	AT001	Titz Geflügelschlachthof GmbH	Rohr an der Raab	Slaughterhouse	Chickens		
AT	AT002	Norbert Marcher GmbH - Graz	Graz	Slaughterhouse + Installation processing animal by-products and/or edible co-products	Pigs; cattle	Other (specify in comments column)	Animal fat
AT	AT003	Fleischhof Raabtal GmbH	Kirchberg an der Raab	Slaughterhouse	Pigs; cattle		
AT	AT004	Steirerfleisch GmbH	Wolfsberg	Slaughterhouse	Pigs		
AT	AT005	Scheucher Fleisch GmbH	Jagerberg	Slaughterhouse	Pigs; cattle		
AT	AT006	Higelsberger GmbH	Schwertberg	Slaughterhouse	Pigs		
AT	AT007	Hubers Landhendl GmbH	Pfaffstätten	Slaughterhouse	Chickens		

Country	Code	Installation / Site name	Town	Main sector	Type(s) of slaughtered animal (in the case of a slaughterhouse)	Type of animal by-product and/or edible co-product processing installation	Raw materials (for installations processing animal by-products and/or edible co-products)
AT	AT008	Alpenrind GmbH	Salzburg	Slaughterhouse	Cattle		
AT	AT009	Rudolf Großfurtner GmbH - Utzenaich	Utzenaich	Slaughterhouse	Cattle		
AT	AT010	Rudolf Großfurtner GmbH - St.Martin	St.Martin	Slaughterhouse	Pigs		
AT	AT011	Herbert Handlbauer GmbH	Linz	Slaughterhouse	Cattle		
AT	AT012	IBOSCHWEIN Vertriebs GmbH	Ried im Traunkreis	Slaughterhouse	Pigs		
AT	AT013	SARIA Bio-Industries GmbH	Tulln	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	
AT	AT014	TKV Oberösterreich GmbH	Regau	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	
AT	AT015	Burgenländische Tierkörperverwertungs GmbH	Unterfrauenhaid	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	

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AT	AT016	Steirische Tierkörperverwertungsgesellschaft m.b.H & CoKG	Gabersdorf	Installation processing animal by-products and/or edible co-products		Other (specify in comments column)	
AT	AT017	Boxmark Leather GmbH & Co KG	Jennersdorf	Installation processing animal by-products and/or edible co-products		Other (specify in comments column)	
BE	BE018	Slachthuis Geel (group Sopraco)	Geel	Slaughterhouse	Pigs and calves		
BE	BE019	Comeco (Common Market Meat Company)	Hoogstraten	Slaughterhouse	Pigs		
BE	BE020	Klaasen & co	Ravels	Slaughterhouse + Installation processing animal by-products and/or edible co-products	Poultry	Rendering and fat melting	Cat. 2 & 3 (also blood and feathers)
BE	BE022	Slachthuis Vanlommel	Olen	Slaughterhouse	Cattle		
BE	BE023	Oleki	Olen	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 2 & 3 (also blood and feathers)

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BE	BE024	Wilki	Ravels	Slaughterhouse	Poultry		
BE	BE025	Cominbel	Sint-Lievens-Houtem	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 2 & 3
BE	BE026	Porc Meat Zele	Zele	Slaughterhouse	Pigs		
BE	BE027	Rendac (installation 934 & 1660)	Denderleeuw	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 1, 2, 3 (also blood and feathers)
BE	BE029	Exportslachthuis Tielt/Debra-Freeze/Debrameat	Tielt	Slaughterhouse	Pigs		
BE	BE030	Exportslachthuis De Coster	Ruiselede	Slaughterhouse	Pigs		
BE	BE031	Fapro	Ichtegem	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 3
BE	BE032	Sonac Gent	Gent	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 3

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BE	BE033	Van-O-Bel	Waregem	Slaughterhouse	Poultry		
BE	BE034	Progra	Hulshout	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 3
BE	BE035	Gerard Van Landschoot & Zonen	Maldegem	Slaughterhouse	Pigs		
BE	BE036	M. Ryckaert	Eeklo	Slaughterhouse	Cattle and pigs		
BE	BE038	Rousselot	Gent	Installation processing animal by-products and/or edible co-products		Gelatine manufacturing	Pig skins
BE	BE039	Tessenderlo Chemie / BP Leiner	Tessenderlo	Installation processing animal by-products and/or edible co-products		Gelatine manufacturing	
BE	BE040	WZI Olen	Olen			Other (specify in comments column)	

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BE	BE044	Lovenfosse sa	Aubel	Slaughterhouse	Pigs		
BE	BE045	Plukon Mouscron sa	Mouscron	Slaughterhouse	Poultry		
DE	DE047	Emsland Frischgeflügel GmbH	Haren	Slaughterhouse	Chickens		
DE	DE048	Celler Land Frischgeflügel GmbH & Co KG	Wietze	Slaughterhouse	Chickens		
DE	DE049	Tönnies Unternehmensgruppe	Rheda-Wiedenbrück	Slaughterhouse	Pigs		
DE	DE050	Tönnies Unternehmensgruppe	Wilhelmshaven	Slaughterhouse	Cattle		
DE	DE051	Danish Crown Fleisch GmbH	Essen (oldenburg)	Slaughterhouse	Pigs		

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DE	DE057	Vion Food Gruppe	Bad Bramstedt	Slaughterhouse	Cattle		
DE	DE058	Vion Food Gruppe	Perleberg	Slaughterhouse	Pigs		
DE	DE059	Müller Fleisch GmbH	Birkenfeld	Slaughterhouse	Cattle		
DE	DE061	Westfleisch SCE mbH	Bakum (Oldenburg)	Slaughterhouse	Cattle		
DE	DE062	Westfleisch SCE mbH	Lübbecke	Slaughterhouse	Cattle		
DE	DE063	Westfleisch SCE mbH	Gelsenkirchen	Slaughterhouse	Pigs		
DE	DE064	Westfleisch SCE mbH	Coesfeld	Slaughterhouse	Pigs		
DE	DE065	Oldenburger Fleischmehlfabrik GmbH	Friesoythe-Kampe	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Multiple input

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DE	DE066	Gustav Denzin GmbH	Viersen	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 1
DE	DE067	Sonac Mering GmbH	Mering	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Multiple input
DE	DE068	Sonac Brünen GmbH	Haminkeln	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Blood
DE	DE069	ZTS Plattling	Plattling	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 1
DE	DE071	Bioceval GmbH & Co. KG	Cuxhaven	Installation processing animal by-products and/or edible co-products		Fishmeal and fish oil production	Fish
DE	DE072	Berndt GmbH	Oberding	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 3
DE	DE073	Berndt GmbH	Waldkraiburg	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 1

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DE	DE074	TBA Kraftisried GmbH	Kraftisried	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 1
DE	DE075	SecAnim Südwest GmbH	Lampertheim	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 1
DE	DE076	Ten Kate GmbH	Sögel	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 3
DE	DE077	Zweckverband Tierkörperbeseitigung Nordbayern	Bamberg	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 1
DE	DE078	VTN Gunzenhausen	Gunzenhausen	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 1
DE	DE079	Sonac Versmold GmbH	Versmold	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Fat
DE	DE080	Gelita AG	Memmingen	Installation processing animal by-products and/or edible co-products		Gelatine manufacturing	Bones

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DE	DE082	Schlachtzentrum Nordfriesland	Husum	Slaughterhouse	Primarily cattle		
DE	DE084	PB Leiner Germany	Nienburg	Installation processing animal by-products and/or edible co-products		Gelatine manufacturing	Bovine hide
DK	DK085	Farmfood A/S	Loegstoer	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Waste from chicken slaughterhouses and rearing of chickens
DK	DK086	Daka Sarval	Loesning	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 3 pork, bristles, blood products
DK	DK087	Daka SecAnim	Randers	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 1, Cat. 2 mixed. Both from slaughterhouses and fallen stock
DK	DK088	Danish Crown Blans	Blans	Slaughterhouse	Pigs		

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DK	DK089	Danish Crown Horsens	Horsens	Slaughterhouse	Pigs		
DK	DK090	Danish Crown Holsted	Holsted	Slaughterhouse	Cattle		
DK	DK091	TripleNine Fish Protein A/S	Thyboroen	Installation processing animal by-products and/or edible co-products		Fishmeal and fish oil production	Fresh fish Offcuts from production of fish products
DK	DK092	FF Skagen	Skagen	Installation processing animal by-products and/or edible co-products		Fishmeal and fish oil production	Fresh fish Offcuts from production of fish products
DK	DK093	HKScan Denmark A/S	Vinderup	Slaughterhouse	Poultry/chickens		
ES	ES095	Complejo industrial Mataderos Industriales Soler, S.A. (PROLONGO) y Frigoríficos Andaluces de Conservas de Carne, S.A. (FACCSA)	Andalucía. Cártama (Málaga)	Slaughterhouse	Pigs		

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ES	ES097	Sánchez Romero Carvajal Jabugo S.A	Andalucía. Jabugo (Huelva)	Slaughterhouse	Pigs		
ES	ES100	Matadero Fribin - Binéfar	Aragón. Binéfar (Huesca)	Slaughterhouse	Pigs, bovine		
ES	ES102	Carnes Selectas 2000 S.A.	Castilla y León. Burgos	Slaughterhouse	Pigs		
ES	ES103	Eurocentro de Carnes	Castilla-La Mancha. La Puebla de Montalbán (Toledo)	Slaughterhouse	Pigs		
ES	ES104	Industrias cárnicas Loriente Piqueras (INCARLOPSA)	Castilla-La Mancha. Tarancón (Cuenca)	Slaughterhouse	Pigs		
ES	ES105	FRIMANCHA Industrias cárnicas	Castilla-La Mancha. Valdepeñas (Ciudad Real)	Slaughterhouse	Bovine, pigs	Rendering and fat melting	Cat. 1

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ES	ES107	MAFRICA - Matadero frigorífico del Cardoner	Cataluña. Sant Joan de Vilatorrada (Barcelona)	Slaughterhouse + Installation processing animal by-products and/or edible co-products	Pigs, Veal, Lambs	Other (specify in comments column)	Cat. 3
ES	ES108	PATEL, SAU	Cataluña. L'Esquirol (Barcelona)	Slaughterhouse	Pigs		
ES	ES109	Viñals Soler S.L.	Cataluña. Argentona (Barcelona)	Slaughterhouse	Bovine, ovine		
ES	ES110	FRISELVA, SA	Cataluña. Riudellots de la Selva (Girona)	Slaughterhouse + Installation processing animal by-products and/or edible co-products	Pigs	Rendering and fat melting	Cat. 3
ES	ES111	OLOT MEATS, S.A.	Cataluña. Olot (Gerona)	Slaughterhouse + Installation processing animal by-products and/or edible co-products	Pigs	Other (specify in comments column)	
ES	ES112	EDAR OLOT	Cataluña. Olot (Gerona)				
ES	ES114	Le Porc Gourmet SAU	Cataluña. Santa Eugenia de Berga (Barcelona)	Slaughterhouse + Installation processing animal by-products and/or edible co-products	Pigs	Rendering and fat melting	Cat. 3

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ES	ES115	Matadero de Sabadell	Cataluña. Sabadell	Slaughterhouse + Installation processing animal by-products and/or edible co-products	Bovine, ovine	Other (specify in comments column)	
ES	ES116	Escorxador Frigorífic D'Osona	Cataluña. Vic (Barcelona)	Slaughterhouse	Pigs		
ES	ES117	Elaborados cárnicos Medina S.A.	C. Valenciana. Buñol (Valencia)	Slaughterhouse	Bovine		
ES	ES119	El Pozo Alimentación	Murcia (Región de). Alhama de Murcia (Murcia)	Slaughterhouse	Pigs		
ES	ES120	PROTECA - Protectora de carnes	Navarra (C. Foral). Pamplona	Slaughterhouse	Bovine, horse, ovine		
ES	ES121	Harinas de Andalucía S.A.	Andalucía. Tarifa (Cádiz)	Installation processing animal by-products and/or edible co-products		Fishmeal and fish oil production	Fish

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ES	ES122	SECANIM BIO-INDUSTRIES, S.A.U.- (SAN MARTÍN Y MUDRIAN)	Castilla y León. San Martín y San Mudrián (Segovia)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 1 and Cat. 3
ES	ES123	SARVAL BIO-INDUSTRIES, S.L.U (SAN MARTIN Y MUDRIAN)	Castilla y León. San Martín y San Mudrián (Segovia)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 3: Poultry line Feather line
ES	ES124	GRAINTO S.L.	Castilla-La Mancha. Portillo de Toledo (Toledo)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 3
ES	ES125	SARVAL BIO-INDUSTRIES S.L.U.- ST. ESTEVE (LA VALL D'EN BAS)	Cataluña. La Vall D'en Bas (Gerona)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 3: Poultry line, Mammals, ruminants & not ruminant. Line Feather-hair)
ES	ES126	SECANIM BIO-INDUSTRIES SAU - TERMENS	Cataluña. Tèrmens (Lérida)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 1 and Cat. 2
ES	ES127	SARVAL BIO-INDUSTRIES S.L.U.- BEGUDÁ (SANT JOAN LES FONTS)	Cataluña. Sant Joan les Fonts (Gerona)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 3 (Poultry line & Pork line)

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ES	ES128	APC EUROPE SLU	Cataluña. Granollers (Barcelona)	Installation processing animal by-products and/or edible co-products		Blood processing	Blood from pigs, cattle and chickens
ES	ES129	AVIFOOD S.L.U.	Cataluña. Santa Bàrbara (Tarragona)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 3 (Poultry line; Feather line; Blood line)
ES	ES130	SARVAL BIO-INDUSTRIES S.L.U. - ALMASSORA	C. Valenciana. Almazora (Castellón)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 3 Line Poultry, Mammals, ruminants & not ruminant
ES	ES131	SELEV PET INDUSTRY, S.L.	C. Valenciana. Silla (Valencia)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 3 Line Poultry, Mammals, ruminants & not ruminant
ES	ES132	SARVAL BIO-INDUSTRIES NOROESTE, S.A.U	Galicia. Arteixo (La Coruña)	Installation processing animal by-products and/or edible co-products		Fishmeal and fish oil production	Fish by-products. Meat by-products.
ES	ES133	Conserveros reunidos	Galicia. Ribeira (La Coruña)	Installation processing animal by-products and/or edible co-products		Fishmeal and fish oil production	Fish by-products
ES	ES134	Auxiliar Conservera SA	Galicia. Ribeira (La Coruña)	Installation processing animal by-products and/or edible co-products		Fishmeal and fish oil production	Fish by-products

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ES	ES135	SARVAL BIO-INDUSTRIES S.L.U.-(ARGANDA DEL REY)	Madrid (Comunidad de). Arganda del Rey	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 3
ES	ES136	SARVAL BIO-INDUSTRIES S.L.U. - HUMANES DE MADRID	Madrid (Comunidad de). Humanes de Madrid	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat.3 Pork line
ES	ES137	COPRESA - Comercial de Productos Recuperados S.A.	Murcia (Región de). Lorca	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	
ES	ES139	GESUGA	Galicia. Cerceda (A Coruña)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 1 and Cat. 3
ES	ES140	SAMI - Leridana de piensos	Cataluña. Vallfogona de Balaguer (Lérida)	Slaughterhouse	Pigs		
ES	ES141	Frigorífics Costa Brava	Cataluña. Riudellots de la Selva (Gerona)	Installation processing animal by-products and/or edible co-products	Pigs	Rendering and fat melting	Cat. 3
FI	FI142	Oravainen destruction plant	Oravainen	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 2, specialised in fur animal carcasses, also other species

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FI	FI143	Honkajoki	Honkajoki	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Cat. 1-3, several separate lines
FI	FI144	Nurmo factory	Seinäjoki	Slaughterhouse	Pigs, poultry		
FI	FI145	Forssa factory	Forssa	Slaughterhouse	Pigs		
FI	FI146	Pietarsaari factory	Pietarsaari	Slaughterhouse	Pigs, cows		
FI	FI147		Säkylä	Slaughterhouse	Poultry		
IE	IE149	Pelagia Feed Ltd. (P0416-04)	Killybegs, Donegal	Installation processing animal by-products and/or edible co-products	Fish	Fishmeal and fish oil production	Fishmeal and Fish oil

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IE	IE150	ABP Cahir (P0039-02)	Cahir Co Tipperary	Slaughterhouse	Beef	Other (specify in comments column)	
IE	IE151	ICM Camolin (P0177-03)	Camolin Co Wexford	Slaughterhouse	Sheep	Other (specify in comments column)	
IE	IE152	ABP Bandon (P0188-02)	Bandon Co Cork	Slaughterhouse	Beef	Other (specify in comments column)	
IE	IE153	Kepak Athleague (P0168-01)	Athleague	Slaughterhouse	Sheep and Cattle		
IE	IE154	Donegal Meat Processors (P0187-03)	Carrigans, Donegal	Slaughterhouse	Cattle/Animal By-Product waste, Category 1 SRM, bones etc. Category 2 sludge/paunch. Category 3 pet food by-products, blood etc. Plus 5th quarter offals.		
IE	IE156	Dawn Meats Ireland Unlimited Company (P0173-02)	Charleville	Slaughterhouse	Beef		

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IE	IE157	Dawn Pork and Bacon (P1075-02)	Grannagh	Slaughterhouse	Pigs	Other (specify in comments column)	
IT	IT158	AGRICOLA TRE VALLI	San Martino Buon Albergo (VR)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Poultry animal by-products Cat. 3 (meat and blood)
IT	IT159	AGRICOLA TRE VALLI	Verona (VR)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Eggshell
IT	IT160	AGRICOLA TRE VALLI	Castegnero (VI)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Poultry animal by-products Cat. 3 (meat and blood)
IT	IT161	SALGAIM	Campagna Lupia (VE)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Animal by-products of Category 3
IT	IT162	SALGAIM	Tezze sul Brenta (VI)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Poultry animal by-products (feathers, animal hair, meat)

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IT	IT163	GRENA	San Bonifacio (VR)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Animal by-products (meat, bones, blood). Category 2
IT	IT164	ECB	Sorgà (VR)	Installation processing animal by-products and/or edible co-products		Feather processing	Poultry animal by-products Category 3 (blood and feathers)
IT	IT165	AL VENTO	Verona (VR)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Animal by-products of Category 3
IT	IT166	KEMIN NUTRISURANCE	Veronella (VR)	Installation processing animal by-products and/or edible co-products			Animal by-products
IT	IT167	SOLAR	Padova (PD)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Animal by-products Category 1, 2, 3. Category 2
IT	IT168	SAPI S.p.A.	Castelnuovo Rangone (MO)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Animal by-products of Category 3
IT	IT169	SAPI S.p.A.	San Martino in Rio (RE)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Animal by-products of Category 2

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IT	IT170	Dusty Rendering srl	Polesine Zibello (PR)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Animal by-products of Category 1
IT	IT171	FARM SERVICE S.R.L.	Reggio nell'Emilia (RE)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Animal by-products Category 3
IT	IT172	CLAI Soc. Coop. Agricola	Faenza (RA)	Slaughterhouse	Pigs and cattle		-
IT	IT173	AVI.COOP	Cesena (FC)	Slaughterhouse	Poultry		-
IT	IT174	POLLO DEL CAMPO	Santa Sofia (FC)	Slaughterhouse	Poultry		-
IT	IT176	ALBERIO SPA	Cirimido (CO)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Animal by-products Category 3
IT	IT177	ECO RENDERING SRL	Fenegrò (CO)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Animal by-products of Category 1

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IT	IT178	Inalca S.p.a.	Ospedaletto Lodigiano (LO)	Slaughterhouse			
SE	SE180	KLS Ugglarps Hörby	Hörby	Slaughterhouse	Cattle, pigs, sheep		
SE	SE181	KLS Ugglarps Kalmar	Kalmar	Slaughterhouse	Cattle, pigs, sheep		
SE	SE182	HKScan Sweden AB Kristianstad	Kristianstad	Slaughterhouse	Pigs		
SE	SE183	HKScan Sweden AB Linköping	Linköping	Slaughterhouse	Beef and lamb		
SE	SE184	Skövde Slakteri AB	Skövde	Slaughterhouse	Cattle and pigs		

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SE	SE185	Dahlbergs slakteri	Brålanda	Slaughterhouse	Beef and Pig		
SE	SE186	Gotlands slagteri	Visby	Slaughterhouse	Beef, Pig, Lamb		
SE	SE189	Konvex, Mosserud	Karlskoga	Installation processing animal by-products and/or edible co-products		Other (specify in comments column)	
SE	SE190	GELITA Sweden AB	Klippan	Installation processing animal by-products and/or edible co-products		Gelatine manufacturing	Pigskin
SK	SK192	GeLiMa, a.s	Liptovsky Mikulas	Installation processing animal by-products and/or edible co-products		Gelatine manufacturing	Fish skin
FR	FR228	Rousselot ISS	Isle sur la Sorgue	Installation processing animal by-products and/or edible co-products		Gelatine manufacturing	Bones

Annexes

Country	Code	Installation / Site name	Town	Main sector	Type(s) of slaughtered animal (in the case of a slaughterhouse)	Type of animal by-product and/or edible co-product processing installation	Raw materials (for installations processing animal by-products and/or edible co-products)
FR	FR229	Gelatines Weishardt	Graulhet	Installation processing animal by-products and/or edible co-products		Gelatine manufacturing	Pig skins
FR	FR231	Socopa viandes	Villefranche d'Allier	Slaughterhouse	Cattle		
FR	FR232	sicarev	Roanne	Slaughterhouse	Cattle		
FR	FR233	LDC Bourgogne	Branges	Slaughterhouse	Poultry		
FR	FR234	KERVALIS Armor	Trémourel	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Fat
FR	FR235	SECANIM Bretagne	Plouvara	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	
FR	FR236	KERVALIS	Vitré	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	
FR	FR237	LDC Keranna	Guiscriff	Slaughterhouse	Poultry		

Country	Code	Installation / Site name	Town	Main sector	Type(s) of slaughtered animal (in the case of a slaughterhouse)	Type of animal by-product and/or edible co-product processing installation	Raw materials (for installations processing animal by-products and/or edible co-products)
FR	FR238	LDC Celvia	Saint Jean Brévelay	Slaughterhouse	Poultry		
FR	FR239	Procanar	Lauzarch	Slaughterhouse	Poultry		
FR	FR240	SNV Volabraye	Savigny-sur-Braye	Slaughterhouse	Poultry		
FR	FR241	SOLEVAL France	Charny sur Meuse	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	
FR	FR242	Charal Metz	Metz	Slaughterhouse	Cattle		
FR	FR243	ATEMAX France	Vénérolles	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	
FR	FR244	Bigard formerie	Formerie	Slaughterhouse	Cattle		
FR	FR245	COPALIS	Le Portel	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	
FR	FR246	ATEMAX France	Saint Langis les Mortagne	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	

Country	Code	Installation / Site name	Town	Main sector	Type(s) of slaughtered animal (in the case of a slaughterhouse)	Type of animal by-product and/or edible co-product processing installation	Raw materials (for installations processing animal by-products and/or edible co-products)
FR	FR247	LDC Aquitaine	Bazas	Slaughterhouse	Poultry		
FR	FR248	ATEMAX France	Le Passage d'Agen	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	
FR	FR249	Somafer	Bessines-sur-Gartempe	Slaughterhouse	Cattle		
FR	FR250	SOLEVAL France	Auterive	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	
FR	FR252	Charal Cholet	Cholet	Slaughterhouse	Cattle		
FR	FR253	Socopa	Evron	Slaughterhouse	Pigs		
FR	FR254	Arrive	Essarts-en Bocage	Slaughterhouse	Poultry		
FR	FR255	Cooperl	Montfort-sur-Meu	Slaughterhouse	Pigs		
FR	FR256	Tendriade	Chateaubourg	Slaughterhouse	Calves		

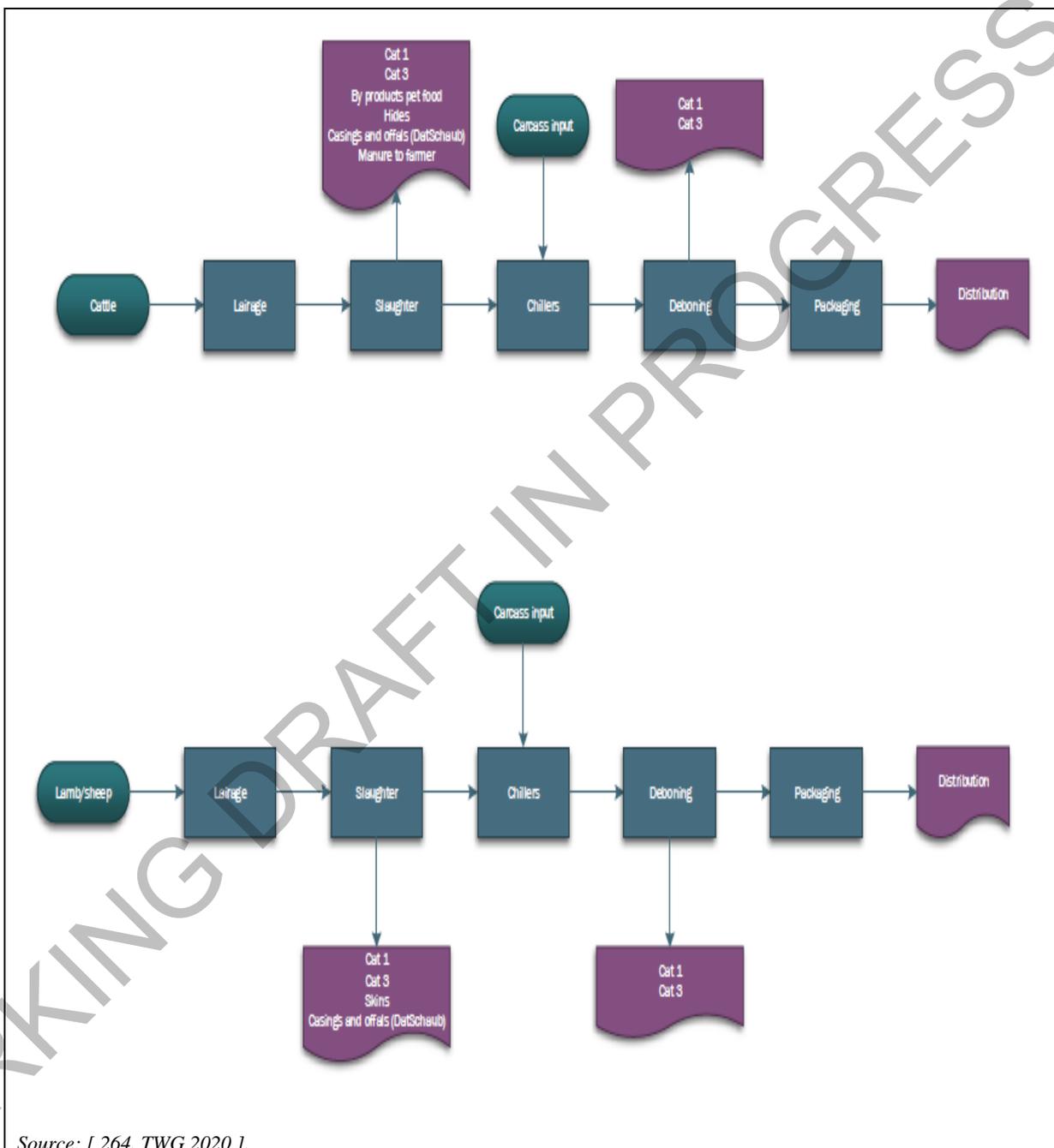
Country	Code	Installation / Site name	Town	Main sector	Type(s) of slaughtered animal (in the case of a slaughterhouse)	Type of animal by-product and/or edible co-product processing installation	Raw materials (for installations processing animal by-products and/or edible co-products)
IT	IT262	Diusa Rendering S.r.l.	Fombio (LO)	Installation processing animal by-products and/or edible co-products		Rendering and fat melting	Animal by-products of Category 3
IT	IT263	C.A.R.N.J. SOCIETA' COOPERATIVA AGRICOLA	Cingoli (MC) Località Cerrete Collicelli	Slaughterhouse			
IT	IT264	C.A.R.N.J. SOCIETA' COOPERATIVA AGRICOLA	Comune di Castelplanio (AN)	Slaughterhouse			
PT	PT265	Lusiaves - Indústria e Comércio Agro-Alimentar, SA	Figueira da Foz	Slaughterhouse	Poultry		
PT	PT269	Carnes Landeiro, S.A	Barcelos	Slaughterhouse	Pig; bovine		
PT	PT270	Empresa Figueirense de Pesca Lda	Figueira da Foz	Installation processing animal by-products and/or edible co-products		Fishmeal and fish oil production	Cat. 3: Fish by-products
PT	PT271	SAVIBEL, Sociedade Avícola, SA - Centro de Abate de Aves	Oliveira de Frades	Slaughterhouse	Poultry (broiler)		
PT	PT272	CRIZAVES - Centro de Abate de Aves, S.A.	Tondela	Slaughterhouse	Poultry (broiler), turkeys		
PT	PT275	Luís Leal & Filhos, S. A.	Santa Maria da Feira	Installation processing animal by-products and/or edible co-products		Other (specify in comments column)	Cat.1 and 3 - with ruminants

Country	Code	Installation / Site name	Town	Main sector	Type(s) of slaughtered animal (in the case of a slaughterhouse)	Type of animal by-product and/or edible co-product processing installation	Raw materials (for installations processing animal by-products and/or edible co-products)
NO	NO280	TripleNine Vedde AS	Langevåg	Installation processing animal by-products and/or edible co-products		Fishmeal and fish oil production	Fresh fish Offcuts from production of fish products
NO	NO281	Pelagia Karmsund Fiskemel	Karmøy	Installation processing animal by-products and/or edible co-products		Fishmeal and fish oil production	Fresh fish Offcuts from production of fish products
IT	IT282	Stabilimento di San Giorgio in Bosco	San Giorgio in Bosco (PD)	Slaughterhouse	Rabbits		
IT	IT283	Stabilimento di Vazzola	Vazzola (TV)	Slaughterhouse	Chickens		
PL	PL284	Animex Foods Starachowice	Starachowice	Slaughterhouse	Pigs		
PL	PL285	Animex Foods Elk	Elk	Slaughterhouse	Pigs		
PL	PL286	Animex Foods Szczecin	Szczecin	Slaughterhouse	Pigs		
PL	PL287	Animex Foods Opole	Opole	Slaughterhouse	Chickens		
PL	PL288	Goodvalley Food Slaughterhouse	Przechlewo	Slaughterhouse	Pigs		
PL	PL289	Animex Foods Iława	Iława	Slaughterhouse	Turkeys/Geese		
CZ	CZ290	MASO UZENINY POLIČKA	Kamenec u Poličky	Slaughterhouse			

9 ANNEX II: EXAMPLES OF FLOWCHARTS

9.1 Slaughterhouses

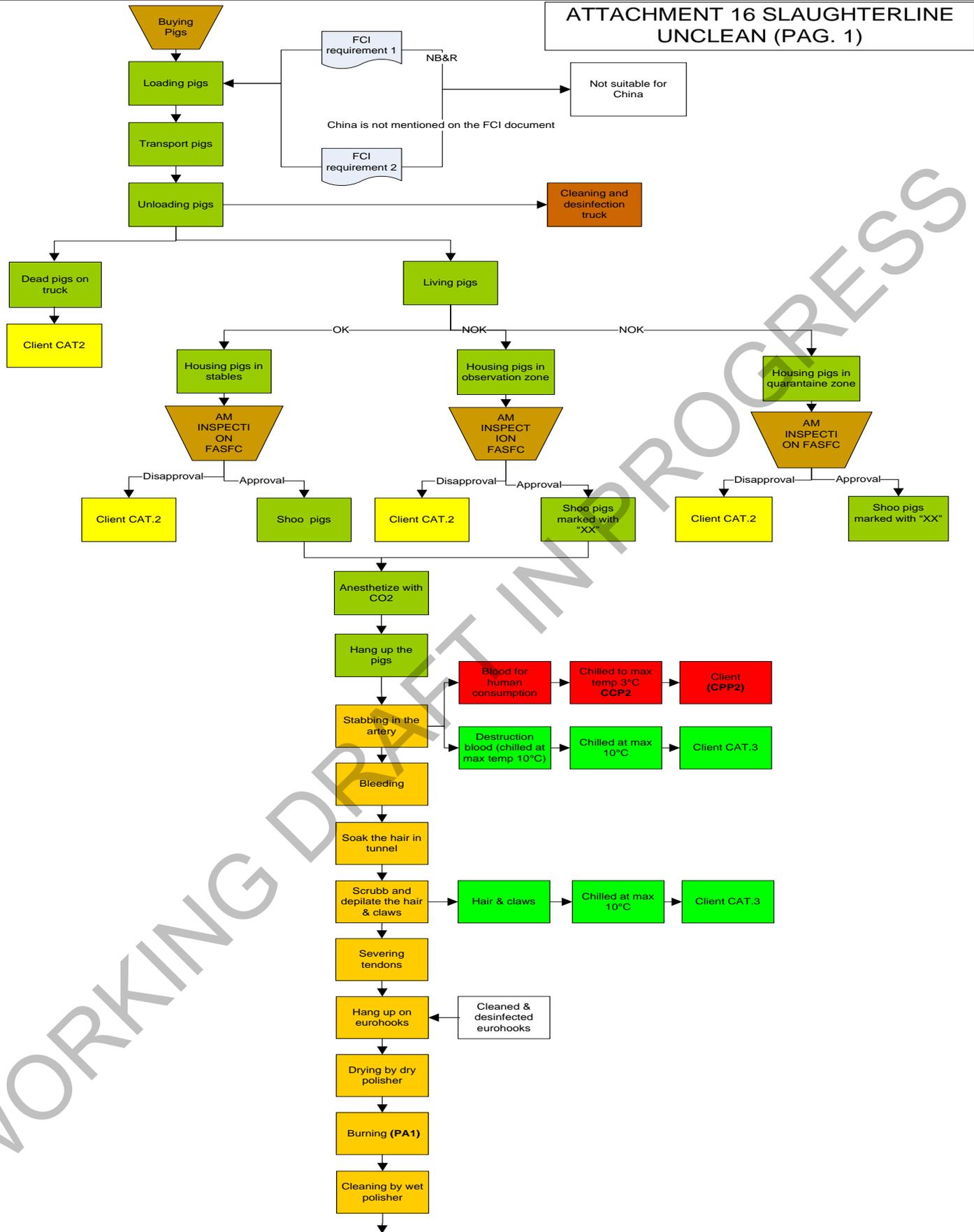
Figure 9.1, Figure 9.2 and Figure 9.3 present the flowcharts of some slaughtering processes.



Source: [264, TWG 2020].

Figure 9.1: Flowchart of a slaughtering process

ATTACHMENT 16 SLAUGHTERLINE
UNCLEAN (PAG. 1)

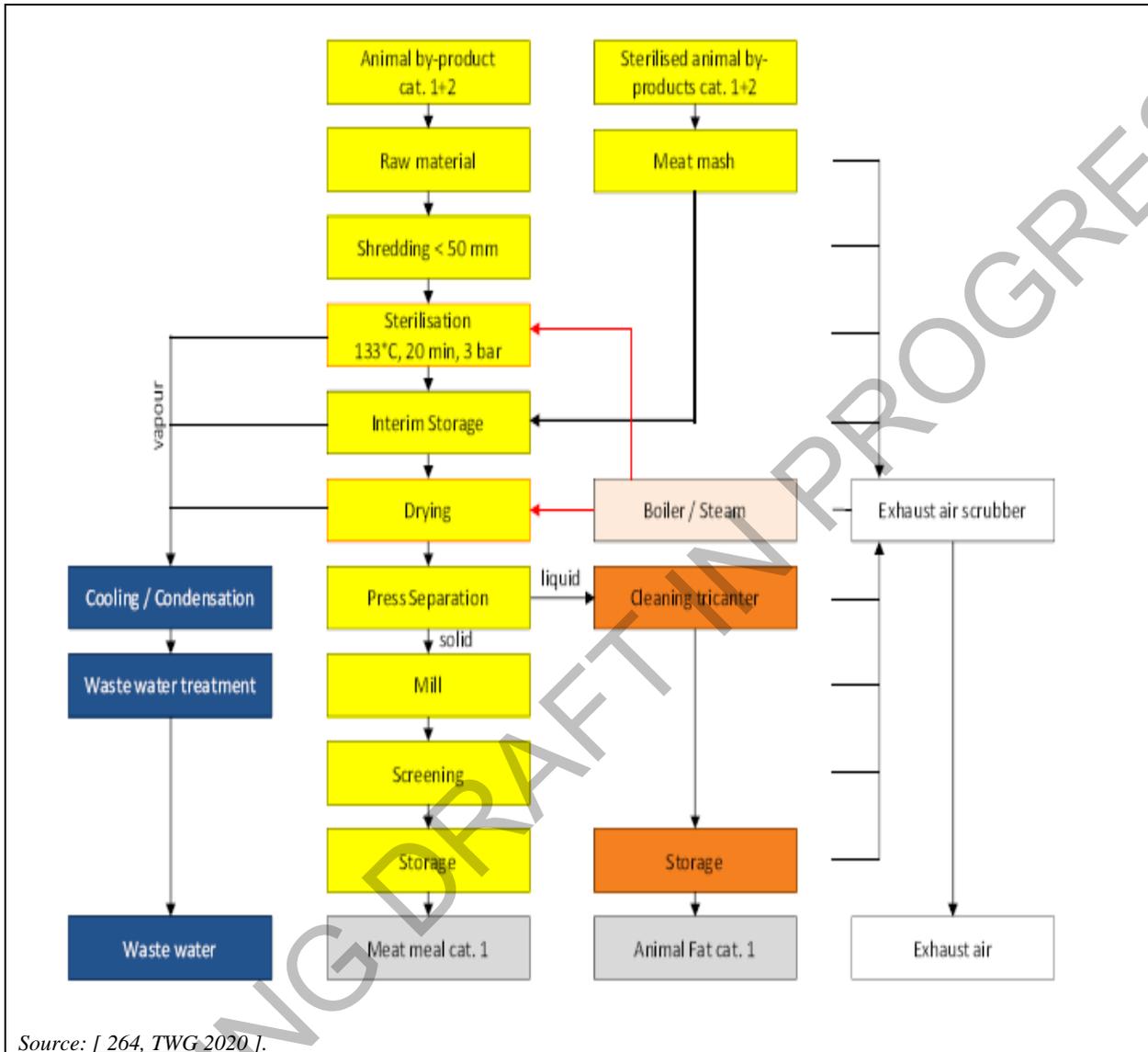


Source: [264, TWG 2020].

Figure 9.2: Flowchart of a slaughtering process (unclean area)

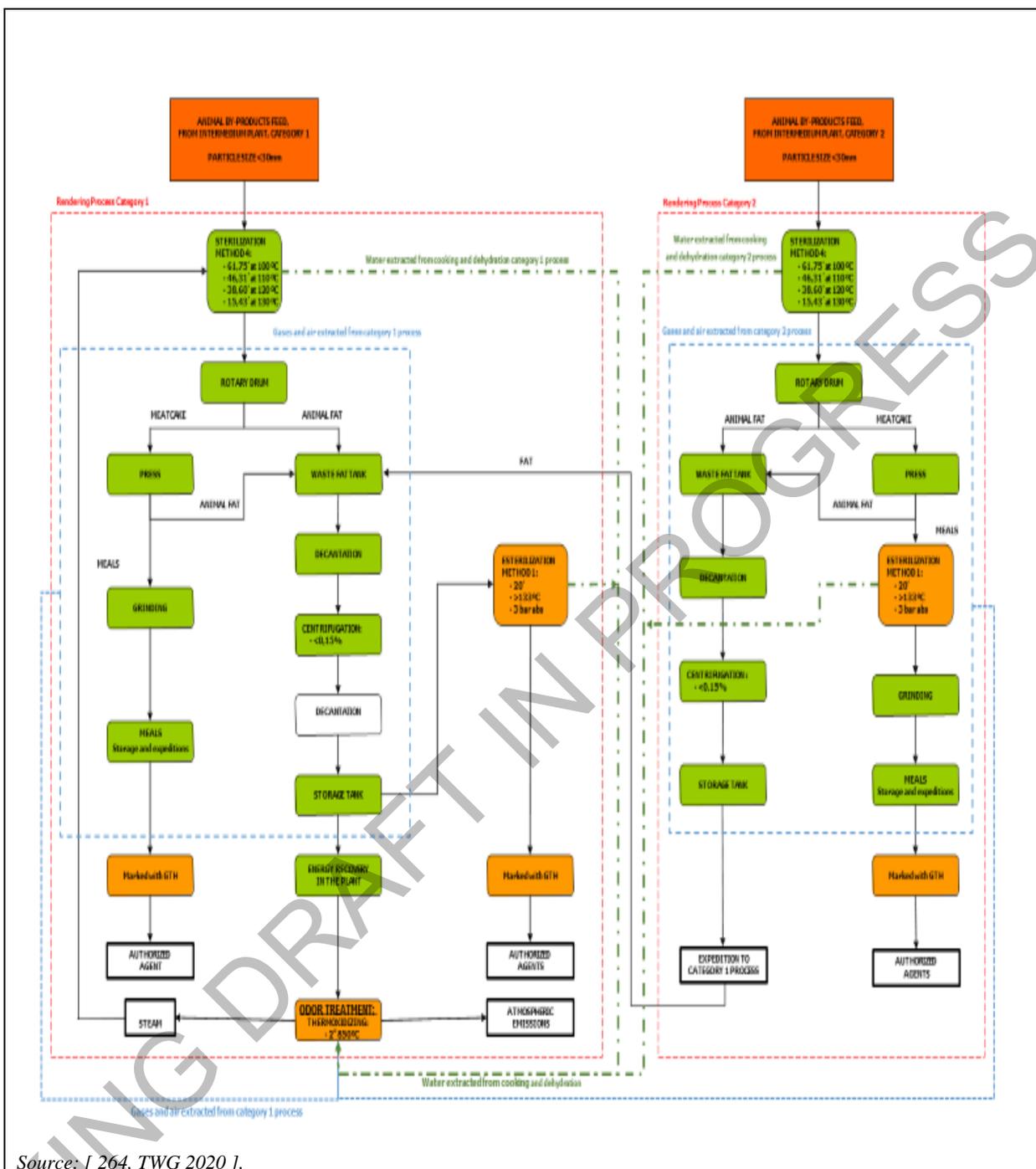
9.2 Processing of animal-by products and/or edible co-products

Figure 9.4, Figure 9.5 and Figure 9.6 present the flowcharts of some rendering processes.



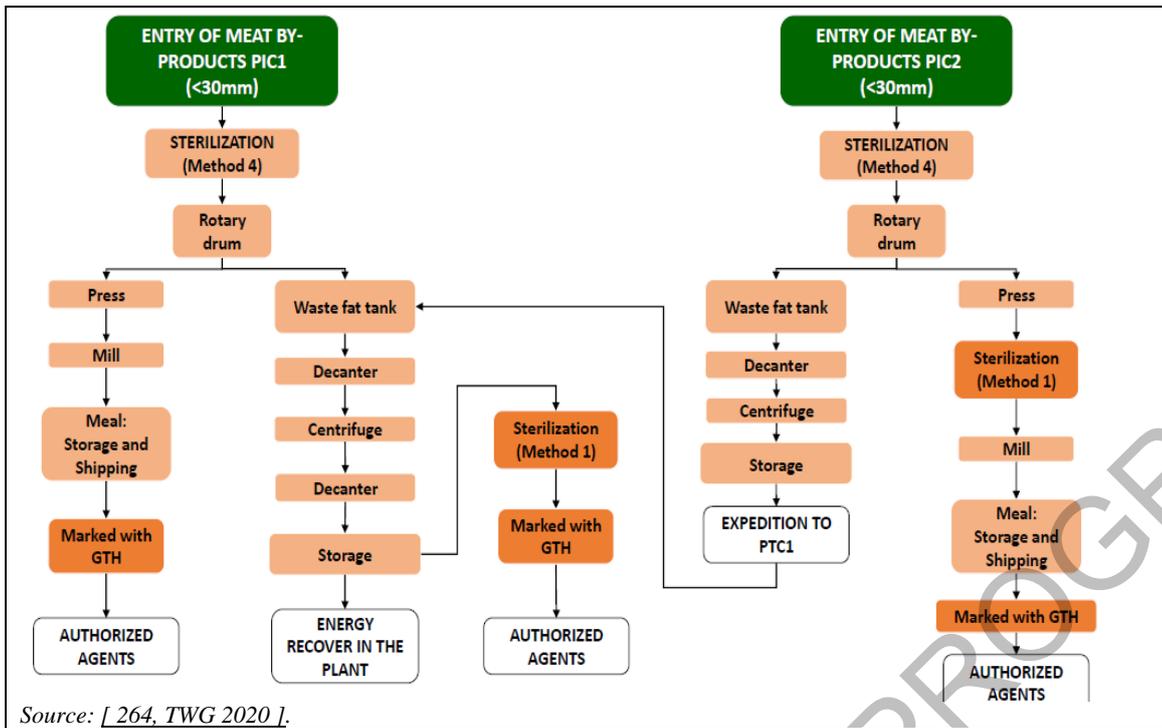
Source: [264, TWG 2020].

Figure 9.4: Flowchart of a rendering process



Source: [264, TWG 2020].

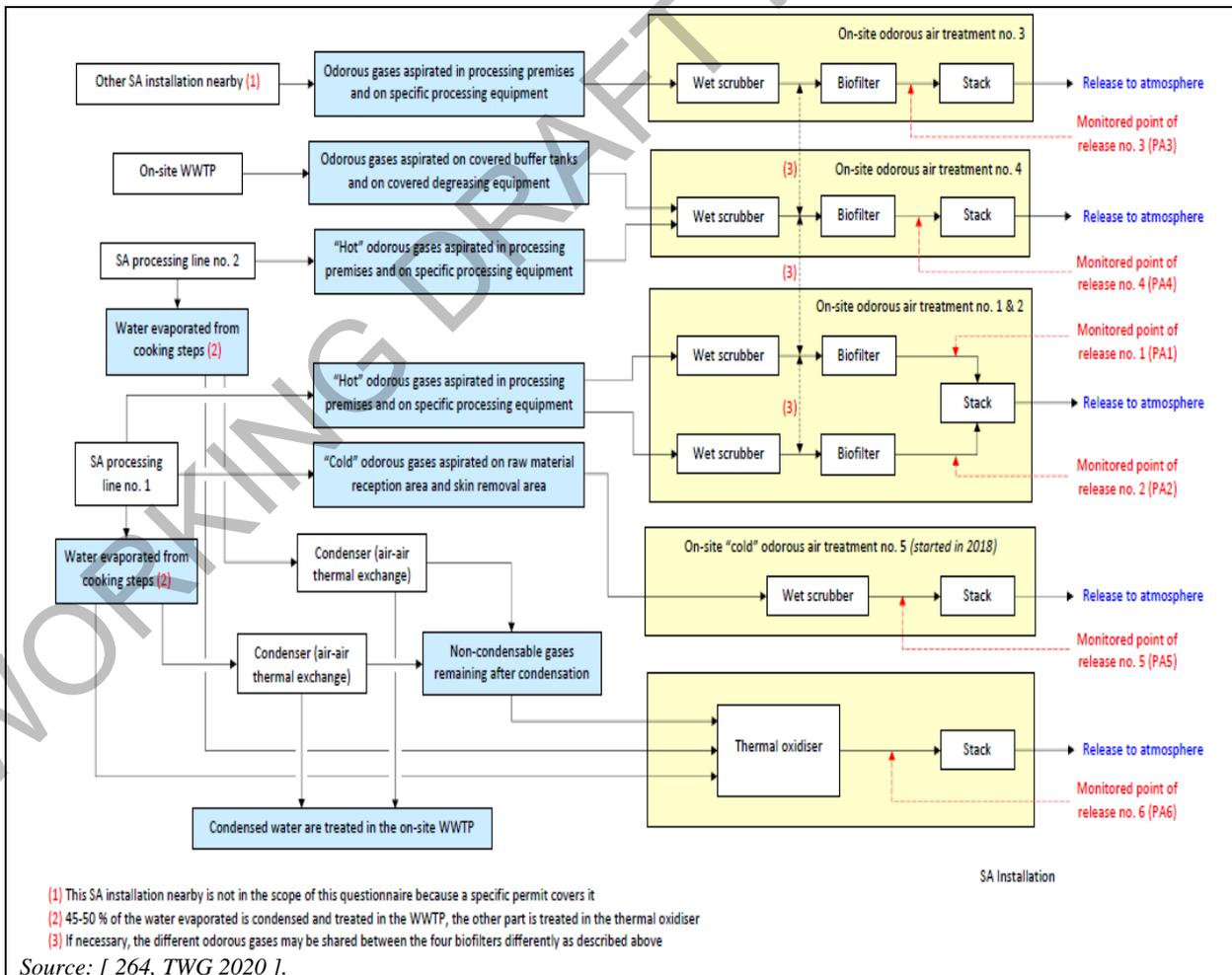
Figure 9.5: Flowchart of a rendering process



Source: [264, TWG 2020].

Figure 9.6: Flowchart of a rendering process

Figure 9.7 and Figure 9.8 present flowcharts of emissions to air from rendering installations.



- (1) This SA installation nearby is not in the scope of this questionnaire because a specific permit covers it
- (2) 45-50 % of the water evaporated is condensed and treated in the WWTP, the other part is treated in the thermal oxidiser
- (3) If necessary, the different odorous gases may be shared between the four biofilters differently as described above

Source: [264, TWG 2020].

Figure 9.7: Flowchart of emissions to air from a rendering installation

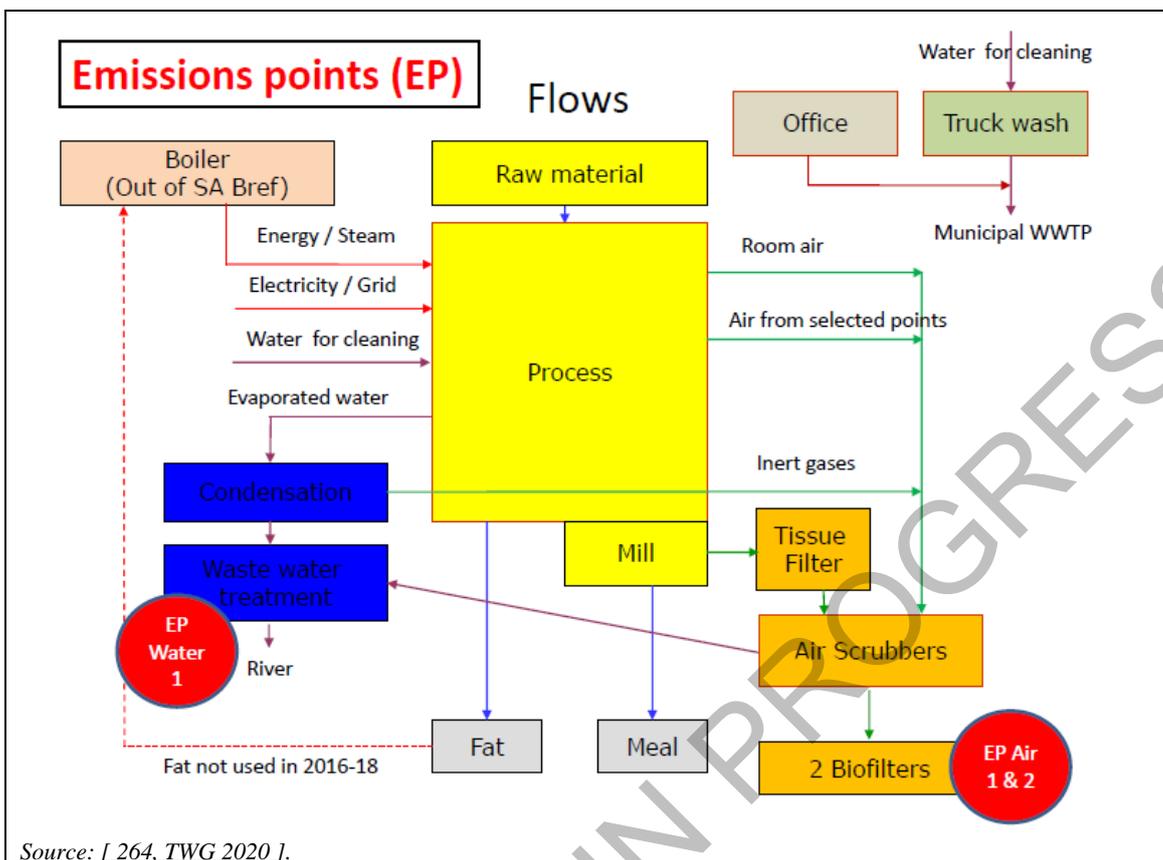


Figure 9.8: Flowchart of emissions to air from a rendering installation

WORKING DRAFT IN PROGRESS

10 GLOSSARY

I. GENERAL TERMS, ABBREVIATIONS, ACRONYMS AND SUBSTANCES

ABP	Animal by-products.
ABP Regulation 1069/2009 1774/2002/EC	Regulation (EC) No 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and repealing Regulation (EC) No 1774/2002 (Animal by-products Regulation). Regulation (EC) No 1069/2009 has been implemented by Commission Regulation (EU) No 142/2011. Regulation (EC) No 1774/2002 of the European Parliament and of the Council of 3 October 2002 laying down health rules concerning animal by products not intended for human consumption
Acid	Proton donor. A substance that, more or less readily, gives off hydrogen ions in a water solution
Activated sludge process	A sewage treatment process by which bacteria that feed on organic wastes are continuously circulated and put in contact with organic waste in the presence of oxygen to increase the rate of decomposition.
Aeration	The act of mixing a liquid with air (oxygen).
Alkali	Proton acceptor. A substance that, more or less readily, takes up hydrogen ions in a water solution
Ammoniacal nitrogen	Nitrogen present as ammonia and ammonium ion in liquid effluents
Anaerobic	A biological process which occurs in the absence of oxygen
Animal meal	See “processed animal proteins”
AOX	Adsorbable organically bound halogens, expressed as Cl, include adsorbable organically bound chlorine, bromine and iodine.
Biocoenosis	Association of different organisms forming a closely integrated community; relationship existing between such organisms
BFB	Bubbling fluidised bed
Biochemicals	Chemicals that are either naturally occurring or identical to naturally occurring substances. Examples include hormones, pheromones and enzymes. Biochemicals function as pesticides through non-toxic, non-lethal modes of action, such as disrupting the mating pattern of insects, regulating growth or acting as repellents.
Biodegradable	That can be broken down physically and/or chemically by microorganisms. For example, many chemicals, food scraps, cotton, wool and paper are biodegradable
Biochemical oxygen demand (BOD _n)	Amount of oxygen needed for the biochemical oxidation of the organic matter to carbon dioxide in <i>n</i> days (<i>n</i> is typically 5 or 7). BOD is an indicator for the mass concentration of biodegradable organic compounds.
Bovine	Of or like an ox
Bristles	Hairs [114, MLC, 1999] [33, MLC 1999]
BSE	Bovine spongiform encephalopathy
Caprine	Of or like a goat
Casings	The outer layer of meat products such as sausages, i.e. the skin of a sausage, produced from intestines [114, MLC, 1999] [33, MLC 1999]

Category 1	See definition in the “Regulation of the European Parliament and of the Council laying down health rules concerning animal by-products not intended for human consumption” Article 4
Category 2	See definition in the “Regulation of the European Parliament and of the Council laying down health rules concerning animal by-products not intended for human consumption” Article 5
Category 3	See definition in the “Regulation of the European Parliament and of the Council laying down health rules concerning animal by-products not intended for human consumption” Article 6
CEN	European Committee for Standardisation
CIP	Cleaning-in-place
CHP	Co-generation of heat and power
Clean whole saleable carcase	(Awaiting definition - see “General information – slaughterhouses section” of BREF)
Chemical oxygen demand (COD)	Amount of oxygen needed for the total chemical oxidation of the organic matter to carbon dioxide using dichromate. COD is an indicator for the mass concentration of organic compounds.
CFD	Computerised fluid dynamics
CJD	Creutzfeld - Jacob disease
Cross-media effects	The calculation of the environmental impacts of water/air/soil emissions, energy use, consumption of raw materials, noise and water extraction (i.e. everything required by the IPPC Directive)
DAF	Dissolved air flotation
DEM	German mark
DEFRA	Department for Environment, Food and Rural Affairs (for England and Wales)
Denitrification	Biological process by which nitrate is converted to nitrogen and other gaseous end-products
Directive (the)	Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control (IPPC Directive)
DKK	Danish kroner
DL	Detection limit
Dressing	The process of removing various parts of the body of an animal following slaughter
DS	Dry solids (content). The mass of a material remaining after drying by the standard method of test
EA	Environment Agency of England and Wales
EAPA	European Animal Protein Association
EDTA	Ethylene diamine tetraacetic acid
Effluent	Physical fluid (air or water together with contaminants) forming an emission
EFSA	European Food Safety Authority.
EIPPCB	European IPPC Bureau
ELV	Emission limit value
Emerging techniques	(Name of a standard chapter in BREFs)
Emis.	Emission
Emission	The direct or indirect release of substances, vibrations, heat or noise from individual or diffuse sources in the installation into the air, water or land
Emission limit values	The mass, expressed in terms of certain specific parameters, concentration and/or level of an emission, which may not be exceeded during one or more periods of time
End-of-pipe technique	A technique that reduces final emissions or consumptions by some additional process but does not change the fundamental operation of the core process. Synonyms: "secondary technique", "abatement technique". Antonyms: "process-integrated

	technique", "primary technique" (a technique that in some way changes the way in which the core process operates thereby reducing raw emissions or consumptions)
EPA	Environmental Protection Agency
EURA	European Renderers Association (amalgamated with UNEGA in 2001 to form EFPRA)
EVC	Exhaust vapour condensate
Evisceration	The removal of the viscera from the carcase [114, MLC, 1999] [33, MLC 1999]
EUR	Euro (currency)
Eutrophication	The pollution of a body of water by sewage, fertilisers washed from the land, and industrial wastes (inorganic nitrates and phosphates). These compounds stimulate the growth of algae, reducing the oxygen content in the water, and so killing animals with a high oxygen requirement.
Existing installation	An installation in operation or, in accordance with legislation existing before the date on which this Directive is brought into effect, an installation authorized or in the view of the competent authority the subject of a full request for authorization, provided that that installation is put into operation no later than one year after the date on which this Directive is brought into effect
FAO	Food and Agricultural Organisation
FFA	Free fatty acid
FGR	Flue gas reduction
Fleshing	Eliminating sub-cutaneous tissue, fat and flesh adhering to the hide or skin, manually or by the mechanical action of a cylinder equipped with cutting blades
F/M ratio	Food to microorganism ratio.
FMD	Foot and mouth disease
FOG	Fats, oils and greases
Gambrelling table	A table that is free standing or bolted to the de-hairing machine. It is a substantial rigid table with a self draining top designed to receive the carcase after it is discharged from the de-hairing machine, to enable the operatives to cut the gam (part of the leg of the pig) and insert the "gambrel", prior to the carcase being elevated onto the dressing line.
GB	Great Britain
GBP	Pound sterling
Grax	An intermediate solid phase, with a high water content, produced during rendering and fishmeal manufacture
Greaves	The solid product of fat melting
HCFC	Hydrochlorofluorocarbon
Hollow knife	Knife used to bleed carcasses, with a hollow blade through which blood runs through the handle and a tube to a collection vessel
HPLV	High pressure low volume
HRT	Hydraulic retention time (days) (reactor volume (m ³)/influent flowrate (m ³ /d))
IBC	Intermediate bulk container
ICP/MSA	Inductive coupled plasma/mass spectrometry
Intestine	Lower part of alimentary canal from pyloric end of stomach to anus
IPPC	Integrated Pollution Prevention and Control
Kjeldahl nitrogen	Nitrogen in an organic compound
Lairage	Area of a slaughterhouse where animals are held before slaughter
LAS	Linear alkylbenzene sulphonates
LECA	Light expanded clay aggregate

Glossary

LPG	Liquefied petroleum gas
LT	Low temperature drier – vacuum drier
M & T	Monitoring and targeting
MAFF	Ministry of Agriculture Fisheries and Food (now DEFRA)
Maturation	The holding of carcasses or standard cuts at refrigerated temperatures (0 - 4 °C) to improve eating quality [114, MLC, 1999] [33, MLC 1999]
MBM	Meat and bone meal – an animal meal produced from meat and bones - see “processed animal proteins”
MBTF	Moving bed trickling filter
Mesophilic	Organisms for which the optimum temperature for growth is within the range of 20 – 45 °C
Min	Minute(s)
MLC	Meat and Livestock Commission
MLVSS	Mixed-liquor volatile suspended solids
Monitoring	Process intended to assess or to determine the actual value and the variations of an emission or another parameter, based on procedures of systematic, periodic or spot surveillance, inspection, sampling and measurement or another assessment methods intended to provide information about emitted quantities and/or trends for emitted pollutants
Mpa	Megapascal
MS(s)	Member state(s)
Mucosa	Mucose membrane
N	Normality of solution, i.e. gramme-equivalents of solute per cubic decimetre (see context – fix for final draft)
n/a	Not applicable
N D	Not detectable
Nitrification	Biological process by which ammonia is converted first to nitrite and then to nitrate
Nitrogen (ammoniacal)	Nitrogen present as ammonia and ammonium ion in liquid effluents
Nitrogen (Kjeldahl)	Ammoniacal nitrogen and nitrogen in an organic compound
NLG	Dutch gilder
NOK	Norwegian kroner
Nitrogen (total)	Organic nitrogen, ammonia, nitrite and nitrate
NPE	Nonyl phenol ethoxylate
NTAA	Nitrilo triacetic acid
Odour unit	A consistent term for odour unit has not been agreed, the data reported is as received
Offal	The edible or inedible soft tissues, i.e. excluding bone, of a carcass removed during the dressing of the carcass of an animal killed for food. Green offal is the digestive tract and associated organs and red offal is the more commonly consumed offal from the carcass such as the liver, kidney and heart [114, MLC, 1999] [33, MLC 1999]
Operator	Any natural or legal person who operates or controls the installation or, where this is provided for in national legislation, to whom decisive economic power over the technical functioning of the installation has been delegated
OTMS	Over Thirty Months Scheme
OU	Odour unit
Ovine	Of or like a sheep
PAC	Pre-accession countries
Paunch	Stomach contents

Pith	Slaughter or immobilise animal by severing the spinal cord, achieved by pushing a nylon rod through the hole left by the captive bolt.
PLC	Programmable logic control
Pollutant	Individual substance or group of substances which can harm or affect the environment
Prion	Hypothetical proteinaceous infectious particle consisting only of protein, thought to be the cause of diseases such as TSE and scrapie
Processed animal proteins	Meat and bone meal, meat meal, bone meal, blood meal, dried plasma and other blood products, hydrolysed proteins, hoof meal, horn meal, poultry offal meal, feather meal, dry greaves, fishmeal, dicalcium phosphate, gelatine and any other similar products including mixtures, feedingstuffs, feed additives and premixtures, containing these products (from 2000/766/EC Council Decision of 4 December 2000 concerning certain protection measures with regard to transmissible spongiform encephalopathies and the feeding of animal protein {88, EC, 2000} [29, COM 2000])
PSE	Pale, soft and exudative meat
PVC	Polyvinyl chloride
relative density	Specific gravity
SBR	Sequencing batch reactor
Scalding	Either plunging pig or poultry carcasses in a tank of water held at about 60 °C for about 5 minutes or passing them through steam or heated water sprays, so as to soften the skin and bristles or the feathers, in preparation for de-hairing and toenail removal or de-feathering
SCR	Selective catalytic reduction
SCS	selective Cull Scheme
SEC	Specific electricity consumption
SEK	Swedish kroner
SHC	Specific heating fuel consumption
Singeing	The burning off of hairs from a pig carcass [114, MLC, 1999] [33, MLC 1999]
SNCR	Selective non-catalytic reduction
Soliped	Solid-hoofed animal
SRM	Specified risk material
SS	Suspended solids (content) (in water) (See also TSS)
Standard cuts	Carcasses, half carcasses, half carcasses cut into no more than three wholesale cuts and quarters
Stunning	Refers to methods used to render an animal insensible to pain, causing unconsciousness, at slaughter [114, MLC, 1999] [33, MLC 1999]
SWC	Specific water consumption - the volume of water used to process one tonne of meat
Tallow	Animal fat separated from the solid (protein/meal) and water fractions of animal tissue, by rendering (the term is usually applied to fat which is either inedible or not intended for human consumption)
Therm	A unit of energy, equivalent to 106 MJ
TKN	Total Kjeldahl nitrogen
TMA	Trimethylamine
Total nitrogen (Total N)	Total nitrogen, expressed as N, includes free ammonia and ammonium nitrogen (NH ₄ -N), nitrite nitrogen (NO ₂ -N), nitrate nitrogen (NO ₃ -N) and organically bound nitrogen.

Glossary

Total phosphorus (Total P)	Total phosphorus, expressed as P, includes all inorganic and organic phosphorus compounds, dissolved or bound to particles.
TSE	Transmissible spongiform encephalopathy
Total suspended solids (TSS)	Mass concentration of all suspended solids (in water), measured via filtration through glass fibre filters and gravimetry.
TVN	Total volatile nitrogen
TWG	Technical working group, established for the duration of the work of preparing the BREF
UKRA	United Kingdom Renderers Association
UNEGA	European Animal Fat Processors Association (amalgamated with EURA in 2001 to form EFPPA)
US	United States
USDA	United States Department of Agriculture

Viscera	Offal from the thoracic, abdominal and pelvic cavities, including the trachea and oesophagus (large animals) [169, EC, 1991] [57, COM 1991] or offal from the thoracic, abdominal and pelvic cavities, and also, where appropriate, the trachea, oesophagus and crop (poultry) [223, EC, 1992] [99, COM 1992]
VHR	Volumetric heat release rate
VOC	Volatile organic compound
VTEC	Verocytotoxin-producing <i>Escherichia coli</i>
WWTP	Waste water treatment plant
WID Council Directive 2000/76/EC	Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste
WHD	Waste heat dewatering

II. COMMON UNITS, MEASUREMENT AND SYMBOLS

bar	bar (1.013 bar = 1 atm)
Bé	(or°B) degree Baumé - a unit of relative density. For liquids lighter than water, the relative density d in °Bé is related to relative density "S" by the formula $d = (144.3/S) - 144.3$ and for heavier liquids the formula is $d = 144.3 - (144.3/S)$
°C	degree Celsius
cm	centimetre
d	day
g	gramme
GJ	gigajoule
h	hour
Hz	Hertz
J	Joule
kg	kilogramme (1 kg = 1000 g)
kPa	kilopascal
kWh	– kilowatt hour (1 kWh = 3600 kJ = 3.6 MJ)
l	litre(s)
m	metre(s)
m ²	square metre
m ³	cubic metre
mg	milligramme (1 mg = 10 ⁻³ gramme)
MJ	megajoule (1 MJ = 1000 kJ = 10 ⁶ J)
MPa	megapascal
N	normality of solution, i.e. gramme-equivalents of solute per cubic decimetre (see context – fix for final draft)
ng	nanogramme (1 ng = 10 ⁻⁹ gramme)
Nm ³	normal cubic metre
OU	odour unit
Pa	pascal
s	second
t	metric tonne
t/d	tonnes per day
t/yr	tonnes per year
Therm	a unit of energy, equivalent to 10 ⁶ MJ
yr	year
µm	micrometre (1 µ = 10 ⁻⁶ m)

III. LIST OF CHEMICAL ELEMENTS AND COMPOUNDS

Al	Aluminium
As	Arsenic
Ba	Barium
C	Carbon
Ca	Calcium
CaCl ₂	Calcium chloride
Ca(H ₂ PO ₄) ₂	Calcium phosphate
Ca ₃ (PO ₄) ₂	Tricalcium phosphate
CaCO ₃	Calcium carbonate
Cd	Cadmium
CH ₄	Methane
Cl	Chlorine
Co	Cobalt
CO	Carbon monoxide
CO ₂	Carbon dioxide
Cr	Chromium
Cu	Copper
F	Fluorine
FeCl ₂	Iron II chloride (ferrous chloride)
HCl	Hydrochloric acid or hydrogen chloride
H ₂ CO ₃	Carbonic acid
Hg	Mercury
H ₂ O	Water
H ₂ S	Hydrogen sulphide
H ₂ SO ₄	Sulphuric acid
K	Potassium
Mg	Magnesium
Mn	Manganese
N	Nitrogen (see context – fix for final draft)
Na	Sodium
NaOH	Sodium hydroxide
NH ₃	Ammonia
Ni	Nickel
NO _x	Oxides of nitrogen
NO ₂	Nitrogen dioxide
N ₂ O	Nitrous oxide
O	Oxygen
P	Phosphorus
Pb	Lead
Si	Silicon
S	Sulphur
SO ₂	Sulphur dioxide
Tl	Thallium
V	Vanadium

11 REFERENCES

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~~Monitoring protocol - ash and particulate testing methods and frequency (for analysis of carbon, nitrogen and amino acid content)~~

~~{6, EA, 1997, 82, EA, 1998}~~

~~This protocol from the Environment Agency of England and Wales has been reproduced for consideration as a monitoring technique—see Section 0.~~

~~PROCESSES SUBJECT TO INTEGRATED POLLUTION CONTROL—ANIMAL REMAINS INCINERATION, INCLUDING MEAT AND BONE MEAL (MBM)~~

~~MONITORING PROTOCOL—ASH AND PARTICULATE TESTING METHODS AND FREQUENCY (FOR ANALYSIS OF CARBON, NITROGEN AND AMINO ACID CONTENT)~~

~~Introduction~~

~~This protocol is issued to provide additional guidance to inspectors for monitoring levels of carbon, nitrogen and amino acids in residues from sites authorised to incinerate animal remains. It must be read in conjunction with (65, EA, 1997) and (6, EA, 1997) and guidance issued previously on how to take representative samples of ash, as described at the end of this protocol. In the case of burning MBM the relevant documents are *S2.1.05 on the combustion of fuel manufactured from or comprised of solid waste in appliances 3MW(th)* (64, EA, 1995) and (82, EA, 1998).~~

~~The Regulator's risk assessment study has shown that risks from burning animal remains in incinerators are negligible. The requirements contained in this protocol are to ensure that those incinerators are operated to acceptable standards. The data generated will allow the Regulator to review the monitoring frequency and authorisation limits on a site by site basis.~~

~~The protocol is applicable to all new plant and any other existing installations which will burn BSE suspects or cattle from the Over Thirty Month Scheme (OTMS).~~

~~Protocol~~

~~Sampling for ash should be carried out as detailed below during commissioning for all combustion processes, as soon as the plant has reached an initial steady state operation, and continued, subsequent to the commissioning period following what is described below. The Amplification Note gives guidance on what commissioning trials are to be undertaken.~~

~~(1) Initial Sampling:~~

~~Daily duplicate samples (minimum of 7 duplicate sets) of incinerator/bottom ash (ie. coarse ash) —These samples should be taken by the operator, with Regulator staff in attendance to observe (either the Site Inspector, Monitoring Liaison Officer, or another designated person), and analysed for total carbon and total nitrogen content, to assess burnout. The Regulator should repeat the analysis of one of the sets of duplicate samples. The preferred method of analysis of these samples is by CHN Elemental Analyser, although other, equivalent, methods may be agreed with the Site Inspector on a site by site basis (see note (a) below). The Site Inspector must be assured that the operator will appoint quality contractors who are suitably accredited for carrying out the required sampling and analysis.~~

~~The Regulator should take the two sets of duplicate samples with the highest carbon and nitrogen content for analysis of amino acid content (see note (b) below).~~

~~3 duplicate samples of baghouse (or other abatement equipment) ash (ie fine ash):~~

References

The operator will collect these samples, with Regulator staff in attendance to observe (either the Site Inspector, Monitoring Liaison Officer, or another designated person). Samples will be analysed by the operator (or their contractor) for total carbon and total nitrogen. The Regulator will take a portion of the sample for analysis of amino acid content.

~~3 particulate stack samples:~~ These samples should be taken by the operator, with Regulator staff in attendance (for at least part of the time) to observe (either the Site Inspector, Monitoring Liaison Officer, or another designated person). Sampling will need to be carried out over an extended period of up to 10 hours to obtain sufficient material for analysis. Samples should be analysed for total nitrogen, total carbon and amino acid content (see note (c) below). If insufficient material (see notes (a) and (b)) has been collected after 10 hours of sampling it will have to be assumed that the results of the bag filter samples are representative of the particulate samples.

~~At least one of the sets of particulate samples and duplicate sets of fine ash samples should be collected under "normal" plant throughput (agreed on a site by site basis with the Site Inspector). One of the remaining sets of samples should be collected during maximum plant throughput (as agreed with the Site Inspector). Care must be taken to ensure that the ash samples taken are representative of the specified loading rate. The Site Inspector should ensure that there is not more than one change of loading rate in any one day of the commissioning period.~~

~~All samples should be collected at the burnout rate initially proposed by the operator. If these fail the action levels detailed below then burnout time will need to be amended and sampling, as above, repeated.~~

~~Sampling at this level should continue in subsequent weeks until results of the analysis are available and an assessment of the data can be made. Assessments should not be made on anything less than a complete week of data which have been collected as specified above.~~

~~(2) The proposed action levels for these samples are:~~

~~**1% total carbon**~~

~~**5 mg/100g sample total protein (aqueous extract) – see note (d) below.**~~

~~Both of these levels should be achievable for all samples although the carbon level is included for guidance only. Sampling frequency will be determined on the total protein levels found in samples collected as part of this protocol.~~

~~If the results of the fine and coarse ash samples collected in (1) above are all less than the levels specified for total protein, sampling frequency may be reduced to 1 fine ash duplicate sample and 1 coarse ash duplicate sample per week, for the operator to analyse for total carbon and total nitrogen. Regulator staff will take a portion of the sample for analysis of amino acid content. If any of the samples exceed these levels, sampling frequency should revert to the frequency specified in (1) until the limits are achieved.~~

~~(3) If the criteria for total protein in (2) above are met for all samples over 4 consecutive weeks, sampling frequency may be reduced to 1 fine ash and 1 coarse ash sample per month, for analysis of total carbon, total nitrogen and amino acid content, as above.~~

~~(4) If the levels for total protein are met for all samples after a period of 6 consecutive months, sampling frequency may be reduced to 1 fine ash and 1 coarse ash per quarter, for the analysis of total carbon, total nitrogen and amino acid content, as above.~~

~~(5) If at any time, samples exceed the action levels for total protein in (2) above or if the Site Inspector considers it necessary, sampling frequency should revert back to the previous stage.~~

~~(6) Particulate stack samples:~~ With the abated emission it may be difficult to collect sufficient particulate material for analysis. Where it is possible, a further duplicate sample should be collected 3 months after the initial one in (1) above. Thereafter sampling should be on an annual basis for total carbon, total nitrogen and amino acid content of particulate material.

~~Minimum sampling frequency will be quarterly for coarse and fine ash, and annually for particulate for the analysis of total nitrogen, total carbon and amino acid content.~~

The onus is on the operator to sample and analyse ash for carbon and nitrogen and this should be clearly stated in the authorisation. The Regulator will carry out a programme of independent check monitoring on approximately 10 % of samples by collecting a portion of a sample (previously taken by the operator) and analysing it for total carbon and nitrogen content by Elemental Analysis. The Site Inspector should ensure that independent samples are collected early on so that problems can be identified sooner rather than later. If at any time the operator's sampling and/or analytical contractor is changed, the Regulator should re-check the accuracy of the new results by further independent tests. Site Inspectors should ensure that operators notify them of any such change.

Regulator policy on charging will apply to all independent samples in that the operator will be recharged. Approximate costs for Regulator samples are currently:

GBP 21.60 per sample for total carbon and total nitrogen content;
GBP 100.00 per sample for amino acid content.

For all operator monitoring (covering any parameters), the Regulator requires at least 2 weeks notice of the proposed date(s) so that the work can be observed by Regulator staff as and when considered appropriate.

Notes

(a) 10g (dry weight) of sample is ideally required for analysis of carbon and nitrogen using elemental analysis.

(b) 1-2g (dry weight) of sample is required for amino acid analysis. Samples should be ground by the operator then securely packaged in plastic containers (or a plastic bag), clearly labelled with the site name, incinerator number (if applicable) and the date (of sample collection). Samples should be sent to a designated Monitoring Liaison Officer. They will then be forwarded on a weekly basis to the contract laboratory for analysis. Samples must be with the designated Monitoring Liaison Officer by noon on Thursday each week in order to be sent to the laboratory.

(c) Particulate samples — once collected, the sample should be divided into 2 portions, each clearly labelled with the site name, incinerator number (if applicable) and the date (of sample collection). One portion should be sent to the designated Monitoring Liaison Officer (as above); the other sent to a laboratory for total carbon and total nitrogen analysis.

(d) Carbon and nitrogen data are required to assess burnout. The limit currently proposed for inclusion in authorisations is 100mg/kg of protein in ash as calculated from amino acid analysis.

References

Stage	Type of Sample	Number of samples	Sampled by	Analysed by	Analysis requirements	Notes
1 (initial sampling)	Incinerator/bottom ash (coarse ash)	7 duplicate samples (i.e. daily)	Operator	Operator	Total carbon and nitrogen	Regulator to repeat the analysis of 1 of the sets of duplicate samples
				Regulator	Amino acid content	Regulator to analyse a portion of the 2 sets of duplicate samples with the highest carbon and nitrogen results
	Baghouse ash (fine ash)	3 duplicate samples	Operator	Operator	Total carbon and nitrogen	
				Regulator	Amino acid content	Regulator to analyse a portion of each of the duplicate samples for amino acid content
	Particulate stack samples	3 single samples	Operator	Operator	Total carbon and nitrogen	
				Regulator	Amino acid content	Regulator to analyse a portion of each sample for amino acid content
2 If at any time samples exceed the action levels for total protein (see (2) on p. 15) or the Site Inspector deems it necessary, sampling should revert back to the previous stage	Incinerator/bottom ash (coarse ash)	1 duplicate sample per week for 4 weeks	Operator	Operator	Total carbon and nitrogen	
				Regulator	Amino acid content	Regulator to analyse a portion of each sample for amino acid content
	Baghouse ash (fine ash)	1 duplicate sample per week for 4 weeks	Operator	Operator	Total carbon and nitrogen	
				Regulator	Amino acid content	Regulator to analyse a portion of each sample for amino acid content

Stage	Type of Sample	Number of samples	Sampled by	Analysed by	Analysis requirements	Notes
3 If at any time samples exceed the action levels for total protein (see (2) on p. 15) or the Site Inspector deems it necessary, sampling should revert back to the previous stage	Incinerator/bottom ash (coarse ash)	1 duplicate sample per month for 6 months	Operator	Operator	Total carbon and nitrogen	
				Regulator	Amino acid content	Regulator to analyse a portion of each sample for amino acid content
	Baghouse ash (fine ash)	1 duplicate sample per month for 6 months	Operator	Operator	Total carbon and nitrogen	
				Regulator	Amino acid content	Regulator to analyse a portion of each sample for amino acid content
4 If at any time samples exceed the action levels for total protein (see (2) on p. 15) or the Site Inspector deems it necessary, sampling should revert back to the previous stage	Incinerator/bottom ash (coarse ash)	1 duplicate sample per quarter	Operator	Operator	Total carbon and nitrogen	
				Regulator	Amino acid content	Regulator to analyse a portion of each sample for amino acid content
	Baghouse ash (fine ash)	1 duplicate sample per quarter	Operator	Operator	Total carbon and nitrogen	
				Regulator	Amino acid content	Regulator to analyse a portion of each sample for amino acid content
6?	Particulate stack samples	1 sample 3 months after the initial test (from stage 1 above); thereafter annual samples	Operator	Operator	Total carbon and nitrogen	
				Regulator	Amino acid content	Regulator to analyse a portion of each sample for amino acid content

REGULATOR – BOVINE TRIALS GROUP

NOTES ON SAMPLING OF ASH

Introduction

The purpose of these guidelines is to ensure that:

- (i) samples of ash are collected in a reasonably consistent manner during trials of incinerating bovine material or whilst a plant is undergoing commissioning;
- (ii) representative samples of ash are obtained as far as is reasonably possible by minimising sampling bias;
- (iii) sample preparation requirements minimise the sampling handling/preparation required by analytical laboratory staff.

They are not necessarily intended for use during full scale plant operation and may not be appropriate for certain types of continuous incinerator. The general principles put forward here may however still apply.

The guidelines given below follow British Standard methods whenever possible; where strict adherence to the standard method is not practical alternative guidelines are given. It is recommended that any deviation from these guidelines, by the operator of the process, should be agreed with Regulator inspectors before sampling is undertaken. It is intended that this method should be employed either by operators or by anyone else taking samples on behalf of the Regulator.

It is envisaged that operators of the incinerator (or power station) will collect the samples with Regulator inspectors observing the collection at least for the first few samples collected and thereafter on a regular (unannounced) basis.

Method

1) Whenever possible, successive samples of ash should represent a similar time period, for example, 24 hours of incineration with samples collected on a daily basis (this may vary depending on the details in the Authorisation). Preferably an empty skip (or other primary ash collector) should be used to collect ash for each successive sample. The smaller the amount of ash present, the easier it will be to collect a representative sample. Depending on the collection process, samples should not exceed a 24 hour burn period.

2) BS3316, Section 4 (4.2) specifies a method for collecting representative samples as follows:

2.1 Record the mass of residue removed from the incinerator and empty it onto a clean and level floor. Spread the residue and remove all glass, metal and large objects – these materials can be discarded.

2.2 Collect and mix the remaining residue into a cone shaped heap using a shovel and flatten the cone until the height of the residue does not exceed 100mm.

2.3 Place 20 scoopfuls, taken from different parts of the heap of not less than 0.2 kg each into an airtight container and remove to a laboratory (remainder of the heap can be discarded).

2.4 In the laboratory, crush the sample to 99 % below 1 mm particle size.

2.5 Divide the sample using a sample division device (see Section 5 of BS1017: Part 1: 1989) until a final sample of 1 ± 0.1 kg remains. Place this sample in an airtight container and send to the laboratory for analysis.

NOTES:

Wherever possible, large aggregates of ash should be broken down into sampleable proportions using a shovel.

20 scoopfuls should be taken at points equally spaced over the heap.

The airtight container should be clearly labelled with site name, date and time of sample collection, skip number (if appropriate), name of person taking the sample and a brief description of the sample.

This method requires a suitable weighing device, a scoop (of at least 0.2kg capacity), a crushing device, a sample division device (see Section 5 of BS1017: part 1: 1989).

In 2.4, "laboratory" means on site laboratory wherever possible; if facilities are not available any crushing will have to be done by the analytical laboratory (who will be undertaking the analysis).

3) Duplicate sampling should be carried out to try to ensure a more representative result is reported. The two samples should be collected simultaneously, with alternate increments being taken for each sample (ie. a total of 40 increments will be taken from the ash heap). Analysis should be carried out on each duplicate and an average result reported.

4) When there is insufficient space at the site to be able to spread the ash according to the standard method, the sample will have to be collected whilst still contained in the skip. Wherever possible, large aggregates of ash should be broken down using a shovel. Increments should be taken from equally spaced points throughout the skip (including close to the sides). The number of increments required should be increased to 35 (as it is more difficult to get a representative sample). Increments may be sampled using either a scoop or an auger (such as illustrated in BS1017: part 1: 1989, Figures 16 and 17). Half the increments should be collected from the bottom of the ash heap by sampling at least 0.3m below the surface (or to half the depth of the ash in the skip whichever is the smaller depth) and taking the increment from the bottom of the hole with a shovel or scoop. An auger can be used to dig down into the ash with the last portion obtained by the auger forming the increment. Once the increments have been collected the duplicate samples are treated as in 2.4 and 2.5 above.

5) If sample dividing devices are not available at the site, the collected sample should be sub-sampled using a smaller scoop using the same principles (and collecting the same number of increments) as in Section 2 (above) to obtain the 1kg sample required for analysis.