



JRC SCIENCE FOR POLICY REPORT

Best Available Techniques (BAT) Reference Document for the Ferrous Metals Processing Industry

*Industrial Emissions Directive
2010/75/EU (Integrated
Pollution Prevention and Control)*

JOINT RESEARCH CENTRE
Directorate B – Growth and Innovation
Circular Economy and Industrial
Leadership Unit
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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 |
| Emissions from Storage | EFS |
| Energy Efficiency | ENE |
| <i>Ferrous Metals Processing Industry</i> | <i>FMP</i> |
| Food, Drink and Milk Industries | FDM |
| Industrial Cooling Systems | ICS |
| Intensive Rearing of Poultry and 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 Tailings and Waste-rock in Mining Activities | MTWR |
| 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 |
| Production of Pulp, Paper and Board | PP |
| Production of Speciality Inorganic Chemicals | SIC |
| Refining of Mineral Oil and Gas | REF |
| Slaughterhouses and Animals By-products Industries | SA |
| Smitheries and Foundries Industry | SF |
| Surface Treatment of Metals and Plastics | STM |
| Surface Treatment Using Organic Solvents (including Wood and Wood Products Preservation with Chemicals) | STS |
| Tanning of Hides and Skins | TAN |
| Textiles Industry | TXT |
| Waste Incineration | WI |
| Waste Treatment | WT |
| Wood and Wood Products Preservation with Chemicals | WPC |
| Wood-based Panels Production | WBP |
| Reference Document (REF) | |
| Economics and Cross-media Effects | ECM |
| Monitoring of Emissions to Air and Water from IED Installations | ROM |

Electronic versions of draft and finalised documents are publicly available and can be downloaded from <http://eippcb.jrc.ec.europa.eu>

PREFACE

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 ferrous metal processing industry (FMP) and on the industrial processes and techniques used within this sector.

Chapters 2 to 6 provide the information given below on specific FMP sectors (i.e. hot rolling, cold rolling, wire drawing, continuous hot dip coating and batch galvanising). For each FMP sector, the chapter is structured as follows (X is the chapter number):

- Section X.1 provides general information on the FMP sector.
- Section X.2 provides information on applied processes and techniques.
- Section X.3 provides data and information concerning the environmental performance of installations within the sector, and in operation at the time of writing, in terms of current emissions, consumption and nature of raw materials, and use of energy.
- Section X.4 describes in more detail the techniques to prevent or, where this is not practicable, to reduce the environmental impact of operating installations in this sector that were considered in determining the BAT. This information includes, where relevant, the environmental performance levels (e.g. emission and consumption levels) which can be achieved by using the techniques, the associated monitoring, the costs and the cross-media issues associated with the techniques.
- Section X.5 presents information on emerging techniques as defined in Article 3(14) of the Directive.

Chapter 7 provides information on the emissions for processes common to more than one sector, i.e. emissions to air from acid recovery and emissions to water from treatment plants processing waste waters that originate from more than one FMP sector. Other streams from non-FMP sectors may be treated together, but the main pollutant load originates from the FMP processes. Data on emissions to water from plants treating waste waters from only one FMP sector can be found in the respective sector-specific chapters 2 to 6.

Chapter 8 provides information on the common industrial processes, abatement systems and general techniques that are used across more than one sector in the FMP industry. It describes in more detail the techniques to prevent or, where this is not practicable, to reduce the environmental impact of installations in this sector that were considered in determining the BAT. This information includes, where relevant, the environmental performance levels (e.g. emission and consumption levels) which can be achieved by using the techniques, the associated monitoring and the costs and the cross-media issues associated with the techniques. Sector-specific techniques to consider in the determination of BAT (i.e. those techniques to consider that are applied specifically in one sector) are described in chapters 2 to 6

Chapter 9 presents the BAT conclusions as defined in Article 3(12) of the Directive, both general and sector-specific.

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 ferrous metal processing industry sectors;
- 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 sections of *Techniques to consider in the determination of BAT*. 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

All comments and suggestions should be made to the European IPPC Bureau at the Joint Research Centre (JRC) at the following address:

European Commission
JRC Directorate B - Growth and Innovation
European IPPC Bureau
Edificio Expo
c/ Inca Garcilaso, 3
E-41092 Seville, Spain
Telephone: +34 95 4488 284
E-mail: JRC-B5-EIPPCB@ec.europa.eu
Internet: <http://eippcb.jrc.ec.europa.eu>

Best Available Techniques Reference Document for the Ferrous Metals Processing Industry

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SCOPE

This document concerns the following activities specified in Annex I to Directive 2010/75/EU:

- 2.3 Processing of ferrous metals:
 - (a) operation of hot rolling mills with a capacity exceeding 20 tonnes of crude steel per hour;
 - (c) application of protective fused metal coats with an input exceeding 2 tonnes of crude steel per hour.
- 2.6 Surface treatment of metals using electrolytic or chemical processes where the volume of the treatment vats exceeds 30 m³ provided that cold rolling, wire drawing or batch galvanising are directly associated to the surface treatment.
- 6.11 Independently operated treatment of waste water not covered by Directive 91/271/EEC, provided that the main pollutant load originates from the activities covered by this document.

This document also covers:

- cold rolling and wire drawing if directly associated with hot rolling and/or hot dip coating activities specified in Section 2.3 (a) or (c) of Annex I to Directive 2010/75/EU;
- the combined treatment of waste water from different origins, provided that the waste water treatment is not covered by Directive 91/271/EEC and that the main pollutant load originates from the activities covered by this document.

This document does not address the following:

- production of welded tubes;
- production of seamless tubes by extrusion;
- metal coating by thermal spraying;
- electroplating and electroless plating. This may be covered by the document for Surface Treatment of Metals and Plastics (STM).

Other BAT conclusions and reference documents which could be relevant for the activities covered by this document include the following:

- Iron and Steel Production (IS);
- Large Combustion Plants (LCP);
- Surface Treatment of Metals and Plastics (STM);
- Surface Treatment using Organic Solvents (STS);
- Waste Treatment (WT);
- 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).

WORKING DRAFT IN PROGRESS

1 GENERAL INFORMATION ON THE FERROUS METAL PROCESSING

The hot and cold forming part of the ferrous metal processing sector comprises different manufacturing methods, like hot rolling, cold rolling and drawing of steel. A great variety of semi-finished and finished products with different lines of production are manufactured.

Literature dealing with the ferrous metals sector uses different ways of splitting and structuring the sector and for delivering data. Some reports distinguish with regard to the forming process: hot - cold; or with regard to the shape of the final product: flat - long.

Others (e.g. NACE¹) separate the sector into groups: iron and steel production (including most of the hot and cold rolled products as well as continuous coated strip), manufacture of steel tubes and 'other first processing of steel' (cold drawing, cold rolling of narrow strip, wire drawing, etc.).

To put together general information on the sector, statistical data (productivity, number/size of plants, distribution, etc.) and economic information is difficult as most of the available sources for data use a different basis and split the sector differently, thus making it impossible to compare the given data.

To present the general information on the hot and cold forming sector in this BREF, an outline in accordance with the manufactured products, as shown in Figure 1.1, was chosen.

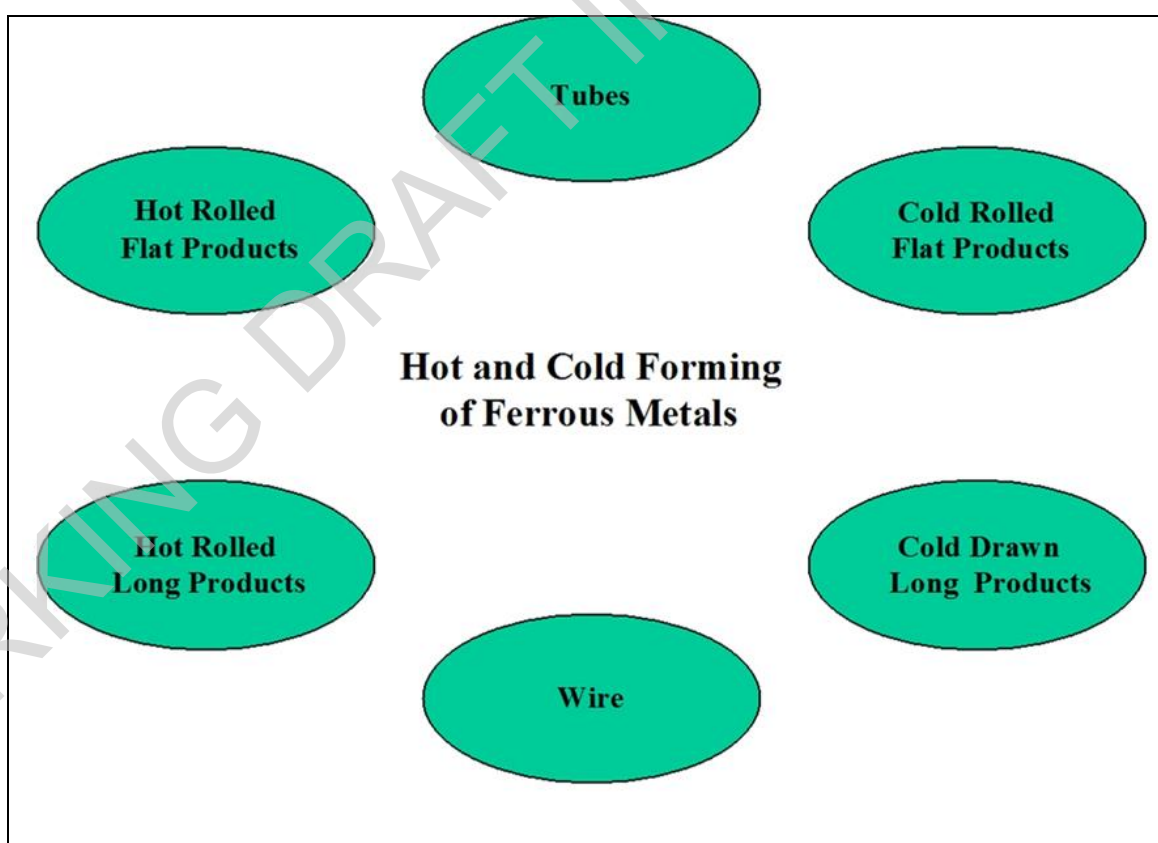


Figure 1.1: Hot and cold formed products covered by this BREF

¹ General industrial classification of economic activities within the European Community.

WORKING DRAFT IN PROGRESS

2 HOT ROLLING

2.1 General information on hot rolling

2.1.1 Hot rolled flat products

For the entire Section 2.1 'General Information on hot rolling', Please provide updated information for Tables 2.1 to Table 2.6 (Reference date; 1996 – OLD DATA)

The total production of hot rolled (HR) products in the EU decreased from 131.7 million tonnes in 1994 [EGKS95] to 127.8 million tonnes in 1996 [Stat97]. Roughly, 62 % of these HR products fall into the category flats, with an annual production of 79.2 million tonnes. Table 2.1 presents production data for individual flat products for each Member State in 1996.

Table 2.1: Production of flat products in the EU-15 in 1996

| | HR wide flats [thousand t] | HR narrow strip [thousand t] | HR wide strip [thousand t] | HR plate [thousand t] | Total HR flat products [thousand t] |
|--|-------------------------------|------------------------------------|----------------------------------|-----------------------------|---|
| Austria | 0 | 0 | 2 621 | 340 | 2 961 |
| Belgium | 0 | 0 | 9 350 | 566 | 9 916 |
| Denmark | 0 | 0 | 0 | 388 | 388 |
| Finland | 0 | 0 | 1 670 | 576 | 2 246 |
| France | 1 | 0 | 9 871 | 845 | 10 717 |
| Germany | 103 | 623 | 19 138 | 2 748 | 22 612 |
| Greece | 0 | 9 | 346 | 4 | 359 |
| Ireland | 0 | 0 | 0 | 0 | 0 |
| Italy | 185 | 48 | 8 061 | 1 385 | 9 679 |
| Luxembourg | 0 | 0 | 0 | 0 | 0 |
| Netherlands | 0 | 0 | 4 136 | 15 | 4 151 |
| Portugal | 0 | 0 | 0 | 0 | 0 |
| Sweden | 46 | 32 | 2 832 | 569 | 3 479 |
| Spain | 0 | 190 | 3 385 | 575 | 4 150 |
| UK | 88 | 145 | 7 396 | 958 | 8 587 |
| Total | 423 | 1 047 | 68 806 | 8 969 | 79 245 |
| NB: Reference year 1996. Source: [Stat97] | | | | | |

Regarding the total production of HR flats, Germany is the largest manufacturer with more than double the production of the next highest producers (France, Belgium, Italy and the UK). The vast majority of HR flat products is wide strip.

At the beginning of 1993, there were 74 production units for flats in operation in the EU-12. The number and size of these plants are given in Table 2.2.

Table 2.2: Size distribution of flat product manufacturing facilities

| | Total number of plants | Total average hourly technical capacity [t/h] | Number of plants with an average hourly technical capacity over 20 t/h |
|---|------------------------|---|--|
| Narrow strip mills | 17 | 45 | 15 |
| Wide strip mills | 25 | 474 | 25 |
| Heavy and medium plate mills | 32 | 109 | 23 |
| Sheet mills | 7 | 12 | NI |
| Universal flat mills | 2 | 31 | NI |
| Re-rolling mills for hot wide strip | 8 | 677 | NI |
| NB: NI = No information provided. Source: [EUROSTAT] | | | |

2.1.2 Hot rolled long products

The remaining 38 % of HR products are categorised as long products. Production figures for all Members States are given in Table 2.3.

Table 2.3: Production of long products in the EU-15 in 1996

| | Track material [thousand t] | Heavy sections/ profiles [thousand t] | Reinforcing steel bars [thousand t] | Merchant bars [thousand t] | Wire rod [thousand t] | HR long products [thousand t] |
|--------------------|-----------------------------|---------------------------------------|-------------------------------------|----------------------------|-----------------------|-------------------------------|
| Austria | 238 | 0 | 159 | 90 | 389 | 876 |
| Belgium | 0 | 61 | 8 | 174 | 805 | 1 048 |
| Denmark | 0 | 0 | 58 | 158 | 0 | 216 |
| Finland | 1 | 0 | 91 | 210 | 294 | 596 |
| France | 255 | 303 | 923 | 1 215 | 1 766 | 4 462 |
| Germany | 243 | 1 914 | 1 566 | 1 287 | 5 268 | 10 278 |
| Greece | 0 | 0 | 635 | 56 | 197 | 888 |
| Ireland | 0 | 311 | 0 | 0 | 0 | 311 |
| Italy | 106 | 927 | 3 725 | 3 538 | 3 270 | 11 566 |
| Luxembourg | 55 | 1 255 | 282 | 260 | 463 | 2 315 |
| Netherlands | 0 | 0 | 453 | 0 | 152 | 605 |
| Portugal | 0 | 0 | 523 | 0 | 138 | 661 |
| Sweden | 48 | 17 | 128 | 587 | 107 | 887 |
| Spain | 64 | 1 180 | 2 315 | 1 381 | 1 883 | 6 823 |
| UK | 211 | 1 951 | 650 | 2 071 | 2 147 | 7 030 |
| Total | 1 221 | 7 919 | 11 516 | 11 027 | 16 879 | 48 562 |
| Source: [Stat97] | | | | | | |

The two major manufacturing countries are Italy and Germany, followed by the UK and Spain. The largest part of the long products sector in tonnage terms is the production of wire rod which accounts for roughly a third of the total production, followed by reinforcing bars and merchant bars with an approximate share of one quarter of the production each.

Table 2.4 compiles the size distribution for the long product manufacturing facilities. In 1993, a total of 306 units were in operation.

Table 2.4: Size distribution of long product manufacturing facilities

| Hourly technical capacity (HTC) [t/h] | < 20 | 20–39 | 40–59 | 60–79 | 80–99 | 100–119 | 120–139 | >= 140 | Total |
|--|------|-------|-------|-------|-------|---------|---------|--------|-------|
| Long products* | 89 | 56 | 53 | 44 | 28 | 14 | 10 | 12 | 306 |
| Heavy sections only | 3 | 2 | 5 | 4 | 3 | 6 | 1 | 3 | 27 |
| Wire rod only | 4 | 7 | 7 | 8 | 5 | 3 | 2 | 3 | 39 |
| Wire rod + reinforcing bars in coils | 0 | 3 | 3 | 2 | 4 | 0 | 4 | 3 | 19 |
| HTC [t/h] | < 30 | 30–49 | 50–69 | 70–89 | >= 90 | NI | NI | NI | Total |
| Heavy sections + merchant bars | 3 | 2 | 4 | 3 | 1 | NI | NI | NI | 13 |
| HTC [t/h] | < 20 | 20–39 | 40–59 | 60–79 | 80–89 | >= 90 | NI | NI | Total |
| Merchant bars only | 55 | 12 | 12 | 7 | 2 | 1 | NI | NI | 89 |
| HTC [t/h] | < 20 | 20–39 | 40–59 | 60–79 | 80–99 | 100–149 | NI | NI | Total |
| Merchant bars + reinforcing bars in length | 3 | 5 | 4 | 2 | 7 | 2 | NI | NI | 23 |
| * Except extrusion presses, forging machinery and sheet piling profiling lines. NB: NI = No information provided. Source: [EUROSTAT] | | | | | | | | | |

2.1.3 Hot rolled tubes

With a production accounting for 20.9 % of the world's total production, the EU is the largest manufacturer of steel tubes, followed by Japan and the US. The European steel tube industry has a highly concentrated structure. Five countries - Germany, Italy, France, the UK and Spain - account for roughly 90 % of the total EU production. In some countries, a single company can account for 50 % or more of the national output. In addition to the major integrated steel tube manufacturers (mainly producing welded tubes), there are a relatively large number of small and medium-sized firms that are independent. Some manufacturers, often small in tonnage terms, operating in high value added markets, concentrate on the manufacture of special dimensions and grades of tubes according to particular customer specifications. At the end of 1994, there were 280 production units in the EU belonging to an estimated 245 enterprises. Of these, 67 were specialised in cold drawing of seamless or welded tubes. [Pan97]

Statistical information from the European Steel Tube Association - for 1994 and the EU-12 - refer to 252 production sites belonging to an estimated 193 companies. [CEAM]

Steel tubes cover three product categories, which differ considerably in terms of the manufacturing process, raw materials, and investment requirements. These categories are classified as:

- seamless tubes;
- welded steel tubes with a circular cross section of over 406.4 mm in outside diameter;
- welded steel tubes with a circular cross section up to and including 406.4 mm in outside diameter together with welded steel tubes with a non-circular cross section of any diameter.

It should be noted that sometimes tubes of different categories (e.g. seamless and welded tubes) and of different grades (e.g. commercial grade, high quality) are manufactured in the same mill.

About 26.4 % of the tubes produced are seamless tubes, and of the remaining 73.6 % welded tubes about 18.9 % have a large diameter. The majority of the total steel tube sector is small-diameter tubes with a share of 54.7 %. [CEAM]

Table 2.5 shows the steel tube production and number of sites and number of employees for individual Member States.

Table 2.5: Steel tube production, number of plants and employees

| | Seamless steel tubes [thousand t] (¹) | Welded steel tubes [thousand t] (¹) | Total steel tubes [thousand t] (¹) | Number of production sites (²) | Number of employees (²) |
|---|--|---|--|---|--------------------------------------|
| Austria | 234 | 255 | 489 | N/A | N/A |
| Belgium | NI | 118 | 118 | 3 | 554 |
| Denmark | NI | 60 | 60 | 4 | 1 100 |
| Finland | NI | 330 | 330 | N/A | N/A |
| France | 566 | 834 | 1 400 | 32 | 8 785 |
| Germany | 1295 | 1 991 | 3 286 | 65 | 22 774 |
| Greece | N/A | N/A | N/A | 26 | 840 |
| Ireland | N/A | N/A | N/A | 1 | 45 |
| Italy | 711 | 2 508 | 3 219 | 49 | 9 050 |
| Luxembourg | NI | 95 | 95 | N/A | N/A |
| Netherlands | NI | 393 | 393 | 5 | 775 |
| Portugal | NI | NI | NI | 2 | 380 |
| Sweden | 131 | 90 | 221 | N/A | N/A |
| Spain | 242 | 662 | 904 | 29 | 4 200 |
| UK | 73 | 1 215 | 1 288 | 36 | 6 325 |
| Total | 3 252 | 8 551 | 11 803 | 252 | 54 828 |
| ⁽¹⁾ Reference year 1996. ⁽²⁾ Reference year 1994. NB: NI = No information provided. Source: [CEAM] | | | | | |

As can be seen in Table 2.6, plants producing welded steel tubes are predominantly small and medium-sized plants, with only 22 out of 161 plants having more than 500 employees. With plants producing seamless tubes this is less the case, as 13 out of 32 plants can be characterised as large plants.

Table 2.6: Number and size of tube plants in 1994

| | Number of companies | | | | Total |
|--|-------------------------------|----------------------|------------|------------------|-------|
| | Small plants ($< 100^*$) | Medium (100–499*) | Large | | |
| | | | (500–999*) | ($> 1\ 000^*$) | |
| Seamless tubes | 5 | 14 | 6 | 7 | 32 |
| Welded steel tubes: | 78 | 61 | 14 | 8 | 161 |
| Welded tubes OD > 406.6 mm | 6 | 17 | 2 | 2 | 27 |
| Welded tubes OD ≤ 406.4 mm | 72 | 44 | 12 | 6 | 134 |
| Total | 83 | 75 | 20 | 15 | 193 |
| * Number of employees. Source: [CEAM] | | | | | |

2.2 Applied processes and techniques in hot rolling

Not all information received from the TWG has yet been revised and incorporated in this section. This will be done after draft 1.

2.2.1 Process overview

In hot rolling, the size, shape and metallurgical properties of the steel slabs, blooms, billets or ingots are changed by repeatedly compressing the hot metal (temperature ranging from 1 050 °C to 1 300 °C) between electrically powered rollers. The steel **input** for hot rolling differs in form and shape, depending on the process route and on the product to be manufactured.

Cast ingots, predominantly with a square cross section, are used for the manufacture of slabs and blooms in slabbing/blooming mills. Slabs and blooms are further processed to plates or strips in other rolling mills. Nowadays, the use of cast ingots and slabbing/blooming is decreasing as continuous casting has made this step obsolete. Approximately 93.7 % (1995) of the crude steel produced in Europe is cast continuously into semi-finished products such as slabs, blooms or billets. Only a minor part is cast into discrete moulds to produce ingots for some special products (e.g. heavy plates).

Slabs (400–2 500 mm wide and 40–500 mm thick) are semi-finished, continuous cast products for the rolling of flat products.

Billets (of a square or rectangular shape with cross sections of 2 500 mm² to 14 400 mm² (50 mm x 50 mm to 120 mm x 120 mm)) and **blooms** (of a square or rectangular shape with cross sections of 14 000 mm² up to approximately 100 000 mm² (120 mm x 120 mm up to 250 mm x 400 mm)) are semi-finished continuous cast products used for the rolling of long products.

Beam blanks (with dimensions of 170 mm x 240 mm up to 500 mm x 1120 mm) are continuously cast to near net shape. Beam blanks are used for rolling of long products. [EUROFER HR]

Hot rolling mills usually comprise the following process steps:

- Surface rectification of the input (scarfing, grinding);
- heating to rolling temperature;
- descaling;
- rolling (roughing including width reduction, rolling to final dimension and properties);
- finishing (trimming, slitting, cutting).

Products obtained from hot rolling are usually classified in two basic types according to their shape: flat and long products. Tubes are also covered by the term 'long product' in this document.

Figure 2.1 shows an overview of products manufactured for various purposes and applications.

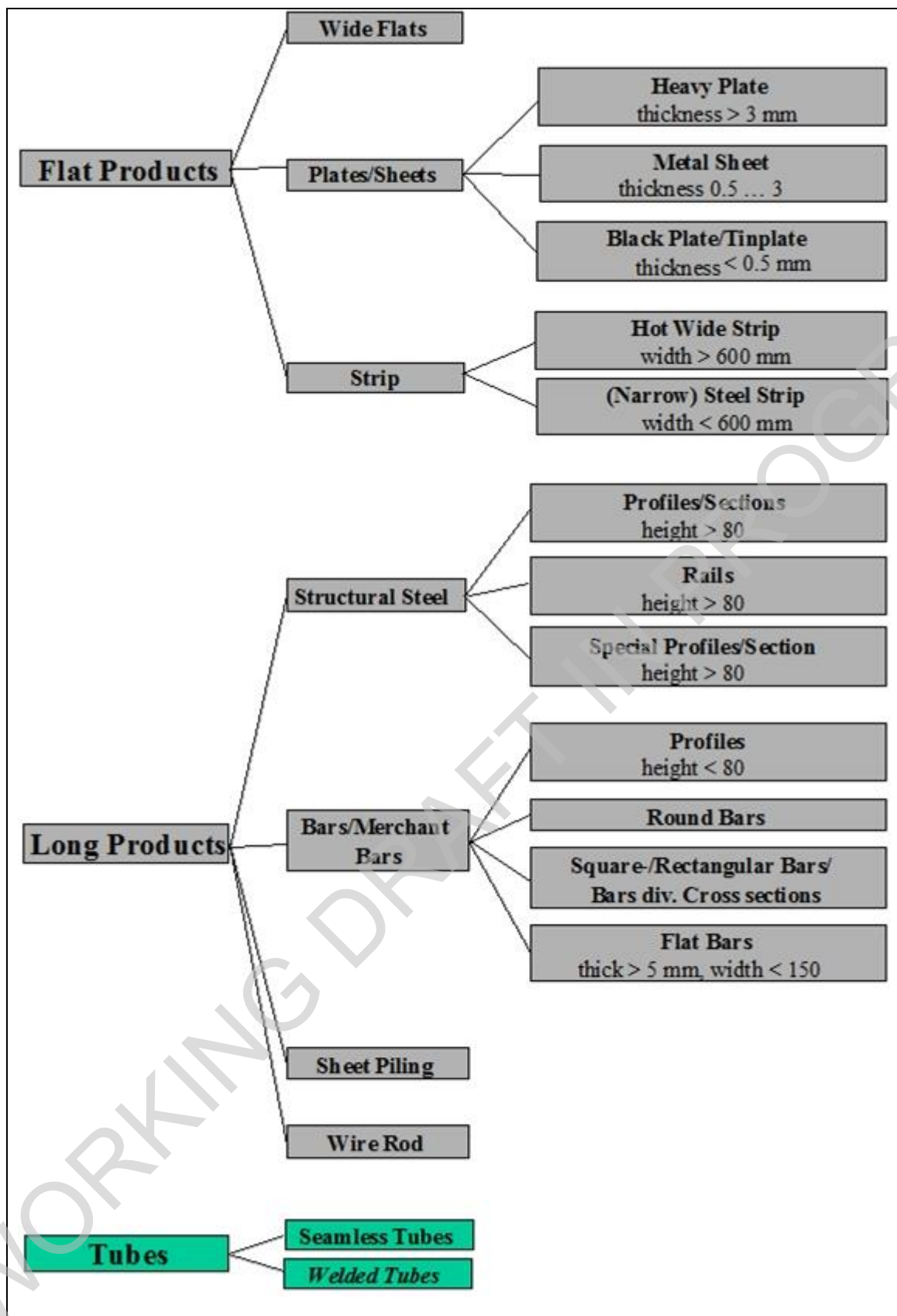


Figure 2.1: Overview of hot rolled products

Hot rolling mills are classified by the type of product that they produce and by their design features. The following chapters give an insight into the different mill layouts and

manufacturing sequences. More detailed information on the individual processing steps, which are often similar in different mills, is given thereafter.

2.2.1.1 Blooming/Slabbing mills

Blooming and slabbing mills are used to roll cast ingots into semi-finished products, like blooms and slabs, for further processing in other mills. The raw material is heated in soaking pits to around 1 300 °C and subsequently formed on heavy two-high reversing stands in 15–30 rolling passes.

The material to be rolled is moved along roller tables, positioned with the aid of manipulators, and fed into the roll gap. The material is repeatedly rotated 90 ° on its long axis during the series of passes.

The main difference between blooming and slabbing stands is the greater height of the stands used for rolling slabs. This is associated with the product characteristics; as slabbing mills are mainly used to roll flat semi-finished products they require a bigger lift height of the upper rolls.

Another rolling system is the universal slabbing stand. Working pairs of rolls are arranged horizontally and vertically in succession. The vertical rolls form the narrow sides.

The rolled semi-finished products are cropped with shears at both ends, and divided into ordered lengths. Surface defects of the product may be removed by flame descaling (scarfing). [Ullmann's]

With the growth of continuously cast products, the number and importance of slabbing and blooming mills has decreased. From 1988 the number dropped by 18 to a total of 67 in 1993 (see Table 2.7).

*Please provide updated information for Table 2.7
(Reference date; 1993 – OLD DATA)*

Table 2.7: Semi-finished product mills

| | Number of plants | Average capacity [t/h] |
|--------------------------------------|------------------|------------------------|
| Blooming mills | 13 | 85 |
| Blooming and billeting | 8 | 84 |
| Blooming and slabbing | 13 | 187 |
| Blooming, slabbing, billeting | 6 | 109 |
| Slabbing (only) mills | 5 | 284 |
| Billeting (only) mills | 20 | 83 |
| Billeting and slabbing mills | 2 | 122 |
| Total | 67 | 122 |
| <i>Source: [EUROSTAT]</i> | | |

2.2.1.2 Hot strip mills

For the production of hot strip, the heated slab - after descaling - passes the roughing mill, where it is reduced from a thickness of approximately 120–300 (500) mm to approximately 20–50 mm (transfer bar). Roughing can also include a reduction in width.

This roughing is done either in several passes through an individual rolling stand by repeated reversing, or in a continuous pass through several roughing stands. The designations of strip mills (semi-continuous hot strip mill, 3/4 continuous hot strip mill and continuous hot strip mill, see Figure 2.2) originate from this plant configuration.

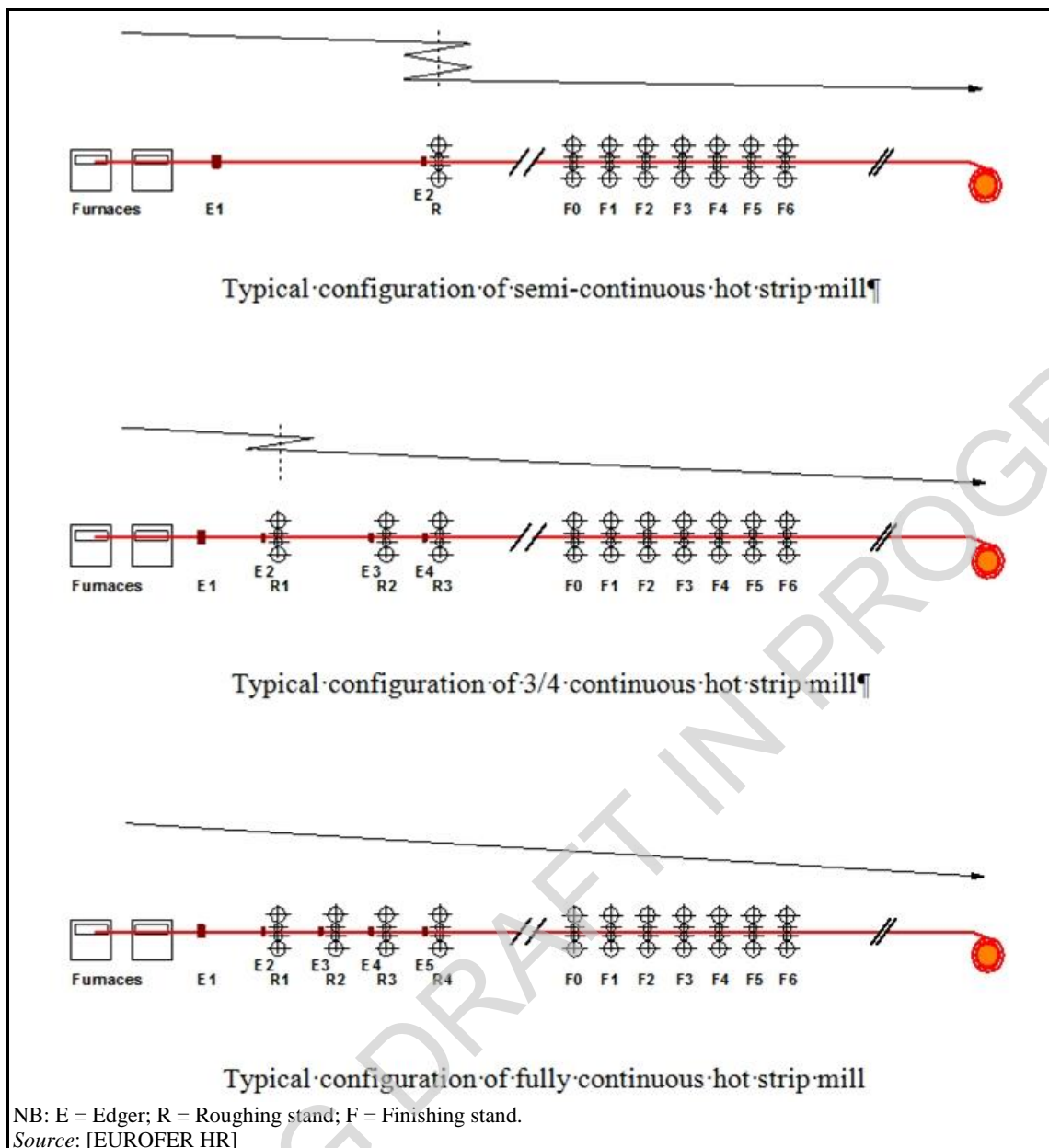


Figure 2.2: Typical designs for hot strip mills

The material reduced to a transfer bar is directed to the finishing train via an intermediate roller table, which in some cases is combined with a so-called coil box. Before entering a train of rolling stands for thickness reduction to the final size (between 1.2 mm and approximately 20 mm), the transfer bar is cropped. Temperature-controlled rolling in the finishing train, involving controlled strip cooling installed at the delivery roller table, provides the requested technological parameters (strength, toughness, etc.) of the hot strip. At the end of the rolling mill, the finished product is wound up in a coil.

Hot strip, which is not foreseen for further processing in the cold mills, is partly sold with rolled strip edges, but depending on the planned external use the strip has to be conditioned. This coil finishing includes side trimming, cutting to small bands on slitting lines and cutting into sheets. [EUROFER HR]

Steckel mill

A special method of hot strip production is rolling in so-called Steckel mills. Here the raw material is usually processed into strip by reversing through a roughing stand and a finishing stand, in some cases even by reversing through one stand only.

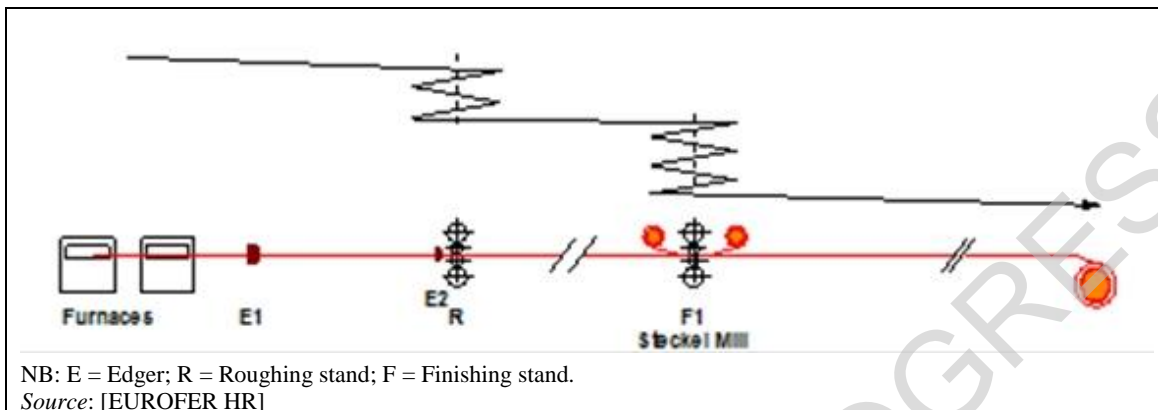


Figure 2.3: Typical Steckel mill configuration

To keep the heat losses during the rather long forming process within reasonable limits and to handle the relatively long strip more easily, heated coiling devices referred to as Steckel coilers are attached on both sides of the rolling stand (finishing stand), where the rolled stock is temporarily stored.

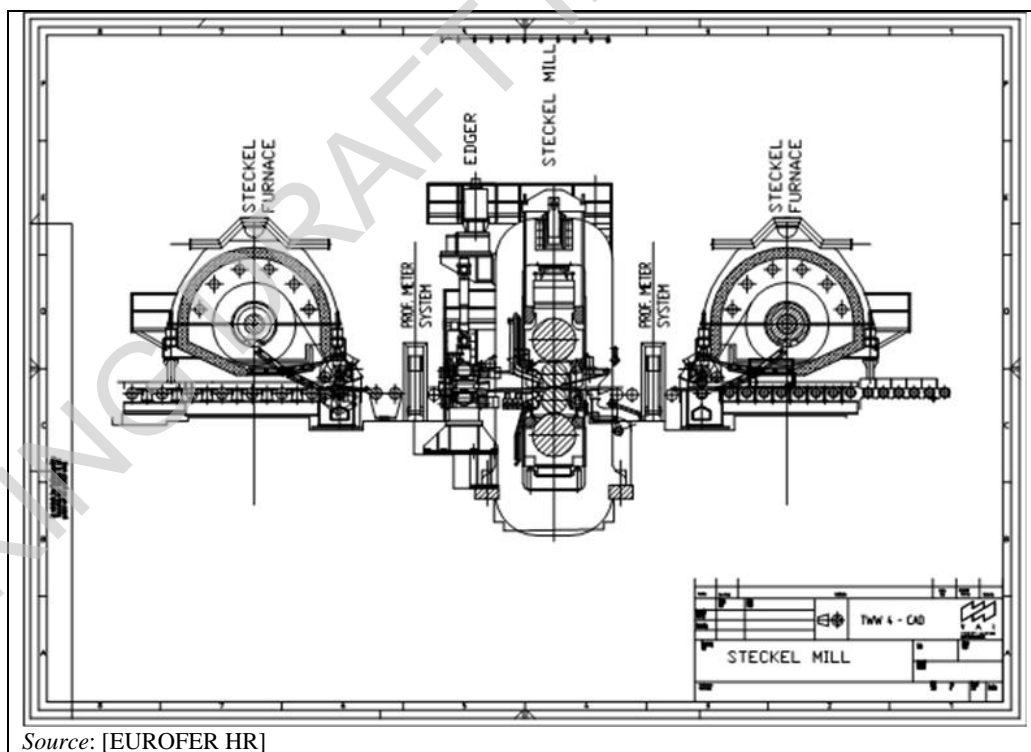


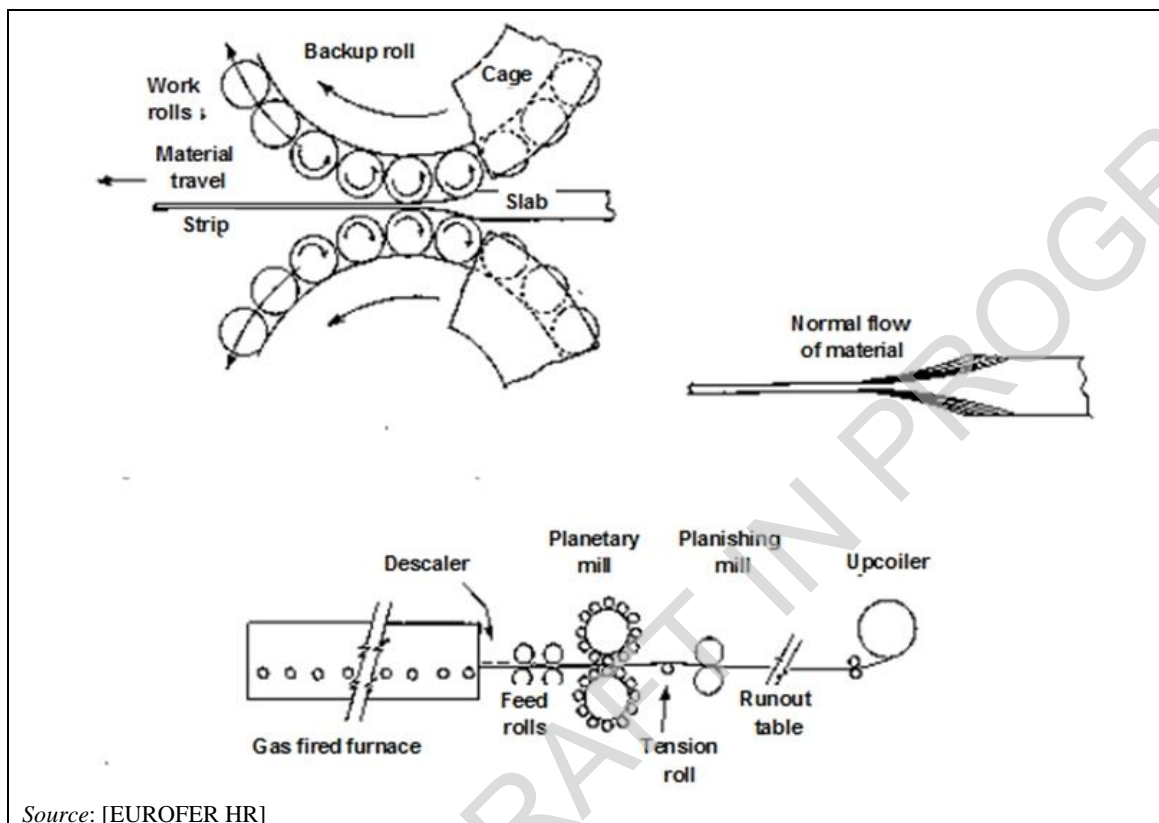
Figure 2.4: Steckel mill with coiling furnaces

Sendzimir planetary mill

Mills of this type are characterised by the use of rotating back-up rolls which drive the work rolls so that the surface of the latter move in a direction opposite to that of the workpiece. The work rolls are held in cages, which rotate around the back-up rolls in a synchronised manner. To

facilitate the use of thicker ingoing material (slabs), planetary mills may be assisted by attached eccentric presses.

Special kinds of planetary mills are the single planetary mill - only the bottom roll set is designed as the planetary type and either a rotating top roll or fixed die is arranged above the passline - and the 'Krupp-Platzer' planetary mill where intermediate rolls are arranged between the work rolls and back-up roll. [EUROFER HR]



Source: [EUROFER HR]

Figure 2.5: Planetary mill (Sendzimir)

2.2.1.3 Plate mills

Production of heavy plates (thickness between 5.0 mm and 380 mm, width up to 5.2 m) is done by reversing operation at one mill stand or in tandem operation.

After rolling, the plates are placed on a cooling bed (cross transfer) and cooled to room temperature and/or temperatures down to maximum 500 °C for further processing. [EUROFER HR]

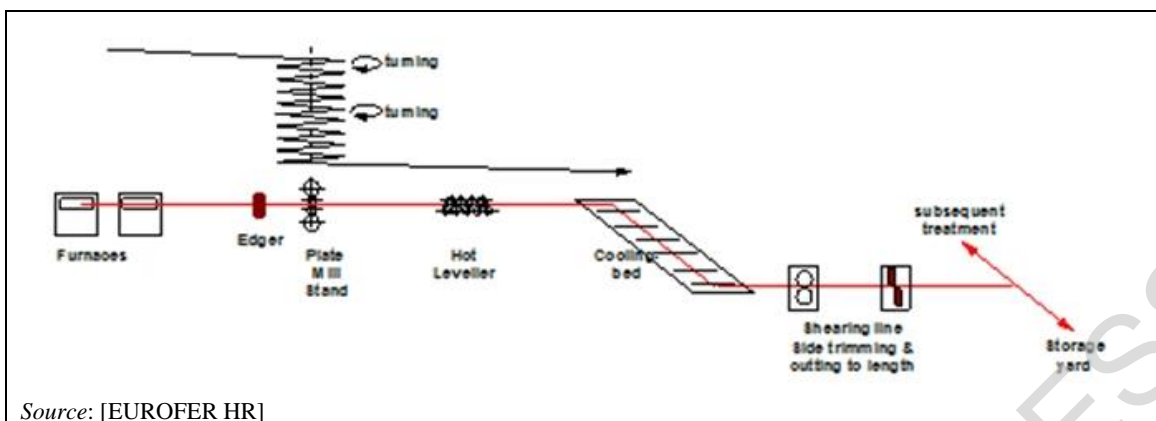


Figure 2.6: Typical plate mill configuration

In special cases, the rolled product is heat-treated by water cooling systems (e.g. water curtains) immediately after hot rolling. Hot and/or cold levellers are arranged before or after the cooling bed to straighten the plates.

After the cooling process on the cooling bed, secondary treatment of the sheets is performed in the finishing shops (shearing, side trimming cutting to length). A part of the production is subjected to a subsequent heat treatment prior to shipment. Such treatments include annealing, spheroidise annealing, stress relieving, normalising, quenching and tempering.

Clads

Special products such as multi-layer plates (clads) require a separate preparation and rolling technique (mainly a two-heat rolling operation). In such products, a corrosion-resistant surface material is permanently bonded to lower-cost, possibly stronger, carbon steel.

The first step involves the fabrication of ‘sandwiches’ which consist of plates of the cladding and the backing materials with thickness in the exact proportion to produce the required plate size with the percentage of metals ordered. The assembly is then rolled to the desired gauge, width and length, with the two materials becoming permanently bonded because of the high rolling pressure.

In the rolling operation, drafts are usually limited and the finishing temperatures are carefully controlled. In some cases the sandwiches are rolled in a first stage into slabs, cut to required sizes and, in a second heat, final rolled either in hot strip mills or in the plate mill. Sometimes heat treatments are required to produce the desired corrosion resistance and physical properties, the resultant scale being removed by sand- or shot-blasting. [EUROFER HR]

2.2.1.4 Bar and rod mills

Bars and rods (wire rods) constitute hot rolled products of relatively small cross sections produced in coiled or straight form. For the rolling operation, profiled rolls are in use to give the steel its desired final shape.

Wire rods

Wire rods generally have circular cross sections with a diameter of 5 mm to 14 mm. Larger cross sections and different section shapes such as oval, square, hexagonal, octagonal, etc. can also be rolled in wire rod mills with adequately shaped rollers. Hot rolled wire rod is mainly used for further processing by cold drawing or cold rolling.

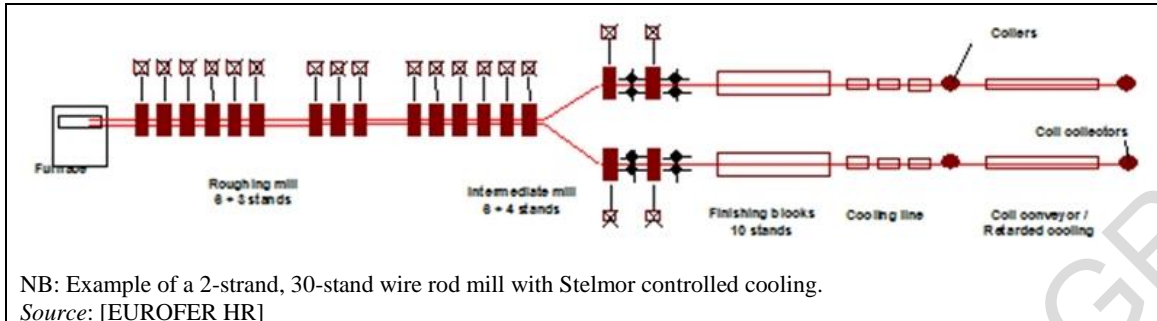


Figure 2.7: Typical layout of a wire rod mill

The billets fed into rod mills are heated to hot rolling temperature in pusher or walking beam furnaces. A descaling system is installed between the furnace exit and the first rolling stand.

Rod mills are continuous mills with roughing, intermediate and finishing sections. The rolling stands are two high and their number is generally in excess of 25, depending on the cross section of the billets feeding the mill (80–155 mm). Roughing and intermediate sections may be multi-strand (up to four strands), while finishing sections are always single-stranded.

Crop shears are installed between the different sections of the mill and are used to provide a clean cut for improved introduction into the following roll stand. Crop shears are also used to cut the bar engaged in the rolling process in case of an incident downstream in the mill.

In-line heat treatment of the wire rod is performed with water cooling ramps located between the final rolling stands and the coilers, followed by air cooling of the coils laid on conveyor belts. Controlled airflow gives the wire rod the desired microstructure for further processing (Stelmor® cooling). [EUROFER HR]

Bars

Hot rolled bars include basically two types of steel products, **merchant steels** or engineering steels with round, square, rectangular, hexagonal, octagonal, L-shaped, [-shaped, I-shaped cross sections smaller than 1 600 mm² and **concrete reinforcing bars** (re-bars) with round cross sections, 6–40 mm in diameter, mostly with ribs on their surface.

Bar rolling mills are similar to the first sections of wire rod rolling mills. They generally have single-strand two-high mills with roughing, intermediate and finishing groups followed by shears that cut the hot rolled product to long bars, which are then conveyed to a cooling bed. High-capacity mills are all continuous with alternating horizontal and vertical stands, while the front groups of lower capacity mills are of the 'open' type.

After cooling, the bars are cut to commercial lengths and may be straightened by a cold straightening machine.

Re-bars are often heat-treated in-line by intensive water-cooling to obtain a high tensile strength (Tempcore® process). A different way for increasing the tensile strength of re-bars is a mechanical treatment after cooling: The bars are deformed by torsion beyond their yield strength until the desired tensile strength is obtained. [EUROFER HR]

Cold drawing of steel bars

Cold drawing concerns the manufacture of steel bars or sections by cold drawing, grinding or peeling of hot rolled steel bars into 'bright steel bars', with the form and characteristics required by the users. Cold finishing during cold drawing operations hardens and increases the tensile strength of the steel, while at the same time reducing the ductility, which may require an annealing treatment of the product after drawing. Bright steel bars mainly have a circular, square, rectangular or hexagonal cross-section, but all kinds of cross-sections can be produced according to demand. Products are non-alloy steel bars, alloy steel bars of different grades including high-speed steel and other tool steel and shapes and sections of different steel grades. [Pan97]

Bright steel bars are used by industries such as the manufacture of motor vehicles, machinery, electrical goods and other industries, where high-quality basic material is compulsory.

2.2.1.5 Structural/Section mills

Like most other types of mills, section rolling mills are divided into roughing, intermediate and finishing stands, preceded by a descaling machine installed between the reheating furnace and the roughing mill.

Roughing stands are generally reversing, two-high stands. The rolls have several sets of profiles, which are used in sequence. The upper roll can be moved vertically in order to progressively reduce the gap between the rolls and thus reduce the passing section.

Cropping shears or hot saws are generally installed between the different sections of the mills and are used to provide a clean-cut bar end to facilitate the introduction into the following rolling stand.

On leaving the finishing stand or train, the bars are cut to cooling bed length or to commercial length by saws. After cooling on the cooling bed, the bars are straightened on mechanical or hydraulic straightening machines and cut to length by saws as required. [EUROFER HR]

To yield the different profile shapes required for sections/structures, either duo-stands with two grooved rolls or 'universal' stands with two horizontal and two vertical rolls are used as shown in Figure 2.8 and Figure 2.9.

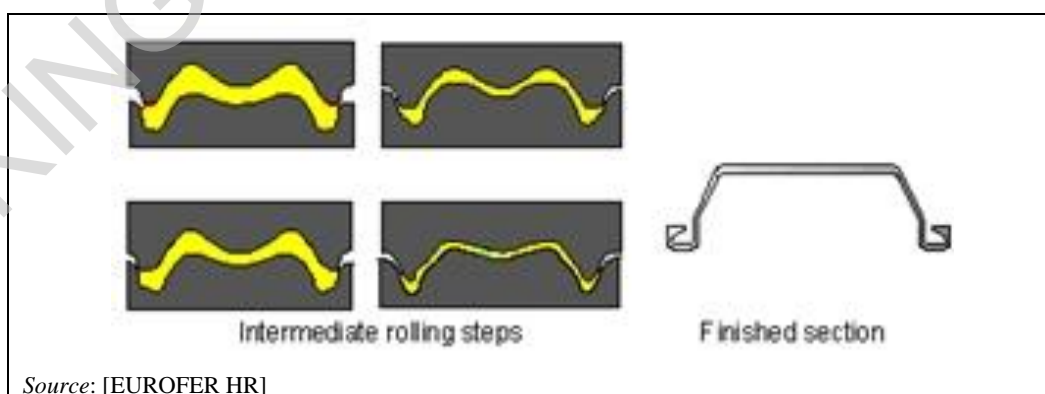


Figure 2.8: Profiled rolls for sheet piling sections

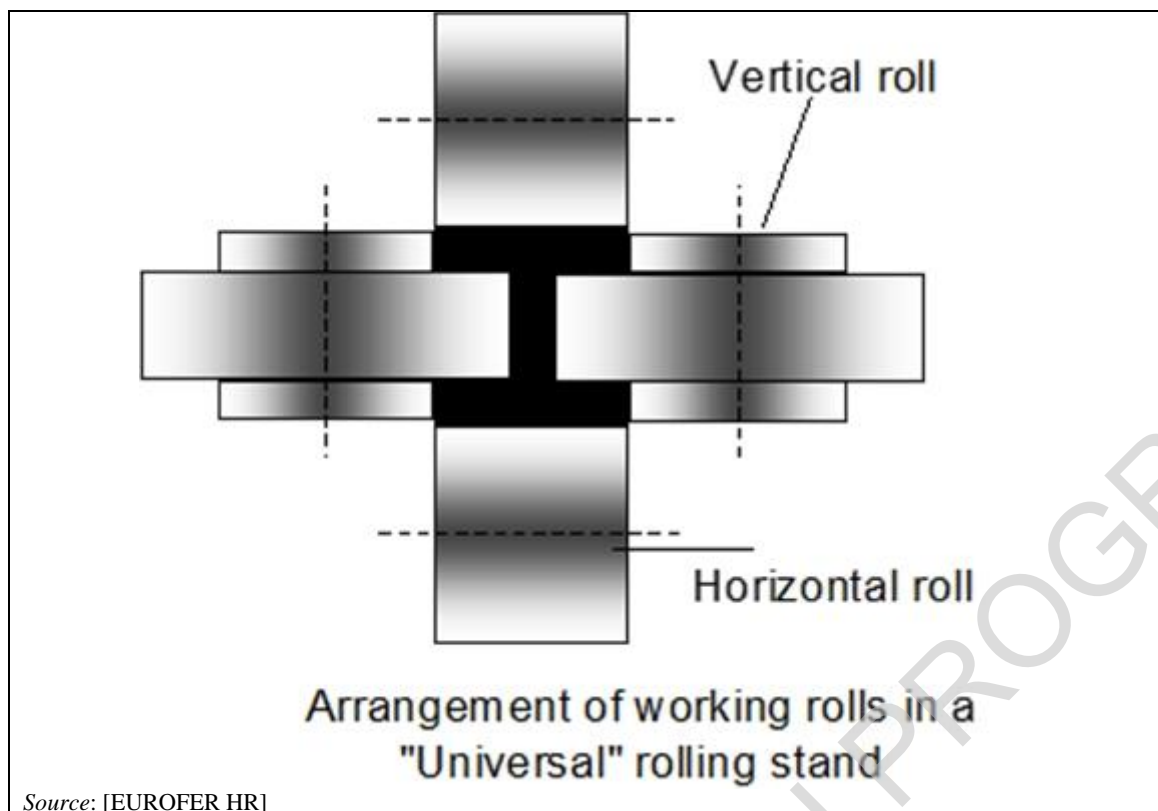


Figure 2.9: Universal stands for parallel flanged products

Geometry control is of the utmost importance in section rolling as relatively tight tolerances are common for hot rolled sections. Measuring devices applying sophisticated techniques including laser beam technology and radioactive sources are commonly used.

The designs of section mills vary greatly according to the manufacturing programme. Figure 2.10 shows the layout of a heavy section mill with universal stands, specialised in parallel flange H and I beams. It includes in-line heat treatment (QST - quenching and self-tempering) to obtain an optimal microstructure for high-strength and high-ductility applications.

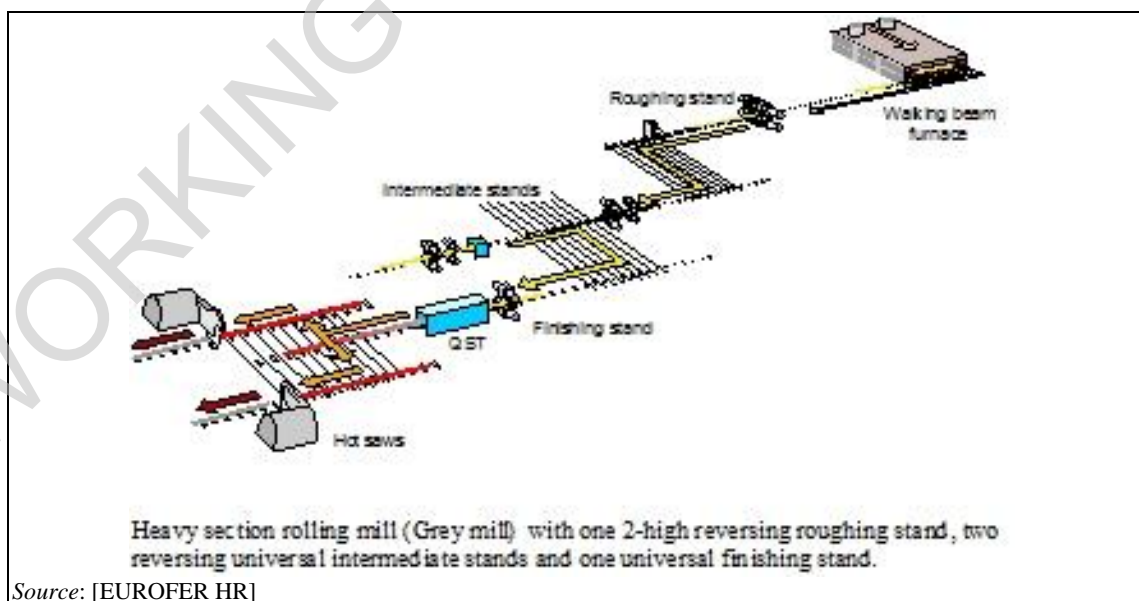


Figure 2.10: Plant layout of a heavy section mill

Figure 2.11 shows the layout of a heavy/medium section mill specialised in the rolling of sheet piling sections. The intermediate stands are of the 'open' type with one common drive. The two-high finishing stand can be replaced by a universal stand for the production of parallel flanged products.

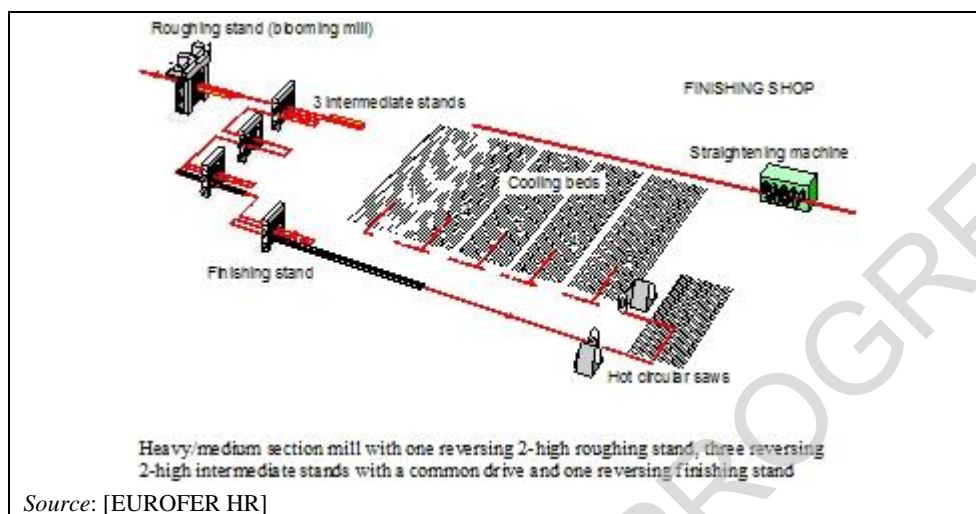


Figure 2.11: Plant layout of a heavy/medium section mill for sheet piling

Section mills increasingly use near-net-shape, continuously cast semis called beam blanks (see Figure 2.12) to increase productivity and decrease energy input.



Figure 2.12: Examples of beam blanks' cross sections

If the production rhythm and the manufacturing programme allow, hot charging of continuously cast semis - from the casting machine run-out area to the reheating furnace of the rolling mill - is applied more and more. Considerable savings in energy consumption may be achieved, but this depends on the proximity of the rolling mill to the continuous casting plant.

2.2.1.6 Tube mills

Seamless tube

Seamless tube production basically consists of the following manufacturing steps:

- heating of the input;
- piercing (press-piercing or oblique rolling);
- elongation/stretching;
- final rolling;
- heat treatment.

The most important types of plants used today are mandrel mills, plug mills, push bench mills and pilger mills. Figure 2.13 and Figure 2.14 show some typical tube mill designs.

Raw material for the production of unalloyed and medium-alloy steel tubes are continuously cast round billets or blooms, although sometimes billets with square cross sections are used. The raw material for high-chrome steel tubes are mainly round bars, rolled from cast billets. The input is heated to rolling temperature in rotary hearth furnaces fired with natural gas or oil. Then a hollow billet (ingot) is produced by piercing. The most important hole-piercing process uses inclined rollers. The hole is produced by two inclined rolls rotating in the same direction, so that the ingot is rolled with a screw motion over a piercer plug to form a hollow bloom. The piercer plug is fixed to a freely rotating rod supported by a thrust bearing on the exit side.

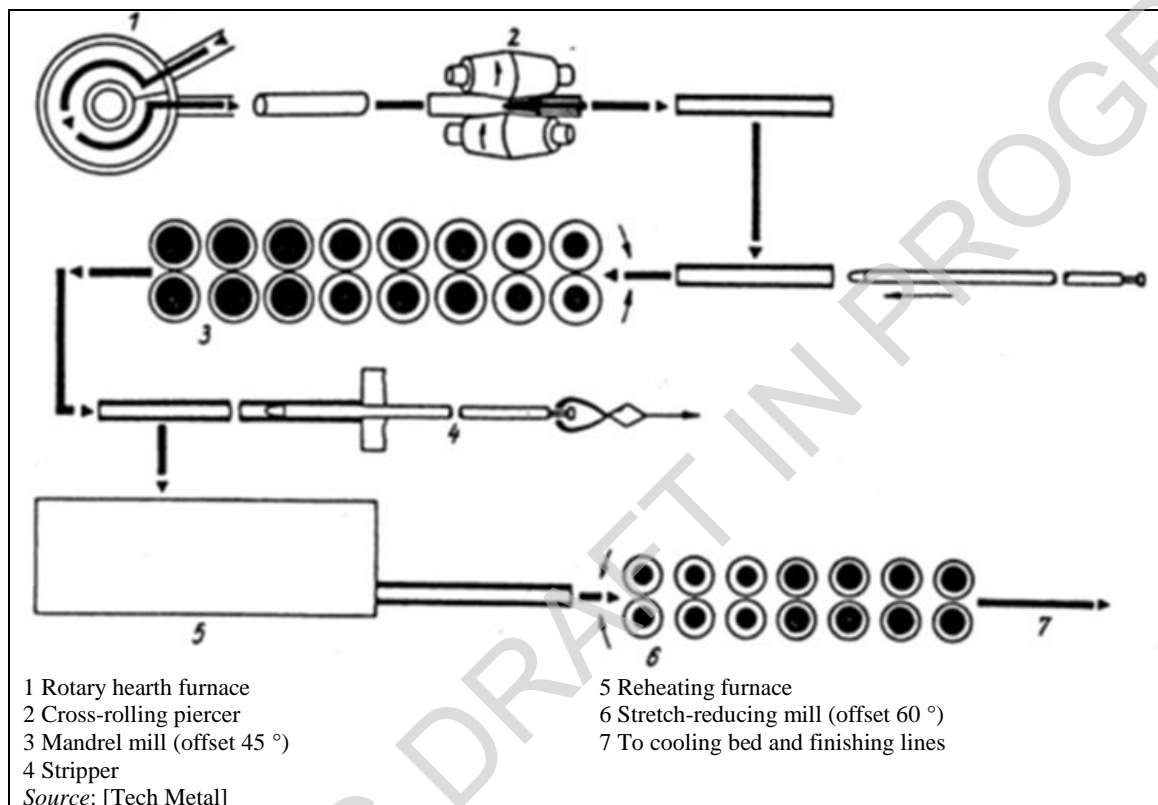


Figure 2.13: Mandrel mill

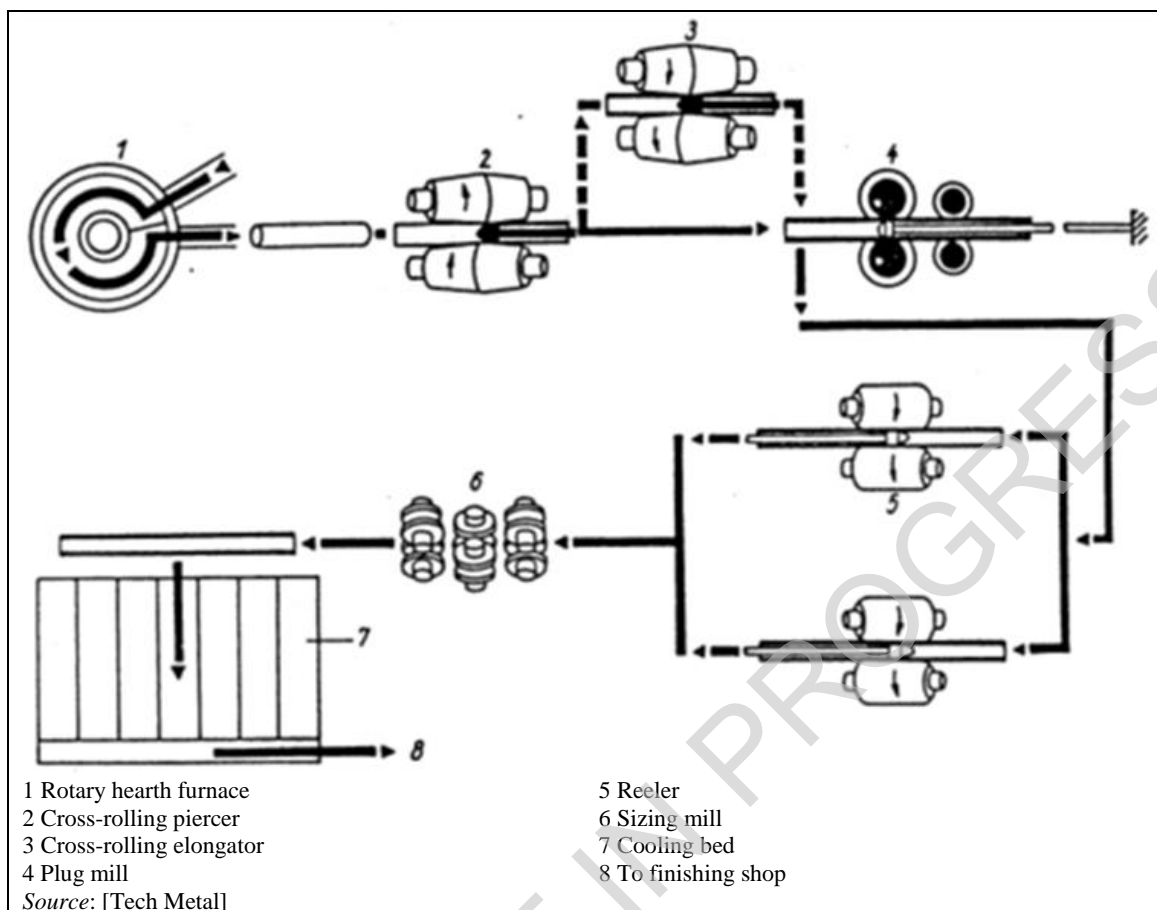


Figure 2.14: Plug mill

Longitudinal rolling, transverse rolling, or presses are used for the elongating stage. The most important one is the continuous tube rolling process, as it is one of the most efficient and productive processes.

Several rolling stands are used simultaneously, usually 6–8 two-high stands per group, at an angle of 90° to each other. The reduction of the wall thickness takes place between the rolls and a cylindrical lubricated mandrel.

Rolling to the finished size is carried out without an inner mandrel in sizing mills or stretch-reducing mills. Sizing mills have 2–10 stands, and can have two or three rolls per stand. As the circumference is reduced, the wall thickness is increased. In stretch-reducing mills, which normally have three rolls per stand, and up to 30 stands, an increase of wall thickness is avoided, as tensile forces are applied between the stands during the process.

Tubes for undemanding applications can be shipped immediately after rolling. For more exacting quality requirements, especially good toughness properties, separate heat treatment is usually carried out after rolling. This can include normalising and tempering.

Welded tubes

Welded tubes are produced from cold rolled or hot rolled steel strip; hot rolled wide strip; or thick plate. In principal the production sequence comprises bending of the strip or plate to an open tube and closing the gap by welding. Figure 1.1 shows a schematic of continuous tube production (Fretz-Moon process).

Figure A.2-15: Flow sheet for continuous tube production [HMIP]

In the Fretz Moon process (pressure welding) coils of hot rolled strip are heated to a high temperature in a tunnel furnace. The edges of the strip are heated to welding temperature by additional burners. The strip is formed into a tube with a longitudinal gap. A two-roll compression device at 90° then reduces the gap and presses the edges together so they become welded.

The semi finished tube passes without further heating through a stretching mill, where the dimensions are reduced as required. A flying saw cuts the continuous tube into lengths, which are then cooled on a cooling bed.

Alternative welding processes are **resistance pressure welding**, in which the required welding heat is generated by high frequency alternating current, conduction or induction. The properties of the welded seams can be improved, either by continuous heat treatment or by separate heat treatment of the individual tube. **Fusion Welding** is mainly used to produce steel pipes with large diameters (> 457.2 mm). shows the main tube welding processes.

- a Fretz Moon welding process
- b High frequency conductive welding
- c High frequency inductive welding

Figure A.2-16: Tube welding processes [EUROFER HR]

2.2.2 Surface rectification and conditioning of input

Slabs, blooms and billets can have surface defects, like cracks, folds or seams. Surface preparation of rolling stock is necessary to ensure the rolled product has flawless surfaces. Surface defects of semi-finished products can also be removed by the following processes.

Scarfig

Scarfig removes surface defects of carbon steel grades by an oxy-fuel flame. The flame is used to rapidly melt and oxidise the steel surface while a separate supply of high-pressure oxygen to the cutter propels the slag product from the surface. Scarfig is either done by hand (for small lot sizes) or by machine.

The scale from machine scarfig is washed from the steel surface by high-pressure water and led to a water pit where the scale is removed by crane. The water is treated and recirculated. From manual scarfig operation, scrap collection is carried out by means of magnets.

Dust emissions from scarfig operation are collected and usually abated by electrostatic precipitators (wet or dry).

Grinding

For stainless steels and special steel grades, thermal removal of the surface defects is not possible. Therefore defects have to be eliminated by grinding. The grinding process is either carried out manually or by machines. Manual grinding is performed by use of handheld power tools, in some cases in booths equipped with fume extraction to bag filter units. Grinding machines are equipped with a roller table on which the workpiece is supported and on which it can be moved. The grinding wheel is mounted on a carriage that permits it to be moved back

and forth over the workpiece. The unit is positioned in an enclosure, which collects the dust generated during grinding and ducts it to a bag filter before discharge to atmosphere.

Cutting slabs to size

In some cases, the slabs have to be cut to the appropriate size. Wedge-type slabs, which result from adjustment of the width in the continuous casting plant (mould adjustment) and from change of the lot size, have to be conditioned by torch cutting to obtain the desired geometrical shape.

2.2.3 Reheating and heat treatment furnaces

For hot rolling, the steel input has to be heated to appropriate rolling temperature between 1 050 °C and 1 300 °C and a uniform temperature distribution has to be ensured.

Depending on the charge material and the hot rolling process, reheating is done in different types of furnaces such as pit furnaces, pusher-type furnaces, walking beam furnaces, rotary hearth furnaces or others. These furnaces are fired directly, usually by oil, natural gas or plant gases such as COG and BFG. Depending on the heating media, different waste gas emissions will occur (mainly SO₂ and NO_x).

2.2.3.1 Batch furnaces

Batch-type furnaces are often used for speciality steels and forgings. A typical example of the batch-type furnace is the **soaking pit**, used to reheat ingots, slabs and other feedstock. It consists of refractory-lined chambers in which the input is placed vertically (ingots) or horizontally (slabs). A moveable cover allows the input to be charged and removed for rolling. Cast ingots can be charged immediately after stripping to conserve energy. The typical soaking pit capacity is 50–170 tonnes with a thermal input of 9.5 MW (Th) and a heating rate of 10.7 t/h.

Soaking pits are no longer in widespread use as steel is increasingly continuously cast, a process, which often bypasses the soaking pits. An example of the soaking pit furnace is shown in Figure 2.15. [EUROFER HR]

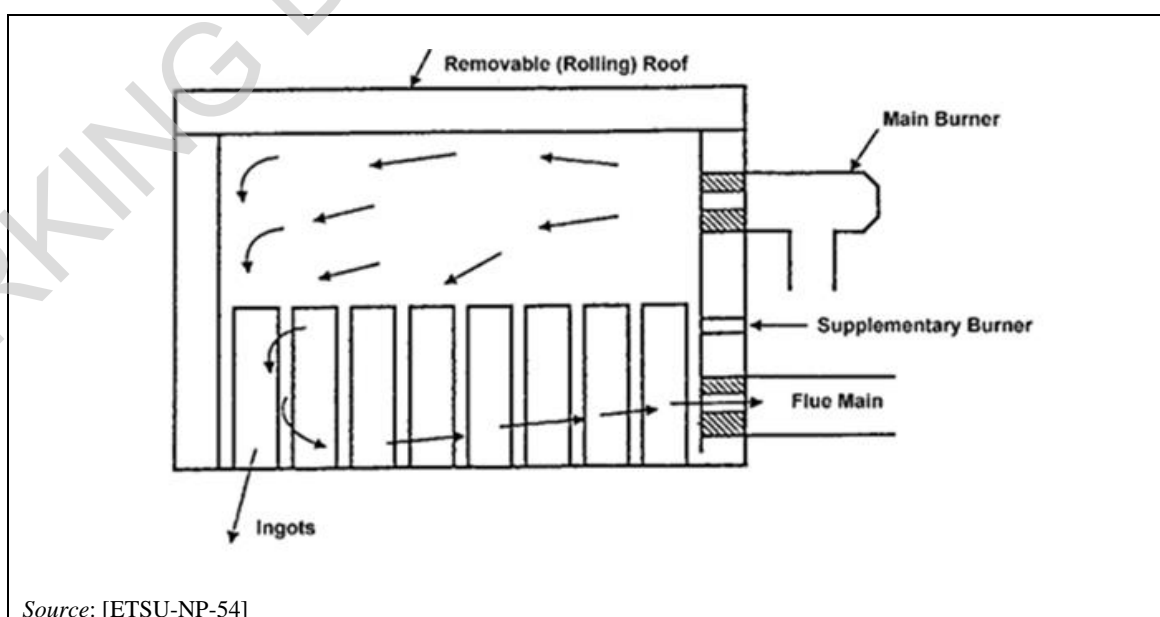


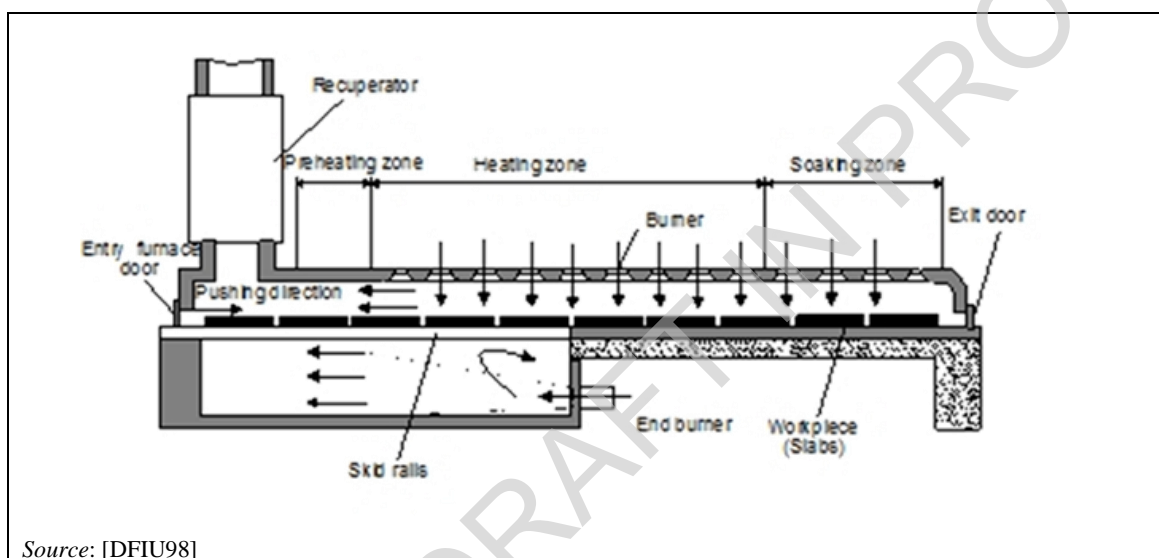
Figure 2.15: Pit furnace

Another type of batch furnace is the bogie hearth furnace. The stock is carried into the furnace chamber on a bogie. The furnace chamber is closed by means of a door and the stock is heated. When the target temperature is reached, the door is opened, the bogie with the stock is removed and the slab or casting is taken away for further use. [EUROFER HR]

2.2.3.2 Continuous furnaces

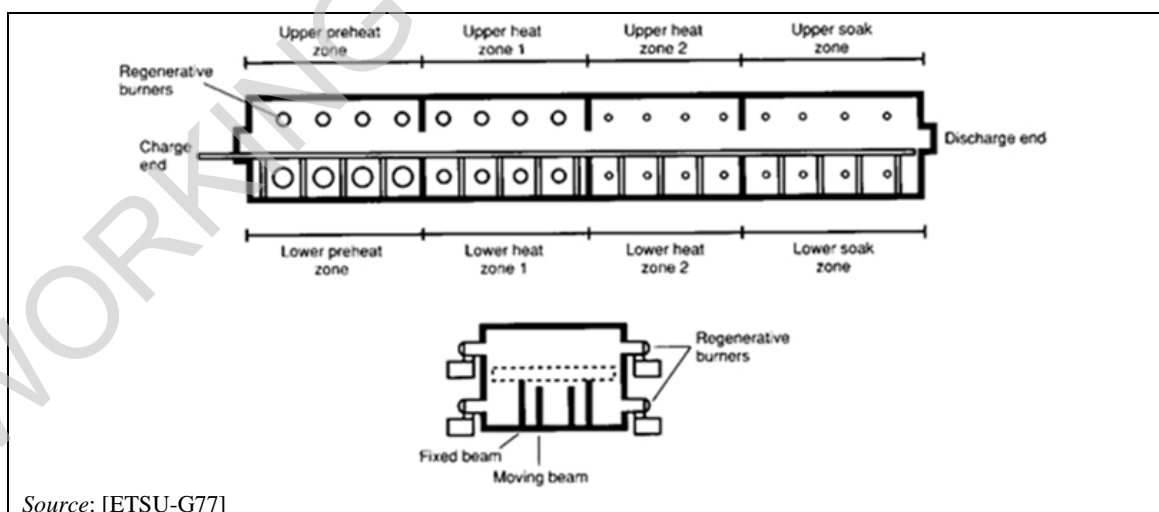
Larger furnaces are usually fed continuously. The stock is pushed through the furnace by the following stock (**pusher-type furnace**) or is moved through by walking beams (**walking beam furnace**), a walking hearth or on/between rollers.

Examples of the larger size (> 20 MWTh) furnaces - the pusher and walking beam furnaces - are shown in Figure 2.16 and Figure 2.17 respectively. The largest currently in operation are walking beam furnaces of approximately 125 MW (Th) and pusher furnaces of 200 MW (Th). [EUROFER HR]



Source: [DFIU98]

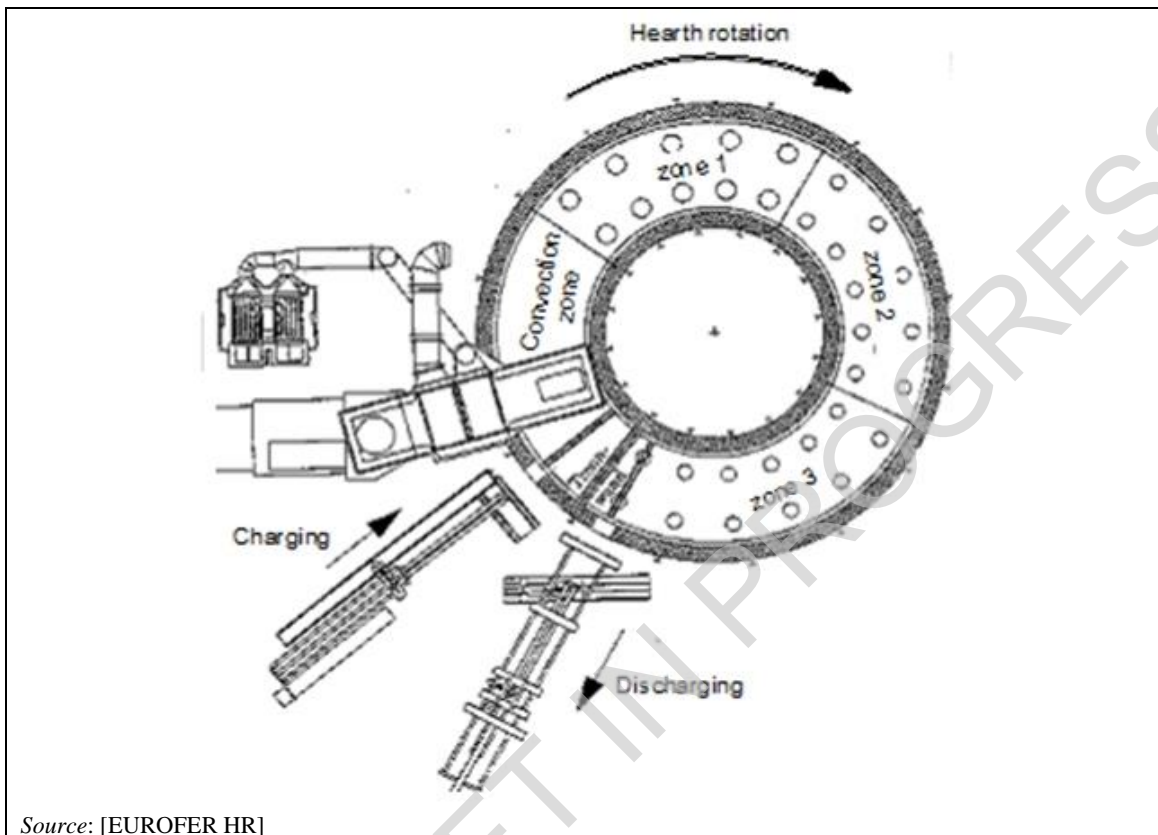
Figure 2.16: Pusher-type furnace



Source: [ETSU-G77]

Figure 2.17: Walking beam furnace

In a **rotary hearth furnace** (see Figure 2.18), the charge material is placed onto a rotary hearth. During the furnace campaign (hearth is rotating), the material is heated and, after completion of a rotation, discharged.



Source: [EUROFER HR]

Figure 2.18: Typical design of a rotary hearth furnace

2.2.4 Descaling

Prior to rolling, adherent scale, which forms during reheating, must be removed, in order to avoid contamination of the stock surface by scale impressed by the rolls (so-called 'rolled in matter').

Mechanical descaling, where the adherent scale is mechanically broken in a light pass (mostly in two-high stands) and then sprayed off or mechanically removed (brushing), is rarely applied any more. Today, a common method of descaling is breaking and spraying off the scale by means of high-pressure water. Power water with pressures of 120–250 bar (exceptionally 600 bar) is applied via flat jet nozzles onto the material surface. For the cleaning effect, the impact pressure (i.e. the pressure determined by the distance of the descaling nozzles to the rolling stock) is more important than the system pressure. The following techniques are applied throughout the whole rolling process:

- Primary descaling in so-called high-pressure descalers installed before the entry into the roughing train and equipped with one or two pairs of, sometimes adjustable, descaling headers.
- Mill stand descaling by means of descaling headers arranged above and below the plate passage on both sides of the reversing stand and on the entry side in the case of continuous stands.
- Descaling at the entry of the finishing train for removing secondary scale, i.e. the scale formed on the rough strip at the conveying roller table of the roughing train and finishing train.

- Pairs of mill stand descaling sprays at the entry of the first stand of the finishing train. [EUROFER HR].

In the case of production lines for long products, the descaling headers are either designed as spray rings or as a combination of vertical and horizontal headers, sometimes adjustable to the material cross section, for proper descaling of all material surfaces. [EUROFER HR]

2.2.5 Edging

Edging is usually applied in the manufacture of strip and plate. The slabs produced in the continuous casting plant are supplied in certain defined stepped dimensions of widths. The width has to be reduced to the specified dimension of the rolled strip, with a trimming allowance as narrow as possible (scrap minimisation and yield improvement). In most cases, this width reduction is performed on so-called edgers (vertical rolling stands) - recently even in slab presses - which are installed before the roughing unit. The accuracy of the width reduction and optimum adherence to the rectangular shape affect the amount of scrap arising from cropping (head and tail end) in the rolling mill and in the finishing shops (trimming).

2.2.6 Roughing

Roughing depicts the first bulk reduction done on the incoming hot rolling stock for the production of strip, rod and sections. Generally, the roughing train consists of one or more horizontal stands for thickness reduction, including edgers (vertical stands) situated before the stand for width adjustment. Reversing roughing mills are sometimes equipped with edgers on both ends of the mill stand. [EUROFER HR]

2.2.7 Strip rolling / Finishing train

In general, the finishing mill consists of a number of rolling stands positioned after one another. The stands have staggered roll gaps so that the thickness reduction to the requested final thickness is done in one pass of the transfer bar. The number of stands depends on the grade and material thickness of the input (slabs) as well as on the thickness range of the finished strip.

Crop shears arranged in front of the finishing stands serve to cut the ends of the rough strip, which may have the form of a tongue or fishtail. This ensures safe entry into the finishing train and avoids damage to the rolls as well as generation of scrap.

In most cases, an additional descaling device (descaling sprays) as described above is installed between the crop shears and finishing train. Sometimes there is also an additional vertical stand, which is mainly used for strip guidance, but occasionally for minor width adjustments as well.

Coilers

Hot strips with lengths of up to 2 km and more are wound up on so-called down (sometimes up-) coilers at the end of the rolling mill at speeds of up to 20 m/s and more. The hot band is guided around an expandable mandrel by specially arranged wrapper rollers. After roughly three to four windings, the wrapper rollers are lifted and the band is coiled onto the expanded mandrel. After the coiling operation is finished, the mandrel is collapsed and the hot coil is transported to a strapping station by means of a coil car. [EUROFER HR]

2.2.8 Rod rolling / Finishing train

The finishing train of rod mills usually consists of rolling blocks with up to 10 sets of alternating horizontal and vertical roller pairs as shown in Figure 2.19.

Rolling speeds of more than 100 m/s are achieved at the final stages. The material used for the roughing and intermediate rolls is generally hardened steel or cast iron while the finishing rolls are made of carbide, a particularly wear-resistant material. The typical calibration used for wire rod mills is a sequence of alternating round and oval calibres.

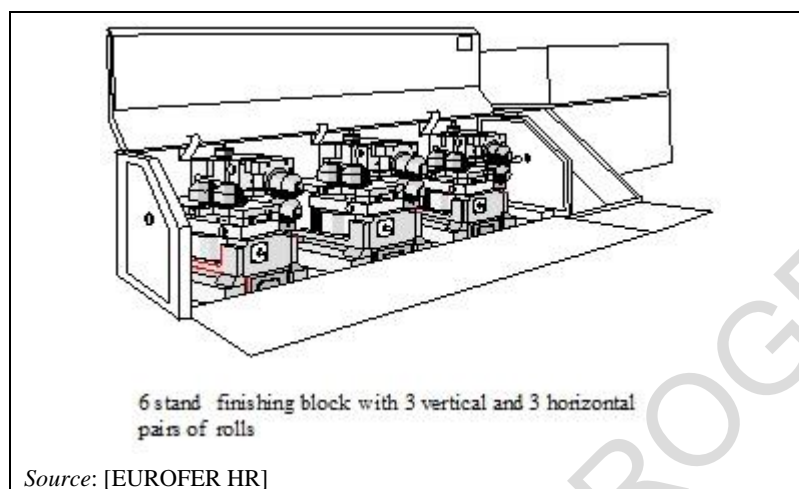


Figure 2.19: Roller arrangement of wire rod finishing section

2.2.9 Plate rolling

Plate rolling by reversing operation is similar to roughing in strip production. The slabs are formed into plates in the so-called multi-stage rolling operations, where the slabs are stretched, turned 90° by means of conical rollers on a special roller table, spread, turned again and rolled to the requested thickness.

2.2.10 Ring rolling

To produce rings by ring rolling, the first two process steps are the heating and cutting of the billets/ingots into blanks. Heavy ring blanks are cut cold using sawing machines. After heating at around 1 200 °C in electrical or LPG-fired furnaces, the blanks are pierced in a press before the material is rolled in rolling mills. The rings produced are normally heat-treated after rolling and some rings are processed in blasting machines to remove mill scale [Sweden, 12-11-2018].

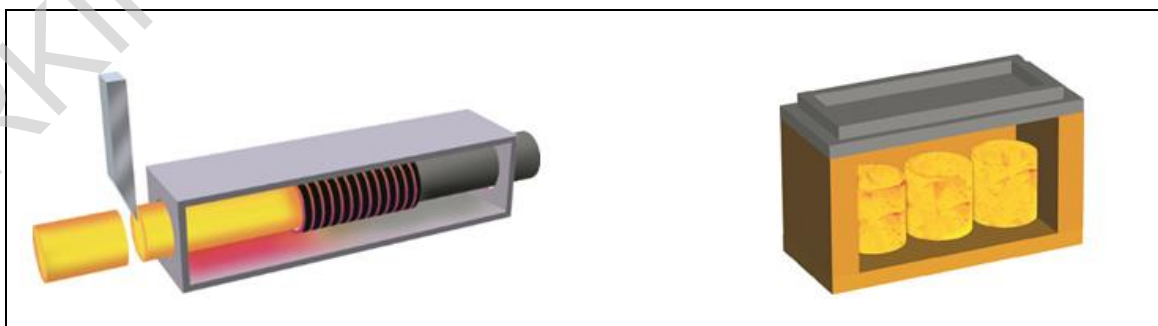


Figure 2.20: Material cut into blanks after heating in an induction furnace and blanks heated in a batch furnace after cutting cold

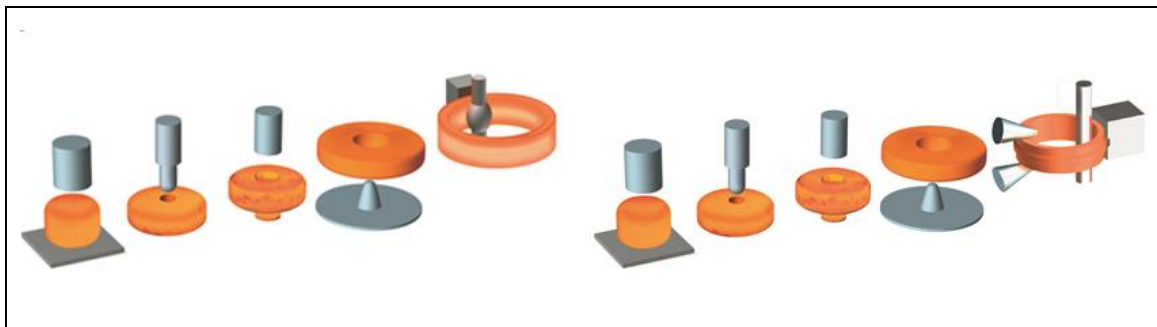


Figure 2.21: Blanks pierced, pressed and rolled in a radial rolling mill and in an axial rolling mill

2.2.11 Transport of rolling stock between rolling stands

Usually, roller tables arranged along the entire strip rolling train are used as a means of transport for the rolling stock. These roller tables consist of individual metallic hollow and/or solid rollers with single drive or group drive by means of an electromotor and gear, if necessary.

In special cases, for example later modernisation of a rolling mill including increase of the weight of single products or installation of additional equipment, the distance between the roughing stand and finishing stand is no longer sufficient to decouple the two processes. So-called coil boxes - developed by STELCO, Steel Company of Canada Ltd. - are then inserted as intermediate storage devices. [EUROFER HR]

2.2.12 Cooling lines

In connection with an appropriate temperature control within the finishing trains, the cooling line provides the material with the desired mechano-technological parameters. The steel is rapidly cooled using either water sprays, water walls or laminar flows (see Figure 2.22).

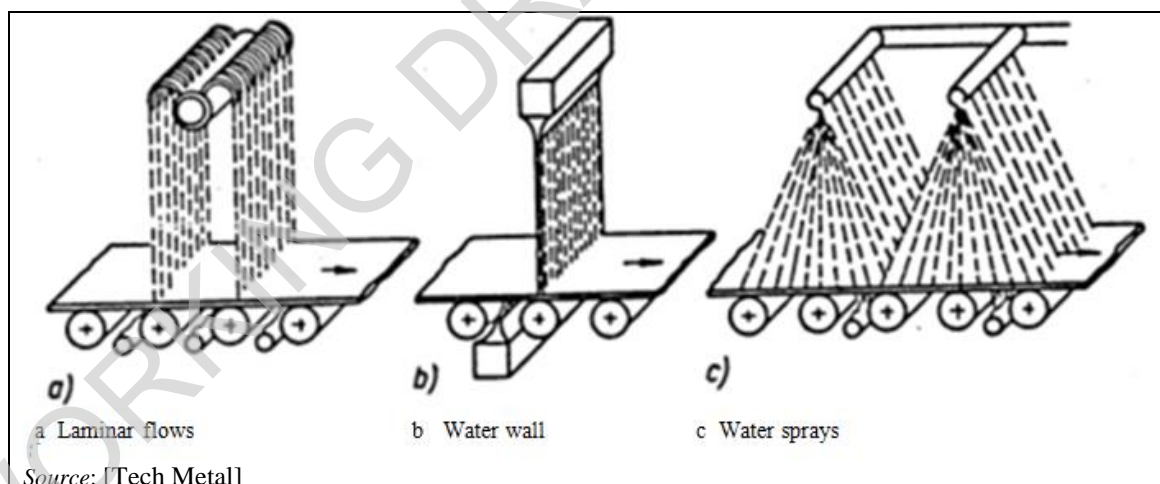


Figure 2.22: Different types of water cooling

Laminar flow cooling on run-out tables is mostly used nowadays. Usually, the spray headers (arranged on the top and bottom of the passline) are grouped into sections, sometimes of different water flow volumes. Each section and/or each header is individually controllable so that the desired cooling temperature may be realised. Cooling lines and the individual sprays are computer-controlled, whereas the spray headers are switched on and off in accordance with

complex mathematical-empirical models, supported by peripheral temperature measurements. [EUROFER HR]

2.2.13 Sheet and plate production

For sheet production, the hot produced coils are decoiled by means of uncoiling reels and supplied to a shearing line which is equipped with levellers to straighten the strip. The rolled sheets with the desired length are piled and stored in the storage yard. [EUROFER HR]

Plate production is carried out on shearing lines following the rolling process. The plates are trimmed on both sides, cropped and cut to the desired length. Cutting to size for special blanks is done by CNC-cutting equipment (torch-, plasma- or laser-beam-cutting units). The internal quality of plates may be determined by ultrasonic techniques. Automatic devices may be installed on the shearing line run-out table.

Finishing operations are computer-controlled in most installations. Consideration is also being given to the in-line quenching and heat treatment of plates following the last rolling pass as a means of conserving energy. [EUROFER HR]

2.2.14 Plate heat treatment

Finished plates are partly subjected to heat treatment. In **annealing**, steel is heated to a subcritical temperature to relieve stresses. For **normalising**, steel is heated above its critical temperature and air-cooled. The purpose is to refine grain sizes and to obtain a carbide distribution, which will dissolve more readily, austenite. **Quenching**, **tempering** and other methods may also be applied.

Several different types of furnaces are used for these purposes, such as walking-beam-type, roller hearth or car bottom furnaces. The heating and combustion system of such furnaces are comparable with the systems related to stock reheating. All usually available heating media may be used for firing the treatment furnaces. [EUROFER HR]

2.2.15 Pickling and oiling of hot rolled steel

In many manufacturing applications and processes using hot rolled steel, scale is undesirable. Therefore, hot rolled steel is pickled to remove scale and oiled to reduce corrosion. These processes are carried out in the hot rolling mill to create a product for end users, called hot rolled pickled and oiled steel (HRPO steel).

2.2.16 Roll shop

The workrolls as well as the back-up rolls for both finishing and roughing mills are conditioned according to well-defined specifications, depending on the product to be rolled. Conditioning of the rolls is performed at the roll shop where typical machine shop techniques are applied, such as machining and grinding. [EUROFER HR]

A roll shop generally includes the following:

- Cooling area where work rolls are cooled either in the open air or by water sprinkling.
- Preparation area where the rolls are dismantled and set up. (In some cases, the roll shop machines allow reconditioning of rolls without prior dismantling.)
- Cleaning area where the rolls to be reconditioned are cleaned of deposits and lubricants. (The cleaning techniques include steam cleaning, application of alkali degreasing solutions, application of organic solvents.)

- Typical machine shop equipment including lathes and grinding machines which have an individual cooling system where the cooling liquid is continuously processed in order to separate turnings and grinding sludge [EUROFER HR].

2.2.17 Water circuits / Water management in hot rolling mills

Throughout the hot rolling process and linked process steps, water is used for cooling and for technological reasons. Electric motors, reheating furnaces, control rooms and power systems, instruments and process control systems are usually cooled indirectly. The steel, rolls, saws, cropped ends, coilers and hot run-out tables are cooled directly. Water is also used for scale breaking, flushing scale and for scale transport. Wherever the water is in contact with the rolled material (process water) and rolling equipment it will be contaminated with scale and oil.

The simplest water feeding system applied is an **open system** (once-through system) as shown in Figure 2.23. The water is taken from natural resources (river, lake or groundwater), flows through the various consumers of the hot mill and is released again to the watercourse.

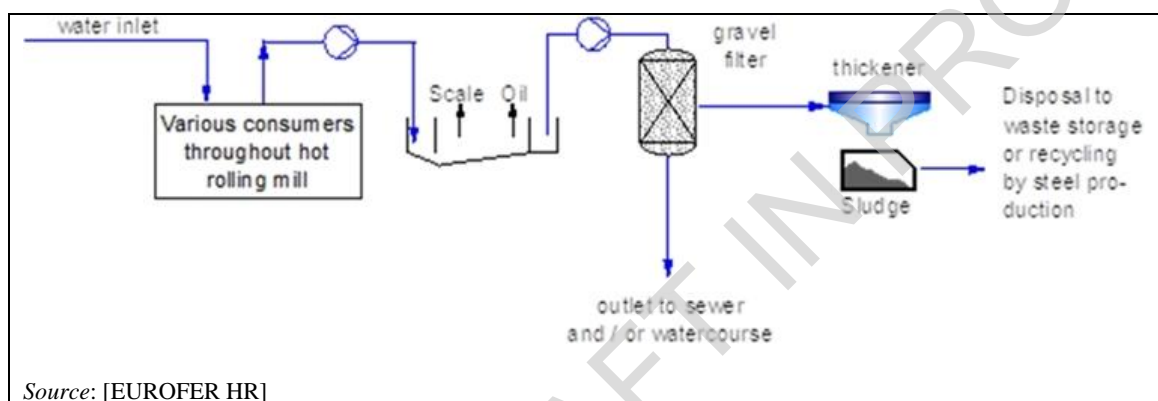


Figure 2.23: Example of a once-through water system

The polluted cooling and process waters are collected and treated prior to discharge. The first treatment stage is a sedimentation basin in which solids, mainly iron oxides, are allowed to settle at the bottom of the basin.

The sedimented solids are discharged via appropriate devices (scraper, screw, etc.) and, in the case of integrated steel plants, returned to the production process via the hot metal route. The oil pollutants floating on the surface are removed by means of suitable skimming devices and are discharged to the respective collecting basins.

The precleaned overflow is supplied via pipes to the filter batteries whose number, size and capacity are designed in conformity with the water volume. In most cases, these filters are gravel filters, i.e. the overflowing water is cleaned by passing through gravel beds.

The pollutants in the gravel filters must be removed by back-washing in order to maintain the function and separation efficiency of the filters. The purified waste water from the filters is discharged into the sewage system and/or lakes and rivers.

The sludge-bearing waters (mostly containing iron oxide) from the filter batteries are separated in a thickener. The overflow is recirculated to the cleaning circuit system. The high-quality feed material contained in the sludge is further dewatered and disposed of or returned to the steel production process, provided the appropriate technical equipment is available.

In order to reduce or avoid waste water discharge from hot rolling operations, semi-closed and closed circuits are implemented.

In **semi-closed circuits**, as shown in Figure 2.24, the water is treated and partly reused depending on the temperature. The water treatment devices are the same as for open systems, but the filtered waste water is not directly disposed of. Instead, it is conveyed into a filter water tank and mixed with cold fresh water, if necessary. Depending on the temperature of the mixed water, the filtered water is returned to the different consumers in the hot rolling mill and only the overflow is discharged. Accordingly, the volume of the circulating water depends on the seasons and the geographical situation.

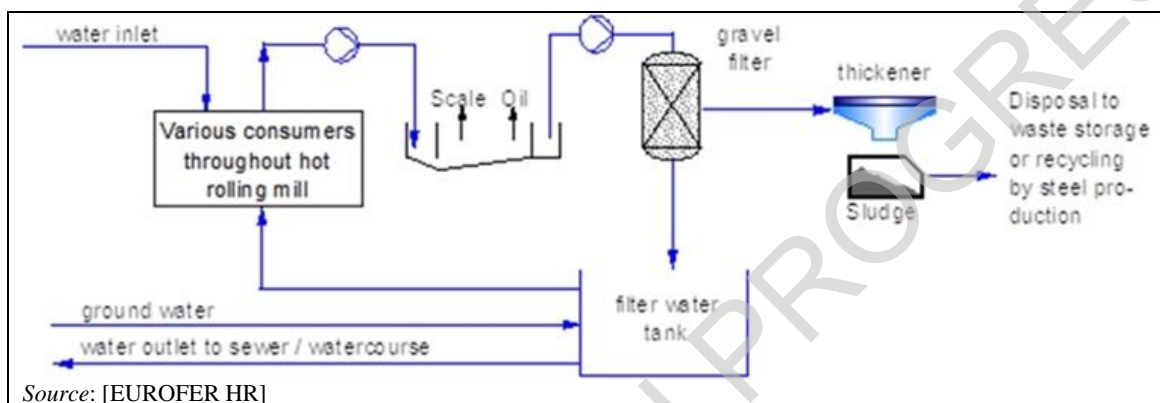


Figure 2.24: Example of a semi-closed water circuit

In **closed water circuits** (see Figure 2.25), the purified water is not discharged, but recooled in cooling towers or heat exchangers to the required temperature and reused in the rolling process. For plants using cooling towers, water consumption is restricted to the additional water (approximately 3–5 %) needed to make up for evaporation and for blowdown losses. When heat exchangers are used, large recirculating volumes of recooling water are required.

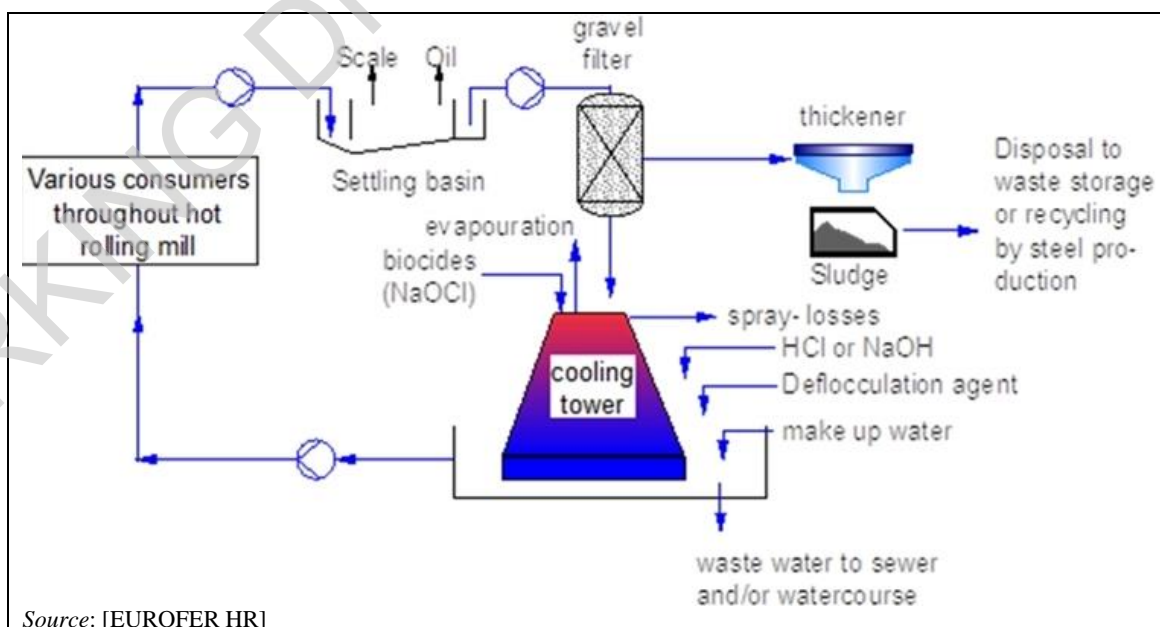


Figure 2.25: Example of a closed circuit water

Water feeding and treatment systems in hot rolling mills are usually very complex, with several partly interconnected water loops and multiple-stage use of water. In some cases, the hot rolling mill water circuit is coupled with the water feeding systems of other iron and steel production units, like for example continuous casting. The reasons for this connection are the similarity of the waste water contents and the proximity of the installations.

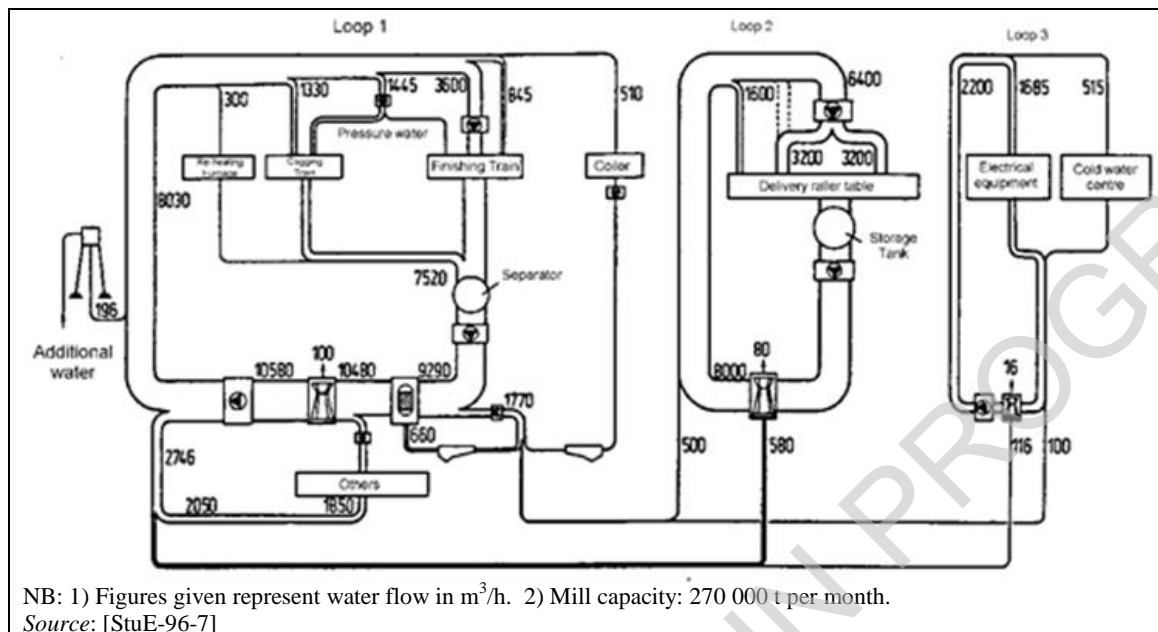


Figure 2.26: Water loops for hot strip rolling mill

Figure 2.26 shows the water circuit of a hot wide strip mill where three water loops are established. Loop 1, with 8 030 m³/h, comprises the cogging stand, finishing train and reheating furnace; loop 2 (8 000 m³/h) the delivery roller table and loop 3 (2 200 m³/h) mainly the electrical equipment. The loops are connected in a way that the water input for loops 2 and 3 is supplied by the clean water side of loop 1. The process water of loops 2 and 3 is sent to the treatment facilities of loop 1 and blowdown water can also be discharged to loop 1.

Figure 2.27 shows another example of a water management system for a hot wide strip mill. The loops established in this case are for furnace and engine cooling, for roller stands and for laminar strip and roller table cooling.

The prevention of effluents by using water in loops or in multiple stages is a well-known and widespread practice within the steel industry. Hot rolling mills offer a high potential for reduction in water consumption and waste water discharge, because of the large quantities of water needed.

Apart from waste water, hot rolling operations generate different kinds of solid and liquid by-products and waste:

- Metallic by-products/waste**, like scrap, downgrades, crop ends, etc. arising from hot rolling, is usually relatively clean and is easily recycled into metallurgical processes (e.g. BOF).

Scale is also sold for external use (e.g. to cement manufacturers) or it is supplied to an external company for treatment (usually thermal treatment to burn the oil content). Thermal treatment plants can yield a product with an iron content of about 60–70 %. If the thermal treatment plant is fed with oily mill scale of about 4.5 %, no additional energy supply is required.

Oxide dusts from air cleaning devices, for example from bag filters for oxide removal at the mill stands, are recyclable to the steel production (e.g. sinter plant) without risks.

Oil and grease, separated and collected at various stages, are energy sources and can be utilised as secondary fuels, for example by injection into the blast furnace or in the coke-making process. Dewatering might be a precondition. Alternatively, these materials can be used at the coke ovens to increase coal bulk density prior to carbonisation. [EUROFER HR] [Com2 HR]

Spent emulsion from the roll shop or other consumers can be split into components: oil and water. The separated oil can be thermally utilised or recycled externally. [Com2 HR]

2.3 Current consumption and emission levels for hot rolling mills

The information contained in this section of the old BREF has been removed and replaced with the data from the data collection. Old information, along with input from the TWG will be revised and added after draft 1.

2.3.1 Mass stream overview

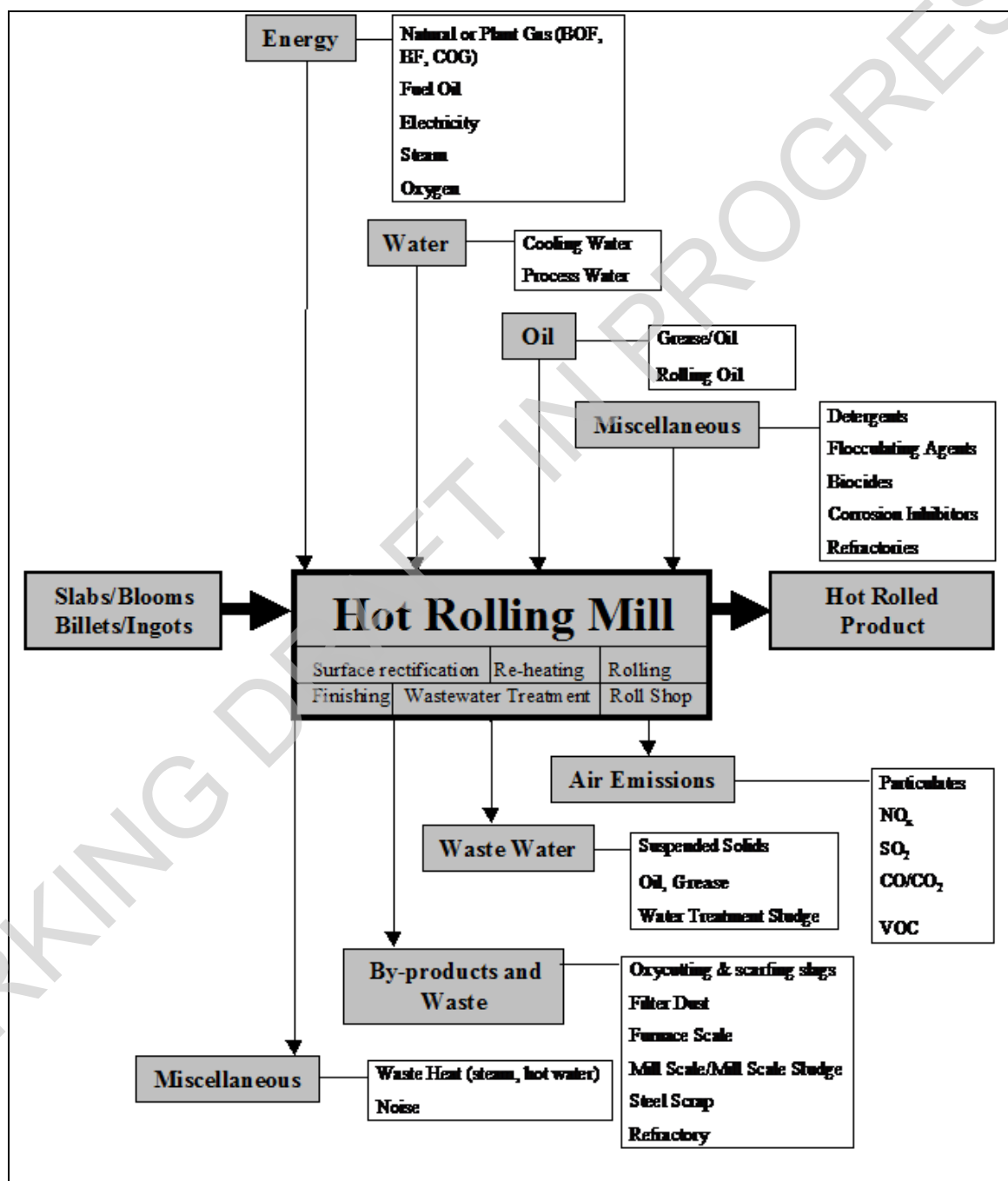


Figure 2.28: Input/output overview for hot rolling mills

The subsequent chapters present specific input and consumption data, as well as specific output and emission data for individual operational steps associated with the manufacture of hot rolled products.

2.3.2 Energy efficiency

Figure 2.29, Figure 2.30 and Figure 2.31, show reported data on the specific energy consumption for feedstock reheating, intermediate heating and post-heating respectively.

Figure 2.32 shows reported data on the specific energy consumption in hot rolling for rolling processes, including roughing and finishing.

2.3.3 Material efficiency

2.3.3.1 Consumption of oils

Figure 2.33 shows reported data on the specific oil consumption for three operating years in hot rolling plants. Values of oil consumption include all types of oils used in the plant (e.g. rolling oil, hydraulic systems oil, lubrication oil, anticorrosive oil, fat and grease).

2.3.3.2 Consumption of acids

Figure 2.34 to Figure 2.37 show reported data on the specific acid consumption for three operating years in hot rolling plants producing HRPO steel. Each figure corresponds to a different acid, namely hydrochloric, sulphuric, nitric and hydrofluoric acid. Specific acid consumption is expressed in kg of acid per m² of treated (pickled) surface. For HCl a concentration of 33%-wt is considered, for H₂SO₄ a concentration of 96%-wt, for HNO₃ a concentration of 49%-wt and for HF a concentration of 70%-wt.

2.3.4 Water consumption

Figure 2.34 shows reported data on the specific water consumption for three operating years in hot rolling plants.

2.3.5 Emissions to air

The abbreviations used in the graphs on emissions to air in hot rolling can be found in the Glossary.

2.3.5.1 Emissions to air from mechanical processing, scarfing and welding

Dust emissions

The reported data on dust emissions to air from mechanical processing, scarfing and welding are shown in Figure 2.39 and Figure 2.40.

Lead emissions

The reported data on lead emissions to air from mechanical processing, scarfing and welding are shown in Figure 2.41.

Nickel emissions

The reported data on nickel emissions to air from mechanical processing, scarfing and welding are shown in Figure 2.42.

2.3.5.2 Emissions to air from heating

Dust emissions

The reported data on dust emissions to air from feedstock heating (reheating, intermediate heating and post-heating) for fuel 100% natural gas and fuel other than 100% natural gas or unknown fuel respectively are shown in Figure 2.43 and Figure 2.44.

TWG, please consider the levels of dust emissions, even for NG firing and provide feedback on techniques to prevent and/or abate dust emissions from heating to be added in Section 2.4.

SO₂ emissions

The reported data on SO₂ emissions to air from feedstock heating (reheating, intermediate heating and post-heating) for fuel 100% natural gas and fuel other than 100% natural gas or unknown fuel respectively are shown in Figure 2.45 and Figure 2.46.

NOX emissions

The reported data on NOX emissions to air from feedstock heating (reheating, intermediate heating and post-heating) for fuel 100% natural gas are shown in Figure 2.47, Figure 2.48 and Figure 2.49.

The reported data on NOX emissions to air from feedstock heating (reheating, intermediate heating and post-heating) for fuel other than 100% natural gas or unknown fuel are shown in Figure 2.50 and Figure 2.51.

Figure 2.52 and Figure 2.53 show the reported data on NOX emissions to air from feedstock heating (reheating, intermediate heating and post-heating) for fuel 100% natural gas and fuel other than 100% natural gas or unknown fuel respectively for reheating of flat products.

Figure 2.54, Figure 2.55 and Figure 2.56 show the reported data on NOX emissions to air from feedstock reheating for all fuels together with the preheating temperature of air used for combustion and the target temperature of the feedstock exiting the furnace.

Figure 2.57 and Figure 2.58 show the reported data on NOX emissions to air from feedstock intermediate and post-heating for all fuels together with the preheating temperature of air used for combustion and the target temperature of the feedstock exiting the furnace.

CO emissions

The reported data on CO emissions to air from feedstock heating (reheating, intermediate heating and post-heating) for fuel 100% natural gas are shown in Figure 2.59 and Figure 2.60.

The reported data on CO emissions to air from feedstock heating (reheating, intermediate heating and post-heating) for fuel other than 100% natural gas or unknown fuel are shown in Figure 2.61.

Figure 2.62, Figure 2.63 and Figure 2.64 show the reported data on NOX emissions to air from feedstock reheating, intermediate and post-heating for fuel 100% natural gas, together with the CO concentration corresponding to the maximum NOX value over the reporting period.

Figure 2.65 and Figure 2.66 show the reported data on NOX emissions to air from feedstock reheating, intermediate and post-heating for fuel other than 100% natural gas or unknown fuel,

together with the CO concentration corresponding to the maximum NOX value over the reporting period.

2.3.5.3 Emissions to air from pickling

Reported data on emissions to air from pickling in the production of hot rolled pickled and oiled steel (HRPO) can be found in the respective section for cold rolling. Data are presented together, as the processes are similar.

2.3.6 Emissions to water

Figure 2.67 to Figure 2.98 show the reported data on emissions to water, for direct and indirect discharges, per pollutant from plants treating waste waters from hot rolling.

2.3.7 Residues

Figure 2.99, Figure 2.100 and Figure 2.101 show the reported data on the specific generation of oil- containing residues, scale and filter dust for three operating years in hot rolling plants.

2.3.8 Figures with consumption and emission levels

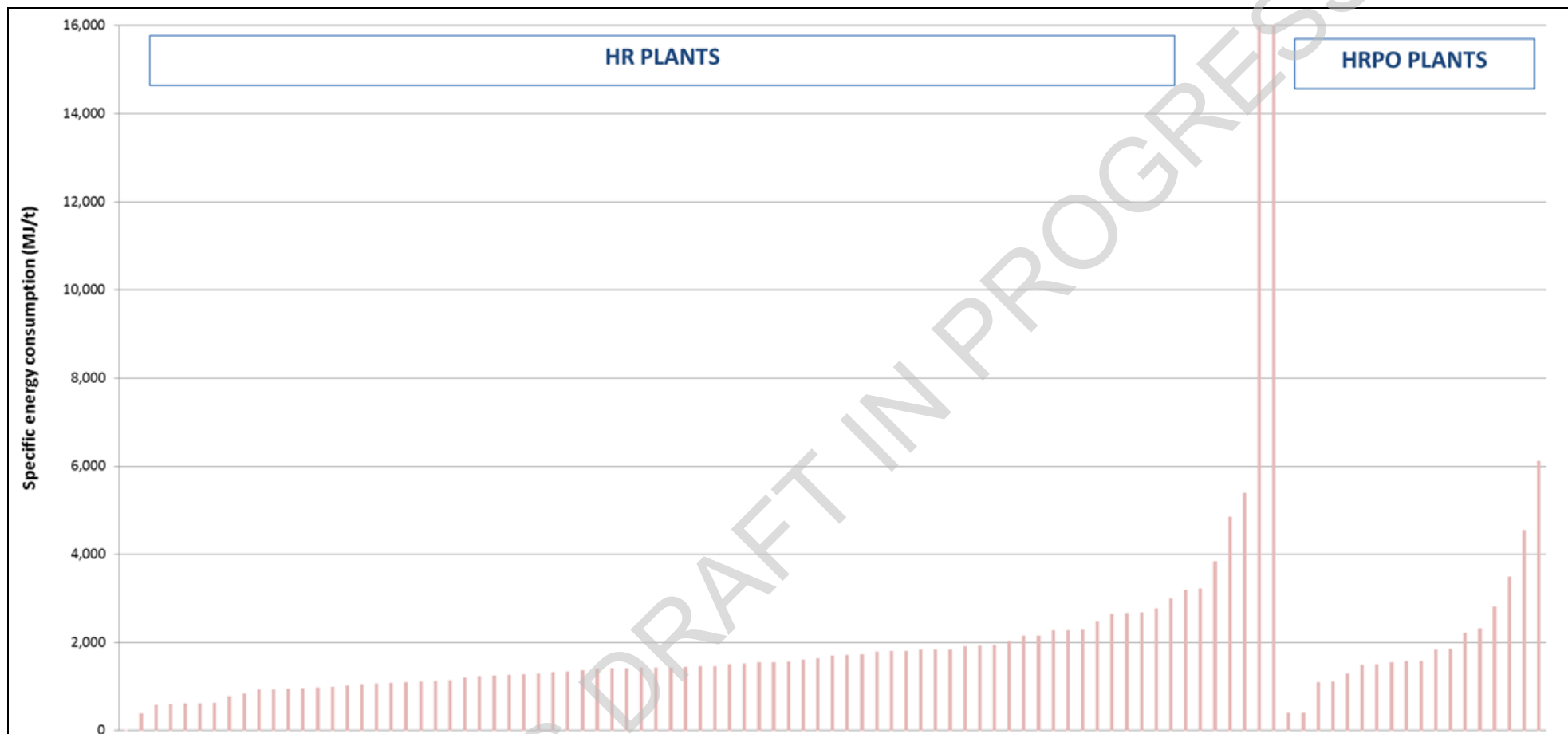


Figure 2.29: Specific energy consumption (MW/t of process throughput) for feedstock reheating. Source: [TWG 2018].

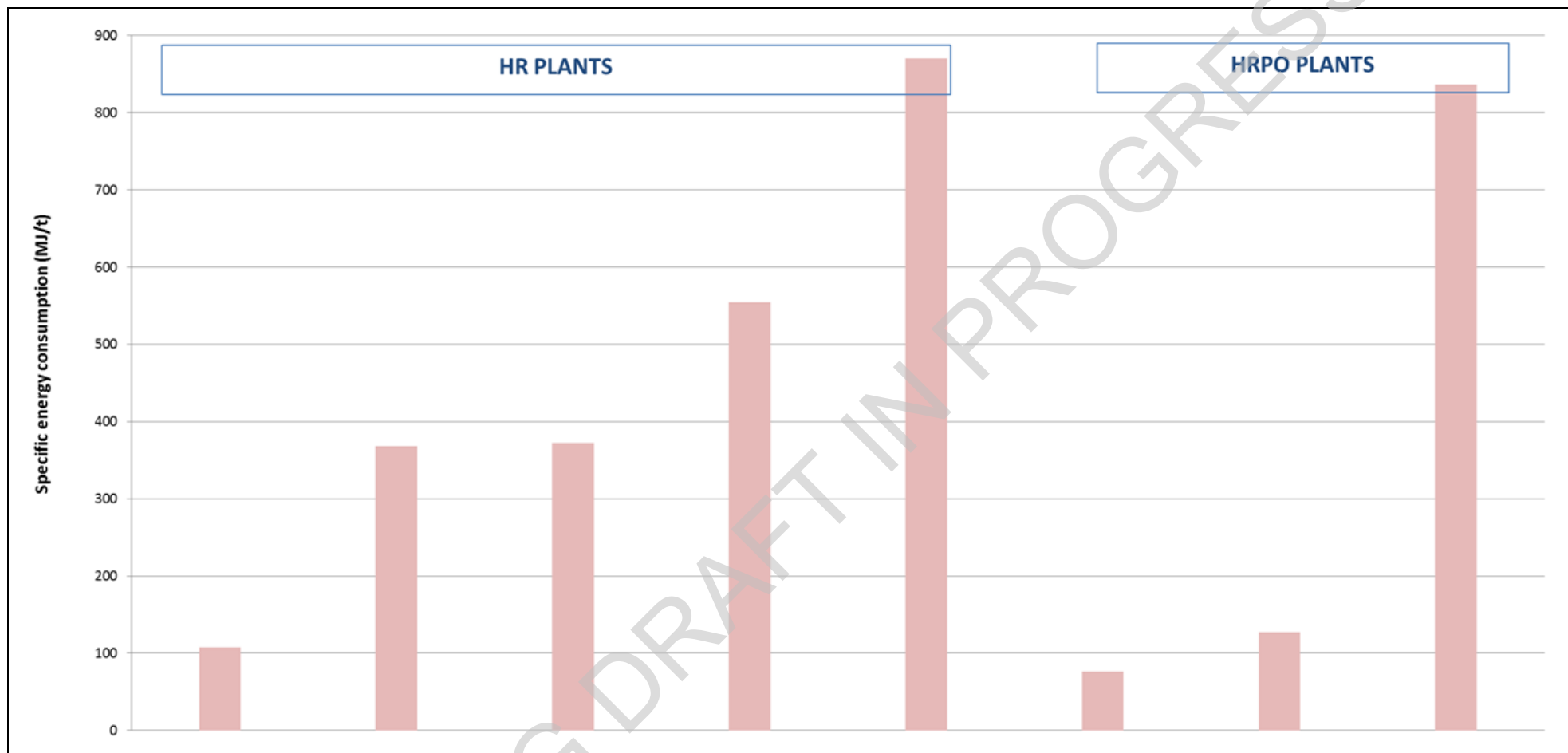


Figure 2.30: Specific energy consumption (MW/t of process throughput) for feedstock intermediate heating. Source: [TWG 2018].

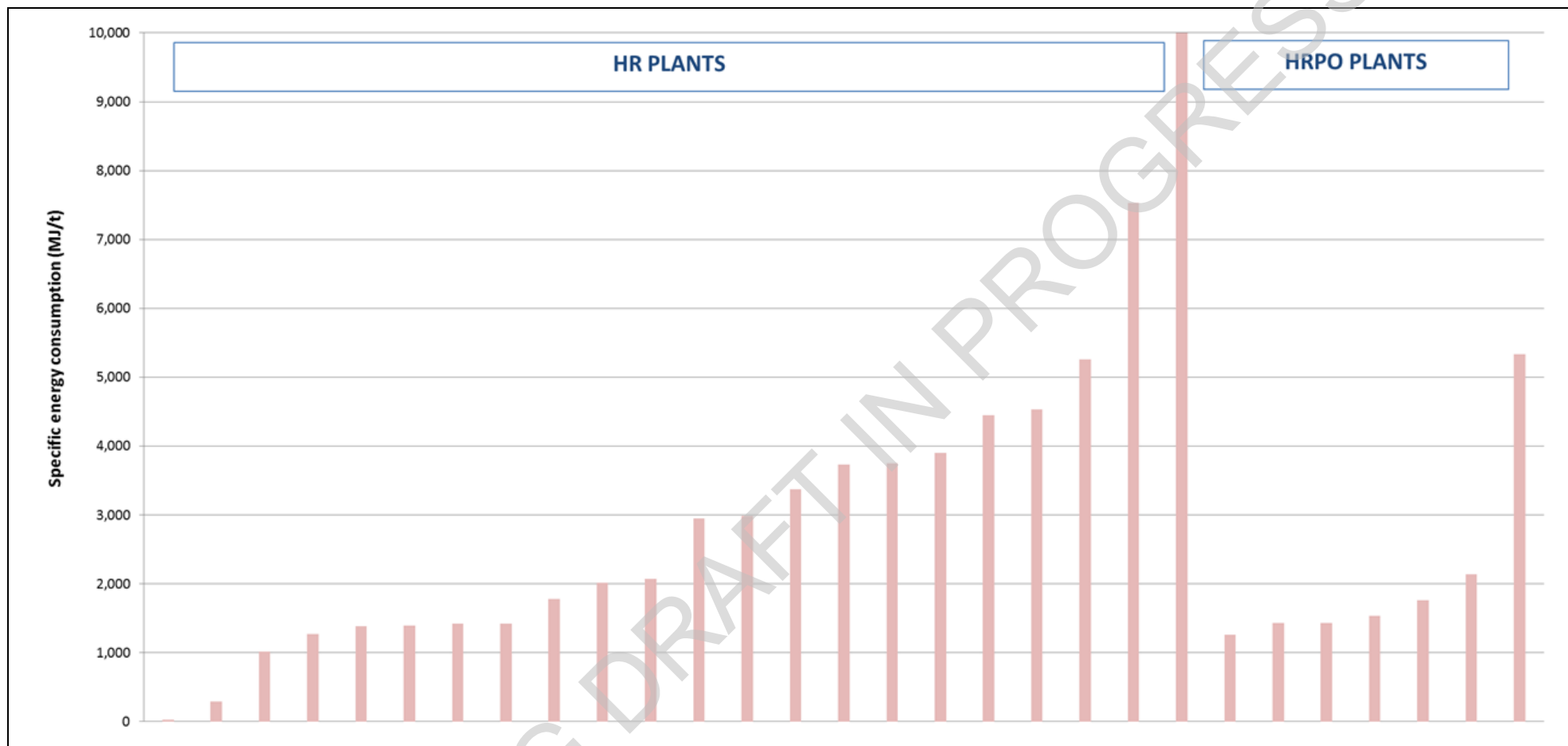


Figure 2.31: Specific energy consumption (MW/t of process throughput) for feedstock post-heating. Source: [TWG 2018].

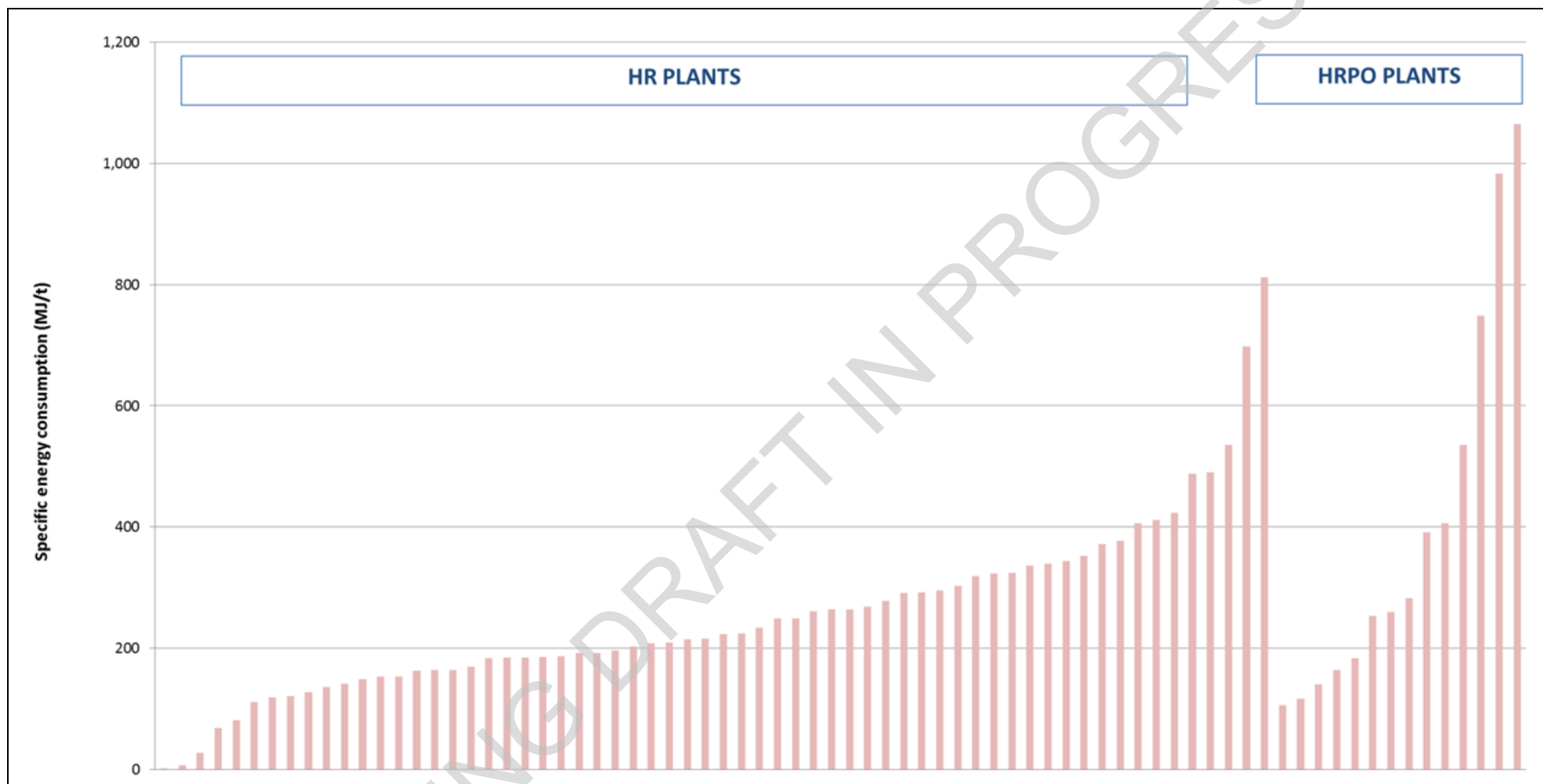


Figure 2.32: Specific energy consumption (MJ/t of process throughput) for rolling processes. Source: [TWG 2018].

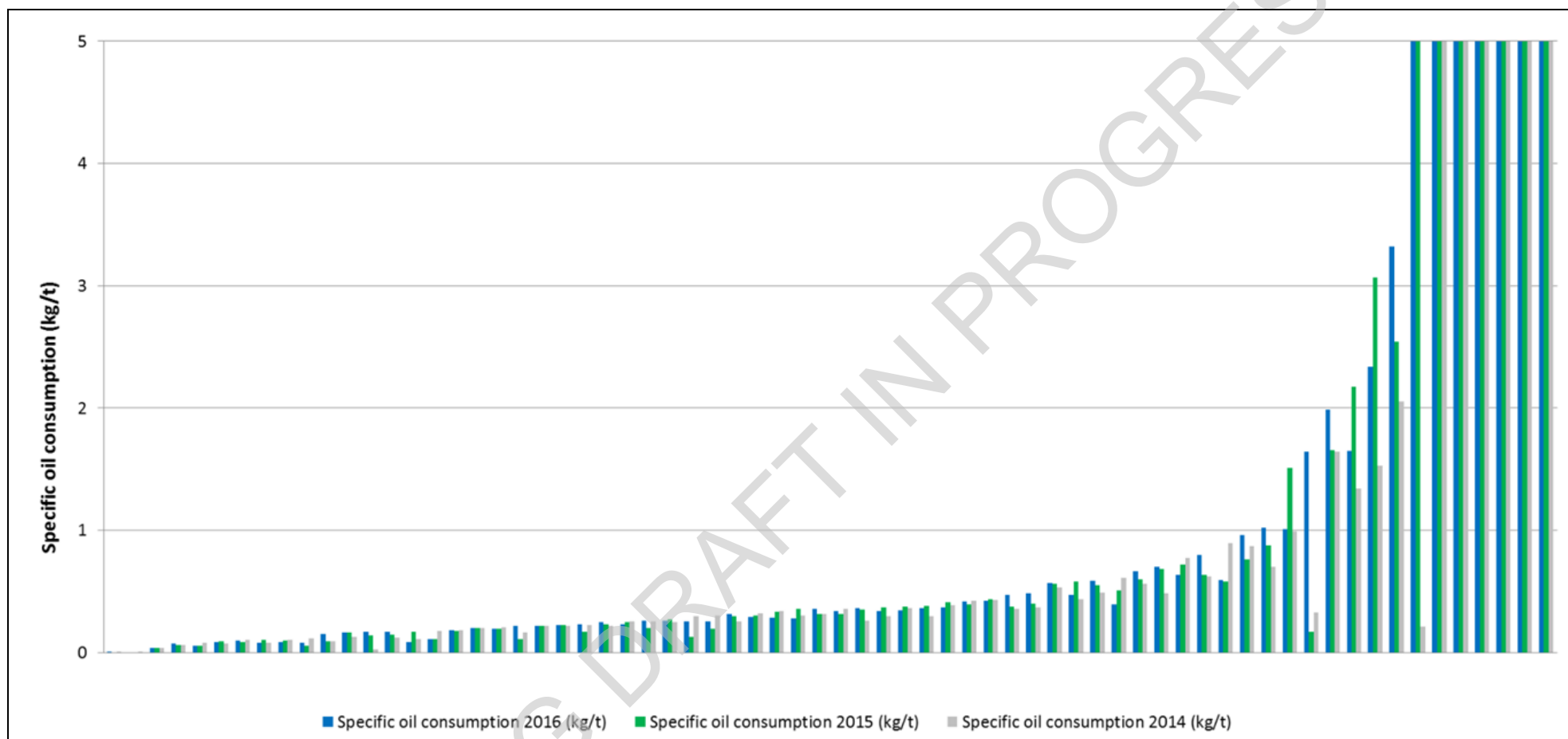


Figure 2.33: Specific oil consumption (kg/t of production) in hot rolling plants. Source: [TWG 2018].

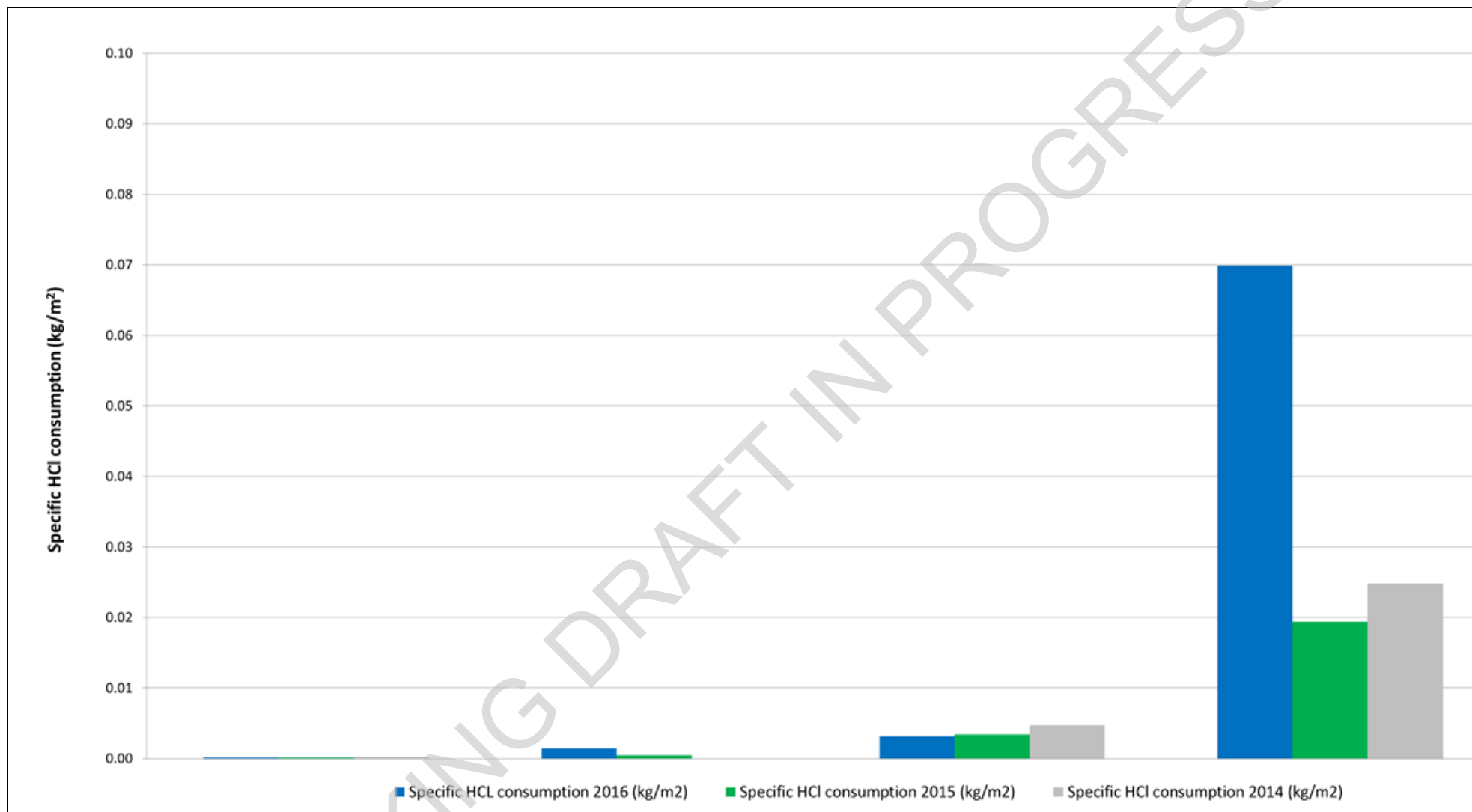


Figure 2.34: Specific HCl consumption (kg/m^2 of treated surface) in hot rolling plants producing HRPO steel. Source: [TWG 2018].

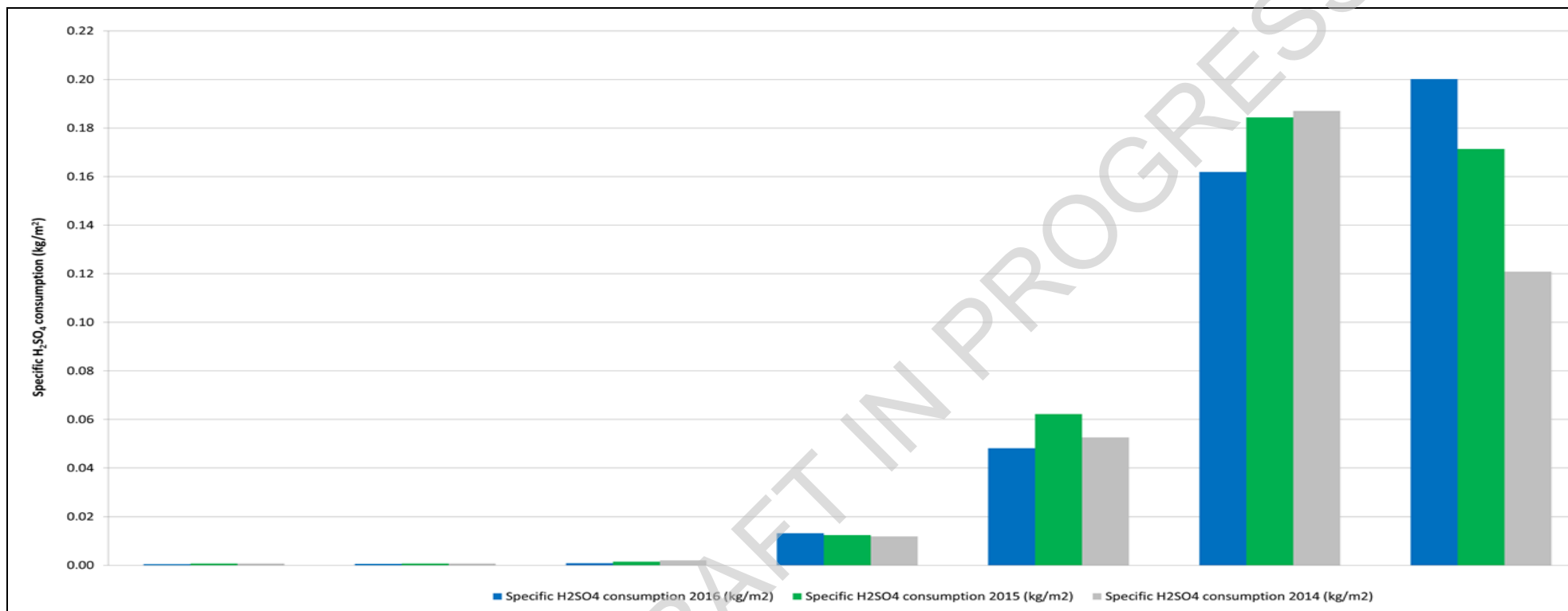


Figure 2.35: Specific H₂SO₄ consumption (kg/m² of treated surface) in hot rolling plants producing HRPO steel. Source: [TWG 2018].

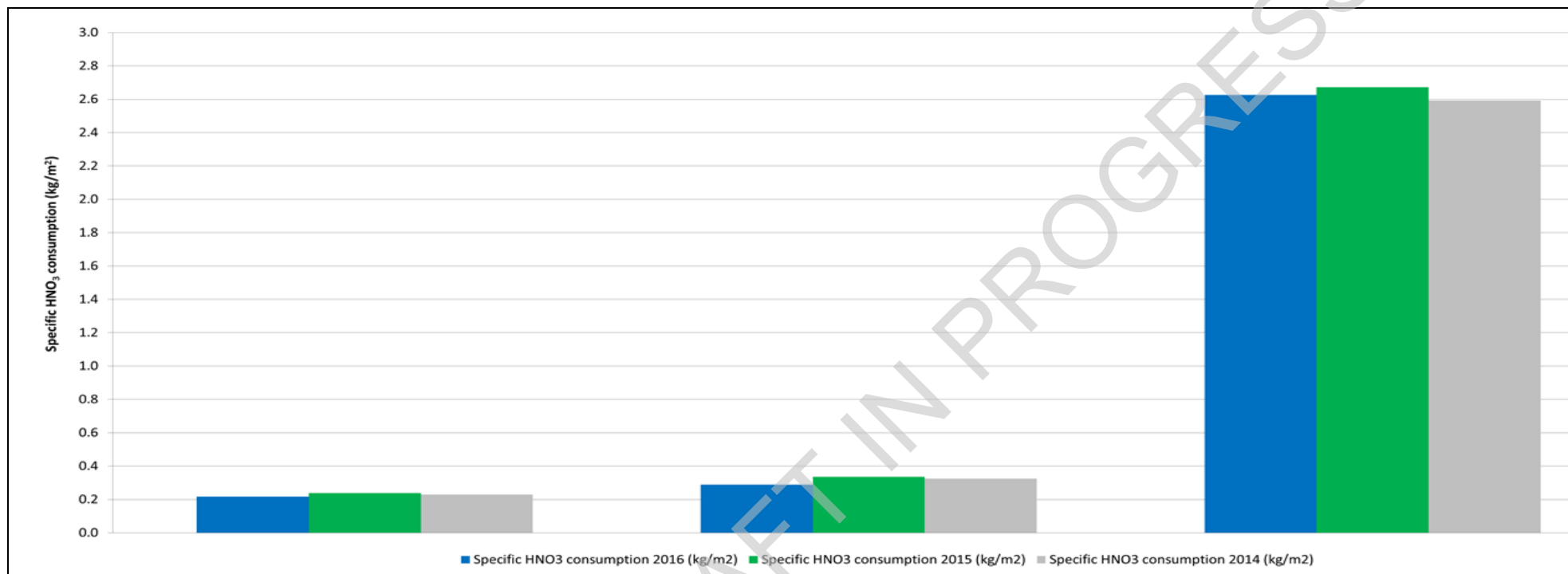


Figure 2.36: Specific HNO₃ consumption (kg/m² of treated surface) in hot rolling plants producing HRPO steel. Source: [TWG 2018].

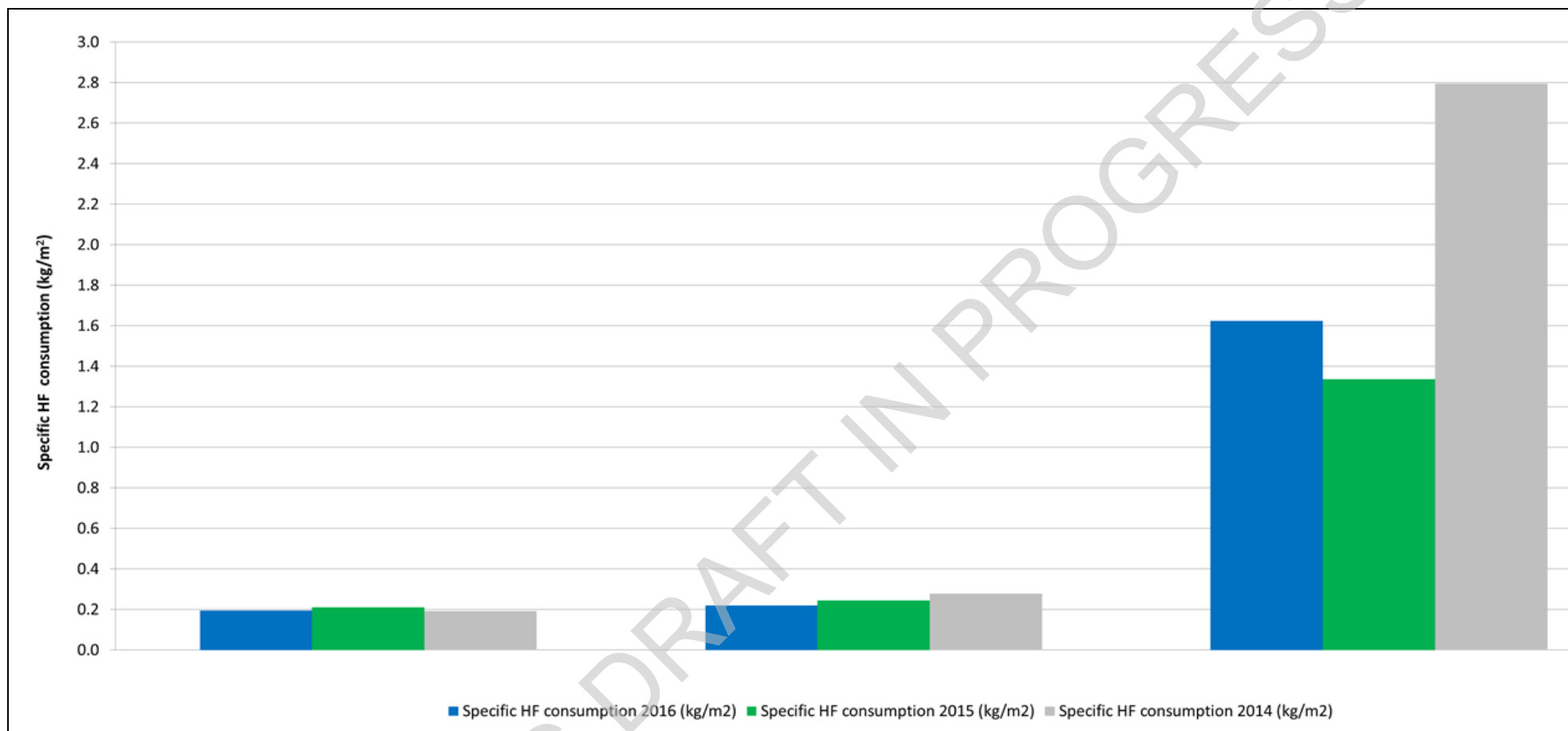


Figure 2.37: Specific HF consumption (kg/m^2 of treated surface) in hot rolling plants producing HRPO steel. Source: [TWG 2018].

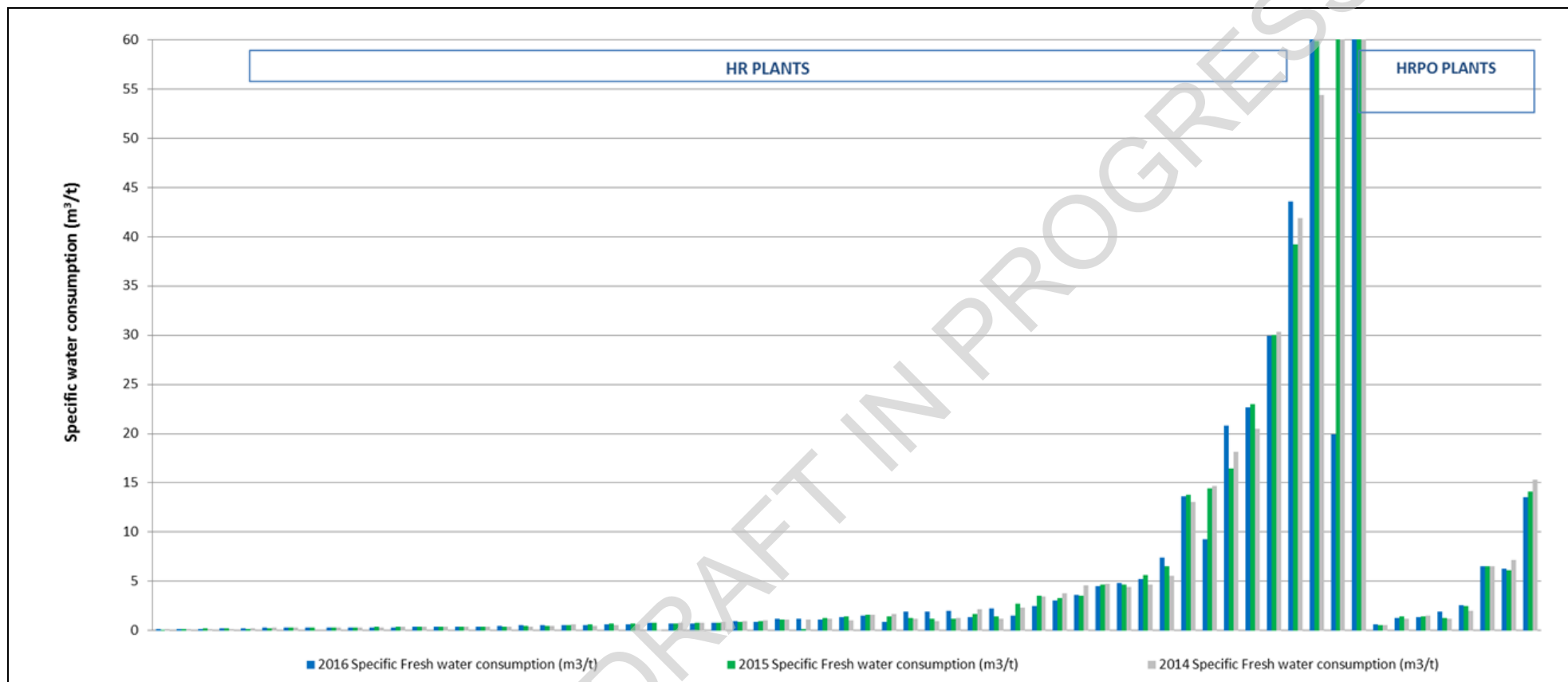


Figure 2.38: Specific water consumption (m³/t of production) in hot rolling plants. Source: [TWG 2018].

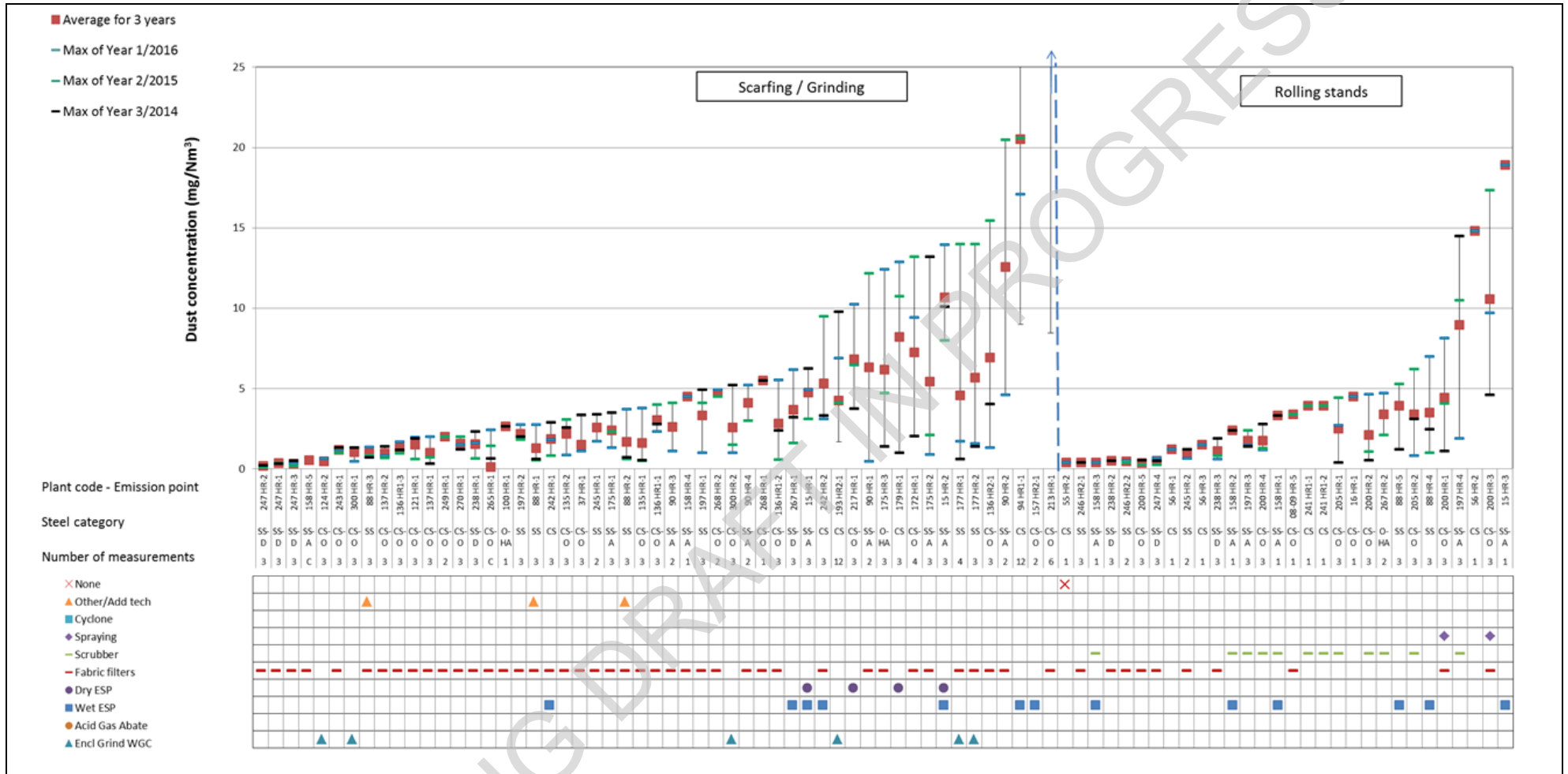


Figure 2.39: Dust emissions from mechanical processing, scarfing and welding (in mg/Nm³) - part 1 of 2. Source: [TWG 2018].

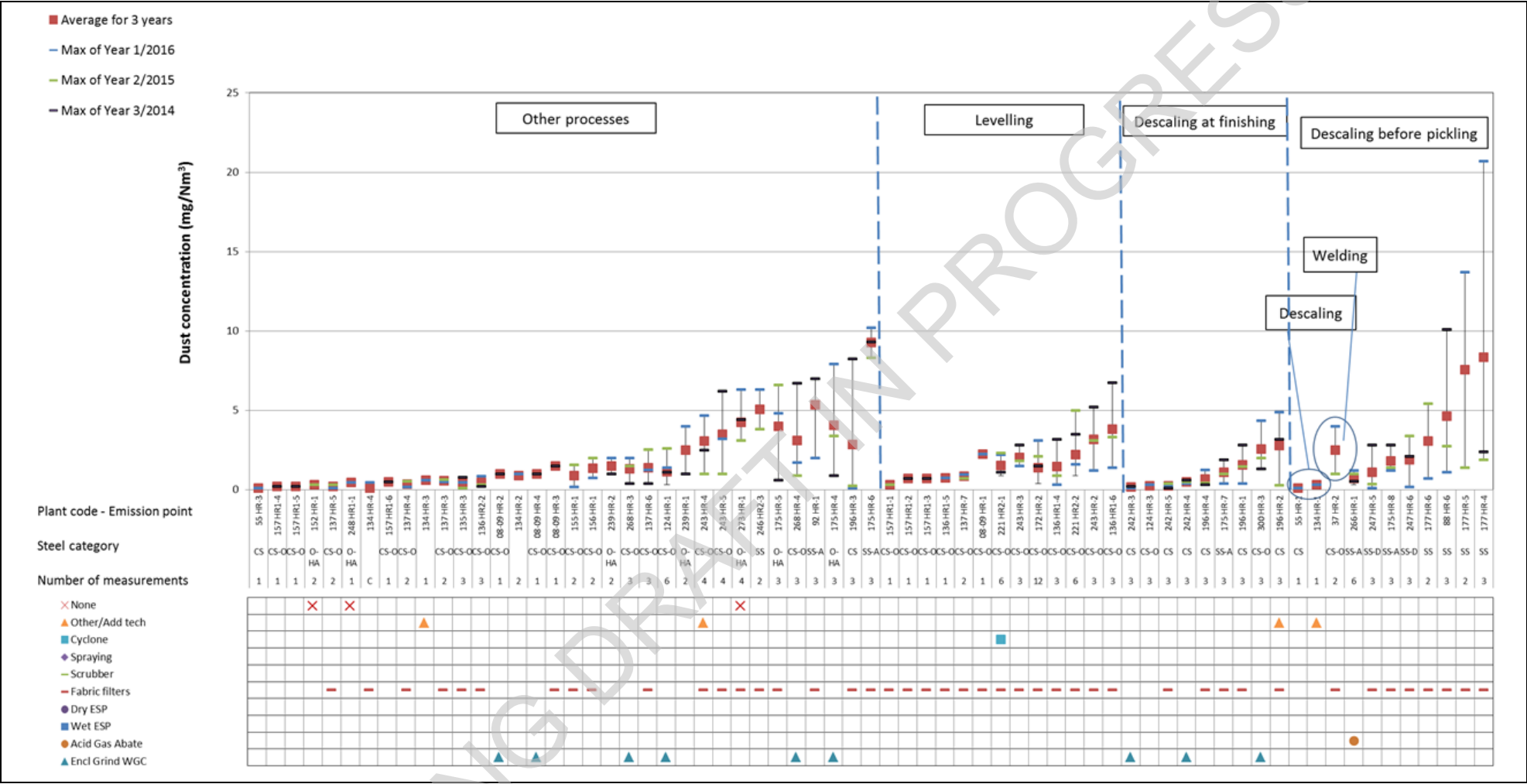


Figure 2.40: Dust emissions from mechanical processing, scarfing and welding, (in mg/Nm³) - part 2 of 2. Source: [TWG 2018].

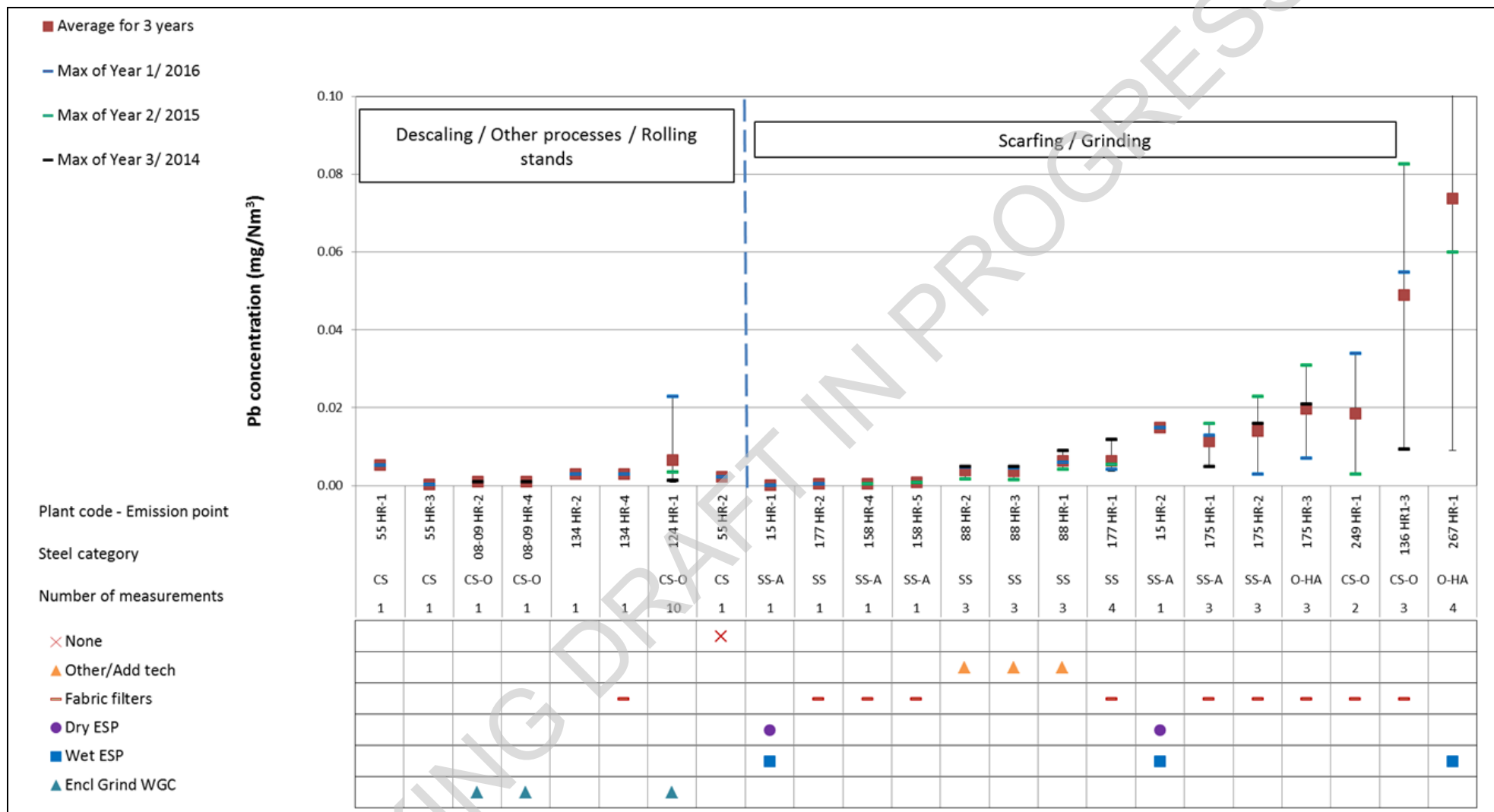


Figure 2.41: Lead emissions from mechanical processing, scarfing and welding (in mg/Nm³). Source: [TWG 2018].

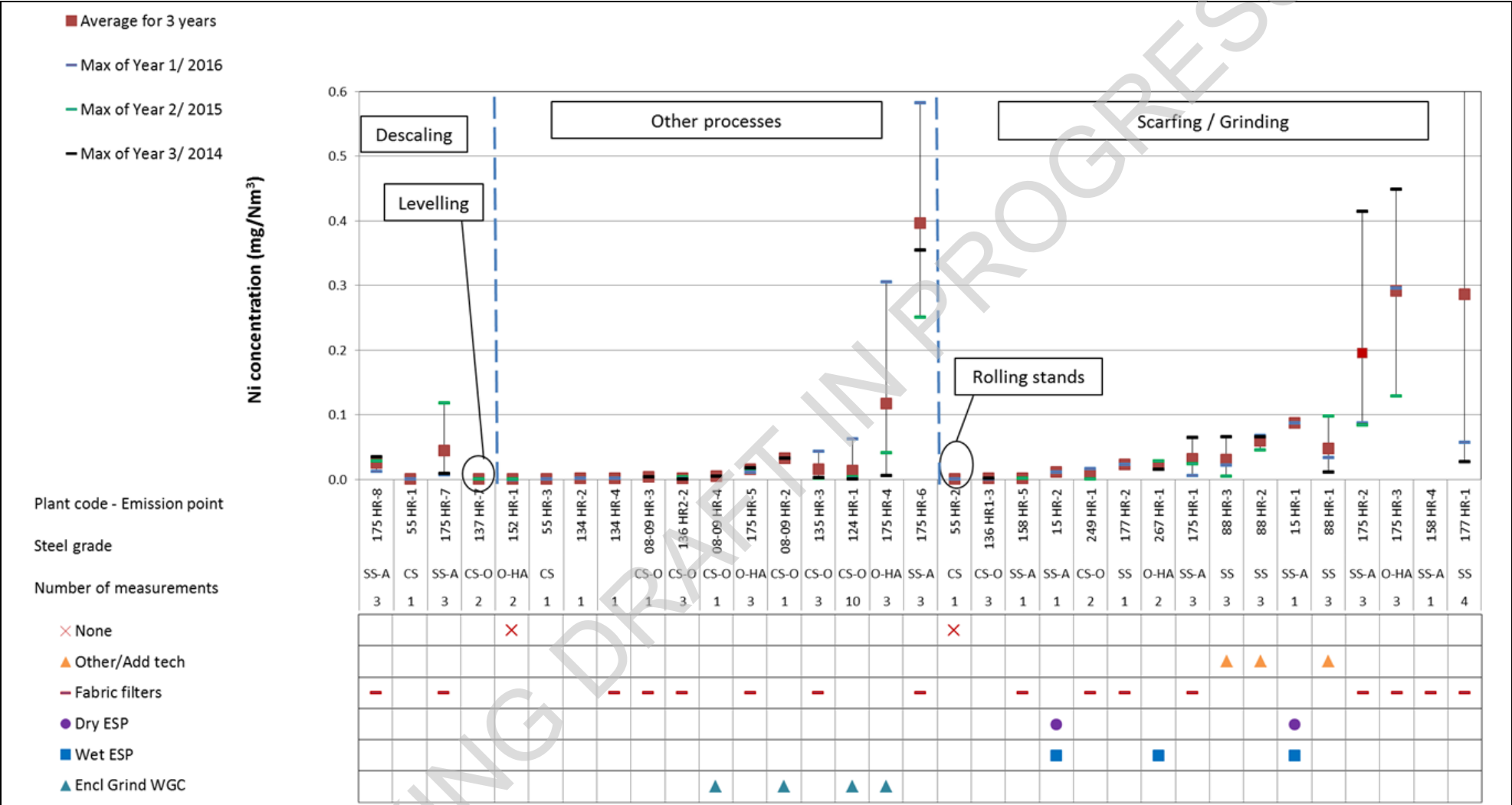


Figure 2.42: Nickel emissions from mechanical processing, scarfing and welding (in mg/Nm³). Source: [TWG 2018].

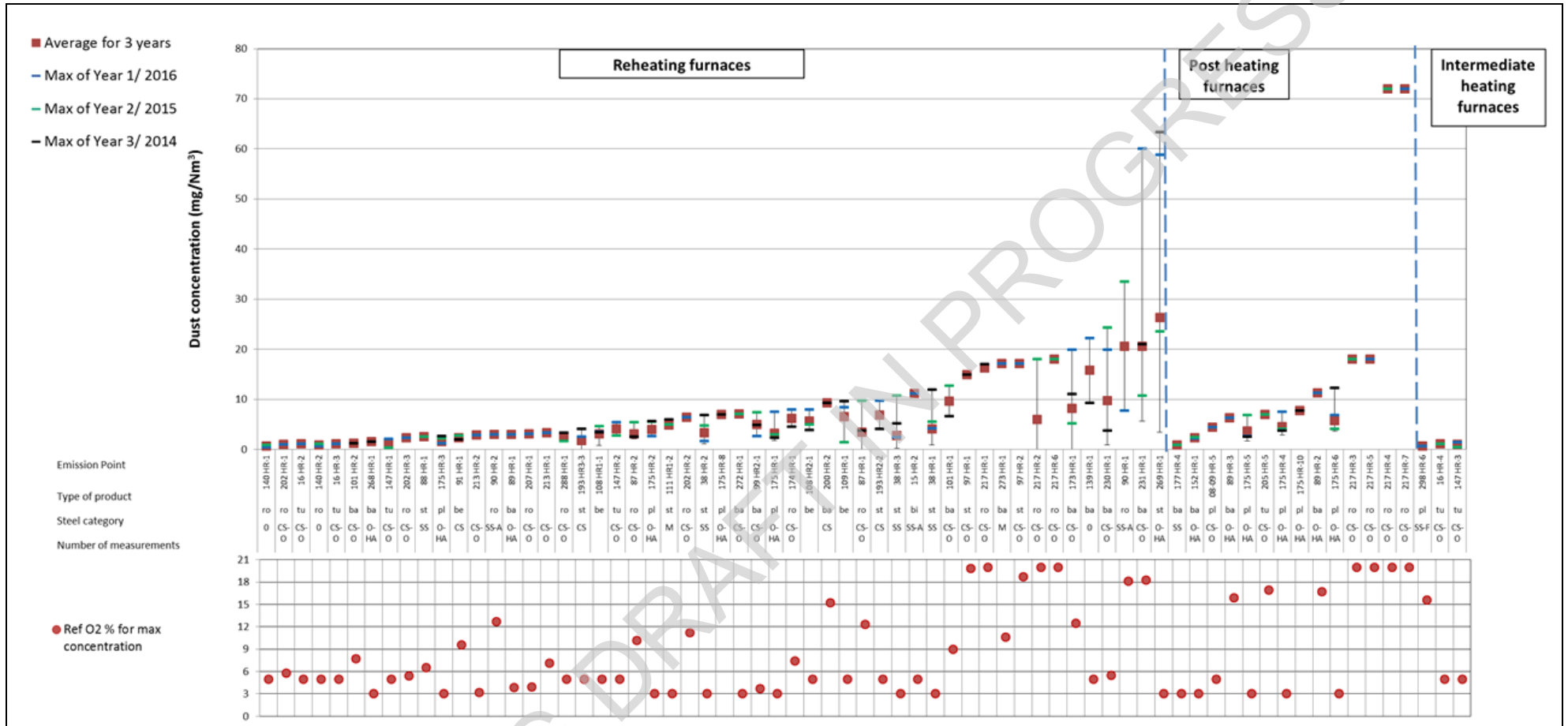


Figure 2.43: Dust emissions from feedstock heating (in mg/Nm^3 at 3% oxygen) for fuel 100% natural gas. Source: [TWG 2018].

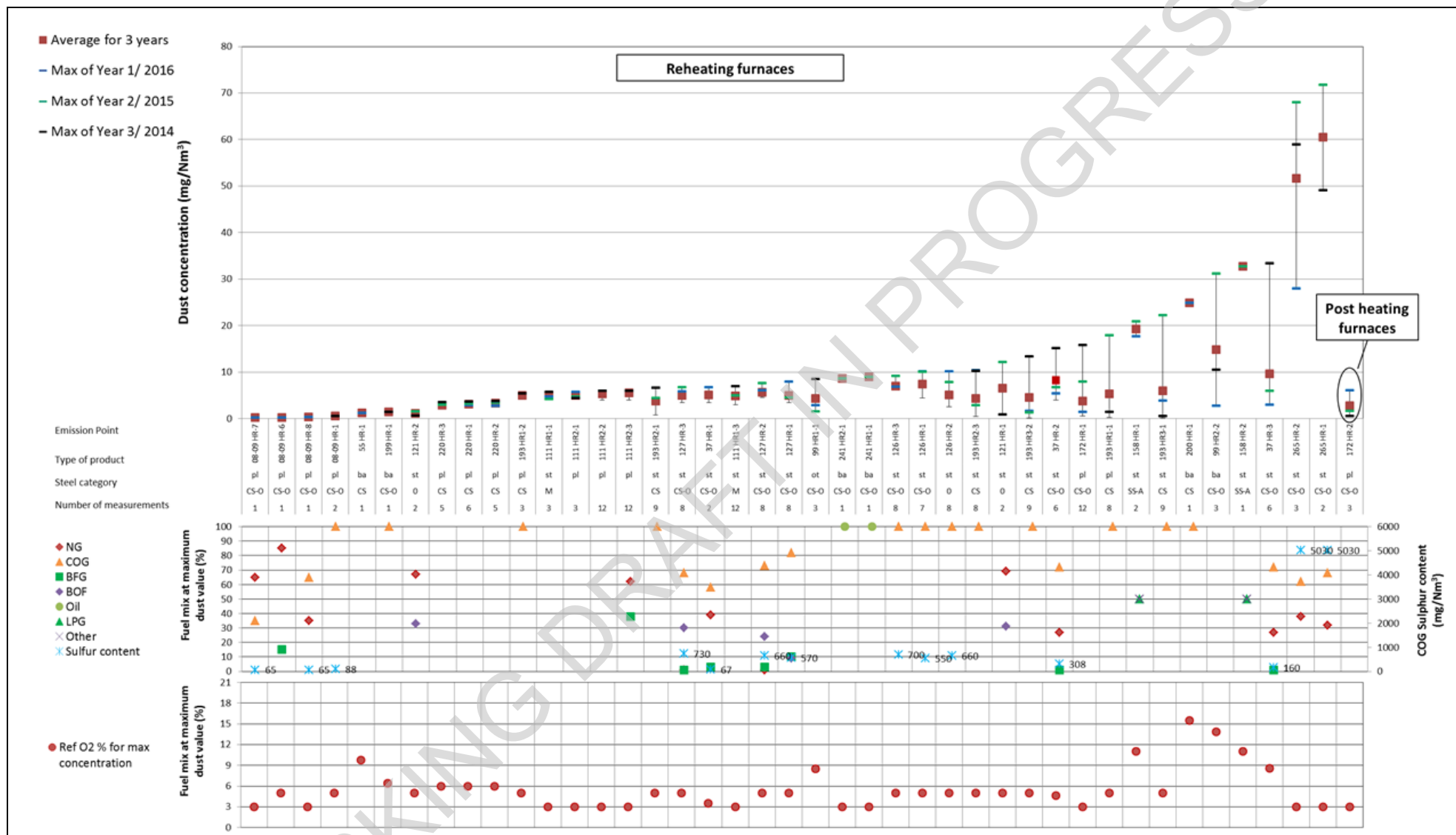


Figure 2.44: Dust emissions from feedstock heating (in mg/Nm³ at 3% oxygen) for fuel other than 100% natural gas or unknown fuel. Source: [TWG 2018].

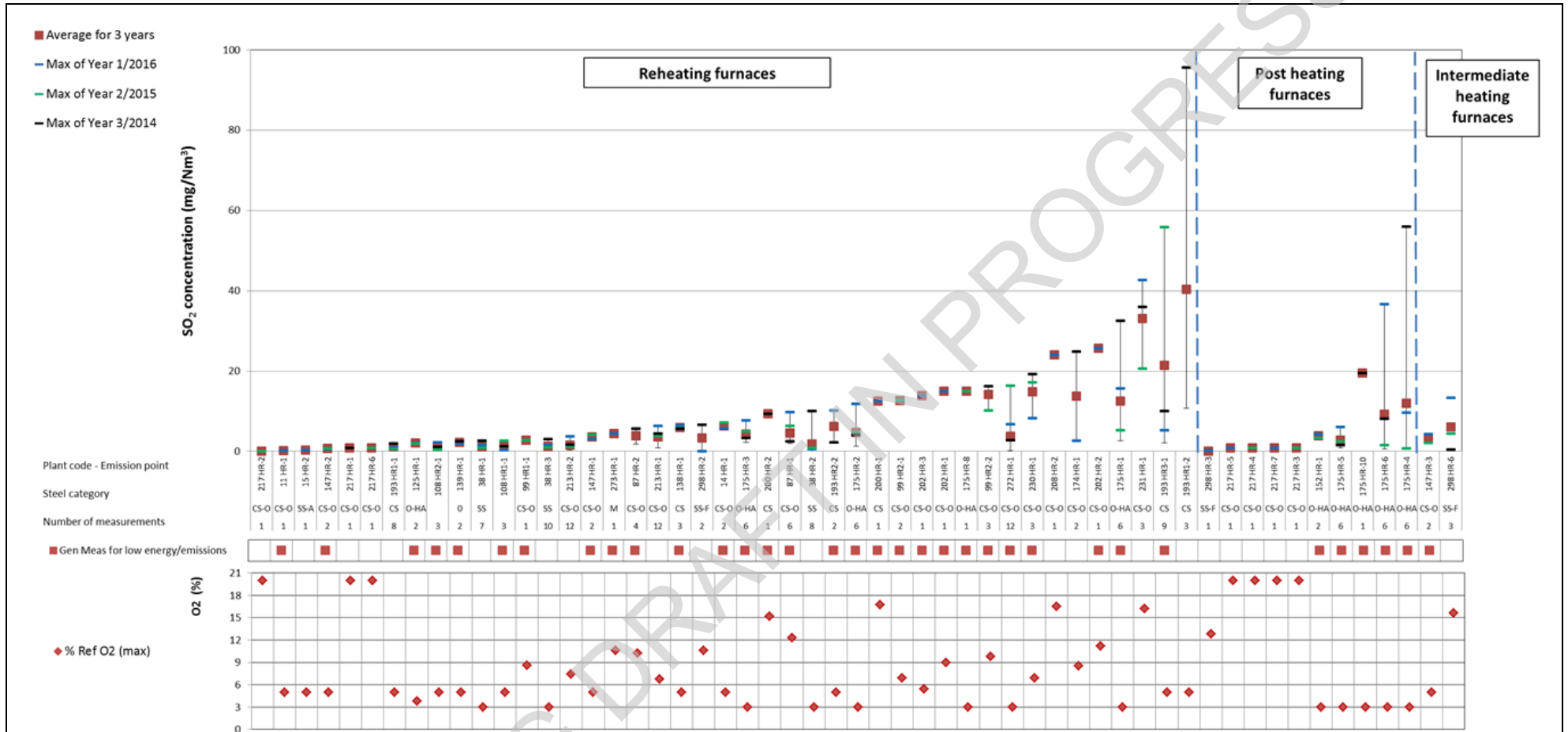


Figure 2.45: SO₂ emissions from feedstock heating (in mg/Nm³ at 3% oxygen) for fuel 100% natural gas. Source: [TWG 2018].

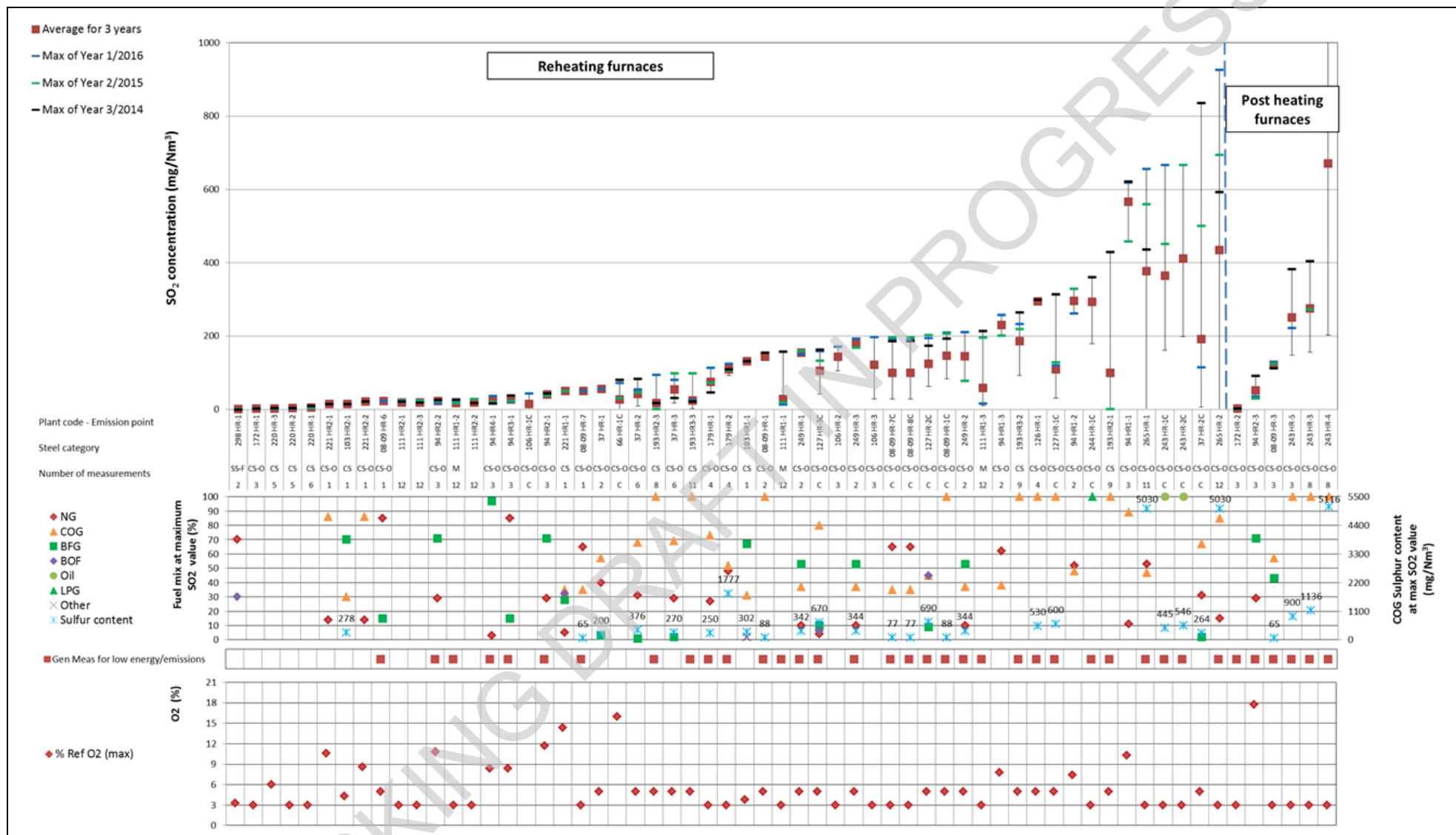


Figure 2.46: SO₂ emissions from feedstock heating (in mg/Nm³ at 3% oxygen) for fuel other than 100% natural gas or unknown fuel. Source: [TWG 2018].

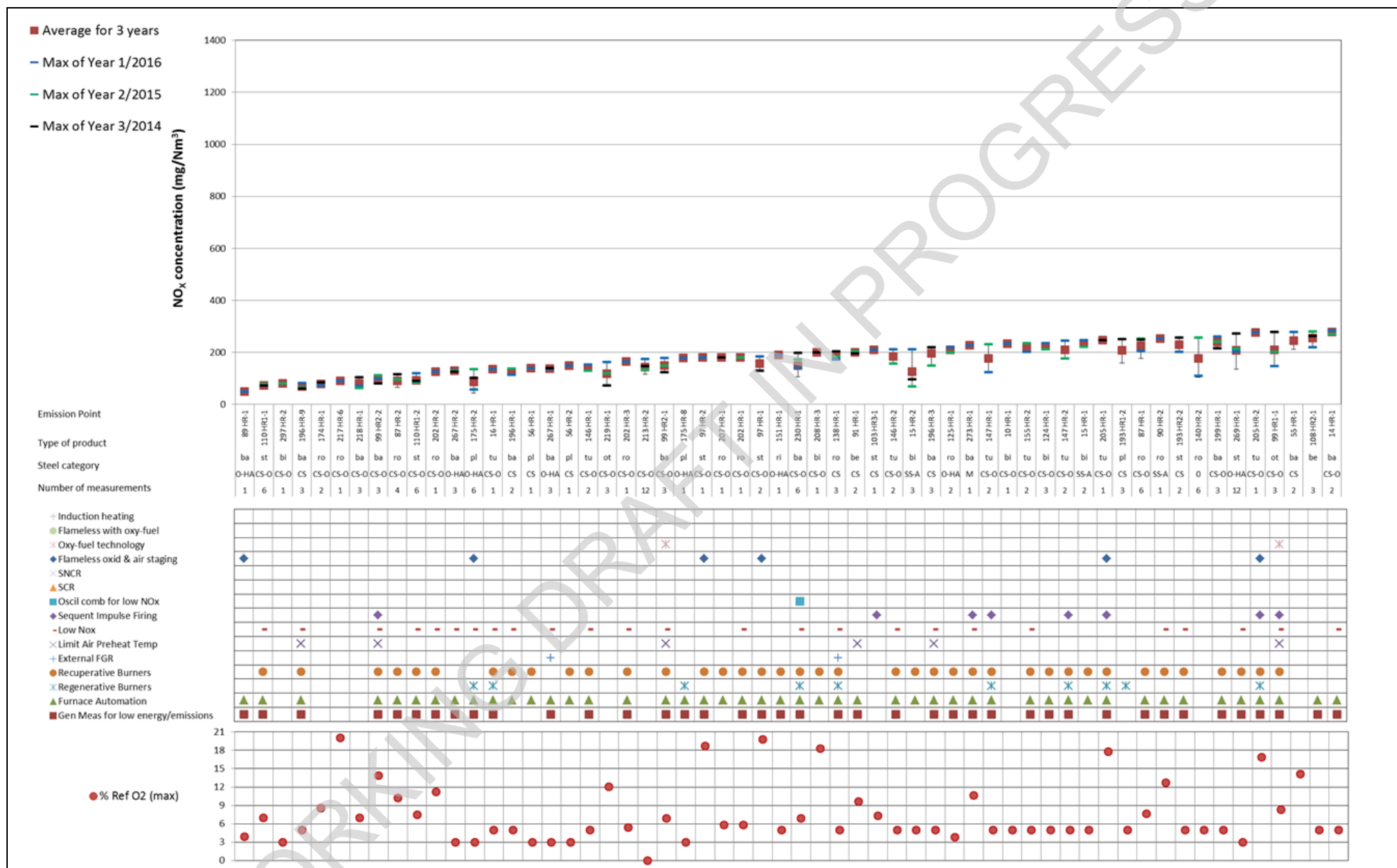
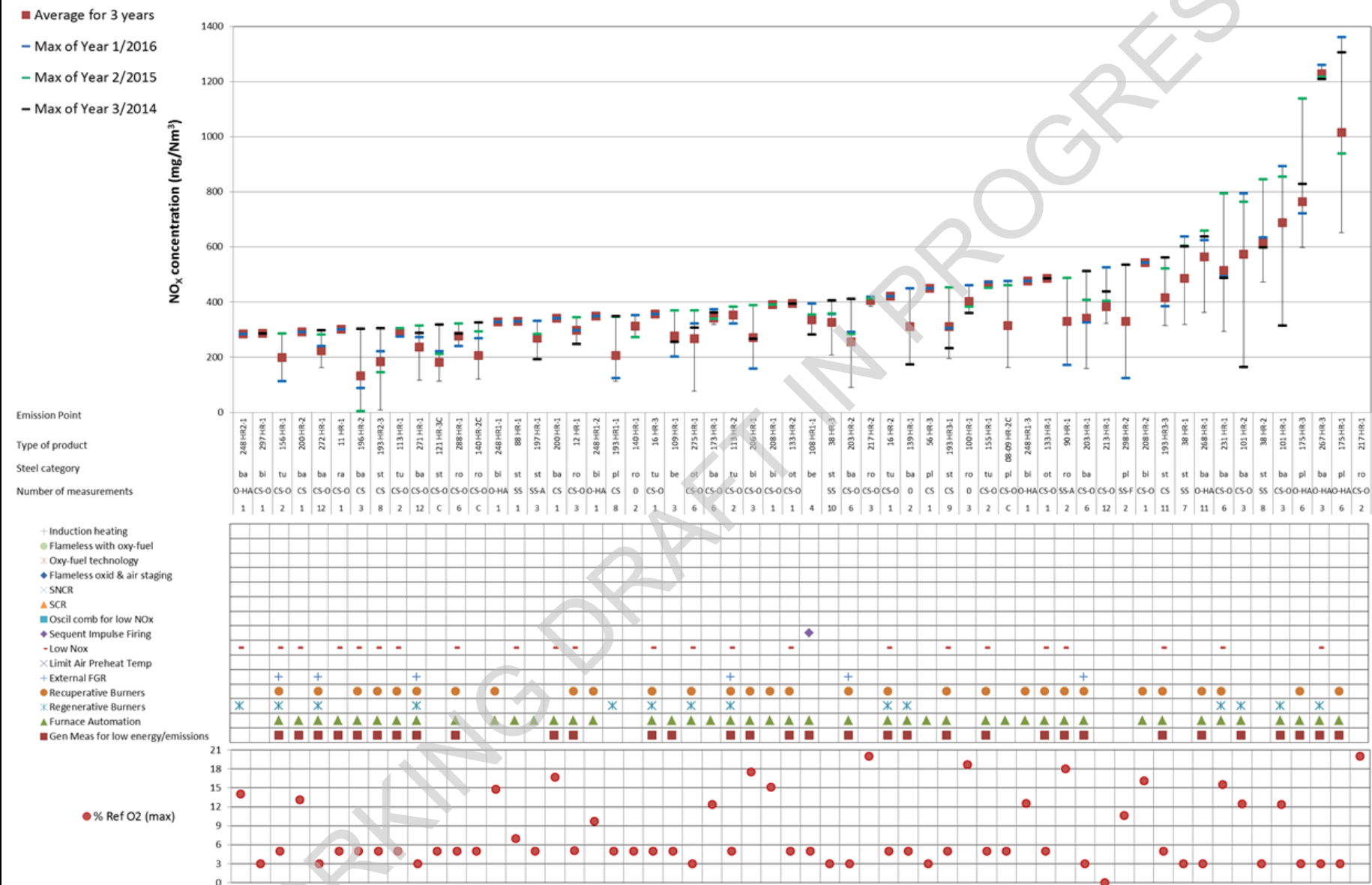


Figure 2.47: NO_x emissions from reheating (in mg/Nm³ at 3% oxygen) for fuel 100% natural gas – part 1 of 2. Source: [TWG 2018].



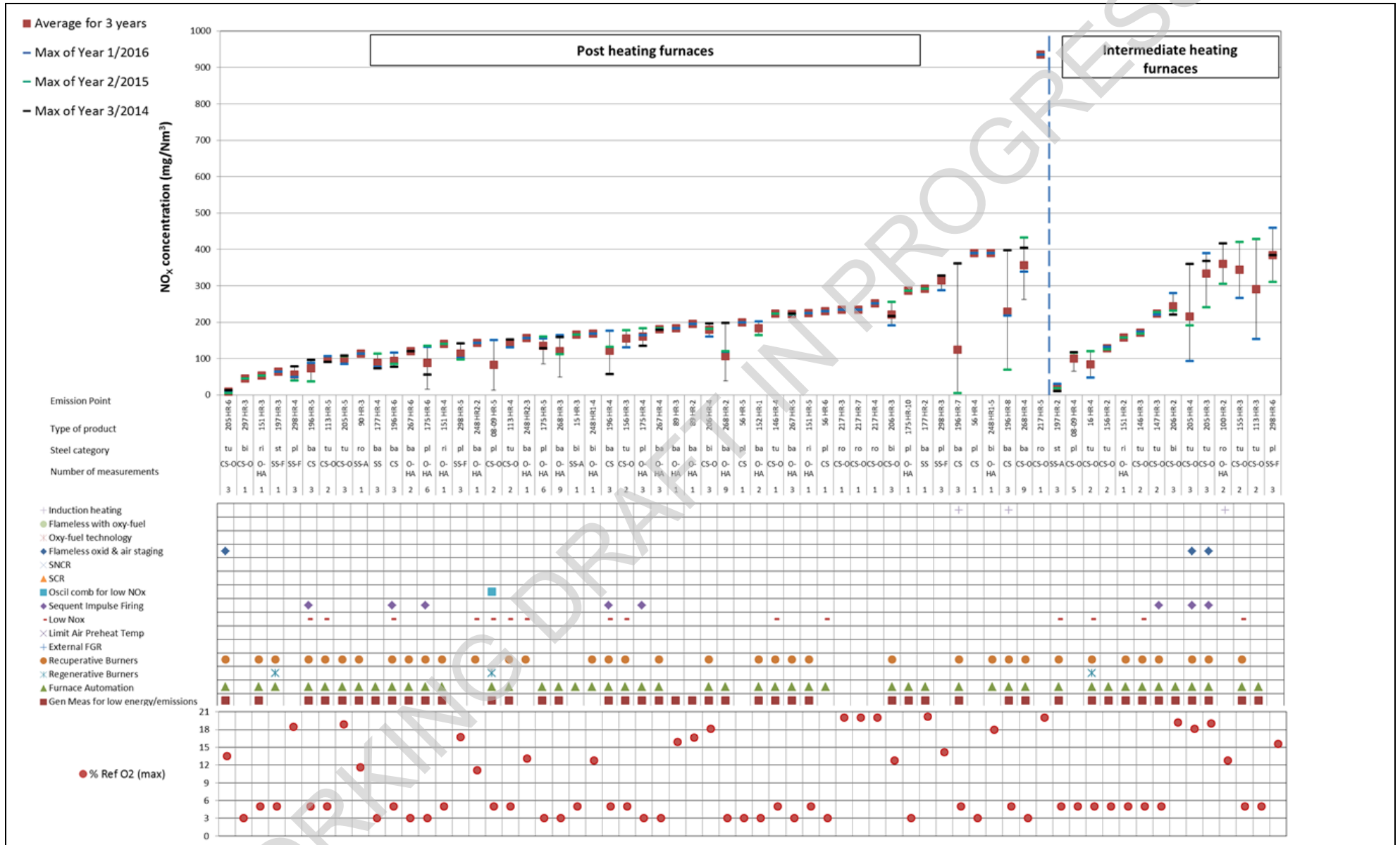


Figure 2.49: NO_x emissions from intermediate and post-heating (in mg/Nm³ at 3% oxygen) for fuel 100% natural gas. Source: [TWG 2018].

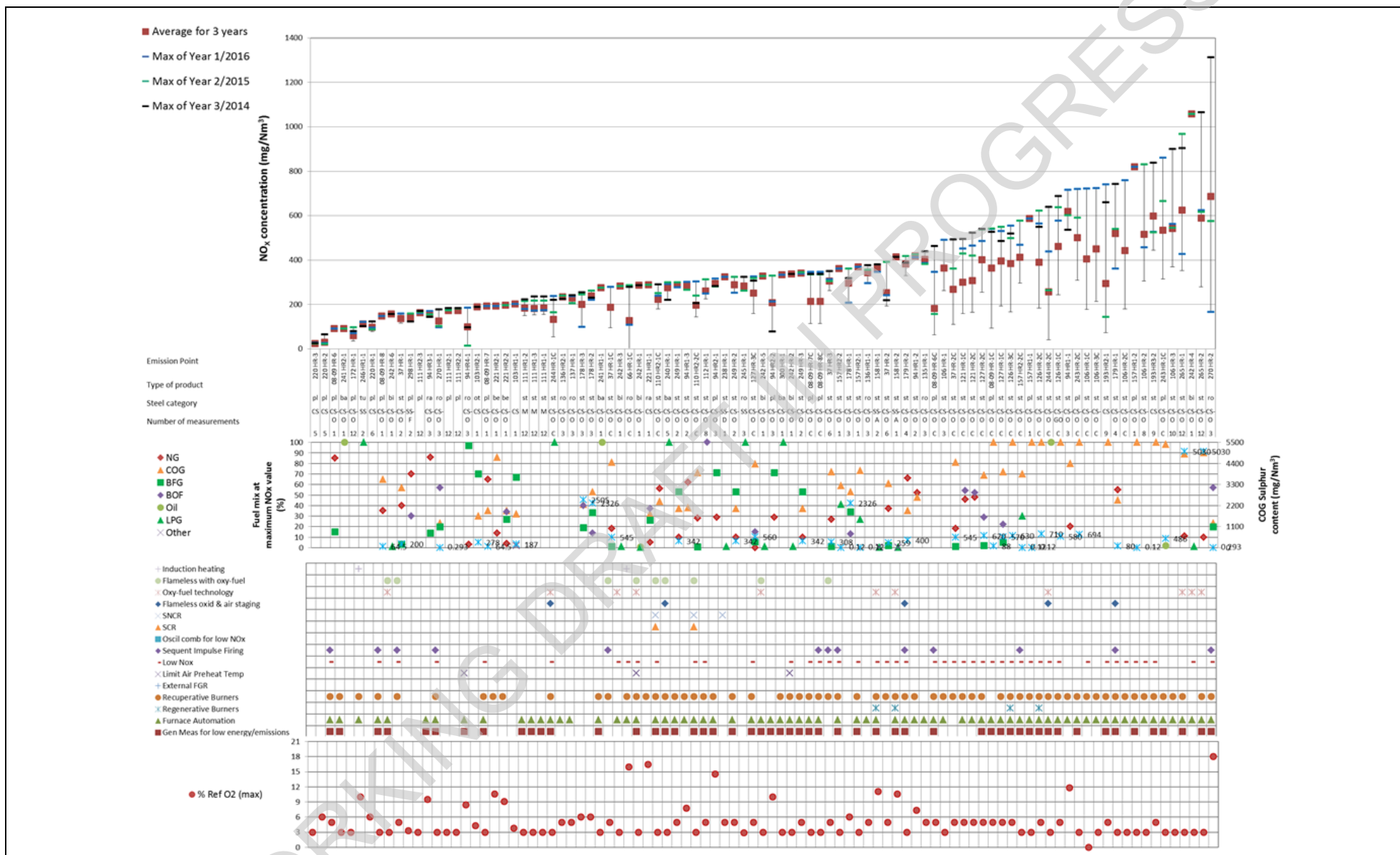


Figure 2.50: NO_x emissions from reheating (in mg/Nm³ at 3% oxygen) for fuel other than 100% natural gas or unknown fuel. Source: [TWG 2018].

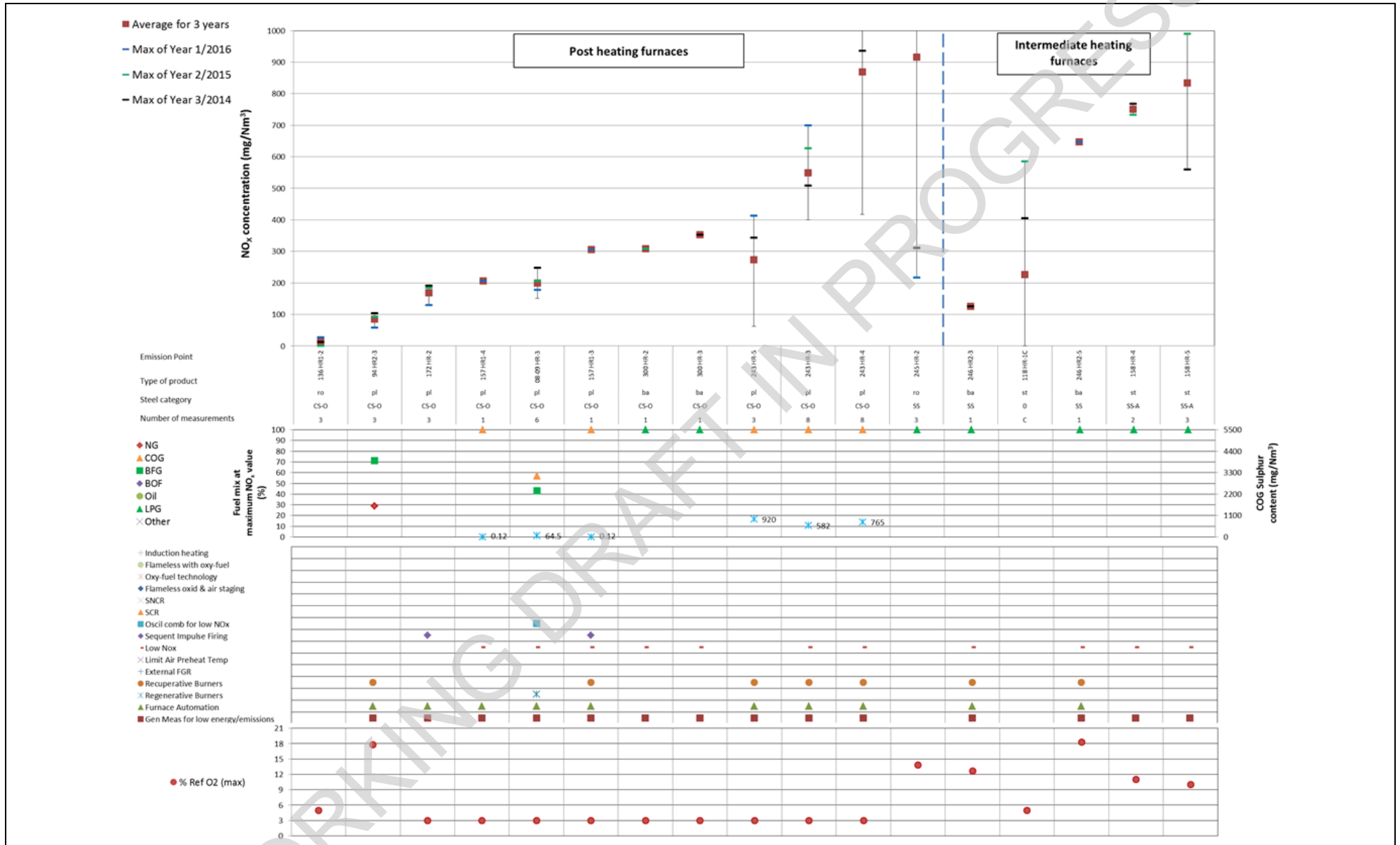


Figure 2.51: NO_x emissions from intermediate and post-heating (in mg/Nm³ at 3% oxygen) for fuel other than 100% natural gas or unknown fuel. Source: [TWG 2018].

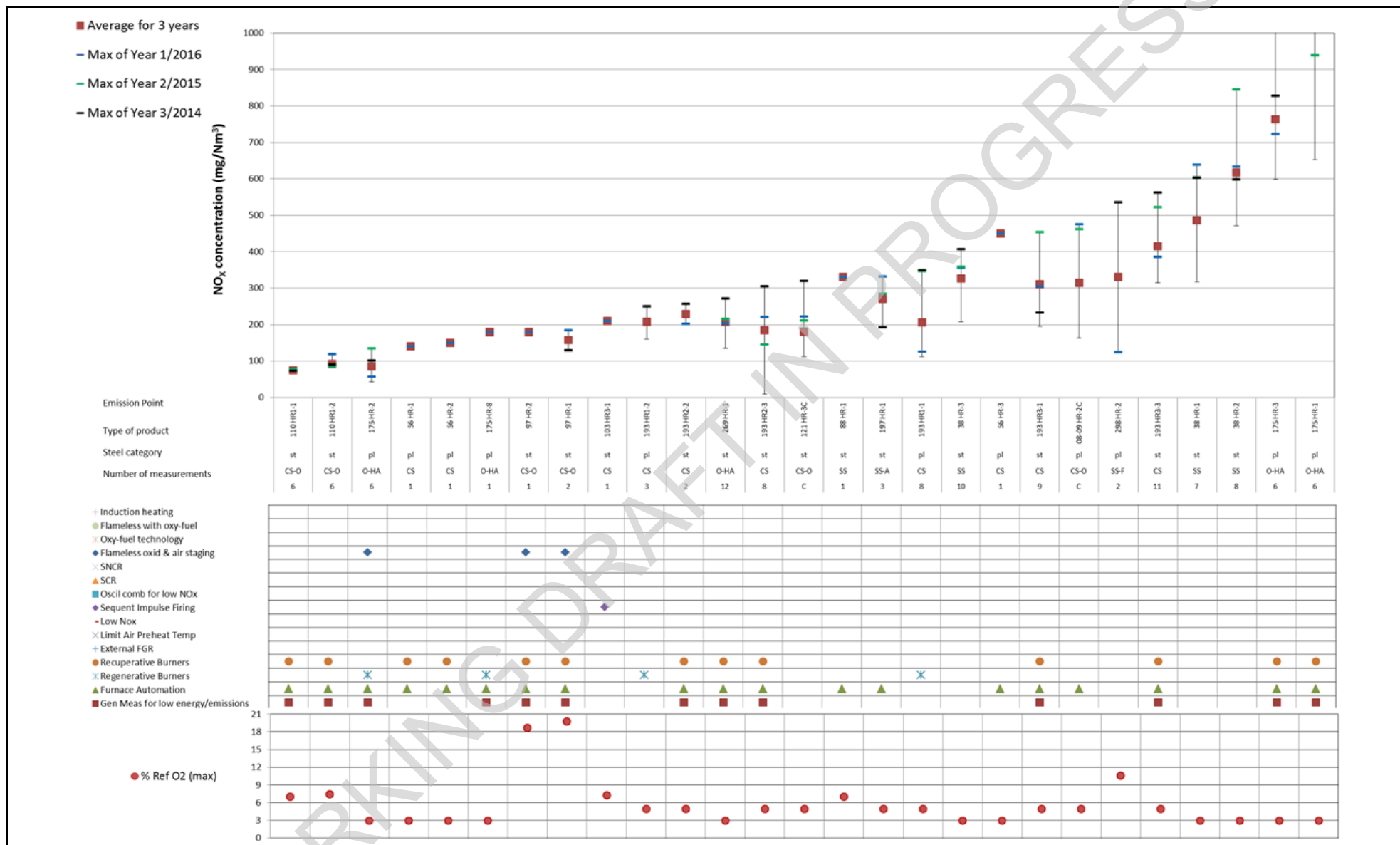


Figure 2.52: NO_x emissions from reheating (in mg/Nm³ at 3% oxygen) for fuel 100% natural gas for reheating of flat products. Source: [TWG 2018].

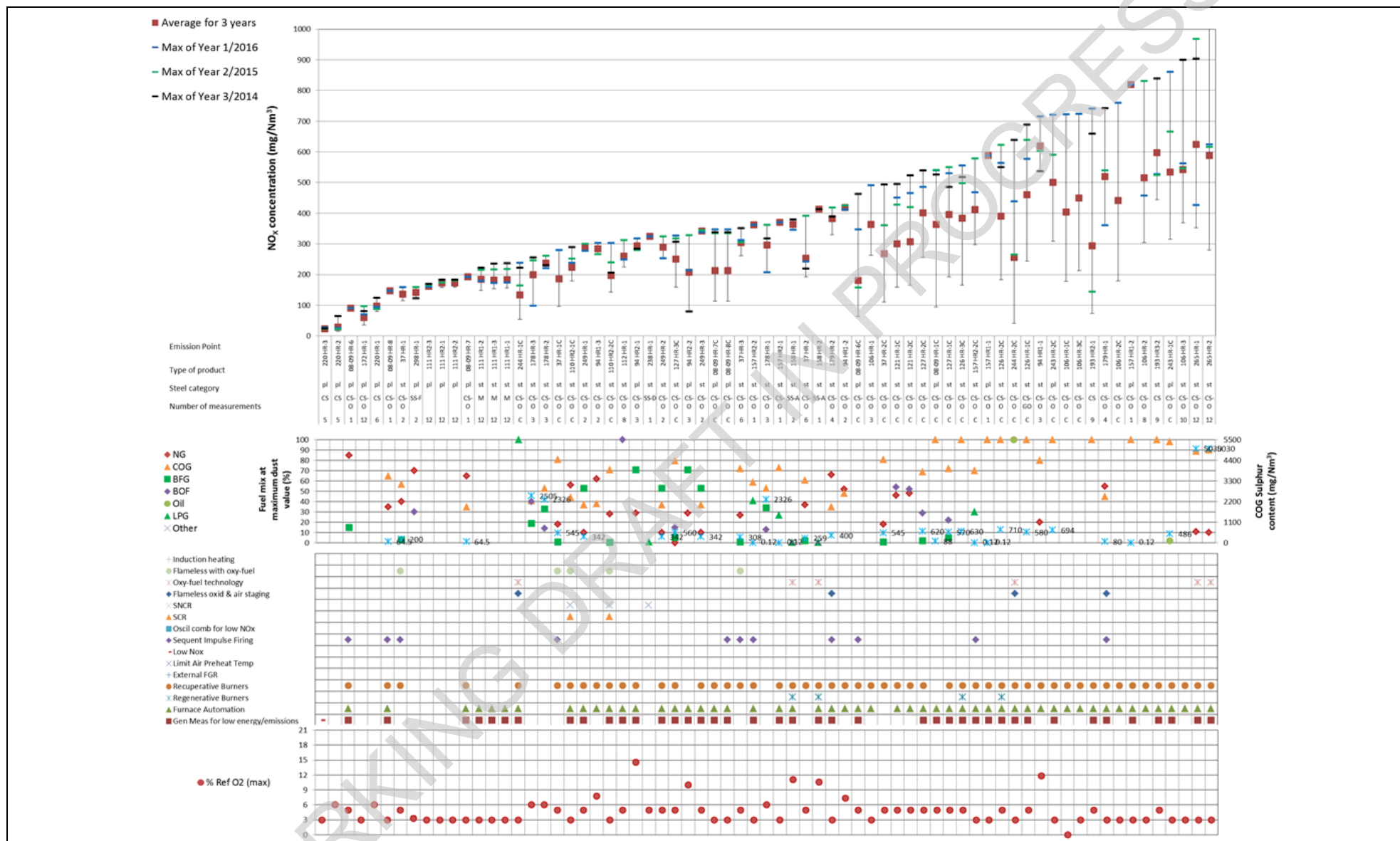


Figure 2.53: NO_x emissions from reheating (in mg/Nm³ at 3% oxygen) for fuel other than 100% natural gas or unknown fuel for reheating of flat products. Source: [TWG 2018].

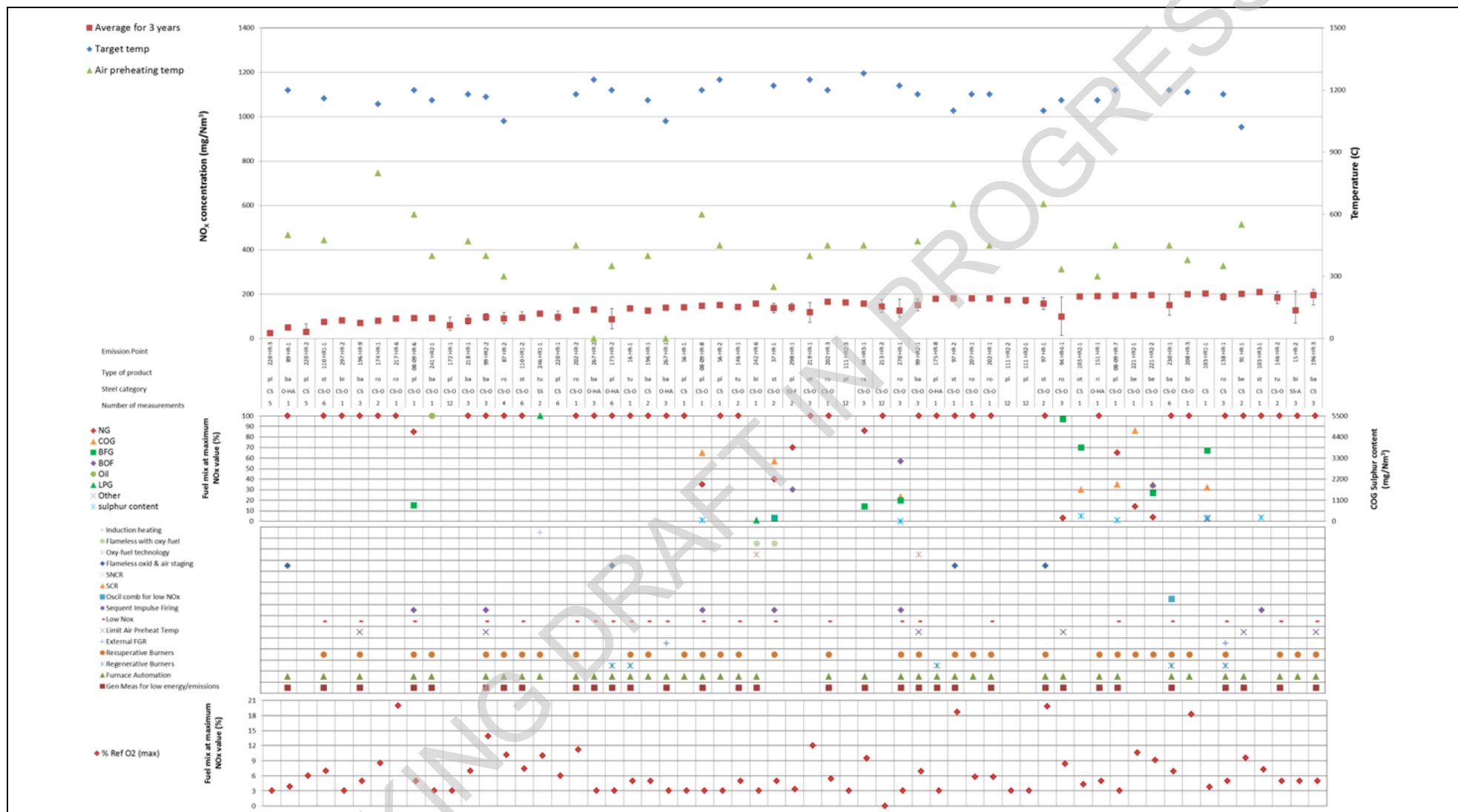


Figure 2.54: NO_x emissions from reheating (in mg/Nm³ at 3% oxygen) for all fuels, with air preheating temperature and feedstock target temperature – part 1 of 3.
Source: [TWG 2018].

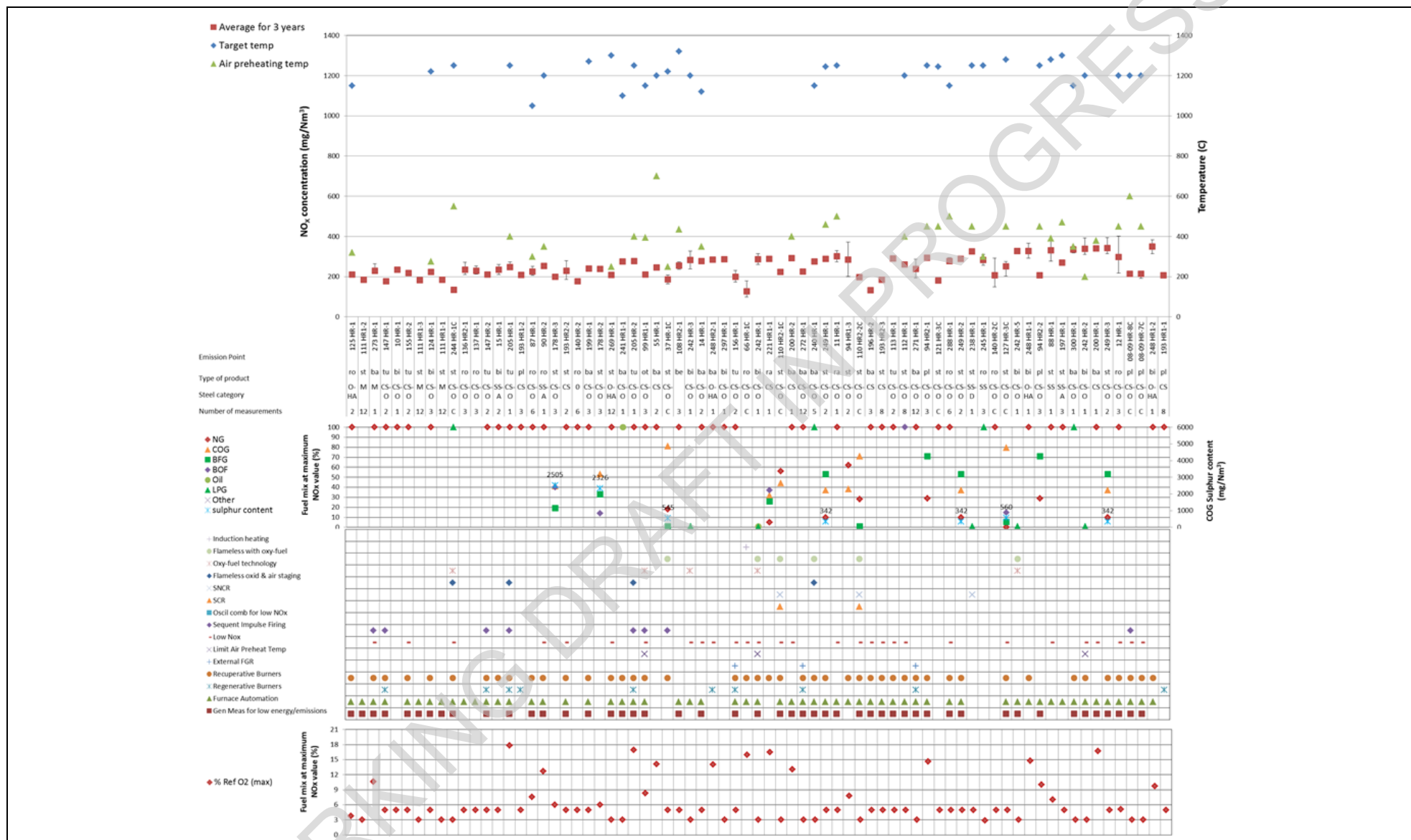


Figure 2.55: NO_x emissions from reheating (in mg/Nm³ at 3% oxygen) for all fuels, with air preheating temperature and feedstock target temperature – part 2 of 3. Source: [TWG 2018].

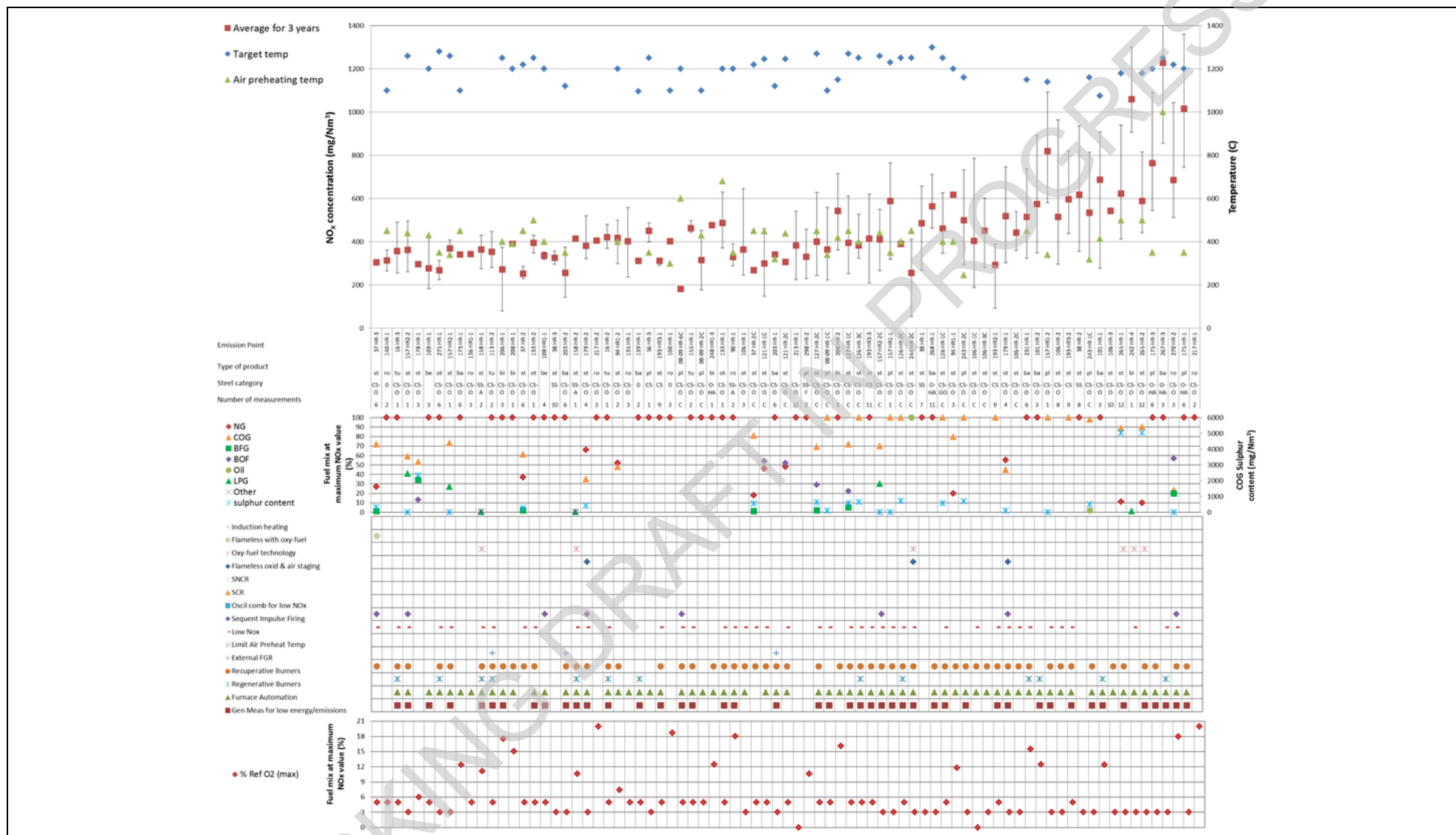


Figure 2.56: NO_x emissions from reheating (in mg/Nm³ at 3% oxygen) for all fuels, with air preheating temperature and feedstock target temperature – part 3 of 3.
Source: [TWG 2018].

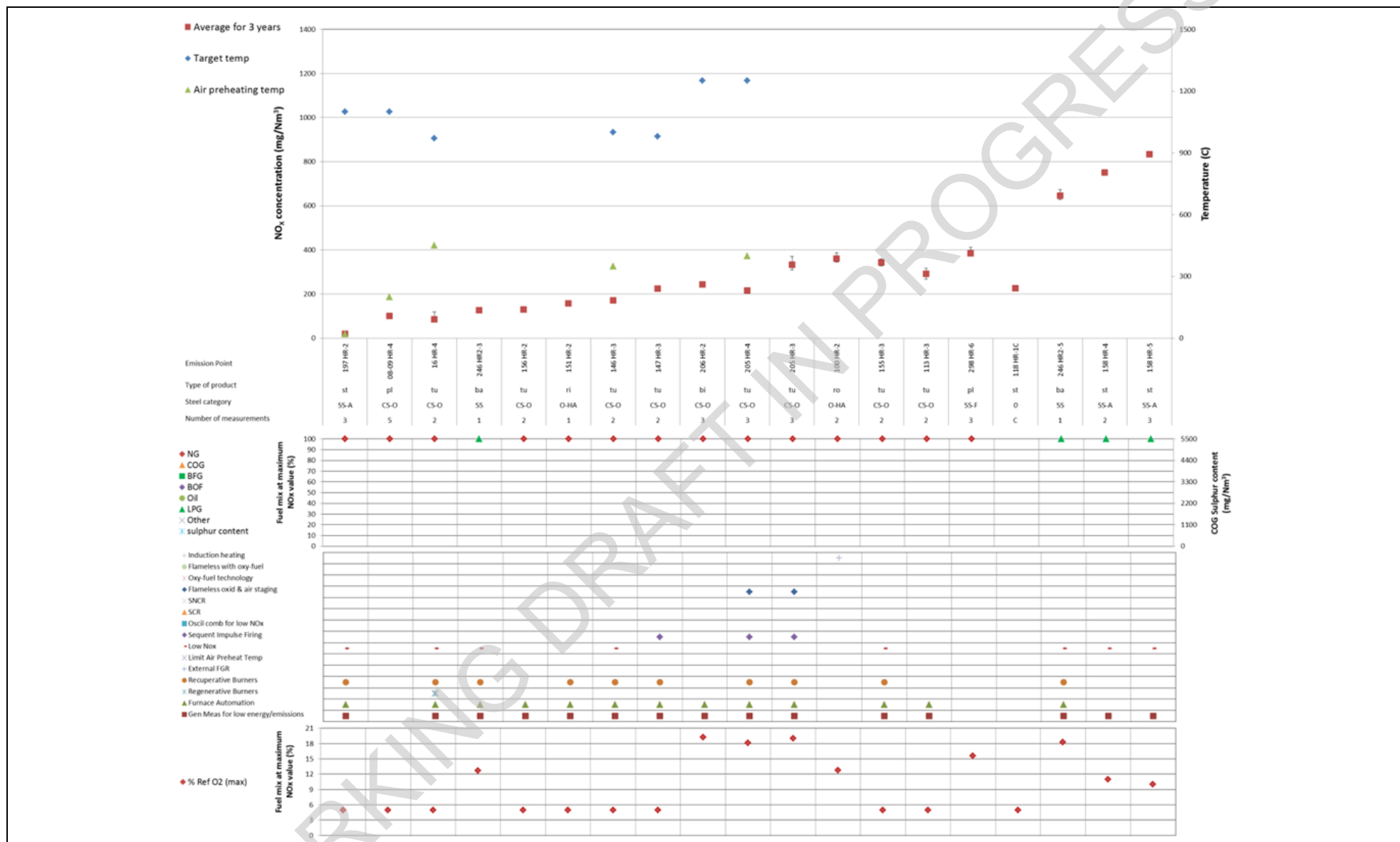


Figure 2.57: NO_x emissions from intermediate heating (in mg/Nm³ at 3% oxygen) for all fuels, with air preheating temperature and feedstock target temperature. Source: [TWG 2018].

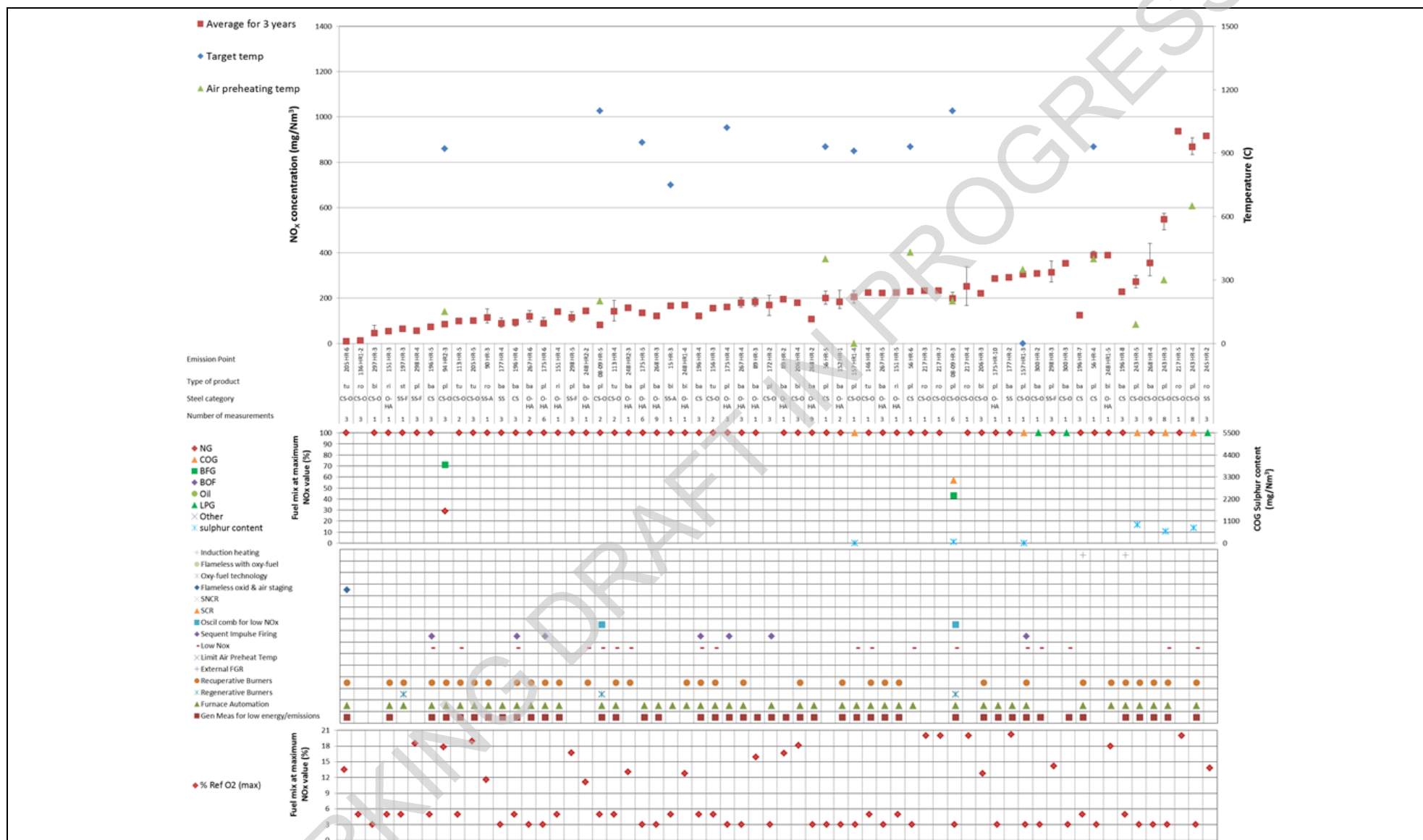


Figure 2.58: NO_x emissions from post-heating (in mg/Nm³ at 3% oxygen) for all fuels, with air preheating temperature and feedstock target temperature. Source: [TWG 2018].

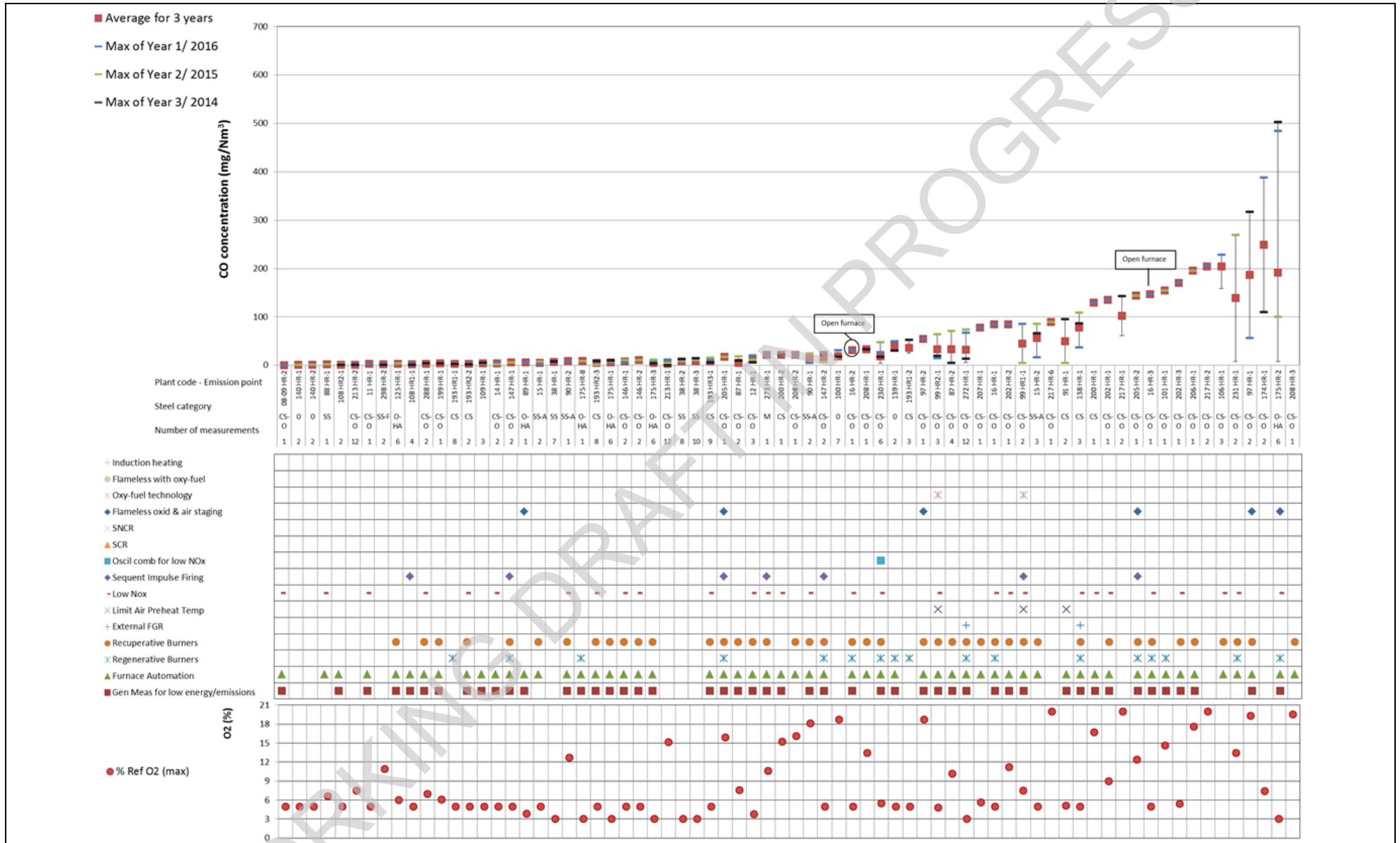


Figure 2.59: CO emissions from reheating (in mg/Nm³ at 3% oxygen) for fuel 100% natural gas. Source: [TWG 2018].

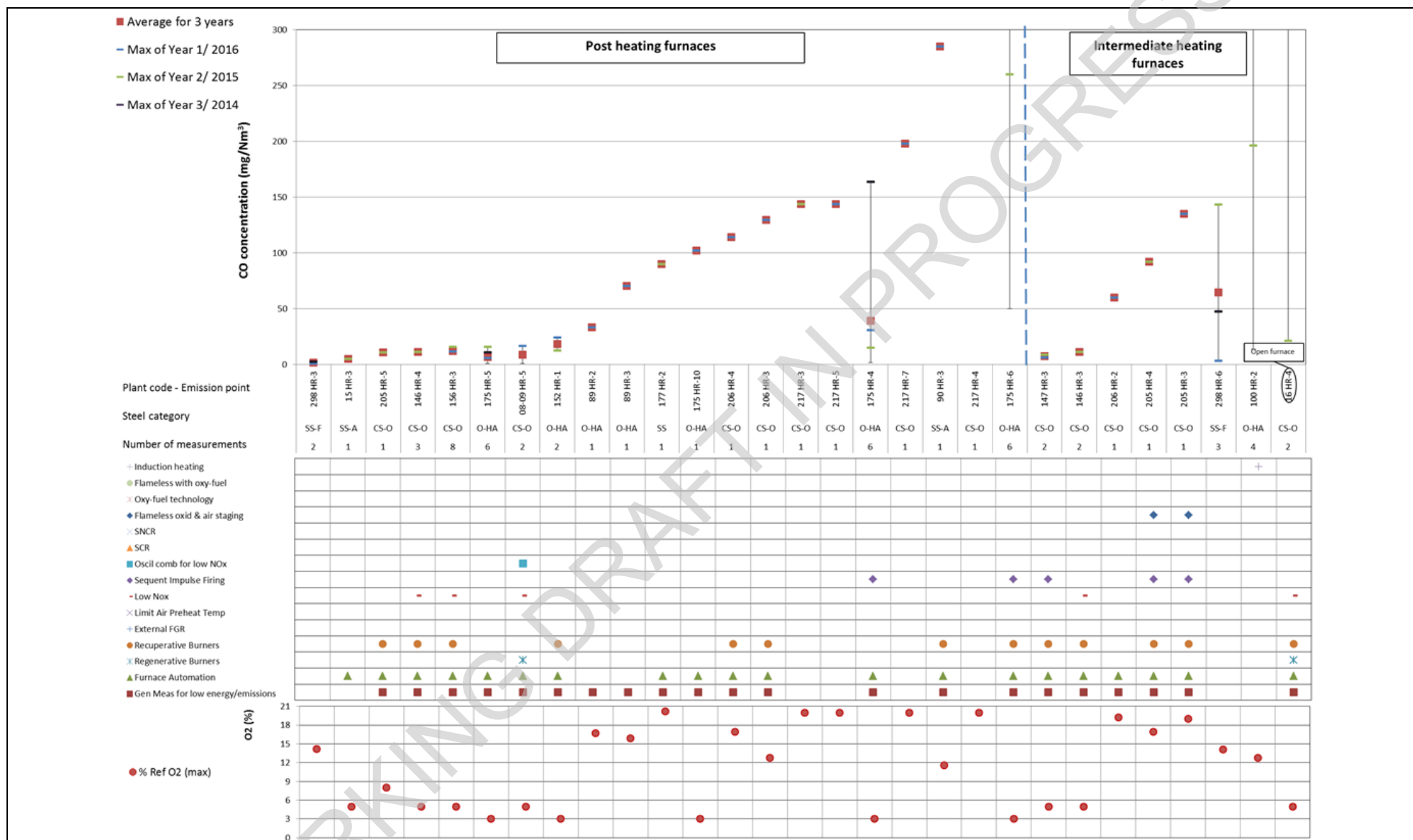


Figure 2.60: CO emissions from intermediate and post-heating (in mg/Nm³ at 3% oxygen) for fuel 100% natural gas. Source: [TWG 2018].

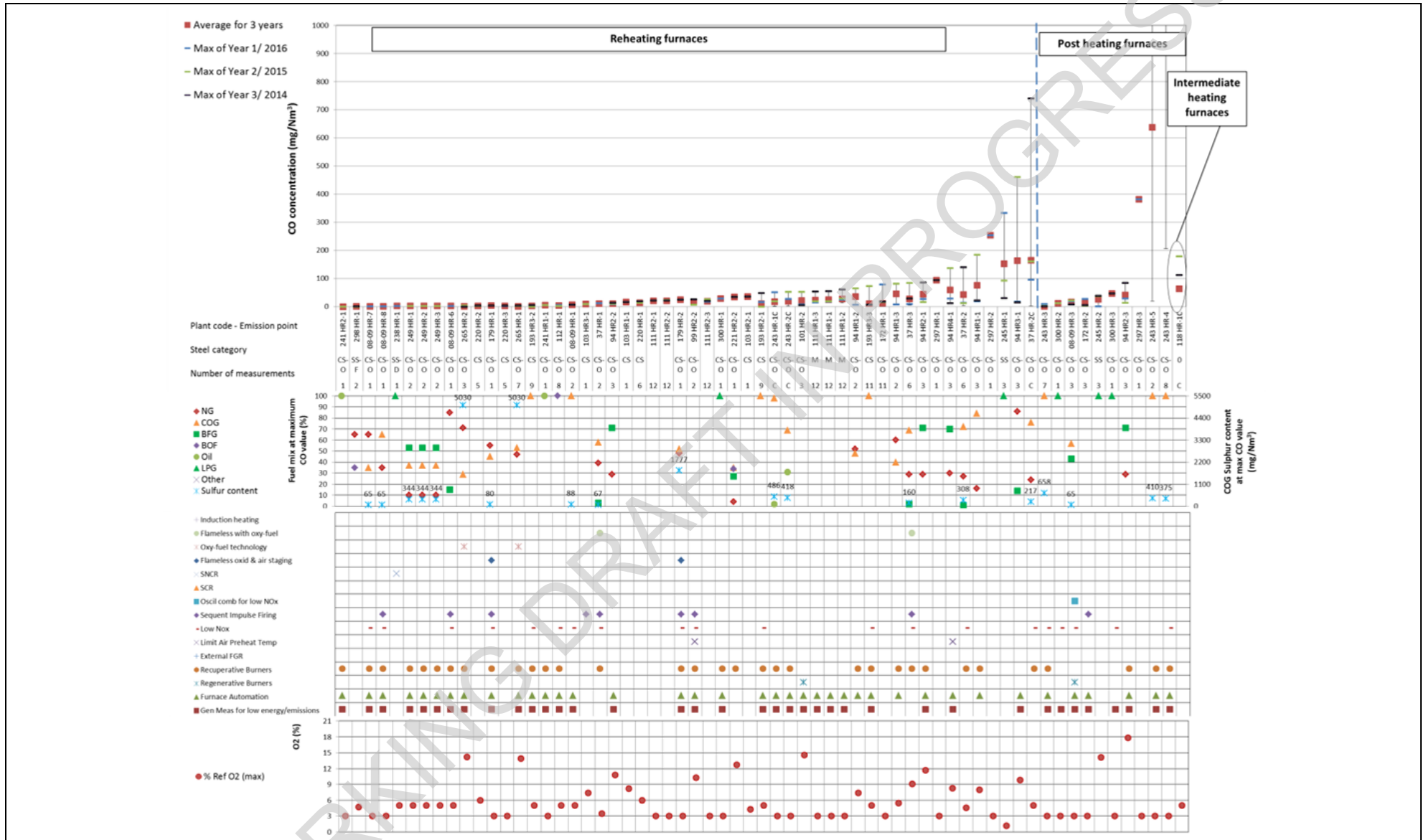


Figure 2.61: CO emissions from reheating, intermediate and post-heating (in mg/Nm³ at 3% oxygen) for fuel other than 100% natural gas or unknown fuel. Source: [TWG 2018]

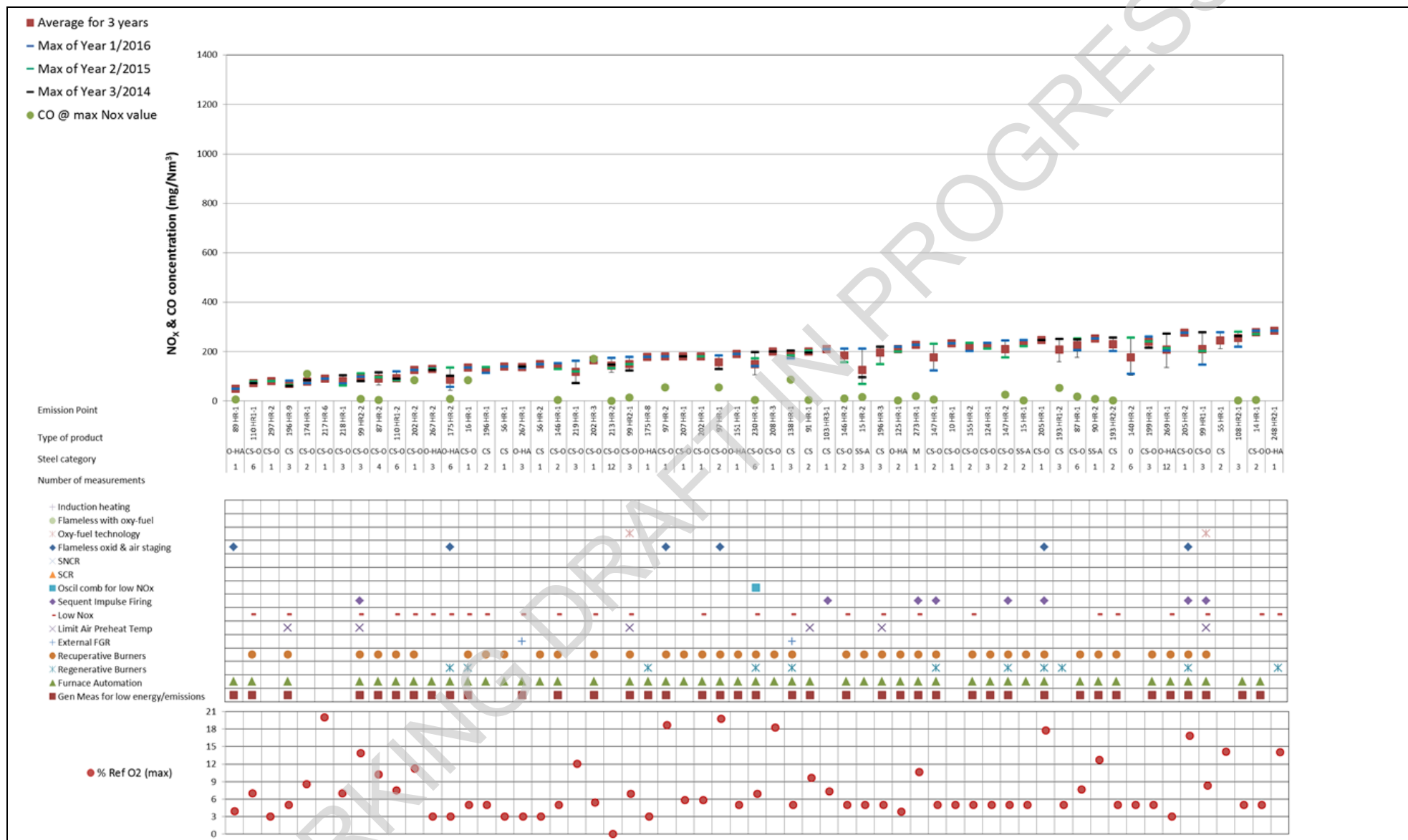


Figure 2.62: NO_x emissions from reheating (in mg/Nm³ at 3% oxygen) for fuel 100% natural gas, together with the CO concentration corresponding to the maximum NO_x value over the reporting period – part 1 of 2. Source: [TWG 2018].

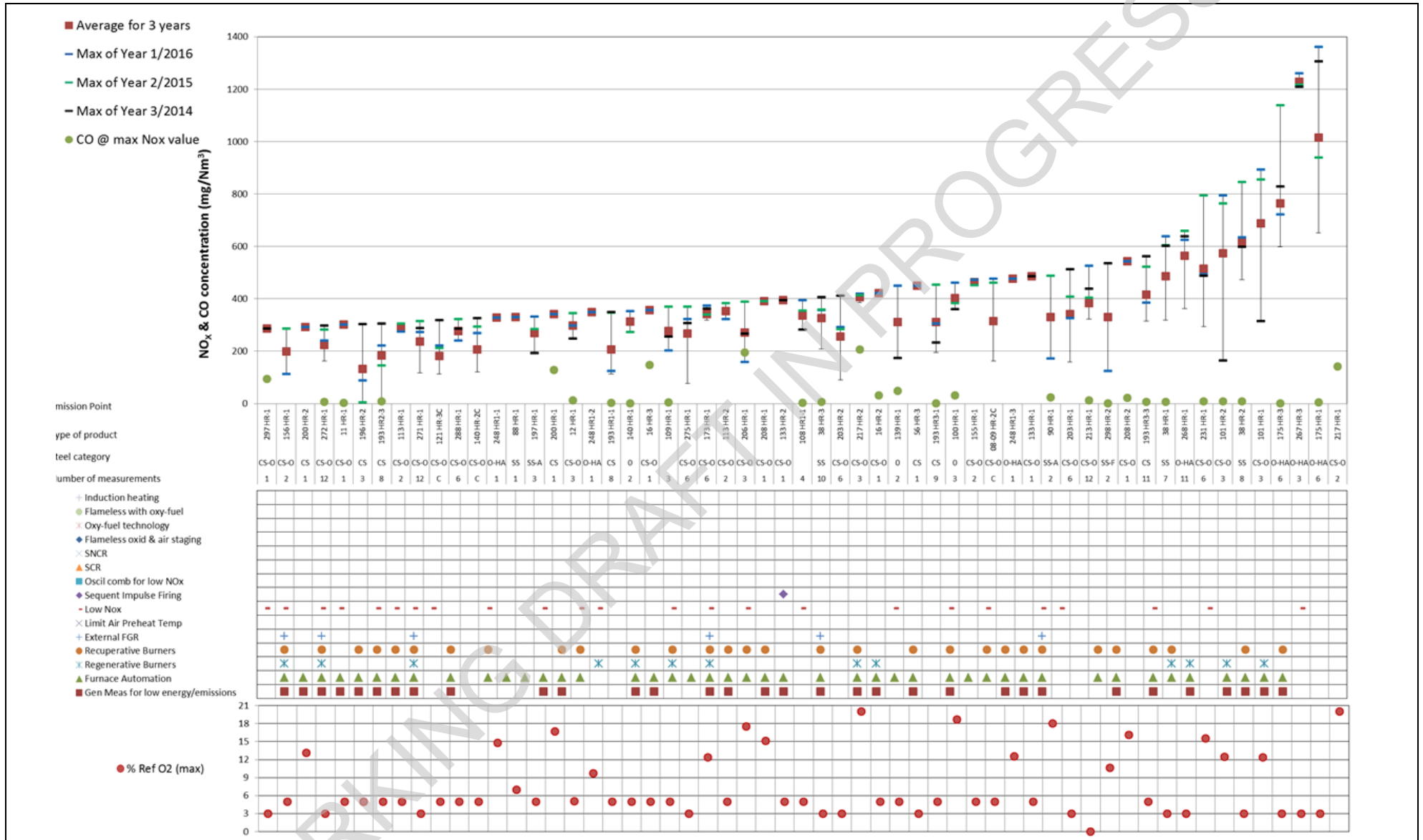


Figure 2.63: NOx emissions from reheating (in mg/Nm³ at 3% oxygen) for fuel 100% natural gas, together with the CO concentration corresponding to the maximum NOx value over the reporting period – part 2 of 2. Source: [TWG 2018].

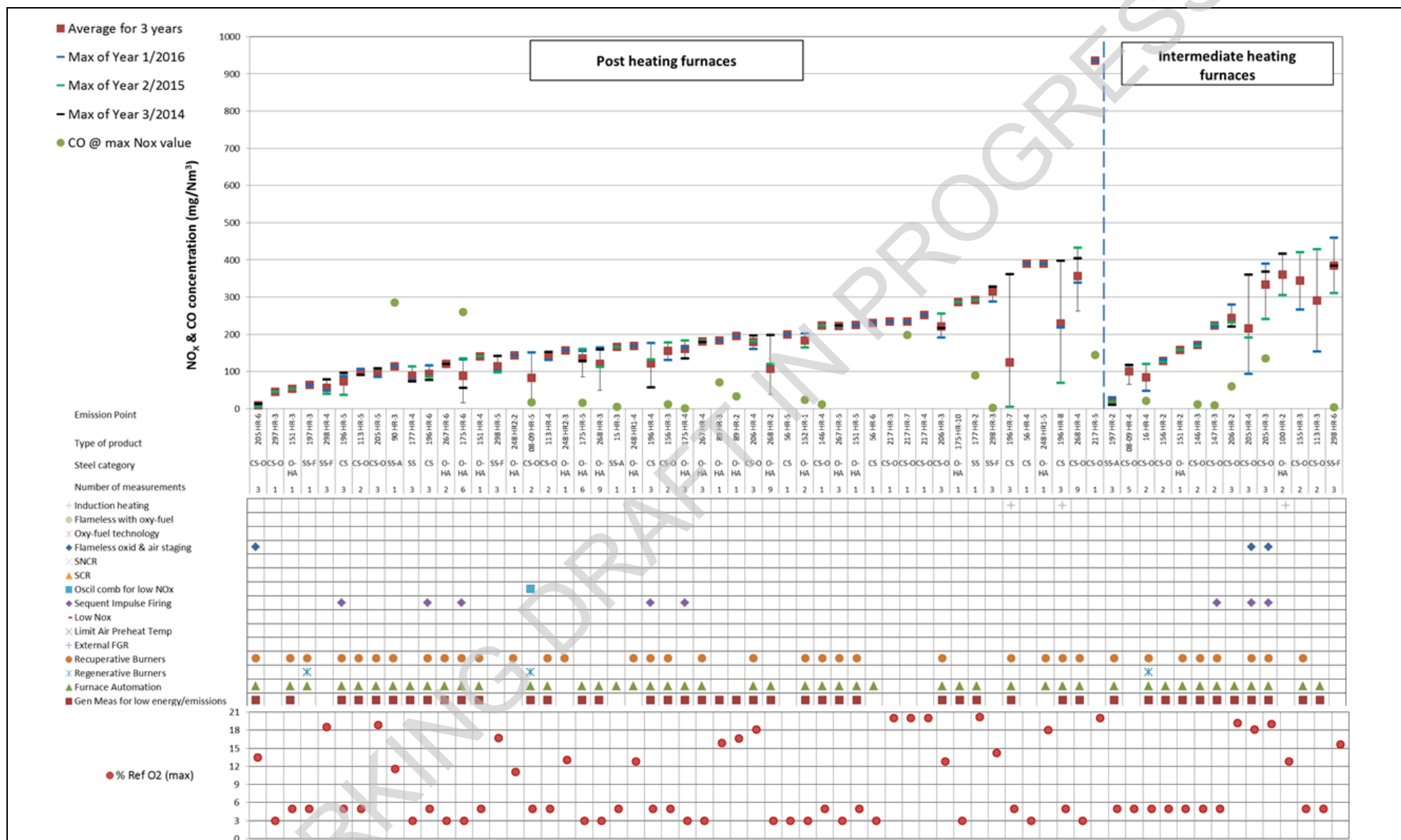


Figure 2.64: NO_x emissions from intermediate and post-heating (in mg/Nm³ at 3% oxygen) for fuel 100% natural gas, together with the CO concentration corresponding to the maximum NO_x value over the reporting period. Source: [TWG 2018].

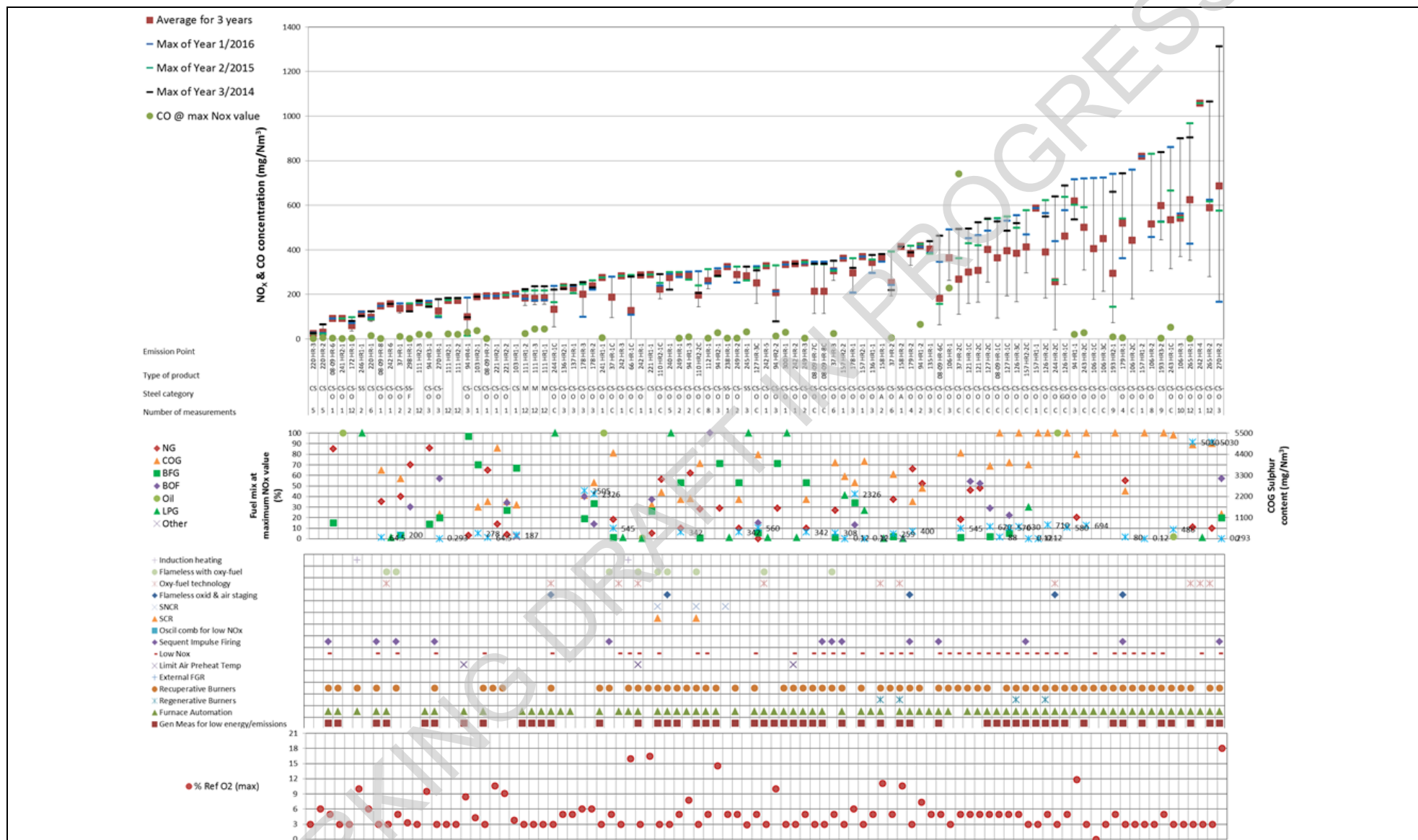


Figure 2.65: NO_x emissions from reheating (in mg/Nm³ at 3% oxygen) for fuel other than 100% natural gas or unknown fuel, together with the CO concentration corresponding to the maximum NO_x value over the reporting period. Source: [TWG 2018].

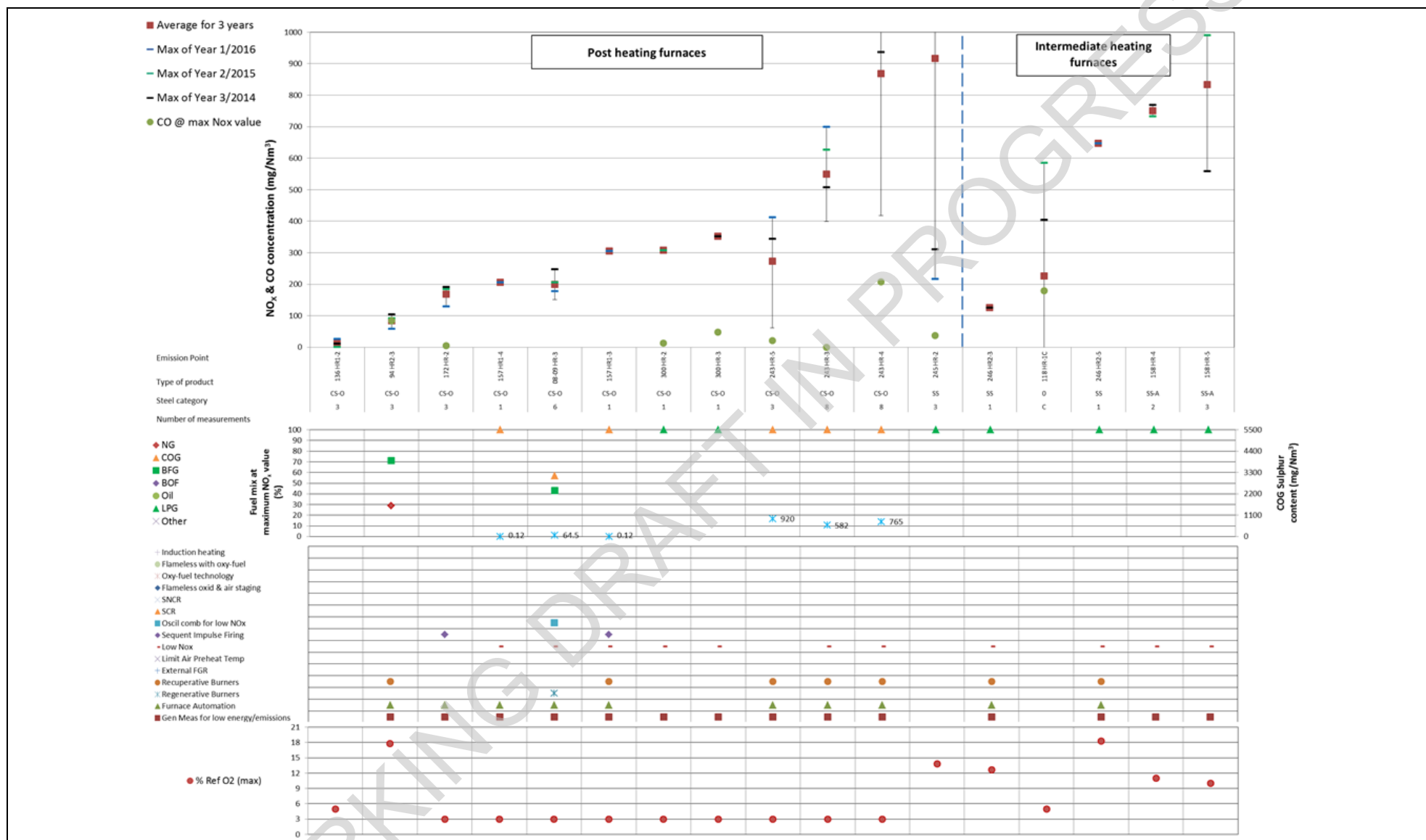


Figure 2.66: NO_x emissions from intermediate and post-heating (in mg/Nm³ at 3% oxygen) for fuel other than 100% natural gas or unknown fuel, together with the CO concentration corresponding to the maximum NO_x value over the reporting period. Source: [TWG 2018].

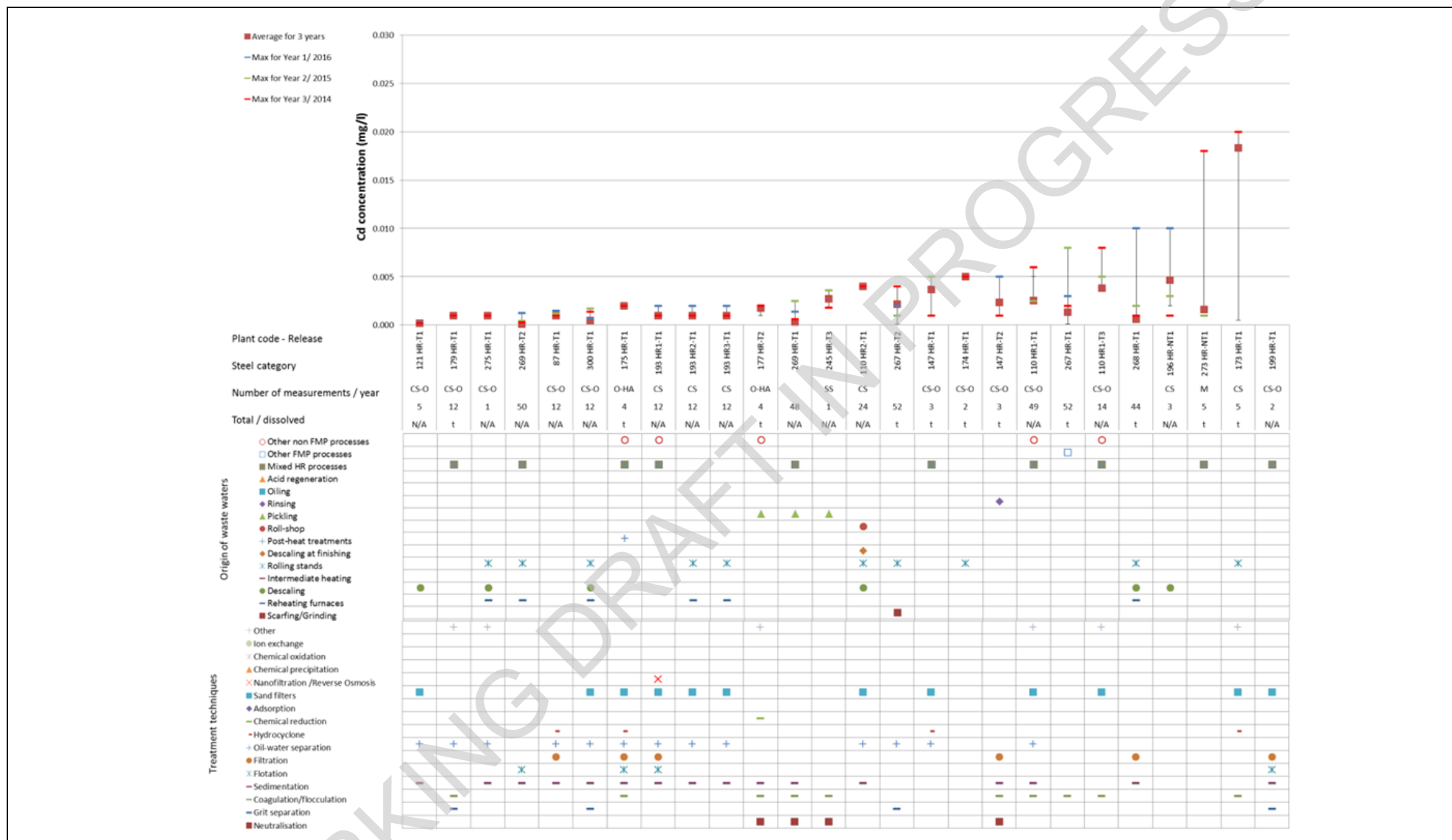


Figure 2.67: Cadmium emissions (in mg/l) for direct discharges. Source: [TWG 2018].

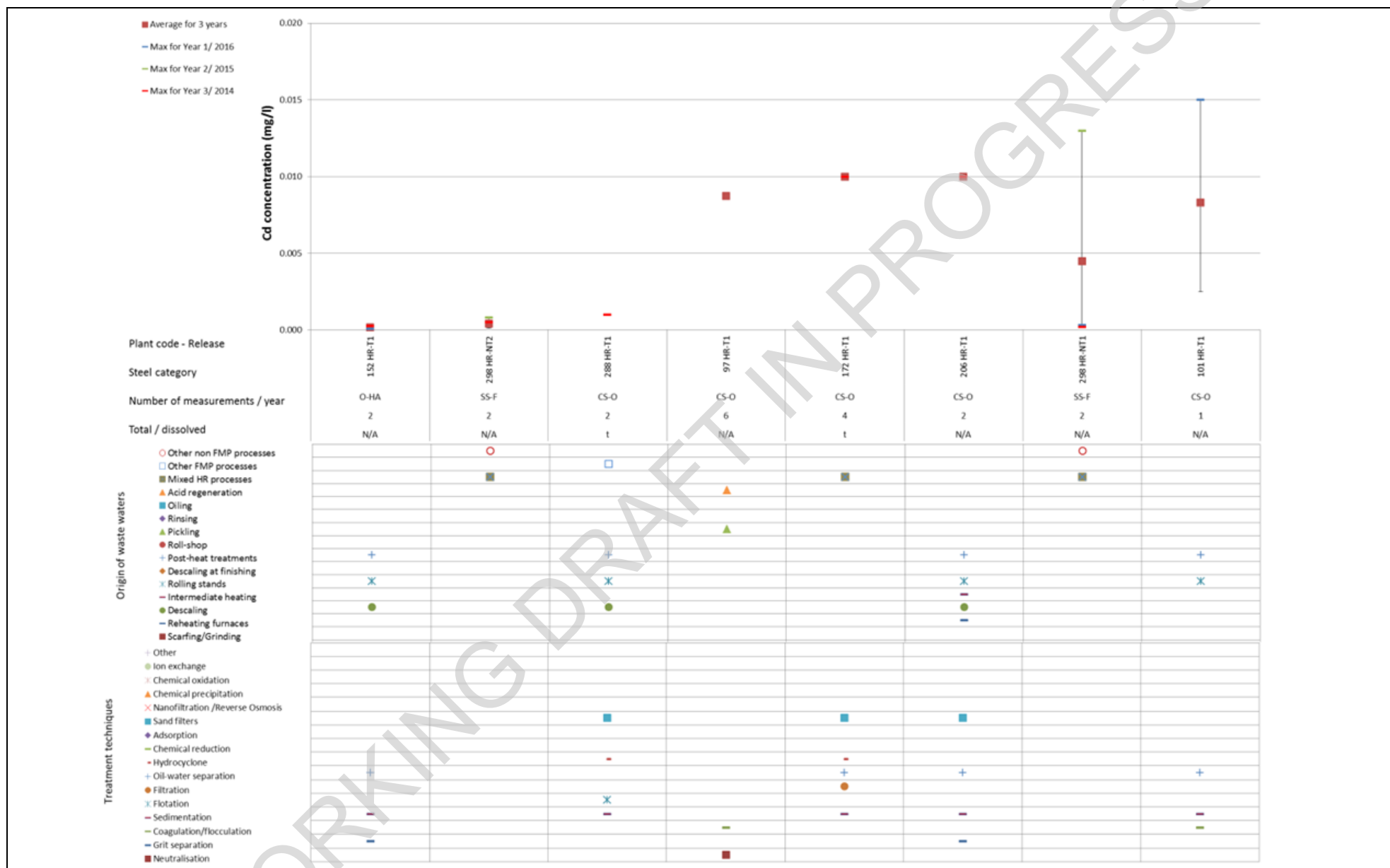


Figure 2.68: Cadmium emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

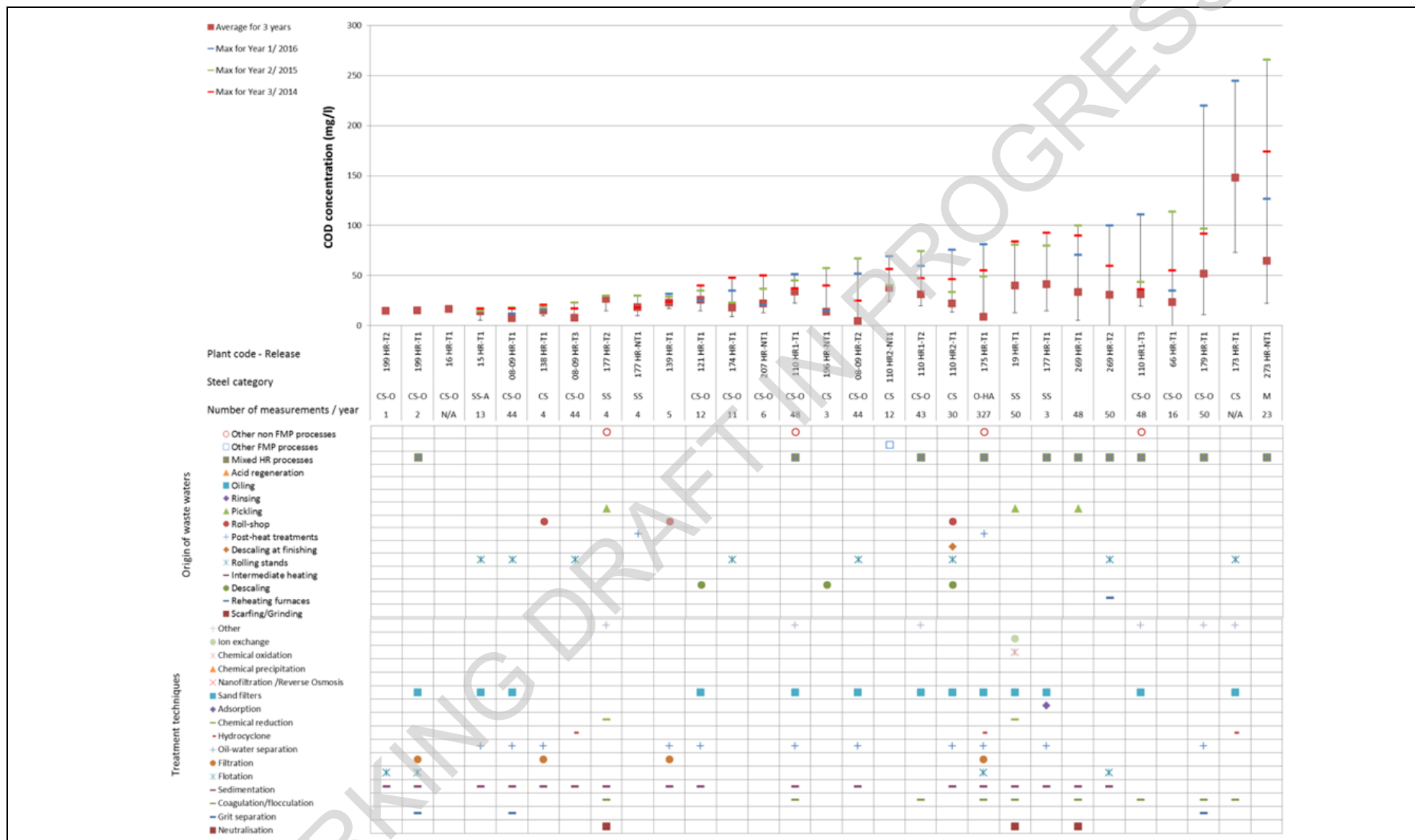


Figure 2.69: COD emissions (in mg/l) for direct discharges. Source: [TWG 2018].

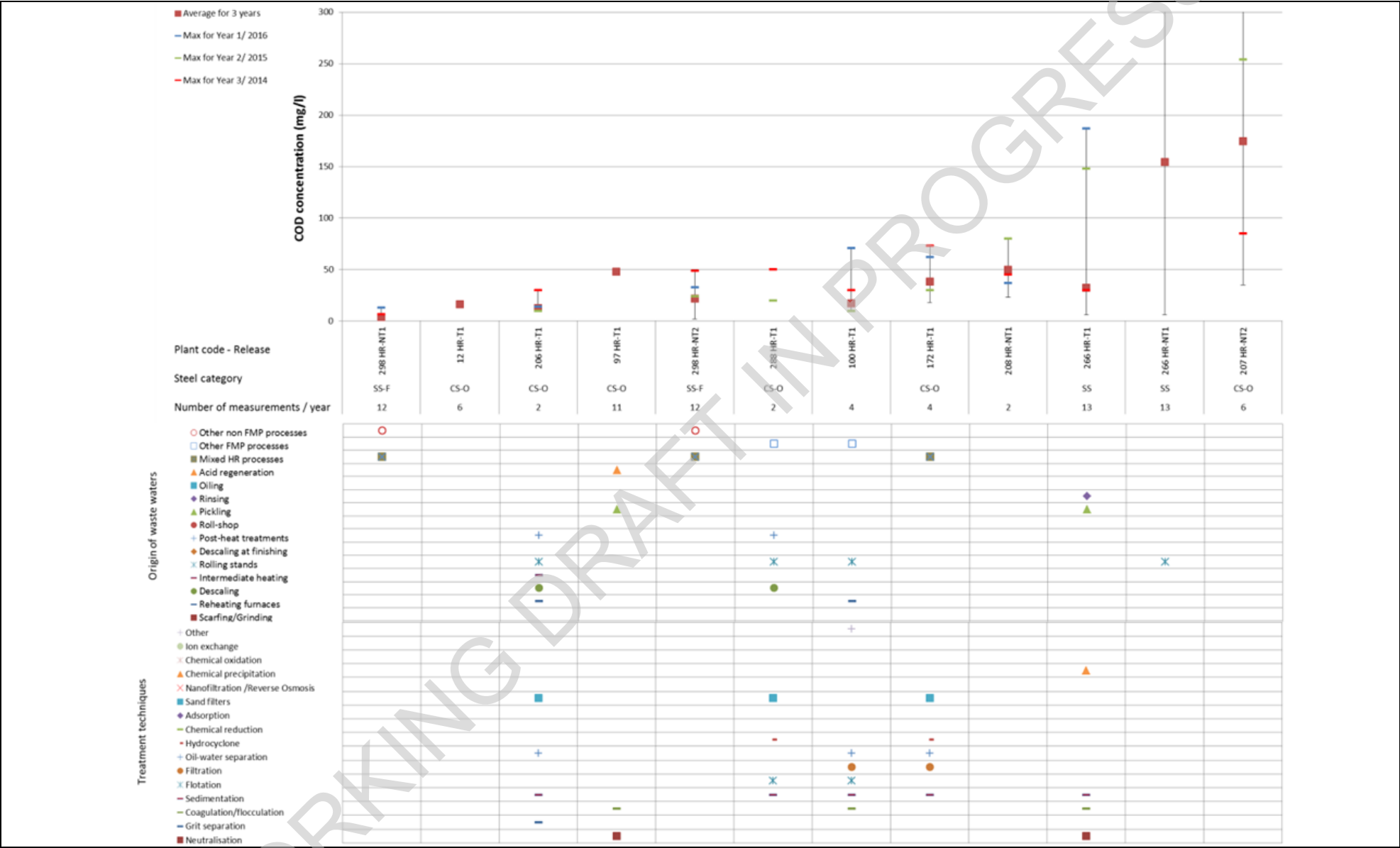


Figure 2.70: COD emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

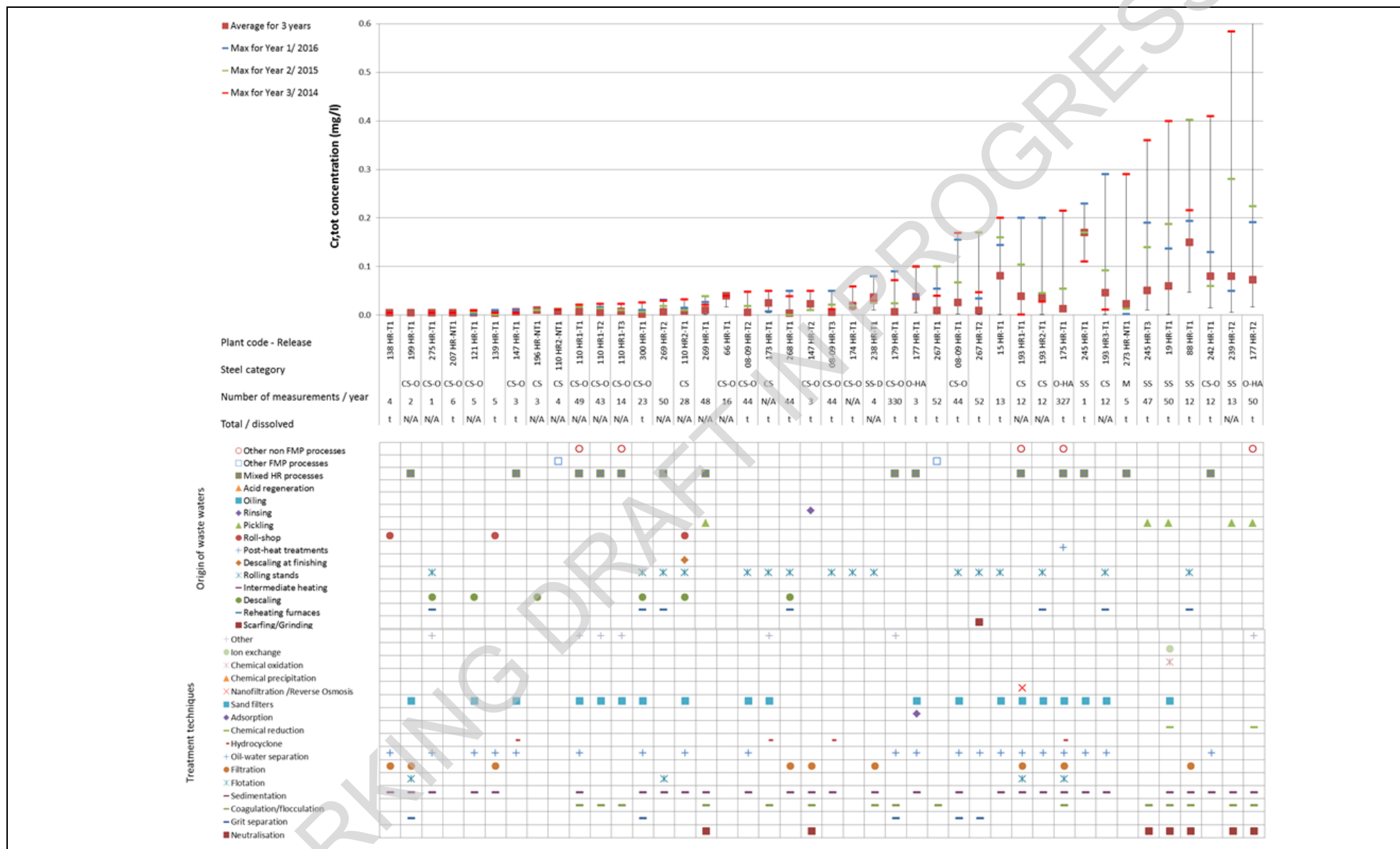


Figure 2.71: Chromium emissions (in mg/l) for direct discharges. Source: [TWG 2018].

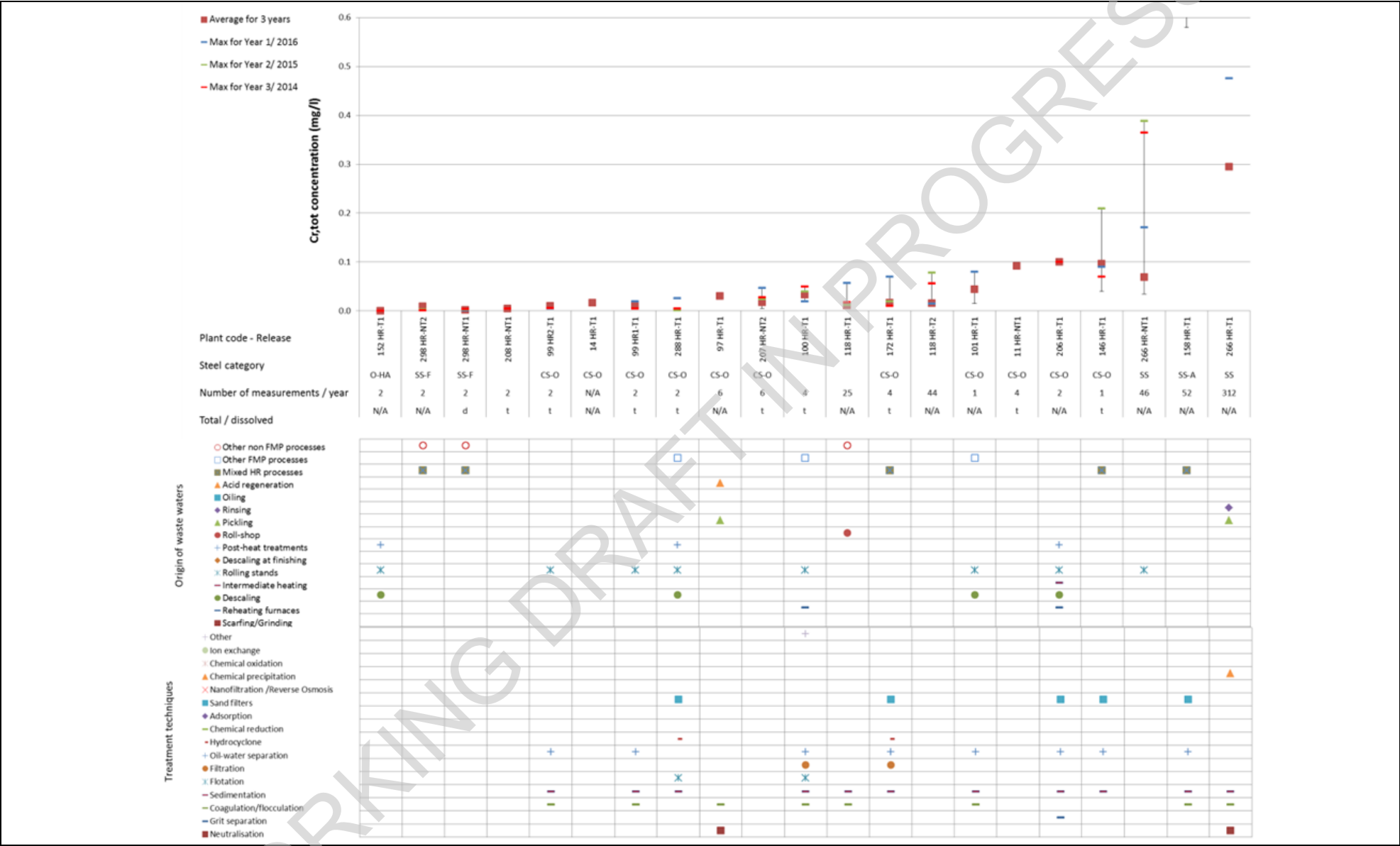


Figure 2.72: Chromium emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

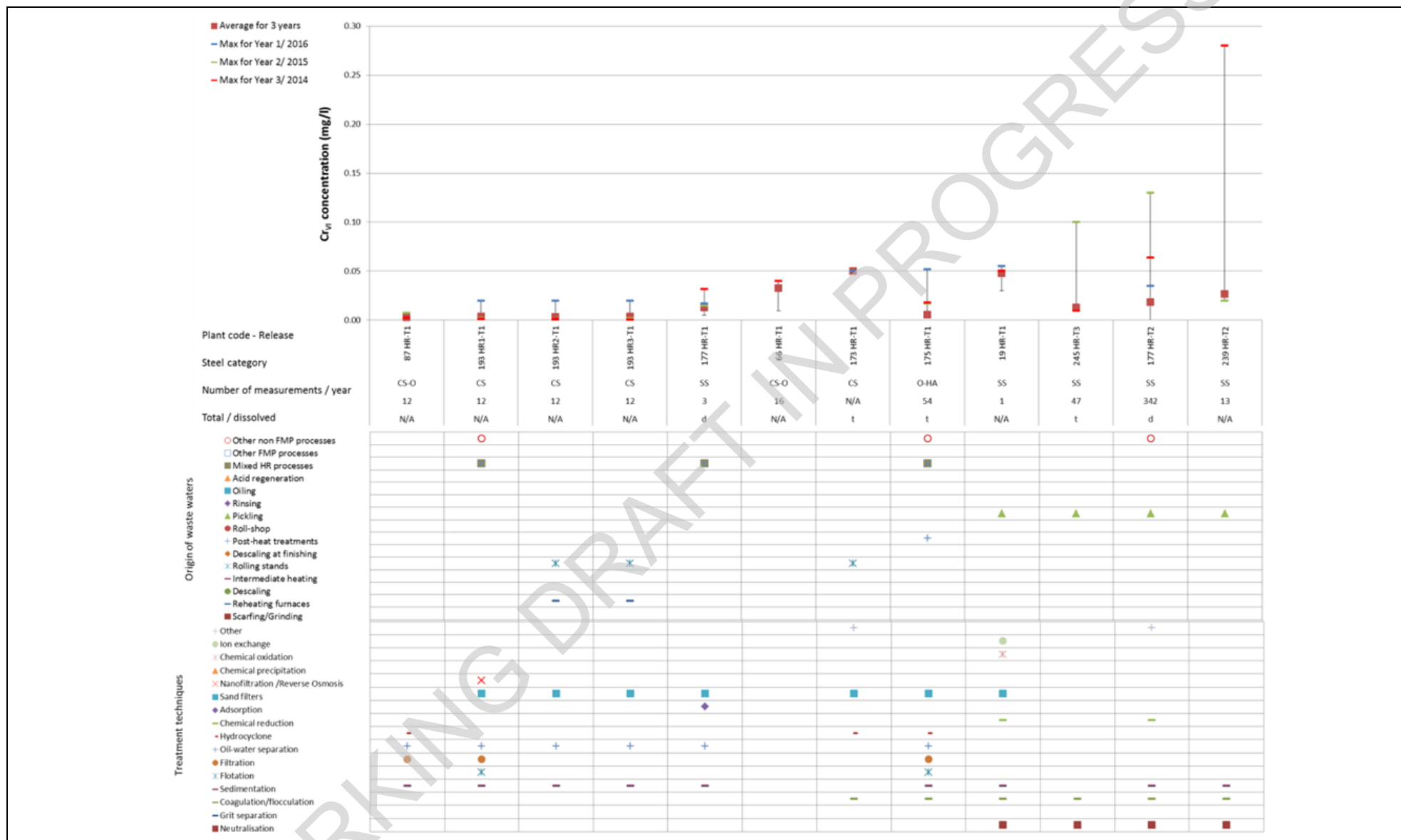


Figure 2.73: Chromium VI emissions (in mg/l) for direct discharges. Source: [TWG 2018].

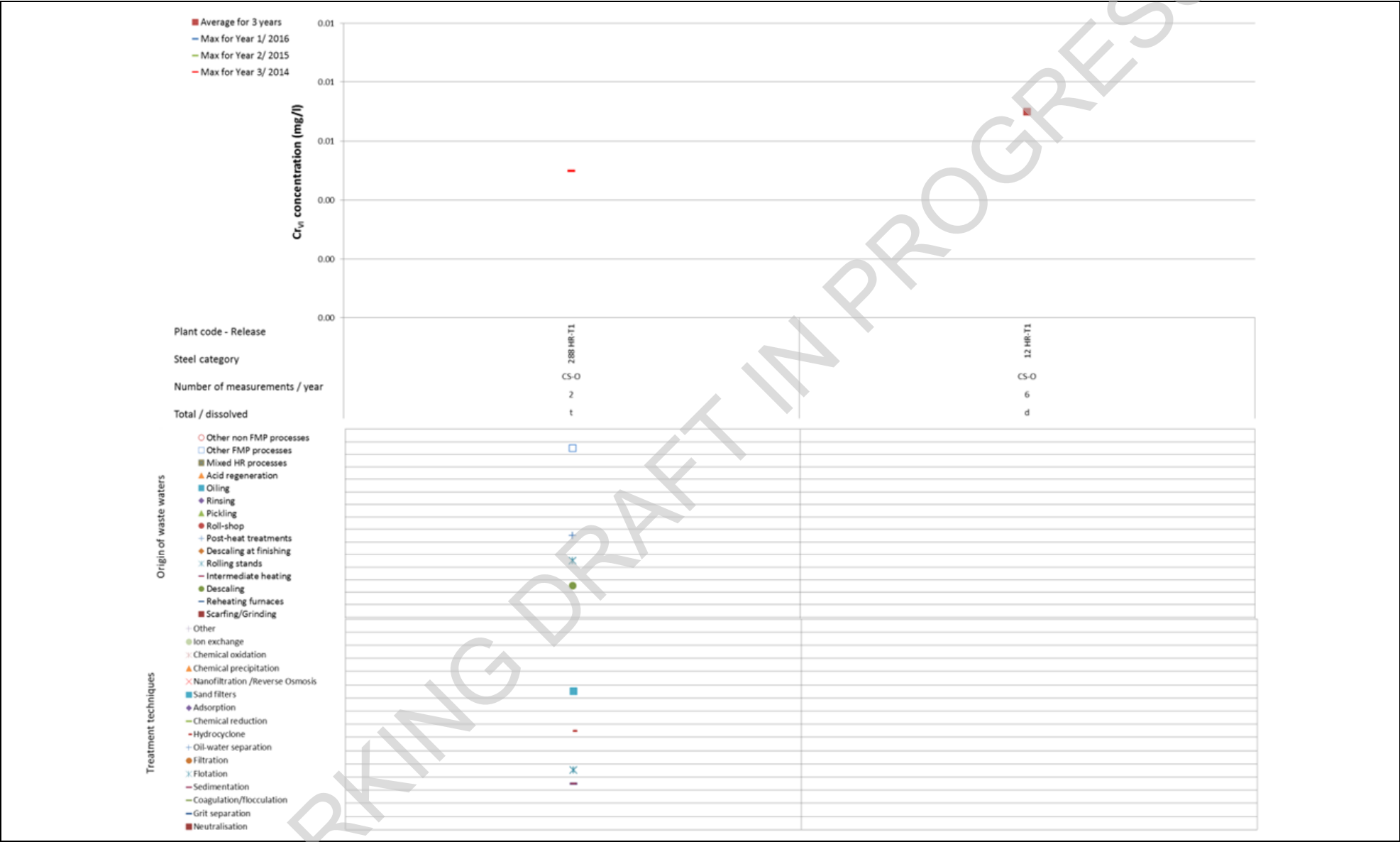


Figure 2.74: Chromium VI emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

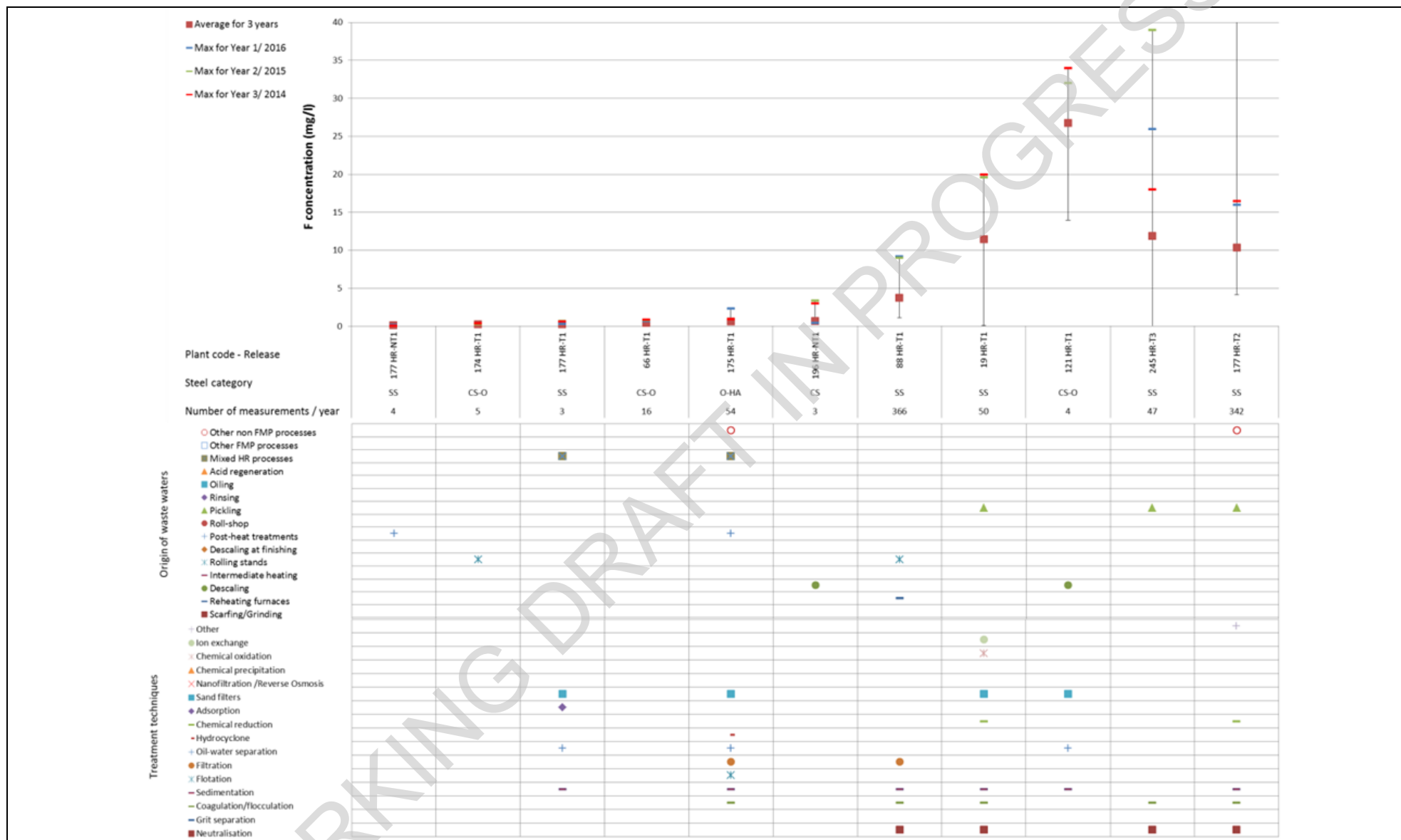


Figure 2.75: Fluoride emissions (in mg/l) for direct discharges. Source: [TWG 2018].

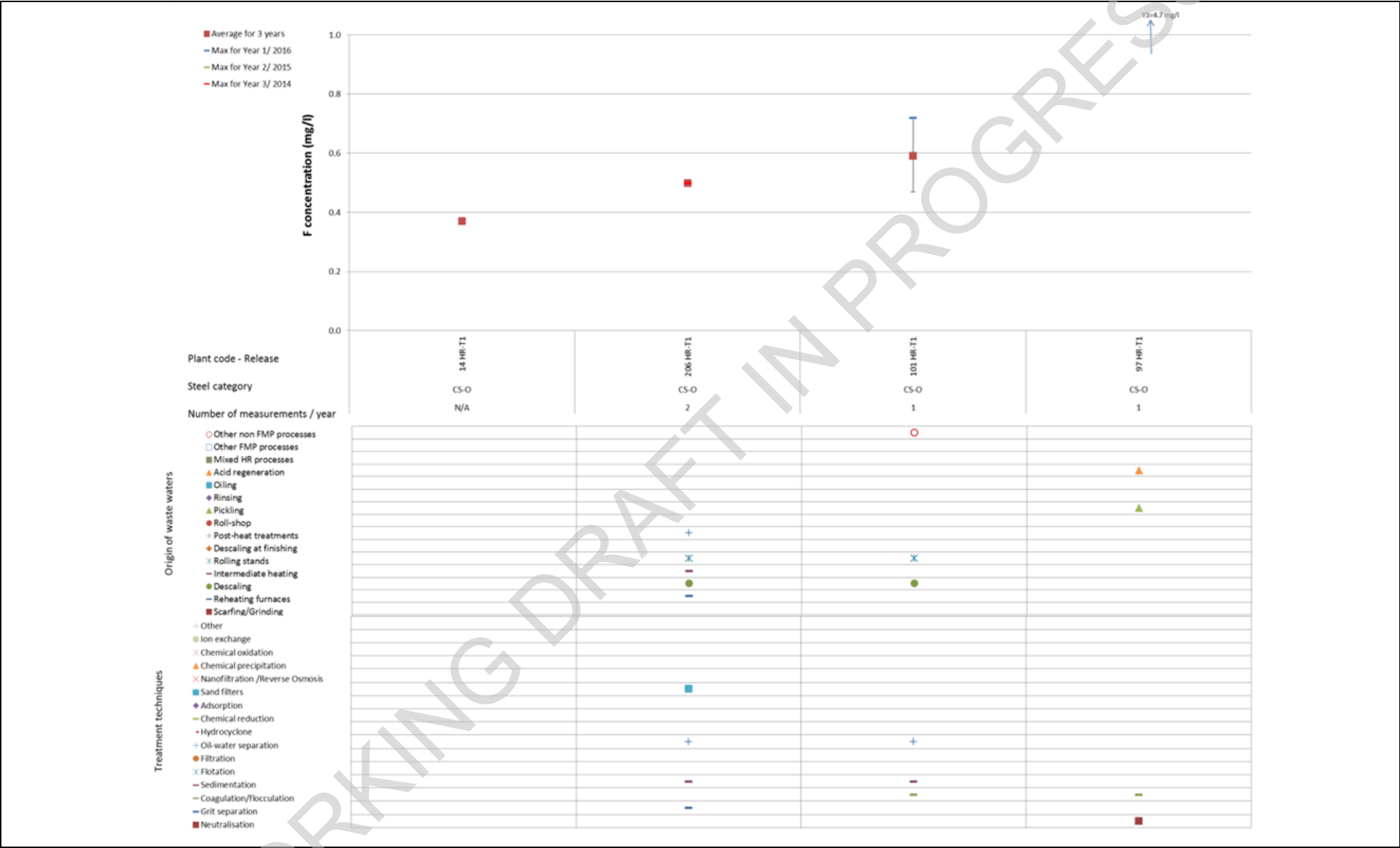


Figure 2.76: Fluoride emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

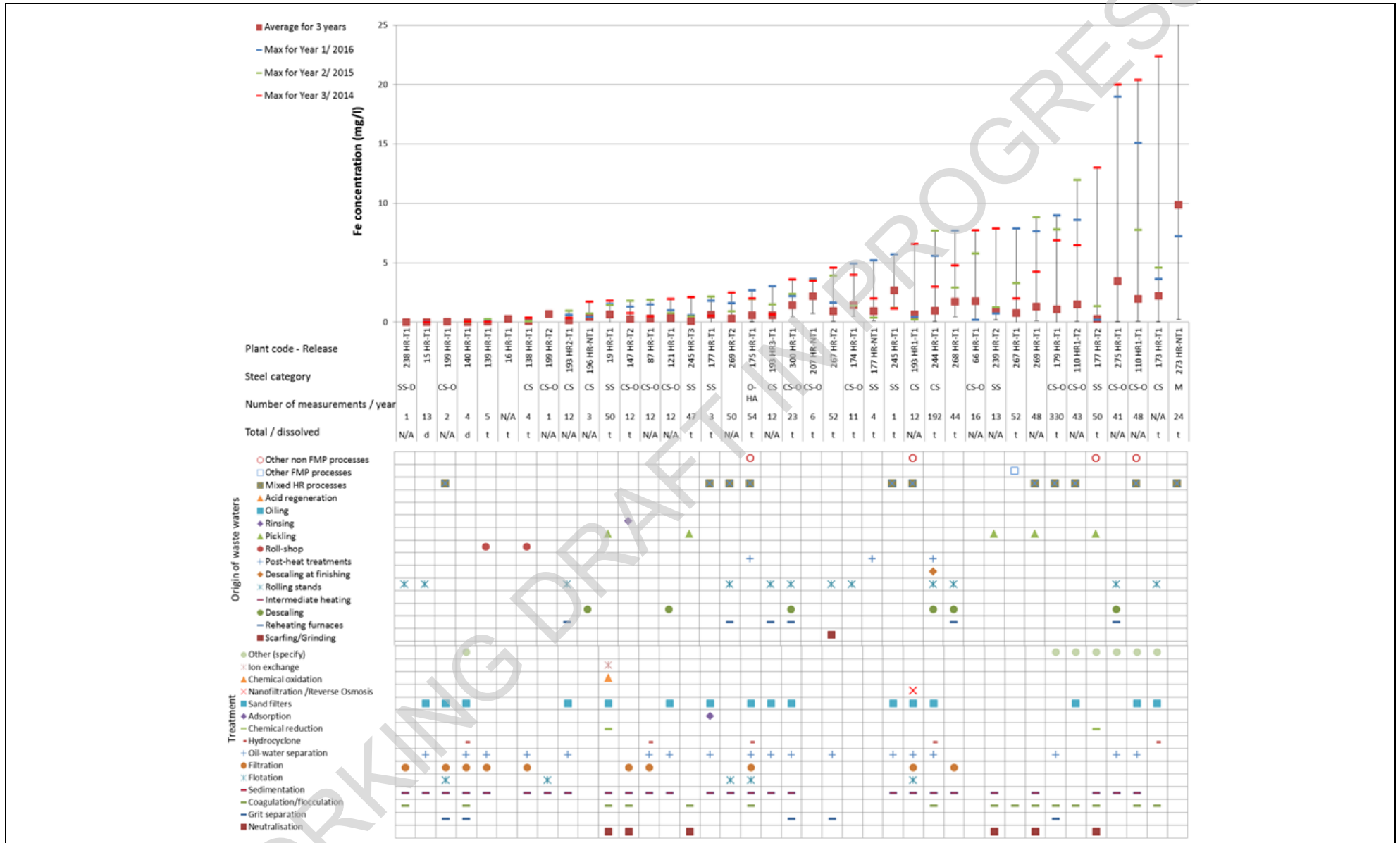


Figure 2.77: Iron emissions (in mg/l) for direct discharges. Source: [TWG 2018].

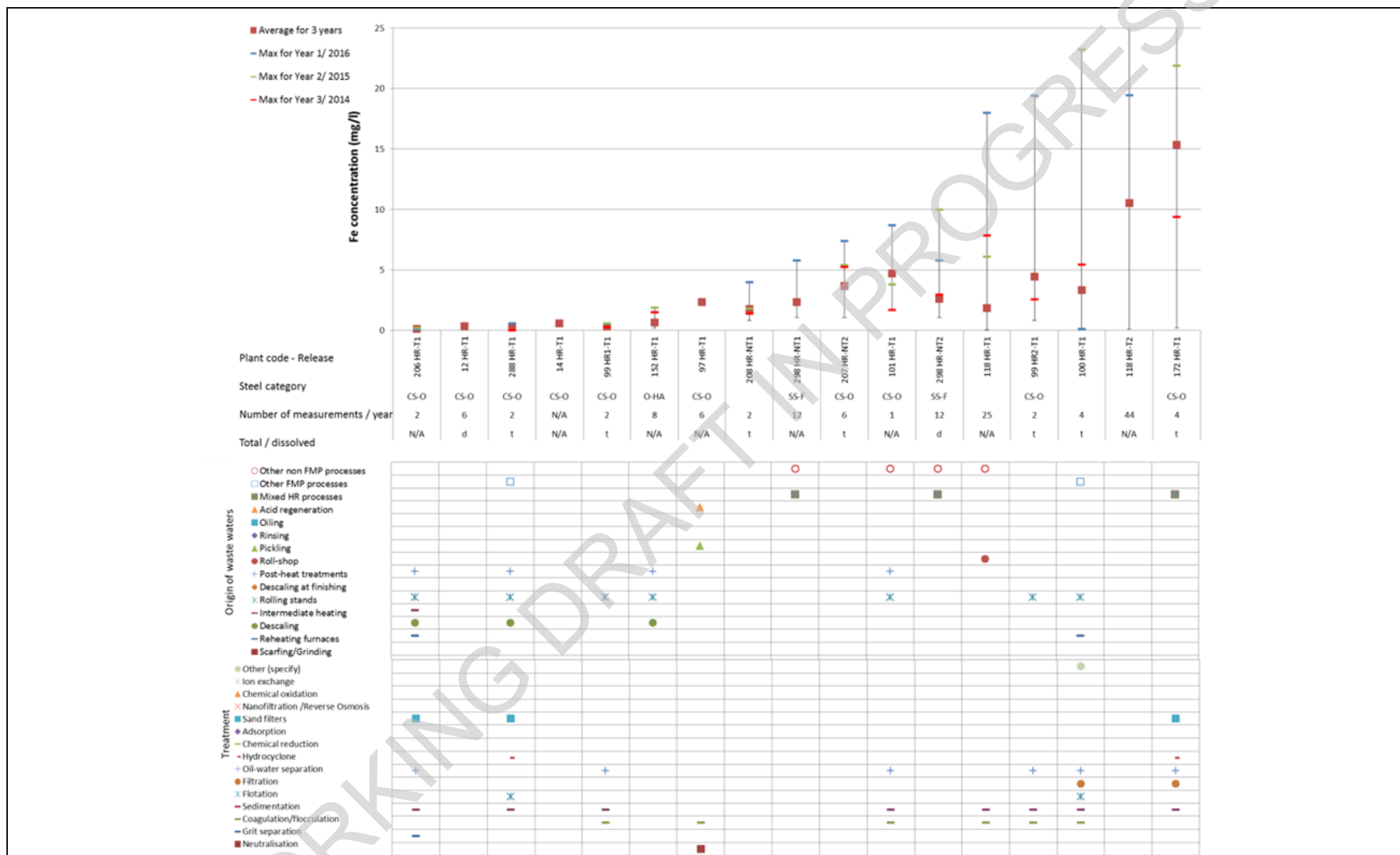


Figure 2.78: Iron emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

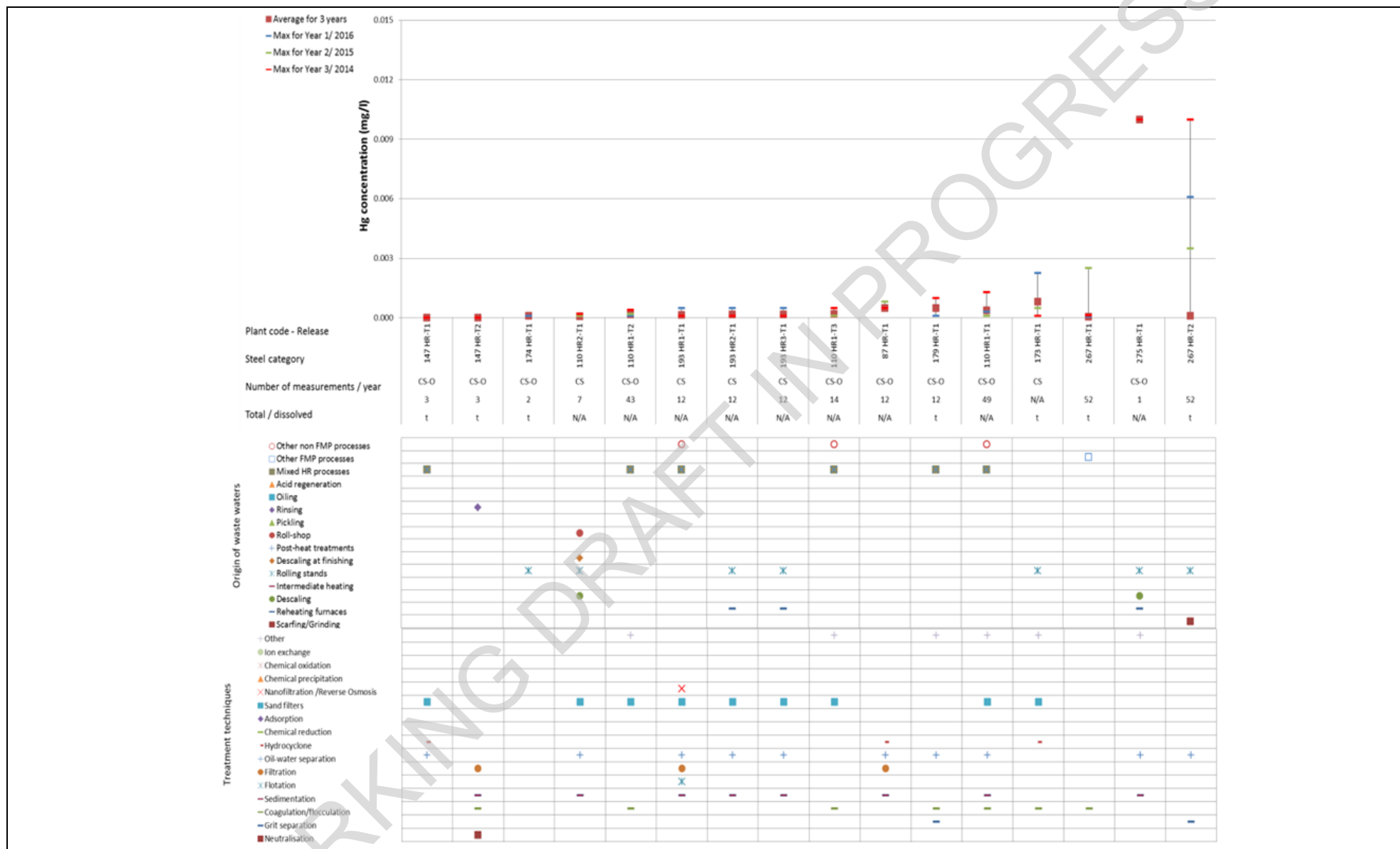


Figure 2.79: Mercury emissions (in mg/l) for direct discharges. Source: [TWG 2018].

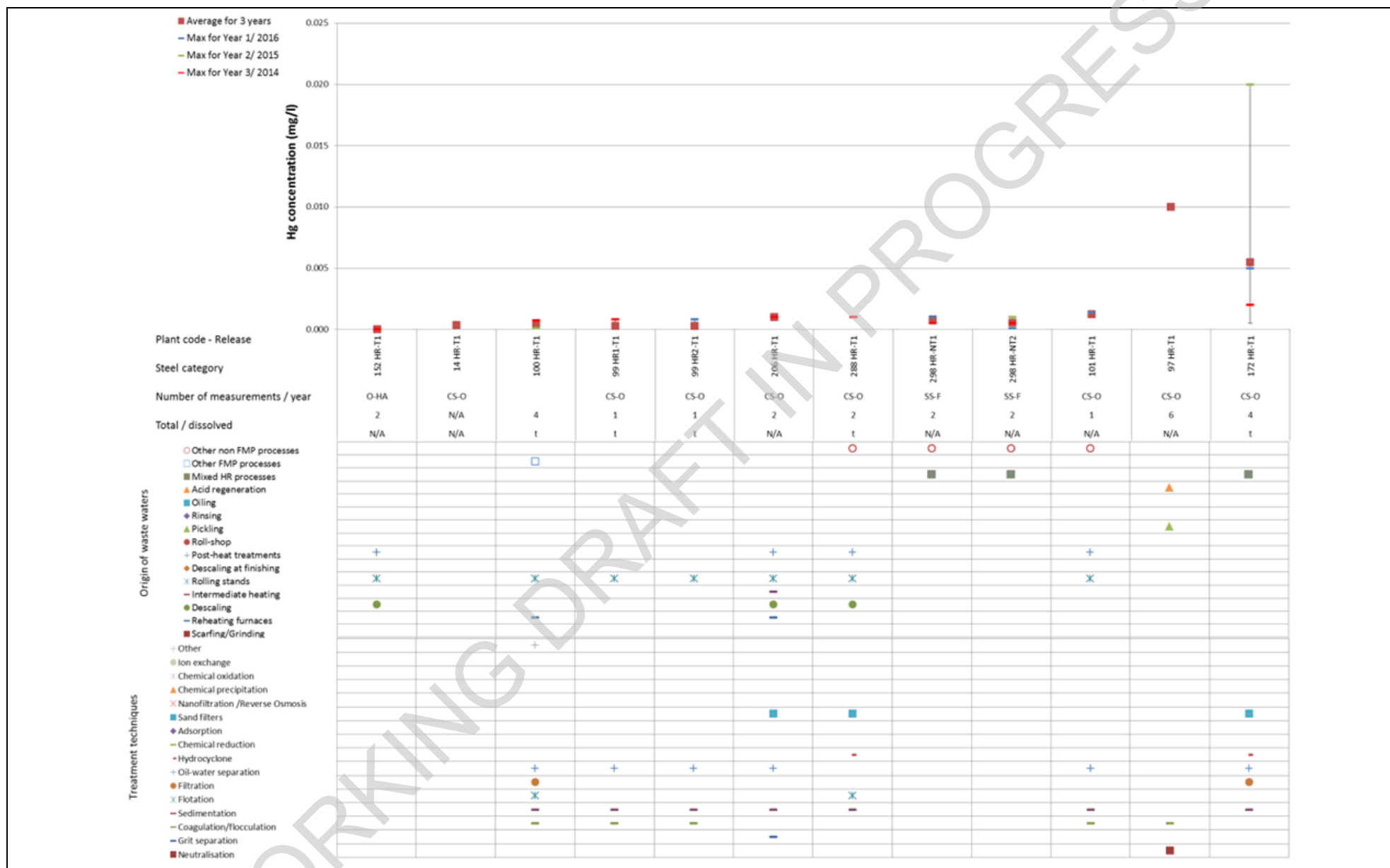


Figure 2.80: Mercury emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

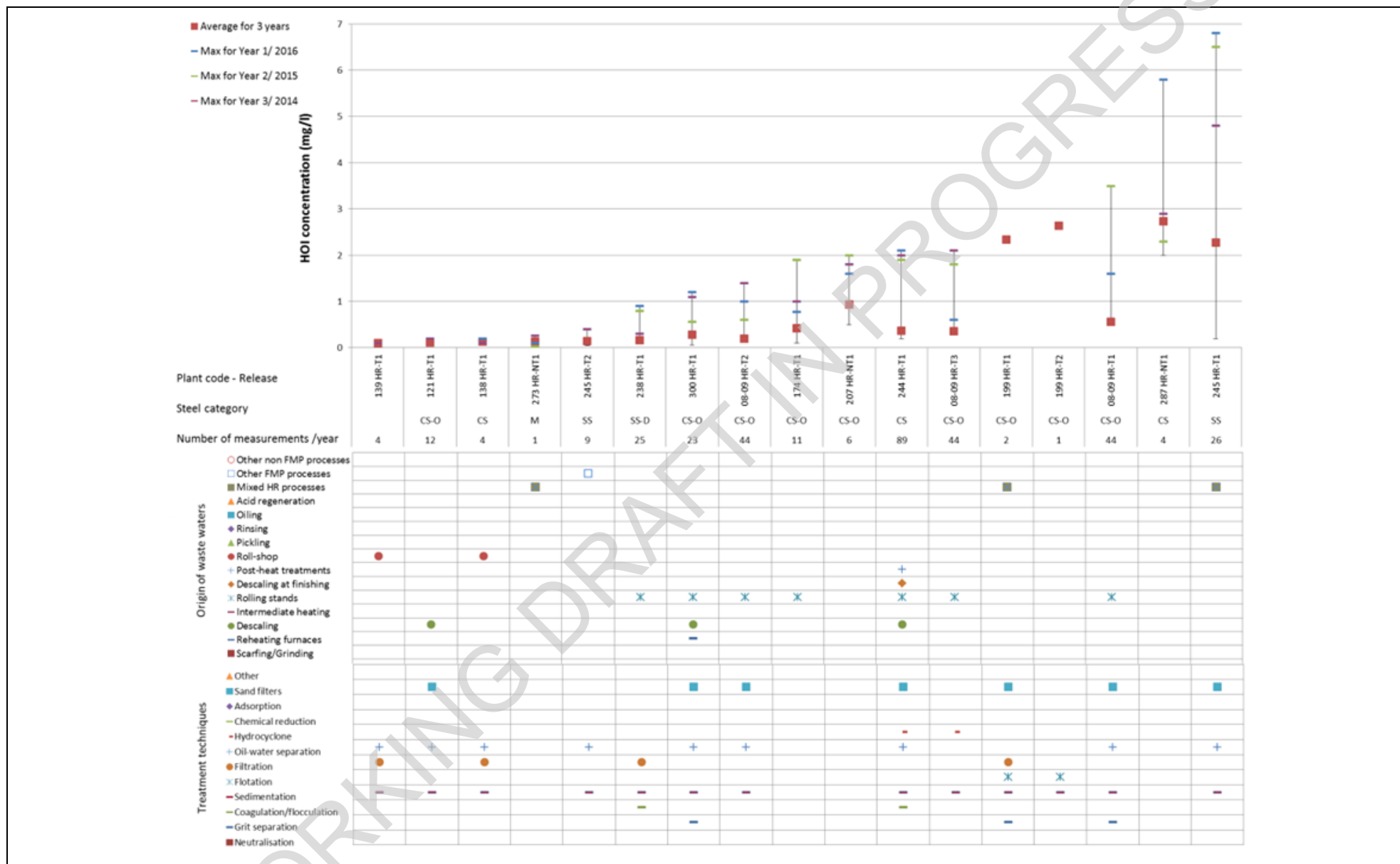


Figure 2.81: Hydrocarbon oil index emissions (in mg/l) for direct discharges. Source: [TWG 2018].

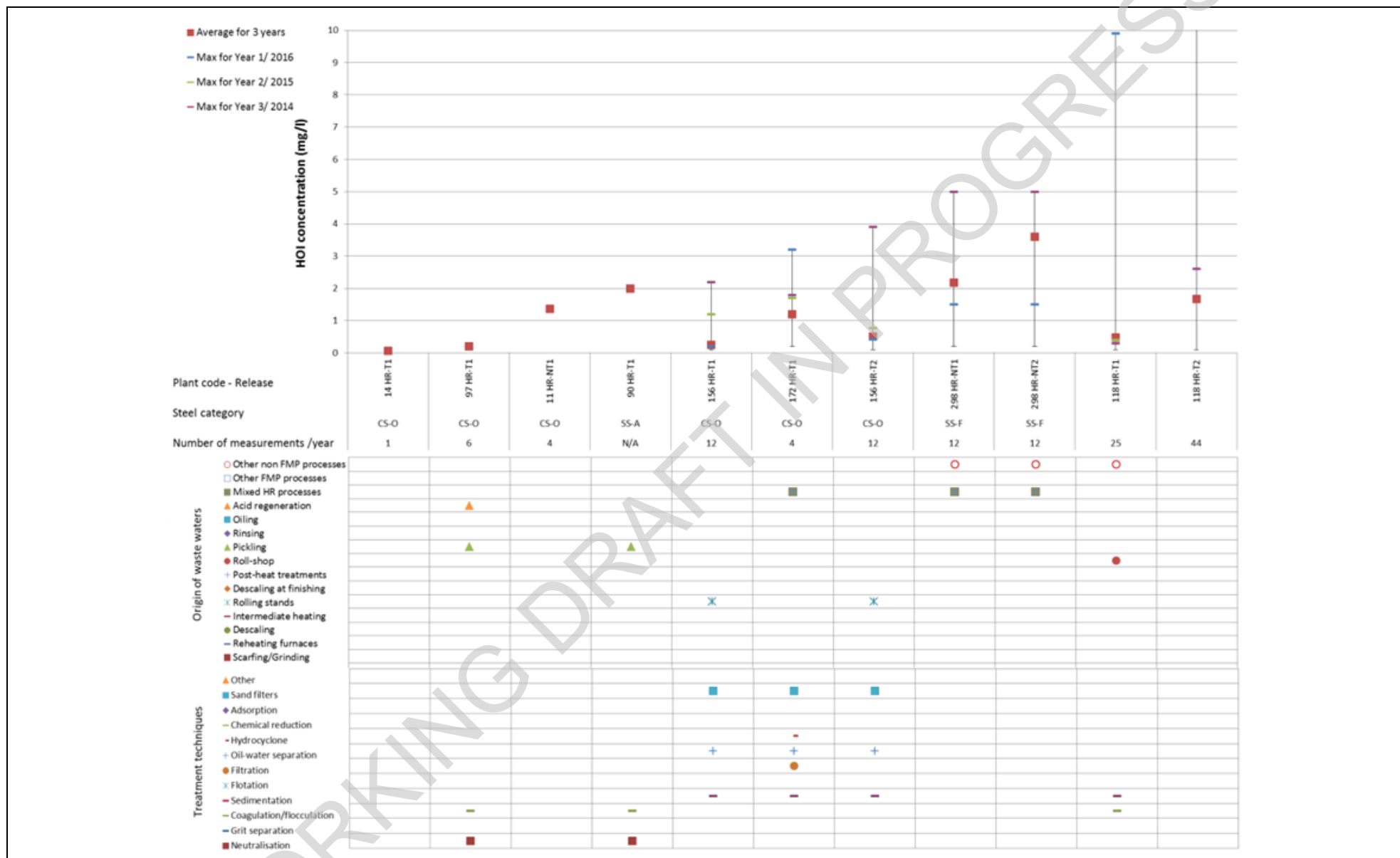


Figure 2.82: Hydrocarbon oil index emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

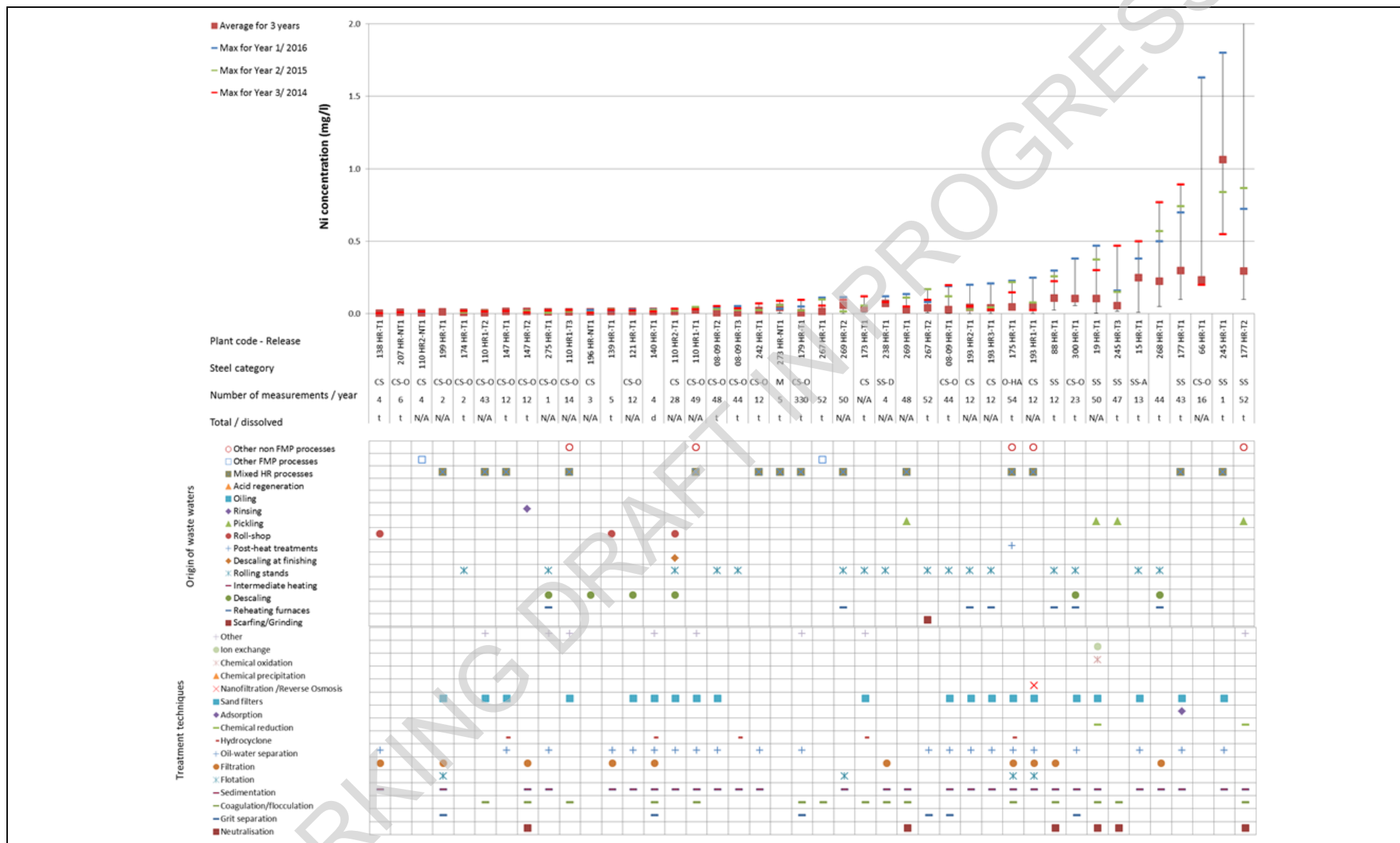


Figure 2.83: Nickel emissions (in mg/l) for direct discharges. Source: [TWG 2018].

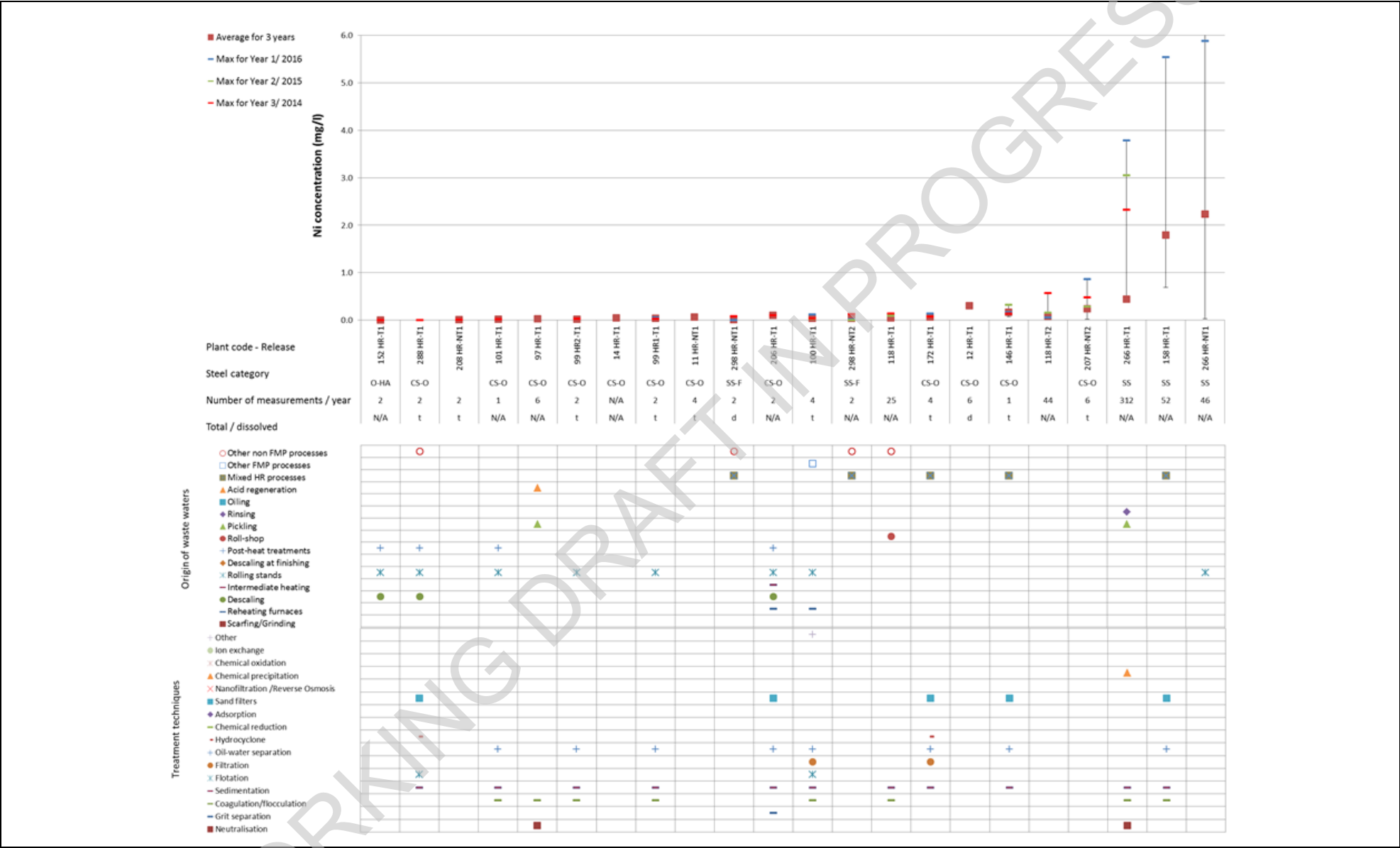


Figure 2.84: Nickel emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

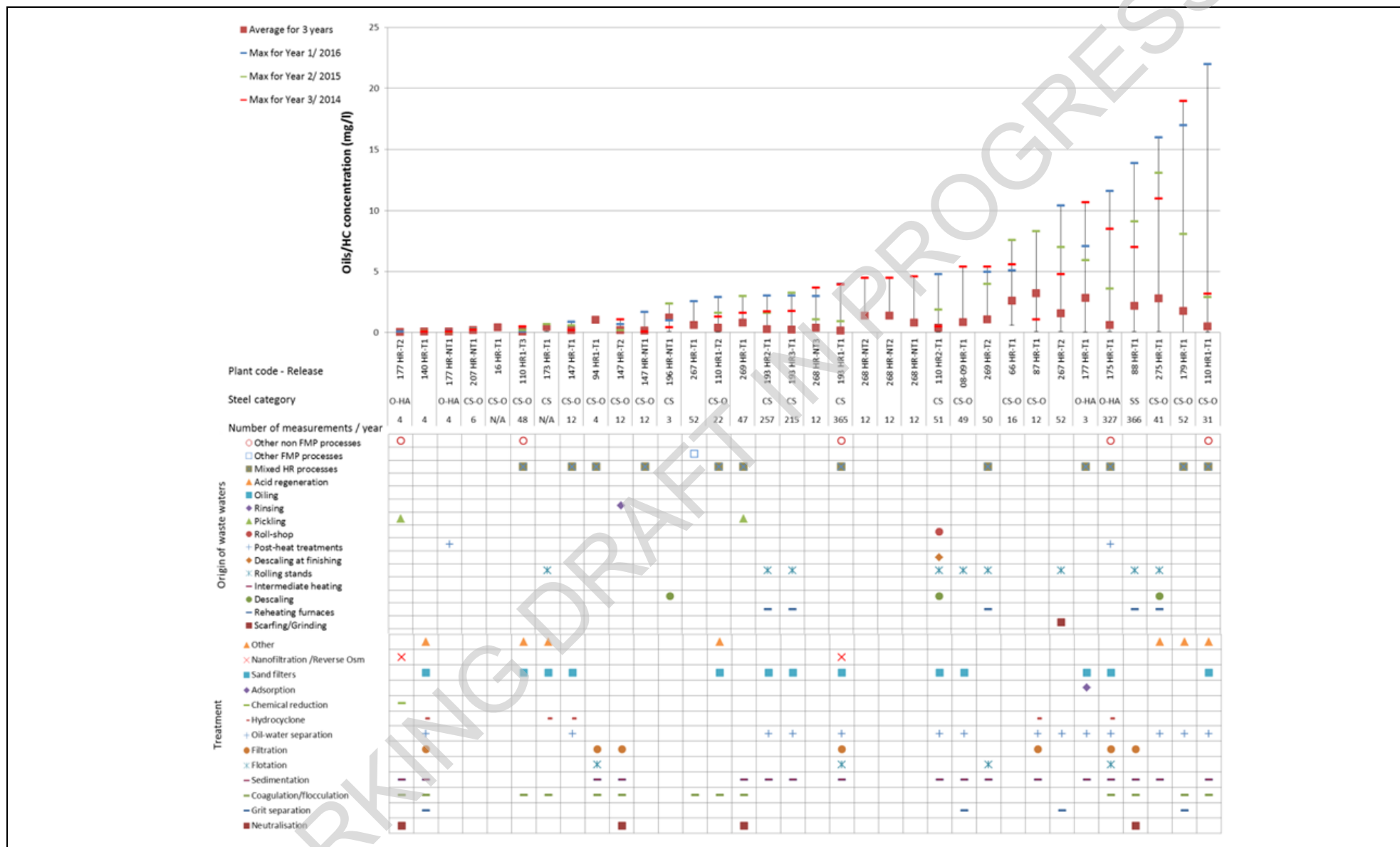


Figure 2.85: Oils emissions (in mg/l) for direct discharges. Source: [TWG 2018].

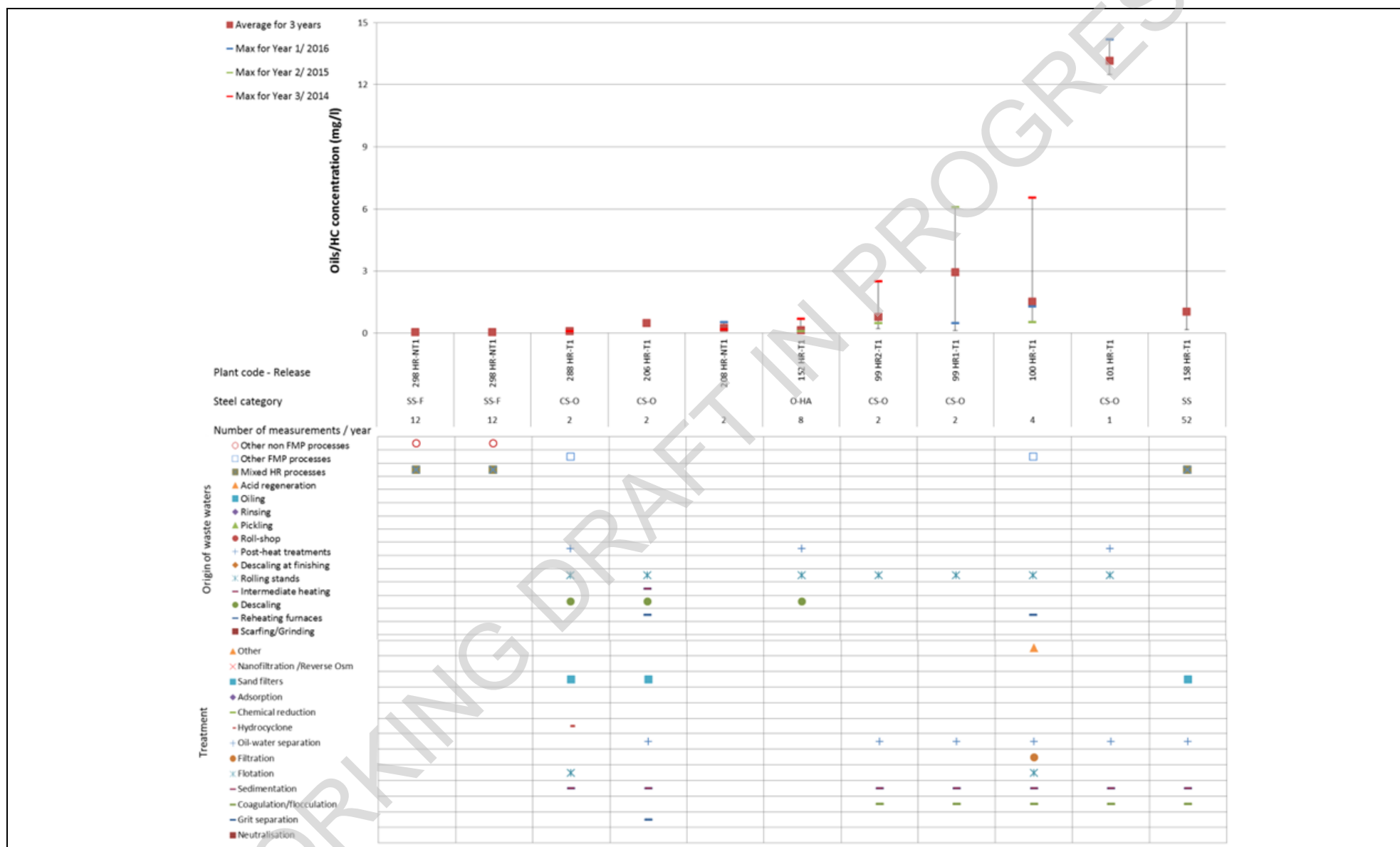


Figure 2.86: Oils emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

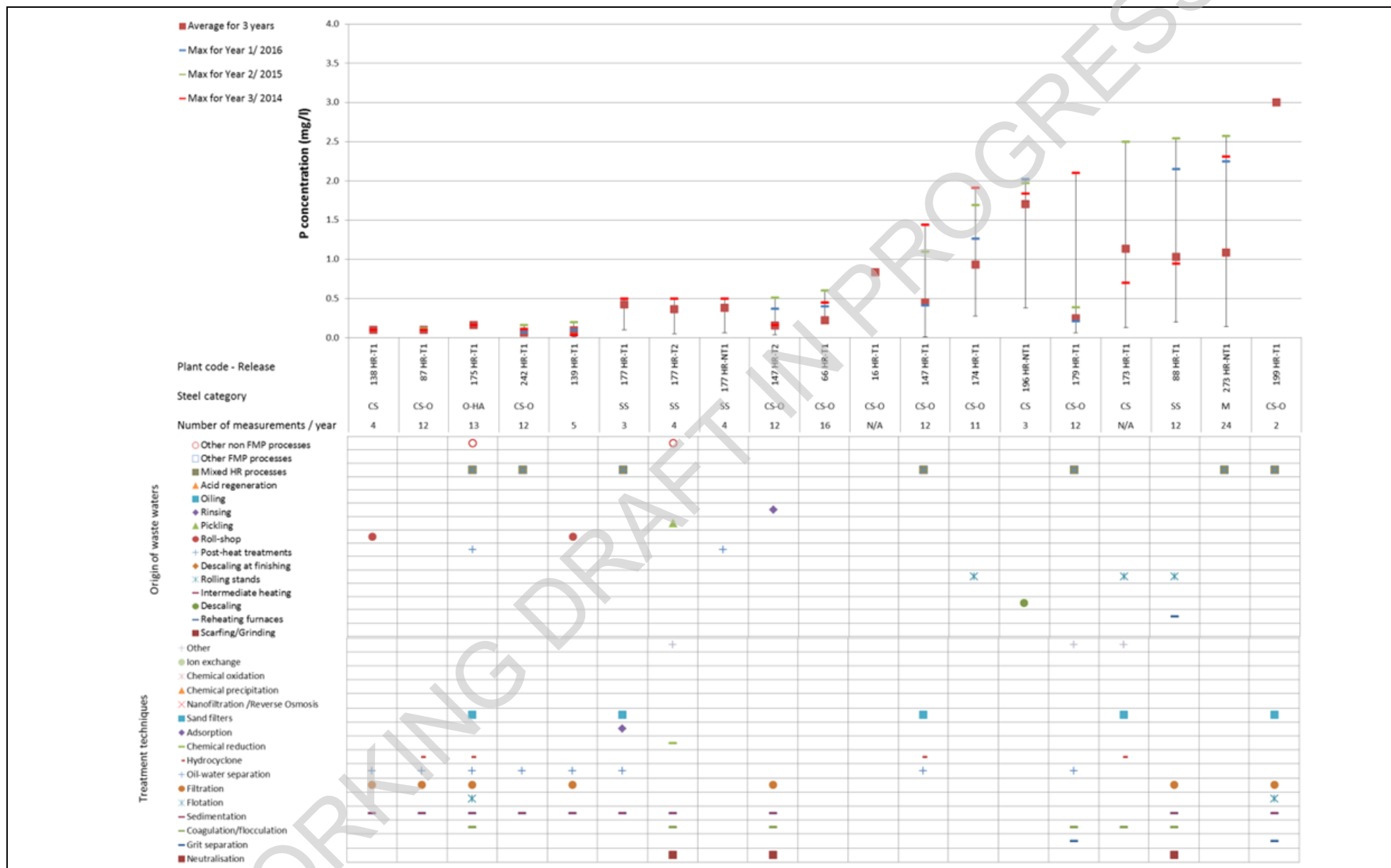


Figure 2.87: Total phosphorous emissions (in mg/l) for direct discharges. Source: [TWG 2018].

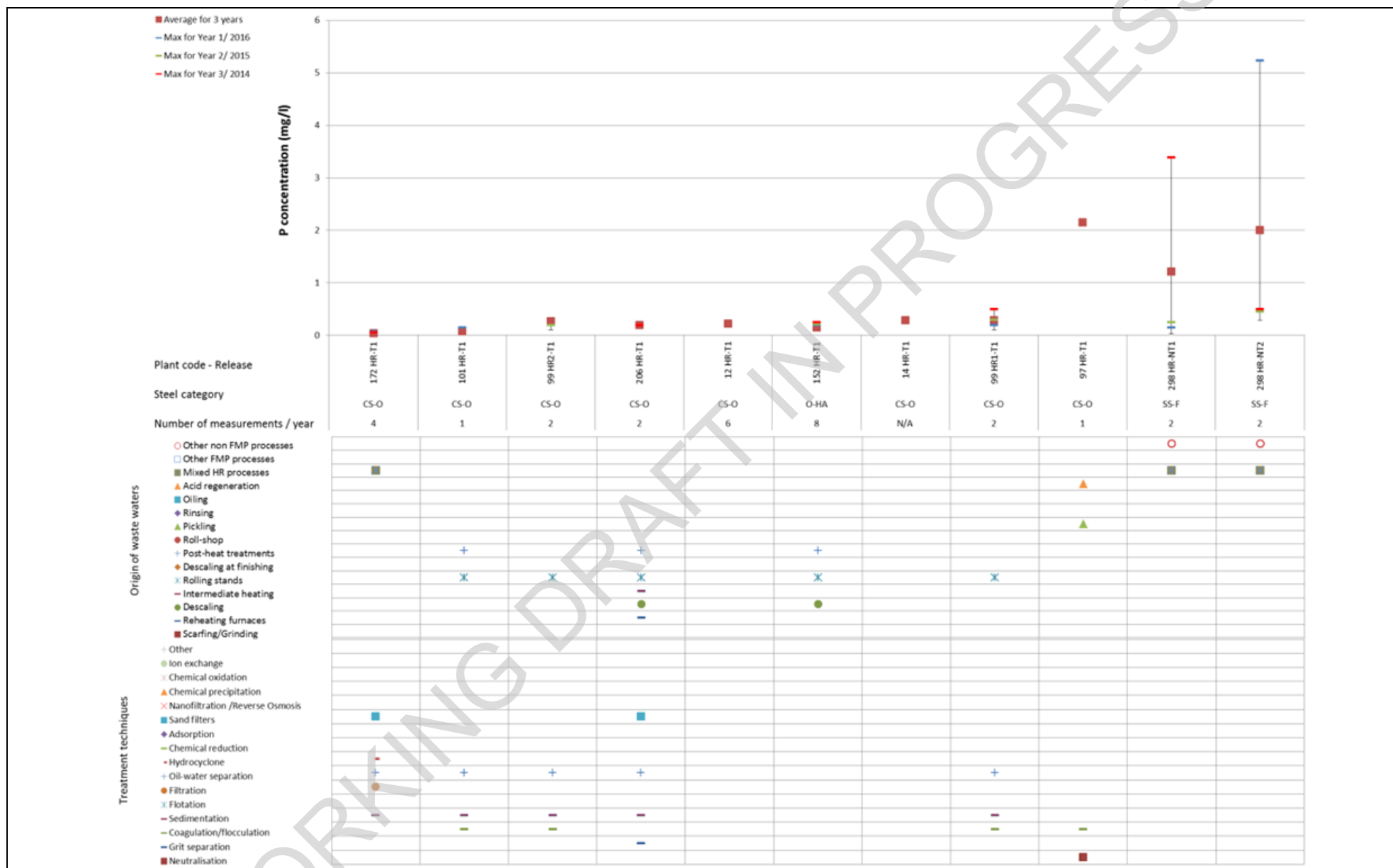


Figure 2.88: Total phosphorous emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

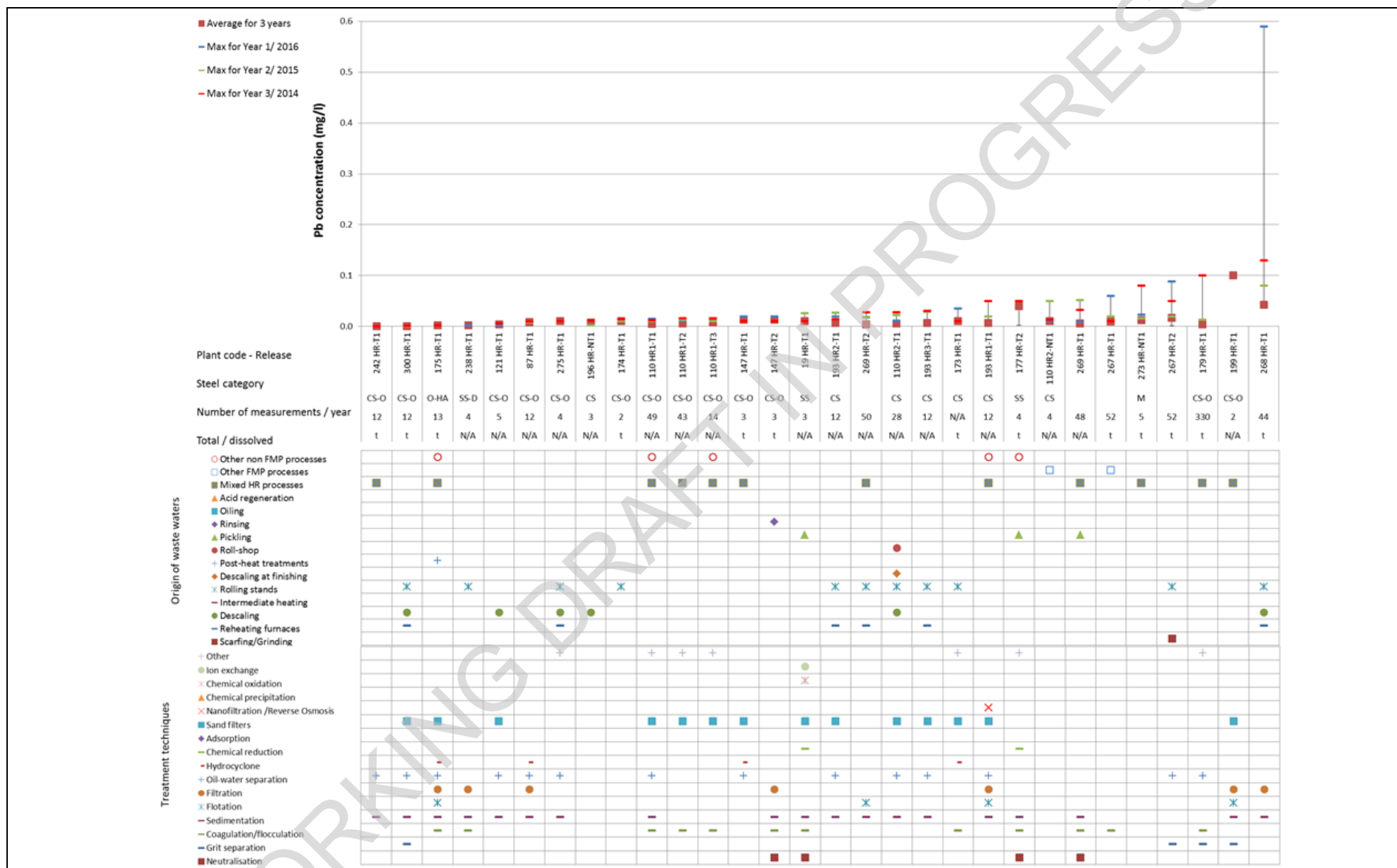


Figure 2.89: Lead emissions (in mg/l) for direct discharges. Source: [TWG 2018].

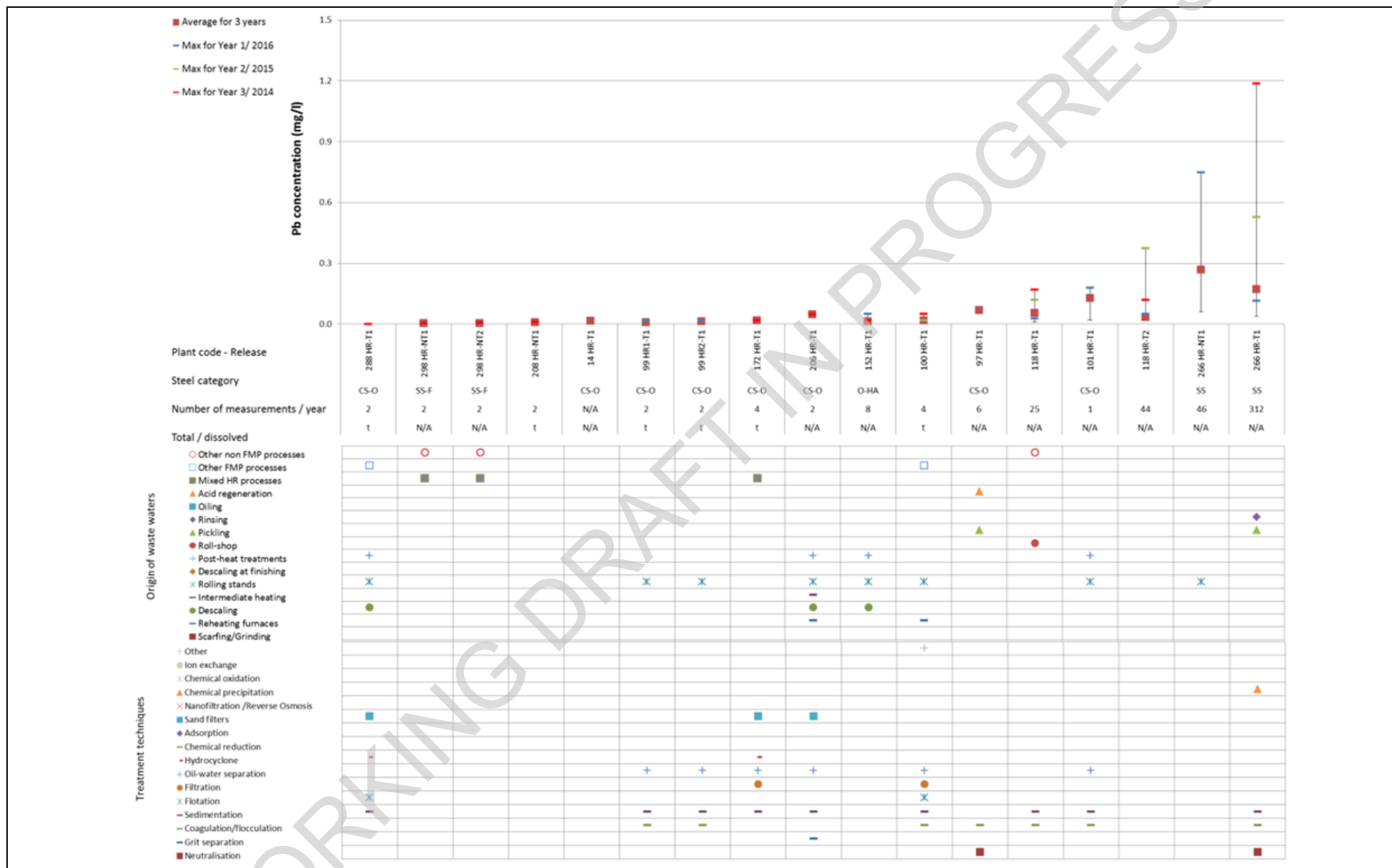


Figure 2.90: Lead emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

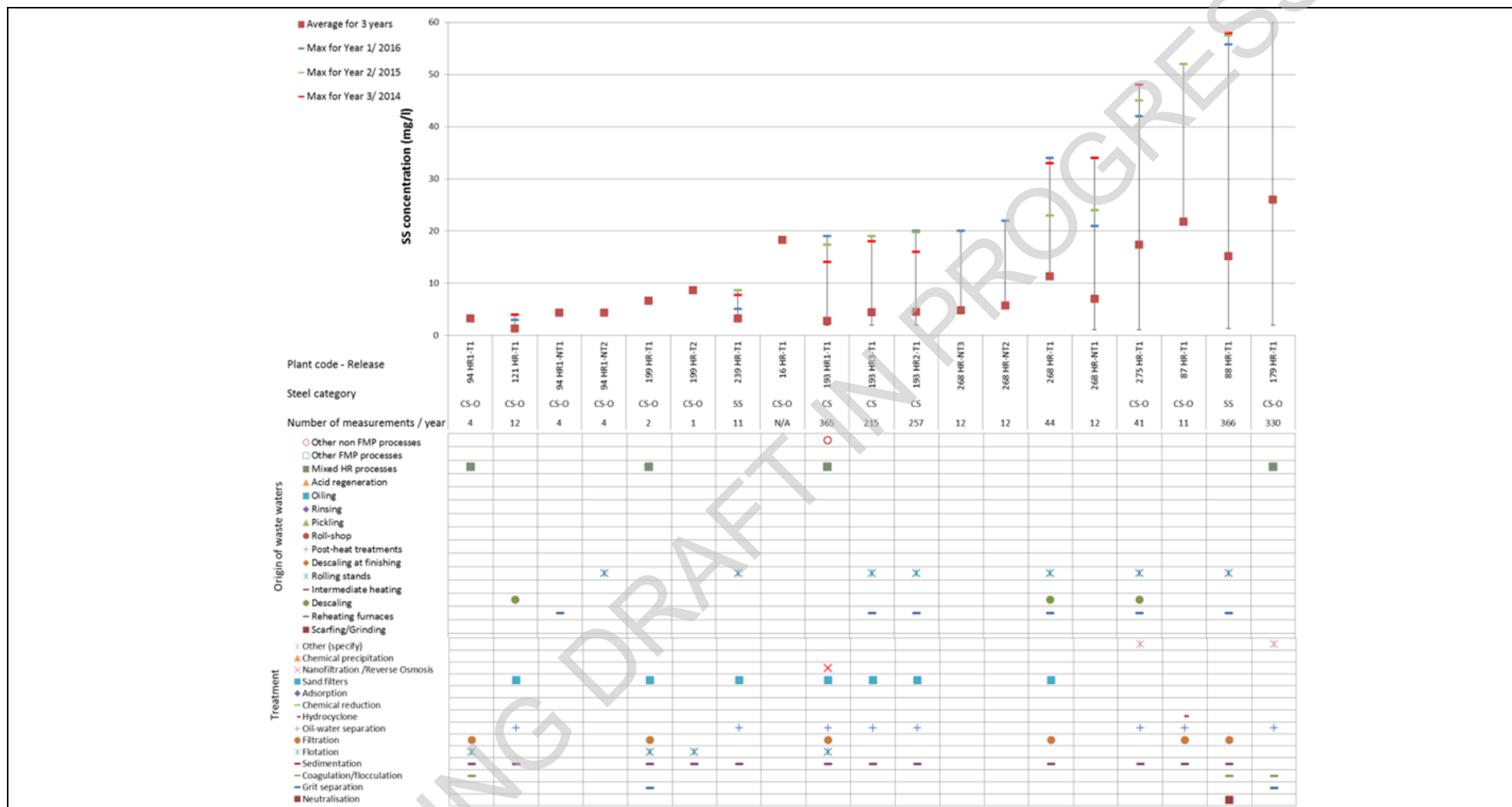
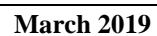


Figure 2.91: Suspended solids emissions (in mg/l) for direct discharges. Source: [TWG 2018].



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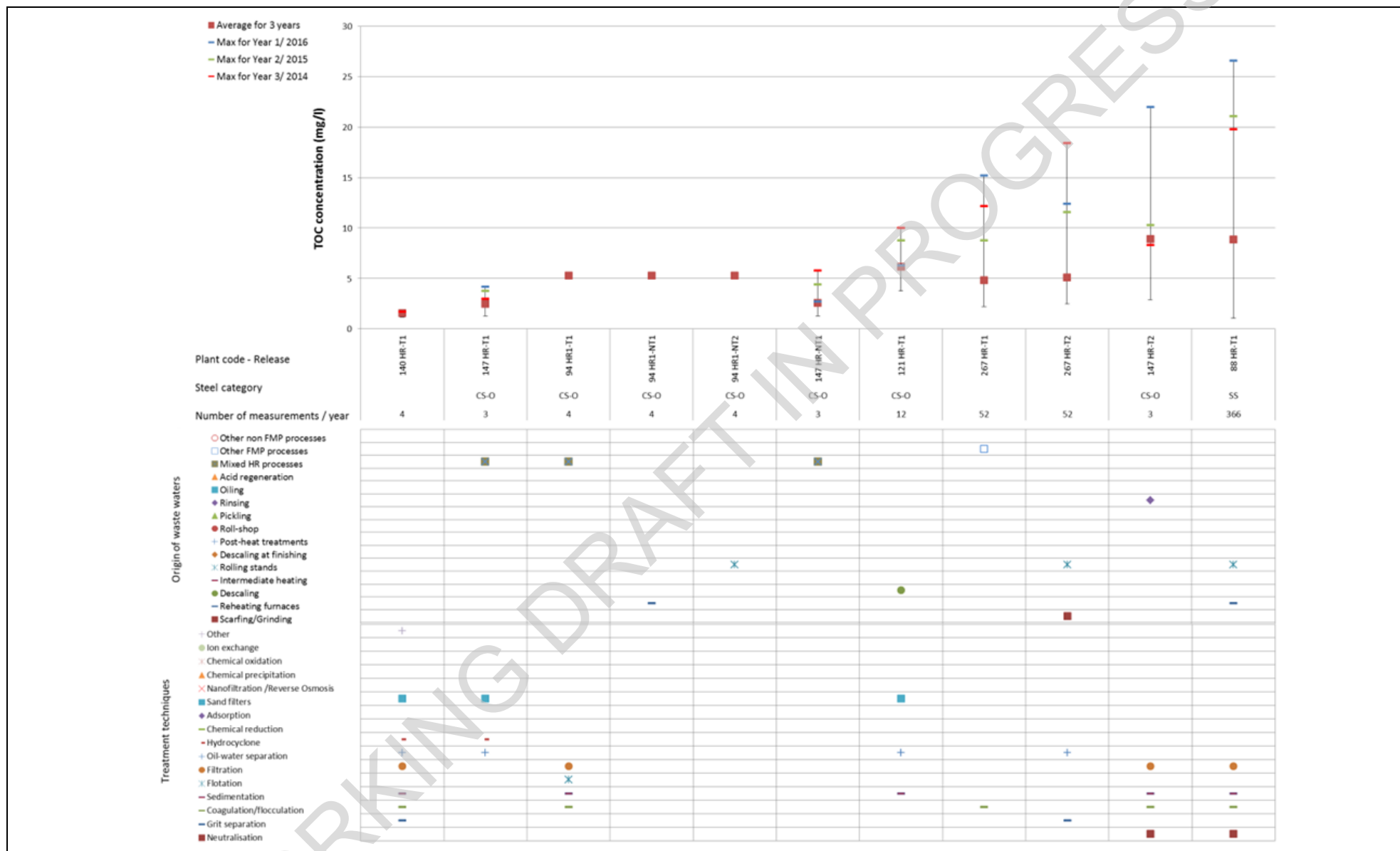


Figure 2.93: TOC emissions (in mg/l) for direct discharges. Source: [TWG 2018].

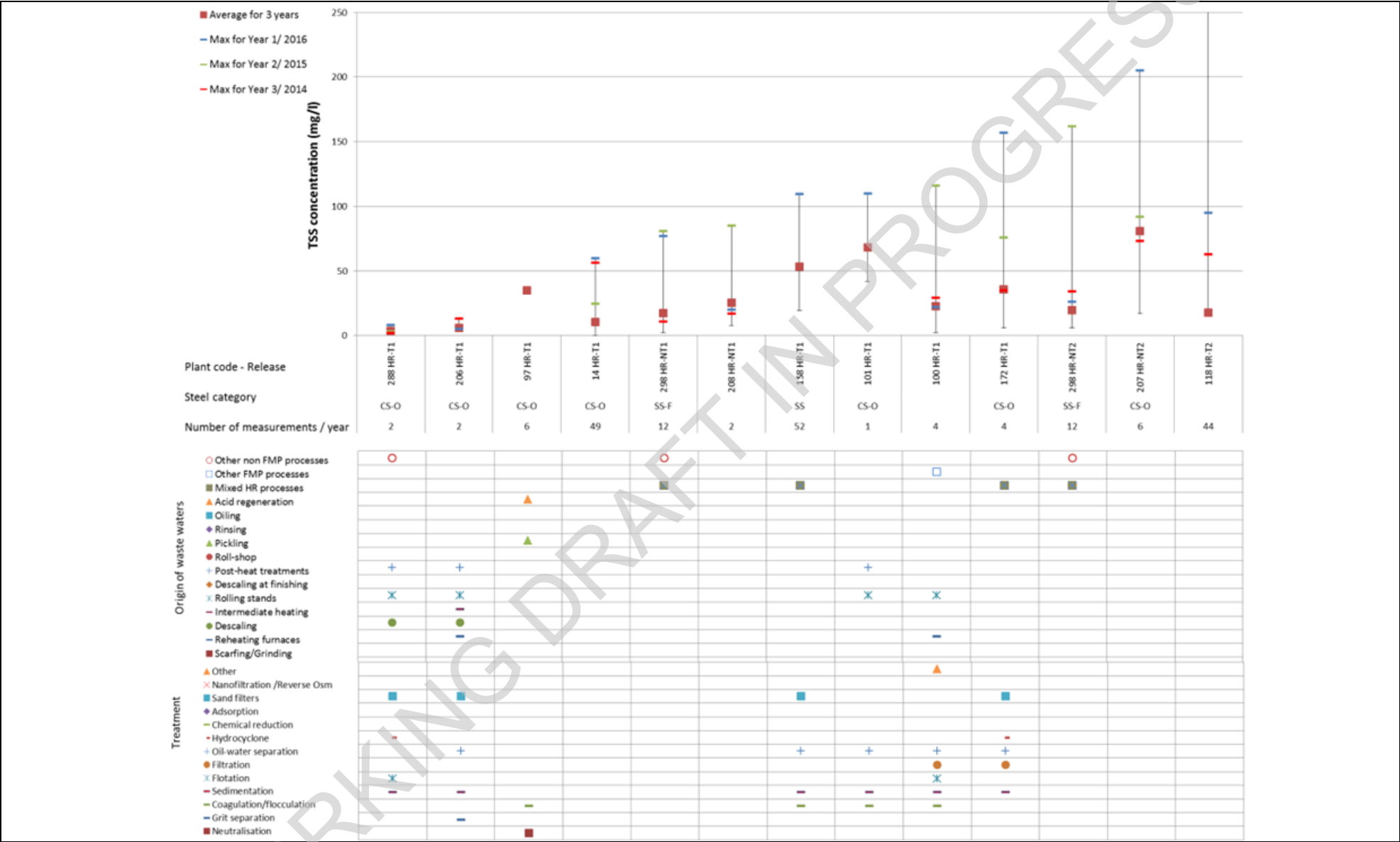


Figure 2.94: TOC emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

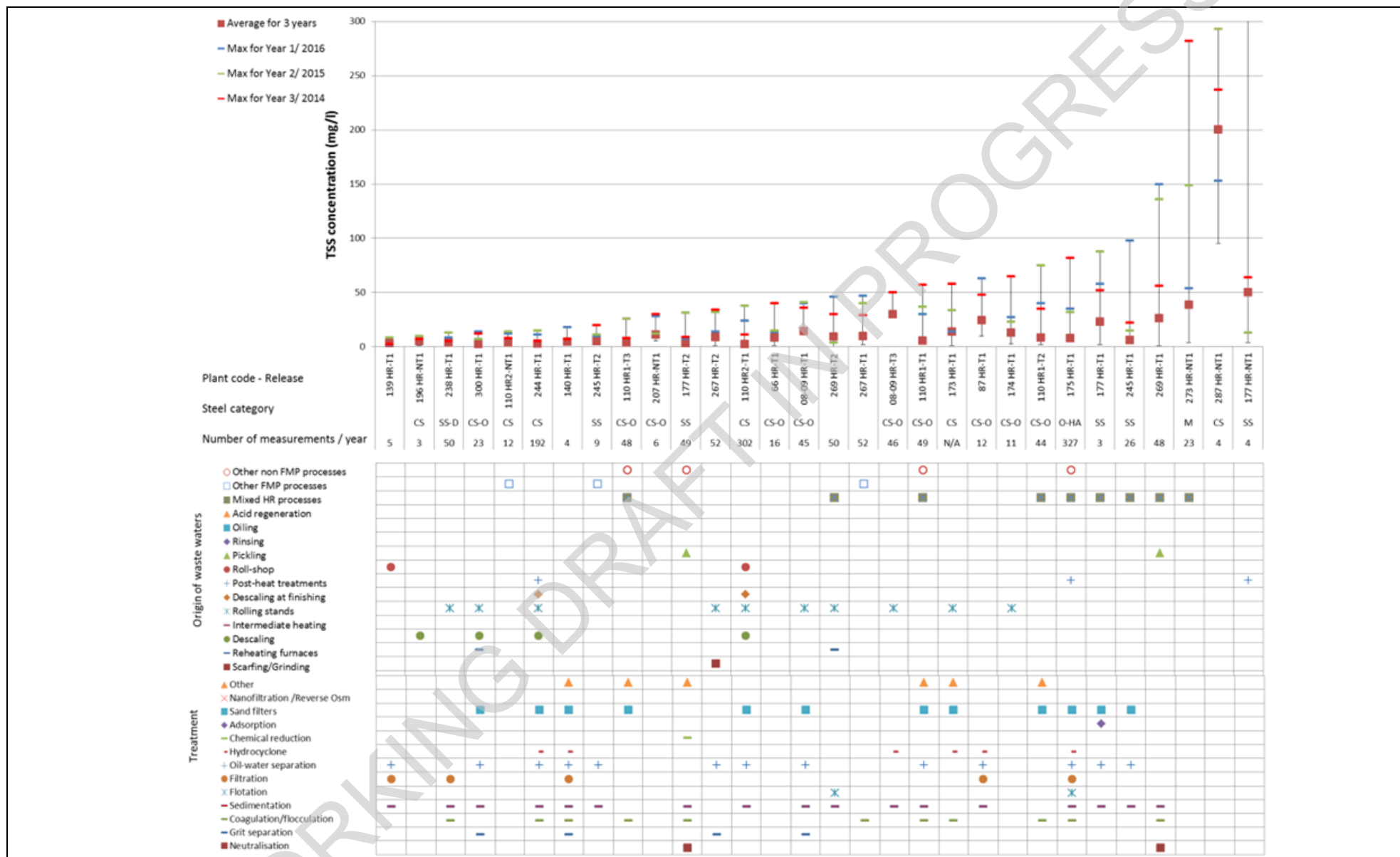


Figure 2.95: Total suspended solids emissions (in mg/l) for direct discharges. Source: [TWG 2018].

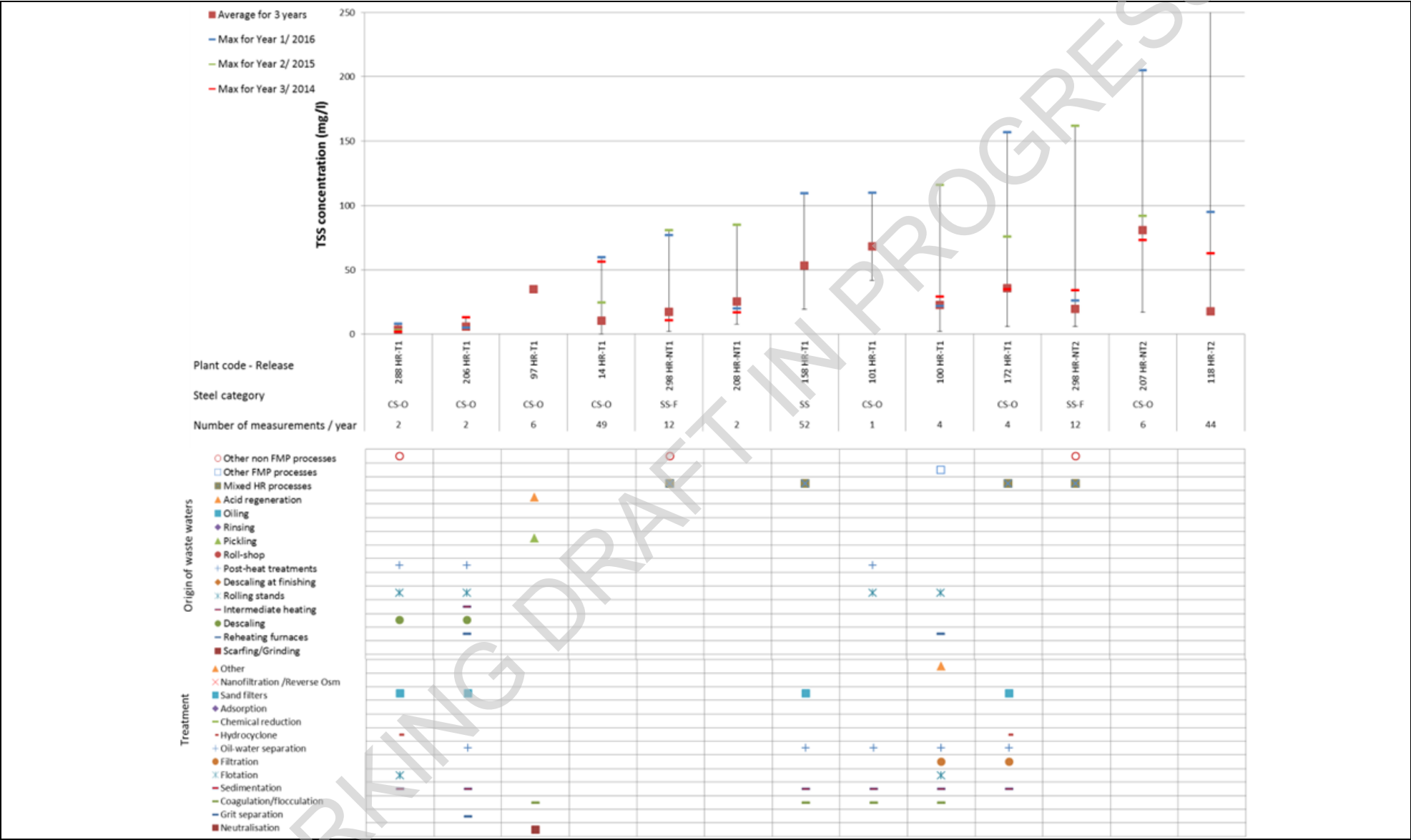


Figure 2.96: Total suspended solids emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

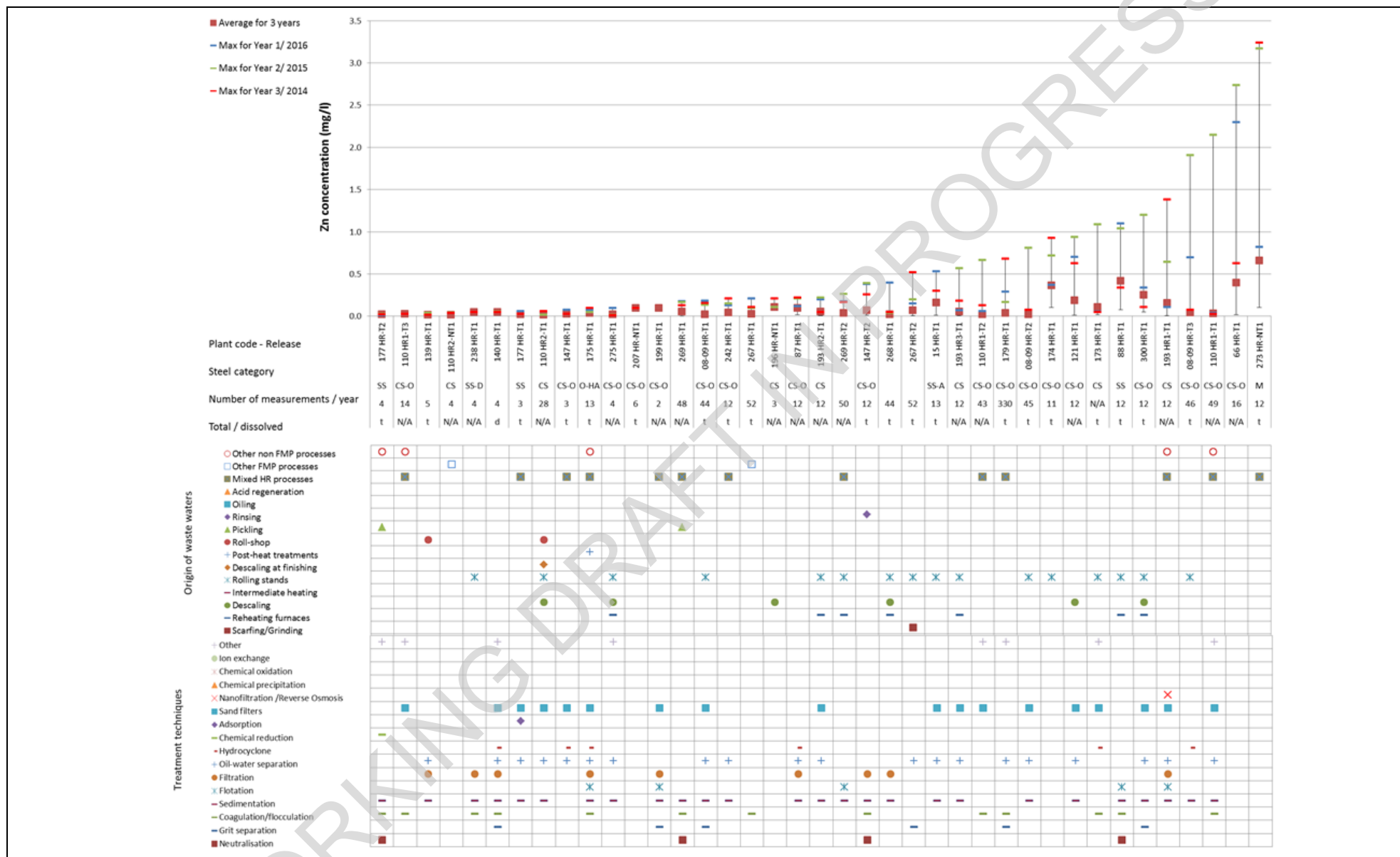


Figure 2.97: Zinc emissions (in mg/l) for direct discharges. Source: [TWG 2018].

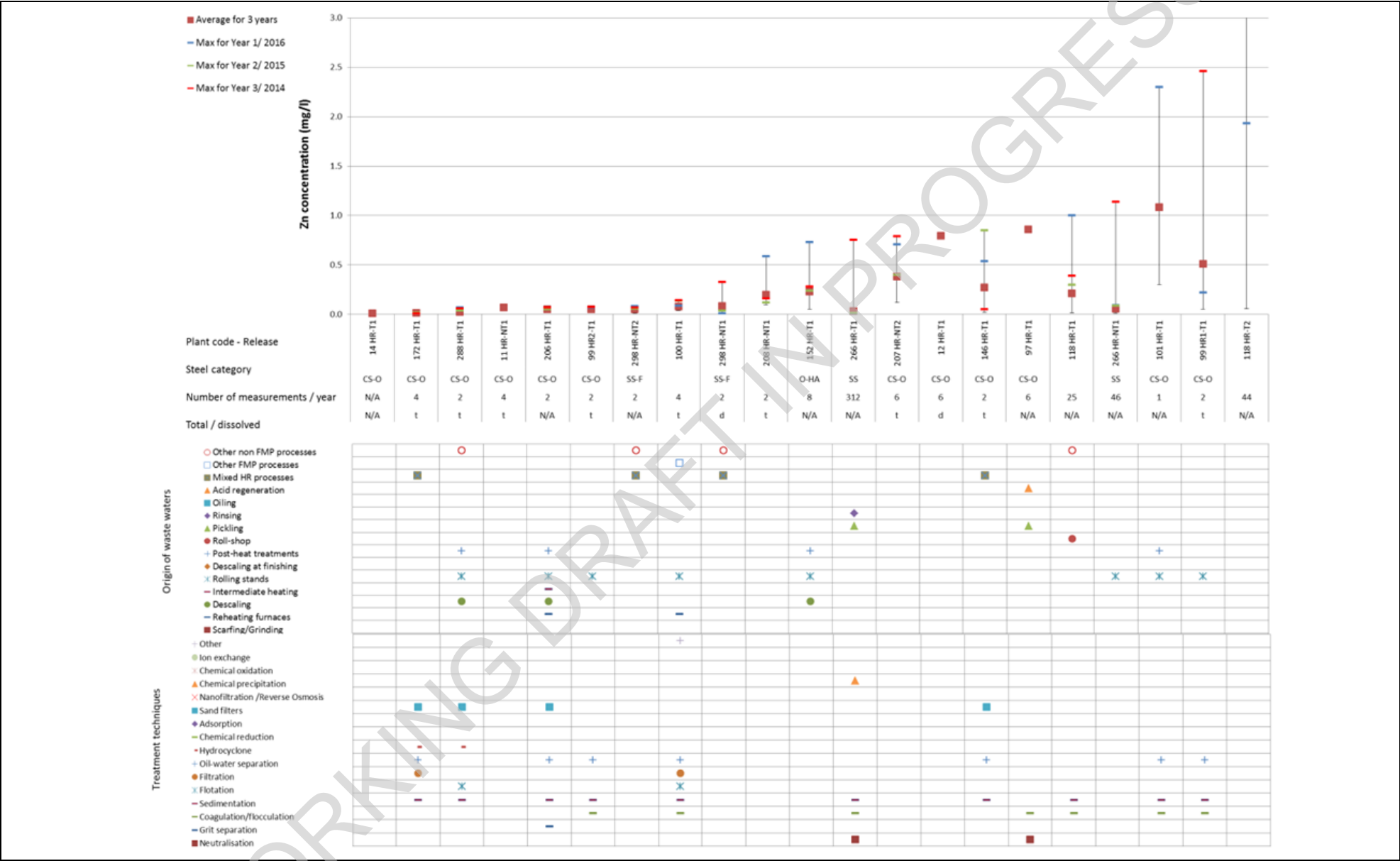


Figure 2.98: Zinc emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

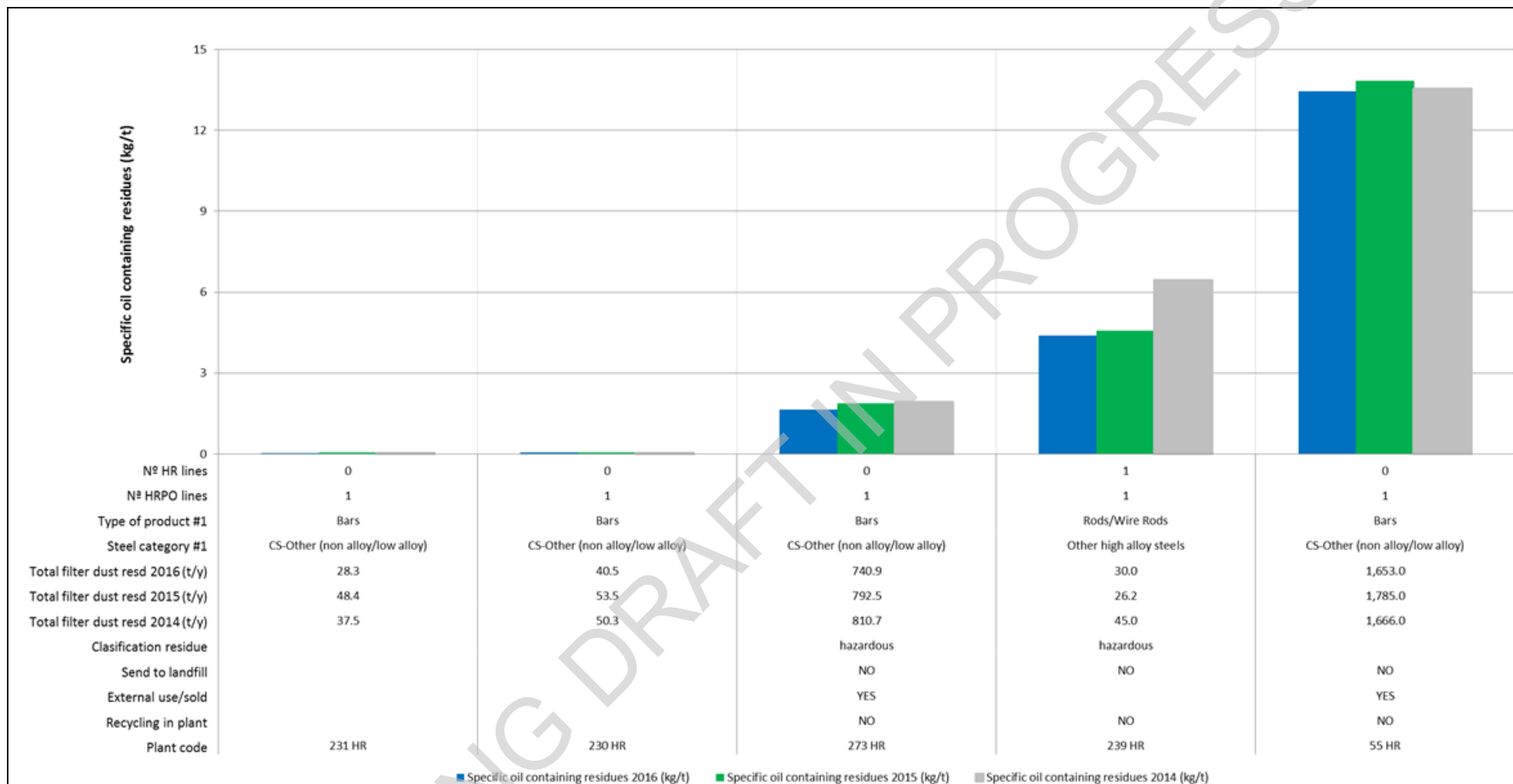


Figure 2.99: Specific generation of oil- containing residues (in kg/t). Source: [TWG 2018].

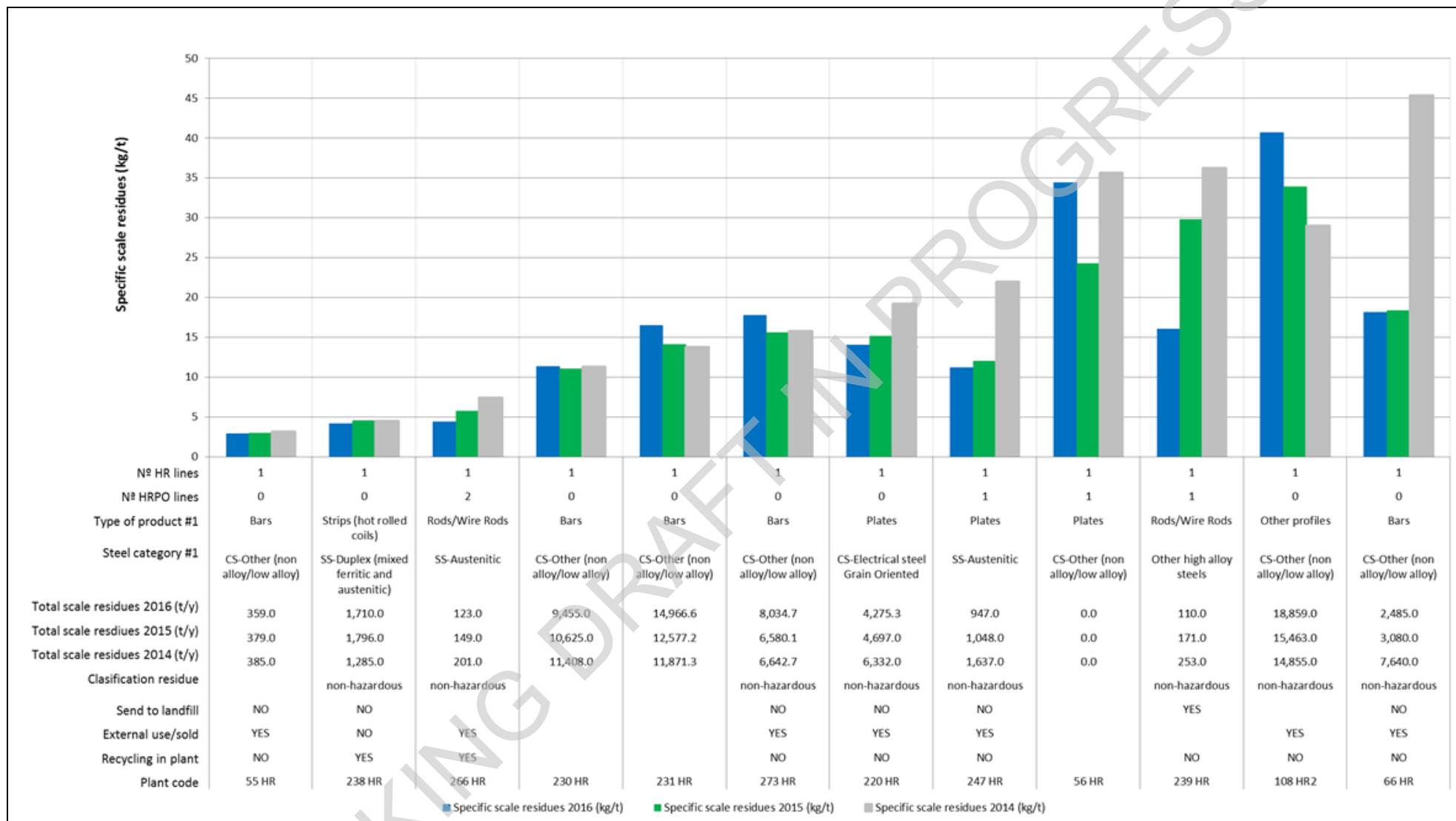


Figure 2.100: Specific generation of scale (in kg/t). Source: [TWG 2018].

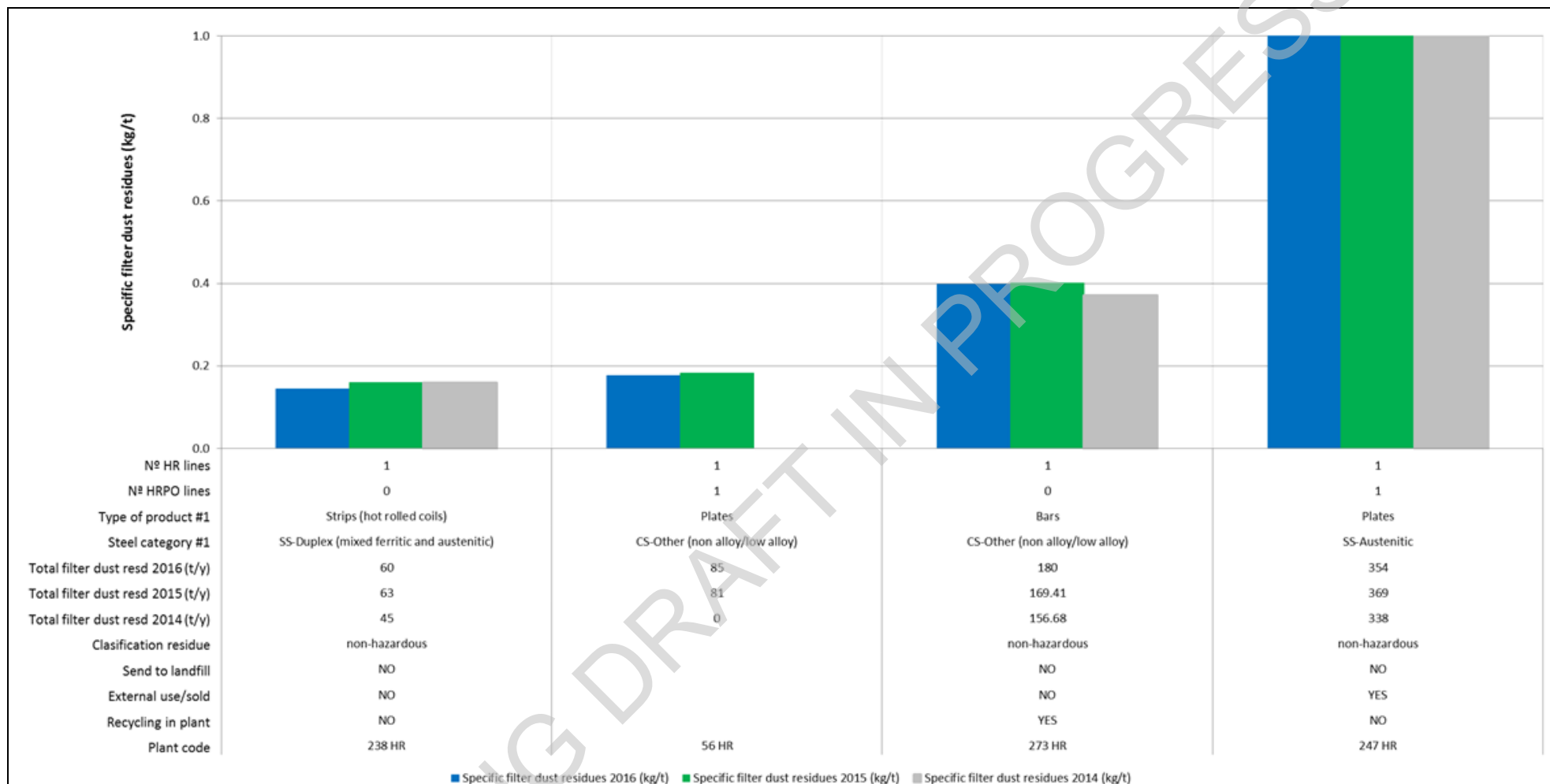


Figure 2.101: Specific generation of filter dust (in kg/t). Source: [TWG 2018].

2.4 Techniques to consider in the determination of BAT for hot rolling

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 as well as process-integrated and end-of-pipe techniques. 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 the prevention or limiting of the environmental consequences of accidents and incidents. They also cover the prevention or reduction of 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 Directive 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 2.8 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 that 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 2.8: 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 | <p>Actual and plant-specific performance data (including emission levels, consumption levels – of raw materials, water, energy – and amounts of residues/wastes generated) from well-performing installations/plants (with respect to the environment taken as a whole) applying the technique accompanied by the relevant contextual information.</p> <p>Any other useful information on the following items:</p> <ol style="list-style-type: none"> 1. how to design, operate, maintain, control and decommission the technique; 2. emission monitoring issues related to the use of the technique; 3. sensitivity and durability of the technique; |

| | |
|--|---|
| | <p>4. issues regarding accident prevention.</p> <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 is included 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 a 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 waters 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 plants or processes within the sector to which the technique cannot be applied; • constraints to implementation in certain generic cases, considering, e.g.: <ol style="list-style-type: none"> I. whether it concerns a new or an existing plant, taking into account factors involved in retrofitting (e.g. space availability) and interactions with techniques already installed; |

| | |
|----------------------------------|---|
| | <p>II. plant size, capacity or load factor; III. quantity, type or quality of product manufactured; IV. type of fuel or raw material used; V. animal welfare; ○ climatic conditions.</p> <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 plant.</p> |
| Economics | <p>Information on the costs (capital/investment, operating and maintenance costs including details on how they 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 euros (EUR). If a conversion is made from another currency, the data in the original currency and the year when the data were collected are 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 is given in order to put costs of techniques into context.</p> <p>Information relevant to both newly built, retrofitted and existing plants is included. 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 its calculation can be reported.</p> <p>The Reference Document on Economics and Cross-media Effects (ECM) and the Reference Report on 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 are provided.</p> <p>This subsection should be very short and use a list of bullet points.</p> |
| Example plants | <p>Reference to a 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 many pages, reference will be made to the relevant page(s) or section(s).</p> |

In Chapter 8 general techniques used in more than one sector are discussed which might also be applicable to hot rolling. These techniques are normally not repeated in this section, unless information specific for this sector was made available.

TWG, Section A.4.1.1 from the old BREF has been moved and the updated information can now be found in Chapter 8 (Section 8.3.1).

2.4.1 Surface rectification and conditioning of input

2.4.1.1 Enclosed scarfing combined with air extraction and waste gas treatment

Description

Scarfig operations are carried out in complete enclosure (e.g. under closed hoods) and air is extracted and treated using electrostatic precipitators (dry or wet) or fabric filters.

Technical description

As shown in Figure 2.102, scarfig takes place in a tightly closed hood, which captures the fume and dust generated by the oxy-fuel flame. The waste air is cleaned by **dry** or **wet electrostatic precipitators** or **fabric filters**. The collected dust is internally recycled within integrated steelworks or disposed of by authorised companies. Water jets are used to remove the slag from the conditioned surface. Spent water and slag are collected in a flume beneath the roller table and transferred to water treatment.

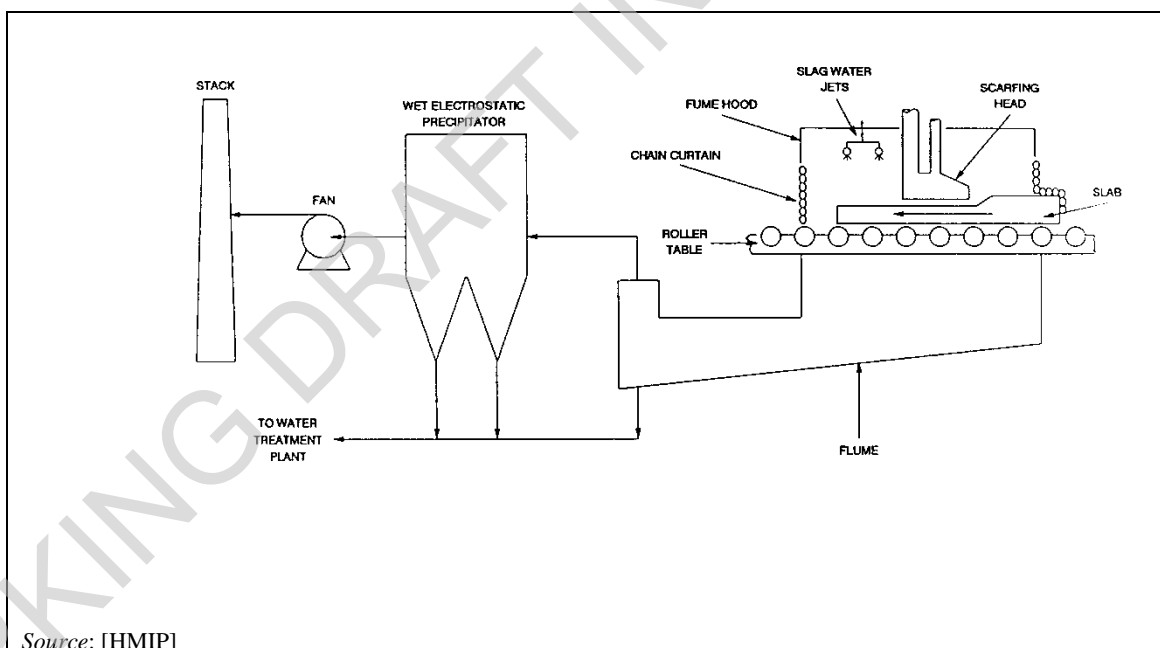


Figure 2.102: Scarfig abatement flowsheet (example with wet EP)

Achieved environmental benefits

Reduced dust emissions to air.

Environmental performance and operational data

ArcelorMittal Ghent:

The scarfig machine is located in a special building (dimensions 32 m x 18 m x 9 m) with acoustic insulated sidewalls leading to a maximum noise level of 85 dBA at 1 m. The fume is captured at the four corners of the roof. The whole installation is operated under suction with an aspiration flow of 200 000 m³/h. The aspiration is controlled automatically as a function of the place where the scarfig takes place (two thirds of fumes are aspirated above the work area). The

exhaust air is cleaned by fabric filters with filter area of 3 576 m², leading to an exit dust concentration of 5–10 mg/Nm³ (continuous optical measurement in stack).

Liberty Speciality Steels UK:

The scarfing machine is situated inside the billet mill and is housed under a hood with extraction towards a wet ESP (as described in Figure 2.29). The hood prevents fugitive emissions of dust and is also equipped with water sprays. Chain curtains situated at the inlet and outlet of the hood contain the water sprayed in the hood as much as possible. Dust emissions are typically within the range 5–10 mg/m³. [EUROFER 23-7-18]

As the fume generated by scarfing is very corrosive, maintenance is an important issue for good performance of the abatement units. Regular inspection of the electrostatic precipitator electrodes and associated internal parts is recommended to survey corrosion. If the fume is very wet, the use of bag filters can be problematic. [Com HR]

TWG to provide updated information (except for emission levels) for the following table or it will be deleted.

Table 2.9: Operational data and achievable emission levels for dust from scarfing operation

| | | Year of Installation | Waste Gas Volume [m³/s] | Particulate Emission [mg/m³] | Energy Consumption¹ [kWh/1000m²] | Costs EURO '000 |
|----------|--------------------------------|-----------------------------|---|--|---|---|
| a | Wet-EP (Billet Scarfer) | 1973 | 32 | 20–115 | | |
| b | Wet-EP | | | <20 | | |
| e | Wet-EP | 1988 | approx. 60 | 30–80 | | n.a. |
| a | Dry-EP (Slab Scarfer) | 1986 | 30 | 20–115 | | |
| b | Dry-EP | | | <50 | | 420 |
| d | Bag filter | data: 1998 | 30 | <10 | | |
| b | Bag filter | | Ø 42 max. 55 | <20 | 155 | I ² : 2200 O ^{1,3} : 0.058 |
| e | Bag filter | | 55.6 | 5–10 | | |

Note: ESP = Electrostatic Precipitator; I = Investment costs; O = Operational costs
a: [EUROFER HR]
b: [CITEPA], levels were reported BAT levels of the air BAT note
e: [Input HR-1]
d: [DFIU98]
e: Company information SIDMAR
¹ Reference base 1000 m² scarfed
² Investment costs given for complete installation, incl. civil engineering, filter (filter area: 3200 m²), hood, ventilators, motors, pipes, control measurement devices etc.
³ Operational costs for full capacity, 60 % manpower

Cross-media effects

- Increased energy consumption.
- Generation of waste / filter dust or sludge which is collected.
- Waste can be reduced by internal recycling.

Technical considerations relevant to applicability

- ~~New plants (difficult to implement in existing plants due to problems with structures of buildings).~~
- Generally, there are no technical restrictions to the applicability of this technique.
- Not applicable to manual scarfing.

Economics

TWG, please provide information.

Driving force for implementation

Prevention of fugitive emissions. [Com HR]

Example plants

ArcelorMittal Ghent, ArcelorMittal Aviles, Liberty Speciality Steels UK.

Reference literature

[EUROFER 23-7-18] [Com HR]

2.4.1.2 Enclosed grinding combined with air extraction and waste gas treatment

Description

Grinding operations are carried out in complete enclosure (e.g. under closed hoods) and air is extracted and treated using fabric filters. The grinding chips are collected separately and can be directly recycled in the BOF plant.

Technical description

The grinding machine is used for surface rectification of slabs. The dust created by grinding operations is collected and precipitated in a fabric filter (Figure 2.103). ~~Manual grinding is carried out in dedicated booths, equipped with collection hoods.~~ Machine grinding may be carried out in soundproofed enclosures. The abatement unit, ~~in both cases,~~ is either stand-alone unit or shop-based. The collected dust is internally recycled within integrated steelworks or disposed of by authorised companies. Grinding chips are collected separately and can be directly recycled as scrap in the BOF plant. [EUROFER 23-7-18]

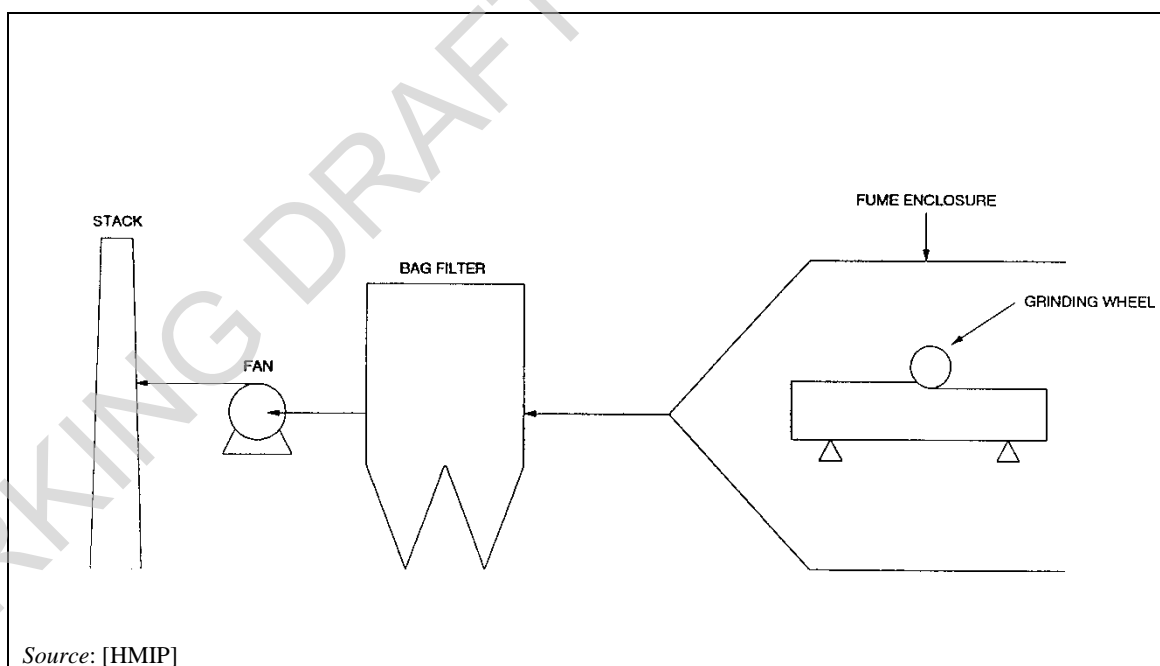


Figure 2.103: Grinding abatement flowsheet

Figure 2.104 depicts a typical grinding machine at a Tata Steel mill composed of a grinding stone, suction hood and a fabric filter. Such installation enables the removal of 2–5 mm of the surface of the slab. [EUROFER 23-7-18]



Source: [EUROFER 23-7-18]

Figure 2.104: Grinding machine equipped with waste gas cleaning abatement system at Tata Steel IJmuiden

Achieved environmental benefits

- Reduced dust emission to air.
- Noise is reduced.

Environmental performance and operational data

TWG to provide updated information (except for emission levels) for the following table or it will be deleted.

Table 2.10: Operational data and achievable emissions for dust reduction from grinding

| | | Year of Installation | Waste Gas Volume [m ³ /s] | Particulate Emission [mg/m ³] | Energy Consumption ¹ [kWh/1000m ²] | Costs EURO '000 |
|--|----------------------------------|----------------------|--------------------------------------|---|---|-----------------|
| a | Compact Cell Filter ² | 1980–1989 | 2.5 | 20–100 | | |
| a | Pulse Jet Filter ³ | 1995 | 7 | <30 | | |
| a: [EUROFER HR], reported typical operational data and emission levels [Com2 HR] ¹ Reference base 1000 m ² ground ² Bag area 120 m ² ³ Bag area 234 m ² | | | | | | |

Tata Steel IJmuiden

The grinding machine is a stand-alone machine installed in 2013 and situated in an open building. The machine is equipped with insulation material to reduce noise emissions. For noise reduction, additional control measures are taken such as encasing of the machine and wall insulation. The grinding machine has an exhaust system with a fabric filter. The flow of the exhaust waste gas cleaning system is 12 000 Nm³/h. The dust emission level is < 1 mg/Nm³. Grinding chips (around 98 % iron content) are recycled at the BOS plant whereas dust is recycled in the sinter plant. [EUROFER 23-7-18]

SSAB Oxelösund

The grinding machine used for surface rectification of the slabs is equipped with fabric filters and the flow of the waste gas cleaning system is 60 000 m³/h. After waste gas cleaning, the dust emission level at the outlet stack is < 2 mg/Nm³. Dust emissions are measured using a triboelectric dust monitor. The captured dust and grinding chips are recycled back to the blast furnace for briquetting. [EUROFER 23-7-18]

Cross-media effects

- Increased energy consumption.
- Generation of waste / filter dust which is collected.
- Waste can be reduced by internal recycling.
- Generation of grinding chips and filter dust which is collected and recycled.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

- Prevention of fugitive emissions. [Com HR]
- Improvement of the quality of the slabs.
- Cost reduction at surface slab conditioning plants.

Example plants

- Tata Steel IJmuiden
- AceriNOX Europa
- SSAB Oxelösund

Reference literature

[EUROFER 23-7-18] [Com HR]

2.4.1.3 Computer-aided quality control (CAQC)**Description**

The quality of slabs is controlled by a computer which allows the adjustment of the casting conditions to minimise surface defects and enables manual scarfing of the damaged area(s) only rather than scarfing of the entire slab.

Technical description

Computer-aided quality control is used to enhance the quality of the continuous casting output by reducing surface defects in the rolled product. This is achieved using a computer model that observes and controls the casting conditions based on various peripheral measurements. Each change in the operation parameters leads to a new pre-setting of the machine for an optimised casting process. Changes in the casting conditions, which cannot be corrected by the control loop and may lead to surface defects, are recognised and visualised by the system so that the location of a possible fault is pinpointed. Subsequently, selective (manual) scarfing of the damaged areas is possible instead of automatically scarfing the entire slab.

Achieved environmental benefits

- Reduction of emissions to air and of waste from scarfing, because selective scarfing is possible.
- Energy consumption for the scarfing process is reduced.
- Enhanced surface quality.
- Reduction of scrap.

Environmental performance and operational data

Table 2.11 compares the operational data concerning the number and types of scarfing operations required at two slab casting facilities equipped with and without CAQC.

Table 2.11: Comparison of amount of scarfing with and without CAQC

| | Without CAQC | With CAQC |
|---|--------------|-----------|
| Machine scarfed | 32 % | 9 % |
| Inspection and selective scarfing | 68 % | 8 % |
| No inspection no scarfing | NI | 83 % |
| NB: NI = No information provided. Source: [DFIU98] | | |

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

New and existing plants

Generally applicable in plants with continuous casting [Com HR].

The adjustment of the casting conditions is only applicable to plants with adjacent continuous casting.

Economics

Only very limited data on economics were reported.

One source reported investment costs of EUR 4 million (Voest [Input-HR-1]); while another reported savings of USD 5 per tonne of steel [Com A] in connection with the implementation of CAQC.

Driving force for implementation

- Improved quality of hot rolled product and increased yield.
- Reduction of slab conditioning costs [Com A].

Example plants

- VA Stahl Linz, Austria.
- EKO Stahl, Germany [Com A].

Reference literature

[Com HR] [Input-HR-1]

Aspects of modern quality control for continuous casting, 3rd European Conference on Continuous Casting, Oct. 20 – 23, 1998 [Com A]

2.4.1.4 Edging or trimming of wedge-type slabs

~~A.4.1.2.4 Rolling of Wedge-type Slabs~~

Description

Wedge-type slabs are rolled under special settings where the wedge is eliminated by edging (e.g. using automatic width control or a sizing press) or by trimming.

Technical description

Instead of flame cutting, wedge-type slabs are rolled under special settings of the hot rolling mill. The wedge is either eliminated by edging technology (automatic width control or sizing press) or by trimming during the subsequent shearing of hot strips.

Achieved environmental benefits

Emissions and wastes normally generated by flame cutting are avoided.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

~~New plants and existing plants in case of major revamping.~~

Only applicable to new plants and major plant upgrades. [ComHR]

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

Plants 37, 106 and 197 apply this technique. [TWG 2018]

Reference literature

[ComHR]

2.4.1.5 Slabs slitting

Description

The slabs (often cast in multiple widths) are slit before hot rolling by means of slitting devices, slit rolling or torches either manually operated or mounted on a machine .

Technical description

In order to ~~improve caster productivity and~~ prevent wedge-type slabs, the slabs (often cast in multiple widths) are slit before hot rolling by means of slitting devices, slit rolling or torches either manually operated or mounted on a machine.

Achieved environmental benefits

Emissions and waste arising from wedge correction are prevented.

Environmental performance and operational data

Operational data for the slabs slitting technique are given below:

- gas consumption: 1.6 Nm³/t slab;
- oxygen consumption: 2.7 Nm³/t slab;
- yield loss: 1.4–3.0 % of slab weight, depending on slab dimensions [Com A].

Cross-media effects

Additional energy consumption [Com A].

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

Higher caster capacity as in twin or triple casting [Com A].

Example plants

Krakatau Steel [Com A].

Reference literature

[Com A]

2.4.2 Reheating and heat treatment furnaces

TWG, Section A.4.1.3.1 from the old BREF (General measures for energy efficiency and low emission operation) has been moved and the updated information can now be found in Chapter 7 (Section 8.5.3.1).

2.4.2.1 Process gas management system - choice of fuel

TWG, This section has been added. The section from the previous BREF containing the paragraph on Choice of fuel in Section A.4.1.3.1 has been revised and replaced by the following, based on information from the IS BREF and information received from the TWG.

Description

A process gas management system enables iron and steel process gases to be directed to the reheating and/or heat treatment furnaces, depending on their availability. Iron and steel process gases with a low average dust and ash content and a low average sulphur and nitrogen content are selected.

Technical description

The three main process gases in the iron and steel industry (e.g. COG, BFG and BOF gas) have different chemical compositions and characteristics (e.g. calorific value) and are consumed throughout the works for many purposes, depending on the gas properties and availability in terms of production and location within a site. Additional information concerning the chemical compositions and characteristics of these three process gases and their use within an integrated steelworks can be found in the LCP BREF (Section 7.3). [LCP BREF]

These process gases may be mixed before supply to reheating and heat treatment furnaces to balance out some of the variations and to enrich blast furnace gas to improve the calorific value. The process gases may be also supplemented with auxiliary fuels (e.g. natural gas or liquid fuels) to ensure continuity of supply. [AT 31-05-17]

Process gas management system:

In the case of an integrated steelworks, a process gas management system enables iron and steel gases to be directed to the reheating and/or heat treatment furnaces in order to optimise the beneficial use of these gases.

The objectives are prioritised as:

1. internal use of the heating potential of the gases in steel production processes;
2. minimisation of use of natural gas and other fuels as auxiliary fuel(s) in the enrichment of process gases, and as fuels combusted alone;
3. sensible use of the gases in the production of steam and/or electricity, so energy is not wasted by flaring;
4. minimisation of fuel gas use through process-integrated techniques;
5. avoidance of imported electricity.

Choice of fuel:

The quality (calorific value and composition) and volume of the different gases vary significantly and these factors have an impact on where the fuels can be efficiently used. The

primary aim of energy management in the steel industry is the efficient distribution and use of the process gases. Local conditions (layout of the plant) can further facilitate this task. Given the different configurations of the integrated steelworks, each site defines its energy management system as is best suited for the whole site. [EUROFER 10-7-18]

When iron and steel process gases are used alone or in combination with auxiliary gases (e.g. natural gas, LPG) in the FMP reheating and heat treatment furnaces, the gases are treated to ensure they exhibit a low average dust and ash content and a low average sulphur content.

The processes employed in the preparation of the iron and steel process gases prior to their use are briefly summarised below and can be found also in the IS BREF (2012).

COG

Sulphur contained in coke oven gas is a major source of SO₂ emissions from heating and reheating furnaces. According to the BAT conclusions of the IS BREF, BAT is to reduce the sulphur content of the COG by desulphurisation using the following techniques:

1. desulphurisation by absorption systems;
2. wet oxidative desulphurisation.

The residual hydrogen sulphide (H₂S) concentrations associated with BAT, determined as daily mean averages, are < 300–1 000 mg/Nm³ in the case of using technique 1 above (the higher values being associated with higher ambient temperatures and the lower values being associated with lower ambient temperatures) and < 10 mg/Nm³ in the case of using technique 2 above. [IS BREF, BAT 48 - 2012]

BF and BOF gas

BF and BOF gas contain low concentrations of sulphur. However, cleaning of these gases is carried out to reduce dust emissions. By applying BAT for BF and BOF gas cleaning, levels < 10 mg dust/Nm³ can be achieved for BF gas and < 10–30 mg dust/Nm³ for BOF gas using dry dedusting (e.g. electrostatic precipitator) techniques for new and existing plants or < 50 mg dust/Nm³ using wet dedusting techniques (e.g. wet electrostatic precipitator or scrubber) for existing plants. [IS BREF, BAT 75 - 2012]

With regard to NOX formation, the individual combustion gases also show a different behaviour. For instance, ~~flue gas from coke oven gas firing contains 50 to 100 % more NOX than the flue gas from natural gas firing~~ higher NOX emissions are observed when a high share of COG is used in the fuel mix used in the furnace.

There are two reasons why NOX emissions are higher with coke oven gas: higher flame temperature and fuel NOX. The composition of the fuel is related to the flame temperature. Methane (natural gas) burns relatively slowly compared to fuels with a high H₂ content (e.g. coke oven gas) that tend to burn more quickly and have a higher NOX emission level (~~up to 100 % higher~~). The type of burner should be appropriate for the available fuel(s). [EUROFER HR]

Fuel NOX results from the oxidation of the ammonia and organic nitrogen as contained in, for example, the COG. Because of relatively high amounts of ammonia and organic nitrogen in the COG, fuel NOX is generated. The amount of fuel NOX is related to the cleaning of COG; higher levels of ammonia in treated COG result in higher NOX emissions. [IS BREF, p.33] [EUROFER 10-7-18]

Achieved environmental benefits

Efficient use of energy resources.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

- Only applicable to plants adjacent to iron and steel production.
- Applicable within the constraints associated with the availability of different types of fuel, which may be impacted by the energy policy of the Member State.

Economics

TWG, please provide information.

Driving force for implementation

Improved energy efficiency.

Example plants

Widely used.

Reference literature

[LCP BREF] [IS BREF, 2012] [EUROFER 10-7-18] [AT 31-05-17]

TWG, Section A.4.1.3.2 from the old BREF (Furnace automation / Furnace control) has been moved and the updated information can now be found in Chapter 8 (Section 8.5.3.3).

2.4.2.2 Optimised furnace door design

Description

Minimisation of heat losses from opening of the furnace door, e.g. by using several liftable segments instead of one in continuous reheating furnaces.

Technical description

Conventional (one-segment) furnace charging doors leave gaps beside the feedstock through which furnace gases escape or ingress air may be sucked into the furnace. This results not only in uncontrolled (fugitive) emissions, but also in a loss of waste gas which could otherwise be used for combustion air preheating. The recuperation efficiency is thus reduced. In the case of air ingress into the furnace, scale formation increases which has a negative influence on slab quality and production yield. [EUROFER 23-7-18]

Charging doors

State-of-the-art furnaces are equipped with charging doors consisting of several individual liftable segments. The width of the segments corresponds to the length of the feedstock in reasonable steps. Accordingly, the furnace charging door can be partly opened and the gaps beside the feedstock are reduced. [EUROFER 23-7-18]

In the reference plant, the furnace door design comprises a number of individual single doors (e.g. 64 doors on a width of 15.6 m) which can be lowered down on the refractory to the left and right of the feedstock. [STuE-117-5]. All segments are lifted together and when part of the slab has passed the door all segments are lowered. Those which are beside the slab close the gap. The others slide over the slab and fall down when it has entered the furnace. [EUROFER 23-7-18]

In the case of roller hearth furnaces, the doors are modified with a special curtain that slides over the surface on top of the slab. [EUROFER 23-7-18]

Discharging doors

On the discharge side, it is fundamental to ensure airtightness and efficient thermal insulation. State-of-the-art furnaces are equipped with solid-state dry discharging doors, composed of one or two elements. Optimised discharging doors prevent heat losses into the furnace, improve the

temperature homogeneity of the reheated products, and enable a better control of the air in excess. No ingress air is sucked into the furnace, preventing scale formation and improving the quality of the combustion. [EUROFER 23-7-18]

Achieved environmental benefits

Reduced energy consumption.

Environmental performance and operational data

The change of the furnace door design (of a walking beam furnace) resulted in an increase of the air preheat temperature (recuperation) of 60 °C with a reduction in energy consumption of 0.05 GJ/t. [STuE-117-5]

Cross-media effects

No negative effects on other media are known.

Technical considerations relevant to applicability

• ~~New and existing plants continuous reheating furnaces.~~

Only applicable to new plants and major plant upgrades.

Economics

TWG, please provide information.

Driving force for implementation

Energy savings.

Example plants

ArcelorMittal Bremen, ArcelorMittal Ghent, Thyssenkrupp Steel Europe AG.

Reference literature

[EUROFER 23-7-18] [STuE-117-5]

2.4.2.3 Regenerative burner

~~A.4.1.3.4 Regenerative Burner System~~

Description

Regenerative burners consist of two burners which are operated alternately and which contain beds of refractory or ceramic materials. While one burner is in operation, the heat of the exhaust gas is absorbed by the refractory or ceramic materials of the other burner and then used to preheat the combustion air.

Technical description

See Section 8.5.4.3 for a detailed technical description.

Achieved environmental benefits

- Reduced energy consumption.
- Reduction of the total volume of flue-gases.

Environmental performance and operational data

Example-A:

A UK plant operating a walking beam furnace to heat various sizes of mild steel tube (up to 200 mm in diameter and 15 m long) from cold to 1 050 °C changed its firing to regenerative burners. The old 44 nozzle mix, natural-gas-fired burners were replaced by 12 pairs of regenerative burners. At the same time, the roof profile was modified to improve zone control and hot gas circulation. As a result of the plant modification the specific energy consumption was reduced from typically 3.55 GJ/t to 1.7 GJ/t, giving a 52 % saving in fuel use. The

productivity potential was improved by 14 %. The payback period was less than three years. [ETSU-G77]

Example B:

Rotherham Engineering Steels revamped one of their soaking pit re-heating units in 1987 with dual fuel, regenerative low NOX burners. The original pit was feeding a billet mill with ingots; a nominal charge being about 100 t heated to about 1300 °C. About 80 % of the charged material was hot charged at about 750 °C, 20 % was charged cold coming from stock (no mixed charges of hot and cold material). The pit was dual fuel fired by NG or heavy fuel oil by a main 6.5 MW burner in the upper part of one of the end walls and by a 750 kW supplementary unit directly beneath. A concentric tube recuperator provided preheated air to the main burner only. Compared with the original plant only the combustion system was changed; the structure, stock tonnage, and the thermal objectives remained essentially the same. An assembly of two regenerative burners was installed at each end of the pit. Long term monitoring showed energy savings of 40 % for oil firing mode. Short term monitoring for oil firing confirmed the same savings. Cost of the modification was £ 170000 (including £ 21500 on site burner development) resulting in a payback period of 2.4 years (2.1 without the burner development). [ETSU NP 54]

Advantages and disadvantages of regenerative burners:

Higher NOX emissions may occur (a typical value is 350 mg/Nm³), but, combined with lower energy consumption and waste gas flow reduction, the specific NOX emission (in g/tonne of steel) is comparable with the specific NOX emission level reached with other systems. [EUROFER HR]

A drawback of regenerative systems is their sensitivity to dust. If the heating process generates substantial amounts of dust the permeability of the ceramic fillings in the regenerator drops very quickly and consequently the fillings have to be replaced. This appears to be a minor problem in reheating furnaces in steel plants. [EUROFER HR]

Regenerative burners are usually bigger than conventional burners. Thus limited space can be an obstacle for installing regenerative burners in existing plants. To date, it has not been possible to use regenerative systems for roof burners. [EUROFER HR]

A regenerative system might be considered for the construction of new reheating furnaces in those cases where, due to the plant layout, the length of the reheating furnace has to be limited. In the same way, an increase in the production capacity of an existing furnace is possible by installing a regenerative system without increasing the length of the furnace (which in most cases is a fixed specification). [EUROFER HR]

This system is particularly interesting for batch processes because batch processes generally do not contain a preheat zone. In continuous furnaces equipped with a central recuperator system, a similar thermal efficiency is reached by means of a long unheated (preheat) zone, where the heat of the flue-gases is transmitted by convection to the cold stock. A thermal efficiency of the furnace of 80 % can be achieved. [EUROFER HR]

Implementation at existing furnaces may be difficult as the two burners of one set have to be installed opposite to each other. Furnace pressure is affected; therefore a new system/model for furnace pressure regulation becomes necessary. [EUROFER 10-7-18]

The use of process gas is challenging because regenerative burner systems are sensitive to dust accumulation. When coke oven gas is used with regenerative burners, there are acidic excretions in the exhaust gas which can cause corrosion on the switch valves and other equipment. [EUROFER 10-7-18]

TWG to provide updated information for the following table or it will be deleted.

Table 2.12: Typically achievable reductions and cost data for regenerative systems

| | Reduction [%] | | Investment cost [M ECU] | |
|-----------------------------|---------------|---------------------|-------------------------|---------------------|
| | NOX | Energy ¹ | New facilities | Existing facilities |
| Regenerative systems | 50 | 40 | 4.0 | 4.5 |

Notes: Source of data [EUROFER HR]. Basis is a furnace with a yearly capacity of 1.5 Mt fired with natural gas with standard burners and without air preheat. Investment costs can be site specific (available room, layout of the existing furnace, number of side and bottom burners)

¹ In percentage terms, the energy reduction is matched by the reduction in SO₂, CO and CO₂ emissions

Cross-media effects

- Higher NOX emissions levels may occur. [EUROFER HR]
- Reduced fuel consumption has a positive effect on SO₂ and CO₂ emissions.
- Higher level of maintenance with a potential increase of the MTBF (Mean Time Between Failure) and NOX emissions. [EUROFER 10-7-18]

Technical considerations relevant to applicability

- New plants.
- Existing plants, provided that space is available.

Generally applicable within the constraints related to the need to control NOX emissions.

Economics

The higher investment costs (regenerative system, more expensive burners) may be compensated by the benefits of shortening the length of the furnace (new plant) and increased fuel efficiency. [EUROFER HR]

Driving force for implementation

Improved energy efficiency.

Example plants

Small number of reheating furnaces.

Reference literature

[ETSU-G76] [ETSU-G77] [EUROFER 10-7-18] [EUROFER HR]

2.4.2.4 Recuperative burner

~~A.4.1.3.5 Recuperator and Recuperative Burners~~

Description

Recuperative burners employ different types of recuperators (e.g. heat exchangers with radiation, convection, compact or radiant tube designs) to directly recover heat from the exhaust gases, which are then used to preheat the combustion air.

Technical description

See Section 8.5.4.3 for a detailed technical description.

Achieved environmental benefits

- Reduced fuel/energy consumption.
- Reduced volume of waste gas.

Environmental performance and operational data

Compared with cold air combustion systems, recuperators can be expected to achieve energy savings of around 30 %. A combination of a recuperator with a low-NOX burner can result in a reduction of energy consumption of 25 % while reducing NOX emissions by 50 %. A recuperative burner can achieve NOX reductions of up to 30 % and reduce energy consumption by 25 %. [EUROFER 10-7-18]

TWG to provide updated information for the following table or it will be deleted.

Table 2.13: Typically achievable reductions and cost data for recuperators and recuperative burners

| Recuperator with low-NOX (2nd generation) | Reduction [%] | | Investment cost [M ECU] | |
|--|----------------------|---------------------------|--------------------------------|----------------------------|
| | NOX | Energy[†] | New facilities | Existing facilities |
| | 50 | 25 | 1.0 | 2.2 |
| Recuperative burner | 30 | 25 | 4.5 | 5.0 |

Notes: Source of data [EUROFER HR]. Basis is a furnace with a yearly capacity of 1.5 Mt fired with natural gas with standard burners and without air preheat. Investment costs can be site specific (available room, layout of the existing furnace, number of side and bottom burners)

[†]In percentage terms, the energy reduction is matched by the reduction in SO₂, CO and CO₂ emissions

Cross-media effects

- The NOX emissions concentration increases with rising combustion air temperature. At the air temperature level achieved with a central recuperator, normally almost no increase in NOX emissions is expected. Otherwise, preheating of combustion air leads to lower fuel consumption and to a lower NOX freight load (mg) (in spite of the small increase in NOX concentration). [EUROFER 10-7-18]
- Reduced energy consumption has a positive effect on the SO₂, CO₂ and NOX load because of the reduced waste gas flow. [EUROFER 10-7-18]

Technical considerations relevant to applicability

- ~~New plants~~
- ~~Existing plants in case of major revamping [Com HR].~~

Generally applicable within the constraints related to the need to control NOX emissions.

Economics

TWG, please provide information.

Driving force for implementation

Increased energy efficiency and reduced fuel consumption. [EUROFER 10-7-18]

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[Com HR] [EUROFER 10-7-18]

2.4.2.5 Oxy-fuel combustion

~~A.4.1.3.6 Oxy-fuel Technology~~

For this section, the content of the old BREF has been deleted as completely new information was supplied.

Description

Combustion air is replaced fully or partially by pure oxygen.

Technical description

Reheating of steel slabs is a very energy-intensive process that uses high-calorific-value gaseous or liquid fuels to reach the high temperatures required. When standard air is used in the combustion process, large volumes of nitrogen enter the furnaces and are heated up by combustion of the fuel at high temperature prior to being exhausted to the atmosphere, resulting

in significant energy losses. When using the oxy-fuel technology, the combustion air composed of 78 % nitrogen and 21 % oxygen is replaced by oxygen (≥ 90 % purity). [EUROFER 10-7-18]

Three stoichiometric equations are shown to illustrate different cases of combusting methane with (i) air combustion, (ii) pure oxygen combustion and (iii) mixed combustion with 50 % oxygen enrichment in the combustion air.

- Normal air combustion with 21 % O₂ and 78 % N₂:

$$\text{CH}_4 + 2 (\text{O}_2 + 3.76 \text{ N}_2) \rightarrow \text{CO}_2 + 2\text{H}_2\text{O} + 7.52 \text{ N}_2$$
- 100 % oxy-fuel combustion:

$$\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$$
- Oxygen-enriched air combustion with 50 % O₂ and 50 % air:

$$\text{CH}_4 + 2 (\text{O}_2 + \text{N}_2) \rightarrow \text{CO}_2 + 2\text{H}_2\text{O} + 2\text{N}_2$$

The removal of nitrogen from the combustion process improves the energy efficiency of the furnace because the final volume of combustion products is significantly reduced when replacing air with oxygen (e.g. down to only three times the volume of fuel used in the case of 100 % oxy-fuel combustion). As a result, the heat generated will be more available to heat up the furnace load. This effect is clearly illustrated in Figure 2.105 where the percentage of available heat in the furnace is plotted against the exhaust gas temperature for different air/oxygen ratios. [EUROFER 10-7-18]

The removal or reduction of nitrogen in the combustion gases also results in a lower exhaust gas volume per unit of energy added (expressed in Nm³ exhaust/kWh) and an increase in the concentration and partial pressures of CO₂ and H₂O. Heat radiation mostly originates from CO₂ and H₂O present in the combustion gases. Accordingly, high concentrations of CO₂ and H₂O considerably increase heat transfer in the furnace. [EUROFER 10-7-18] [J.V. Schéele (2010)]

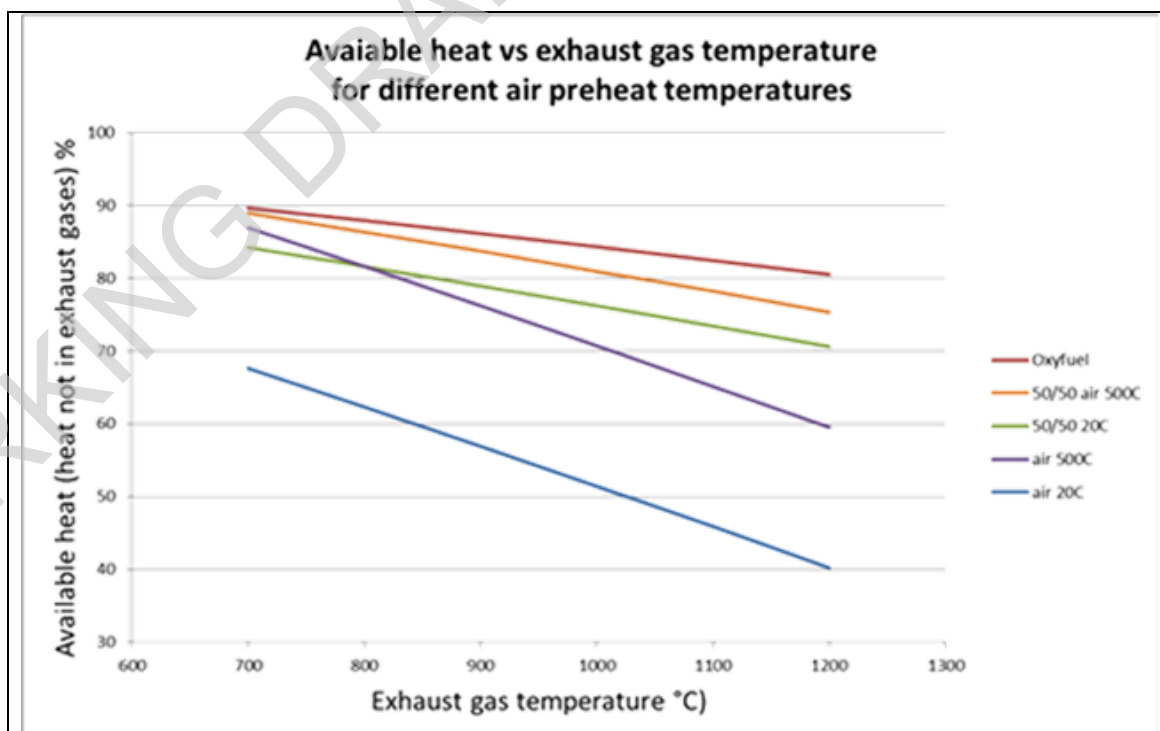


Figure 2.105: Available heat versus exhaust gas temperature for different air preheat temperatures

Finally, since the volume flow of exhaust gases is much less in the case of oxygen-enhanced combustion, the heat is released to the feedstock more efficiently. Besides, the conversion from air to oxygen-enhanced combustion often leads to a lower exit exhaust gas temperature.

Several configurations are possible for using the oxy-fuel technology in reheating and heat treatment furnaces including the following:

- **Oxy-fuel burner with 100 % oxygen**

In this configuration, oxy-fuel burners are employed with 100 % oxygen and no air. The design can vary depending on the specific situation (e.g. type of fuel used and burner position). Like for air burners, the oxy-fuel burner might need a pilot burner or a flame-stabilising system in order to operate at temperatures below self-ignition temperatures.

Impact on NOX emissions

Although in theory a furnace without nitrogen does not produce NOX, most industrial furnaces have leakages where ambient air can enter into the furnace and as a result NOX is formed. To achieve low NOX emissions using an oxy-fuel burner, the fuel and oxygen injection points are normally separated in order to dilute the concentration of oxygen (often below 21 % O₂) and fuel before the combustion reaction takes place, as depicted in Figure 2.106. A high injection velocity promotes recirculation of combustion products into the oxygen and fuel. A low concentration of oxygen and fuel in the flame reduces the peak flame temperature and suppresses NOX formation. [EUROFER 10-7-18]

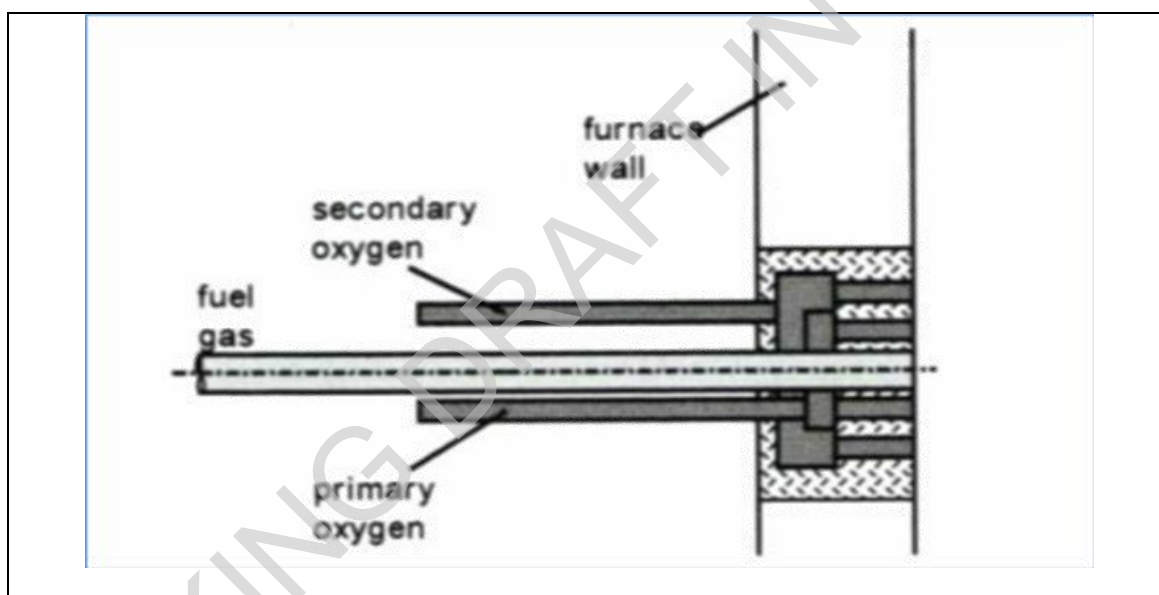


Figure 2.106: Schematic of a typical oxy-fuel burner operating with 100 % oxygen

- **Oxygen enrichment using conventional burners**

This technique consists of adding oxygen into the combustion air to increase the oxygen content from 21 % to about 25–28 % in the air stream. The conventional burners employed for air combustion can usually be used and the benefit is that it is very easy to switch between oxygen-enriched mode and normal air-fuelled mode if required. One disadvantage is that the burner design very seldom is designed for the purpose and that the NOX emissions tend to increase. [EUROFER 10-7-18]

- **High Level Lancing**

The High Level Lancing (HLL) technique is a specific application developed to enable the benefits of oxy-fuel combustion in existing furnaces without the need to replace the burners themselves. Instead of adding oxygen into the combustion air stream of each burner as done with traditional oxygen enrichment, oxygen is injected at high velocity at a short distance from

the burner, allowing the oxygen to be diluted by furnace fumes before it takes part in the combustion (see Figure 2.107). Oxygen enrichment levels of approximately 30–50 % can be reached. Using High Level Lancing, combustion similar to that of a flameless oxy-fuel burner is achieved and resulting in very low NO_x emissions. [EUROFER 10-7-18] [Niemi et al., 2013]

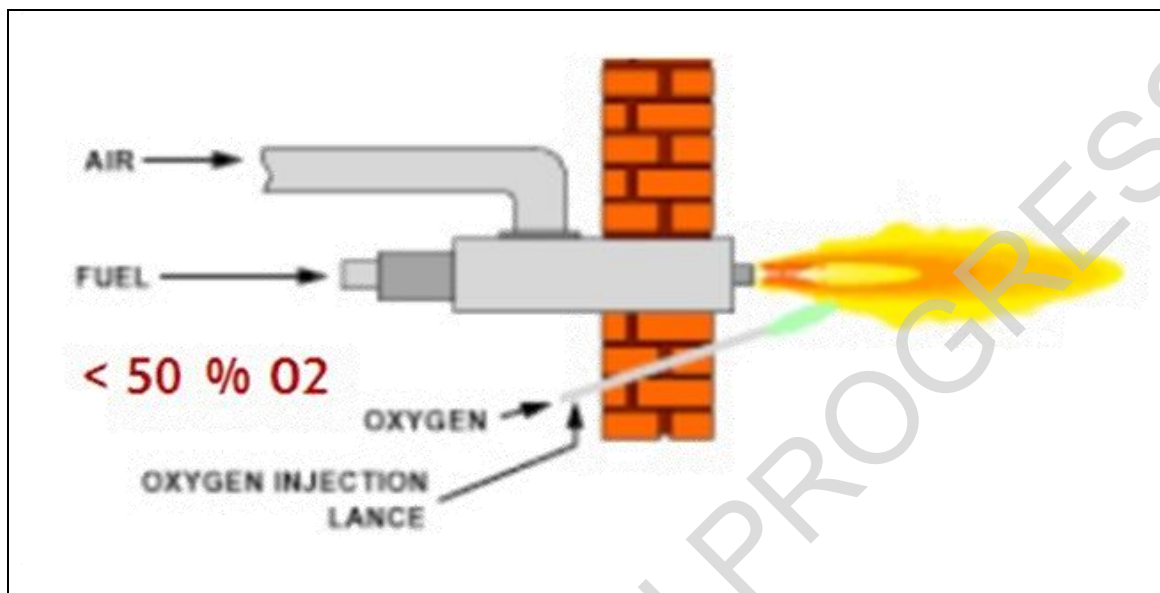


Figure 2.107: Schematic of a burner with High Level Lancing (HLL) for oxygen injection

For oxygen enrichment and High Level Lancing it is important to have good control of the flow of air, oxygen and fuel in order to achieve the correct total oxygen to fuel ratio. [EUROFER 3-5-17]

The choice between the three oxy-fuel options presented above (i.e. 100 % oxygen burner, oxygen enrichment or HLL) depends on the plant characteristics and performance. For instance, when additional heating capacity in the furnace is needed, the use of 100 % oxy-fuel burners might be the best option. For furnaces equipped with ordinary air-fuelled burners exhibiting good efficiency, the HLL technique could be the best solution to further reduce energy consumption. [EUROFER 10-7-18]

Achieved environmental benefits

- Reduced energy consumption and CO₂ emission.
- Reduced CO and overall NO_x emissions.

Environmental performance and operational data

In general, the following improvements are obtained using the oxy-fuel technology [EUROFER 10-7-18]:

- An increase in the partial pressures of CO₂ and H₂O and longer residence times for gases in the furnace result in higher heat transfer by gas radiation, reduced melting time and increased productivity.
- A significant reduction in the exhaust flue-gas volumes and the exhaust flue-gas temperature, resulting in smaller downstream waste gas abatement systems in terms of size.
- The injection of oxygen can result in an increase in the flame temperature and can be controlled independently from the furnace operation, if required.
- The replacement of nitrogen in the burner with pure oxygen reduces the partial pressure of nitrogen gas and can reduce thermal NO_x formation. However, if oxygen is injected near the burner or if there is significant air ingress in the furnace, higher specific NO_x emissions (expressed in mg/Nm³) are possible due to the higher gas temperature. However,

the overall mass emissions of NOX (expressed as mass-NOX/tonne produced or mass-NOX/energy used) are reduced because of the significant reduction in the total volume of exhaust gases achieved with the oxy-fuel technology.

- Reduced specific energy consumption.
- Reduced need for and dependency on heat recovery systems.

For example, at SSAB reheating furnaces in Borlänge, HLL is implemented. The energy savings ranged between 1.7 kWh/m³ and 2.5 kWh/m³ of oxygen depending on production conditions and the furnace. In percentage terms, the energy consumption (and also the CO₂ emissions) has been lowered by 5–16 %, with an average of 10 %. [EUROFER 10-7-18]

At ArcelorMittal Shelby (USA), the specific gross fuel consumption decreased by 65 % after installation of oxy-fuel combustion in comparison with the original air-fuelled installation. Meanwhile, annual NOX emissions were lowered by 76 % in comparison with the initial air-fuelled installation. In addition, emissions of CO₂ were lowered by 65 %. [Lantz et al., 2008]

Cross-media effects

- Higher specific NOX emission concentrations, although overall NOX emissions are reduced.
- The potential safety hazard from using pure oxygen requires that additional precautions are put in place to ensure safety in the workplace.
- Significant reduction of CO₂ emissions compared to air-fuelled furnaces. [Lantz et al., 2008]
- Taking into consideration the overall environmental impact and total energy use, the environmental impact and energy consumed for the production of oxygen have to be considered.

Technical considerations relevant to applicability

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

Economics

- Low investment costs.
- High running cost if no increase in production is achieved.
- The main operating cost of oxy-fuel combustion is the cost of oxygen. The oxy-fuel technology can only be considered a viable solution if oxygen is available at a low price, enabling cost savings when comparing the price of energy and fuel consumption and the price of purchasing oxygen.
- High-purity oxygen may be replaced with oxygen with a purity of around 90 %, thus reducing costs.
- Higher furnace temperatures are reached, resulting in reduced melting time and increased productivity.

Driving force for implementation

- Increased productivity.
- Energy savings.
- Overall reduction of NOX emissions.

Example plants

SSAB Borlänge, furnaces 301 and 302 (Sweden).

Ovako Steel Hofors, 3 Rotary Hearth Furnaces, 5 Chamber furnaces, 48 pit cells (Sweden).

Ovako Bar AB, Smedjebacken WHF (Sweden).

Outokumpu Stainless, Avesta APL 76 (Sweden).

Outokumpu Stainless, Degerfors (Sweden).

Sandvik Materials Technology (Sweden).

Outokumpu Stainless, Tornio (Finland).

ArcelorMittal, Galati (Romania).

Ascometal, Fos Sur Mer and les Dunes (France).
ArcelorMittal Shelby Tubular Products (USA) - [Lantz et al., 2008].

Reference literature

[EUROFER 10-7-18]

[J.V. Schéele (2010)]

J. V. Scheele, (2010). Oxyfuel Combustion in the Steel Industry: Energy Efficiency and Decrease of CO₂ Emissions, Energy Efficiency, Jenny Palm (Ed.), ISBN: 978-953-307-137-4, InTech, Available from: <http://www.intechopen.com/books/energy-efficiency/oxyfuel-combustion-in-the-steel-industry-energyefficiency- =and-decrease-of-co2-emissions>

[Niemi et al., 2013]

Niemi T., Paatalo J., Engdahl J., Lugnet A., Ritzen O., 2013. Experiences from Oxygen Lancing in slab reheating. International Flame Research Foundation. The Finnish and Swedish National Committees, Finnish – Swedish Flame Days.

[Lantz et al., 2008]

Lantz M., Hassenzahl D., Lugnet A., Moroz G, Carlsson., 2008. 25 % Increased Reheating Throughput and 50 % Reduced Fuel Consumption by Flameless Oxyfuel at ArcelorMittal Shelby - Tubular Products, Ohio. Paper presented at AISTech 2008 — The Iron and Steel Technology Conference and Exposition, Pittsburgh.

2.4.2.6 Flameless combustion

This is a new section with updated information received from the TWG which has been inserted here (that section was originally present in the emerging technique chapter (A.6.1.2.1) of the old BREF but contained little information)

Description

Flameless combustion is achieved by injecting fuel and combustion air separately into the combustion chamber of the furnace at high velocity to suppress flame formation and reduce the formation of thermal NO_x while creating a more uniform heat distribution throughout the chamber. Flameless combustion can be used in combination with oxy-fuel combustion.

Technical description

Flameless combustion can be achieved using conventional air-fuelled furnaces equipped with a flameless burner or using oxy-fuel flameless burners.

Flameless combustion

Heating and heat treatment furnaces of the iron and steel industry usually operate at high process temperatures. Whereas energy losses can be minimised with recuperative burners using the exhaust gases to preheat the combustion air, the formation of nitrogen oxides also increases at higher temperatures of the combustion air. Atmospheric nitrogen oxidises in particular in the hot zones of the flame front to form nitrogen oxides. [EUROFER 10-7-18]

Flameless combustion can be achieved with intense mixing of the fuel gas, the combustion air and the recirculated exhaust gases. Fuel gas and combustion air are injected separately into the combustion chamber at high velocity. Inside the combustion chamber, a very intensive internal flue-gas circulation mixes the combustion air, the fuel gas and the products of combustion. Under these conditions, flameless combustion occurs provided that the combustion temperature inside the furnace is above the auto-ignition of the mixture (e.g. > 800 °C using natural gas and air) and the flue-gas recirculation ratio is higher than three. [Abuelnor, 2014] [EUROFER 10-7-18]

With flameless combustion, the temperature peak of the flame front does not exist, reducing to a large extent the formation of NO_x in comparison with conventional burners. Another additional

benefit provided by flameless combustion is that the fuel oxidises throughout the entire volume of the combustion chamber, providing a very homogeneous furnace temperature. With the uniform distribution, it is possible to maintain a higher combustion chamber temperature, resulting in reduced melting time, increased energy efficiency, and lower CO emissions since complete combustion is achieved. Finally, flameless combustion results in lower noise emissions and reduced thermal stress for the burner. [Abuelnor, 2013] [EUROFER 10-7-18]

Flameless combustion in combination with oxy-fuel

Flameless burners can be installed in combination with the oxy-fuel technique. The oxy-fuel technique principles are described in Section 2.4.2.5. Briefly, this technique involves the replacement of the combustion air with oxygen (> 90 % purity), leading to a significant reduction in thermal NOX formation, reduction of the total exhaust gas volume, and increased energy efficiency.

Compared with conventional oxy-fuel combustion, flameless oxy-fuel combustion provides higher production rates, better temperature uniformity in the combustion chamber and very low NOX emissions. Flameless oxy-fuel combustion is achieved by dilution of the flame by recirculating the flue-gases to the burner and by injecting separately the fuel and oxygen at high velocities in the furnace. [J.V. Schéele (2010)]

Another significant benefit gained with flameless oxy-fuel combustion is fuel flexibility. In integrated steelworks, there is an increasing need to combust low-calorific fuels (e.g. fuels exhibiting a calorific value below 2 kWh/m³) such as blast furnace gas (e.g. calorific value < 1 kWh/m³). Using flameless oxy-fuel burners, it is possible to use blast furnace gas alone or in combination with other gases because no flame stability is required. [J.V. Schéele (2010)]

Achieved environmental benefits

- Reduced NOX emissions.
- Reduced CO emissions.
- Reduced energy consumption.

Environmental performance and operational data

Flameless oxy-fuel combustion is installed at two sites belonging to Ascométal at Fos-sur-Mer (France). In total, nine soaking pit furnaces have been retrofitted with flameless oxy-fuel burners. As a result, the heating capacity increased by 50 %, fuel consumption was reduced by 40 % and NOX emissions were reduced by 40 %. [Iron and Steel Today, 2008]

In 2003, a walking beam furnace belonging to Outokumpu Stainless situated in Degerfors (Sweden) was rebuilt and refurbished by replacing the air-fuelled system (including recuperators) with flameless oxy-fuel burners. As a result, the heating capacity increased by 40–50 %, the fuel consumption was reduced by 25 % and overall NOX emissions lower than 70 mg/MJ were achieved. [Iron and Steel Today, 2008]

Other co-benefits of the flameless oxy-fuel combustion technique include reduce scale formation and reduced noise emissions.

Cross-media effects

Taking into consideration the overall environmental impact and total energy use, the environmental impact and energy consumed for the production of oxygen have to be considered.

Technical considerations relevant to applicability

- Applicability to existing plants may be limited by a lack of space.
- Not applicable to furnaces operating at a temperature lower than the auto-ignition temperature required for flameless combustion.

Economics

- Application of oxy-fuel burners requires the additional purchase or on-site production of oxygen. Accordingly, the flameless oxy-fuel technique is often only economically viable at plants where oxygen is available at a low price. To study the economic viability of an installation, the expected cost savings in energy and fuel needed are compared with the purchase price of oxygen. [EUROFER 10-7-18]
- Higher furnace temperatures are reached, resulting in reduced melting time and increased productivity.

Driving force for implementation

- Increased productivity.
- Energy savings.
- Overall reduction of NOX emissions.

Example plants

Ascométal - Soaking pit furnaces (Fos-sur-Mer, France).

Outokumpu Stainless - Walking beam and catenary furnaces (Degerfors, Sweden).

Reference literature

[EUROFER 10-7-18]

[J.V. Schéele (2010)]

J. V. Scheele, (2010). Oxyfuel Combustion in the Steel Industry: Energy Efficiency and Decrease of CO₂ Emissions, Energy Efficiency, Jenny Palm (Ed.), ISBN: 978-953-307-137-4, InTech, Available from: <http://www.intechopen.com/books/energy-efficiency/oxyfuel-combustion-in-the-steel-industry-energyefficiency-and-decrease-of-co2-emissions>

[Abuelnor (2014)]

A. Abuelnor, M.A. Wahid, M. Osman, 2014. Characterisation of a low NOX flameless combustion burner using natural gas. Jurnal Teknologi (Sciences and Engineering) 66:2, 121-125

[Iron and Steel Today, 2008]

Wide-ranging benefits of flameless oxyfuel combustion. Article published in Iron and Steel Today, June / July 2008 Issue, 17-18.

2.4.2.7 Pulse-fired burner

This is a new section inserted here with updated information received from the TWG and reworked also by EIPPCB.

Description

Heat input in the furnace is controlled by the firing duration of the burners or by the sequential start of the individual burners instead of modulating air and gas flows.

Technical description

In pulse firing, the control of the burners is frequency-modulated. The burners can be switched between two states, and the cycling of the burners controls the heat input in the furnace. Usually, the burners are fired at high fire for a certain time and then either cycled to low fire or turned off. This cycle can be repeated relatively frequently, in some designs every six seconds. [Curry, 2011]

For instance, the burner always operates at nominal gas flow and the power of the burner is adjusted by the firing time of the burner: for example, a heat demand of 40 % means that the burner is operating only for 40 % of the 60-second cycle time. Another option is the modulation of the burner firing rate by a sequential start of the individual burners. [EUROFER 10-7-18]

Even with a low furnace load, the full power of each burner is available. Slab temperature uniformity is improved in the side-fired furnace because heat is brought homogeneously into the whole furnace width in every production condition.

Achieved environmental benefits

Reduction of energy consumption

Environmental performance and operational data

TWG, please provide information, if possible, on which plant is actually described in the example below, this information is missing ?

Example of reheating furnaces running in parallel:

- AP4: commissioned in 1997; flow control and top zones equipped with roof burners, bottom zones equipped with side burners, LPG used at top zones and soaking zone.
- AP5: commissioned in 2005; last two top zones equipped with roof burners, other zones equipped with side pulse-fired burners, COG/LPG used as fuel, LPG used as fuel in the soaking zone).
- 10 % lower energy consumption is achieved with side pulse-fired burners.

Table 2.14: Consumption and NOX emission data (daily average)

| 2016 data | AP4 | AP5 |
|---|------|------|
| Energy consumption (GJ/t) | 1.60 | 1.42 |
| NOX (mg/Nm ³) (3 % O ₂), periodic | 325 | 360 |
| NOX (mg/Nm ³) (3 % O ₂), continuous | NI | 400 |
| NB: NI = No information provided. | | |

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

Only applicable to new furnaces.

Economics

Investment costs competitive with other techniques. Valve maintenance can add extra costs if impurities are present in the fuel gas.

Driving force for implementation

Energy savings.

Example plants

SSAB Raahe, Finland. HSM/Walking beam furnace 5 (side burners with pulse firing, two modulative top zones), HPM/heat treatment NU1 (total pulse firing), heating 2 + soaking zones of reheating furnaces 3 and 4 in Avilés are equipped with pulse-fired burners.

Reference literature

[Curry, 2011]

Curry, D., October 2011. The basics of pulse firing. In Industrial Heating – Industrial gases / Combustion.

[Wünning, 2015]

Wünning, G., Milani, A. Handbook of Burner Technology for Industrial Furnaces. 2015. pp. 123-127.

[EUROFER 10-7-18]

2.4.2.8 Low-NOX burners

Description

The technique (including ultra low-NOX burners) is based on the principles of reducing peak flame 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 NOX and the formation of thermal NOX, while maintaining high combustion efficiency.

Technical description

See Section 8.8.2.6 for a detailed technical description.

Achieved environmental benefits

- Reduced NOX emissions.
- Increased energy efficiency. [EUROFER 10-7-18]

Environmental performance and operational data

TWG, the following section from the old BREF is to be deleted and replaced with the new information provided below.

~~For low NOX burners the NOX level is less dependent on the air preheat temperature. Sometimes in industrial practice, low NOX burners do not show best performance in NOX emission. This shows that the total NOX output is influenced by a lot of other parameters such as furnace design, type of fuel, heating temperature, operation and maintenance. [EUROFER HR] Special care is therefore necessary regarding operating conditions and control of operation.~~

~~Compared to conventional burners a reduction in the NOX emission level of approximately 30 % can be obtained. A typical value for natural gas is 300 mg NOX /Nm³.~~

~~In two cases, using COG and heavy oil, guaranteed emission levels of 330 mg NOX/m³ (dry waste gas at 5 % O₂) were reported. [DFIU]~~

Examples

~~**Voest Alpine** is operating 2 pusher-type (350 t/h) and 2 heat treatment furnaces. The reduction of the NOX level can only be obtained, when the burner capacity is higher than 20 %. During an unscheduled or scheduled delay time (burner capacity < 20 %) the NOX level can be double or more. Investment costs were reported to be EUR 1 m/furnace (350 t/h). [Input HR-1]~~

~~**EKO Stahl** operates a walking beam furnace with a capacity of 200 t/h. The furnace is equipped with low NOX burners and is operated with natural gas and an air preheating temperature of 450° C (waste gas volume 140000 m³/h). Levels of 400 mg/m³ for NOX and <100 mg/m for CO (reference 5 % O₂) are achieved as daily averages in the case of cold charging.~~

~~NOX emissions of 250 mg/m³ (reference 3 % O₂) with Low NOX burners were also reported, compared to conventional burners with 300—500 mg/m³ **ACB**~~

Table 2.15: Typically achievable reductions and cost data for low-NOX burners

| | Reduction [%] | | Investment cost [M ECU] | |
|--|---------------|--------|-------------------------|---------------------|
| | NOX | Energy | New facilities | Existing facilities |
| Low-NOX burners with internal flue gas recirculation (1st generation) | 40 | 0 | 0 | 0.8 |
| Low-NOX burners with internal flue gas recirculation and air staging (2nd generation) | 65 | 0 | 0.2 | 1.2 |

Notes: Source of data [EUROFER HR]. Basis is a furnace with a yearly capacity of 1.5 Mt fired with natural gas with standard burners and without air preheat. Investment costs can be site specific (available room, layout of the existing furnace, number of side and bottom burners)

Table A.4 7: Typically achievable reductions and cost data for low-NOX burners

Examples

NOX emissions at three reheating furnaces equipped with low-NOX and ultra low-NOX burners are show in the table below.

TWG, Please provide information on operating conditions (e.g. furnace temperature and type of fuel/gas burned to complete the following table.

Table x. Range of NOX emissions at reheating furnaces equipped with low-NOX and ultra-low-NOX burners [EUROFER 10-7-18]

| Site / Furnace | Burner Type | NOX emissions range (mg/Nm ³) |
|--|--|---|
| Liberty Speciality Steels – Brinsworth Strip mill / Reheating furnace | Low-NOX – Roof flat-flame (hot air recuperated) burner | 111–265 |
| Liberty Speciality Steels Rotherham / Billet Annealing and reheating furnace | Low-NOX – (hot air recuperated) burner | 162–266 |
| Liberty Speciality Steel – Stocksbridge / Billet reheating furnace | Ultra-Low-NOX – FGR burner | 120–148 |

In addition to low-NOX burners, further improvements in energy efficiency and environmental performance can be achieved by implementing new burner control systems. [EUROFER 10-7-18]

Depending on the burner design, additional valves for air/fuel staging may be necessary. In the case of flameless burners, a furnace temperature (walls) above the self-ignition value is required. Safety interlocks need to be considered. [EUROFER 10-7-18]

Cross-media effects

- ~~The internal flue gas re-circulation, a design feature of low-NOX burners, reduces the NOX level, but may increases energy consumption.~~

TWG, please provide information.

Technical considerations relevant to applicability

- ~~New furnaces.~~
- ~~Existing plants in case of major revamping (limitation for the replacement of existing burners may be given with respect to the size). [Com HR] Existing conventional burners can generally be converted into first generation low-NOX burners by changing burner baffle and port block. A conversion to second generation low-NOX burners is more difficult and requires a modification of the furnace lining. [EUROFER HR]~~

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

Economics

TWG, please provide information.

Driving force for implementation

- Reduction of NOX emissions. [EUROFER 10-7-18]
- Increased energy efficiency. [EUROFER 10-7-18]

Example plants

~~EKO Stahl, Aceralia, Voest Alpine, Preussag, etc.~~

- Liberty Speciality Steels - Stocksbridge Billet Mill Continuous Furnaces.
- Liberty Speciality Steels - Rotherham billet annealing / soaking pits.
- Liberty Speciality Steels - Brinsworth Strip Narrow Strip Mill Slab reheating furnace.
- ArcelorMittal - Fos-sur-Mer Hot Strip Mill reheating furnaces.
- ArcelorMittal - Asturias Wire Rod Mill reheating furnace.

Reference literature

[LCP BREF] [EUROFER 10-7-18]

2.4.2.9 Selective catalytic reduction (SCR)**Description**

The SCR technique is based on the reduction of NOX to nitrogen in a catalytic bed by reaction with urea or ammonia at an optimum operating temperature of around 300–450 °C. Several layers of catalyst may be applied. A higher NOX reduction is achieved with the use of several catalyst layers.

Technical description

See Section 8.8.1.4 for a detailed technical description.

Achieved environmental benefits

Reduced NOX emissions.

Environmental performance and operational data

Example: Tata Steel IJmuiden

The SCR technique is applied both at the walking beam furnaces and at the pusher furnaces which produce about 5.5 million tonnes of hot rolled steel annually. ~~Due to the specific construction of the flue gas channel, it was possible to build the ordinary SCR catalyst into the existing channel.~~ Figure 2.108 depicts the configuration of the walking beam furnaces. Usually, the type of catalysts used is suitable to operate within the temperature range 270–450 °C. Short periods of temperatures up to 500 °C do not harm the catalyst. However, at the pusher furnaces, temperatures near the catalyst range from 300 °C to 550 °C (with an average of 75 % of the time above 520 °C) and therefore another type of catalyst is required to resist such temperatures. The abatement of NOX emissions with this other catalyst is lower however (around 60 %). [EUROFER 23-7-18]

To increase the NOX abatement efficiency at the pusher furnaces, a combination of SCR and SNCR is used, resulting in an overall NOX emissions reduction rate of about 75 %. [EUROFER 31.3] [EUROFER 3.4]

TWG, the following two paragraphs below are proposed for deletion and will be replaced with the new information provided below.

~~With this type of installation it is possible to get an overall reduction rate of more than 80 %. The permit of the plant describes a reduction from 800 mg/Nm³ to 320 mg/Nm³ and a demand to achieve more than 85 % reduction, which can probably be done. The cost efficiency of the SCR at the walking beam furnace at Corus/Hoogovens is NLG 4.20 per kg NOX reduced. [EUROFER 31.3] [EUROFER 3.4]~~

In IJmuiden no SCR behind a pusher type furnace is installed yet, but one is under construction. Start of operation is scheduled for June 2000. For the second pusher furnace, installation of an SCR is planned for early next year. The performance will probably be much worse than in the case of the walking beam furnace. Due to the very high temperatures of the flue gas (75 % above 520°C) an experimental type of catalyst has to be used. This type only functions properly within a temperature range of 300–520°C. At temperatures above 520° no ammonia can be injected any more because of potential damage to the catalyst. Unless the high temperatures are dealt with (i.e. technical solutions for this problem are found or additional measures are taken), it is estimated that the overall reduction of NOX will not be more than 30 %. [EUROFER 31.3]

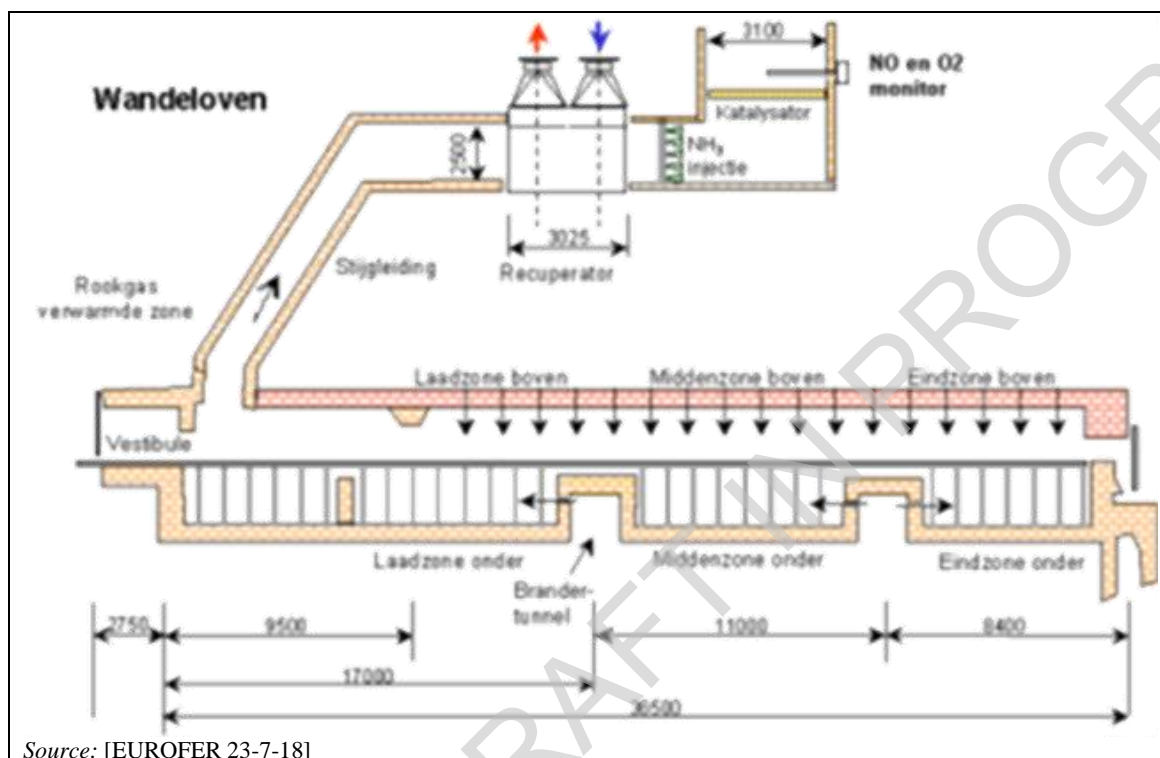


Figure 2.108: Schematic view of a walking beam furnace with De-NOX

The NOX emissions concentration depends on the composition of the fuel used. Usually, natural gas is used with a maximum of 60 % coke oven gas (COG). The efficiency of the NOX reduction at the walking beam furnace is better than the pusher furnace. (See Figure 2.109.) [EUROFER 23-7-18]

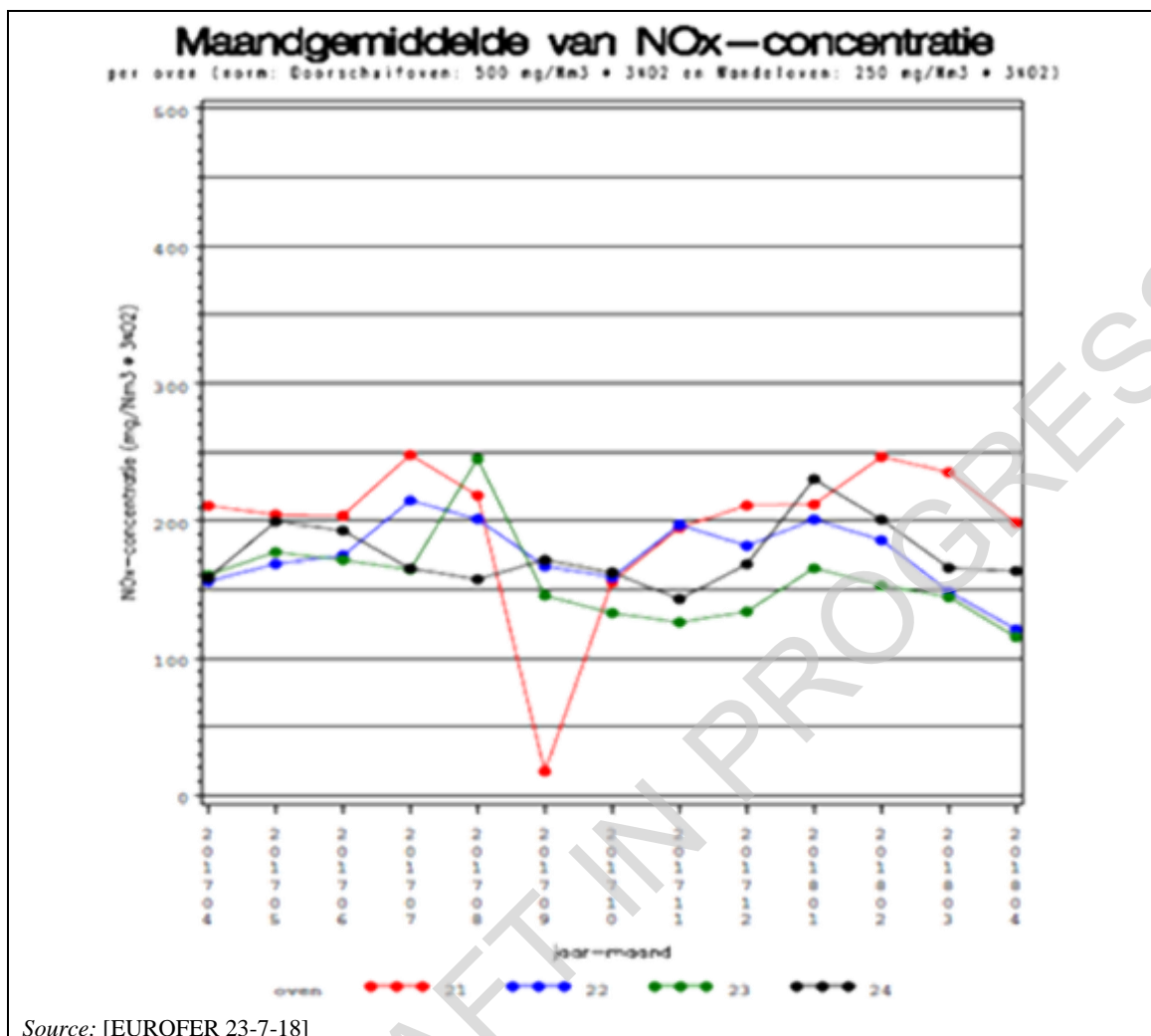


Figure 2.109: NOX emissions concentrations at Tata Steel IJmuiden pusher furnaces (No 21 and 22) with SCR and SNCR and at the walking beam furnaces (No 23 and 24) with SCR

Some doubts were expressed regarding the technical feasibility of SCR which may limit the applicability to reheating furnaces:

There are a certain number of aspects to consider when applying SCR in reheating furnaces:

- Some practical problems are likely to be encountered in the application of SCR in steel reheating/heat treatment furnaces as the production rate (and therefore thermal input) and temperature profiles are not steady state. To avoid either excessive NH₃ slip or excess NOX in the stack, the ammonia injection rate would need to be controlled to match rapidly changing exhaust flow rates and NOX concentrations. [ETSU-GIR-45]
- SCR technology requires certain limits of temperature and volume flow, which might not be achieved by some plants. [DK 30.6]
- The required flue-gas temperature suitable for SCR may not be readily available. If the temperatures are too high, dilution air could be used, although furnace draughting may then not be acceptable. [ETSU-GIR-45]
- In the case of regenerative burners, the efficiency of flue-gas heat recovery would be affected, unless the SCR could be incorporated midway in a regenerator bed (e.g. the bed would need to be split). [ETSU-GIR-45]
- Many plants recover the waste heat of the exhaust gases for reasons of energy efficiency. The resulting temperature of the waste gas is in the range 150–210 °C and needs to be increased for the SCR catalyst to work properly. Consequently, additional energy input would be necessary [EUROFER 2.7]

- ~~As there is only very limited experience with the application of SCR at reheating furnaces (only one plant and only for walking beam furnaces), it not verified whether the technique will work under all temperature conditions and air ratios, [EUROFER 30.6].~~
- With higher dust concentrations in the waste gas (e.g. if fuel oil is used as the energy source) dedusting measures would be required to protect the catalyst. [EUROFER 2.7]
- In integrated steel plants, plant gases (blast furnace top gas, BOF converter gas or coke oven gas) are used as fuel. They usually contain only negligible traces of zinc or other metals, but these could still contaminate the surface of the catalyst and gradually reduce its efficiency and lifetime. [EUROFER 2.7]
- A problem which can arise is the formation of acidic ammonium sulphate $((\text{NH}_4)_2\text{SO}_4)$ or bisulphate $((\text{NH}_4) \text{HSO}_4)$ particles by the reaction of excess ammonia carried over from the SCR reactor with SO_2 and SO_3 in the cooler flue-gases downstream. Deposition of these particles can cause fouling, erosion and corrosion of downstream equipment surfaces. The formation of ammonium sulphate is minimised by use of slightly sub-stoichiometric amounts of NH_3 (0.9–1.0 mole per mole of NOX) to suppress carry-over. [HMIP-95-003] [ETSU-GIR-45]
- When implementing SCR in an existing plant, the additional pressure and temperature drop of the waste gas flow must be considered as it can affect recuperator units or additional downstream facilities, for example steam boilers. [EUROFER 23-7-18]

Cross-media effects

- Use of ammonia gas (transport and storage can be hazardous and subject to stringent safety regulations).
- Risk of air pollution due to ammonia slip.
- Possible increase in energy consumption [Vercaemst 27.7].
- Possible increase in waste; deactivated catalyst, which can be reprocessed by the manufacturer. This waste stream probably will be minimal. [Vercaemst 27.7] [Oekopel 7.9]

Technical considerations relevant to applicability

- ~~New and existing plants.~~

In existing plants, there may be a lack of space.

Economics

- ~~NLG 4.20 per kg NOX reduced [EUROFER 3.4]~~

The cost efficiency at Tata Steel is EUR 2 per kg of NOX reduced.

Driving force for implementation

Environmental legislation.

Example plants

~~Hoogovens Steel, walking beam furnace [Com NL]~~

Tata Steel IJmuiden (walking beam and pusher furnaces)

Reference literature

[EUROFER 31.3] [EUROFER 3.4] [EUROFER 23-7-18] [ETSU-GIR-45] [DK 30.6]
[EUROFER 2.7] [HMIP-95-003] [Vercaemst 27.7] [Oekopel 7.9]

2.4.2.10 Selective non-catalytic reduction (SNCR)

Description

SNCR is based on the reduction of NOX to nitrogen by reaction with ammonia or urea at a high temperature. The operating temperature window is maintained between 800 °C and 1 000 °C for optimal reaction.

Technical description

See Section 8.8.1.5 for a detailed technical description.

Achieved environmental benefits

Reduced NOX emissions.

Environmental performance and operational data

Example: Avesta Sheffield

At the hot strip mill for rolling stainless steel slabs to strip, there are two reheating furnaces (walking beam furnaces), each with a capacity of 100 t/h and using propane/butane gas as fuel. Furnace A, supplied by Stein Heurty, became operative operation in 1992, and Furnace B, supplied by Italimpianti, in 1996.

Because this is the plant's largest emission source of NOX, action has been taken to reduce these emissions through the introduction of a SNCR installation. The installation comprises mainly a storage tank for ammonia (25 % water solution), pumps, pipes, injection lances, and a computerised measurement and control system, where ammonia is added to the exhaust gas of each furnace on the basis of continuous NOX measurement.

The installation was put into continuous operation in October 1999 and was regulated during the autumn. Measurements in January 2000 gave the following results (NOX measured as NO₂):

| | NOX content (mg/MJ fuel) | Reduction (%) | NOX (mg/Nm ³) |
|-----------|--------------------------|---------------|--|
| Furnace A | 74 | 70 | 205 |
| Furnace B | 62 | 30 | 172 (ammonia slip 5 mg/Nm ³) |

The measurement results are averages of continuous measurements taken during 32 hours at Furnace A and 42 hours at Furnace B. They are considered normal and expected to remain at these levels in continuous operations.

The reason why the reduction is lower at Furnace B is that the nitrogen oxide content without ammonia is lower than in Furnace A.

The following cost information was given to the Swedish Environment Court in December 1999 in a report on the possibilities of reducing the emissions of nitrogen oxides from these furnaces:

~~The capital investment (including installation and running in costs as well as the cost of all equipment): SEK 6.3 m (EUR 0.76 m)~~

~~Operating costs (mainly ammonia and maintenance): SEK 1.4 m per year (EUR 0.169 m per year)~~

~~Total capital and operating costs: SEK 3.3 m per year (EUR 0.40 m per year)~~

~~With the NOX reduction mentioned above, the emissions of nitrogen oxides can be reduced by 60 tonnes per year, corresponding to a specific cost of SEK 55 (EUR 6.63) per kg NOX reduced (measured as NO₂). [EUROFER 17.4]~~

Other sources report an efficiency of NOX removal by SNCR of typically 50–60 % with 20–30 ppm NH₃ slip [ETSU-GIR-45], but even higher reductions of up to 85 % are reported in connection with ammonia injection in a natural-gas-fired regenerative burner. Others reported on the use of ammonia and urea injected into the flue of a burner (operating at 900 °C air preheat) burning a mixture of blast furnace and coke oven gases. For both reagents, the maximum reduction was of the order of 80 %. These data derive from test furnaces not exceeding 600 kWth, which in this case was a 1/3 scale version of a soaking pit furnace. [HMIP-95-003]

~~Some doubts were expressed regarding the technical feasibility of SNCR which may limit the applicability to reheating furnaces. Problems in applying SNCR to reheating furnaces due to large variations in process conditions (waste gas temperature, volume flow etc.) and or non-~~

~~availability of a suitable temperature window is probably the same as for the application of SCR (see above):~~

The temperature window for SNCR is about 850–1 100 °C (depending on the reagent). For those regenerative systems which have furnace temperatures well in excess of 1 000 °C, the appropriate SNCR temperature range is likely to be found within the regenerator bed, which may discourage the use of the method. Control systems would be complicated if there were a need to ‘follow’ a temperature window which can change its location within the furnace/burner as thermal inputs and production rates are altered. [HMIP-95-003] [EUROFER HR]

When implementing this technique in an existing plant, the additional pressure and temperature drop of the waste gas flow must be taken into consideration. This can affect recuperator units or additional downstream facilities, for example steam boilers. [EUROFER 23-7-18]

Cross-media effects

- Use of ammonia gas (transport and storage can be hazardous and subject to stringent safety regulations).
- Risk of air pollution due to ammonia slip.
- A potential drawback of the SNCR technique is the formation of ammonium sulphate by the carry-over of excess NH_3 . The use of clean gaseous fuels such as natural gas in conjunction with SNCR should avoid the reported problems of adhesive and corrosive compounds that can otherwise occur. This may not be the case with sulphur-containing steelworks gases. [HMIP-95-003]
- Energy consumption to heat the exhaust gases to the operating temperature for SNCR. [EUROFER 23-7-18]

Technical considerations relevant to applicability [EUROFER 23-7-18]

- ~~New and existing plants.~~

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

Economics

~~The economic data of the Swedish plants shows that the cost of 6.63 euro per kg of NOX reduced gives rise to additional costs of 0.33 euro in the manufacture of 1 tonne of rolled steel. Based on a price of about 400 euro per tonne of hot wide strip, the relative expenditure comes to 0.08 %. Annual production of the two plants was estimated to be 1.2 million tonnes of rolled steel. [Germany 7.4]~~

The cost efficiency at Tata Steel walking beam furnaces is EUR 2 kg of NOX reduced.

Driving force for implementation

Environmental legislation.

Example plants

Avesta Sheffield, walking beam furnaces.

In Tata Steel IJmuiden, the SCR technique is applied both at the walking beam furnaces and the pusher furnaces which produce about 5.5 million tonnes of hot rolled steel annually. The NOX reduction rate for the walking beam furnace is about 80 %. Because of the high temperatures of the flue-gas (75 % above 520 °C), the reduction rate for the pusher furnaces would be much lower (30 %) and therefore since 2003 a combination of SCR and SNCR has been used. The overall reduction rate for the pusher furnace (SCR and SNCR) is about 75 %. [EUROFER 31.3] [EUROFER 3.4]

Reference literature

[HMIP-95-003] [ETSU-GIR-45] [EUROFER 17.4] [EUROFER HR] [EUROFER 31.3] [EUROFER 3.4] [EUROFER 23-7-18]

2.4.2.11 Flue-gas recirculation (FGR)**A.4.1.3.10 External Flue Gas Recirculation (FGR)****Description**

Recirculation of part of the flue-gas to the combustion chamber to replace part of the fresh combustion air, with the dual effect of limiting the O₂ content for nitrogen oxidation and reducing the combustion temperature, thus limiting NOX generation.

Technical description

See Section 8.8.2.7 for a detailed technical description.

Achieved environmental benefits

Reduced NOX emissions.

Environmental performance and operational data

- For a COG-fired steel slab reheater with a capacity of at least 140 t/h, NOX reductions of 51.4 %, 69.4 % and 79.8 % (from a base level of 657 mg/m³) for 10 %, 20 % and 30 % FGR respectively are reported. [ETSU-GIR-45]
- Increased water vapour contents in the combustion products can increase scaling of the steel. [EUROFER 23-7-18]
- A potential decrease of furnace performance and therefore a lower throughput rate must be considered, especially when reaching the operational limit of the furnace. [EUROFER 23-7-18]
- In some cases, a potential loss of flame stability and burner shutdown may occur. [EUROFER 23-7-18]
- The burner capacity is reduced and the burner has to be downrated to compensate when replacing some of the combustion air with low-oxygen flue-gases. [EUROFER 23-7-18]
- Potentially difficult to control in cases where composition and hence waste gas volumes are variable (e.g. on integrated sites where mixed plant gases are used).

Cross-media effects

- Potential increase in fuel consumption (as long as waste gas flow and temperature are not affected by FGR, the combustion efficiency and fuel consumption will remain the same, but this implies an increase of the air preheat temperature).
- Increases in fuel consumption (and hence CO₂ emissions) for different burner designs range from 1.1 % to 9.9 % (FGR ranging from 10 % to 50 %). [ETSU-GIR-45]
- Higher emissions of carbon monoxide and unburnt hydrocarbons. [EUROFER 23-7-18]

Technical considerations relevant to applicability

- ~~New and existing furnaces.~~
- ~~In principle, FGR is applicable to most reheating and heat treatment processes. However, in practice, for retrofitting, there may be space limitation for ductwork and problems of accessibility. [HMIP 95-003]~~

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

Economics

For the retrofitting of FGR, no costs are provided.

FGR is often applied with other primary measures such as low-NOX burners, so it is difficult to estimate the costs of FGR alone.

Driving force for implementation

Environmental legislation.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[ETSU-GIR-45] [EUROFER 23-7-18]

TWG, Section A.4.1.3.11 from the old BREF "Waste heat boiler" has been moved and the updated information can now be found in Chapter 7 (8.5.4.5).

2.4.2.12 Optimised skid design to reduce skid marks

Description

The design of skids in reheating furnaces is optimised to minimise skid marks (e.g. cold spots) on steel slabs using skid riders, skid shifting or a skid mark compensation device.

Technical description

Reheating furnaces are used to reheat steel slabs before hot rolling. Inside reheating furnaces, steel slabs are supported by water-cooled refractory-coated pipes called skids. The skids can to a certain extent block thermal radiation resulting in the apparition of skid marks (e.g. cold spots) on a steel slab. With skid marks, the temperature of the steel slab is not uniform at the exit of the furnace which has detrimental effects on the final quality of the product after hot rolling.

In order to minimise skid marks on steel slabs, three techniques are usually employed:

Skid mark compensation (SMC) device

The slabs heated in a pusher-type furnace lean on water-cooled supporting pipes which cause local underheating (skid marks) on the bottom side of the slabs and must be compensated for during the residence time in the soaking hearth to avoid thickness variations of the finished product. The soaking time can be reduced if the skid marks are reheated by application of suitable methods, e.g. local inductive heating (skid mark compensation device). Losses due to the cooling system and the hearth wall are almost constant over time, regardless of whether the furnace is operated under full load or partial load.

Furnace skid riders

An additional measure to reduce the formation of skid marks is the use of the so-called skid riders. These are fixtures for the water-cooled furnace rails made from special material (metal alloy or ceramics), which reduce temperature dissipation.

Skid shifting

In modern walking beam furnaces, the material supporting skids are not straight all along the furnace. Mainly the last section of skids, near the furnace exit side, is shifted with an offset designed to distribute and therefore to decrease the skid marks.

Achieved environmental benefits

- The reduction of the residence time on the hearth and, consequently, of the throughput time, results in energy savings in the case of SMC. But it was also reported that SMC requires high energy input for inductive heating. [Com2 HR]
- Using skid riders, a reduction of the temperature compensation combined with an increased throughput and reduced energy consumption is possible.
- Using skid shifting, the slab quality is enhanced and the waste output reduced.

Environmental performance and operational data

The reported reductions for skid shifting, skidmark compensation or furnace skid riders were 1 % for energy consumption and 1 % for NOX emissions. [EUROFER HR]

Cross-media effects

SMC requires a high energy input for inductive heating. [Com2 HR]

Technical considerations relevant to applicability

- Furnace skid riders and skid shifting: only applicable to new installations as they have to be considered at the design stage.
- Skid mark compensation device: ~~new and existing installations~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

- Increased energy efficiency.
- Improved product quality.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[Com2 HR] [EUROFER HR]

2.4.2.13 Reduction of energy loss through feedstock transportation device

Description

The number of feedstock-supporting structures inside the furnace (e.g. beams, skids) are minimised and suitable insulation is used to reduce the heat losses from water cooling of the structures in continuous reheating furnaces.

Technical description

In reheating furnaces, water cooling is used to protect some components and maintain their physical strength; examples include doors, lintels and the stock transport mechanism or support system. Water-cooled components represent a significant source of energy losses. In particular, the loss through stock transport systems in continuous (walking beam) furnaces can account for 6–12 % of the fuel input under typical operating conditions. Close to the end of a furnace operating campaign, when insulation of the cooled components begins to degrade, the loss can be as high as 20–25 %. [ETSU-G76] [Com2 HR].

Losses from feedstock-supporting structures can be minimised at the design stage by optimising/reducing the number of cooled beams and supports and by using suitable insulation. [ETSU-G76]

Achieved environmental benefits

A reduction in water cooling losses of 26.7 GJ/h (equivalent to a fuel saving of 44.5 GJ/h) was reported [ETSU-G76].

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

- 46 % reduction in water use [ETSU-G76].
- Reduced energy consumption of pusher mechanism [ETSU-G76].
- Reduced skid marks, improved quality [ETSU-G76].

Technical considerations relevant to applicability

- ~~New furnaces and existing furnaces.~~

- Only applicable to new plants and major plant upgrades.
- For existing furnaces, optimisation can be done during refractory maintenance [Com2 HR].

Economics

TWG, please provide information.

Driving force for implementation

Increased energy efficiency.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[ETSU-G76] [Com2 HR]

2.4.2.14 Heat recovery from skids cooling

Description

Steam produced when cooling the skids supporting the feedstock in the reheating furnaces is extracted and used in other processes of the production plant.

Technical description

Skid cooling energy losses can be used to generate steam. A closed forced cooling circuit, which circulates a mixture of approximately 95 % water and 5 % saturated steam, can be installed in reheating furnaces. Steam produced by cooling the supporting beams (skids) of rolling stock is extracted from the circuit and fed to other consumers for further use. [EUROFER HR]

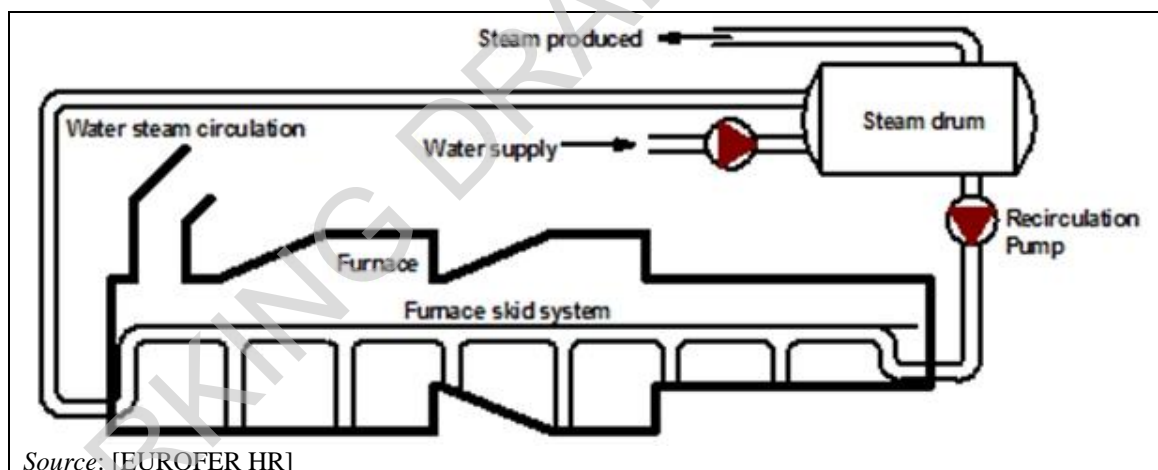


Figure 2.110: Typical schematic of evaporative furnace skid cooling

Achieved environmental benefits

Efficient energy use saves resources as no fuel is consumed at other stages for producing the steam and emissions are reduced.

Environmental performance and operational data

Example EKO Stahl [Input-HR-1]

- average working pressure in the boiler: 23 bar;
- average temperature of cooling water: 222 °C (at 23 bar);

- possible steam production for the turbine: 10–41 t/h (depending on the situation of the refractory material and the working conditions of the furnace);
- generator capacity: 4.16 MW;
- steam production (cold charging): Ø 18 t/h;
- steam production (hot charging): Ø 22 t/h;
- recovered energy: n.a.

Cross-media effects

No negative effects on other media are known.

Technical considerations relevant to applicability

- ~~New and existing installations.~~ Generally, there are no technical restrictions to the applicability of this technique.
- Only sensible when there is a specific requirement for steam. [ETSU-G76]

Economics

TWG to provide updated information for the following table or it will be deleted.

Reported general reduction potential and cost data are given in the following table.

Table 2.16: Typically achievable reductions and cost data for evaporative furnace skid cooling

| Evaporative furnace skid cooling | Reduction ¹ [%] | | Investment cost [M ECU] | |
|----------------------------------|----------------------------|---------------------|-------------------------|---------------------|
| | NOX | Energy ² | New facilities | Existing facilities |
| | 7 | 7 | 4.0 | 4.0 |

Notes: Source of data [EUROFER HR]. Basis is a furnace with a yearly capacity of 1.5 Mt fired with natural gas with standard burners and without air preheat. Investment costs can be site-specific (available room, layout of the existing furnace, number of side and bottom burners).

¹ Evaporative furnace skid cooling has a negligible effect when combined with recuperators or with regenerative systems.

² The energy reduction in terms of percentage has an equal effect on the reduction in SO₂, CO and CO₂ emissions.

Only a marginal effect can be expected from evaporative furnace skid cooling when it is combined with good insulation of the skids.

Driving force for implementation

Increased energy efficiency.

Example plants

Svenskt Stål AB, EKO Stahl.

Reference literature

[EUROFER HR] [Input-HR-1] [ETSU-G76]

TWG, Section A.4.1.3.15 from the old BREF (Feedstock preheating) has been moved and the updated information can now be found in Chapter 7 (Section 8.5.4.1).

2.4.2.15 Heat conservation during transfer of feedstock before the roughing mill

~~A.4.1.3.16 Heat conservation box / thermal covers~~

Description

Insulated chambers or insulated shields are used between the source of feedstock and the reheating furnace and/or between the furnace and the roughing mill.

Technical description

Hot boxes or insulated chambers are used to promote heat retention in the steel and to provide a link between the source of hot stock and the furnace. Semi-finished products, which cannot be charged immediately (because of programme co-ordination and for bridging gaps caused by interruptions), are stored in this unheated, heat-insulated box instead of being stored in open stockyards. Heat losses of the slabs are reduced and the charge temperature is maintained at a high level. On average, the storage time for slabs is 8 hours. The temperature of insulated stored slabs is approximately 220 °C higher than that of open stored slabs. [EUROFER HR] [ETSU-G76].

Another method for reducing the furnace operating temperature and preventing heat loss between the furnace and the rolling mill is insulated shields (heat-retaining covers) installed between the furnace discharge and the rolling stands. Heat losses during transport from the casting machine to the reheating furnace can be prevented by the same kind of measures. [DFIU98] [ETSU-G76]

Achieved environmental benefits

- Reduced energy consumption in reheating.
- Thermal covers for the transport of slabs between a continuous caster and a reheating furnace can save about 0.33 GJ/t [DFIU98].

Environmental performance and operational data

An investigation into potential measures to increase the charging temperature of continuous cast slabs to a heating furnace was done at Stahlwerke Bremen using numerical modelling (Figure 2.111). The results based on computer simulation and measurements for that installation showed that the core temperature of slab immediately after casting was about 950 °C. On the way to the stockyard of the hot rolling mill the slabs cooled down to 750 °C: during the storage time of 24 hours the temperature of the slabs dropped further, leaving a remaining charging temperature in the heating furnace of about 350 °C. By optimising the synchronisation of the continuous caster and the rolling schedule, the storage time could be reduced to a third. Additionally, the slabs were covered with thermal covers with a 50 mm mineral wool lining. It was proven that during an 8-hour storage period, starting from 750 °C, a charging temperature of 700 °C could be maintained. Compared to the old charging practice (350 °C), this represented an additional energy input to the furnace of 0.26 GJ/t, resulting half from the shorter storage time and half from the thermal insulation. [StuE-117-5]

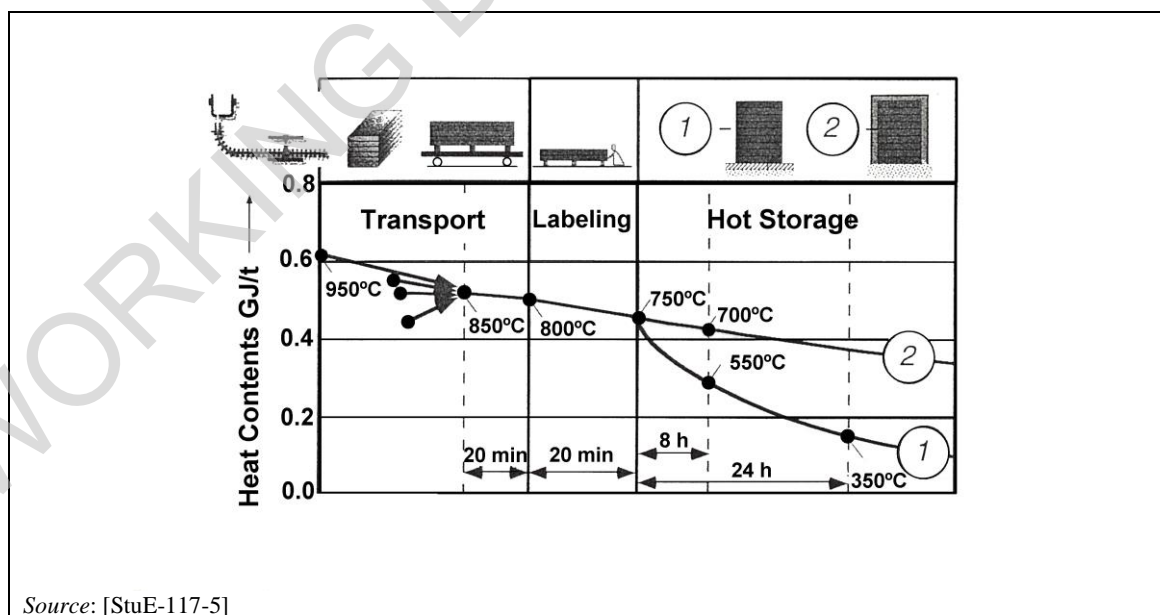


Figure 2.111: Modified storage to increase charge temperature

Cross-media effects

No negative effects on other media are known.

Technical considerations relevant to applicability

- ~~New and existing installations.~~ Generally, there are no technical restrictions to the applicability of this technique.
- All continuous casting plants with an adjacent rolling mill [Com A].
- The same limitations may apply as for hot charging [Input-HR-1].

Economics

- Return on investment in 1 year at VA Stahl Linz [ComA].
- Investment costs of EUR 2 million reported by Voest [Input-HR-1].

Driving force for implementation

- Increased furnace and rolling mill capacity.
- Increased hot charging rate in connection with CAQC. [Com A].

Example plants

- VA Stahl Linz, (maximum 5 000 t), Austria [Input-HR-1].
- HADEED, Saudi Arabia [Com A].
- Stahlwerke Bremen [STuE-117-5].

Reference literature

[EUROFER HR] [ETSU-G76] [DFIU98] [StuE-117-5] [Input-HR-1]
 Ideas and Concepts for Hot or Direct Charging, Paper No. 50, 7th International Continuous Casting Conference, May 20 – 22, 1996 [Com A].

2.4.2.16 Hot charging / Direct rolling**Description**

Continuous-cast steel products are directly charged in the reheating furnaces or directly transferred to the rolling mill in hot conditions.

Technical description

Contrary to the conventional process (storage and cooling of the material), the residual heat from the continuous cast slabs, blooms, beam blanks or billets is utilised by charging them directly (with their residual heat content) into the heating furnaces. Hot charging refers to charging temperatures of 300–600 °C; direct rolling to charging temperatures of 900–1 000 °C. These techniques can only be applied if the surface quality is good enough that cooling and scarfing is not required and if the manufacturing programmes of the steel-making plant and the hot rolling mill can be adequately tuned. Control computers are used to coordinate the production of both departments according to customers' orders and to prepare the rolling schedules.

Figure 2.112 presents a possible material flow in a plant allowing both cold charging and warm or hot charging. An optimised production planning and control system to synchronise the production schedules of a steelworks and a rolling mill can achieve a hot charging share of over 60 % at about 800 °C. A soaking furnace placed before the rolling mill may be required.

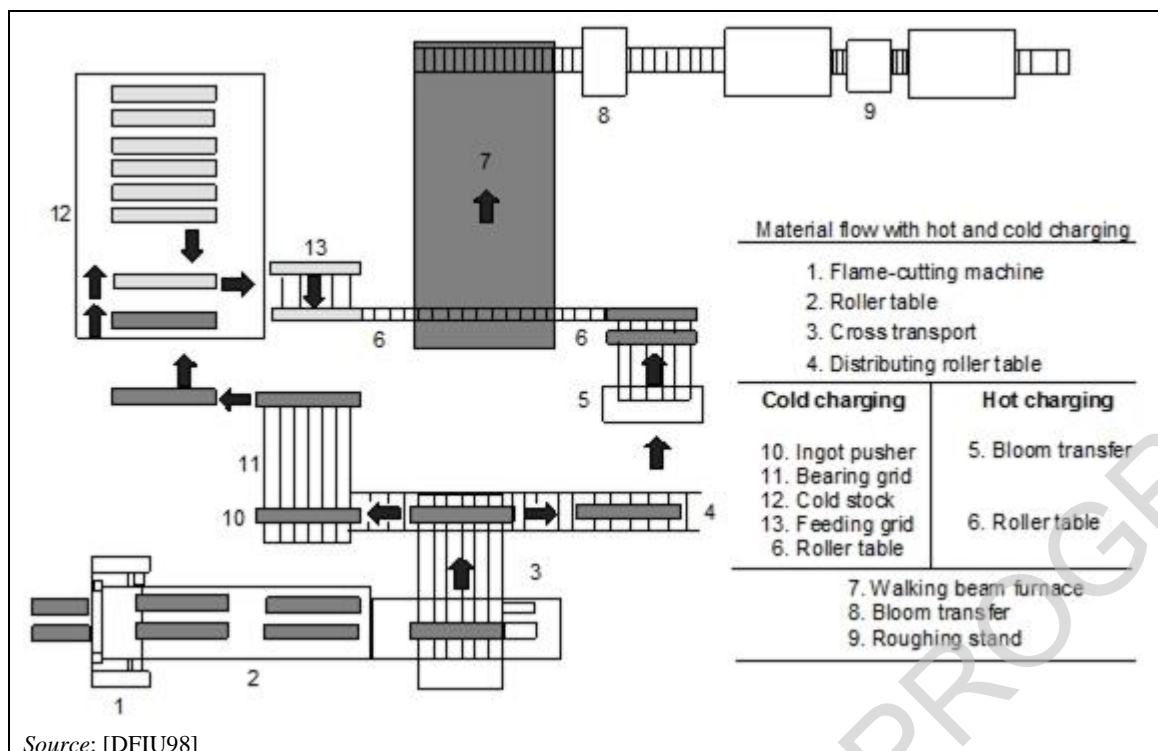


Figure 2.112: Material flow: cold versus hot charging

Achieved environmental benefits

- Reduction in energy consumption (fuel savings).
- Reduction in SO₂, CO and CO₂ emissions.

Environmental performance and operational data

Table 2.17 illustrates the influence of hot charging on energy consumption and production time for hot charging. In the examples shown, the production potential was increased by 10 % for a hot charging temperature of 400 °C and by 25 % for a charging temperature of 700 °C.

Table 2.17: Effect of hot charging on fuel consumption and residence time

| Charging Temperature | | | |
|--|-----------|-----------|-----------|
| | 20 °C | 400 °C | 700 °C |
| Specific energy consumption (fuel) | 1.55 GJ/t | 1.25 GJ/t | 0.94 GJ/t |
| Percentage Reduction | 0 % | 19 % | 39 % |
| Heat to steel | 0.80 GJ/t | 0.56 GJ/t | 0.37 GJ/t |
| Residence time in furnace ¹ | 100 min | 90 min | 75 min |

¹ Example based on: billets, mild steel, top-fired pusher furnace, discharge temperature 1 200 °C.

Source:[ETSU-G77]

Examples

EKO Stahl hot charging of slabs [Input-HR-1]

- percentage of hot charging: 4.63–31.65 %, Ø in 1998 14.64 %;
- average charging temperature of slabs: 700–900 °C;
- fuel consumption (natural gas): 17 Nm³/t;
- energy saving: 0.6 GJ/t.

Rotherham Engineering Steels hot charging of blooms [ETSU-CS-263]

- percentage of hot charging: 66.4 %;
- charging temperature of blooms: ~ 700 °C;

- c. specific energy consumption (SEC): 1.1 GJ/t during productive periods;
1.23 GJ/t including light-up energy;
energy saving: ~ 0.67 GJ/t (compared with a walking-beam type furnace with similar structural energy loss, efficiency of 67 % and SEC 1.9 GJ/t).

Stahlwerke Thuringen hot charging beam blanks [StuE-118-2]

- percentage of hot charging: > 60 %.

British Steel, Scunthorpe hot charging concast blooms [Input-HR-1]

- charging temperature of blooms: ambient up to concast exit temperature ~1 300 °C;
- energy savings of about 33 %;
- specific energy consumption (SEC): 1.35 GJ/t (2.1 GJ/t without hot charging).

Energy savings for hot charging at 300 °C of 15 % were reported in [EUROFER HR].

Imatra Steel, Imatra hot charging of blooms

- engineering steel grades, billets / heavy bars 74 / 26 %;
- percentage of charging via hot route 91–93 %;
- direct hot charging 700–900 °C;
- charging via hot buffer (natural gas fired) 700 °C;
- soaking temperature 1 250–1 290 °C;
- specific energy consumption 0.87 GJ/t (average for production 1998 (98 % natural gas + 2 % electricity) including hot buffer, cold charging, weekends and light-up energy).

Hot buffer is used:

- to eliminate effects of short stoppages in rolling mill;
- to balance the production speed difference when rolling bars (the casting speed cannot be lowered to match the speed of the old rolling mill);
- for slow preheating of cold blooms at weekends.

Cross-media effects

- Reduced stock residence time in the furnace.
- Higher production rates (e.g. 10–25 %).
- Improved yields and product quality due to reduced scaling and decarburisation.
- Waste reduction in the following processes, e.g. descaling.
- Temperature of exhaust gas may increase. [ETSU-G77].

Technical considerations relevant to applicability

- New and existing installations.
- Application may be limited at some existing plants because of plant layout and operational logistics. Important technological parameters are mill type and configuration, proximity of the caster to furnace and rolling mill (time required for the transfer of the stock from the steel plant to the reheating furnace) as well as steel specifications. Sometimes application to furnaces with unfired preheating zones is not possible. The implementation of hot charging or direct rolling depends furthermore on the installation of equipment to allow a higher furnace throughput, temperature normalisation (e.g. edge heaters), schedule free rolling, potential to align the production schedule of the steel plant (caster) and the production schedule of the rolling mill, high quality slabs (surface quality) etc. [DFIU98], [ETSU-G77].

Only applicable to plants adjacent to continuous casting and within the limitations of plant layout and customer demand.

Economics

TWG to provide updated information for the following table or it will be deleted.

Table 2.18: Investment costs for hot charging

| Type of investment | Investment cost | |
|--|---------------------------|--------------------------------|
| | New facilities (M ECU) | Existing facilities (M ECU) |
| Hot charging (at 300 °C) | 1.5 | 2.0 |
| Notes: Basis is a furnace with yearly capacity of 1.5 Mt fired with natural gas with standard burners and without air preheat. Investment costs can be site-specific (available room, layout of the existing furnace, number of side and bottom burners) | | |
| Source: [EUROFER HR] | | |

Driving force for implementation

Reduced energy consumption.

Example plants

- EKO Stahl, [Input-HR-1]
- Rotherham Engineering Steels [ETSU-CS-263]
- Stahlwerke Thuringen [StuE-118-2]

Reference literature

[Input-HR-1] [ETSU-CS-263] [StuE-118-2] [EUROFER HR] [ETSU-G77]

2.4.2.17 Near net shape casting for thin slabs

Description

Thin slabs are produced by combining casting and rolling into one process step. The need to reheat the feedstock before rolling and the number of rolling passes is reduced.

Technical description

Near net shape casting is a process of casting metal to a form close to that required for the finished product. For production of flat products, near net shape casting consists of applying a series of advanced continuous thin slab casting techniques in which the thickness of the produced slab is reduced as far as possible to the required end product shape. Overall, near net shape casting integrates the casting and hot rolling of steel into one process step, thereby reducing the need to reheat the steel before rolling it. [Worrell et al., 2010]

~~'Near net shapecasting' or thin slab casting comprises an improved continuous casting technology in which the thickness of the produced slab is reduced as far as possible to the required end product shape.~~

The technical solutions available differ mainly in the thickness of the slabs, ranging from 15 mm up to 80 mm (conventional thickness ranges 150–300 mm), in the reheat technique and the linkage between caster and hot rolling mill. Available thin slab casting techniques include the following:

- **Compact Strip Production (CSP):** using funnel-type moulds with a casting thickness of approximately 50 mm.
- **Inline Strip Production (ISP):** the cast strand of about 60 mm thickness undergoes a soft reduction (on liquid core) with rolls below the mould, followed by a shaping of the solidified strand creating a slab thickness of about 15 mm.
- **Continuous Thin Slab Casting and Rolling (CONROLL):** using straight parallel moulds with a casting thickness of 70–80 mm.
- **Direct Strip Production (DSP):** 90 mm caster mould and soft-reduction to 70 mm.

The casting machines may be linked to all main configurations of hot rolling finishing mills, e.g. finishing train, planetary mills, Steckel mills, etc.

Figure 2.113 and Figure 2.114 show as examples the schematics of the CSP and the ISP processes.

Furnaces of different design – achieving a uniform incoming slab temperature - are the linkages between the caster and the hot rolling mill. Depending on the type of thin slab production plant, tunnel furnaces or 'cremona boxes' are used. The main target of these facilities is to equalise and homogenise the temperature of the continuous cast slabs of different cross sections and lengths of around 50 m up to 300 m nowadays [Com2 HR] and to regulate the feed to the finishing rolling mill. Dependent on the casting strands, one or two furnaces are installed, connected by a shuttle device.

Firing of continuous furnaces and combustion systems is in general comparable with the common systems of reheating furnaces.

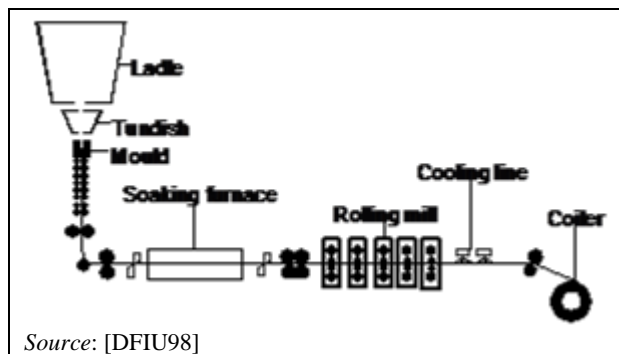


Figure 2.113: Schematic of the CSP process

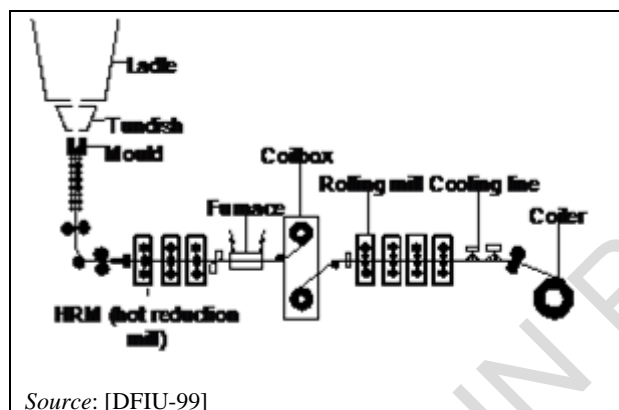


Figure 2.114: Schematic of the ISP process

Achieved environmental benefits

Reduced energy consumption.

Environmental performance and operational data

The production of 1–3 mm thick strip by conventional slab casting - with a charging temperature for the furnace of 20 °C and discharge at 1 200 °C - requires a specific energy consumption of 1.67 GJ/t. A thin slab casting line - with a charging temperature for the furnace of 960 °C and discharge at 1 150 °C - has a specific energy consumption of 0.50 GJ/t.

Grades cast by thin slab casting (commercial production):

- Plain carbon steels outside peritectic range (CSP).
- (0.065–0.15 %C) (CSP).
- High alloyed and stainless (CSP).
- Unalloyed structural steels (ISP).
- Alloyed structural steels (ISP).
- Line pipe steels (HSLA) (ISP).
- Oil field pipe steels (ISP).
- High alloyed austenitic and ferritic steels (ISP)
- Stainless steels CONROLL [Near-Net-Shape].
- Low and ultra-low carbon steel (CSP) [StuE-118-5] [AC-Kolloq].
- C-steel grades with > 0.22 %.
- High strength (micro- and unalloyed) structural steel.
- Deep steel drawing grades.
- Microalloyed Nb steels.

- Cu alloyed structural steels [Near-Net-Shape].

Near net shape casting is employed for the production of :

- ~~For the production of~~ low-carbon steel, higher strength unalloyed and micro-alloyed structural steel and C-steel > 0.22 % [STuE-118-5];
- ~~For production of~~ high-quality stainless steel (austenitic grades, ferritic grades as well as martensitic grades (BHM, 142Jg. 1997, Heft 5, 210 – 214) [Com A].

Table 2.19: Comparison of consumption figures for conventional and thin slab production route

| | Conventional production route Typical Consumption | Thin slab production route Typical Consumption |
|--|---|--|
| Electrical energy ¹ (deformation energy) | 72 - 115 kWh/t average 94 kWh/t (reported by members of shadow group) | approx. 70 kWh/t (deformation only) approx. 77 kWh/t (incl. Coil box) |
| Reheating energy (fuel consumption) ² | approx. 1300 - 1900 MJ/t | approx. 300 - 650 MJ/t |
| ¹ Depends on the degree of deformation; temp. of intermediate strip; material hardness ² fuel consumption depends on the furnace design and thickness of ingoing slab Source: [EUROFER HR] | | |

Cross-media effects

No negative effects on other media are known.

Technical considerations relevant to applicability

- ~~Applicable for new plants.~~
- Only applicable to plants adjacent to continuous casting and within the limitations of plant layout and customer demand.

Economics

The thin slab casting technique effectively opened the flat rolled market to mini mills., ~~which up to that time had been bound more or less to the production of long products.~~ Implementation of this technology shrinks the size of the caster and eliminates the roughing mill, resulting in capital cost savings. Hot band, in the non-critical surface segment, can now be economically produced with capacities of 0.8–1.0 Mt/year (with one-strand casters).

Driving force for implementation

- Increased productivity.

Example plants

Table 2.20: Thin slab casting plants (by July 1995)

TWG could provide updated information for the following table (OLD DATA).

| | Slab dimensions [mm] | Capacity [Mt/a] | Rolled Thickness [mm] | Start Date |
|--|--|--------------------|-----------------------|---------------|
| Compact Strip Production | | | | |
| Nucor Crawfordsville, USA | 50 x 900 - 1350 50 x 500 - 1350 | 0.8 1 | 1.6 1.6 | 7/89 4/94 |
| Nucor Hickman, USA | 50(75) x 1220 - 1560 50(75) x 1220 - 1560 | 1 1 | 1.5 1.5 | 8/92 5/94 |
| Nucor , Berkeley County, USA | 50 x 1680 | 1.5 | 1.2 | 3/97 |
| Geneva Steel Provo, USA | 150-250 x 3200 max or 50 x 1880 max | 1.9 | plate | 7/94 - 95 |
| AST , Terni, Italy | 50 x 1000 - 1560 | NI | NI | 12/92 |
| Hylba SA , Monterrey, Mexico | 50 x 790 - 1350 | 0.75 | 1.2 | 11/94 |
| Hanbo Steel Asan Bay, Korea | 50 x 900 - 1560 50 x 900 - 1560 | 1 1 | 1.5 1.5 | 6/95 12/95 |
| Gailatin Steel , Warsaw, USA | 50 x 1000 - 1560 | 1 | 2.1 | 2/95 |
| Steel Dynamics , Butler, USA | 40-70 x 990 - 1560 | 1.2 | 1.2 | 1/96 |
| Nippon Denro Ispal Calcutta, India | 50 x 900 - 1560 | 1.2 | 1.2 | 8/96 |
| Amalgamated Steel Mills Malaysia | 50 x 900 - 1560 | 2 | 1.2 | 10/96 |
| Ac. Compacta Bizcaya Bilbao, Spain | 53 x 790 - 1560 | 0.91 | 1.3 | 7/96 |
| Acme Metals Riverdale, USA | 50 x 900 - 1560 | 0.9/1.8 | 1.25 | 10/96 |
| Inline Strip Production | | | | |
| Arvedi ISP Works Cremona, Italy | 60* x 1070 - 1250 *(red. to 40 during solidification) | 0.5 | 1.2 | 1/92 |
| Posco , Kwangyang, Korea | 75* x 900 - 1350 *(red. to 60 during solidification) | 1 0.8 | 1.0 1.0 | 1996 1996 |
| Nusantara Steel Corp Malaysia | NI | NI | NI | NI |
| Saldanha , South Africa | NI | (1.4) ¹ | NI | NI |
| Ipsco , USA | NI | (1) ¹ | NI | NI |
| Pohang Iron and Steel South Korea | NI | (2) ¹ | NI | NI |
| Hoogovens Staal ² Ijmuiden, NL | 70 – 90 x ?? | (1.3) | 1 – 2.5 | NI |
| CONROLL | | | | |
| Avesta , Sweden | 80-200 x 660–2100 | NI | NI | 12/88 |
| Armco , Mansfield, USA | 75-125 x 635-1283 | 0.7/1.1 | 1.7 | 4/95 |
| Voestalpine , Linz, Austria | NI | NI | NI | NI |
| Direct Strip Production | | | | |
| Algoma , CAN ³ | 90* x 200 *(red. to 60 during solidification) | NI | 1 | 11/97 |
| NB: NI = No information provided. Source of data [Jahrbuch Stahl 1996], reference year of information 1995 ¹ Source [StuE-116-11], ordered plants, reference year of information 1996 ² Source [Steel News, march 1998] ³ Source [algoma.com] | | | | |

Reference literature

[Worrell et al., 2010]

E. Worrell, P. Blinde, M. Neelis, E. Blomen, E. Masanet (October 2010). Energy efficiency improvement and cost saving opportunities for the US Iron and Steel Industry. An Energy Star® guide for energy and plant managers. pp. 96-97.
[Com2 HR] [Near-Net-Shape] [StuE-118-5] [AC-Kolloq] [Com A]

2.4.2.18 Near net shape casting for beam blanks

Description

Beam blanks are produced by combining casting and rolling into one process step. The need to reheat the feedstock before rolling and the number of rolling passes is reduced.

Technical description

Beam blank casting offers similar advantages for the production of beams as thin slab casting does for the production of flat products including lower rolling costs, higher productivity and reduced energy consumption.

Another – more common - form of ‘near net shape casting’ is applied in the field of long product rolling of structural steel. Instead of the traditional bloom with a rectangular or square cross section, the continuous caster produces an H, I or double T shaped beam blank.

Achieved environmental benefits

Reduced energy input in reheating and rolling.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

No negative effects on other media are known.

Technical considerations relevant to applicability

~~New plants or existing plants in case of a major revamp.~~

Only applicable to plants adjacent to continuous casting and within the limitations of plant layout and customer demand.

Economics

Beam blank casting provides several economic advantages including reduced rolling costs at the roughing mill with approximately 30 % lower investment costs, 15 % increased productivity, 1.5 % higher yield and 55 % reduced energy consumption at the roughing stand. [Hoedl et al., 2003].

Driving force for implementation

- Increased yield in the continuous caster due to the reduced material to be cropped.
- Increased specific heat transfer in the reheating furnace.
- Reduced time in the rolling process, increase in productivity [Com HR].

Example plants

Northwestern Steel & Wire, USA [StuE-114-8]

Chaparral Steel, USA [StuE-114-8]

Kawasaki Steel, Nucor-Yamato, Yamato Steel Tung Ho Steel [StuE-114-9]

Stahlwerke Thuringen [StuE-118-2]

Reference literature

[Com HR] [StuE-114-8]

[Hoedl et al., 2003]

H., Hoedl, F., Wimmer, K.F., Mayrhofer, 2003. VAI beam-blank casting technology – Fundamentals and examples of plant installations. Nota technical – La Metallurgia Italiana, 63-66.

2.4.3 Descaling

2.4.3.1 Material tracking

Description

Peripheral sensors and automation are used to track the position of the rolling stock and adjust the volume of descaling water.

Technical description

Automation of the respective train areas and peripheral sensors allows the exact determination of the entry into and the delivery of the materials from the descaling equipment and allows the operator to open the valves of the pressure-water pipes accordingly. As a result, the water volume can be continuously adjusted to the requirements.

Achieved environmental benefits

- Reduced water consumption.
- Reduced energy consumption.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

- Generally applicable in roughing, finishing and plate mills.
- ~~New and existing~~ Generally applicable in hot rolling mills for flat products.

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

2.4.3.2 Use of high-pressure storage equipment

Description

High-pressure storage vessels are used to keep the water pressure constantly at a high level while reducing the number of start-up of high-powered pumps, thereby reducing energy consumption.

Technical description

Appropriately sized high-pressure storage vessels are used to temporarily store the high-pressure water and to reduce the starting phase of the high-powered pumps. In addition, it is

possible to keep the pressure at a constant level when several simultaneous descaling processes are performed. This method helps to keep the energy consumption within reasonable limits and, in the case of several descaling processes at the same time, helps to ensure optimum cleaning and high-quality products due to the constant system pressure.

Achieved environmental benefits

Reduced energy consumption.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

- Generally applicable in roughing, finishing and plate mills' descaling systems.
- ~~New and existing~~ Generally applicable in hot rolling mills for flat products.

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

2.4.4 Edging

2.4.4.1 Sizing press

Description

Using a sizing press before the roughing mill enables an efficient width reduction of slabs together with a uniform increase of the slab thickness both at the edges and centre of the product. The shape of the final slab is nearly rectangular, reducing significantly the number of rolling passes necessary to reach product specifications.

Technical description

In conventional vertical rolling, width reduction is limited to the slab edges with only little effect on the centre of the slabs. The material thickness increases at the edges, forming dog-bone-shaped cross sections. In horizontal rolling, a significant return in width (e.g. side spreading) takes place, resulting in low width reduction efficiency.

In-line size presses, due to the forging effect on the slab, also increase the material thickness in the middle of the slab. The shape of the cross section is nearly rectangular and side spreading during horizontal rolling passes is reduced.

With the introduction of a sizing press prior to the rougher the width intervals of the caster and the number of wedge-type slabs are reduced. The caster productivity and hot charging rate may therefore be increased. [EUROFER HR]

Achieved environmental benefits

- Reduced energy consumption.
- Reduced trimming and cropping scrap.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

- ~~Roughing and plate mills.~~
- ~~New hot rolling mills for flat products.~~
- ~~Applicability is limited for existing mills.~~

Only applicable to new plants and major plant upgrades for the production of flat products.

Economics

TWG, please provide information.

Driving force for implementation

Improved yield.

Example plants

Sollac Fos, Thyssen Bruckhausen.

Reference literature

[EUROFER HR]

2.4.4.2 Automatic width control comprising short stroke control

Description

With an automatic width control and short stroke function system, the edging process is assisted and controlled by computer models, resulting in fewer defects of the final slab product with less width variations across the transfer bar and a more rectangular shape at the strip ends.

Technical description

In conventional edging the width of the slab is reduced independently of the actual width and temperature of the material, therefore generating width variations along the transfer bar, especially under high width reductions. With the aid of an AWC system, the edging process is performed via computer models. For the strip ends (head and tail), the edging values are reduced across a defined length and thus the formation of so-called tongues at the strip head and/or fishtails occurring in conventional rolling are avoided (See Figure 2.115).

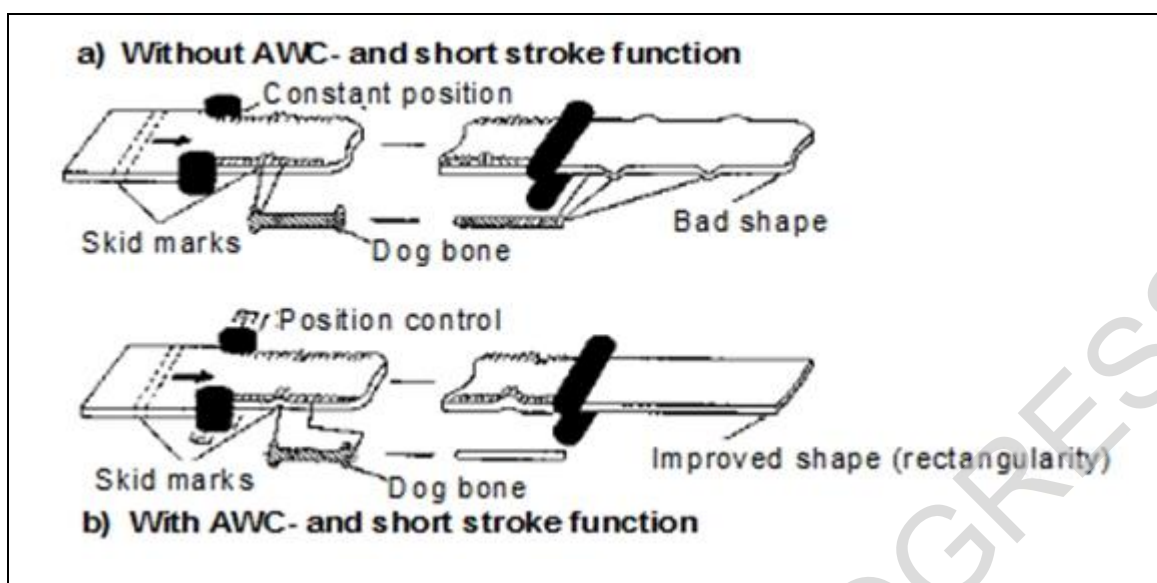


Figure 2.115: AWC operation

Achieved environmental benefits

Reduced trimming, head and tail scrap.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

Increased product quality, improved yield, therefore less material has to be recycled; energy consumption and emissions are reduced.

Technical considerations relevant to applicability

- Generally applicable in roughing, finishing and plate mills.
- ~~New and existing~~ Generally applicable in hot rolling mills for flat products.

Economics

TWG, please provide information.

Driving force for implementation

Improved yield.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

2.4.5 Roughing

2.4.5.1 ~~Process automation~~ Computer aided rolling optimisation

Description

The thickness reduction is controlled using a computer to minimise the number of roll passes.

Technical description

The use of computers allows the adjustment of the thickness reduction per pass. In other words, slabs and blooms are reduced to a rough strip by applying the lowest possible number of passes, even in the case of short interruptions resulting in temperature losses of the material.

Achieved environmental benefits

- Reduced energy consumption.
- Furnace discharge temperature can be decreased.
- Number of roll passes is optimised.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

- ~~Roughing and plate mills.~~
- ~~New and existing hot rolling mills for flat products.~~

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

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

2.4.6 Transport of rolled stock from roughing mill to finishing train

2.4.6.1 Coil boxes

~~A.4.1.7.1 Coil Box~~

Description

Coil boxes are installed between the roughing mill and the finishing mill to minimise temperature losses from transfer bars during coiling/uncoiling processes and allow for lower rolling forces.

Technical description

The intermediate product produced in the roughing train (transfer bar) is wound up to a coil without a mandrel by means of appropriately arranged, electrically driven pinch/bending rolls and cradle rolls. After completion of coiling, the coil is placed on an uncoiling device, decoiled, and passed to the finishing stand (See Figure 2.116). During the uncoiling process and finishing rolling, the coiler is free to receive the next rough strip. In this way, bottlenecks in the production flow can be avoided.

This equipment has the advantage that the temperature distribution across the length of the transfer bar remains constant and the loads during finishing rolling are reduced. On the other hand, the additional energy requirement for the coiling operations must be considered. When modernising existing mills, the product range may be increased.

In the event of a cobble downstream, the coiled bar may be held for a longer period than would otherwise be possible. For longer mill breakdowns, the coiled transfer bar might be stored in so-called heat recovery furnaces. Both measures thereby improve the yield. However, coil boxes may result in increased surface defects.

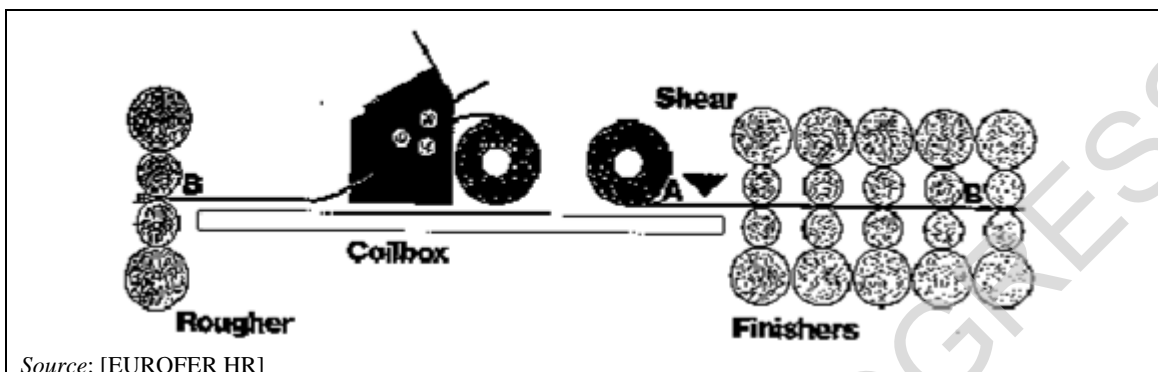


Figure 2.116: Coil box arrangement

Achieved environmental benefits

- Reduced energy consumption.
- Less rolling force required (temperature in stock is higher and more uniform).

Environmental performance and operational data

In some cases a coil box can limit the maximum mill production. [Com HR]

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

- ~~Run-out table of roughing mills.~~
- ~~New and existing hot rolling mills for flat products.~~

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

Economics

TWG, please provide information.

Driving force for implementation

Improved yield.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[Com HR]

2.4.6.2 Coil recovery furnaces

Description

Coil recovery furnaces are used as an addition to coil boxes to restore the rolling temperature of coils and return them to a normal rolling sequence in case of rolling mill interruptions.

Technical description

Coil recovery furnaces were developed as an addition to coil box installations, so that in case of longer rolling interruptions the coils could be restored to rolling temperature and returned to the rolling sequence, which results in a yield improvement. Temperature losses are minimised and even rolling breaks of up to 2 hours can be covered.

Heating and cooling temperature models determine the correct heating cycle for each coil, taking into account the temperature profile of the coil at the start of heating. This profile is determined from data from the mill computer on the temperature at the roughing pass, the time elapsed before and after coiling, as well as bar size and grade. Coils saved using the recovery furnace are rolled into prime hot band, providing they are rolled within 2 hours. Coils held for longer periods are processed to 'non-surface critical' products. (The furnace can be built with an inert gas system.)

Achieved environmental benefits

Reduced energy consumption.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

- Generally applicable in combination with coil boxes at roughing stands.
- ~~New and existing~~ Generally applicable in hot rolling mills for flat products.

Economics

TWG, please provide information.

Driving force for implementation

Improved yield.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

2.4.6.3 Heat conservation during transfer of feedstock after the roughing mill

Description

Insulated shields are used on feedstock transfer tables between the roughing mill and the finishing mill.

Technical description

To minimise temperature loss in a bar while it is conveyed from the rougher to the finishing mill and to decrease the temperature difference of the head and tail ends on entering the finishing train, the transfer roller table can be equipped with heat shields. These are insulated covers applied to the conveyor. For those sizes where the rolled products reach the limit of capacity of the rolling train, this equipment achieves lower rolling loads. However, a potentially higher risk of surface defects (rolled-in scale) and potential damage caused by curled transfer bars was reported for heat retention shields.

Achieved environmental benefits

- Reduced energy consumption.

- Reduced temperature loss.

Environmental performance and operational data

Heat shields on transfer tables involve high maintenance costs as the shields are easily damaged by cobbles. [Com2 HR]

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

- Generally applicable in transport roller table between roughing and finishing mills.
- ~~New and existing~~ Generally applicable in hot rolling mills for flat products.

Economics

TWG, please provide information.

Driving force for implementation

Improved yield.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[Com2 HR]

2.4.6.4 Strip edge heating

Description

Transfer roller tables in hot strip mills are equipped with natural gas burners or inductive heating devices to heat the surface edges of slabs and to maintain uniform slab temperatures.

Technical description

In order to raise the temperature of the cooler strip edges to the overall temperature level and achieve a constant temperature profile across the strip width, the transfer roller table is equipped with additional gas or inductive heating devices.

Achieved environmental benefits

- Reduced energy consumption in finishing rolling.
- Reduced wear occurring on the work rolls (less grinding sludge).

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

Energy used for edge heating.

Technical considerations relevant to applicability

- Generally applicable in transport roller table between roughing and finishing mills.
- ~~New and existing~~ Generally applicable in hot rolling mills for flat products.

Economics

TWG, please provide information.

Driving force for implementation

Improved yield.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

2.4.7 Rolling

2.4.7.1 Crop optimisation

Description

The cropping of the feedstock after roughing is controlled by a shape measurement system (e.g. camera) in order to minimise the amount of metal cut off.

Technical description

By the use of CCD cameras, combined with a width measurement subsequent to the roughing train, the real crop shape of the ingoing rough strip is identified. An automatic system ensures that the cutting action of the shears is limited to cutting off materials outside the rectangular area of the transfer bar (See Figure 2.117).

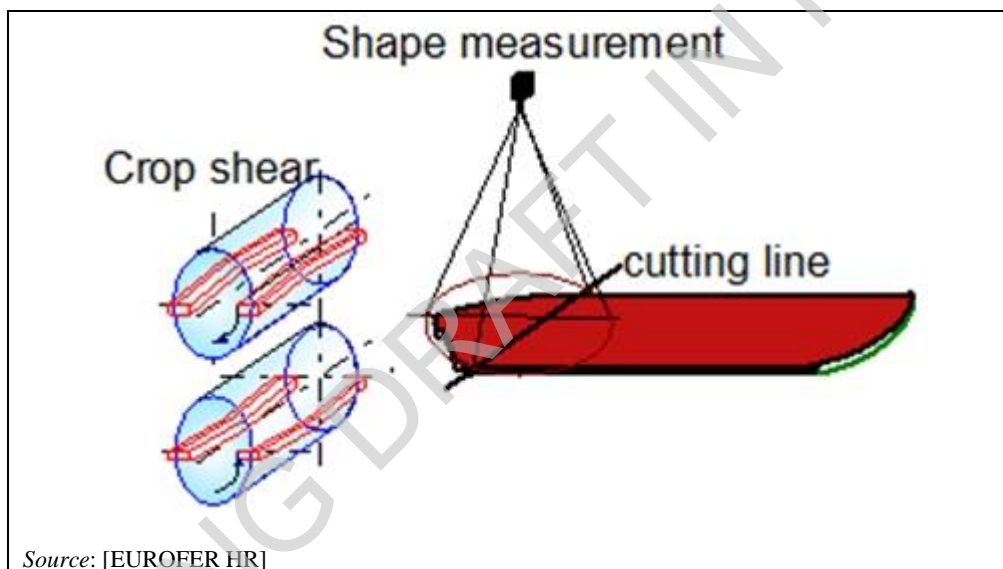


Figure 2.117: Crop optimisation system

Figure A.4-12: Coil Crop optimisation system

Achieved environmental benefits

Scrap (head and tail) reduction.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

- Generally applicable at the entry of finishing trains.
- ~~New and existing~~ Generally applicable in hot rolling mills for flat products.

Economics

TWG, please provide information.

Driving force for implementation

Improved yield.

Example plants

ArcelorMittal Sidmar (Ghent, Belgium).

Reference literature

TWG, please provide information.

2.4.7.2 Reduction of the rolling friction**2.4.7.2 Work roll lubrication system****Description**

Rolling oils are carefully selected and emulsion systems are operated to reduce the friction between the working rolls and the feedstock and to ensure minimal oil consumption.

Technical description

Rolling oils are supplied to the roll gap via nozzles in order to reduce the friction between material and roll, to lower the drive power requirements, to decrease rolling forces and to improve the surface quality of rolled material.

Achieved environmental benefits

- Reduced energy consumption by reduced rolling load.
- Reduced roll wear (especially at the strip edge areas), resulting in a longer lifetime of work rolls and reduction of grinding sludge.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

Contamination of water system with rolling oils.

Technical considerations relevant to applicability

- ~~Finishing stands.~~
- ~~New and existing hot rolling mills for flat products.~~

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

Economics

TWG, please provide information.

Driving force for implementation

Higher mill productivity ~~and increased pickling rate.~~

Example plants

Large number of plants.

Reference literature

TWG, please provide information.

2.4.7.3 Forced interstand strip cooling**Description**

Forced interstand strip cooling helps to maintain the required exit rolling temperature over the whole strip length using water sprays or water curtains and enables rolling at a higher speed, increasing the mill production.

Technical description

Forced interstand cooling of the strip by water sprays or water curtains is employed to permit acceleration of the finishing train while still attaining a constant finishing temperature.

Achieved environmental benefits

- The formation of scale and oxide fumes is suppressed.
- Decreased wear rate of the work rolls in successive stands and reduced grinding sludge.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

Generation of waste water.

Technical considerations relevant to applicability

- Generally applicable between finishing stands.
- ~~New and existing~~ Generally applicable in hot rolling mills for flat products.

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

2.4.7.4 Interstand strip tension control

Description

Looper systems combined with computer models are used to accurately calculate the strip tension between finishing stands in order to prevent necking of the strip after threading and to reduce excessive trimming of strips.

Technical description

Normally loopers are used for controlling strip tension between finishing stands. Various looper designs (hydraulic, low inertia and tension measuring devices) are available. Additionally, so-called looper-less techniques have been developed but their successful operation depends largely on the measurement accuracy of processing parameters. Improved looper systems combined with computer models for calculating the strip tension and appropriate electronics control facilitates the independent control of both tension and looper height. This mainly avoids necking of the strip after threading and unstable operation.

Automatic systems for controlling the strip width when leaving the finishing mill train and/or approaching the coilers (with feedback to the computer models of the finishing train) supports the tension control system.

Achieved environmental benefits

Trimming scrap is reduced by avoiding ‘necking’ during threading and unstable operation.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

- Generally applicable in finishing trains.
- ~~New and existing~~ Generally applicable in hot rolling mills for flat products (part of mill automation systems).

Economics

TWG, please provide information.

Driving force for implementation

Improved yield.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

2.4.7.5 Strip profile and flatness control**Description**

In hot strip mills, the cross-sectional profile and flatness of the hot band is controlled using advanced computer models in order to achieve the desired strip profile without exceeding the required flatness tolerances.

Technical description

The cross-sectional profile and flatness of the hot band is of importance for subsequent processing and is dependent on a number of operating conditions including the pass schedule practice.

The principle purpose of strip profile and flatness control in rolling mills is to achieve the desired strip profile without exceeding the required flatness tolerances. In application to hot rolling mills, strip profile and flatness control systems are commonly designed to achieve the following targets:

- strip crown control range from approximately 0 μm to 75 μm ;
- strip crown tolerances;
- strip flatness of approximately 10 I-Units (I-Unit: $\Delta L/L = 10^{-5}$ m);
- reduction in edge drop.

To maintain good strip flatness in hot strip mills, there are only certain maximum changes in the strip crown to thickness ratio that are possible in one rolling pass without introducing undesirable disturbances to strip flatness, known as ‘flatness deadband’. Different actuators are developed for an objective selection of strip profile and flatness:

- work roll and back-up roll bending systems;
- flexible body adjustable crown rolls;
- flexible edge adjustable crown rolls;
- roll crossing systems;
- axially shifting systems with non-cylindrical rolls;
- axially shifted cylindrical rolls;
- automatic gauge control.

In hot strip mills, each stand is usually equipped with a roll bending system that can be either crown in, crown out or both. If that is not sufficient to reach the crown requirements, the stands can be equipped with additional actuators such as CVC rolls (Continuously Variable Crown), UPS rolls, roll crossing systems or others. A computer mill set-up model, sometimes comprising neural networks, calculates the required settings of profile and flatness actuators under consideration of the thermal crown of the roll body to obtain the desired strip crown and flatness.

Downstream of the mill stands, profile measuring devices (sensors) are installed to monitor the actual crown. The actual crown is compared to the target and the difference is used to produce changes mainly in the roll bending forces. Flatness control loops lead to nearly constant strip crown-to-thickness ratio. Shape meter devices are installed either at the end of the finishing train or between mill stands to monitor the actual flatness. Detected flatness errors are again used to adjust roll bending forces.

Achieved environmental benefits

Reduced scrap.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

- Generally applicable in finishing and plate mills.
- ~~New and existing~~ Generally applicable in hot rolling mills for flat products (part of automatic process control).

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

2.4.7.6 Work roll cooling

Description

Different water spray nozzle types and spray header configurations are used to cool the work rolls, prevent damage and cracks in the rolls and reduce the formation of scale.

Technical description

In the mill stands a wide variety of water spray nozzle types and spray header configurations are used to cool the work rolls. This is important to avoid damage and cracks in the rolls (which means less grinding operations and waste generation) and reduces the formation of scale.

Achieved environmental benefits

- Reduced scale formation.
- Reduced roll wear and reduced grinding sludge.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

- Generally applicable in roughing, finishing and plate mills.
- ~~New and existing~~ Generally applicable in hot rolling mills for flat products.

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

2.4.7.7 Finishing train automation – process and basic automation

Description

Process computers supported by control loops are used for production planning and control of furnaces in rolling mills, allowing real-time updates of the production schedule in case of interruptions.

Technical description

High-quality materials can be produced by using process computers supported by appropriate control loops (basic automation - level I) for production planning and control of furnaces and roughing mills. In the event of short rolling interruptions, the implemented flexible software models allow pass schedule changes up to the last moment (just before grabbing in the first stand).

Achieved environmental benefits

Reduced scrap from short mill breakdowns.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

- Generally applicable in finishing mill.
- ~~New and existing~~ Generally applicable in hot rolling mills for flat products.

Economics

TWG, please provide information.

Driving force for implementation

Increased yield.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

TWG, the title of the following technique has been modified.

2.4.7.8 Air extraction of emissions from mechanical processes and welding combined with waste gas treatment

~~A.4.1.8.8 Reduction of Fugitive Emissions / Oxide Removal System~~

Description

Emissions from slitting, descaling, roughing, rolling, finishing, levelling and welding are collected as close as possible to the source using for example hood or lip extraction. Abatement systems employed to treat dust emissions include fabric filters, ESPs and wet scrubbers.

Technical description

Dust particles (e.g. iron oxide) are released in the hot rolling process as fugitive emissions. The airborne particles are released mainly at the exit side of mill stands (where the speed of the mill stands is the highest). They may be suppressed by water sprays or removed by dedicated exhaust systems: suction hoods, dust hoods, lip extraction or suction lines. Fugitive emissions are treated using different types of abatement systems including water sprays, venturi scrubbers, wet electric filtering or other exhaust systems such as pulse-jet filters (dry-type, bag filters) or wet-filters.

Water sprays

With the spray water, the suppressed oxides are led to the roller table flumes and on to the water treatment, where they are recovered in settling basins and filters.

Venturi scrubbers

In roughing mills, the rolling dust is extracted with a high-pressure scrubber (30 bar) and conducted to venturi scrubbers. The collected sludge is led on to the scale canal and to the hot rolling mill water circuit. Scale is collected from the water circuit and can be further processed as raw material in the melt shop. [EUROFER 23-7-18]

Wet electric filters

Dust from hot rolling mills is cleaned using a two-step wet electric filter. The first step consists of treating the dust-bearing gas to be purified using water sprays to saturate it with water vapour

before entering a second step in an electrical field where it is precipitated. Collected dust sludge can be further processed to be used as a raw material in the melt shop. [EUROFER 23-7-18]

Pulse-jet filters (dry or fabric filter) / Wet- filters

Another option is to install an exhaust system, where dust hoods are installed between the mill stands (mainly behind the last three finishing stands) to collect the dust and oxides. Via suction pipes at the mill drive side, the oxide-dust mixture is drawn off and routed to pulse-jet filters (dry-type, fabric filter) or wet- filters. The separated dust and oxides are transported into buckets via screw conveyors and are recycled in integrated steel plants.

Achieved environmental benefits

Reduction of dust emissions.

Environmental performance and operational data

TWG, the previous BREF information of that section is to be deleted and replaced by the new TWG input below.

Table 2.21: Achieved emission levels and operational data for oxide removal systems

| | | Particulate Emission [mg/m ³] | Capacity [Mt/a] | Costs EURO '000 |
|----------|--|---|---------------------------|----------------------------------|
| a | Water sprays | | | IC: 50 |
| a | Hood and Bag filter¹ | <50 | 3 | IC: 280 |

a: [CITEPA], level was reported BAT level of the air BAT note
IC: Investment costs

Examples Water sprays:

Water sprays are installed in the last finishing stand. The equipment comprises 6 nozzles in the upper part and 8 nozzles in the lower part at each stand. The water is sprayed at a flow rate of 22 l/min and a pressure of 8 bars. The total water flow of the spraying system is 35 m³/h. Costs given for 1994: 50000 ECU.

Table 2.22: Typical reduction of fugitive emissions by water spraying

[Input HR 1]

| Sampling location Sampling Duration: 3 h | Concentration of particulate matter | |
|---|--|-------------------------|
| | without spraying | with spraying |
| Above the finishing mill | 6.02 mg/Nm ³ | 2.35 mg/Nm ³ |
| Roof | 2.77 mg/Nm ³ | 0.63 mg/Nm ³ |

The measuring system does not correspond to any standard, because the emissions are more or less diffuse. The sampling points were chosen valuing from where the emissions came due to aspiration in the workshop because there were no well defined flows.

Annual average dust emission levels of less than 10 mg/Nm³ can be achieved with venturi scrubbers and less than 5 mg/Nm³ with wet electric filtering. Venturi scrubbers typically have separation efficiencies of 90–95 %. Wet electric filters typically have separation efficiencies of 99 %. [EUROFER 23-7-18].

Cross-media effects

- Water sprays result in waste water; oxides have to be recovered from the waste water.
- Dry systems consume energy but, like exhaust/bag filters, have the advantage that they avoid the need to recover the oxides from waste water and the collected dust can be recycled internally. [Com2 HR].
- Consumption of water and electricity.

Technical considerations relevant to applicability

- Generally applicable in finishing mills.
- ~~New and existing~~ Generally applicable in hot rolling mills for flat products.

Economics

TWG, please provide information.

Driving force for implementation

- Reduction of dust emissions.
- Reduction of emissions of ferrous oxides. [Input-HR-1]

Example plants

- Outokumpu Tornio.
- Water sprays WSM Avilés, Aceralia; Sidmar, Hoogovens, US Steel Košice.
- Exhaust System Voestalpine.

Reference literature

[EUROFER 23-7-18] [Com2 HR] [Input-HR-1]

TWG, Section A.4.1.8.9 from the old BREF (Minimisation of hydrocarbon contamination of process water) has been moved and the updated information can now be found in Chapter 7 (Section 8.7.3).

2.4.7.9 Hydraulic coilers comprising step control

Description

Hydraulically operated coilers with step control systems lift the wrapper rollers automatically using sensors when the strip head passes the individual roller in order to reduce the amount of crop scrap and increase the production yield.

Technical description

In conventional coiling, the strip is in contact with the wrapper rollers during at least three turns of the mandrel and penetrates the overlaying winding. These parts of the hot band have to be removed for subsequent processing in the cold rolling mill. Hydraulically operated coilers comprising step control systems lift the wrapper rollers automatically, commanded by sensors, when the strip head passes the individual roller.

Achieved environmental benefits

The amount of crop scrap in the subsequent processes is reduced.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

- Generally applicable in hot strip mills.
- ~~New and existing~~ Generally applicable in hot rolling mills for flat products.

Economics

TWG, please provide information.

Driving force for implementation

Increased yield.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

TWG, the title of the following technique has been modified.

2.4.7.10 Control of the feedstock shape during rolling**Description**

The deformations of the feedstock during rolling are monitored and controlled in order to ensure that the rolled steel has a shape as rectangular as possible and to minimise the need for trimming.

Technical description

During conventional plate rolling by maintaining a constant plate thickness during each rolling pass, a distinct distortion of the plate plan view from true rectangular shape takes place. Employing shape-controlled rolling, tapered thickness profiles or dog bones will be produced during rolling. Supported by measurements (load or shape), the amount of dog bone formation or tapering is computed and the correction signals are sent to the roll-adjusting system. The plan view control is mainly employed as an addition to the automatic gauge system. The term 'shape rolling or plan view control' is applied to a range of techniques that employs rolling a plate of variable thickness during the intermediate passes, which results in rectangular final plate shape and a reduction in trimming scrap.

Achieved environmental benefits

Reduced scrap.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

- Generally applicable in plate mills.
- Generally applicable in new plants and with limitations for existing plants.

Economics

TWG, please provide information.

Driving force for implementation

Increased yield.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

2.4.7.11 On-line heat treatment (accelerated cooling)

Description

On-line heat treatment with accelerated cooling enables the production of steel rolled products with the required material structure and mechanical properties without the need for additional reheating steps to reach specifications.

Technical description

On-line heat treatment of rolled materials with accelerated cooling is used at hot rolling plants to reach the required material structure and mechanical properties without the need for reheating. Heat treatment provides an efficient way to manipulate the properties of steel provided that the cooling rate of the steel product is controlled accurately. The rate of cooling is defined by a heat transfer coefficient. Good controllability of the heat transfer coefficient can be reached using either air-water or water nozzles. Thus, an on-line heat treatment with the assistance of spray nozzles enables a manufacturing process that can improve product performance by increasing steel strength, hardness and other desirable characteristics, while reducing the overall energy consumption of the hot rolling mill. [Hnizdil et al., 2018] [Kotrbaček et al., 2006]

Cooling devices of various design (e.g. water curtains, water pillows, etc.) are arranged behind the rolling mill stand. By controlling the cooling water volume under consideration of sheet temperatures, in-line treatment, such as normalising or quenching, can be applied.

Achieved environmental benefits

Reduced energy consumption and emissions from subsequent heat treatment furnaces.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

- Generally applicable in plate mills.
- Generally applicable in new plants and with limitations for existing plants.

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[Hnizdil et al., 2018]

M. Hnizdil, M. Chabíčovský, 2018. Experimental study of in-line treatment of 1.0577 structural steel. *Procedia Manufacturing* 15, 1596 – 1603.

[Kotrbaček et al., 2006]

P. Kotrbaček, M. Horský, M. Pohanka, 2006. Experimental study of heat transfer in hot rolling, *Revue de Metallurgie, Cahiers D'Informations Techniques* 103-7, 333–341.

2.4.7.12 Thermomechanical rolling operation

Description

Thermomechanical rolling allows the production of steel slabs with very high strength and toughness without the need for additional heat treatments, resulting in an overall reduction of energy consumption in the rolling mill.

Technical description

In a 'thermomechanical rolling operation', the properties of hot rolled plates or sections are influenced to reduce the need for subsequent heat treatment. Slabs or blooms/beam blanks from the reheating furnace are rolled to an intermediate thickness, followed by a holding period (during which water sprays may be applied) to cool down to a desired temperature and are then finally rolled. Thermomechanical rolling leads to the slab achieving a finer-grained microstructure. This technique provides very high strength and very good toughness to the slab product using less alloying additives and with or without a reduced need for subsequent heat treatments, such as normalising. In addition, thermomechanically rolled steels exhibit much better weldability than normalised steel.

Achieved environmental benefits

- Reduced energy consumption.
- Reduction of emissions from heat treatment.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

- Generally applicable in plate and section mills.
- ~~New and existing plants~~ Generally applicable, provided sufficient rolling power is available [Com HR].

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[Com HR]

2.4.7.13 Three-roll reducing and sizing block

Description

A three-roll reducing and sizing block (RSB) is a finishing rolling mill composed of three rolls with adjustable positions enabling the fabrication of wire rods and bars of intermediate sizes without having to change the rolls, increasing production flexibility and productivity while reducing energy and lubricant consumption.

Technical description

A three-roll RSB is a finishing rolling mill suitable for use in wire rod and bar mills. It is composed of a rolling stand containing three rolls and associated guides with adjustable positions which enable the rolling of products to very tight size tolerance and any desired finished size within a specified size range. Compared to conventional intermediate mills, the three-roll RSB technique increases the production flexibility and productivity of the plant while reducing energy and lubricant consumption.

In conventional rolling mills, the tolerance of the finished product is influenced mainly by the variations in the cross section of the feed material entering the finishing section of the mill. A three-roll RSB for the production of wire rod and bar allows twist-free rolling of quality steels, special grades, super alloys, sintered materials as well as non-ferrous metals and their alloys in very compact blocks. In addition, a three-roll RSB reduces the spread during deformation. As a result, deformation homogeneity during rolling is improved.

A three-roll RSB is equipped with a quick stand changing system and advanced roll changing and adjustment facility in the roll shop, enabling extremely quick stand and roll changes. It also provides the possibility to jump to and from any size in the mentioned range of finished bar sizes (sequence-free rolling). As a result, the production flexibility of the plant is significantly improved and productivity is increased with high gains in yield and throughput. Finally, a three-roll RSB allows rolling at temperatures lower than in conventional finishing mills, resulting in significant energy savings. [Ammerling, 2005]

Figure 2.118 provides a schematic of a three-roll RSB.

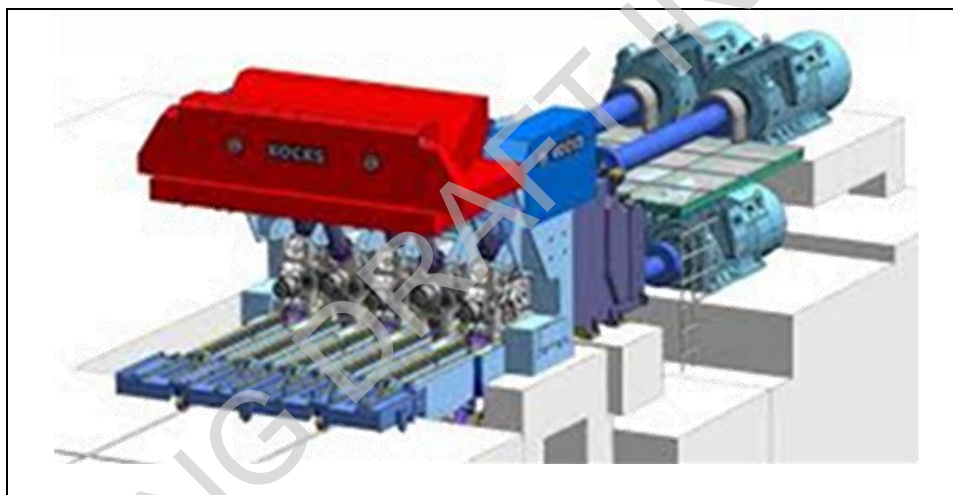


Figure 2.118: Schematic of a three-roll reducing and sizing block

Several versions of the three-roll technologies are commercially available including:

- **Three-roll reducing and sizing block [RSB]**
Finishing block for bar and/or pre-finishing block for wire rod within a diameter range of 5.0–160.0 mm as well as corresponding hexagon dimensions.
- **Three-roll pre-finishing block [PFB]**
For sizing of entry cross section for the wire rod finishing block within a diameter range of 5.0–30.0 mm as well as corresponding hexagon dimensions.
- **Three-roll reducing block [RB]**
In roughing and intermediate mills of wire rod and bar mills to produce intermediate sizes within a diameter range of 12.0–160.0 mm as well as corresponding hexagon dimensions.
- **Three-roll wire rod finishing block [WRB]**
Finishing block in wire rod mills for finishing sizes within a diameter range of 5.0–23.0 mm as well as corresponding hexagon dimensions.

Achieved environmental benefits

- Reduced oil consumption due to lower rolling temperatures and quick stand changes.
- Reduced energy consumption due to reduced temperatures during rolling.

Environmental performance and operational data

It has been reported that the installation of a three-roll RSB at a conventional bar mill has resulted in a productivity increase of 14.9 % (the productivity being expressed in tonnes/operating hours). Similarly, in conventional wire rod and bar mills, productivity increases between 14.4 % and 16.1 % are reported. Installation of a three-roll RSB also significantly reduces the oil consumption (e.g. approximately 20 % and 80 % decrease in the consumption of lubricating and hydraulic oils, respectively, in comparison with conventional wire rod and bar mills). [EUROFER 10-7-18]

Cross-media effects

None.

Technical considerations relevant to applicability

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

Economics

- Economic benefits due to reduced downtime for size and grade changes (quick stand and roll changing).
- Economic benefits due to increased rolling speed and throughput.
- The installation of a three-roll RSB in a conventional mill increases the rolling speed and productivity by approximately 20 % which provides a quick return on the relatively high initial investment costs. [Seki et al., 2007]

Driving force for implementation

- Reduced costs due to minimised downtime and increased productivity by transferring all operations that interrupt production from the mill line to the roll shop. [Ammerling, 2005]
- Increased flexibility within the intermediate mill with the possibility of rolling different finished sizes at any time.
- The utilisation of a three-roll RSB results in very uniform deformation, with less spreading and more elongation during the rolling process.

Example plants

In total, 93 plants worldwide were retrofitted with a three-roll RSB between 1977 and 2018. The European plants equipped with this technology include:

- Acciaierie Valbruna, Bolzano – Italy;
- Liberty Speciality Steels, Rotherham – UK;
- Ascometal, Hagondange – France;
- Saarstahl, Neunkirchen & Nauweiler & Volklingen – Germany;
- BGH Edelstahl, Frittal – Germany;
- Rodaccia, Milan – Italy;
- Acciaierie Bertoli Safu, Pozzuolo del Friuli – Italy;
- Arcelor Mittal Steel, Gandrange – France.

Reference literature

[EUROFER 10-7-18]

[Seki et al., 2007]

Seki, R., Nakajima, K., Hasegawa, K., Yoshimura, K., 2007. Making to High performance and productivity improvement of steel bar and wire rod rolling process. Nippon Steel Technical Report N. 96, 21-28.

[Ammerling, 2005]

Ammerling, W.J., 2005. Implementation of a new 3-roll reducing and sizing block in a wire rod and bar mill. In *Millenium Steel - Hot rolling*, 215-219.

2.4.8 Cooling lines

2.4.8.1 Optimised water pumps for laminar flows

Description

Optimised cooling water flow control systems are installed in a hot strip mill to accurately control the amount of cooling water supplied to the laminar cooling pump station in order to cool down the rolled strips while optimising water consumption and energy use.

Technical description

In hot strip mills, a series of pumps feed cooling water to a laminar cooling pumping station that is used to provide a continuous stream of water for cooling rolled strips. The cooling water flow control system is composed of pumps equipped with electric motors for suction and delivery of water (servo-drive or variable speed) and water piping for the supply of water to the rolled strip. The strip is cooled using a stream of water delivered both from the top and the bottom in automatic mode, according to cooling strategies for specific technological codes, to coiling temperature, or depending on the hot strip rolling thickness. Generally, the amount of water necessary for cooling is controlled and varies depending on the required outlet temperature of the strip. [EUROFER 31-5-17]

Two main systems are developed for the optimisation of the strip cooling:

- Optimised flow control of the valves with servo-drive, and conventional drives for electric motors.
- Optimised flow control of the pumps with electric motors: variable speed drive (through variable frequency), and conventional valves with on/off control. It is important to note that with the variable speed drive technology, the maintenance required is higher compared to the optimised control-valve technology. In order to ensure uniform cooling of the strip, side water blowers are installed behind each cooling section to remove cooling water from the strip. [EUROFER 31-5-17]

These optimised flow control systems enable the delivery of the exact quantities of cooling water required for cooling rolled strips to the right temperature, thereby reducing water consumption and the energy costs related to pumping water.

Achieved environmental benefits

Reduced energy and cooling water consumption [EUROFER 31-5-17]

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

TWG, please provide information.

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[EUROFER 31-5-17]

TWG, Section A.4.1.10.1 from the old BREF " Subsequent sheet production and leveller dust removal" has been deleted as it is now covered under Section 2.4.7.8.

TWG, the following Section has been added to cover HRPO.

2.4.9 Pickling and oiling of hot rolled steel (HRPO)

For techniques to consider in the determination of BAT see techniques applied in cold rolling (section 3.4.1) and general techniques in Chapter 8 (sections 8.8.4 and 8.8.7).

2.4.10 Roll shop**2.4.10.1 Good operational practices for roll shops****Description**

The conditioning of work rolls and back-up rolls used in finishing and roughing mills is carried out in the roll shop where good operational practices are used for solvent usage and management of residues (e.g. recycling or disposal). The grinding sludge is treated by magnetic separation for recovery of metal particles and recycled to iron and steel production. Worn working rolls unsuitable for texturing are recycled to iron and steel production or returned to the manufacturer for refabrication.

Technical description

In the roll shop, work rolls are cooled and reconditioned using a range of cleaning techniques to remove deposits and lubricants. Typical cleaning techniques are stem cleaning, use of alkali solutions or organic solvents for degreasing. For all these operations, good operational practices are implemented concerning the following:

Use of solvents

- As far as technically acceptable for the degree of cleanliness required, water-based degreasing should be applied.
- If organic solvents are used, preference should be given to non-chlorinated solvents.

Management of wastes and residues

- Grease removed from roll trunnions is collected and disposed of properly (e.g. by incineration).
- Grinding sludge is treated by magnetic separation for recovery of metal particles which are recycled into the steel-making process.
- ~~Mineral residues from grinding wheels are deposited in landfills.~~
- Steel and iron turnings are recycled into the steel-making process.
- ~~Worn grinding wheels are deposited in landfills.~~
- Worn rolls which are unsuitable for further reconditioning are recycled into the steel-making process or returned to the manufacturer for refabrication.
- Cooling liquids and cutting emulsions are treated for oil/water separation. Oily residues are disposed of properly (e.g. by incineration).

- Waste water effluents from cooling and degreasing as well as from emulsion separation are recovered by the hot rolling mill water treatment plant.

Achieved environmental benefits

Reduction of the overall environmental impact.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

~~New and existing~~ Generally applicable in roll shops.

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

2.4.11 Water treatment

2.4.11.1 Semi-closed and closed cooling water circuits

~~A.4.1.12.1 Reduction of Water Consumption and Discharge~~

Description

Semi-closed and closed loop water circuits are used in hot rolling mills to reuse the cooling water after treatment and to minimise water consumption.

Technical description

A technical description of semi-closed and closed loop water circuits, with discharge as low as possible, is provided in Section 2.2.17.

Achieved environmental benefits

Reduction of waste water and pollutant discharge.

Environmental performance and operational data

Table 2.23 shows the emission levels achieved with semi-closed and closed water circuits. For comparison, the levels achieved using an open circuit (e.g. once-through) are also given.

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Table 2.23: Typically achieved effluent levels for different water treatment systems

| Parameter | Open circuit | Semi-closed circuit | Closed circuit |
|---|-----------------|---------------------------|--------------------------|
| Suspended solids (SS) | ≤ 40 mg/l | ≤ 40 mg/l | ≤ 40 mg/l |
| Specific emission of SS | approx. 800 g/t | approx. 480 g/t | 0 - 40 g/t |
| Water consumption | 100 % | approx. 60 % ¹ | approx. 5 % ¹ |
| COD (O ₂) | ≤ 40 mg/l | ≤ 40 mg/l | ≤ 40 mg/l |
| Specific emission of COD | approx. 800 g/t | approx. 480 g/t | approx. 38 g/t |
| Hydrocarbons (HC) (related to mineral oil) | ≤ 5 mg/l | ≤ 5 mg/l | ≤ 5 mg/l |
| Specific emission of HC | approx. 100 g/t | approx. 60 g/t | approx. 5 g/t |

Notes: Based on a production of approx. 3.0 Mt. Waste water treatment consisting of a combination of individual measures as described in the following chapter (no detailed information available)

¹ Compared with open-circuit, absolute values for water consumption depends on the individual plant situation.

Source: [EUROFER HR].

Cross-media effects

- Increased energy consumption and consumption of chemicals.
- Waste (sludge) generation.

Technical considerations relevant to applicability

- In some cases, upgrading existing plants from 'wet mills' (once-through) to mills equipped with semi-closed or closed water circuits is not possible owing to insufficient space for installing a waste water treatment plant.
- Depending on local conditions (where sufficient cooling water and receiving surface water are available), once-through water cooling systems are applied. [EUROFER 23-7-18]
- Once-through systems are commonly applied to large-capacity installations such as integrated steelworks at locations where sufficient cooling water and receiving surface water are available. Using a once-through system has the advantage of avoiding the formation of fog and industrial snow in cold European climatic conditions as a result of the condensation of steam emissions from the cooling towers. [EUROFER 23-7-18]

Economics

Investment costs strongly depend on factors such as the existing infrastructure, secondary cooling water quality or local climatic conditions. [EUROFER 23-7-18]

TWG to provide updated information for the following table or it will be deleted.

Table 2.24: Estimated costs for different water treatment plants

| Process | Investment costs | Operating costs | Water volume flow/consumption |
|------------------------------------|-----------------------------|--------------------|---|
| Open circuit treatment plant | ECU 9.4 – 14.4 million | ECU 0.5 – 0.65 / t | 4000 m ³ /h |
| Semiclosed circuit treatment plant | ECU 13.0 – 14.5 million | ECU 0.6 – 1.15 / t | 2500 m ³ /h |
| Closed circuit treatment plant | | | m ³ /h |
| •with cooling tower | ECU 25.0 up to 40.0 million | ECU 1.45 / t | additional water consumption (cooling tower) and/or cooling water in large quantities for heat exchangers |
| •with heat exchanger | ECU 43.2 million | ECU 1.6 – 1.75 / t | |

Notes: Source of data [HR]. Basis is a production of about 3.0 Mt/year hot rolled products. Investment costs exclude costs for building ground and shops, but include the necessary infrastructure. Operating costs are typical examples only; sludge and dust removal (disposal) is not considered.

Driving force for implementation

TWG, please provide information.

Example plants

Semi-closed: *TWG, please provide information.*

Closed: ArcelorMittal Bremen, U.S.Steel Košice

Reference literature

[EUROFER 23-7-18]

TWG, Section A.4.1.12.2 from the old BREF "Treatment of scale and oil bearing process water" has been moved and the updated information can now be found in Chapter 8 (Section 8.7.8).

TWG, Section A.4.1.12.3 from the old BREF "Cooling water treatment" has been moved and the updated information can now be found in Chapter 8 (Section 8.7.9).

TWG, Section A.4.1.13.1 from the old BREF "Internal recycling of dry or drained oxides" has been moved and the updated information can now be found in Chapter 8 (Section 8.11.1.5).

TWG, Section A.4.1.13.2 from the old BREF "Recycling technologies for oily mill scale" has been moved and the updated information can now be found in Chapter 8 (Section 8.11.1.2).

2.5 Emerging techniques for hot rolling

TWG, the content of the previous BREF in this Section has been deleted for Draft 1.

Emerging techniques present in the old BREF, for which information was received from the TWG, have been moved and integrated as BAT candidates. For other remaining emerging techniques, the TWG is requested to indicate whether they should be kept (in which case updated information should be sent), or deleted.

Finally, the TWG is requested to send information on possible new emerging techniques that could be considered in the revised version of the BREF document.

3 COLD ROLLING

3.1 General information on cold rolling

For the entire Section 3.1 'General Information on cold rolling', Please provide updated information for Tables 3.1 to Table 3.4 and Figures 3.1 and 3.2 (Reference dates; 1996 – OLD DATA)

3.1.1 Cold rolled flat products

The total production of cold rolled products in 1994 was 39.7 million tonnes in the EU-15. Production of stainless and electrical sheet stood at 2.3 million tonnes and 1.14 million tonnes respectively, representing 6.4 % and 3.2 % of the total. [EGKS95]

Cold rolled wide strip

Cold rolled sheets and plates production was 39.6 million tonnes in 1996. [EUROFER CR] Table 3.1 gives the production of cold rolled sheet and strip for individual Member States. The number and production capacity for different cold rolling mills in the EU is shown in Table 3.2.

Table 3.1: CR sheet and strip production in 1996

| | Production of cold rolled sheet and strip [thousand t] |
|-------------------------|---|
| Austria | 1 289 |
| Belgium | 3 852 |
| Denmark | 0 |
| Finland | 890 |
| France | 6 296 |
| Germany | 10 615 |
| Greece | 380 |
| Ireland | 0 |
| Italy | 4 271 |
| Luxembourg | 336 |
| Netherlands | 2 088 |
| Portugal | 202 |
| Sweden | 1 174 |
| Spain | 3 093 |
| UK | 4 026 |
| Total | 38 512 |
| <i>Source: [Stat97]</i> | |

Table 3.2: Number and nominal capacity of CR mills

| | Number of mills | Average hourly technical capacity [t/h] | Scheduled for closure after 1993 |
|--|------------------------|--|---|
| Wide strip tandem mills | 44 | 138 | 2 |
| Wide strip reversing quattro high mills | 36 | 31 | NI |
| Wide strip multiple-cylinder cold mills | 43 | 16 | NI |
| Skin pass mills | 91 | 63 | 4 |
| NB: NI = No information provided. <i>Source: [EUROSTAT]</i> | | | |

Cold rolled (narrow) strip

The number of companies declined from 166 in 1989 to 141 in 1995, with 61 plants in Germany, 22 in Italy, 16 in the UK, 15 in Belgium/Luxembourg, 13 in France, 10 in Spain, 2 in Greece, 1 in Portugal and 1 in the Netherlands. Production in the EU was 2.98 million tonnes in 1994. [Pan97]

Cold rolled strip production can be divided into different production sectors: cold rolling narrow hot strip with a width of less than 500 mm (further referred to as CR strip) and cold rolling wide hot rolled sheet and subsequent slitting (further referred to as slit strip). Around two thirds of the total narrow strip requirement in the EU is produced by slitting wide sheet. [Bed95]

The cold rolled strip industry in the EU-15 is both concentrated and fragmented. The largest 10 companies account for 50 % of the production while another 140 companies account for the remaining 50 %. The structure of the sector is marked by national differences in company size and industry concentration. For example, in France small companies are producing specialist high-value strip products whilst in Spain a significant number of larger companies are producing lower-value strip. Most of the largest companies are situated in Germany, which dominates the market with about 57 % of the EU-15 production (1.57 million tonnes in 1994). The majority of companies, however, can be classified as small or medium-sized enterprises. [Bed95]

The distribution and average size of companies in the EU is given in Table 3.3.

Table 3.3: Distribution and average company size of cold rolling strip plants

| | Number of CR strip producers | Average production per company [thousand t] | Average number of employees |
|---|------------------------------|---|-----------------------------|
| Germany | 60 | 26 | 167 |
| Italy | 22 | 18 | 58 |
| UK | 16 | 13 | 73 |
| Spain | 10 | 18 | 80 |
| France | 13 | 7 | 80 |
| Rest of the EU | 30 | 11 | 70 |
| Total EU (15) | 151 | 18 | 109 |
| NB: Reference year 1994. Source: [Bed95] | | | |

The production of cold rolled strip in the EU-15 in 1994 was estimated to be 2.77 million tonnes with

- 2.09 million tonnes of non-alloy steel strip (C content < 0.25 %);
- 0.46 million tonne of non-alloy steel strip (C content > 0.25 %);
- 0.12 million tonnes of coated steel strip;
- 0.10 million tonnes of HSS and other alloy strip.

A breakdown of the total strip production (CR rolled strip and slit strip) by country is given in Table 3.4, Figure 3.1 and Figure 3.2.

Table 3.4: Production of CR strip and slit strip

| | CR strip production [thousand t] | Slit strip production [thousand t] | Total strip production [thousand t] |
|--------------------|-------------------------------------|---------------------------------------|--|
| Germany | 1 570 | 1 950 | 3 520 |
| Italy | 390 | 900 | 1 290 |
| UK | 210 | 500 | 710 |
| Spain | 180 | 330 | 510 |
| France | 90 | 900 | 990 |
| Rest of EU: | 320 | 970 | 1 290 |
| Sweden | 140 | NI | NI |
| Benelux | 100 | NI | NI |
| Greece | 30 | NI | NI |
| Portugal | 30 | NI | NI |
| Finland | 10 | NI | NI |
| Austria | 10 | NI | NI |
| Total | 2 760 | 5 550 | 8 310 |

NB: Reference year 1994.
NI = No information provided.
Source: [Bed95]

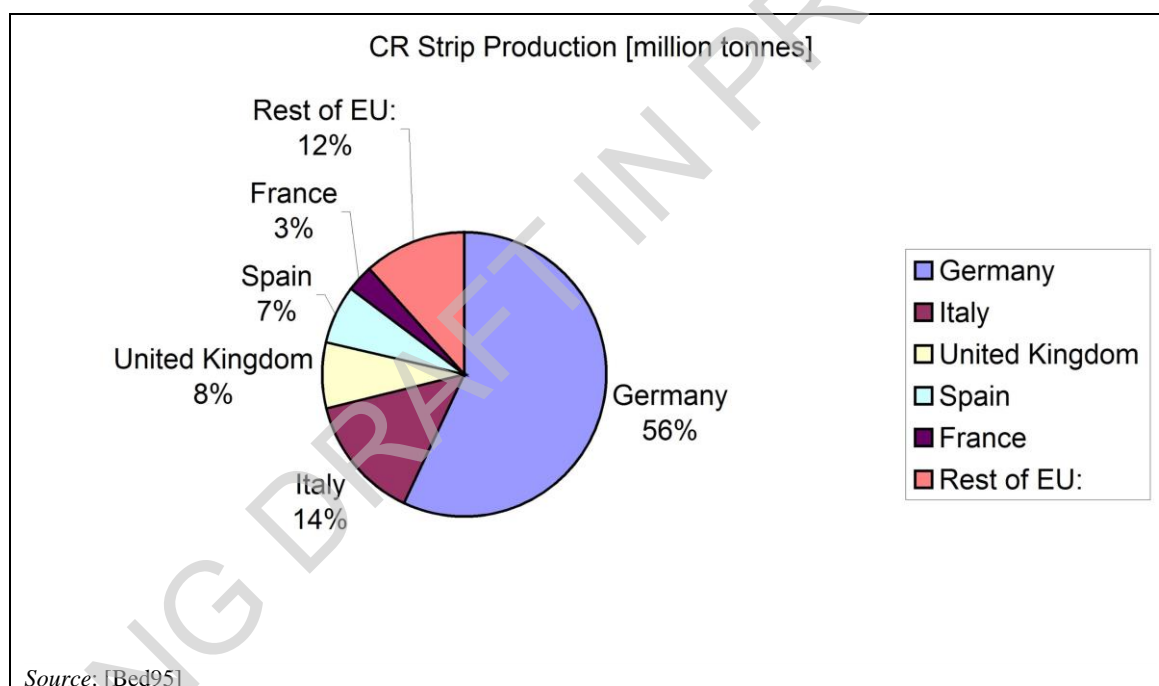


Figure 3.1: CR Strip production in 1994

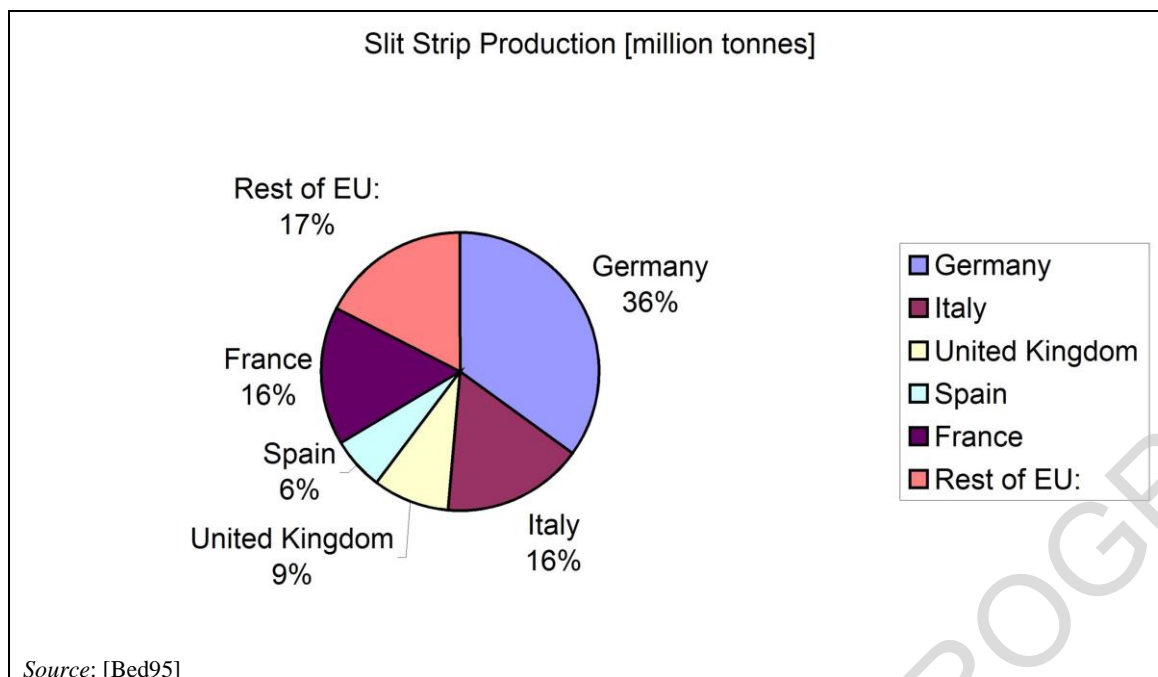


Figure 3.2: Slit strip production

3.1.2 Cold drawn long products / Bright steel bars

TWG, Delete or update this section ?

The production of bright steel bars in the EU was about 2.4 million tonnes in 1994. The number of companies declined from 154 in 1988 to 130 in 1995, with 46 companies in Germany, 26 in Spain, 25 in Italy, 15 in the UK, 14 in France, 2 in Portugal, 1 in Denmark and 1 in Belgium. Bright steel bars are used by industries such as the manufacture of motor vehicles, machinery, electrical goods and other industries, where high-quality basic material is compulsory. [Pan97]

3.2 Applied processes and techniques in cold rolling

Information received from the TWG has not yet been revised and incorporated in this section. This will be done after draft 1.

3.2.1 Process overview

In cold rolling, the properties of hot rolled strip products, e.g. thickness, mechanical and technological characteristics, are changed by compression between rollers without previous heating of the input. The input is obtained in the form of coils from hot rolling mills.

The processing steps and the sequence of processing in a cold rolling mill depends on the quality of the steel treated. **Low-alloy and alloy steel (carbon steels)** processing usually follows the order: pickling, rolling, annealing, temper rolling/skin pass rolling and finishing.

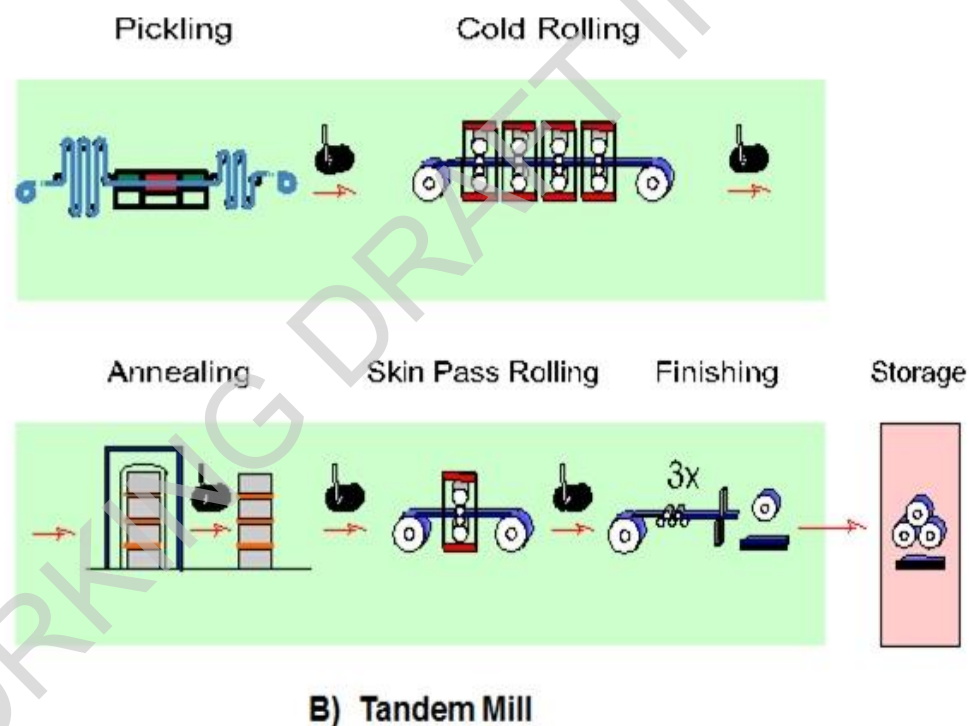
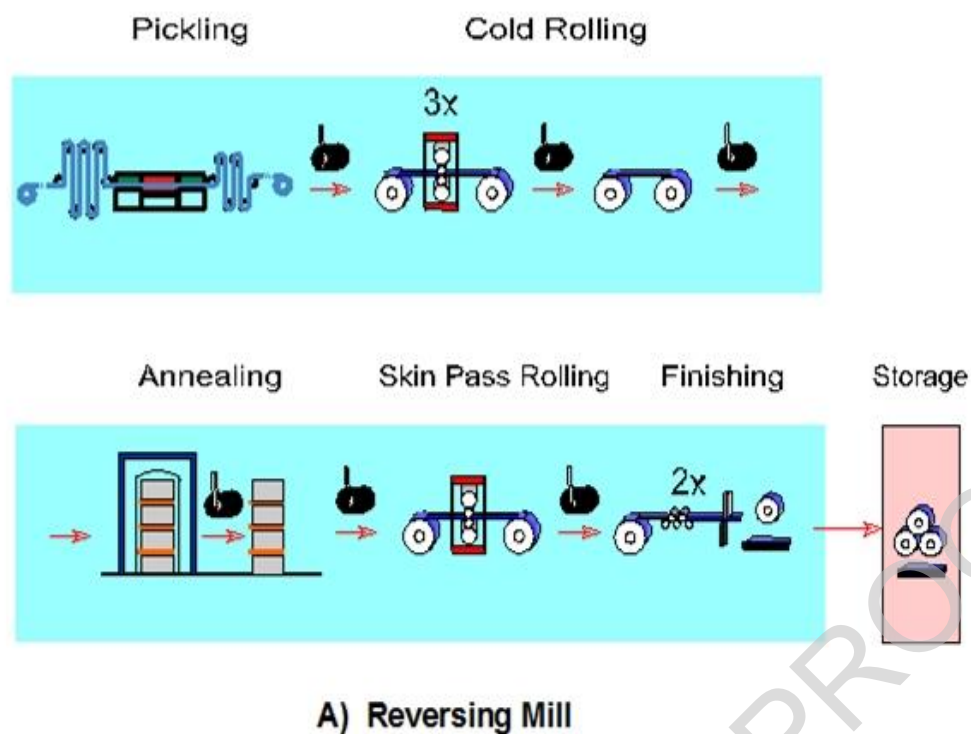
The process route for **high-alloy steel (stainless steel)** requires an initial annealing step prior to pickling due to the hardness of the steel quality and, furthermore, several additional annealing and/or pickling steps during rolling may be necessary.

Cold rolled products are mainly strips and sheets (thickness typically 0.16–3 mm) with a high-quality surface finish and precise metallurgical properties for use in high-specification products.

Cold rolling mills (CR strip mills)

Typical layouts for cold rolling mills are shown in Figure 3.3. The plants usually comprise the following:

- **Continuous pickling line**, where the oxide layer formed during the hot rolling is removed by pickling with sulphuric, hydrochloric or a mixture of nitric and hydrofluoric acid. A stretcher leveller or an in-line skin pass may be used to improve the shape of the strip and to mechanically break the oxide layer.
- **Cold rolling mill** generally consisting of a 4-stand or a 5-stand four-high tandem mill or of a four-high reversing mill. Cold rolling reduces the initial thickness of the hot rolled strip by typically 50–80 %.
- **Annealing facilities** to restore the ductility of the steel strip that is lost as the result of work hardening during the cold rolling.
- **Temper mills** to give the annealed material the required mechanical properties (prevents the formation of Lüders lines during drawing). The material is subject to a slight skin pass rolling typically on a four-high skin pass mill. The roughness of the work rolls of the mill is transferred to the strip by the roll pressure.
- **Inspection and finishing lines**, where coils with different lengths may be welded together to meet the required weight or may be slit to the required width. Also, coils are cut into sheets with the required length and width. At the same time, defective sections of strip can be discarded.
- **Packaging lines for coils or sheets** according to the destination and/or the means of transport.
- **Roll shop**, where the work rolls and the back-up rolls for the cold rolling mill and the temper mill are prepared.



Source: [EUROFER CR]

Figure 3.3: Typical configurations of cold rolled strip mills

For electrical steel sheet production, the mill design is similar to those described above. The rolling mill usually comprises a four-high reversing mill stand, which is enlarged to rolling and alternative skin pass rolling operation (rough pass up to 7 % deformation).

For higher silicon contents, flash butt welding of the head and tail of the coils to an endless strip has to be replaced by ‘agraphing’ the ends of the coils.

Technical trends and developments in cold rolled strip production, driven by increasing market demands and competition from alternative materials, aim at increasing the efficiency and the output of plants by minimising the processing time and the consumption of materials and energy. Simultaneously, the environmental impacts of the facilities are reduced. Figure 3.4 shows as an example a modified plant concept which shortens the process time for annealing and the following operations from 3–7 days (2–3 days when hydrogen is used) to approximately 10 minutes. [EUROFER CR] [Com VDMA]

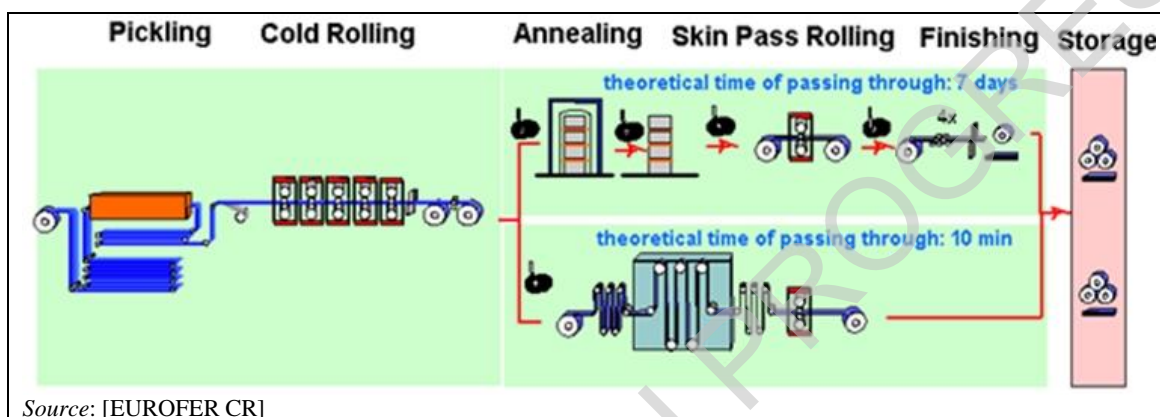


Figure 3.4: Cold rolling process line with continuous annealing

3.2.2 Pickling of low-alloy and alloy HR steel

The entire surface of the hot rolled coil is covered with a thin layer of scale containing oxides, which must be removed prior to cold rolling. This is done by pickling with hydrochloric acid or sulphuric acid, at temperatures typically ranging from 75 °C to 95 °C.

Once the strip or sheet is pickled, it must be thoroughly rinsed with demineralised (or equivalent quality) water and subsequently dried. Oiling is done either with rolling oil or anti-corrosive oil. [EUROFER CR]

Pickling lines

Pickling can be done as a batch (usually for bars, rods or tubes), semi-batch or continuous process and can also involve a number of stages using several acid baths. The following process description refers to continuous pickling lines on which steel is pickled in a coiled shape. Each of the pickling steps described below can also be performed as an individual batch process.

A typical pickling plant may incorporate the following:

- Anticoil break equipment on the decoiler to avoid the occurrence of flow lines (Lüders' lines) on the entering hot rolled coil.
- Welding of the hot rolled coils to continuous strip to ensure defined constant pickling times.
- Straightening equipment prior to the entry of the hot rolled strip into the pickling tanks. The flatness of the hot rolled strip is increased by straightening, and the capacity for pickling is improved by the scale breaking effect of straightening.
- Chemical pickling zone; deep tank or shallow tank (turbulent) pickling equipment.
- Rinsing zones to remove the remaining acid on the strip surface.
- Trimming of the strip to obtain cut edges and exact widths.
- Inspection of the strip for dimensional tolerances, surface defects and residues.
- Oiling of the strip (this may not be required in a combined pickling and rolling line).

The pickling is carried out in totally enclosed equipment or tanks fitted with hoods. In both cases, the units are under continuous extraction to remove any fumes generated.

Modern pickling plant design comprises pickling tanks equipped with external pumps. Instead of simply passing the steel strip continuously through an acid bath, the acid is pumped via a circulation system through nozzles mounted in the bath itself. The turbulence resulting from this promotes the pickling reactions. [EUROFER CR]

Large continuous pickling lines can have capacities of up to 2.4 million t/year. Figure 3.5 shows the operational steps in continuous pickling lines. [DFIU98]

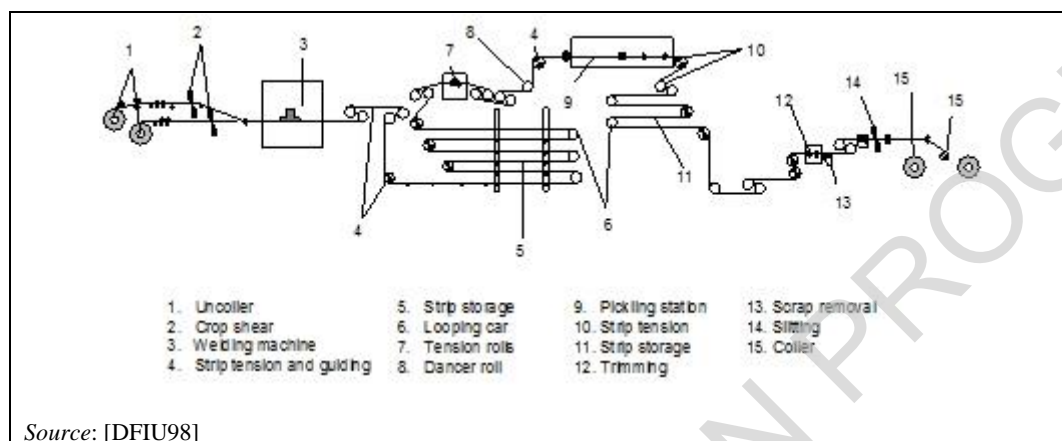


Figure 3.5: Schematic of a continuous pickling line

3.2.3 Annealing (I) and pickling (I) of high-alloy HR steel

The coils of stainless steel strip produced by hot rolling are known as ‘hot band’ coils. Due to the presence of an oxide scale and chromium-depleted layer formed during the hot rolling the steel must also be descaled/pickled prior to cold rolling. In addition, the greater hardness of the steel compared with carbon steels necessitates an initial annealing (I). The annealing process has three components, heating to annealing temperature, temperature equalisation and cooling. Both continuous and batch annealing processes may be used. [EUROFER CR]

Annealing

Ferritic grades are generally annealed as tightly wound coils in a **batch heat treatment** facility. Such installations may be used for the full heating, temperature equalisation and cooling cycles. One or more coils are placed on the furnace base and covered to form a closed furnace chamber. Heating may be achieved via gas firing or electrical heating. An inert protective atmosphere (nitrogen/hydrogen) is required for metallurgical reasons. Ferritic steels are generally annealed at steel temperatures of up to 800 °C. [EUROFER CR]

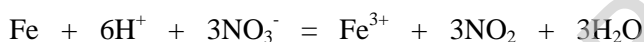
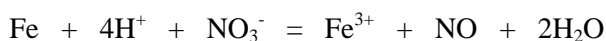
For **continuous annealing of austenitic steels**, the steel coil is unwound and passed through one or more heat treatment furnaces. These furnaces typically consist of a refractory- (or other form of insulation) lined steel structure and are usually directly fired by gaseous fuels. An oxidising atmosphere is needed to form a scale, which is rich in oxygen to allow a better pickling. The waste gases are exhausted via flues under natural or forced draught. Strip temperatures typically up to 1 100 °C are necessary for annealing austenitic steels. The steel strip then passes through the cooling section and may be cooled using gas jets, air, water sprays or water quenching. Continuous annealing is generally combined with a descaling/pickling plant as described above to form a continuous annealing and pickling line. [EUROFER CR]

Descaling and pickling

After annealing, the steel is descaled to produce a steel surface suitable for cold rolling. Mechanical descaling such as shot blasting or scale breaking may be used prior to chemical pickling to remove the heavy scale burden. However, careful control of such mechanical processes is necessary to minimise damage to the strip surface, which could affect the final product quality.

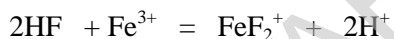
Final scale removal including the removal of the chromium-depleted layer beneath the scale is generally done by pickling in a mixture of nitric and hydrofluoric acids at temperatures of up to 70 °C. The acid concentrations employed depend on the material being processed but are normally in the range 10–18 % nitric acid and 1–5 % hydrofluoric acid.

The chemical reactions that take place during the pickling of stainless steels are complex and involve the removal of the adherent scale layer by the combined action of the acids used. The dominating chemical reaction during pickling is the dissolution of metals by the nitric acid. As a by-product of these reactions both nitrogen monoxide and nitrogen dioxide are formed. The reactions shown below are for the dominant metal iron but similar reactions also occur for the alloy elements present in the stainless steel such as nickel and chromium.



The NOX generated is partially soluble in the acid but once the limit of solubility is reached the NOX fumes transfer to the gaseous phase and are released from the pickling tanks. The rate of formation of NOX increases with increasing temperature.

The metal ions formed in the dissolution reactions then react with the hydrofluoric acid, leading to the formation of metal complexes.



The combination of these two sets of reactions results in the consumption of both nitric and hydrofluoric acids. To maintain the optimum conditions for descaling, regular additions of fresh acid are made as required. The iron fluoride complexes produced in the dissolution reactions have a limited solubility and if the concentration of iron is allowed to reach 5 % (40 g/l) then precipitation of iron fluoride will commence. This precipitation causes the formation of large quantities of a hard crystalline sludge.

The pickling line design is usually the same as for pickling of low-alloy steels, except that, on exiting the last pickling tank, the steel strip is rinsed with water to remove traces of acid, then dried. Oil is not applied to the strip because of the corrosion resistance of the stainless steel. [EUROFER CR]

3.2.4 Cold rolling of the pickled hot rolled strip

3.2.4.1 Low-alloy and alloy steel

In cold rolling, the pickled hot rolled bars, sheets or strips are passed through sets of rolls in reversing mills or in continuous in-line mills. Low-carbon steels, which are less hard, are generally rolled in multi-stand tandem mills due to the higher capacity of these mills. They consist of a series of four- or six-high stands. The strip enters the first stand and undergoes an initial thickness reduction; further reductions are achieved in each subsequent stand until the final gauge is attained.

For low-carbon strip, generally an emulsion of 0.5–4 % (10–20 % for direct application) of oil in water is necessary for:

- lubrication;
- cooling of the strip, work and back-up rolls;
- removal of Fe particles.

In the rolling process, the wide strip is mainly deformed in a longitudinal direction, with transverse deformation being practically negligible. The thickness reduction of the material is obtained by the influence of the rolling forces and the strip tensions (forward and back) applied. The cold forming process leads to a corresponding hardening of the material. Exact mass flow control (control of rolling force and/or position), assisted by laser control of the strip speed and tension, may be used. Additional automatic control loops for flatness (roll bending, zone cooling, etc.) are used to obtain the required flatness of the strip. The roughness texture of the strip surface is applied in the last stand of the tandem mill.

For optimum strip surface cleanliness, it is important to avoid contamination of the tandem emulsion by the hydraulic oil, by the Morgoil oil, by grease or by the cooling water (used to cool the emulsion). Precautions taken to avoid any contamination may include:

- continuous monitoring of oil levels;
- monitoring of the oil concentration;
- regular control of hydraulic equipment and bearings;
- monitoring of emulsion parameters such as temperature, pH value, saponification index, acid value, conductivity;
- filtering of the tandem emulsion (using techniques such as magnetic filters, paper filters, precoat filters).

To clean the strip and remove any remaining soap or oil, it may be subjected to chemical and/or electrochemical degreasing. For this purpose, cleaning zones are installed on the entry side of the downstream processing plants such as hot dip galvanising plants or continuous annealing plants. [EUROFER CR]

Conventional discontinuous rolling

The pickled hot rolled strip is fed into the cold rolling mill coil by coil. This results in a variation in the strip thickness corresponding to the geometrical conditions of the line at the strip ends during threading and at the exit of the coil end.

To produce ‘mill clean sheet’, often a thin emulsion with a maximum concentration of 1 % can be used on the last stands of the tandem mill. The emulsion is usually applied via spray nozzles onto the rolls and the strip. Sometimes, higher concentrations are used in direct application systems.

Discontinuous rolling offers a high degree of process flexibility to account for variations in product mix. The technique is preferable for certain steel qualities. [EUROFER CR]

Continuous rolling

To achieve the narrowest possible thickness tolerances, maximum output and optimum productivity figures, a shallow tank turbulence pickling plant can be coupled with a tandem mill, which is enlarged by one stand. Usually, an accumulator and a welding machine before a tandem has the same good results and a bigger increased capacity. The use of a welding machine and the accumulator allows joining coils and the strip to be fed to the mill continuously.

On a tandem line, the entering pickled hot rolled strip is reduced to the desired final thickness on a single pass through the line. Owing to the installation of several separate emulsion systems, a special emulsion can be applied in the last stand to increase the cleaning effect. For this purpose, either a detergent or a thin emulsion (1 % oil content) can be used.

Continuous rolling can allow good control of the strip thickness for coil ends and of surface quality. This can have a beneficial effect on material yield. In addition, it allows oil consumption to be optimised. [EUROFER CR]

3.2.4.2 High-alloy steel

After the initial annealing and pickling, the steel is generally rolled to the required thickness on reversing cluster mills for a number of passes until the desired dimensions are achieved or until work hardening necessitates further annealing.

The process of cold reduction generates heat, part of which is transferred to the rolling oil which is sprayed onto the steel and rolls for cooling as well as lubrication. This heat is subsequently dissipated through heat exchangers to cooling water systems.

Mineral oils are generally used as rolling oil and close control of the oil cleanliness is necessary for optimum performance. This may be achieved using oil filtration circuits, which incorporate media element filters or powder precoat filter systems. Although the use of mineral oils predominates, emulsion cooling systems similar to those used for carbon steels may be employed. In such cases additional precautions must be taken to control oil cleanliness in order to avoid strip marking.

Collection hoods are fitted to the mill and operate under continuous extraction to remove the oil mist that is generated. [EUROFER CR]

3.2.5 Annealing of low-alloy and alloy steel

The basic stages of the annealing process comprise:

- heating to annealing temperature (above 650 °C);
- holding at annealing temperature;
- cooling.

This annealing process may be carried out in batch furnaces or continuous furnaces. The annealing cycle has a significant influence on the mechanical properties and, consequently, on the formability of the steel strip. The main parameter controlling the annealing cycle is the temperature profile. It varies depending on whether the annealing is carried out in a continuous or batch furnace and depending on the required strength or hardness of the product. The annealing cycle depends on a number of parameters including the actual material analysis, the reduction realised during cold rolling, the required mechanical properties and the required surface cleanliness, the type of protective gas, etc.

Continuous annealing and batch annealing are considered to be complementary processes and not fully interchangeable. Production-related issues are integral to the selection of the annealing technique.

3.2.5.1 Batch annealing

Degreasing/Cleaning by means of alkali

Prior to the annealing process, the strip may be cleaned (degreased) to produce a cleaner surface. The cleaning serves to remove oil residues from the steel surface. The process is similar to that used for acid pickling except for the chemicals that are used. The most frequently used cleaning agents are phosphates, alkaline silicates, caustic soda and soda ash. Electrolytic cleaning and brushes are also used in some cases to remove iron fines from the strip surface.

The steel sheet is unwound from the coil and passed through cleaning tanks, which may be stirred to improve the cleaning effect. Subsequently, the steel is rinsed with water and recoiled. The degreasing solution can be regenerated and recycled.

Annealing

The cold rolled coiled strip is stacked in a hood furnace for annealing (see Figure 3.6). The combustion chamber (space between heating and protecting hood) is heated by oil or gas burners. Heat passes through the protective hood into where the steel coils are stacked. A circulating fan provides as uniform a temperature distribution as possible. The atmosphere in conventional plants is usually HNX gas (a nitrogen-hydrogen mixture with a hydrogen content close to the flammability limit). The atmosphere can also be 100 % H_2 as in parts of the working cycle of high-convection furnaces.

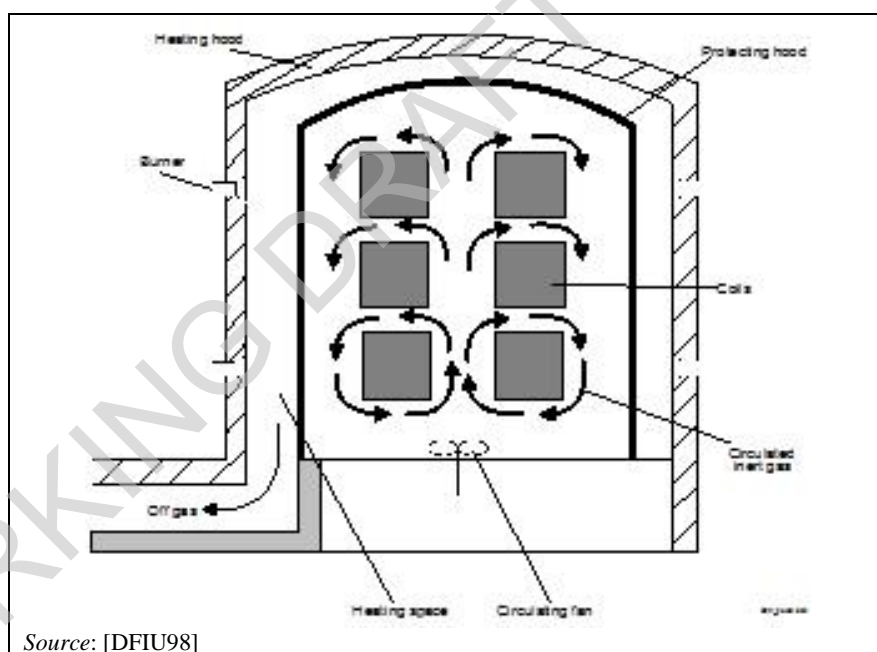


Figure 3.6: Schematic of a hood-type annealing furnace

The heat passes into the coils through their outer edges, so that these areas are always hotter than the inner windings, especially during heating up. The heat treatment causes the organic residues of the emulsion to partly burn off; a partial distillation process takes place. Products of the reactions taking place are CO/CO_2 , H_2 , FeO_x and CH_4 . The strip is heated to recrystallisation temperature, and annealed at about $700^\circ C$, resulting in complete recrystallisation of the cold rolled steel. For cooling the coils, the heating hood is removed. The cooling effect can be enhanced by spraying water on the protecting hood, by covering it with a

cooling bell and blowing air on it or by using a cooling bypass system which cools the protective atmosphere under the protective hood. The time necessary for annealing depends on the annealing temperature and the weight of the charge and can take 2 to 7 days.

Annealing in this type of furnace is very slow and also the cooling rate is not suitable for certain steel grades. Therefore, an annealing process in a 100 % hydrogen atmosphere was developed, yielding shorter annealing times and faster cooling.

3.2.5.2 Continuous annealing

For continuous annealing the coils are welded together on the entry side of the plant and subjected to the following process steps:

- alkaline/electrolytic cleaning of the strips;
- heating and holding at the required annealing temperature;
- cooling (slow jet cooling, high gas jet cooling (using cooling rates up to 150 °C/s, hot water quench (HOWAQ), overaging, roll cooling, final cooling, misting jet cooling).

The continuous annealing is carried out by passing the steel strip through a multi-zone heating furnace with a heating chamber, annealing chamber, cooling zone, tempering zone and a second cooling zone. The steel is heated to a range between 650 °C and 830 °C and then cooled by gas jets, gas-water sprays, contact rolls or water quenching, depending on the desired metallurgical properties. These furnaces are usually fired by gas (direct or indirect) or electrically heated. The steel can be protected by an inert gas atmosphere or a reducing gas atmosphere in parts of the furnace. The principle operational steps for continuous annealing are shown in Figure 3.7.

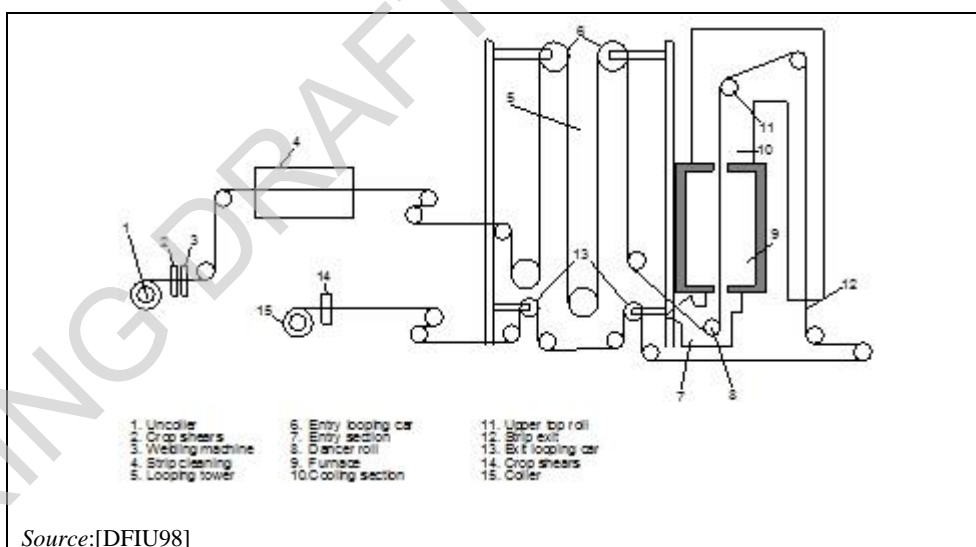


Figure 3.7: Example of a continuous annealing furnace

Continuous annealing gives a shorter processing time (about 10 minutes), less intermediate storage, uniform mechanical properties and a superior surface cleanliness. Continuous annealing is more appropriate for the production of higher-strength steels. The layout of the furnace facilitates energy recovery from the exhaust gas.

3.2.6 Annealing (II) and pickling (II) of high-alloy steel

Degreasing

Prior to the final annealing process, degreasing of the strip may be required to remove any contaminants from the steel surface. This can be achieved using an alkali-based cleaning system, which may be incorporated in the entry section of continuous annealing lines.

The steel coil is unwound and passed through a series of tanks containing the cleaning solutions. Agitation of the solution is usually incorporated to enhance the cleaning. Afterwards the strip is rinsed with water. Demineralised water can be used for the final rinsing step. [EUROFER CR]

Annealing

TWG, please provide additional information below on the peculiarities of bright annealing compared to common annealing.

The process route for final annealing and pickling is dictated by the surface finish required. Examples of this are EN standard finish '2R' which requires a bright annealing treatment and surface finish '2B' which requires annealing and pickling.

Bright annealing is generally conducted in an electrically heated or gas-fired furnace with a protective inert atmosphere of nitrogen and/or hydrogen. Both batch annealing and continuous annealing may be used. Degreasing of the steel surface is required to prevent surface discolouration.

Material with a '2B' surface finish is generally processed on continuous annealing and pickling lines. The furnace design and operation is generally similar to that for the annealing of hot band material described above. The steel is unwound and passed through one or more furnaces, which are usually gas-fired. Annealing takes place in an oxygen-rich atmosphere. This is necessary to ensure that the scale generated in the furnace is of a composition that is readily removable by the downstream chemical pickling processes.

Pickling

Unlike the descaling of hot band material described above, mechanical descaling techniques cannot be employed to assist in the removal of this scale due to the surface damage which would result for the final cold rolled strip. Therefore only chemical pickling is applied. This is done in the same manner as described above for hot band pickling.

Scale of high-alloy steel, due to the presence of oxides of alloying elements, cannot always be removed in just a single acid descaling step. Additional treatment or pretreatment processes may be necessary. These may include scale removal by an initial electrolytic descaling process (using for example sodium sulphate) installed prior to the mixed acid section. Generally these facilities operate with neutral salts or acids as the electrolyte. It is appropriate to consider the electrolytic process as a pre-pickling system as satisfactory descaling cannot be achieved with this section alone. However, the length of the mixed acid section required (and hence the acid consumption and environmental impacts) is considerably reduced. Furthermore, the combination of electrolytic and mixed acid can provide an improved surface finish. [EUROFER CR] [Com2 CR]

3.2.7 Tempering of cold rolled strip

3.2.7.1 Low-alloy and alloy steel

After annealing, the surface finish and mechanical properties of the steel are modified in line with customer requirements. This is done by temper rolling which consists of subjecting the strip to a light rolling pass with a thickness reduction between 0.3 % and 2 %. Before tempering, the strip temperature must be less than 50 °C.

Temper rolling is carried out in the temper mill which comprises typically 1 or 2 four-high stands, although two-high or six-high stands are also possible. For tin plate production, 2 four-

high stands is common. The rolls for these stands have an extremely precise surface finish in order to control the final roughness of the strip in line with the end use of the finished product. Tempering also improves strip flatness.

To avoid residues from the rolling process remaining on the strip, cleaning agents (a wet temper rolling agent) can be used during tempering. The rolls may also be brushed with mechanical polishing equipment and an associated extraction system. [EUROFER CR]

3.2.7.2 High-alloy steel

Similar to the process route for carbon steels, temper rolling or skin pass rolling is completed in order to attain the desired surface finish on the steel. This cold rolling treatment, comprising a minimal reduction in gauge (up to 2 %), is generally performed dry without application of oil for cooling. The temper mill usually comprises a single two- or four-high stand with precision ground rolls.

3.2.8 Finishing

Finishing comprises slitting into coils of different width strip and transversal shearing to obtain sheet. Additional steps such as straightening, sampling, oiling and marking are also completed. In general, the techniques used are similar for both low-alloy and high-alloy steels; however, oiling is not required for stainless steels.

The finishing process comprises the following operations:

- dimensional control (width, thickness and length);
- inspection for surface defects and their removal;
- sampling to determine the mechanical and technological properties, the strip roughness structure and the content of residue of particles from roll wear and carbon on the strip surface (statistical sampling);
- trimming the coils to exact width;
- straightening the strips to optimum flatness;
- oiling the strips with electrostatic oiling machines or with oiling machines equipped with sprays or rolls oiling machines (anti-corrosive oils or prelubes);
- marking the finished products with coil number, production date, etc.;
- welding of different smaller coils to bigger coils.

In the finishing shops, the coil weights used for maximising productivity are cut into the coil weights ordered by the customers. Defective coil parts are eliminated or, if necessary, the material is subjected to additional treatment for removal of the defects. This can include additional annealing, tempering or straightening. [EUROFER CR]

Strip grinding

Grinding of the steel surface may be used to generate a uniform surface quality as well as to rectify defects. The strip is usually decoiled on dedicated process lines, sprayed with oil and ground with belts of varying surface roughness. Mineral oil is generally used for this process and filtration circuits employed to separate the swarf generated during grinding. [EUROFER CR]

Packing

The material, now in its final form, is usually packed ready for despatch to the customer. The packaging is designed to ensure that no damage occurs either during storage or transport to the end user. Control measures also have to be taken to prevent damage from mechanical and climatic sources. In addition, the lifting and transport equipment in the production plant should also be designed and operated to minimise damage to the steel. After finishing, packing of the

individual items ordered by the customers is done. The packing materials used include: steel bands, paper, plastic, wood, seaworthy packing, special packing. [EUROFER CR]

3.2.9 Roll shop

The activities generally consist of the dismantling of the rolls, the grinding of the rolls, the texturing of the work rolls and the reassembly of the rolls.

To satisfy the required strip tolerances and surface standards, the rolls must be regularly reground. During this grinding operation the rolls are usually cooled and lubricated with a grinding emulsion. The spent emulsion can be recirculated and filtered, but partial replacement is required periodically. In addition, used oil and grinding sludge are produced which require disposal.

The principal roll texturing systems used include the following:

- SBT (Shot Blast Texturing): This is a mechanical application of the texture onto the roll using grit blasting.
- EDT (Electron Discharge Texturing): The work rolls are textured by spark generation in an oil bath.
- EBT (Electron Beam Texturing): In this system the roll is placed in a vacuum chamber and the texture is applied by means of an electron beam gun.
- Laser Tex (Laser Texturing): The roll is textured to a predetermined roughness by a laser gun.
- Pretex (Premium Texturing): The roll is textured by a rough electrolytical chromium plating. The chromium plating process is fully enclosed and fitted with an exhaust gas system using a wet scrubber. The whole process operates without an effluent discharge, because of the evaporative losses [EUROFER CR].

3.2.10 Water and process baths management in cold rolling mills

Water is used in cold rolling mills to clean the surface of rolling stock, for preparation of pickling and degreasing baths, for rinsing and for cooling. Pickling and related processes (rinsing, gas cleaning operations, acid regeneration) cause acidic waste water streams. In the event that degreasing is part of the processing alkaline waste water also arises.

For cooling and lubrication, water/oil emulsions are used in the rolling sections, which gives rise to oil- and suspended-solid-loaded waste water streams. Generally, emulsion and degreasing solutions are recycled to the process in closed loops. Water used for indirect cooling is also operated in closed loop circuits. (Classifications and definitions for water circuits are analogous to those used in hot rolling; refer to Section 2.2.17.

3.2.10.1 Emulsion system

In cold rolling mills, emulsion cycles as shown in Figure 3.8 are normally installed. To maintain these loops, the circulated liquids have to be treated and conditioned by emulsion settling and cooling. Measures to maintain the quality of the emulsion and to extend the lifetime are described in Sections 3.4.2.7 and 3.4.4.3.

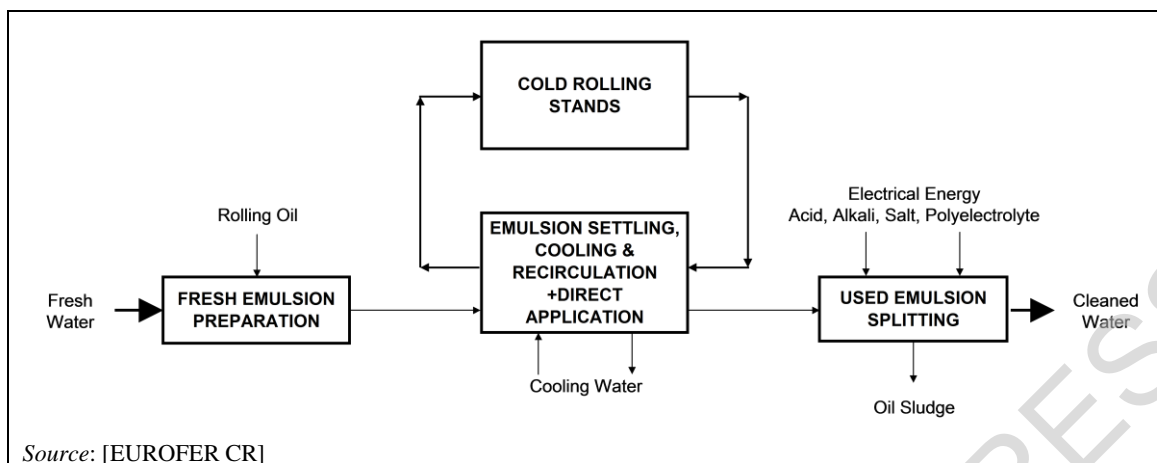


Figure 3.8: General emulsion flow

3.2.10.2 Degreasing solution system

In degreasing solution systems (see Figure 3.9) the recirculation of the solution is enabled by removing oil and other contamination, e.g. by magnetic filtering or ultrafiltration. Cleaning measures are described in Chapter 4.

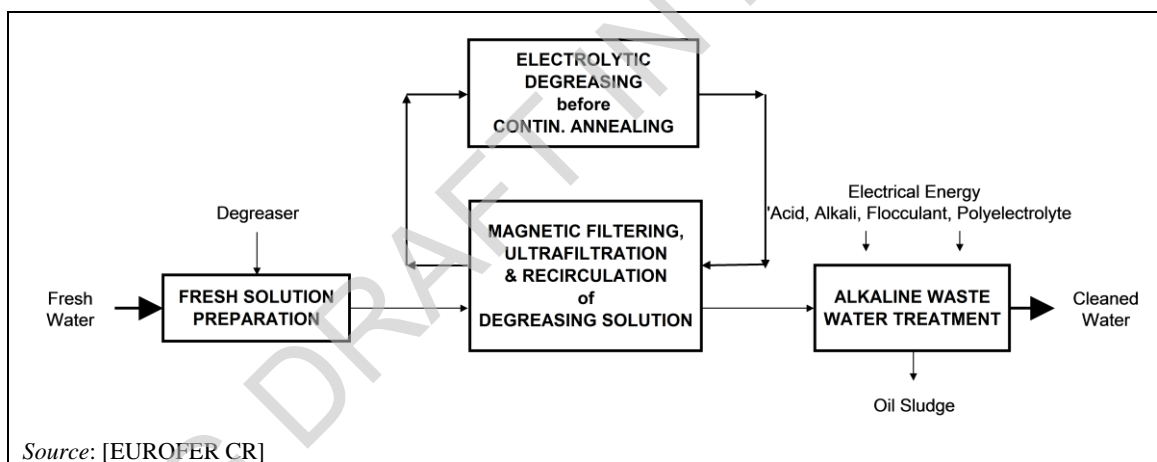


Figure 3.9: Degreasing solution flow (continuous annealing line)

3.2.10.3 Cooling water systems

In cold rolling mills, cooling water is required to dissipate excessive heat from the rolling process (rolling energy) and from the annealing furnaces (heating energy). The rolling energy is mainly transferred via the emulsion and/or the emulsion cooler and partly via the lubricant and hydraulic cooler to the cooling water. The main cooling water consumers are:

- emulsion cooling for tandem line;
- skin pass mill stand installed downstream of the batch annealing plant;
- continuous annealing plant with skin pass mill stand;
- cooling of transformers and motors;
- oil lubrication facilities.

The thermally loaded cooling water is recooled with industrial water in plate heat exchangers, if adequate water supplies are available, or by evaporation in cooling towers. Recooling in heat exchangers offers the advantage that considerable amounts of chemicals for cooling water (such

as corrosion inhibitors, hardness stabilisers, dispersants and biocides) can be saved and are not discharged into the sewage system. The cooling water circuits are treated with corrosion inhibitors, but discharge of a partial flow with a high salt content is not necessary with these closed circuits. For cooling tower circuits, in contrast, regular discharge of partial flows to a sewage system is required to counteract salt concentration resulting from evaporation. Moreover, the formation of water vapour (industrial snow), associated with cooling towers and sometimes a problem in some areas in Europe, is avoided.

In principle, both the use of recooling and evaporative cooling towers are viable systems for use and the choice of system will depend on the location and other site-specific issues. In some countries, taxes are levied on abstraction and discharging water which can affect the choice of system used. [Com2 CR]

Figure 3.10, Figure 3.11 and Figure 3.12 show examples of cooling water cycles.

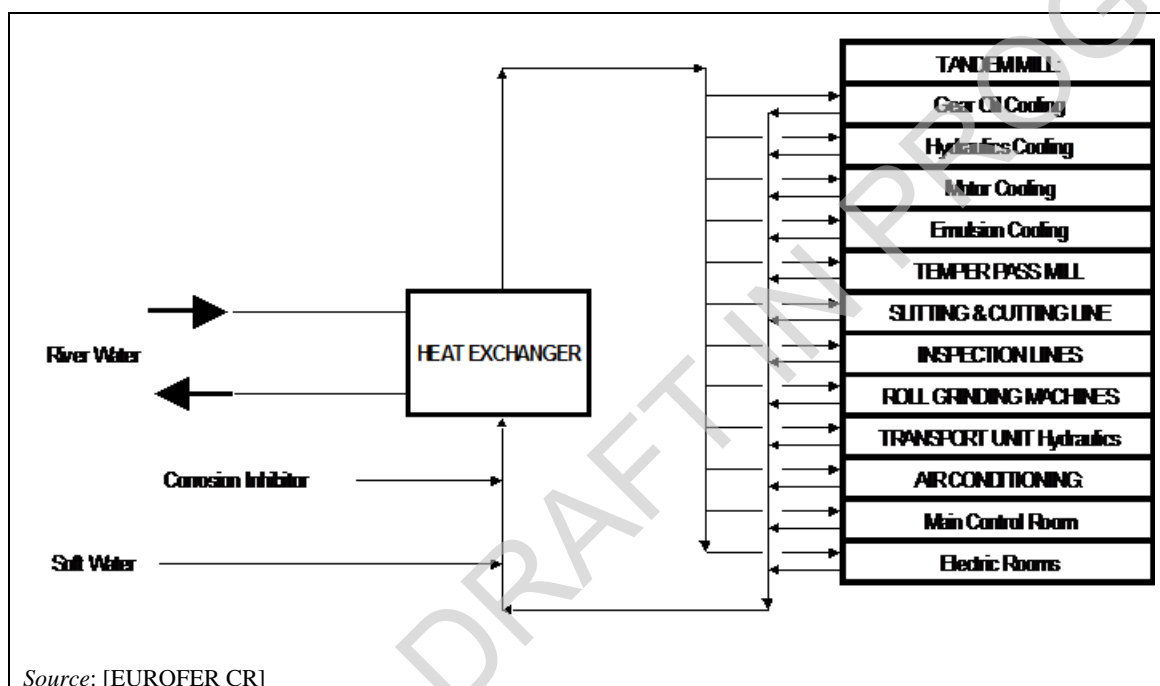


Figure 3.10: Cooling water system for a cold mill

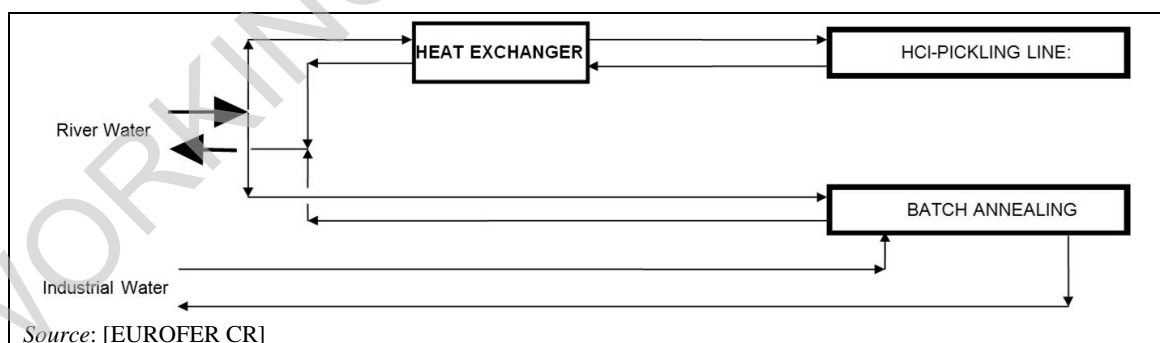


Figure 3.11: Cooling water system for HCl pickling and batch annealing

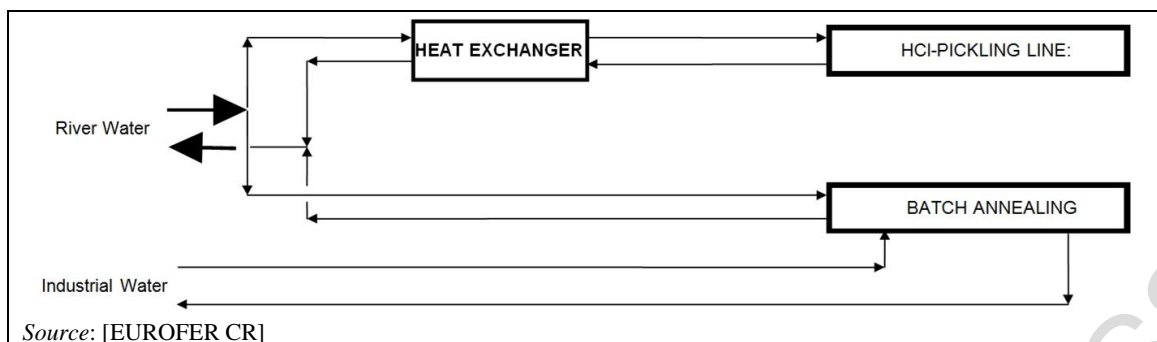


Figure 3.12: Cooling water system for a continuous annealing line

3.2.10.4 Waste water treatment

Waste water from cold rolling operations which cannot be regenerated or used elsewhere in the production line has to be treated prior to discharge.

Acidic waste water from rinsing or acid regeneration is usually treated by neutralisation with agents, such as calcium hydroxide or sodium hydroxide. The dissolved metal ions are precipitated as hydroxides and then separated by sedimentation techniques including clarification or filtration. Flocculants are sometimes used to assist the process. The sludge is dewatered, e.g. by filter presses, to reduce the final volume of sludge.

Where electrolytic chemical pre-pickling processes are used, additional effluent treatment steps may be required. Typically these can incorporate chromium (VI) reduction processes using sodium bisulphite or iron (II) compounds.

Alkaline waste water streams may be neutralised using HCl, filtered and then discharged.

Spent coolants/lubricants (emulsions) are treated by emulsion breaking, either done thermally, chemically, mechanically or physically, followed by the separation of the water and the oily phase.

3.2.11 Waste and by-product management in cold rolling mills

Cold rolling gives rise to solid residues, such as scrap (cleaning rags, cleaning paper), sludges from the waste water treatment plants, the remainder of the packing material and dust.

Scrap is recycled in the works for steel production. The **oil-containing sludges** from the waste water treatment plants may be used in blast furnaces.

Acid regeneration sludges can be recycled in steel plants (EAF and blast furnace) or given to external recycling firms for the production of iron oxides.

The **iron sulphate-heptahydrate** from the sulphuric acid regeneration plant can be used:

- for the production of complex iron-cyan salts;
- as flocculation agents in waste water treatment plants;
- for the production of gas adsorption mass;
- as a chemical amelioration agent;
- for the production of iron oxide pigments; and
- for the production of sulphuric acid [Com D].

The **iron oxide** from the hydrochloride acid regeneration can be used in several industries as high-quality input, e.g.:

- as input for the production of ferromagnetic materials;
- as input for the production of iron powder; or
- as input for the production of construction material, pigments, glass and ceramics [Com D].

Sludges from oil recovery are externally used, either by incineration or for oil recuperation in specially dedicated plants.

Only a small part of the **sludges from waste water treatment** is internally recycled; the vast majority is landfilled.

Oily wastes (oil, emulsion, greases) arising are recycled internally or treated externally by incineration.

3.3 Current consumption and emission levels for cold rolling

A.3.2 Cold Rolling Mills

3.3.1 Mass stream overview

The information contained in this section of the old BREF has been removed and replaced with the data from the data collection. Old information, along with input from the TWG will be revised and added after draft 1.

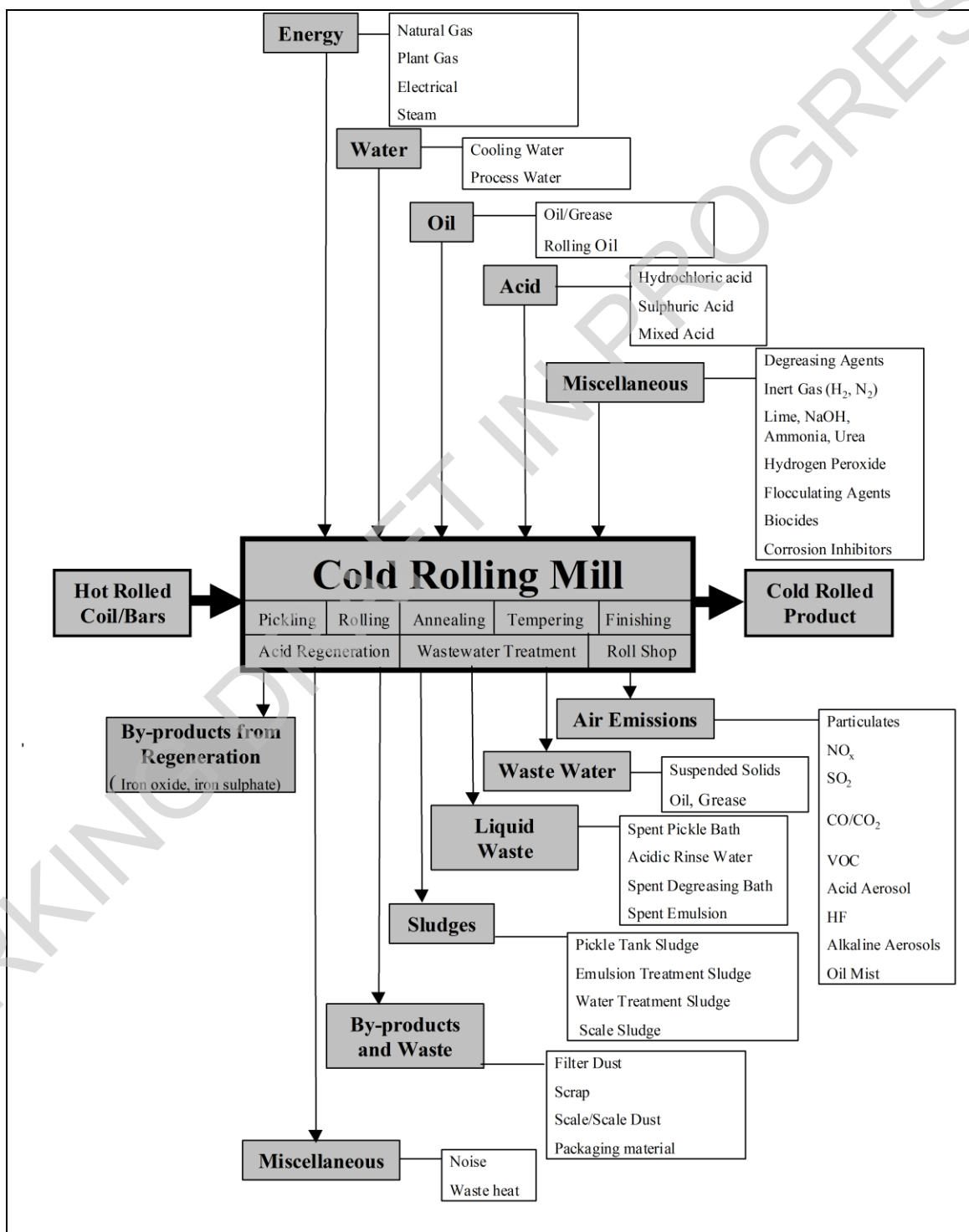


Figure 3.13: Input/output overview for cold rolling mills

The subsequent chapters present specific input and consumption data, as well as specific output and emission data for individual operational steps associated with cold rolling activities.

3.3.2 Energy efficiency

Figure 3.14 shows reported data on the specific energy consumption for rolling.

Figure 3.15, Figure 3.16 and Figure 3.17 show reported data on the specific energy consumption for annealing before and after rolling.

3.3.3 Material efficiency

3.3.3.1 Consumption of oils

Figure 3.18 shows reported data on the specific oil consumption for three operating years in cold rolling plants. Values of oil consumption include all types of oils used in the plant (e.g. rolling oil, hydraulic systems oil, lubrication oil, anticorrosive oil, emulsion oil, fat and grease).

3.3.3.2 Consumption of acids

Figure 3.19 to Figure 3.22 show reported data on the specific acid consumption for three operating years in cold rolling plants. Each figure corresponds to a different acid, namely hydrochloric, sulphuric, nitric and hydrofluoric acid. Specific acid consumption is expressed in kg of acid per m² of treated (pickled) surface. For HCl a concentration of 33%-wt is considered, for H₂SO₄ a concentration of 96%-wt, for HNO₃ a concentration of 49%-wt and for HF a concentration of 70%-wt.

3.3.4 Water consumption

Figure 3.23 shows reported data on the specific water consumption for three operating years in cold rolling plants.

3.3.5 Emissions to air

The abbreviations used in the graphs on emissions to air in cold rolling can be found in the Glossary.

3.3.5.1 Emissions to air from mechanical processing and welding

Dust emissions

The reported data on dust emissions to air from mechanical processing and welding are shown in Figure 3.24 and Figure 3.25.

Lead emissions

The reported data on lead emissions to air from descaling before pickling are shown in Figure 3.26.

Nickel emissions

The reported data on nickel emissions to air from descaling before pickling are shown in Figure 3.27.

3.3.5.2 Emissions to air from heating

Dust emissions

The reported data on dust emissions to air from feedstock heating (annealing before pickling and batch and continuous annealing after rolling) for fuel 100% natural gas and fuel other than 100% natural gas or unknown fuel respectively are shown in Figure 3.28 and Figure 3.29.

SO₂ emissions

The reported data on SO₂ emissions to air from feedstock heating (annealing before pickling and batch and continuous annealing after rolling) for fuel 100% natural gas and fuel other than 100% natural gas or unknown fuel respectively are shown in Figure 3.30 and Figure 3.31.

NOX emissions

The reported data on NOX emissions to air from feedstock heating (annealing before pickling and batch, continuous and bright annealing after rolling) for fuel 100% natural gas and fuel other than 100% natural gas or unknown fuel respectively are shown in Figure 3.32 and Figure 3.33.

Figure 3.34 shows the reported data on NOX emissions to air from feedstock heating (annealing before pickling and batch, continuous and bright annealing after rolling) for all fuels, together with the preheating temperature of air used for combustion, the inlet temperature of the feedstock entering the furnace and target temperature of the feedstock exiting the furnace.

CO emissions

The reported data on CO emissions to air from feedstock heating (annealing before pickling and batch and continuous annealing after rolling) for fuel 100% natural gas and fuel other than 100% natural gas or unknown fuel respectively are shown in Figure 3.35 and Figure 3.36.

3.3.5.3 Emissions to air from pickling

Dust emissions

The reported data on dust emissions to air from pickling are shown in Figure 3.37. The figure includes hot rolling plants (HR in the plant code), cold rolling plants (CR in the plant code) as well as hotdip coating plants (HDC in the plant code).

HCl emissions

The reported data on HCl emissions to air from pickling are shown in Figure 3.38. The figure includes hot rolling plants (HR in the plant code), cold rolling plants (CR in the plant code) as well as hotdip coating plants (HDC in the plant code).

SO_x emissions

The reported data on SO_x emissions to air from pickling are shown in Figure 3.39. The figure includes hot rolling plants (HR in the plant code) as well as cold rolling plants (CR in the plant code).

NO_x emissions

The reported data on NO_x emissions to air from pickling are shown in Figure 3.40. The figure includes hot rolling plants (HR in the plant code) as well as cold rolling plants (CR in the plant code).

HF emissions

The reported data on HF emissions to air from pickling are shown in Figure 3.41. The figure includes hot rolling plants (HR in the plant code) as well as cold rolling plants (CR in the plant code).

3.3.5.4 Emissions to air from rolling stands and finishing**TVOC emissions**

The reported data on TVOC emissions to air from rolling stands and finishing are shown in Figure 3.42.

3.3.6 Emissions to water

Figure 3.43 to Figure 3.66 show the reported data on emissions to water, for direct and indirect discharges, per pollutant from plants treating waste waters from cold rolling.

3.3.7 Residues

Figure 3.67 and Figure 3.68 show the reported data on the specific generation of oil- containing residues, scale and steel scrap for three operating years in cold rolling plants.

3.3.8 Figures with consumption and emission levels

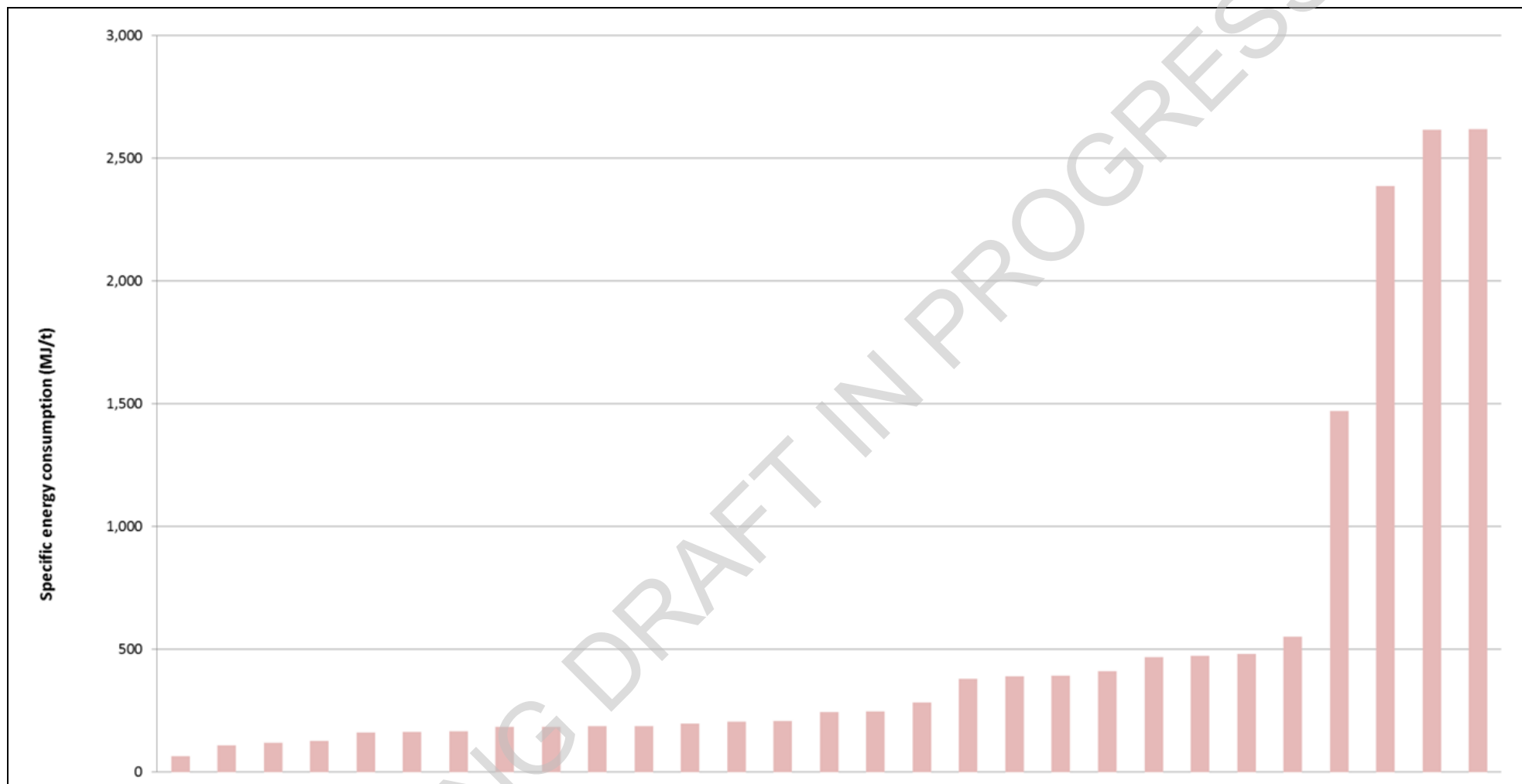


Figure 3.14: Specific energy consumption (MW/t of process throughput) for rolling. Source: [TWG 2018].

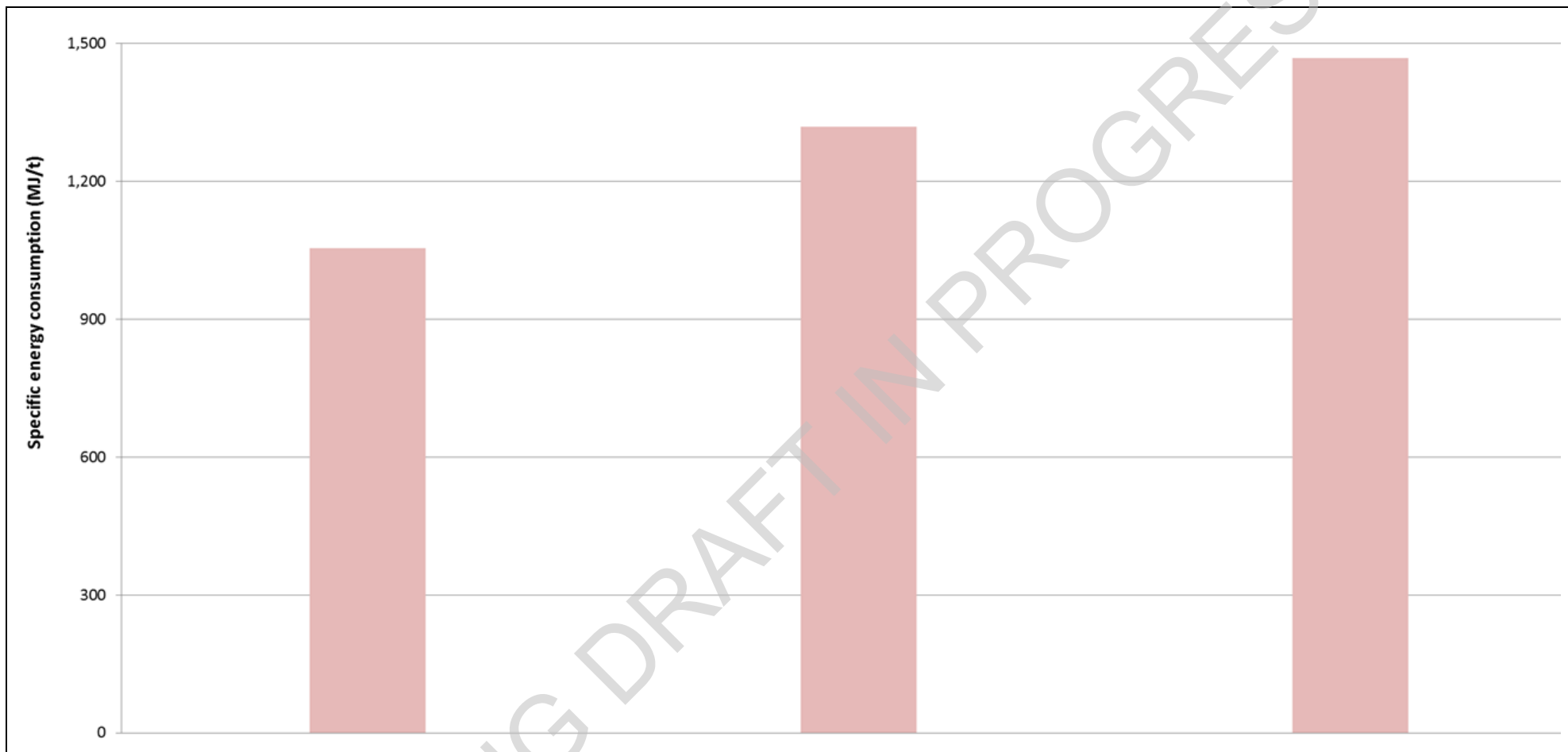


Figure 3.15: Specific energy consumption (MW/t of process throughput) for annealing before rolling. Source: [TWG 2018].

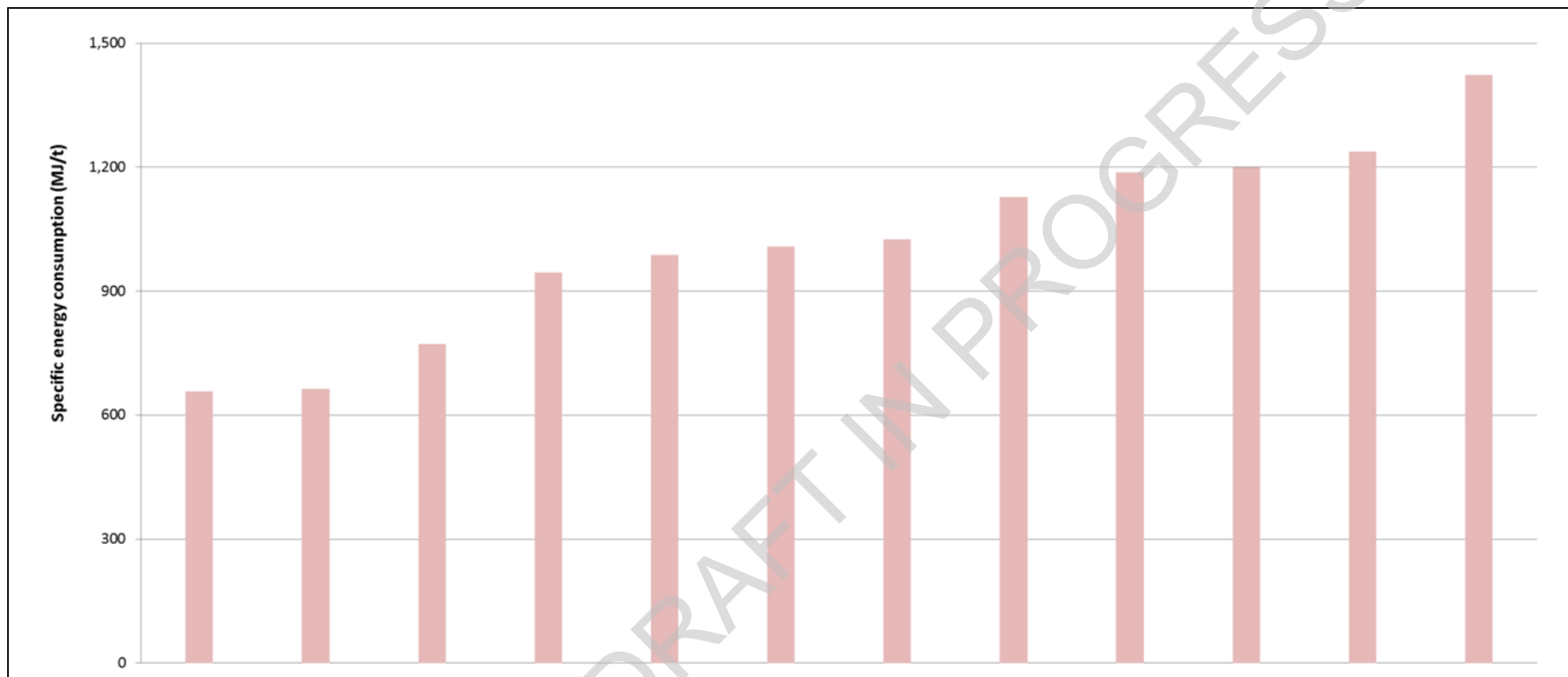


Figure 3.16: Specific energy consumption (MW/t of process throughput) for continuous annealing after rolling. Source: [TWG 2018].

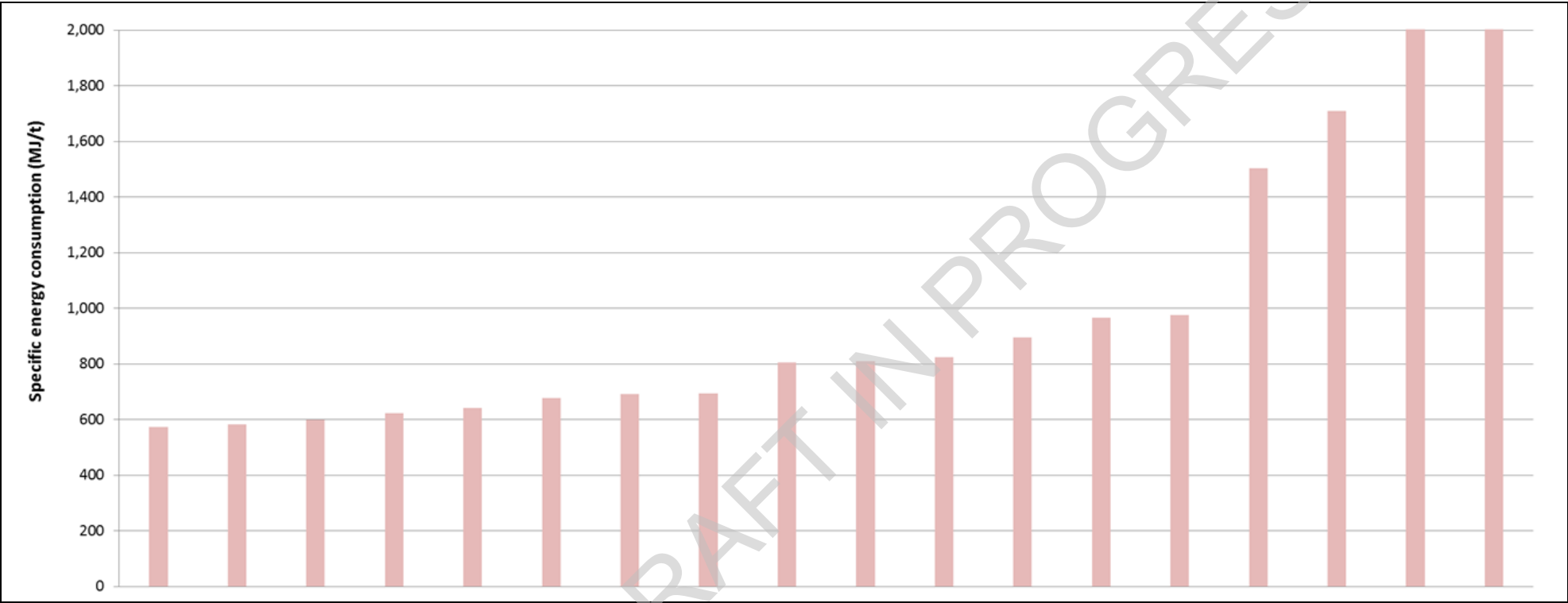


Figure 3.17: Specific energy consumption (MW/t of process throughput) for batch annealing after rolling. Source: [TWG 2018].

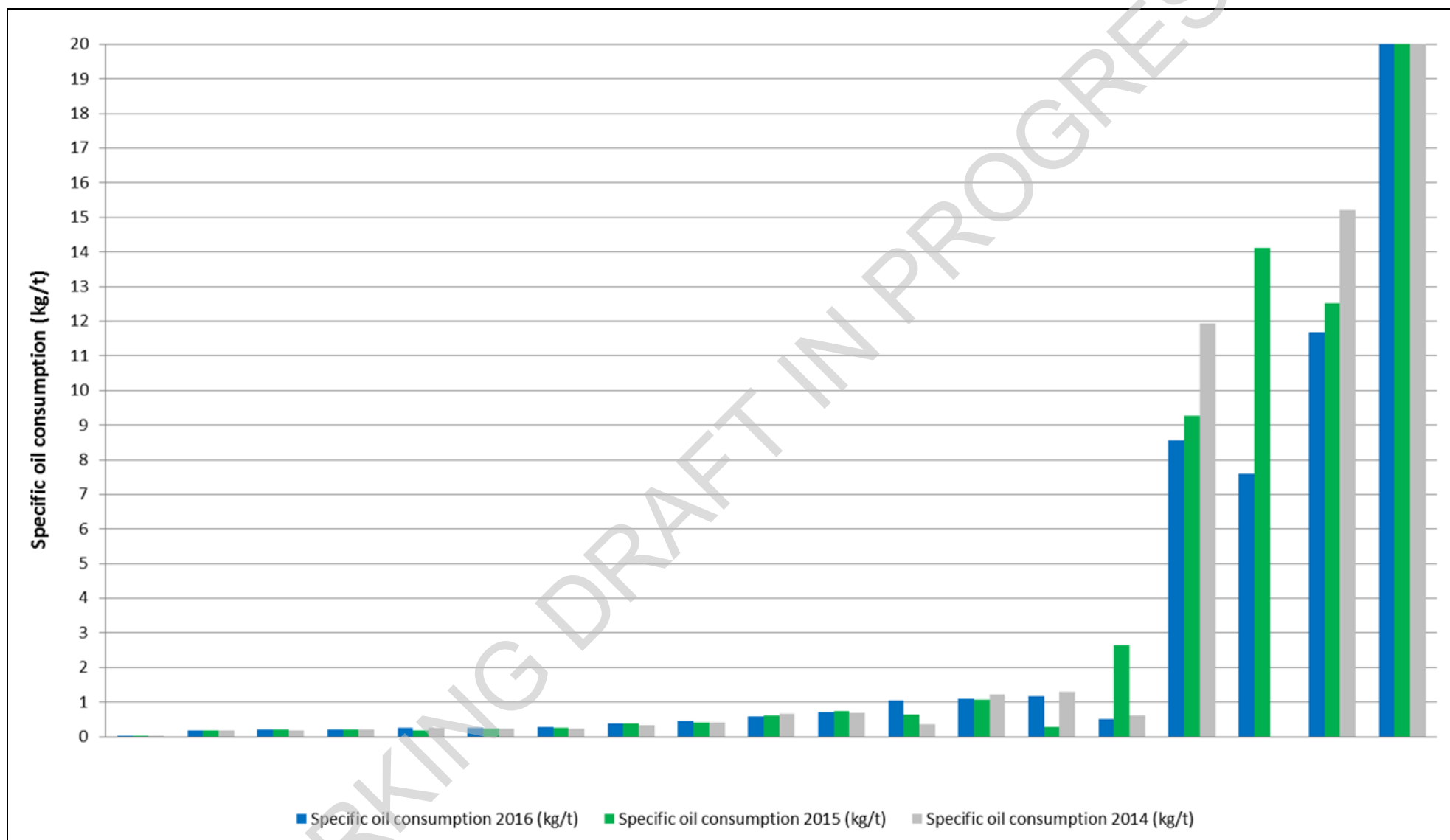


Figure 3.18: Specific oil consumption (kg/t of production) in cold rolling plants. Source: [TWG 2018].

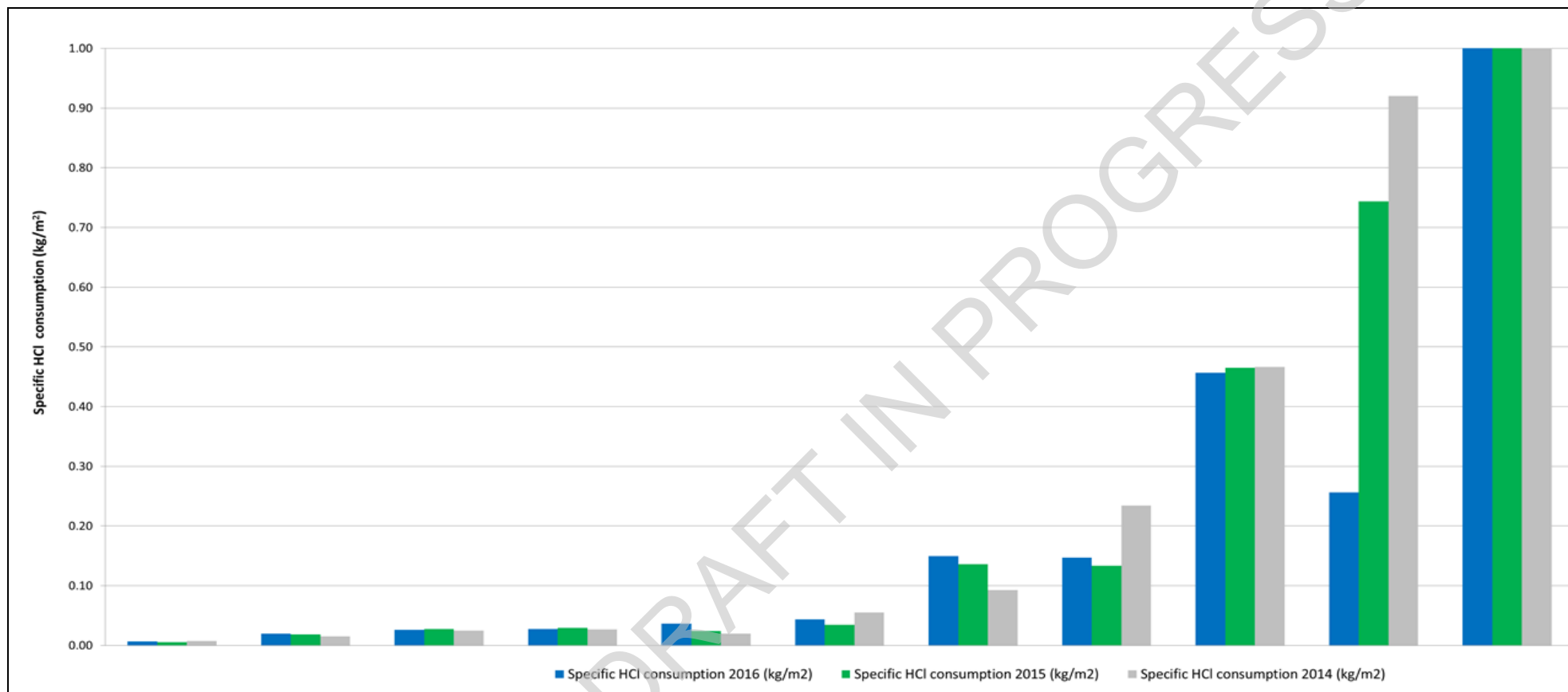


Figure 3.19: Specific HCl consumption (kg/m² of treated surface) in cold rolling plants. Source: [TWG 2018].

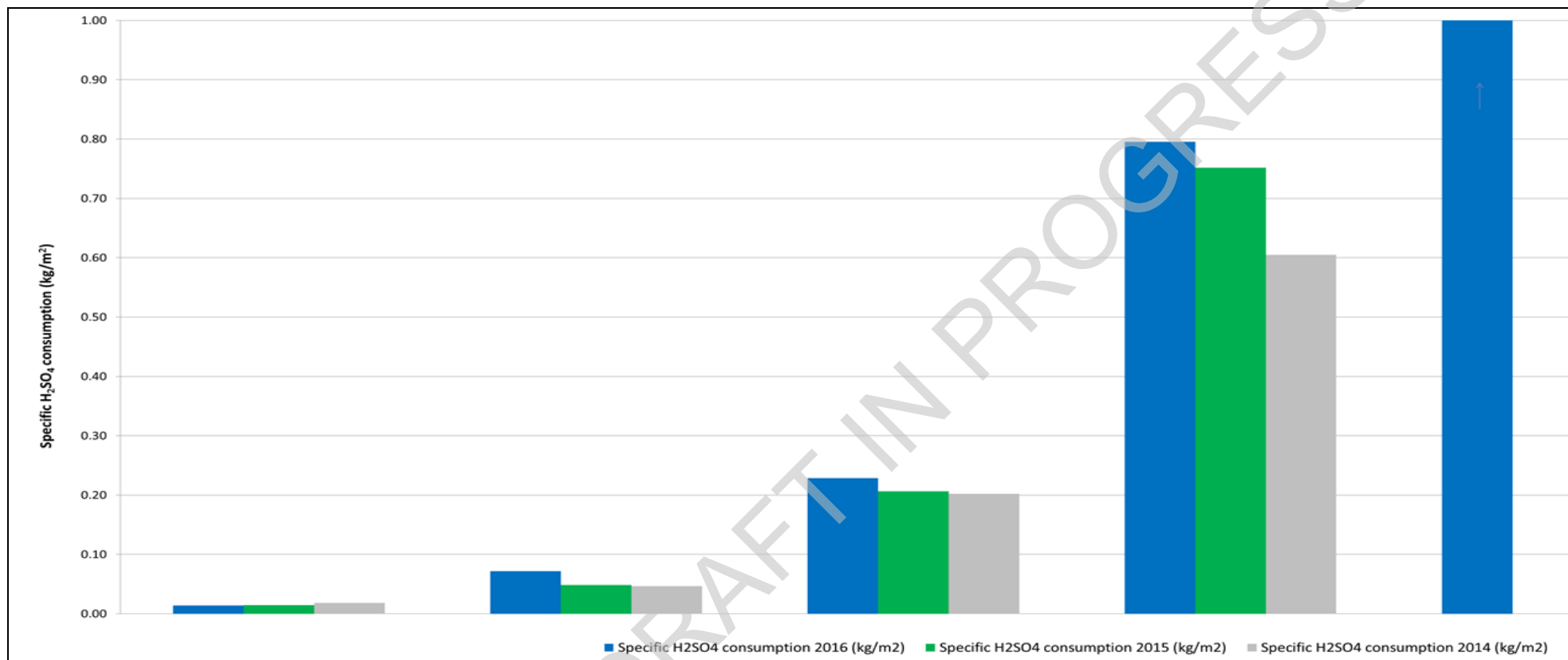


Figure 3.20: Specific H_2SO_4 consumption (kg/m^2 of treated surface) in cold rolling plants. Source: [TWG 2018].

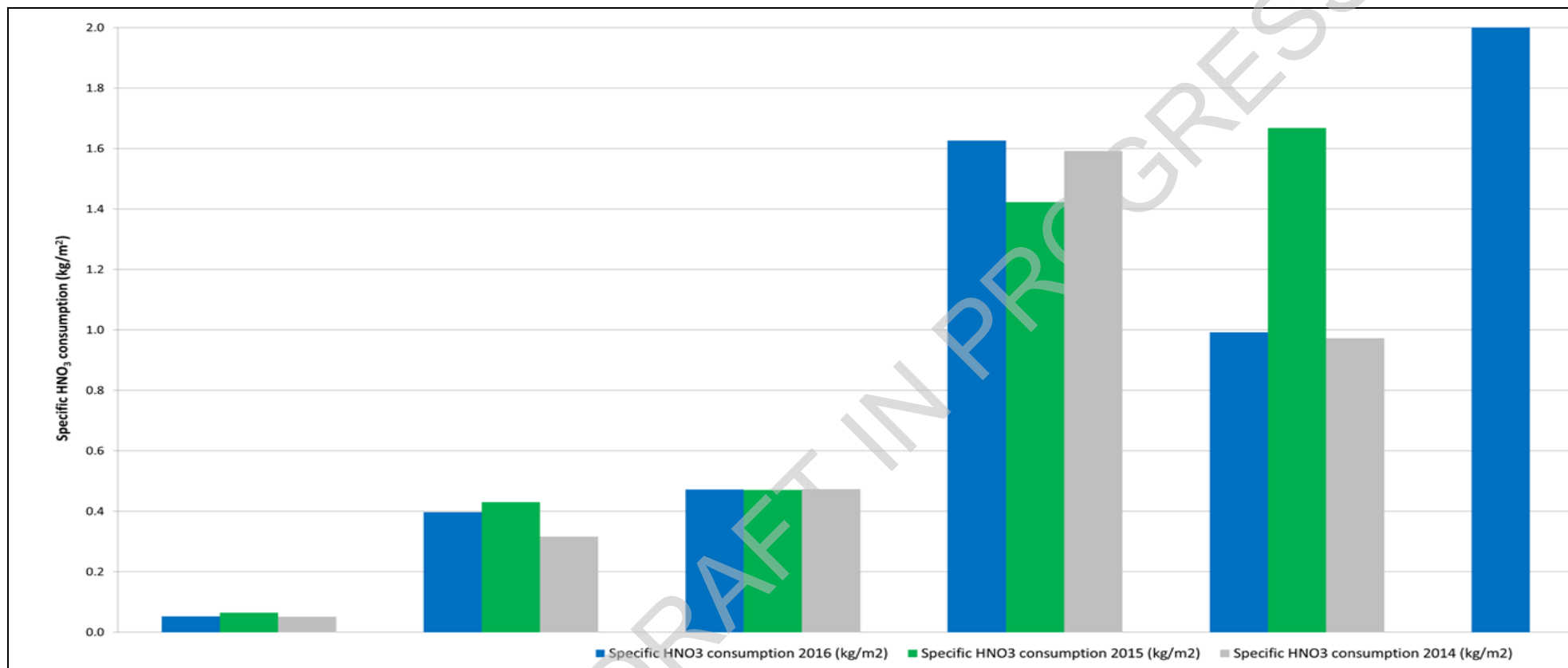


Figure 3.21: Specific HNO₃ consumption (kg/m² of treated surface) in cold rolling plants. Source: [TWG 2018].

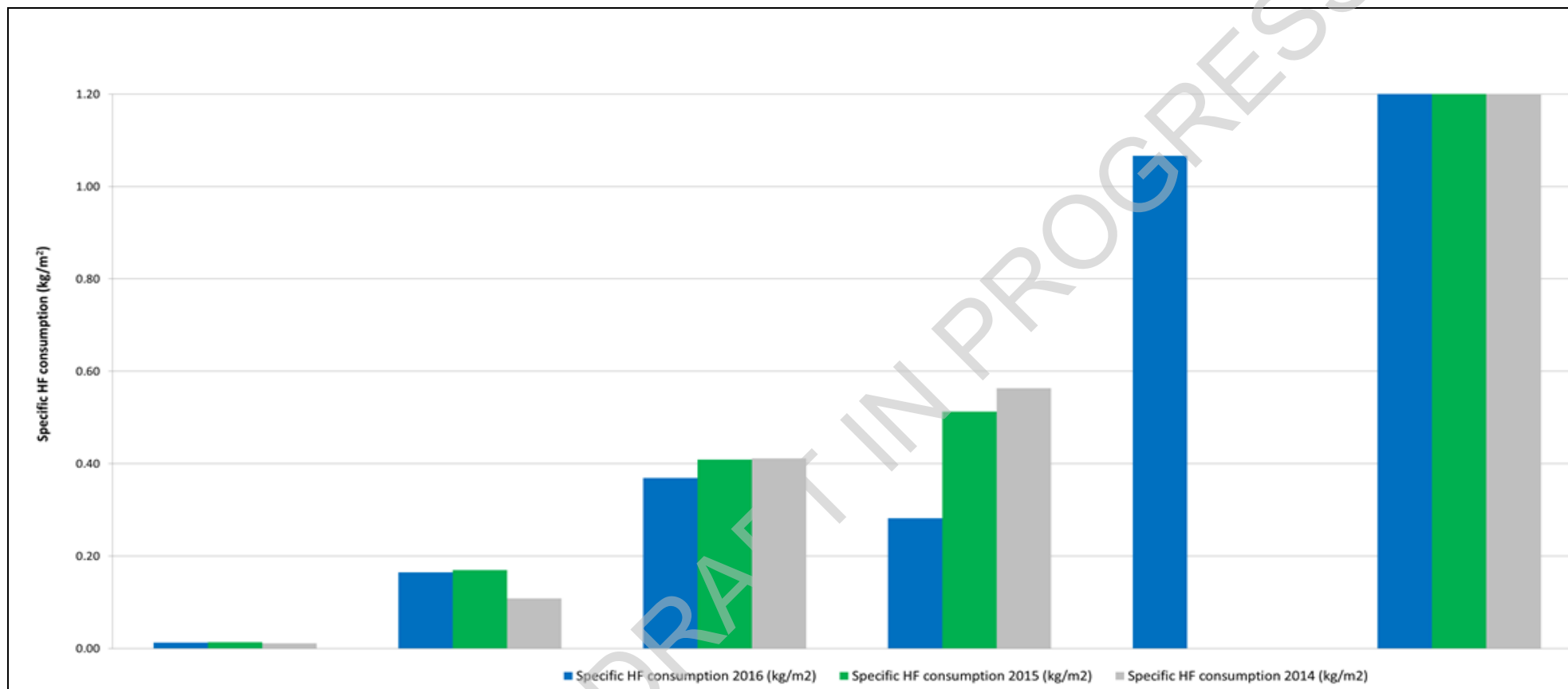


Figure 3.22: Specific HF consumption (kg/m² of treated surface) in cold rolling plants. Source: [TWG 2018].

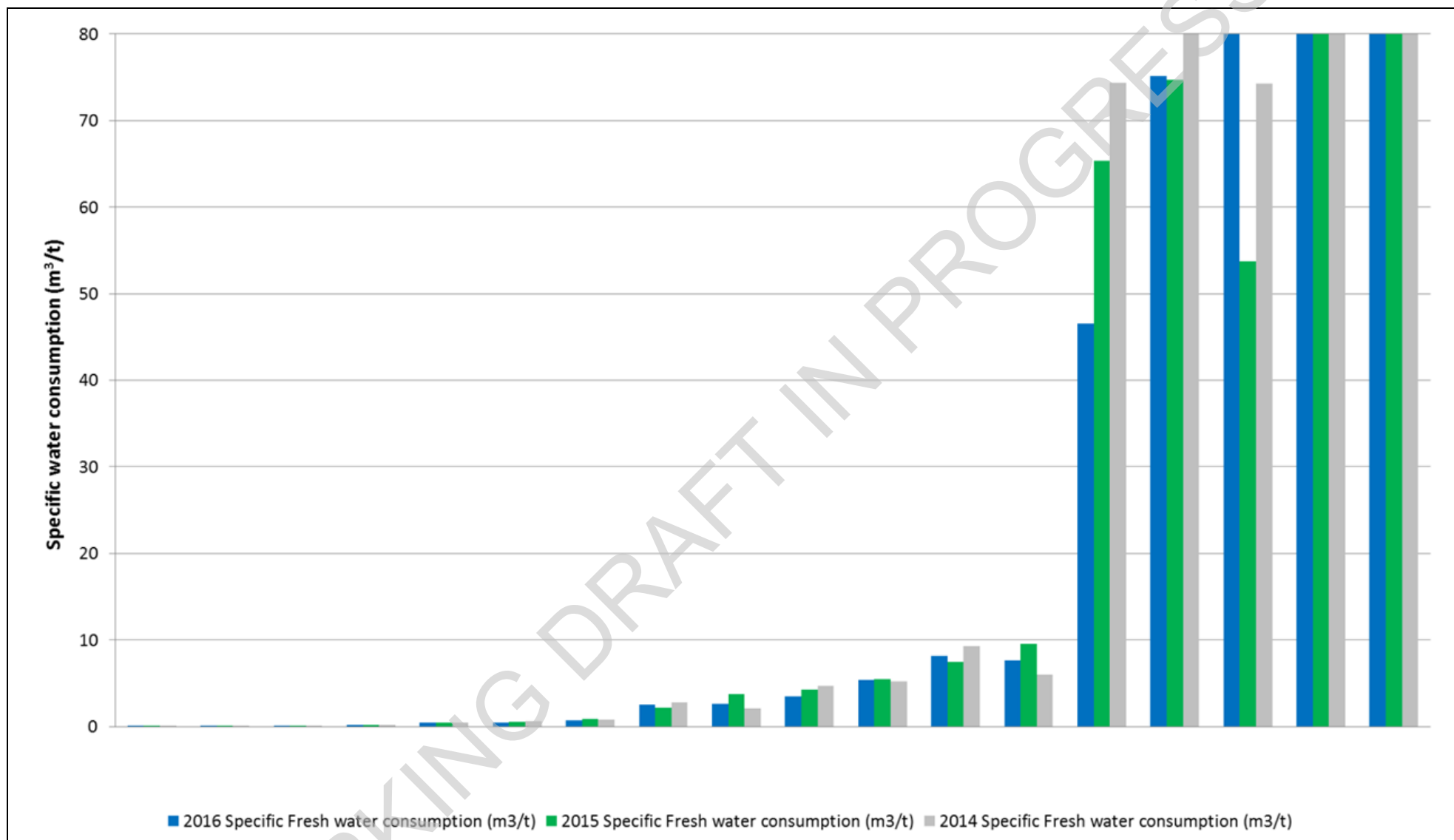


Figure 3.23: Specific water consumption (m³/t of production) in cold rolling plants. Source: [TWG 2018]

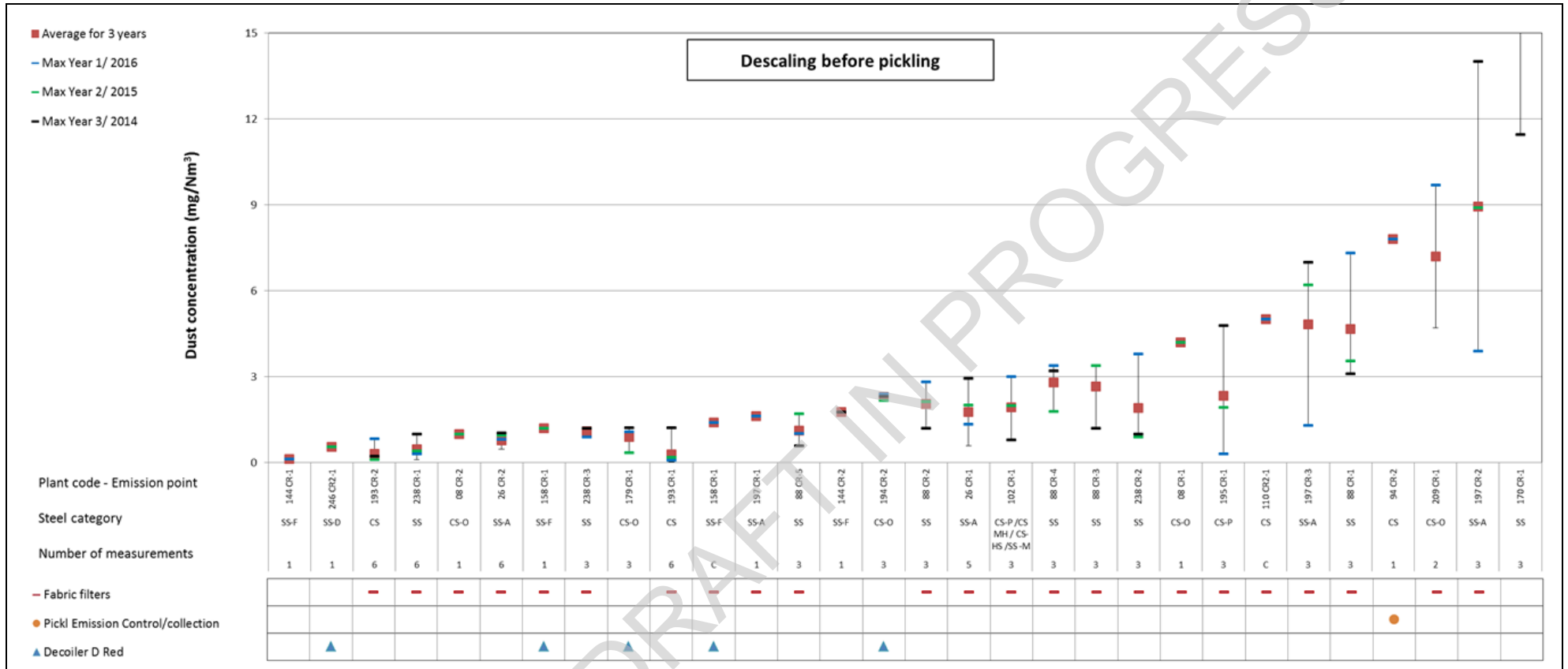


Figure 3.24: Dust emissions from mechanical processing and welding - part 1 of 2. Source: [TWG 2018].

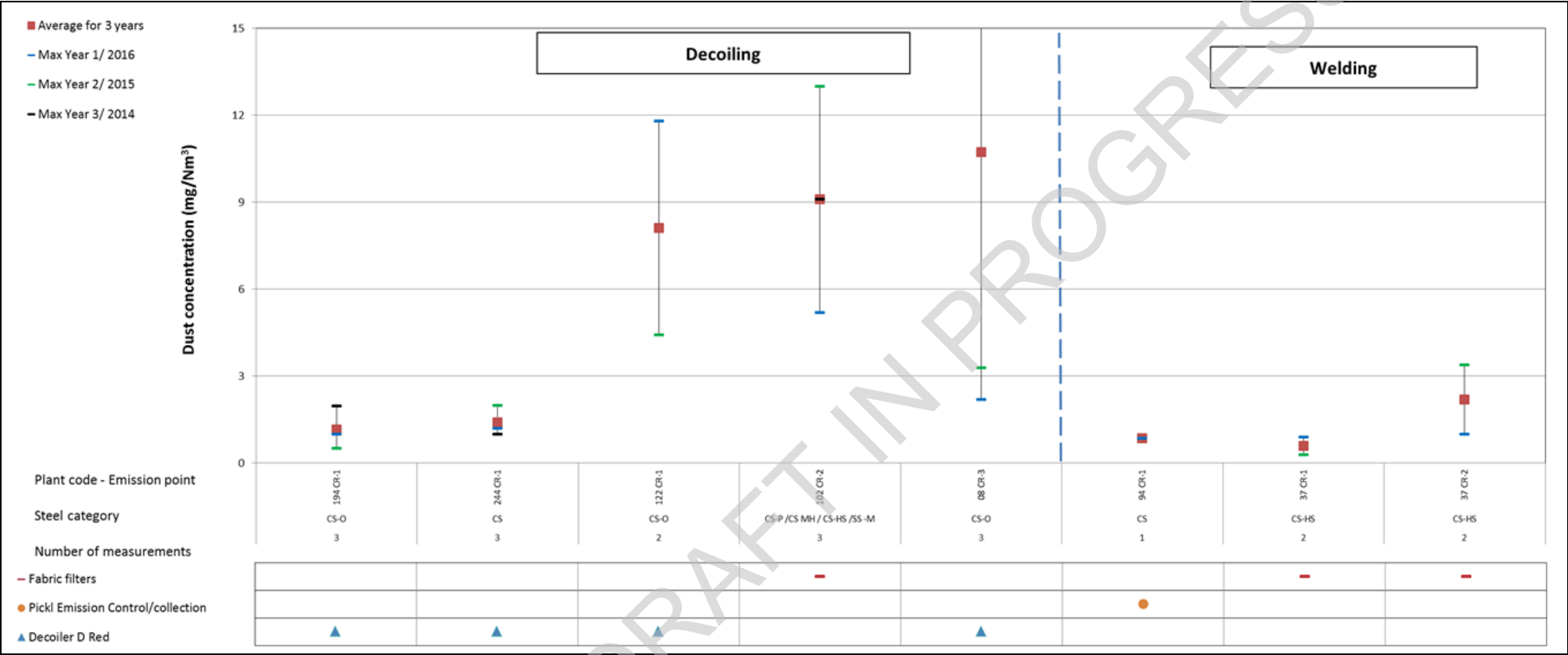


Figure 3.25: Dust emissions from mechanical processing and welding - part 2 of 2. Source: [TWG 2018].

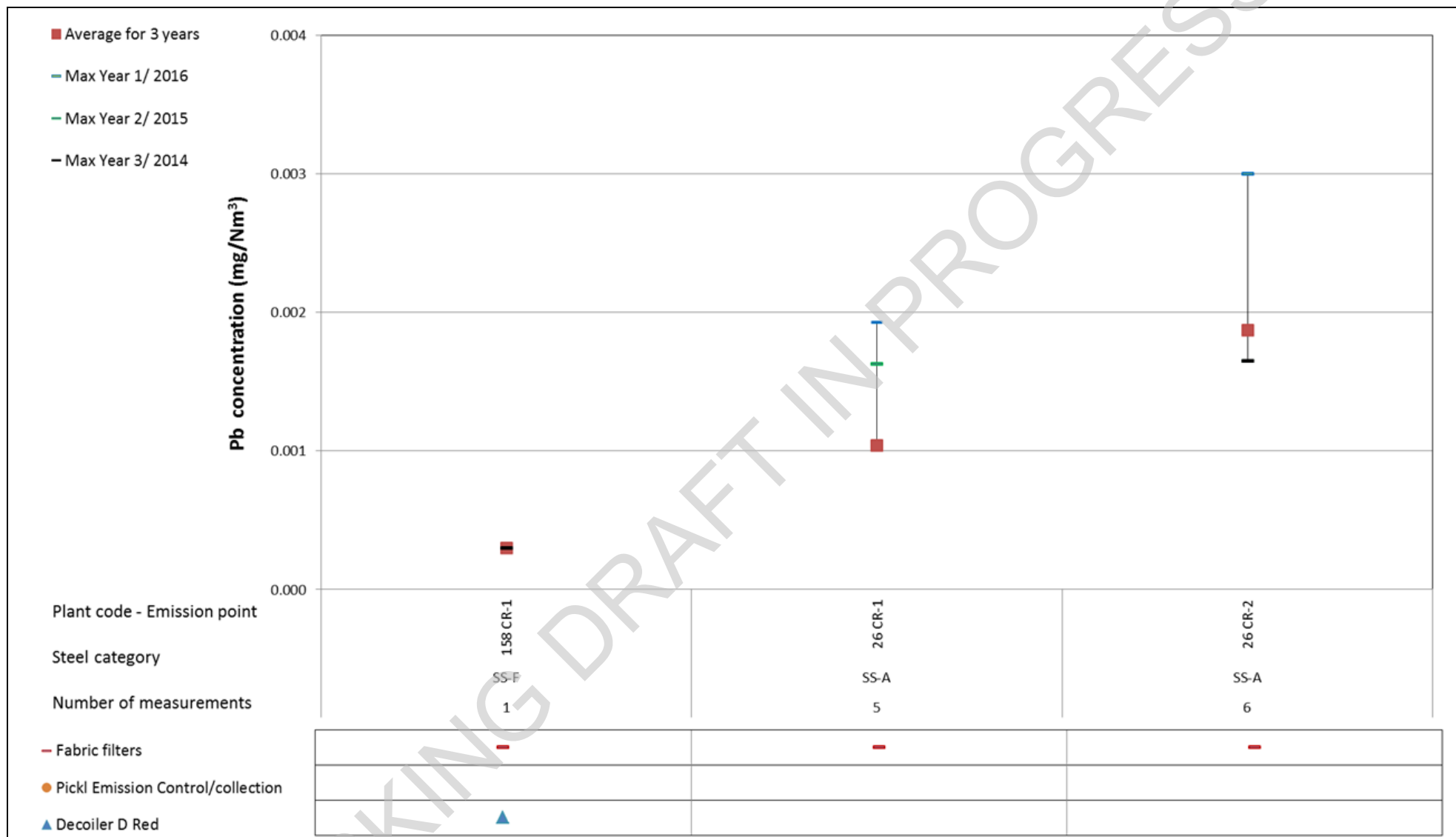


Figure 3.26: Lead emissions from descaling before pickling. Source: [TWG 2018].

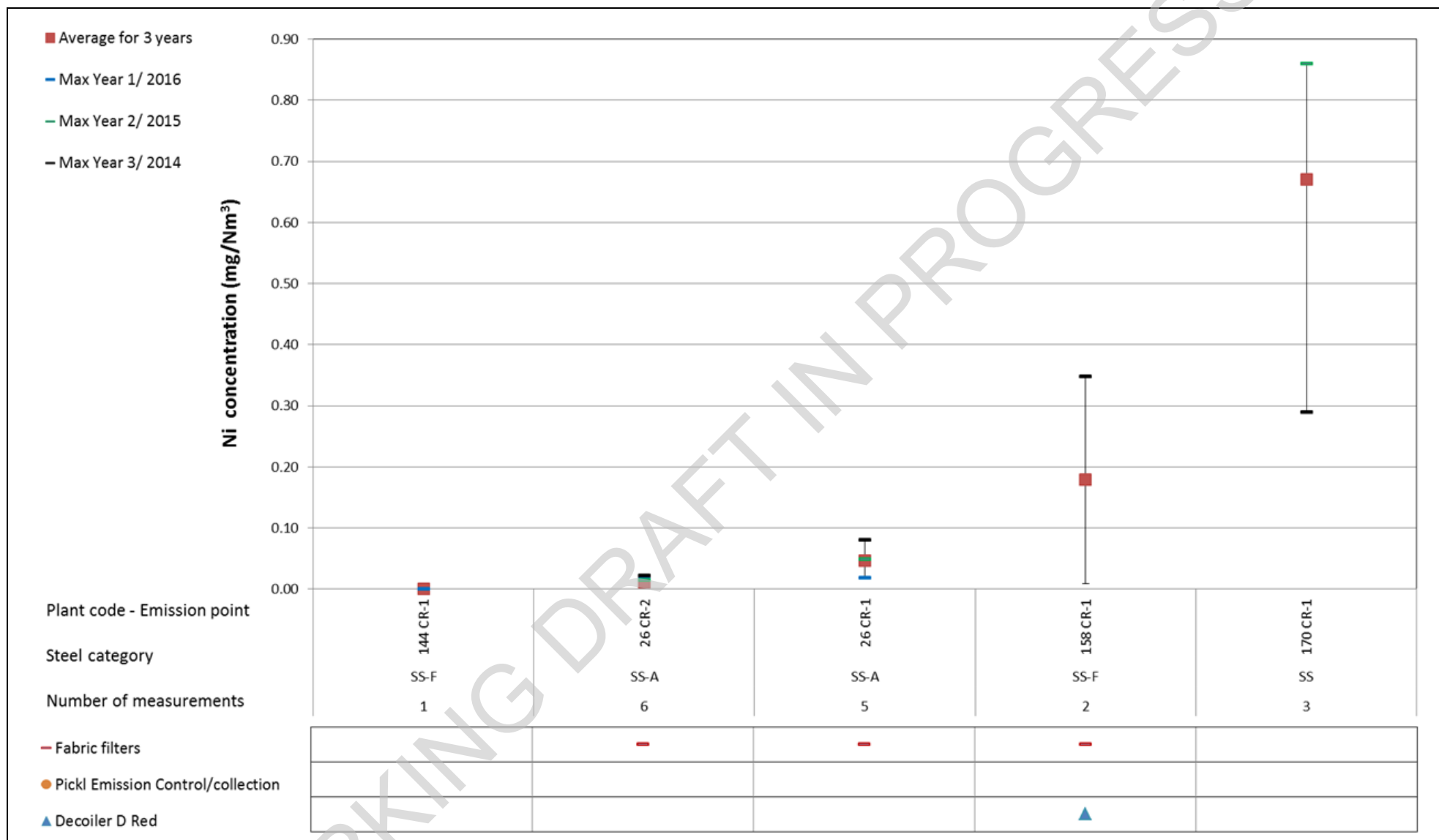


Figure 3.27: Nickel emissions from descaling before pickling. Source: [TWG 2018].

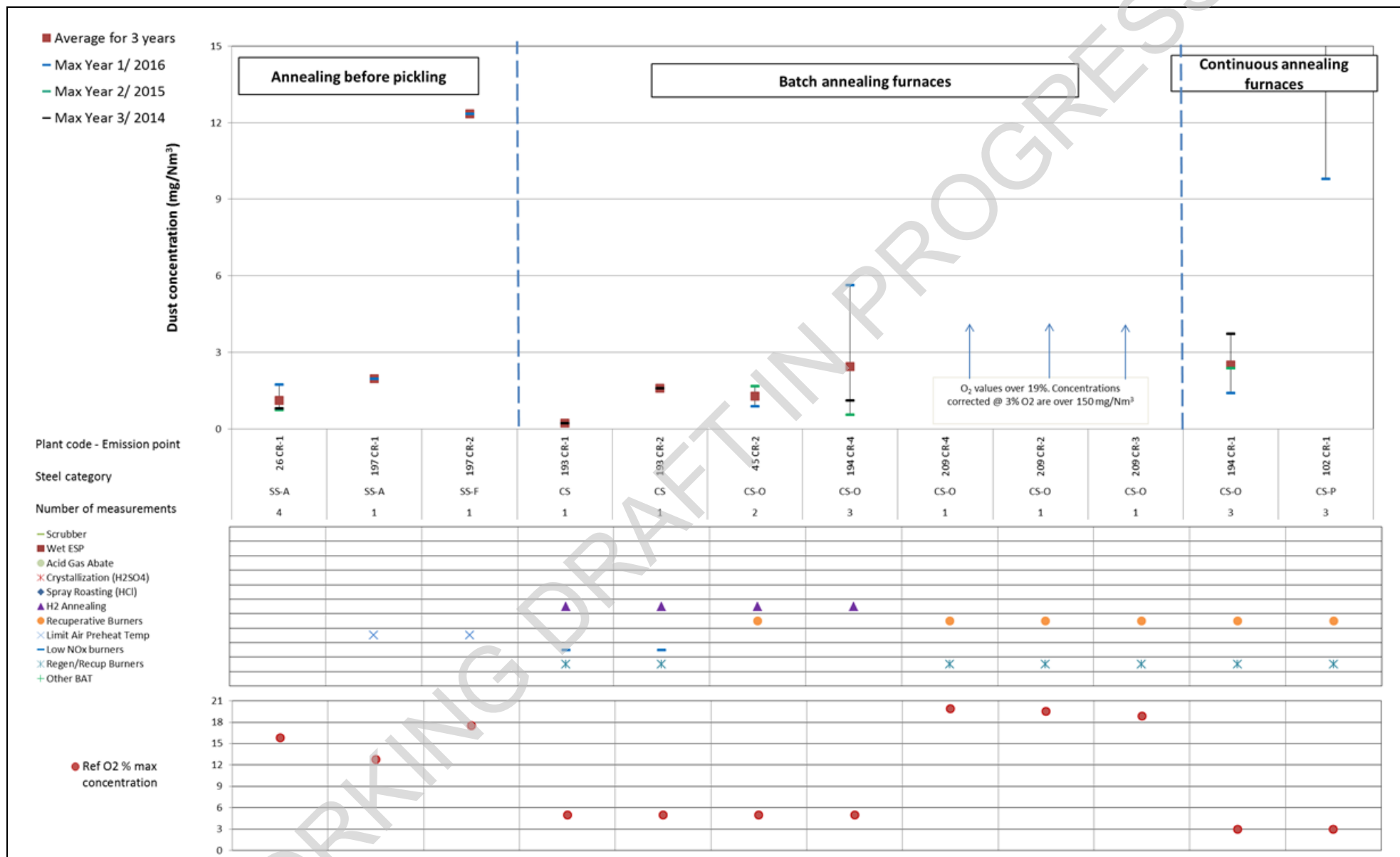


Figure 3.28: Dust emissions from feedstock heating (in mg/Nm³ at 3% oxygen) for fuel 100% natural gas. Source: [TWG 2018].

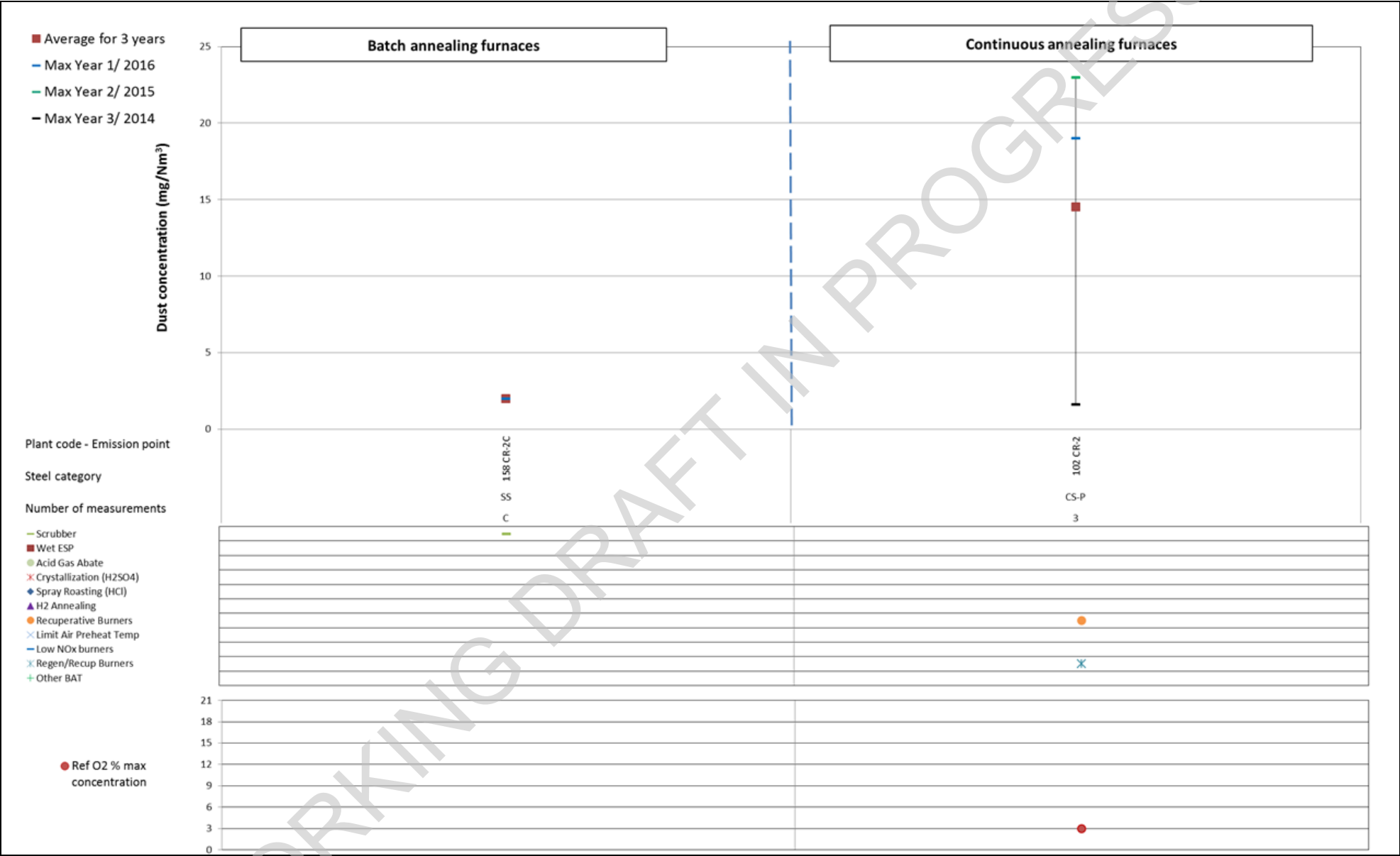


Figure 3.29: Dust emissions from feedstock heating (in mg/Nm³ at 3% oxygen) for fuel other than 100% natural gas or unknown fuel. Source: [TWG 2018].

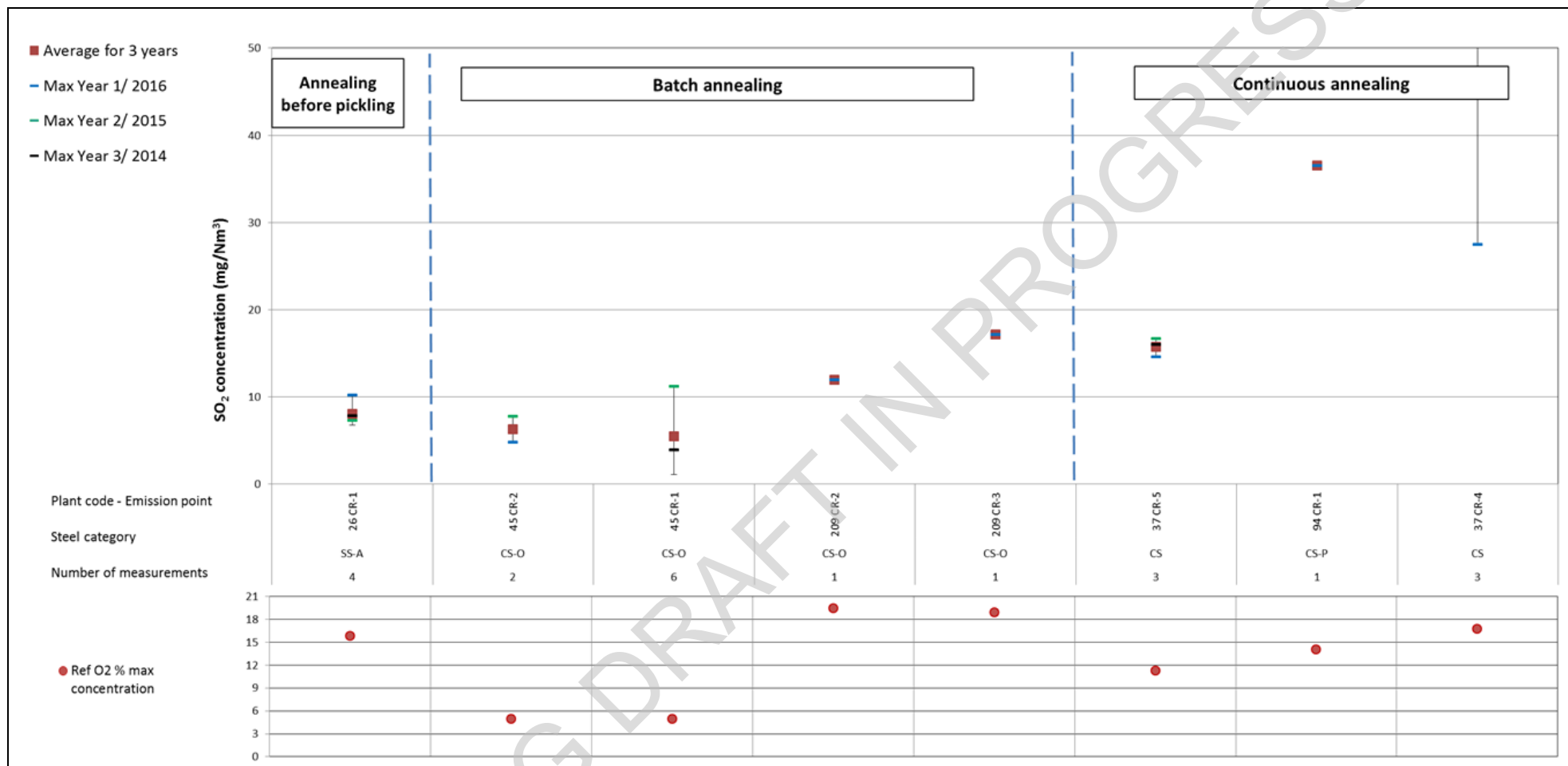


Figure 3.30: SO₂ emissions from feedstock heating (in mg/Nm³ at 3% oxygen) for fuel 100% natural gas. Source: [TWG 2018].

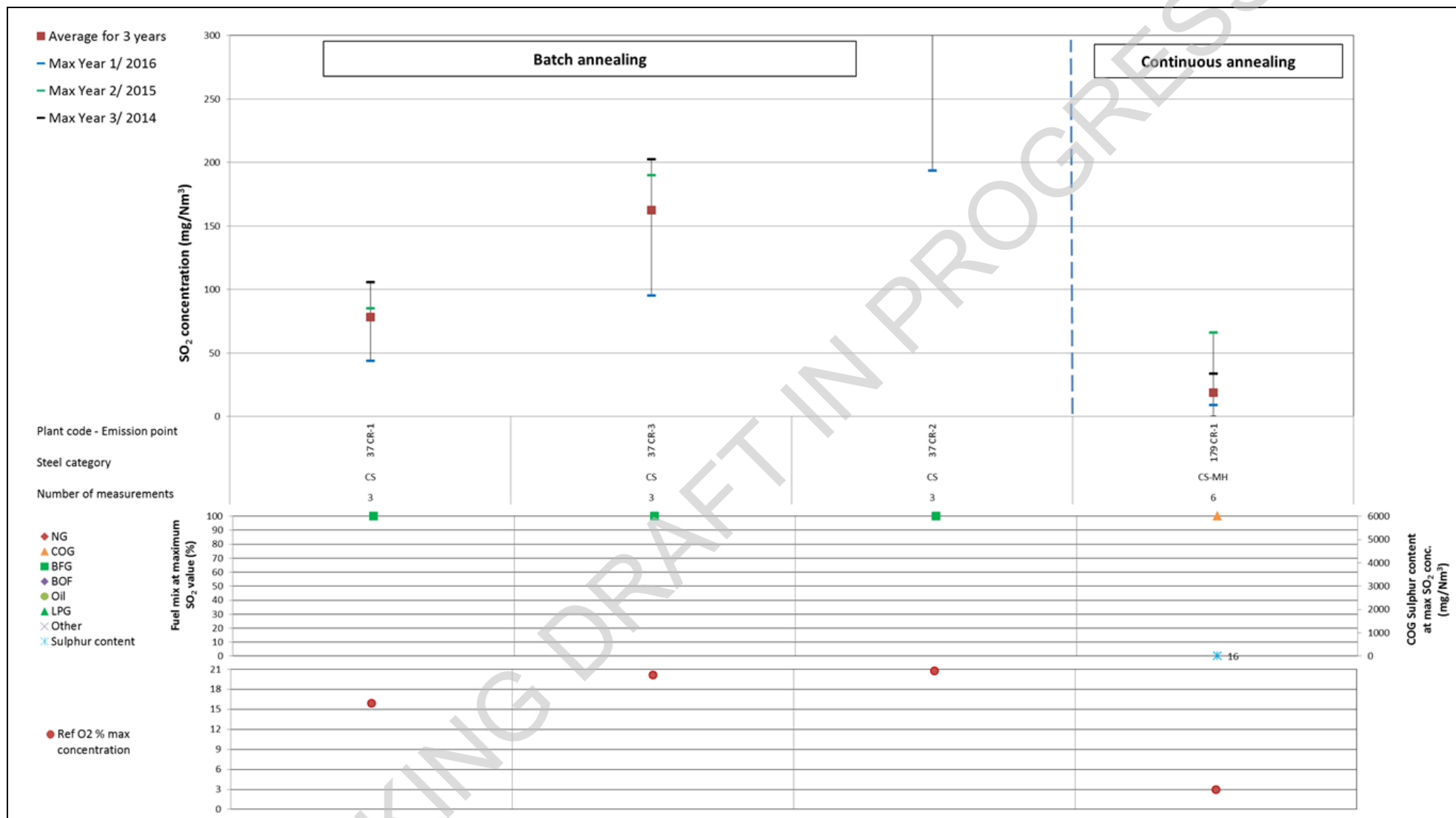


Figure 3.31: SO₂ emissions from feedstock heating (in mg/Nm³ at 3% oxygen) for fuel other than 100% natural gas or unknown fuel. Source: [TWG 2018].

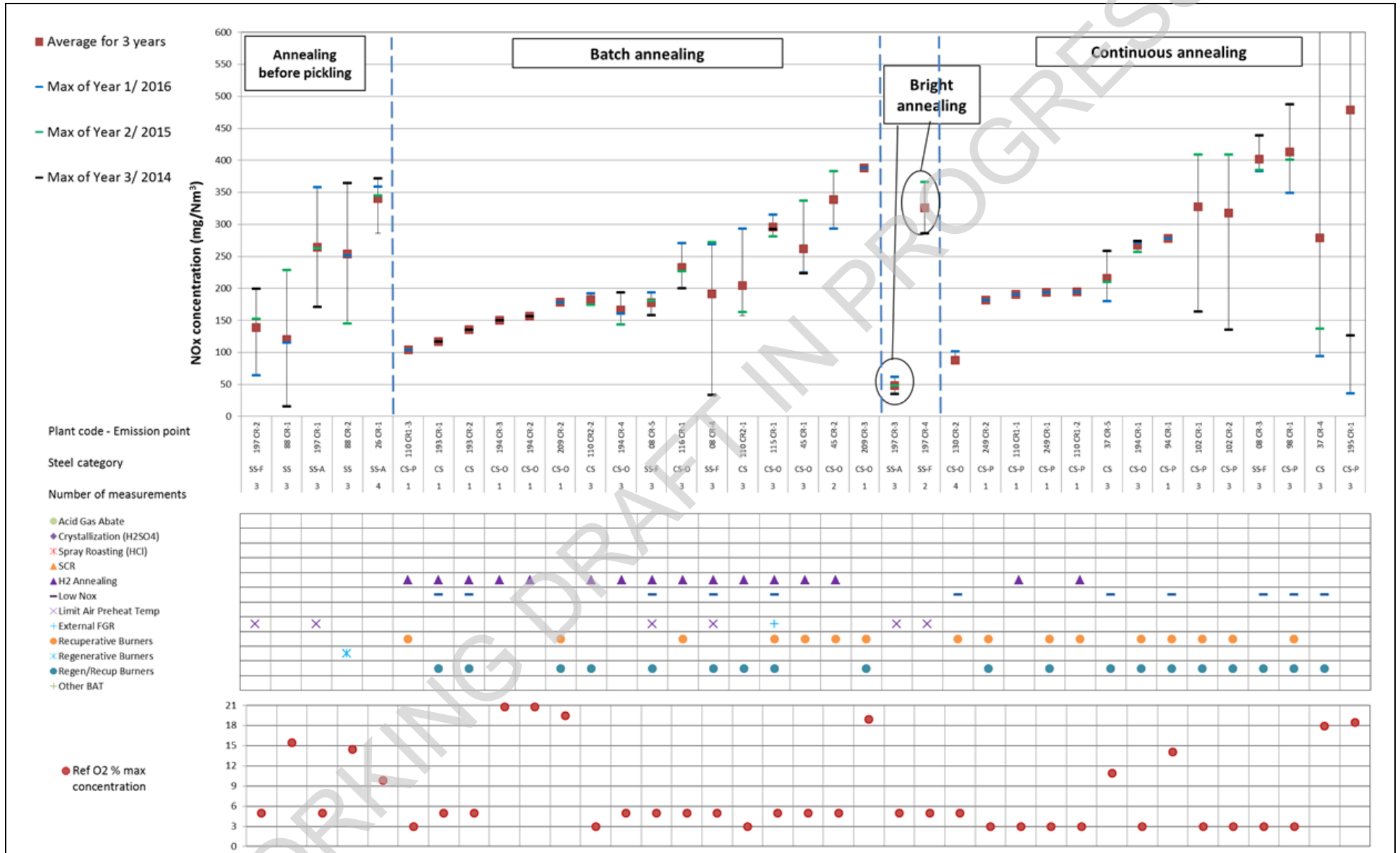


Figure 3.32: NO_x emissions from feedstock heating (in mg/Nm³ at 3% oxygen) for fuel 100% natural gas. Source: [TWG 2018].

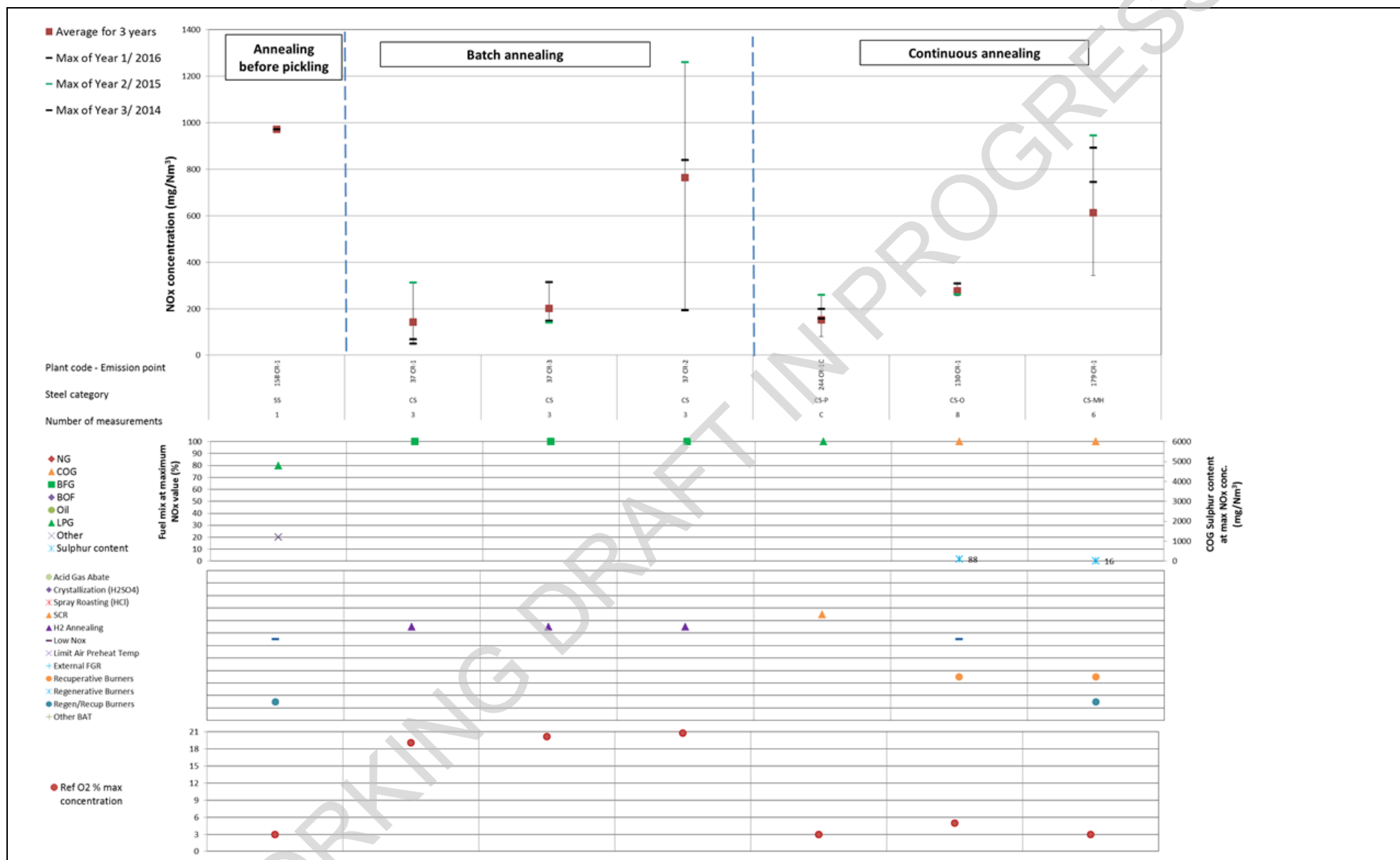


Figure 3.33: NO_x emissions from feedstock heating (in mg/Nm³ at 3% oxygen) for fuel other than 100% natural gas or unknown fuel. Source: [TWG 2018].

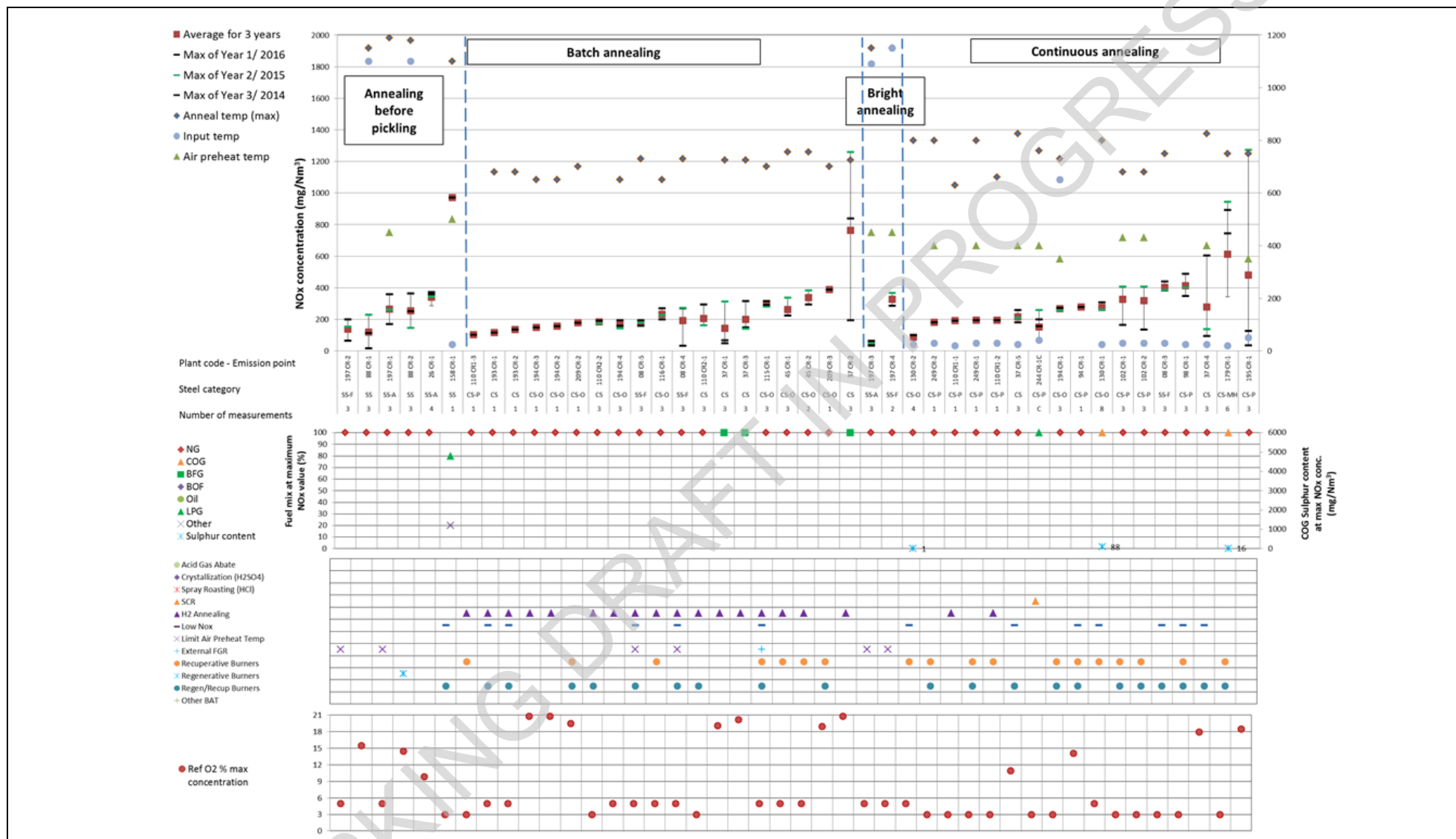


Figure 3.34: NOx emissions from feedstock heating (in mg/Nm³ at 3% oxygen) for all fuels, with air preheating temperature and feedstock inlet and target temperature. Source: [TWG 2018].

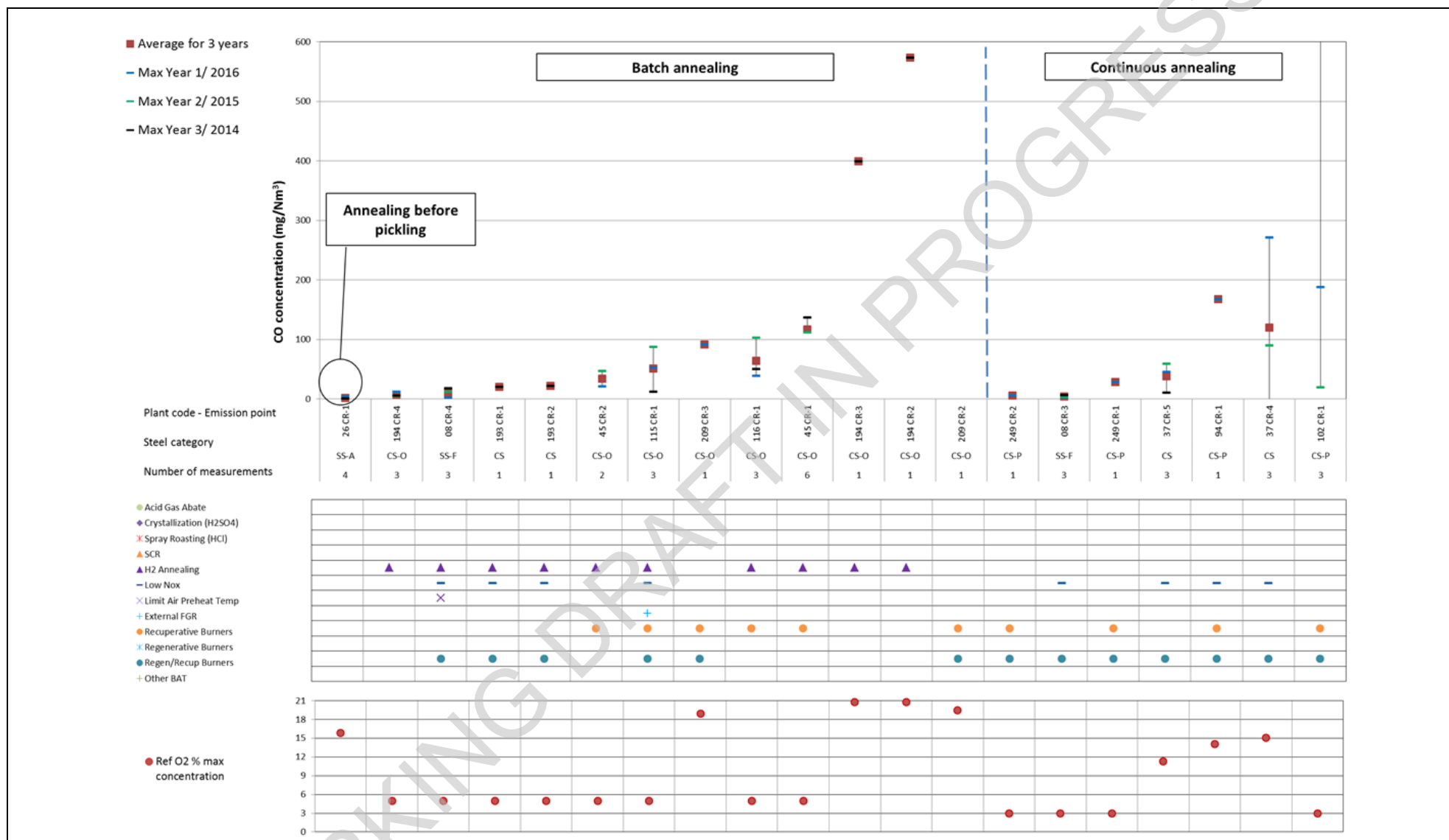


Figure 3.35: CO emissions from feedstock heating (in mg/Nm³ at 3% oxygen) for fuel 100% natural gas. Source: [TWG 2018].

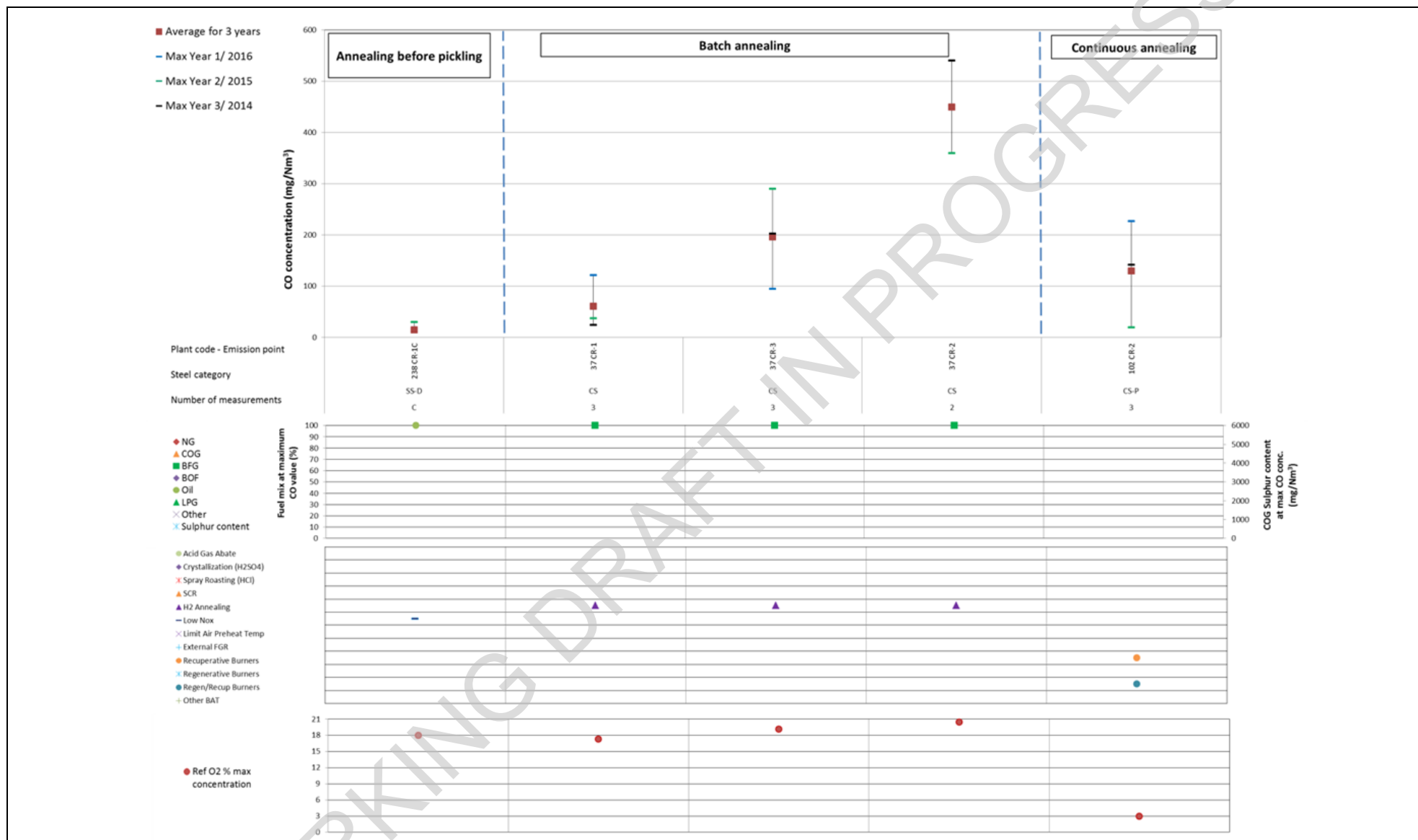


Figure 3.36: CO emissions from feedstock heating (in mg/Nm³ at 3% oxygen) for fuel other than 100% natural gas or unknown fuel. Source: [TWG 2018].

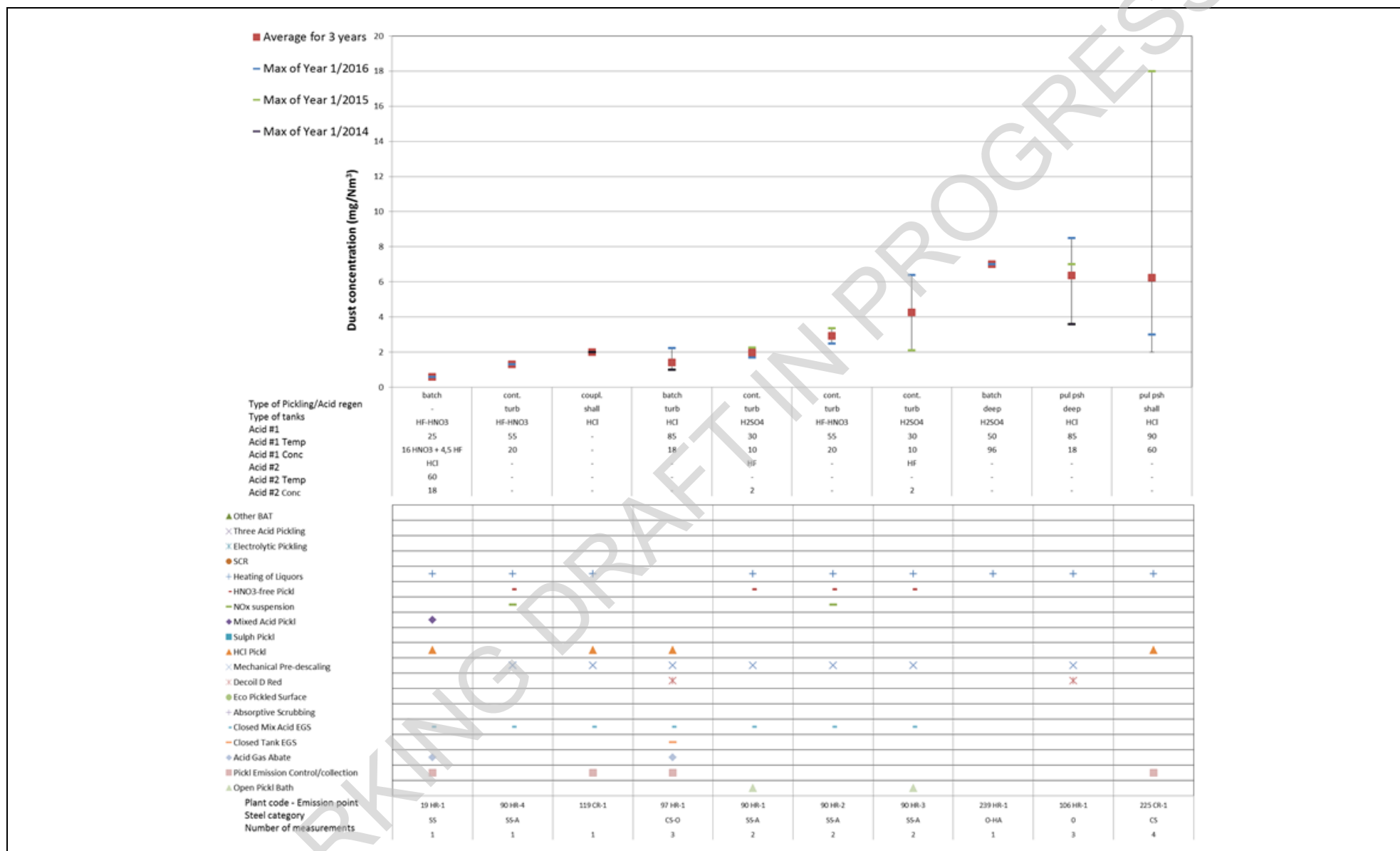


Figure 3.37: Dust emissions from pickling (in mg/Nm³) in hot rolling and cold rolling plants. Source: [TWG 2018]

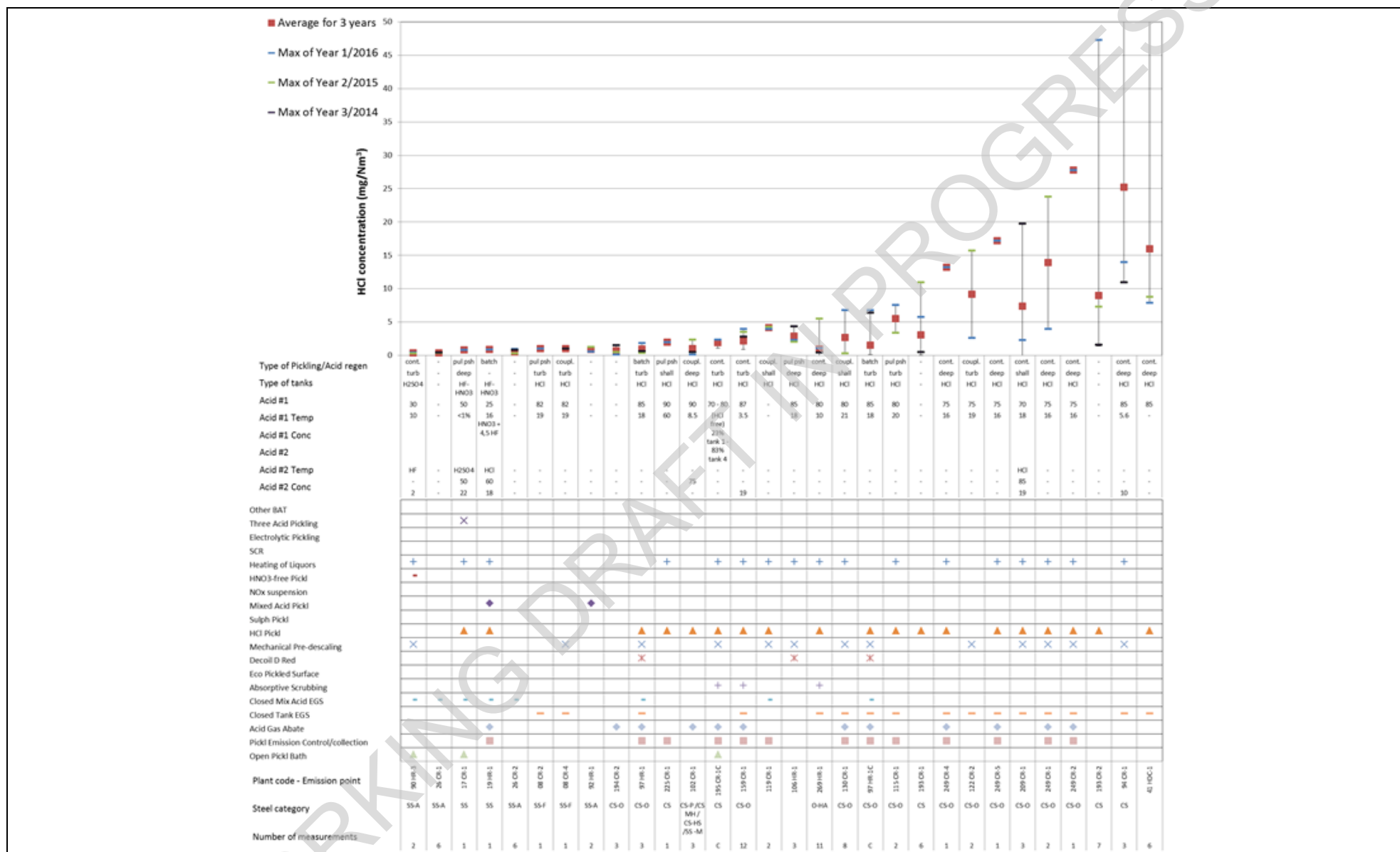


Figure 3.38: HCl emissions from pickling (in mg/Nm³) in hot rolling, cold rolling and hot coating plants. Source: [TWG 2018]

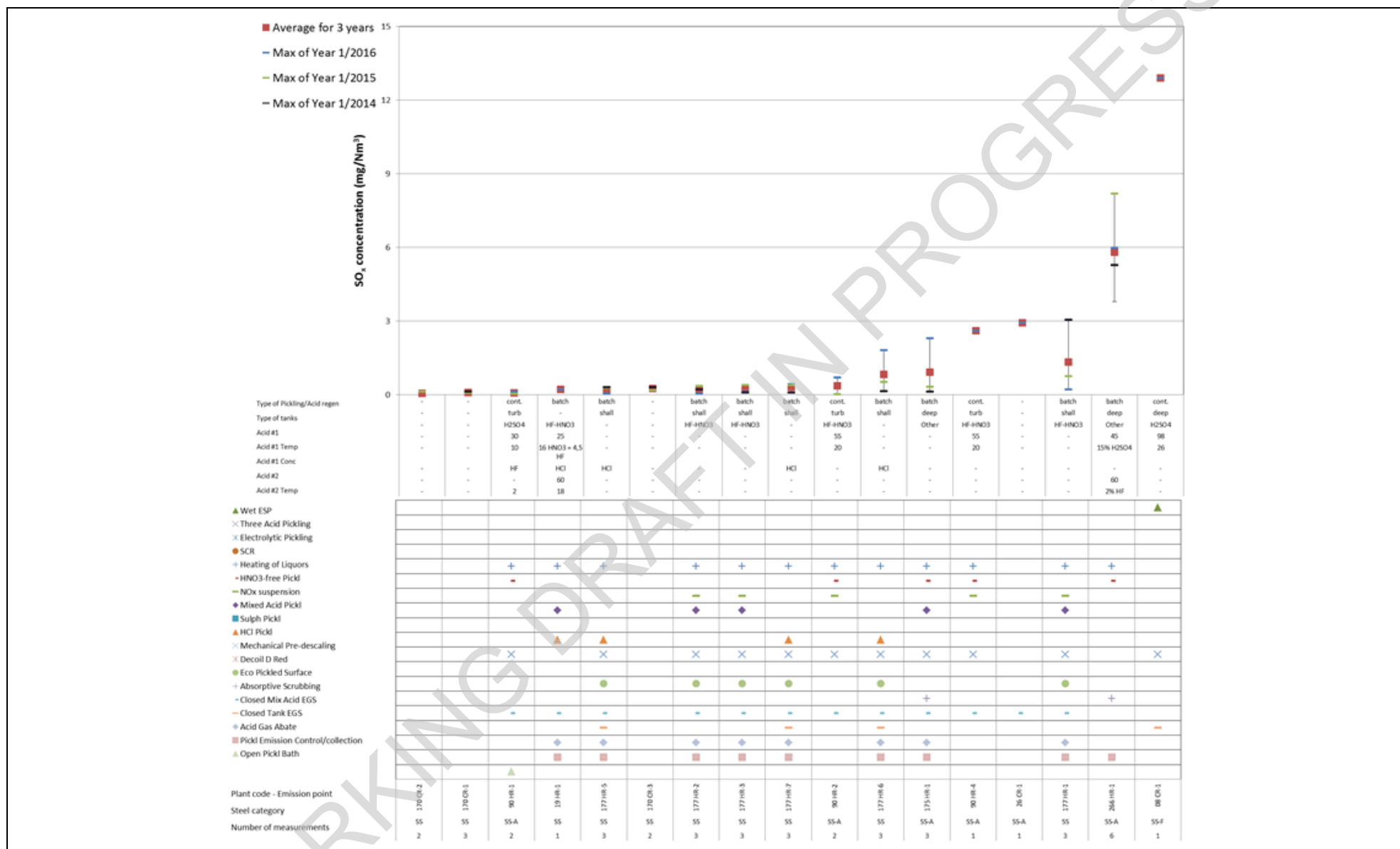


Figure 3.39: SO_x emissions from pickling (in mg/Nm³) in hot rolling and cold rolling plants. Source: [TWG 2018].

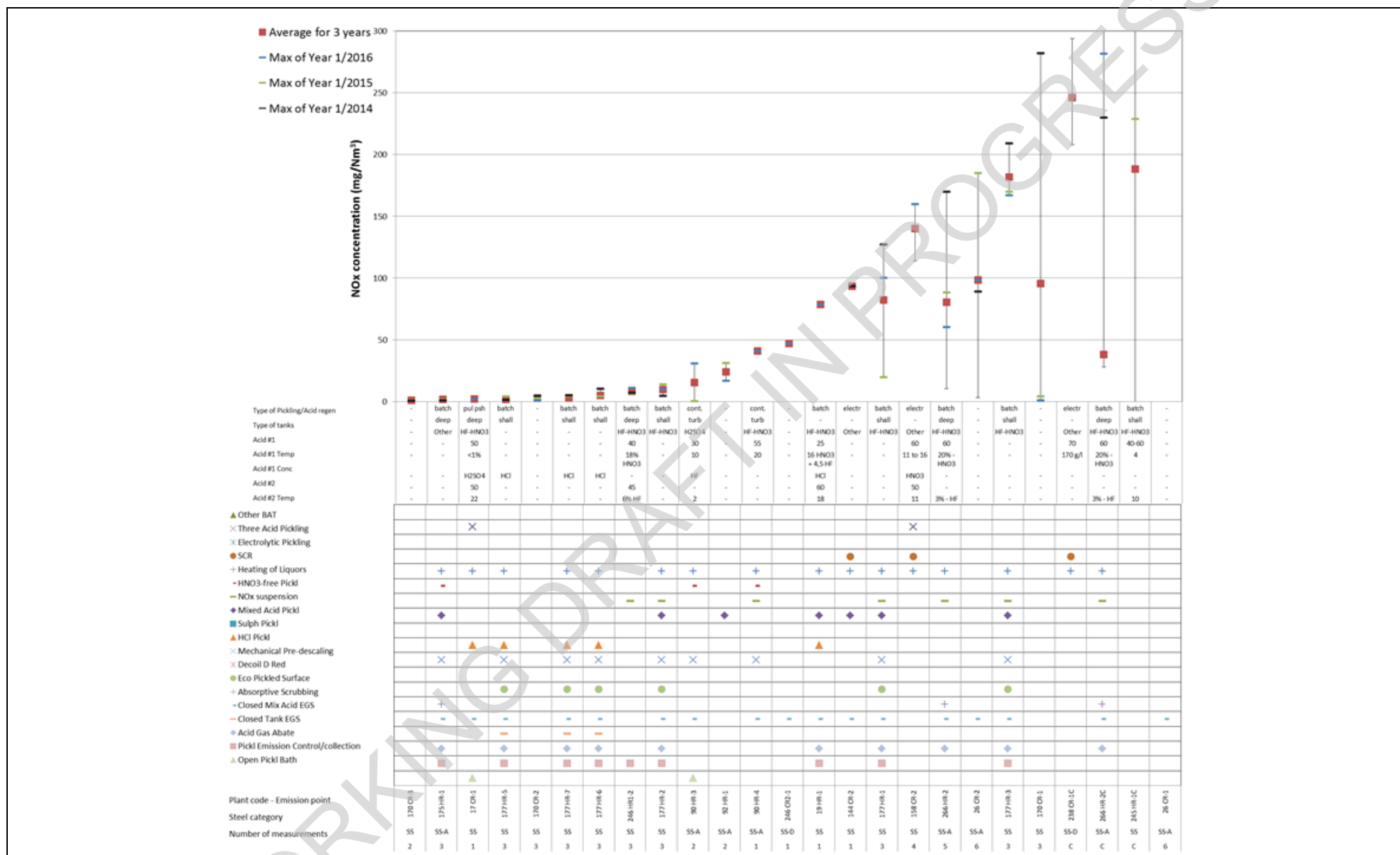


Figure 3.40: NOx emissions from pickling (in mg/Nm³) in hot rolling and cold rolling plants. Source: [TWG 2018].

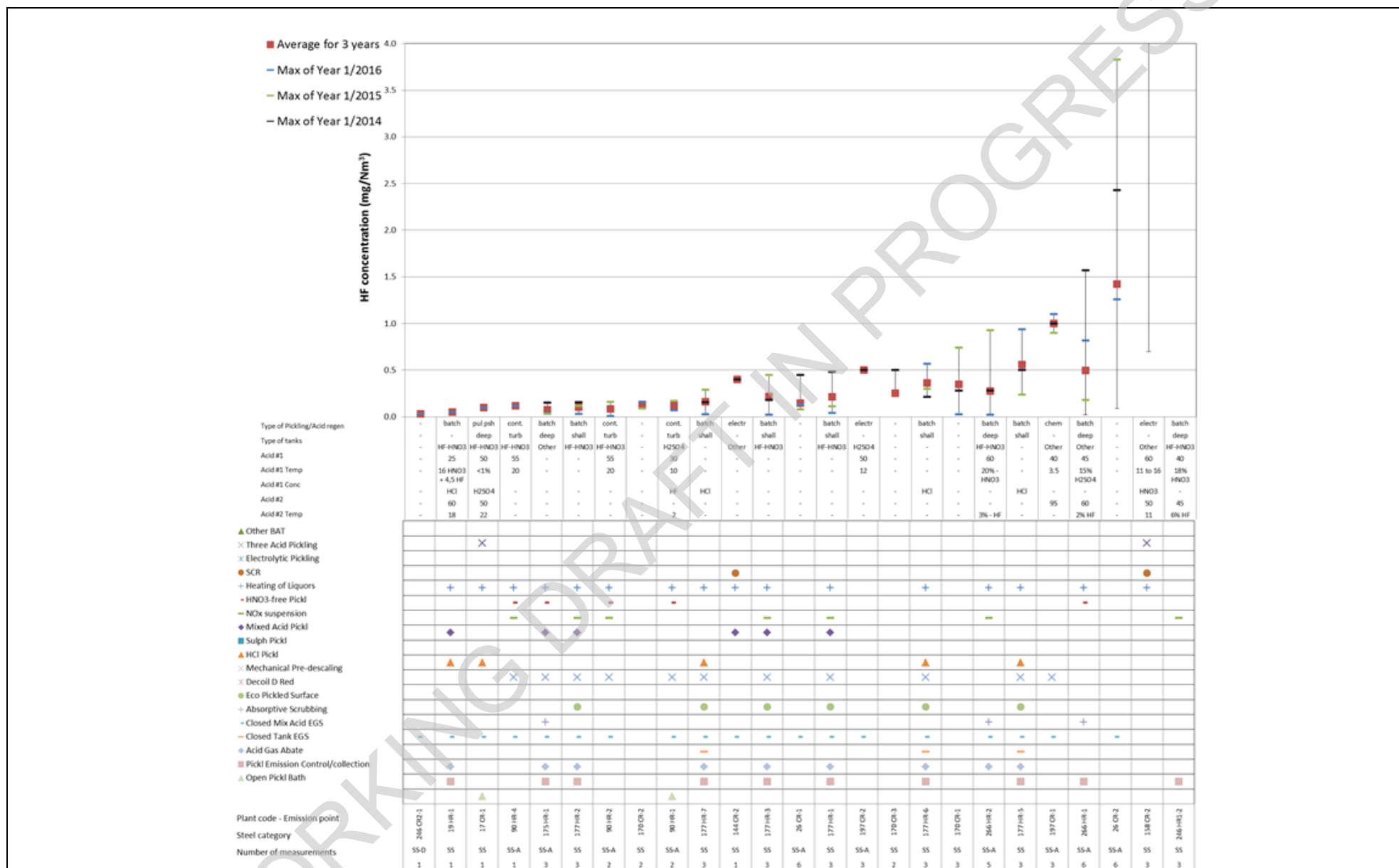


Figure 3.41: HF emissions from pickling (in mg/Nm³) in hot rolling and cold rolling plants. Source: [TWG 2018].

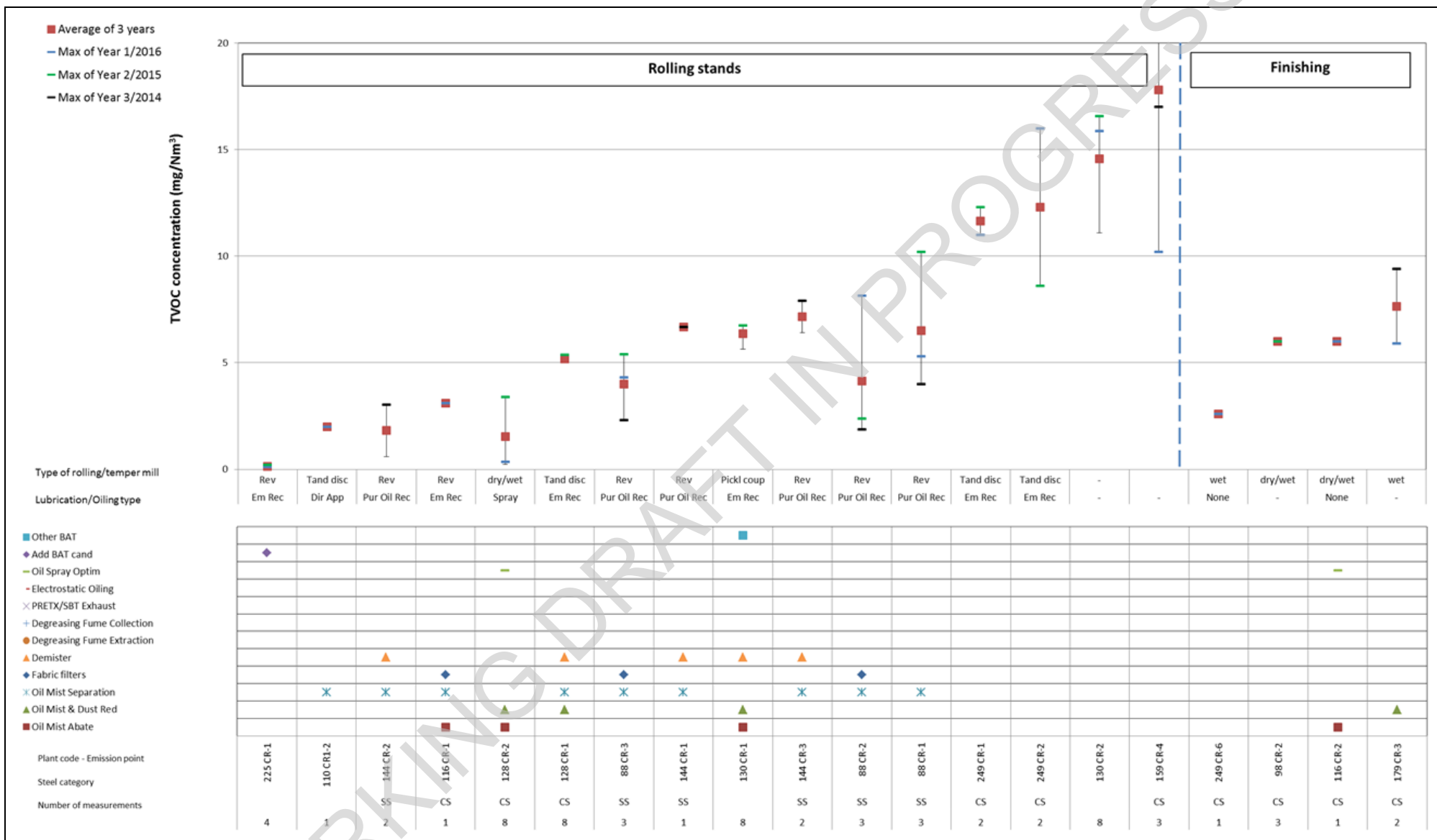


Figure 3.42: TVOC emissions from rolling stands and finishing (in mg/Nm³). Source: [TWG 2018]

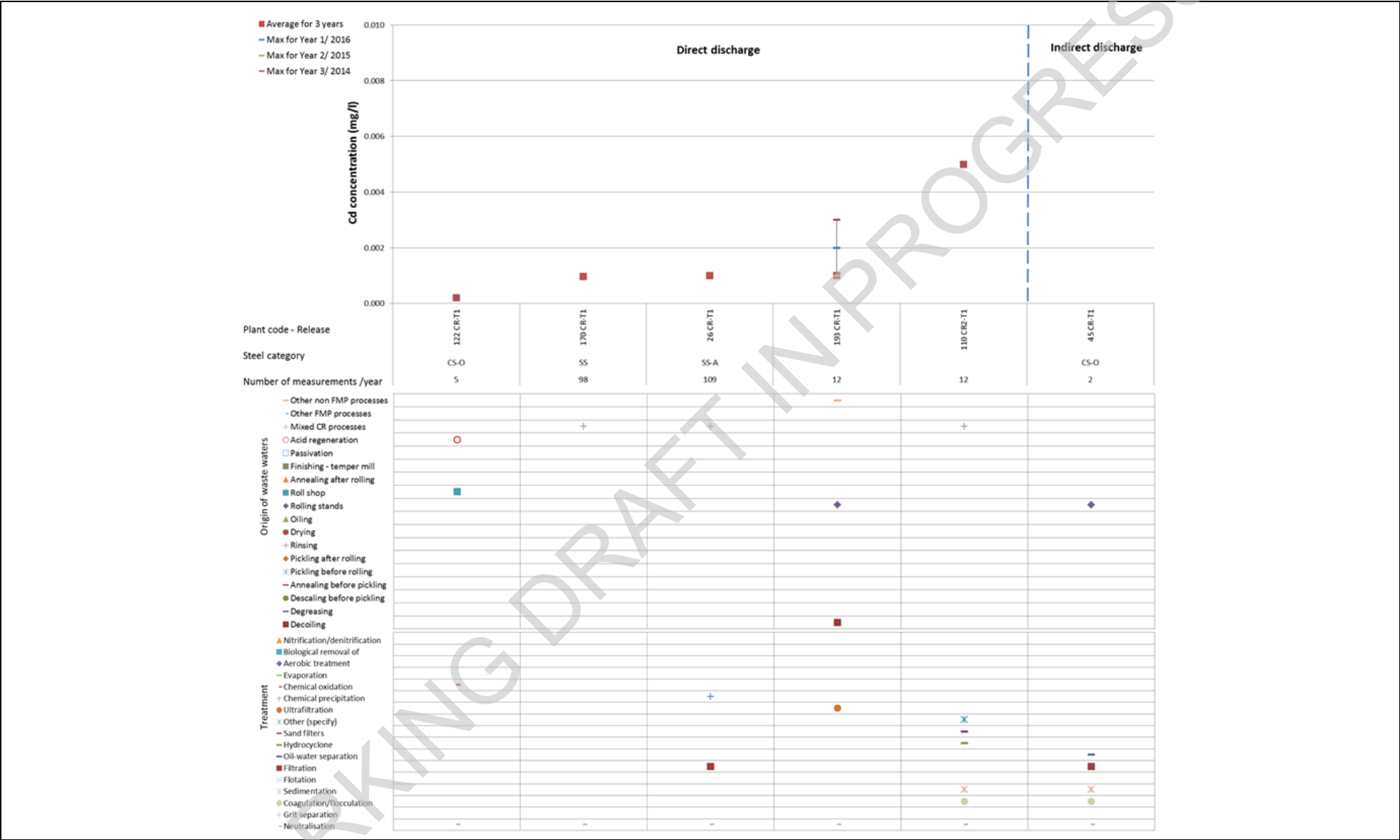


Figure 3.43: Cadmium emissions (in mg/l) for direct and indirect discharges. Source: [TWG 2018].

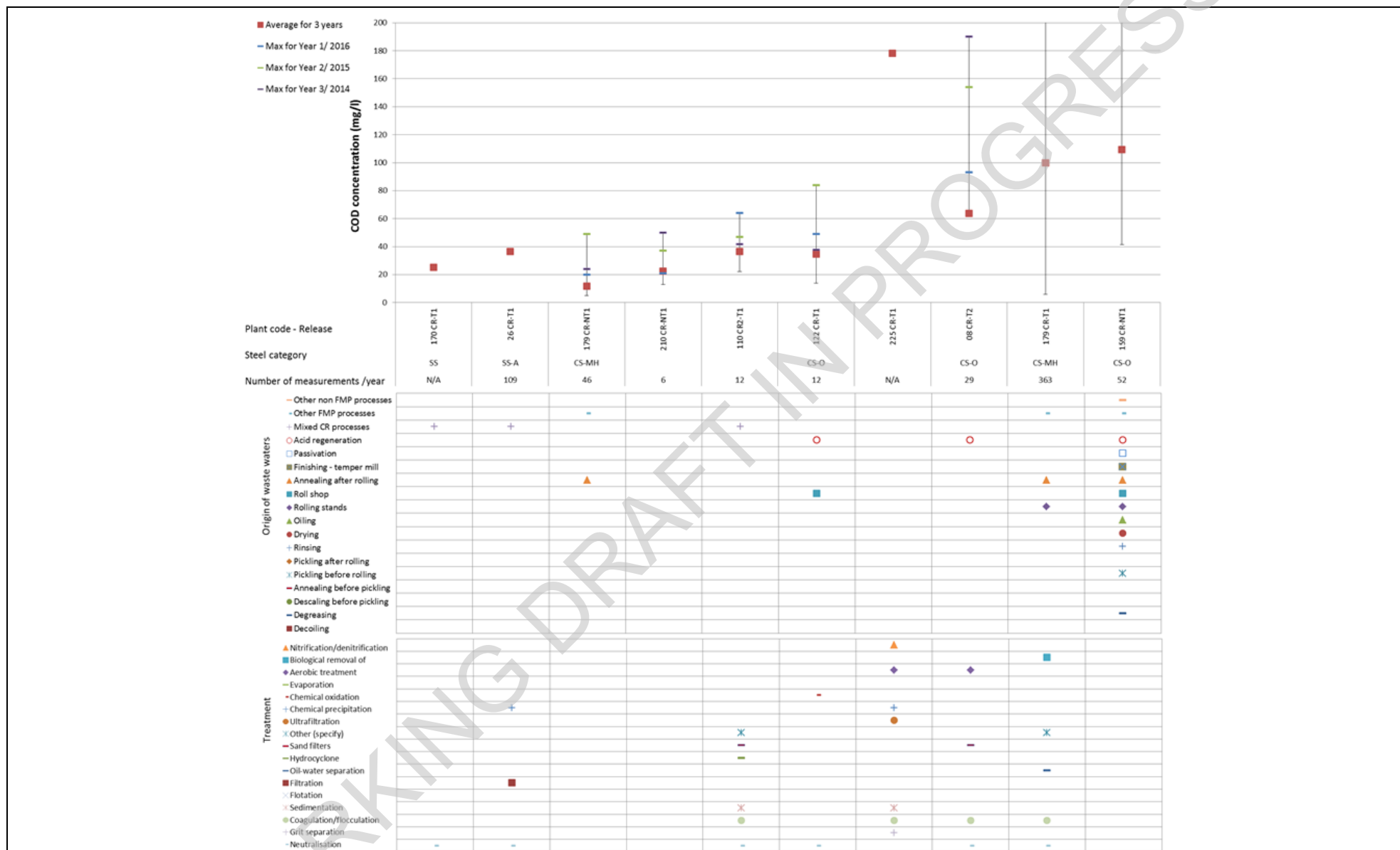


Figure 3.44: COD emissions (in mg/l) for direct discharges. Source: [TWG 2018].

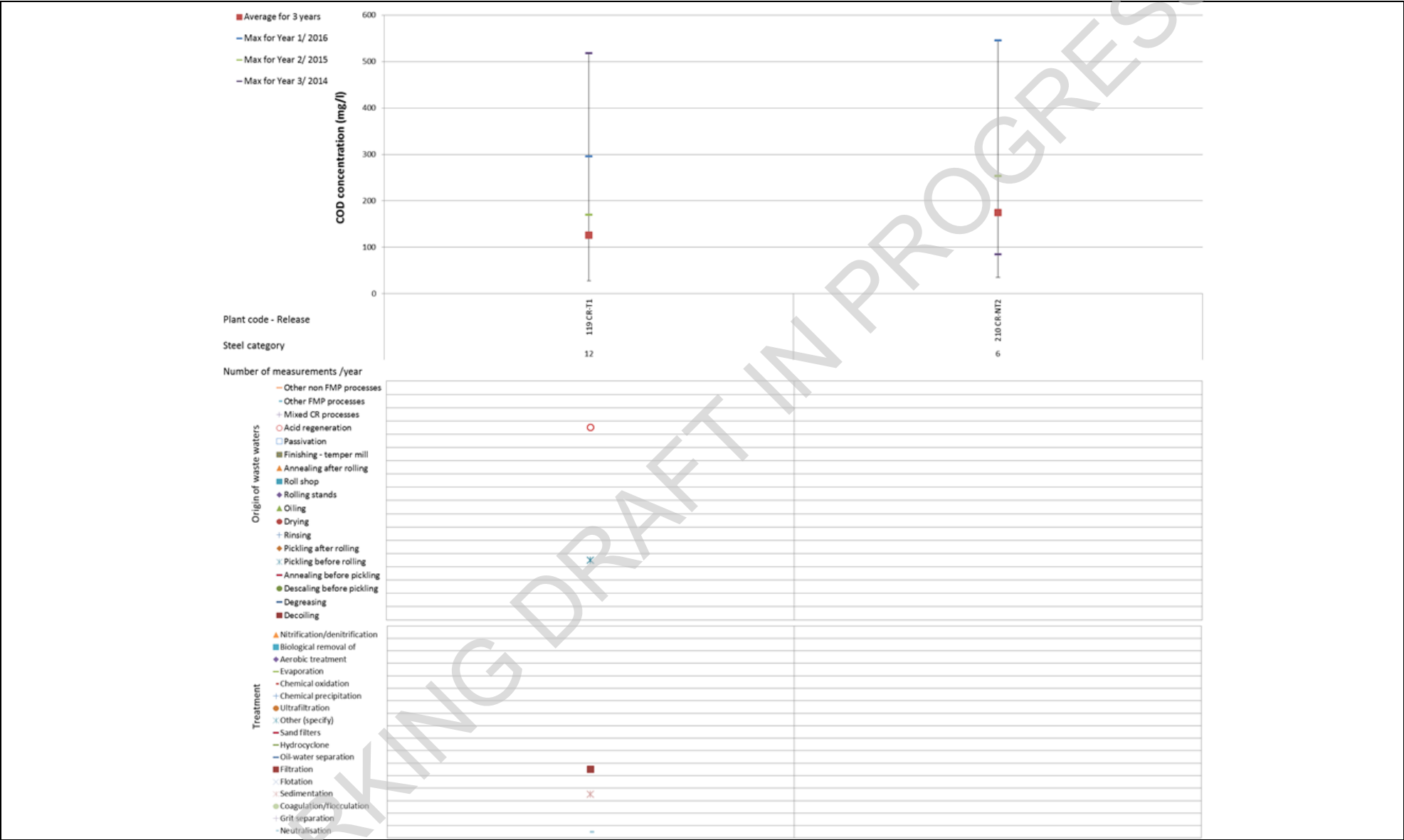


Figure 3.45: COD emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

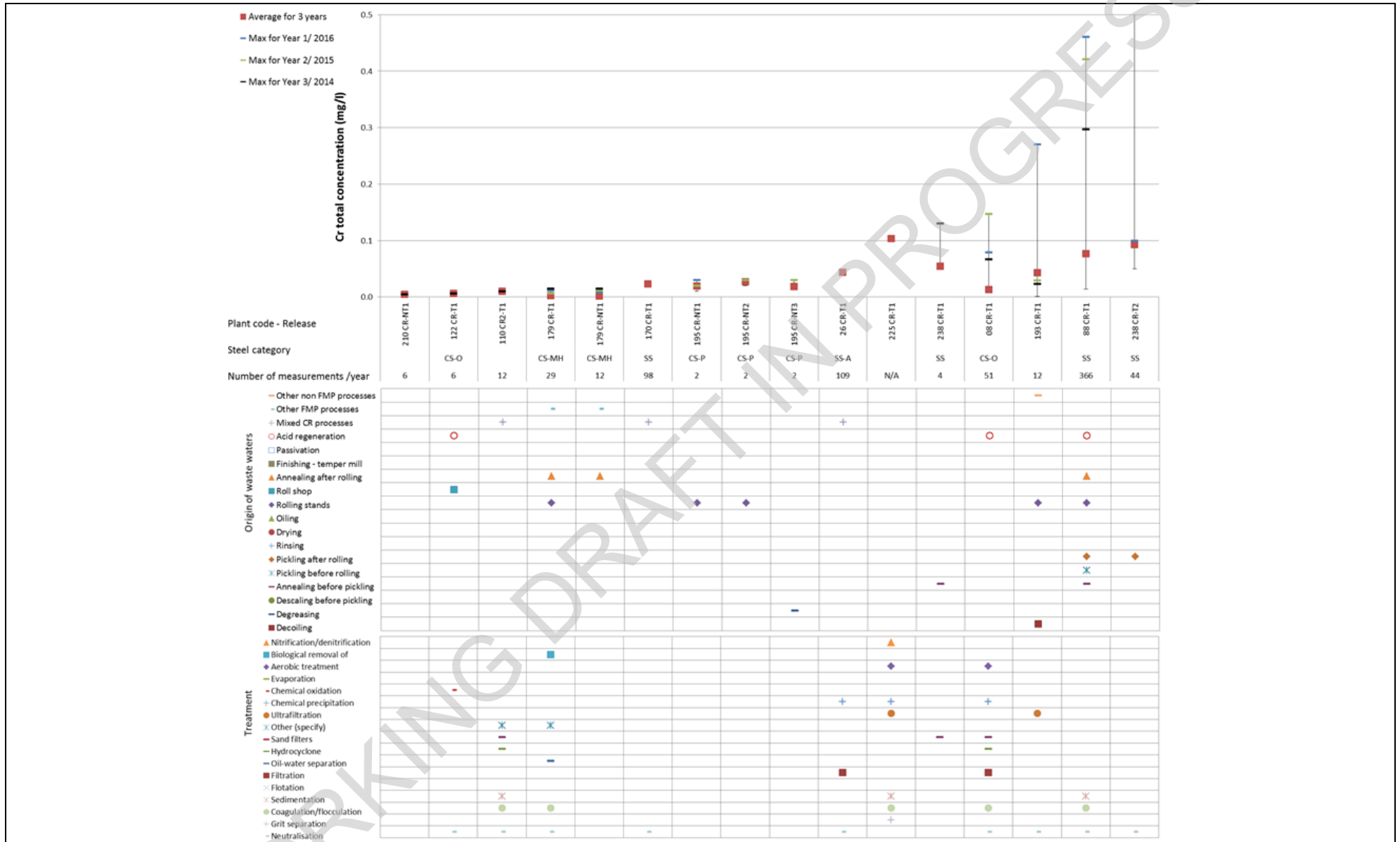


Figure 3.46: Chromium emissions (in mg/l) for direct discharges. Source: [TWG 2018].

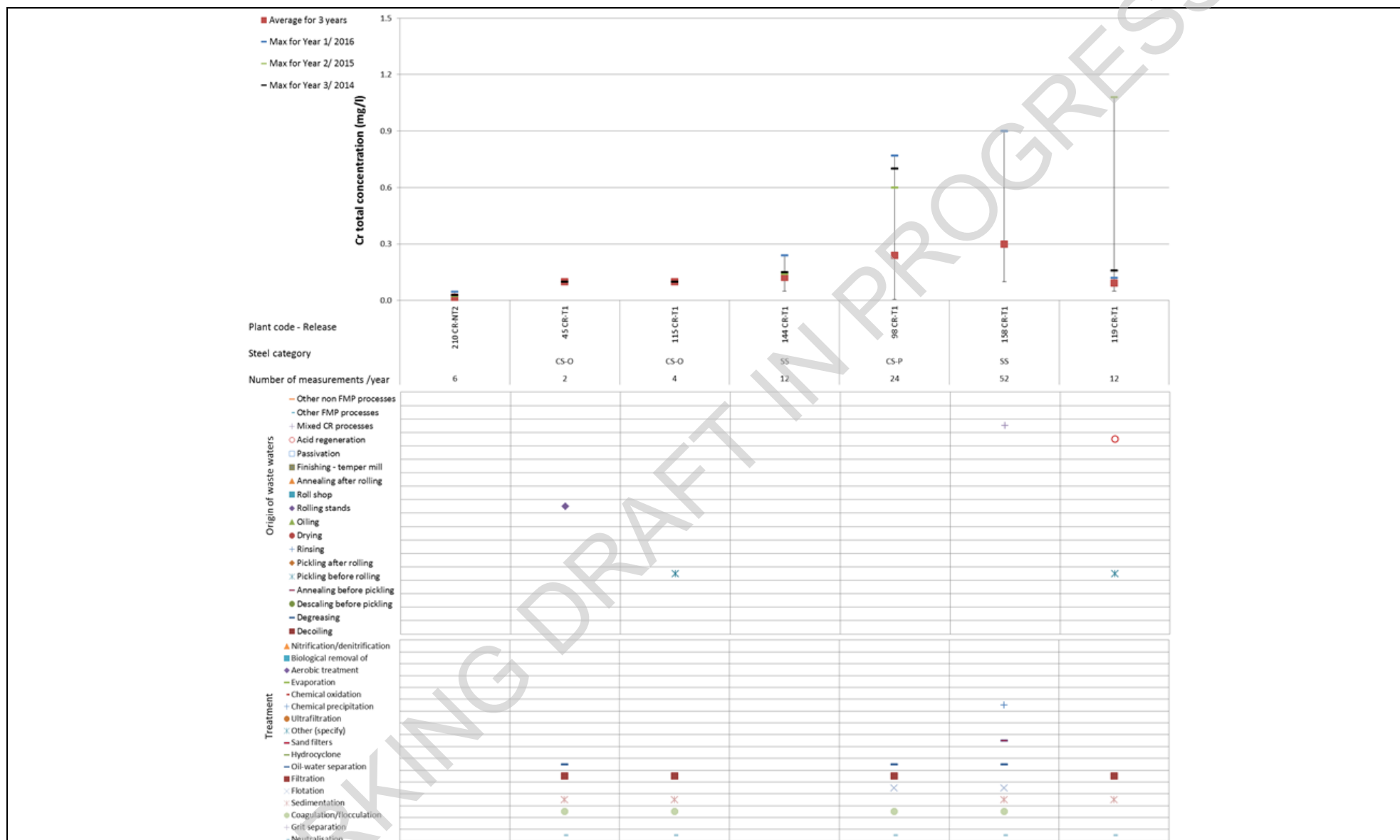


Figure 3.47: Chromium emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

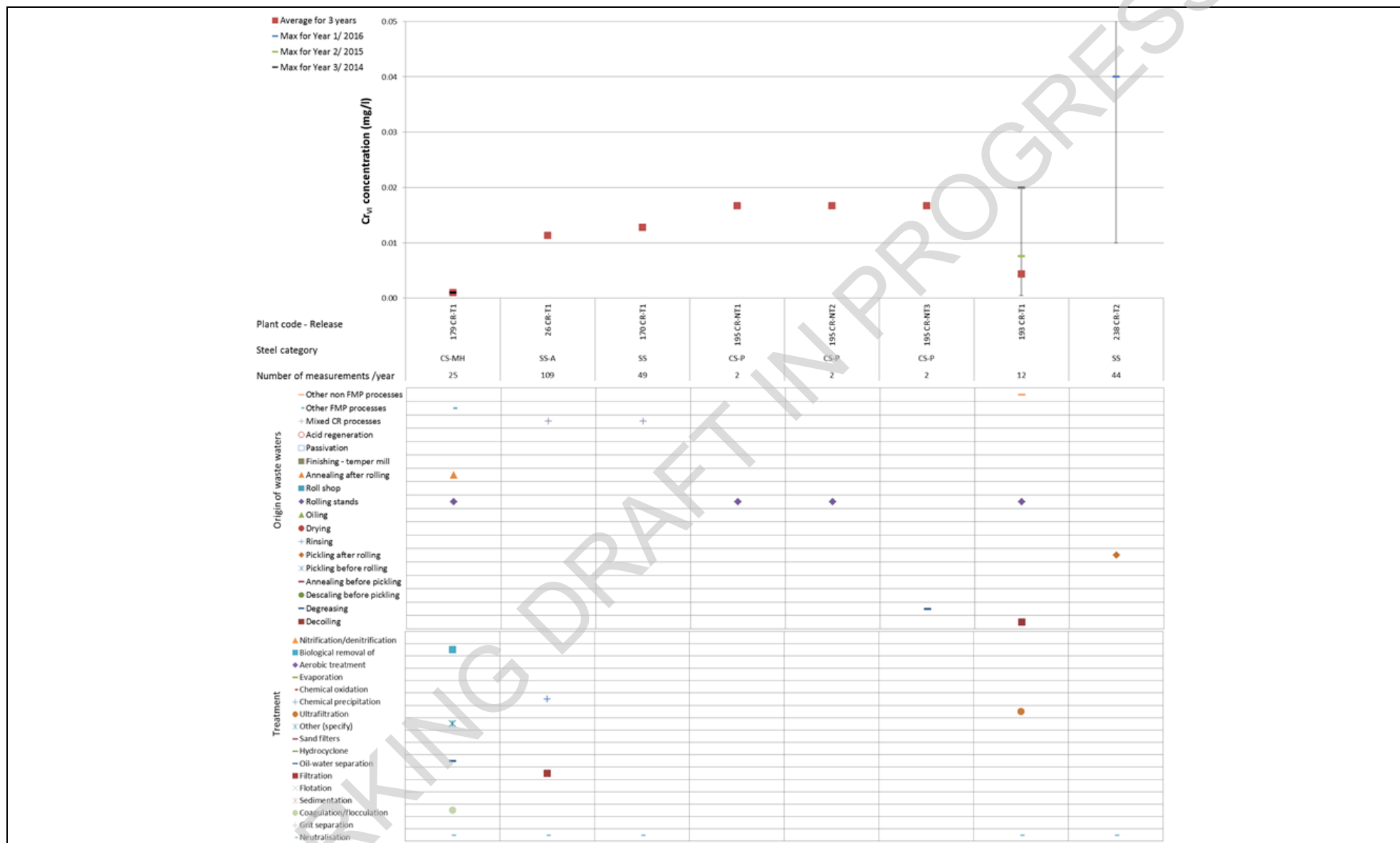


Figure 3.48: Chromium VI emissions (in mg/l) for direct discharges. Source: [TWG 2018].

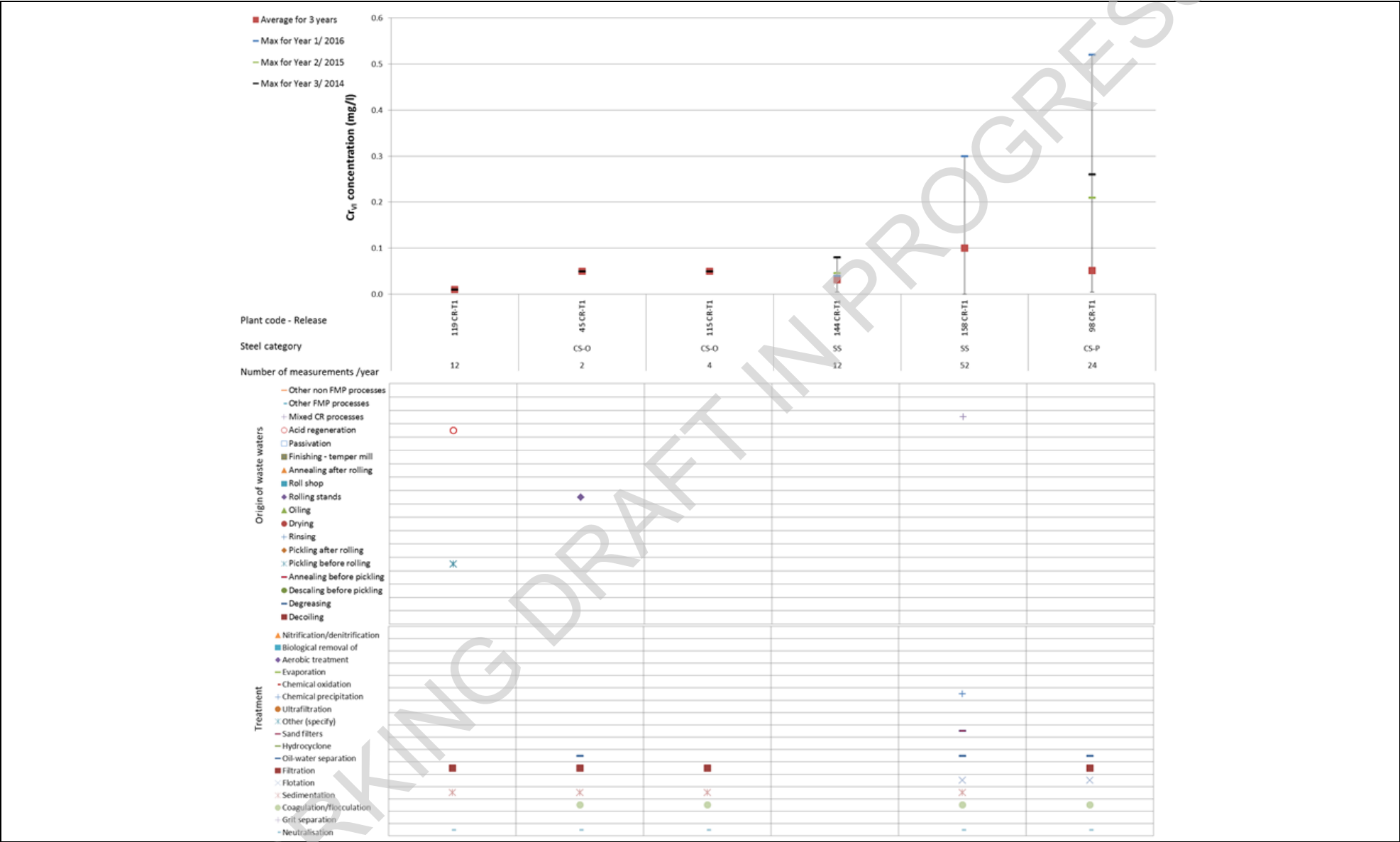


Figure 3.49: Chromium VI emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

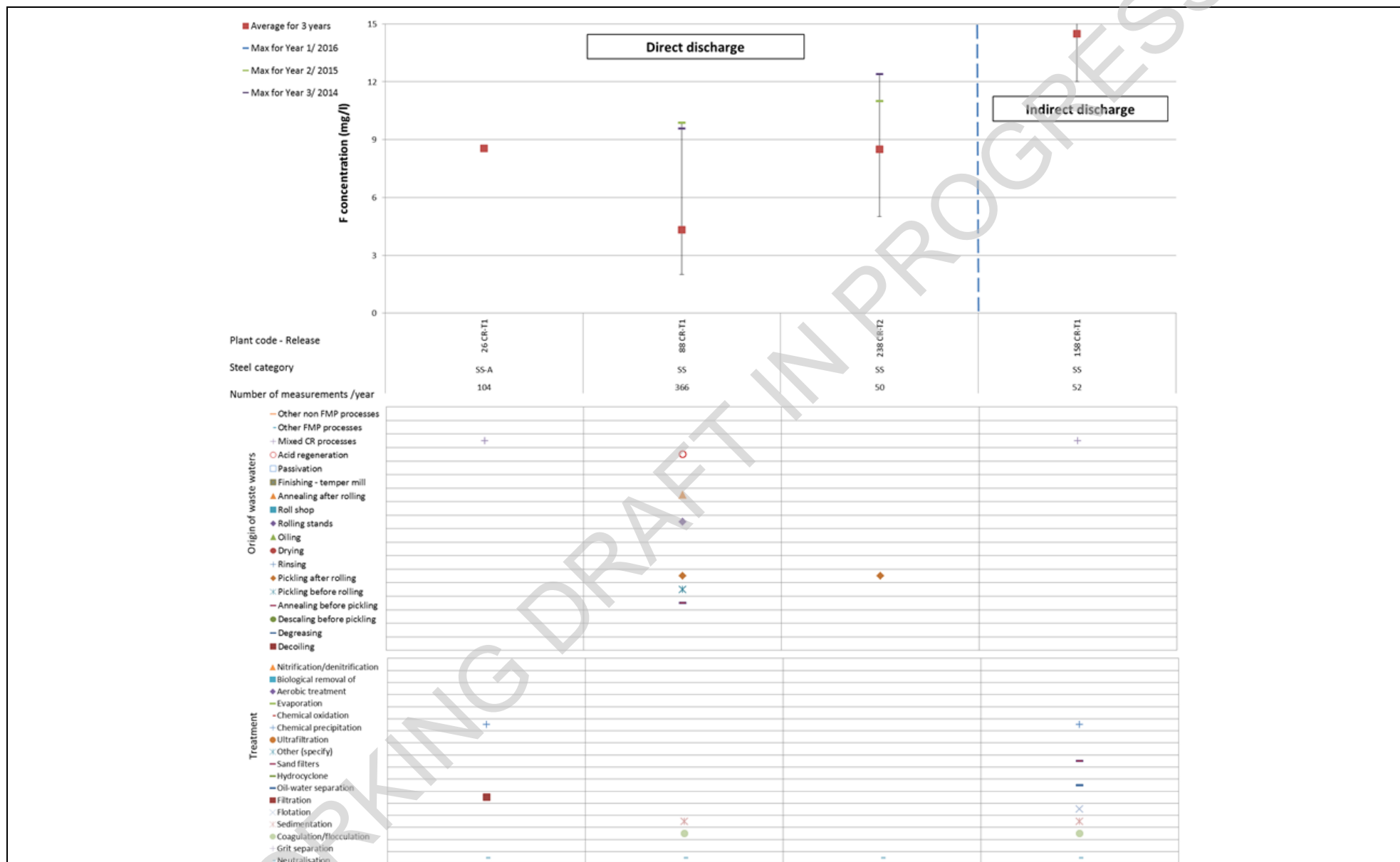


Figure 3.50: Fluoride emissions (in mg/l) for direct and indirect discharges. Source: [TWG 2018].

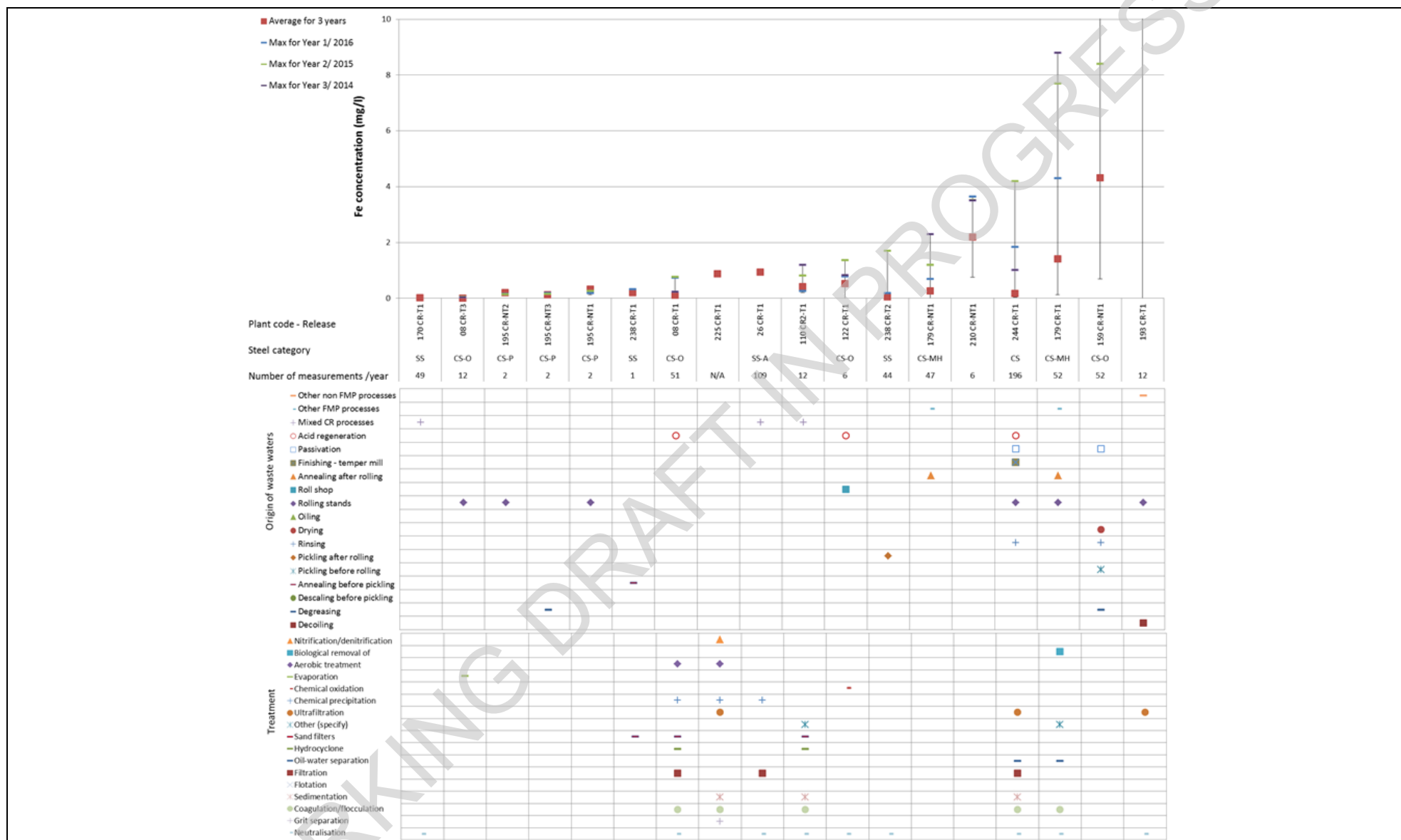


Figure 3.51: Iron emissions (in mg/l) for direct discharges. Source: [TWG 2018].

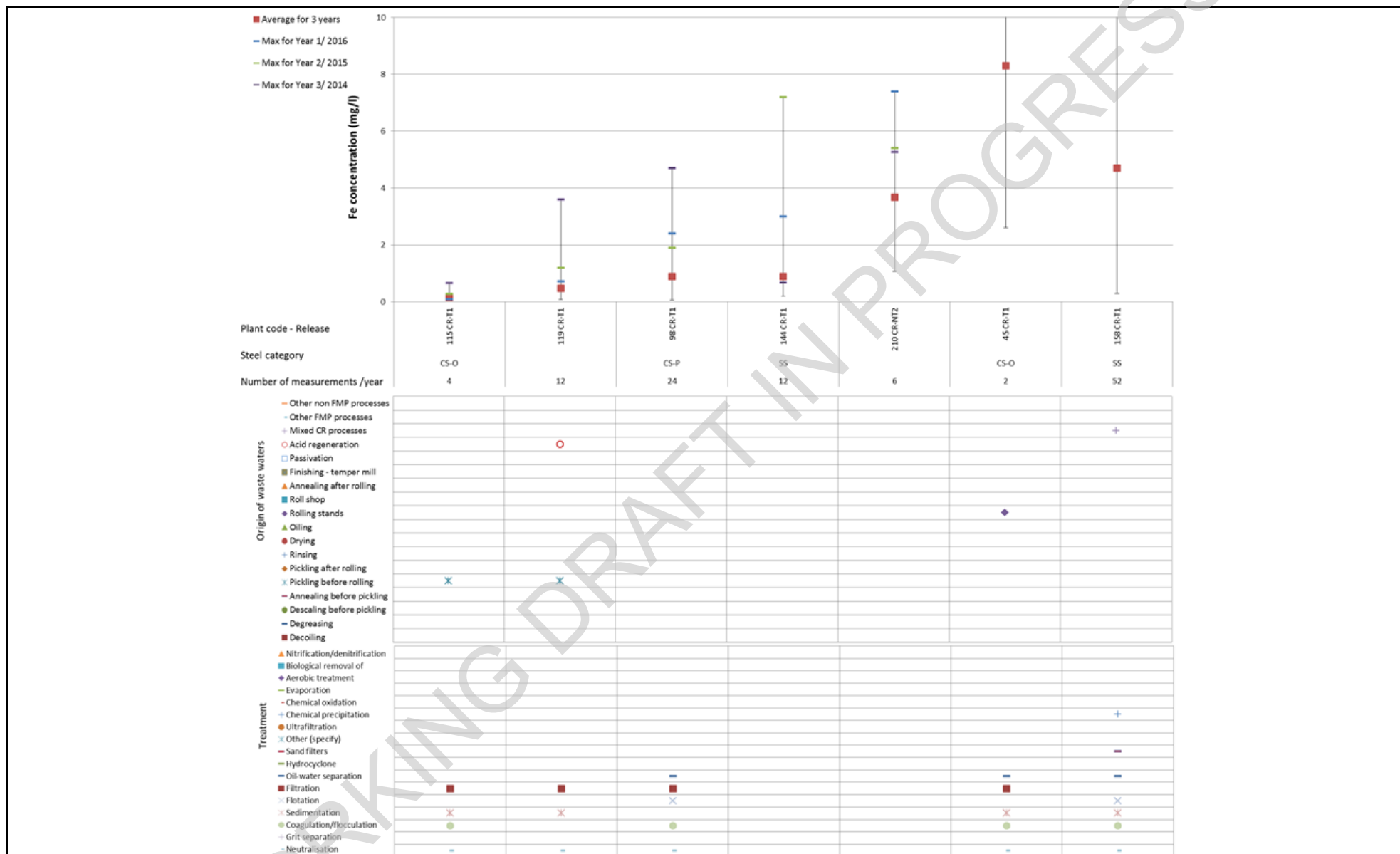


Figure 3.52: Iron emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

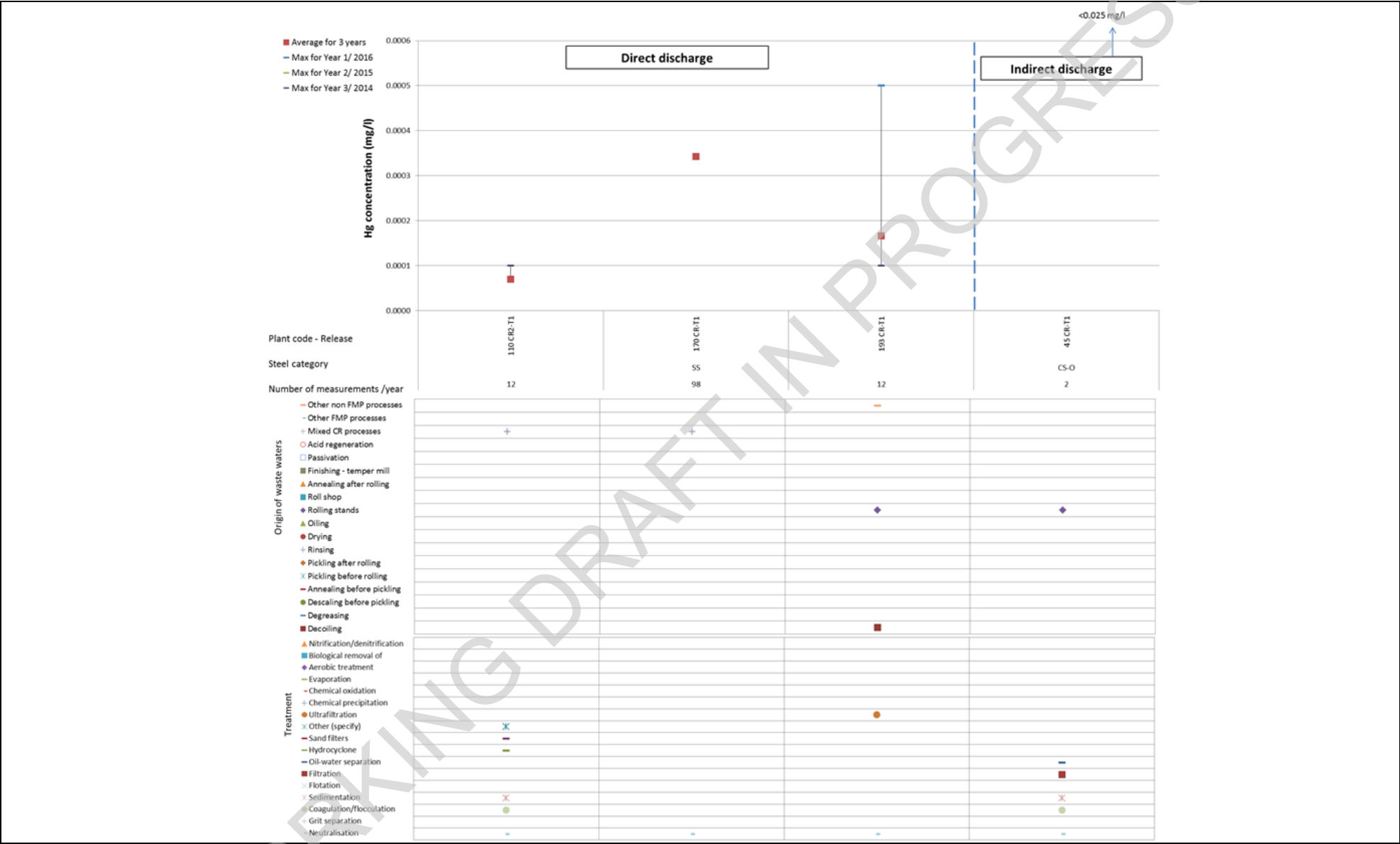


Figure 3.53: Mercury emissions (in mg/l) for direct and indirect discharges. Source: [TWG 2018].

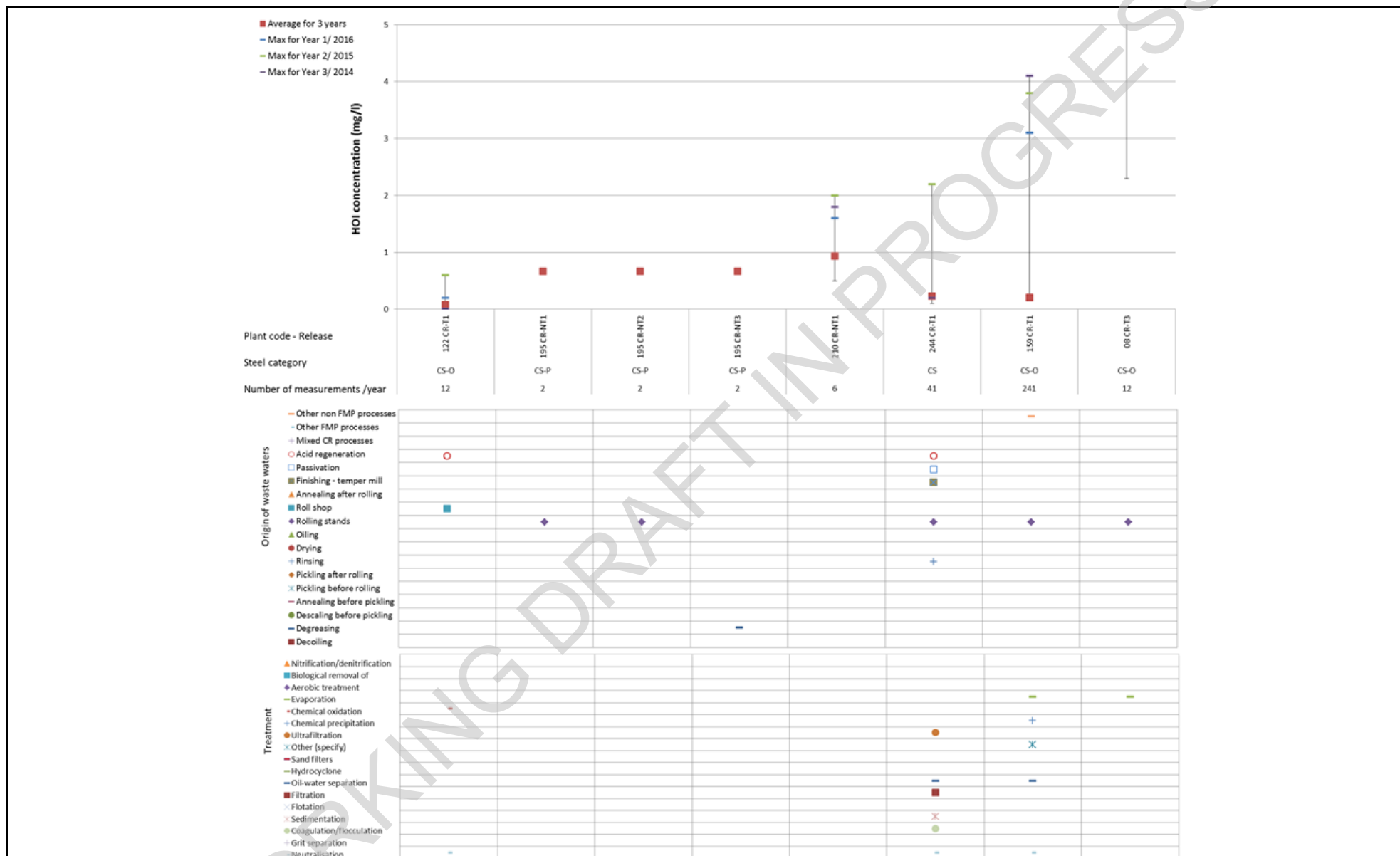


Figure 3.54: Hydrocarbon oil index emissions (in mg/l) for direct discharges. Source: [TWG 2018].

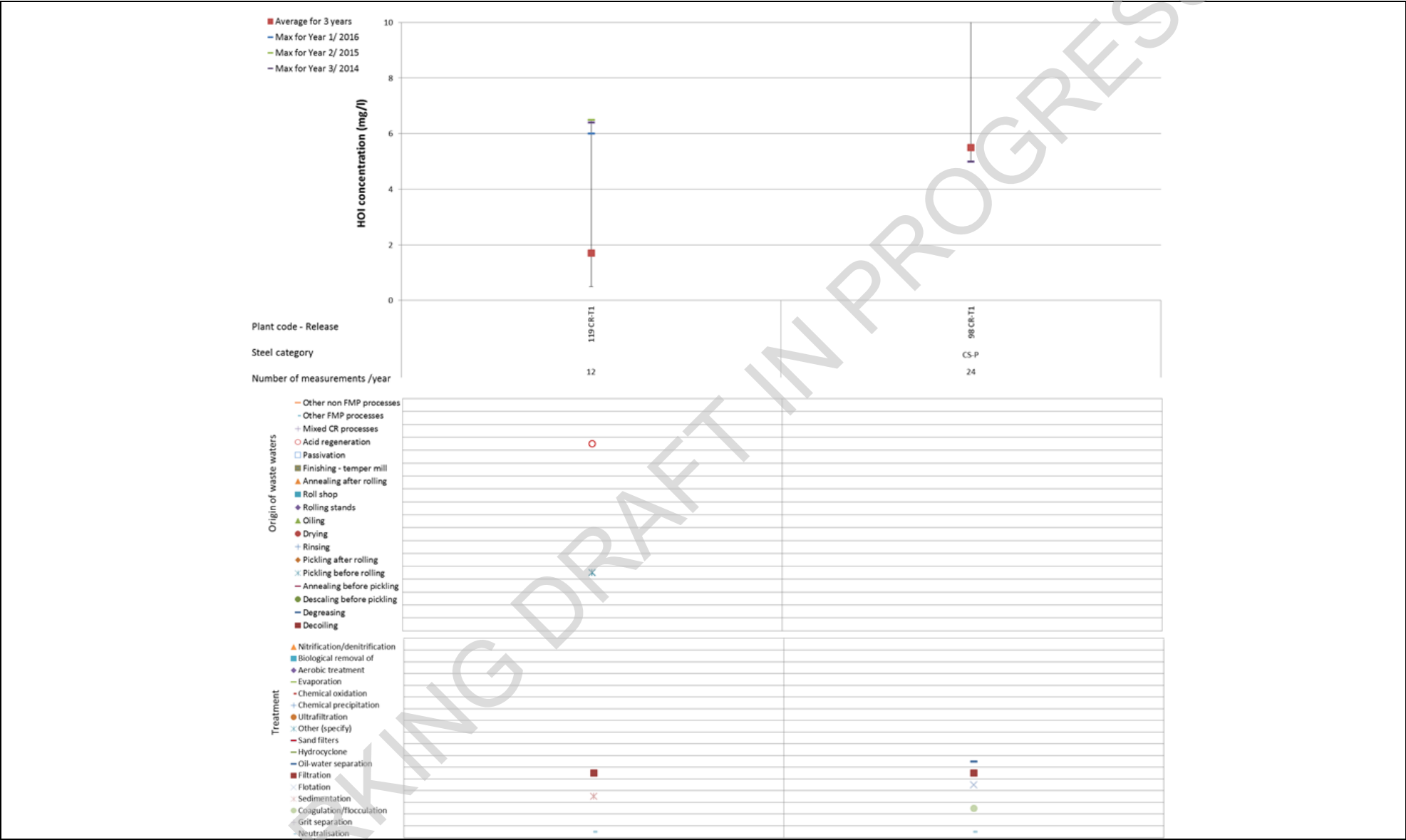


Figure 3.55: Hydrocarbon oil index emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

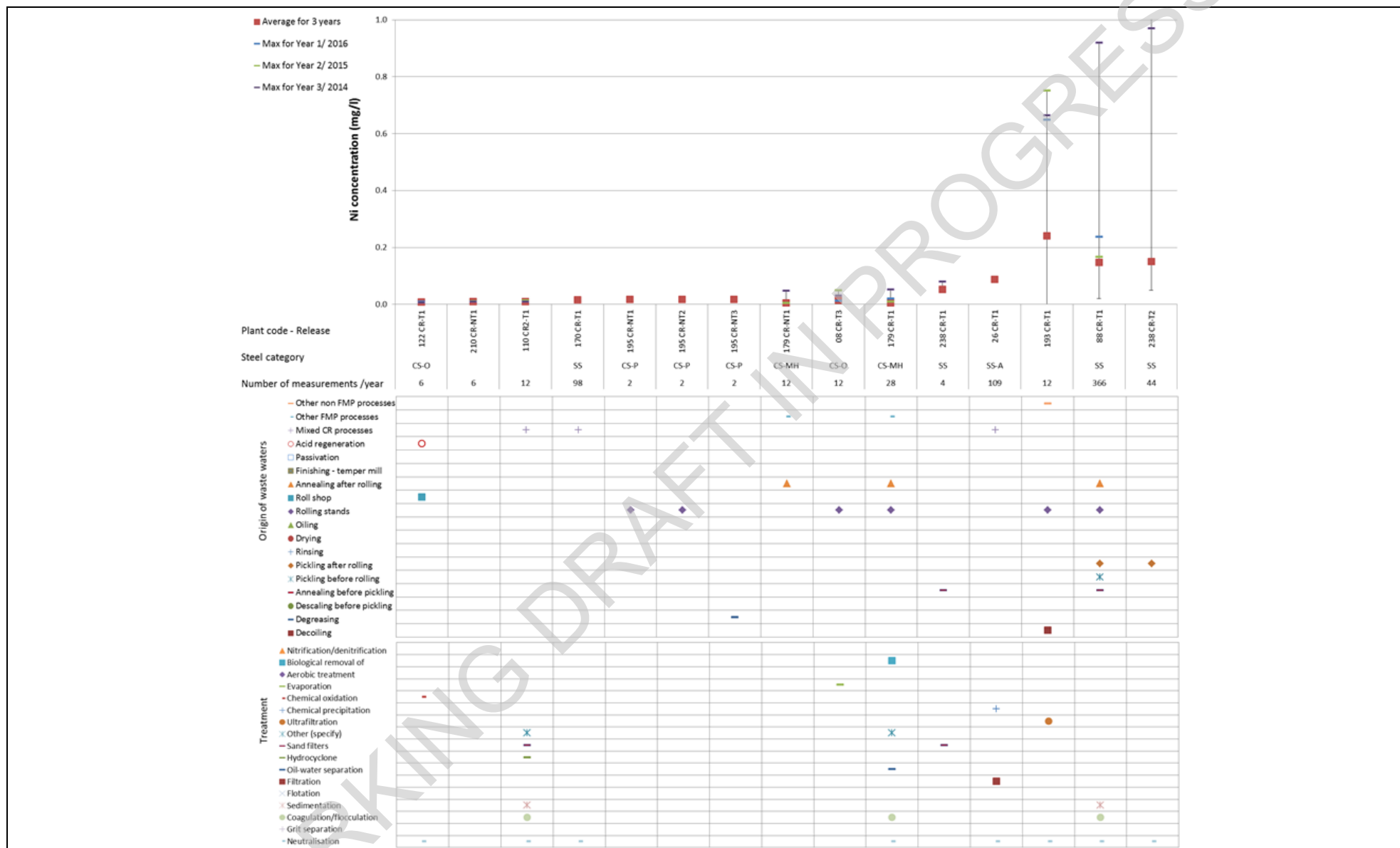


Figure 3.56: Nickel emissions (in mg/l) for direct discharges. Source: [TWG 2018].

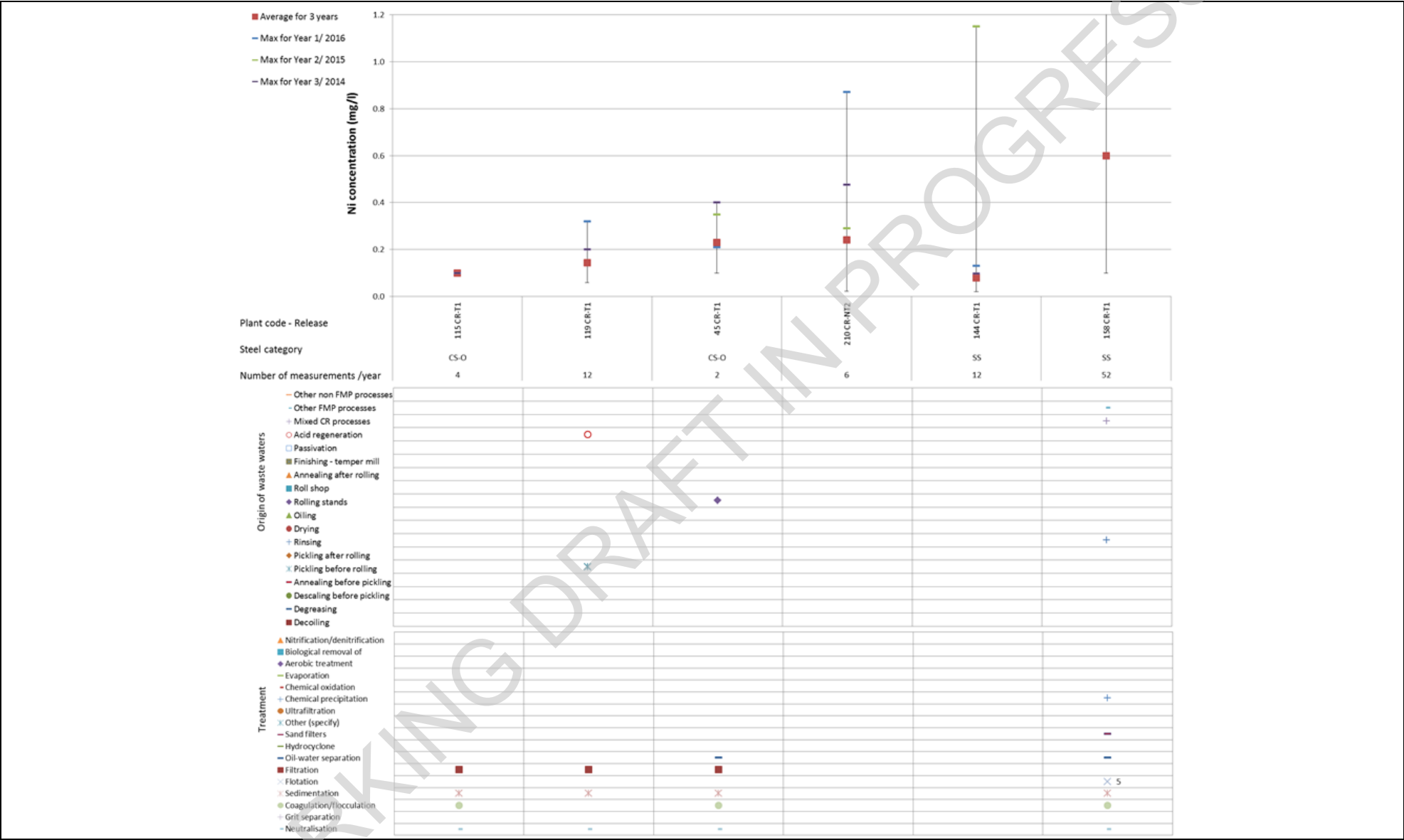


Figure 3.57: Nickel emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

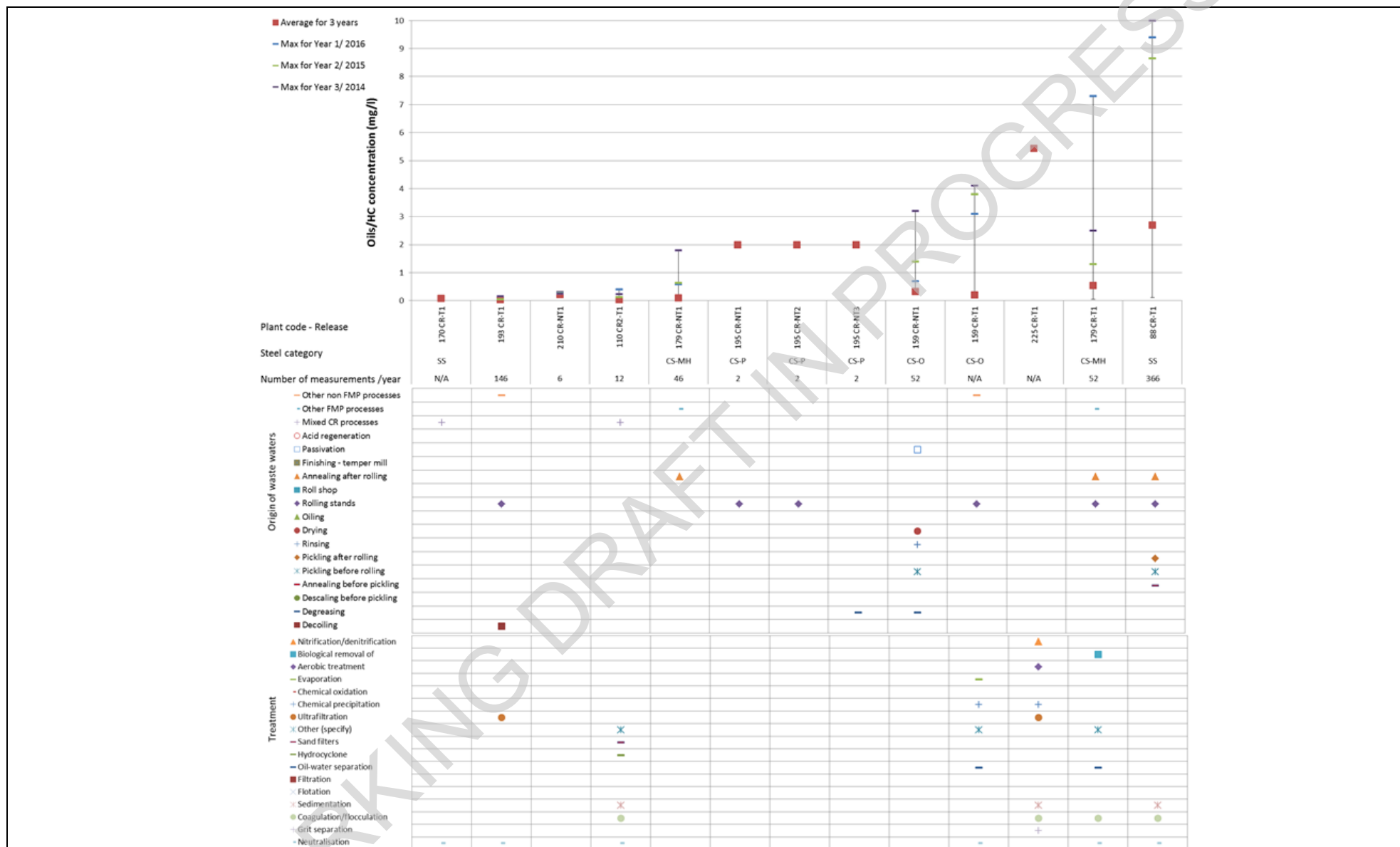


Figure 3.58: Oils emissions (in mg/l) for direct discharges. Source: [TWG 2018].

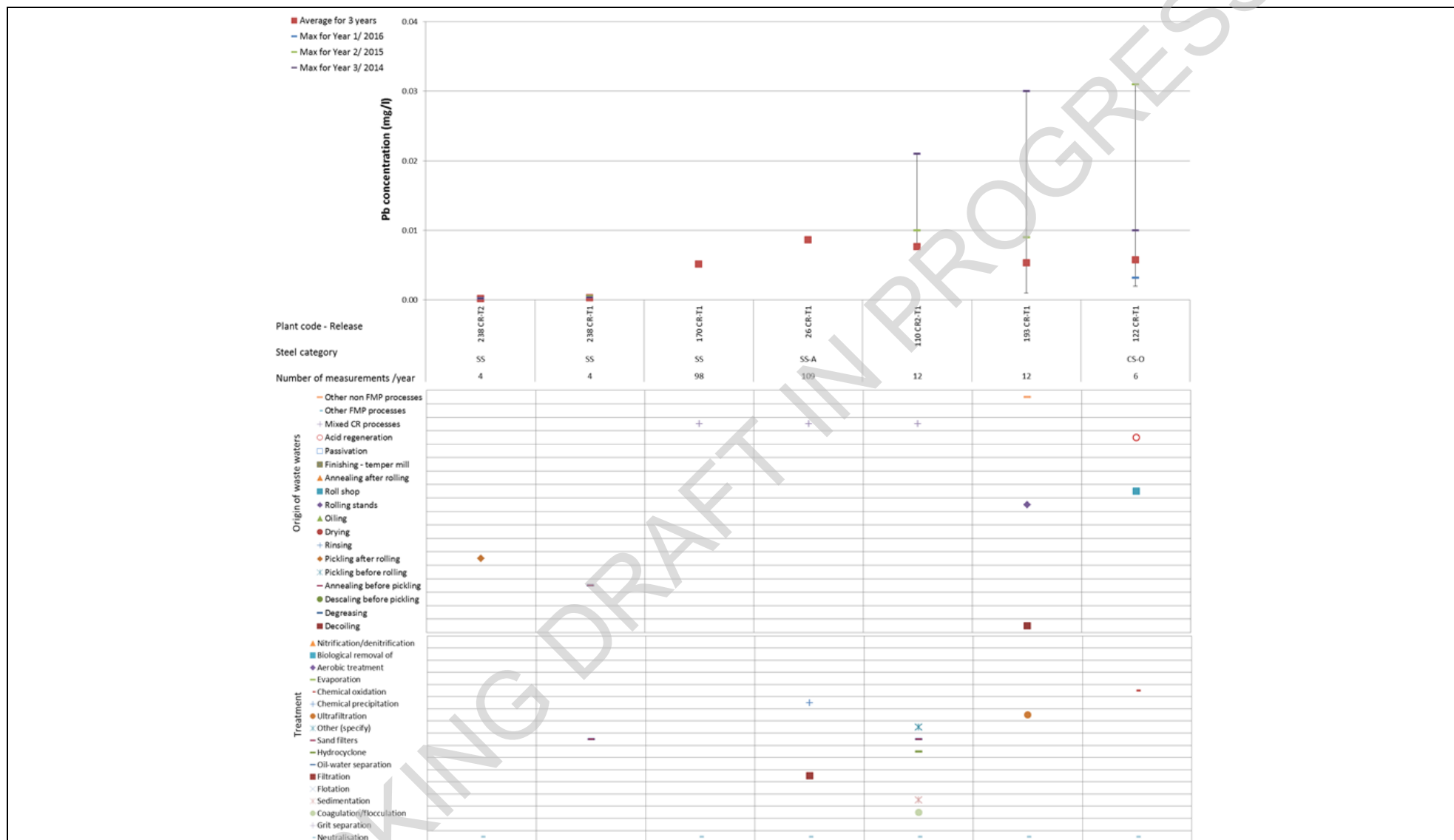


Figure 3.59: Lead emissions (in mg/l) for direct discharges. Source: [TWG 2018].

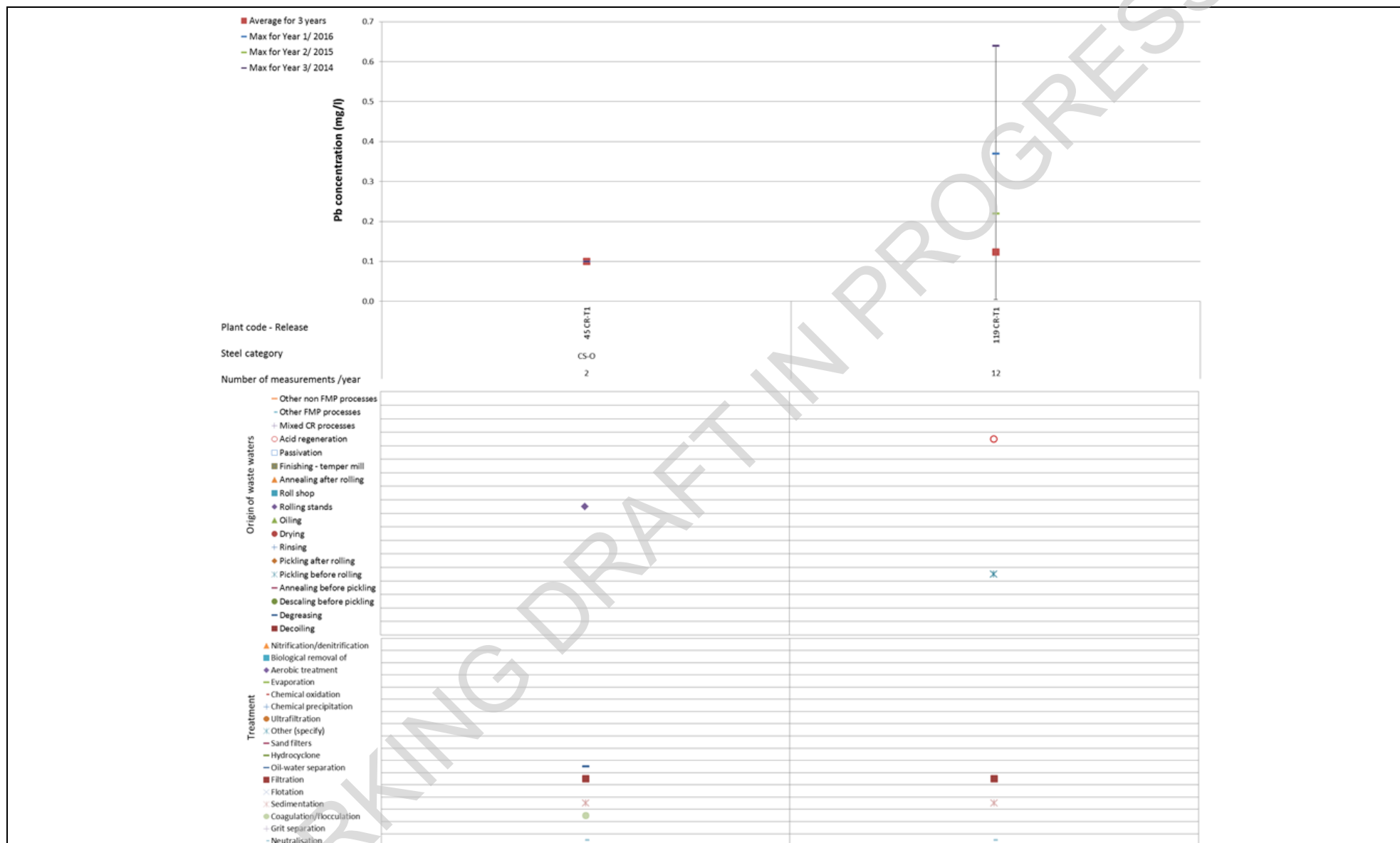


Figure 3.60: Lead emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

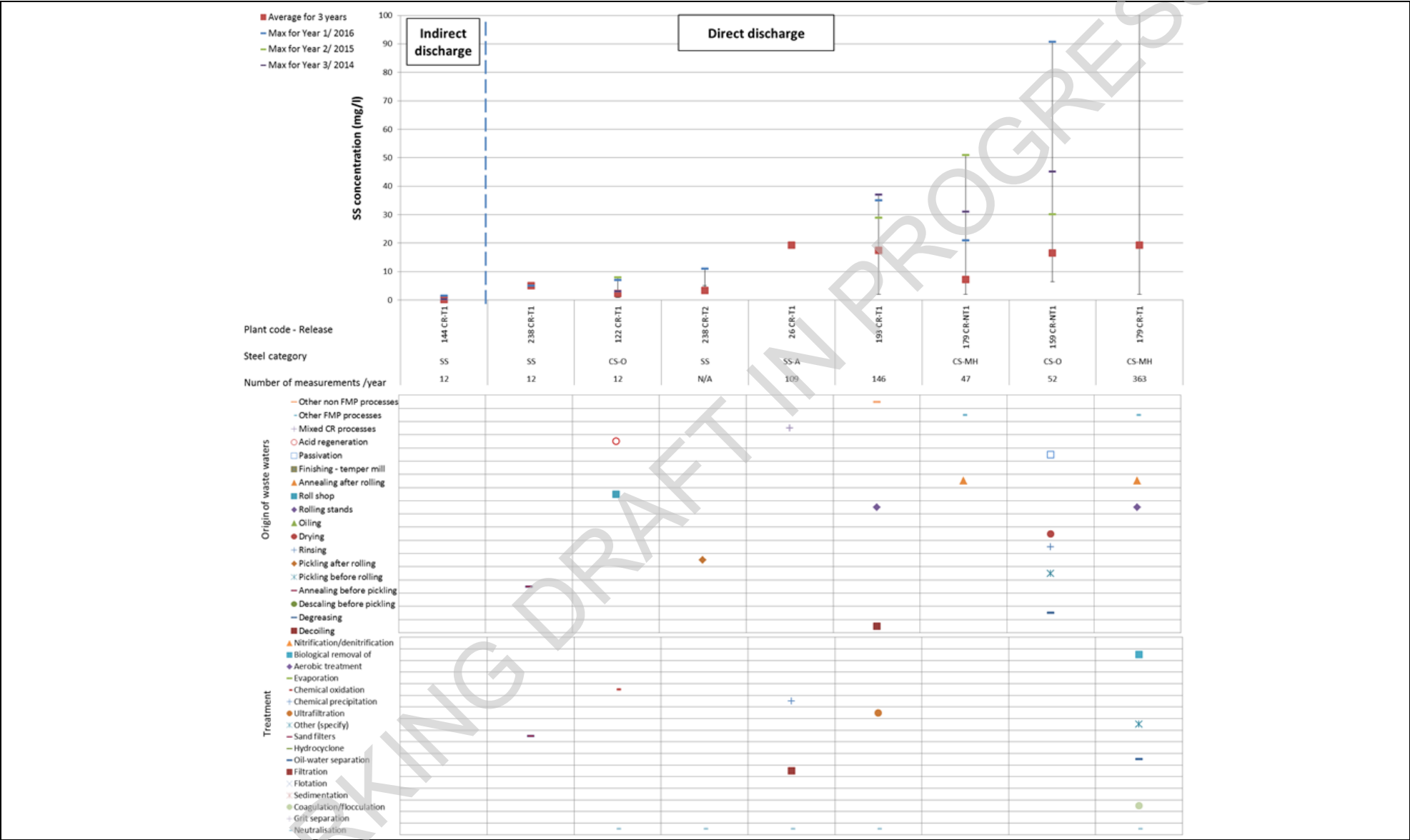


Figure 3.61: Suspended solids emissions (in mg/l) for direct and indirect discharges. Source: [TWG 2018].

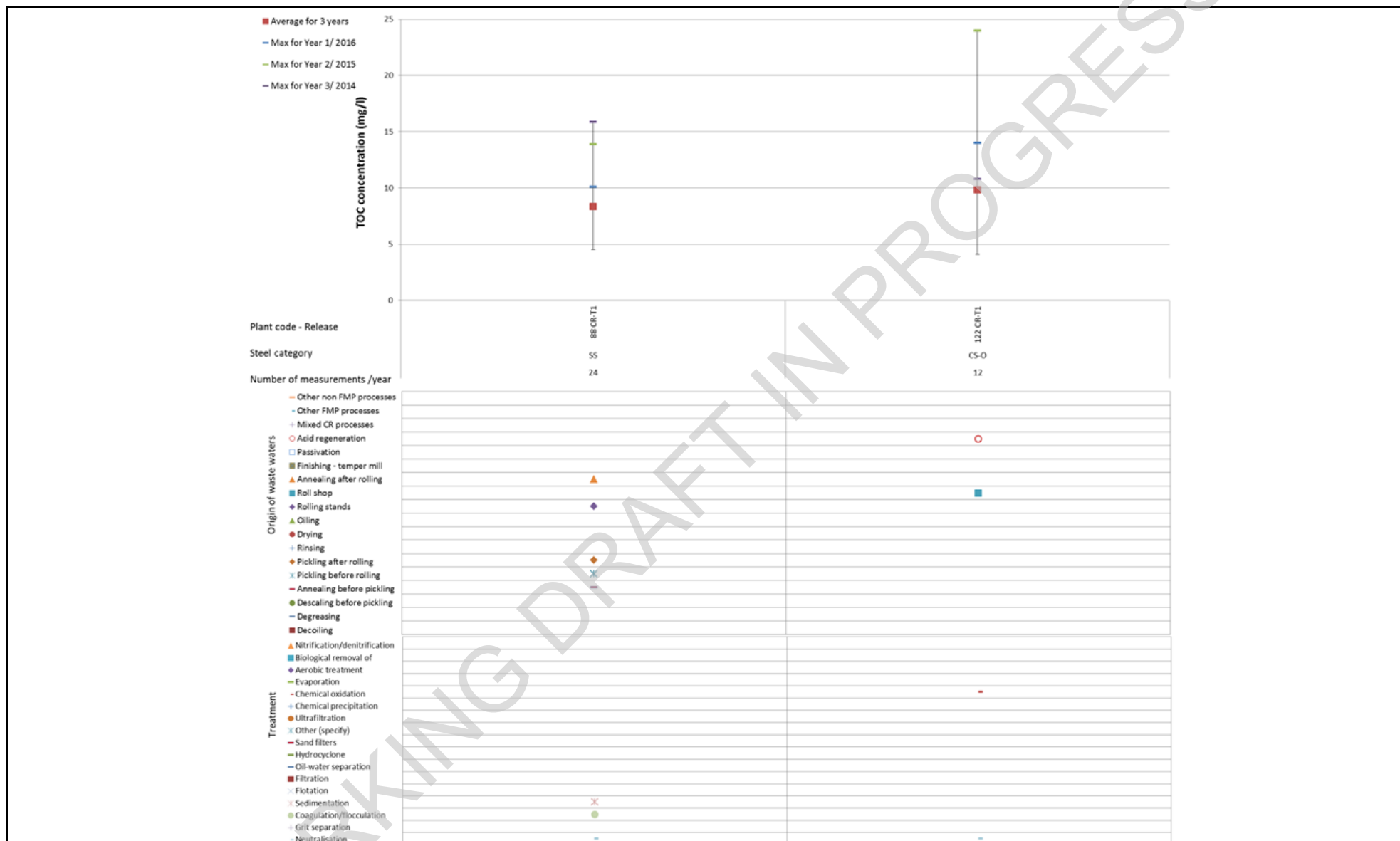


Figure 3.62: TOC emissions (in mg/l) for direct discharges. Source: [TWG 2018].

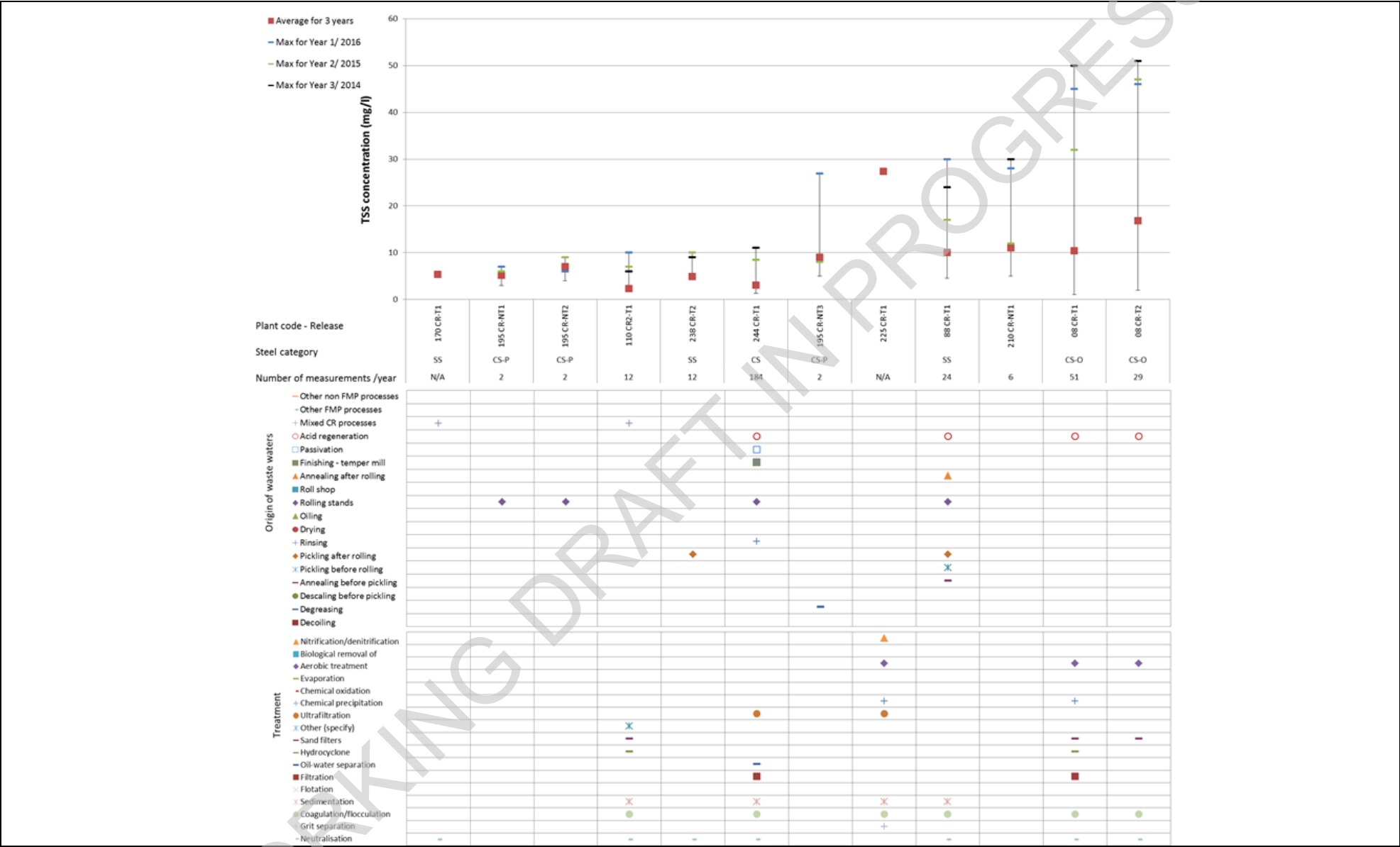


Figure 3.63: Total suspended solids emissions (in mg/l) for direct discharges. Source: [TWG 2018].

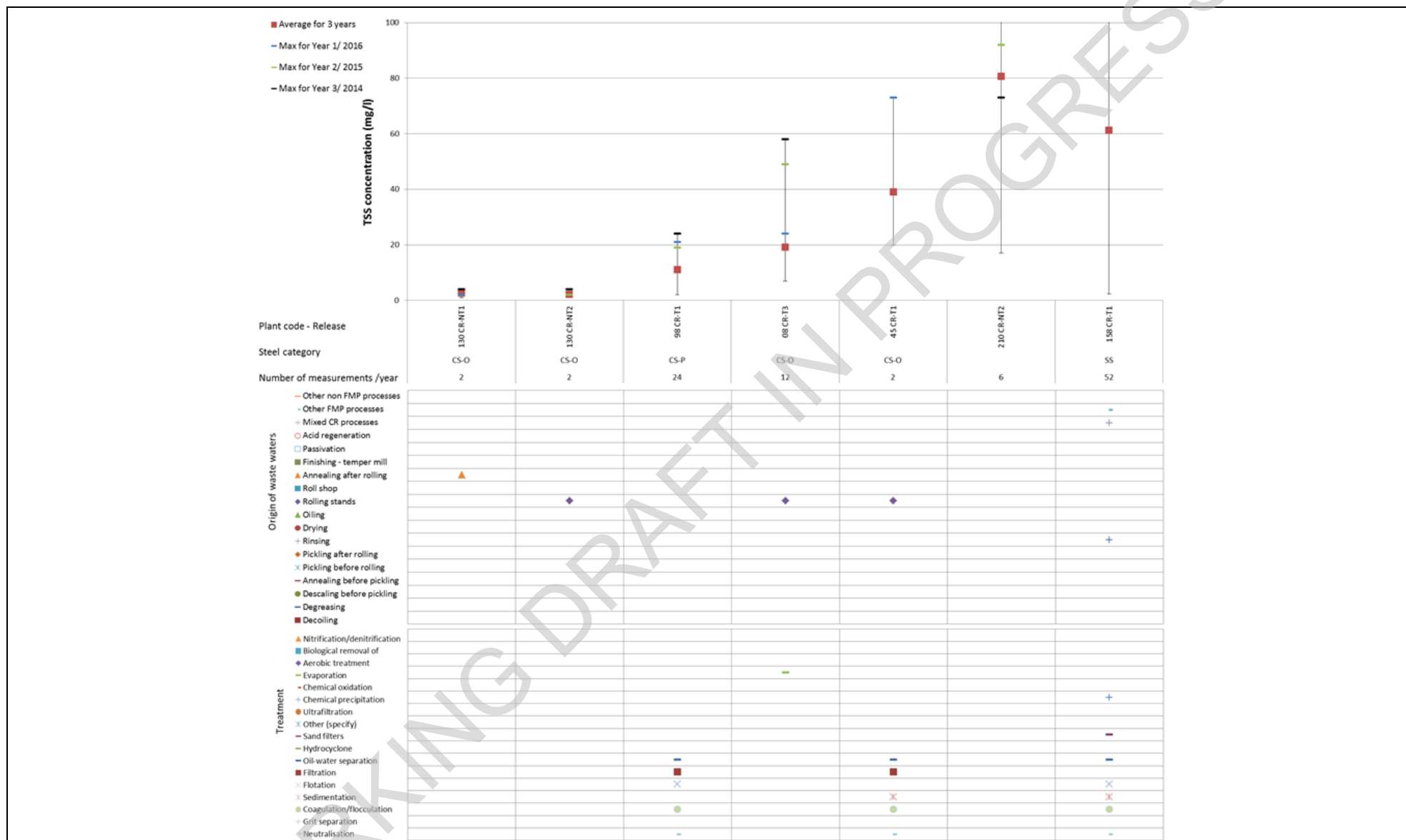


Figure 3.64: Total suspended solids emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

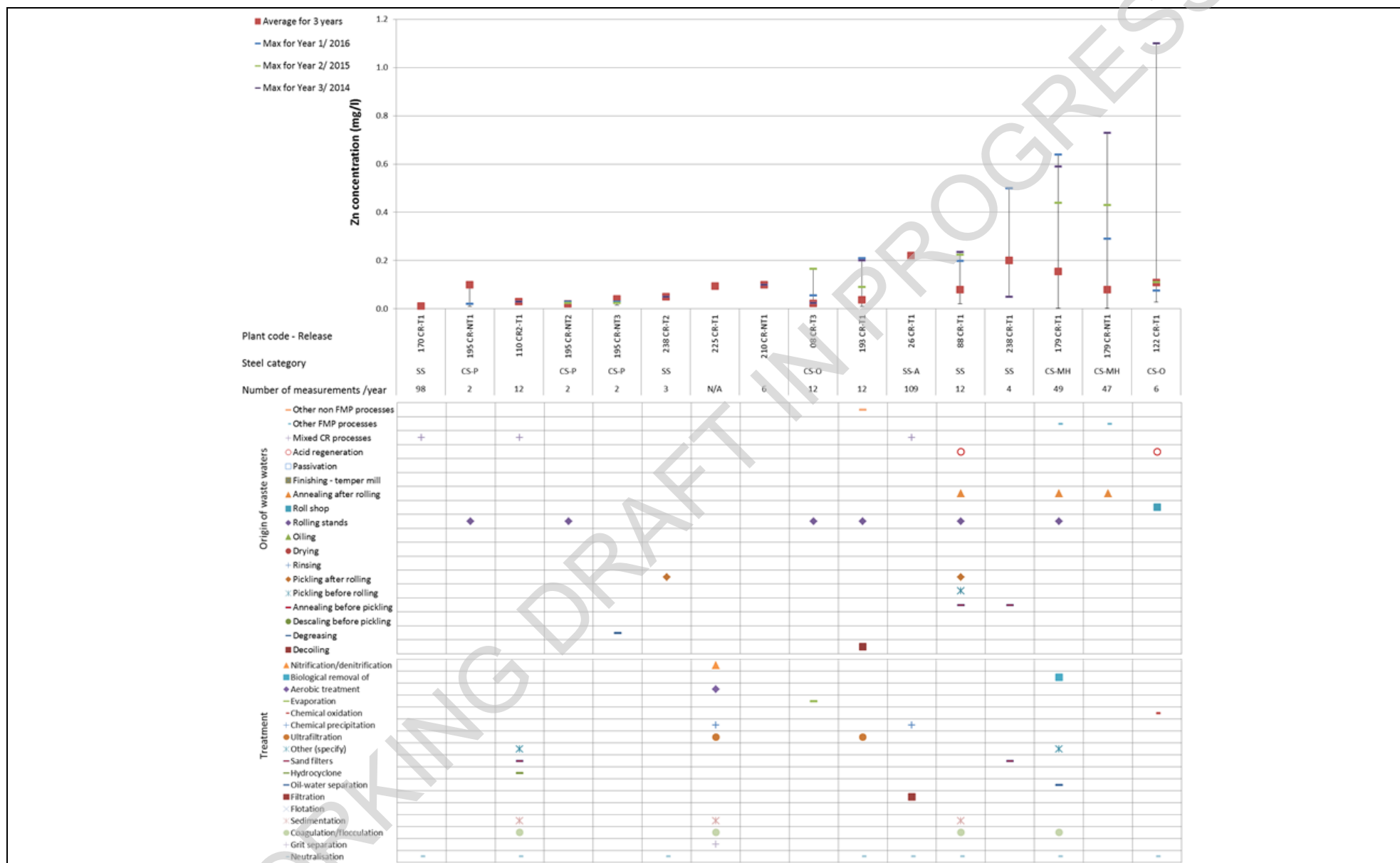


Figure 3.65: Zinc emissions (in mg/l) for direct discharges. Source: [TWG 2018].

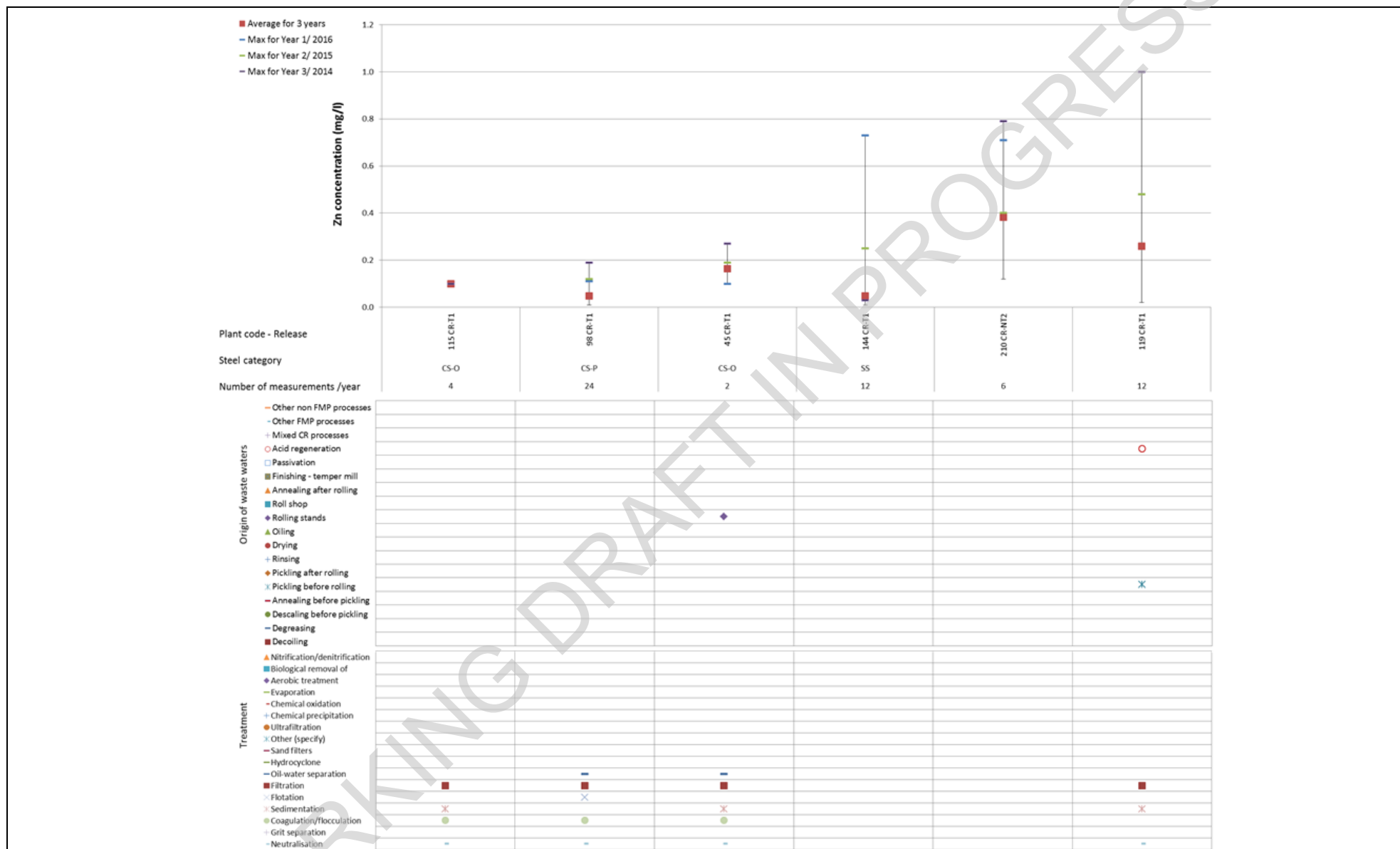


Figure 3.66: Zinc emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

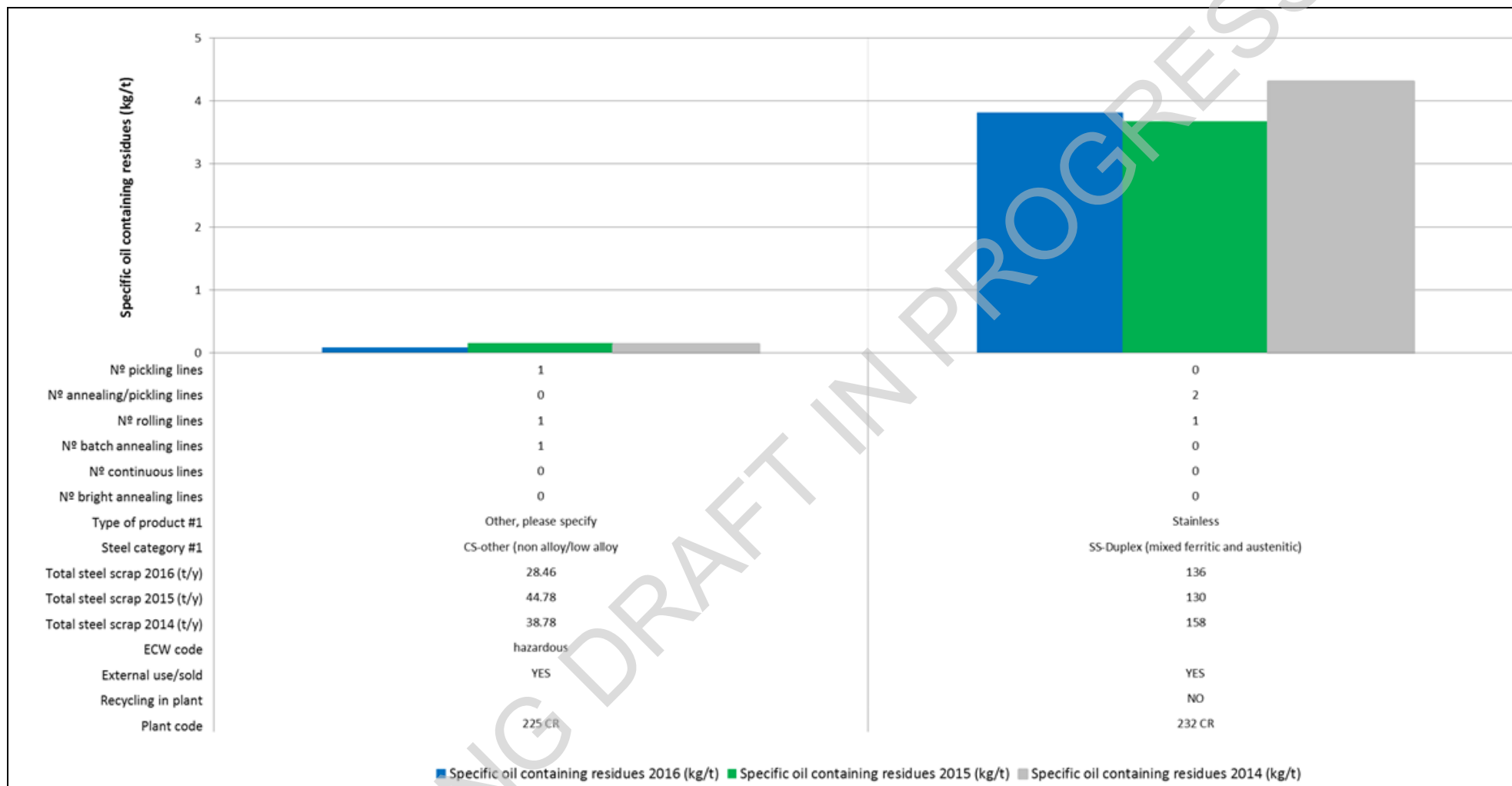


Figure 3.67: Specific generation of oil- containing residues (in kg/t) Source: [TWG 2018].

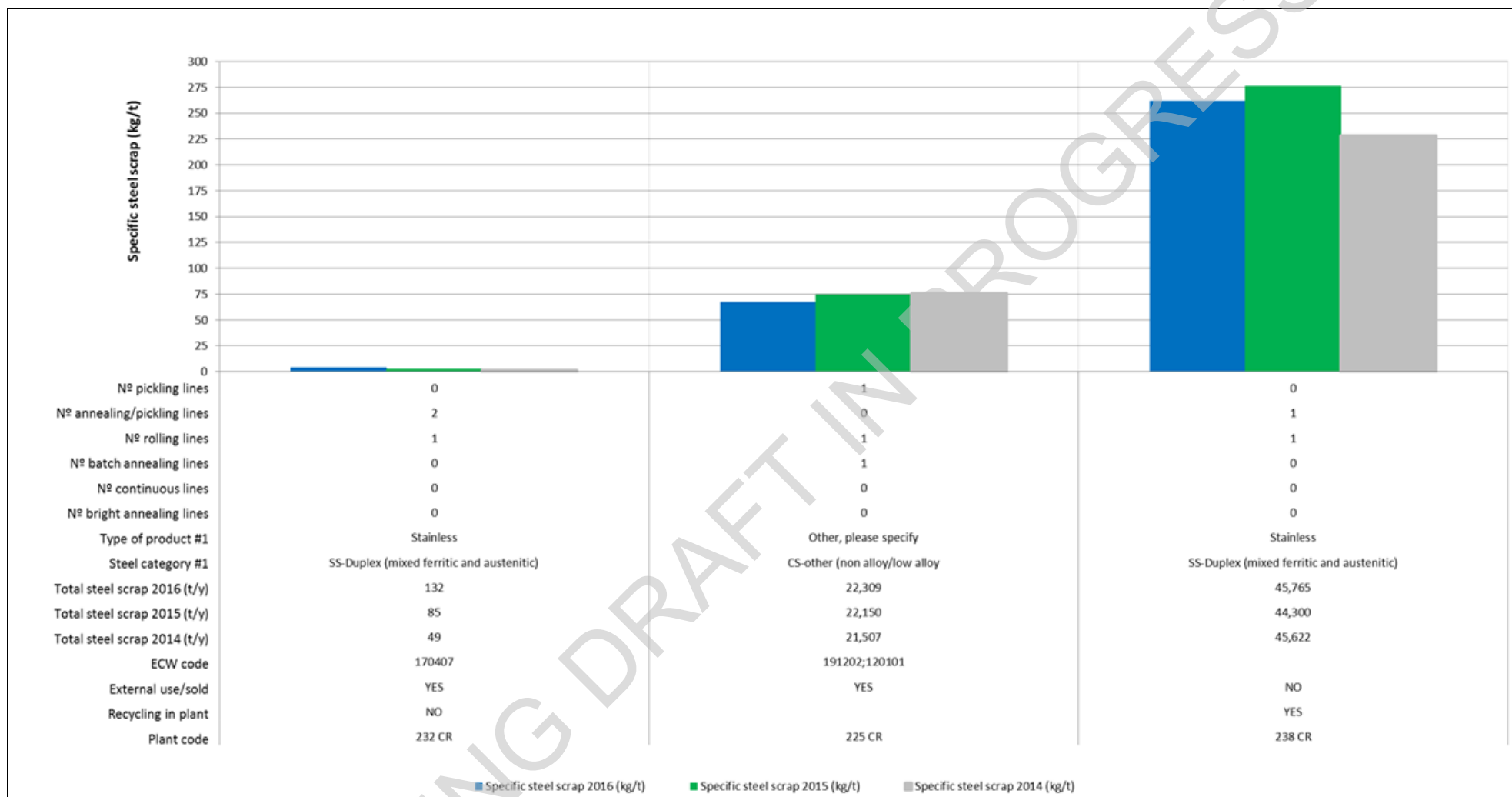


Figure 3.68: Specific generation of steel scrap (in kg/t). Source: [TWG 2018].

3.4 Techniques to consider in the determination of BAT for cold rolling

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 as well as process-integrated and end-of-pipe techniques. 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 the prevention or limiting of the environmental consequences of accidents and incidents. They also cover the prevention or reduction of 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 Directive 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 2.8 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 that 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.

In Chapter 8 general techniques (i.e. those used that are commonly used) are discussed which might also be applicable to cold rolling. These techniques are normally not repeated in this section, unless information specific for this sector was made available.

3.4.1 Pickling

TWG, Section A.4.2.2.1 from the old BREF "Reduction of waste water volume contaminant loading" was largely covered by other BREF sections. Some techniques related to optimised pickling bath operation can now be found in Chapter 8 (Section 8.6.2.6). The other techniques were deleted.

3.4.1.1 Dust emission control at the decoilers

~~A.4.2.2.2 Reduction of Dust Emission at the Decoilers~~

Description

Iron oxide dust is formed during de-coiling operations. Emissions of dust are prevented by the use of water curtains equipped with a separator system to recover the iron oxide particles entrained by water. In some cases, fabric filters are used to abate dust emissions.

Technical description

Iron oxide dust is formed by stretching the strip during the decoiling operation. The formation of dust can be prevented by the use of **water curtains**. This wet method requires a separator system to remove the iron oxide from the spraying water. This can either be a stand-alone system or it is integrated in the global water treatment system of the plant.

In some cases the water spray method leads to an undesired build-up of iron oxide particles on the rolls in the pickling line and hence to roll marks on the strip. In these cases, **an exhaust**

system, usually equipped with **fabric filters**, is used as an alternative to prevent the dispersion of the dust.

Water curtains:

TWG, please provide information.

Dry exhaust system:

The decoilers are equipped with suction hoods, which lead the air containing iron oxide dust directly to the fabric filters. The cleaned air is emitted via the chimney. The fabric filters are cleaned using backwashing with pressurised air. The iron oxide dust is collected at the bottom of the fabric filter using rotary valves. [EUROFER 23-7-18]

Achieved environmental benefits

- Prevention of dust emissions in the surrounding workplace area.
- ~~Reduction of air emissions.~~
- Reduction of dust emissions.

Environmental performance and operational data

Table 3.5: Operational data for a dry dedusting system installed at the decoilers (Voestalpine cold rolling mill)

| | |
|----------------------------------|---------------------------------------|
| Suction capacity | 40 000 m ³ /h |
| Number of tube filters | 240 |
| Rotary valves | 2 |
| Maximum filter loading | 100 m ³ /m ² /h |
| Residual dust content | max. 5 mg/m ³ |
| <i>Source: [EUROFER 23-7-18]</i> | |

Cross-media effects

- Additional consumption of energy.
- Additional consumption of resources (water).
- Generation of waste water in case of wet de-dusting (filter dust).
- The filter dust requires disposal or pretreatment prior recycling.

Technical considerations relevant to applicability

~~New and existing plants:~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

Investment costs were reported to be EUR 50 000 for water sprays and EUR 280 000 for an exhaust system equipped with fabric filter (for a 3 Mt/yr plant) [CITEPA].

Driving force for implementation

- Environmental legislation.
- Health and safety considerations.

Example plants

Voestalpine Stahl GmbH.

Reference literature

[EUROFER 23-7-18] [CITEPA]

TWG, Section A.4.2.2.3 from the old BREF "Mechanical pre-descaling" has been moved and the updated information can now be found in Chapter 8 (Section 8.6.2.3)

TWG, Section A.4.2.2.4 from the old BREF "Optimised rinsing procedure / cascade rinsing" has been moved and the updated information can now be found in Chapter 8 (Section 8.7.6)

3.4.1.2 Turbulence pickling

Description

Injection of the pickling acid at high pressure via nozzles.

Technical description

~~Recent developments in pickling techniques aim mainly at improving the process itself; enhancing efficiency, pickling speed and quality and making the process easier to control.~~

Figure 3.69 shows the development from deep pickling tanks via shallow tanks to turbulent pickling where the acid is sprayed onto the strip at the narrow gap between the pickling tanks. Turbulence pickling consists of injecting at high pressure using a series of nozzles the heated acid into the pickling channel along which the strip is passing. It results in a high level of turbulence, leading to maximum contact between the surface of the strip and the pickling acid. Using turbulence pickling, the acid is continuously forced into the cracks in the scale layer, facilitating the pickling process. As a result, the process is more efficient and lower temperatures are possible for the acid bath, leading to a reduction in acid consumption [Metal 194].

New acid consumption and/or regeneration capacities for spent acid are reduced [Metal 194].

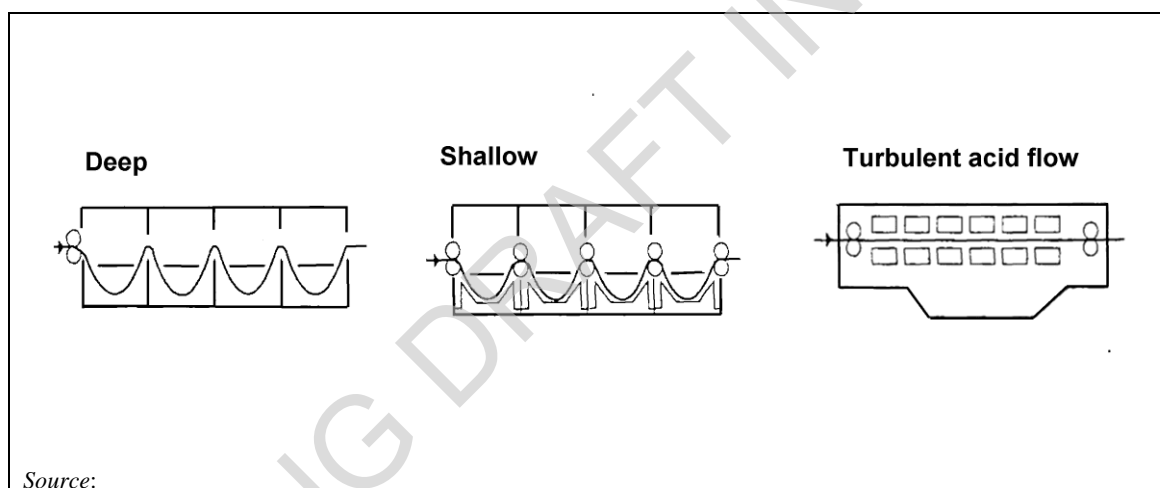


Figure 3.69: Different types of pickling tanks

Achieved environmental benefits

- Reduction in energy consumption.
- Reduction in acid consumption.

Environmental performance and operational data

As turbulence pickling is easier to control (and may be equipped with additional process models) a more effective control of the pickling effect is possible, leading to less over-pickling and thus a reduction in pickling loss (20–30 % or 0.8–1.2 kg/t) [Metal 194].

Cross-media effects

Increased energy consumption for high-pressure injection.

Technical considerations relevant to applicability

~~New pickling plants and existing in connection with major revamping.~~

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

Economics

Low investment and operational costs

Driving force for implementation

- Improvement of pickling process efficiency.
- Improved quality of the product.
- Savings in acid consumption.

Example plants

Stahlwerke Bochum AG (Germany); BHP (Australia); Sumitomo Metals (Japan); Sidmar (Belgium); Thyssen Stahl (Germany); ILVA (Italy); ALZ (Belgium), Avesta (Sweden); Allegheny Ludlum (USA) [Metal 194]

Reference literature

[Metal 194]

TWG, Section A.4.2.2.6 from the old BREF "Cleaning and reuse of acid pickle liquor" has been moved and the updated information can now be found in Chapter 8 (Section 8.6.2.7).

3.4.1.3 Hydrochloric acid regeneration by spray roasting

Description:

~~See Chapter D.6.10.1.2 for regeneration process description and chapter D.6.3 for emission abatement.~~

Description

The pickling solutions are injected via spray nozzles in the pyrohydrolytic reactor at high temperature where they react with oxygen and water to form a highly valuable iron oxide solid product. The hydrochloric acid is recovered using an adiabatic column where rinse water from the pickling line is used as absorption water.

Technical description

See Section 8.6.5 for a technical description of the spray roasting regeneration process.

Achieved environmental benefits

- Reduced consumption of fresh acid (from 12–17.5 kg/t to 0.7–0.9 kg/t; HCl concentration 33 %).
- Reduced waste water volume and sludge.

Environmental performance and operational data

~~and TWG, this table will be updated at a later stage based on the data collection.~~

Table 3.7 presents data on consumption and emissions associated with HCl spray roasting.

Further details are given in Section 8.6.5.

Table 3.6: Consumption and emission levels for HCl spray roasting

| Input / Consumption Level | | |
|--|------------------------|-------------------|
| Spent acid | 0.7 - 0.9 | kg/t |
| Cooling water (in) | 0.07 - 0.09 | m ³ /t |
| Industrial + demineralised water | 0.09 - 0.15 | m ³ /t |
| Energy: | | |
| Electrical energy | 4 - 15 | MJ/t |
| Caloric energy (natural gas) | 102 - 119 | MJ/t |
| Output / Emission Level | | |
| | Specific Emission | |
| Solid by-product: Fe ₂ O ₃ | 5.1 - 5.4 (5.6 Sidmar) | kg/t |
| Recycled acid (20 %) | 23 - 40 | kg/t |
| Cooling water (out) | 0.07 - 0.09 | m ³ /t |
| Waste gas | 24 - 38 | m ³ /t |
| Waste water (discharge) | 0.04 - 0.07 | m ³ /t |
| Source: [EUROFER] | | |

TWG, this table will be updated at a later stage based on the data collection.

Table 3.7: Emissions to air from HCl spray roasting

| | Concentration [mg/Nm ³] | Specific Emission [kg/t product] | Reduction rate ¹ [%] | Method of analysis |
|--|--|-------------------------------------|------------------------------------|---|
| Dust | 20—50 | n.a. | n.a. | EPA |
| SO ₂ | 50—100 | n.a. | n.a. | SO ₄ detection by Ion Chromatography (NBN T95 202) |
| NO ₂ ² | 300—370 | 0.014 | >90 | NO ₃ detection by Ion Chromatography (NBN T95 301), Luminiscence |
| CO | 150 | 0.006 | >90 | Umwelt BA EM K1 |
| CO ₂ | 180000 | 6855 | >90 | Infrared |
| HCl | 8—30 | 3.05 E-4 | >98 | Ion chromatography (ASTM D 4327 84), Potentiometric titration (NEN 6476) |
| ¹ Reduction rate based on mass flow of constituent before/after abatement measure | | | | |
| ² (3 % O ₂) | | | | |
| Source: [EUROFER CR] | | | | |

- A plant supplier claims pollutant concentrations of less than 2 mg/m³ of HCl and free Cl₂ [Karner 1]
- Specific emissions of suspended solids of 2.86 g/t product (in treated waste water).
- Reduction of new acid to be produced (supplier).
- Generates a sellable solid by-product: iron oxide, which can be reused in the ferrite industry or in color and glass production.

Cross-media effects

- Additional consumption of energy and water.
- Generation of emissions to air (combustion product and acid), which have to be reduced by e.g. wet scrubbers.

Technical considerations relevant to applicability

- New plants and existing plants depending on size.

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

Economics

TWG, please update the economic information in this section.

Depending on site circumstances, the high acid consumption and amounts of waste acid generated and the savings generally obtained from regeneration may justify the investment in a regeneration plant.

~~For a countercurrent packed water scrubber with final alkaline scrubbing HCl emission levels of <15 mg/m³ with investment cost of 1175 kECU and operating costs of 6 kECU/a (electricity 300 kWh, V=10000 m³/h) were reported by [CITEPA].~~

The iron oxide produced has a commercial value and can be traded directly on the market. [EUROFER 23-7-18]

Driving force for implementation

Reduced costs due to increased material efficiency.

Example plants

[Karner-1]

TWG, please provide up-to-date information for the following table.

| Company | Year of contract | Capacity [t/h] | Remarks |
|--|------------------|----------------|-------------------|
| Hoesch Stahl AG; Dortmund, FRG | 1989 | 9000 | |
| Ornatube Enterprise; Kaohsiung; Taiwan | 1989 | 900 | |
| Shanghai Cold Strip; China | 1989 | 2900 | |
| China Steel; Kaohsiung, Taiwan | 1989 | 1900 | |
| Sidmar S.A.; Gent, Belgium | 1990 | 11000 | |
| Anshan Iron & Steel; China | 1991 | 2 x 6000 | high-purity oxide |
| Benxi Iron & Steel; China | 1992 | 5000 | |
| Karaganda Met. Komb.; Kazakhstan | 1992 | 2 x 10000 | |
| MMK; Magnitogorsk, Russia | 1993 | 11000 | |
| Baoshan Iron & Steel; China | 1994 | 2 x 2900 | high-purity oxide |
| Hanbo Steel; Korea | 1994 | 11000 | |

Reference literature

[Karner-1]

[Kladnig, 2008]

W.F. Kladnig, 2008. New development of acid regeneration in steel pickling plants. Journal of Iron and Steel Research 15(4), 1-6.

[EUROFER 23-7-18]

3.4.1.4 Hydrochloric acid regeneration by fluidised bed

Description:

~~See Chapter D.5.10.1.1 for regeneration process description and Chapter D.5.3 for emission abatement.~~

Description

The spent pickle liquor is fed into a fluidised bed reactor, where it is thermally decomposed at high temperature in the presence of water vapour and oxygen into hydrochloric acid and iron oxide. Off-gases from the reactor are cooled and fed to an absorber, where HCl is absorbed by rinse liquor and fresh water.

Technical description

See Section 8.6.5 concerning the technical description of the fluidised bed regeneration process.

Achieved environmental benefits

- Reduced consumption of fresh acid.
- Reduced waste water volume and sludge.

Environmental performance and operational data

See Section 8.6.5.

Cross-media effects

Additional consumption of energy and water.

Technical considerations relevant to applicability

~~New plants and existing plants depending on size.~~

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

Economics

The economics of a modern pickling plant with the fluidised bed process involve the following factors:

- raw acid consumption;
- utilisation of rinse and scrubber water;
- production of clear, iron-free hydrochloric acid;
- production of iron oxide which can be used in different industries.

Generally, the capital costs of a pickling plant, including the fluidised bed process, are favourable compared with the operation costs and resulting benefits. Overall economics will vary from one installation to another, due to local differences in acid cost, waste pickle liquor regeneration cost and the cost involved in modernising existing facilities or constructing new facilities. [Rituper-1]

Driving force for implementation

Reduced consumption of acid.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[Kladnig, 2008]

W.F. Kladnig, 2008. New development of acid regeneration in steel pickling plants. Journal of Iron and Steel Research 15(4), 1-6.

3.4.1.5 Effluent-free HCl strip pickling plant

Description

An effluent-free HCl strip pickling plant enables complete regeneration of the spent pickle liquor using a fluidised bed recovery process with complete recycling of the rinse water (e.g. no water emissions) and extremely low acid consumption.

Technical description

In an effluent-free HCl strip pickling plant, the spent pickle liquor is completely regenerated in a recovery system using a fluidised bed process. The pickle liquor recycled between the pickling tanks and regeneration unit results in nearly zero consumption apart from small evaporation losses. The rinse water is completely reused. This makes an effluent-free operation of the pickling plant possible. No environmental pollution is caused by the pickling process. [Rituper-1]

~~In determining the waste water from pickling operation: spent pickle liquor, rinse waste water, and scrubber water have to be taken into account. Using the fluidised bed process, the pickle~~

liquor recycled between the pickling tanks and regeneration unit, results in a nearly zero consumption of raw acid apart from some small amount of evaporation loss. [Rituper-1]

Since the fluidised bed process operates at approximately 850 °C, additional rinse and scrubber water from the pickle line can be utilised in the regeneration plant. In accordance with the energy balance of the venturi scrubber, a certain amount of water is necessary for cooling the reactor off-gas by evaporation. [Rituper-1]

The quantity of rinse and scrubber water, which can be utilised in the fluidised bed process, depends on the iron content of pickle liquor. An example of rinse water utilisation is shown in Figure 3.70. A portion of the rinse water is used for absorption, with the remainder directly added to the venturi scrubber. [Rituper-1]

In the example shown in Figure 3.70, a total of 5 943 l/h of rinse water can be used for the absorption of HCl. Depending on the iron content of the pickle liquor, approximately 500 l/h of rinse water at 105 g/l Fe^{++} and approximately 1 750 l/h of rinse water at 130 g/l Fe^{++} can be used in addition.

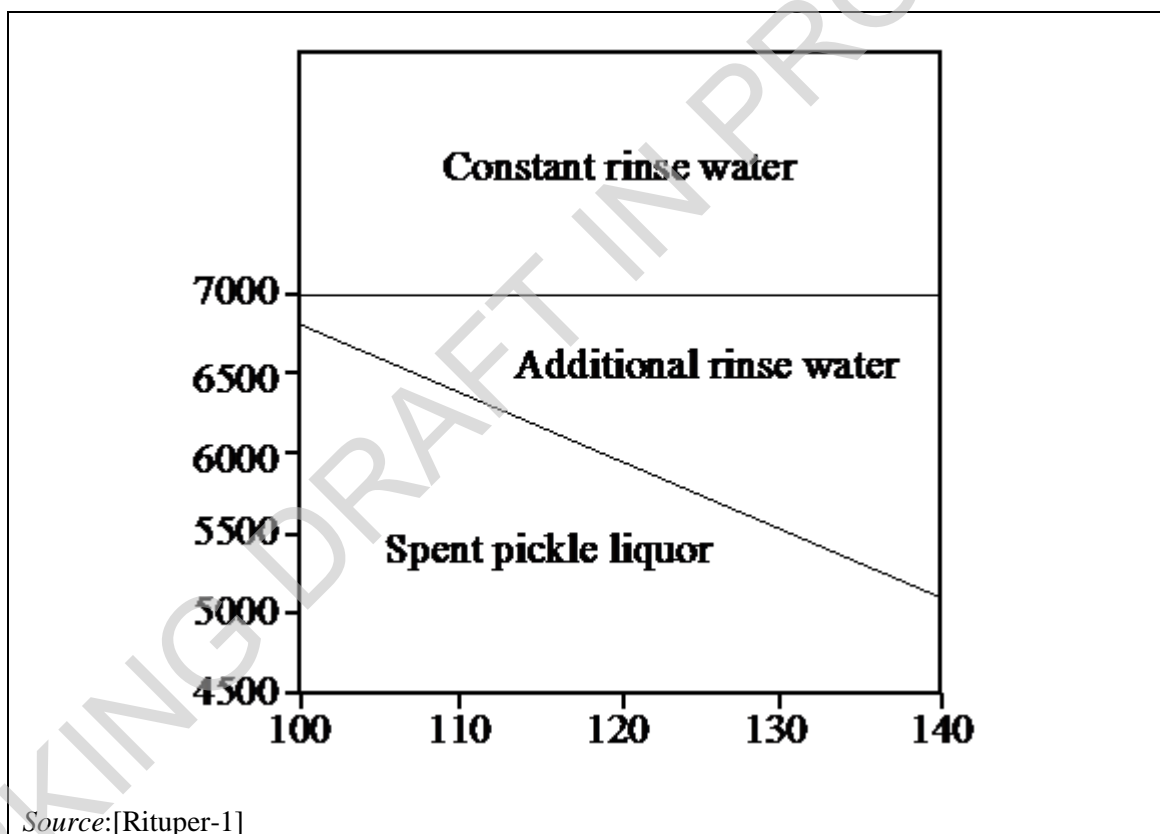


Figure 3.70: Dependence of rinse water utilisation on iron content

This example shows that an economical effluent-free pickling line operation can be achieved considering spent pickling liquor as well as rinse water quantities and concentrations.

Achieved environmental benefits

No water discharge/pollution.

Environmental performance and operational data

This process is capable of operating a completely closed, effluent-free pickling plant and has already been installed in several modern facilities. These facilities are operating with

hydrochloric acid consumption of less than 0.2 kg acid/tonne of pickled material. One example of an effluent-free strip pickling line in operation is illustrated in Figure 3.71. [Rituper-1]

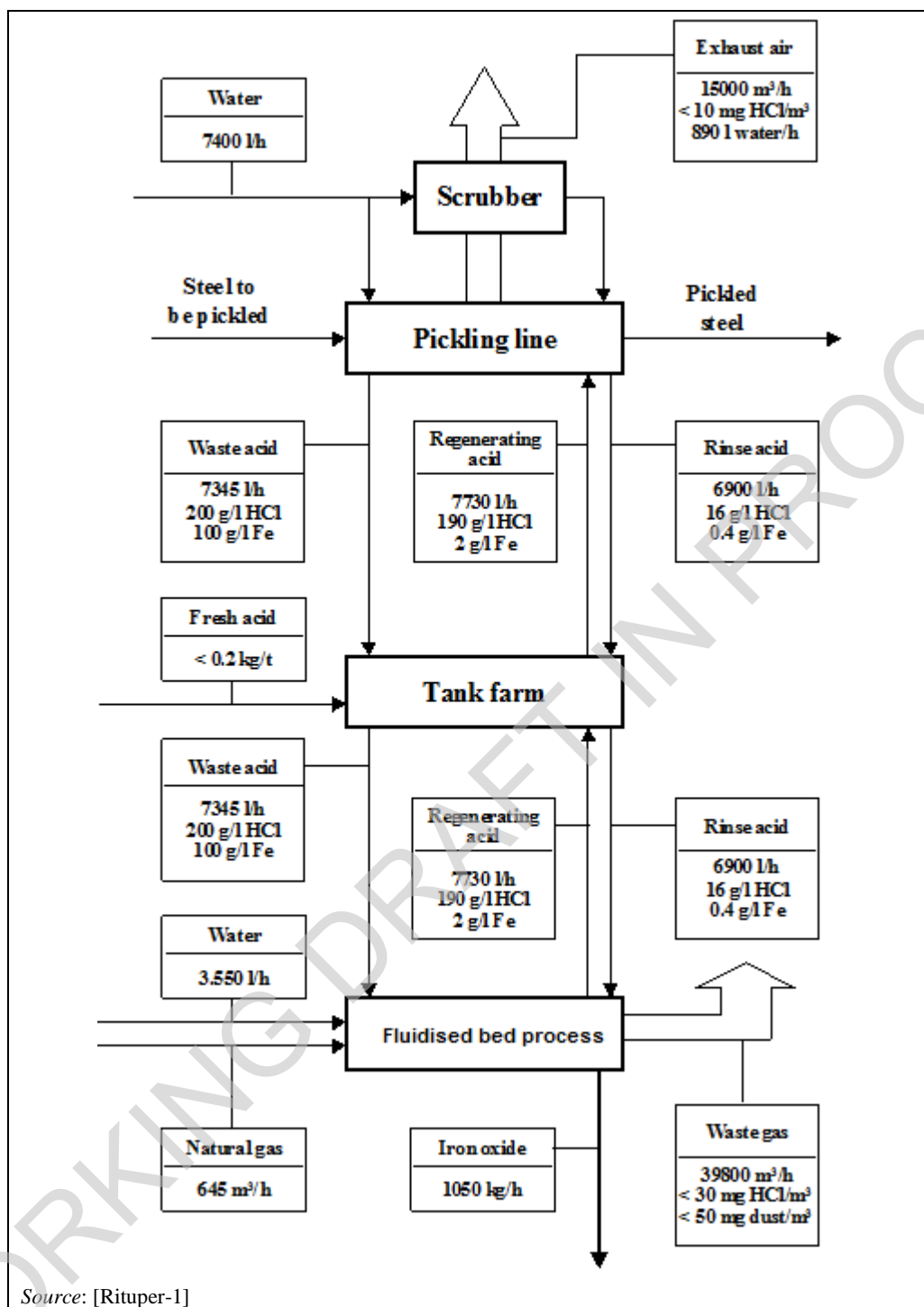


Figure 3.71: Example of effluent-free HCl pickling and acid regeneration

Cross-media effects

Additional consumption of energy and water.

Technical considerations relevant to applicability

~~New plants and existing plants depending on size.~~

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

Economics

Reduced production costs because of low acid consumption.

Driving force for implementation

- Environmental legislation.
- Savings in acid consumption.

Example plants

[Rituper-1]

Reference literature

[Rituper-1]

3.4.1.6 Sulphuric acid recovery by crystallisation

Description: see Chapter D.5.9.1 and D.6.3 for reduction of air emissions (scrubbing).

Description

The ferrous sulphate accumulated in the acid is crystallised and removed as a ferrous sulphate heptahydrate material. The crystallisation is achieved using indirect cooling, a cyclone treatment or by decompression evaporation under vacuum.

Technical description

See Section 8.6.5 concerning the technical description of the sulphuric acid recovery process by crystallisation.

Achieved environmental benefits

- Reduced consumption of fresh acid.
- Reduced waste water volume and sludge.

Environmental performance and operational data

Table 3.8 and Table 3.9 present data on consumption and emissions associated with H₂SO₄ vacuum crystallisation.

TWG, Table 3.9 will be updated at a later stage based on the data collection.

Table 3.8: Consumption and emission levels for H₂SO₄ vacuum crystallisation

| Input / Consumption Level | | |
|----------------------------------|-------------------|-------------------|
| Spent acid | 7 - 10 | kg/t |
| Cooling water (in) | 2 - 3.5 | m ³ /t |
| Industrial + demineralised water | 0.2 - 0.4 | m ³ /t |
| Energy: | | |
| Electrical energy | 1 - 20 | MJ/t |
| Caloric energy | 100 - 200 | MJ/t |
| Output / Emission Level | | |
| | Specific Emission | |
| Solid by-product: Fe-sulphate | 26 - 30 | kg/t |
| Recycled acid (20 %) | 0 - 10 | kg/t |
| Cooling water (out) | 2 - 3.5 | m ³ /t |
| Waste gas | 70 - 90 | m ³ /t |
| Waste water (discharge) | 0.2 - 0.4 | m ³ /t |
| Source of data [EUROFER CR] | | |

Table 3.9: Emissions to air from H₂SO₄ vacuum crystallisation

| | Concentration [mg/Nm ³] | Specific Emission [g/t product] | Reduction rate [†] [%] | Method of analysis |
|--|--|------------------------------------|------------------------------------|--------------------|
| SO ₂ | 8 - 20 | 0.5 - 1.5 | ≥ 95 | Infrared |
| H ₂ SO ₄ | 5 - 10 | 0.3 - 0.6 | ≥ 95 | Titration |
| Source of data [EUROFER CR] | | | | |
| [†] Reduction rate based on mass flow of constituent before/after abatement measure | | | | |

Cross-media effects

- Increased energy consumption.
- Emissions to air from recovery.

Technical considerations relevant to applicability

New plants and existing plants depending on size.

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

Economics

TWG, please provide information.

Driving force for implementation

Reduced consumption of acid.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[EUROFER CR]

3.4.1.7 Mixed acid (HNO₃ and HF) regeneration by spray roasting

Description: see Chapter D.5.10.1.2 and D.5.3

Description

The pickling solutions are injected via spray nozzles in the pyrohydrolytic reactor at high temperature where they react with oxygen and water to form a highly valuable iron oxide solid product. The acid is recovered using a two-stage isothermal adsorption unit followed by a selective catalytic reduction unit to reduce NOX emissions.

Technical description

See Section 8.6.5 for a technical description of the spray roasting regeneration process.

Achieved environmental benefits

- Reduction in fresh acid consumption (from 2.5–7 kg/t HF and 3–10 kg/t HNO₃ down to 0.8–1.2 kg/t HF), reduction of new acid to be produced (supplier) [Com Karner].
- Reduction of neutralisation sludge [Com Karner].

Environmental performance and operational data

TWG, emission levels will be updated at a later stage based on the data collection.

Table 3.10 presents data on consumption and emissions of mixed acid regeneration by spray roasting.

TWG, emission levels will be updated at a later stage based on the data collection.

Table 3.10: Consumption and emissions of mixed acid regeneration by spray roasting

| Input/Consumption Level | | |
|---|----------------|--|
| Spent acid | 25 - 100 | kg/t |
| Cooling water (in) | 1.5 - 9 | m ³ /t |
| Urea (for DeNOX) | 0.4 - 1 | kg/t |
| Caustic soda | | |
| Energy: | | |
| Electrical energy | 5 - 20 | MJ/t |
| Caloric energy (natural gas) | 60 - 230 | MJ/t |
| Output/Emission Level | | |
| Solid by-product: mixed oxide | 1.7 - 5 | kg/t |
| Recycled acid (HF 6 %, HNO ₃ 10 %) | 26 - 108 | kg/t |
| Cooling water (out) | 1.5 - 9 | m ³ /t |
| Waste gas: | 25 - 100 | m ³ /t |
| NOX | <100 (= 200 | ppm mg/m ³ calc. NO ₂) |
| HF | <2 | mg/Nm ³ |
| Dust | <10 | mg/Nm ³ |
| Waste water | 0.003 - 0.01 | m ³ /t |
| Source of data [Com-Karner], example Pyromars | | |

Cross-media effects

- Consumption of energy and chemicals.
- Generation of air emissions which have to be reduced/controlled.
- Generation of waste water which has to be treated.
- Generation of usable by-product mixed oxide [Com Karner].

Technical considerations relevant to applicability

~~New and existing plants. [Com Karner].~~

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

Economics

The produced iron oxide has a commercial value and can be traded directly on the market. [EUROFER 23-7-18] [Kladnig, 2008]

The economic advantage calculated for a steelworks producing 350 000 tonnes of hot rolled mild steel is estimated to be EUR 800 000 per year in chemicals and work. [Kladnig, 2008]

Driving force for implementation

Besides the environmental benefits of reducing the overall acid consumption and waste water emissions, the spray roasting technology allows the recovery of iron oxide which can be recycled in the smelting process or commercially traded on the market. [EUROFER 23-7-18]

Example plants

TWG, Please provide updated information for Table 3.11 (Old data)

Table 3.11: Example plants equipped with mixed acid regeneration by spray roasting

| Company | Capacity [l/h] | Year of Start |
|------------------------|----------------|---------------|
| AceriNOX, Spain | 3000 | 1992 |
| Yieh United, Taiwan | 4500 | 1994 |
| Posco, Korea | 4500 | 1994 |
| Columbus, South Africa | 4500 | 1995 |
| [Com Karner] | | |

Reference literature

[Com Karner]

W. Karner, W.Hofkirchner, Modern pickling and acid regeneration technology, MPT-Metallurgical Plant and Technology No.2, 1996, 92 -100.

[Kladnig, 2008]

W.F. Kladnig, 2008. New development of acid regeneration in steel pickling plants. Journal of Iron and Steel Research 15(4), 1-6.

[EUROFER 23-7-18]

3.4.1.8 Mixed acid (HNO₃ and HF) recovery by ion exchange

Description

Pickling solutions are treated using a side-stream acid purification unit which utilises filters and an ion exchange resin to selectively adsorb metallic salts from the pickling acid. Once the purification unit is saturated, the free acid is desorbed by backwashing with water and recycled to the pickling process.

Technical description

In the mixed acid pickling of stainless steel, metals are continuously dissolved in the pickling solution. When the dissolved metals reach high concentrations, technical problems such as salt precipitation with formation of sludges start to occur. To prevent this, the pickling liquor is treated using special resins which have the ability to separate the dissolved metals (e.g. iron, nickel, chrome and others) from the free pickling acid. Once the purification unit is saturated, the free acid is desorbed by a fresh water stream and recycled to the pickling process. [EUROFER 23-7-18] [Agrawal, 2009]

Achieved environmental benefits

Reduced acid consumption

Environmental performance and operational data

Table 3.12: Consumption and emission levels for mixed acid recovery by ion exchange

| Input / Consumption Level | | |
|---------------------------|------------------------------|-------------------|
| Spent mixed acid | 0.05 - 0.2 | m ³ /t |
| Water | 0.05 - 0.2 | m ³ /t |
| Energy: | | |
| Electrical energy | 2 - 5 | MJ/t |
| Output / Emission Level | | |
| Specific Emission | 0.05 - 0.2 m ³ /t | |
| Recovered mixed acid | | |

| | |
|--|------------------------------|
| Free HF recovery rate: | 75 - 85 % |
| Free HNO ₃ recovery rate: | 80 - 85 % |
| Metals removal rate: | 50 - 55 % |
| Metal containing weak acid solution | 0.05 - 0.2 m ³ /t |
| | |

Source of data [EUROFER CR]

Cross-media effects

Increased energy consumption.

Technical considerations relevant to applicability

New and existing

Generally applicable in stainless steel plants. [EUROFER 23-7-18]

Economics

Savings made due to reduced consumption of acids. [EUROFER 23-7-18]

Driving force for implementation

Reduction of acid consumption.

Example plants

Allegheny Ludlum, USA

Outokumpu Germany Krefeld. [EUROFER 23-7-18]

Reference literature

[EUROFER 23-7-18]

[Agrawal, 2009]

Agrawal, A., Sahu, K. K., 2009. An overview of the recovery of acid from spent acidic solutions from steel and electroplating industries. Journal of Hazardous Materials 171, 61-75.

3.4.1.9 Mixed acid (HNO₃ and HF) recovery by diffusion dialysis

Description: see D.5.9.4

Description

A positively charged membrane is used to separate the spent pickle liquor to be regenerated from fresh water. The membrane allows diffusion of the acid to the fresh water side while the metal salts remain in the spent liquor side, resulting in high recovery of the acid.

Technical description

See Section 8.6.5 concerning the technical description of the mixed acid recovery process by diffusion dialysis.

Achieved environmental benefits

Reduction of waste and fresh acid consumption.

Environmental performance and operational data

~~Thanks to the filtration of the used acids, a membrane cleaning does become necessary very seldom. By means of a corresponding pretreatment of the process solution it was reached, that a diffusion dialysis plant, installed in Sweden in 1989, for regeneration of stainless steel pickling acid (HF/HNO₃, 300 l/h) has been operating until today (1993) without any membrane cleaning with perfect results. [OSMOTA]~~

A diffusion dialysis plant was installed at a Swedish Plant in 1989 for regeneration of stainless steel pickling acid with a capacity of 300 l/h. [OSMOTA]

The recycling rate of free acid is about 80–85 %. The diffusion dialysis plant is simple to operate and requires little supervision. Although the process is not entirely selective, less than 5 % of metal salts are present in the regenerated mixed acid solution after treatment. [Dahlgren, 2010]

A pretreatment of the spent pickling liquor is required to prevent the surface of the membrane from becoming clogged. [Dahlgren, 2010]

Cross-media effects

Increased energy consumption.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

The investment cost for a diffusion dialysis plant with a capacity of 1 m³/h mixed acid is about SEK 1.5 million. [Dahlgren, 2010]

Driving force for implementation

Regeneration of mixed acid.

Example plants

Outokumpu Avesta (Sweden).

Reference literature

[OSMOTA]

[Luo et al., 2011]

Luo, J., Wu, C., Xu, T., Wu, Y., 2011. Diffusion dialysis-concept, principle and applications. Journal of Membrane Science 366, 1-16.

[Dahlgren, 2010]

L. Dahlgren, 2010. Treatment of spent pickling acid from stainless steel production: a review of regeneration technologies with focus on the neutralisation process for implementation in Chinese Industry. Master of Science Thesis, University of Stockholm, pp. 17-18, ISSN 1402-7615.

3.4.1.10 Mixed acid (HNO₃ and HF) recovery by evaporation

~~Description:~~ See Chapter D.5.10.4 and D.5.10.5.

Description

In a vacuum evaporator, the mixed acids are driven off and condensed prior to being recycled to the main pickling tank whereas sulphate metal salts are formed, precipitated in a crystalliser as slurry and neutralised to form hydroxide sludge.

Technical description

See Section 8.6.5 concerning the technical description of the mixed acid recovery process by evaporation.

Achieved environmental benefits

- Reduction of fresh acid consumption by recycling both free and bounded HNO₃ and HF.
- Significant reduction of nitrates in waste waters.
- No dust emissions [Com2 FIN].

Environmental performance and operational data

TWG, the following table is to be deleted and replaced by updated information received from the TWG – see below.

Table 3.13: Consumption and emission levels for mixed acid recovery by evaporation

[Com2 FIN]

| Input/Consumption Level | |
|---|-----------------|
| Spent acid | 15—30 litres /t |
| H ₂ SO ₄ (95 %) | 4.0—6.0 kg /t |
| Cooling water | 3.8—5.8 kg /t |
| Energy: | |
| — Electricity | 2.3—3.5 MJ /t |
| — Steam | 16—24 kg /t |
| — Propan | 3.2—4.8 MJ /t |
| Output/Emission Level | |
| Cooling water | 3.8—5.8 kg /t |
| Recycled acid: | 14—20 litres /t |
| — 130 g/l HNO ₃ | |
| — 55 g/l HF | |
| Metal sulphate: | 5.0—7.6 kg /t |
| — Fe | 0.6—0.8 kg /t |
| — Cr | 0.09—0.13 kg /t |
| — Ni | 0.08—0.12 kg /t |
| — SO ₄ | 1.9—2.9 kg /t |
| — H ₂ SO ₄ | 1.7—2.5 kg /t |
| Waste gas: | |
| — Dust | None |
| — HF | <2 mg /l |
| — NO ₂ | <100 mg /l |
| The data above is based on measurements during plant operation. | |

Table A.4 28: Consumption and emission levels for mixed acid recovery by evaporation

In Outokumpu (Tornio, Finland), three evaporation regeneration units have been installed for mixed acid regeneration. The recycling rate for HNO₃ is 98 % and 99 % for HF. [EUROFER 23-7-18] [Dahlgren, 2010].

Cross-media effects

- Consumption of energy and H₂SO₄.
- Consumption of energy to evaporate acids. [EUROFER 23-7-18]
- Consumption of sulphuric acid. [EUROFER 23-7-18]
- Generation of metal sulphates, which can be neutralised to metal hydroxides [Com2 FIN].
- The process equipment has to be constructed using high-quality materials. Special corrosion-resistant steels and fluorocarbon polymers are extensively used as construction materials for the process equipment. [EUROFER 23-7-18]
- HF and NOX emissions. [EUROFER 23-7-18]

Technical considerations relevant to applicability

New and existing plants

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

Economics

- Savings due to reduced consumption of acids.
- Easy to maintain constant composition of pickling acids.
- No need for acid neutralisation [Com2 FIN].

Driving force for implementation

Total regeneration of mixed pickling acids [Com2 FIN].

Example plants

Outokumpu Tornio (Finland):

- Regeneration plant 1, capacity 1.5 m³/h, start year 1984.
- Regeneration plant 1, capacity 3.0 m³/h, start year 1997.
- Regeneration plant 3, capacity 6.0 m³/h, start year 2003.

Reference literature

[Com2 FIN] [EUROFER 23-7-18]

B.Nyman, T.Koivunen, The Outokumpu process for pickling acid recovery, Iron Control in Hydrometallurgy, Toronto, 19 - 22 Oct 1986, p 519-536, John Wiley & Sons.

[Dahlgren, 2010]

L. Dahlgren, 2010. Treatment of spent pickling acid from stainless steel production: a review of regeneration technologies with focus on the neutralisation process for implementation in Chinese Industry. Master of Science Thesis, University of Stockholm, pp. 17-18, ISSN 1402-7615.

TWG, Section A.4.2.2.15 from the old BREF "Electrolytic pre-pickling for high-alloy steel" has been moved and the updated information can now be found in Chapter 8 (Section 8.6.2.4).

TWG, Section A.4.2.2.16 from the old BREF "Cleaning and reuse of electrolytic pickle liquor" has been moved and the updated information can now be found in Chapter 8 (Section 8.6.2.4). It has been merged with the section "electrolytic pre-pickling for high-alloy steel".

TWG, Section A.4.2.2.17 from the old BREF "External use of spent acid pickle liquor" has been deleted as it contained no information.

TWG, Section A.4.2.2.18 from the old BREF "Reduction of emissions from pickling/closed HCl and H₂SO₄ pickling tanks with exhaust gas scrubbing" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.4.4).

TWG, Section A.4.2.2.19 from the old BREF "Reduction of emissions from pickling/closed mixed acid pickling tanks with exhaust gas scrubbing" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.4.3).

TWG, Section A.4.2.2.20 from the old BREF "Suppression of NOX from mixed acid pickling by addition of H₂O₂ (or urea) to pickling bath" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.5.2).

TWG, Section A.4.2.2.21 from the old BREF "Selective catalytic reduction" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.1.4).

TWG, section A.4.2.2.22 from the old BREF document "NOX reduction from pickling by SNCR" has been deleted since this technique is not applied in mixed acid pickling.

TWG, section A.4.2.2.23 from the old BREF document "Nitric acid free pickling of stainless steel" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.5.1).

3.4.1.11 Optimised oil use for low-alloy and alloy steel

Description

Optimised use of rolling or anticorrosive oil is achieved by oiling the pickled sheet with an electrostatic oiling machine that can deliver an oil flow adapted to the required oil film thickness.

Technical description

When oiling the sheet (with rolling oil or anticorrosive oil), optimisation of the oil spray chambers or the oiling machines leads to a reduction in oil consumption. An electrostatic oiling machine has the advantage that the oil flow can be continuously adapted to the required oil film thickness at the actual line speed.

If the pickled sheet (product) is to be used for cold rolling, oiling with rolling oil may not be required at the pickling line. On the other hand, oiling with anticorrosive oil is not necessary if the next process step follows immediately.

Achieved environmental benefits

Reduction of oil and anticorrosive oil consumption.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

3.4.1.12 Magnetic pumps (low-alloy and alloy steel)

Description

Magnetic drive pumps are employed instead of mechanical pumps to reduce water consumption and prevent leakages of fluids.

Technical description

Mechanical pumps need a constant gland water flow on the mechanical seals. Substitution of mechanical by magnetic pumps reduces the water needs. In addition, magnetic drive pumps are sealless pumps which do not use packing or mechanical seals to isolate the process fluid. Accordingly, magnetic drive pumps prevent leakages of fluids.

Achieved environmental benefits

- Reduction of water consumption.
- Prevention of leakages of fluids.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

New and existing plants: Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

TWG, Section A.4.2.2.26 from the old BREF "Acid heating by heat exchangers" has been moved and the updated information can now be found in Chapter 8 (Section 8.6.2.1).

TWG, Section A.4.2.2.27 from the old BREF "Acid heating by submerged combustion" has been moved and the updated information can now be found in Chapter 8 (Section 8.6.2.1).

3.4.1.13 Treatment of acidic waste water**Description**

Where acidic water blowdown from the system cannot be avoided, acidic waste water is neutralised and metals are precipitated and separated by sedimentation. The metal sludge is dewatered in filter presses and disposed of.

Technical description

Acidic waste water from rinsing and from fume absorbers of the pickling tank exhaust system, if it cannot be used in the pickling tanks, and the waste water from flushing (plant cleaning) require treatment prior to discharge. The waste water is neutralised (e.g. with alkaline waste waters from other plant operations), dissolved metal ions are transformed into hydroxides or sparingly soluble salts and subsequently eliminated by sedimentation, in many cases by adding flocculants. The precipitated metal sludge is dewatered in filter presses and disposed of.

Achieved environmental benefits

Reduction of volume and contaminant load to water.

Environmental performance and operational data

TWG, emission levels in this heading will be updated at a later stage based on the data collection.

Table 3.14: Pollutant concentration in water discharge of HCl pickling and regeneration plants

| | Concentration [mg/l] | Specific Emission [g/t product] | Reduction rate¹ [%] | Method of analysis |
|-------------------------|--------------------------------|---|--|---------------------------|
| Suspended solids | 50 | 2.86 | ≥ 90 | DIN 38409 H2 |
| Fe total | 2 | 0.114 | ≥ 90 | DIN 38406 |
| Zn total | 0.06 – 1 | NI | NI | " |
| Ni total | 0.1 – 0.5 | NI | NI | " |
| Cr total | 0.02 – 0.5 | NI | NI | " |
| Cr^{VI} | 0.01 – 0.1 | NI | NI | " |
| Temperature | < 30 °C | NI | NI | Thermometer |

| | | | | |
|---|---------|----|----|-------------|
| pH | 6.5–9.5 | NI | NI | DIN38404-C5 |
| Source of data [EUROFER CR]. Data based on weekly, volume proportional 24 h sampling | | | | |
| ⁺ Reduction rate based on mass flow of constituent before/after abatement measures | | | | |
| NB: NI = No information provided. | | | | |

Table 3.15: Pollutant concentration in water discharge of HCl pickling and regeneration plants
[Com2 D]

| Substance | Concentration in mg/l ¹⁾ | Type of sampling | Measurements in 1998 Operator/Comp. authority |
|--|-------------------------------------|-------------------------|--|
| Fe | 0.41 | Qualified random sample | 12/6 |
| Oil | <0.28 | Qualified random sample | 12/6 |
| Suspended solids | <10 | Qualified random sample | 12/6 |
| Cr | <0.01 | Qualified random sample | 12/6 |
| Ni | 0.03 | Qualified random sample | 12/6 |
| Zn | 0.02 | Qualified random sample | 12/6 |
| Source of data: Senator für Bau und Umwelt Bremen. Plant: Stahlwerke Bremen. | | | |
| ¹⁾ Mean values of the qualified random samples from 1998. Waste water volume: 264528 m ³ | | | |

Table 3.16: Pollutant concentration in water discharge of H₂SO₄ pickling and regeneration plants

| | Concentration [mg/l] | Specific Emission [g/t product] | Reduction rate ¹ [%] | Method of analysis |
|--|----------------------|---------------------------------|---------------------------------|--------------------|
| Suspended solids | 40–50 | 16–20 | > 90 | DIN 38409 H2 |
| Fe total | 1.4–2 | 0.3–0.5 | > 95 | DIN 38406 |
| Zn total | 0.15–1 | NI | NI | " |
| Ni total | 0.1–0.5 | NI | NI | " |
| Cr total | 0.5 | NI | NI | " |
| Cr ^{VI} | 0.01–0.1 | NI | NI | " |
| Temperature | <30 °C | NI | NI | Thermometer |
| pH | 6.5–9.5 | NI | NI | DIN38404-C5 |
| Source of data [EUROFER CR]. Data based on weekly, volume proportional 24 h sampling | | | | |
| ⁺ Reduction rate based on mass flow of constituent before/after abatement measure | | | | |
| NB: NI = No information provided. | | | | |

Cross-media effects

- Generation of a large quantity of sludge.
- The sludge, mainly consisting of iron hydroxide and water, can be recycled for iron production as long as it is not contaminated by unacceptable metals (e.g. zinc) or by other constituents. Care should be taken to avoid mixing of waste water streams or sludges which can make recycling difficult.
- Neutralisation can also create large amounts of neutral salts (e.g. NaCl, CaCl₂, Na₂SO₄, CaSO₄), most of which are very soluble in water and are discharged with the treated water. Removal is only possible by very special, and in most cases uneconomical, treatment (reverse osmosis, electrodialysis or evaporation followed by ion exchange and concentrate evaporation with salt drying). Even if these salts are removed, their mixed composition limits reuse and disposal to landfill may be restricted by their solubility.

Technical considerations relevant to applicability

New and existing plants. Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Environmental legislation.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

TWG, The following section has been added – New BAT candidate provided by the TWG.

3.4.1.14 Three-acid pickling for stainless steel**Description**

In the three-acid pickling technique, nitric acid is partially substituted with sulphuric acid for pickling stainless steel products, reducing the consumption of nitric acid.

Technical description

Conventional pickling in stainless steel production is usually performed using mixed acid (HF/HNO₃). In the three-acid pickling technique, the nitric acid is partially substituted with sulphuric acid and used in combination with HF. The price of nitric acid is higher than the price of sulphuric acid; accordingly, substantial economic savings can be made with this technique. In addition, three-acid pickling results in a significant reduction in waste water emissions of nitrates.

In conventional mixed acid pickling, HNO₃ concentrations typically ranges from 180 g/l to 380 g/l while HF concentrations ranges from 10 g/l to 40 g/l. [Dustou et al., 2017]

In three-acid pickling, the nitric acid concentrations are reduced to 40–90 g/l depending on the type of product and H₂SO₄ concentrations are within the range of 50–160 g/l. [EUROFER 10-7-18]

In stainless steel pickling plants, the acid regeneration process lead to emissions to water of nitrates, particularly during the neutralisation process. With three-acid pickling, these emissions can be reduced since the quantities of nitric acid employed are substantially reduced. [EUROFER 10-7-18]

Achieved environmental benefits

- Significant reduction of nitrate emissions.
- Reduction of nitric acid consumption.

Environmental performance and operational data

The three-acid pickling technique is currently implemented in Outokumpu Tornio (Finland). The use of this technique is restricted to pickling plants employing an evaporation process for regeneration of the acid because the presence of sulphuric acid would cause issues in other types of acid regeneration processes. (See Section 8.6.5.) The pickling liquor is first mixed with sulphuric acid before entering the evaporator. The evaporation takes place under vacuum at 80 °C and at a pressure of 5 kPa which vaporises HF and HNO₃. These are then condensed and recirculated back to the pickling bath. The slurry is led to a crystallisation tank for precipitation of different metal sulphates. After thickening, the metal sulphate slurry is separated from the excess sulphuric acid, which is recirculated to the evaporator. [Dahlgren, 2010]

Reductions of nitrate emissions of between 25 % and 70 % can be achieved depending on the level of nitric acid substitution. Metals in the pickling bath are precipitated mainly as sulphates instead of fluorides, resulting also in a reduction of about 10 % in HF consumption. [EUROFER 10-7-18]

The acid neutralisation process is more difficult to control when using sulphuric acid, resulting sometimes in difficulties to maintain the concentrations of the suspended solids in waste water emissions from the neutralisation plant at < 20 mg/L. [EUROFER 10-7-18]

Cross-media effects

None.

Technical considerations relevant to applicability

- The use of this technique is restricted to stainless steel pickling plants employing an evaporation process for regeneration of the mixed acid because the presence of sulphuric acid causes issues for other types of acid regeneration processes.
- In some cases, three-acid pickling might not be suitable for the production of special steel grades.

Economics

The price of H_2SO_4 is lower than the price of HNO_3 , making the three-acid pickling technique financially viable.

Driving force for implementation

Reduction of nitrate waste water emissions.

Example plants

Outokumpu Tornio (Finland).

Reference literature

[EUROFER 10-7-18]

[Dahlgren, 2010]

L. Dahlgren, 2010. Treatment of spent pickling acid from stainless steel production: a review of regeneration technologies with focus on the neutralisation process for implementation in Chinese Industry. Master of Science Thesis, University of Stockholm, pp. 17-18, ISSN 1402-7615.

[Dustou et al., 2017]

B., Dustou, L., Latapie, F., Chauvet, J.M., Bergerat, T. Tzedakis, 2017. Analytical Method to Monitor Industrial Pickling Baths Initially Constituted by HF, HNO_3 . Journal of Analytical Sciences, Methods and Instrumentation, 7, 116-135.

TWG, The following section has been added – New BAT candidate provided by the TWG.

3.4.1.15 Chemical reduction of hexavalent Cr(VI) with sulphur dioxide

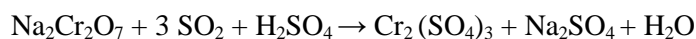
Description

The sludges from the electrolytic pre-pickling baths are treated in acidic conditions to reduce their hexavalent chromium concentrations (Cr(VI)) using sulphur dioxide as the reducing agent. After the chemical reduction process, the solution is fed into the neutralisation step of the waste water treatment plant together with acidic rinsing waters from the mixed acid pickling.

Technical description

The suspensions to be treated are first stored in a mixing tank to level concentration differences of different feed streams. Sulphuric acid is fed into mixing tank to lower the pH of the solution. Indeed, a low pH value increases the rate of the Cr(VI) reduction reaction. Furthermore, the chemical reaction also consumes sulphuric acid so it must be fed into the mixing tank before the actual reduction reaction takes place. After mixing, the solution is pumped into a feeding tank. It is also possible to control the pH value of the solution at this point. From the feeding tank, the solution is pumped into a first reduction reactor that overflows into a second reduction reactor.

In total, two reactors in series are used and SO₂ is fed into both reactors. The reduction reaction of Cr(VI) is as follows:



The reduction of Cr(VI) is monitored through pH and redox-potential values. An automated analyser continuously analyses the Cr(VI) concentration in the feeding tank and adjusts the rate of sulphur dioxide addition accordingly. The controller also uses the feed rate and the redox-potential value as inputs for the calculation of required SO₂ addition. After the reduction process, the solution is fed into the neutralisation process together with acidic rinsing waters from the mixed acid pickling. [Lindfors and Kostamo, 2006] [EUROFER 10-7-18]

Achieved environmental benefits

Reduction of Cr(VI) emissions to water in stainless steel pickling plants.

Environmental performance and operational data

Cr(VI) concentrations < 0.1 mg/l can be achieved.

Cross-media effects

The use of SO₂ as a reducing chemical requires special safety considerations in the workplace. [EUROFER 10-7-18]

Technical considerations relevant to applicability

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

Economics

Sulphur dioxide is a more effective reducing agent than the more widely used sodium metabisulphate (Na₂S₂O₅). As a result, the use of sulphur dioxide enables the use of smaller reactor sizes and decreases the investment costs. [Lindfors and Kostamo, 2006]

Driving force for implementation

Minimisation of Cr(VI) emissions to water.

Example plants

Outokumpu Tornio.

Reference literature

[EUROFER 10-7-18]

[Lindfors and Kostamo, 2006]

N.O., Lindfors, P. Kostamo, 2006. BAT examples from the Nordic iron and steel industry. ISBN 92-893-1286-6

3.4.2 Rolling**3.4.2.1 Continuous instead of conventional discontinuous rolling for low-alloy and alloy steel****Description**

Continuous rolling is employed instead of conventional discontinuous rolling, allowing for stable feed and less frequent start-ups and shutdowns.

Technical description

Continuous rolling is employed in the production of low-alloy and alloy steel as it presents many advantages compared to discontinuous rolling (e.g. stable feed, reduced start-ups and shut-downs, improvement in quality and yield).

Achieved environmental benefits

- Reduction in oil consumption.
- Reduction of electricity consumption.

Environmental performance and operational data

- Improvement of the material yield due to the better control of gauge for coil ends.
- Improvement on quality yield.
- Reduction in roll change frequencies.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

- Applicable for installations with a high production capacity and the same kind of products.
- New installations or major upgrades of existing installations.

Economics

TWG, please provide information.

Driving force for implementation

Improved quality and increased yield.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

3.4.2.2 Pickling plant coupled with the tandem mill**Description**

Pickling lines are coupled with a tandem cold rolling mill to increase the production throughput and minimise the amounts of defects (e.g. scrap).

Technical description

Coupling pickling lines with tandem cold rolling mills enables high rolling yield and efficiency, a significant reduction of the processing time and the possibility to achieve narrower thickness tolerances. Also, coupled pickling lines and tandem cold rolling mills minimise the amounts of defects (e.g. scrap). [Bos et al., 2006]

Achieved environmental benefits

Reduced scrap (minimisation of defects).

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

For new installations or major upgrades of existing plants.

Economics

This technique reduces operational processing costs (labour and maintenance costs).

Driving force for implementation

Reduced processing time, minimisation of defects, increased yield.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[Bos et al., 2006]

B. Bos, K. Willems, M. Hoglinger, K. Janhofer, A. Kemmer, 2006. Operational experience of coupled pickling lines / tandem cold rolling mills. Stahl und Eisen 126 (5).

3.4.2.3 Reduction of the rolling friction

Description

Rolling oils are carefully selected and emulsion systems are operated to reduce the friction between the working rolls and the feedstock and to ensure minimal oil consumption.

Technical description

In cold rolling, the proper choice of a tandem or reversing mill oil/emulsion is important for quality reasons (lubricant effect in the roll gap, good distillation properties, easy removal in degreasing lines). Besides that, to limit the oil consumption, a tandem mill oil must satisfy a number of performance criteria:

- Good lubrication characteristics allow a decrease in the oil consumption and reduced friction between rolls and strip. [EUROFER 23-7-18]
- An easy separation caused by accidental leakages from the hydraulic system or from the Morgoil bearings is necessary. If separation is not possible, a partial or a complete renewal of the emulsion is necessary.
- The actual process parameters (cold reduction, gauge, rolling forces, speed, roughness) and the available emulsion preparation station determine the requirements on the stability of the emulsion and on the dispersion of the oil in the emulsion.
- The quality of the oil has to remain unaffected by longer periods of line stop conditions (stability of the emulsion, formation of bacteria) in order to avoid a need for the premature disposal of the emulsion.
- Nowadays, supplier and user are developing together the rolling oil/emulsion system tailored to the specific mill conditions. [EUROFER 23-7-18]
- Incoming hot strip which is pickled and oiled should be adapted to the emulsion system. [EUROFER 23-7-18]

Achieved environmental benefits

- Reduction in oil consumption.
- Reduced disposal of waste emulsion.
- Reduction in energy consumption by optimising friction. [EUROFER 23-7-18]

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

~~New plants and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

ArcelorMittal Ghent (Cold rolling mill). [EUROFER 23-7-18]

Reference literature

[EUROFER 23-7-18]

International Conference on Steel Rolling, 10; 1022-102. Metallurgical Industry Press, Beijing; 2010.

3.4.2.4 Monitoring and adjustment of the rolling emulsion quality

Description

Important characteristics of the rolling emulsion (e.g. oil concentration, pH, emulsion particle size, saponification value, viscosity) are monitored regularly or continuously to detect anomalies in the emulsion quality and take corrective action, if needed.

Technical description

The quality of the emulsion can be downgraded by a lot of accidents, which are difficult to monitor: carry-over of acid from the pickling line, contamination from the emulsion cooling water, contamination with hydraulic or Morgoil oil, destruction of the emulsion properties by bacteria, or concentration of iron fines. These accidents very often result in the need for a partial or a complete renewal of the tandem emulsion.

A regular or, if possible, continuous measurement of the important emulsion characteristics (oil concentration, pH, saponification index, acid concentration, concentration of possible pollutants, concentration of iron fines droplet size, bacteria population, etc.) offers the possibility to detect and to remedy anomalies in the emulsion quality. [EUROFER 23-7-18]

In addition, the measurements generate data which allow additions of oil and water to compensate the drag-out and keep the parameters as constant as possible. [EUROFER 23-7-18]

Achieved environmental benefits

- Reduction in oil/emulsion consumption.
- Reduction of waste emulsion to be treated and disposed of.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

~~New plants and existing plants~~: Generally, there are no technical restrictions to the applicability of this technique.

Economics

Cost reduction and increased yield. [EUROFER 23-7-18]

Driving force for implementation

- Reduction of waste emulsion through long lifetime. [EUROFER 23-7-18]
- Reduction of oil use. [EUROFER 23-7-18]
- Cost reduction through long lifetime. [EUROFER 23-7-18]

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[EUROFER 23-7-18]

3.4.2.5 Inspection and maintenance of the emulsion system

~~A.4.2.3.5 Prevention of Contamination~~

Description

Regular inspections and preventive maintenance of the emulsion system (e.g. pump seals, piping and filters) to reduce oil leakages and thus contamination of the rolling emulsion.

Technical description

In the cold rolling of carbon steel, it is very important to protect the rolling emulsion from any sources of pollution. [EUROFER 23-7-18]

Contamination of the emulsion can occur from different sources including:

- leakages of hydraulic oil or Morgoil oil;
- incompatible oil from oiled hot strip as well as acid residues from pickling;
- cleaning system in the circulation with filters and separators not working correctly;
- deposits and settlements in the piping and tanks as well as deposits from the mill stands;
- growth of bacterial population;
- contaminated water for emulsion set-up / water addition.

Preventive maintenance of the entire system helps to extend the lifetime of the emulsion as does regular cleaning of the roll stands: [EUROFER 23-7-18]

- Regular control of seals and piping helps to prevent leakages and contamination of the rolling emulsion with hydraulic oil or Morgoil oil. Preventive maintenance where seals and piping are changed on a regular basis is not unusual.
- Make the incoming oiled hot strip as compatible as possible and keep acid level in the rinse of the pickling under control.
- Regular maintenance of the circulation system with the filters, magnetic separator for proper functioning.
- Regular cleaning of the tanks, piping and mill stands to prevent bacterial growth.
- Beside the use of fungicides, a regular heat treatment kills bacteria. Running the emulsion with low temperatures and heat treatment can keep bacterial growth under control without the need to use fungicides.
- Fresh deionised set-up water prevents unexpected contamination.

Achieved environmental benefits

- Reduced emulsion consumption.
- Reduced waste water treatment and discharge.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

~~New plants and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Long lifetime of the emulsion without unexpected disposal. [EUROFER 23-7-18]

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[EUROFER 23-7-18]

3.4.2.6 Optimised emulsion/oil use

Description

The oil concentration in the last stand is limited to the minimum required for lubrication. Emulsion cellars, shielding of the mill stands or working air knife with edge suction is employed to reduce to a minimum the amounts of residual oil on strips leaving the mill.

Technical description

The residual oil concentration left on the strip leaving the mill, which is responsible for the major part of the oil consumption, is a function of the oil concentration in the last stand in tandem mills. Therefore oil concentration in the last stand should be limited to the minimum required for lubrication and the carry-over of emulsion from the previous stands, where the oil concentration is higher, should be lower than the minimal working concentration. The possible measures (separating the emulsion cellars, shielding of the mill stands) are specific for each installation. An efficient working air knife combined with edge suction reduces the residual oil/emulsion on the strip leaving the mill. [EUROFER 23-7-18]

Achieved environmental benefits

Reduction of oil consumption

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[EUROFER 23-7-18]

TWG, Section A.4.2.3.7 from the old BREF "Cleaning and reuse of degreasing solution" has been moved and the updated information can now be found in Chapter 8 (Section 8.6.1.6).

3.4.2.7 Cleaning and reuse of the rolling emulsion

~~A.4.2.3.7 Cleaning and Reuse of Emulsion~~

Description

Particulate matter (e.g. dust, steel slivers and scale) contaminating the rolling emulsion is removed in a cleaning circuit (usually based on sedimentation combined with filtration and/or magnetic separation) in order to maintain the emulsion quality.

Technical description

See Section 8.9.14 for a detailed technical description.

Achieved environmental benefits

- Reduced consumption of new cold rolling emulsion.
- Reduced waste water volume.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

3.4.2.8 Treatment of spent rolling emulsion

~~A.4.2.3.8 Treatment of Spent Emulsion~~

Description

The partial flow of the emulsion circuit cleaning system that is discarded is de-oiled in an emulsion splitting plant into oil sludge and water, and the purified water is then discharged. The separated, oil-containing sludge may be used in the blast furnaces or coke oven batteries in an integrated steelworks. [EUROFER 23-7-18]

Technical description

Treatments available comprise:

- thermal: by evaporation and splitting with chemical additions;
- chemical: acid splitting, salt splitting, combined dosage of coagulants and polyelectrolytes;
- flotation;
- adsorption;
- electrolytical;
- membrane filtration (ultrafiltration, reverse osmosis).

See Section 8.9 for additional information on these techniques.

Achieved environmental benefits

Reduced emissions to water.

Technical considerations relevant to applicability

~~New plants and existing plants~~. Generally, there are no technical restrictions to the applicability of this technique.

Thermal treatment:

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

- High energy consumption.
- Waste gas treatment required.
- Little COD in effluent [Woll].

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

Chemical treatment:

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

- Generation of additional oil-containing neutralisation sludges [Com D].
- Consumption of chemicals [Woll].
- COD in effluent [Woll].

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[EUROFER 23-7-18] [Com D] [Woll]

Electrolytic treatment:**Environmental performance and operational data**

Figure 3.72 shows an example of an emulsion splitting system using electrolytic splitting.

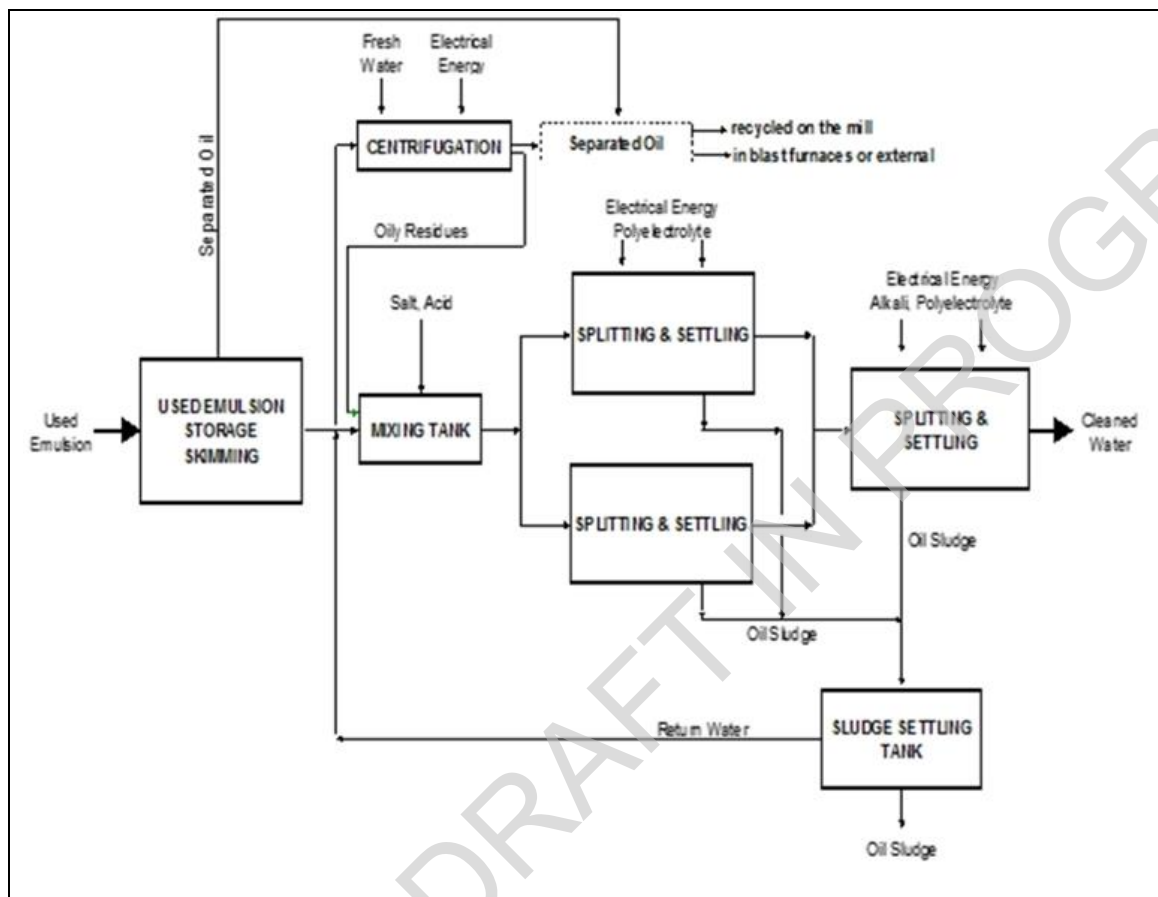


Figure 3.72: Spent emulsion splitting system
[EUROFER CR]

Table 3.17: Operational data for electrolytic emulsion splitting

| Input / Consumption Level | | | | |
|---|-------------------------|-------------------------------------|------------------------------------|-----------------------|
| | Tandem Mill | | Reversing Mill | |
| Spent emulsion | 5 - 13 | kg/t | 0.06 | m ³ /t |
| Industrial water | 0.5 - 1 | kg/t | NI | |
| Salt | 0.025 - 0.05 | kg/t | 0.125 (NaCl) | kg/t |
| Polyelectrolyte | 0.003 - 0.005 | kg/t | 0.012 | kg/t |
| Al-Anodes | 0.003 - 0.006 | kg/t | 0.012 | kg/t |
| Electrical energy | 5 - 10 | MJ/t | 3 - 3.5 | MJ/t |
| Output / Emission Level | | | | |
| Purified waste water | 5 - 13 | kg/t | 0.06 | m ³ /t |
| Water (-> coke plant) | NI | | NI | |
| Oily sludge (disposal) | 0.1 - 0.3 | kg/t | 1.9 | kg/t |
| Oily sludge (internal recycling) | 2.5 - 3.5 | kg/t | NI | |
| Oil (+/- 20 % water, → blast furnace) | 1.3 - 2 | kg/t | NI | |
| | Concentration [mg/l] | Specific Emission [kg/t product] | Reduction rate ¹ [%] | Method of analysis |
| Settleable solids | 7 - 10 | 5.8 - 8 E -5 | > 90 | DIN 38409-H9 |
| Σ Hydrocarbons | 6 - 18 | 5.2 - 18 E -5 | > 90 | DIN 38409-H18 |
| Chlorides | 800 -1400 | 6.7 - 10 E -3 | NI | DIN 38405-D1 |
| Sulphide | 0.004 - 0.4 | 3.3 - 330 E -8 | NI | DIN 38405-D26 |
| NO ₂ ⁻ | 8 -10 | 8 - 9 E -5 | NI | DIN 38405-D19 |
| Pb total | 0.03 - 0.3 | 2.65 - 27 E -7 | > 90 | DIN 38406 |
| As total | 0.075 - 0.1 | 6.2 - 7.5 E -7 | > 90 | DIN 38406 |
| Zn total | 0.08 - 1.6 | 6.6 - 132 E -7 | > 90 | DIN 38406 |
| Ni total | 0.4 - 0.5 | 3.3 - 4 E -6 | > 90 | DIN 38406 |
| Cr total | 0.008 - 0.4 | 6.6 - 2500 E -8 | > 90 | DIN 38406 |
| Cu total | 0.06 - 0.4 | 5 - 33 E -7 | > 90 | DIN 38406 |
| AOX | 0.1 - 0.4 | 8.3 - 32 E -7 | NI | DIN 38409-H14 |
| BTX | 0.02 - 0.08 | 1.7 - 6.6 E -7 | NI | DIN 38407-F9 |
| Temperature | 28 °C | NI | NI | Thermometer |
| pH | 7.6 | NI | NI | DIN 38405-C5 |
| Notes: - Source of data [EUROFER CR] - Data based on weekly, volume proportional 24-h sampling NI = No information provided. | | | | |

Cross-media effects

All of the oil contained in the emulsion has to be removed as sludge

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

Ultrafiltration:**Environmental performance and operational data**

- No chemical addition required [SIDMAR-ArcelorMittal Ghent].
- No oily sludge is generated [SIDMAR-ArcelorMittal Ghent].

- Nearly 100 % oil removal efficiency, independent of influent oil content [SIDMAR ArcelorMittal Ghent].

Cross-media effects

TWG, please provide information.

Economics

Saves costs.

Driving force for implementation

TWG, please provide information.

Example plants

ArcelorMittal Ghent [EUROFER 23-7-18]

Reference literature

[SIDMAR-ArcelorMittal Ghent] [EUROFER 23-7-18]

3.4.2.9 Rolling fumes extraction and oil separation

~~A.4.2.3.9 Extraction of Oil Mist Emissions and Oil Separation~~

Description

Rolling emulsion or rolling oil fumes from the mill stands are extracted and passed through separators to recover the oil from the extracted airflow. The separated emulsion can be returned to the emulsion/oil system.

Technical description

Rolling emulsion or rolling oil fumes from the mill stands ~~Emulsion fumes from the mill stand~~ are extracted and passed through separators for cleaning. Eliminators containing baffle packing and impingement plates or mesh pads to separate the oil from the extracted airflow and in some cases electrostatic precipitators are used. The separated emulsion/oil can be returned to the emulsion/oil system. [EUROFER 23-7-18]

Achieved environmental benefits

- Reduction of emulsion fumes, efficiency > 90 %.
- Reduction of oil mist emissions from cold rolling. [EUROFER 23-7-18]

Environmental performance and operational data

Table 3.18: Achievable emission levels for emulsion fume separation at rolling mills

| | | | | |
|---------------------------------|----------------------|-------------------|--------------------------------|--------------------------------|
| | | Tandem Mill | Reversing Mill Low alloy | Reversing Mill High alloy |
| Emulsion Fume Exhaust Separator | | | Steel fabric droplet separator | Steel fabric droplet separator |
| Volume | [m³/t] | n.a. | 175 - 850 | 3000 - 12000 |
| Energy Consumption | [MJ/t] | 5 -10 | 12 - 13 | n.a. |
| Achieved Emission Levels | | | | |
| Pollutant | | Dust ² | Hydrocarbons ¹ | Hydrocarbons ¹ |
| Concentration | [mg/m ³] | 10 -50 | 5 - 20 | 10 - 12 |
| Specific Emission | [g/t] | 96 | 7 | 8.4 - 10.1 |
| Reduction Rate ³ | [%] | > 90 | > 90 | > 90 |
| n.a. | | | | |

Source of data [EUROFER CR]

¹ as organic carbon, method of analysis Umwelt-BA EM-K1, EPA S 008

² method of analysis EPA

³ Reduction rate based on mass flow of constituent

A total hydrocarbon level (THC) of less than 10 mg/Nm³ can be achieved as an annual average. [EUROFER 23-7-18]

Cross-media effects

Oil recovered from the separators may be recirculated, although in some cases the return of the oil from the emulsion filters might be impossible due to the poor quality of the oil (bacteria) [Com HR].

Technical considerations relevant to applicability

- Rolling and strip grinding operations.
- ~~New plants and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Reduction of oil mist to air. [EUROFER 23-7-18]

Example plants

- Outokumpu Tornio, mechanical separators and electrostatic filters are both applied for different mills.
- AceriNOX Europe.

Reference literature

[EUROFER 23-7-18]

TWG, Section A.4.2.3.10 from the old BREF "Cooling water cycles/special cooling water systems" has been moved and the updated information can now be found in Chapter 8 (Section 8.7.9).

3.4.3 Annealing

3.4.3.1 Reverse cascade degreasing

Description

Degreasing is carried out in two or more steps in series where the flow of degreasing solution is countercurrent to the feedstock flow.

Technical description

The degreasing step is important for the quality of a final annealed strip because minor quantities of oil or emulsion residues can lead to undesirable discolouration of the strip surface and reduce the quality of the final product.

The degreasing operation before annealing and coating removes oil residues and iron fines left on the strip after cold rolling. Usually, for degreasing, the strip is uncoiled and undergoes several steps including pre-degreasing, brushing, electrolytic degreasing, rinsing and drying (see Figure 3.73). At the end of these processes, the strip is coiled again. The reuse of the electrolyte solutions reduces the total liquid flow to be treated. Typically, this is carried out with bath cascades where the fresh electrolyte used in the electrolytic section is reused in the preceding brushing and pre-degreasing sections. [EUROFER 19-6-17]

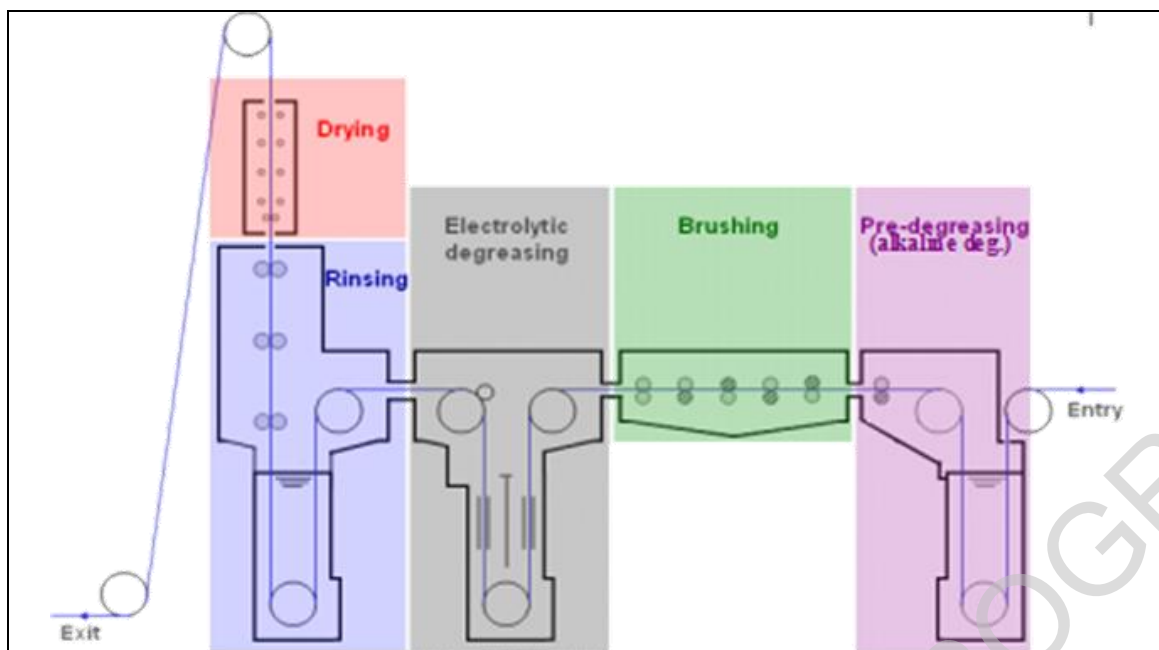


Figure 3.73: Classical degreasing process [EUROFER 19-6-17]

Achieved environmental benefits

Reduction of the generation of spent degreasing solution.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

Reduced costs due to increased material efficiency.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[EUROFER 19-6-17]

3.4.3.2 Hot water pre-degreasing

→ No description and technical information submitted.

Description

Pre-degreasing is carried out using hot water to eliminate oily and iron dust residues from the surface of the final strip product.

Technical description

Hot water pre-degreasing is a pretreatment step which serves to eliminate most of the oily residues, thus decreasing the subsequent use of degreasing soda. It consists of removing from the steel surface residual oil and iron dust particles originating from prior processing steps, before the steel enters the annealing furnace. Indeed, oil or iron dust can adversely affect the furnace and the furnace rolls. This can lead to major quality defects, e.g. the appearance of pick-ups on the furnace rolls. [EUROFER 19-6-17]

Usually, degreasing with hot water is done at temperatures between 60 °C and 80 °C. [EUROFER 19-6-17]

The water may be heated, e.g. by a boiler, using the exhaust gases of continuous annealing furnaces of HDG. [EUROFER 19-6-17]

Achieved environmental benefits

TWG, please provide information.

Environmental performance and operational data

About 99 % of the residual oil is removed.

Cross-media effects

None.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[EUROFER 19-6-17]

TWG, Section A.4.2.4.3 from the old BREF "Cleaning and reuse of degreasing solution" has been moved and the updated information can now be found in Chapter 8 (Section 8.6.1.6).

TWG, Section A.4.2.4.4 from the old BREF "Treatment of spent degreasing bath and alkaline waste water" has been moved and the updated information can now be found in Chapter 8 (Section 8.9.14).

TWG, Section A.4.2.4.5 from the old BREF "Extraction system for degreasing facilities" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.3.1).

TWG, Section A.4.2.4.6 from the old BREF "Special cooling water systems and water reuse" has been moved and the updated information can now be found in Chapter 8 (Section 8.7.9).

TWG, the section A.4.2.4.7 from the old BREF "Batch annealing with 100 % hydrogen" has been moved and the updated information can now be found in Chapter 8 (Section 8.5.3.5), describing techniques that are applied to several sectors.

TWG, the section A.4.2.4.8 from the old BREF "Continuous instead of batch annealing" has been deleted as it contained no substantial information.

3.4.3.3 Regenerative or recuperative burners for annealing furnaces

Description

Annealing furnaces are equipped with regenerative or recuperative burners for preheating the combustion air.

Technical description

See Sections 8.5.4.4 for a detailed technical description.

Achieved environmental benefits

Reduction in energy consumption.

Environmental performance and operational data

Example

The ~~old~~ annealing furnace for stainless strip was operated with three individually controlled zones, but at the same temperature of about 1 100 °C, heated by electric elements mounted in the sidewalls. The maximum throughput was 1 t/h. In 1989, structural modifications were done to increase capacity and to improve the circulation of furnace gas. The three zones remained, but the first two were equipped with two pairs of 5.5 therm/h integral bed burners (IBB) whereas in the third zone a self-recuperative burner was installed.

NOX emissions were measured at burner firing rates of 21–84 % of the maximum and ranged from 225 ppm to 317 ppm corrected to 3 % oxygen (460–650 mg/m³).

Assuming a mean throughput of 100 t/week and 46 production weeks per year, the primary energy consumption was reduced by 50.6 % (taking into account the primary energy consumption at the power station for the former electrical heating system). The payback period in that case study was 5.5 years, but the payback time depends to large extent on the energy costs (fuel, gas, electricity, etc.). [ETSU-FP-64]

Cross-media effects

Potential increased NOX emission level (concentration).

Technical considerations relevant to applicability

~~New and existing furnaces.~~

Generally applicable within the constraints related to the need to control NOX emissions.

Economics

Calculated payback periods for other scenarios were reported: 2.5 years for GBP 2.93/GJ gas and GBP 11.77/GJ electricity. [ETSU-FP-64]

Driving force for implementation

Improved energy efficiency.

Example plants

~~British Steel Stainless, Sheffield.~~

Outokumpu Stainless Ltd., Sheffield.

Reference literature

[ETSU-FP-64]

3.4.3.4 Low-NOX burner for annealing furnaces

A.4.2.4.10 Reduction in NOX Emission by Low-NOX burner

Description

The technique (including ultra-low-NOX burners) is based on the principles of reducing peak flame 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 NOX and the formation of thermal NOX, while maintaining high combustion efficiency.

Technical description

See Section 8.8.2.6 for a detailed technical description.

The generation of NOX resultant from the combustion processes can be reduced by selection of low NOX burners.

Achieved environmental benefits

Reduced NOX emissions.

Environmental performance and operational data

TWG, emission levels in Table 3.19 will be updated at a later stage based on the data collection.

Table 3.19: Achievable emission levels with low-NOX burners in batch annealing furnaces

| | Concentration [mg/m ³] | Emission [kg/t product] | Reduction ¹ [%] | Method of analysis |
|--|---------------------------------------|----------------------------|-------------------------------|---|
| Dust | 5–10 | NI | NI | EPA |
| SO ₂ | 60–100 | 9–14 E-03 | NI | Infrared, UV-fluorescence |
| NO ₂ ² | 150–380 | 25–110 E-02 | 60 | Chemiluminescence (NBN T94-303) |
| CO | 40–100 | 15–40 E-03 | 87 | Umweltbundesamt-EM-K1, IR-spectrometry |
| CO ₂ | 200000–220000 | 31200 | 0 | IR-absorptions-spectrometry |
| Notes: Source of data [EUROFER CR] M ³ are based on standard conditions; (waste gas 10000 – 16000 m ³ /h, 200 - 250 m ³ /t) ¹ reduction rate based on mass flow of constituent ² reference 3 % O ₂ , mg/m ³ dry NI = No information provided. | | | | |

TWG, emission levels in Table 3.20 will be updated at a later stage based on the data collection.

Table 3.20: Achievable emission levels with low-NOX burners in continuous annealing furnaces

| | Concentration [mg/m ³] | Emission [kg/t product] | Reduction ¹ [%] | Method of analysis |
|---|---------------------------------------|----------------------------|-------------------------------|---|
| Dust | 10–20 | 0.16–0.32 | NI | EPA |
| SO ₂ | 50–100 | 0.08–1.6 | NI | Infrared, UV-fluorescence |
| NO ₂ ² | 400–650 | 0.14–0.22 | 60 | Chemiluminescence (NBN T94-303) |
| CO | 50–120 | 0.08–0.2 | 87 | Umweltbundesamt-EM-K1, IR-spectrometry |
| CO ₂ | 180000–250000 | 62.5–86.8 | 0 | IR-absorptions-spectrometry |
| Notes: Source of data [EUROFER CR] m ³ are based on standard conditions; (waste gas 350 – 400 m ³ /t) ¹ reduction rate based on mass flow of constituent ² reference 3 % O ₂ , mg/m ³ dry NI = No information provided. | | | | |

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

~~New and existing furnaces.~~

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

Economics

TWG, please provide information for economics

Investment costs of 100 kECU (for a continuous annealing furnace, capacity: 540 000 t/yr) were reported. [CITEPA]

Driving force for implementation

Reduction of NOX emissions and energy efficiency.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[CITEPA]

3.4.3.5 Preheating the feedstock

Description

The feedstock is preheated either by a direct contact between the strip and the flue-gases or the heat can be transferred to the strip by the protective gas which is heated by the waste gas using heat exchangers.

Technical description

Preheating the material in the continuous annealing line with waste gas

This can either be done by a direct contact between the strip and the flue-gases or the heat can be transferred to the strip by the protective gas heated by the waste gas in heat exchangers. Direct contact is only possible in controlled circumstances (depending on the temperature of the gas and of the strip, the oxidation potential of the gas, the moisture, the contamination of the gas with particles). The result is a reduction of energy consumption.

Achieved environmental benefits

Reduced energy consumption.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

Energy efficiency.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

3.4.3.6 Heat recovery for heating the degreasing bath**~~A.4.2.4.12 Heat Utilisation for Heating Degreasing Bath~~****Description**

The heat in the exhaust gases of the annealing furnaces is recovered and used for heating the degreasing baths. [EUROFER 19-6-17]

Technical description

In annealing lines, the waste heat can be used not only to preheat combustion air but also to heat the degreasing baths. In this case, it is important to consider that steam production is influenced by the product mix (and no steam production occurs when the line stops). For this reason, this source of energy must be integrated and combined with a natural-gas-operated steam boiler to ensure constant pressure/flow in the plant steam network. The possibility of hot water or steam production is related to the temperature of exhaust gases; this is possible with recuperative burners but it is not possible in the case of regenerative burners. This technique can be used both for continuous annealing and hot dip coating lines. [EUROFER 19-6-17]

Achieved environmental benefits

Reduced energy consumption.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

Energy efficiency.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[EUROFER 19-6-17]

3.4.4 Tempering**3.4.4.1 Optimisation of wet temper rolling emulsion application systems****~~A.4.2.5.1 Optimisation of Emulsion System~~****Description**

In the wet temper rolling process, temper emulsions are applied onto the strip surface using spray nozzles to minimise atomisation and the spray patterns are optimised to the width of the strip in order to reduce oil emissions and consumption.

Technical description

Wet temper rolling consists of applying an emulsion (e.g. temper fluid) onto the annealed strip prior to and during the rolling step. Temper rolling is necessary to attain the required metallurgical properties such as hardness, yield strength of the surface and elongation. The way temper rolling emulsions are applied onto the surface of the strip is optimised in order to reduce both oil emissions and consumption.

In practice, the following measures are taken:

- **Use of low-pressure sprays for the emulsion:**
Atomisation of the temper rolling emulsion has to be minimised by the use of the appropriate type of spray nozzles at the appropriate pressure.
- **Adapt the number of emulsion jets to the width of the strip:**
Since the temper rolling emulsion is not recycled, optimisation of the spray patterns reduces emulsion consumption.

Achieved environmental benefits

- Reduced oil emissions.
- Reduced oil consumption.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

~~New plants and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Material efficiency.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

3.4.4.2 Dry tempering and low-volume lubrication in wet tempering

~~A.4.2.5.2 Change to Dry Temper Process~~

Description

In dry tempering, no water or lubricants are used.

In wet tempering, low-volume lubrication systems are employed to supply precisely the amount of lubricants needed for reducing the friction between the working rolls and the feedstock. Liquid nitrogen is used to clean the working rolls and improve the strip surface finish.

Technical description

Tempering (e.g. skin-pass milling) is a post-processing step of steel strips after annealing for recrystallisation purposes. Skin-pass milling is carried out to achieve the following goals: fine-adjusting of the mechanical properties, improving the strip flatness and applying a defined

surface fine-structure. Skin-pass mills can be operated in the wet or dry mode. There are applications where only the wet temper application (e.g. especially with higher extensions) are used and other applications where wet tempering cannot be applied.

In the dry mode, no water or any kind of fluid medium is used for lubrication. [EUROFER 31-5-17]

Skin-pass mills exist as stand-alone facilities or are installed after the continuous furnace of hot dip galvanising continuous annealing lines for in-line treatment of the annealed steel strip. Depending on the type of products, skin-pass mills can be configured as a duo, four-high stand, six-high stand or X-high mill. In the case of a four-high stand configuration, a very common layout nowadays, there are two back-up rolls and two working rolls. The working roll diameter and surface structure can be chosen depending on steel grade, strip dimension and customer requirements. [EUROFER 31-5-17]

If processing uncoated steel (e.g. during in-line skin-pass milling in a continuous annealing line), operating the skin-pass mill in a 'dry mode' will be favoured. This means that no water or any other kind of fluid is used to clean the back-up or working rolls. Although the dry mode is very efficient to avoid rust points, unfortunately it increases the amount of particles which can cause surface defects. In particular, this occurs when dust originating from the wear of rolls and strip is not removed sufficiently from the skin-pass mill due to the absence of a cleaning medium. [EUROFER 31-5-17]

Recent developments concerning (dry) skin-pass milling focus on processing steels with increasing strength (e.g. the so-called advanced high-strength steels, AHSS), avoiding quality defects (e.g. dirt on the steel surface) and fulfilling specifications regarding steel surface appearance for high-quality applications (e.g. automotive outer panel parts). Therefore, existing stand-alone or in-line skin-pass mills have to be modernised continuously. Additionally, the surface fine-structure of the working rolls used underlies an ongoing development regarding new texturising methods and/or improved surface properties of the steel strip to be processed. [EUROFER 31-5-17]

New developments in wet skin-pass mills operation also include the use of low-volume lubrication systems and liquid nitrogen for cleaning the strip surface and work rolls. Using a low-volume lubrication system, the lubricant is applied in the skin-pass stand entry, it reduces the friction in the roll gap and improves the flatness while minimising oil consumption. [Holz et al., 2010]

Achieved environmental benefits

- No oil consumption in the case of dry skin-pass mills.
- Reduced oil consumption in the case of skin-pass mills equipped with low-volume lubrication systems.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

- Generates emissions to air.
- Requires an exhaust system and generates waste (filter dust).

Technical considerations relevant to applicability

~~New plants and existing plants.~~

- Dry tempering is not applicable to tinplate packaging products.
- Wet tempering is not applicable to stainless steel products.

Economics

TWG, please provide information.

Driving force for implementation

Increased material efficiency.

Example plants

ThyssenKrupp Steel Europe, Dortmund, Four-high stand with low-volume lubrication and liquid nitrogen.

Reference literature

[EUROFER 31-5-17]

[Holz et al., 2010]

R. Holz, K. Hoen, K. Weiss, 2010. Advanced technology in skin-pass rolling. Millenium Steel – Finishing Processes, 129-133.

3.4.4.3 Cleaning of temper mill emulsion

Description

Temper mill emulsions containing only a few volume percent of oil are used as lubricant and roll coolant in sheet temper mills. The emulsions are treated after use to separate oil from water. [EUROFER 23-7-18]

Technical description

The used temper mill emulsion has to be cleaned before disposal. This emulsion is generally treated together with the tandem mill emulsion and the other oily residues in the emulsion treatment system.

Achieved environmental benefits

Reduced emissions to water.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

Energy and raw material consumption.

Technical considerations relevant to applicability

~~New plants and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[EUROFER 23-7-18]

3.4.4.4 Extraction system in tempering

~~A.4.2.5.4 Reduction of Oil Mist and Dust~~

Description

Oil mist and dust from temper mills are extracted via the exhaust system and treated using wet or dry filters, oil mist eliminators or cyclones.

Technical description

Oil mist and dust in temper mills are extracted via an exhaust system, equipped with wet or dry filters. Also, oil mist eliminators (mechanical) and cyclones may be applied.

Achieved environmental benefits

- Prevention of oil discharge and overall reduction of hydrocarbon emissions to air. [EUROFER 23-7-18]
- Reduction of dust emissions to air. [EUROFER 23-7-18]

Environmental performance and operational data

TWG, This table is proposed for deletion according to revised information received from the TWG.

Table 3.21: Achievable emission levels for fabric droplet separators

| | Concentration [mg/Nm ³] | Specific Emission [g/t product] | Reduction rate ¹ [%] | Specific Volume [m ³ /t] | Method of analysis |
|--|--|---------------------------------------|------------------------------------|---|--------------------|
| Example: Steel fabric droplet separator | | | | | |
| Hydrocarbon | 5–15 | 0.273 | ≥ 90 | 90–110 | Umwelt BA EM K1 |
| Note: Source of data [EUROFER-CR] | | | | | |

~~Table A.4.43: Achievable emission levels for fabric droplet separators~~

Oil mist emissions reported by [CITEPA]: ~ 10 mg/m³.

Cross-media effects

- Increased energy consumption. [EUROFER 23-7-18]
- Generation of dry or sludge residues, which have to be recycled or disposed of externally. [EUROFER 23-7-18]

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

~~Oil mist eliminator: investment costs: 375 kECU (125 for oil abatement, 250 for dust), operating costs: 6 kECU/a, electricity: 70 kWh [CITEPA]~~

~~Cyclone: investment costs: 25 kECU, operating costs: 2.5 kECU/a electricity 45 kWh [CITEPA]~~

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[CITEPA] [EUROFER 23-7-18]

3.4.5 Finishing

3.4.5.1 Capture and abatement of oil mists from oiling operation

Description

Oil mist emissions from finishing operations (e.g. oiling strips for conservation) are extracted as close as possible to the source, using for example hood or lip extraction, and are treated using a demister.

Technical description

Oil emissions that arise from spraying oil mist on strips for conservation purposes can be reduced by extraction hoods, followed by a demister ~~mist eliminator~~ (baffle-type) and electrostatic precipitator. The oil captured in the mist eliminator can be recirculated into the oiling process.

Achieved environmental benefits

- Reduction of fugitive oil mist emissions.
- Reduced oil consumption.

Environmental performance and operational data**Example**

By the described measure it is possible to capture the mist arising from oiling almost completely (visual judgement: all visible emissions are captured). The mist eliminator efficiency was reported to be 72 %. Measurements of the waste gas showed concentrations of oil droplets after the mist eliminator, but before the EP, of up to 296 mg/m^3 (average 104 mg/m^3). The maximum concentration measured after the EP was 6.3 mg/m^3 with an average emission of 3.0 mg/m^3 . The efficiency of the EP was between 97 % and 98 %. The carbon contents of the unabated waste gas was measured $17.5\text{--}21.3 \text{ mg/m}^3$; after the EP around $10.6\text{--}11.9 \text{ mg/m}^3$. [UBA-Kloeckner-82]

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

~~New and existing plants~~. Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

Stahlwerke Bremen.

Reference literature

[UBA-Kloeckner-82]

TWG, Section A.4.2.6.2 from the old BREF "Electrostatic oiling" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.7.1).

3.4.5.2 Dust reduction from levelling and welding**Description**

Emissions from levelling and welding are collected as close as possible to the emission source using for example hood or lip extraction. Particulate emissions are abated using fabric filters.

Technical description

Particulate emissions from welding and levelling are captured by hoods and abated by fabric filters. [CITEPA]

Achieved environmental benefits

Reduction of emissions to air, especially fugitive dust.

Environmental performance and operational data

Dust emissions of $5\text{--}30 \text{ mg/m}^3$ were reported in [CITEPA] for an installation operated 5 % of the time to reduce emissions from welding (discontinuously) and continuously for dust reduction from levelling. The hourly electricity demand was 110 kWh (0.64 kWh/t). [CITEPA]

Other sources [Vanroosb 3.4] reported for an installation filtering the exhaust gases from the stretcher leveller, the welding machine, the leveller and the decoiler dust emission values of: 16 - 7 - 39 - 22 - (change of bags) - 24 - 29 - 35 - 39 mg/Nm^3 .

Each emission value is the result of six isokinetically taken samples on six different places in the cross-section of the chimney. There are therefore two sampling points at 90 ° from each other. Each sampling campaign takes about 6 hours. The sampling frequency is about six times per year.

Installation data:

| | |
|------------------------|---|
| Filter area | 687 m ² |
| Number of filter bags | 441 |
| Dimensions filter bags | Diameter 120 mm x length 4 030 mm |
| Type of filter bags | PE/PE - weight 550 g/m ² - thickness 1.9 mm - density 0.29 g/cm ³ - air permeability 150 l/dm ² ; min at 196 Pa (20 mm water column) |
| Number of exhaust fans | 3 x 55 kW - 1470 rev/min |
| Gas flow (design) | 90 000 m ³ /h |
| Pressure drop (design) | 120 daPa |
| Cleaning cycle | 50 msec at a pressure of 4–6 bar [Vanroosb 3.4] |

Cross-media effects

- Increased energy consumption.
- Generation of waste (filter dust).

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please update the cost information.

Investment costs of 625 kECU (for collection devices, pipes, filters, fans, electrical equipment, motors hood) and operating costs of 10 kECU were reported. [CITEPA]

Bags are changed when it is observed that the bags present cracks. This change takes about 50 man-hours and requires a stop of the pickling line of at least two shifts - the cost is about BEF 400 000 (EUR 10 000). [Vanroosb 3.4]

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[CITEPA] [Vanroosb 3.4]

TWG, the technique A.4.2.6.5 "Optimised finishing operation" from the previous BREF has been deleted as it contained no information.

3.4.6 Roll shop

3.4.6.1 Cleaning and reuse of grinding emulsion

Description

Grinding emulsions are treated using lamellar or magnetic separators or using a sedimentation/clarification process in order to remove the grinding sludge and reuse the grinding emulsion.

Technical description

The main function of the grinding emulsion is cooling during the grinding operation and the removal of the grinding sludge containing the residue from the grinding process (grinding stone and metallic roll abrasion). The circulation of the tailor-made water-based emulsion with additives passes the cleaning sections to ensure a residue-free reapplication for the grinding process. To avoid contamination from rolling emulsion, the rolls are usually cleaned in advance. To maintain the grinding emulsion over a long time in the circulation system, different techniques can be used for cleaning of grinding emulsions in order to remove the grinding sludge. [EUROFER 23-7-18]

The main techniques available for cleaning grinding emulsions are described below:

Lamellar separator:

The high solid concentration in the clarifier influences each individual particle, with the result that the sedimentation speed is similar for all particles. Separated particles are discharged intermittently via an automatic sludge conveyor, making manual tank cleaning unnecessary. The settling height in the clarifier is reduced due to the inclined settling surfaces. These surfaces form individual ducts extending across the full width of the sedimentation compartment. The ducts are 20 mm high and are self-cleaning. While the cleaned medium rises to the top of the duct, the separated particles sink into the sludge conveyor. [EUROFER 23-7-18]

Magnetic separators:

Magnetic separators can be used in a recirculation system to recover the grinding sludge. However, bacterial contamination can shorten their lifetime. Accordingly, antibacterial additives are employed. A smarter solution can be to treat the cleaned grinding emulsion with UV light in a bypass to keep the bacterial population to a low level which reduces the need for antibacterial agents and improves workplace hygiene. [EUROFER 23-7-18]

Bandex system:

The grinding sludge is recovered in a three-step process:

1. pre-sedimentation and venting;
2. sedimentation;
3. clarification. [EUROFER 23-7-18]

Achieved environmental benefits

Environmental protection and work hygiene. [EUROFER 23-7-18]

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

Consumption of energy and water. [EUROFER 23-7-18]

Technical considerations relevant to applicability

Generally, there are no technical restrictions to the applicability of this technique. [EUROFER 23-7-18]

Economics

TWG, please provide information.

Driving force for implementation

Work hygiene and environment. [EUROFER 23-7-18]

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[EUROFER 23-7-18]

3.4.6.2 Dust reduction during surface texturing of working rollers**A.4.2.7.2 Exhaust System (PRETEX/STB)****Description**

Surface texturing of working rollers is carried out in dedicated booths equipped with collection hoods. For shot blast texturing, dust emissions are abated using bag filters while for hard chromium plating, dust emissions are treated using a wet scrubber.

Technical description

Working rollers in cold rolling mills are subjected to surface treatments in order to create specific topography at the surface of the rollers which can be transferred to the steel sheet during rolling operations and gives the final product a new kind of roughness. Surface texturing of rollers can provide good protective paint finishing because the presence of microcavities with small dimensions can minimise the roughness amplitude and increase smoothness after the painting operation. Also, texturing can provide a desirable uniform matte appearance which is of particular interest to the car industry. [De Mello et al., 2013] [Gorbunov et al., 2009]

Two methods are principally employed for working rolls texturing:

- Shot blast texturing (SBT): In SBT, incisions at the surface of the work rolls are created by shot-blasting steel spheres at the surface of the rolling rolls. [Gorbunov, 2009]
- Hard chromium plating: This process consists of coating the work rolls using chromium plating to change the surface topography. In addition, it also helps sustain the surface texture for longer periods. [Gorbunov, 2009]

For SBT, enclosures and dedicated booths are applied, equipped with collection hoods and dust abatement for the extracted air by fabric filters. [EUROFER 31-5-17]

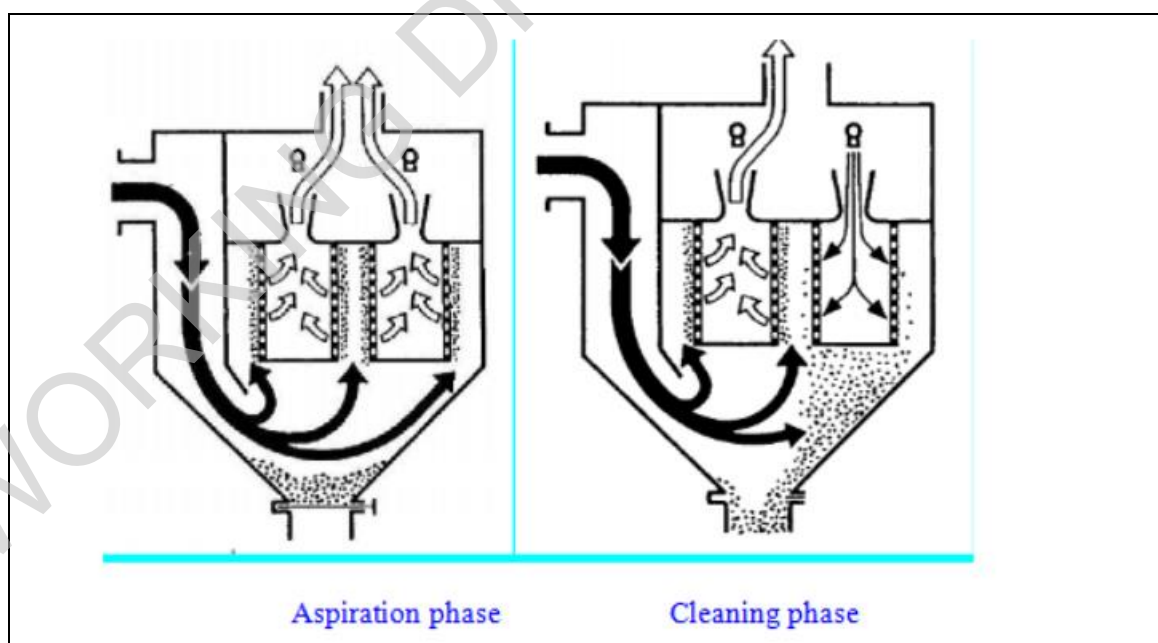


Figure 3.74: Dust abatement for shot blast texturing operations [EUROFER 31-5-17]

The machines are equipped with dust capture and replaceable bag filters. This system is automatic, suitable to treat dry air exhibiting low levels of humidity or oil. The process follows distinct phases as shown in Figure 3.74:

- The waste air enters the first part of the filter and a first settling occurs.
- The air is forced into the hopper in the lower part of the filter and undergoes a second settling to remove the heaviest particles.
- The air goes through the filter and the dust is removed.
- The clean air is expelled to atmosphere. [EUROFER 31-5-17]

In hard chromium plating, the plating process is fully enclosed and fitted with an exhaust gas system using a wet scrubber. The whole process operates without effluent discharge because of evaporative losses. [EUROFER 31-5-17]

Achieved environmental benefits

Reduction of dust emissions.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

TWG, please provide information.

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

Salzgitter Flachstahl GmbH (Germany) – Hard chromium plating.

Reference literature

[De Mello et al., 2013]

J.D.B., De Mello, J.L., Goncalves, H.L. Costa, 2013. Influence of surface texturing and hard chromium coating on the wear of steels used in cold rolling mill rolls. *Wear* 302, 1295 – 1309.

[Gorbunov et al., 2009]

A.V., Gorbunov, V.K., Belov, D.O., Begletsov, 2009. Texturing of rollers for the production of auto-industry sheet. *Steel in Translation*, Vol. 39 No.8, 696 – 699.

[EUROFER 31-5-17]

TWG, Section A.4.2.7.3 from the old BREF "Reduction and recycling of scrap" has been deleted since it is now covered in Chapter 8 (Section 8.11.1.4)

3.5 Emerging techniques for cold rolling

TWG, the content of the previous BREF in this Section has been deleted for Draft 1.

Emerging techniques present in the old BREF, for which information was received from the TWG, have been moved and integrated as BAT candidates. For other remaining emerging techniques, the TWG is requested to indicate whether they should be kept (in which case updated information should be sent), or deleted.

Finally, the TWG is requested to send information on possible new emerging techniques that could be considered in the revised version of the BREF document.

4 WIRE DRAWING

4.1 General information on wire drawing

For the entire Section 4.1 'General Information on wire drawing, Please provide updated information for Table 4.1 and update the text accordingly (Reference date; 1996/1994 – OLD DATA)

The European Union has the world largest wire drawing industry, followed by Japan and North America. It produces about 6 million tonnes of wire per year. Including the various wire products, like barbed wire, grill, fencing, netting, nails etc., the production of the sector reaches more than 7 million tonnes per year. The European wire drawing industry is characterised by a large number of medium sized, specialised companies with an average of 121 employees and an annual turnover of ECU 13.7 million per company. The industry's output, however, is dominated by a few large producers. It is estimated that about 5 % of the companies account for 70 % of the industry's output (25 % of the companies for 90 %).

Over the past 10 years, independent wire drawing companies have become increasingly vertically integrated. Downstream wire drawing and producing finished wire products have shown a high degree of integration, but also upstream there has been some integration between steel-making and wire rod producing industries and wire drawing. Approximately 6 % of the wire drawers in Europe are integrated producers representing about 75 % of the total production of steel wire [C.E.T].

The largest producer of steel wire is Germany with 32 % of the wire production followed by Italy (approximately 22 %), UK, Benelux (mainly Belgium), France and Spain. Other Member States which have a small wire drawing industry are Sweden, Austria, Greece and Portugal. The distribution of wire drawing installations in EU, size and number of plants for individual Member States is given in Table 4.1.

Table 4.1: Wire drawing industry in the EU

| | Wire production [thousand t] ⁽¹⁾ | Wire products [thousand t] ⁽¹⁾ | Number of plants ⁽²⁾ | Average number of employees per plant ⁽²⁾ |
|-----------------|--|--|------------------------------------|---|
| Austria | 120 | 115 | 2 | N/A |
| Benelux | 619 | 246 | 20 | 325 |
| Denmark | N/A | N/A | N/A | N/A |
| Finland | N/A | N/A | N/A | N/A |
| France | 406 | 102 | 36 | 136 |
| Germany | 1 908 | 89 | 85 | 125 |
| Greece | 140 | 60 | 2 | N/A |
| Ireland | N/A | N/A | N/A | N/A |
| Italy | 1 250 | 300 | 74 | 58 |
| Portugal | 82 | 30 | 2 | N/A |
| Sweden | 135 | 63 | 11 | 85 |
| Spain | 463 | 138 | 26 | N/A |
| UK | 735 | 105 | 25 | 110 |
| Total | 5 858 | 1 248 | 283 | 121 |

⁽¹⁾ Reference year 1996.

⁽²⁾ Reference year 1994.

Source: [C.E.T.] [Euro-Strategy]

4.2 Applied processes and techniques in wire drawing

4.2.1 Wire drawing process overview

Wire drawing is a process in which wire rods/wires are reduced in size by drawing them through cone-shaped openings of a smaller cross section, so-called dies. The input is usually wire rod of diameters ranging from 5.5 mm to 16 mm obtained from hot rolling mills in the form of coils. A typical wire drawing process line comprises the following steps:

- pretreatment of the wire rod (mechanical descaling, pickling);
- dry or wet drawing (usually several drafts with decreasing die sizes);
- heat treatment (continuous/discontinuous annealing, patenting, oil hardening);
- finishing.

Wire is manufactured in different grades of steel: low-carbon steel with a carbon content of up to 0.25 %, high-carbon steel with a carbon content of over 0.25 %, stainless and other alloy steel. Non-alloy steel wire can be uncoated or coated with zinc, copper, brass, tin, nickel, chrome, plastic or varnish. Wire is sent in coil form to further processing, like coating and manufacturing of finished products (e.g. cable, mesh, barbed wire, wire fencing, grill, springs, nails). [Bekaert94] [Pan97]

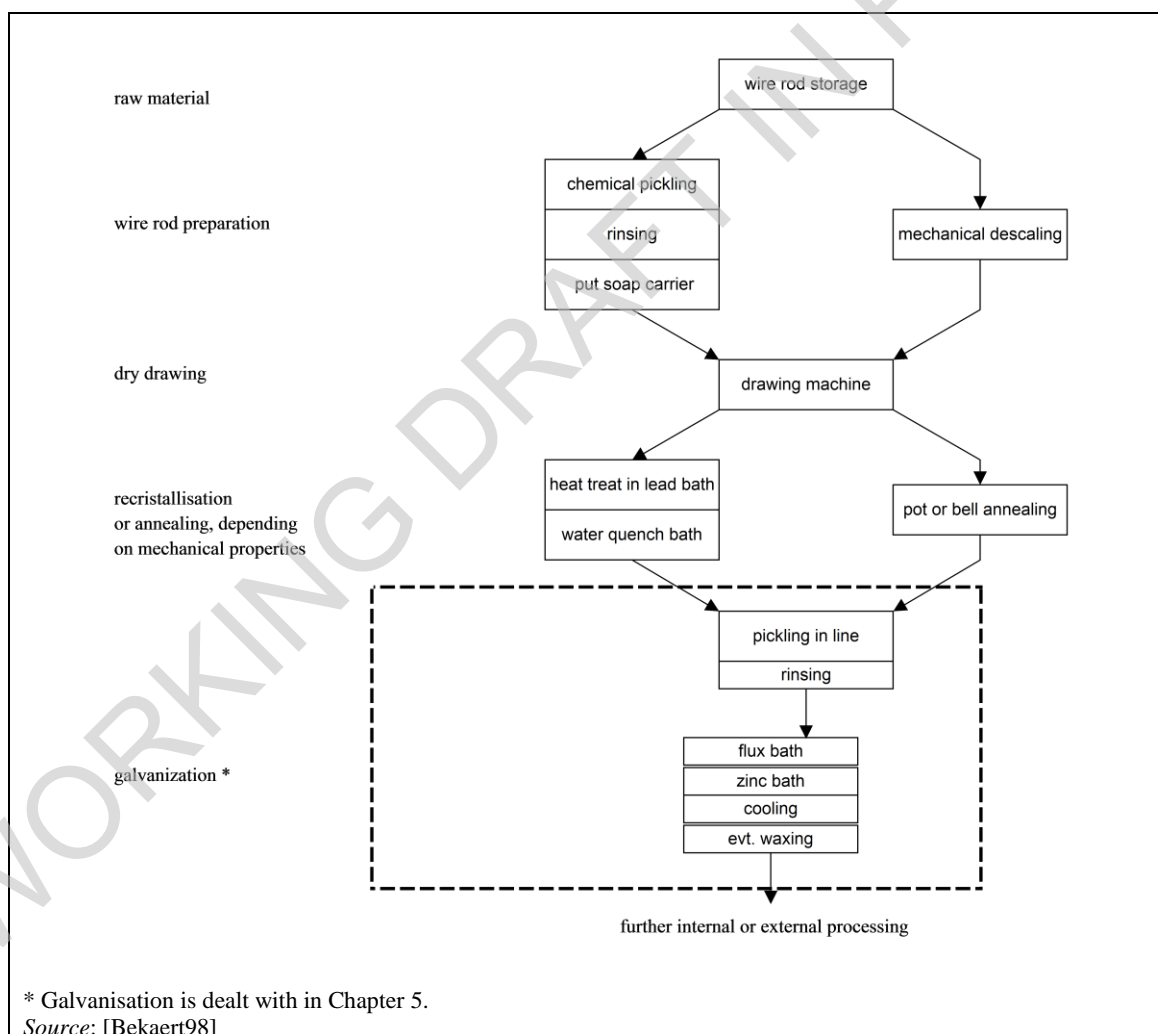


Figure 4.1: Production of low-carbon galvanised wire

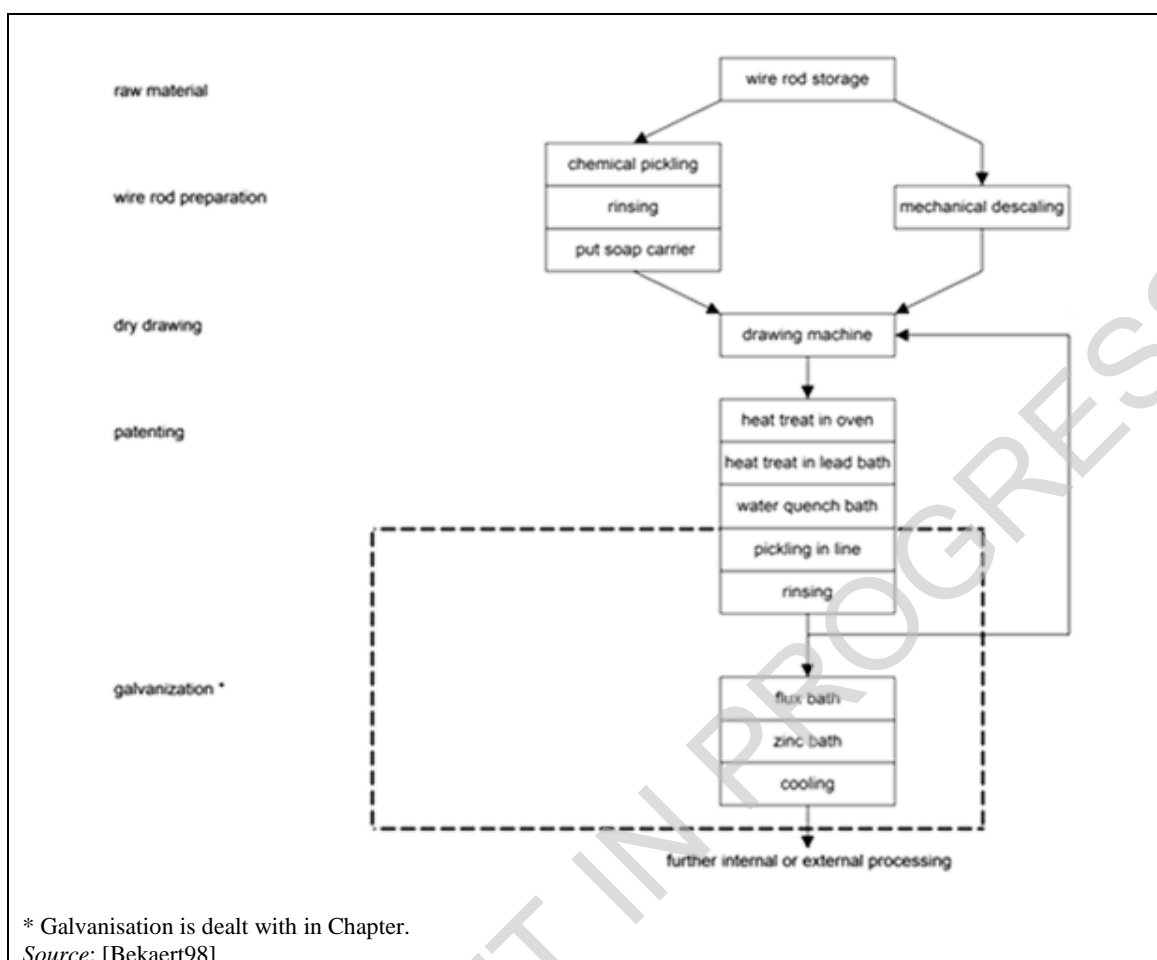


Figure 4.2: Production of high-carbon galvanized wire

Because of the huge variety of wire products, many different processing schemes exist, dictated by wire diameter and required mechanical and other quality specifications. The process schemes shown in Figure 4.1 and Figure 4.2 cover the majority of galvanized wire that is produced in Europe (and worldwide). A fraction is sold as such; a fraction is processed further by wet drawing or by processes that fall outside the scope of this document, such as welding, electroplating, weaving, cabling, bunching, painting, plastic coating, cutting to length, etc.

4.2.2 Wire rod preparation

Air-cooling after rolling produces an iron oxide layer (scale) on the wire rod surface. This layer is very hard, brittle and not deformable and must therefore be removed before any further processing can take place. In most cases, this is done by the wire industry. For stainless steel however, this is typically done by the steel mill.

Two techniques for descaling wire rods are applied: mechanical descaling and chemical pickling. Some categories of end products can only be produced from mechanically descaled wire at a reduced drawing speed (needing more drawing machine capacity, meaning higher investment costs). The decision on the descaling technique is therefore taken by each individual plant, based on product qualities and economic considerations.

4.2.2.1 Mechanical descaling of wire rod

In the most common mechanical descaling method applied, wire bending, the wire is bent to cause the brittle scale to peel off. Other descaling techniques, like sanding, brushing or shot-blasting, are used as a finishing step after wire bending to remove loose scale or are used as stand-alone techniques.

Batch shot-blasting is a common technique for mechanical descaling of large-diameter wire rod (e.g. used for cold heading applications). However, mechanical descaling is generally done in a continuous way.

Depending on the finish of the wire rod and the quality requirements of the product, descaling by reverse bending is completed or possibly replaced by an abrasive method such as sanding, brushing, shot-blasting or stream descaling. By combining reverse bending with one of these auxiliary methods, complete removal of the oxide layer can be achieved, reaching a similar surface cleanliness as with chemical pickling. [Com2 BG]

Compared to chemical pickling of wire rod, mechanical descaling has the advantage that one production step is eliminated as the descaling unit is normally coupled directly to the drawing machine. On the other hand, it is difficult to obtain the same level of drawability with mechanical descaling. [CET-BAT]

4.2.2.2 Chemical descaling (pickling) of wire rod

In chemical descaling, the mill scale is removed by dissolution in acid. Acids used are:

- sulphuric or hydrochloric acid for low-carbon wire;
- hydrochloric acid for high-carbon wire.

Pickling is mostly done in a batch process. Each roll of wire rod is immersed in the acid bath. The acid slowly dissolves the oxide layer by transforming it into iron chlorides or sulphates. When pickling in HCl, an H₂-inhibitor is used to suppress the reaction: $2 \text{HCl} + \text{Fe} \rightarrow \text{FeCl}_2 + \text{H}_2$ and reduce the unwanted loss of iron.

After pickling, the wire rod coils are rinsed in water. This is usually done in cascade rinsing (e.g. rinsing three times) to achieve maximum rinsing efficiency and minimum water consumption. [Bekaert94] [Bekaert98]

4.2.2.3 Application of soap (lubricant) carrier

In some cases, soap carrier is applied to enhance the adhesion of the lubricant to the wire. A wide range of soap carriers is available. Selection is made on an economic basis and based on required properties in downstream processes. Traditional soap carriers include lime, borax and zinc phosphate. Modern soap carriers are typically mixtures of soluble salts, e.g. sodium and potassium sulphate, chloride, borax, phosphate or silicate. They are adapted to a particular soap and a particular drawing situation.

Soap carrier is applied before drawing by dipping the wire in a watery soap carrier solution. This can be done in a batch process, usually associated with chemical descaling, or continuously in association with mechanical descaling.

4.2.3 Drawing

4.2.3.1 Dry drawing of wire

Dry drawing is typically used to draw wire rod (> 5.5 mm) to a product diameter of 1–2 mm and sometimes even lower. The diameter of the wire is reduced by passing it through a series of dies with diminishing diameters. Before entering the dies, the wire is passed through a dry lubricant. In most cases, soap-based lubricants are used with the soap formulation depending on the choice of fats from which the soap is produced, choice of fillers or choice of additives. In exceptional cases (e.g. special steels, wire with special metal coatings), other lubricants like pastes or oils can be used.

The drawing operation heats both (wire and drawing die) through friction of the wire. Cooling is done indirectly, by cooling the capstans in contact with the wire with water.

4.2.3.2 Wet drawing of wire

Wet drawing is typically used to draw wire with an intermediate product diameter of 1–2 mm to the final diameter. The wire is also passed through a series of dies with diminishing diameters, but wire, dies and capstans are immersed in a lubricant liquid that provides lubrication and cooling. Typically, soap or oil emulsions (for some applications plain oil) are used. The heat resulting from the drawing operation is taken up by the lubricant, which is cooled indirectly with water.

4.2.4 Heat treatment of wire

Heat treatment of wire has different goals. Therefore different types of heat treatment are available depending on the type of steel (low-carbon / high-carbon / stainless) and the final use (desired ductility and strength). Heat treatment also thermally removes soap and lubricant residues.

A considerable percentage of the output of the wire industry does not need any heat treatment. The heavy deformation of the metal crystal structure caused by drawing is mostly a positive property, as it increases the hardness and the strength of the wire in the axial direction.

4.2.4.1 Batch annealing of low-carbon steel wire

Drawing profoundly deforms the shape of the metal crystals of the wire. Annealing is one of the different methods to reobtain a suitable crystal shape. Batch annealing, typically used for low-carbon steel wire to obtain a very soft and ductile end product, is done in bell or pot furnaces.

Batch annealing is done by putting coils of drawn wire in chambers (called ‘pots’ or ‘bells’), filled with a protective gas. The protective gas is either neutral or reducing. The most common protective gases are nitrogen, hydrogen, nitrogen/hydrogen mixtures and partly oxidised natural gas (or similar fuel). The chambers are heated from outside, typically by gas or fuel. The warming up from room to peak temperature (roughly 700 °C) takes several hours; cooling down again also takes several hours. In order to keep an over-pressure in the ‘pots’ or ‘bells’, a fraction of the protective gas is continuously purged.

In some cases, the wire is oiled immediately after annealing.

4.2.4.2 Continuous (in-line) annealing of low-carbon steel wire

Continuous annealing or strand annealing has a similar goal to batch annealing: restore a suitable crystal texture to the steel in the wire after drawing. But the desired crystal shape and metal properties are different to those that are desired when batch annealing is applied. Continuous annealing is a typical heat treatment method for low carbon products.

Strand annealing is a fast continuous process. The wire is heated up to the recrystallisation temperature (500–700 °C), kept at this temperature for a few seconds, and cooled down again by quenching in a water bath.

A typical line is equipped for 15–50 wires and is characterised by a particular $v \times d$ (wire speed \times wire diameter). This means that wires of different diameters can be processed together at the same line, but the greater the diameter of a wire, the lower its speed. Modern lines have a $v \times d$ of 100–200 m/min \times mm (in other words, a 1 mm wire is processed at speeds of 100–200 m/min). For specialities, lines with a few or only one wire and/or operating at a lower $v \times d$ are used. Strand annealing is often combined in one production line with other unit processes, e.g. with hot dip coating.

Commonly, the wire is heated by passing through a molten lead bath. A fast heat-up is essential for strand annealing. Due to the very high heat transfer coefficient of lead (3 000 W/m².K), equilibrium between the wire and lead bath temperature is reached after a few seconds. Other methods such as an oven or inductive heating are alternatives, only in some niches, e.g. one-wire lines, lines operating at low speed or lines designed to run with only one diameter at a time.

After the heat treatment, the wire is generally quenched in water. This can be followed by in-line pickling with warm or cold HCl to remove oxides which also partly dissolves the potentially dragged lead. Other acids or electrolytically assisted pickling can be used as well. Pickling is followed by a rinsing cascade. At some plants, pickling is done as the first operation of the next process step. Often pickling is omitted after heat treatment under a protective atmosphere.

4.2.4.3 Continuous (in-line) annealing of stainless steel wire

Stainless and high-alloy steel wire is continuously annealed to obtain suitable metal crystal properties for (further) drawing operations. For stainless steel, the heat treatment is done under a protective gas atmosphere. If no protective atmosphere was used, the stainless steel wire would be oxidised; removal of these oxides would require pickling with special acids such as HNO₃, HNO₃/HF, etc. (compare with production of stainless steel strip). The temperature profile used varies with the type (content of Ni, Cr or other alloying elements) of stainless steel that is processed (700–1 100 °C).

The wire is passed through tubes or a muffle, under a protective gas. The purge of protective gas is similar to what is described for batch annealing. The first part of the tubes or muffle is placed in an oven (indirect heating of the wire); the second part is cooled indirectly, e.g. by cooling with water. The heating can be done by electricity (resistance heating, inductive heating) or by combustion. [CET-BAT]

4.2.4.4 Patenting

Patenting is a heat treatment method typically used for high-carbon and alloy steel products to create a special crystal structure, which allows easy further deformation. In contrast to annealing where iron and iron/carbon compounds tend to be separated, patenting yields a structure where the carbon is homogeneously distributed in the iron.

Patenting is done by heating the wire to 850–1 000 °C, then cooling fast to 450–600 °C and keeping the wire at this temperature for a while, and finally quenching in water. Patenting is usually done continuously and often combined with other unit processes, e.g. hot dip coating.

Heating to 850–1 000 °C is done in an oven where the wire is in contact with the combustion gases. Intermediate cooling and keeping the wire at 450–600 °C is done in a lead bath. For small lines designed for specialities (e.g. fine diameters or mono-wire lines), other heating methods such as heating under a protective gas atmosphere and electric ovens can be used. For the patenting of thick diameters, sometimes a molten salt bath is used.

In the fuel-fired oven, a slight substoichiometric mixture is used in the burners. In this way, all O₂ is excluded from the oven atmosphere, in order to minimise the formation of iron oxides at the wire surface. Excessive formation of iron oxide leads to high losses of wire material and to excessive consumption of pickling acid, and leads to excessive drag-out of lead.

Final cooling is done by quenching in a water bath followed by the same procedure as in continuous annealing.

4.2.4.5 Oil hardening and tempering (oil tempering)

Oil hardening and tempering creates a special crystal structure in the steel with a high percentage of martensite, resulting in increased hardness and wear resistance combined with good toughness. First, the wire is heated to 850–1 000 °C, followed by rapid cooling.

Heating is typically done under a protective atmosphere using electricity (radiation, inductive heating) or combustion. The purge of protective gas is similar to what is described for batch annealing. Quenching is traditionally done in oil, but other quenching media can also be used such as water or water with additions. (Note: although it is not unusual to quench in other media than oil, the normal way of referring to this process step is still oil hardening).

Oil hardening is always followed by a tempering or stress-relieving step, in order to remove the stresses caused by the extremely fast cooling. This is done by heating the wire again to 300–500 °C. Typically a normal oven is used, with electrical heating or direct heating with a typical combustion gas, but inductive heating can also be used.

4.2.4.6 Stress-relieving

The goal of stress-relieving is to remove internal stresses in the wire caused by a previous processing steps, without changing the shape and structure of the steel crystal. The internal stresses can be caused by deformation (mechanical stresses) or by fast cooling (thermal stresses). Stress-relieving as a stand-alone heat treatment step is a typical process step for the production of PC strand (wire for prestressed concrete).

Stress-relieving can be done at various temperatures (200–500 °C), dependent on the desired characteristics of the final product. Typically a normal oven is used, with electrical heating or direct heating with a typical combustion gas, but inductive heating can also be used. After stress-relieving, the wire is cooled relatively slowly in air or water. [CET-BAT]

4.2.5 In-line pickling

In-line pickling is a typical operation after heat treatment and/or before hot dip coating of wire. It is used to clean the wire and to remove metal oxides. The wire is passed continuously through one or more acid baths. The most common acid is HCl, but other acids can be used. The

pickling takes place in a very short time (a few seconds); therefore the acid is often heated and/or used in concentrated form. After pickling, the wire is rinsed in water.

Finishing of wire includes the application of metallic or non-metallic coatings. Galvanising of wire and in-line pickling of wire are covered in Chapter 5 of this document.

WORKING DRAFT IN PROGRESS

4.3 Current consumption and emission levels for wire drawing

A.3.3 Wire Plant

4.3.1 Mass stream overview

The information contained in this section of the old BREF has been removed and replaced with the data from the data collection. Old information, along with input from the TWG will be revised and added after draft 1.

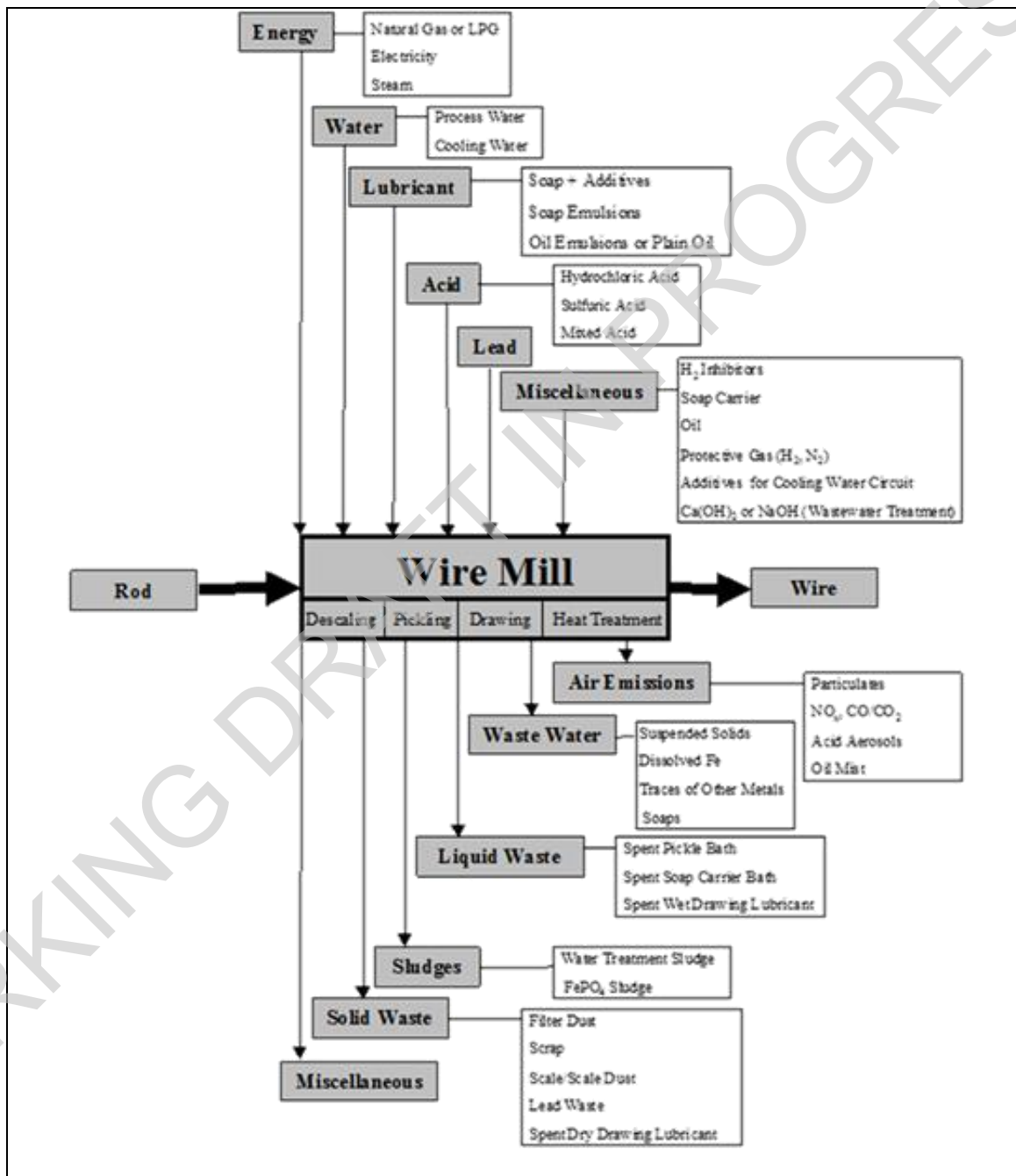


Figure 4.3: Input/output balance for a wire mill

The subsequent chapters present input and consumption data, as well as output and emission data for individual operational steps associated with wire production (wire rod preparation, drawing, heat treatment process steps). It should be noted that specific consumption and

emission data (expressed per tonne of product) can show huge variations with the wire diameter produced.

4.3.2 Energy efficiency

Figure 4.4 shows reported data on the specific energy consumption for drawing.

4.3.3 Material efficiency

4.3.3.1 Consumption of acids

Figure 4.5 shows reported data on the specific HCl consumption for three operating years in wire drawing plants. Specific HCl consumption is expressed in kg of 33-wt% acid per m² of treated (pickled) surface.

4.3.4 Water consumption

Figure 4.6 shows reported data on the specific water consumption for three operating years in wire drawing plants.

4.3.5 Emissions to air

The abbreviations used in the graphs on emissions to air in wire drawing can be found in the Glossary.

4.3.5.1 Emissions to air from dry drawing

Dust emissions

The reported data on dust emissions to air from dry drawing are shown in Figure 4.7.

4.3.5.2 Emissions to air from heating

Dust emissions

The reported data on dust emissions to air from feedstock heating (annealing) are shown in Figure 4.8 (No oxygen reference level was reported).

SO₂ emissions

The reported data on SO₂ emissions to air from feedstock heating (annealing) are shown in Figure 4.9 (No oxygen reference level was reported).

NOX and CO emissions

The reported data on NOX and CO emissions to air from feedstock heating (annealing) are shown in Figure 4.10 (No oxygen reference level was reported).

4.3.5.3 Emissions to air from pickling

HCl emissions

The reported data on HCl emissions to air from pickling of wire rod are shown in Figure 4.11.

4.3.6 Emissions to water

Figure 4.12 to Figure 4.16 show the reported data on emissions to water, for direct and indirect discharges, per pollutant from plants treating waste waters from wire drawing.

4.3.7 Residues

Table 4.2 shows the reported data on the specific generation of spent HCl, scale and scrap for three operating years in wire drawing plants.

Table 4.2: Specific generation of residues in wire drawing plants

| Residue | Specific generation in kg/t |
|---------------------------|-----------------------------|
| Spent HCl | 41-47 |
| Scale | 2.4 |
| Scrap | 1.8 |
| <i>Source: [TWG 2018]</i> | |

4.3.8 Figures with consumption and emission levels

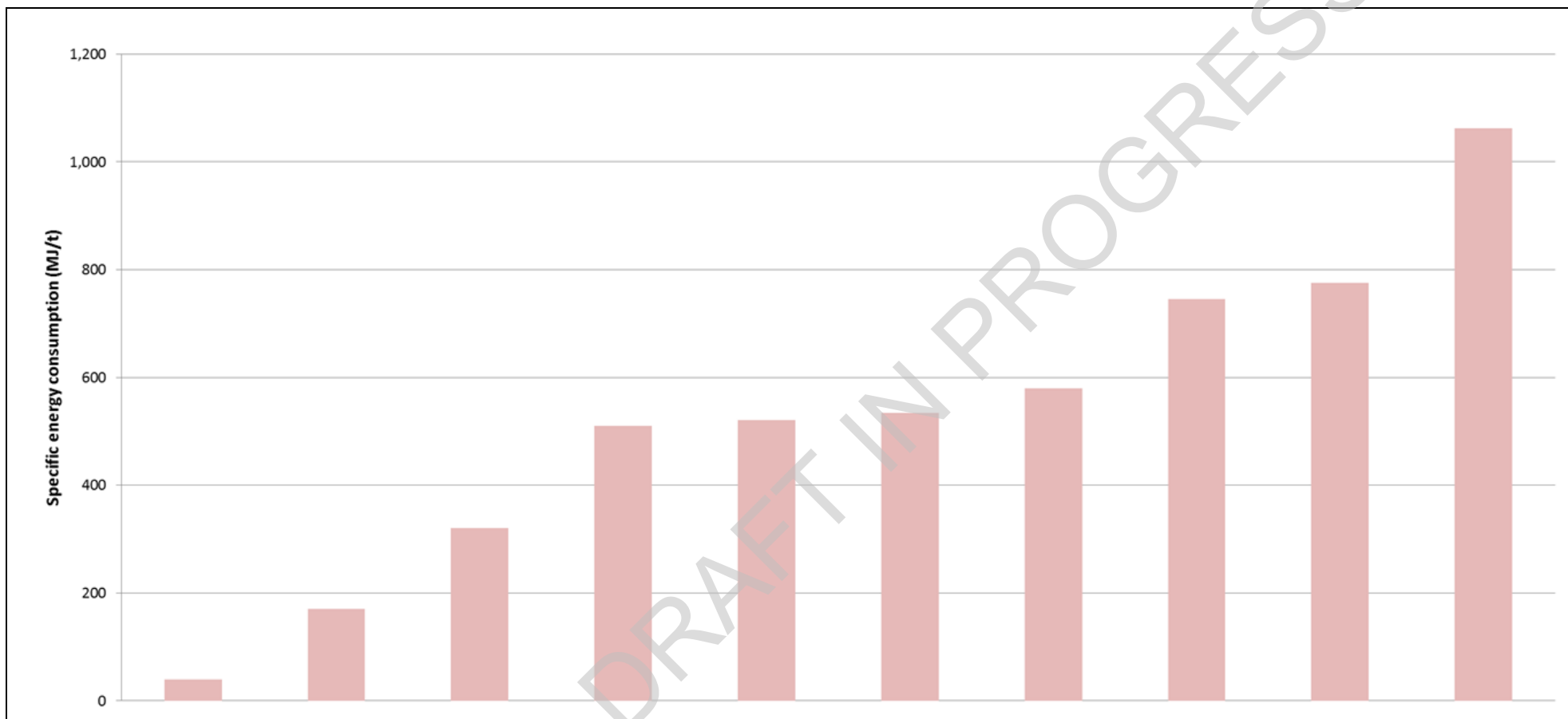


Figure 4.4: Specific energy consumption (MW/t of process throughput) for drawing. Source: [TWG 2018].

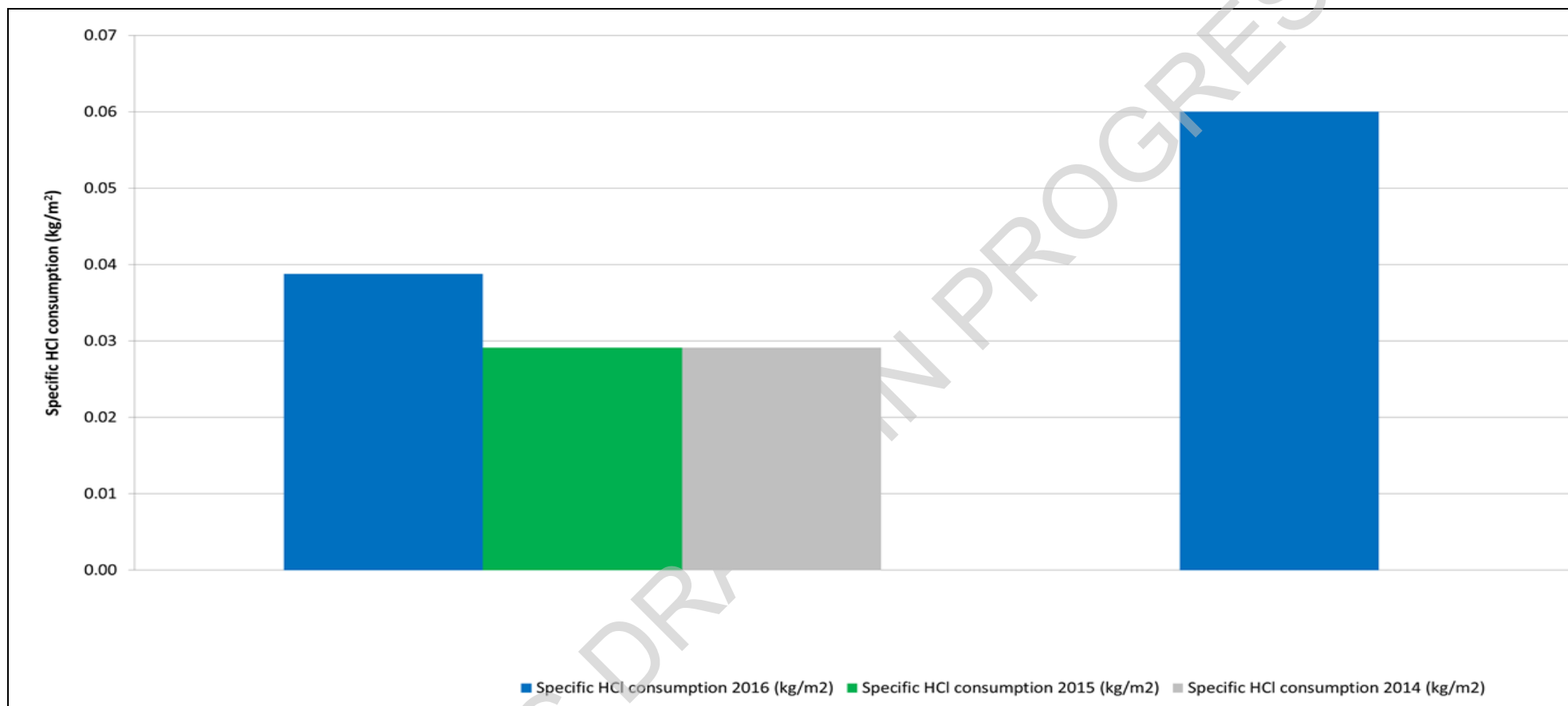


Figure 4.5: Specific HCl consumption (kg/m² of treated surface) in wire drawing plants. Source: [TWG 2018].

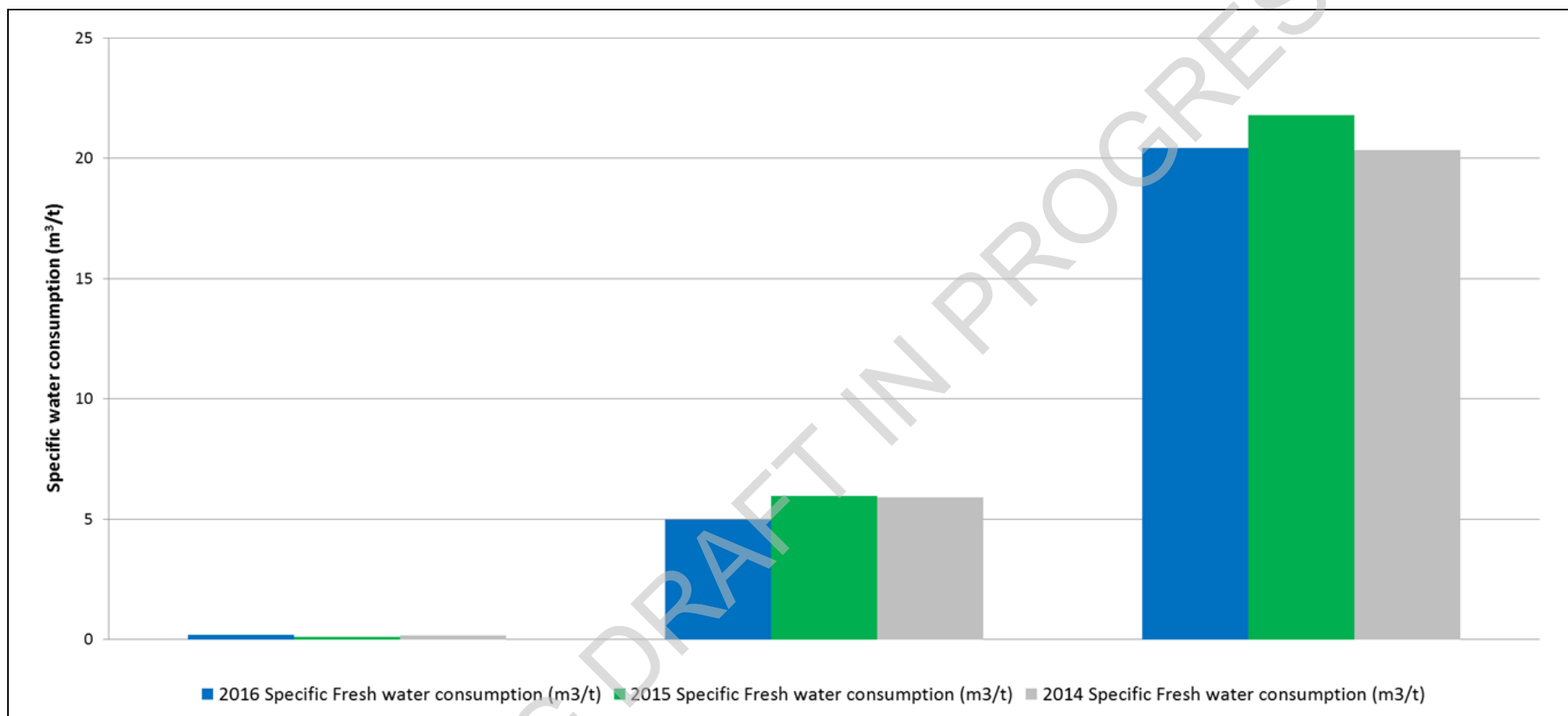


Figure 4.6: Specific water consumption (m³/t of production) in wire drawing plants. Source: [TWG 2018].

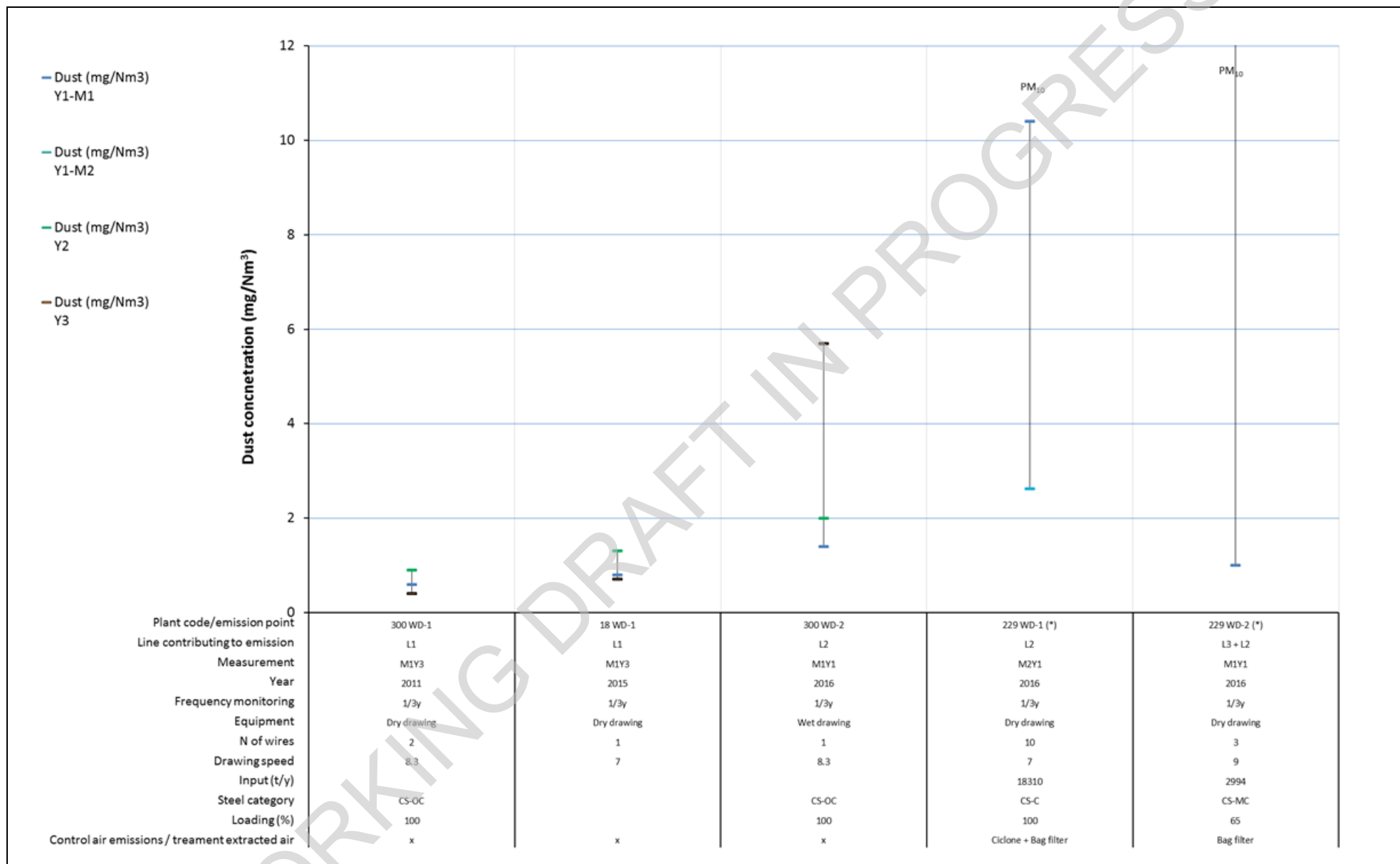


Figure 4.7: Dust emissions from dry drawing. Source: [TWG 2018].

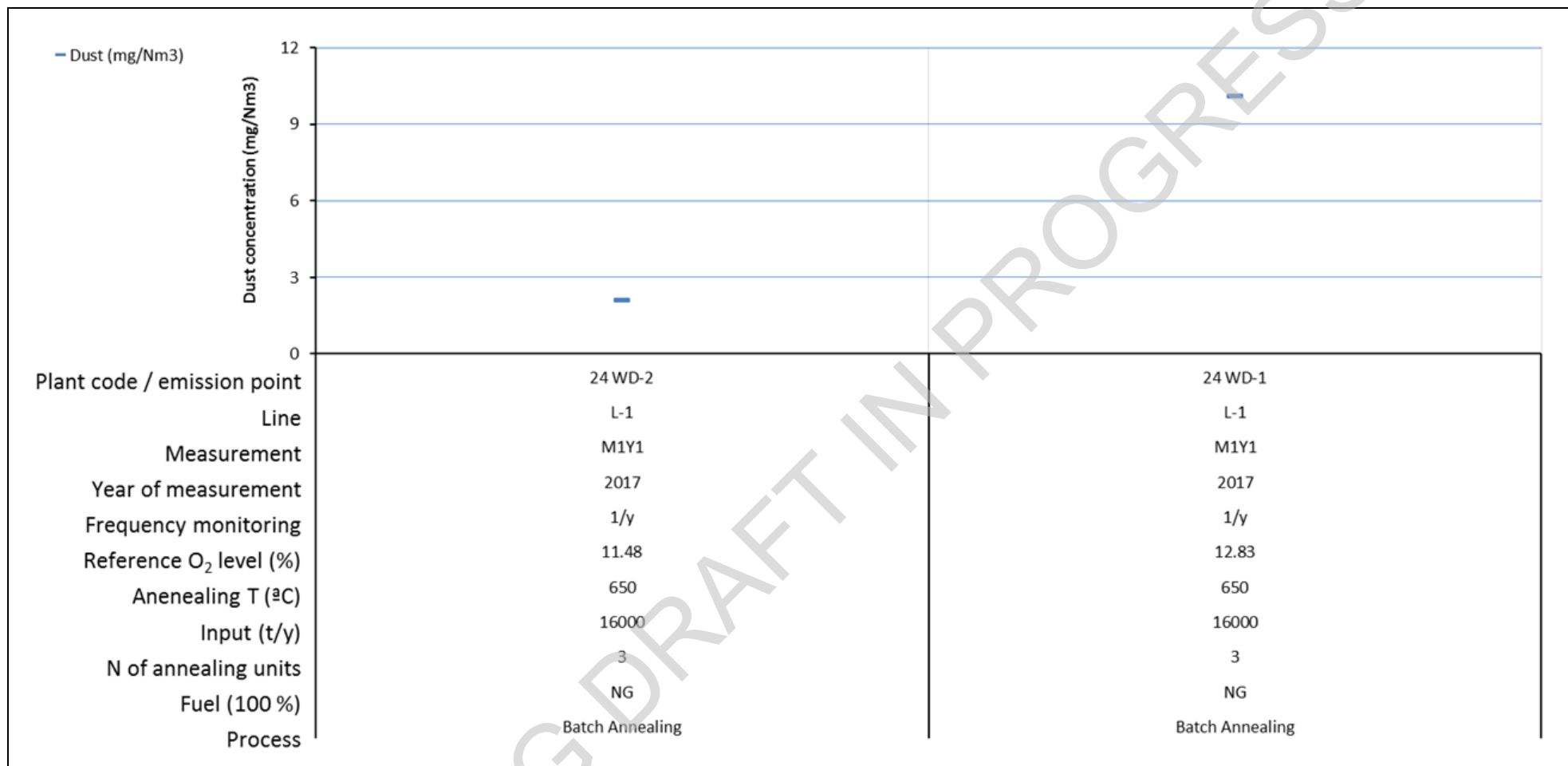


Figure 4.8: Dust emissions from feedstock heating. Source: [TWG 2018].

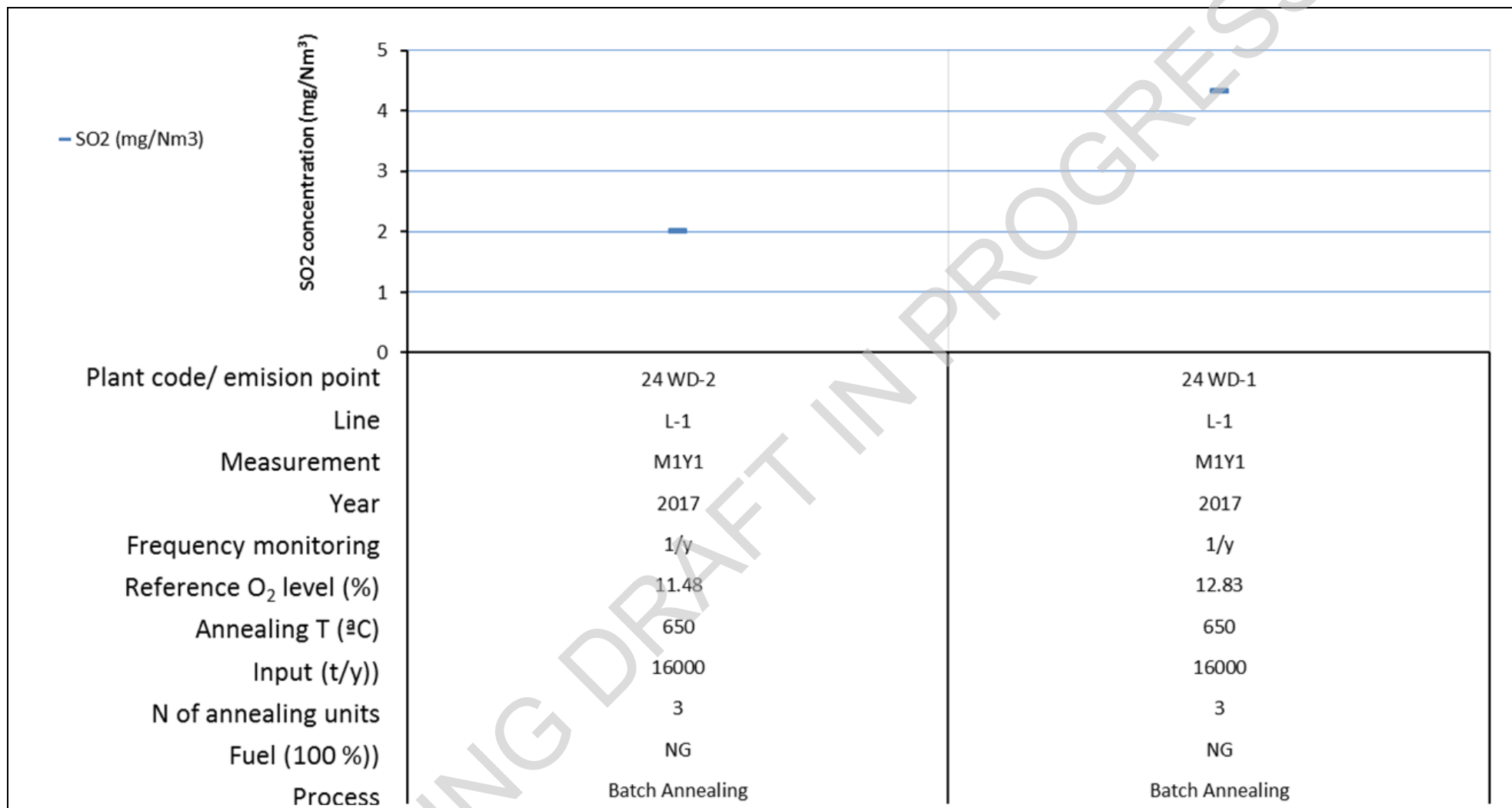


Figure 4.9: SO₂ emissions from feedstock heating. Source: [TWG 2018].

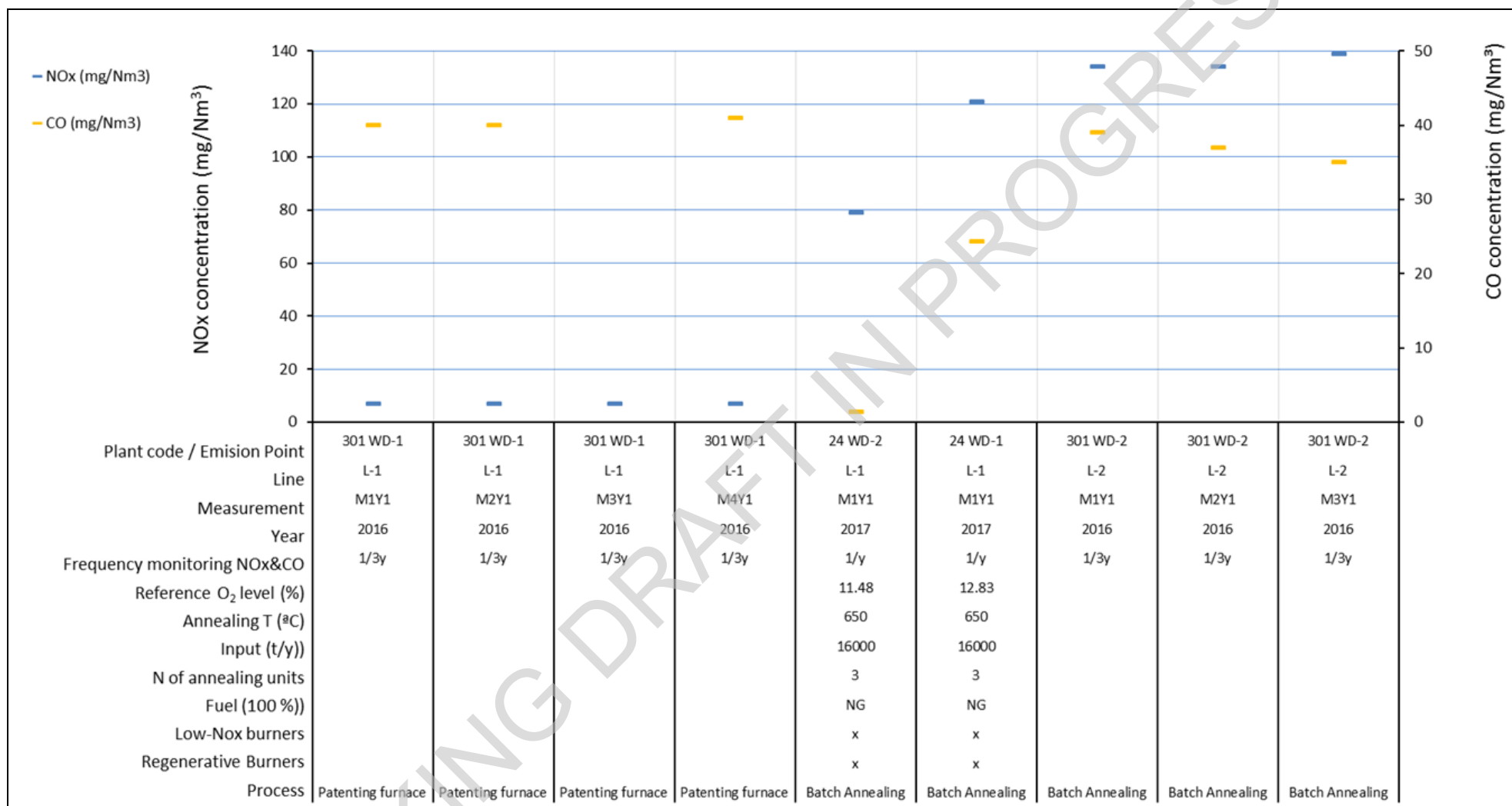


Figure 4.10: NOx and CO emissions from feedstock heating. Source: [TWG 2018].

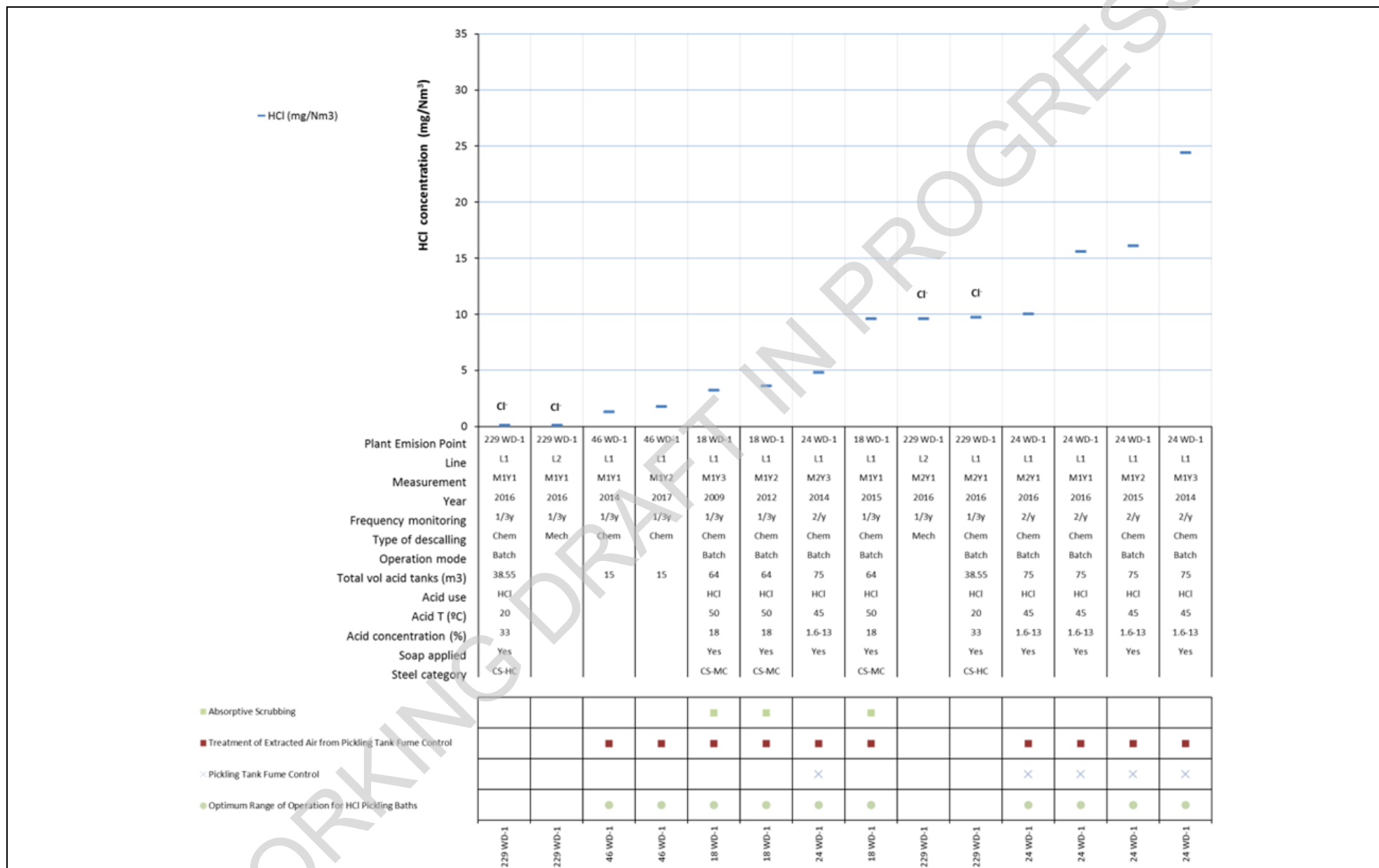


Figure 4.11: HCl emissions from pickling of wire rod (in mg/Nm³) in wire drawing plants. Source: [TWG 2018].

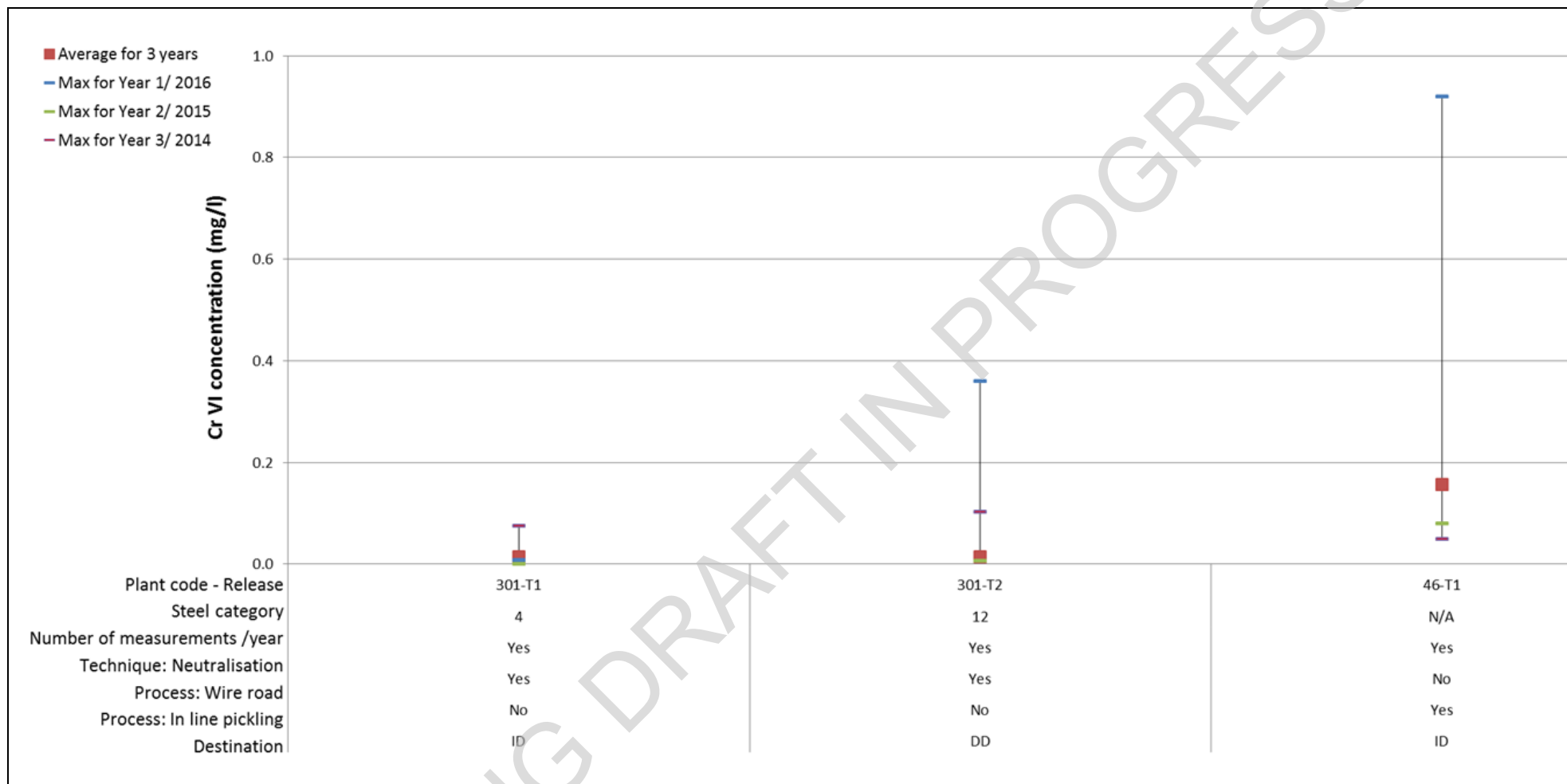


Figure 4.12: Chromium VI emissions (in mg/l) for direct and indirect discharges. Source: [TWG 2018].

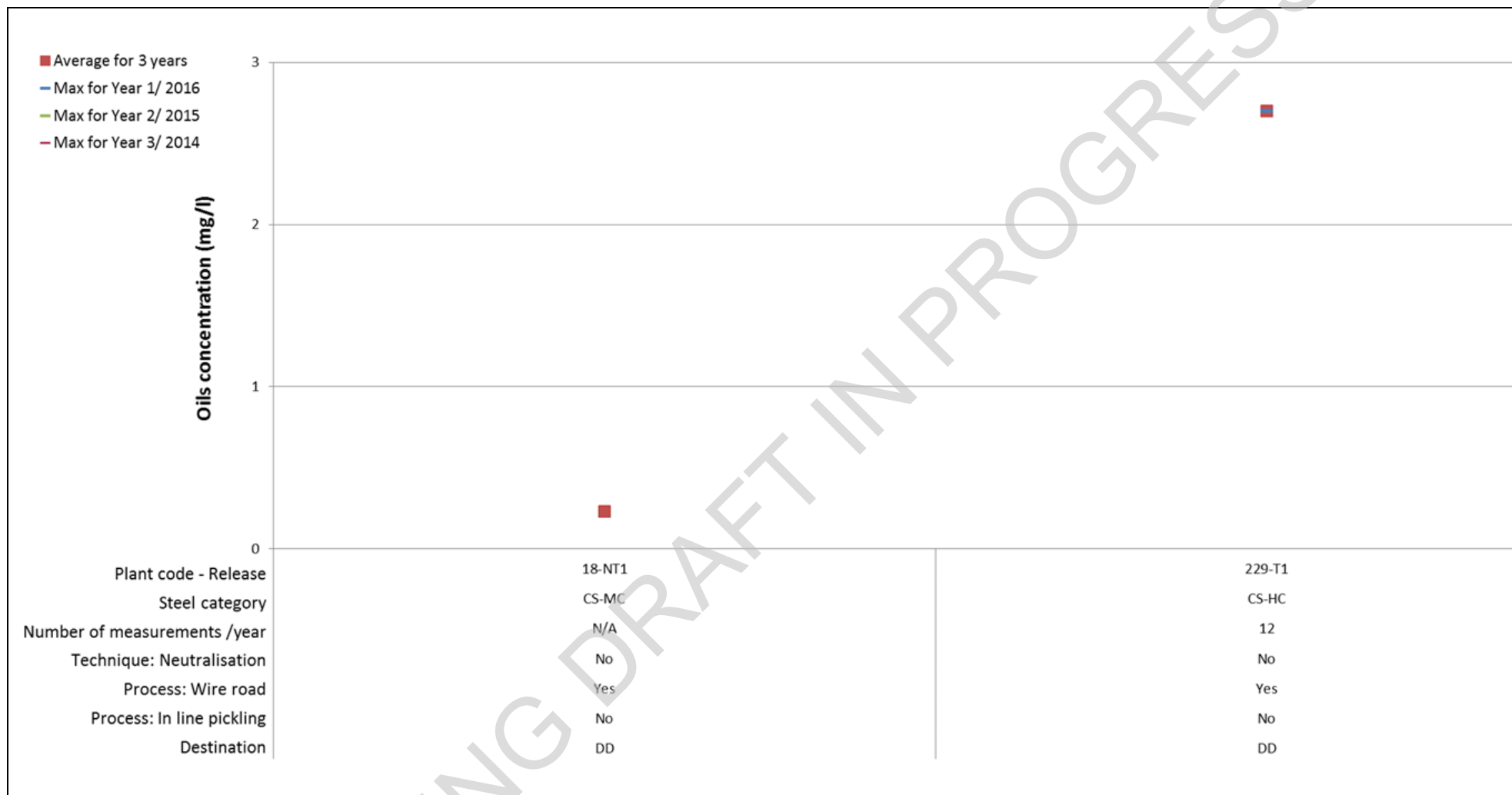


Figure 4.13: Oils emissions (in mg/l) for direct discharges. Source: [TWG 2018].



Figure 4.14: Lead emissions (in mg/l) for direct and indirect discharges. Source: [TWG 2018].

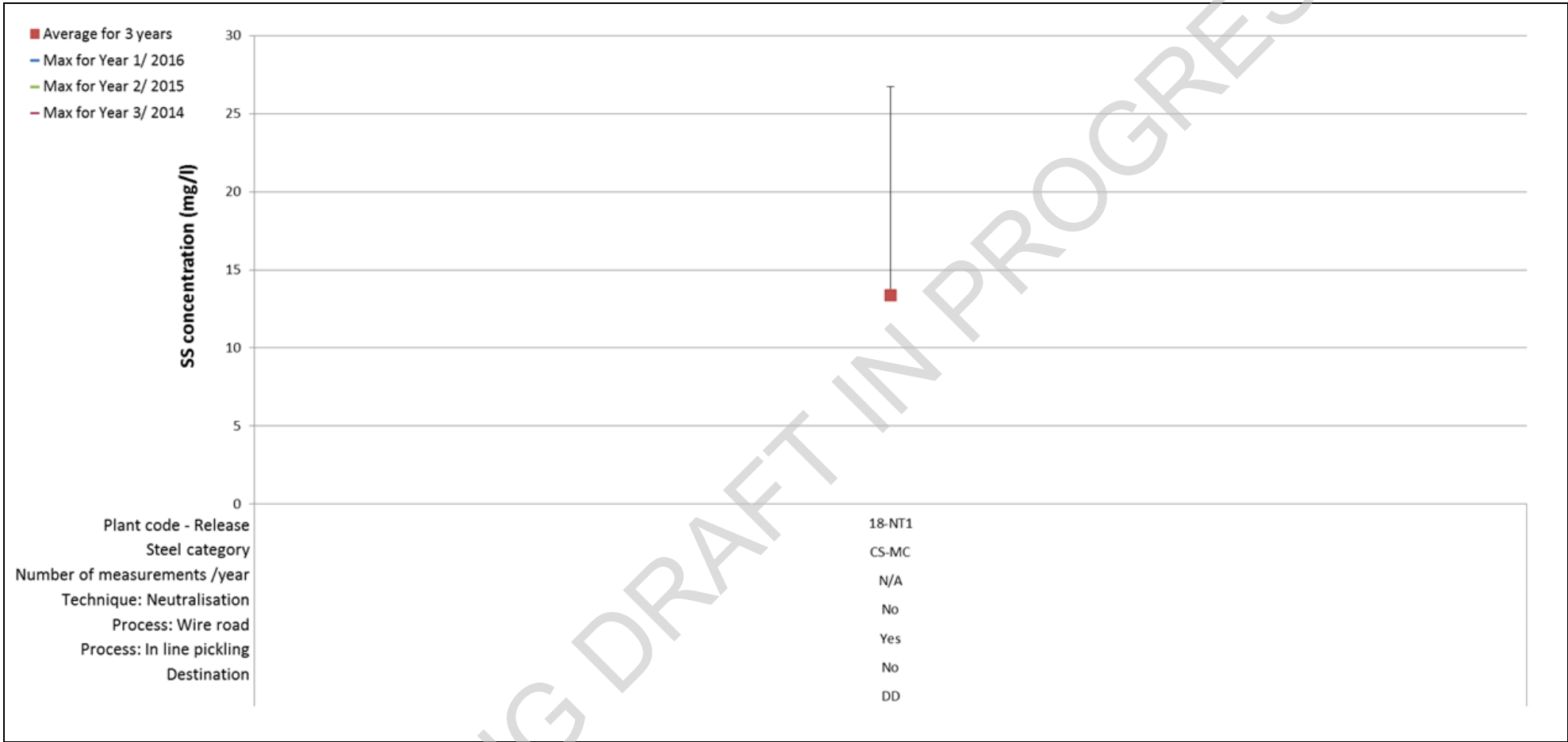


Figure 4.15: Suspended solids emissions (in mg/l) for direct discharges. Source: [TWG 2018].

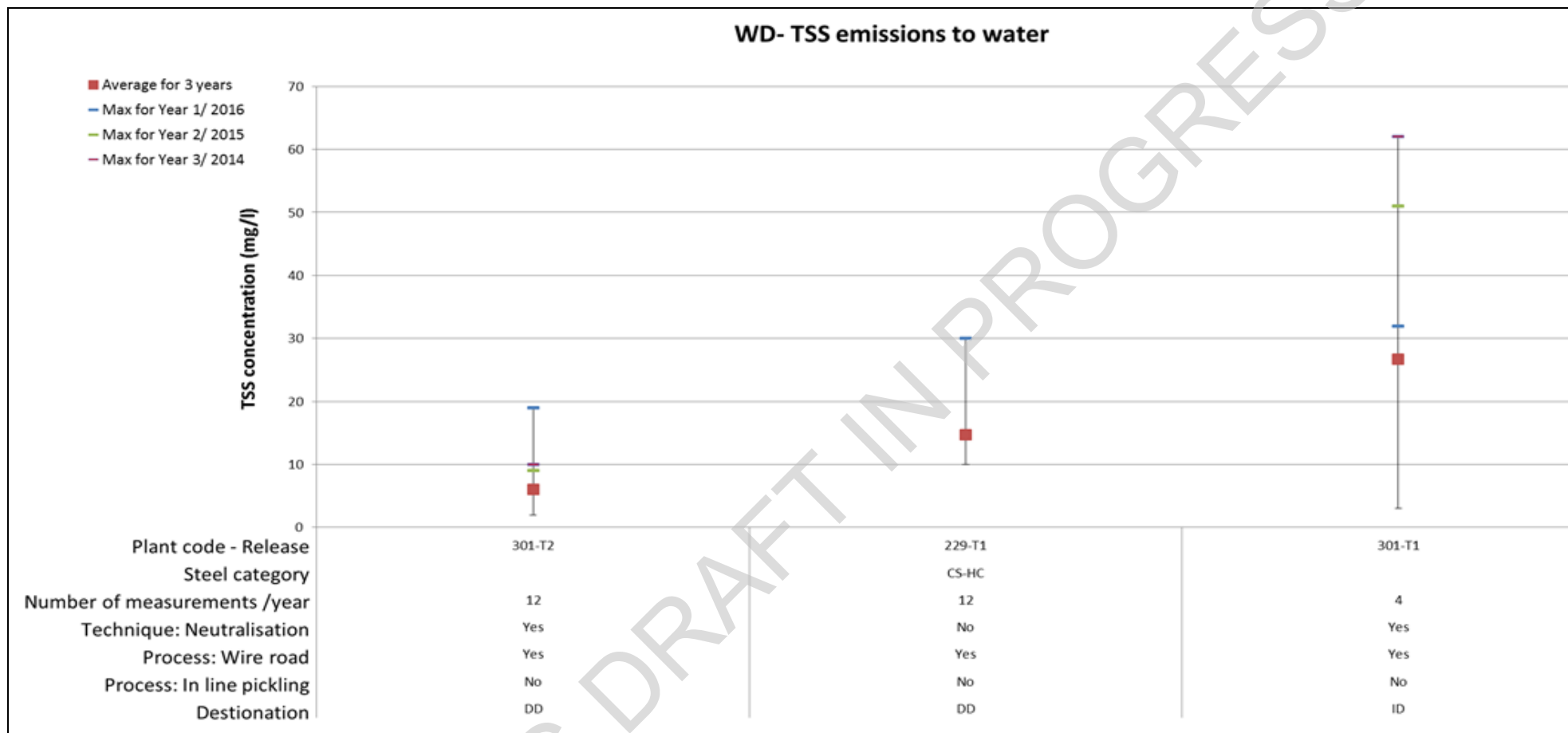


Figure 4.16: Total suspended solids emissions (in mg/l) for direct and indirect discharges. Source: [TWG 2018].

4.4 Techniques to consider in the determination of BAT for wire drawing

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 as well as process-integrated and end-of-pipe techniques. 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 the prevention or limiting of the environmental consequences of accidents and incidents. They also cover the prevention or reduction of 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 Directive 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 2.8 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 that 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.

In Chapter 8 general techniques (i.e. those used that are commonly used) are discussed which might also be applicable to wire drawing. These techniques are normally not repeated in this section, unless information specific for this sector was made available.

TWG, Section A.4.3.1 from the old BREF has been moved and the updated information can now be found in Chapter 8(Section 8.3.3).

4.4.1 Mechanical descaling

4.4.1.1 Mechanical descaling by reverse bending and recycling of scale

Description

Scale collected during mechanical descaling (e.g. reverse bending) is directly recycled to the iron and steel production to recover the iron content.

Technical description

The bulk of descaling in the wire industry is done by reverse bending, leading to a scale which consists mainly of metal oxides and which is oil- and water-free. Due to bending and torsion of the wire, the scale breaks down and drops into collection containers. All wire companies can keep the scale separated from other waste streams to allow recovery of the iron content by recycling to the primary iron and steel industry. Whether recycling is done or not depends to a large extent on the interest of the local steel industry, which has little to gain by the recycling of this small amount of rather difficult to handle secondary raw material. [CET-BAT]

In some exceptional cases where abrasives are used (e.g. shot blasting, sanding), scale gets mixed with other products. Recovery of shot-blasting media from scale is a common practice with both economical (less consumption) and environmental (less waste) benefits. Infinite recovery is not possible and not desired (quality loss, higher degree of dust formation). [CET-BAT]

Achieved environmental benefits

Reduction of waste [CET-BAT].

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

- ~~New and existing plants~~: Generally, there are no technical restrictions to the applicability of this technique.
- Technically possible for all scale from mechanical descaling of wire (rod).
- Limitation of recycling not due to technical factors, but due to acceptance by the potential recycler [CET-BAT].

Economics

TWG, please provide information.

Driving force for implementation

Increased material efficiency.

Example plants

Plant 300 (Data collection)

Reference literature

[CET-BAT]

TWG, the following section on shot blast descaling has been moved here under mechanical descaling (previously this section was after the chemical descaling section)).

4.4.1.2 Shot blast descaling: separation of scale and blast media

Description

Shot blasting involves the propulsion of thousands of steel shot particles per second, towards the surface of the material. This causes the scale to break and fall off the base metal. The scale is mixed with the shot blasting media which can be also recovered.

Technical description

Shot blasting is possible as in-line or bulk processing. It involves the propulsion of thousands of steel shot particles per second, towards the surface of the material. This causes the scale to break and fall off the base metal. The shot blast or blast cleaning system consists of the following:

1. A cabinet to house and contain the descaling operation.
2. A series of blast wheels of varying power depending on required line speeds, production requirements, etc.
3. A reclaim system to return used shot or media to a recycling system.
4. A recycling system where media is cleaned and small particles of dust and scale are removed.
5. A storage area within the system where shot is stored before being distributed once again to the blast wheels.
6. A dust collection system.

The blast cabinet is a confined enclosure where the blast descaling operation takes place. A series of blast wheels are mounted to the cabinet and propel the media, usually steel shot, by centrifugal force towards the wire.

The reclaim system provides a means to retrieve the used shot and dust from the descaling operation and brings it to the recycling system.

Recycling of the shot media involves separating the good reusable media from the contaminants and dust gathered in the mix. By passing the collected media through an air wash separator, the fine dusts and smaller contaminants are drawn from the system by a vacuum effect, leaving the cleaned shot particles to be returned to a storage system. From this storage system, the media will be distributed through a series of controls or valves back to the blast wheels. By synchronising the entire system, a continuous flow of media is directed toward the wire to achieve the desired results in the fastest and most expedient manner.

Stream descaling

This method involves pre-descaling of wire rod by bending and torsion and fluidisation of the scale obtained in this descaling. In a special chamber the fluidised scale is then blown onto the wire rod surface by means of jet pumps and compressed air. The rod is descaled to its metallic surface. The scale is transported to a dust collection system (cyclone, cloth filter) by the compressed air. Coarse scale is returned to the jet pumps and used again. The fine scale is utilised as a component in the production of paints.

This method is reported to be applicable to low-carbon steel wire rod and high-carbon steels. Another advantage is that no other media as shot or grit is needed.

Achieved environmental benefits

- Scale is collected separately and can be reused.
- Consumption of shot-blasting media is reduced.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

Initial investment costs and space requirements are reported to be very low.

Driving force for implementation

TWG, please provide information.

Example plants

Stream descaling: Wire Factory in Gliwice, Poland application low-carbon wire, reduced production costs (planned or implemented?)

Reference literature

Stream descaling:

'A new Method of mechanical Descaling of Carbon Steel Wire Rods', Conference Proceedings – Wire association International Incorporated, 65th Annual Convention Atlanta, 1995.

4.4.2 Chemical descaling / Pickling of wire rod

4.4.2.1 Control of pickling emissions

Chemical pickling of wire rod is mostly done in batch operation. In some cases, in-line pickling is also carried out.

In the case of batch pickling, the general techniques to control acid emissions from pickling tanks that are described in Section 8.8.4 apply including:

- restricted operating range using hydrochloric acid (Section 8.8.4.1);
- air extraction as close as possible to the source (Section 8.8.4.2);
- wet scrubbing followed by a demister (Section 8.8.4.4).

In the case of continuous pickling, the general techniques to control acid emissions from pickling tanks that are described in Section 8.8.4 apply including:

- closed pickling tanks combined with air extraction (Section 8.8.4.3);
- wet scrubbing followed by a demister (Section 8.8.4.4).

TWG, Section A.4.3.3.1 from the old BREF "Optimum range of operation for HCl pickling baths" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.4.1).

TWG, Section A.4.3.3.2 from the old BREF "Pickling tank fume control" has been deleted as it is now covered under Chapter 8 (Sections 8.8.4.2, 8.8.4.3 and 8.8.4.4).

TWG, Section A.4.3.3.3 from the old BREF "Treatment of extracted air from pickling tank fume control" has been deleted as it is now covered under Chapter 8 (Section 8.8.4.4).

TWG, Section A.4.3.3.4 from the old BREF "cascade pickling" has been deleted as it is now covered under Chapter 8 (Section 8.6.2.8).

TWG, Section A.4.3.3.5 from the old BREF "Minimizing carry-out from pickling" has been deleted as it is now covered under Chapter 8 (Section 8.6.2.9).

4.4.2.2 Acid recovery

Pickling acids used in the wire drawing sector can be recovered using the general techniques described into more details in Section 8.6.5 including:

- crystallisation for H_2SO_4 ;
- evaporative recovery for HCl;
- pyrohydrolysis via spray roasting for HCl.

TWG, Section A.4.3.3.6 from the old BREF "Separation and reuse of free acid fraction" has been deleted as it is now covered under Chapter 8 (Section 8.6.5).

TWG, Section A.4.3.3.7 from the old BREF "Regeneration of spent acid" has been deleted as it is now covered under Chapter 8 (Section 8.6.5).

4.4.2.3 Reuse of spent acid as secondary raw material

Description

Spent acid can be used by the chemical industry as a secondary raw material for the production of FeCl_3 and, to a minor extent, for pigments.

Technical description

The chemical industry uses spent acid as a secondary raw material for the production of FeCl_3 and, to a minor extent, for pigments. The possibility to recycle spent acid for the production of valuable chemicals is available in many regions in Europe. Some contractors impose or have to

impose strict limits for some metal impurities in the spent acids. A few contractors have recently developed and patented special processes to remove Zn or Pb for example from some types of spent acid. [CET-BAT]

Achieved environmental benefits

Reduction of acidic waste.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Reduction of spent acid sent for disposal.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[CET-BAT]

TWG, Section A.4.3.3.9 from the old BREF "Minimise rinsing water consumption by cascade rinsing" has been deleted as it is now covered under Chapter 8 (Section 8.7.6).

4.4.3 Dry drawing

4.4.3.1 Capture of emissions from drawing machines and abatement

~~A.4.3.5.1 Control of Air Emissions from Drawing Machines / Treatment of Extracted Air~~

Description

TWG, Please could you confirm exactly which type of filter is used for abatement of dust emissions from dry drawing and whether there are technical considerations in the case of soap dust ?

The entire drawing machine is enclosed in order to avoid dispersion of dust and air is extracted.

Technical description

A hood or cover is installed above parts of the drawing machine that are in contact with the wire. The cover needs to be designed in such a way that it can be removed easily for frequent tasks, such as threading a wire through the machine, fixing a broken wire, adjusting or replacing a die or adding soap. The air within the cover is extracted.

The extracted air can be treated by a filter or similar device to capture soap dust.

Achieved environmental benefits

Reduction of emissions to air, especially of fugitive soap dust [CET-BAT].

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

- ~~New plants.~~
- ~~Technical problems expected in existing plant due to design reasons.~~

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

Economics

TWG, please provide information.

Driving force for implementation

The goal is to limit the spread of lubricant-dust over the area around the drawing machine. Total elimination of soap dust is impossible (e.g. soap dust leaving the drawing machine with the drawn wire). This is mainly done to improve the working environment. [CET-BAT]

Example plants

~~All recent dry drawing machines are to a large extent enclosed [CET-BAT].~~

Widely used.

Reference literature

[CET-BAT]

4.4.3.2 Closed loop for cooling water

Description

Water that is used to cool the dies and the wire is circulated in a closed loop, equipped with a wet cooling tower, an air cooler or similar device.

Technical description

The drawing operation heats both the wire and drawing die through friction of the wire. So both the dies and the wire (indirectly, through cooling of the capstans in contact with the wire) are water-cooled. In order to reuse the cooling water, the water circuit is equipped with a wet cooling tower, an air cooler or similar device. [CET-BAT]

Achieved environmental benefits

Reduced water consumption.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Reduced water consumption.

Example plants

Widely used.

Reference literature

[CET-BAT]

4.4.3.3 Use of low-borax drawing soaps**Description**

Low-borax drawing soaps are used as an alternative to the classical borax drawing soaps.

Technical description

Low-borax drawing soaps, with a borax content of 6.5 wt-% or lower, are used to increase the drawing speed while minimising lubricant consumption and reducing borate emissions to water.

Achieved environmental benefits

Reduction of losses of borates and emissions of borate to waste water.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

- Generally, there are no technical restrictions to the applicability of this technique.
- The low-borax drawing soaps can be used for most of the wire drawing processes.

Economics

The prices of low-borax drawing soaps is comparable with the traditional drawing soaps.

Driving force for implementation

The low-borax soaps are outside the scope of the REACH legislation.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[VITO 30-1-17]

Grommen, R., 2016 -2017, Communications on the use of Borax at Bekaert.

Piessens P., 2016 -2017, Communications on the use of Borax at Trebos.

4.4.4 Wet drawing**4.4.4.1 Closed loop for cooling water****Description**

Heat is generated during drawing. Most of the heat is transferred to the lubricant which is cooled using cooling water.

Technical description

The drawing operation heats both the wire and drawing die through friction of the wire. This heat is taken up by the lubricant. The lubricant in turn is cooled; often this is done indirectly with cooling water. [CET-BAT]

Achieved environmental benefits

Reduced water consumption.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

Widely used.

Reference literature

[CET-BAT]

4.4.4.2 Cleaning of drawing lubricant / coolant

Description

A cleaning circuit, e.g. with filtration and/or centrifugation, is used to clean the wire-drawing lubricant for reuse.

Technical description

Wire drawing lubricants, water-miscible oil emulsions or straight oils accumulate metal fines during operation. As the contents of fines increases, operational problems develop, such as wire-drawing breaks, capstan wear and poor quality of wire, requiring replacement of the lubricant. **Media filtration** and/or **centrifuges** are used to clean the lubricant and to prolong the lifetime. [El-Hindi]

Achieved environmental benefits

Reduction of waste drawing lubricant [El-Hindi].

Environmental performance and operational data

Cleaning of drawing lubricant can improve the operational behaviour as it reduces wire-drawing breaks and improves the wire quality (thus also reducing operational problems downstream). [El-Hindi]

Cross-media effects

Generation of waste filter media [El-Hindi].

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Increased material efficiency.

Example plants

Widely used.

Reference literature

[El-Hindi]

4.4.4.3 Treatment of waste drawing lubricant: oil and oil emulsions**Description**

The organic phase is separated from the aqueous phase, e.g. by skimming or by emulsion splitting with suitable agents, evaporation or membrane filtration. The organic phase may be used for other purposes (e.g. as a fuel).

Technical description

See Section 8.9.14.

Achieved environmental benefits

- Reduced disposal volume.
- In case of incineration, thermal utilisation of waste.

Environmental performance and operational data

Reduced waste disposal costs.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Reduction of waste water contamination.

Example plants

Widely used.

Reference literature

TWG, please provide information.

4.4.4.4 Treatment and disposal of waste drawing lubricant: soap emulsions**Description**

If the quantities are small, the spent lubricant is mixed with other waste waters. If the quantities are comparably big, the spent lubricants are treated separately by coagulation and precipitation, coagulation and flotation, membrane filtration, evaporation or other suitable methods.

Technical description

For soap emulsions based on a fatty acid alkali soap, the treatment depends on the amount of waste lubricant. If the quantities are small compared to other waste waters of the plant, the spent lubricant is mixed with other waste waters. The soaps are bounded in the filter cake during almost all existing water treatment methods for acidic waste waters. If a biological treatment is used, the fatty acid soaps are easily biodegradable. [CET-BAT]

If the quantities are comparably big, the spent lubricants are treated separately by coagulation and precipitation, coagulation and flotation, membrane filtration, evaporation or other suited methods. [CET-BAT]

Achieved environmental benefits

Reduced emissions to water.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

Generation of sludge and filter cake from water treatment.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Reduction of waste water contamination.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[CET-BAT]

4.4.5 Batch annealing of wire

4.4.5.1 Burn purge of protective gas

Description

The fraction of the protective gas that is continuously purged contains decomposition products of the lubricants and in some types of protective gases combustible components, which are converted to less harmful products in an open flame.

Technical description

In order to keep an over-pressure in the 'pots' or 'bells', a fraction of the protective gas is continuously purged.

This gas stream contains, apart from the components of the actual protective gas, decomposition products of the lubricant. These are formed by pyrolysis/cracking of the lubricant molecules; typical decomposition products are low molecular weight olefins and alkanes.

These volatile organic components and the combustible components in some types of protective gases (CO, H₂) should be converted to less harmful products. As the purge is a very small flow of combustible gas, this is simply done in an open flame. [CET-BAT]

Achieved environmental benefits

Reduced emissions to air.

Environmental performance and operational data

TWG, please provide information.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Cross-media effects

TWG, please provide information.

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[CET-BAT]

4.4.6 Continuous (in-line) annealing of low-carbon wire

TWG, Section A.4.3.8.1 "Lead-bath: good housekeeping;has been modified. Three new short sections have been created instead. See below.

4.4.6.1 Prevention of heat losses and lead oxidation in the lead baths**Description**

Floating protective layers and tank covers are use to prevent heat losses and lead oxidation in the lead bath.

Technical description

A protective layer (particulate material) or cover is maintained on the lead bath to minimise loss of lead by oxidation and drastically reduce energy losses of the bath.

Achieved environmental benefits

Increased energy and material efficiency.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

Reduction of dust and lead emissions.

Example plants

Widely used.

Reference literature

[CET-BAT]

4.4.6.2 Minimisation of carry-over of lead

Description

Techniques include the use of anthracite gravel to wipe off lead and coupling the lead bath with in-line pickling.

Technical description

- Prevent formation of dust while removing impurities from the lead bath.
- Minimise drag-out of lead with the wire by maintaining a suitable surface condition on the half-product (both economically and environmentally attractive).
- Minimise drag-out of lead with the wire by using an anthracite gravel wipe or similar immediately after the lead bath.
- Apply a method that minimises/eliminates the spread of lead dust that is possibly dragged out with the wire. In many production lines, this is done by coupling the in-line heat treatment to in-line pickling. Other methods are: coating of the wire with a suitable product or adapted packaging of the wire. [CET-BAT]

Achieved environmental benefits

Increased material efficiency.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

Reduction of lead emissions in the workplace and carry-over towards subsequent production process.

Example plants

Widely used.

Reference literature

[CET-BAT]

4.4.6.3 Air extraction as close as possible to the source and treatment of lead bath emissions

Description

Emissions from the lead bath are collected, for example using hood or lip extraction, and are treated using a fabric filter.

Technical description

Lead bath emissions are extracted, using lip or hood extraction, and treated using fabric filter (See Section 8.8.1.3).

Achieved environmental benefits

Reduced emissions from lead bath (Pb from the bath itself, CO and TOC from incomplete burning of residues on the wire) [CET-BAT].

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

Environmental legislation.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[CET-BAT]

TWG, Section A.4.3.8.2 from the old BREF "Recycling of Pb-containing residues" has been moved and the updated information can now be found in Chapter 8 (Section 8.11.3.2)

4.4.6.4 Closed-loop operation of quench bath and waste water treatment

Description

Quench baths are operated using low-quality recovered water or in a closed water loop configuration. Waste water from quenching is treated in such a way that insoluble $\text{Pb}(\text{OH})_2$ and PbCO_3 is removed prior to discharge.

Technical description

As the water quality requirements for quench baths are generally low, it is possible to use recovered water for this purpose or to operate the quench bath in closed loop. [CET-BAT]

Waste water from a quench bath is treated in such a way that contamination (mainly contamination with insoluble $\text{Pb}(\text{OH})_2$ and PbCO_3 is removed prior to discharge. [CET-BAT]

There are several configurations possible for the treatment of quenching water in wire drawing plants:

1. Each site has to determine its own waste water treatment facility in such a way that it can handle the mix of waste waters that originates at that site. This mix is different for each site and is highly dependent on the product range of that site (use of acid or not, availability of recycling services for spent acid or not, use of wet drawing emulsions or

not, use of plating baths or not and type of plating baths, etc.) and on the local environmental requirements.

2. If a heat treatment without protective atmosphere is used (e.g. a heat treatment involving the use of a molten Pb bath), then also acid pickling is used. In this case, at least spent rinsing water containing acid and iron has to be treated. To do this, wire plants use a traditional physico-chemical waste water treatment, in other words neutralisation with lime milk followed by precipitation of Fe and Pb and other heavy metals, followed by decantation and filter-pressing of the cake.[Com BG2]

Achieved environmental benefits

Reduced lead emissions to water.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

Generation of waste/sludges from waste water treatment.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Environmental legislation.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[CET-BAT] [Com BG2]

TWG, No specific information is provided concerning the continuous annealing of stainless steel wire. Please, are there any specific information that should be taken into consideration here. Otherwise, the Section 4.4.7 will be deleted.

4.4.7 Continuous (in-line) annealing of stainless steel wire**4.4.7.1 Burn purge of protective gas**

~~See Section 4.4.5.1.~~

4.4.8 Patenting**4.4.8.1 Optimised operation of the oven****Description**

A slightly substoichiometric mixture is used in the burners to exclude O₂ from the oven atmosphere, in order to minimise the formation of iron oxides at the wire surface. Excess CO is then converted to CO₂ by adding air in a controlled way to the hot exhaust of the oven.

Technical description

A slightly substoichiometric mixture is used in the burners. In this way, all O₂ is excluded from the oven atmosphere, in order to minimise the formation of iron oxides at the wire surface.

Excessive formation of iron oxide leads to high losses of wire material and to excessive consumption of pickling acid, and leads to excessive drag-out of lead. [CET-BAT]

Excess CO must be converted to CO₂ by adding air in a controlled way to the hot exhaust of the oven. The CO content of the oven atmosphere and the exhaust gas must be controlled regularly, e.g. after every major change in the product mix or at least every month. [CET-BAT]

Because of the heating method, NOX formation is not an issue. [CET-BAT]

Achieved environmental benefits

- Reduced consumption in following process steps (e.g. acid).
- Reduced CO content.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[CET-BAT]

TWG, Sections A.4.3.10.2 to A.4.3.10.4 from the old BREF have been deleted as these sections contained no information are are not relevant to patenting.

TWG, No specific information is provided concerning oil hardening and tempering (See below).

4.4.9 Oil hardening and tempering

~~A.4.3.11~~ Hardening and Tempering

4.4.9.1 Burn purge of protective gas

Refer to Section-4.4.5.1-

4.4.9.2 Extraction of oil mists from quench baths and abatement

~~4.4.9.2~~ Extraction of oil mists from quench baths and abatement

Description

Emissions from oil quench baths are collected, for example using lateral hood or lip extraction and are abated using a demister.

Technical description

Evacuation of the oil mist and removal of the oil mist from the extracted air.

Achieved environmental benefits

Reduction of fugitive emissions to air, especially oil emissions.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

Environmental legislation.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

4.4.10 Heat treatment of wire (different processes)

4.4.10.1 Inductive heating of wire

Description

The wire to be heated is guided through a coil. In this coil, a magnetic field is generated which induces an electric current in the wire. The wire is heated through the Joule effect of the induced current.

Technical description

The wire to be heated is guided through a coil; in this coil a magnetic field is generated. Typically, applied frequencies are 5–50 kHz (mid-frequency heating). Exceptionally, high-frequency heating (well above 50 kHz) is used. This magnetic field induces an electric current in the wire; the wire is heated through the Joule effect of the induced current. The induced current is mainly in a small layer towards the outside of the wire section; this phenomenon is called the ‘skin-effect’.

The applicability of inductive heating is highly dependent on the wire material, wire diameter and required temperature increase:

- Material is preferably magnetic.
Steel and certain steel alloys are magnetic. Most types of stainless steel are non-magnetic. Most metal coatings are non-magnetic.
- Wire diameter is preferably high, e.g. above 2–3 mm.
The smaller the diameter, the higher the frequency should be in order to maintain a sufficient skin-effect.
- Above the ‘Curie-temperature’, a magnetic material loses its magnetic properties. Steel loses its magnetic properties at approximately 760 °C.

Applications outside this range are available. However, expensive high-frequency equipment has to be used and energetic efficiency is on average lower.

The vast majority of the applications of inductive heating are found in single wire lines. Induction heating in a single wire line concept can be used for austenitising and tempering. Austenitising is the first step of several thermal treatment operations: patenting (see Section 4.4.8), oil hardening and tempering (see Section 4.4.9).

An exact control of the wire temperature is a necessity for these thermal treatments.

Induction heating in a multi-wire line concept can be used for preheating of the wires (e.g. to the Curie-temperature). Another application is diffusion of Cu and Zn coatings on a steel wire in order to obtain a brass-coated wire.

Achieved environmental benefits

Emissions to air from combustion are avoided in the plant.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

Consumption of fuel (typically NG or LPG) is replaced by consumption of electricity. When taking into account the fuel consumption of electricity generation, this cross-media effect is negligible.

Typical electrical energy efficiencies of mid-frequency inductive heating are in the range of 60–85 %. The typical energy efficiency of a NG-based heating method for similar applications is 25–45 %. Taking into account the efficiency of NG-based electricity generation, e.g. a STAG reaching 50–55 %, one can conclude that there is hardly any difference in primary fuel consumption.

Cooling water is needed to cool the induction coil.

Technical considerations relevant to applicability

The applicability of inductive heating in a single wire line concept is quite wide and includes applications where exact temperature control is required.

Use of inductive heating in a multi-wire line concept is limited to applications where exact temperature control is not an issue, e.g. preheating.

Applicability is dependent on wire properties. See above.

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

4.4.11 In-line pickling

See Section 5.2.5.1.

WORKING DRAFT IN PROGRESS

4.5 Emerging techniques for wire drawing

TWG, the content of the previous BREF in this Section has been deleted for Draft 1.

Emerging techniques present in the old BREF, for which information was received from the TWG, have been moved and integrated as BAT candidates. For other remaining emerging techniques, the TWG is requested to indicate whether they should be kept (in which case updated information should be sent), or deleted.

Finally, the TWG is requested to send information on possible new emerging techniques that could be considered in the revised version of the BREF document.

WORKING DRAFT IN PROGRESS

5 CONTINUOUS HOT DIP COATING

5.1 General information on continuous hot dip coating

For the entire Section 5.1 'General Information on continuous hot dipping, Please provide updated information for Tables '5.1 and 5.2 and revise Figure 5.1 (Reference date; 1997 – OLD DATA)

The production of continuous hot dip coating lines in the EU-15 was 15 Mt in 1997. The number of continuous plants in EU Member States - operating, under construction and planned - is shown in Table 5.1.

Table 5.1: Number of continuous coating lines in the EU-15

| | Number of continuous coating lines |
|-----------------------------------|------------------------------------|
| Austria | 4 |
| Belgium | 6 |
| Denmark | NI |
| Finland | 2 (+ 1 under construction) |
| France | 14 |
| Germany | 10 |
| Greece | 1 |
| Ireland | NI |
| Italy | 8 |
| Luxembourg | 3 |
| Netherlands | 1 (+1 projected) |
| Portugal | 1 |
| Sweden | 2 |
| Spain | 4 (2 under construction) |
| United Kingdom | 7 |
| Total | 63 |
| NB: NI = No information provided. | |
| Source of data: [EUROFER CC] | |

The vast majority of coatings applied, as shown in Figure 5.1, were zinc. Aluminium coatings and especially terre coatings played only a minor role.

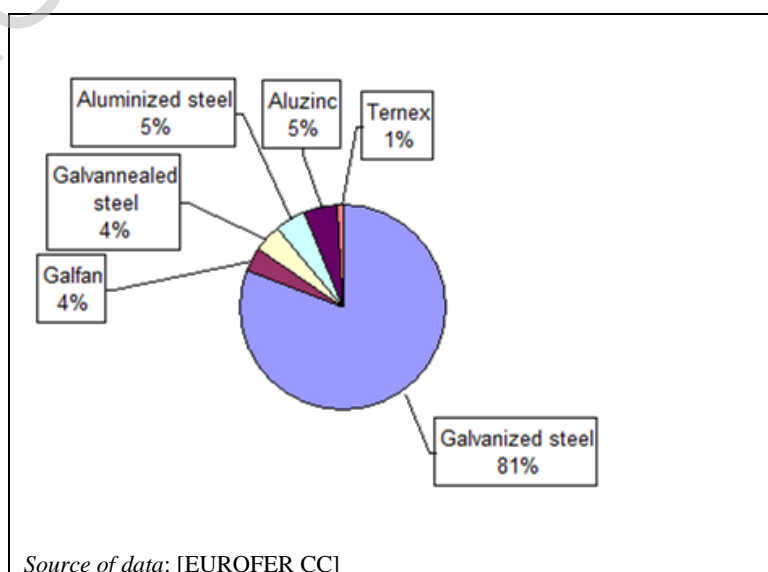


Figure 5.1: Production share for different hot dip coatings

The hot dip galvanising production for western European companies in 1997 is shown in Table 5.2.

Table 5.2: Hot dip galvanising companies and their production

| Company | Production [thousand t] |
|-------------------------------------|----------------------------|
| Usinor | 2 124.7 |
| Cockerill Sambre | 1 917.1 |
| Thyssen | 1 661.2 |
| British Steel S.P. | 1 568.0 |
| Krupp-Hoesch | 1 310.0 |
| Riva | 1 024.0 |
| Aceralia | 722.5 |
| Arbed | 680.8 |
| Hoogovens Ijmuiden | 375.0 |
| Lucchini | 600.0 |
| Rautaruukki | 572.5 |
| Voest-Alpine | 520.0 |
| Preussag | 520.0 |
| SSAB | 505.0 |
| Others | 595.5 |
| TOTAL | 14 696.3 |
| <i>Source of data: [EUROFER CC]</i> | |

Table 5.3 shows the shares of galvanised-products-consuming industries in the EU.

Table 5.3: Main consuming industries for galvanised products

| Sector | Consumption [thousand t] |
|-------------------------------------|-----------------------------|
| Transport | 2 570 |
| Construction | 4 759 |
| White Lines | 364 |
| Others | 4 547 |
| Total | 12 231 |
| <i>Source of data: [EUROFER CC]</i> | |

5.2 Applied processes and techniques in continuous hot dip coating

Information received from the TWG has not yet been revised and incorporated in this section. This will be done after draft 1.

5.2.1 Continuous hot dip coating process overview

In the hot dip coating process, the steel is continuously passed through molten metal. An alloying reaction between the two metals takes place, leading to a good bond between the coating and the substrate.

Metals suitable for use in hot dip coating are those which have a melting point low enough to avoid any thermal changes in the steel product, for example aluminium, lead, tin and zinc.

The principal hot dip coatings for steel sheet are shown in Table 5.4. Wire is hot dip coated with zinc (galvanised) or tin. Zinc coating is mainly applied as corrosion protection. Tin gives the wire a shiny appearance and also provides a solder adhesive layer.

Table 5.4: Main hot dip coatings for steel sheet

| Coating base | Bath | Coating | |
|---|-------|------------------------------|--------------|
| | | Type | Name |
| Zinc base | Zn | Zn | Galvanised |
| | Zn | Zn-Fe | Galvannealed |
| | Zn | Lead-free | |
| | Zn-Al | 99 % Zn, 1 % Al | Crackfree |
| | Zn-Al | 95 % Zn, 5 % Al | Galfan |
| Aluminium Base | Al-Zn | 55 % Al, 43.5 % Zn, 1.5 % Si | Galvalume |
| | Al | Al | Type I |
| | Al-Si | 87 % Al, 13 % Si | Type II |
| Lead base | Pb-Sn | 8.25 % Sn | Terne |
| | | 75–92 % Pb | |
| Source of data: [EUROFER CC] [Com-CC-2] | | | |

In general, **continuous coating lines for sheet** comprise the following steps:

- surface cleaning by means of chemical and/or thermal treatment;
- heat treatment;
- immersion in a bath of molten metal;
- finishing treatment.

Continuous wire galvanising plants involve the following steps:

- pickling;
- fluxing;
- galvanising;
- finishing.

5.2.2 Galvanising of sheet (zinc and zinc alloy coating)

In continuous hot dip galvanising, steel strip is coated with a zinc or zinc alloy layer as corrosion protection. Figure 5.3 shows the layout of a continuous galvanising line (without pickling). Plant layouts may vary in the design of the entry section (with/without pickling or alkaline degreasing), in the design of the annealing furnaces (vertical or horizontal) or the post-dipping treatment (galvannealing etc.)

Hot dip galvanising of cold rolled strip is more common than galvanising hot rolled strip. The process is similar, except that for hot rolled products additional descaling (pickling) is necessary.

5.2.2.1 Pickling

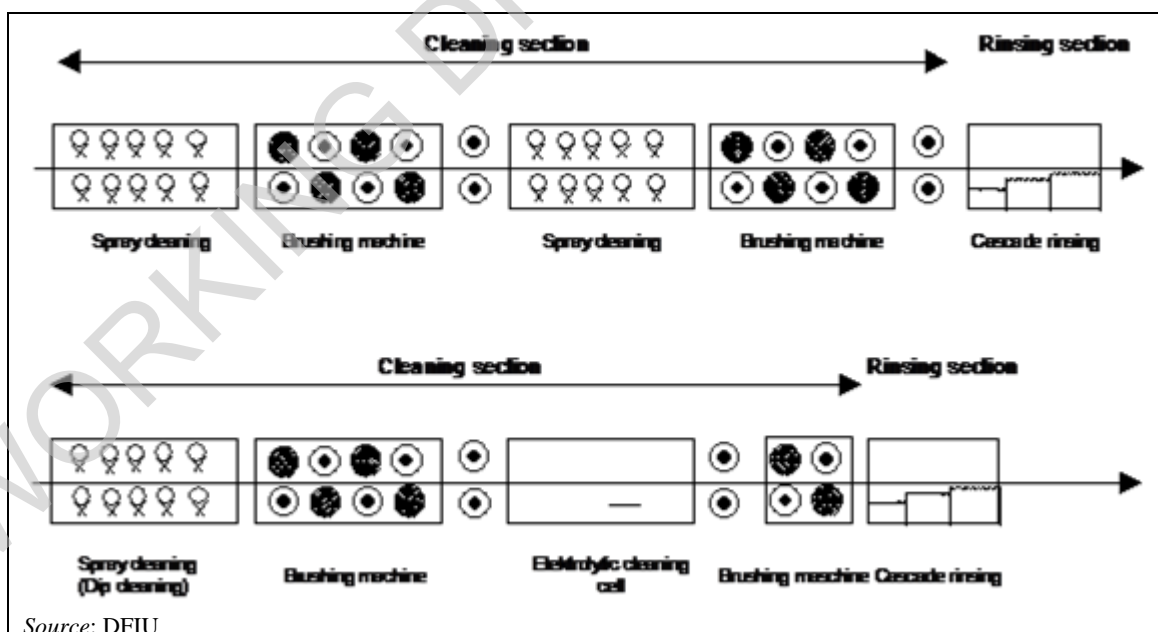
Pickling for descaling is only necessary for galvanising hot rolled products to remove hot mill scale. Pickling of unannealed cold rolled coil is done for activation. Both processes are done in hydrochloric acid, followed by rinsing. The technology is the same as the pickling process described in Chapter 3 of this BREF.

5.2.2.2 Degreasing

It is essential that the surface of the steel coil is free of impurities such as grease, oil or abraded iron fines to ensure that the entire surface is exposed to the coating product and strong adherence is achieved. Although degreasing is not necessary when the strip is subsequently heat-treated, it is often applied in any case. The cleaning process involves several or all of the following steps:

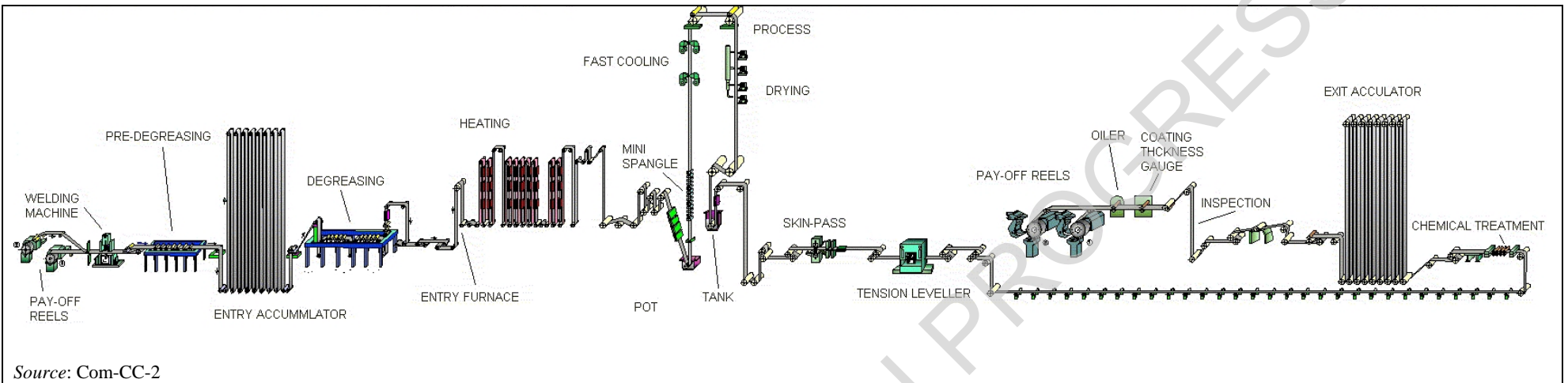
- alkaline degreasing via immersion or by spraying; may be coupled with brushing;
- alkaline degreasing by an electrolytic system; may be coupled with brushing;
- rinsing with water with intermediate brushing between rinsing tanks;
- drying.

Figure 5.2 shows two possible layouts for modern degreasing lines.



Source: DFIU

Figure 5.2: Degreasing line layouts



Source: Com-CC-2

Figure 5.3: Typical layout for a hot dip zinc coating line

The degreasing agent is usually a non-siliceous alkaline solution with a concentration of 25 g/l and a temperature between 70 °C and 95 °C. Aqueous systems are now standard and solvent degreasing is obsolete. [ERM95] [Com-CC-2]

The same aqueous solution containing mainly sodium hydroxides, orthophosphates and surfactant compounds is used in spray degreasing and in electrolytic degreasing. Once the solution in the electrolytic degreasing section has reached a certain oil level, it is reused in the spraying section (cascade use). It is also possible that the solution is treated in an emulsion separation centre and then biologically treated [Com-CC-2] When the solution has reached the maximum oil content it is regenerated, usually off site. [EUROFER CC]

Fumes generated in degreasing and brushing are collected and scrubbed prior to release, using water or caustic soda solution, and/or led through a demister for cleaning. [Com-CC-2] Spent degreasing agent and waste water from the rinsing and brushing operations are sent to waste water treatment before release. [EUROFER CC]

5.2.2.3 Heat treatment

Hot and cold rolled steel coil are passed through a furnace with controlled atmosphere prior to galvanisation to degrease and dry the surface, to improve the adhesive properties of the surface, to obtain the required mechanical properties of the steel and to allow the steel to reach the required temperature before dipping. The following types of furnaces are used:

Sendzimir furnace

This type of furnace is no longer used in modern coating lines, but some older plants might still operate this horizontal continuous furnace, which comprises a directly heated preheating furnace (oxidising zone) and indirectly heated reduction and holding zones with reducing H_2/N_2 atmospheres, followed by cooling zones. In the preheating part of the furnace, the temperature is 450–550 °C. The strip is cleaned by burning off the oil and the oil emulsion residues. In the reduction zone, at a temperature of 980 °C and in an inert atmosphere the oxides are reduced. The holding zone allows for recrystallisation and normalisation. The strip is then cooled to a temperature slightly above that of the molten metal (around 500 °C) and is fed into the zinc bath, under protective gas, by means of a so-called snout.

Direct-flame furnace (DFF)

The direct-flame furnace (non-oxidising type) can be divided into different sections:

- a warming-up section where the strip is preheated using the gas flow coming from the furnace; the temperature raises from 20 °C to approximately 250 °C);
- the furnace itself, where the coil is heated directly by means of a naked flame, reaching a temperature between 560 °C and 750 °C;
- the annealing zone where electric or radiant elements heat the strip up to 830 °C and maintain this temperature under a reducing atmosphere (HN_x atmosphere, 3–20 % hydrogen);
- two cooling areas, with different cooling rates, where the temperature of the steel is reduced by jet cooling down to 450–480 °C;
- the exit area where the steel goes towards the galvanising bath.

This type of furnace cleans the coil surface and does not require any prior degreasing of the metal, but emissions to air are generated as the remaining oil from the surface is burnt. Furthermore, combustion products H_2 and N_2 arise from the furnace (fired by natural gas or desulphurised coke gas). [EUROFER CC] [Com-CC-2]

Radiant tube furnace (RTF)

The radiant tube furnace is a variation with indirect heating. The combustion gases circulate through radiant tubes and do not come into contact with the strip. The soaking zone can be fitted

with radiant tubes or electric heating. Alkaline degreasing and radiant tubes or electric heating are required for very high quality standards and for improving the adherence of the following metallic coating. The fast-cooling areas are similar to those of a DFF. The annealing furnace is combined with alkaline degreasing equipment. [EUROFER CC] [Com-CC-2] [Com2 CC]

Fuels used are desulphurised coke oven gas and natural gas. Energy conservation is a primary consideration in modern furnace designs. Recuperative features, such as infrared waste gas preheaters, preheating of combustion air in direct-flame furnaces and radiant tube furnace burners, preheating of furnace atmosphere gas and installation of waste heat boilers are generally incorporated when feasible.

5.2.2.4 Hot dipping (galvanising)

The galvanising bath consists of one or more tanks, usually made of ceramic material. These pots, which can be either fixed or mobile, contain the molten metal at a temperature of 440–490 °C, through which the strip is passed. The bath contains zinc and any other required additive (i.e. antimony, lead or aluminium). The bath contains a sufficient amount of molten zinc in order to prevent the wide fluctuations in the operating temperature that may appear under maximum operating conditions. Most pots are nowadays heated by electrical induction systems. However, natural gas as fuel for heating the pots is an alternative when considering the environment as a whole and taking environmental aspects of power generation into account. [EUROFER CC] [Com-CC-2]

As the steel passes through the molten zinc bath the surface is coated, to some extent with layers of different iron-zinc alloys, but, due to the high speed of the steel strip (maximum 180 m/min) and the short exposure time, the coating mainly consists of zinc.

Temperature control of the bath is essential, as a high temperature will increase the rate of oxidation at the surface of the molten bath, resulting in increased ash generation. A low bath temperature will increase the viscosity of the molten coating metal, thus inhibiting the formation of a thin coating layer. The bath temperature is therefore optimised to meet the individual quality requirements of the final coated product.

The strip leaves the bath with some amount of liquid zinc on the surface. In order to achieve the exact thickness of coating required, the strip passes through a series of jets placed above the surface of the bath. By blowing air or nitrogen, the excess zinc is removed from the steel. The system is usually controlled by an automatic gauge, which measures the thickness of the coating using X-ray measurement technology or a similar technique.

Special galvanising processes to produce one-sided coatings are also applied. Examples are the Monogal process in which the zinc coating after normal galvanising is brushed off by rotating metal brushes and processes in which the zinc is applied by carrier rolls.

On leaving the bath, the strip is gradually cooled by air coolers, followed by a water quench tank and a dryer.

5.2.2.5 Galvannealing

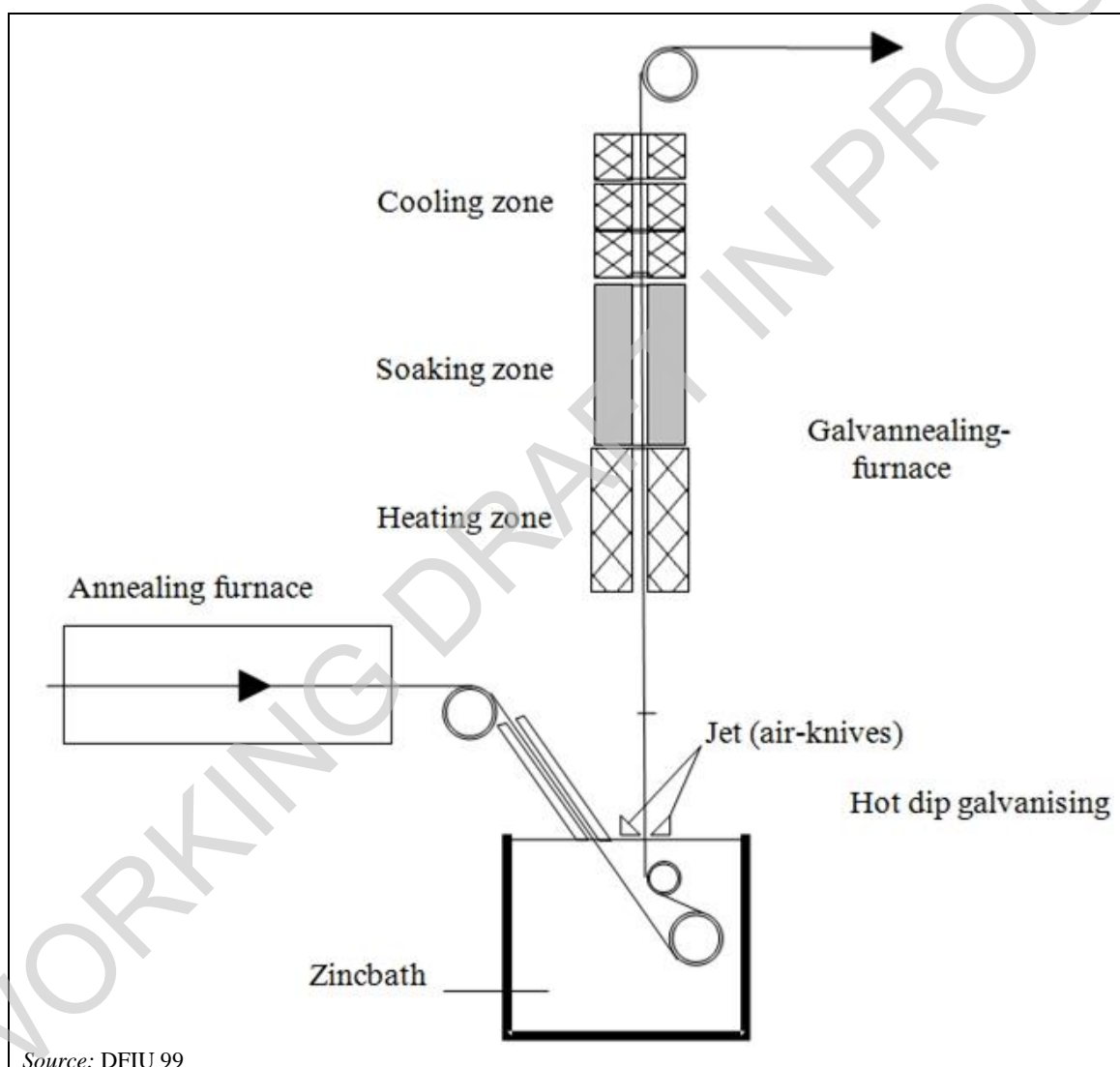
Galvannealing is a special post-treatment applied in some installations in which the strip, after galvanising, is heated to a temperature that allows the formation of a zinc-iron alloy (10 % iron). Galvannealing results in the product having a particularly smooth appearance.

Galvannealing is the alloying of the zinc layer by the diffusion of iron (Fe) from the steel substrate. The iron diffusion is obtained by maintaining the steel at a temperature of about 500 °C, for low-carbon steel, to a temperature of about 540 °C, for new-generation high strength

steel, during a sufficient time. Such furnaces are divided in two zones: a heating zone and a soaking zone. The available space for the furnace is limited. For the same available surface, a very quick heating from the zinc bath temperature (460 °C) to the soaking temperature allows a longer soaking time to be applied. Some furnaces are equipped with an induction heating system in the heating zone and electrical elements or radiant tubes in the soaking zone. The induction heating technique is characterised by a short heating time, a short reaction time, and an accurate regulation of the temperature and no emissions on the site. The alloying and surface qualities are improved.

Other galvannealing furnaces are equipped in the heating zone and in the soaking zone with radiant tubes characterised by a longer heating time. In that case, the site emissions and the energy consumption are improved by the use of low-NOX burners and regenerative or recuperative burner systems. [Com2 CC]

Figure 5.4 shows the schematic of view of the coating section and the galvannealing furnace.



Source: DFIU 99

Figure 5.4: Schematic coating section of a galvannealing line

5.2.2.6 Post-treatments

Following the coating, the steel strips are usually subjected to post-treatment in order to prevent surface damages and flaws, like white rust caused by water condensation in the case of

insufficient air access. Voluminous corrosion products such as zinc hydroxides (white rust) affect further processing, e.g. painting. The formation of condensate during transportation and storage is to be generally prevented. [Com-CC-2]

Resistance against white rust is considerably increased by the application of a post-treatment, like oiling, passivation, phosphating, organic coating or a combination of such treatments. [Com-CC-2]

Oiling

To apply a wet film of oil on the surface of the strip dip spray, wingrolls or electrostatic oiling machines are used. The oiling coat is between 0.25 g/m²/side and 3 g/m²/side. [Com-CC-2]

Passivation

Chemically passivated steel strips from the steel-making industry are produced inline in a galvanising line. This means that the passivation solution is applied through a spray header onto the top and bottom sides (superfluous wet film is squeezed off by means of hard rubber rollers) or supplied with a chemcoater on the bare galvanised strip. The wet film is subsequently dried in a hot-air dryer.

Product description

There are many possibilities, which depend on the chemical passivation ingredients (non-exhaustive list as follows):

- I. Cr⁶⁺ passivation (although this is not considered asBAT due to environmental issues;
- II. Cr-free passivation one; e.g. consisting of types of manganese, zinc, titanium fluoride, phosphates and molybdates;
- III. Cr-free passivation two; an organic system, e.g. consisting of acrylic and carboxylatic polymers and phosphates;
- IV. Cr(III) - passivations; e.g. consisting of types of Cr(III) fluorides;
- V. Cr-free or Cr(III)-based passivation with organic polymers; e.g. consisting of types of Cr(III) fluorides or Cr(III) nitrates with water-soluble polymers of acrylic acid, latex polymers and other organic polymers.

This solution for example consists of a combination of phosphoric acid combined with titanium, molybdenum and manganese complexes. This solution almost achieves the performance of thin Cr(VI)-containing coatings.

The coating has a very fine structure, and the one of the chromium-free passivation coatings was proven to be completely amorphous with the aid of discontinuous X-ray fluorescence measurements. The protective properties of this coating formed by a conversion reaction are predominantly a function of a very effective barrier against corrosive ions and substances.

The corrosion protection of this chromium-free passivation coating as demonstrated in the saltwater spray test strongly depends on the coating thickness. The coating thickness (an important quality criterion) is determined by the lead element titanium and by means of X-ray fluorescence analysis. If the coating thickness is too thin, corrosion protection will not be sufficient in the saltwater spray test. If the coating thickness is too thick, weldability and the metallic shine of the surface will be lost.

Cr(III) and Cr -free chemical passivation techniques are now well established, but in continuous development, in several applications and are considered the state-of-the-art for chemical passivation in Europe at the time of writing this document.

Passivation is a treatment with solvents containing chromic acids, applied by spraying or applicator rolls. For hot dip metal-coated strip, a coat of 10–35 mg/m² per side is applied. The coat thickness is therefore extremely thin (a few nanometres only). During passivation, Cr⁶⁺ is mainly converted to Cr³⁺. Almost all of the installations have a small heater after the treatment

to make sure that the temperature rises over 120 °C, which is necessary for the chemical reaction of excess Cr^{6+} with the additives of the passivation solution and conversion to Cr^{3+} . The strip is treated with solutions between 0.5 % and 2 % Cr^{6+} and temperatures between 70 °C and 120 °C. [Com-CC-2] [Com2 D]

Phosphating

In phosphating, a phosphate coat of approximately 1–1.8 g/m² is applied. The phosphating procedure is more or less a precipitation reaction of zinc phosphate crystals at the surface of the metal coat caused by an increase in the pH value at the metal surface due to a pickling reaction. The tri-cation phosphation process could be used (the hopeite crystal $\text{Zn}_3(\text{PO}_4)_2 \cdot 4 \text{H}_2\text{O}$ incorporates approximately 1 % nickel and 5 % manganese). Thus, this process forms the same chemical structure of the phosphate coat as the high-quality phosphating processes for cars and household appliances do. [Com-CC-2]

5.2.2.7 Finishing

To give the steel a special surface appearance, smoothness, etc. as required by the customers or to meet width tolerances, the following operations may be applied:

Mini- or no-spangle treatment

If the cooling rate of the top layer of pure zinc is sufficiently low, large crystals will form resulting in a ‘spangled’ appearance. Sometimes, smaller zinc spangles or even a no-spangle effect is requested. In that case, the strip is either cooled more rapidly or the number of points of spangling are increased by steam spraying, steam spraying with a chemical additive (usually phosphate-based) or spraying with zinc powder. [ERM95]

Matte mill

The strip is skin-passed to obtain a matte finish surface.

Skin-pass treatment can be done in three different ways: dry, wet (only water) or wet (with water and detergent). The ‘temper mill’ solution generated in the latter process must be collected and sent to a waste water treatment plant when it is spent.

Edge cutting

For certain applications, edge cutting must be done in order to obtain the width tolerance needed and to avoid little dog bone defects. There are two places to realise this process:

- in the pickling line before cold rolling;
- in the hot dip coating process.

A perfect product schedule tries to reduce this process to the minimum to increase the line yield. [Com-CC-2]

5.2.2.8 Cooling water circuits

In coating plants, cooling water is required to discharge excessive heat from furnaces. Part of the heat energy is emitted directly to the air (with the waste gases), via the coated strip or the shop air. The rest is transferred to the cooling water. The main cooling water consumers are the furnace (roll bearings) and final cooling of the strip.

A coating plant is supplied with cooling water recirculated from central cooling water systems. In these systems, pumps convey the cooling water to the consumers; the heated water is returned and recooled again in plate heat exchangers with industrial water (e.g. from the river).

Due to the insertion of the closed recooling water circuits, the industrial water, even in the event of the leakage of a cooler, does not come into contact with the equipment of the consumers; so the entry of chemicals or oil into the industrial water and pollution of the sewage system are prevented.

There are several variants of recooling; two of them are:

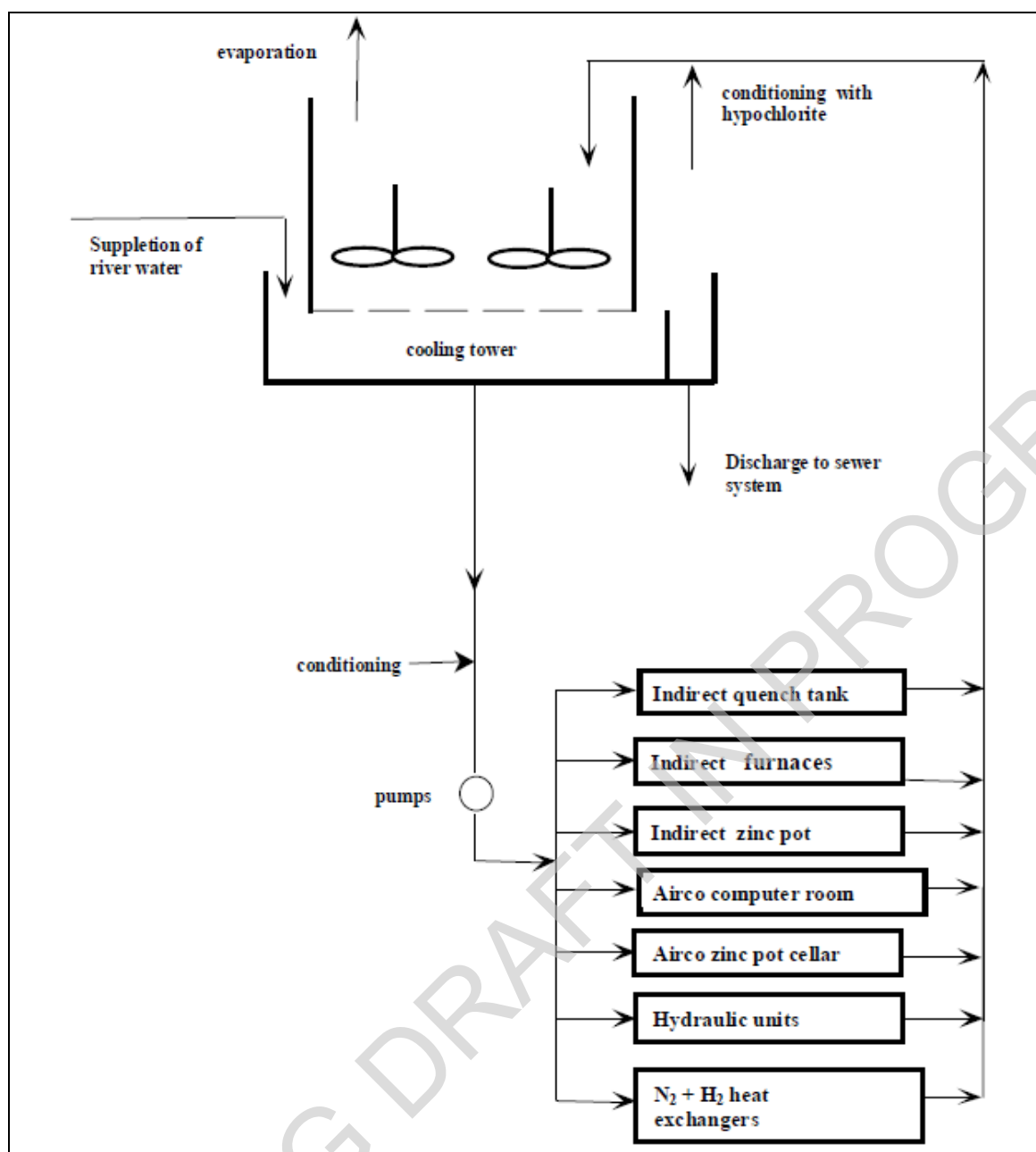
- recooling with industrial water in heat exchangers; and
- recooling by evaporation in cooling towers.

Compared to recooling in towers, recooling in plate exchangers offers the advantage that considerable amounts of chemicals for cooling water treatment (such as corrosion inhibitors, hardness stabilisers, dispersants and biocides) can be saved, and are not discharged into the sewage system. Another advantageous feature is that it is not necessary to discharge partial flows with a high salt content caused by the evaporation, as was the case of cooling towers. [EUROFER CC]

Typical configuration of a cooling loop with cooling towers

The little discharge that is necessary for keeping a low salt concentration in the water sent to the sewer system is mostly carried out continuously. Algaecide (for avoiding the saturation of the contact zone between the water and the air) is dosed. The frequency is variable depending on the weather (between one and three times a week).

Other chemicals could be necessary depending on the composition of the water used in the circuit (hardness, etc.).



Source: CC 11/99

Figure 5.5: Typical configuration of a cooling loop with cooling towers

Configuration for recycling water using a plate heat exchanger

Cooling water is recirculated in several closed cooling systems and heated by the heat expelled from the process (machine cooling, gas cooling, etc.). The cooling water is recooled by river water in heat exchangers. The river water on the secondary side of the heat exchanger is never in contact with the strip or harmful media and is therefore not contaminated. The water becomes only heat-loaded and can be drained back to the river. The main cooling water consumers are the preheating and annealing furnaces, the zinc pots, several roll coolings, the immersed water coolers, the activation section, the electrical equipment, the hydraulics and air conditioning.

All heat which is not removed by the cooling water has to be discharged either as waste gas or to the ambient air.

With this system, the addition of algacide and scale-preventer is avoided. The outlet water is only heat-loaded. This is advantageous if the system water does not come into contact with any contaminants.

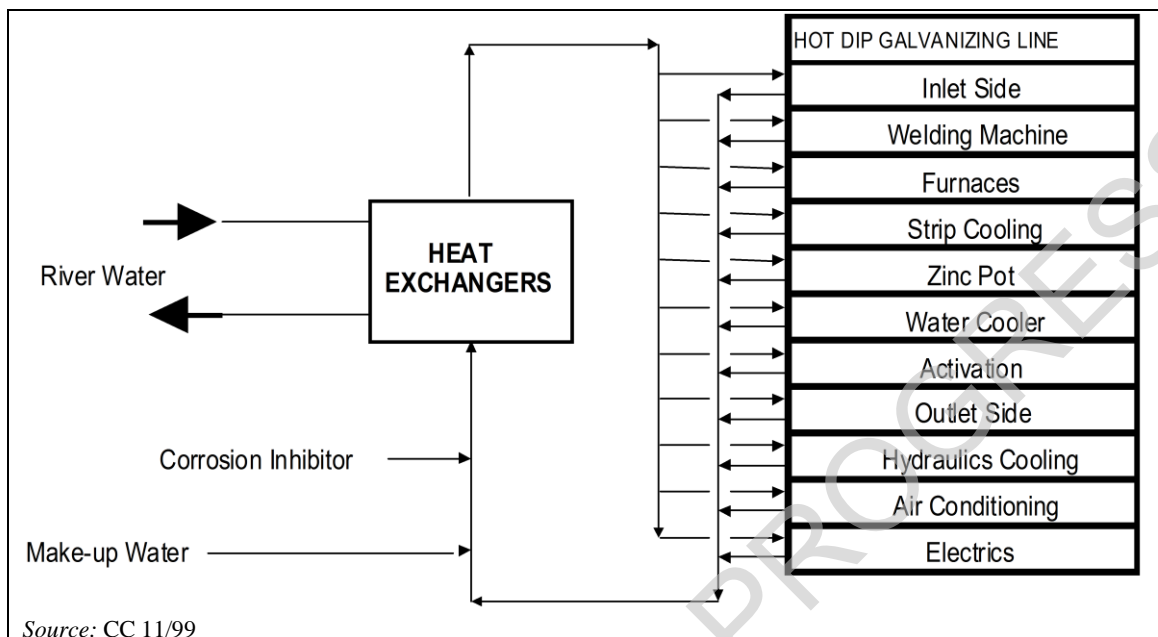


Figure 5.6: Cooling water system with heat exchangers

5.2.2.9 Water circuits / Water management

Process water is water which is used for make-up of chemical solutions or which is in direct contact with the strip (e.g. water for direct strip cooling). It may be contaminated by the process and has then to be treated as waste water. The following process water streams are used at galvanising lines and are finally discharged as waste water:

- Make-up water (usually deionised water) for concentrate preparation of the chemical strip treatment sections (pretreatment, electrolytic treatment, post-treatment). The different concentrates are sprayed onto the strip or the strip is run through the concentrate bath. The concentrates are usually recirculated by pumps. They are clarified or filtered in recycling plants during recirculation. Only a small flow is discharged to the water treatment plant.
- Rinsing water (usually deionised water) for chemical treatment sections (pretreatment, electrolytic treatment, post-treatment). The rinsing water is used for removal of the remaining concentrate from the strip. The water is sprayed onto the strip in a cascade of rinsing sections, with the water flowing countercurrently to the strip. It is finally discharged as low concentrated waste water to the water treatment plant.
- Make-up water for the water cooler. In the water cooler, the strip is cooled first by recirculated spray water and finally by being run through a water bath with an immersed turn back roll. The water will be contaminated by abrasion dust and has to be discharged from time to time to the skin-pass mill water treatment plant.
- Spray water for the skin-pass mill. The water is used for keeping the working rolls clean. It is sprayed onto the rolls and contaminated by Zn-containing abrasion dust and lubricating oil and is discharged to the skin-pass mill water treatment plant.

5.2.3 Aluminising of sheet

Most aluminium-coated steel coil is produced by some variation on the hot dip galvanising process. Figure 5.7 shows the schematic line of production for applying aluminium coatings.

The production line usually includes a passivation section, which is either in-line or is off line in a separate process unit.

Due to the affinity of aluminium for oxygen, it is extremely important to ensure against the formation of an oxide layer which would prevent diffusion of the aluminium into the steel substrate. The steel is sometimes spray or chloride gas pickled prior to annealing [ERM95]. The formation of an oxide layer can then be prevented by using a number of methods, like:

- passing the washed and pickled steel through a furnace with a hydrogen atmosphere to eliminate oxygen (the absorbed hydrogen further protects the substrate as it passes into the molten aluminium bath);
- dipping the pickled steel in a molten aluminium bath that is kept saturated with hydrogen injected by submerged jets.

The aluminium bath is generally maintained at temperatures of about 690 °C. The coated coil can then be further heat-treated at 820–930 °C, which converts the aluminium coating completely to steel-aluminium alloy if required. [ERM95]

Following the coating, the strips may be subjected to post-treatment in order to prevent surface damage and flaws, such as white rust caused by condensation in the case of insufficient air access.

Anti-fingerprint: wringer rolls treatment of a polymer base coating on the strip surface. A coat weight (after drying) of < 1.5 g/m² per side is applied.

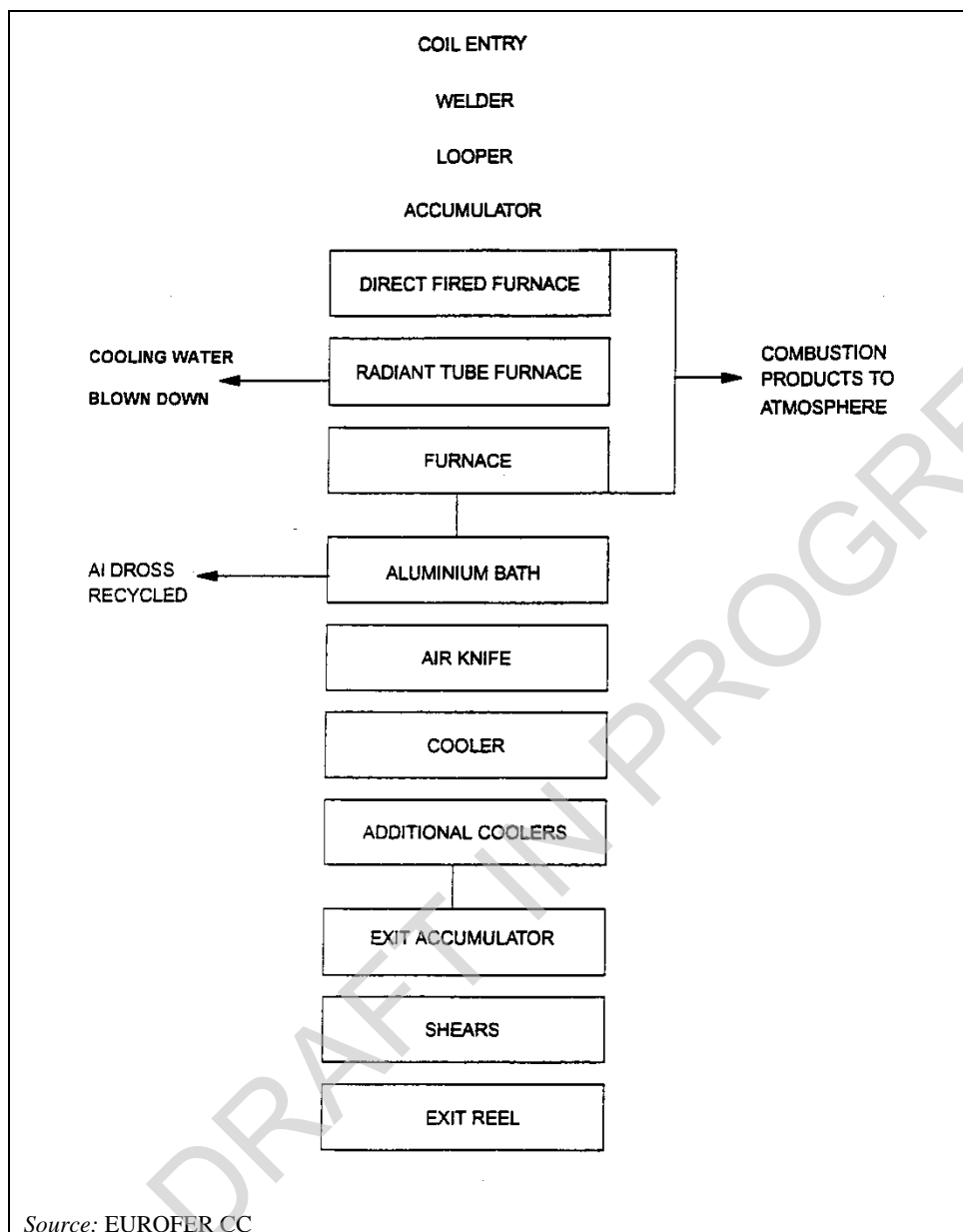


Figure 5.7: Aluminium coating process

5.2.4 Lead-Tin coating of sheet

Pure lead is never used as coating material for steel due to the fact that it is not possible to produce a lead-steel alloy and obtain an adhesive coating. However, steel coils are coated with a lead-tin alloy containing 8–25 % tin, called ‘terne’ metal. The terne metal can also contain up to 3 % antimony. Tin and antimony first form alloys with the steel substrate, which provides the adhesion for the lead-tin surface coating.

Terne coating provides a high degree of external corrosion resistance. The coating keeps its integrity during deep drawing and forming, and it also acts as a lubricant during the same operations. Terne coating has excellent solderability and is usually welded. It is widely used in the automotive industry for the manufacture of petrol tanks and for different applications such as gas meters.

A flow sheet for lead-tin coating (ternex process) is shown in Figure 5.8. First, the cold reduced substrate is cleaned by (electrolytical) degreasing and pickled, usually in warm diluted hydrochloric or nitric acid. Then, in cases of nickel flash terne coating, a thin nickel coating is

applied electrolytically. This improves the wetting of the substrate by the alloy in the following hot dip stage and yields continuous and uniform coatings. [ERM95]

The continuous film of nickel on both surfaces of the steel strip will readily alloy with tin to form the basis for a discontinuity-free layer ofterne metal. The strip is passed through plating cells, containing titanium baskets filled with nickel pellets. An electrolyte consisting of Watts solution (nickel sulphate/chloride) is heated and recirculated through the plating cell and is maintained at 65 °C with a pH of 2.5–5.0. [Com-CC-2]

In the following step, the steel enters the molten terne bath at a temperature of 310 °C through a zinc ammonium chloride flux. To control the coating thickness, air knives are used nowadays. These provide a wiping action to remove surplus lead from the strip's surface. Oil baths, which have been used in coating thickness control before, have been replaced due to their bad environmental performance. After cooling, the coil can be post-treated for protection either by oiling or passivation.

Passivation

To seal the surface of the strip and passivate any pores or exposed areas of substrate against oxidation, the strip is led through a dip tank with the passivation agent, usually chromic-acid-based. A squeegee roll system on the exit of the tank stops any carry-over from the tank and controls the film thickness. If required, a dryer can be used to raise the temperature of the strip and cure the chromate film on the surface of the strip.

Oiling

To apply a wet film of oil on the surface of the strip roller coater systems, spray systems or electrostatic oiling machines can be used.

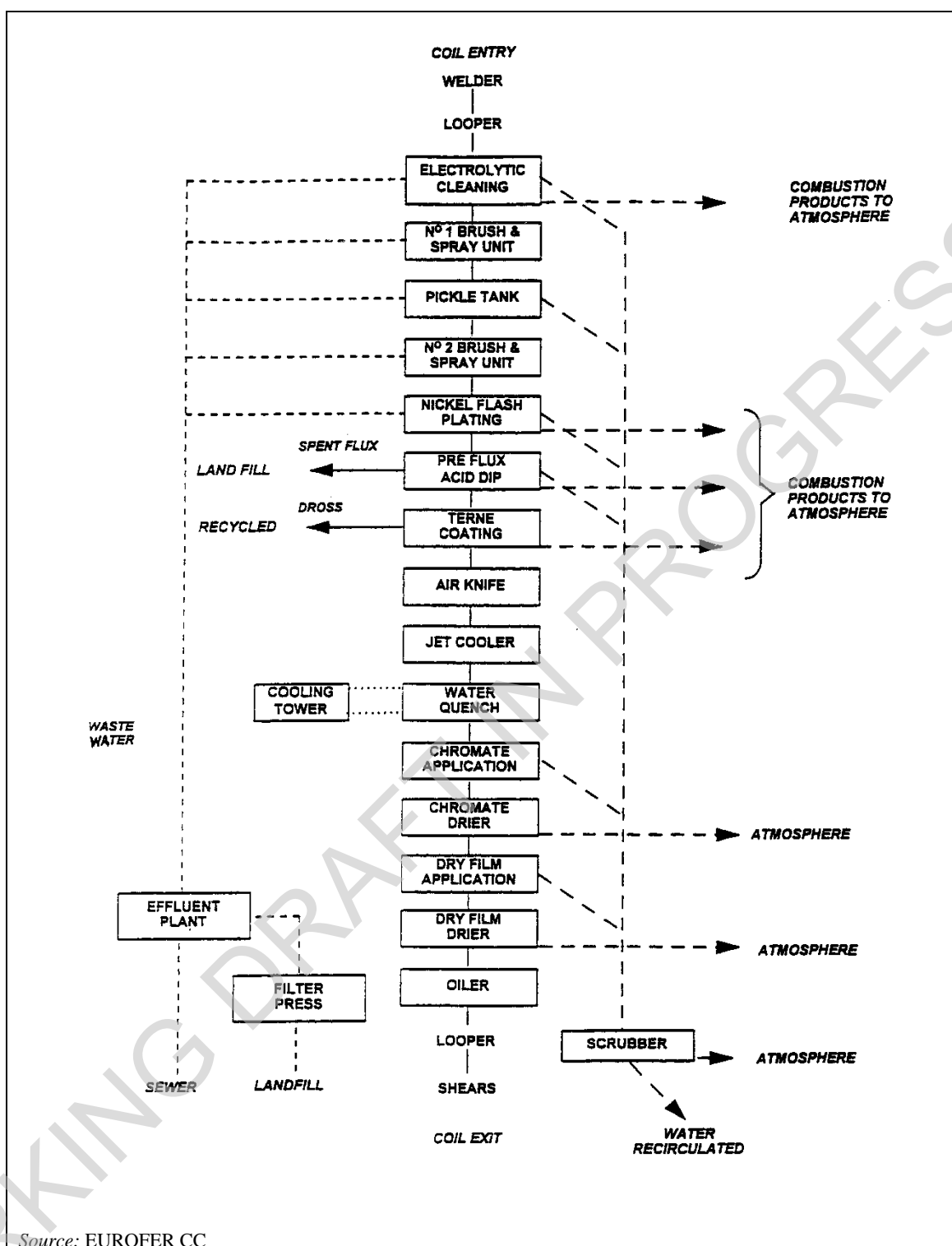


Figure 5.8: Ternex process

5.2.5 Wire hot dip coating

Wire is hot dip coated mainly with zinc and zinc alloys (e.g. Galvan (95 % Zn, 5 % Al)); the main function of these types of coating is corrosion protection. Other coatings that are applied by hot dipping are tin and aluminium. Aluminium is used for some corrosion protection on niche products. Tin gives a shiny appearance and also provides a solder adhesive layer. The application processes for these hot dip coatings are basically the same.

A continuous hot dip coating line for wire consists of the following process steps: the wire is pickled, rinsed, dipped in a flux bath, dried, passed through the molten metal bath and cooled again. Finally, a water-based protective coating (so-called wax) can be applied after the hot dip coating step. [Com BG]

5.2.5.1 Continuous pickling of wire

~~Following heat treatment (see also Section A.2.3.5),~~ After in-line pickling or as a starting step for hot dip coating, the wire is pickled to remove surface debris to improve its appearance or to prepare the surface for the application of coatings. This is usually done in-line either by immersing the wire in an acid bath or by subjecting it to a neutral salt bipolar electrolysis cell.

In acid pickling, the wire is cleaned by passing it continuously through one or more hydrochloric acid baths; sometimes H_2SO_4 is used. Due to the short residence times, the HCl acid is often heated (up to 60 °C) or is used in concentrated form. The type of impurities that are removed in this bath depend on the previous process step:

- For heat-treated wire: metal oxides, residues of soap carrier, possibly traces of lead.
- For drawn wire: residues of soap, oil or other lubricants and traces of rust. Sometimes a degreasing agent is added to the HCl bath to enhance removal of these substances. [Com BG].

Faster pickling and higher wire speeds are realised by increasing the length of the bath, by increasing the temperature of the HCl, by increasing the concentration of the bath or by applying electrolytic assisted pickling. HCl fumes from the pickling baths are collected and removed by scrubbing.

After pickling, the wire is passed through a rinsing cascade. [Com BG]

5.2.5.2 Fluxing

For good adhesion of the zinc coating, the wire is passed through a flux bath, a heated watery solution of $ZnCl_2$ and NH_4Cl (pure $ZnCl_2$ is used for tin coating). Excess flux is removed from the wire by wiping. Prior to coating, the wire is dried; this can be done in a furnace or with the internal heat of the wire. With high wire diameters and/or efficient wipers, the internal heat of the wire (due to the heating in the flux bath) is sufficient to secure a dry wire. The wire must be dry before entering the flux bath to prevent squirting at the inlet of the zinc bath.

The same flux media are used as for batch galvanising; however, the concentration is generally much lower. For zinc coatings, usually a $ZnCl_2/NH_4Cl$ mixture is used (pure $ZnCl_2$ is used for tin coating). [Com BG]

5.2.5.3 Hot dipping (galvanising)

The wire is passed through a molten zinc bath (430–470 °C). In the zinc bath, an iron-zinc diffusion layer is formed, consisting of sublayers of several Fe-Zn alloys. A zinc layer is formed on top of this at the moment the wire leaves the zinc bath. Galvanising can be divided into heavy (vertical) galvanising (high coating thickness; coating mainly consists of the withdrawn zinc) and regular (horizontal) galvanising (low coating thickness; the coating is mainly an iron-zinc alloy layer). [Com2 BG]

Most zinc baths are heated through the bottom and the side walls with natural gas or other fuel. Exceptionally, electric heating is used and/or heating is done from above the zinc bath.

A protective layer of particulate material or a bath cover can be applied on (a part of) the zinc bath, in order to minimise formation of zinc oxides and energy losses.

After the zinc bath, the wire is cooled to near ambient temperature using air and cooling water.

Hot dipping in other metals or alloys is done in the same way. [Com BG]

5.2.5.4 Finishing

Finally, a wax layer is applied for protection against formation of so-called white rust (superficial corrosion of the zinc layer).

5.3 Current consumption and emission levels for continuous hot dip coating

The information contained in this section of the old BREF has been removed and replaced with the data from the data collection. Old information, along with input from the TWG will be revised and added after draft 1.

5.3.1 Continuous coating mass stream overview

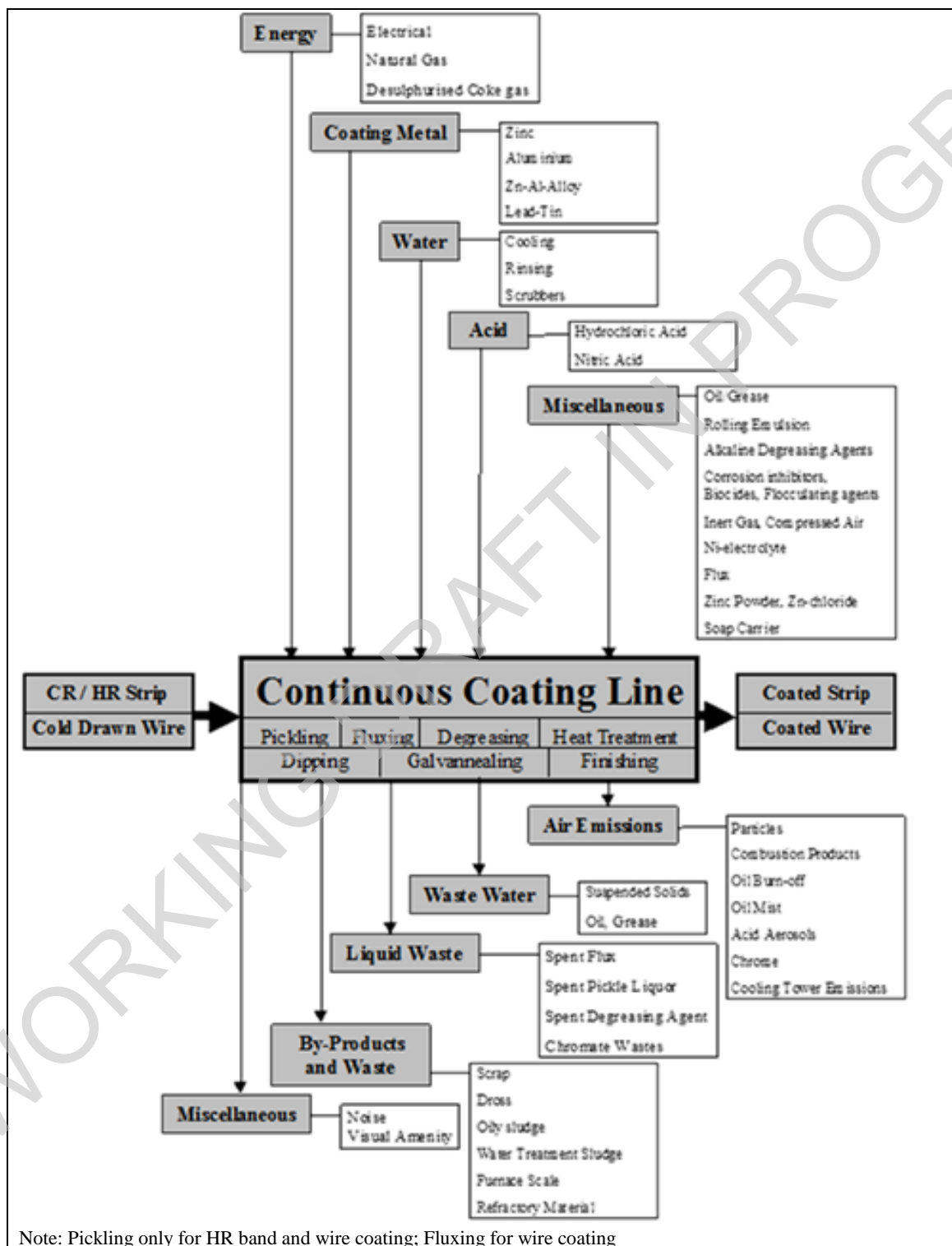


Figure 5.9: Input/output balance for continuous hot dip (sheet) coating lines

5.3.2 Energy efficiency

Figure 5.10 shows reported data on the specific energy consumption for feedstock heating before hot dipping of sheet and wire.

5.3.3 Material efficiency

5.3.3.1 Consumption of oils

Figure 5.11 shows reported data on the specific oil consumption for three operating years in hot dip coating plants of sheet and wire. Values of oil consumption include all types of oils used in the plant (e.g. hydraulic systems oil, anticorrosive oil, emulsion oil).

5.3.3.2 Consumption of acids

Figure 5.12 shows reported data on the specific HCl consumption for three operating years in hot dip coating plants. Specific HCl consumption is expressed in kg of 33-wt% acid per m² of treated (pickled) surface.

5.3.4 Water consumption

Figure 5.13 shows reported data on the specific water consumption for three operating years in hot dip coating plants of sheet.

5.3.5 Emissions to air

5.3.5.1 Emissions to air from heating

Dust emissions

The reported data on dust emissions to air from feedstock heating of sheet (heat treatment before dipping and galvannealing) are shown in Figure 5.14.

SO₂ emissions

The reported data on SO₂ emissions to air from feedstock heating of sheet (heat treatment before dipping and galvannealing) are shown in Figure 5.15.

NOX emissions

The reported data on NOX emissions to air from feedstock heating of sheet and wire (heat treatment before dipping and galvannealing) are shown in Figure 5.16.

CO emissions

The reported data on CO emissions to air from feedstock heating of sheet and wire (heat treatment before dipping and galvannealing) are shown in Figure 5.17.

5.3.5.2 Emissions to air from degreasing and oiling

TVOC emissions

The reported data on TVOC emissions to air from degreasing and oiling of sheet are shown in Figure 5.18.

5.3.5.3 Emissions to air from pickling

Reported data on dust and HCl emissions to air from pickling in hot dip coating can be found in the respective section for cold rolling. Data are presented together, as the processes are similar.

5.3.6 Emissions to water

Figure 5.19 to Figure 5.40 show the reported data on emissions to water, for direct and indirect discharges, per pollutant from plants treating waste waters from hot rolling.

5.3.7 Residues

Figure 5.41 shows the reported data on the specific generation of hard zinc (zinc dross) for three operating years in hot dip coating plants.

5.3.8 Figures with consumption and emission levels

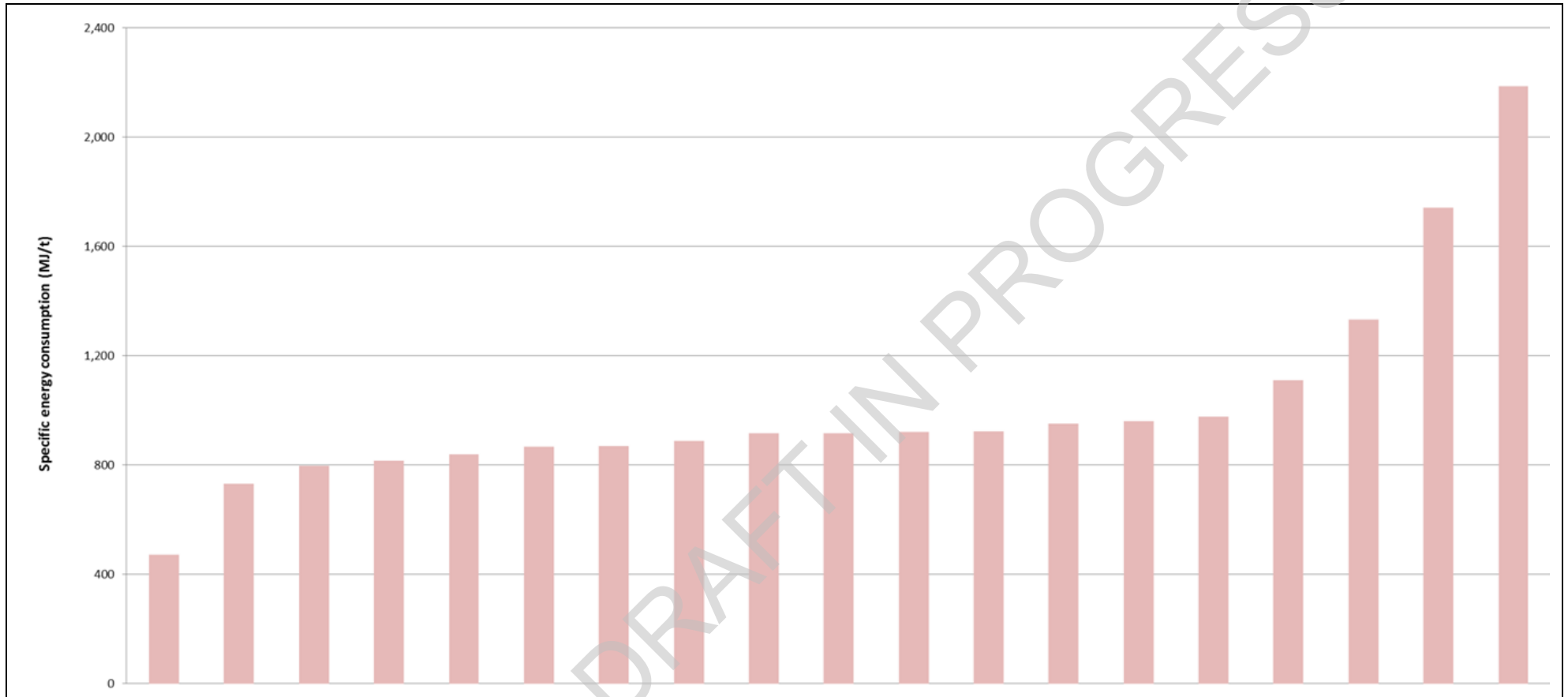


Figure 5.10: Specific energy consumption (MW/t of process throughput) for feedstock heating before hot dipping of sheet and wire. Source: [TWG 2018].

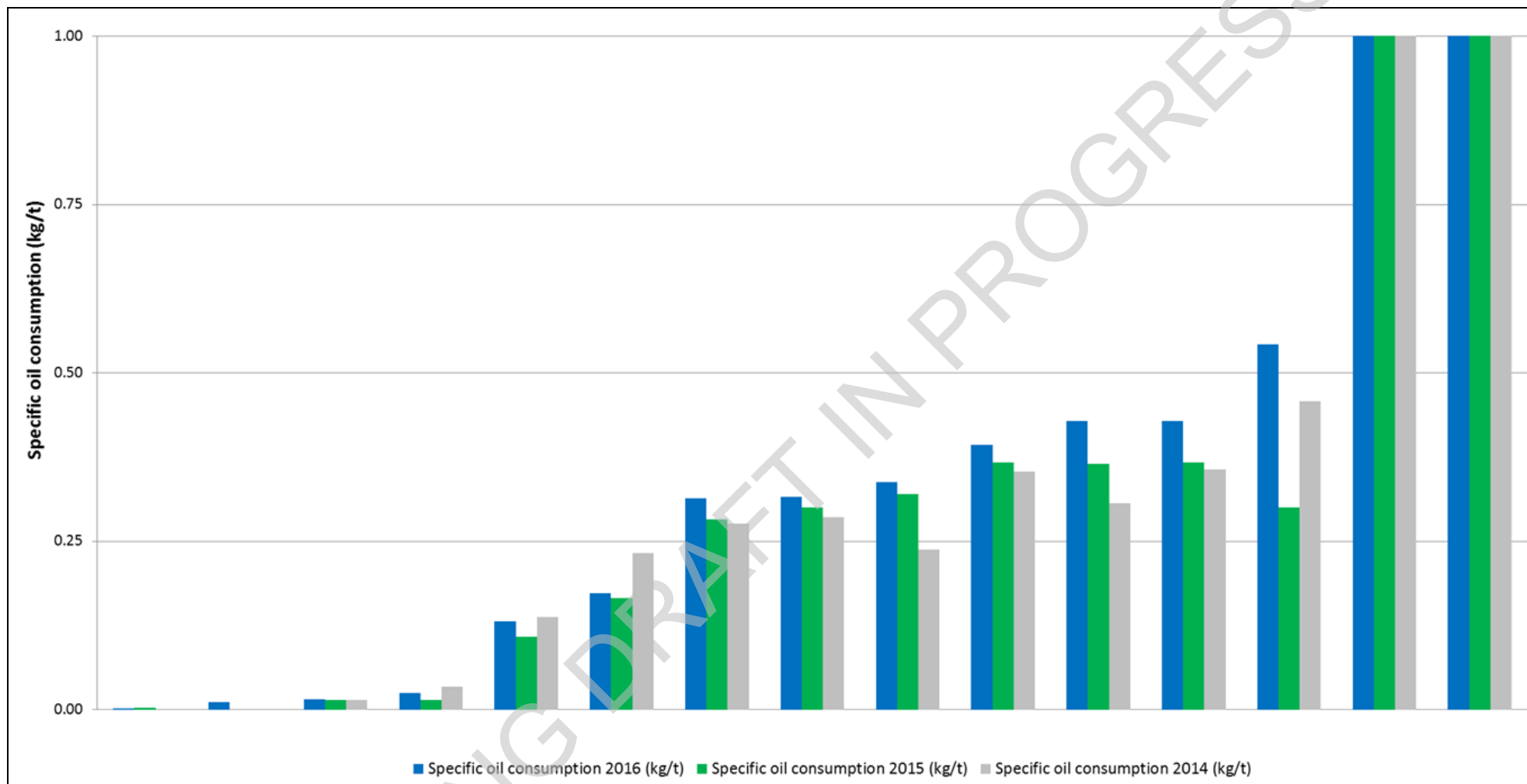


Figure 5.11: Specific oil consumption (kg/t of production) in hot dip coating plants of sheet and wire. Source: [TWG 2018].

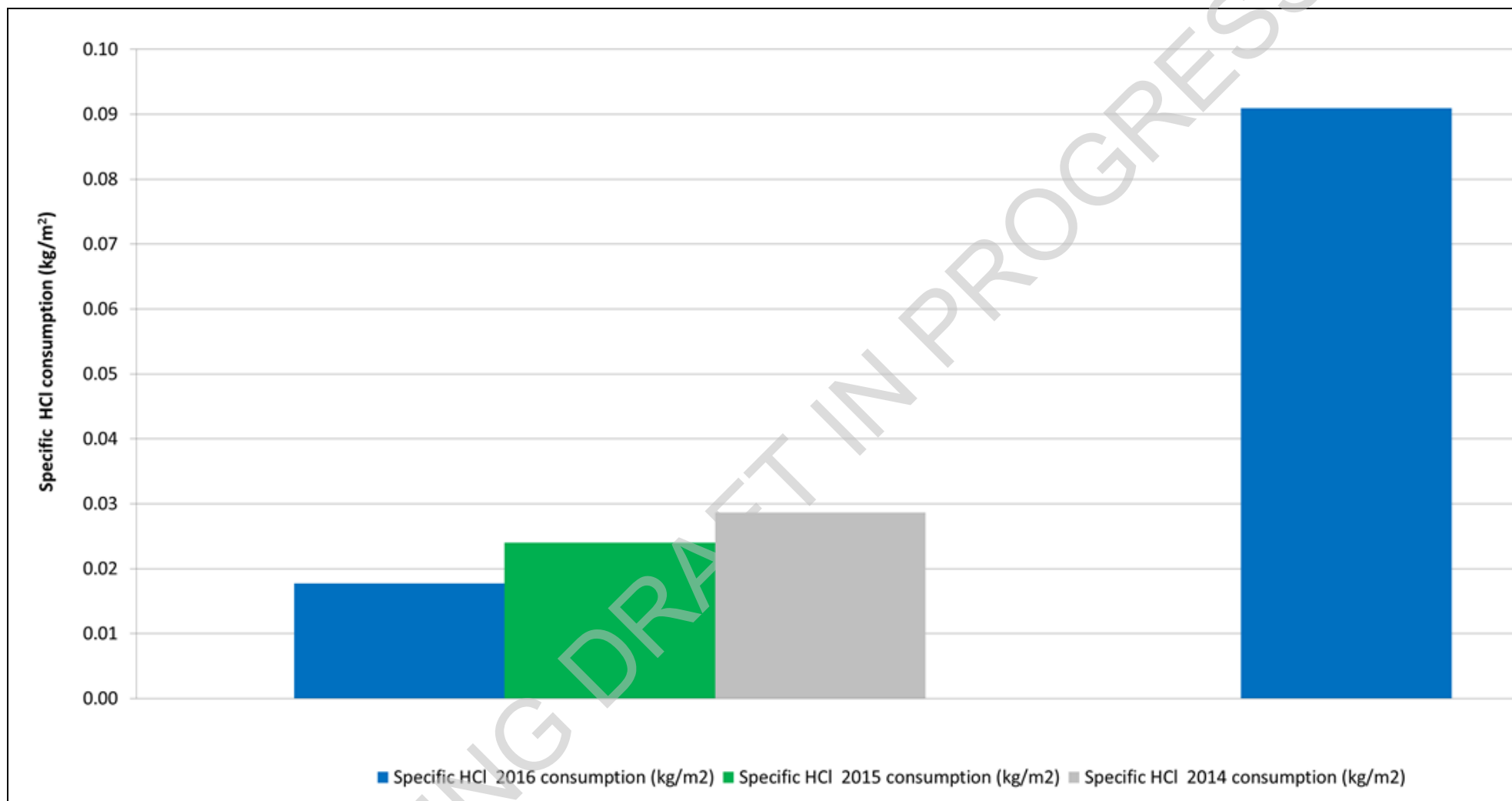


Figure 5.12: Specific HCl consumption (kg/m² of treated surface) in hot dip coating plants. Source: [TWG 2018].

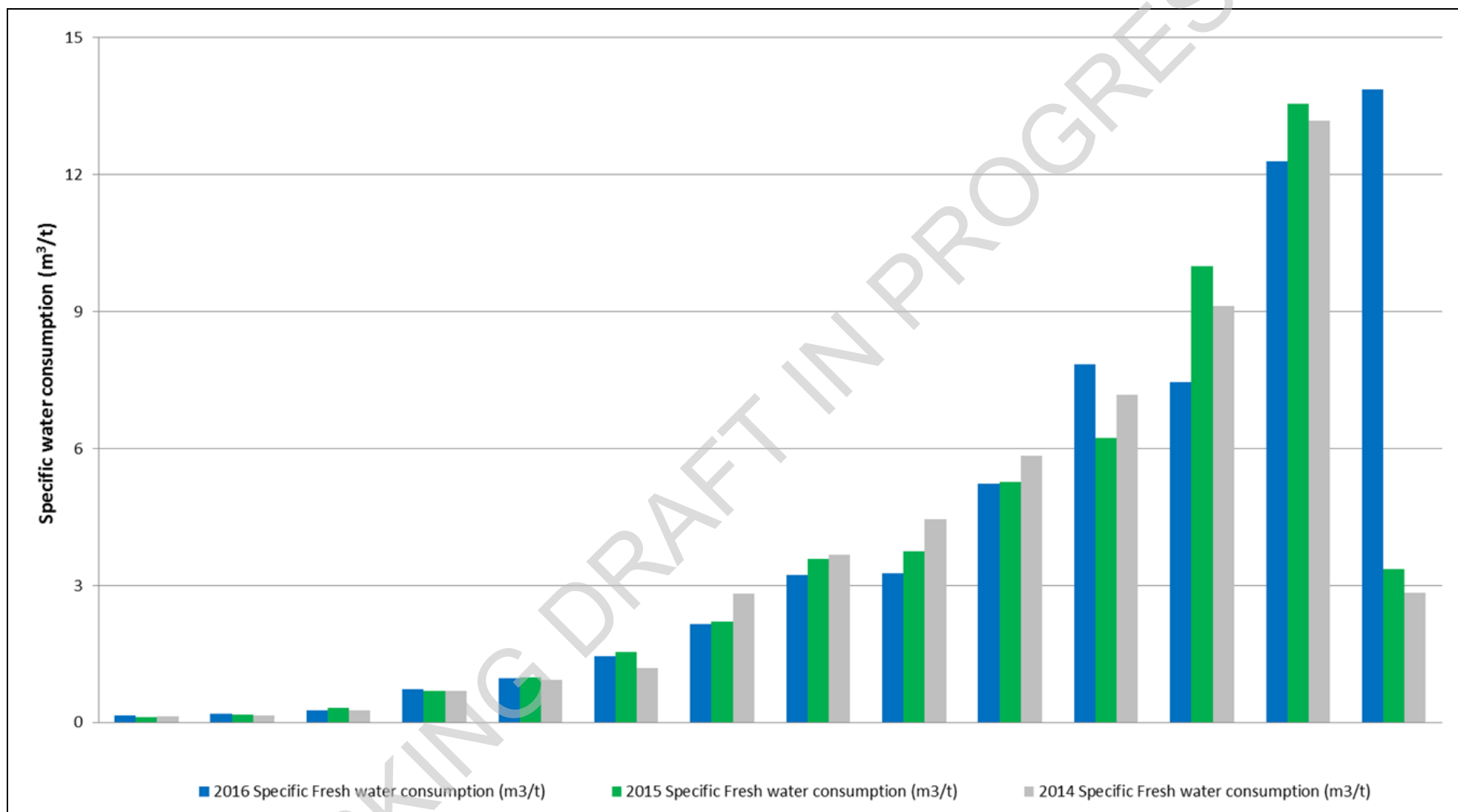


Figure 5.13: Specific water consumption (m³/t of production) in hot dip coating plants of sheet. Source: [TWG 2018].

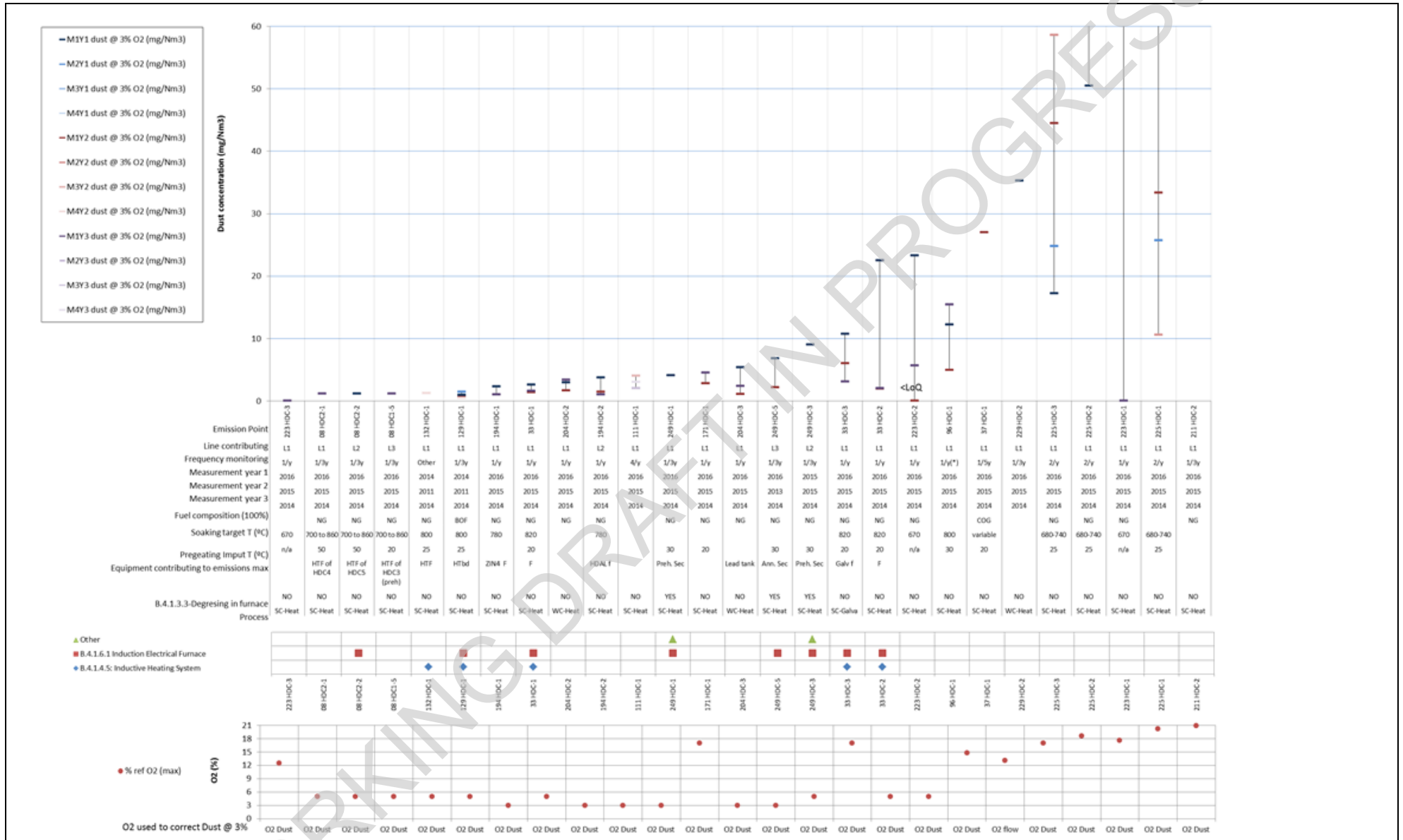


Figure 5.14: Dust emissions from feedstock heating (in mg/Nm3 at 3% oxygen) of sheet. Source: [TWG 2018].

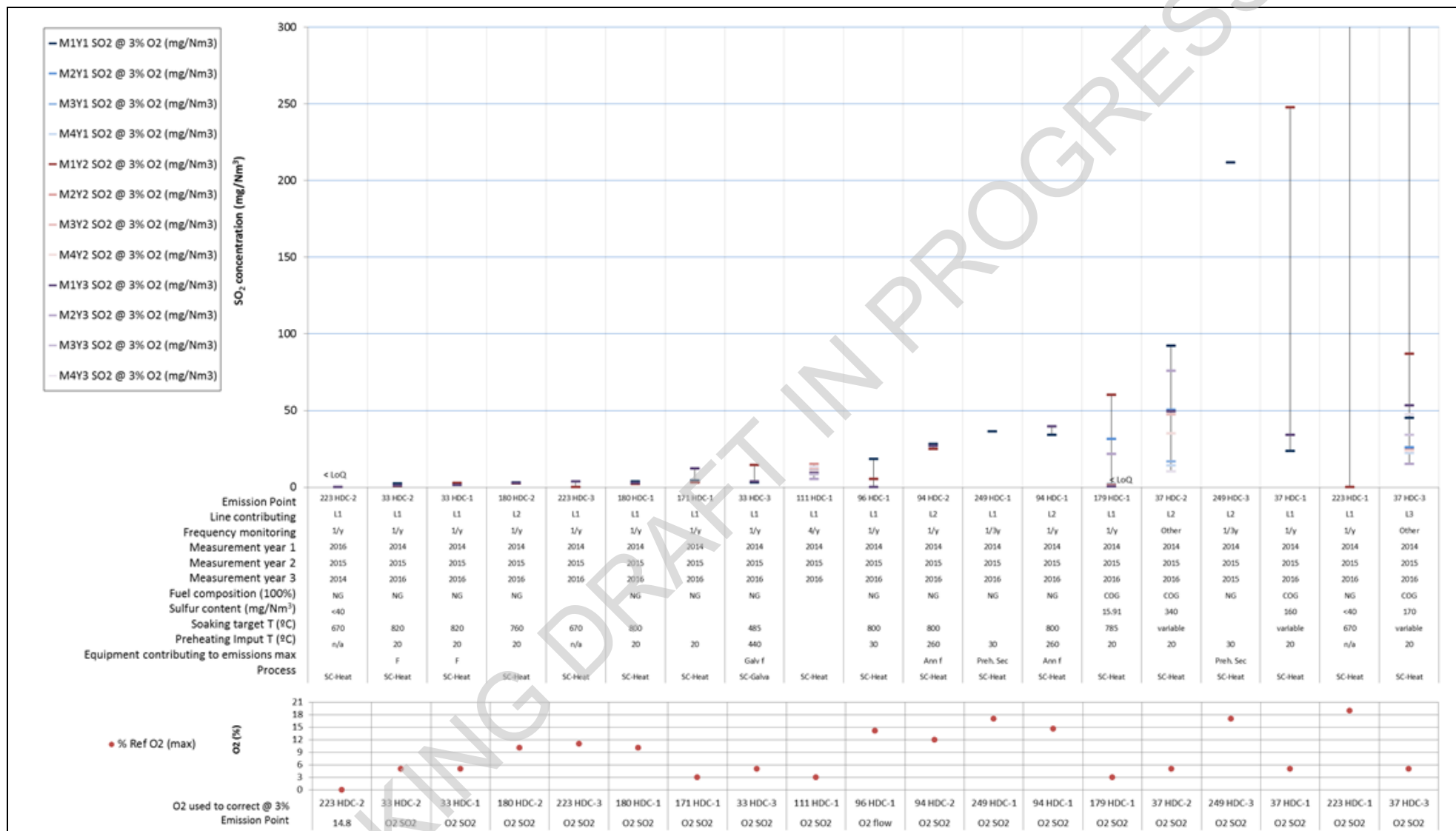
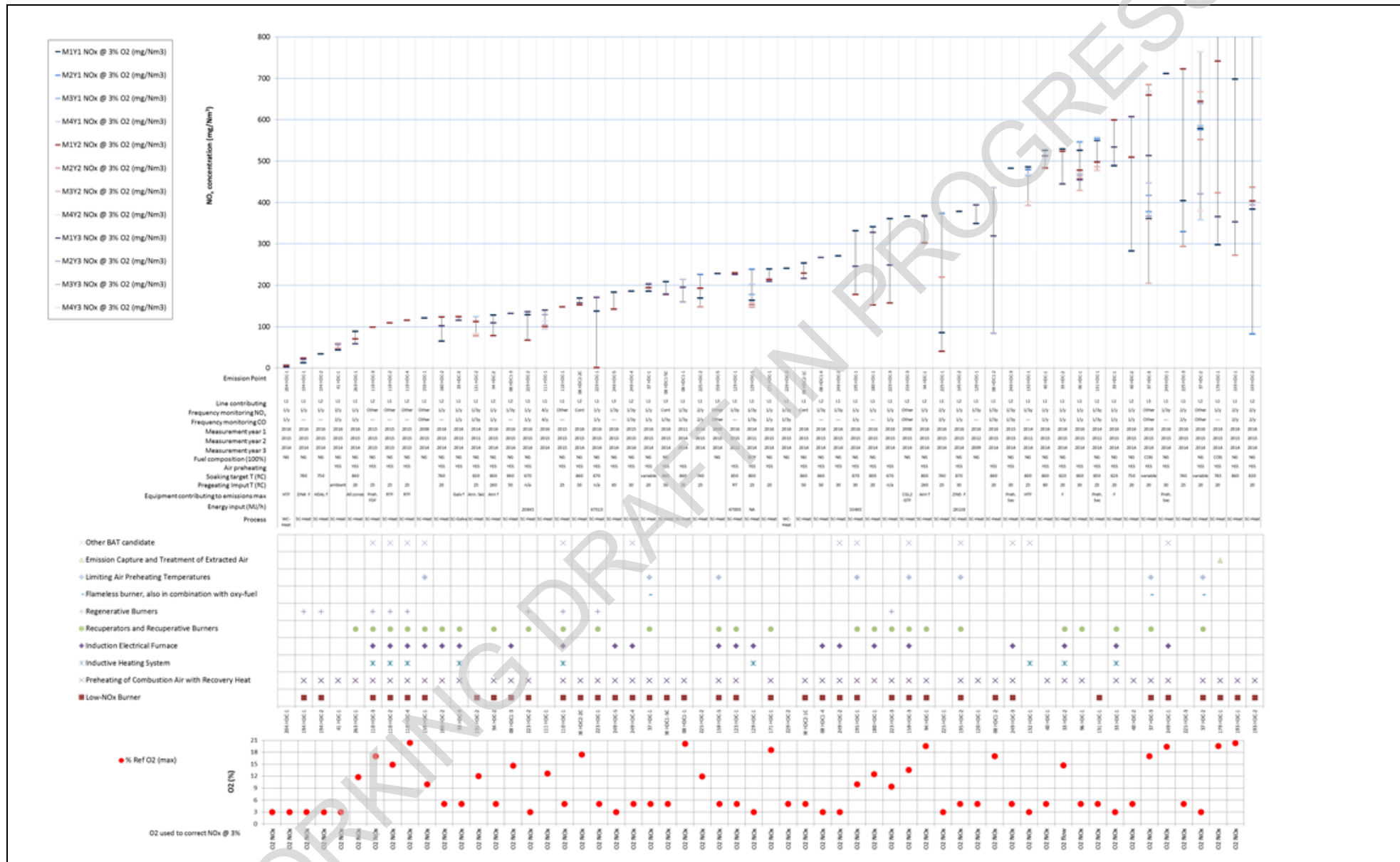


Figure 5.15: SO₂ emissions from feedstock heating (in mg/Nm³ at 3% oxygen) of sheet. Source: [TWG 2018].





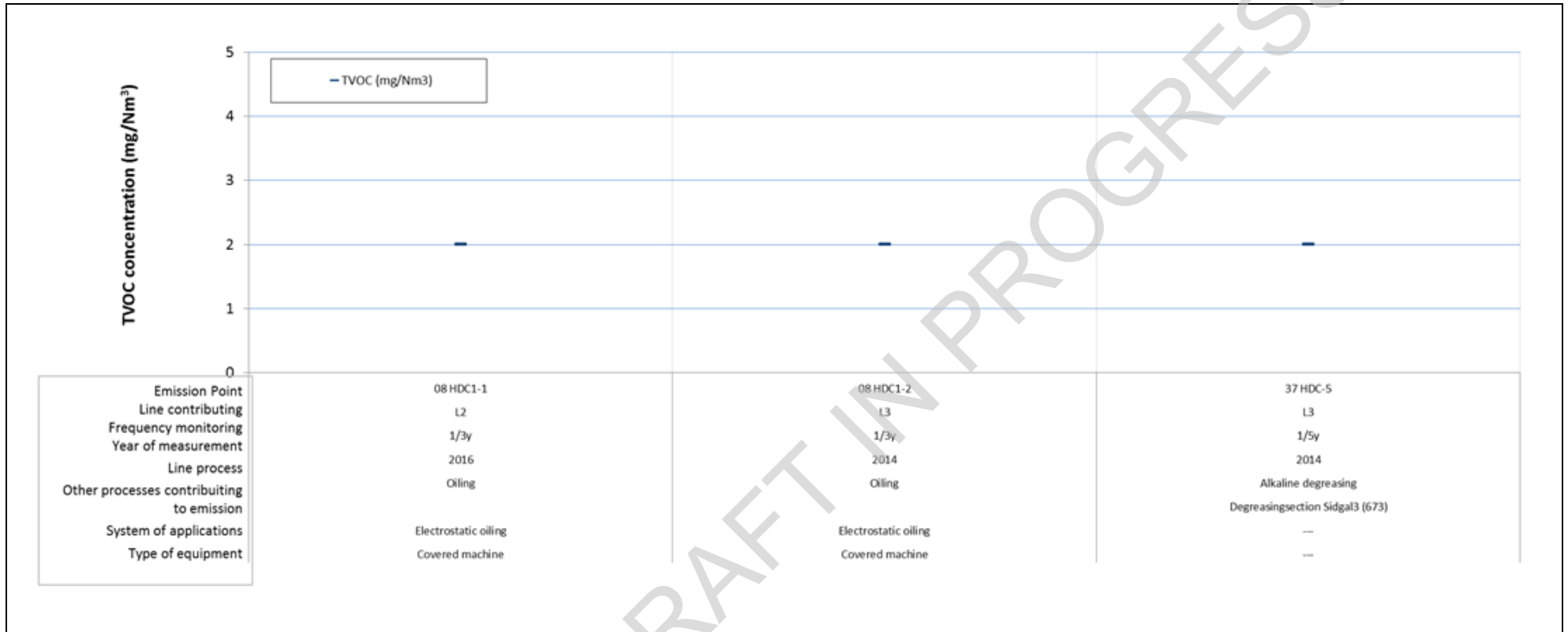


Figure 5.18: TVOC emissions from degreasing and oiling of sheet. Source: [TWG 2018].

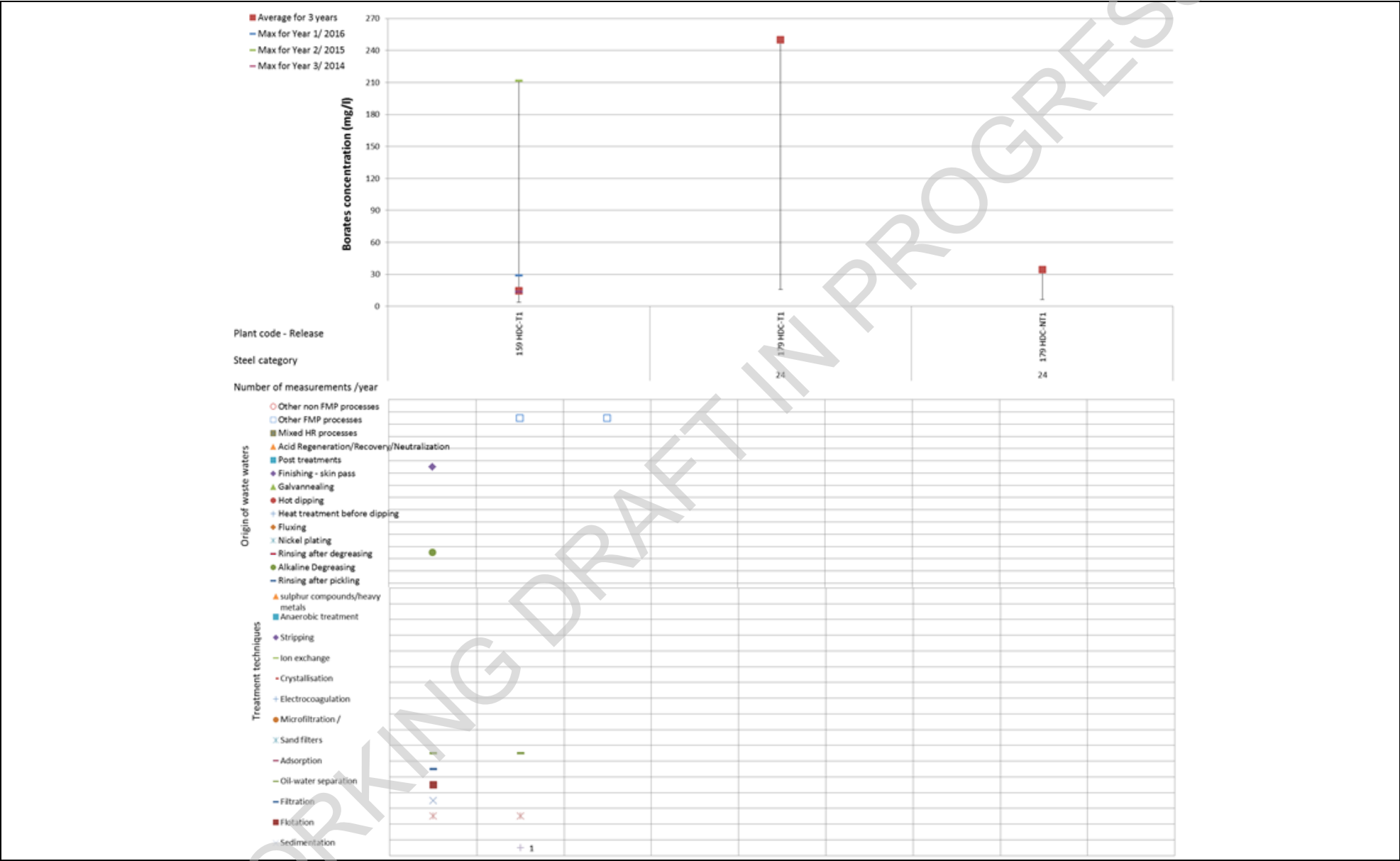


Figure 5.19: Borates emissions (in mg/l) for direct discharges. Source: [TWG 2018].

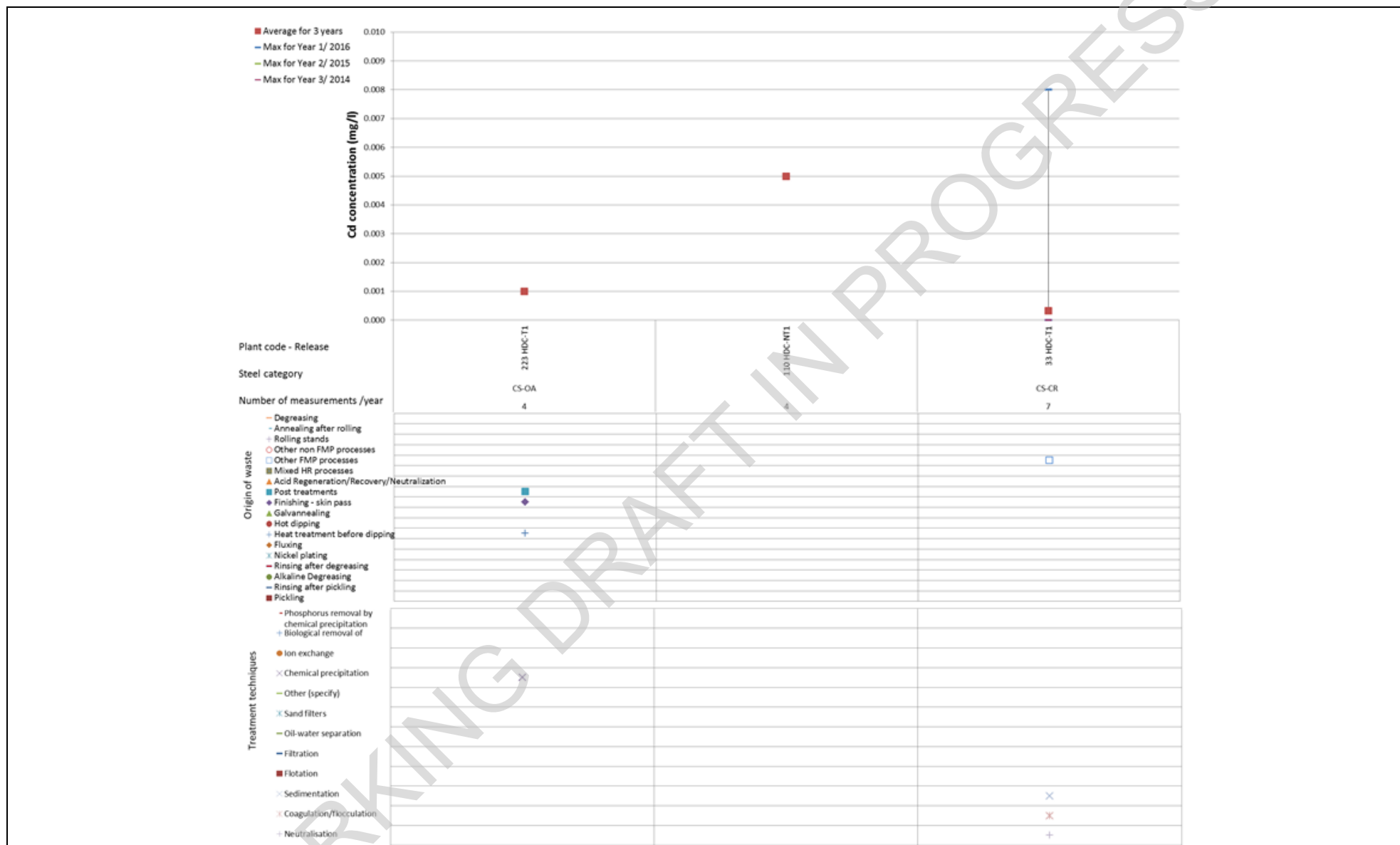


Figure 5.20: Cadmium emissions (in mg/l) for direct discharges. Source: [TWG 2018].

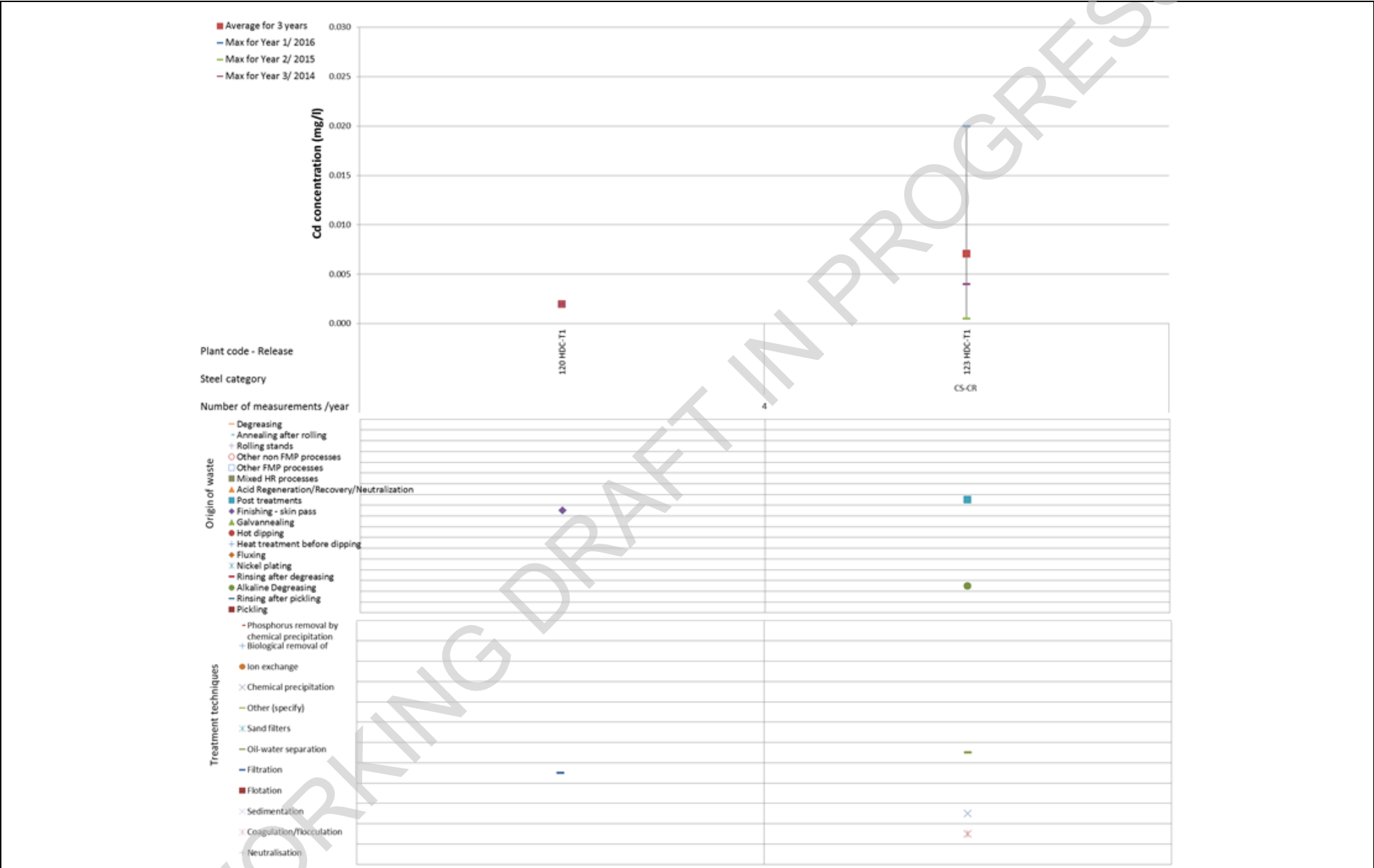


Figure 5.21: Cadmium emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

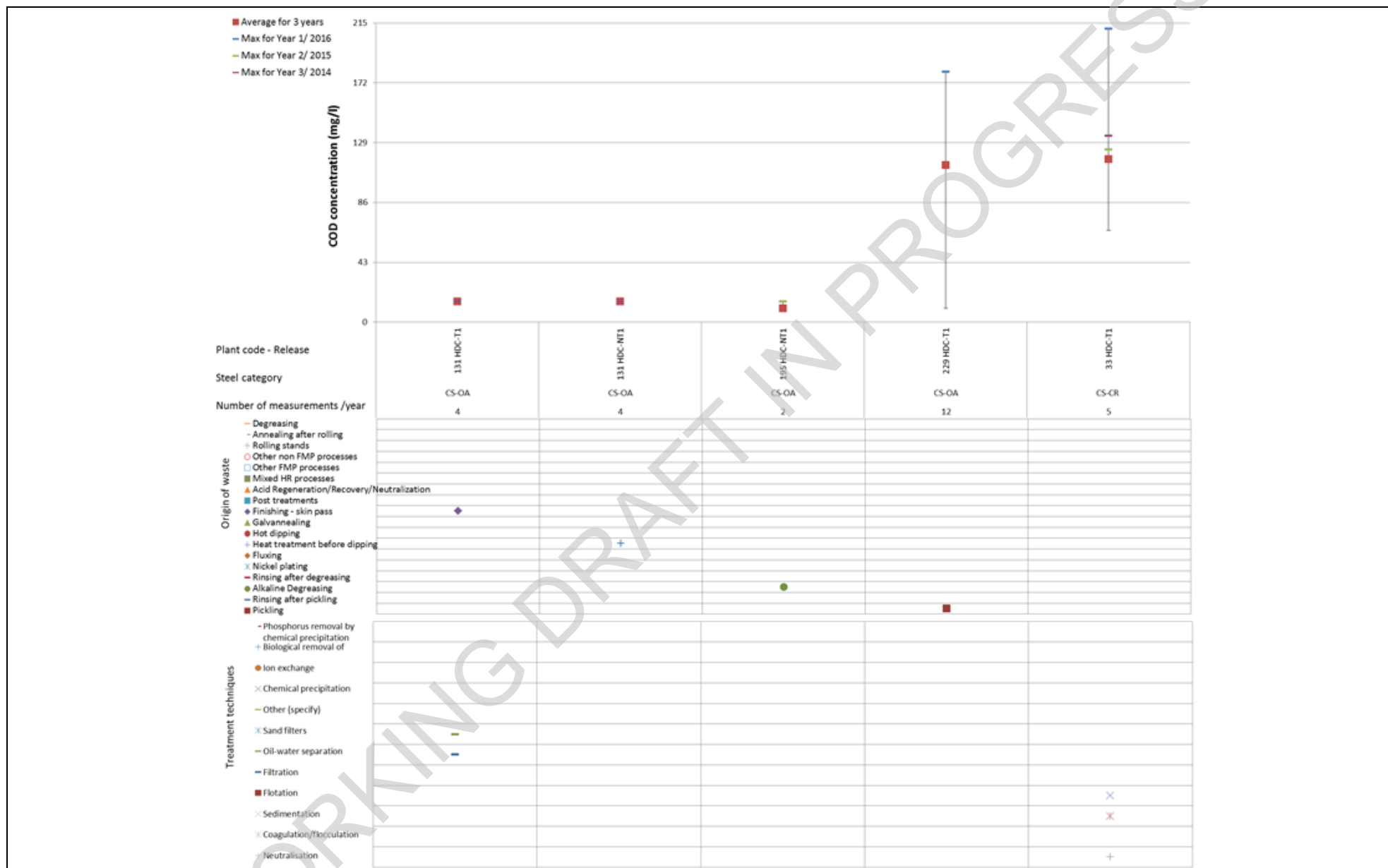


Figure 5.22: COD emissions (in mg/l) for direct discharges. Source: [TWG 2018].

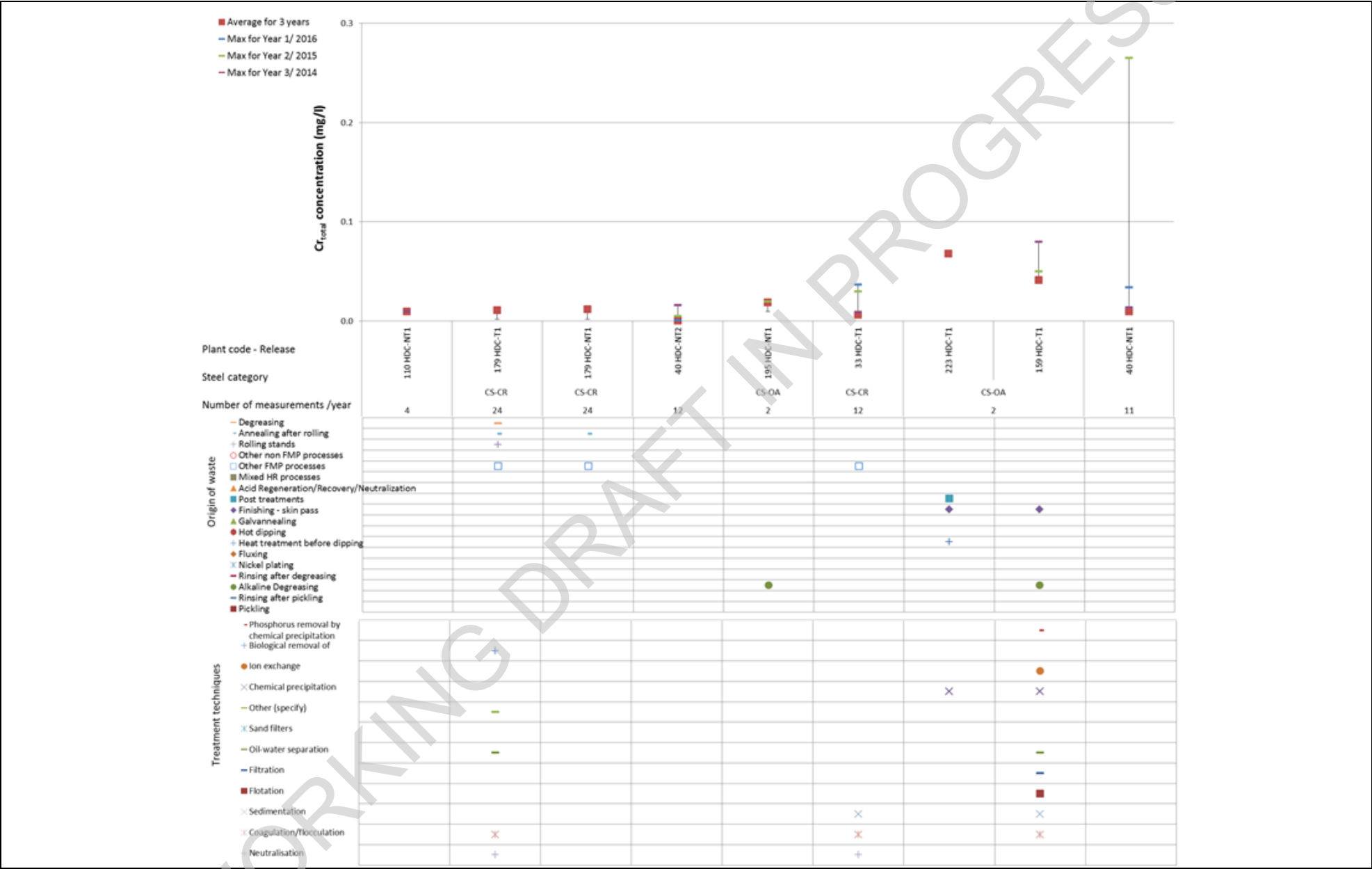


Figure 5.23: Chromium emissions (in mg/l) for direct discharges. Source: [TWG 2018].

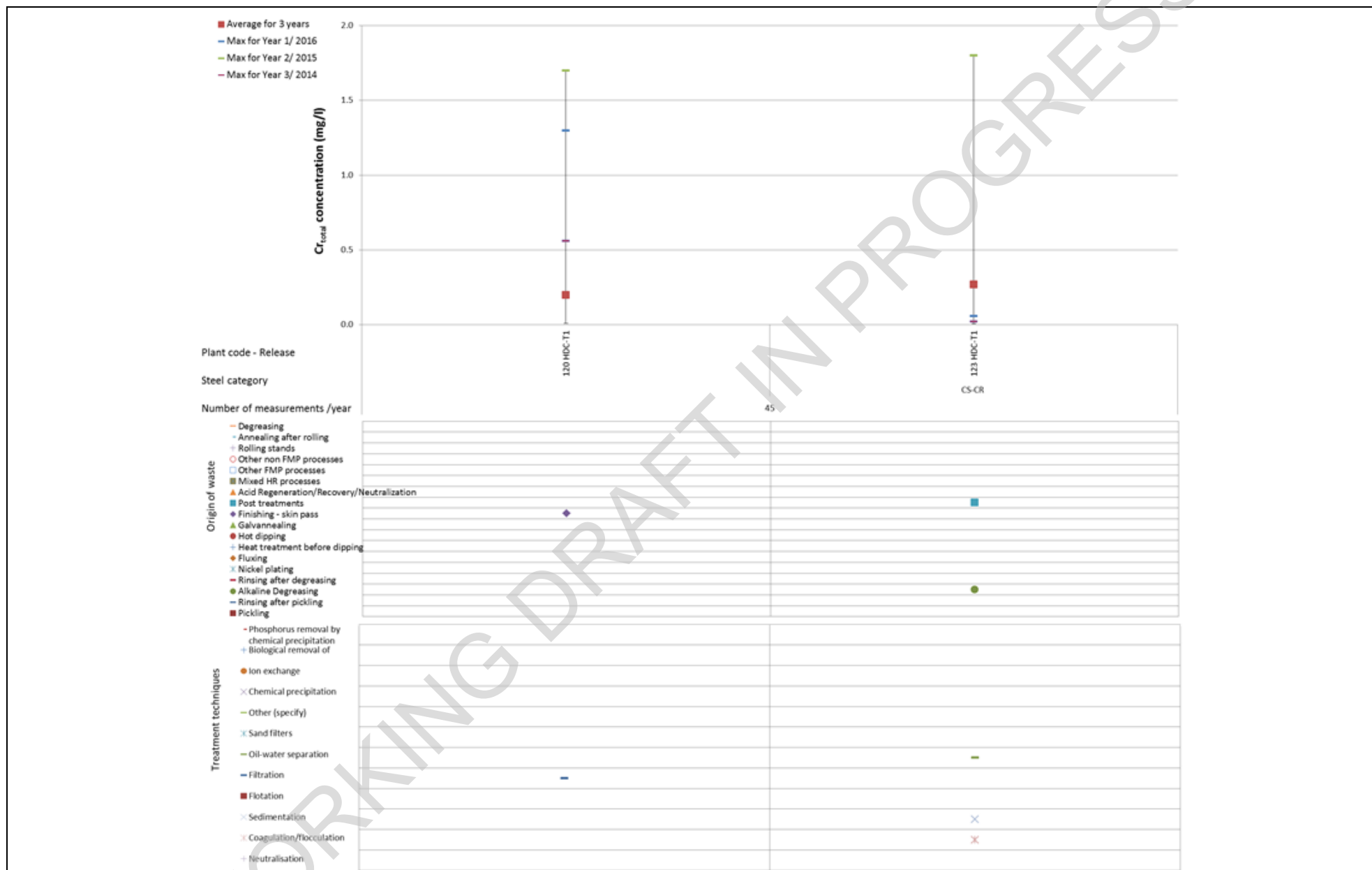


Figure 5.24: Chromium emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

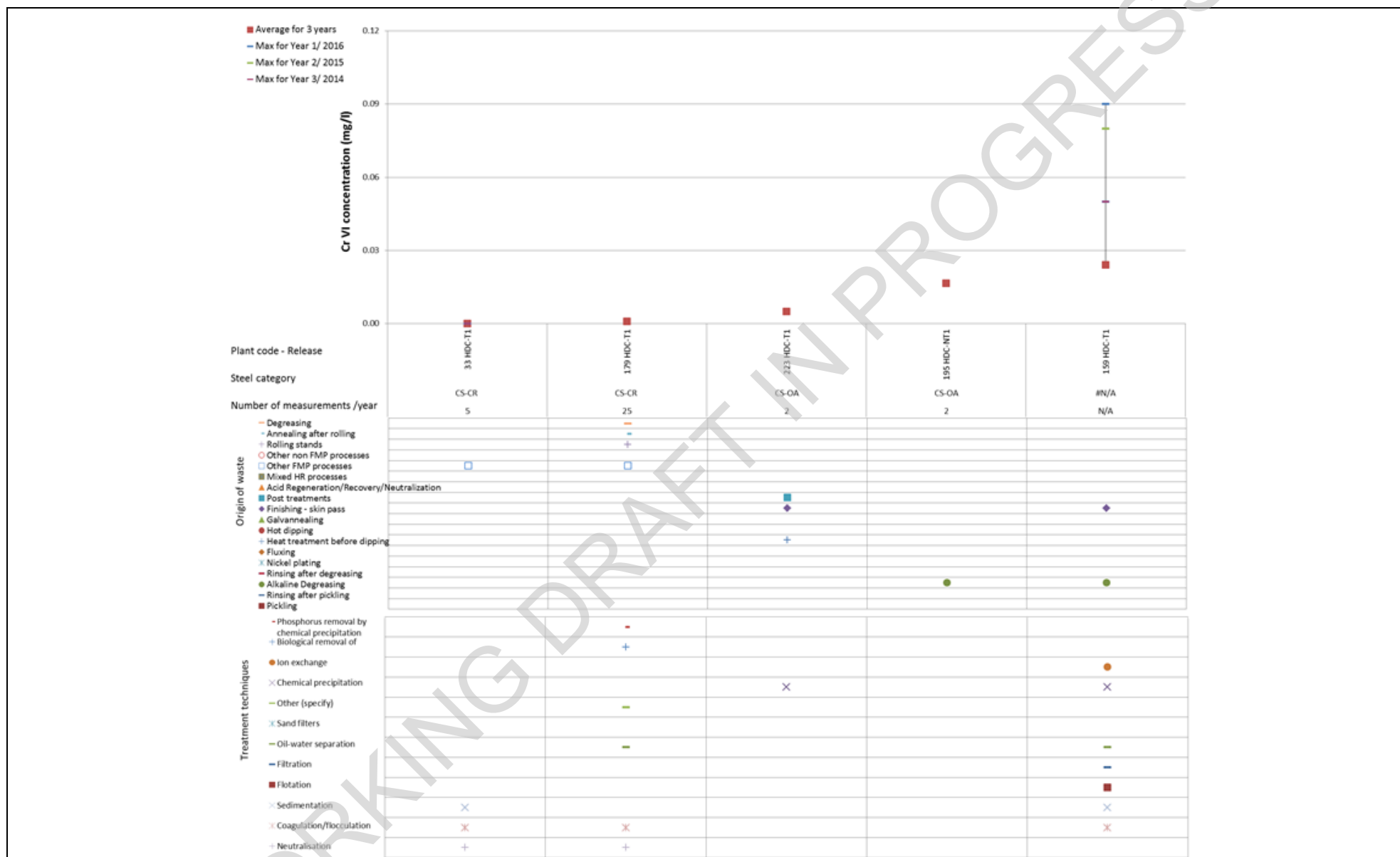


Figure 5.25: Chromium VI emissions (in mg/l) for direct discharges. Source: [TWG 2018].

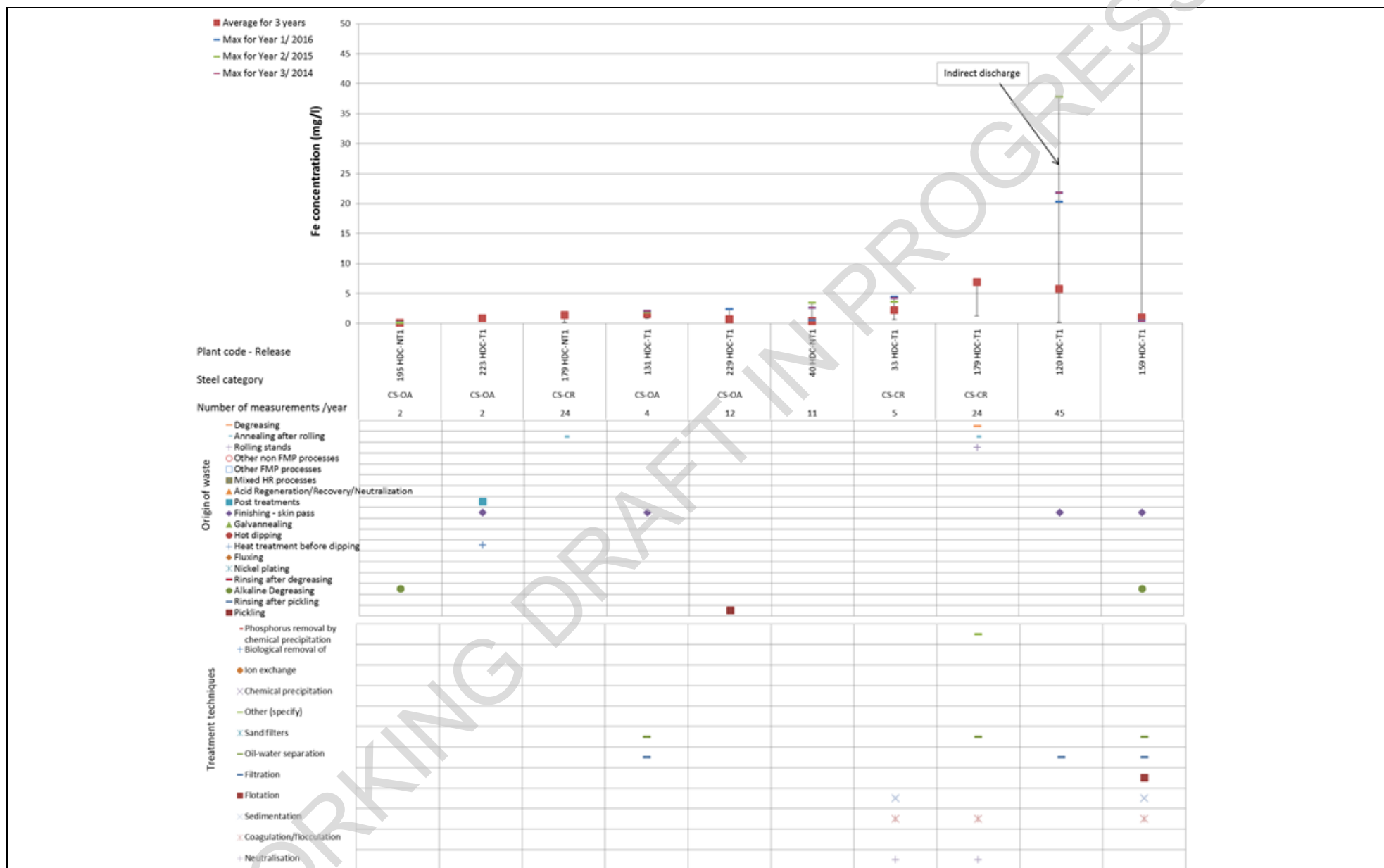


Figure 5.26: Iron emissions (in mg/l) for direct and indirect discharges. Source: [TWG 2018].

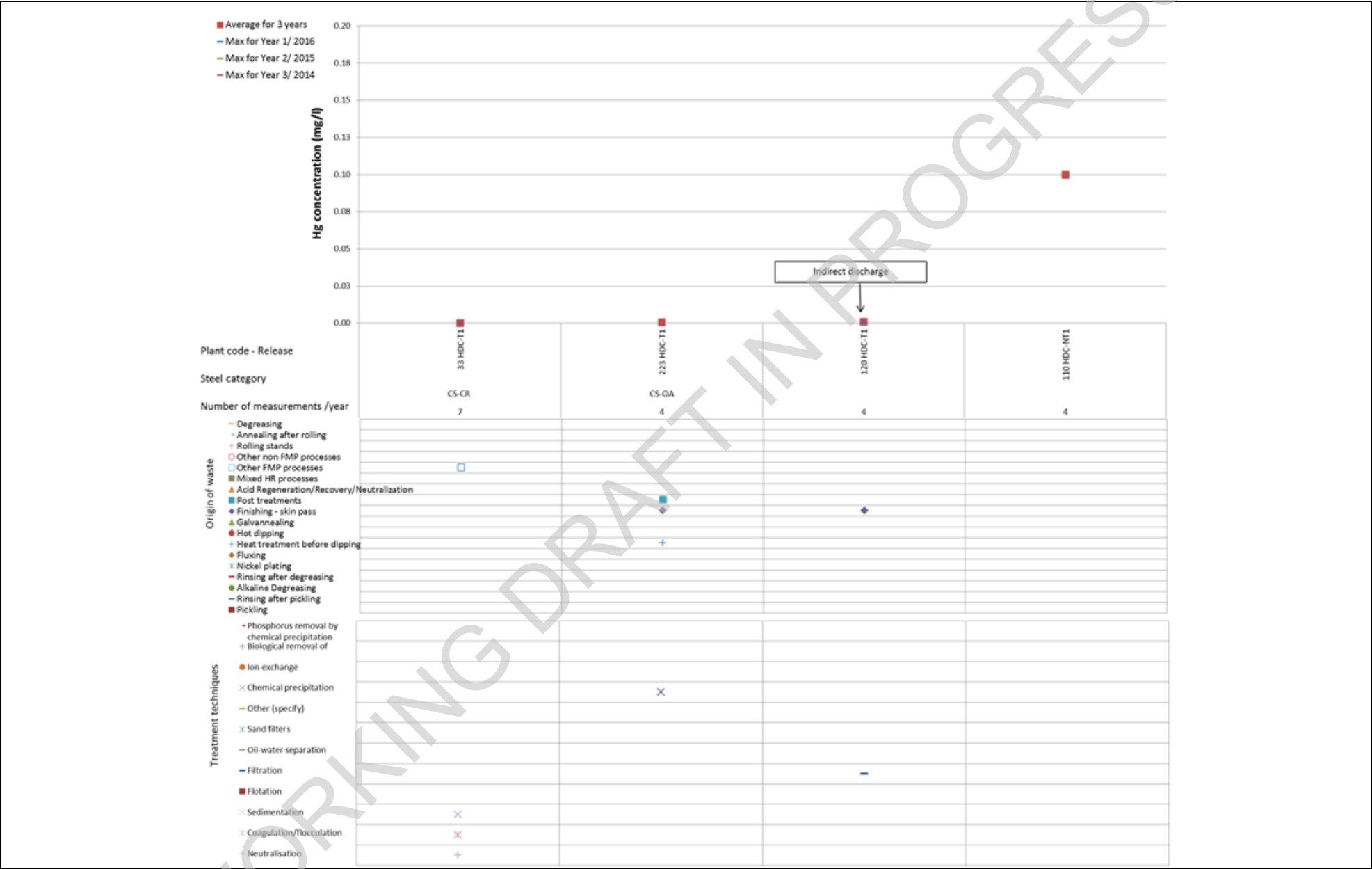


Figure 5.27: Mercury emissions (in mg/l) for direct and indirect discharges. Source: [TWG 2018].

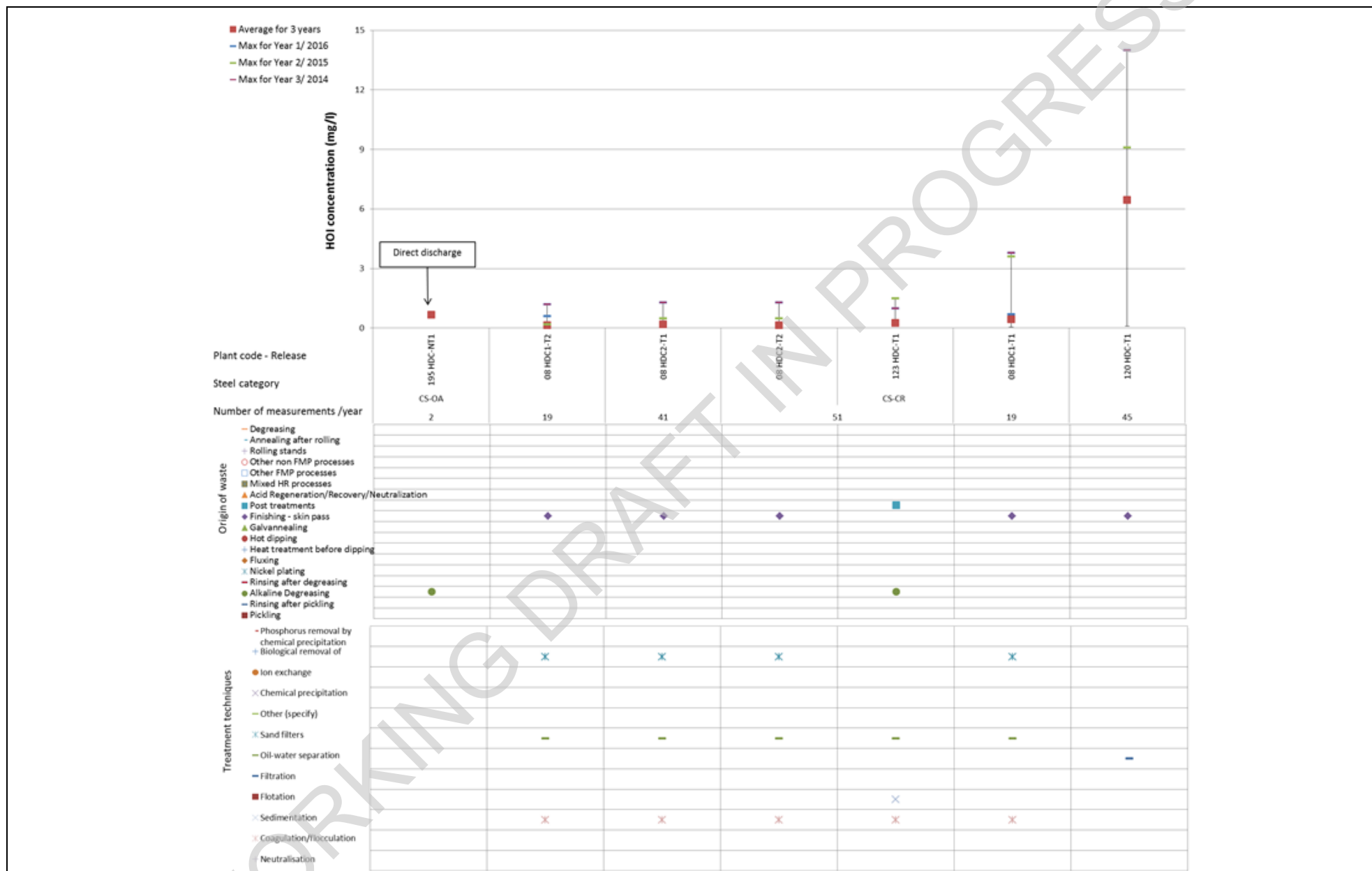


Figure 5.28: Hydrocarbon oil index emissions (in mg/l) for direct and indirect discharges. Source: [TWG 2018].

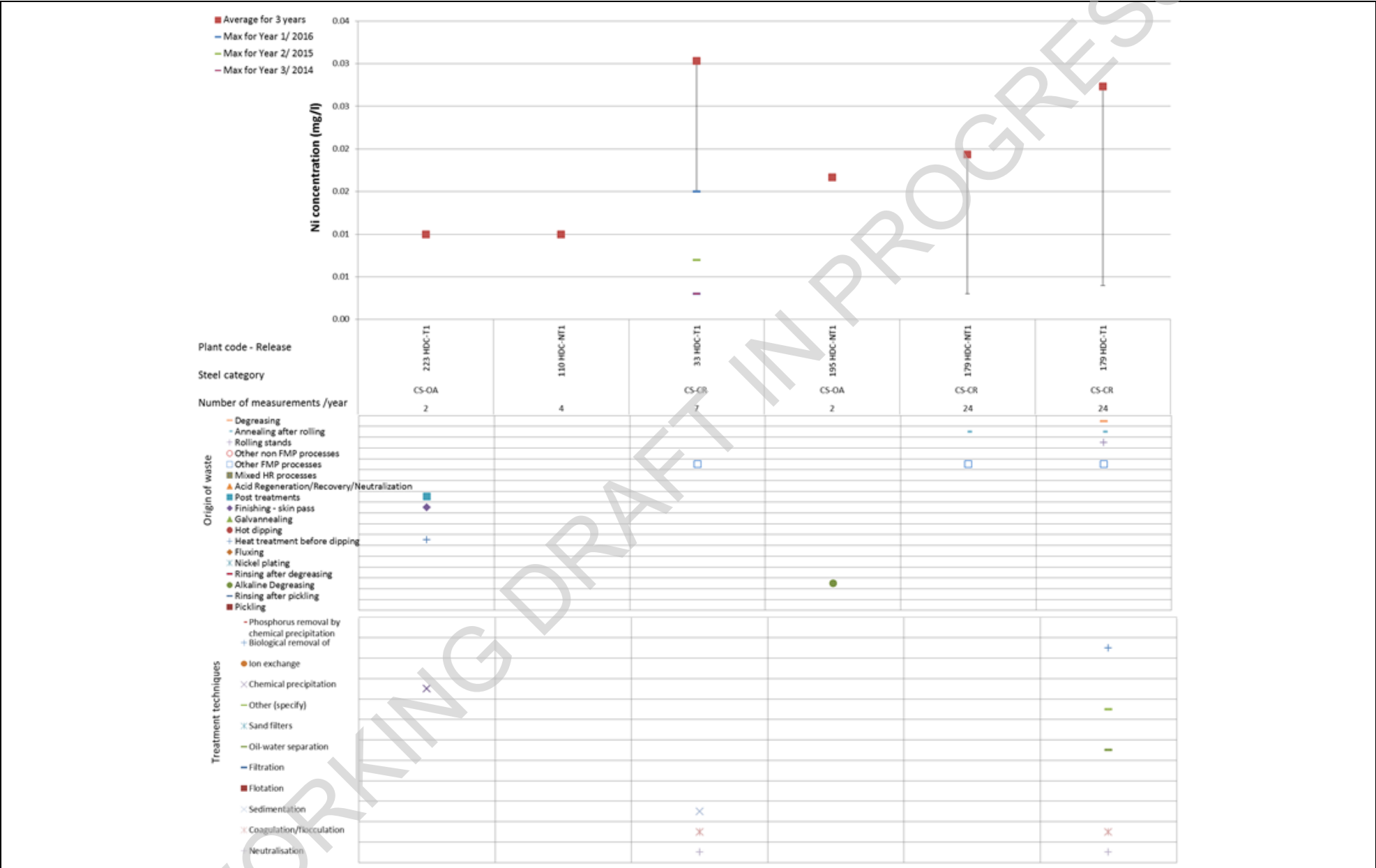


Figure 5.29: Nickel emissions (in mg/l) for direct discharges. Source: [TWG 2018].

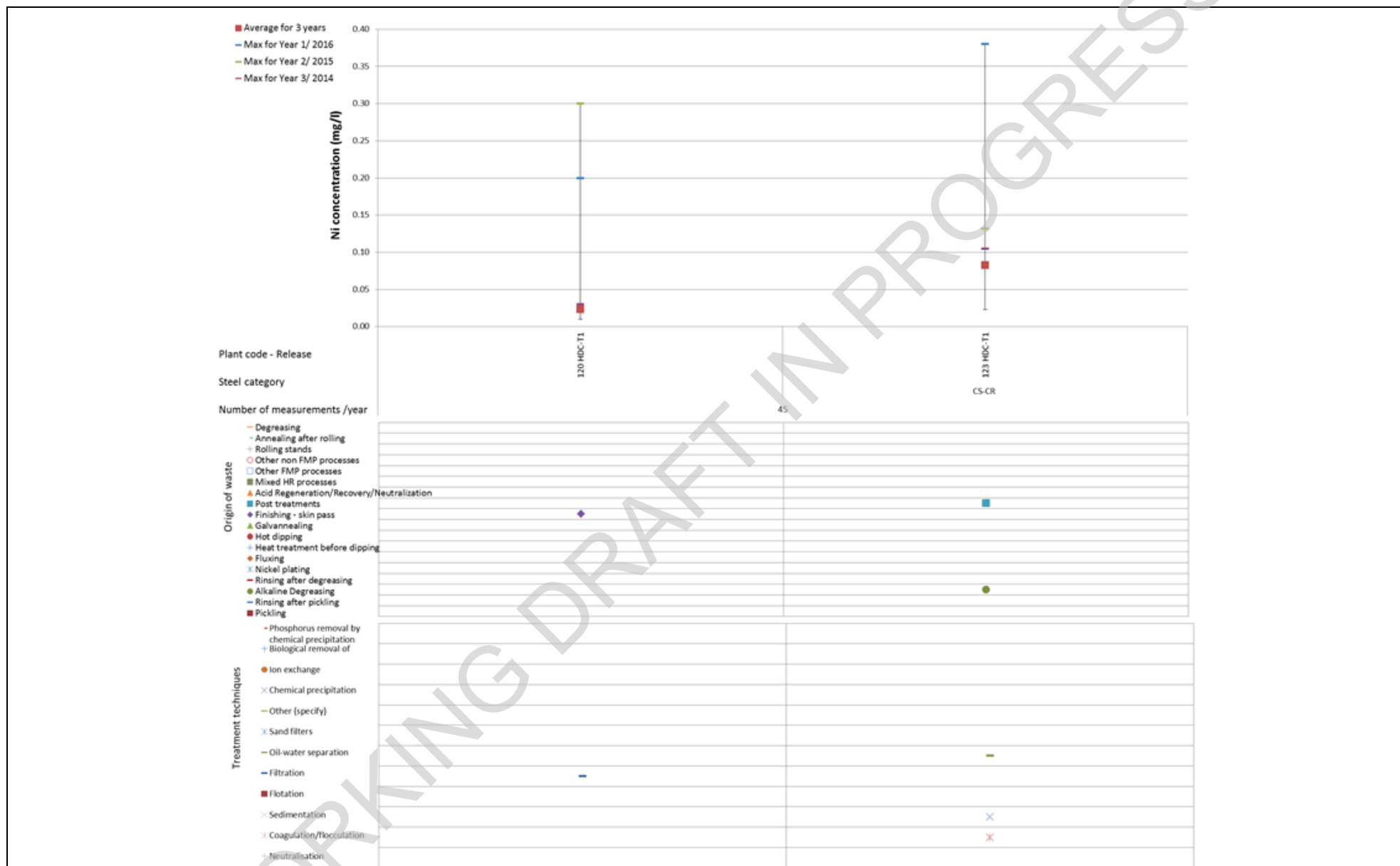


Figure 5.30: Nickel emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

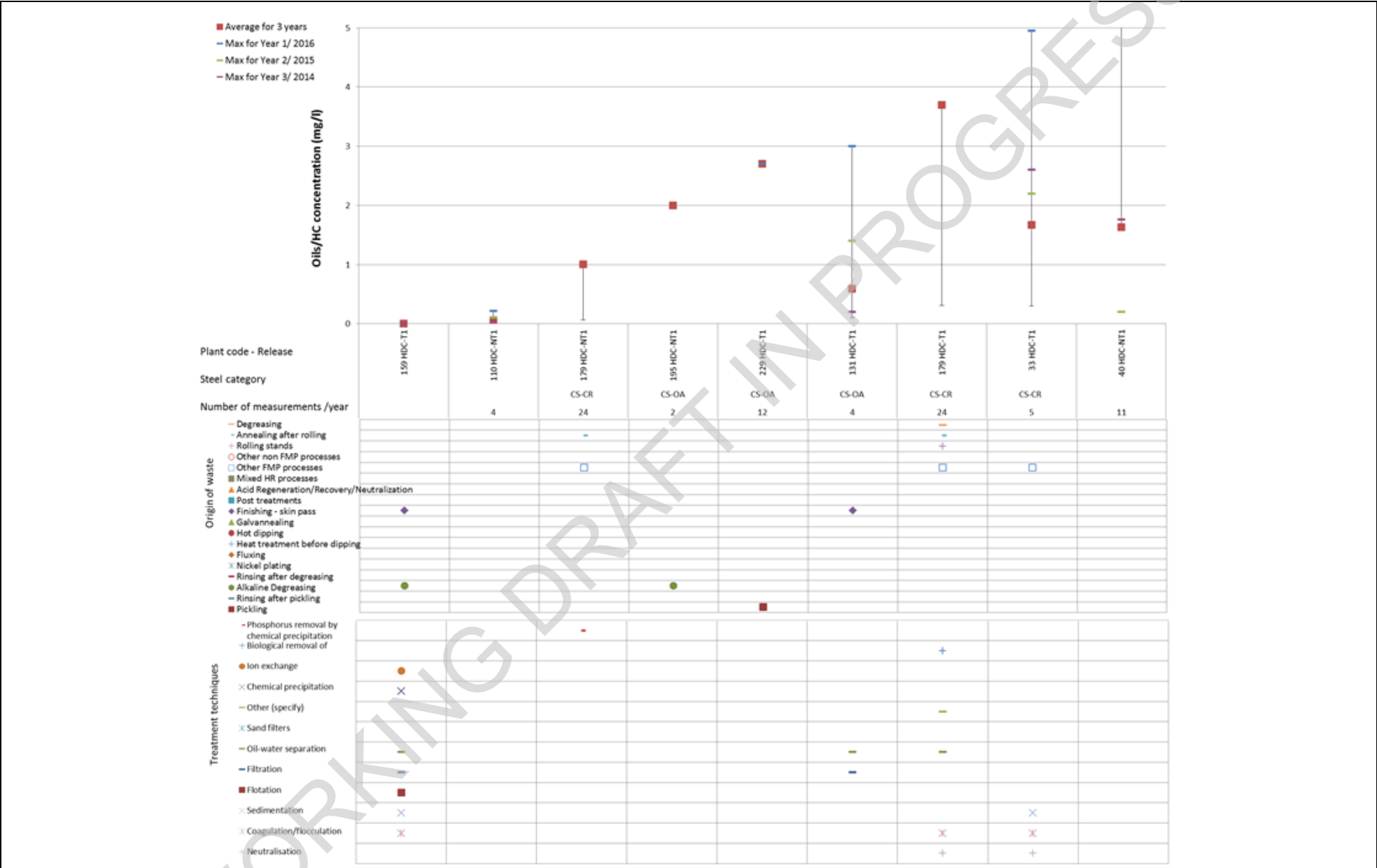


Figure 5.31: Oils emissions (in mg/l) for direct discharges. Source: [TWG 2018].

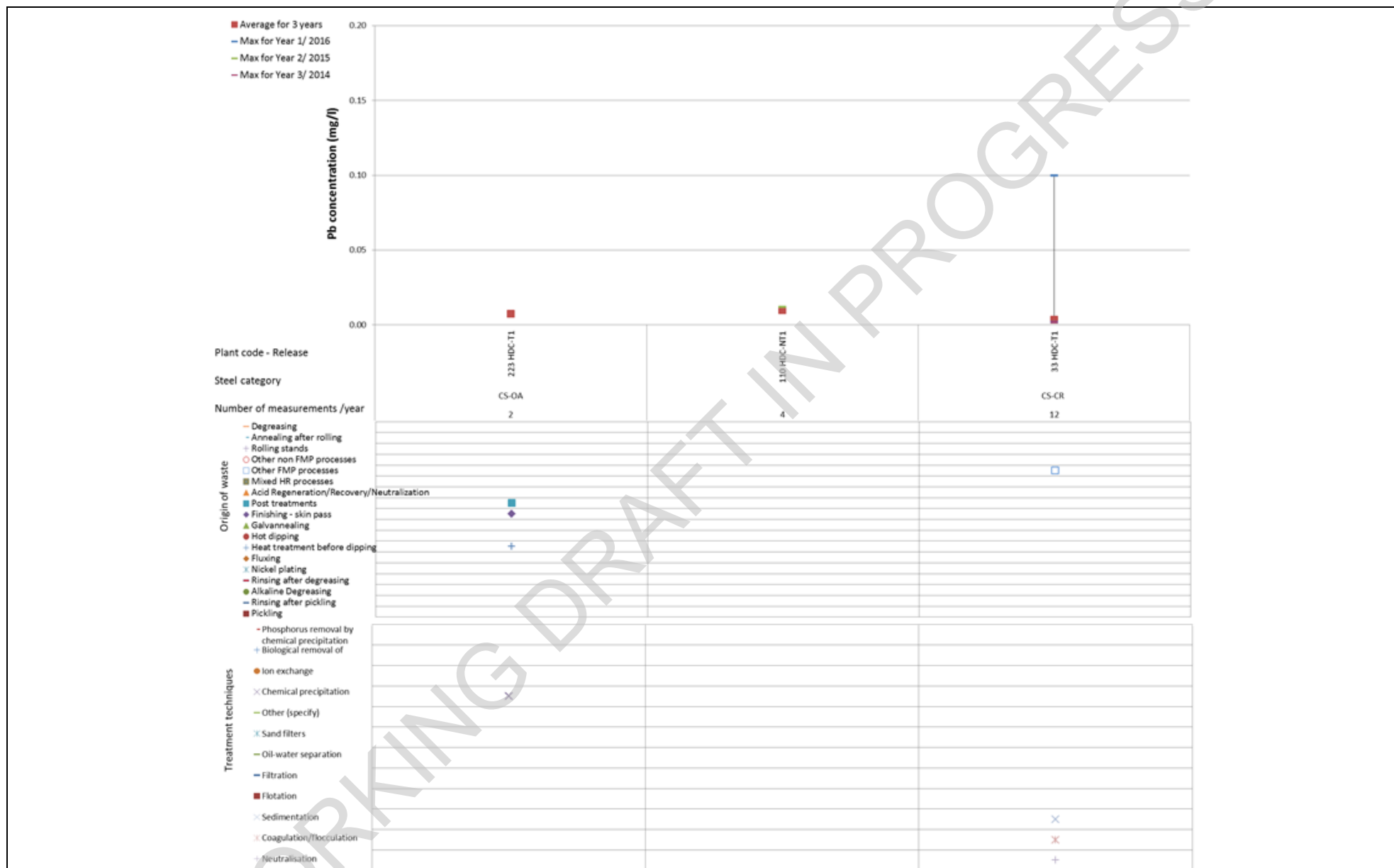


Figure 5.32: Lead emissions (in mg/l) for direct discharges. Source: [TWG 2018].

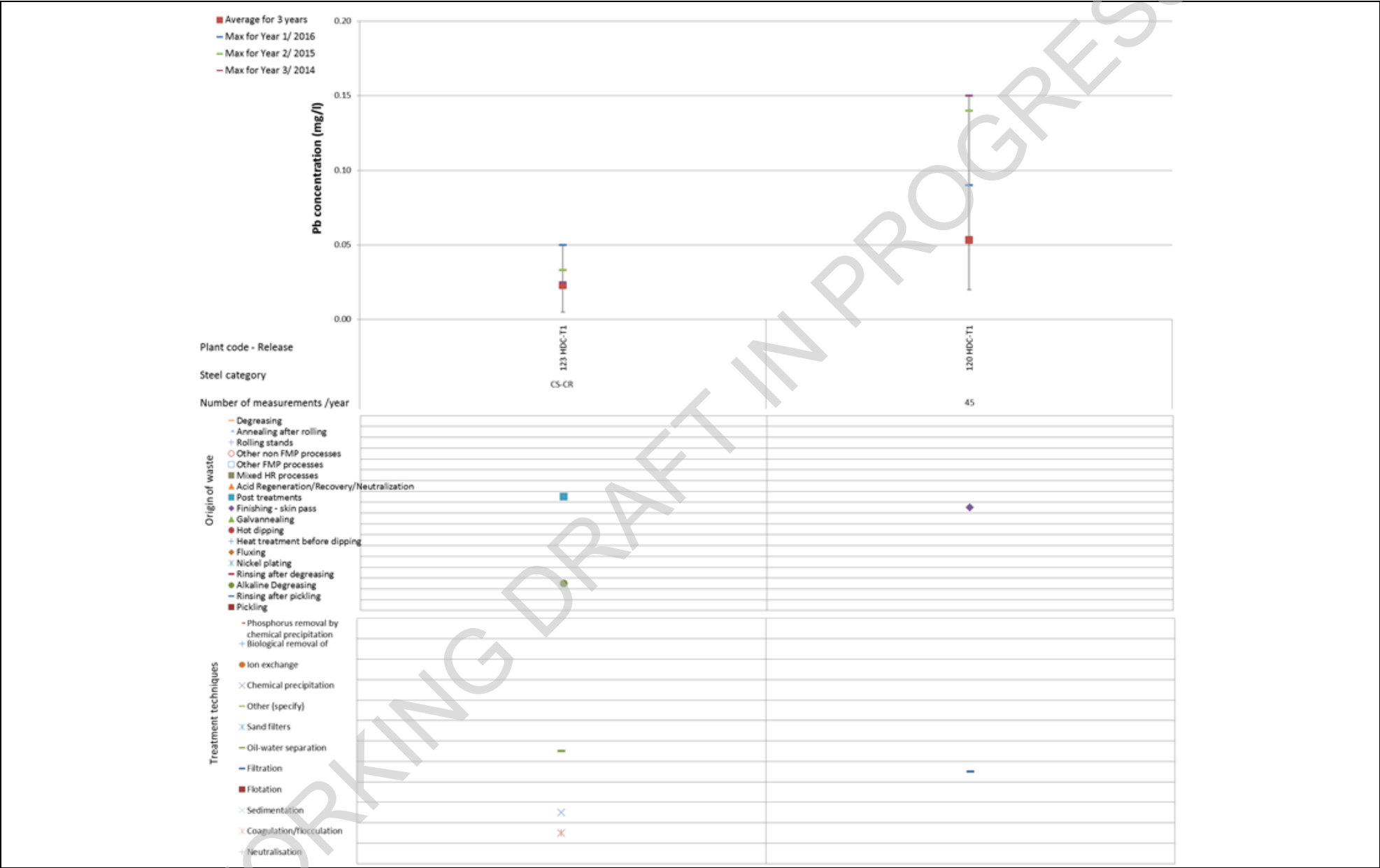


Figure 5.33: Lead emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

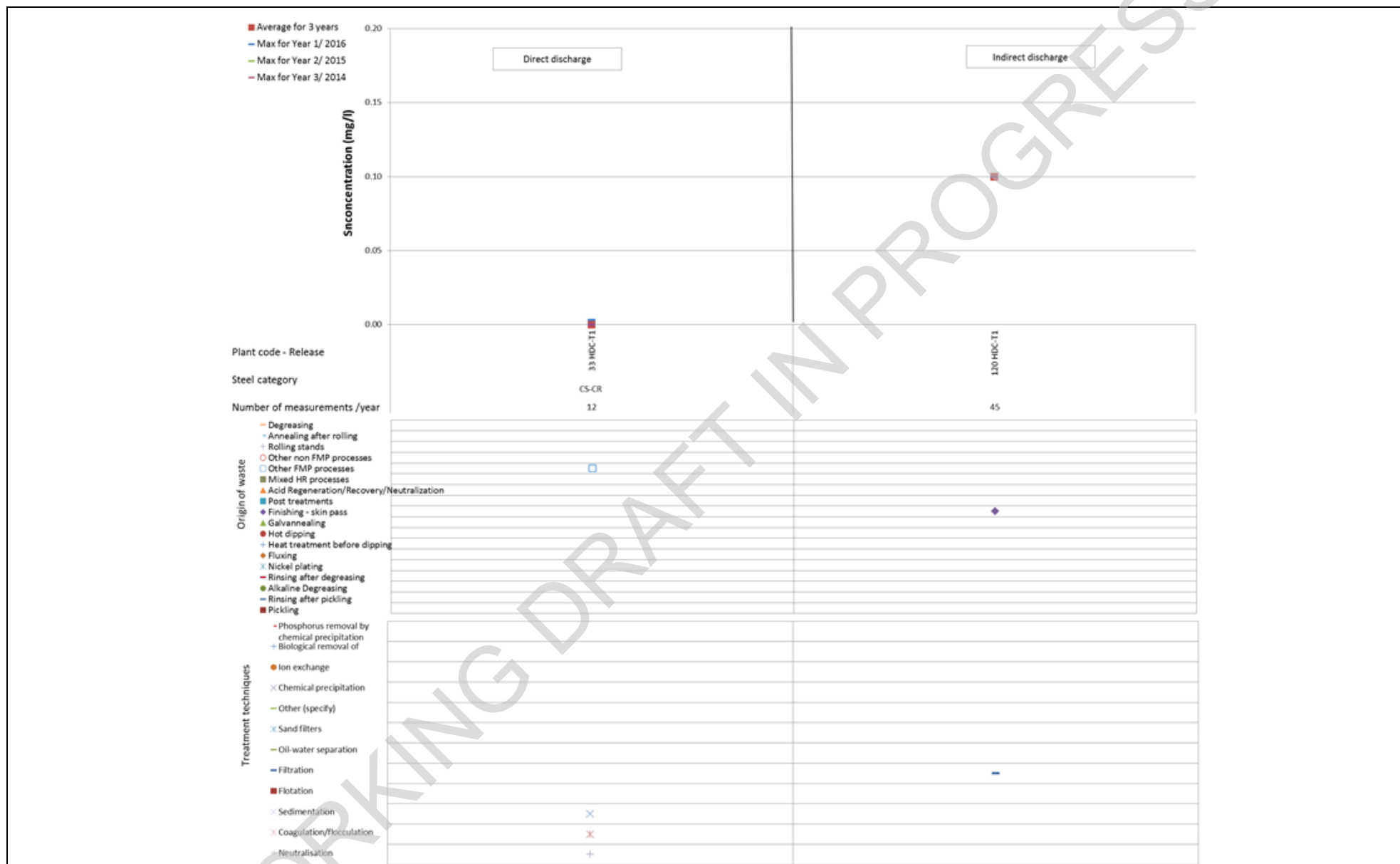


Figure 5.34: Tin emissions (in mg/l) for direct and indirect discharges. Source: [TWG 2018].

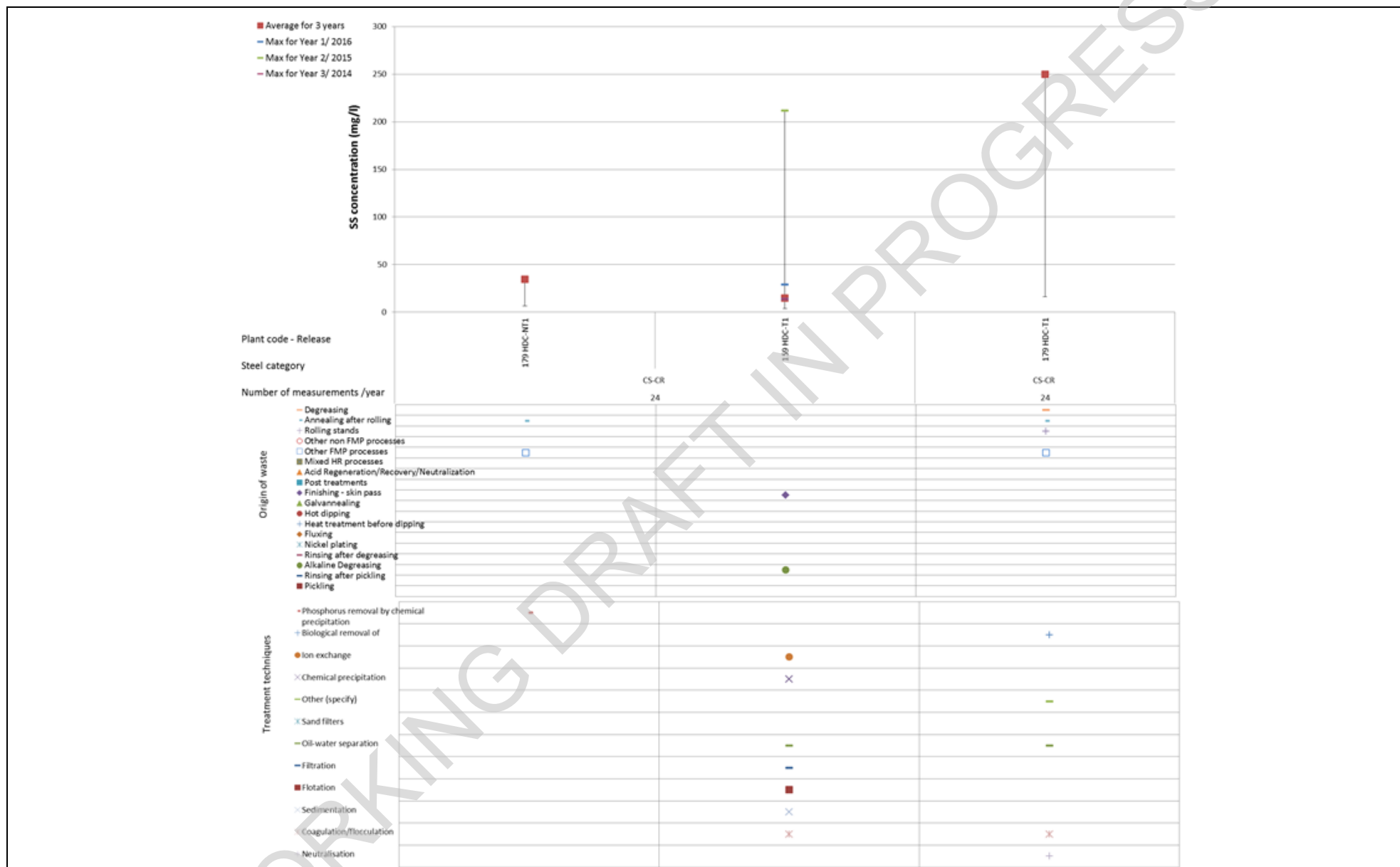


Figure 5.35: Suspended solids emissions (in mg/l) for direct discharges. Source: [TWG 2018].

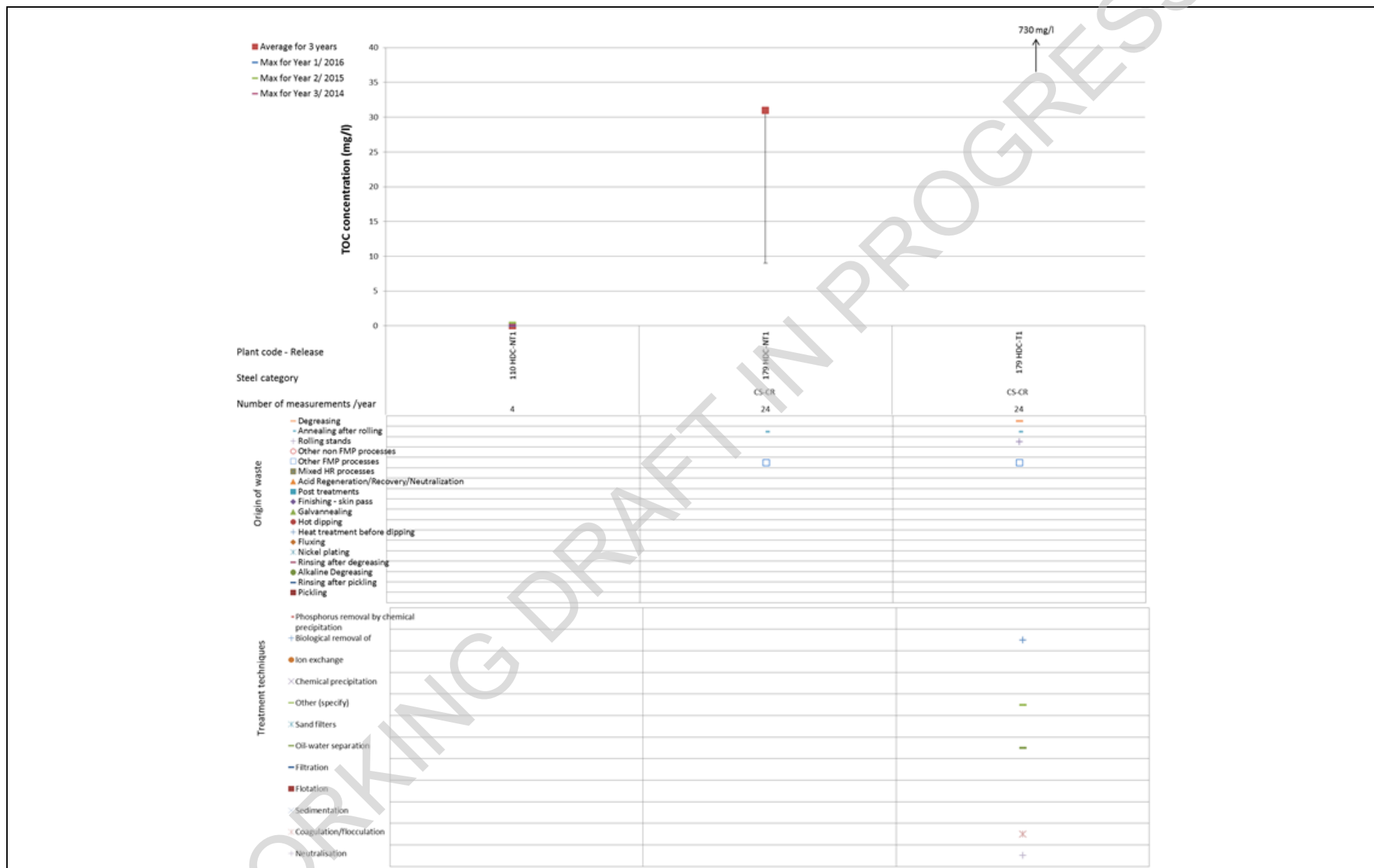


Figure 5.36: TOC emissions (in mg/l) for direct discharges. Source: [TWG 2018].

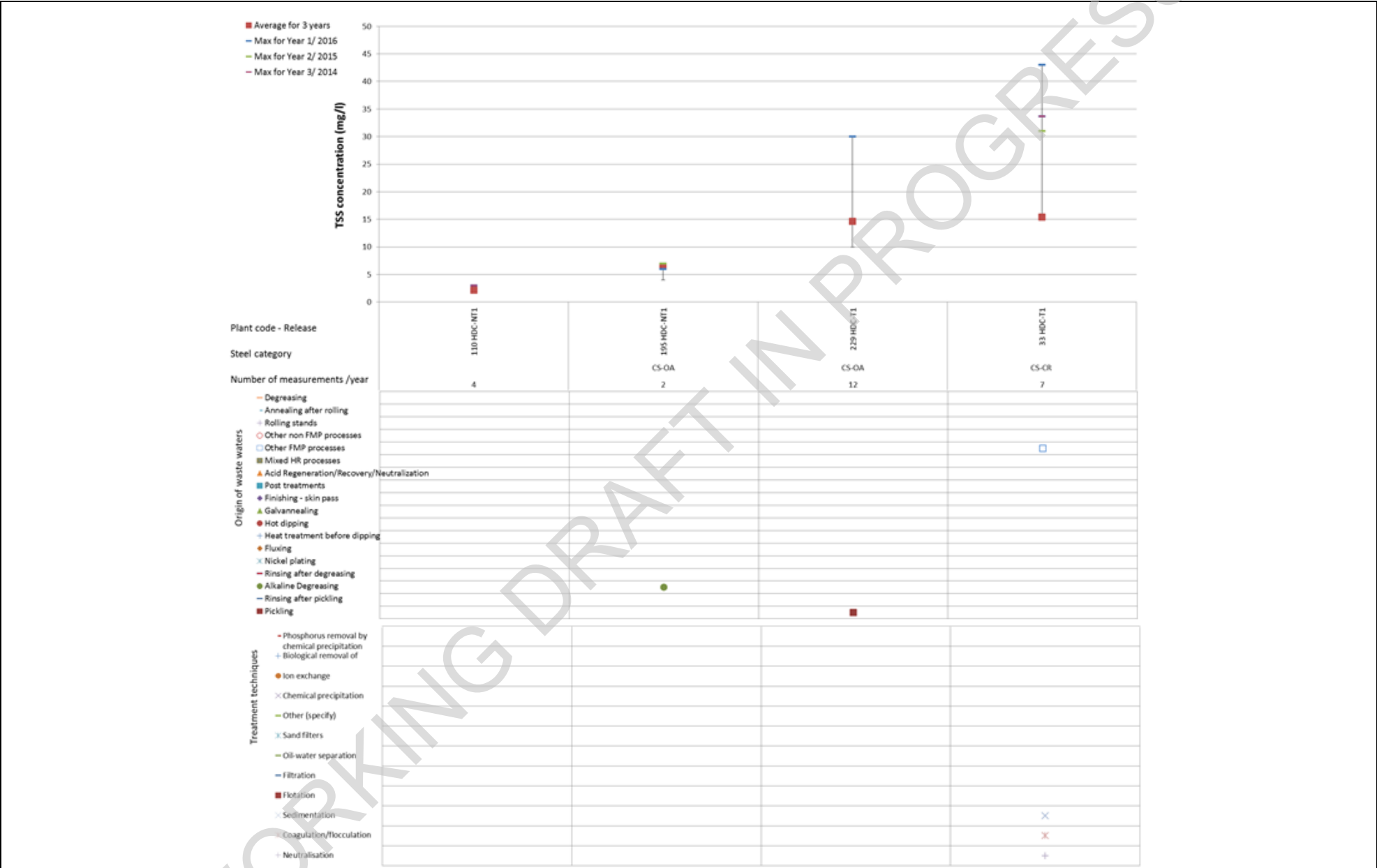


Figure 5.37: TSS emissions (in mg/l) for direct discharges. Source: [TWG 2018].

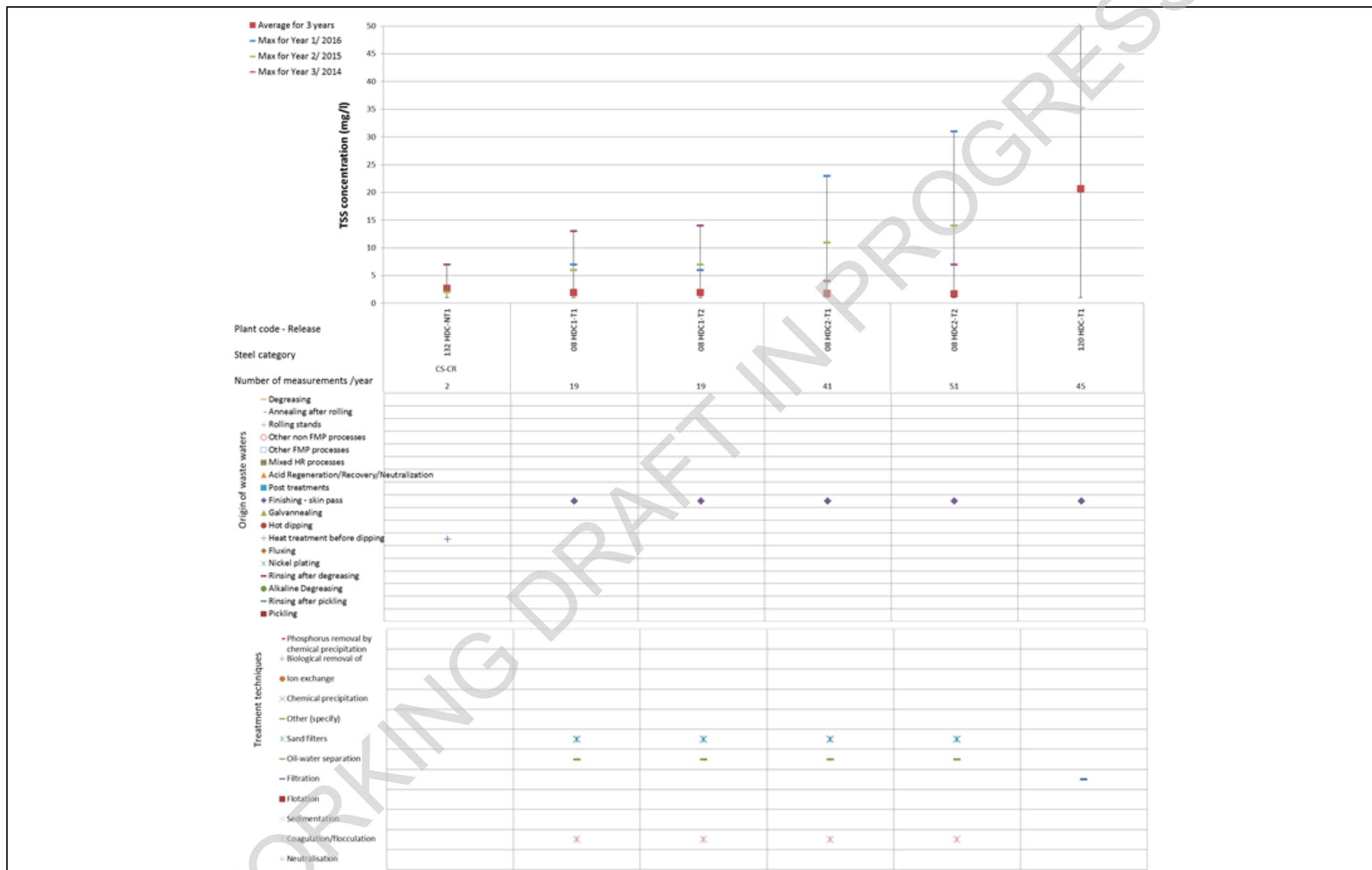


Figure 5.38: TSS emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

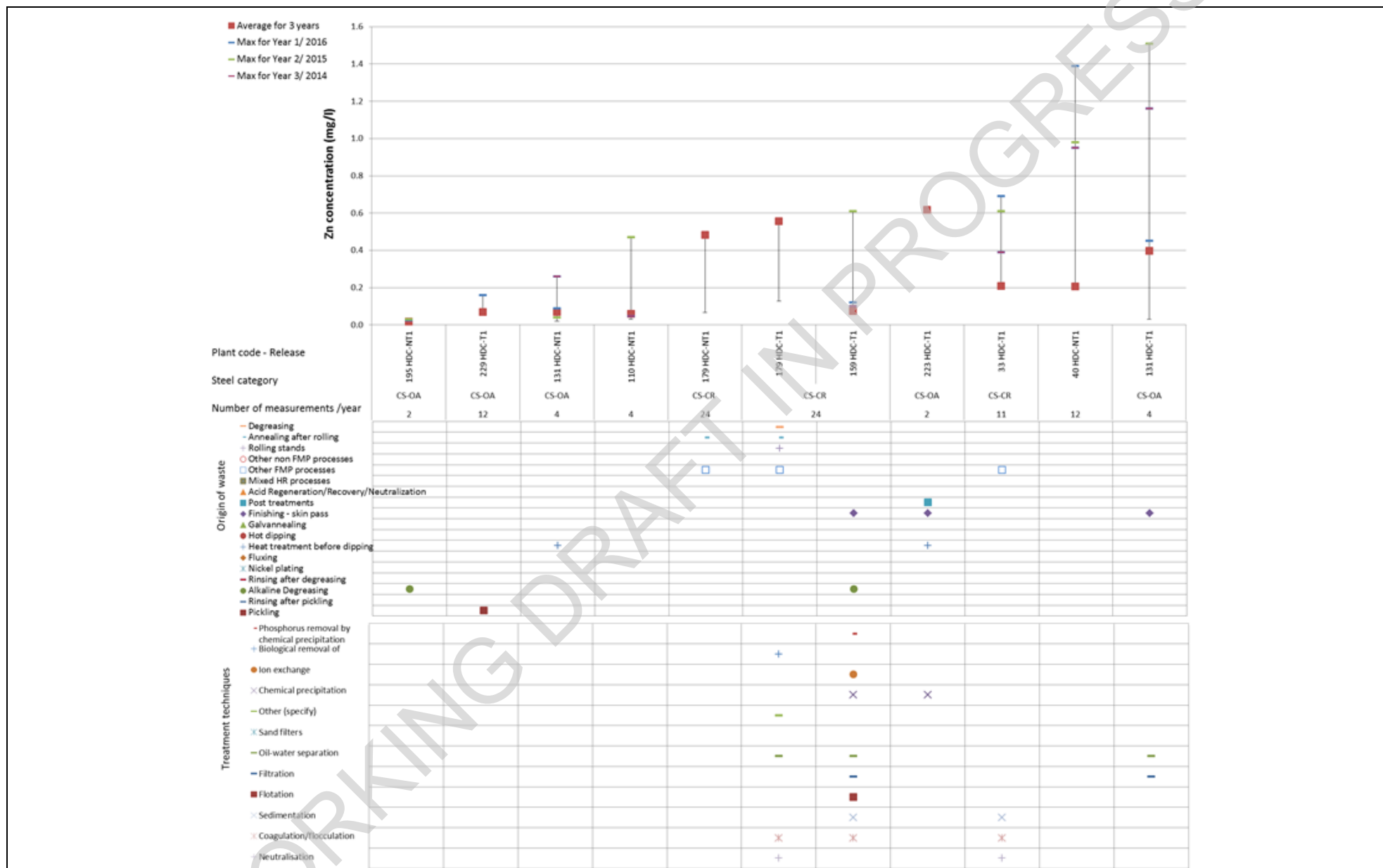


Figure 5.39: Zinc emissions (in mg/l) for direct discharges. Source: [TWG 2018].

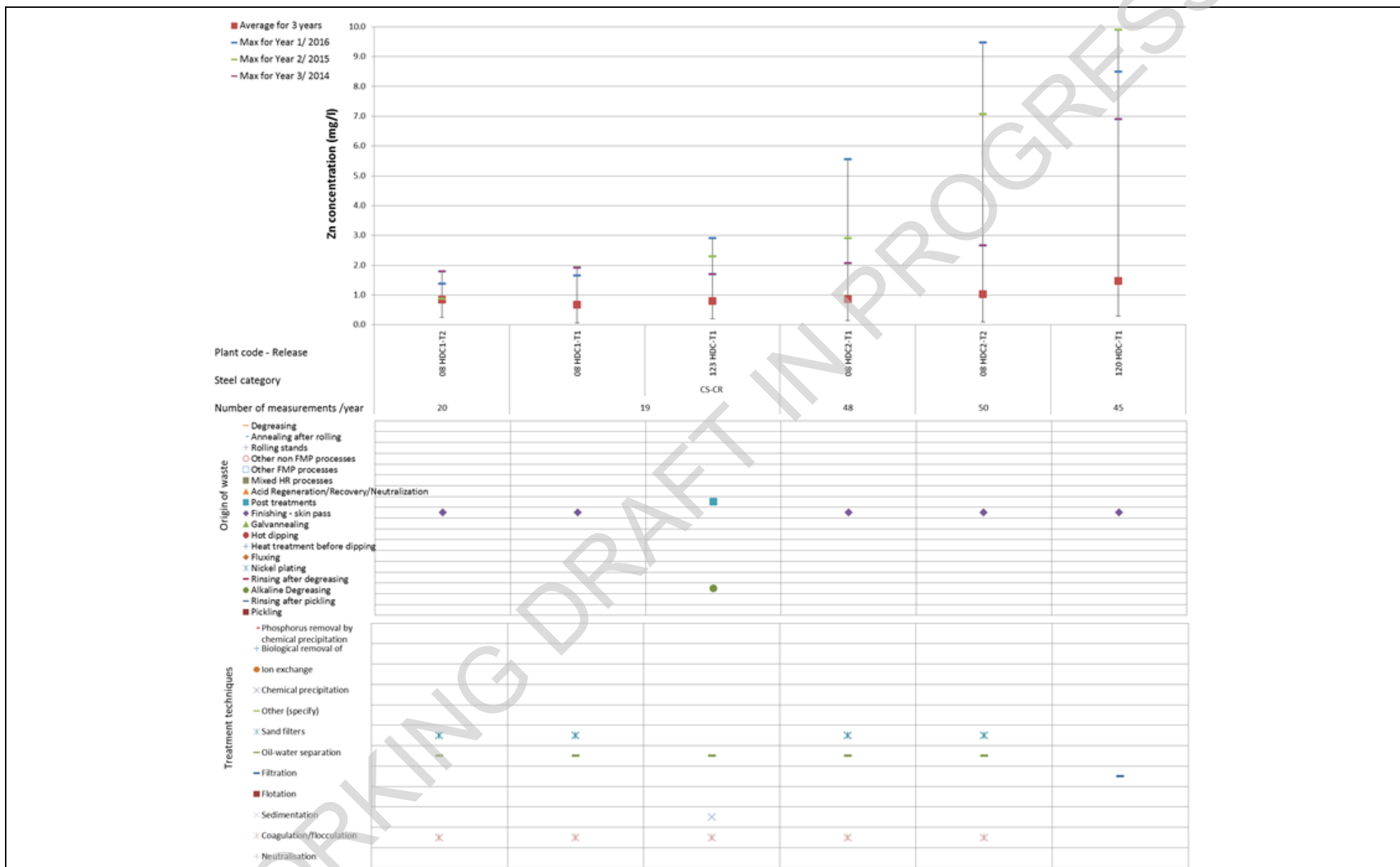


Figure 5.40: Zinc emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

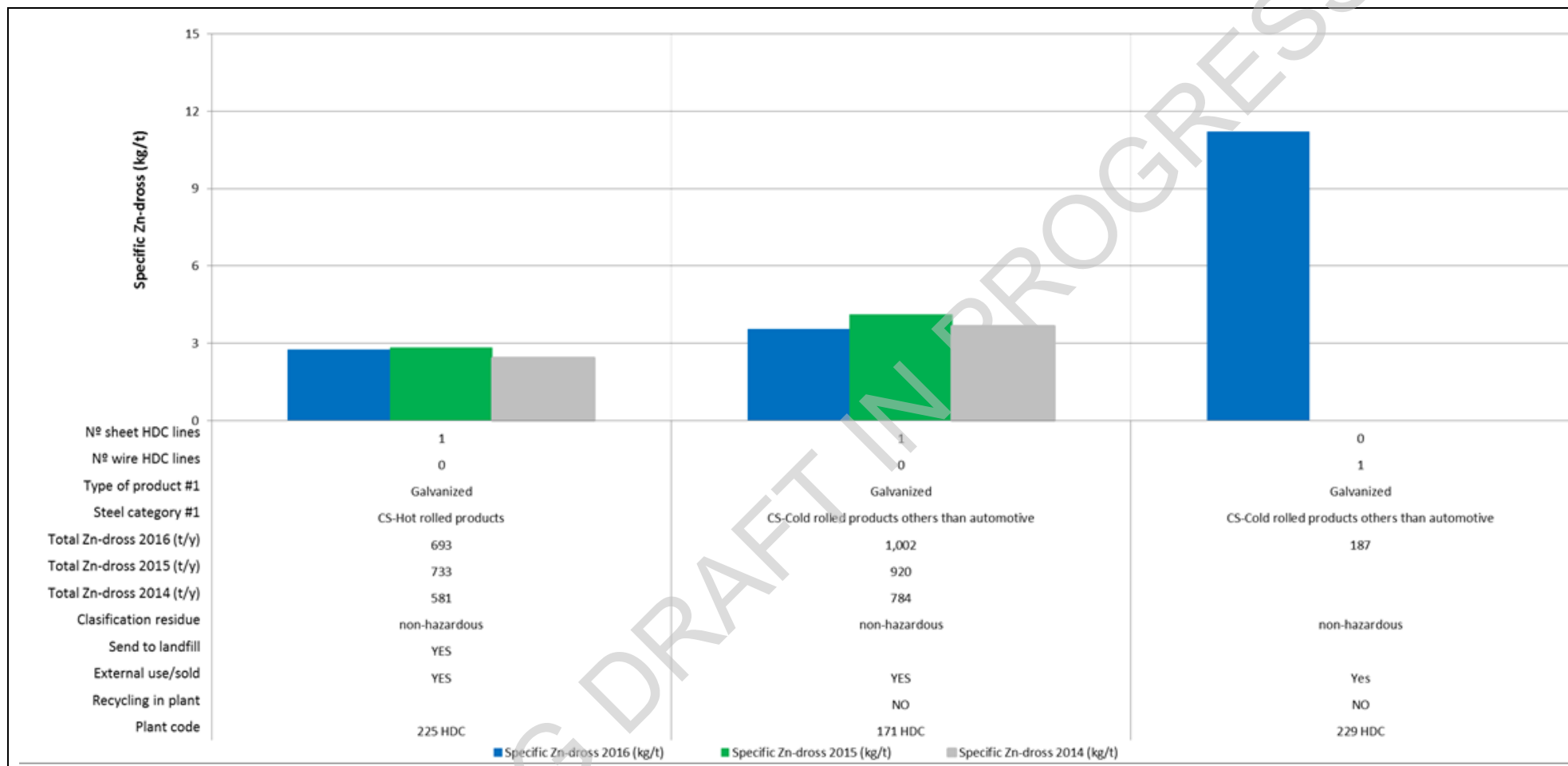


Figure 5.41: Specific generation of hard zinc (in kg/t). Source: [TWG 2018].

5.4 Techniques to consider in the determination of BAT for continuous hot dip coating

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 as well as process-integrated and end-of-pipe techniques. 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 the prevention or limiting of the environmental consequences of accidents and incidents. They also cover the prevention or reduction of 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 Directive 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 2.8 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 that 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.

In Chapter 8 general techniques (i.e. those used that are commonly used) are discussed which might also be applicable to continuous hot dip coating. These techniques are normally not repeated in this section, unless information specific for this sector was made available.

5.4.1 Galvanising of sheet

5.4.1.1 General advice / Whole plant

TWG, Section B.4.1.1 from the old BREF has been moved and the updated information can now be found in Chapter 8 (Sections 8.3.2 and 8.11.1.6).

5.4.1.2 Pickling of steel sheet

Ex-Section B.4.1.2 deleted as it covered by the generic techniques related to pickling and described in Chapter 8

5.4.1.3 Degreasing

5.4.1.3.1 Reverse cascade degreasing in the case of continuous degreasing

Description

Degreasing is carried out in two or more steps in series where the flow of degreasing solution is countercurrent to the feedstock flow.

Technical description

The solution is used in previous degreasing steps, for example the solution from the electrolytic degreasing section is reused in the spray section, once a certain oil level is reached. The spent

degreasing solution of the spray section is sent away to be regenerated. The oil residues from the regeneration devices are incinerated off site, and the rinse waters are treated in the main water treatment plant. Leakages and splashes are collected and treated.

Achieved environmental benefits

- Reduced degreasing solution consumption (fresh water consumption).
- Reduction of waste water and sludge in the water treatment plant [Com-CC-2].

Environmental performance and operational data

A total of 15 m³/h of demineralised water is needed for the material that needs this quality with a production yield of 68 t/h. [Com-CC-2]

Cross-media effects

Increased energy consumption [Com-CC-2].

Technical considerations relevant to applicability

New plants and existing lines, provided space is available. [Com-CC-2].

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

Economics

Investment costs are medium and operating costs are low. [Com-CC-2]

Driving force for implementation

TWG, please provide information.

Example plants

Several plants [Com-CC-2].

Reference literature

[Com-CC-2]

5.4.1.3.2 Cleaning and recirculation of degreasing baths-reuse of the degreasing solution**Description**

Physical treatment (e.g. magnetic separation, oil separation, micro- or ultrafiltration) is used to clean the degreasing solution for reuse.

Technical description

In general, fresh water is added against the travel direction of the strip. The amount of fresh water is added to make up the evaporation losses of water in the spray cleaning after the electrolytic cleaning section in such a way that a minimum of overflow into the electrolytic cleaning section is established. Thus this fresh water is added towards the two recirculation circuits (alkaline and electrolytic degreasing). About 25 % of the circulated degreasing solution is treated in a separate flow, e.g. by magnetic separation, oil separation, micro or ultrafiltration. Part of this flow is periodically sent to the waste water treatment plant. The rods of the magnetic separator are cleaned by a scrubbing robot. The resulting iron fines are collected separately.

Figure 5.42 shows an example of a degreasing solution circuit.

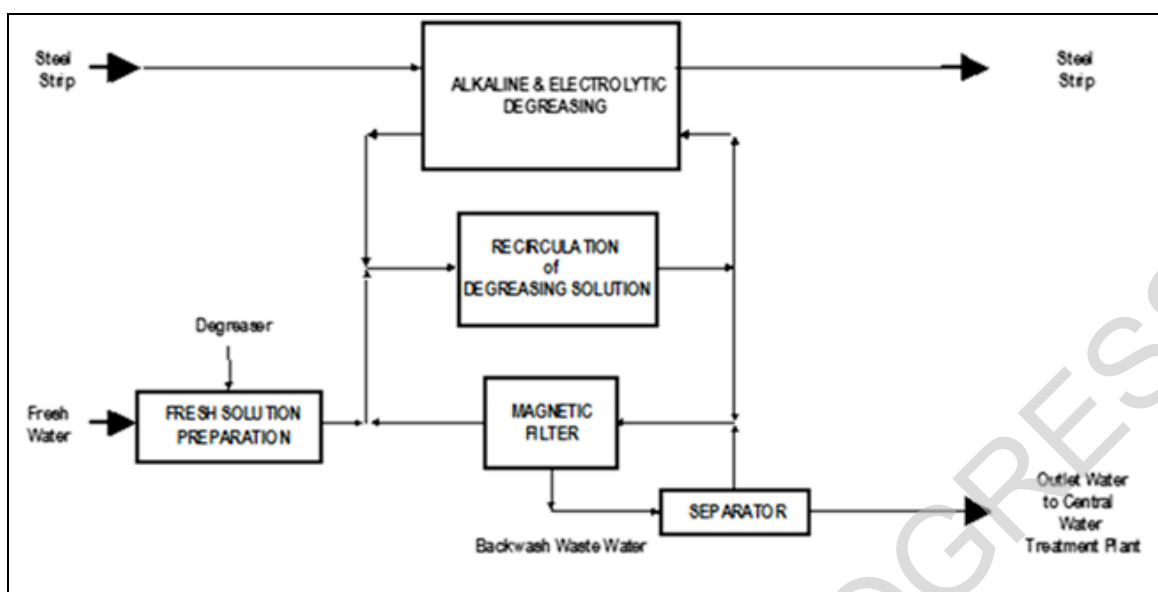


Figure 5.42: Example of a degreasing solution recycling system
[CC 11/99]

For more detailed information see Chapter D.4.3. Section 8.6.1.6.

Achieved environmental benefits

- Reduction of alkaline chemical consumption, [Com-CC-2].
- Reduction of water volume and sludge volume in the water treatment plant. [Com-CC-2].

Environmental performance and operational data

Water consumption of 5 m³/h with the same consideration as before is needed for a production yield of 68 t/h. [Com-CC-2]

Cross-media effects

Energy consumption [Com-CC-2].

Technical considerations relevant to applicability

New and existing plants in plants with no space problems for pumps, pipes, tanks, etc. [Com-CC-2].

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

Economics

High investment and operational costs. [Com-CC-2]

Driving force for implementation

- Mainly product requirements.
 - Quality of incoming coils (iron and oil residuals) can be also a driving element.
- Environmental requirements. [Com-CC-2]

Example plants

Voestalpine line 1 and 2, Aceralia line 2, Galtec 1, Florange, Aviles 2, Sagunto and others [Com-CC-2]

Reference literature

[EUROFER 23-7-18] [Com-CC-2]

TWG, Section B.4.1.3.3 from the old BREF "Degreasing by burning oil in the heat treatment furnace" has been moved and the updated information can now be found in Chapter 8 (Section 8.6.1.2).

5.4.1.3.3 Squeeze rolls

B.4.1.3.7 Using Squeeze Rolls

Description

Squeeze rolls are used before the steel strip leaves the treatment section to ensure minimal drag-out of solution into the next section.

Technical description

The remaining degreasing solution or rinse water on the steel strip is removed from the strip by squeeze rolls before leaving each treatment section. This will assure that drag-out of solution into the next section is minimised and loss of chemicals and contamination of rinse water are also minimised. [Com-CC-2]

Figure 5.43 shows an example of a chemical pretreatment section of a hot dip galvanising line for sheet using squeeze rolls and cascade rinsing (for efficient rinse water use).

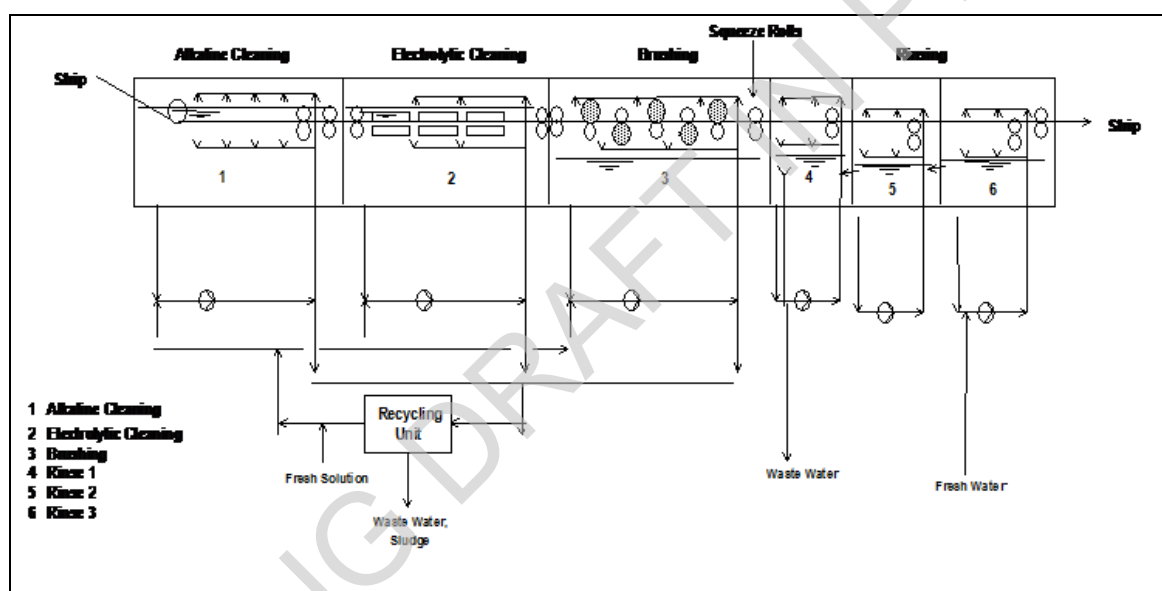


Figure 5.43: Chemical pretreatment section for a sheet hot dip coating line (example)
[CC 11/99]

Achieved environmental benefits

- Reduction of raw materials consumption [Com-CC-2].
- Reduction of waste water volume and of sludge in the waste water treatment plant [Com-CC-2].

Environmental performance and operational data

TWG, please provide information.

Technical considerations relevant to applicability

New and existing plants with degreasing and rinsing sections. [Com-CC-2].

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

Cross-media effects

No [Com-CC-2].

Economics

The initial investment is not high and the operating cost is low. [Com-CC-2]

Driving force for implementation

TWG, please provide information.

Example plants

Many plants. [Com-CC-2]

Reference literature

[Com-CC-2]

5.4.1.3.4 Treatment of spent degreasing baths

Ex-Section B.4.1.3.4 deleted as it was empty and is covered by Section 8.6.1.6.

5.4.1.3.5 Treatment of alkaline waste water

Ex-Section B.4.1.3.5 deleted as it was empty and is covered by Section 8.9.10.

TWG, Section B.4.1.3.6 from the old BREF "Degreasing vapour collection and treatment" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.3.1).

5.4.1.4 Heat treatment

See Section 8.5.3 and Section 8.8 for techniques related to energy efficiency and emissions to air, respectively.

5.4.1.4.1 Inductive heating system

Description

Induction heating is used instead of gas burners for part of the heating pattern. [EUROFER 19-6-17]

Technical description

In a hot dip galvanising line, induction heaters can be installed as follows:

- At the entry of the annealing furnace in order to boost the heating process. Induction heaters increase the productivity and facilitate the temperature transients.
- After the melt pot and the air knives, in order to produce the galvannealing coating, in the case of automotive GA (galvannealed) products.
- Inside the furnace to increase the strip temperature again after the cooling section in the case of a particular annealing cycle (mainly AHSS).

The technology is composed of a solenoidal inductor with a longitudinal flux. The power supply is at very high frequency (400–450 kHz), using transistor-based inverters. The use of very high frequency, recently developed, offers the best electrical efficiency with uniform heating along the strip width.

Achieved environmental benefits

Reduction of emissions to air from gas combustion.

Environmental performance and operational data

When the inductor is placed before the furnace, the temperature is controlled in order to avoid the burning point of emulsion residuals being reached. In addition, a higher temperature is avoided to prevent massive oxidation of the strip.

In some cases, the inductor might be connected directly to the furnace (in that case it is located in a confined space with fume extraction and an inert atmosphere) but it adds technical complexity and cost and in this case the real advantage has to be evaluated.

It should also be highlighted that the efficiency of electrical heating systems depends, among others, on the temperature range.

Cross-media effects

In the event that electricity is produced by combustion, emissions to air are generated.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[EUROFER 19-6-17]

5.4.1.5 Hot dipping (galvanising)

TWG, Section B.4.1.5.1 from the old BREF "Dross treatment" has been deleted as it is now covered under Chapter 8 (Section 8.11.2.2).

TWG, Section B.4.1.5.2 from the old BREF "External recycling of coating material slag" has been deleted as it is now covered under Chapter 8 (Section 8.11.2.2 and Section 8.11.2.3).

5.4.1.5.1 Limitation of the excess coating with metals or alloys

~~B.6.1.5 Application of the Fuzzy-logic for the Controlling of the Air knives~~

Description

After hot dipping, the coating thickness is measured by a gauge and controlled by air jets which blow the surplus of coating metal or alloy from the steel surface back into the galvanising kettle. The efficiency of the surplus removal can be improved when the oscillations of the metal sheet are limited by applying an electromagnetic field.

Technical description

After being dipped in the molten zinc bath, the strip is blown on with the air knives.

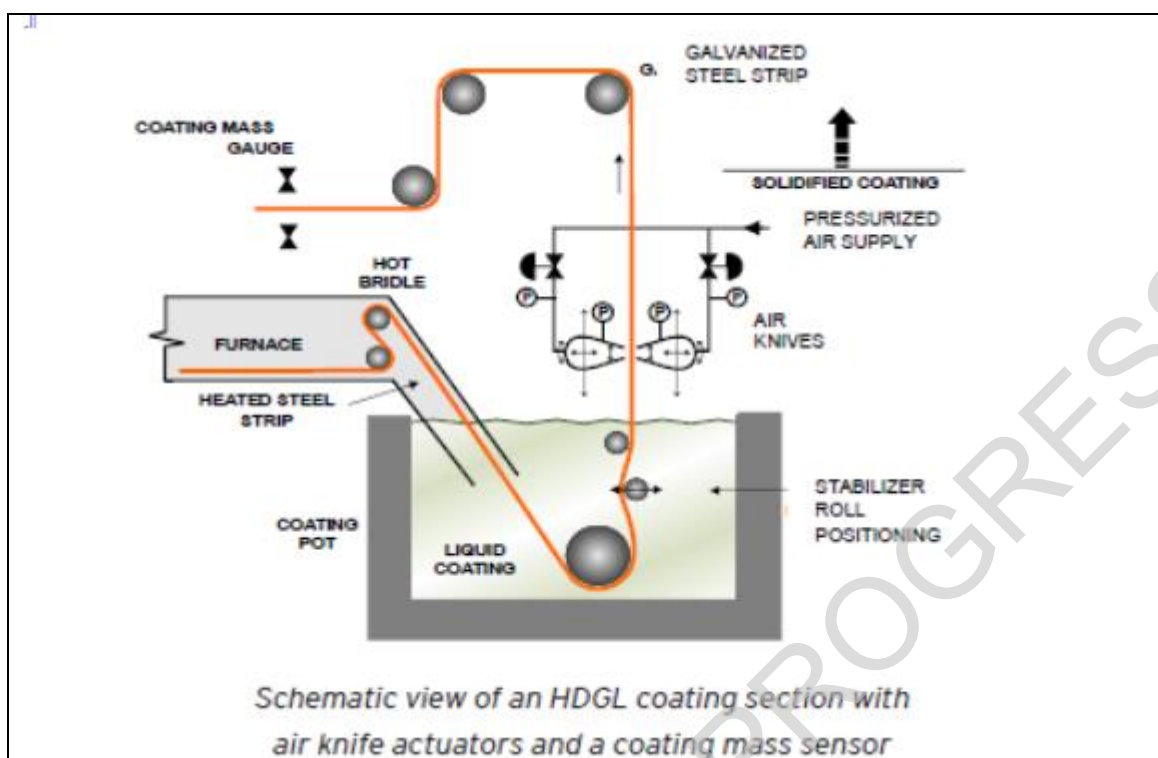


Figure 5.44: Schematic of a hot dip galvanising line coating section with air knife actuators and a coating mass sensor [EUROFER 31-3-17]

~~With an Artificial Neural Networks (ANN) software, the thickness gauge would feed back the gap of the air knives to optimise the coating. The system is designed as a knowledge based system to learn from its previous experience. [Com-CC-2]~~

With a dedicated algorithm, the zinc thickness gauge feeds back the gap of the air knives to optimise the coating. This solution enables the nozzle skew movement to be adjusted automatically.

Achieved environmental benefits

Reduced consumption of coating material.

~~This technique would produce a reduction of the consumption of the coating material, and improvement in the quality of the thickness of the metallic layer and, then, an increase in the yield. This is equivalent to a better energy efficiency. [Com-CC-2]~~

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

Energy consumption.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

Improvement of ~~in~~ the quality of the thickness of the metallic layer and, ~~then~~, therefore ~~an~~ increase ~~in~~ of the yield.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

5.4.1.5.2 Electromagnetic stabilisation

Description

The oscillations of the metal sheet are limited by applying an electromagnetic field, which improves the efficiency of the removal of the coating surplus.

Technical description

After being dipped in the molten zinc bath, the zinc-coated strip is blown on, with air knives. The electromagnetic stabiliser is applied to stabilise the strip using the electromagnetic field. The system is installed on the vertical section of the strip, after the air knives. It consists of electromagnetic actuators on both sides of the strip, installed in two specially designed housings. The number of actuators depends on the strip's width (approximately one actuator every 25 cm of width). When the strip passes between the actuators, its position is continuously measured. Every time the position deviates from the central reference position, it is corrected through specific actuators. It generates a tensile force on the strip in the active state. The strip is thus stabilised, reducing oscillations in the air knives section. Another major application for electromagnetic strip stabilisation is the installation in the cooling tower of a hot dip galvanising line. The cooling blowers may induce torsional vibration of the strip, which may result in strip contact with the blowers. Using a strip stabilisation system, these oscillations are almost completely eliminated and damage to the strip surface is actively prevented.

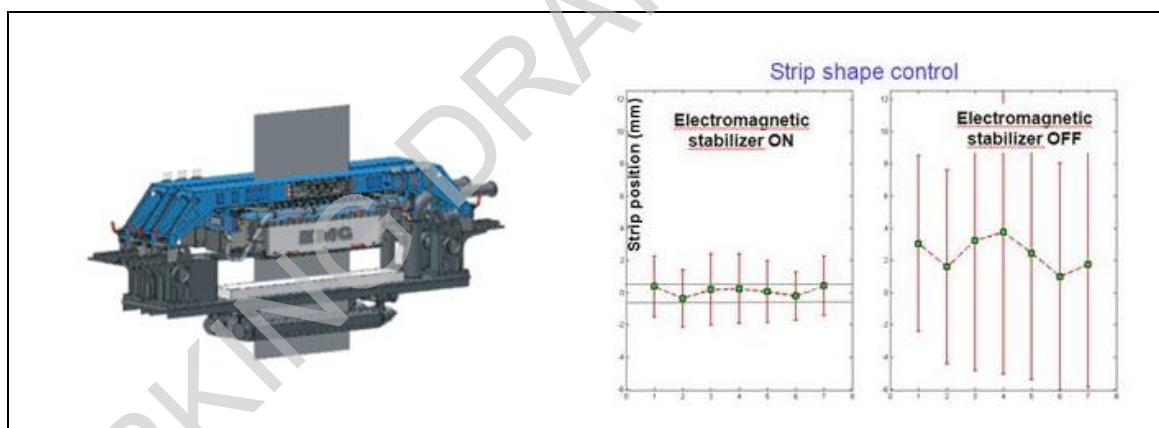


Figure 5.45: Schematic of an electromagnetic stabiliser [EUROFER 31-3-17]

Achieved environmental benefits [EUROFER 10-7-18]

Reduced consumption of coating material.

Environmental performance and operational data

The electromagnetic stabilisation implies increased maintenance efforts. In particular, if electromagnetic stabilisers are installed separately from the air knives (as shown above), the usual regular cleaning procedure of the air knives will be hindered and the cleaning efforts will increase. Integrated solutions (electromagnetic stabilisers directly combined with air knives) can avoid this drawback but require a complete system change, which is very cost-intensive.

Cross-media effects

Slightly increased energy consumption.

Technical considerations relevant to applicability

Applicable only to new plants and major plant upgrades.

Economics

High investment costs, especially for integrated solutions.

Driving force for implementation

The driving force for the implementation of this technique is mainly quality issues. It is especially relevant for applications with strict requirements for the zinc coating thickness.

Example plants

Thyssenkrupp Steel Europe AG Hot dip galvanising line 7, AM Sagunto.

Reference literature

[EUROFER 10-7-18]

5.4.1.5.3 Thin film batch hot dip galvanising technology

Description

Zinc coatings of 5–10 µm (compared to well over 80 µm from the classic process) are achieved by using the eutectic zinc-aluminium alloy (95 % Zn, 5 % Al).

Technical description

The thin film galvanising technology is based on the batch HDG method using the eutectic zinc-aluminium alloy (95 % Zn, 5 % Al). The required wetting behaviour of steel with this kind of zinc alloy is attained by means of a special pretreatment of the steel surface before the galvanising step. The characteristics of the resulting zinc layer are significantly influenced by the high aluminium content in the zinc smelter. The kinetics of the zinc layer formation are controlled in order to suppress the diffusion process from zinc and iron and hence the formation of zinc-iron phases of about 80 µm common in the conventional batch HDG process according to ISO 1461. Instead, with the thin film galvanising technology, the zinc coating is characterised by a eutectic solidification base structure with globular, hypoeutectic Zn-rich β -phase substructures, where the layer thickness is limited to an average of 10 µm. [DE 19-4-2018]

Achieved environmental benefits

- The reduction of zinc consumption by more than 80 % in the galvanising process.
- The reduction of the zinc bath temperature saves energy.
- There is no hard zinc and zinc ash accumulation is low. Therefore the thin film galvanising technology significantly reduces the amount of zinc-containing waste (see Table 5.5).

Environmental performance and operational data

The performance of the thin film galvanising technology is evaluated using the specific consumption per m² of coated surface (see Table 5.5).

Table 5.5: Performance of the thin-film galvanising

| Specific consumption or waste generation per m ² of coated surface | Zinc (kg/m ²) | Energy (kWh/m ²) | Hard zinc (kg/m ²) | Zinc ash (kg/m ²) |
|---|---------------------------|------------------------------|--------------------------------|-------------------------------|
| HDG (according to ISO 1461) | 1 500 | 11.25 | 125 | 150 |
| Thin-film galvanising technology | 200 | 10.5 | - | 70 |

Source: [DE 19-4-2018]
 Note: the data presented for the thin film galvanising process refers to its first year of operation (2017). In 2015 and 2016 only 'start-up operation' took place.

Like the standard process, the thin film galvanising process involves the chemical cleaning of steel. An absolutely grease-free and clean surface is a prerequisite for the subsequent process steps. The required wetting behavior of steel with this type of zinc alloy is achieved by means of a special temperature-resistant flux. The material is then preheated to > 100 °C in the drying oven (conventional HDG < 100 °C). The hot dip galvanising kettle is made of a special material that prevents the Zn-Al alloy from leaking out of the kettle.

Cross-media effects

None.

Technical considerations relevant to applicability

In general, the thin film galvanising process can be applied unless a layer thickness according to ISO 1461 is required by the customer.

Economics

The process steps in the thin film galvanising process are mostly the same as in the standard process according to ISO 1461. However, in view of the requirement for a very clean surface after pretreatment, additional investment costs may occur due to an intensification of the pretreatment. In addition, the drying oven needed for material preheating and the special material of the galvanising vessel increase the investment volume. As a rough estimate, it can therefore be assumed that the capital costs for the thin film galvanising technology are by a factor of 1.1 to 1.3 (depending on the degree of automation) higher than for the standard technology according to ISO 1461.

The savings potential of the thin film galvanising technology lies in the reduced use of zinc (and savings in the area of zinc-containing waste).

Driving force for implementation

Reduced consumption of coating material.

Example plants

Plant in Hagen, DE.

Reference literature

[DE 19-4-2018]

Pinger, T.: Realitätsabbildende Kurzzeitprüfungen für das Stückverzinkungssystem microZINQ® (Short terms tests of the thin film batch hot dip galvanizing system microZINQ® under realistic conditions), METALL 68, March 2014, p. 94-96

Pinger, T.: Entwicklungen in der Stückverzinkung -Binäre und ternäre Systeme – (Developments in hot dip batch galvanizing - binary and ternary systems), Journal für Oberflächentechnik (JOT), Korrosionsschutz 2012, p. 20-22

Pinger, T.: Dünne Zn-Al Stückverzinkungsschichten unter Klimawechselbelastung – (Thin Zn-Al zinc-coated layers under alternating climatic conditions), Journal für Oberflächentechnik (JOT), Korrosionsschutz 2013, p. 16-18

5.4.1.6 Galvannealing

5.4.1.6.1 Induction electrical furnace

Description

The technique can be used to galvanneal the coated strip, as well as in the drying stage of the organic coating in the final finishing phase.

See Section 5.4.1.4.1 for more information about this technique.

Description

~~An induction electrical furnace is a relatively new technique, which is applied in the hot dip coating process. It is possible to use it to galvanneal the coated strip, as well as in the dryer stage of the organic coating (if there were any) in the final finishing phase. Strictly speaking, this technique is not new (it appeared about five years ago). However, it undergoes continuous innovation, such as frequency variations and others.~~

~~This application could improve the environmental performance of the conventional furnaces when dealing with a hot dip process context, since there are no gas emissions from this stage. The price of the electrical power is not necessarily acceptable. [Com CC 2]~~

~~Reduced emissions to air.~~

Cross-media effects

Economics

Driving force for implementation:

Reference literature

5.4.1.7 Post-treatments

TWG, Section B.4.1.7.1 from the old BREF "Covering the strip oiling machine" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.7.2)

TWG, Section B.4.1.7.2 from the old BREF "Electrostatic oiling" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.7.1)

5.4.1.7.1 Cleaning and reuse of the spent phosphating solution

Description

A cleaning circuit with, for example with filtration is used to clean the spent phosphating solution for reuse.

Technical description

The phosphate solution is filtered through filters while recirculated. Only a small amount of exhausted solution is discharged from time to time and treated externally. The waste water from the rinsing section is also treated externally in the water treatment plant. This treatment may also be carried out off site. [Com-CC-2]

Achieved environmental benefits

- Reduction of phosphating chemical consumption, [Com-CC-2].
- Reduction of water outlets and volume of sludge in the water treatment plant. [Com-CC-2].

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

Energy consumption [Com-CC-2].

Technical considerations relevant to applicability

- ~~New installations and existing if space is not a problem in revamping [Com-CC-2].~~
- Generally, there are no technical restrictions to the applicability of this technique.

Economics

The investment and operating costs are medium. [Com-CC-2]

Driving force for implementation

Reduced consumption of chemicals.

Example plants

~~Voest Alpine [Com-CC-2]~~

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

~~Voest Alpine, internal document. [Com-CC-2]~~

[EUROFER 23-7-18] [Com-CC-2]

5.4.1.7.2 Cleaning and reuse of Chromating the spent passivation solution

~~B.4.1.7.4 Cleaning and Reuse of Chromating Solution~~

Description

A cleaning circuit with, for example, filtration is used to clean the spent passivation solution for reuse.

~~The solution is filtered through filters while recirculated. Exhausted solution is discharged from time to time and treated externally in the water treatment plant. This treatment may also be carried out off site. [Com-CC-2]~~

Technical description

The passivation solution is filtered through filters while recirculated. Occasionally, the exhausted solution is discharged and treated externally in the water treatment plant or off site.

Achieved environmental benefits

- Reduction of passivation chemical consumption, [Com-CC-2].
- Reduction of water outlets and volume of sludge in the water treatment plant. [Com-CC-2].

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

Energy consumption [Com-CC-2].

Technical considerations relevant to applicability

- ~~New and revamped lines if no space problems [Com-CC-2].~~

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

Economics

The investment and operating costs are medium. [Com-CC-2]

Driving force for implementation

Reduced consumption of chemicals.

Example plants

All five hot dip galvanising plants of Voestalpine Stahl GmbH.

Reference literature

~~Voest Alpine, internal document. [Com-CC-2]~~

[EUROFER 23-7-18] [Com-CC-2]

5.4.1.7.3 **Covered Capture and treatment of emissions from process baths and storage tanks**

Description

Air from the chemical storage tanks and chemical baths is extracted, for example using lateral hood or lip extraction, or the tanks or baths are located in enclosed areas equipped with roof or wall extraction..

Technical description

~~Storage tanks and chemical treating bathes are covered (extraction system) to collect emissions of fumes and aggressive waste air. [Com-CC-2]~~

See Sections 8.8.1.1 and 8.8.1.6 for the descriptions of demister and wet scrubbing, respectively.

Achieved environmental benefits

- Prevention of fugitive releases of chemical fumes. [Com-CC-2].
- Reduction in exhaust air volumes. [Com-CC-2].
- Reduction of energy and water demand through lower evaporation and insulation.

Environmental performance and operational data

These measures are not necessary for the process baths if, for the cleaning, pickling or post-treatment procedures, rolls, rinsing systems or dipping (soaking) baths are used instead of spraying systems and the dominant temperatures during process and storage are low.

By using rolls, rinsing systems or dipping (soaking) baths and low dominant temperatures for the processes, there are no fugitive emissions because the formation of aerosols and vapours is not possible.

Cross-media effects

None.

Technical considerations relevant to applicability

- ~~New and existing plants. [Com-CC-2]~~
 - Not applicable when the storage temperature is low.

- Only applicable when the treatment is carried out by spraying or when the treatment temperature is high.

Economics

- The investment and operating costs are medium. [Com-CC-2]
- Cost savings (possibility of low-temperature insulation) through reduction of energy demand.

Driving force for implementation

- Prevention and reduction of employee exposure to fugitive emissions of chemicals.
- Reduction of fugitive emissions to the environment.
- Reduction of energy consumption.

Example plants

Voestalpine lines 2, 3, 4 and 5 Voest Alpine line 2 [EUROFER 10-7-18]

Reference literature

[Com-CC-2]

5.4.1.7.4 Minimisation of carry-over of chemical solution

Use of squeeze rolls

Description

~~The remaining solution on the steel strip is removed from the strip by squeeze rolls before leaving each treating section. This will assure that drag out of solution into next section is minimised and loss of chemicals. [Com-CC-2]~~

The carry-over of chemical solution into the following process step is minimised by passing the steel sheet through squeeze rolls.

Technical description

TWG, please provide information.

Achieved environmental benefits

Reduction of raw materials consumption [Com-CC-2].

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None. [Com-CC-2]

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally applicable in plants with the passivation process. [Com-CC-2].

Economics

The initial investment is not high and the operating cost is low. [Com-CC-2]

Driving force for implementation

TWG, please provide information.

Example plants

Many plants. [Com-CC-2]

Reference literature

[Com-CC-2]

5.4.1.7.5 Use of roll coaters

Description

Roll coaters are used to apply a passivation or a phosphate-containing layer on the metal surface. This allows to better control layer thickness and thus to reduce the consumption of chemicals.

Technical description

Roll coaters are used to apply a thin passivation layer on galvanised steel strip. These passivation layers, e.g. of chromium, chromium-free or phosphate-containing medium, form a conversion layer which protects the underlying metal from corrosion. Phosphate-containing layers provide furthermore good sliding properties during cold forming.

Especially thin organic coatings (TOC) or chemical passivation is applied by roll coater. A roll coater makes it possible to apply a precise metered amount of liquid chemical to both sides of strip although line speed varies in a big range.

The roll coater is located in hot dip galvanising lines as one of the last process steps, usually before an exit looper in order to prevent strongly fluctuating speeds during the coating.

In a galvanising line, the type of roll coater is normally a two-rolls coater which contains a pick-up roll and applicator roll. An individual coating head is used for the top side and bottom side. Both coating heads can be operated independently. The coater configuration can be horizontal or vertical. The application method can be forward or reverse, i.e. the applicator roll is rotated forward or against the strip movement.

A pick-up roll lifts liquid chemical from a coating pan. A pick-up roll is in contact with the applicator roll which sweeps the liquid from the pick-up roll and transfers it onto galvanised strip (see Figure 5.46).

The thickness of the layer is adjusted especially by the batch concentration and the mode of operation (rotating / contra-rotating operation and peripheral speed of the coating rolls). The main parameters in controlling the wet film thickness are the contact pressure between the pick-up and applicator roll and the roll speed. Normally the roll speed is controlled automatically and adjusted in relation to the strip speed. A uniform application is achieved by the adjustment of the filling level of the tub, the contact pressure of the scoop to the coating roll, as well as the setting force on the galvanised steel strip. After the coating process, the passivation layer is dried by an air dryer.

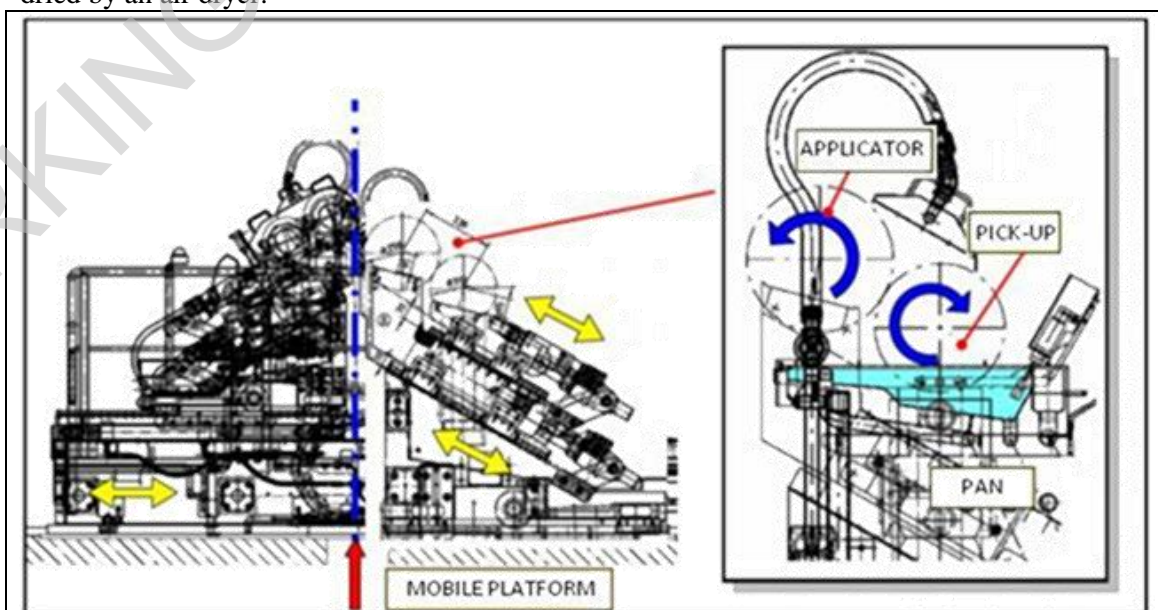


Figure 5.46: Roll coater**Achieved environmental benefits**

More accurate passivation film thickness control reduces passivation chemical consumption. Especially with thick strip, heavy coating can be avoided at strip edges.

With the dip/spray squeeze method, it is necessary to use separate air nozzles at strip edges for thick material. This creates a lot of aerosol and dust which are safety risks. With a roll coater, this risk can be eliminated.

The amount of zinc dissolved into the passivation solution is estimated to be reduced by about 90 % compared to dip/squeeze or spray/squeeze methods. The need for cleaning the system and the amount of waste are decreased.

Environmental performance and operational data

The presetting of coating parameters can be made according to parameter tables. However, the final adjustments are made according to the measured film thickness of finished product. Therefore a coating mass or thickness control is recommended.

A continuous wet film gauge can be placed after roll coaters. Normally passivation layer mass or TOC film thickness is measured from coated samples. The coating mass is determined by the content of certain tracer elements in the chemical (Cr, Ti, P, Mn, etc.). Analysis is carried out with the XRF method or with a wet chemical method (AAS, ICP). TOC layer thickness can be measured by the beta backscatter method.

Regular cleaning of the roll coaters is necessary. Especially water-based acrylic easily sets on rolls. This causes quality problems and rejections of galvanised products. Cleaning procedures require extra manpower and waste water is created. However, the need for cleaning is related to chemical type used. In comparison to the traditional dip/spray squeeze method, the roll coater does not create significantly more waste water. In many cases, the waste water can be used to replenish new working solution.

The roll coating method is also commonly used in other types of production lines, e.g. in coil coating lines (similar equipment).

When acrylic resin is applied onto galvanised steel strip, a certain temperature is required for curing the coating. Depending on the galvanising line layout, the relatively high exit temperature (80–120 °C) might cause problems.

Roll coating is applicable for a wide range of liquid chemicals. Depending on the chemical, UV or IR curing can be used instead of hot air oven.

Cross-media effects

None.

Technical considerations relevant to applicability

The roll coating method is generally applicable to flat products.

Economics

The investment cost of a complete roll coating facility is around EUR 1.2 million. This contains two shuttle-type roll coaters, a working solution premixing and circulation system and a hot air oven for curing.

The operational costs excluding the chemical price are comparable to conventional spray bar squeeze roll systems. The total operational costs depend on application methods used: special engraved pick-up rolls are more expensive than polished rolls, reverse rotating applicator roll wear is faster, etc.

Driving force for implementation

Improved quality and versatility.

Example plants

SSAB Hämeenlinna Site, hot dip galvanising line # 3, Finland.

ThyssenKrupp Steel AG, hot dip galvanising line no. 8.

ArcelorMittal Piombino HDG 4.

Reference literature

[EUROFER 10-7-18]

GFG double shuttle vertical acrylic coater, operator manual, 2000.

Optimization of the Chemcoater process to passivate galvanized steel strip in galvanizing line no. 8 of TKS, M. Dinter, M. Dubke, K. Hüttenbräucker, R. Schönenberg (ThyssenKrupp Steel AG), La Revue Metallurgie-CIT, September 2006.

Lindfors, N-O., Kostamo, P., BAT examples from the Nordic iron and steel industry, TemaNord 2006:509, (2006)

5.4.1.7.6 Cr-free and Cr (III) chemical passivation techniques in hot dip galvanising lines

Description

Use of Cr(III) and Cr-free chemical passivation in hot dip galvanising lines.

Technical description

Cr (VI) passivation is not to be considered BAT due to environmental issues.

Cr-free passivation consist of using different types of manganese, zinc, titanium fluoride, phosphates and molybdates solutions or of organic compounds, e.g. acrylic and carboxylatic polymers and phosphates (see also Section 5.4.1.7.7).

Cr(III)-based passivations consists of, for example, types of Cr(III) fluorides.

The coating has very little/fine structure, and the chromium-free passivation coating was proven to be completely amorphous with the aid of discontinuous X-ray fluorescence measurements. The protective properties of this coating formed by a conversion reaction are predominantly a function of a very effective barrier against corrosive ions and substances.

The corrosion protection of the chromium-free passivation coating as demonstrated in the saltwater spray test largely depends on the coating thickness. The coating thickness (an important quality criterion) is determined by the lead element, e.g. titanium, and by means of X-ray fluorescence analysis. If the coating thickness is too thin, corrosion protection will not be sufficient in the saltwater spray test. If the coating thickness is too thick, weldability and the metallic shine of the surface will be lost.

Cr(III) chemical passivation techniques are well established for several applications and are considered the state of art for chemical passivation in Europe. Cr-free passivations are in continuous evolution.

Achieved environmental benefits

- Avoidance of Cr(VI) emissions to the environment.
- Avoidance of heavy metal, fluoride and waste emissions to the environment (that holds for the passivation solution II and III).

- Avoidance of employees' exposure to Cr(VI).

Environmental performance and operational data

It is necessary to control the process parameters, e.g. conductivity, the concentration of titanium manganese or phosphate in the bath. The layer weight would be controlled by XRF methods or by wet chemical methods. With a mobile XRF device, the titanium or the phosphate layer weight (mg Ti/m^2) is checked offline on the steel strip at the end of the hot dip galvanising plant. In wet chemical analysis, the layer thickness is measured indirectly from the chromium content of the stripping solution.

Sometimes sediments build up in the passivation solution (Mn, Zn, Ti-phosphates or Cr(III) fluorides) which need to be disposed of.

The amount of energy needed is the same as for the Cr(VI) passivation.

The amount of passivation solution needed is about 0.5–2.0 l/t Cr-free chemically passivated product.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

Applicability may be restricted due to product quality requirements or specifications.

Economics

Compared to the well-established Cr(III)-based passivations, the Cr-free passivations lead to approximately twice the costs.

Driving force for implementation

Avoid the use of chromium (VI) for passivation.

Employee safety and protection against exposure to chromium (VI).

Example plants

Today many hot dip galvanising plants have implemented the Cr(III)-based passivation technology (for example plants of Voestalpine Stahl GmbH); nevertheless, part of the production is done using the Cr-free passivation technology.

SSAB Europe Hämeenlinna Works HDG lines n°1 and n°3 in Finland use Cr (III) technology as well as AM HDC lines (for Example Aviles, Piombino).

Reference literature

[EUROFER 10-7-18]

Patent: DE 10 2005 027 568 A1

Patent: EP 0880410 B1

Patent: DE 44 12 138 A1

Patent: EP 1836330 (published since 26.9.2007)

Patent: WO 93/05198

X. Zhang, Cr(VI) and Cr(III)-Based conversion Coatings on Zinc, Den Haag, 2005

5.4.1.7.7 Thin organic coating passivation

Description

A thin organic coating based on polymers such as acrylic, epoxy, ethylene, polyurethane or polyester is applied to the steel surface for passivation. [EUROFER 31-3-17]

Technical description

Thin Organic Coated (TOC) galvanised steel strips are produced in-line on a galvanising line. The solution is applied on the top and/or bottom side of a newly galvanised strip by a chem-coater (rollcoater), spray system, squeegee rolls and other coating techniques. The wet film is subsequently dried.

TOC is a film-forming coating based on polymers such as acrylic, epoxy, ethylene, polyurethane or polyester. The dry-film thickness is usually 0.5–3 µm. The coating can contain some corrosion inhibitors, for example compounds of titanium, trivalent chromium, vanadium or silicon. The coating not only enhances the corrosion resistance of galvanised strip but also acts as a dry lubricant and adds an anti-fingerprint feature to the strip, suitable for direct post-painting without further surface treatment. [EUROFER 10-7-18]

Achieved environmental benefits

Cr(VI)-emissions are avoided by use of Cr(VI)-free chemical.

Environmental performance and operational data

Dry-film thickness can be measured offline using a beta backscattering measuring device. Titanium, phosphate, chromium or other trace elements in the coating can be measured using XRF.

Any excess fluoride-containing solution is properly disposed of in a waste treatment facility. The amount of energy can be higher than for the standard passivation due to the increased need for drying/curing the applied film (with IR or with a gas-operated dryer).

The expected wet film thickness is 1.5–6 g/m².

Compared to chemical passivation, Thin Organic Coating provides better resistance against so-called white rust of galvanised surface. It also helps in forming processes by acting as a dry lubricant. The anti-fingerprint feature is achieved.

Cross-media effects

Higher energy consumption due to the higher drying temperature and the necessary subsequent cooling.

Technical considerations relevant to applicability

- Generally, there are no technical restrictions to the applicability of this technique.
- For existing plants, available space might be a limiting factor (especially if additional drying/curing capacity is required).

Economics

High investment and medium operational costs.

Driving force for implementation

Avoid the use of chromium (VI) for passivation.

Example plants

SSAB Hämeenlinna Works, galvanising line n°3, Finland.

ArcelorMittal Piombino.

Voestalpine Stahl GmbH HDC line 2.

Reference literature

Lindfors, N-O., Kostamo, P., BAT examples from the Nordic iron and steel industry, TemaNord 2006:509, (2006)

[EUROFER 10-7-18]

5.4.1.7.8 Use of reverse osmosis to produce deionised water

Ex-Section B.4.1.7.7 deleted as covered now in Section 8.9 as far as the treatment of waste water is concerned. In addition, the production of deionised water is not specific to the FMP sector.

5.4.1.8 Finishing

5.4.1.8.1 Collection and treatment of ~~skin-pass~~ temper mill emulsion solution

See Section 3.4.4.3.

5.4.1.9 Waste water treatment in galvanising line

Description

Generally, the waste water treatment plants treat not only the water from coating plants but also all the effluents generated in the rolling facilities. Normally, these plants consist of three different circuits: **chromic water** line, **oily water** line and the **general waste water line**.

Alkaline cleaning is used in the galvanising lines to clean the oily residues and metallic particles from the surface of steel strip. Emulsions are used in the galvanising line temper mill. Passivation fume scrubbing causes very small amounts of dilute chromic-containing waters. All effluents from these treatments are treated in a galvanising line water treatment plant where oil, heavy metals (Zn, Cr), Fe, phosphates and other suspended solids are separated from the water. Techniques in use are oil separation, flotation, chromium reduction, neutralisation, flocculation, sedimentation, activated carbon filtration and ion exchange. [EUROFER 23-7-18]

See Section 8.9 for more information about the techniques used.

5.4.1.9.1 Chromic water line

Ex-Section B.4.1.9.1 deleted as covered now in Section 8.9.4.

5.4.1.9.2 Oily water circuit

Ex-Section B.4.1.9.2 deleted as covered now in Section 8.9.

5.4.1.9.3 General waste water circuit

Ex-Section B.4.1.9.3 deleted as covered now in Section 8.9.

5.4.1.10 Cooling water systems

Ex-Section B.4.1.10 deleted as it is now covered by Section 8.7.9.

5.4.2 Aluminising and lead-tin (terne) coating of sheets

Techniques to be considered in the determination of BAT are the same as for galvanising of sheets, when the same processing steps are applied (e.g. pickling, passivation, etc.). ~~Some additional measures for lead-tin (terne) coating are listed below:~~

Ex-Section B.4.2.1 " Nickel plating" has been deleted as electroplating is not in the scope of the FMP BREF.

5.4.2.1 Air knives for thickness control

Ex-Section B.4.2.2.1 deleted as identical to the one applied for galvanising of sheets.

5.4.3 Wire hot dip coating (galvanising)**5.4.3.1 Continuous pickling of wire**

Ex-Section B.4.3.1 deleted as the techniques described in this Section are already covered by generic techniques, namely:

- *Ex-Section B.4.3.1.1 is covered by Section 8.8.4.3*
- *Ex-Section B.4.3.1.2 is covered by Section 8.6.2.8*
- *Ex-Section B.4.3.1.3 is covered by Section 8.6.5*
- *Ex-Section B.4.3.1.4 is covered by Section 8.6.5*
- *Ex-Section B.4.3.1.5 is covered by Section 8.6.5*
- *Ex-Section B.4.3.1.6 is covered by Section 8.6.5*
- *Ex-Section B.4.3.1.7 is covered by Section 8.6.2.8 and 8.7.6*

5.4.3.2 Fluxing

Ex-Sections B.4.3.2.1, B.4.3.2.2 and B.4.3.2.3 deleted as they are now covered by generic techniques described in Section 8.6.3.

5.4.3.2.1 Enclosed Covered flux bath**Description**

The flux bath is covered with a hood or bath cover to minimise heat losses.

Technical description

~~A flux solution (a heated watery solution of a mixture of $ZnCl_2$, NH_4Cl and possibly other salts) emits only water vapour. The flux bath is could be covered with a hood or bath cover. [CET-BAT]~~

~~Enclosed flux baths were not considered BAT because the vapour escaping from the baths is not really dangerous and the advantage for the environment is too small compared to the costs. [Com2-B]~~

Achieved environmental benefits

~~This can have an advantage in terms of Minimisation of heat losses, when the flux bath is heated. [CET-BAT]~~

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

TWG, please provide information.

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[CET-BAT]

5.4.3.3 Hot dipping (galvanising)

5.4.3.3.1 Zinc bath: good housekeeping

Description

Good housekeeping mainly involves maintaining a protective layer or a cover on the zinc bath to minimise zinc oxidation and heat loss and drying the wire before entering the zinc bath to avoid dust formation.

Technical description

The most important housekeeping methods are as follows:

- Maintain a protective layer (particulate material) or a cover on the zinc bath. This minimises loss of zinc by oxidation, minimises the formation of flux fumes and drastically reduces energy losses of the zinc bath.
- Any moisture dragged into the zinc bath evaporates explosively. This cause of zinc dust can be eliminated by having a dry wire at the inlet of the zinc bath. [CET-BAT]

Achieved environmental benefits

TWG, please provide information.

Environmental performance and operational data

By good housekeeping methods, it is perfectly possible to run a hot dip galvanising bath at very low emissions of Zn and dust (below 5 mg/Nm³ Zn, below 10 mg/Nm³ dust). [CET-BAT]

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

TWG, please provide information.

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[CET-BAT]

Ex-Sections B.4.3.3.2, B.4.3.3.3 and B.4.3.3.4 deleted because they are now covered by the generic techniques in Sections 8.8.6.4, 8.8.6.1 and 8.11.2.4, respectively.

Ex-Section B.4.3.3.5 deleted because it is covered by generic techniques described in Section 8.7.9.

5.5 Emerging techniques for continuous hot dip coating

B.6 Emerging Techniques for Continuous Coating Lines

TWG, the content of the previous BREF in this Section has been deleted for Draft 1.

Emerging techniques present in the old BREF, for which information was received from the TWG, have been moved and integrated as BAT candidates. For other remaining emerging techniques, the TWG is requested to indicate whether they should be kept (in which case updated information should be sent), or deleted.

Finally, the TWG is requested to send information on possible new emerging techniques that could be considered in the revised version of the BREF document.

WORKING DRAFT IN PROGRESS

6 BATCH GALVANISING

6.1 General information on batch galvanising

For the entire Section 6.1 'General Information on batch galvanising, Please provide updated information for Tables 6.1 and 6.2 (Reference date; 1997 – OLD DATA)

General galvanising is a service industry, offering the application of zinc coating corrosion protection to steel fabricators or the users of fabricated steel products. The sector operates with short lead times and short order books to provide an enhanced service to customers. Distribution issues are important and so plants are located close to market concentrations. Consequently, the industry consists of a relatively large number of plants servicing regional markets in order to minimise distribution costs and increase economic efficiency. Only a few 'niche' operators are prepared to transport certain classes of fabricated products longer distances in order to exploit their special expertise or plant capability. Opportunities for these specialist operators are limited.

About 600 galvanising plants with more than 30 000 employees are distributed throughout the EU, as shown in Table 6.1.

Table 6.1: Distribution of galvanising plants in the EU

| Member State | Number of plants in 1997 | Steel galvanised [t/yr] |
|-----------------------------------|--------------------------|-------------------------|
| Austria | 17 | 132 916 |
| Belgium | 22 | 263 268 |
| Denmark | 17 | 122 500 |
| Finland | 19 | 73 360 |
| France | 69 | 690 105 |
| Germany | 185 | 1 428 610 |
| Greece | 4 | n.a |
| Italy | 74 | 810 716 |
| Luxembourg | 1 | n.a. |
| Netherlands | 21 | 242 717 |
| Portugal | 9 | 42 368 |
| Spain | 35 | 314 509 |
| Sweden | 34 | 120 000 |
| United Kingdom (+ Ireland) | 88 | 738 928 |
| Total: | 595 | 4 979 997 |

Source of data: [EGGA5/98] [EGGA/99]

The zinc consumption of the EU galvanising industry (excluding Greece and Luxembourg) in 1997 was 381 188 tonnes. The main galvanising countries were Germany with of 27.5 % of the production, Italy with 15.6 %, the UK and Ireland with 14.2 % and France with 13.3 %. [EGGA/99]

In recent years, the markets for galvanised steel have grown more rapidly than previously. The share of the total market accounted for by various market sectors is shown in Table 6.2.

Table 6.2: Market segmentation for Galvanised Steel

| Market | Tonnage [t] | Percentage [%] |
|----------------------------------|------------------|----------------|
| Construction | 2 022 886 | 39.0 |
| Infrastructure and highways | 832 634 | 16.1 |
| Power transmission | 531 042 | 10.2 |
| Agriculture | 524 586 | 10.1 |
| Transport | 308 786 | 6.0 |
| Fasteners | 254 056 | 4.9 |
| Other | 712 264 | 13.7 |
| Total | 5 186 254 | 100.0 |
| <i>Source of data: [EGGA/99]</i> | | |

Industry turnover is estimated at EUR 1 800 million per year. The capacities of the most economic operating units are related to the size of the steel fabrications to be treated and to the demand in the accessible market. Most companies in the sector are small or medium-sized enterprises financed by private capital. Integration in the zinc production or steel fabrication industry is very unlikely. About half of the European capacity is in the hands of businesses that own one or two plants. Larger companies, owning up to 20 plants, have emerged in some Member States. Even so, the assets of these groups are widely distributed in order to service regional markets and the opportunity for concentration of productive capacity is limited. [EGGA5/98]

In recent years the cost of entry has risen, reflecting greater capital intensity arising from the use of improved technology and increased environmental control. This has discouraged the entry of poor-quality short-life operators. On the other hand, the sector is highly competitive with regards to the price and quality of service. [EGGA5/98]

In general, the sector enjoys reasonable economic success but it is occasionally subject to price pressures because of over-capacities in some markets and variations in the price of zinc.

A significant part of recent investment has been spent on emission control measures. The hot dip galvanising process gives rise to zinc-containing waste/by-products such as zinc skimmings and dross. These are recycled as raw material to the secondary zinc industry for the recovery of the valuable zinc. Aqueous process streams which contain zinc are either treated on site for the extraction of metals before the aqueous stream is discarded, or aqueous blowdown is removed from the site by specialist contractors for further recovery treatment. [EGGA5/98]

6.2 Applied processes and techniques in batch galvanising

6.2.1 Batch hot dip coating overview

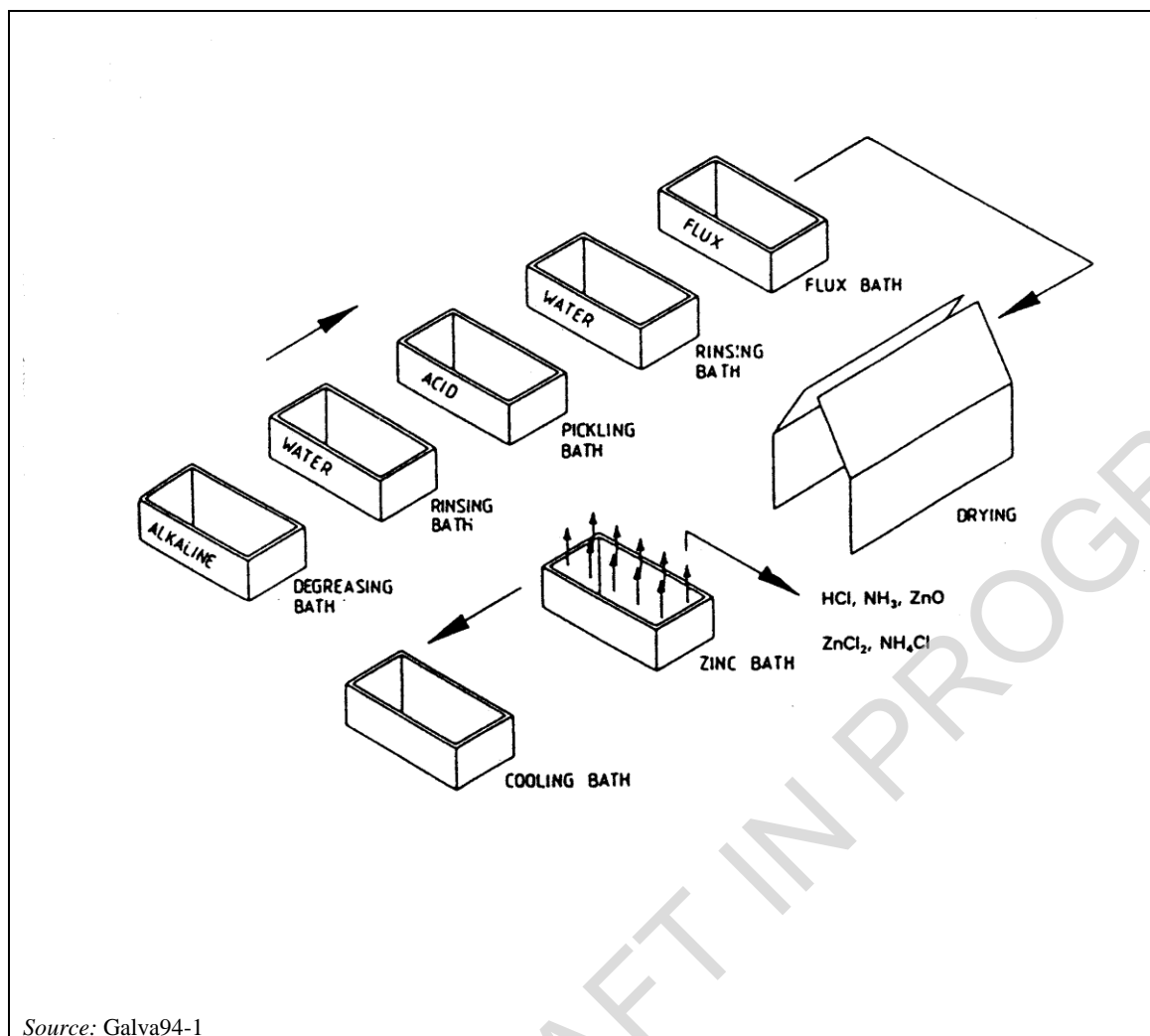
Hot dip galvanising is a corrosion protection process in which iron and steel fabrications are protected from corrosion by coating them with zinc. Prevalent in batch hot dip galvanising is job galvanising - also referred to as general galvanising - in which a great variety of input materials are treated for different customers. The size, amount and nature of the inputs can differ significantly. The galvanising of pipes or tubes, which is carried out in semi- or fully automatic special galvanising plants, is not usually covered by the term job galvanising.

The items to be coated in batch galvanising plants are steel fabrications, such as nails, screws and other very small items; lattice grates; construction parts; structural components; light poles; and many more. Tubes are sometimes also galvanised in conventional batch coating plants. Galvanised steel is used in construction, transport, agriculture, power transmission and everywhere that good corrosion protection and long lifetime are essential. [EGGA5/98]

Figure 6.1 shows the sequence of operations in a batch galvanising plant, which usually comprises the following process steps:

- degreasing;
- pickling;
- fluxing;
- galvanising (melt metal coating);
- finishing.

A galvanising plant essentially consists of a series of treatment or process baths. The steel is moved between tanks and dipped into the baths by overhead cranes.



Source: Galva94-1

Figure 6.1: Typical process flow for a general galvanising plant

There are two basic plant layouts, distinguished by the design of the pretreatment section: open and closed pretreatment.

Galvanising plants with open pretreatment locate pretreatment vats and the other process operations in one bay. In these cases, pickling baths are operated at room temperature to avoid emissions to air (acid fume) and the associated corrosion of installations.

Galvanising plants with dedicated, tightly enclosed pretreatment sections are designed to operate pickling baths at elevated temperatures and thus reduce the number of pickling vats and the pickling time. Fume generated from the acid vats is collected and, in some cases, cleaned by suitable abatement devices.

For some special applications, the galvanising bath can be operated at elevated temperature using ceramic-lined kettles instead of steel kettles; this process variation is referred to as 'high-temperature galvanising'.

Installations for tube galvanising represent a special type of galvanising plant in which tubes are quasi-continuously coated. The handling of tubes in these plants is partly or fully automated. Figure 6.2 shows the dipping principle of such plants.

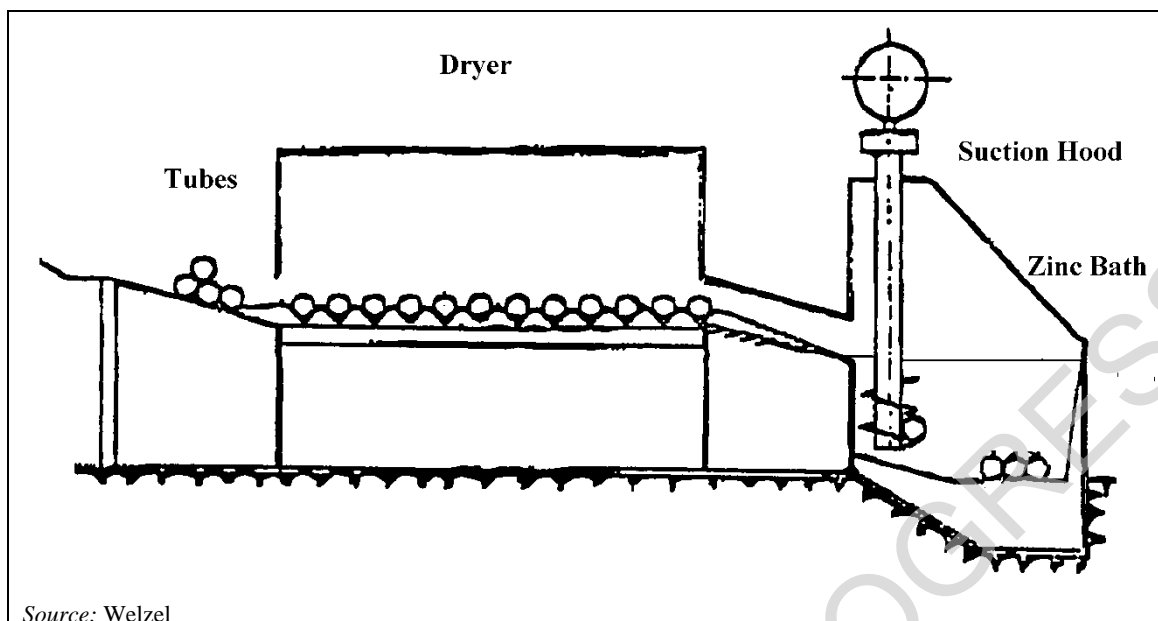


Figure 6.2: Principle of tube galvanising

The principal pretreatment steps are the same as for general galvanising but, following the coating, the excess zinc is removed from the outside of the tubes by blowing with compressed air. The excess zinc on the inside is removed by a water/steam pressure pulse.

Although the basic technological principles have remained unchanged over the past 150 years, some developments have taken place mainly to improve the coating quality of reactive steels or small parts. Research has been done on adding vanadium and titanium to the molten zinc bath and on developing a zinc-tin coating. Technigalva, with the addition of approximately 0.03 % to 0.08 % nickel to the zinc bath, has been applied for some time now at full industrial scale. Zinkopal, in which a zinc-aluminium coating for small parts is used, was developed in Germany, where one plant is in operation. [Galva-97-1] [Com EGGA]

6.2.2 Raw material handling

Zinc is received in bulk form and stored close to the galvanising process. Chemicals, principally 28 % HCl, an input to the pickling process, are received in plastic or glass containers or by road tanker, and are stored according to manufacturers' instructions. Other agents, such as mist suppressants and degreasing fluids, are similarly received in drums and stored according to manufacturers' instructions. Materials for processing, consisting of a wide variety of steel fabrications, are received on site, usually by road haulage, and are unloaded by forklift truck or crane. [EGGA5/98]

6.2.3 Preparation of the input

Steel fabrications are inspected to ensure that they are suitable for galvanising. Iron and steel castings and some threaded components are abrasive blast cleaned before pickling. To handle fabrications throughout the galvanising process, they are attached to jigs or strongbacks by means of hooks or steel wire. Fasteners and other small components are loaded into perforated baskets, which are attached to the jigs. [EGGA5/98]

6.2.4 Degreasing

To guarantee satisfactory galvanising and to enhance the performance of filtering separators, a degreasing step is used to remove traces of coolants and lubricants from the fabricated steel. This is commonly done using **alkaline degreasing** baths. These baths contain surfactants, which remove oil and grease from the metal surface by emulsifying. The resulting unstable emulsions float on the surface of the bath and can be removed by gravitational separators, skimmers, micro- or ultrafiltration, etc.

The concentration, bath temperature and immersion time of the workpieces determine the efficiency of the degreasing baths. The normal temperature range for indirectly heated degreasing baths is 30–70 °C, although in some cases hot degreasing is applied at a temperature of about 85 °C. The baths consists of a sodium hydroxide solution (1–10 %) plus other alkaline reagents, such as soda, sodium silicate, condensed alkaline phosphates and borax, and specific surfactants, emulsifying agents and dispersion agents.

An alternative method is **acidic degreasing**. Degreasing baths consist of diluted strong inorganic acids, like hydrochloric acid and/or phosphoric acid with additives. Acidic degreasing agents usually form stable oil emulsions which obstruct bath maintenance measures such as skimming, separating, centrifuging or ultrafiltration. [ABAG]

When degreasing is skipped or when insufficiently degreased workpieces enter the process flow, there is a risk of organic pollutants being carried over to subsequent process steps, possibly leading to organic pollution in the flux fume arising from the galvanising kettle during dipping. Organic pollutants in the waste gas lead to operational problems with filtering precipitators (clogging, etc.) and make the recycling of precipitated dusts difficult or even impossible. [EGGA5/98] [ABAG]

Degreasing may only be omitted if the input material is oil-free, which is the exception rather than the rule in batch galvanising.

After degreasing, rinsing is necessary to prevent carry-over of degreasing agents which would shorten the lifetime of pickling baths and reduce the reusability of the bath.

6.2.5 Pickling

6.2.5.1 HCl pickling

To remove casting skin, roll skin, grit or scale, the items are pickled in diluted hydrochloric acid. Therefore, a galvanising plant usually comprises a series of pickling baths with different acid concentrations ranging from 2 % to 16 %, normally 12 % to 16 % when freshly prepared. To prevent excessive pickling of steel items, especially in pickling high-tensile steels, and to protect the steel pickling vats, pickling inhibitors (e.g. hexamethylenetetramine) are added to the bath. [EGGA5/98] [ABAG] [Com EGGA]

During operation the iron content of the pickling bath increases, while the amount of free acid decreases, making it necessary to top up the bath occasionally by adding fresh acid. Iron(II) chloride has a limited solubility in HCl. When the maximum is reached, pickling becomes impossible, but usually the pickling bath has to be replaced even sooner at lower FeCl_2 concentrations. Discarding concentrations of 170 g FeCl_2/l (= 75 g Fe^{2+}/l) and 100–120 g Fe/l have been reported. [EGGA5/98] [ABAG] [Com EGGA] [Com DK]

Raising the temperature of the pickling bath can enable its use at relatively high concentrations of FeCl_2 , e.g. 175–200 g/l with the bath at 35 °C, with some increase in emissions. [Com2 EGGA]

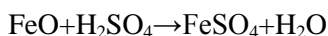
Operators sometimes degrease articles with less heavy deposits of oil in the pickling tank. This practice may lead to an increased pickling time, greater volumes in discarded pickling bath per tonne of product and increased consumption of zinc. This practice cannot be considered environmentally friendly.

Pickling in plants with open pretreatment is usually done at ambient air temperature; plants with an enclosed pretreatment sometimes operate with higher acid temperatures. Gaseous emissions of the pickling agent can arise from the pickling baths, depending on the concentration and temperature of the bath, and from the pickled items. Hydrogen vesicles formed during the pickling process can also contain acid droplets. [EGGA5/98] [VDI-RL 2579]

6.2.5.2 H₂SO₄ pickling

The vast majority of batch galvanising plants use HCl for pickling. Pickling by sulphuric acid solution was reported to be more common for galvanised tube production. The pickling process is basically the same as for HCl pickling.

Cleaning of the steel items' (tubes) surface prior to hot-dip galvanising is performed by pickling after degreasing. Steel tubes are placed into pickling tanks containing a dilute sulphuric acid solution (20 % H₂SO₄, 80 % H₂O) heated to 60 °C. During this step, the surface of the steel tubes is cleaned of iron oxide through the chemical reaction:



Inhibitors are used to limit and ideally prevent the following reaction $\text{Fe} + \text{H}_2\text{SO}_4 \rightarrow \text{Fe}_2\text{SO}_4 + \text{H}_2$ affecting the iron surface corrosion.

The activity and rate of pickling are kept constant by means of a continuous process in which a control system keeps the set of the operating conditions steady (temperature and concentration of the acid solution) through continuous feeding of fresh pickling solution. [IT 18-4-17] [BG Q 198]

6.2.6 Stripping

Sometimes it is necessary to clean the suspension devices of zinc coatings, to remove faulty coatings from steel fabrications or to de-zinc fabrications whose coatings have to be renewed. This is commonly done by dipping in diluted pickling acid.

When pickling and stripping are carried out in the same treatment vat, pickle liquors are created which contain iron chloride and zinc chloride. Some galvanisers operate separate pickling and stripping baths because, in their technical and economic environment, this favours recycling of the zinc contained in them. Spent stripping liquor can be either treated on site for zinc recovery or sent off site to a contractor for zinc recovery.

In some cases, spent stripping liquor is sent for neutralisation and disposal by external contractors. [Com2 Wedge]

6.2.7 Rinsing

Rinsing is a very important step in the galvanising process as it prolongs the lifetime of subsequent treatment baths, reduces the generation of waste and increases the reusability of by-products. After degreasing and pickling, the fabricated steel is therefore rinsed/dipped in water baths, which are sometimes heated.

Carry-over of solution between baths depends on the type of workpiece (i.e. its capacity for fluid retention) and the way in which it is handled, especially the drainage time permitted above a bath before the workpiece is moved. The quantity of liquid carried over can vary between 5 l/t and 20 l/t of black steel. Carry-over of degreasing solution into the pickling baths eventually leads to neutralisation of the bath; carry-over of acids and iron salts from pickling into the flux baths and further to the galvanising pot would increase both the generation of hard zinc (dross) and the consumption of zinc. A carry-over of 1 g of iron results in about 25 g of hard zinc. [Com EGGA] [ABAG] [Com2 EGGA]

Water from rinsing can be used to prepare fresh pickling or degreasing baths as a way of recycling water and minimising aqueous blowdown.

6.2.8 Fluxing

The purpose of fluxing is to enable liquid zinc to wet the surface of the steel, a necessary prerequisite for the galvanising reaction, and, with ammonium-chloride-containing fluxes, to provide additional pickling (cleaning of the surface) during hot dipping. At temperatures of above 200 °C the ammonium chloride in the flux decomposes into NH_3 and HCl , which results in an additional pickling effect. [EGGA5/98] [ABAG]

Fluxing is carried out in two different ways: dry and wet.

In **dry fluxing**, the steel is immersed in a fluxing bath, usually an aqueous solution of zinc chloride and ammonium chloride, typically maintained at 40–80 °C. Cold fluxing is possible but reduces the potential for air drying of the work after removal from the flux bath. Typical bath characteristics are:

- ZnCl_2 : 150–300 g/l;
- NH_4Cl : 150–300 g/l;
- density: 1.15–1.30 g/ml;
- dissolved iron: < 2 g/l.

The pH value of flux baths is normally adjusted to approximately 4.5 to secure precipitation of iron ions as iron(III) hydroxide, but the pH of flux baths may be in the range of 1 to 5.0.

The total concentration of flux salt (sum of zinc chloride and ammonium chloride) and the ratio of the zinc chloride to ammonium chloride are both very important. Ammonium chloride in a typical good flux often accounts for 40–60 % of the total flux salt. [Com DK]

Ammonium chloride provides quick drying and better removal of iron oxides from the surfaces of the items, but also causes more fume, ash and dross formation during the coating process. When the pretreatment of the workpieces is insufficient, more ammonium chloride is required. Zinc chloride prevents oxidation of the workpiece surfaces. This is particularly important when the drying time is long. Altogether, the optimum flux concentration and composition must be adjusted to the particular circumstances. [Com DK]

The iron content of the flux bath is extremely important for process control, economy and the environment. A high concentration of iron in the flux (originating from drag-out from the pickling bath) will also influence the quality of the zinc coating. Iron carry-over from the flux bath to the zinc kettle will generate dross and may also increase the final thickness of the zinc layer for many steel grades. [Com DK]

To reduce the environmental impact of ammonium chloride during dipping, some galvanisers have changed to 'smoke-reducing' fluxing agents in which ammonium chloride has partly or completely been substituted by potassium chloride. [ABAG]

After withdrawing the workpieces from the flux bath, some of the water from the adhering fluxing fluid evaporates. The extent of evaporation depends on the temperature of the flux bath and, if the bath is hot, the rate of removal of workpieces from the bath (slower removal gives more evaporation). Further drying is sometimes achieved in dedicated drying. Exhaust gases from the galvanising kettle can sometimes be a useful indirect source of heat to such a drying unit, although ancillary burners are often also used. Drying of the workpiece helps reduce splashing and ejection of metal from the zinc bath as the workpiece is dipped, a benefit which is increased if the workpiece retains heat after leaving the dryer, i.e. if preheating is applied. [Com2 EGGA]

A small number of galvanising works, especially those with exceptionally demanding fluxing requirements for intricate parts, operate an alternative process, called **wet fluxing**. In this process, the fluxing agents flow as a layer of molten salt on the surface of the galvanising bath. Steel parts to be galvanised are passed through the flux layer into the zinc bath. Then the molten salt layer is drawn back from the surface by means of a rake to allow the steel parts to be withdrawn from the galvanising bath without further contact with the flux. [EGGA5/98]

6.2.9 Hot dipping

The fluxed steel fabrications are slowly lowered into a bath of molten zinc. With very long items, which do not fit in the kettle, double dipping has to be applied to cover the whole surface. The steel reacts with the zinc to form a coating consisting of a series of zinc-iron alloy layers topped by a layer of pure zinc when the parts are withdrawn from the bath. The period of immersion varies from several minutes for relatively light steelwork up to 30 minutes for the heaviest structural parts. [EGGA5/98]

The molten zinc has a temperature of 440–475 °C. Kettle dimensions vary greatly, depending on the market served and the type of fabricated product treated. Typical dimensions are 7 m long by 1.4 m wide by 2.6 m deep, but kettles as long as 20 m and as deep as 4 m are in use. The kettle, enclosed by the furnace casing, is installed in a pit or at floor level with access platforms. The kettle is normally heated externally, commonly by gas or oil-fired burners. Heating by immersion burners or by canopy heaters is used when the zinc temperature is above about 460 °C (and a steel kettle cannot be used) or where there is insufficient kettle wall surface to transfer heat into the melt. Where economically viable, electrical heating is used, usually via radiation from the sides or top, occasionally also by induction or resistance. [EGGA5/98] [Com2 EGGA] [Com2 Fin]

The zinc bath usually also contains very small amounts of other metals, which either are impurities of the zinc input or are added as alloying elements. A typical bath composition is:

- zinc: 98.9 wt-%;
- lead: 1.0 wt-%;
- iron: 0.03 wt-%;
- aluminium: 0.002 wt-%;
- cadmium: 0.02 wt-%;
- traces of other metals (e.g. tin, copper).

Aluminium and lead are added because of their influence on the thickness and the appearance of the coating. The addition of lead (from 0.1 % to 0.15 %) has an influence on the physical properties of the zinc, especially the viscosity and surface tension. It helps to wet the steel before galvanising and the zinc to flow from the surface after galvanising. Lead can also be used to protect the kettle. In this case, the molten zinc floats on a layer of molten lead on the bottom of the kettle. The thickness of the kettle's steel walls is measured on a regular basis to prevent breaking. [ABAG] [Com2 EGGA]

Where steel kettles are used, it is important that the kettle material (typically low-carbon steel with minimal additions of reactive elements such as silicon) is correctly chosen so as to reduce the effect of zinc attack, and that it is manufactured to withstand the high hydrostatic loads and thermal stresses generated during the heating up to operating temperature. Steel kettles internally clad to resist zinc attack can be obtained but are significantly more expensive. [Com2 EGGA]

A small number of plants carry out 'high-temperature galvanising' using refractory-lined vessels, which allow the zinc bath to be operated at higher temperatures, usually about 530 °C. This process is required to treat certain classes of steel (steel grades) and specific types of components. [EGGA5/98]

Ammonium chloride, a component of the fluxing agent, has a sublimation temperature below the zinc bath temperature, and this, together with the other reactions taking place, causes fumes to be generated during hot dipping. Galvanising kettles are generally contained in a vented enclosure or ventilated by a lip extraction system. Commonly, the ventilation air is cleaned in bag filters and the precipitated dust is shipped off site for recovery of valuable substances, namely fluxing agent. In some cases, the precipitated dust is sent for landfill. [Com2 Wedge] Some operators apply venturi scrubbers and use the scrubber blowdown for flux solution make-up. [EGGA5/98] [Com2 EGGA]

Reactions of zinc with steel, either from the fabricated products that are being galvanised or from the kettle itself, lead to a build-up of zinc-iron alloy in the bath, which is known as hard zinc or dross. Dross can adhere to the walls of the bath, but mostly accumulates at the bottom where it is periodically removed using a submerged scoop or grab. Excess dross may interfere with galvanising and may cause overheating of an externally heated kettle. The material removed is returned to the secondary zinc industry for recovery of the zinc content or to the zinc chemicals industry for the manufacture of zinc oxide. [EGGA5/98] [Com EGGA] [Com2 EGGA]

Zinc ash is formed at the surface of the zinc bath due to the reaction of zinc with oxygen in the air and with the flux. The oxidised material is removed and is reused directly in the plant or returned to the secondary zinc industry for recovery. [EGGA5/98] [GE6] [Com2 FIN]

6.2.10 Finishing and post-treatment

Steel fabricated products are withdrawn from the zinc bath; excessive zinc is removed by wiping or, in some cases, by rattling. The fabricated products are then cooled and inspected. Small surface imperfections are repaired and the fabricated products are removed from the jigs and made ready for dispatch. After hot dip coating, some steel products are quenched in water to give them special properties. As protection against white rust, the products may be covered with oil emulsions or undergo passivation.

Out of 99 lines (87 plants), 71 lines were reported not to apply any passivation. Only 12 lines were using Cr (VI) passivation, while the remaining 16 lines apply alternative (Cr-free) passivation, such as Cr³⁺ passivation or organic passivation. [FMP data collection 2018]

In galvanising fasteners and small components, a perforated steel basket containing the components is immersed in liquid zinc in the usual way. When the basket is withdrawn from the liquid zinc it is placed into a centrifuge system. Excess zinc coating is removed by centrifugal force. The galvanised components are ejected from the basket and cooled, while the basket is returned to the process. Proprietary and custom-built systems are known. [Com2 EGGA]

When galvanising tubes and pipes, the outside is blown off with compressed air, and the inside with steam to remove excess zinc after withdrawal from the zinc bath. During removal of excess

zinc with steam, zinc dust is emitted, but the zinc particles can be collected and returned to the zinc baths or be utilised in the secondary zinc industry for zinc recovery. [EGGA5/98] [GE6]

WORKING DRAFT IN PROGRESS

6.3 Current consumption and emission levels for batch galvanising

The information contained in this section of the old BREF has been removed and replaced with the data from the data collection. Old information, along with input from the TWG will be revised and added after draft 1.

6.3.1 Batch galvanising mass stream overview

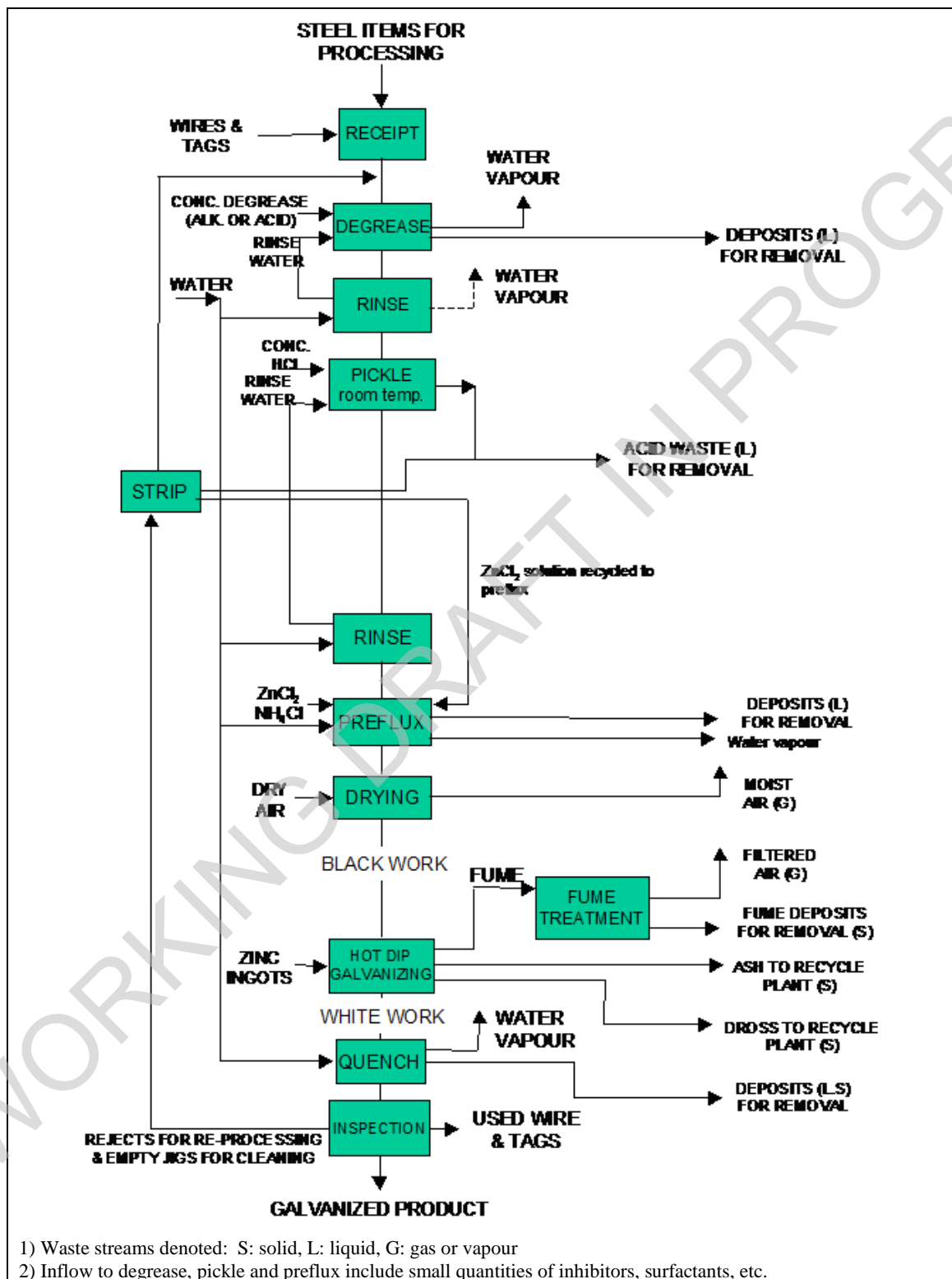


Figure 6.3: Material flow sheet for general galvanising plants

6.3.2 Energy efficiency

Figure 6.4 shows reported data on the specific energy consumption for heating the galvanising kettle.

6.3.3 Material efficiency

Figure 6.5 and Figure 6.6 show reported data on the specific acid and alkaline consumption respectively in degreasing for three operating years in batch galvanising plants.

Figure 6.7, Figure 6.8 and Figure 6.9 show reported data on the specific HCl consumption, specific pickling inhibitors consumption and specific flux agent consumption in pickling for three operating years in batch galvanising plants. Specific HCl consumptions are expressed in kg of 28 %-wt HCl per ton of coated steel. Specific H_2SO_4 consumptions are expressed in kg of 98 %-wt H_2SO_4 per ton of coated steel.

6.3.4 Water consumption

In batch galvanising, no waste water is generated. Fresh water is only used for the initial preparation of the treatment baths (degreasing, pickling, stripping, rinsing, fluxing) and post treatment baths and as make-up water to compensate for evaporation.

6.3.5 Emissions to air

6.3.5.1 Emissions to air from heating

NOX and CO emissions

The reported data on NOX and CO emissions to air from heating the galvanising kettle are shown in Figure 6.10.

The reported data on NOX and CO emissions to air from feedstock drying are shown in Figure 6.11.

6.3.5.2 Emissions to air from pickling

HCl emissions

The reported data on HCl emissions to air from pickling are shown in Figure 6.12.

6.3.5.3 Emissions to air from hot dipping

Dust emissions

The reported data on dust emissions to air from hot dipping are shown in Figure 6.13.

6.3.6 Residues

Figure 6.14 to Figure 6.21 show the reported data on the specific generation for three operating years of:

- spent alkaline degreasing solution;
- spent acidic degreasing solution;
- oily sludge from alkaline degreasing solution;
- oily sludge from acidic degreasing solution;
- spent HCl from pickling;
- spent flux;
- hard zinc (bottom dross);
- zinc ash.

6.3.7 Figures with consumption and emission levels

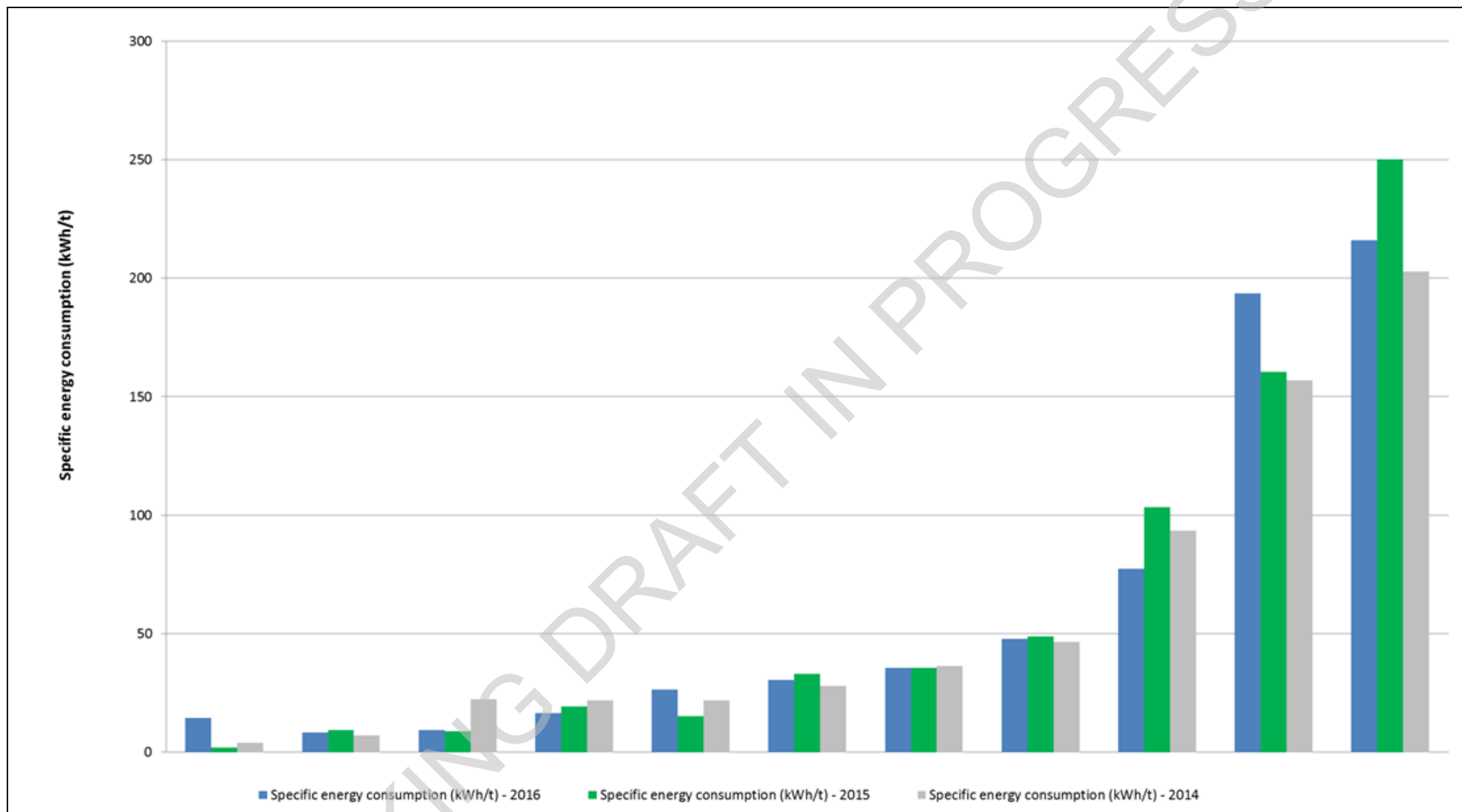


Figure 6.4: Specific energy consumption (kWh/t of process throughput) for heating the galvanising kettle. Source: [TWG 2018].

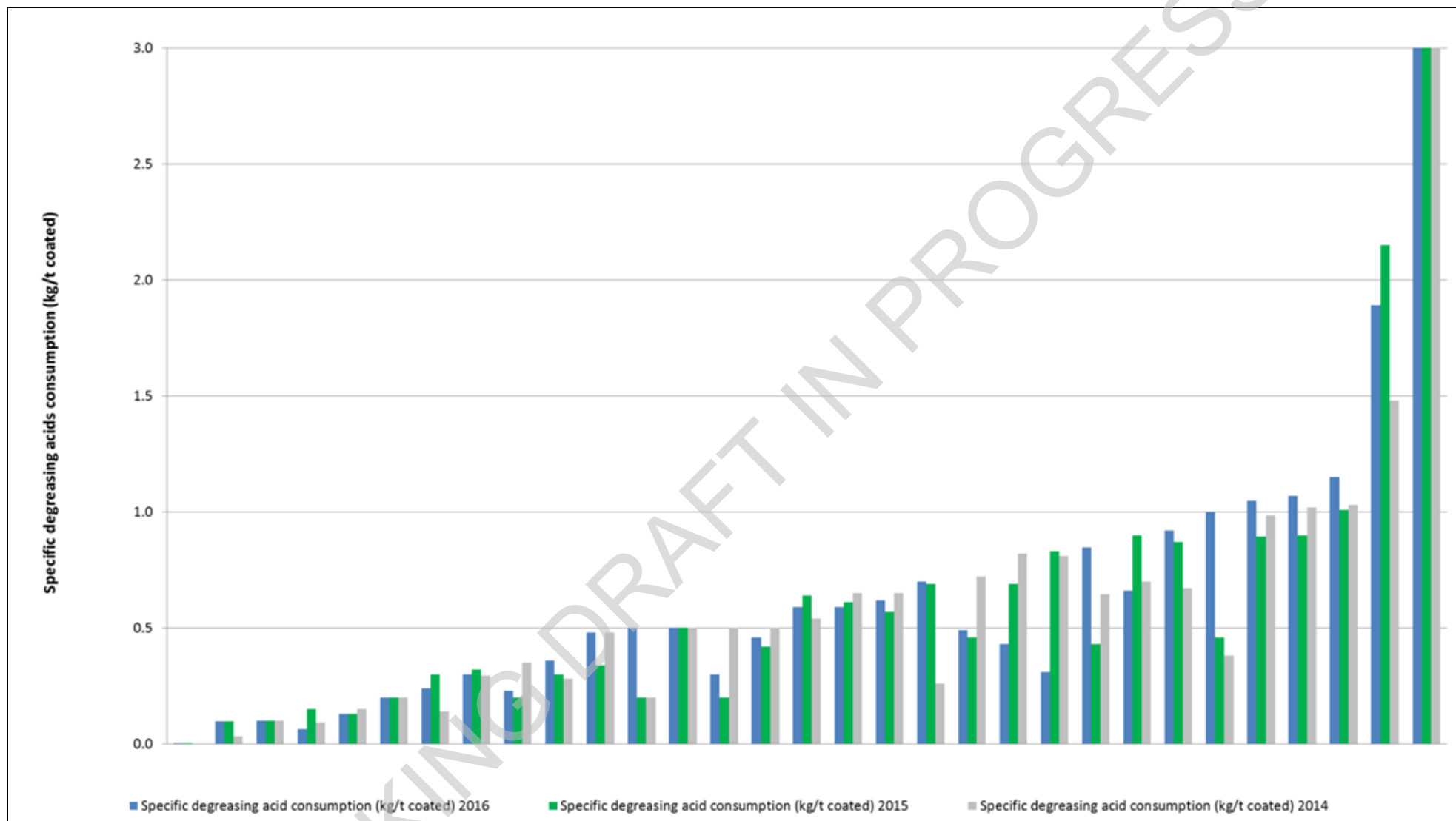


Figure 6.5: Specific acid consumption (kg/t of steel coated) in degreasing in batch galvanising plants. Source: [TWG 2018].

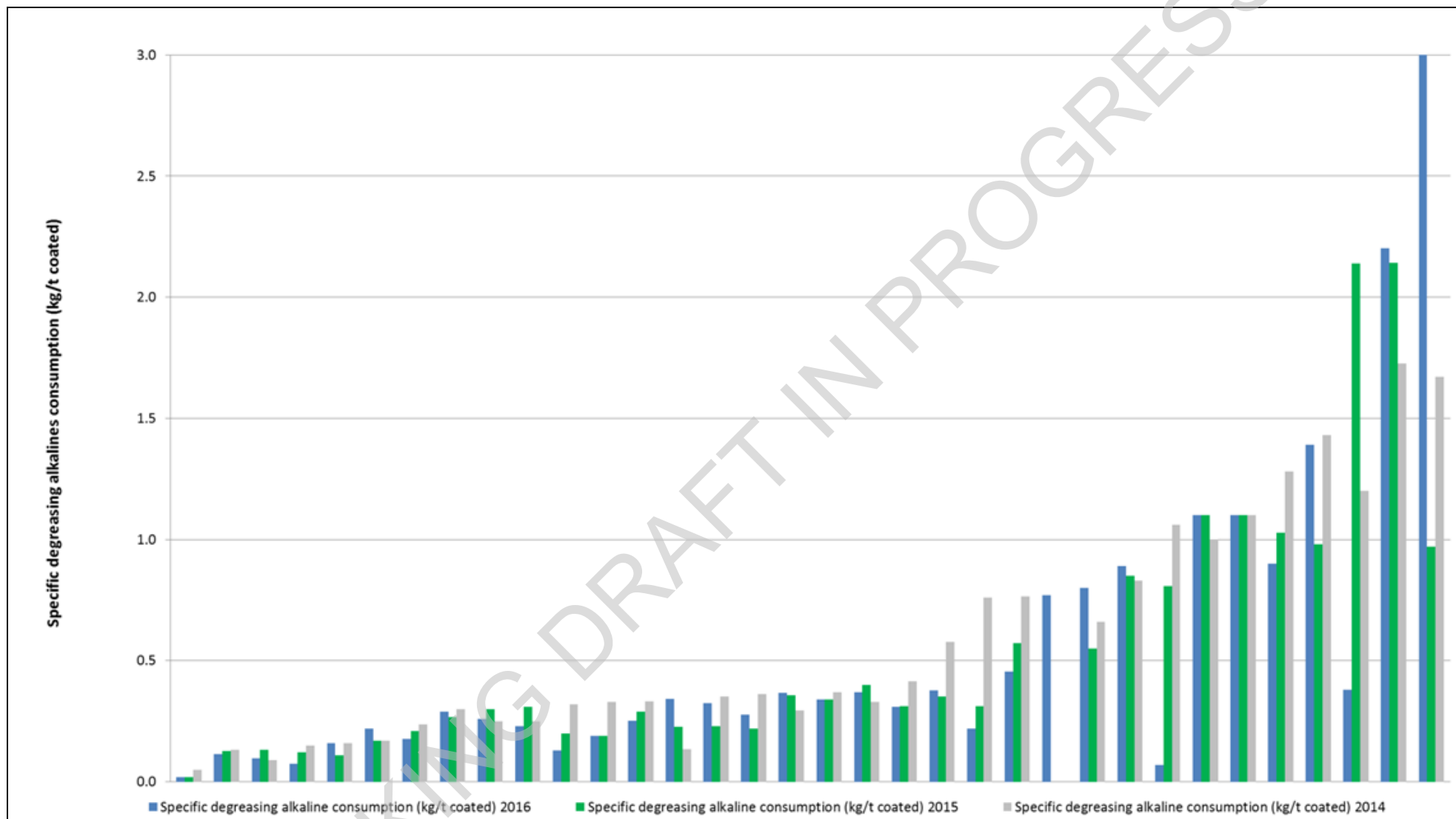


Figure 6.6: Specific alkaline consumption (kg/t of steel coated) in degreasing in batch galvanising plants. Source: [TWG 2018].

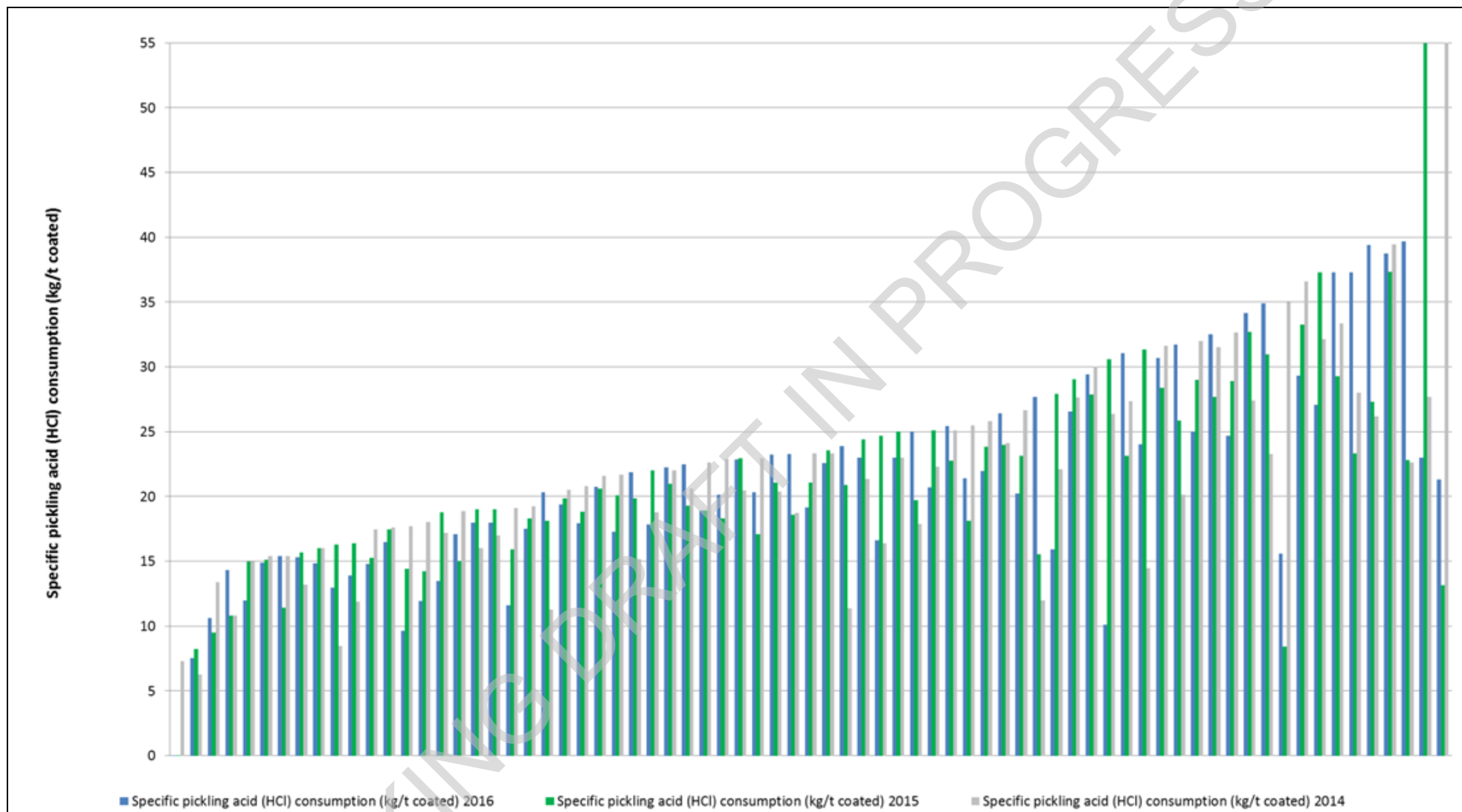


Figure 6.7: Specific HCl consumption (kg/t of steel coated) in pickling in batch galvanising plants. Source: [TWG 2018].

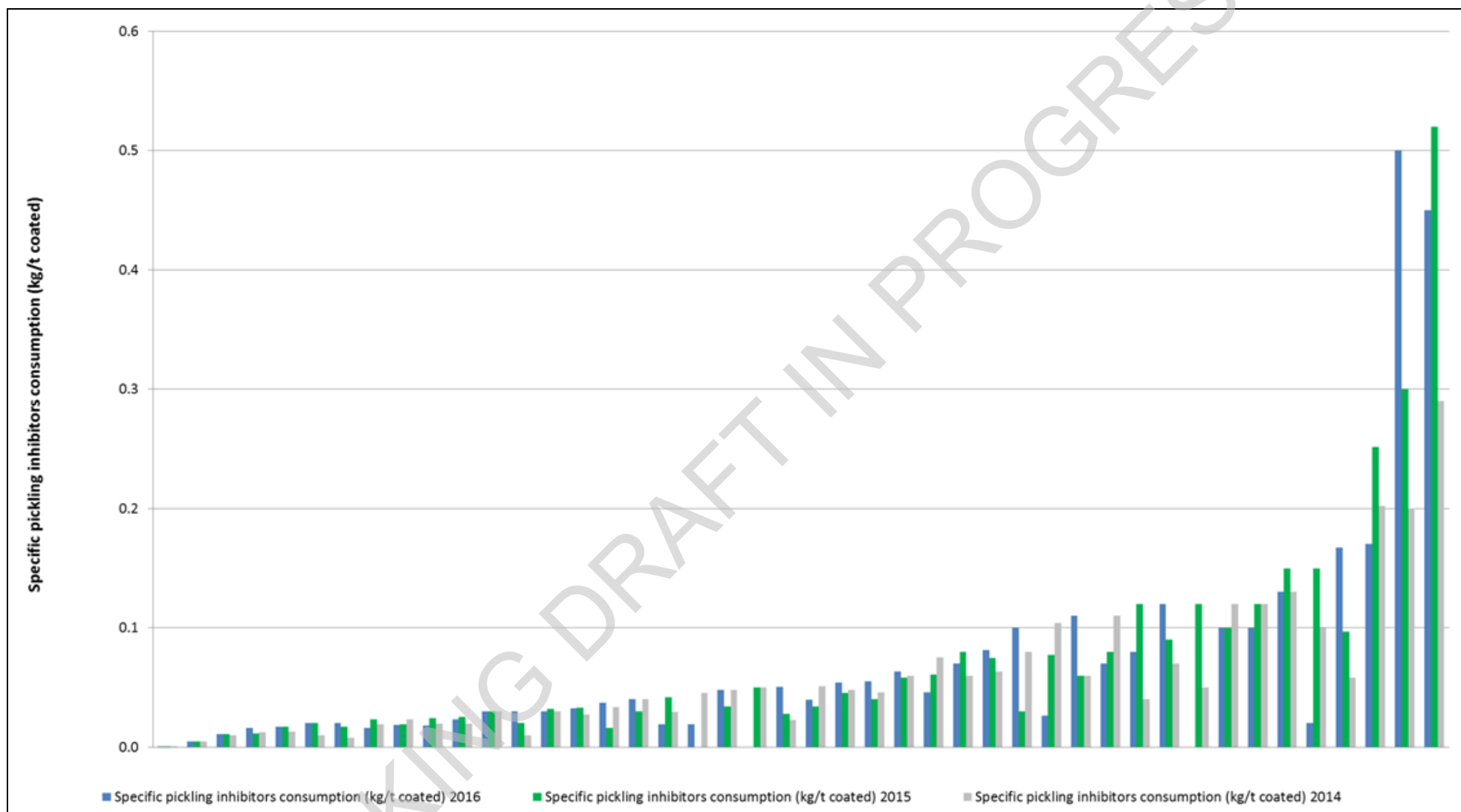


Figure 6.8: Specific pickling inhibitors consumption (kg/t of steel coated) in pickling in batch galvanising plants. Source: [TWG 2018].

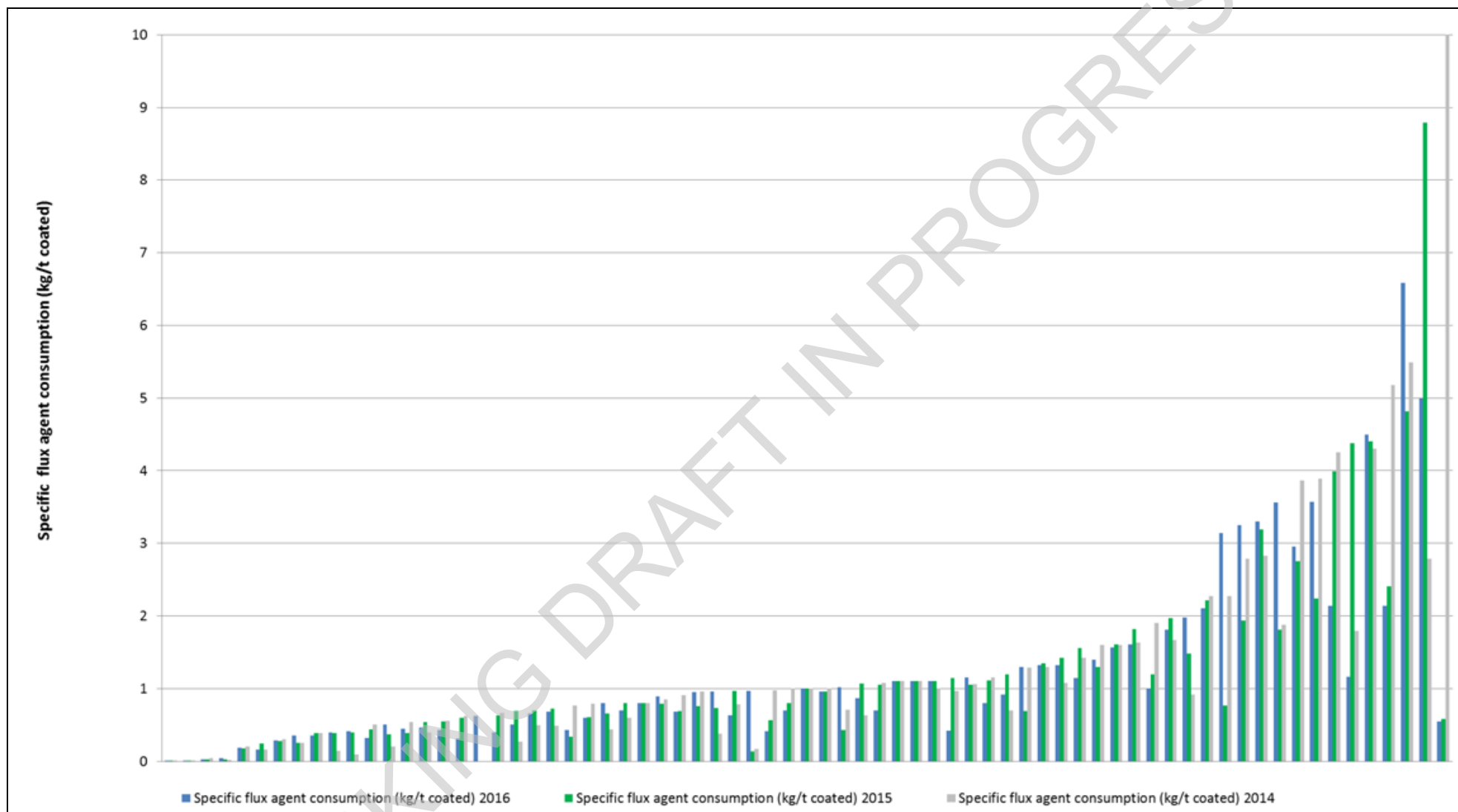


Figure 6.9: Specific flux agent consumption (kg/t of steel coated) in pickling in batch galvanising plants. Source: [TWG 2018].

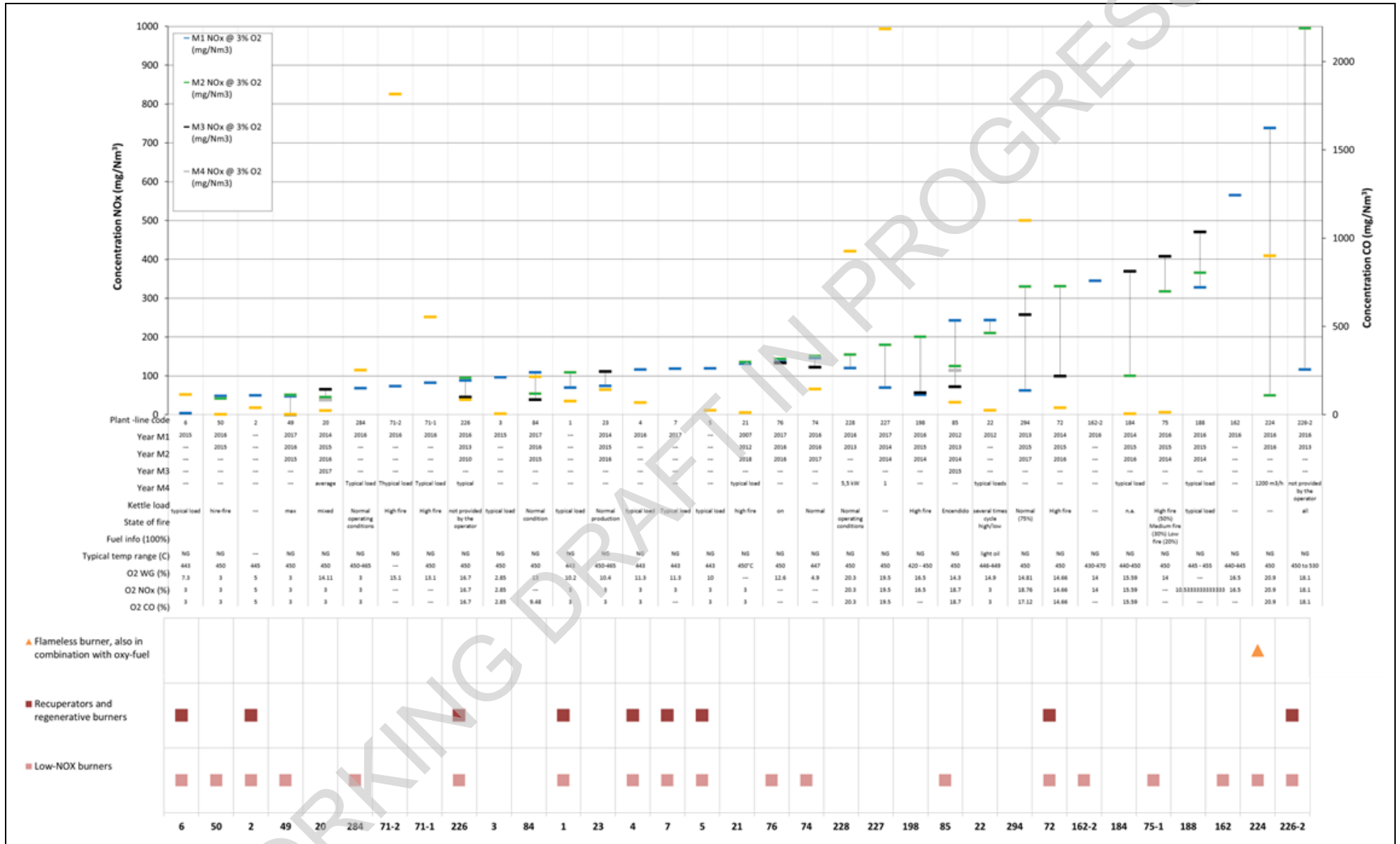


Figure 6.10: NOx and CO emissions from heating the galvanising kettle (in mg/Nm³ at 3% oxygen). Source: [TWG 2018].

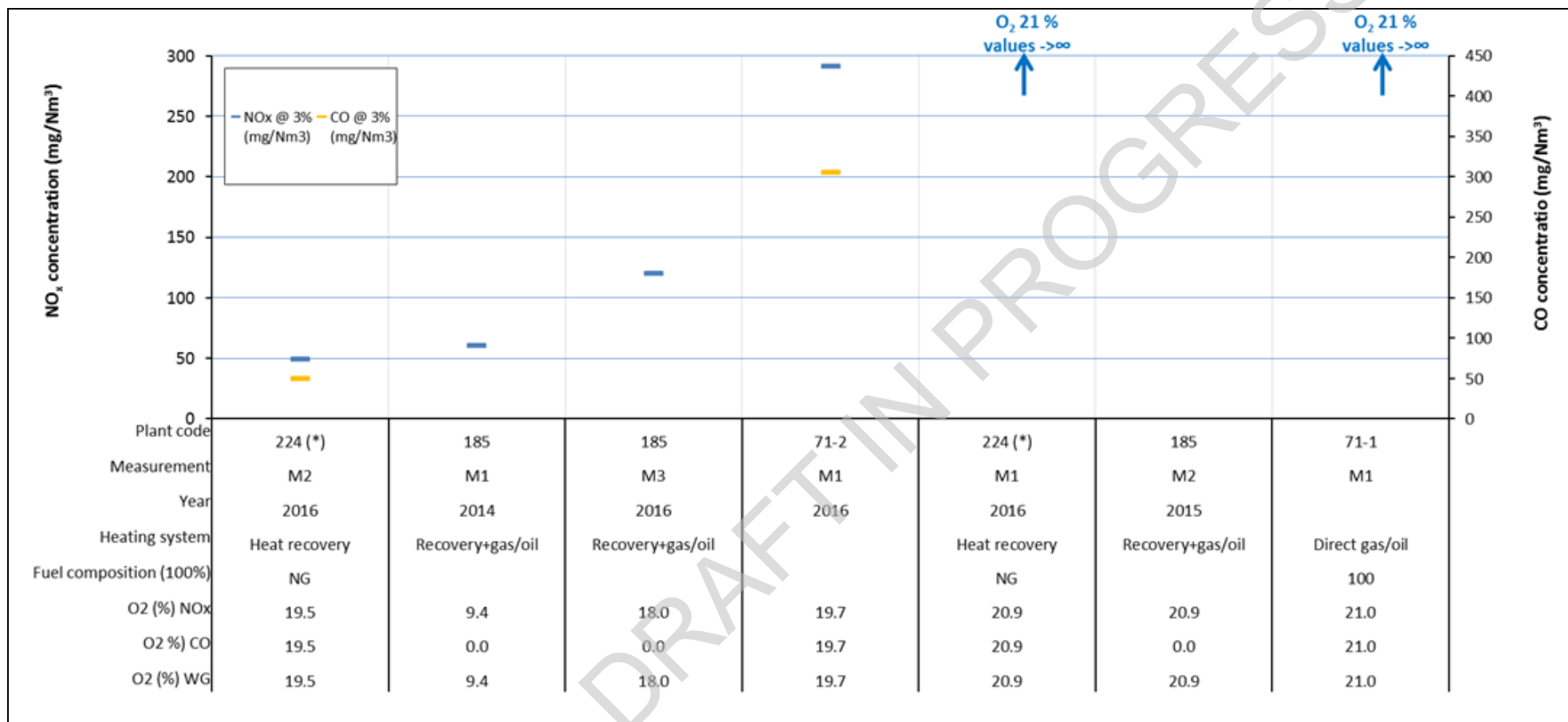


Figure 6.11: NOx and CO emissions from feedstock drying (in mg/Nm³ at 3% oxygen). Source: [TWG 2018].

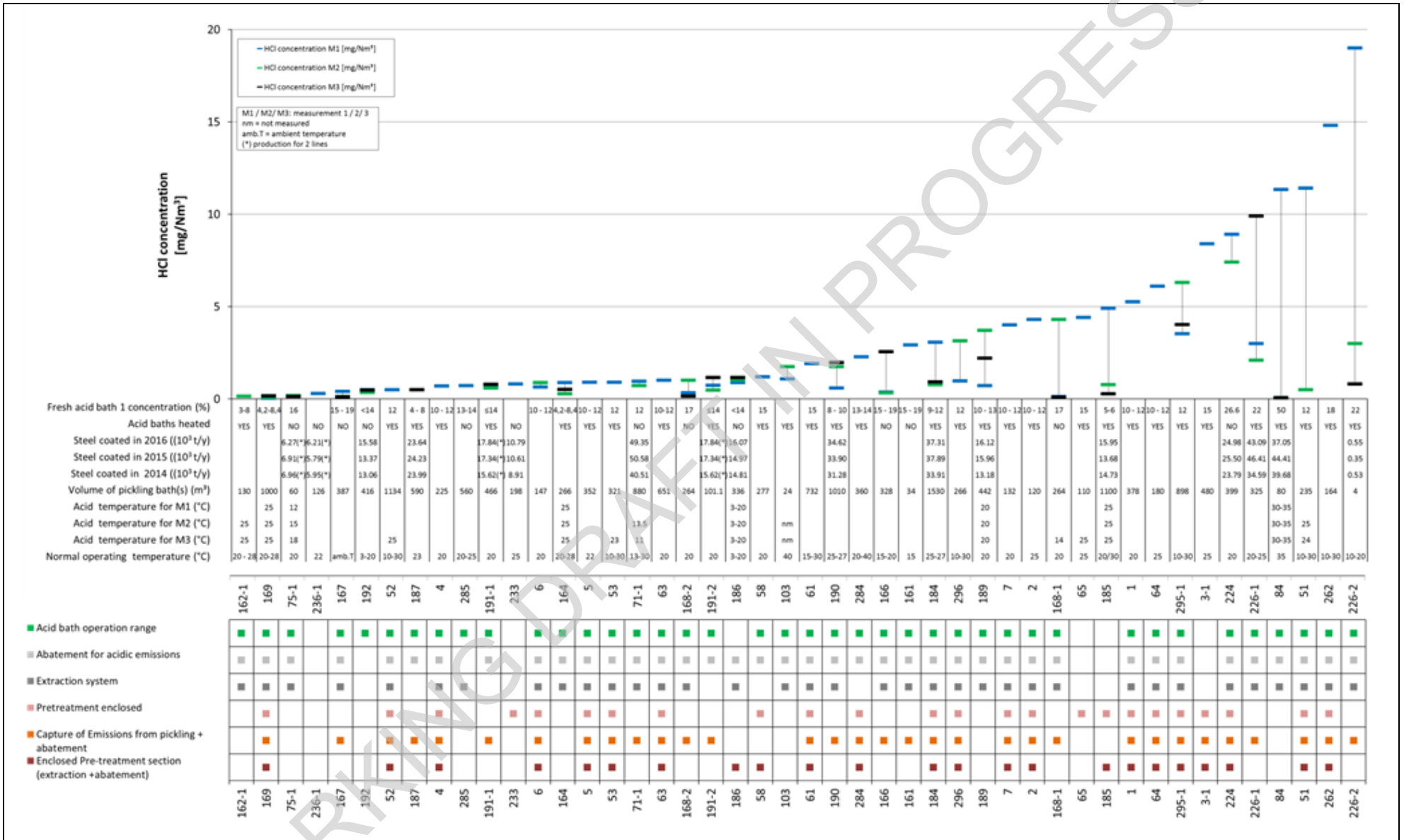
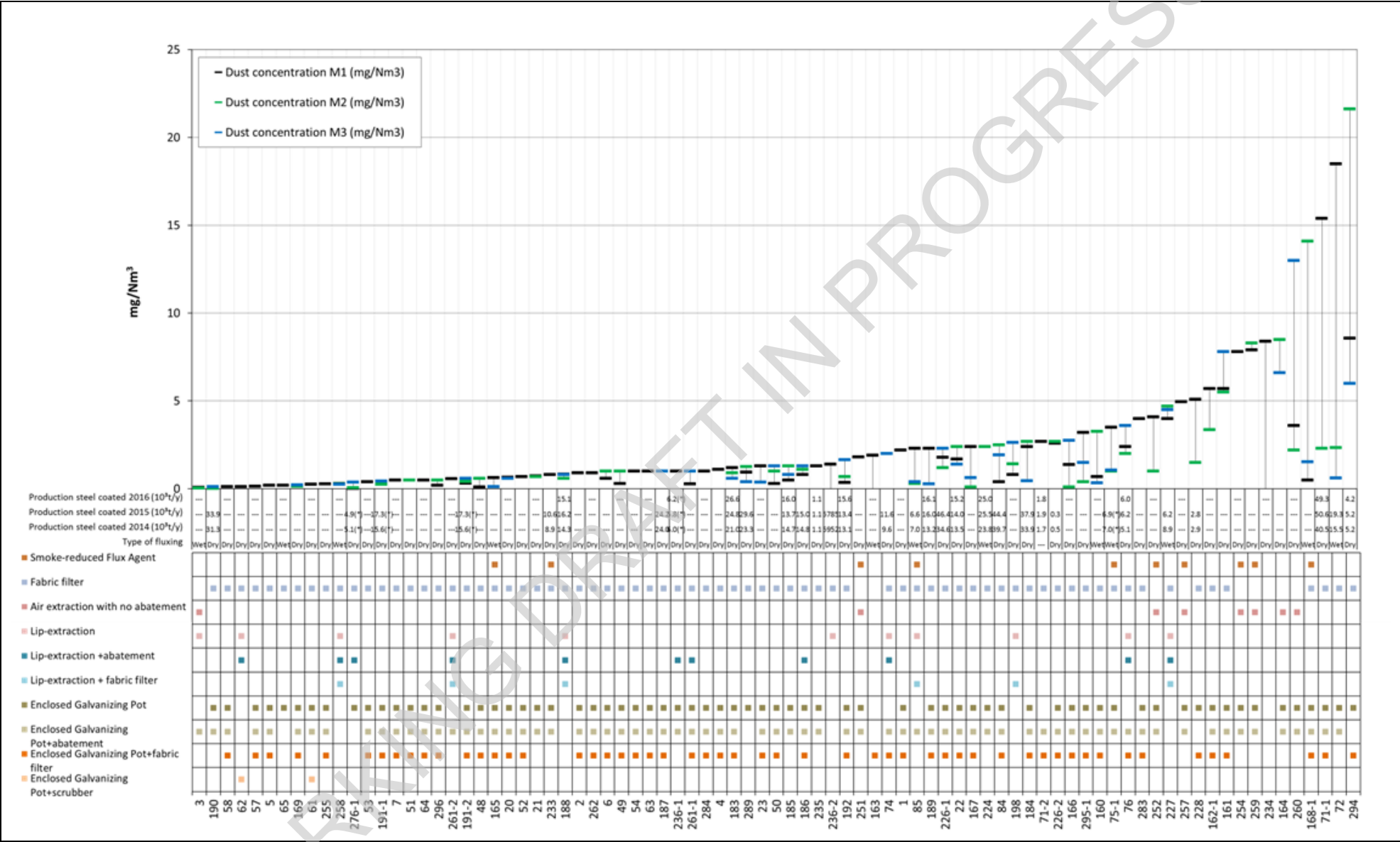


Figure 6.12: HCl emissions from pickling of wire rod (in mg/Nm3) in batch galvanising plants. Source: [TWG 2018].



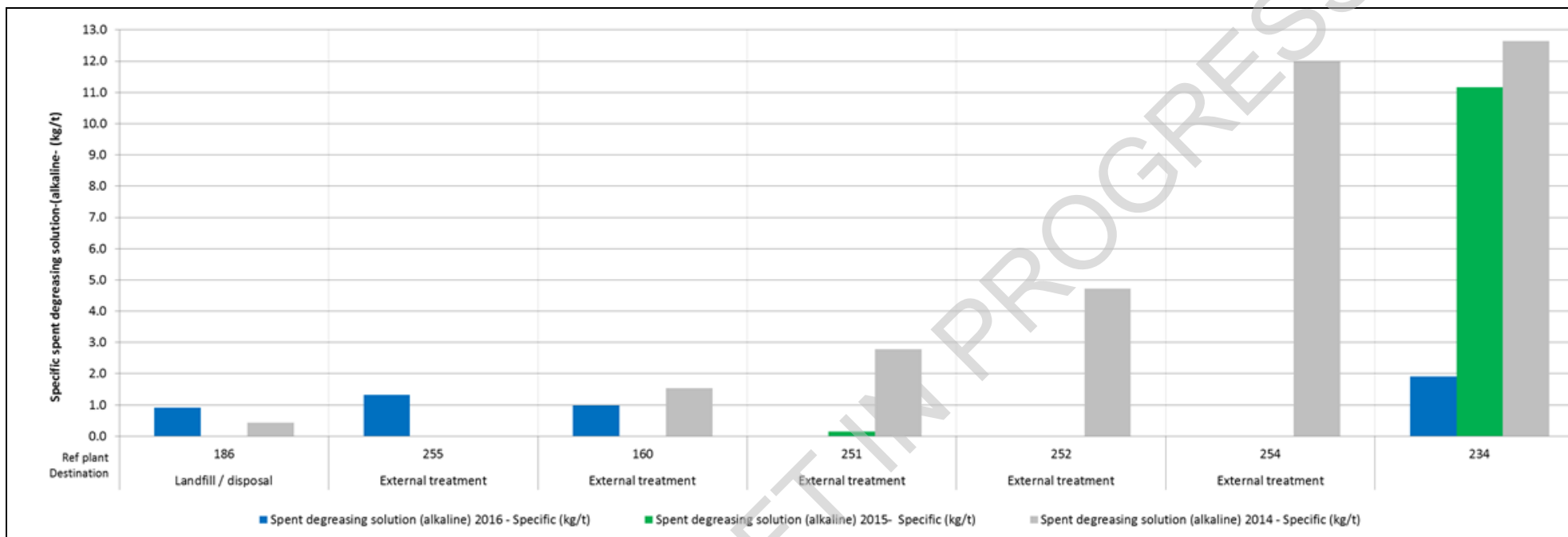


Figure 6.14: Specific generation of spent alkaline degreasing solution (in kg/t). Source: [TWG 2018].

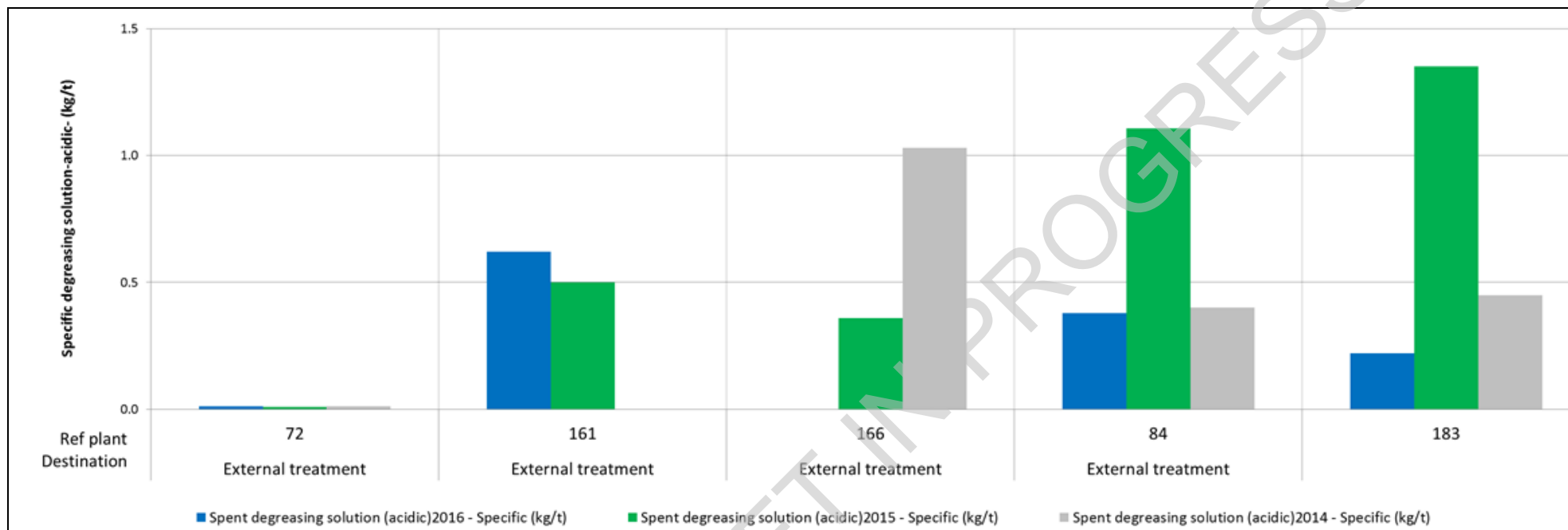


Figure 6.15: Specific generation of spent acidic degreasing solution (in kg/t). Source: [TWG 2018].

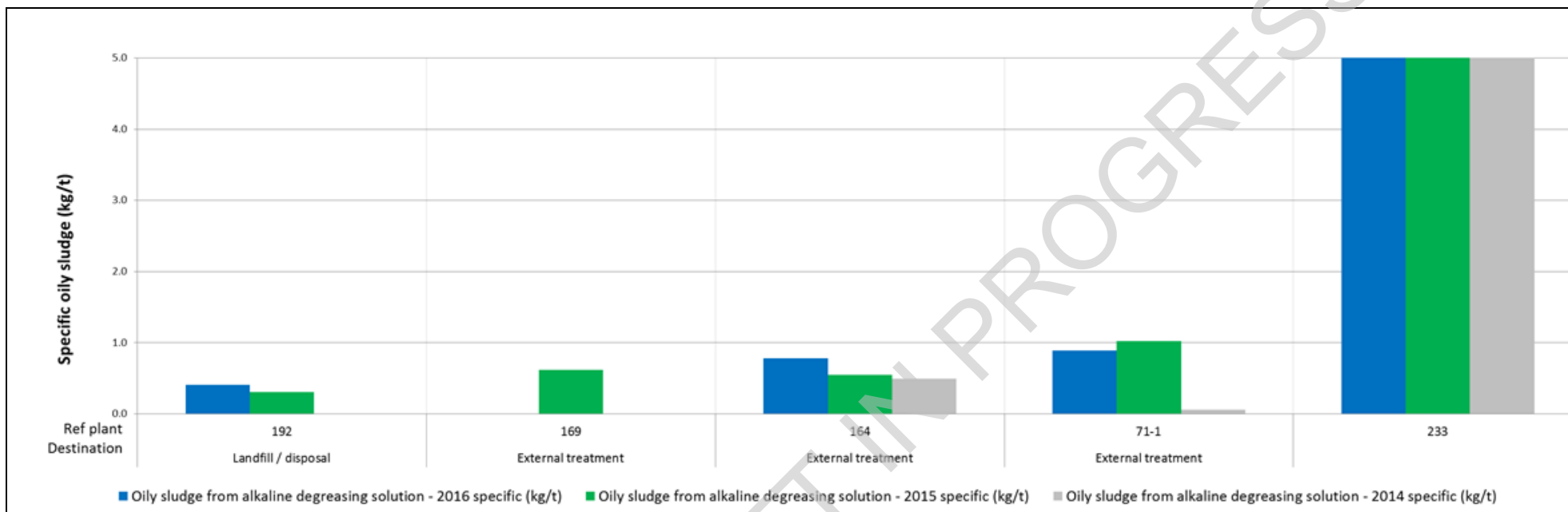


Figure 6.16: Specific generation of oily sludge from alkaline degreasing solution (in kg/t). Source: [TWG 2018].

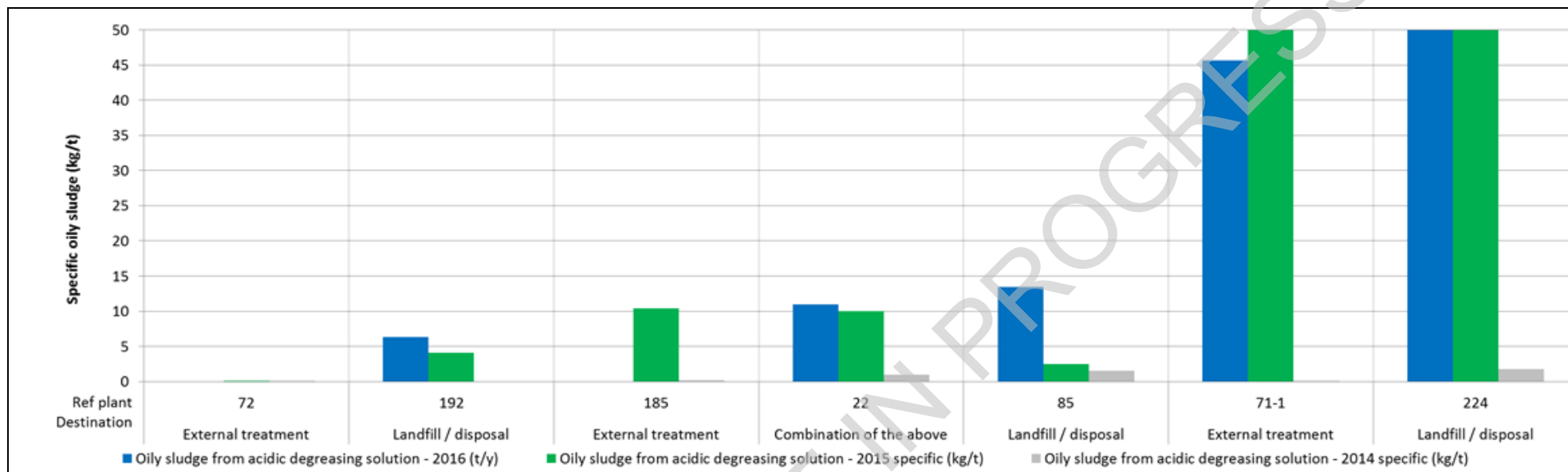


Figure 6.17: Specific generation of oily sludge from acidic degreasing solution (in kg/t). Source: [TWG 2018].

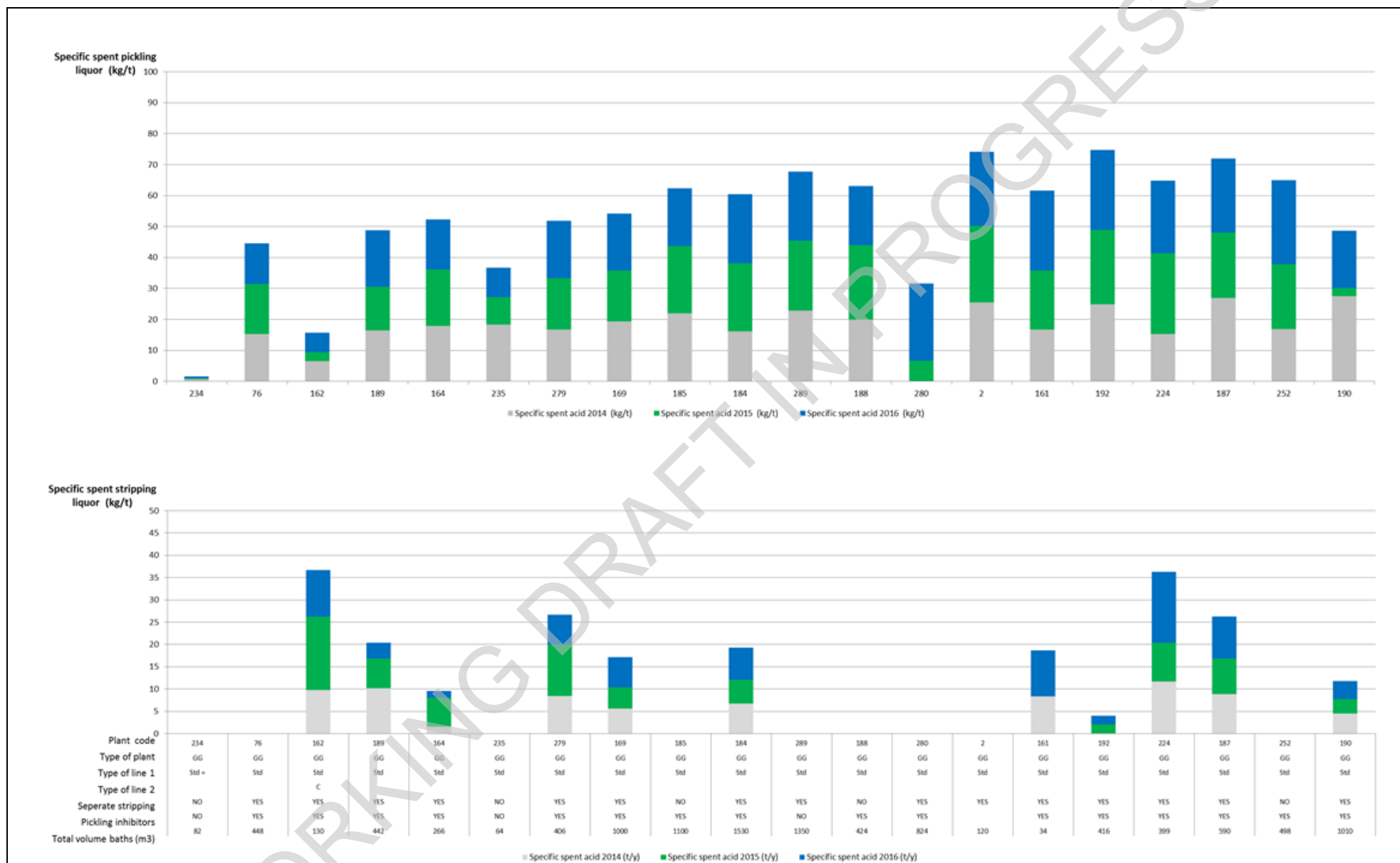


Figure 6.18: Specific generation of spent HCl from pickling and stripping (in kg/t). Source: [TWG 2018].

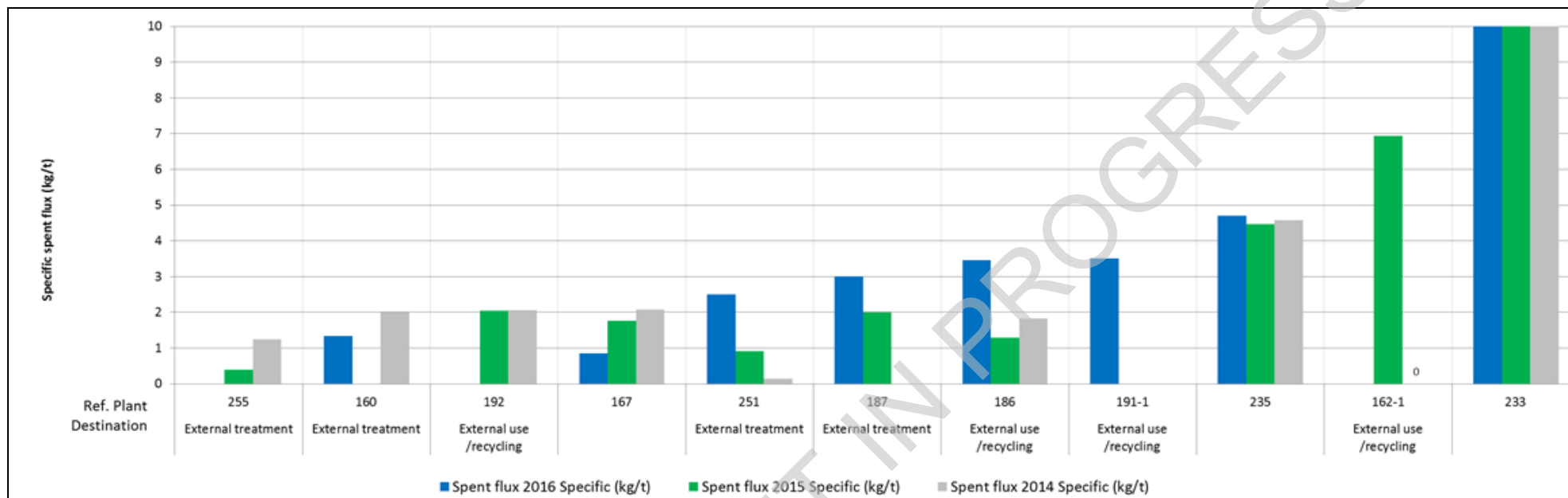


Figure 6.19: Specific generation of spent flux (in kg/t). Source: [TWG 2018].

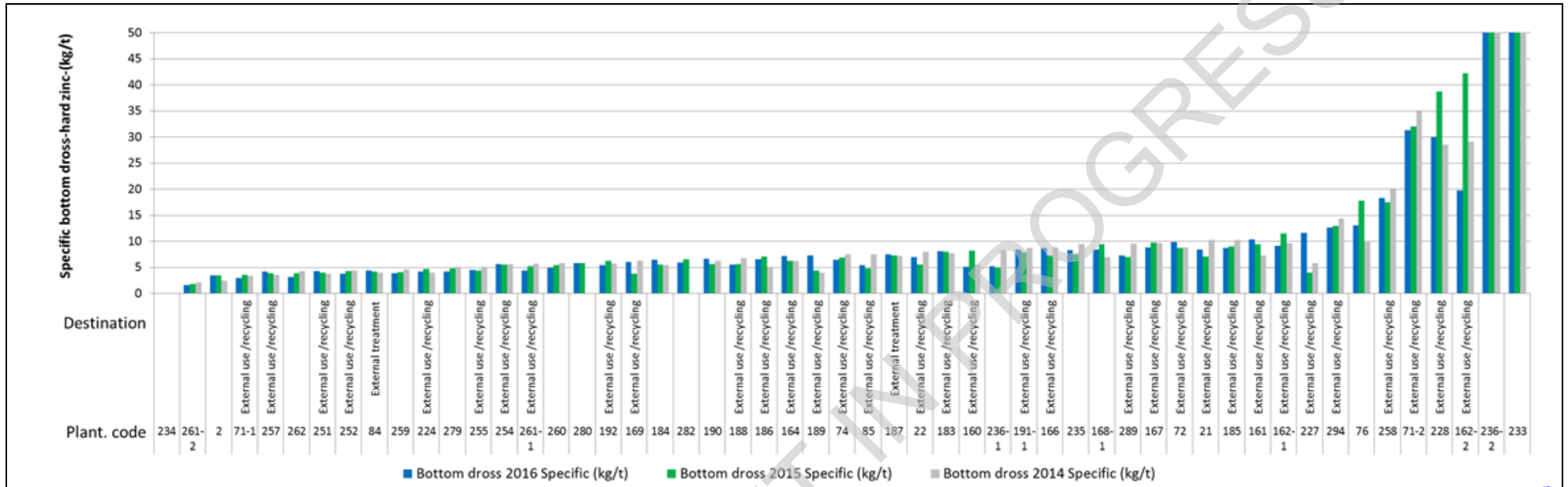


Figure 6.20: Specific generation of hard zinc (bottom dross) (in kg/t). Source: [TWG 2018].

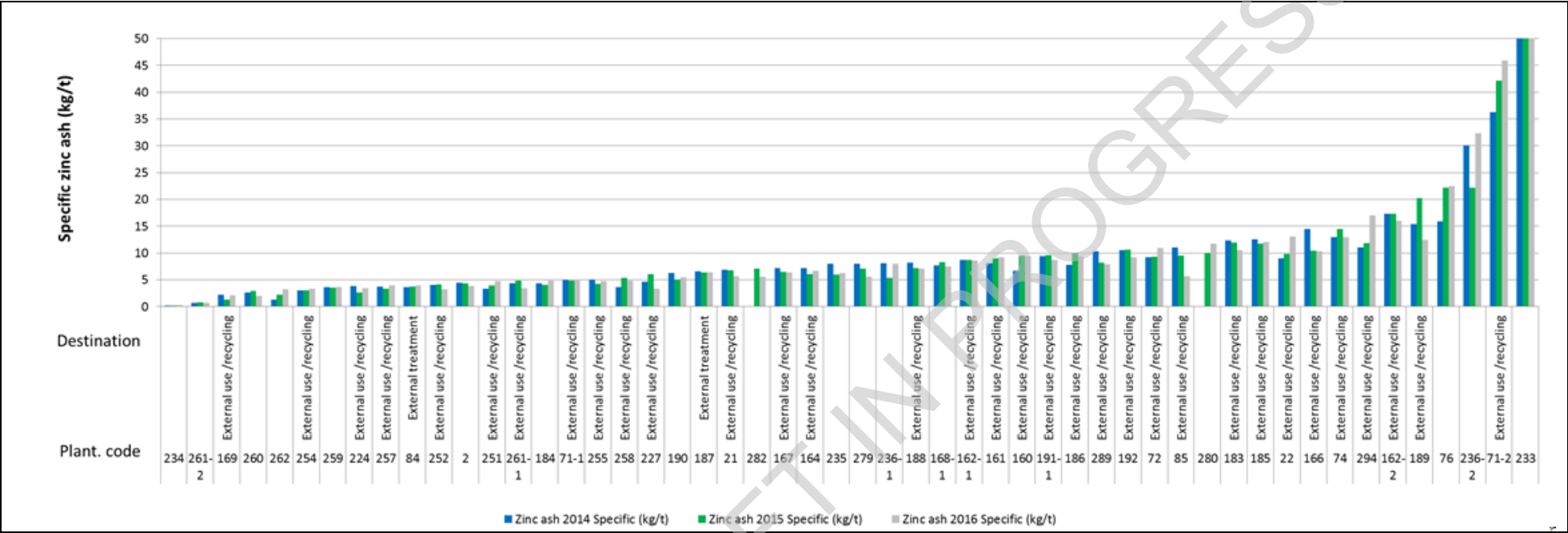


Figure 6.21: Specific generation of zinc ash (in kg/t). Source: [TWG 2018].

6.4 Techniques to consider in the determination of BAT for batch galvanising

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 as well as process-integrated and end-of-pipe techniques. 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 the prevention or limiting of the environmental consequences of accidents and incidents. They also cover the prevention or reduction of 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 Directive 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 2.8 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 that 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.

In Chapter 8 general techniques (i.e. those used that are commonly used) are discussed which might also be applicable to batch galvanising. These techniques are normally not repeated in this section, unless information specific for this sector was made available.

TWG, Section C.4.1 from the old BREF has been deleted, as it did not contain any information.

6.4.1 Degreasing

TWG, Sections C.4.2.1 (Minimization of Oil and Grease Input) and C.4.2.2 (Optimized Bath Operation) from the old BREF can now be found in Chapter 7 (Sections 8.6.1.1 and 8.6.1.3, respectively).

6.4.1.1 Slow lifting of workpieces

Description

Workpieces are lifted slowly from the degreasing solution to allow for a sufficient dripping time.

Technical description

TWG, please provide information.

Achieved environmental benefits

Increased material efficiency.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

TWG, please provide information.

Economics

TWG, please provide information.

Driving force for implementation

Reduced costs due to increased material efficiency.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

TWG, relevant information from Section C.4.2.3 (Maintenance and Cleaning of Degreasing Baths) from the old BREF has been moved to Chapter 7 (Section 8.6.1.6).

6.4.1.2 Continuous Biological treatment Degreasing of the degreasing bath ('biological degreasing')

Description

Degreasing is supported by using microorganisms. The excess sludge generated is removed via sedimentation.

Technical description

Oil and grease, accumulated in the degreasing bath, are decomposed by microorganisms. The waste product is resulting biological sludge which is drained off out of the system daily. The degreasing bath will get an unlimited service lifetime with, and the bath will provide optimum degreasing at any one time can be achieved. [DK-EPA-93]

The degreasing solution ~~degreaser liquid~~ is based on alkali, phosphates, silicates and as well as nonionic and ~~kation-active~~ cationic tensides. A concentrate of these chemicals and microorganisms is mixed continuously. In the degreasing tank itself, air is admitted to keep the biological processes ongoing. Water is also added to compensate for the evaporation loss, as the bath is kept at the optimum operating temperature of 37 °C. The liquid from the degreaser tank is circulated across a lamellar separator at a rate of approximately 1 m³/h. In the lamellar separator, the accumulated sludge consisting of a mixture of live and dead microorganisms (~~biosludge~~) is separated off. The sludge (approximately 10 l/d) is drained off manually via a bottom valve. The dosing of chemicals is performed by dosing pumps in the outlet box downstream of the lamellar separator. It may be difficult to be totally accurate, and excess consumption will probably be common. The dosing of required chemicals is automatically controlled to maintain a pH value of 9.13. [DK-EPA-93]

Achieved environmental benefits

- Increased material efficiency.
- ~~Reduction of waste (spent degreasing bath) and thus of treatment sludge.~~ Reduced waste water and sludge.

Environmental performance and operational data

Example Næstved Varmforzinkning

Næstved Varmforzinkning introduced the process in 1987 and the operational experience is very positive (see Figure 6.22). ~~Today~~ Compared to degreasing with warm caustic soda lye, the degreasing is much more efficient and consistent, ~~than when they degreased in warm caustic soda lye and this results~~ resulting in quicker pickling with less acid attack on the base material. Both the consumption of pickling acid and of discarded waste have dropped. ~~When~~ After pickling, has been completed the surface is more even and uniform than before. This has in turn resulted in lower consumption of zinc in the hot-dip galvanising process itself. The new degreasing process has meant that the plant has been able to reduce the zinc content of the pickling bath from 10–15 % to 4–8 %. This has greatly improved the occupational environment in the production hall in that the conventional 'acid smell' has by and large disappeared. In practice, the consumption of ~~Camex Bio 104~~ chemicals has been about six times higher than expected (per tonne of products per year). This is probably due to both overdosing and a necessary additional consumption of chemicals for the heavily oiled items processed at the plant. Furthermore, the items have a very large surface per unit weight which requires more chemicals per tonne of products. The system is probably 3–6 times bigger than necessary for Næstved Varmgalvanisering. The company simply bought the smallest system for biological degreasing sold by the provider ~~Swedish firm, Camex~~. [DK-EPA-93]

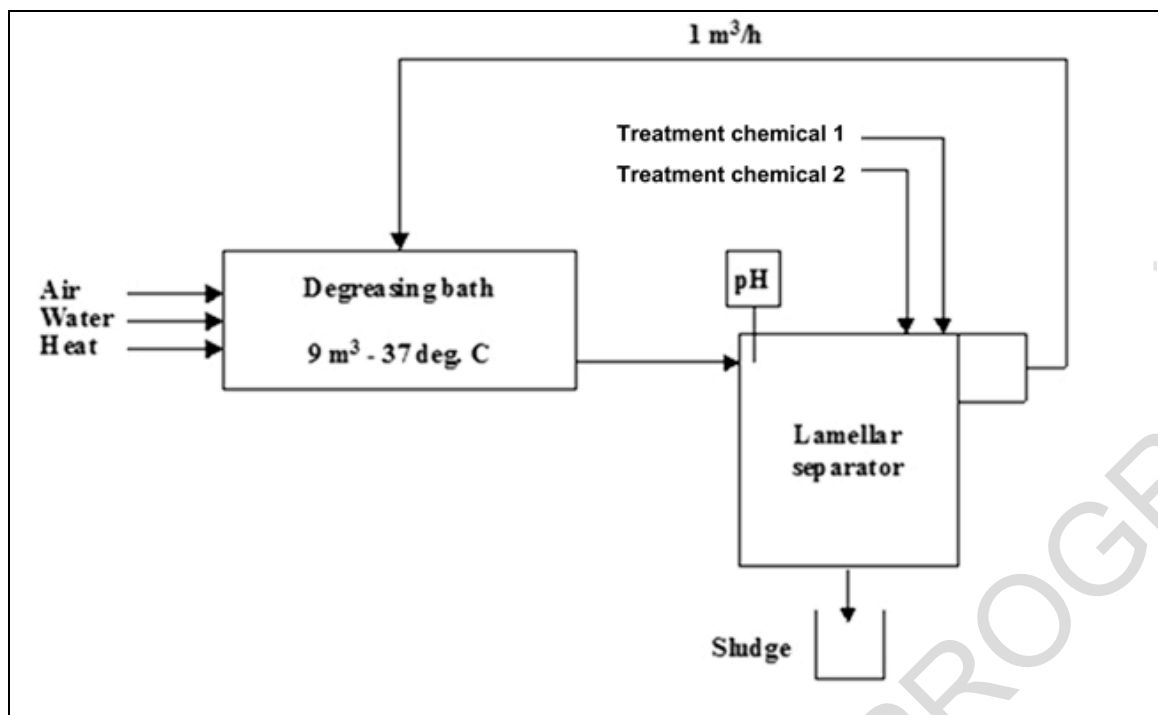


Figure 6.22: Flowsheet for biological degreasing
[DK-EPA-93]

Example galvanising plant, Germany [ABAG-Bio]

The galvanising plant switched operation from acidic degreasing to biological degreasing in the period of December 1994 to April 1995. The initial production line included an acidic degreasing bath, consisting of diluted phosphoric acid and HCl, tensides and corrosion inhibitors, followed by a rinse. The bath quality was maintained by removing the oil from the surface and refreshing the acidic bath liquor. The acidic degreasing was changed to alkaline degreasing followed by a biological rinse bath treatment. Reported advantages of the switch of operation were:

- reduced pickling time (20–25 %);
- increased pickling quality;
- reduced fresh acid consumption;
- reduced rejects;
- reduced oily sludge.

Cross-media effects

Higher energy consumption to heat the degreasing bath.

Technical considerations relevant to applicability

~~New and existing galvanizing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please update the economic data of this section.

Example Næstved Varmforzinkning

| | | |
|--|-----|---------|
| Capital costs (as of 1987) incl. installation, but excl. degreaser tank: | DKK | 325 000 |
| Operational costs: | | |
| Treatment chemical 1 | DKK | 40 300 |
| Treatment chemical 2 | DKK | 2 600 |
| 2.5 tonnes of sludge at DKK 2440 | DKK | 6 100 |
| Total per year excl. hours and electricity | DKK | 49 000 |

It is difficult to quantify the financial advantages ~~to~~ of the plant ~~as compared with the earlier process where they degreased~~ to degreasing in warm caustic soda lye. The consumption of acid and zinc have dropped considerably and fewer products are scrapped ~~since they introduced biological degreasing~~. However, the savings are also caused by other changes in products and production during the period in question. It is therefore difficult to decide exactly what financial advantages the new degreasing process is offering. [DK-EPA-93]

Example galvanising plant, Germany [ABAG-Bio]

The investment cost (excluding investment cost for treatment vats) for change of operation were reported to be DM 181 000 for a galvanising plant with a capacity of 10 000 tonnes per year. The energy consumption ~~was~~ increased (higher temperature of degreasing and biological rinse bath, pumps) and also the man-hours to run the system ~~was~~ increased. Nevertheless, for this case study, annual savings ~~potential~~ of DM 250 000 were reported and the time of amortisation was calculated to be 0.8 years. [ABAG-Bio]

Driving force for implementation

- Reduced costs due to increased material efficiency.
- Reduced waste water and sludge.
- Accelerated and improved pickling.

Example plants

Næstved Varmforzinkning ApS (period of experience: 6 years) [DK-EPA-93]; France; Verzinkerei Dieren, NL. ~~1 or 2 plants in Germany~~
Voigt & Schweitzer Henssler GmbH & Co. KG (Plant 49) [FMP data collection 2018]

Reference literature

[DK-EPA-93] [ABAG-Bio] [FMP data collection 2018]

TWG, Sections C.4.2.5 ('Utilization of Oily Sludge and Concentrates') and C.4.2.6 'Reduction of Carry-over to the Pickling Baths' from the old BREF can now be found in Chapter 8 (Sections 8.11.1.6 and 8.6.2.9 respectively).

6.4.2 Pickling and stripping

TWG, Section C.4.3.1 ('Optimized Bath Operation and Control') from the old BREF has been moved and the updated information can now be found in Chapter 8 (Section 8.6.2.6).

TWG, Section C.4.3.2 ('Minimising spent pickle liquor by use of pickling inhibitors') from the old BREF has been moved and the updated information can now be found in Chapter 8 (Section 8.6.2.11).

TWG, Section C.4.3.3 ('Activated pickling') from the old BREF has been moved and the updated information can now be found in Chapter 8 (Section 8.6.2.12)

6.4.2.1 Turbulence pickling using an immersed turbine

Description

Agitation of the pickling acid using an immersed turbine.

Technical description

Turbulence pickling is based on an immersed turbine which agitates the pickling acid to reach a turbulent flow regime with a high Reynolds number. [IT 18-4-17]

Achieved environmental benefits

Increased material efficiency.

Environmental performance and operational data

In one concrete case, the turbine shows an engine power equal to 7.5 kW and is capable of circulating more than 5 000 m³/h of acid with a very low energy consumption. The agitating and recirculating system requires the use of a bath divided into two interconnected channels. A normal pickling tank is split into two compartments, one where the workpieces are actually pickled and the other the turbine is installed. Depending on the compartments and the volume of the workpieces, the speed of the pickling acid near the surface of the workpieces is more than 0.5 m/s. The geometric complexity of the workpieces immersed also helps to increase the speed of the pickling acid. The complete homogeneity of the flow of the pickling acid is guaranteed in both directions by the bidirectional action of the turbine. [IT 18-4-17]

Cross-media effects

Slightly increased energy consumption due to the operation of the turbine.

Technical considerations relevant to applicability

TWG, please provide information.

Economics

TWG, please provide information.

Driving force for implementation

- Reduced costs due to increased material efficiency.
- Accelerated and improved pickling.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[IT 18-4-17]

TWG, Section C.4.3.5.1 from the old BREF ("Fluidised Bed Process and Spray Roasting") has been deleted, as it was reported in the old BREF that the technique was not used in batch galvanising.

TWG, the order of the following sections has changed.

6.4.2.2 Separated pickling and stripping

Description

Pickling and stripping are carried out in separate tanks in order to avoid the generation of spent pickling acids with a high zinc content.

Technical description

In general, mixed spent acids containing large amounts of both iron and zinc are very difficult to reuse or recycle. By pickling and stripping in separate tanks, the zinc content in the pickling acid iron pickle baths can be kept as low as possible. Additionally, either single use suspensions should be used where possible (wire) or multiple use suspensions should be stripped before using. [ABAG]

Achieved environmental benefits

- Reduction of waste.

- ~~Keeping waste streams separate allows for regeneration.~~
Easier recycling of spent pickling acid.

Environmental performance and operational data

TWG, please provide information.

~~To reduce waste water generation, quenching water is often used to prepare and refresh pickle solutions. However, quenching water can add large amounts of zinc to pickling baths. Careful acid management can achieve zinc contents of 5–10 g/l in iron pickling baths. [ABAG] TWG, this information was moved to Section 8.7.5.~~

Cross-media effects

None.

Technical considerations relevant to applicability

- ~~New plants and existing plants.~~

~~For~~ In existing plants, there may be a lack of application ~~may be limited due to space restrictions~~ (for additional tanks).

Economics

TWG, please provide information.

Driving force for implementation

Reduced costs due to increased material efficiency.

Example plants

Otto, Kreuztal, Germany [Com2 D]

Reference literature

[ABAG] [Com2 D]

C.4.3.4 HCl Recovery from Spent Pickle Bath

6.4.2.3 Evaporative recovery (HCl)

Description

See Section 8.6.5.

Technical description

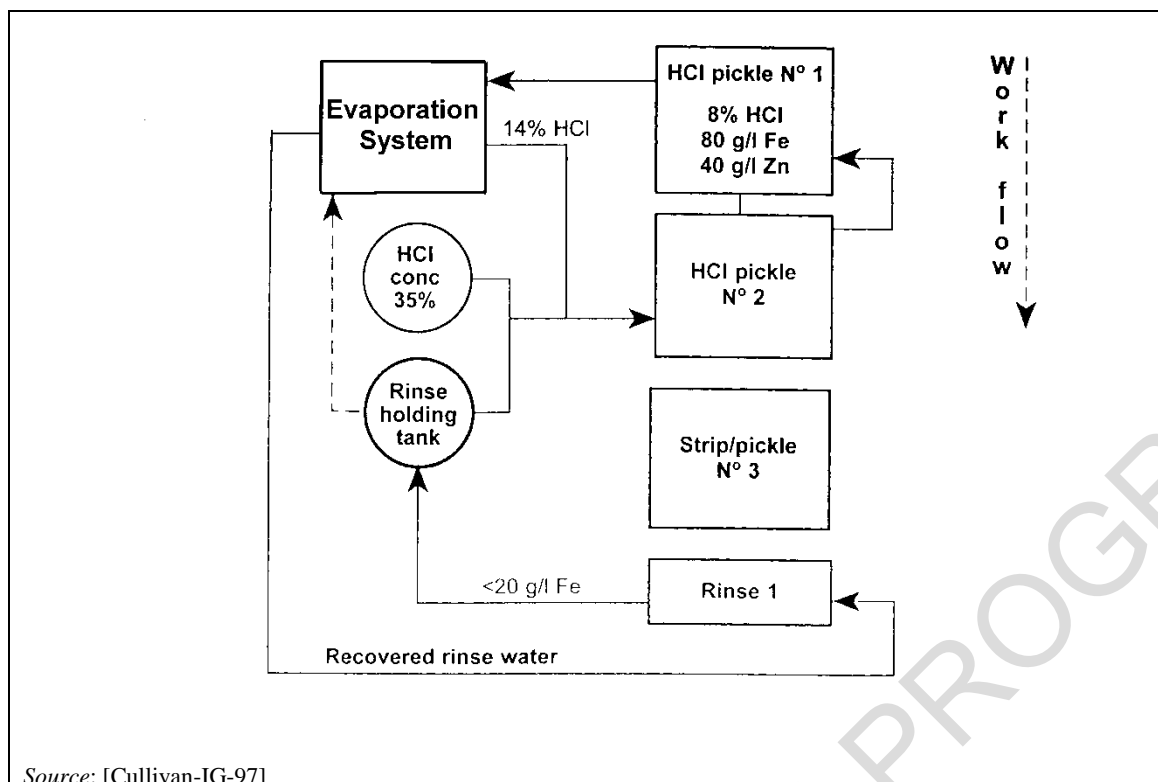
See Section 8.6.5.

Achieved environmental benefits

See Section 8.6.5.

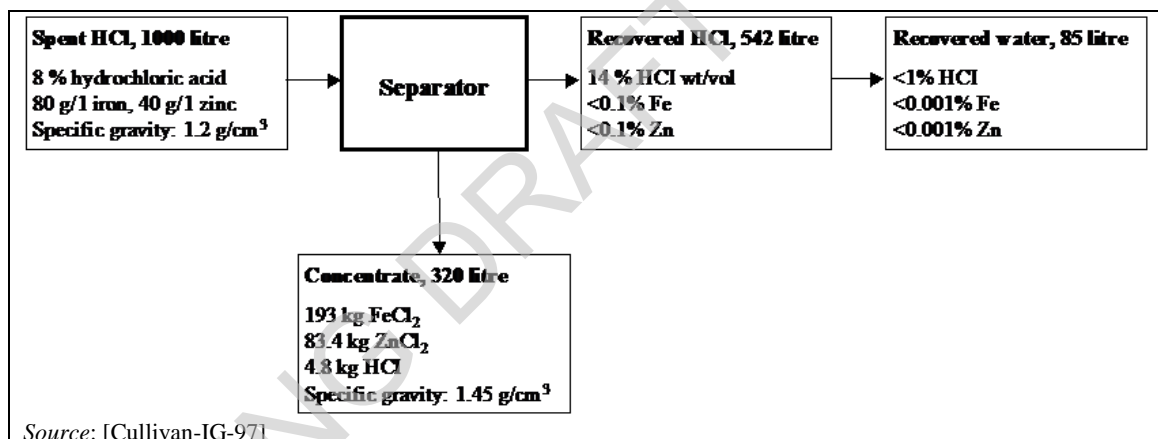
Environmental performance and operational data

Figure 6.23 and Figure 6.24 show the flowsheet and the mass balance for an example galvanising plant.



Source: [Cullivan-IG-97]

Figure 6.23: Example flowsheet for evaporative HCl recovery



Source: [Cullivan-IG-97]

Figure 6.24: Example mass balance for evaporative HCl recovery

The recovered acid can be returned to the pickling tank. Additional fresh acid blended into the pickling tank will make up for volume losses generated by the removal of the iron chloride solution and water. The recovered water can proceed either to the rinse tank, to the pickle tanks or to the flux bath. [Cullivan-IG-97]

The energy consumption for the plant as a whole is 230 kWh/m³ treated, with a net energy recovery of 150 kW by use of using a special heat exchanger. [Com2 EGGA]

Cross-media effects

- High energy consumption [Com2 D].
- Generation of a concentrated iron chloride solution (concentrate) that may not be suitable for recycling.

Technical considerations relevant to applicability

See Section 8.6.5.

Economics

TWG, please provide information.

Driving force for implementation

See Section 8.6.5.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[Cullivan-IG-97] [Com2 EGGA] [Com2 D]

TWG, Section C.4.3.7 from the old BREF "Reduction of Zinc to Iron Ratio" has been deleted, as it was reported in the old BREF that the technique was not used in practice.

TWG, Section C.4.3.7.1 from the old BREF "Pre-treatment for Increased Reuse Options" has been deleted, as the technique is described in Chapter 8 (Section 8.6.5).

6.4.2.4 Zinc recovery by ion exchange removal from hydrochloric acid pickling baths

Description

Spent pickling acids containing high concentrations of zinc are pumped through an ion-exchange column to selectively remove zinc. The zinc-free liquid is returned to the pickling bath. The stripping solution from the regeneration of the column contains ZnCl_2 and NH_4Cl . It is used as fluxing solution.

Technical description

The process (see Figure 6.25) is divided into four stages, namely:

- zinc removal;
- rinsing I (elution 1);
- stripping and regenerating;
- rinsing II.

Pickling acid is pumped out of the bath through a plate filter to remove any solid particles. The clear liquid then flows through the column. In the column, zinc is removed from the pickling acid and bound to ~~absorbed by~~ the ion-exchange material. After leaving the column, the zinc-free liquid is pumped back into the pickling bath. Thus the system recycles the acid. However, the acid does not necessarily have to be recirculated and can be processed and then stored in a vessel (once-through process) or pumped out into another vessel, run through the column and stored in a third tank (batch process). ~~In the second stage, after the ion-exchange material becomes saturated with zinc, the column has to be rinsed to remove the pickling acid~~

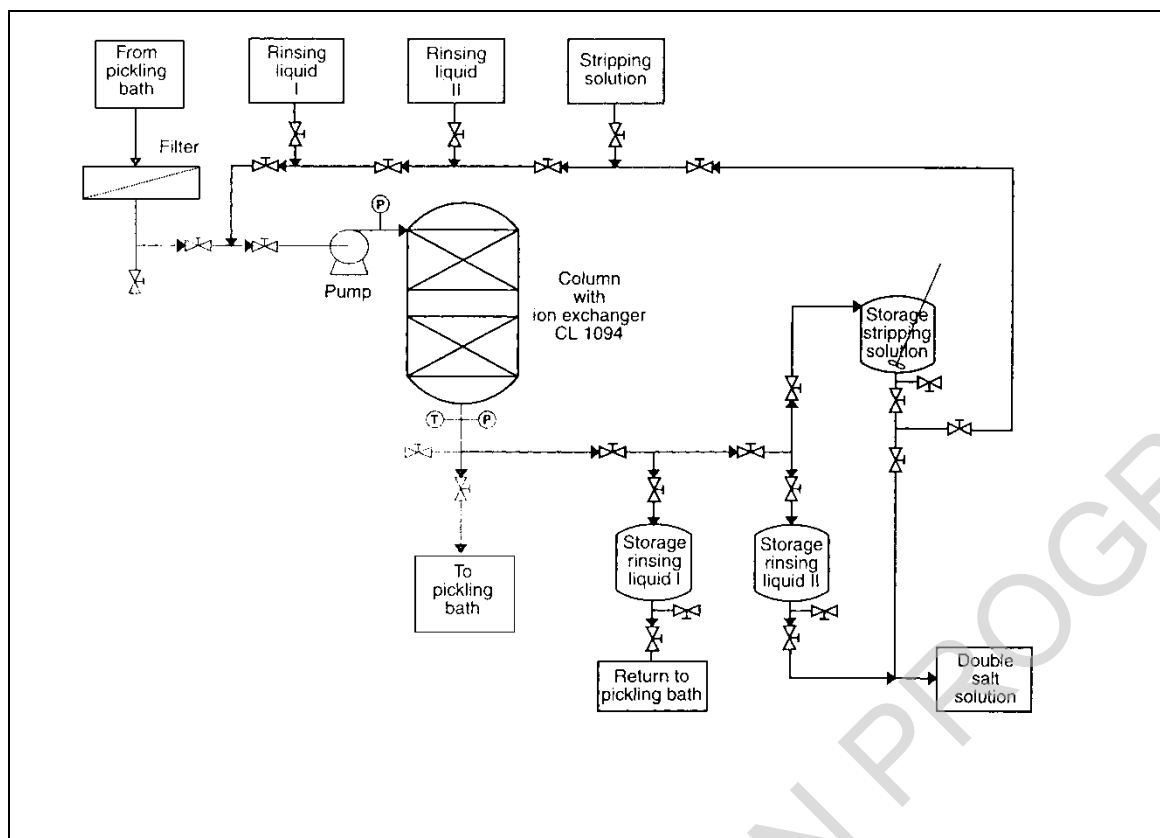


Figure 6.25: Flow chart for removal of zinc from pickling baths [Sprang-IG-97]

In the second stage, after the ion-exchange material becomes saturated with zinc, the column has to be washed to remove the pickling acid. ~~The wash is then pumped out of the stock vessel, through the column, and into a separate storage vessel.~~ The solution thus obtained is an HCl solution that can be used to modify the strength of the pickling bath. In the third stage, the ion-exchange material is stripped with an alkaline solution in order to remove the zinc. If second-stage rinsing does not take place, iron hydroxide is precipitated, interfering with the process. The stripping solution is used several times before it becomes concentrated. When the stripping solution has reached saturation it can be used to modify the composition of the flux bath. The stripping solution contains only ZnCl_2 and NH_4Cl . After the ion-exchange material has been stripped and regenerated, the last remains of the solution must be removed. This is done in the fourth stage by rinsing with tap water. ~~If this were not done~~ Otherwise, the pickling acid would become polluted by NH_4^+ and, although solving the initial problem of zinc contamination, would create a new one (NH_4^+ pollution).

Achieved environmental benefits

Reduced waste:

- Increased material efficiency.
- Reduction of acid sent for disposal.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

Increased consumption of chemicals.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

It was commented that this technique requires considerable capital ~~costs~~ and running costs and that scales of economy are a critical factor ~~and~~ which may not be achievable ~~with~~ by many typical size ~~general~~ galvanising plants with typical sizes ~~sites~~. [Com2 UK Galv]

Driving force for implementation

Reduced costs due to increased material efficiency.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[Com2 UK Galv]

6.4.2.5 Iron removal and reuse as fluxing solution**Description**

Spent pickling acids containing high concentrations of zinc are treated with hydrogen peroxide to oxidise iron and subsequently neutralised with aqueous ammonia. The iron hydroxide sludge is separated. The remaining liquid contains high concentrations of zinc and ammonium chloride and is used as fluxing solution.

Technical description

~~Spent hydrochloric acid from combined pickling and stripping with high concentrations of iron and zinc can be processed and recovered like a flux bath (see Chapter D.7.1.1). After oxidation with hydrogen peroxide and neutralisation with ammonia the iron hydroxide sludge is separated. The remaining liquid contains high concentrations of zinc chloride and ammonium chloride and can be reused as a flux solution. [Com DK]~~

See Section 8.6.3.3.

Achieved environmental benefits

~~Reduced waste:~~

- Increased material efficiency.
- Reduction of acid sent for disposal.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

Increased consumption of chemicals.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Reduced costs due to increased material efficiency.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

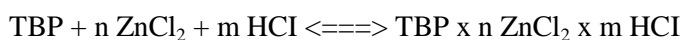
[Com DK]

6.4.2.6 Zinc and iron recovery of spent mixed pickle liquor by solvent extraction**Description**

Spent pickling acids containing high concentrations of zinc are mixed with liquid tributyl phosphate (TBP) for the selective removal of zinc. The organic phase is separated by decantation. Zinc is subsequently re-extracted with water. Following this, the TBP is reused while the aqueous phase is concentrated by evaporation and sold.

Technical description

The solvent extraction process for selective zinc removal from spent HCl pickling acids uses the extractant tributylphosphate (TBP) and is based on the following simplified reaction:



ZnCl₂ and HCl from the aqueous feed is bound as a chloride complex together with HCl to form a complex in the organic phase, which is less dense than the aqueous phase. Thus, the two phases can be separated by decantation. When the loaded organic phase is intensively contacted with a fresh new aqueous solution phase, the complexing reaction is reversed (re-extraction) so the stripped organic extractant can be recycled and a dilute aqueous ZnCl₂ solution is produced. The ZnCl₂ solution is evaporated to increase the zinc concentration. The condensate from evaporation is recycled to re-extraction and the concentrate is sold. Figure 6.26 illustrates the whole process schematically.

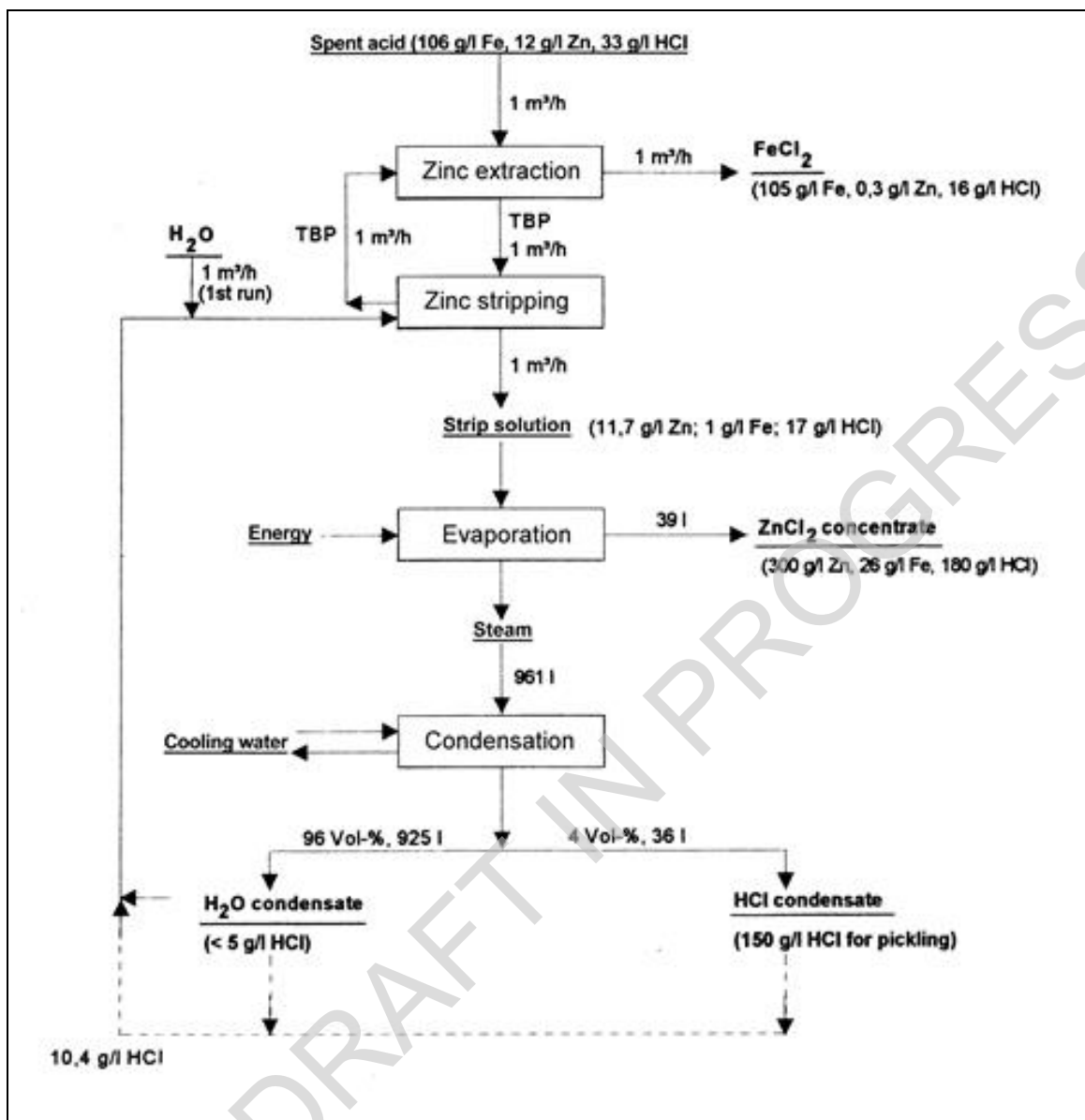


Figure 6.26: Schematic of the solvent extraction process

Spent acid, stored in a special tank or in the pickling vessel, passes through a filter in which solid particles such as metal swarf, oxide scale, insoluble oils, dirt and cigarette ends etc. are captured. The filtrate passes a buffering device and enters the first of three conventional mixer-settlers for zinc extraction by TBP. Zinc is extracted together with some free HCl and FeCl₃.

The zinc-loaded organic phase leaves the extraction section after three countercurrent contacts with the spent acid. More or fewer stages are possible and depending on the zinc concentration. The organic phase, which is less dense than in comparison to the aqueous phase, leaves the settler over a weir which adjusts the phase boundary and organic to aqueous volume ratio.

The zinc-free FeCl₂ raffinate leaves the last mixer-settler (third extraction stage) from the bottom and is captured by a coalescer to remove any residual organic phase. The raffinate is pumped to the storage vessel of the plant, which may be a fixed tank or a tank truck. The zinc-loaded organic phase enters the re-extraction section (same container) consisting of three further mixer-settlers. Here it comes into contact with normal tap water and condensate from the evaporation unit. ZnCl₂, FeCl₃ traces and HCl are washed from the extractant, which is recycled to the extraction vessel. The aqueous solution (strip solution) again passes a coalescer and is pumped to the evaporation container.

The strip solution ~~is~~ shows a very low ~~in~~ zinc concentration and normally has no further direct use. For that reason, it is concentrated to about 300 g zinc per litre. Any other suitable concentration can be achieved.

Evaporation is carried out by a steam-heated evaporator ~~constructed of PVDF~~.

The zinc concentration in the pregnant liquor is of minor interest for the extraction process. Ideally, the strip solution will contain about 30 g/l zinc. The lower the zinc concentrations in the spent acid, the higher the nominal throughput of acid will be due to a higher aqueous/organic ratio. However, higher zinc feed leads to higher treatment costs.

~~Heat for evaporation is delivered by steam produced in two small steam generators. The steam generators can be fired with natural gas or propane and have a high conversion efficiency. Steam is fed under pressure to the PVDF tubes of the evaporator. Heat is thus transferred to the strip solution.~~

The vapour passes a condenser cooled by salt-free tapwater in a circuit. In this way it is possible to completely recover the evaporated water and HCl with a cooling tower.

Vapour condensation can be arranged in two steps. First, the water with low free HCl (< 5 g/l in total volume) will be captured. This fraction is about 85–95 % of the total condensate. Then the tank is changed and filled with the remaining condensate, rich in acid. A final concentration of 15–18 %, suitable for pickling, should be achievable. The acid can be reused in-house. Due to technical problems, this selective HCl recovery was not possible within the project period.

Evaporation can be carried out more or less continuously. It is complete when the zinc concentration in the evaporator feed reaches 300 g/l. The final concentration can vary depending on the customer's requirement.

Achieved environmental benefits

~~Reuse of mixed (zinc-containing) acid.~~

- Increased material efficiency.
- Reduction of acid sent for disposal.

Environmental performance and operational data

Some operational data are given in Figure 6.26.

Cross-media effects

- Increased consumption of chemicals ~~used/solvents~~.
- Increased energy consumption.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Reduced costs due to increased material efficiency.

Example plants

A liquid-liquid extraction plant for the recovery of acids containing zinc and iron is operated by Norsk Hydro at Oberhausen, Germany.

Trials and investigations were done with a mobile plant at the Berliner Grossverzinkerer/Metaleurop. Meanwhile the mobile unit has been turned into a stationary plant. [Com2 D]

Reference literature

[Com2 D]

6.4.2.7 Treatment of waste acid by neutralisation

TWG, Section C.4.3.10 from the old BREF "Treatment of Waste Acid by Neutralisation" has been deleted, as preference should be given to techniques for the recovery of spent acids. Moreover, neutralisation is a technique described in Chapter 8 (Section 8.9.10).

TWG, Section C.4.3.11 from the old BREF "Restriction of the operational range for HCl open pickling bath" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.4.1).

TWG, Section C.4.3.12 from the old BREF "Capture of emissions from pickling and abatement" has been moved and the updated information can now be found in Chapter 8 (Sections 8.8.4.2 and 8.8.4.4).

TWG, Section C.4.3.13 from the old BREF "Enclosed pre-treatment section (degrease/pickling)/air extraction and abatement" has been moved and the updated information can now be found in Chapter 8 (Sections 8.8.4.3 and 8.8.4.4).

6.4.3 Rinsing

TWG, Sections C.4.4.1 "Installation of Rinsing Bath/ Static Rinse Tank" and Section C.4.4.2 "Rinsing Cascade" from the old BREF have been moved and the updated information can now be found in Chapter 8 (Sections 8.6.3.1 and 8.7.7).

6.4.4 Fluxing

TWG, Section C.4.5.1 from the old BREF "Bath maintenance" has been moved and the updated information can now be found in Chapter 8 (Section 8.6.3.2).

TWG, Sections C.4.5.2 / C.4.5.3 / C.4.5.4 / C.4.5.5 - from the old BREF "Iron removal from flux baths" have been moved and the information can now be found in Chapter 8 (Section 8.6.3.3).

TWG, Section C.4.5.6 from the old BREF "Reuse/Regeneration of Spent Flux Baths (off-site)" has been moved and the updated information can now be found in Chapter 8 (Section 8.6.3.4).

6.4.5 Hot dipping

TWG, Section C.4.6.1 from the old BREF "Enclosed galvanizing pot" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.6.4).

TWG, Section C.4.6.2 from the old BREF "Lip-extraction at galvanizing pots" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.6.3).

TWG, Section C.4.6.3 from the old BREF "Smoke-reduced flux agent" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.6.1).

TWG, Section C.4.6.4 "Reuse of Filter Dust" from the old BREF has been moved and the updated information can now be found in Chapter 8 (Section 8.11.2.1).

TWG, Section C.4.6.5 "Reducing the generation of hard zinc" from the old BREF has been moved and the updated information can now be found in Chapter 8 (Section 8.6.4.1).

TWG, Section C.4.6.6 "Reducing the Generation of Splashes" from the old BREF has been moved and the updated information can now be found in Chapter 8 (Section 8.6.4.2).

TWG, Section C.4.6.7 "Reuse of Zinc Ash" from the old BREF has been moved and the updated information can now be found in Chapter 8 (Section 8.11.2.2).

TWG, Section C.4.6.8 from the old BREF (Heat recovery from galvanising kettle heating) has been moved and the updated information can now be found in Chapter 8 (Section 8.5.4.2).

TWG, Section C.4.6.9 from the old BREF (Efficiency of furnace heating / control) has been moved and the updated information can now be found in Chapter 8 (Section 8.5.3.6).

TWG, Section C.4.6.10 from the old BREF (Capture/Treatment of Emissions from Tube Finishing Operations) did not contain any information and was thus deleted.

6.4.5.1 Optimised dipping time

Description

The dipping time is optimised to achieve the coating thickness specifications.

Technical description

TWG, please provide information.

Achieved environmental benefits

Increased material efficiency.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

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

Economics

Savings result from the reduced zinc consumption.

Driving force for implementation

Reduced costs due to increased material efficiency.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

6.4.5.2 Slow withdrawal of workpieces from the bath

Description

By withdrawing the galvanised workpieces slowly from the galvanising kettle, the drain-off is improved and zinc splashes are reduced.

Technical description

TWG, please provide information.

Achieved environmental benefits

Increased material efficiency.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

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

Economics

Savings result from the reduced zinc consumption.

Driving force for implementation

Reduced costs due to increased material efficiency.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

6.4.5.3 Modified fluxing solution to increase the aluminium content of the bath

Description

By means of a modified fluxing solution, the aluminium content of the bath can be increased to 0.03–0.05 wt-%. This reduces the coating thickness of steels with a high silicon and/or phosphorus content. [IT 18-4-17]

Technical description

Most galvanising plants add aluminum to the molten zinc bath at levels of 0.002–0.006 wt-% for better fluidity and brighter appearance of the galvanised coating. Moreover, the addition of aluminium allows to better control the coating thickness, as it reduces the reactivity of so-called reactive steels (i.e. steels with high silicon and/or phosphorus content). [IT 18-4-17]

The amount of aluminium that can be added to the bath is however limited, as the aluminum can react with the zinc-ammonium chloride from the fluxing solution, causing defects such as bare/black spots in the coatings. [AGA 30-9-2015]

By means of a modified (patented) composition of the fluxing solution, it is possible to increase the aluminium content in the bath to 0.03–0.05 wt-%. This increases the fluidity of the zinc bath and, more importantly, reduces the rate of the zinc-iron reaction, specifically in the case of

the so-called reactive steels. Consequently, this results in reduced zinc consumption. [IT 18-4-17]

Achieved environmental benefits

Increased material efficiency.

Environmental performance and operational data

Reported performance data indicate that additions of aluminium up to 0.03 wt-% can reduce the coating thickness on so-called hyper-sandelin steel (i.e. steel with a high silicon content) by approximately 20 %, but do not cause any thickness reduction on hypo-sandelin steel (i.e. steel with a low silicon content), where a reduction would not be desirable. When adding 0.05 wt-% of nickel (a more commonly used element to control the reactivity of reactive steels), the obtained thickness reduction was reported to be only 5 %. [IT 18-4-17]

Cross-media effects

Some additional aluminium is consumed due its higher content in the bath.

Technical considerations relevant to applicability

TWG, please provide information.

Economics

Savings result from the reduced zinc consumption.

Driving force for implementation

Reduced costs due to increased material efficiency.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[AGA 30-9-2015] Website of American Galvanizers Association: 'Effects of Adding Pure or Scrap Aluminum to the Zinc Bath', 30-9-2015.

[IT 18-4-17]

6.4.5.4 Recovery and use of zinc-containing particles from steam blow-out (tube finishing)

Description

Zinc-containing particles from blowing off excess zinc from galvanised tubes are recovered. They are reused in the galvanising kettle or sent for zinc recovery.

Technical description

Zinc-containing particles originating from steam blow-out of galvanised tubes are collected. They can be returned to the galvanising kettle. Alternatively, the particles can be used in the secondary zinc industry.

Achieved environmental benefits

- Increased material efficiency.
- Reduction of waste sent for disposal.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

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

Economics

Savings result from the reuse of zinc-containing particles in the galvanising kettle or from selling them to the secondary zinc industry.

Driving force for implementation

Reduced costs due to increased material efficiency.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

6.5 Emerging techniques for batch galvanising

TWG, the content of the previous BREF in this Section has been deleted for Draft 1.

Emerging techniques present in the old BREF, for which information was received from the TWG, have been moved and integrated as BAT candidates. For other remaining emerging techniques, the TWG is requested to indicate whether they should be kept (in which case updated information should be sent), or deleted.

Finally, the TWG is requested to send information on possible new emerging techniques that could be considered in the revised version of the BREF document.

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C.7 CONCLUDING REMARKS

TWG, The content has been deleted and will be completed after D1.

WORKING DRAFT IN PROGRESS

7 CURRENT CONSUMPTION AND EMISSION LEVELS FOR PROCESSES COMMON TO MORE THAN ONE SECTOR

7.1 Acid recovery

7.1.1 Emissions to air

Dust emissions

The reported data on dust emissions to air from acid recovery are shown in Figure 7.1 (values are given as reported, without conversion to a reference oxygen concentration).

HCl emissions

The reported data on HCl emissions to air from acid recovery are shown in Figure 7.2 (values are given as reported, without conversion to a reference oxygen concentration).

SO_x emissions

The reported data on SO_x emissions to air from acid recovery are shown in Figure 7.3 (values are given as reported, without conversion to a reference oxygen concentration).

NO_x emissions

The reported data on NO_x emissions to air from acid recovery are shown in Figure 7.4 (values are given as reported, without conversion to a reference oxygen concentration).

HF emissions

The reported data on HF emissions to air from acid recovery are shown in Figure 7.5 (values are given as reported, without conversion to a reference oxygen concentration).

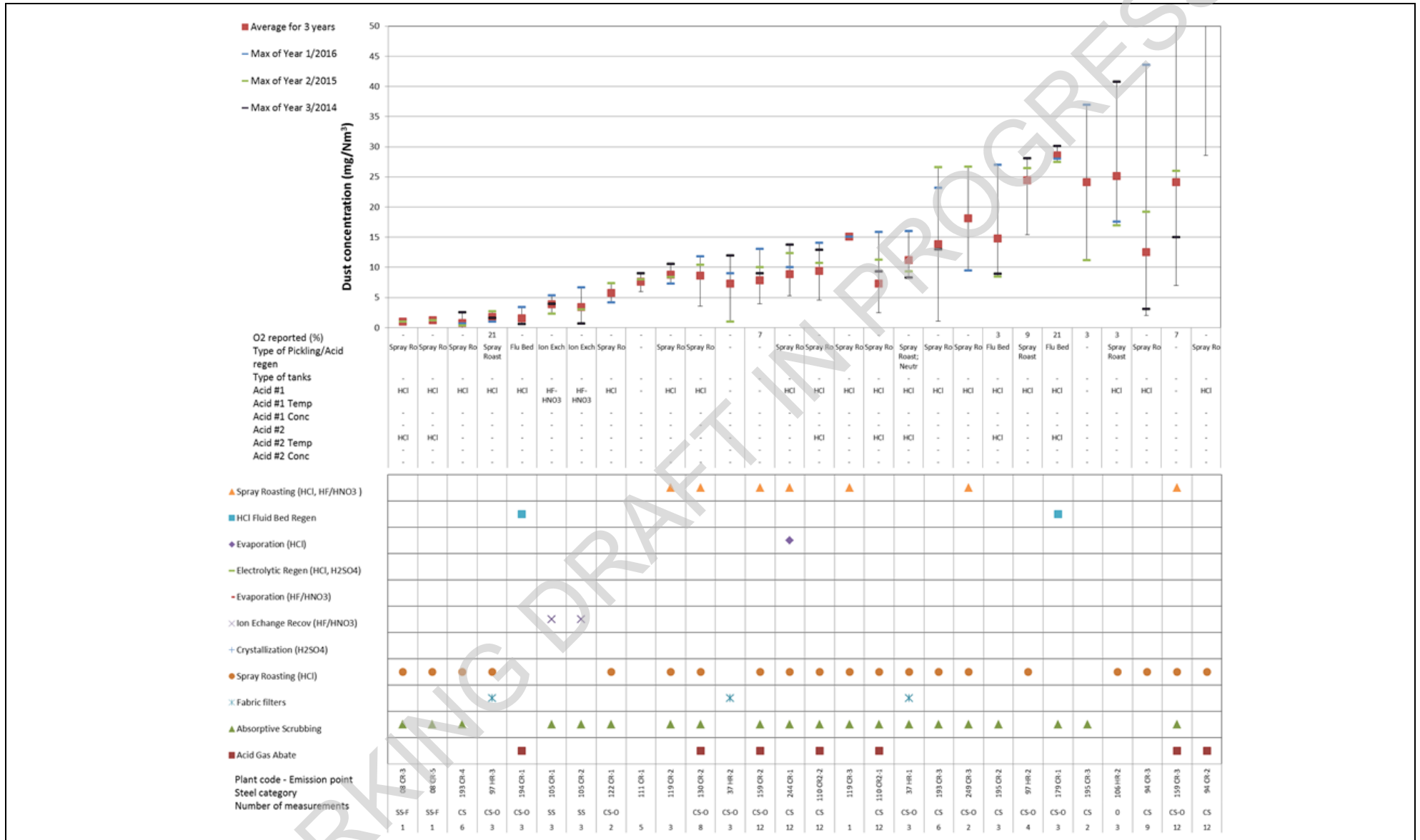


Figure 7.1: Dust emissions from acid recovery (in mg/Nm³). Source: [TWG 2018].

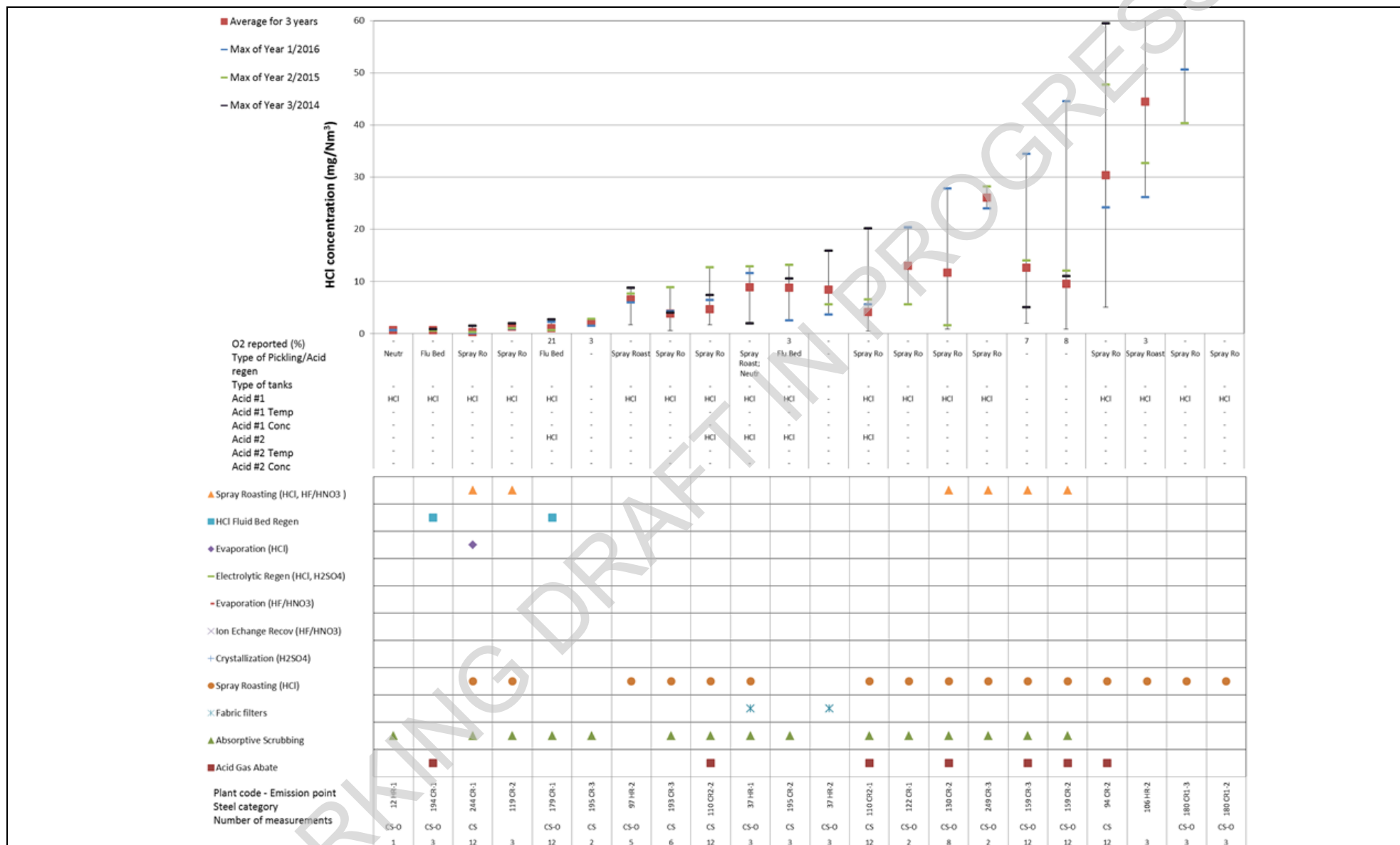


Figure 7.2: HCl emissions from acid recovery (in mg/Nm³). Source: [TWG 2018].

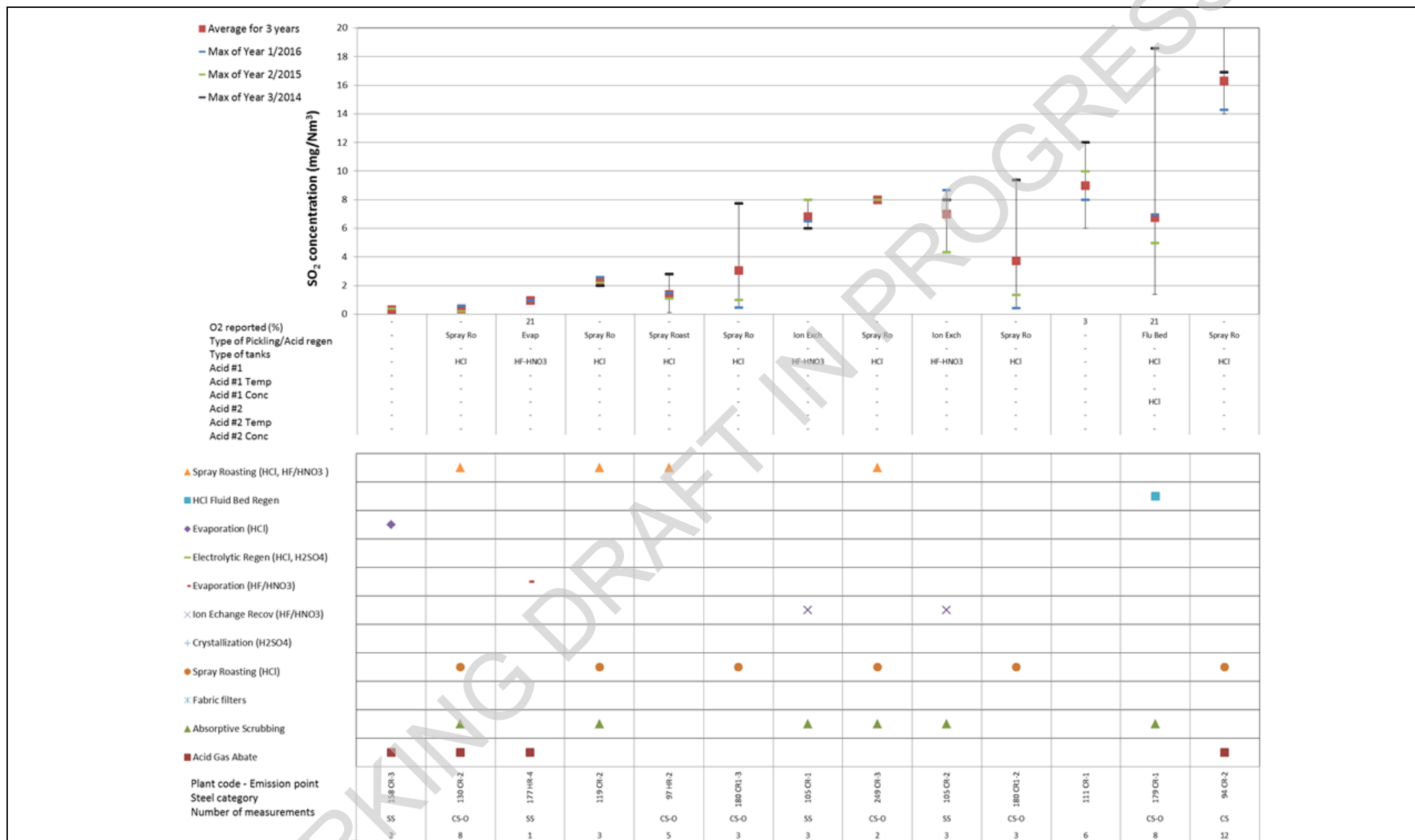
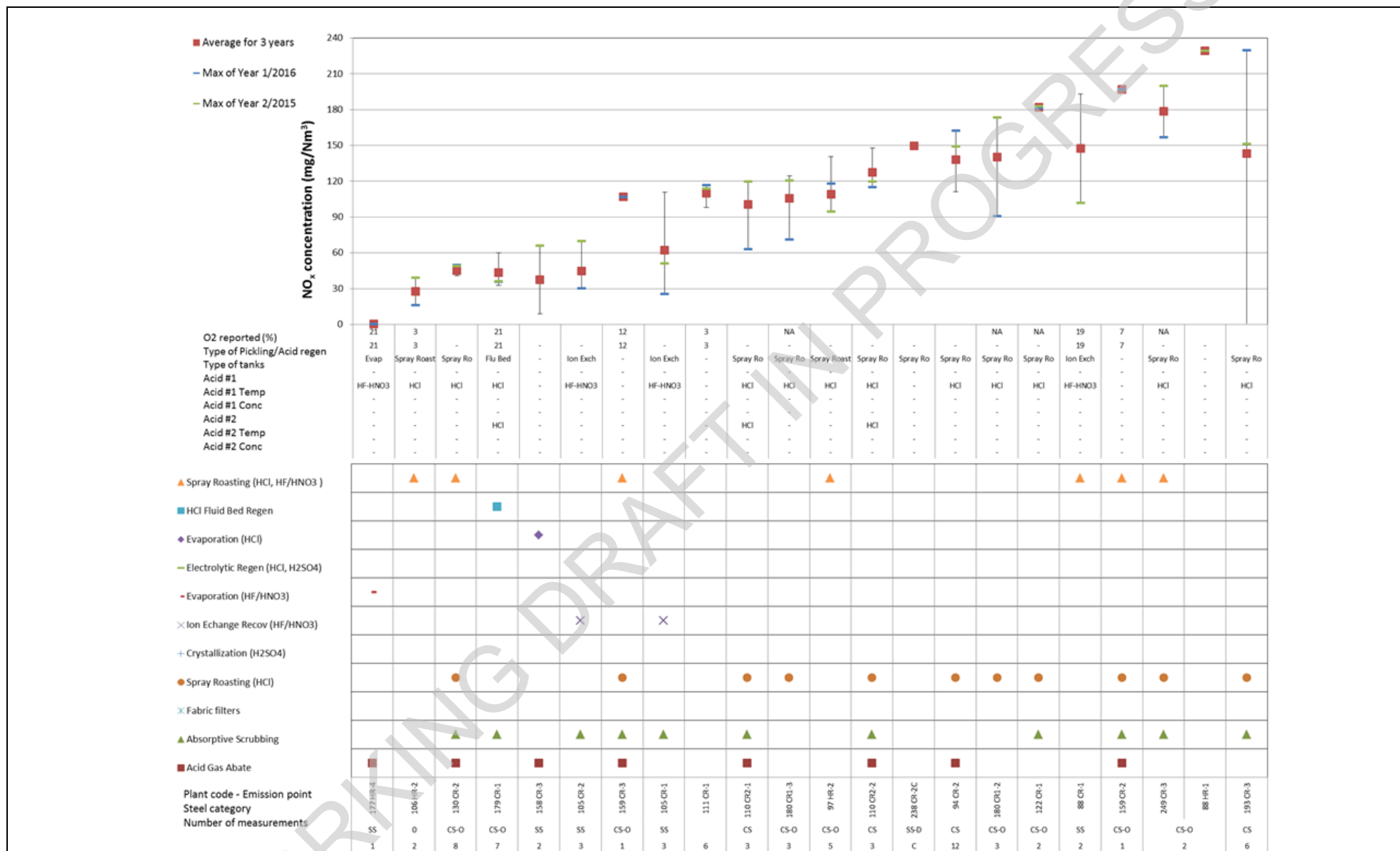


Figure 7.3: SO_x emissions from acid recovery (in mg/Nm³). Source: [TWG 2018].

Figure 7.4: NO_x emissions from acid recovery (in mg/Nm³). Source: [TWG 2018].

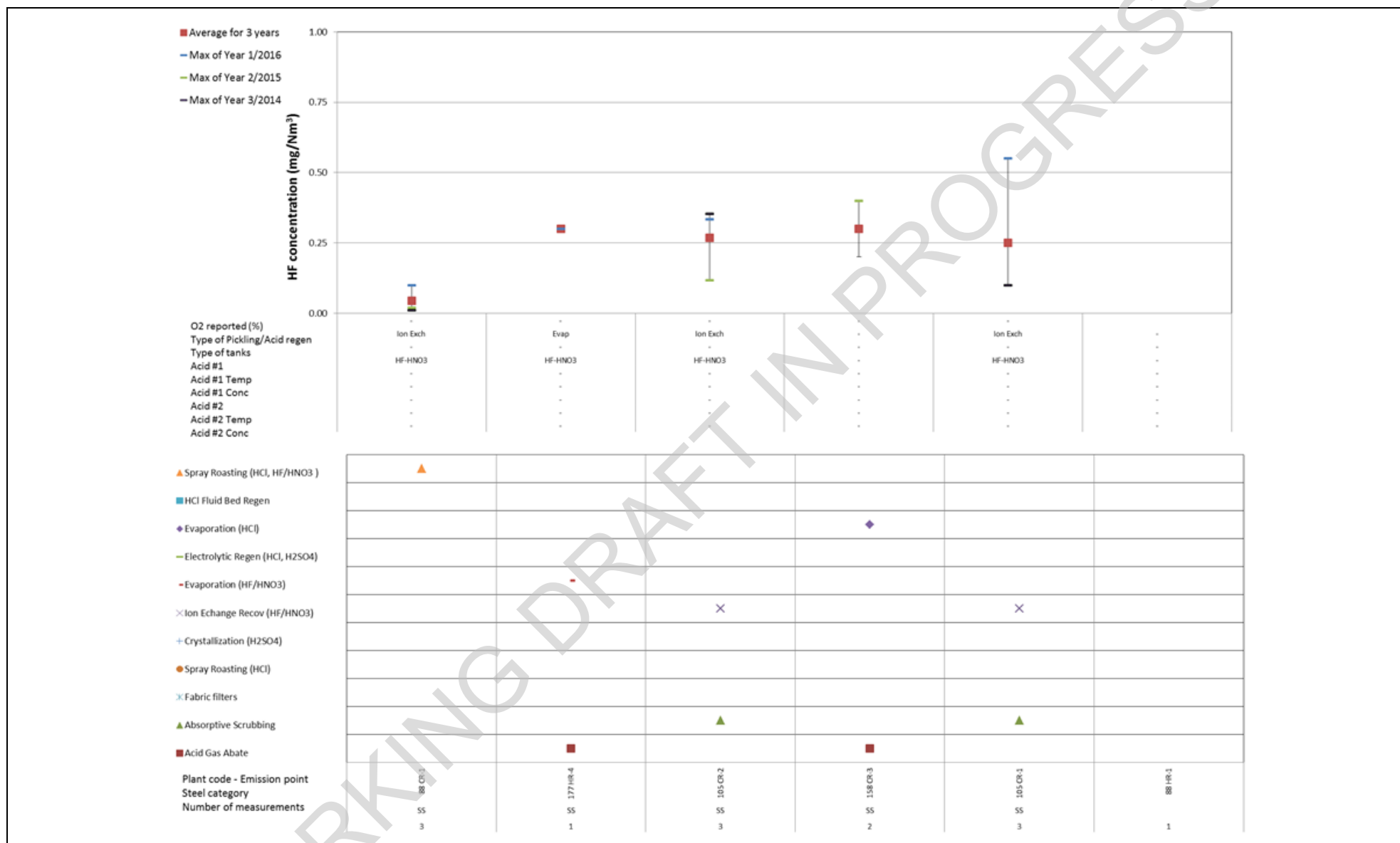


Figure 7.5: HF emissions from acid recovery (in mg/Nm³). Source: [TWG 2018].

7.2 Waste water treatment of streams from more than one sector

7.2.1 Emissions to water

This section contains information on the emissions to water from treatment plants processing waste waters that originate from more than one FMP sectors. Other streams from non FMP sectors may be treated together, but the main pollutant load originates from the FMP processes. Data on emissions to water from plants treating waste waters from only one FMP sector can be found in the respective sector specific chapters.

Figure 7.6 to Figure 7.38 show the reported data on emissions to water, for direct and indirect discharges, per pollutant

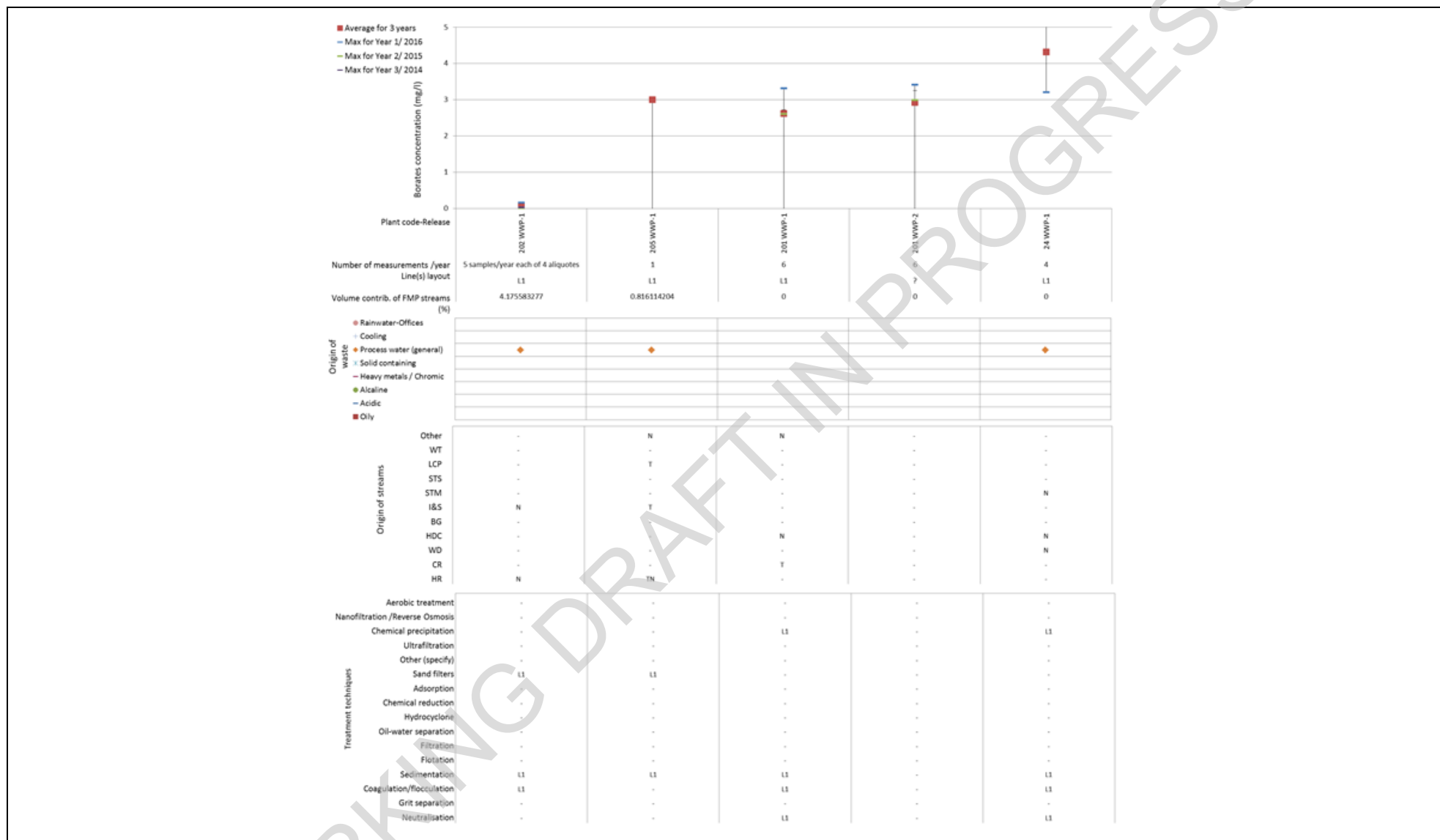


Figure 7.6: Borates emissions (in mg/l) for direct discharges. Source: [TWG 2018].

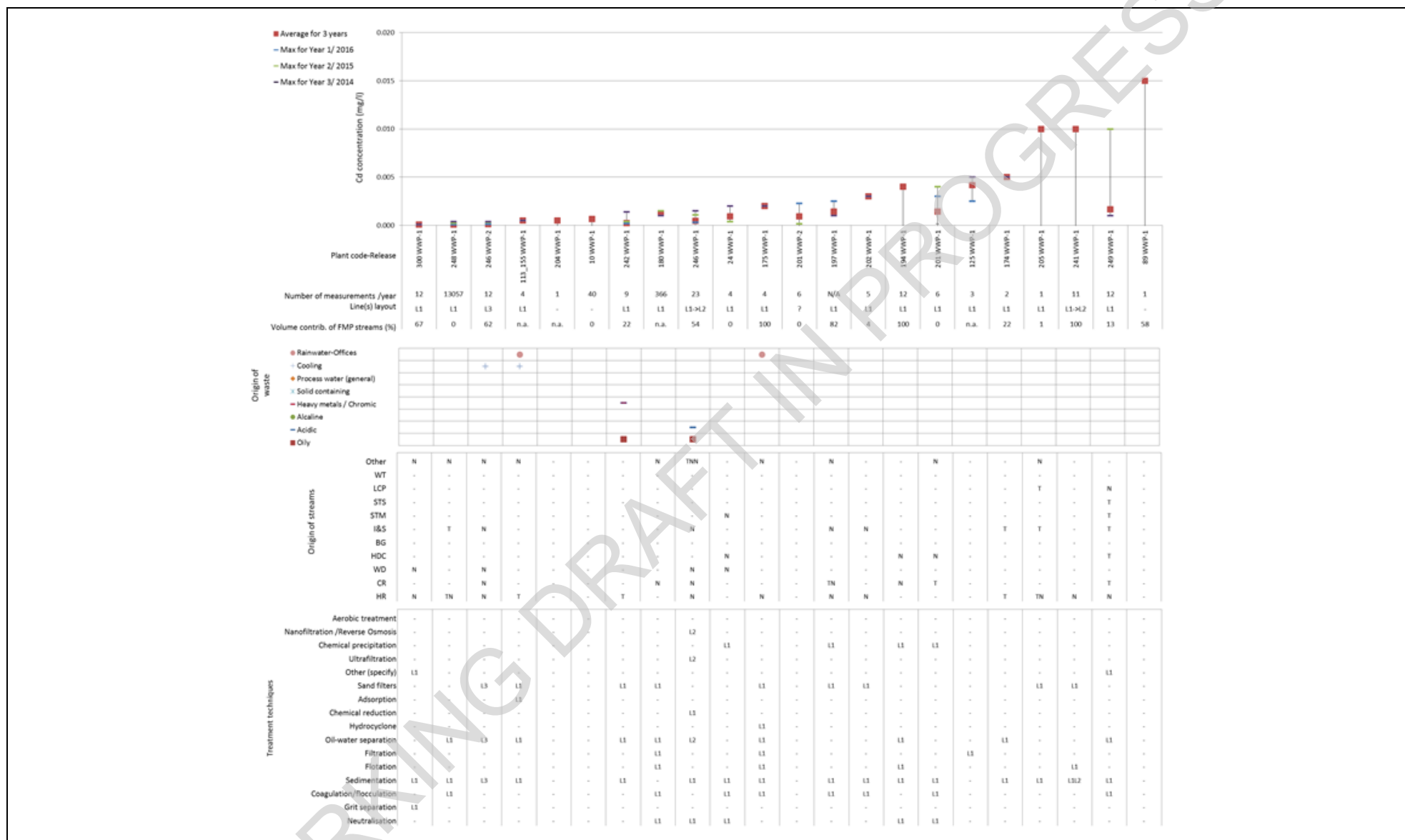


Figure 7.7: Cadmium emissions (in mg/l) for direct discharges. Source: [TWG 2018].

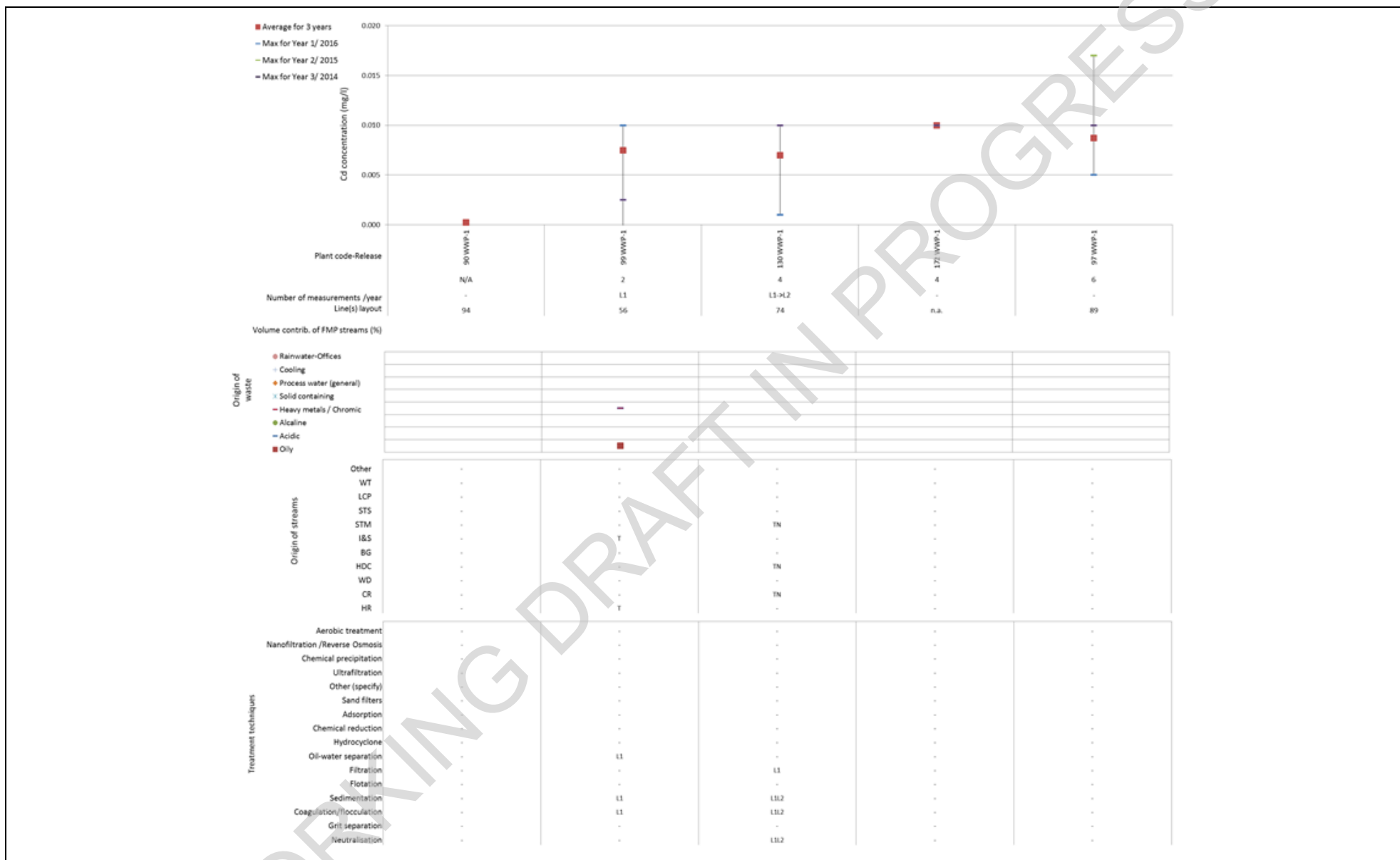


Figure 7.8: Cadmium emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

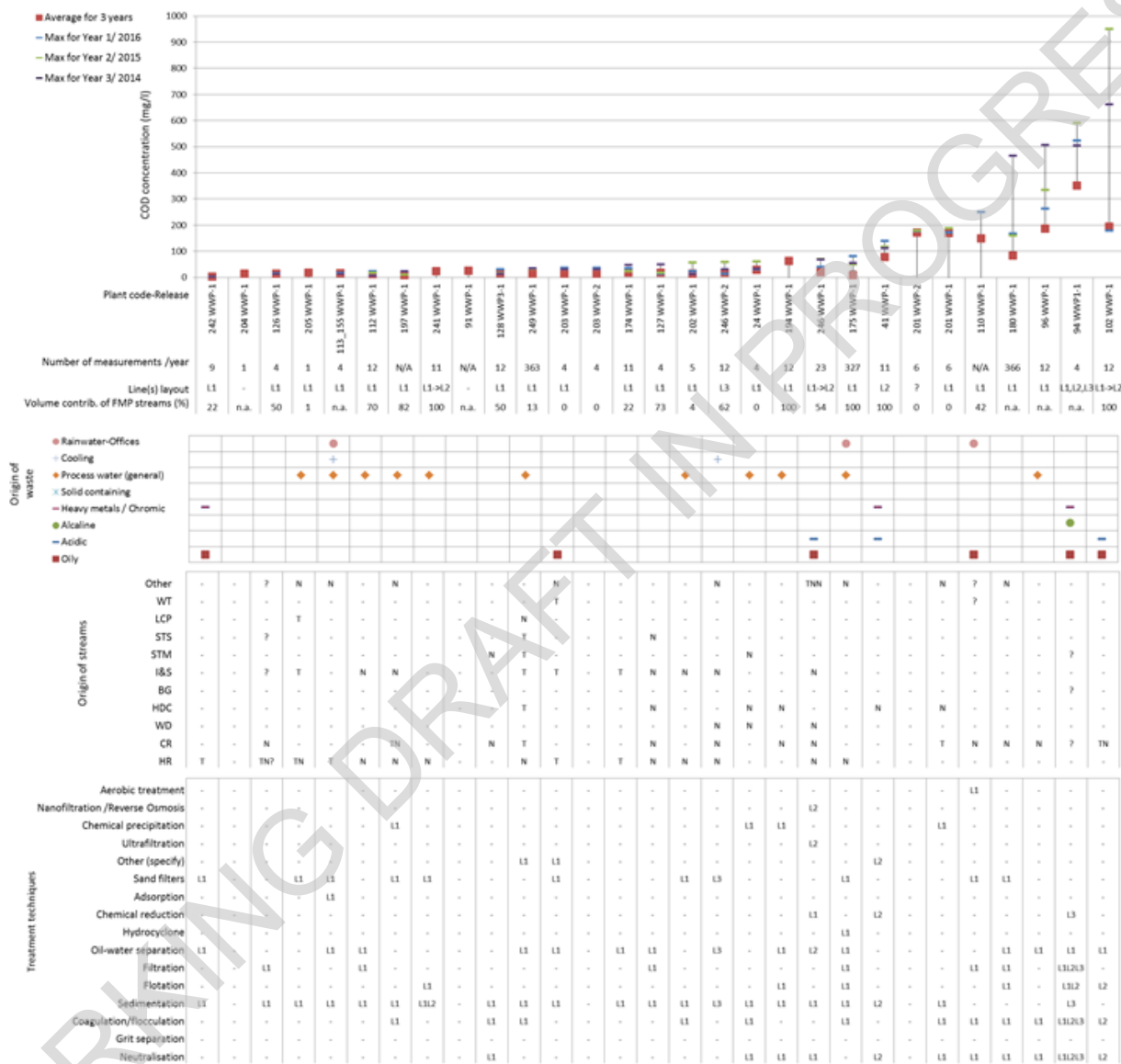


Figure 7.9: COD emissions (in mg/l) for direct discharges. Source: [TWG 2018].

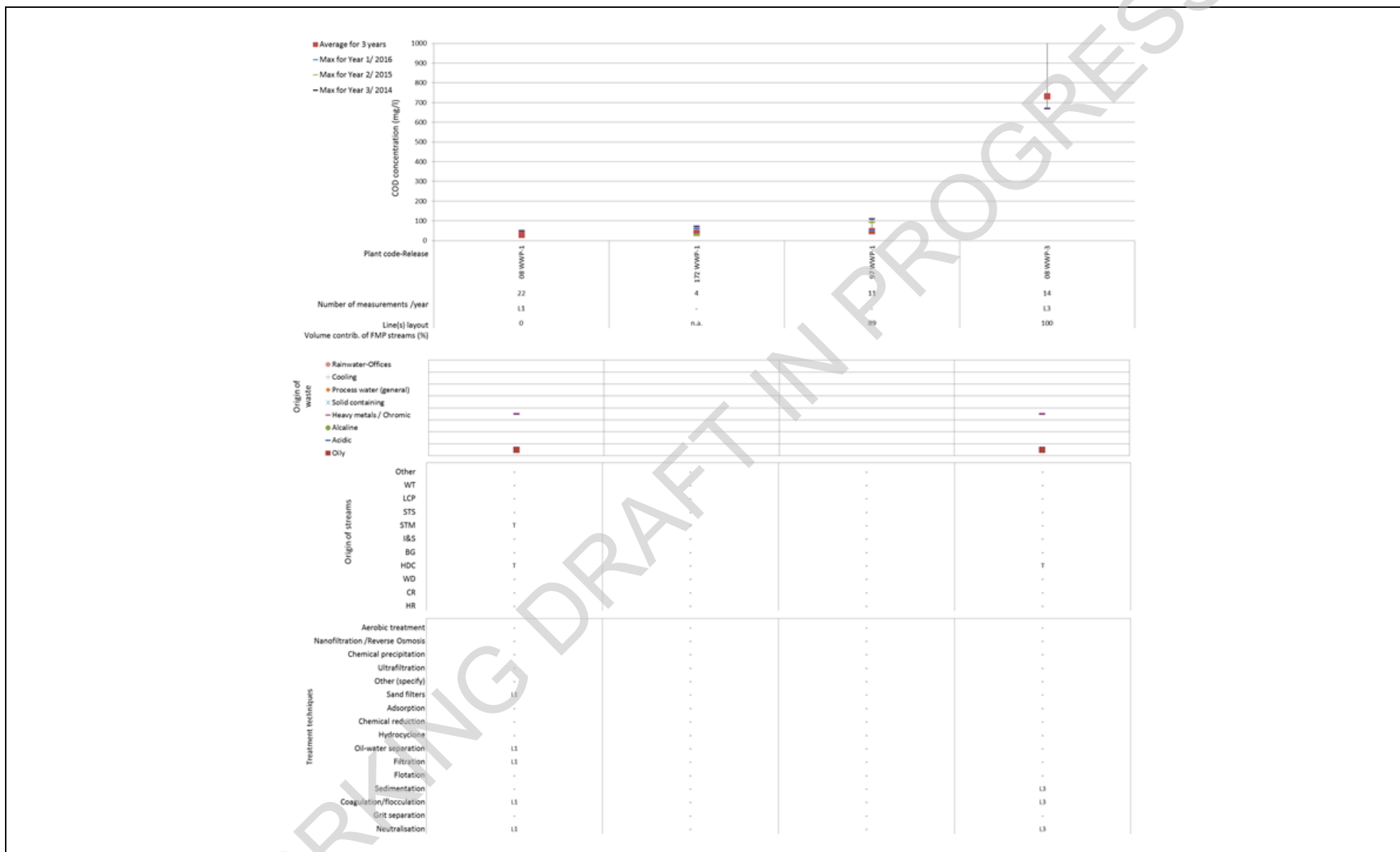
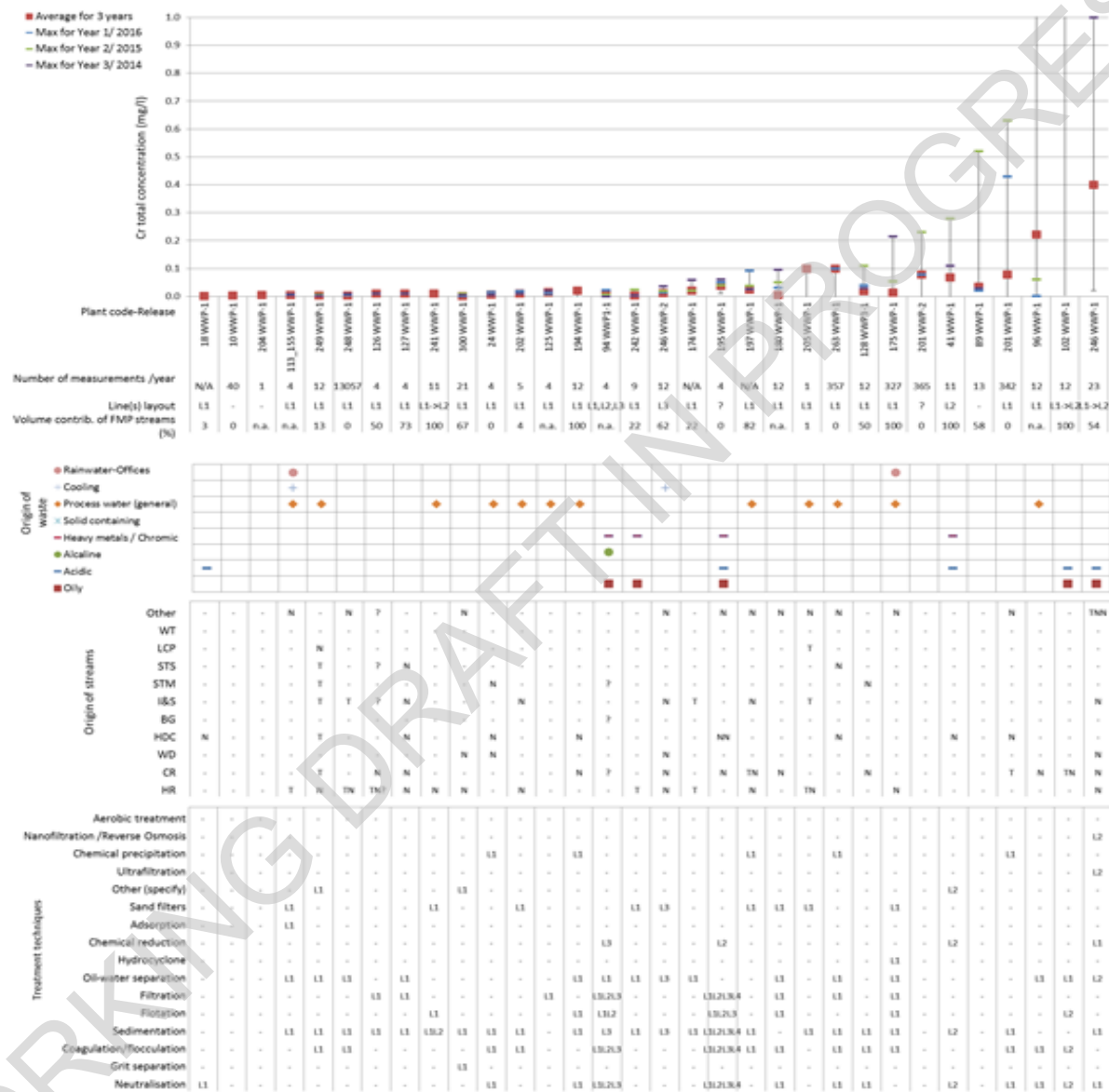


Figure 7.10: COD emissions (in mg/l) for indirect discharges. Source: [TWG 2018].



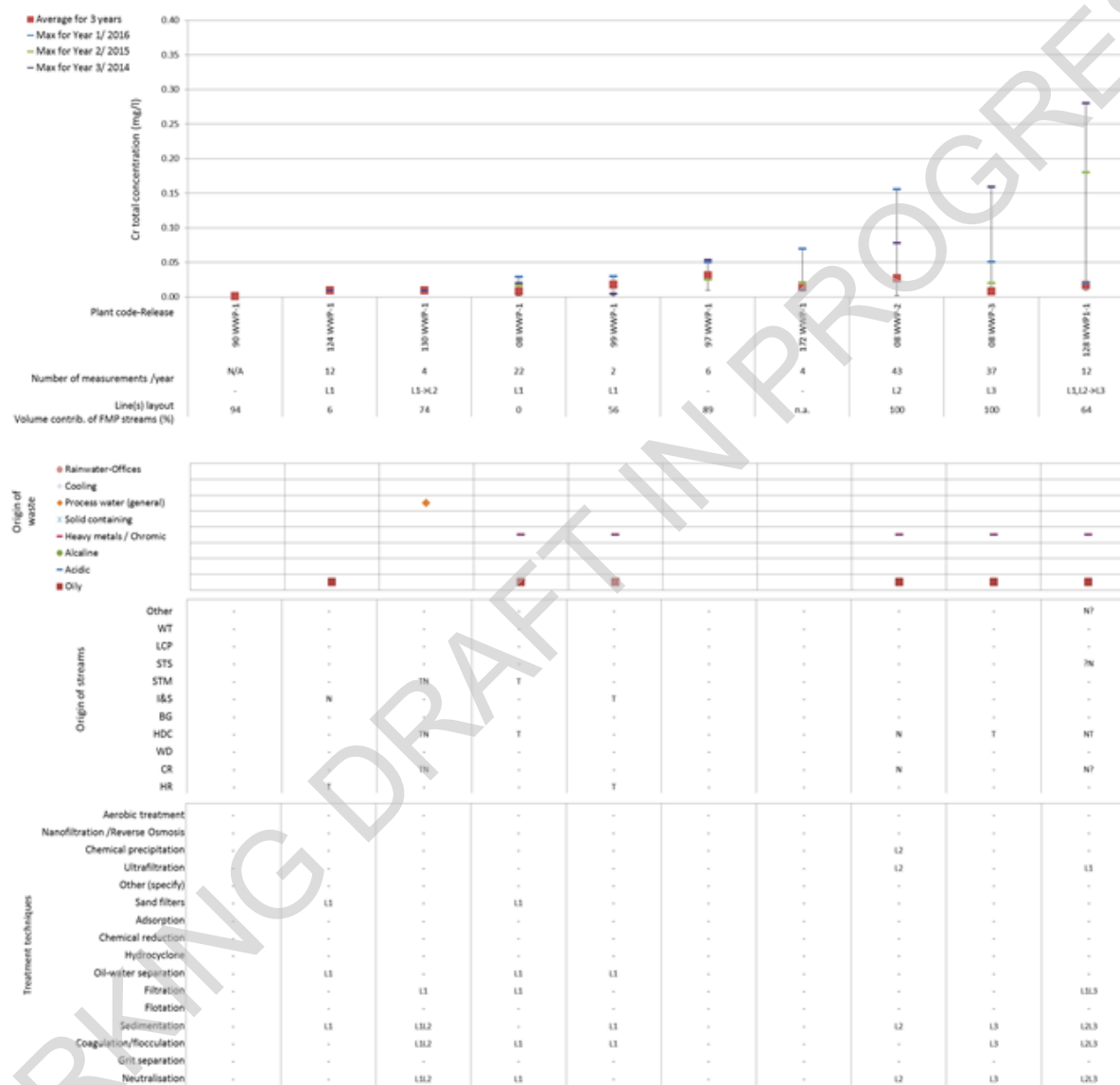


Figure 7.12: Chromium emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

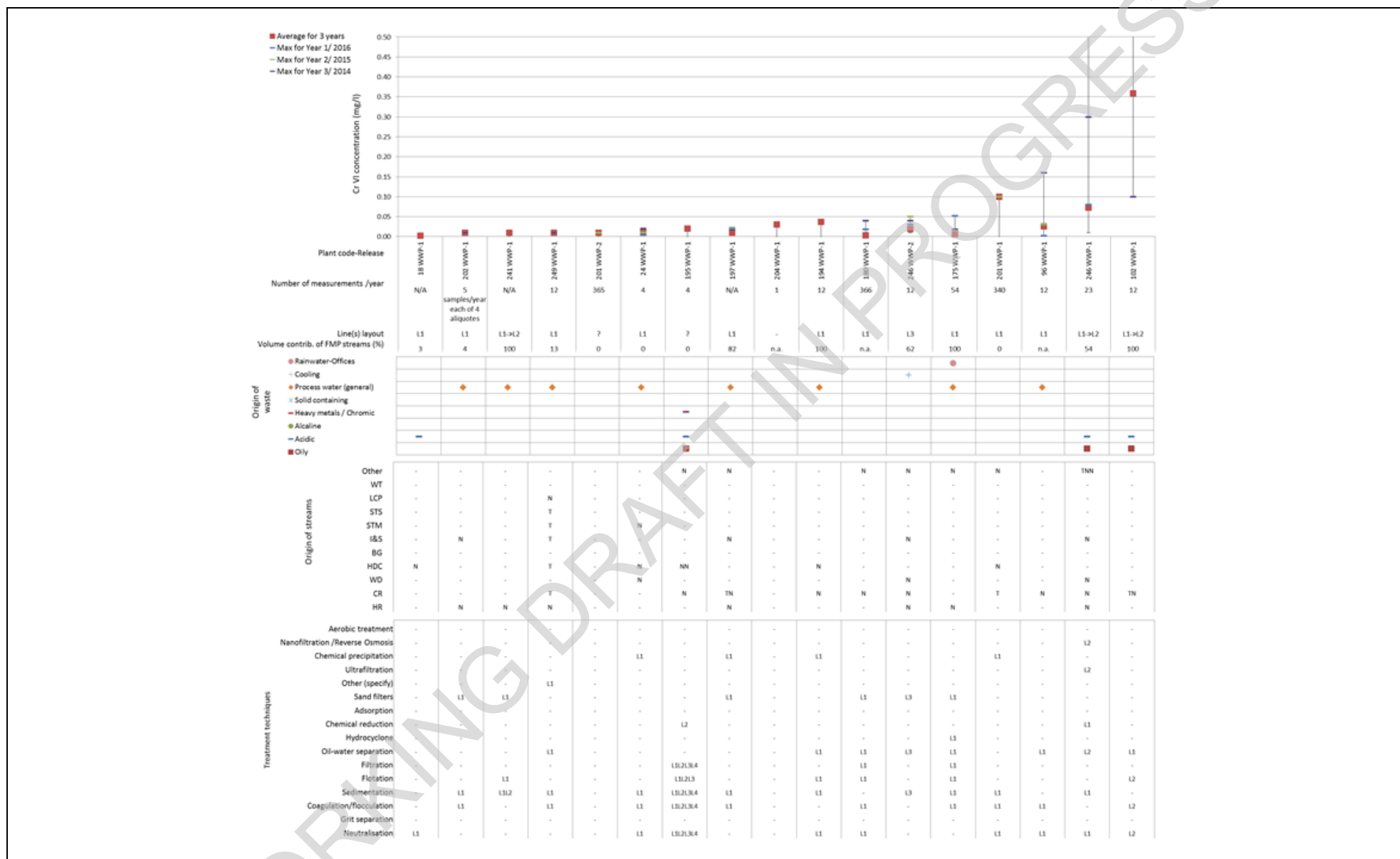


Figure 7.13: Chromium VI emissions (in mg/l) for direct discharges. Source: [TWG 2018].

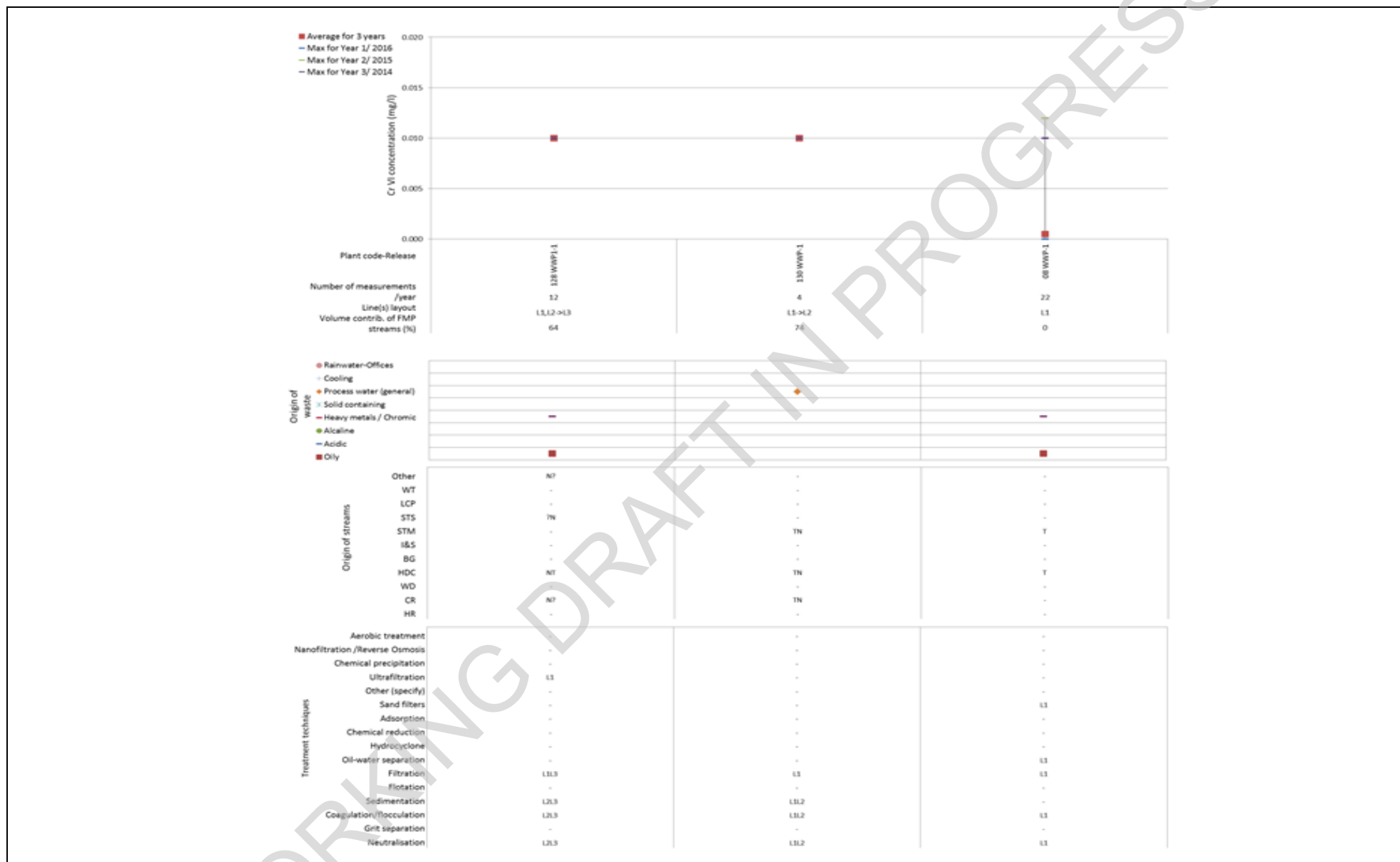


Figure 7.14: Chromium VI emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

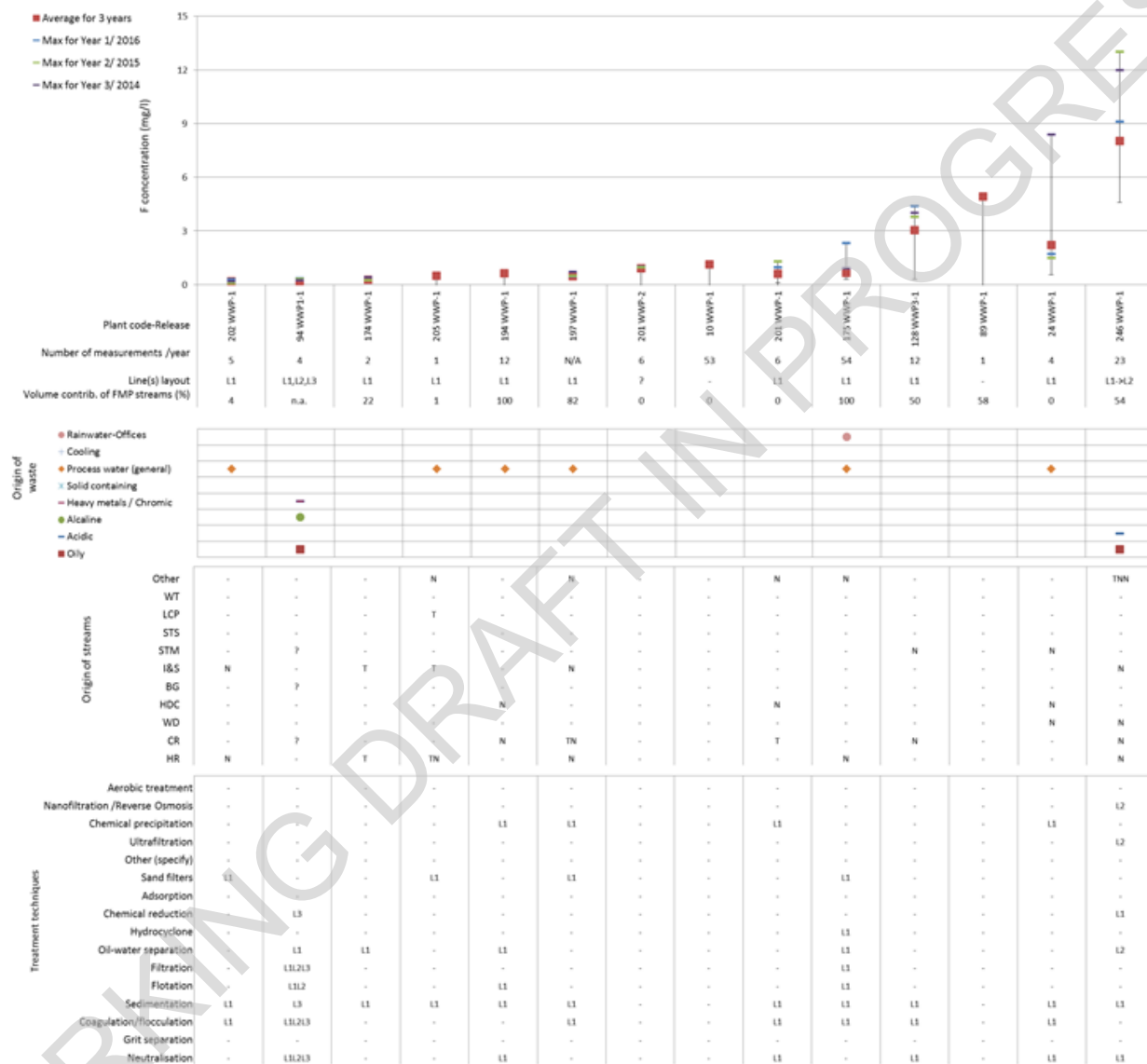


Figure 7.15: Fluoride emissions (in mg/l) for direct discharges. Source: [TWG 2018].

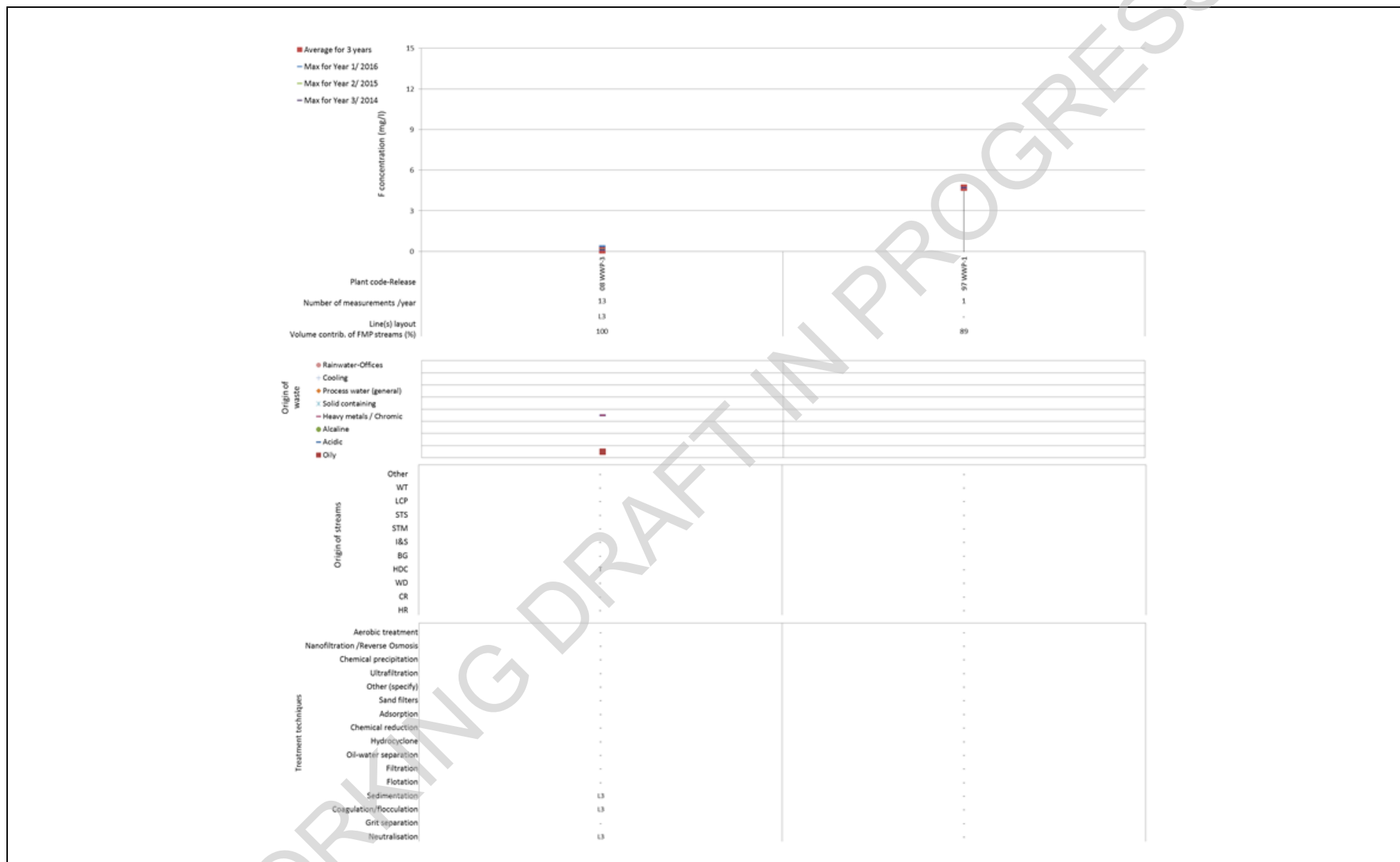


Figure 7.16: Fluoride emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

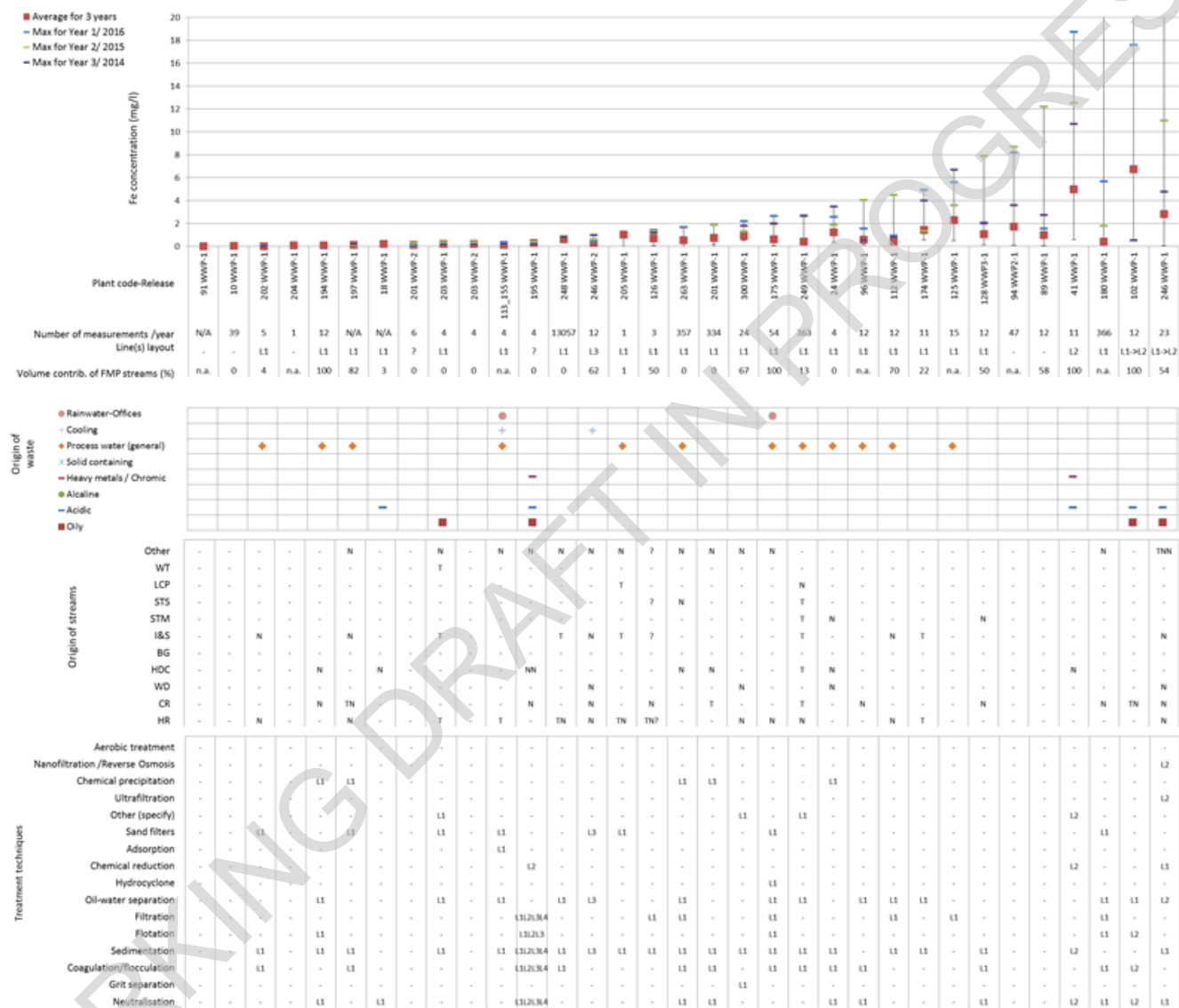


Figure 7.17: Iron emissions (in mg/l) for direct discharges. Source: [TWG 2018].



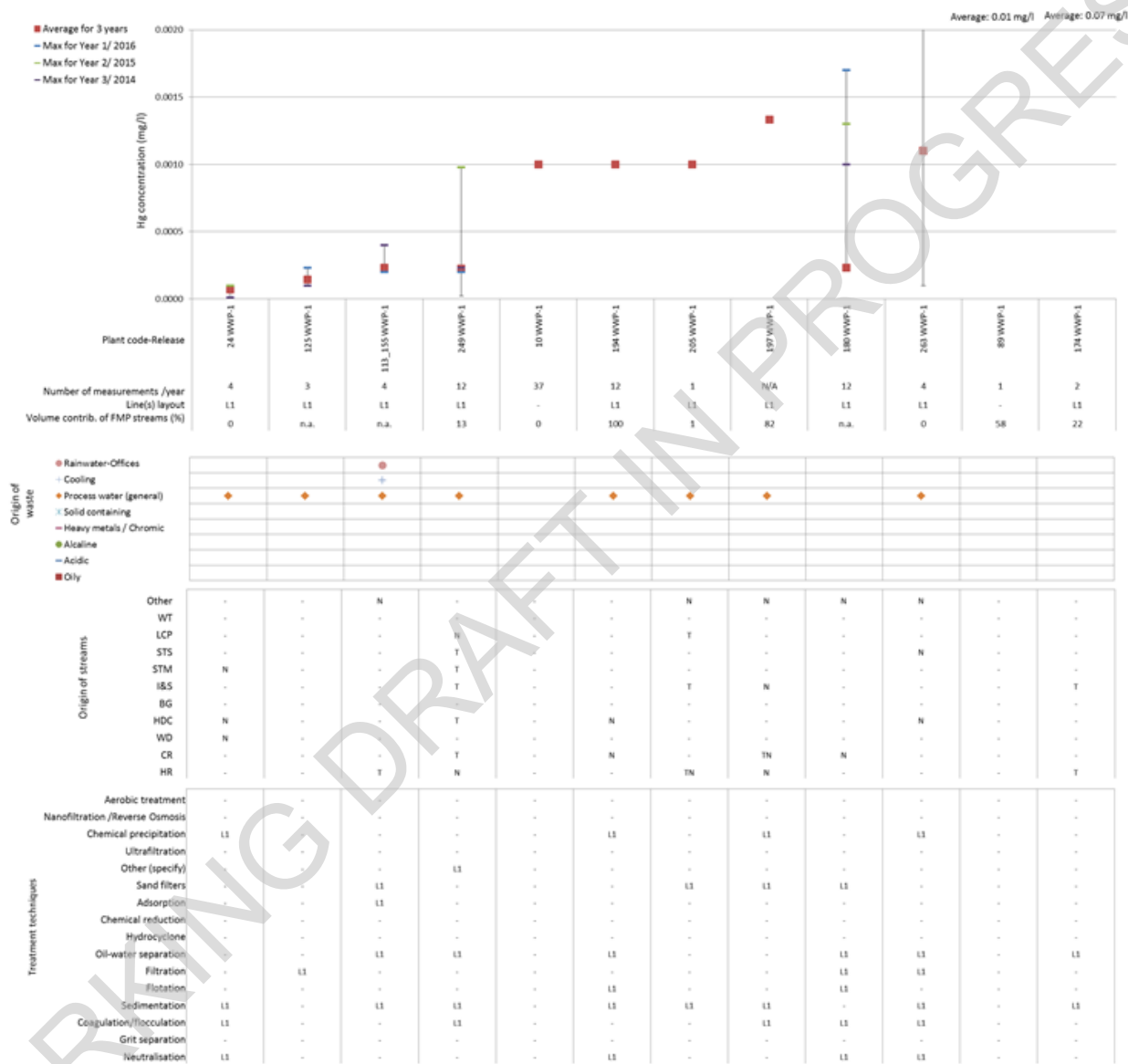


Figure 7.19: Mercury emissions (in mg/l) for direct discharges. Source: [TWG 2018].

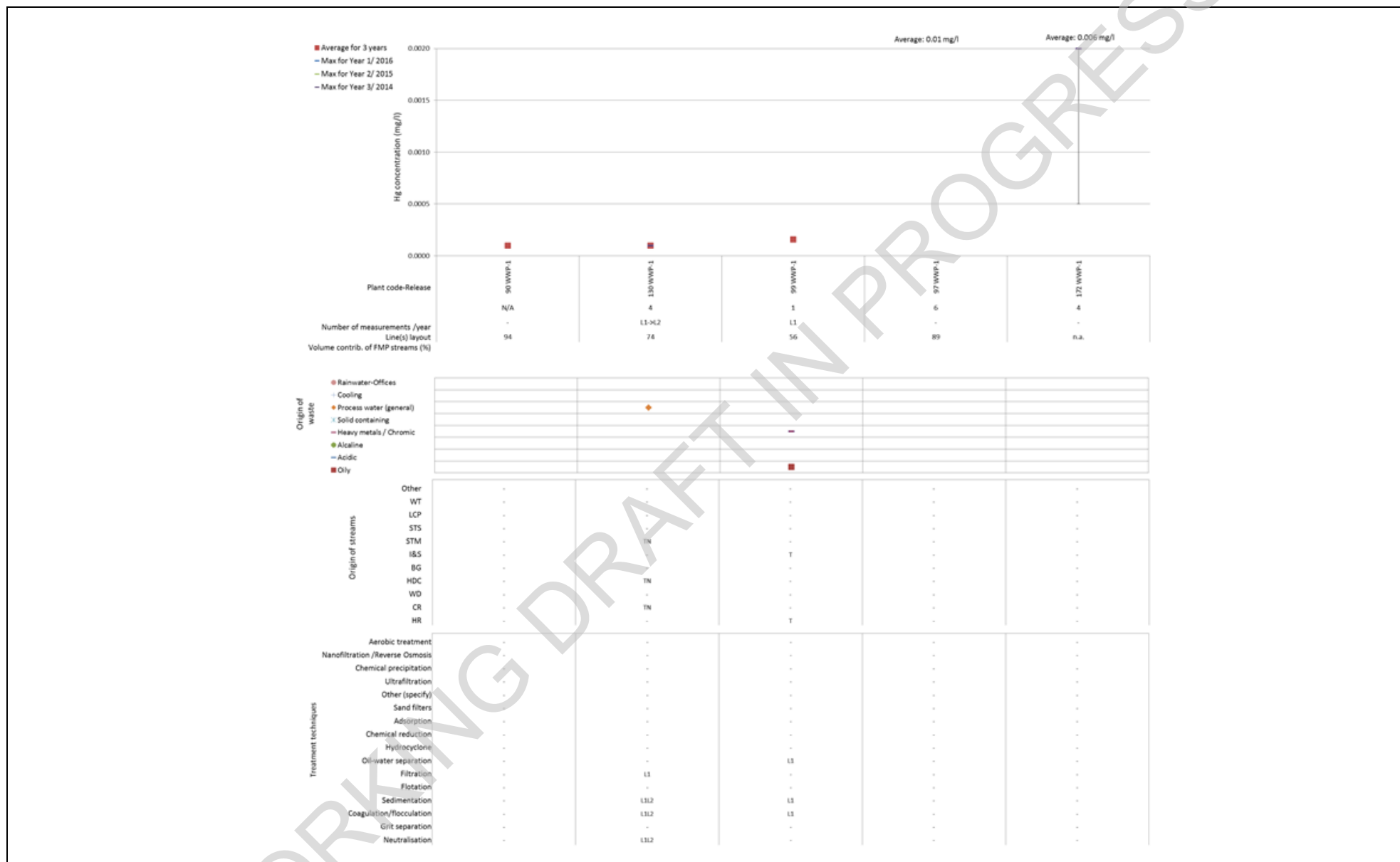


Figure 7.20: Mercury emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

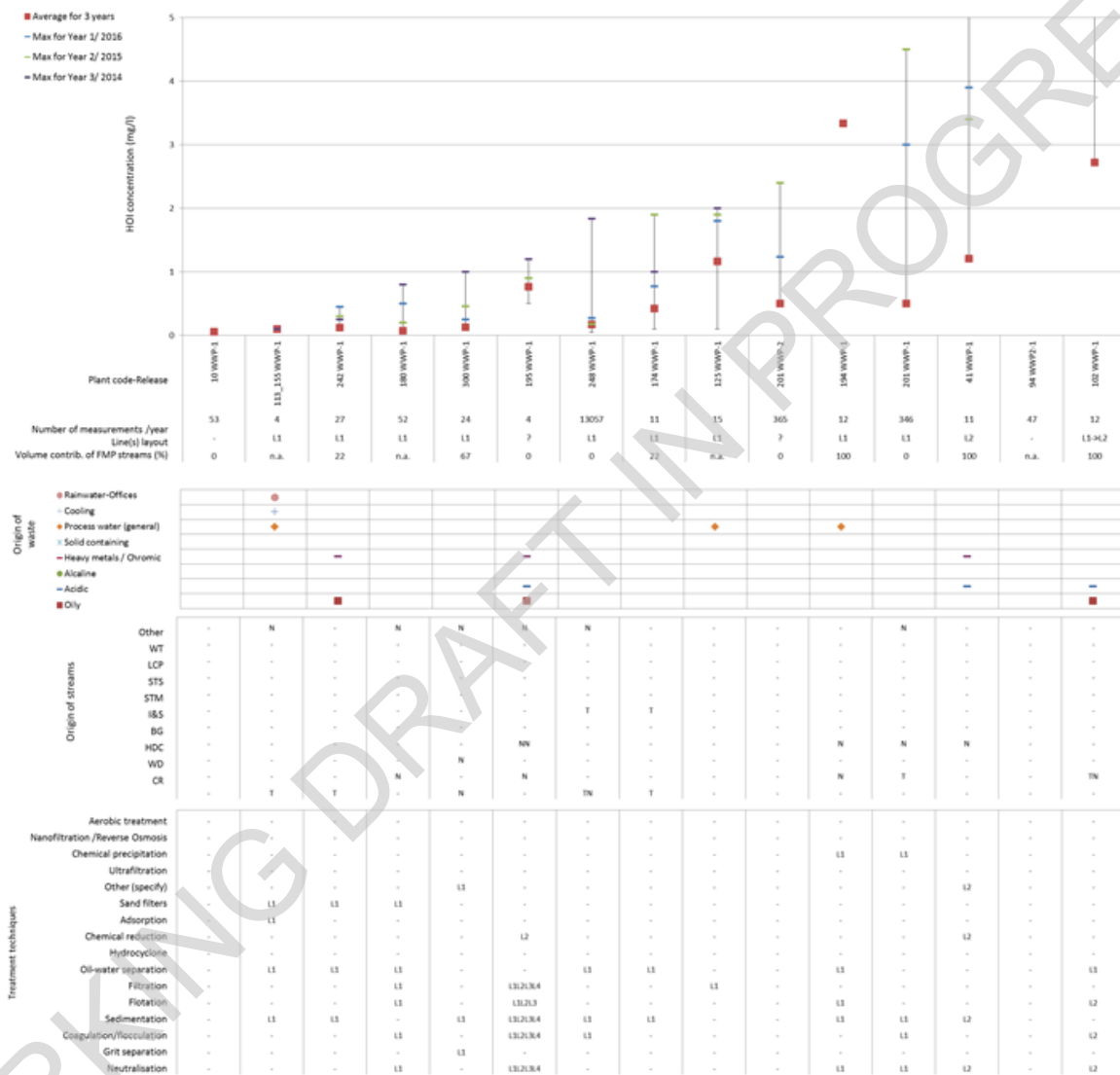


Figure 7.21: Hydrocarbon oil index emissions (in mg/l) for direct discharges. Source: [TWG 2018].

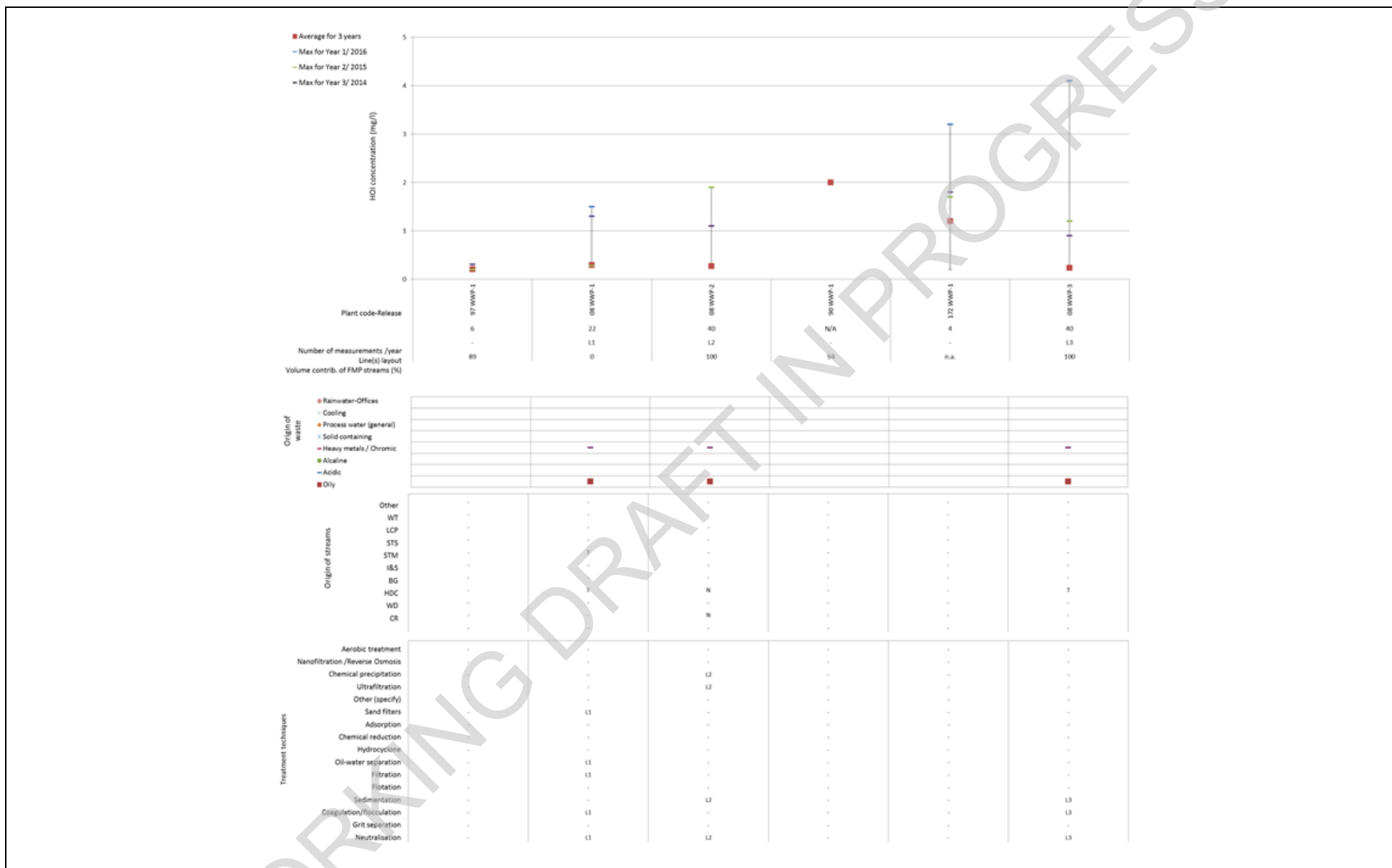


Figure 7.22: Hydrocarbon oil index emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

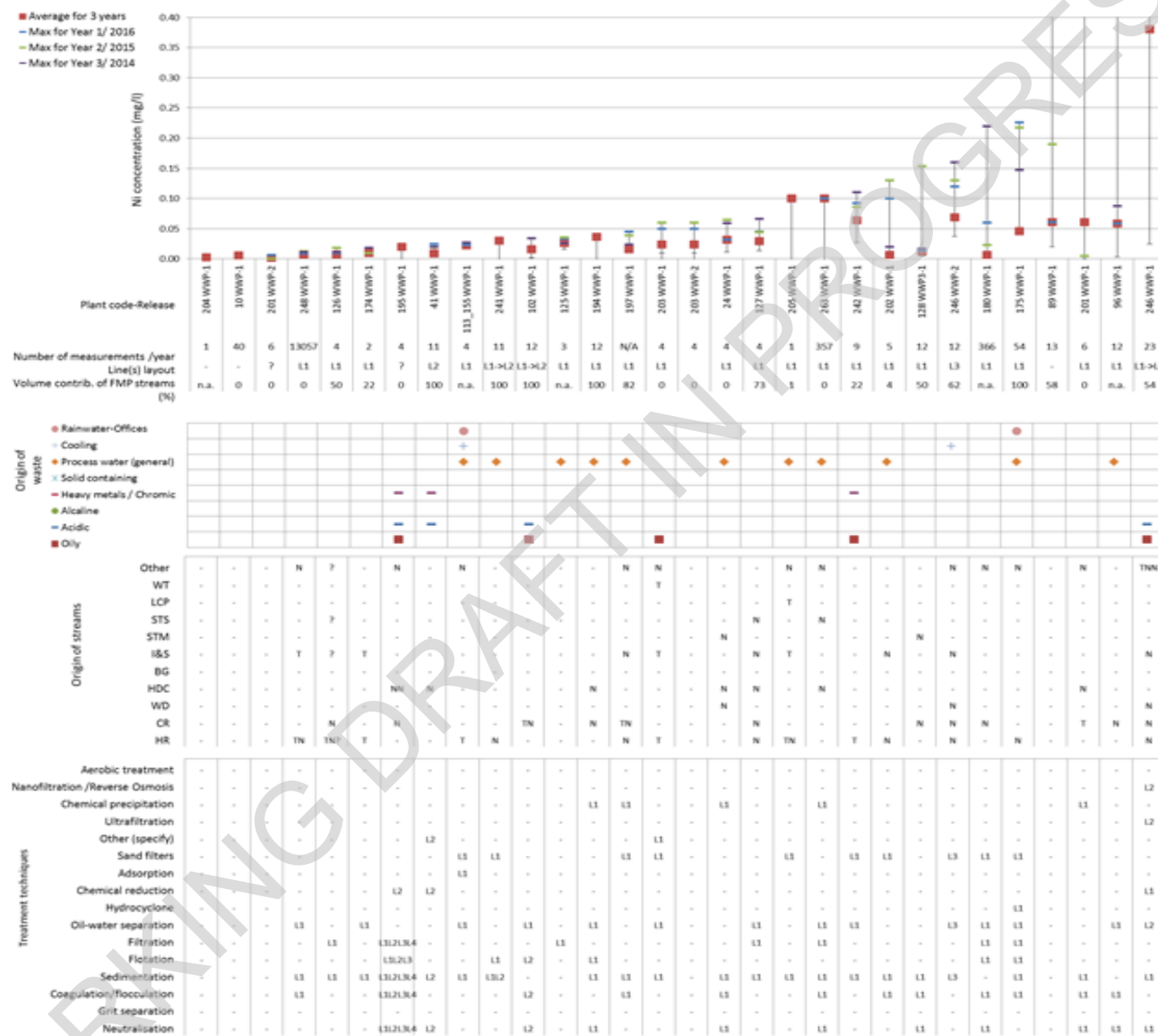


Figure 7.23: Nickel emissions (in mg/l) for direct discharges. Source: [TWG 2018].

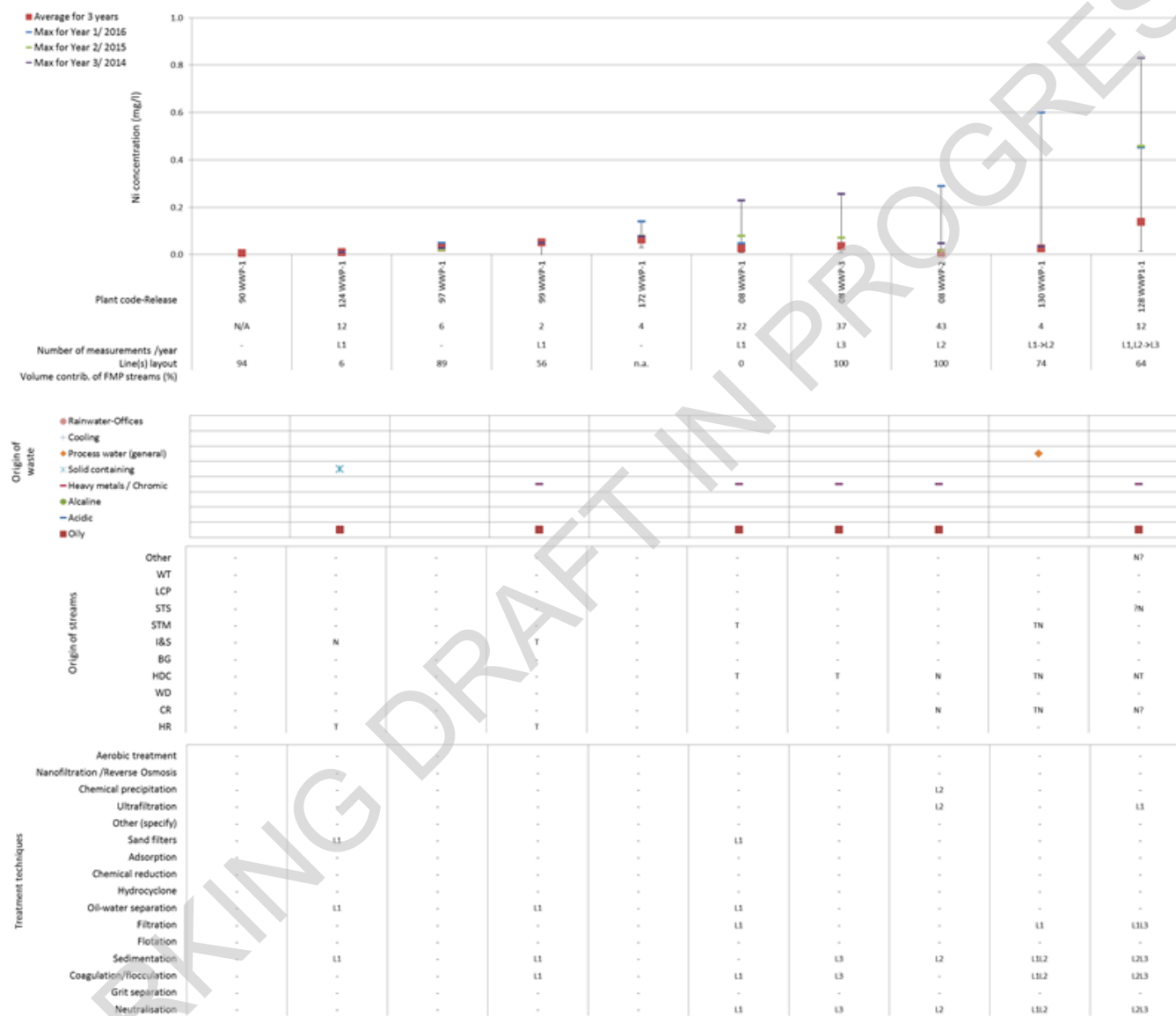


Figure 7.24: Nickel emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

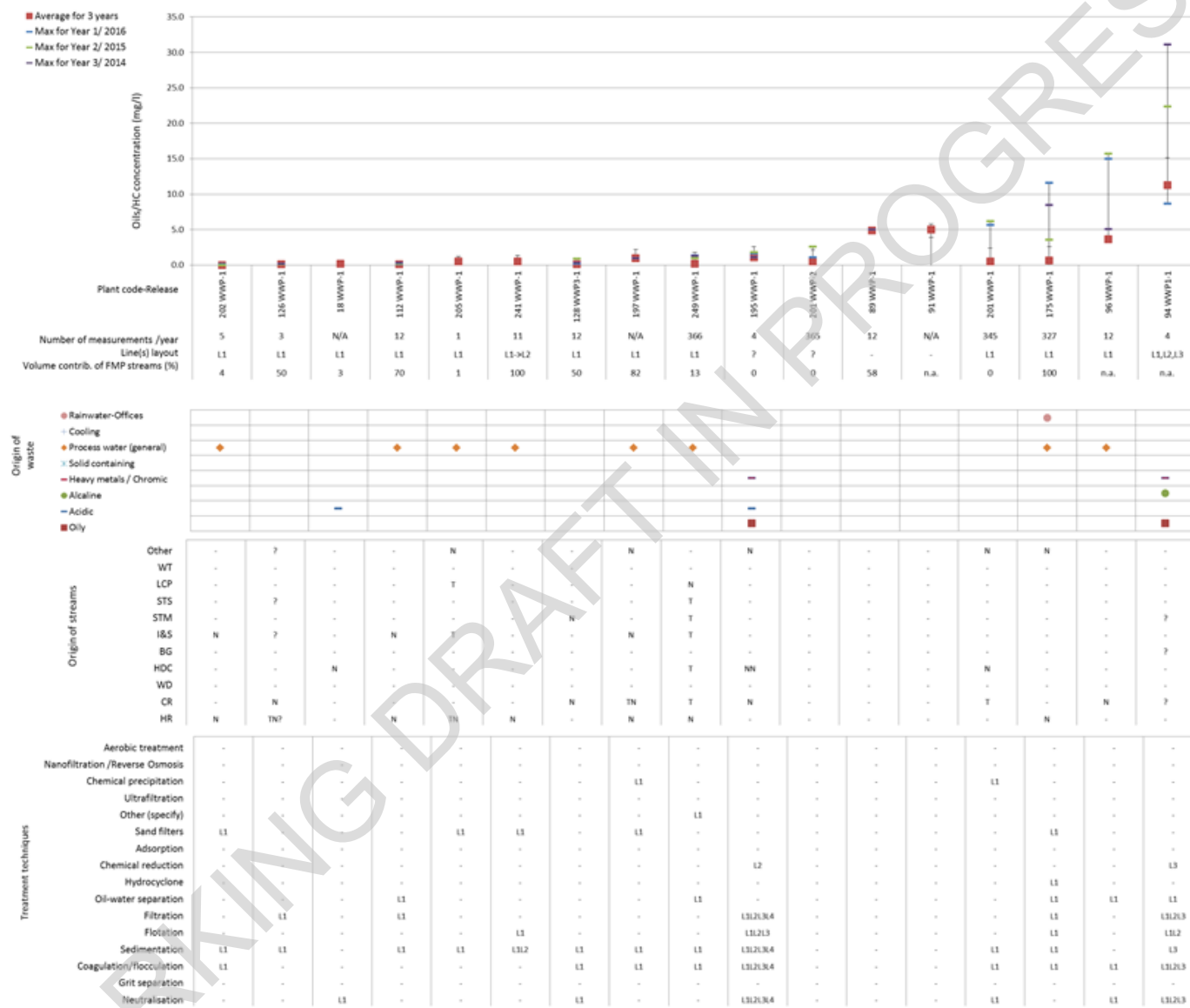


Figure 7.25: Oils emission (in mg/l) for direct discharges. Source: [TWG 2018].

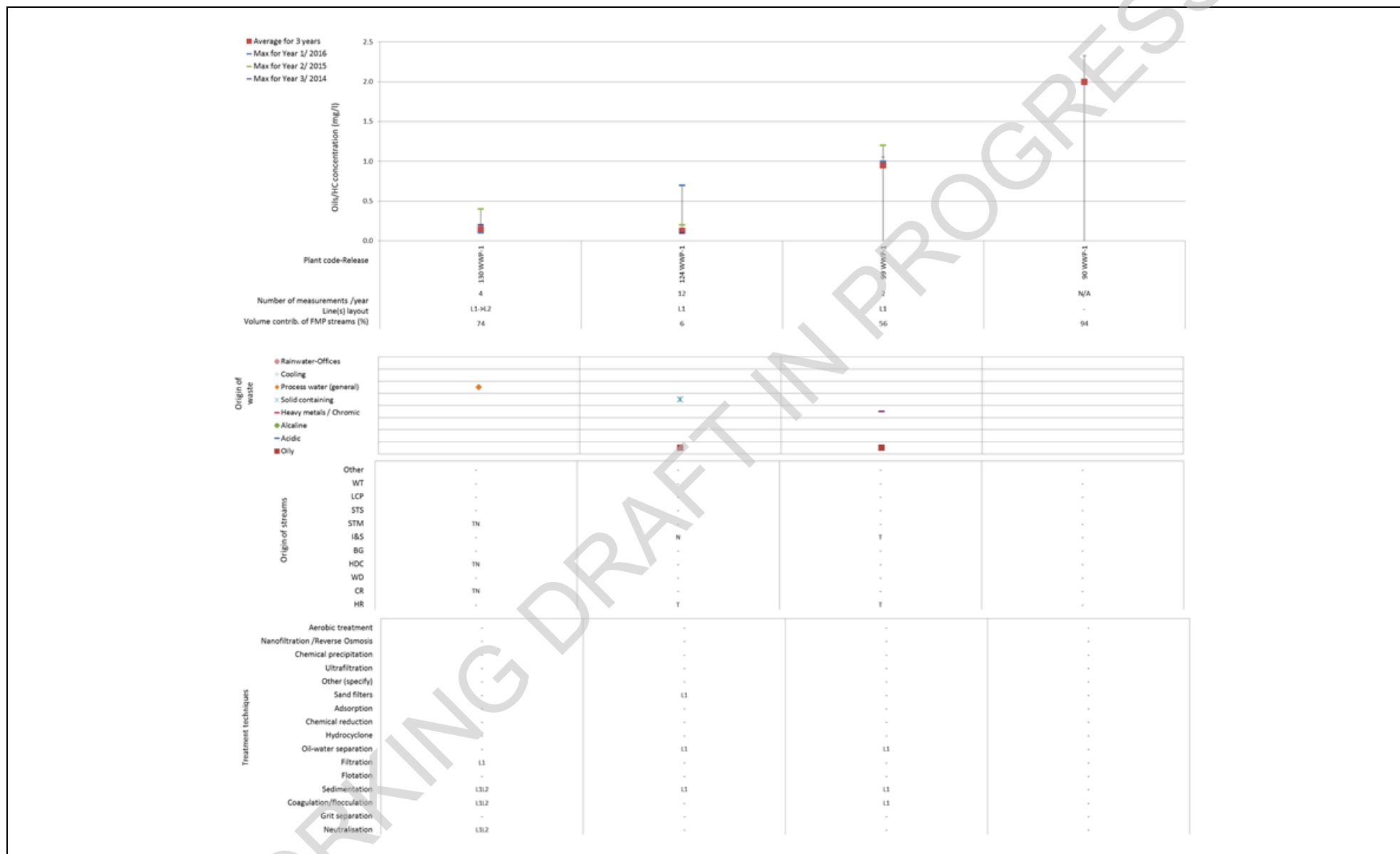


Figure 7.26: Oils emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

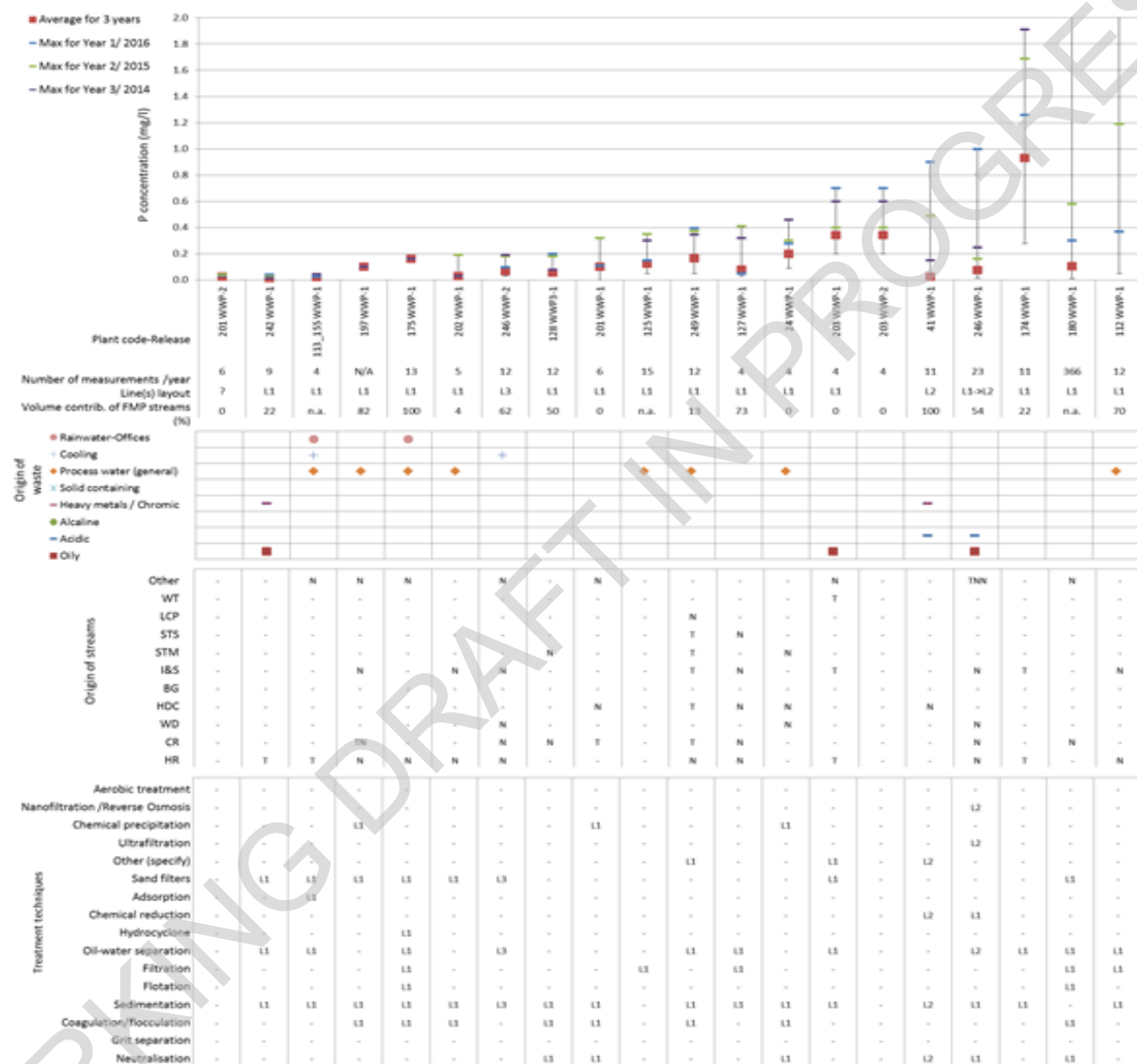


Figure 7.27: Phosphorous emissions (in mg/l) for direct discharges. Source: [TWG 2018].

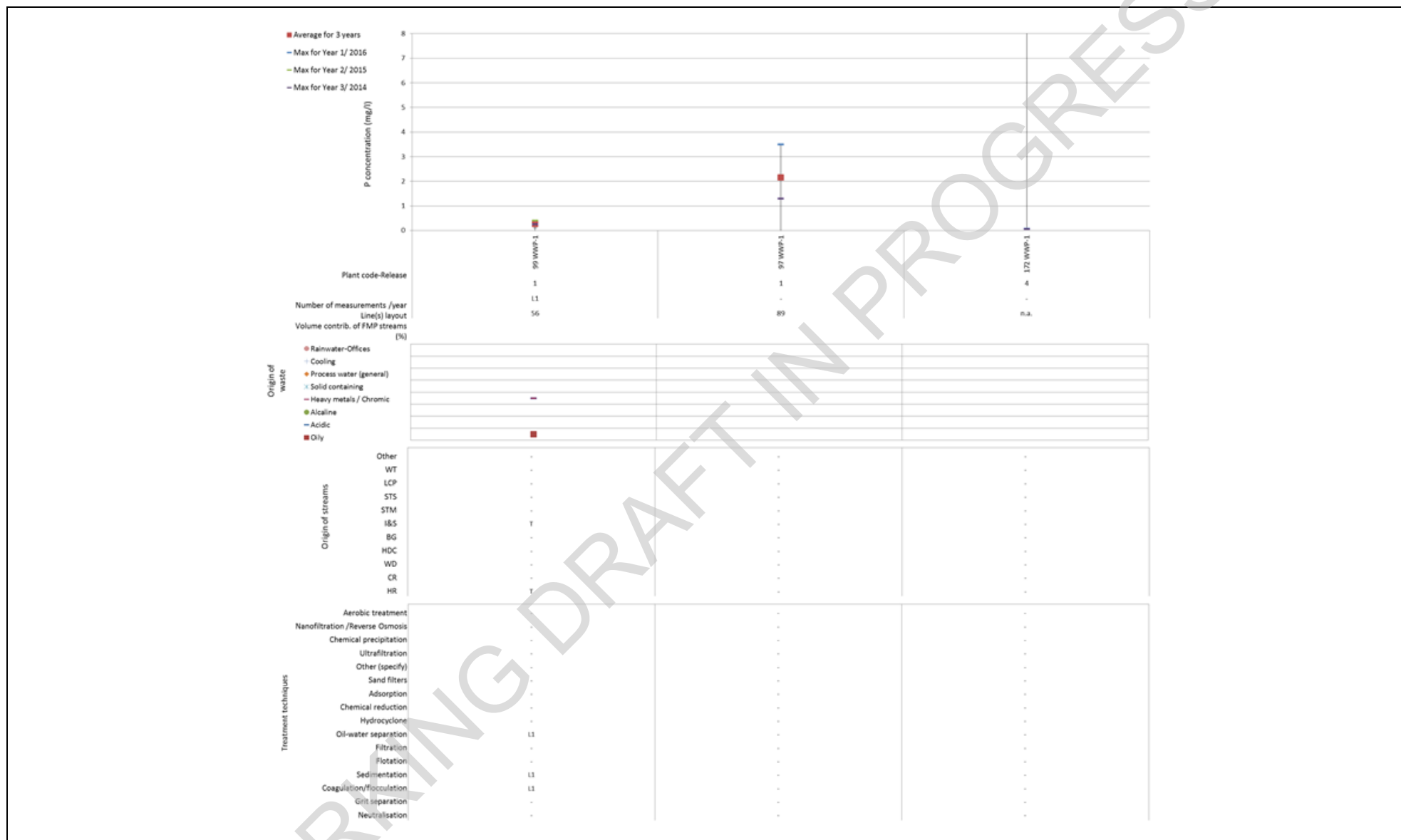


Figure 7.28: Phosphorous emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

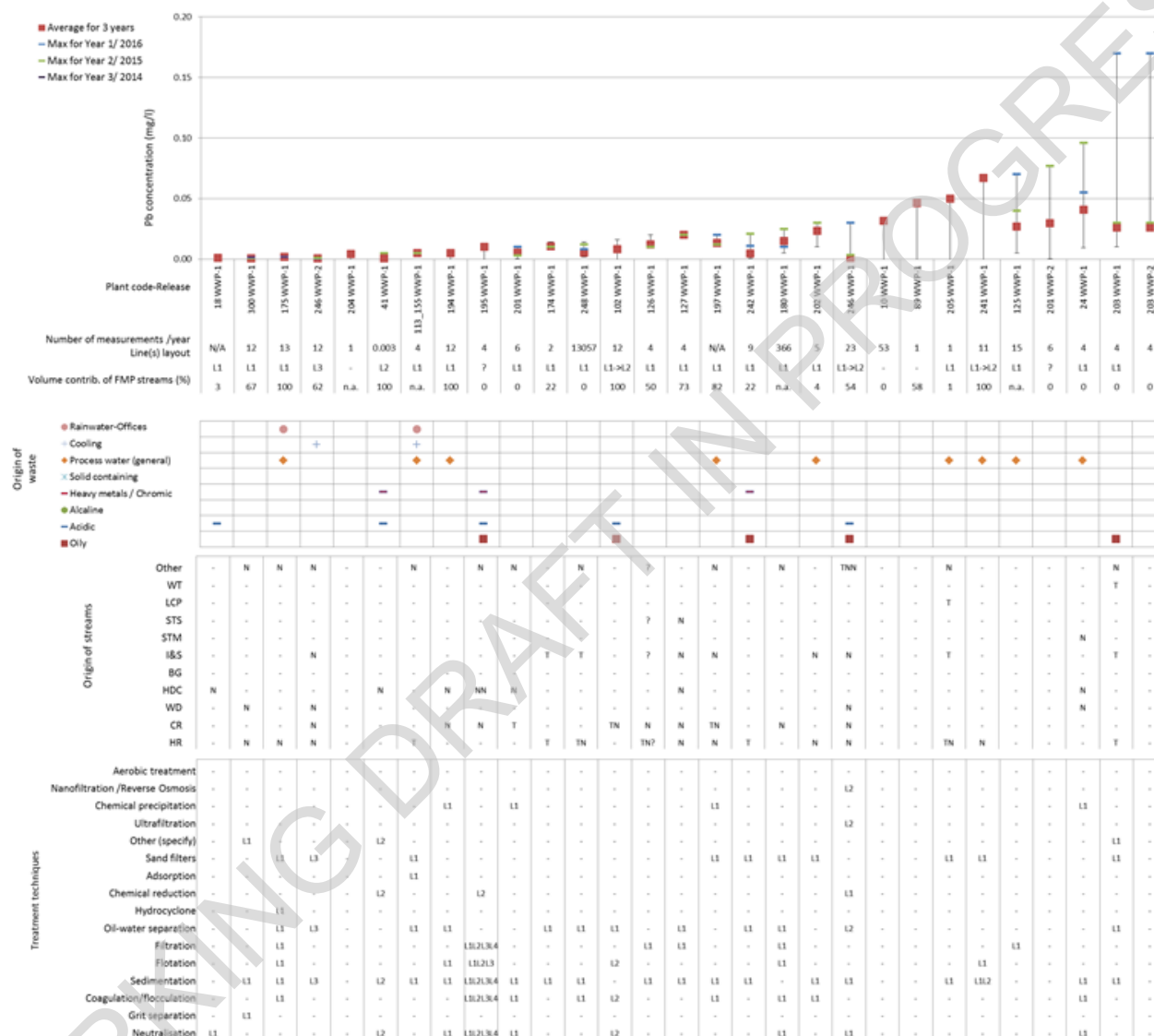


Figure 7.29: Lead emissions (in mg/l) for direct discharges. Source: [TWG 2018].

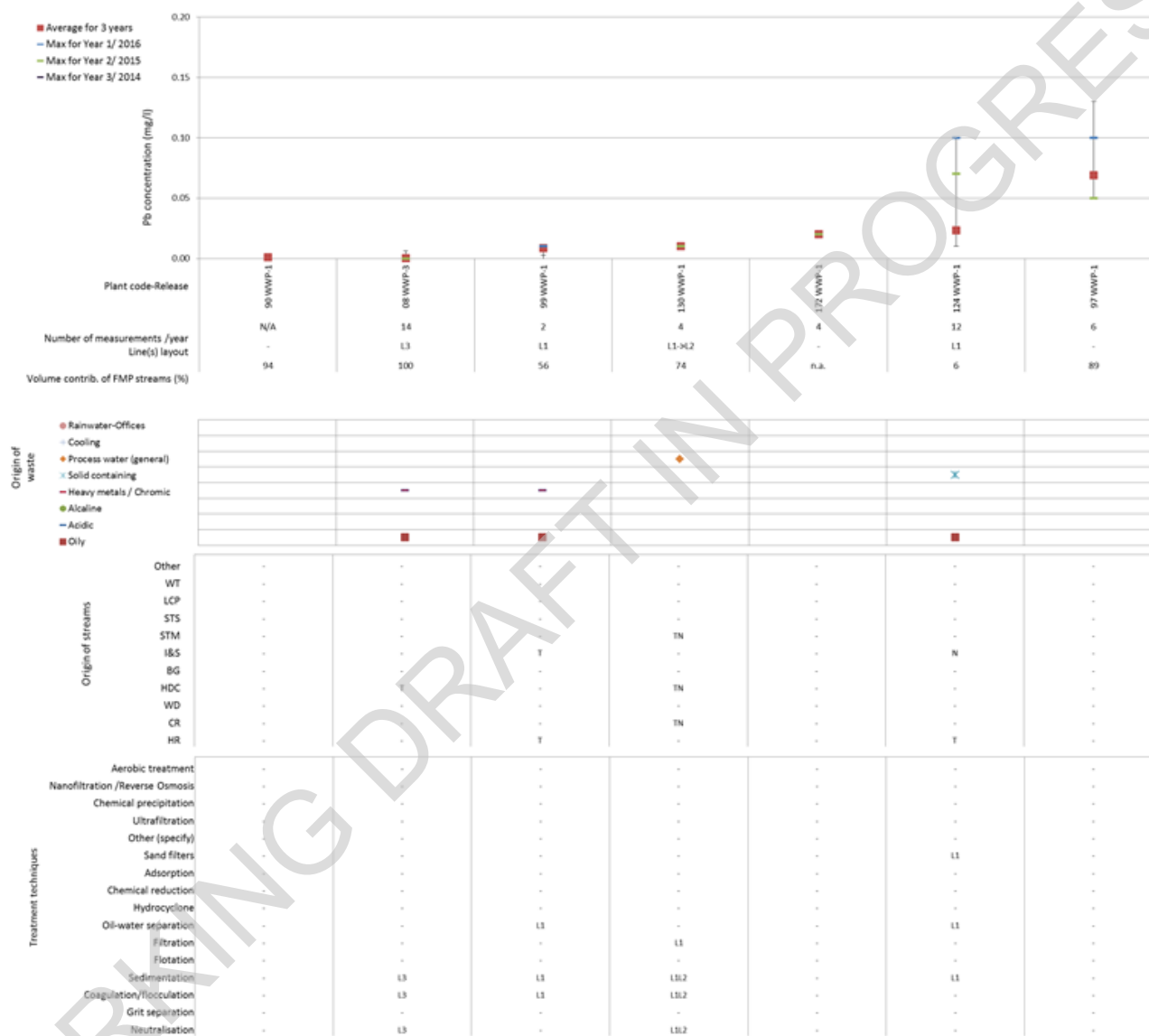


Figure 7.30: Lead emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

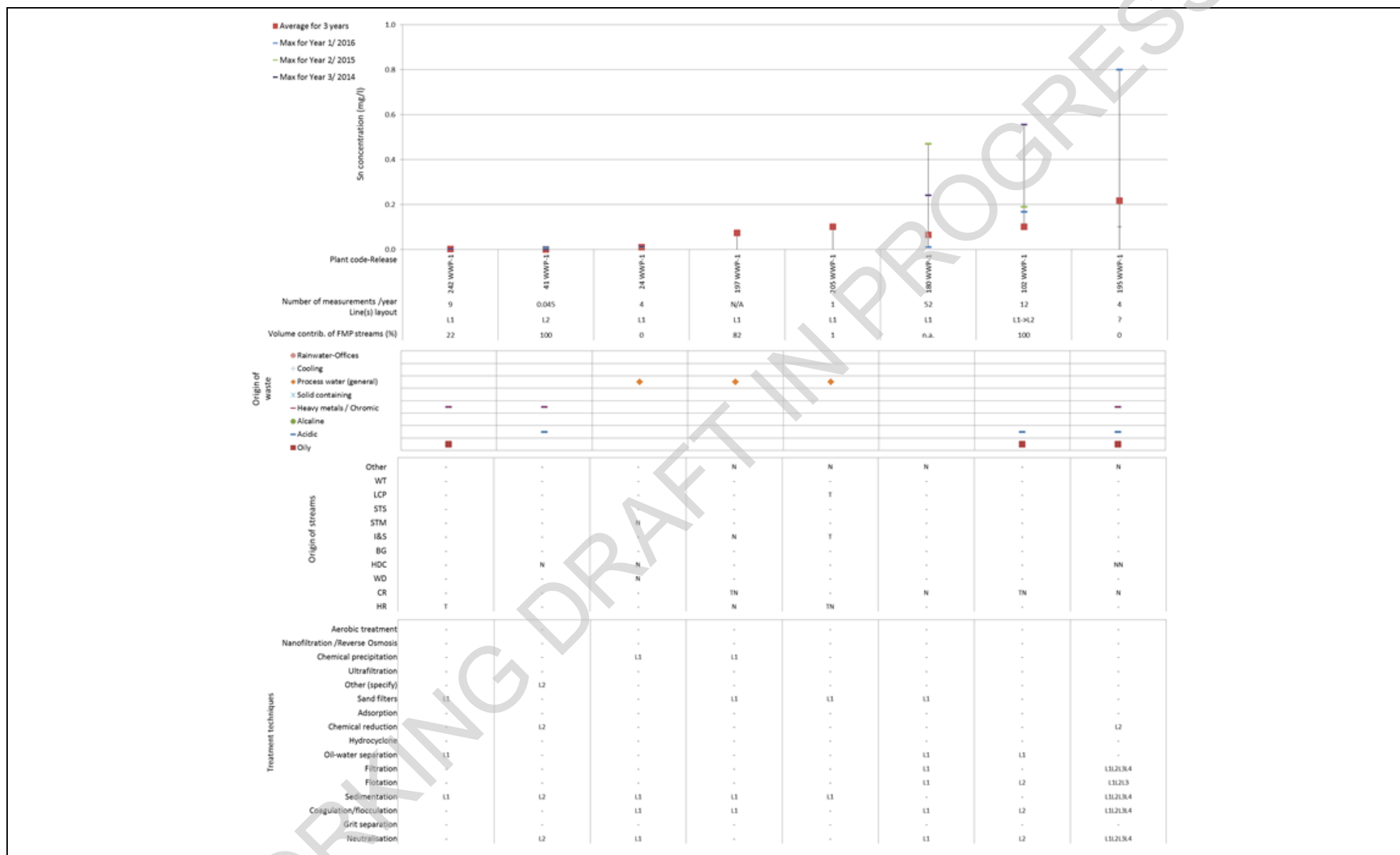


Figure 7.31: Tin emissions (in mg/l) for direct discharges. Source: [TWG 2018].

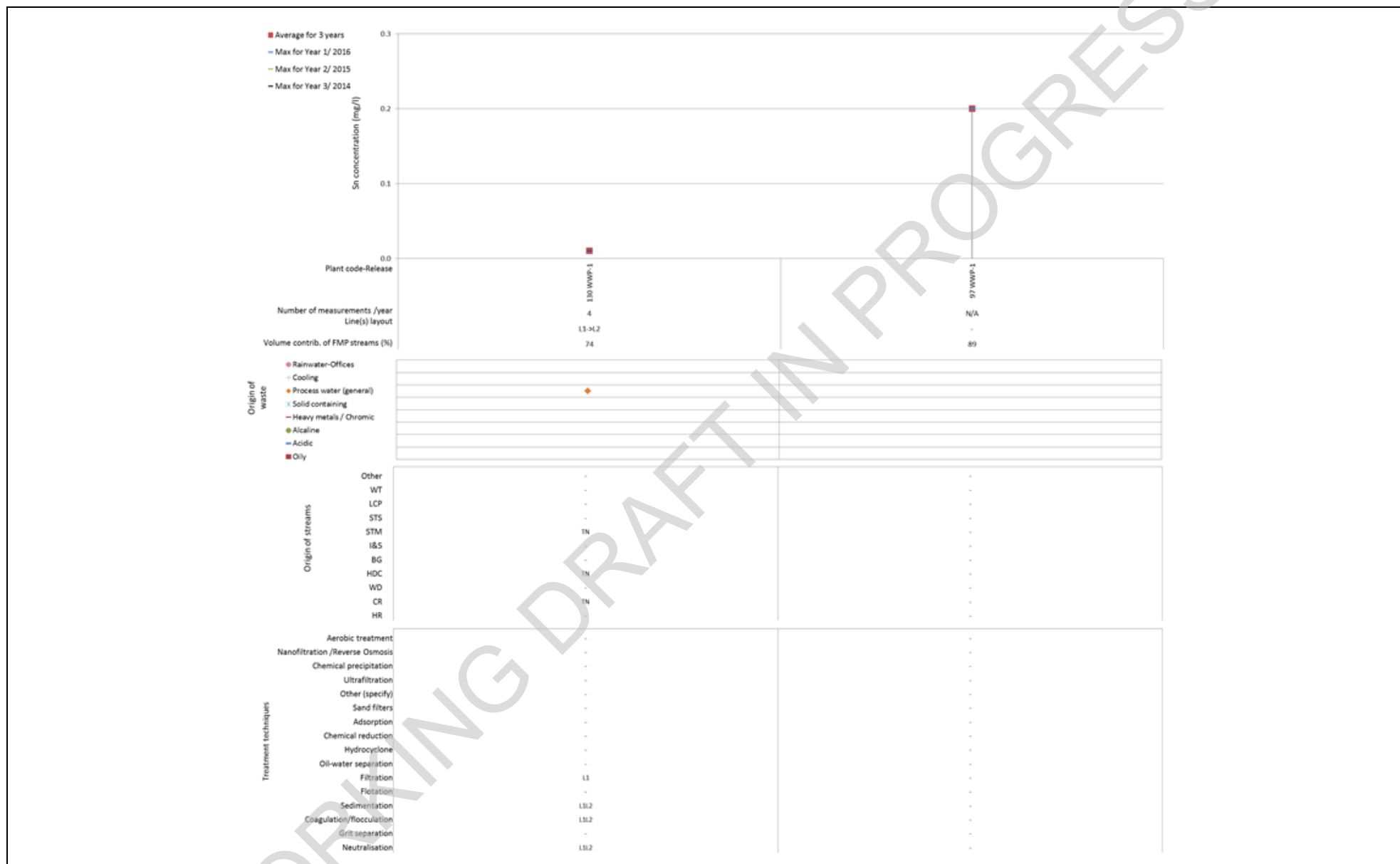


Figure 7.32: Tin emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

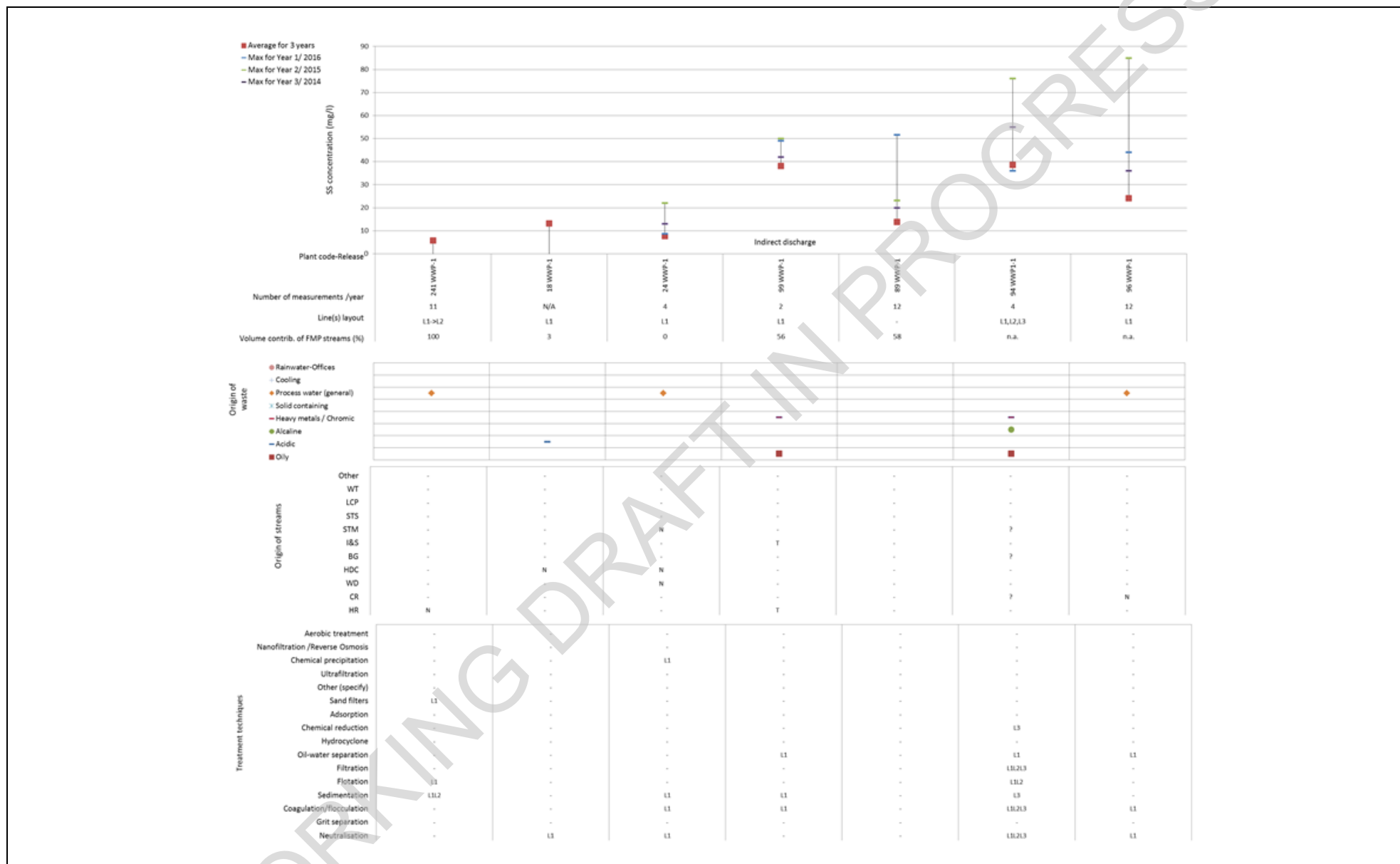


Figure 7.33: Suspended solids emissions (in mg/l) for direct and indirect discharges. Source: [TWG 2018].

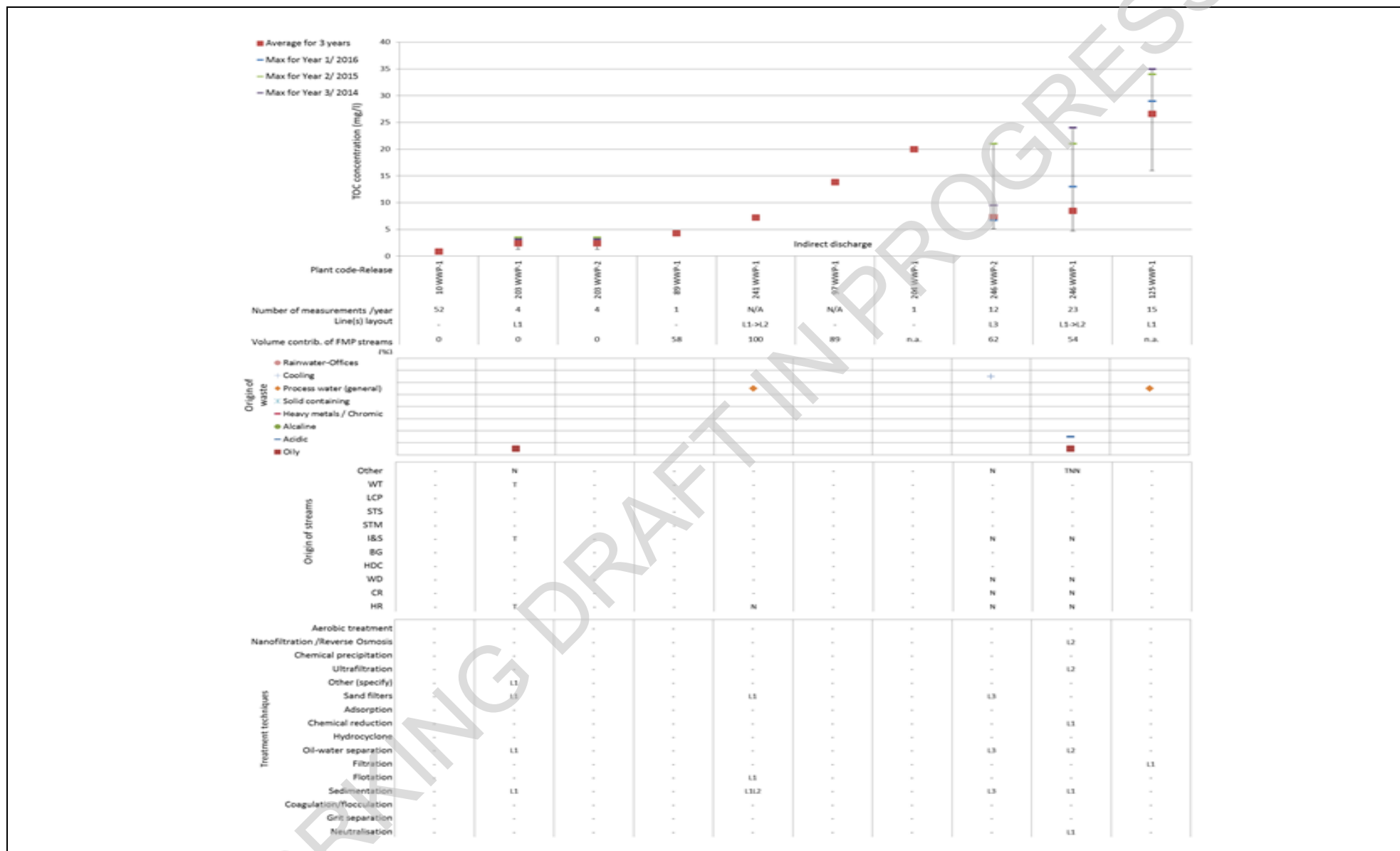


Figure 7.34: TOC emissions (in mg/l) for direct and indirect discharges. Source: [TWG 2018].

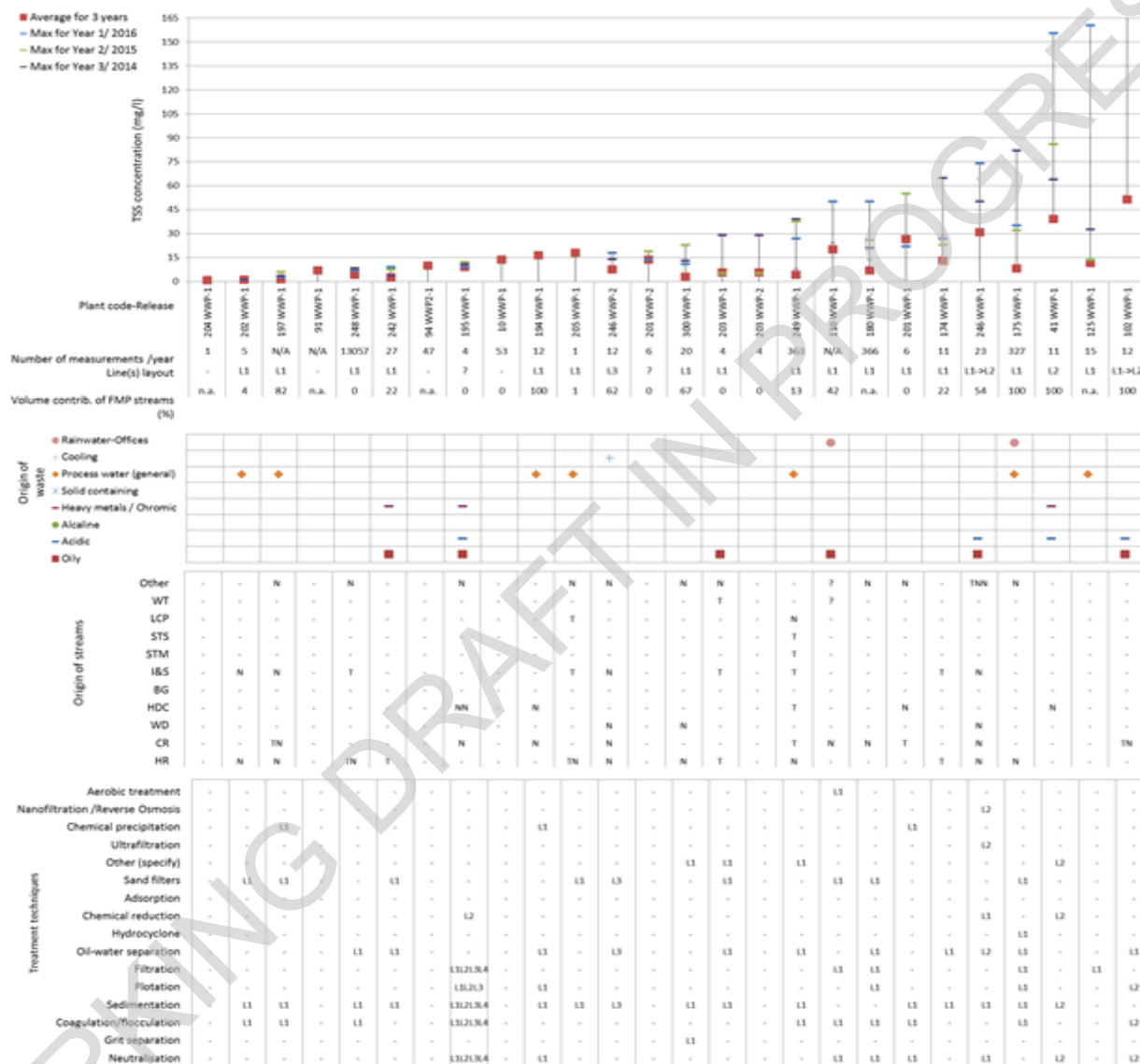


Figure 7.35: Total suspended solids emissions (in mg/l) for direct discharges. Source: [TWG 2018].

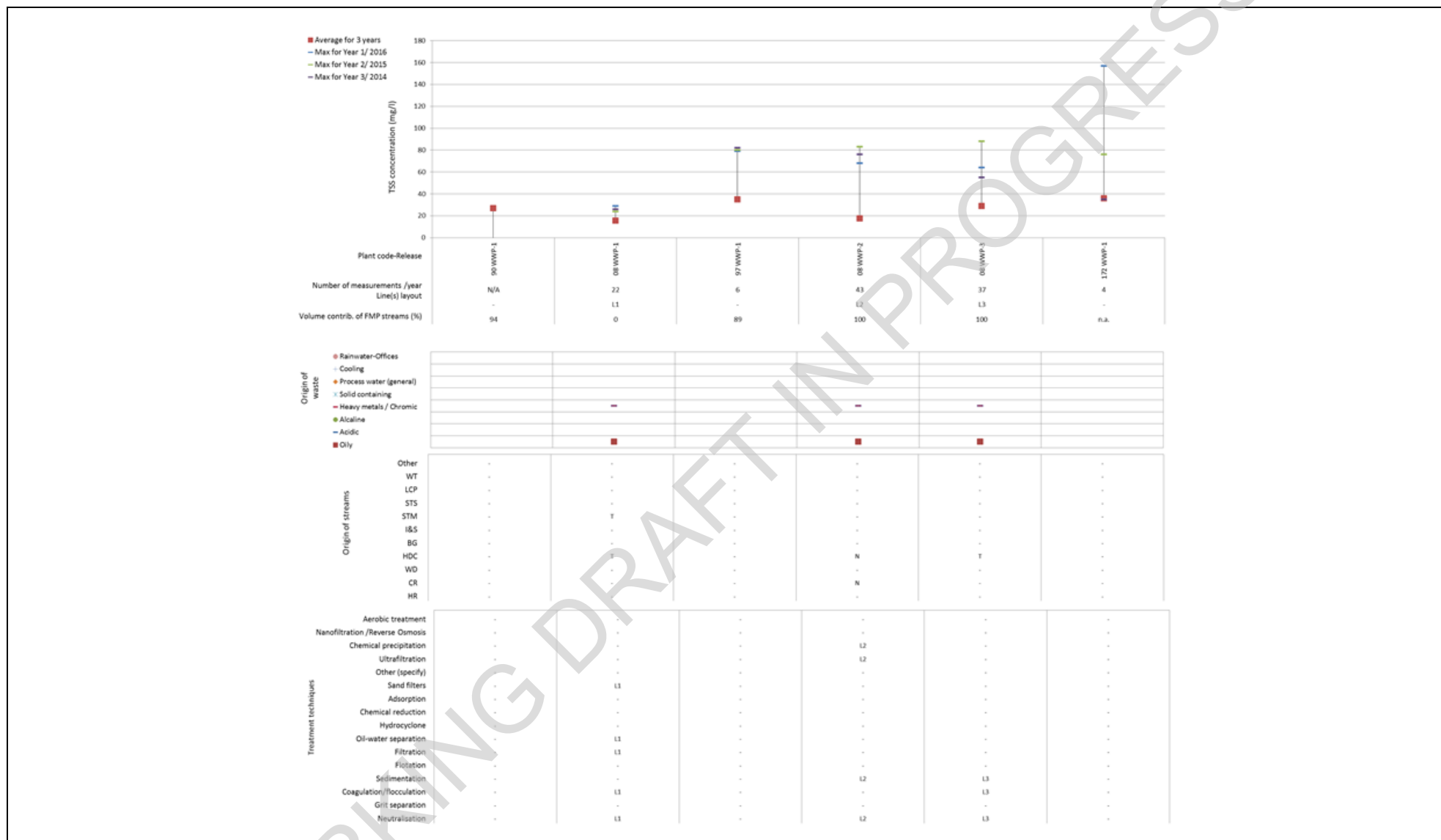


Figure 7.36: Total suspended solids emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

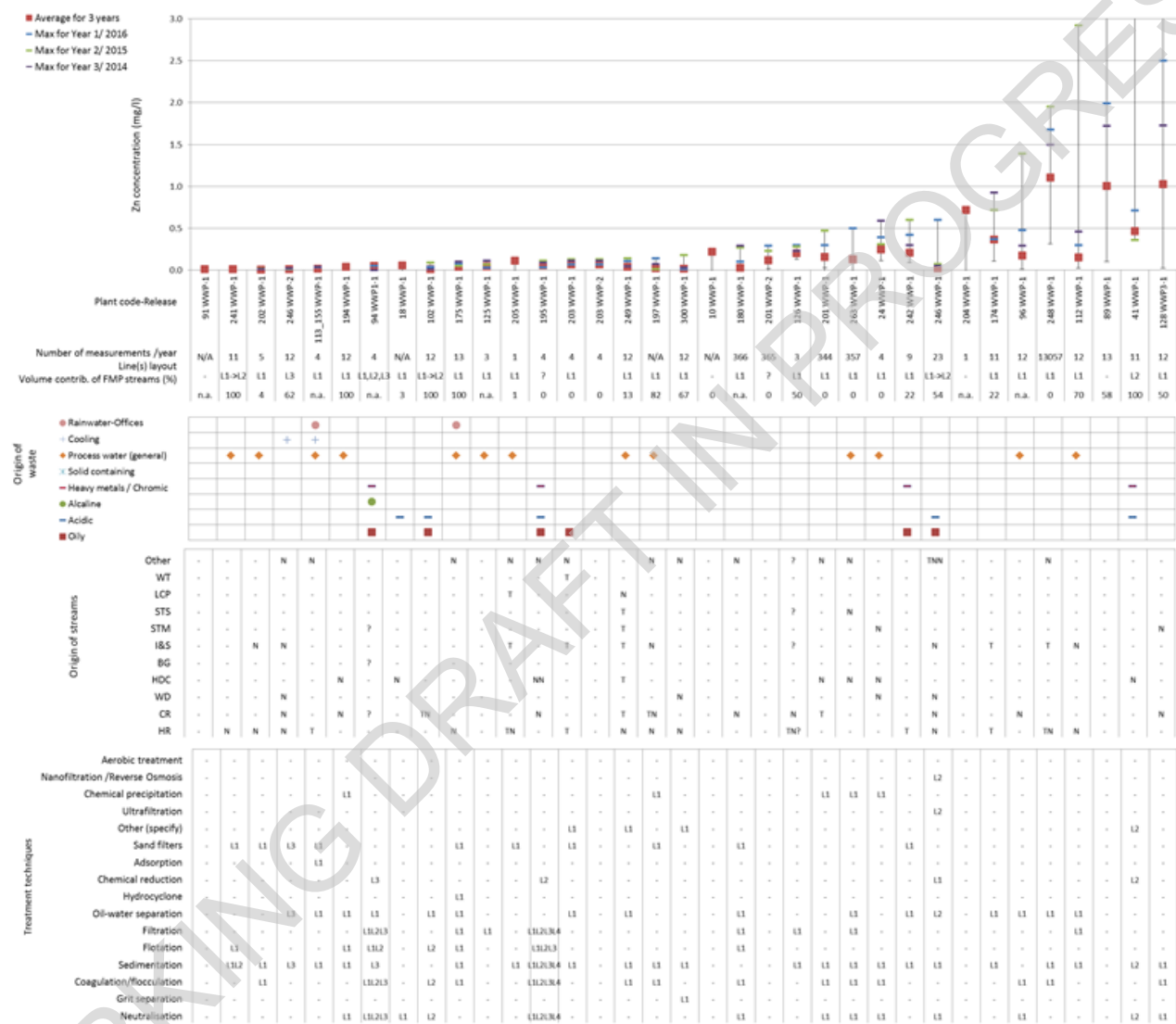


Figure 7.37: Zinc emissions (in mg/l) for direct discharges. Source: [TWG 2018].

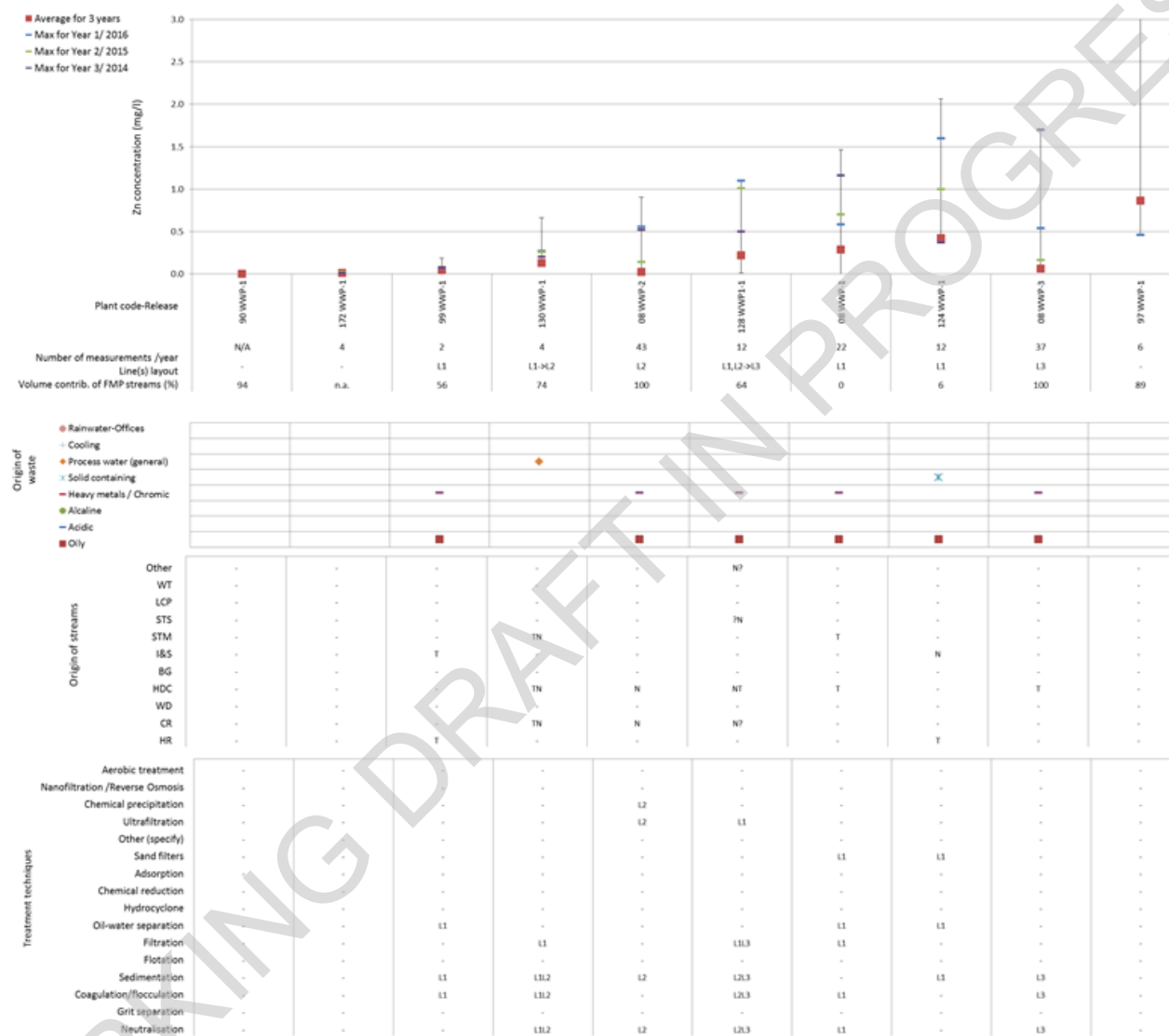


Figure 7.38: Zinc emissions (in mg/l) for indirect discharges. Source: [TWG 2018].

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8 TECHNIQUES TO CONSIDER IN THE DETERMINATION OF BAT IN MORE THAN ONE SECTOR

In order to avoid repetition in describing certain techniques considered in the determination of BAT, this section contains techniques which are used in several sectors. In this section, a general technical description of the techniques is provided. Sector-specific aspects of the techniques (main achieved environmental benefits, applicability, cross-media effects, reference plants, operational data, economics, driving force for implementation and reference literature), if any, are sometimes further covered in the relevant Chapters 2 to 6 of this document, in which cross-references to Chapter 8 are included where relevant.

TWG, Section D.3 from the old BREF "Oil emulsions" has been moved and the updated information can now be found in Chapter 8 (Section 8.9.14).

TWG, Section D.4.1 from the old BREF "Implementation of degreasing bath cascades" has been moved and the updated information can now be found in Chapter 8 (Section 8.6.1.5)

TWG, Section D.4.1 from the old BREF "Implementation of degreasing bath cascades" has been moved and the updated information can now be found in Chapter 8 (Section 8.6.1.5).

TWG, Section D.4.2 from the old BREF "Hot water pre-degreasing" has been moved and the updated information can now be found in Chapter 8 (Section 3.4.3.2).

TWG, Section D.4.3 from the old BREF "Maintenance and cleaning of degreasing baths" has been moved and the updated information can now be found in Chapter 8 (Section 8.6.1.6).

TWG, Section D.4.4 from the old BREF "Treatment of spent degreasing bath" has been deleted as it is covered by the generic techniques for treatment of emulsions in Chapter 8 (Section 8.9.14).

TWG, Section D.4.5 from the old BREF "Treatment of alkaline wastewater" has been deleted as it is covered by the generic technique about neutralisation in Chapter 8 (Section 8.9.10).

TWG, Section D.4.6 from the old BREF "degreasing fume collection and treatment" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.3.1).

TWG, Section D.5.1 from the old BREF "Open pickling bath operation" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.4.1)

TWG, Section D.5.2 from the old BREF "Emission control / Collection from pickling" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.4.2 and 8.8.4.3)

TWG, Section D.5.3 from the old BREF "Abatement techniques for acid gases, vapour and aerosols from pickling (and acid regeneration)" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.4.4)

TWG, Section D.5.4 from the old BREF "Hydrochloric acid pickling" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.4.2 and 8.8.4.3)

TWG, Section D.5.5 from the old BREF "Sulphuric acid pickling" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.4.2 and 8.8.4.3)

TWG, Section D.5.6 from the old BREF "Electrolytic pickling" has been deleted as it contained no information.

TWG, Section D.5.7 from the old BREF "Mixed acid pickling" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.4.4).

TWG, Section D.5.8.1 from the old BREF "NOX suppression by injection of hydrogen peroxide (or urea)" has been moved and the updated information can now be found in 8 (Section 8.8.5.2)

TWG, Section D.5.8.2 from the old BREF "Nitric acid-free stainless steel pickling" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.5.1)

TWG, Section D.5.8.3 from the old BREF "Absorptive scrubbing" has been moved and the updated information can now be found in 8 (Section 8.8.5.3)

TWG, Section D.5.8.4 from the old BREF "SCR" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.5.4)

TWG, Section D.5.8.5 from the old BREF "SNCR" has been deleted as it contained no information.

TWG, Section D.5.8.6 from the old BREF "SCR" has been moved and the updated information can now be found in Chapter 8 (Section 8.8.1.4)

TWG, Section D.5.9 from the old BREF "Free acid reclamation" has been moved and the updated information can now be found in Chapter 8 (Section 8.6.5)

TWG, Section D.5.10 from the old BREF "Acid regeneration" has been moved and the updated information can now be found in Chapter 8 (Section 8.6.5)

TWG, Section D.5.11 from the old BREF "treatment of acidic waste / wastewater has been move as it is now covered in Chapter 8 (Section 8.9)

TWG, Section D.6 from the old BREF "Heating of process liquors (acid, emulsions, ...)" has been moved and the updated information can now be found in Chapter 8 (Section 8.6.2.1).

TWG, Section D.7 from the old BREF "Fluxing" has been moved and the updated information can now be found in Chapter 8 (Section 8.6.3.3).

TWG, Section D.8 from the old BREF "Rinsing" has been moved and the updated information can now be found in Chapter 8 (Section 8.7.6).

TWG, Section D.9.1 from the old BREF "Treatment of oil- and scale-bearing process water" has been moved and the updated information can now be found in Chapter 8 (Section 8.7.8).

TWG, Section D.9.2 from the old BREF "Cooling systems and cooling water treatment" has been moved and the updated information can now be found in Chapter 8 (Section 8.7.9).

8.1 Environmental management techniques

8.1.1 Environmental management system (EMS)

Description

A formal system to demonstrate compliance with environmental objectives.

Technical description

The Industrial Emissions 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 8.1).

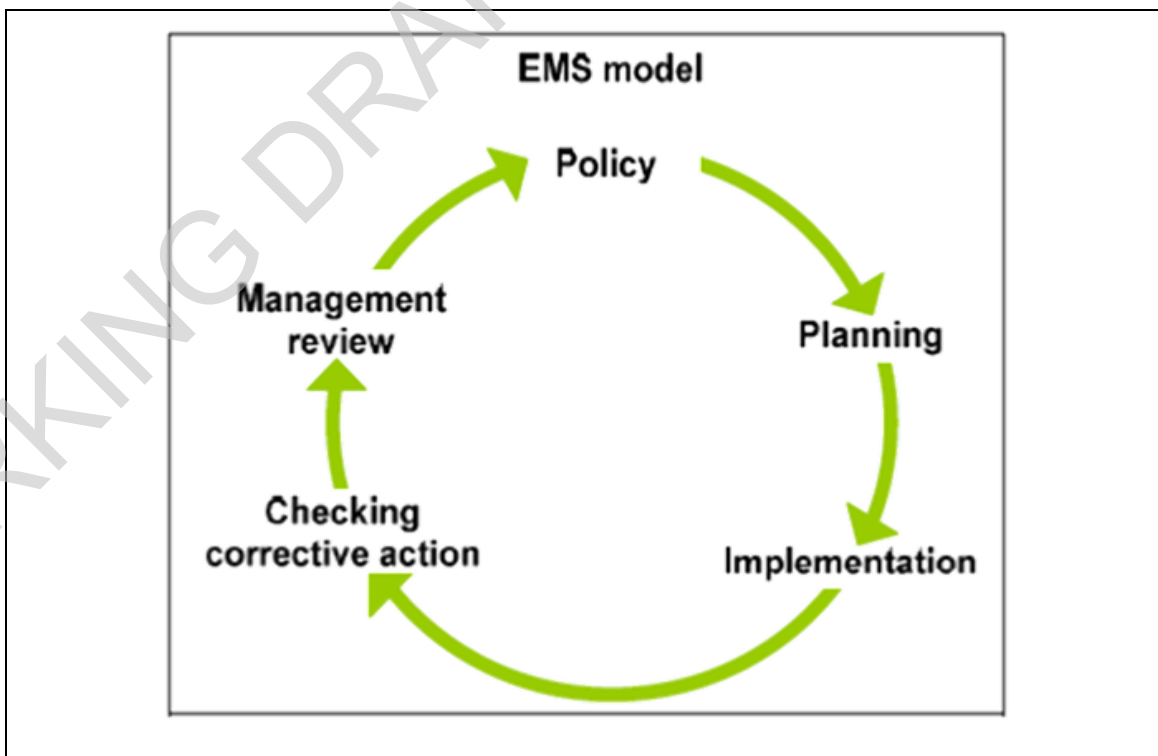


Figure 8.1: Continuous improvement in an EMS model

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 14001:2015, 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.

Specifically for the ferrous metals processing sector, the following features are included in the EMS:

- xxi. a plan for the prevention and control of leaks and spillages (see Section 8.3.3);
- xxii. an OTNOC management plan (see 8.3.5);
- xxiii. an energy efficiency plan (see Section 8.5.1);
- xxiv. a water management plan (see Section 8.7.1);
- xxv. a residues management plan (see Section 8.11.1);
- xxvi. a noise and vibrations management plan (see Section 8.10.1).

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.

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 accurately determine 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.

Driving forces 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 number of installations throughout the EU.

Reference literature

[251, EU 2009] [252, COM 2010] [253, COM 2015] [254, CEN 2015] [250, IAF 2010]

8.1.2 Stream inventory**Description**

The compilation of relevant basic data on the composition and quantity of waste water and waste gas streams – each one individually – is done in a stream inventory (register). The emitted streams are listed respective to their source (i.e. process) from which they originate. This is a key element in assessing their degree of contamination and the nature of the contaminants, as well as the possibilities of reduction at the source.

Technical description

A stream inventory (register) addresses the following aspects, if relevant to the particular local conditions:

- (i) information about the characteristics of the waste to be treated and the waste treatment processes, 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 at source including their performances;
- (ii) information about the characteristics of the waste water streams, such as:
 - (a) average values and variability of flow, pH, temperature, and conductivity;
 - (b) average concentration and load values of relevant substances and their variability (e.g. total suspended solids, COD/TOC, hydrocarbon index, phosphorus, metals, fluorides);
- (iii) information about the characteristics of the waste gas streams, such as:
 - (a) average values and variability of flow and temperature;
 - (b) average concentration and load values of relevant substances and their variability (e.g. dust, NOX, SO₂, CO, metals, acids);
 - (c) presence of other substances that may affect the waste gas treatment system or plant safety (e.g. oxygen, nitrogen, water vapour, dust, oil mist, soaps).

Achieved environmental benefits

Achieved environmental benefits include the reduction of emissions to water and/or air. Identification of relevant waste water/waste gas streams is a prerequisite for efficient waste water/waste gas management and for the reduction of emissions by technical and management measures.

Environmental performance and operational data

No information provided.

Cross-media effect

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 for setting emission limit values.

Example plants

The use of a stream inventory is applied in a number of installations throughout the EU.

Reference literature

[WT BREF]

WORKING DRAFT IN PROGRESS

8.2 Monitoring

8.2.1 Overview

Real data are required on the precise effects of the activities of the industrial site on the environment. It is thus necessary to conduct a planned, regular sampling and monitoring programme. The parameters monitored include:

- point sources channelled, diffuse and fugitive emissions to the atmosphere, water or sewer;
- wastes, particularly hazardous wastes;
- contamination of land, water and air;
- use of water, fuels, energy, oxygen, nitrogen and other gases (e.g. argon);
- 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.

In parallel to this document, a Reference Report on Monitoring of Emissions to Air and Water from IED installations exists to which the reader is referred for further information [See ROM BREF, COM 2018].

8.2.2 Monitoring of emissions to water

Description

Regular monitoring of emissions to water.

Technical description

Monitoring of the relevant parameters can be accomplished by online measurements (that facilitate rapid intervention and control of the waste water treatment plant - WWTP) or analytical results derived from waste water samples. Parameters to be monitored and the frequency of monitoring depend on the activities which are connected to the WWTP and to the destination of the treated effluent (direct discharge or indirect discharge after further treatment in another industrial WWTP or a municipal WWTP).

Common parameters monitored are found in the relevant sector sections on emissions and include: TSS, COD, HOI, TSS, B, Cd, Cr total, Cr(VI), Fe, Ni, PB, Sn, Zn, Hg, total P and fluoride.

The monitoring of emissions is carried out in accordance with EN standards or, if EN standards are not available, in accordance with 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 waste treatment plant helps to maintain the proper operation of the waste treatment plant 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

This information is detailed later in this document for each type of waste water treatment plant in the dedicated chapters (Chapters 2 to 6).

Cross-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 chromate).

Technical considerations relevant to applicability

Generally applicable to all waste water treatment plant where there are emissions to water.

Economics

The costs associated with monitoring the effluent waste water of a waste water treatment plant relate to personnel and equipment used for sampling and measurement.

Driving force for implementation

Environmental legislation.

Example plants

See the relevant sector sections for emissions to water in Chapters 2 to 6.

Reference literature

[ROM BREF, COM 2018]

8.2.3 Monitoring of channelled emissions to air

Description

Proper operation of a waste treatment plant requires the monitoring and targeted adjustment of various process parameters in the channelled emissions to air of the waste treatment plant.

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 waste treatment and on the characteristics of the type of wastes treated 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 waste treatment plant helps to maintain the proper operation of the waste treatment plant 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 waste treatment in the dedicated chapters (Chapters 2 to 6).

Cross-media effects

Some equipment, ancillary materials and energy are required for carrying out monitoring.

Technical considerations relevant to applicability

Generally applicable to all FMP plants where there are channelled emissions to air.

Economics

The costs associated with monitoring the waste gas of a waste treatment plant relate to personnel and equipment used for sampling and measurement.

Driving force for implementation

Environmental legislation.

Example plants

See the relevant sector sections for emissions to water in Chapters 2 to 6.

Reference literature

[ROM BREF, COM 2018]

WORKING DRAFT IN PROGRESS

8.3 General environmental performance

This section covers the areas, processes and activities of the FMP installation that are not covered elsewhere, as they refer to issues that are common for most of the FMP sectors. In particular, it covers the prevention of emissions to soil, groundwater and surface water, although the techniques are also relevant to the prevention of fugitive emissions to air resulting from the delivery/receipt of raw materials and other chemicals to/at the FMP plant up to their final preparation step prior to application. However, when considering the integrated operation and the complexity of an IED installation, overlaps and repetition with other sections are inevitable: these have been cross-referenced where found.

The design, construction and operation, also referred to 'good housekeeping' or 'good practice' plays an important role in the reduction of fugitive emissions and in occupational health. For many companies, simple, affordable good housekeeping measures are being effectively applied to minimise oil or acid consumption, improve efficiency, achieve a cleaner workplace and reduce costs.

Measures to prevent spillages and leakages are described extensively elsewhere, such as in the EFS BREF. The following sections are therefore a brief summary of key issues for this sector, together with more specific information relevant to the scale and type of operation.

8.3.1 Set-up and implementation of a plan for the prevention and control of leaks and spillages

Description

Preparation and implementation of a plan for the prevention and control of potential leaks and spillage incidents/accidents.

Technical description

A plan for the prevention and control of leaks and spillages is part of the EMS (see Section 8.1.1) and includes, but is not limited to:

- site incident plans for small and large spillages;
- identification of the roles and responsibilities of persons involved;
- ensuring staff are environmentally aware and trained to prevent/deal with spillages incidents;
- identification of areas at risk of spillage and/or leaks of hazardous materials and ranking them according to the risk;
- identification of suitable spillage containment and clean-up equipment and regularly ensuring it is available, in good working order and close to points where these incidents may occur;
- waste management guidelines for dealing with waste arising from spillage control;
- regular (at least on an annual basis) inspections of storage and handling areas, testing and calibration of leak detection equipment and prompt repair of leaks from valves, glands, flanges, etc.

Achieved environmental benefits

Prevents or minimises the contamination of surface waters, groundwaters and soils, and assists in site decontamination on cessation of activities. Also reduces fugitive emissions from solvent spillages.

Environmental performance and operational data

Small spills are likely to happen more often and the sum effect of these if not detected and dealt with is significant increases of fugitive emissions to air, soil and groundwater.

Cross-media effects

None.

Technical considerations relevant to applicability

Generally, there are no technical restrictions to the applicability of this technique. The level of detail of the plan will generally be related to the nature, scale and complexity of the plant, as well as to the type and quantity of liquids used.

Economics

The following costs need to be considered:

- Staff time for training and updating plans.
- Materials for spillage and clean-up.

Driving forces for implementation

- Reduced risks of liability from contamination.
- Reduced risks of associated accidents, e.g. preventing slippery floors, risk of fire.

Example plants

Widely used in all FMP sectors.

Reference literature

TWG, please provide information.

8.3.2 Use of oil-tight trays or cellars

Description

Hydraulic stations and oil- or grease-lubricated equipment are situated in oil-tight trays or cellars.

Technical description

Hydraulic stations and oil- or grease-lubricated equipment are situated in oil-tight trays or cellars to avoid penetration of oil into the ground in the event of leakage. Accidental releases are prevented by periodic checks and preventive maintenance of seals, gaskets, pumps and piping. In the event of spillage, oils are drained to pump sumps where they are discharged by a third party or used as fuel in iron and steel production (e.g. blast furnaces or coke ovens). [Com-CC-2]

Achieved environmental benefits

Prevention of oil (hydrocarbon) contamination of water.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

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

Economics

Installation costs and operating costs are both low. [Com-CC-2]

Driving forces for implementation

- Reduced risks of liability from contamination.
- Workplace health and safety objectives including reduced risks of associated accidents, e.g. preventing slippery floors, reducing risk of fire.

Example plants

Widely used.

Reference literature

[Com-CC-2]

8.3.3 Prevention and handling of acid spillages**Description**

Storage tanks for both fresh and spent acid are equipped with sealed secondary containment protected with an acid-resistant coating which is regularly controlled for potential damage and cracks. Loading and unloading areas for the acids are designed in such a way that any potential leak is sent directly to further treatment.

Technical description

All storage tanks for both fresh and spent acid ~~must be~~ are equipped with efficient and sealed secondary containment and, if required, also with protective shields. This secondary containment ~~must be~~ is completely protected with an acid-resistant coating which ~~must be~~ is regularly controlled for potential damage and cracks. Furthermore, the loading and unloading area for the acids ~~must be~~ is designed in such a way that any potential leak is directly discharged to the waste water treatment plant or can be collected separately.

Achieved environmental benefits

Prevention of acid contamination of water.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving forces for implementation

- Reduced risks of liability from contamination.
- Workplace health and safety objectives including reduced risks of accidents from workers' exposure to highly corrosive acids.

Example plants

Widely used.

Reference literature

TWG, please provide information.

8.3.4 Techniques for storage and handling of coils**Description**

Process-integrated techniques for preventing soil contamination with oil during storage and handling of coils as intermediate or finished products, for avoiding coil damages, reworking (post-processing) and subsequent increase of the waste generated.

Technical description

Storage conditions for coils

As a matter of principle, the following is to be observed when storing steel coils:

- Avoid impairment or damage to material;
- Avoid confusion of materials/ensure retrieval of stored coils
- Ensure occupational health and safety/prevent accidents
- Prevent environmental impact resulting from leaking of anti-corrosion oil.

In the warehouse, coils are deposited in areas equipped with suitable coil supports allowing the coils to be deposited without being damaged. The coil supports are made of plastic, steel or wood. Steel scrims are lined with rubber or plastic. The design of the coil supports corresponds to the coil geometry so as to avoid deformation and damage (See Figure 8.2). Drip trays can be used for the storage of oiled coils (See Figure 8.3).



Figure 8.2: Coil support lined with rubber corresponding to the coil geometry



Figure 8.3: Coil support with oil drip trays

Coil handling

Permissible hoisting gear for handling coils are cranes with coil tongs (See Figure 8.4), C hooks magnets (See Figure 8.5), or pilers with mandrels (See Figure 8.6). Load-handling attachments are adjusted to the inner diameter of the coil. Chains, ropes and belts are not used as slings. The condition of the load-handling attachments is periodically checked, and wear parts are replaced depending upon their condition. The coils are checked at the exit section of the plant and protected from damage. Coils intended for 'outdoor storage area' are strapped with two steel straps.



Figure 8.4: Coil tong with protector



Figure 8.5: C-hook magnet for hoisting of coils



Figure 8.6: Piler with mandrels for coil manipulation and transport

Coil transfer (in-plant)

Coils are transferred with due care in order to avoid damage. In-plant transfer is performed using only permitted and designated means of transportation. This can be done using the following:

- Forklift trucks: Mandrel pilers may be used for transferring coils to a outdoor storage area. If transportation trailers are loaded and unloaded using mandrel pilers, special care is taken not to damage the inner and outer wraps of the coils during depositing. Furthermore, adequate distance is kept between the coils.
- Transportation trailers or railway cars: The coil supports are made of plastic, steel or wood. Steel scrims are lined with rubber or plastic. The design of the coil supports corresponds to the coil geometry. In order to ensure loading and unloading without damage, adequate distance is kept between the individual coils allowing the crane grab tongs to reach between the coils or the mandrel piler to load a coil onto or unload a coil from a trailer without coming into contact with the other coils. Transportation trailers and railway cars have appropriate coverings in order to protect them from rain and snow.

Achieved environmental benefits

- Prevention of soil contamination with oil
- Energy savings through avoidance of further product treatment, finishing or reworking (post-processing)

Environmental performance and operational data

Approximately 10 % productivity loss can be expected via an increase in the scrap production if if no appropriate measures with respect to the storage and handling of intermediate and finished products are taken. {EUROFER 10-7-18]

Cross-media effects

None.

Technical considerations relevant to applicability

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

Economics

An exactly cost calculation through the implementation of these measures is not possible. The estimated costs saved by optimising the storage and handling system correspond to approximately 10 % of the production value.

Driving force for implementation

- Material savings through less damage to intermediate products.
- Product saving through less damage to coils.
- Increased productivity.
- Reduction of scratched products
- Preservation of product quality

Example plants

Voestalpine Stahl GmbH Linz

Reference literature

[EUROFER 10-7-18]

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

Description

The set-up and implementation of an inspection, maintenance and monitoring management plan to maximise critical equipment availability and performance by reducing the frequency of occurrence of OTNOC (e.g. plant start-ups and shutdowns) and minimising emissions during OTNOC.

Technical description

When applying the processes described above in Chapters 2 to 6, the FMP 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;
- 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 8.1.1) is put into place and may include 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 the bag filter);
- set-up and implementation of a preventive maintenance plan for critical equipment (see Section 8.1.1);
- monitoring and recording of emissions during OTNOC and 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.

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;
- replace 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. to focus unscheduled maintenance.

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 FMP installations by:

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

Driving forces for implementation

- Reduces downtime.
- Maintains product quality and throughput.

Example plants

Widely used.

Reference literature

TWG, please provide information.

WORKING DRAFT IN PROGRESS

8.4 Hazardous substances

8.4.1 Avoiding the use of hexavalent chromium compounds in passivation

Description

The use of chromium (VI) compounds in galvanising for passivation is avoided. Alternatively, chromium (III) solutions or chromium-free solutions (e.g. containing manganese, zinc, titanium fluoride, phosphates and/or molybdates) or organic polymer solutions (e.g. containing polyurethanes or polyesters) are employed.

More information on the techniques

See Sections 5.4.1.7.6 and 5.4.1.7.7.

Technical considerations relevant to applicability

Applicability may be restricted due to product quality requirements or specifications.

8.5 Energy efficiency

8.5.1 Energy efficiency plan

Description

An energy efficiency plan is part of the EMS (see Section 8.1.1) and entails defining and calculating the specific energy consumption of the activity, setting key performance indicators on an annual basis (e.g. MWh/tonne of product) and planning the periodic improvement targets and related actions. The plan is adapted to the specificities of the plant in terms of process(es) carried out, materials, products, etc.

Technical description

Extensive information about energy efficiency can be found in the Energy Efficiency BREF [ENE BREF, COM 2009]. Some techniques applicable to increase the energy efficiency of FMP 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.
- 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 product).
- d. Carrying out an energy survey to identify the opportunities for further energy savings.
- e. Using heat recovery techniques from flue-gases.
- f. Applying operating, maintenance and housekeeping measures to the most relevant energy consumption plants, such as:
 - air conditioning, process refrigeration and cooling systems (leaks, seals, temperature control, evaporator/condenser maintenance);
 - operation of motors and drives (e.g. high-efficiency motors);
 - compressed gas systems (leaks, procedures for use);
 - steam distribution systems (leaks, traps, insulation);
 - room heating and hot water systems;
 - 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.
- g. 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;
 - vehicle maintenance;
 - efficient plant layout to reduce pumping distances;
 - phase optimisation of electronic motors;
 - heat recovery;
 - ensuring equipment is switched off, if safe to do so, when not in use;
 - ensuring on-site vehicle movements are minimised and engines are switched off when not in use.
- h. Applying basic, low-cost, physical techniques to avoid gross inefficiencies; including insulation, containment methods (for example seals and self-closing doors) and avoiding unnecessary discharges of heated water or air (for example by fitting simple control systems).
- i. Applying energy efficiency techniques to building services.
- j. Setting the time of operation of the high-energy equipment to off-peak periods.
- k. Using landfill gas to produce electricity and heat.
- l. Using heat from the furnaces and engines for vaporisation, drying and for preheating activities.

Achieved environmental benefits

Reduction of energy consumption and emissions relevant for that energy use.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

The level of detail of the energy efficiency plan will generally be related to the nature, scale and complexity of the plant and the energy types used.

Economics

TWG, please provide information.

Driving force for implementation

Energy savings.

Example plants

Widely used.

Reference literature

[ENE BREF, COM 2009]

8.5.2 Energy balance record

Description

An annual energy balance record is carried out, providing a breakdown of the energy consumption and generation (including energy export) by the type of energy source (e.g. electricity, natural gas, iron and steel process gases, renewable energy, imported heat and/or cooling).

Technical description

The technique involves the drawing up on an annual basis of an energy balance record which provides a breakdown of the energy consumption and generation (including energy export) by the type of source (e.g. electricity, natural gas, iron and steel process gases, renewable energy, imported heat and/or cooling). This includes:

- (i) defining the energy boundary of the processes;
- (ii) information on energy consumption in terms of delivered energy;
- (iii) information on energy exported from the plant;
- (iv) energy flow information (e.g. Sankey diagrams or energy balances) showing how the energy is used throughout the processes.

The energy balance record is adapted to the specificities of the plant in terms of process(es) carried out, materials, products, etc.

Achieved environmental benefits

Reduction of energy consumption.

Environmental performance and operational data

The reduction of emissions from the energy system can only be evaluated with a proper calculation of the actual emissions generated. The breakdown between generation and

consumption can help to optimise the balance between them and hence to optimise the use of energy resources.

Cross-media effects

None.

Technical considerations relevant to applicability

The level of detail of the energy balance record will generally be related to the nature, scale and complexity of the plant and the energy types used..

Economics

The requirements are basic and cost little.

Driving force for implementation

Reduction of energy costs.

Reference literature

[ENE BREF, COM 2009]

8.5.3 General techniques to increase the energy efficiency of heating

8.5.3.1 Optimum furnace design for reheating and heat treatment

Description

This includes techniques such as the following:

- Optimisation of key furnace characteristics (e.g. number and type of burners, air tightness and furnace insulation using suitable refractory materials).
- Minimisation of heat losses from furnace door openings, e.g. by using several liftable segments instead of one in continuous reheating furnaces.
- Minimisation of the number of feedstock supporting structures inside the furnace (e.g. beams, skids) and the use of suitable insulation to reduce the heat losses from water cooling of the structures in continuous reheating furnaces.

Technical description

Furnace design

The design of the furnace and the degree of insulation have a significant effect on thermal efficiency. The furnace together with the number and the capacity of the burners ~~should be~~ are carefully calculated starting from several realistic production scenarios. Different heating temperatures of the stock, differences in production rhythm caused by changes in the dimensions of the stock or as a result of changes in the production rhythm of the hot mill, as well as periods where hot or direct charging is applied ~~have to be~~ are taken into account. [EUROFER HR]

The appropriate equipment is available to limit the emissions and the energy consumption in case of a sudden line stop. This means that the temperature can easily be turned down or burners switched off in certain furnace sections. In the latter case, a N₂ purge might be necessary for safety reasons. [EUROFER HR] [Com HR]

Generally, the following recommendations are considered, preferably in the design process:

- Radiant burners in the roof of the furnace, due to quick dissipation of energy, produce lower NOX levels.

- The insulation properties of the refractory material are important; therefore constructional measures should be taken to increase the lifetime of the refractory material, as damage in the refractory material cannot be repaired immediately.
- Use of low-thermal-mass refractory material can reduce stored energy losses and reduce light-up energy and time [ETSU-G76].
- ~~Ceramic fibres are generally cheaper than pre-cast concrete modules and have good insulating properties. However, following a European Directive, their use is or will be limited because they may cause cancer by inhalation. In new condition the fibres are dust producing when being manipulated and may cause some skin irritation. After heating, cristoballite is formed which is suspected to cause cancer. Nevertheless, new ceramic fibres are also considered suspect [Com2 HR].~~
- Improved airtightness of furnaces and installation of specially designed doors, to reduce tramp air [ETSU-G76].
- Door areas and/or charge and discharge door gaps are minimised, and insulating refractory curtains used for times when doors are necessarily open (provided that excessive mechanical damage to stock can be avoided) [ETSU-G76].

More information on the minimisation of heat losses from door openings and on the minimisation of the number of feedstock supporting structures to reduce heat losses can be found in the specific sections 2.4.2.2 and 2.4.2.13, respectively.

Achieved environmental benefits

- Reduced energy consumption.
- Reduction of NOX and CO emissions.

Environmental performance and operational data

The furnace is run with 'good craftsmanship'. Even sophisticated installations can give poor results in emission and thermal efficiency if the process is not properly operated and if the installations are not maintained on a regular basis. Experience has shown that good housekeeping can lead to fuel savings of up to 10 %. [ETSU-G76]

Furnace control is very important for efficient operation and different techniques such as pulse firing can increase the efficiency of fuel use and good temperature control. [EUROFER 10-7-18]

Turbulence in the flame of the burners is avoided. Investigations showed indeed a marked increase in the NOX produced by temperature fluctuations compared to the NOX values produced by a steady flame operating at the same mean temperature.

Air excess is also an important factor for the control of the NOX emission level, the energy consumption and the formation of scale. The air excess should be minimised without excessive CO emission. Special care should be taken to avoid the presence of tramp air, which increases the energy consumption as well as the NOX emission. A mass spectrometer is useful in keeping the air/gas ratio at an optimal level for fuels with a variable or unknown composition. [EUROFER HR]

Heat stored in the refractories is supplied during the start-up period and the first production shift. During continuous operation this stored heat is usually regarded as negligible. When down-shift practices are employed (e.g. at weekends) or when furnaces are deliberately cooled for maintenance reasons, these energy losses can become an important factor as this energy has to be put in during furnace heat-up for the next production period. For two cases, the stored energy losses during weekend plant shutdown were reported: 0.409 GJ/m² and 0.243 GJ/m². During production stoppages and weekends, doors should be closed and sealed to retain the heat. The use of low-thermal-mass refractories can reduce light-up time, energy consumption and operating costs. [ETSU-G76]

Maintenance of control systems and burners is very important. Control valves, linkages, burner internal components and cooling systems are maintained using good planned maintenance standards to ensure reliable and efficient operation. Damaged burners and control valves can result in elevated emissions from the furnace and inefficient use of fuel. [EUROFER 10-7-18]

Cross-media effects

None.

Technical considerations relevant to applicability

Only applicable to new plants and major plant upgrades.

Economics

TWG, please provide information.

Driving force for implementation

- Reduced energy consumption.
- Reduction of NOX and CO emissions.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[EUROFER HR] [Com HR] [ETSU-G76] [EUROFER 10-7-18]

8.5.3.2 Combustion optimisation

Description

Measures taken to maximise the efficiency of energy conversion in the furnace while minimising emissions (in particular of CO). This is achieved by a combination of techniques including good design of the furnace, optimisation of the temperature (e.g. efficient mixing of the fuel and combustion air) and residence time in the combustion zone, and the use of furnace automation and control.

See the LCP BREF for more information.

Reference literature

[LCP BREF]

8.5.3.3 Furnace automation and control

Description

The heating process is optimised by using a computer system controlling in real time key parameters such as furnace and feedstock temperature, the air to fuel ratio and the furnace pressure.

Technical description

Furnace automation takes care of the combustion, the energy consumption, material handling, temperature control of the slabs and process safety continuously. In addition, it enables adjustment of the air to fuel ratio for optimum combustion which in turn minimises NOX emissions. [EUROFER 23-7-18]

With the help of a process computer, the heating process can be optimised (e.g. no unnecessary overheating of slabs during interruptions, more accurate temperature control) in accordance with the material quality and dimensions. [EUROFER HR]

Furnace pressure control: If the furnace pressure is below atmospheric pressure, cold air will be drawn into the chamber through doors and openings. Conversely, if it is above atmospheric pressure, hot gases will be forced out through the same openings. For reasons of energy efficiency, consistency of operation and product quality, furnaces are usually operated at a slight positive pressure compared with the outside air. [ETSU-G76] Another reason to maintain a slightly positive furnace pressure is for safety, to prevent air ingress which might provide an explosive mixture if fuel/gas were ignited, especially on start-up. [Com HR]

Air to fuel ratio control: Control of the air to fuel ratio is necessary to regulate the quality of the combustion, as it ensures flame stability and complete combustion. Adjusting the air to fuel ratio as close as possible to stoichiometric conditions results in higher fuel efficiency and reduced exhaust gas energy losses. Measurements of the oxygen concentration in the combustion products in the furnace can be used to provide a signal to trim air to fuel ratio control systems (*Oxygen Trim Control*). [ETSU-G76]

Material temperature control: By using a supervisory computer system to calculate the temperature of the slab, heating above the target temperature is prevented. The Furnace Optimisation Control System (FOCS) determines set points for temperature in various zones of the furnace and controls the furnace flow on the basis of the calculated workpiece temperatures and current production status in order to produce optimally heated materials. [JF-D799] [EUROFER 23-7-18]

Achieved environmental benefits

- Reduced energy consumption.
- NOX reduction.

Environmental performance and operational data

Example: Oxygen Trim Control

A system using zirconia-based oxygen measuring cells has been installed at Rotherham Engineering Steels walking beam furnace which is used for reheating square billets from cold to 1 200 °C. The 110 t/h capacity furnace operates six independently controlled temperature zones. It is usually fired by natural gas or with heavy fuel as an alternative during interruptions in gas supply. The oxygen trim resulted in a lower average oxygen concentration in the furnace than with conventional air to fuel ratio control. Energy savings of about 2 % were achieved: although the reduction in oxygen content suggests that savings of around 4.7 % could realistically be achieved, this potential has been reduced by an increase in temperature in the heating zones. Additional benefits included improved product quality and reduced maintenance costs. [ETSU-FP15] [ETSU-G77]

~~Energy reductions of 2 % were equivalent to an approximate fuel cost saving of GBP 26 000/y, giving a simple payback time of 1 year on the initial investment of GBP 26 572 (reference year 1989). [ETSU-FP15]~~

Raahe Plate Mill uses continuous oxygen control in all bottom and top zones. The oxygen set point is low for the majority of slabs and a higher oxygen set point is used only for special slabs. [EUROFER 23-7-18]

Example: Computer-controlled furnace management

Computer-controlled furnace management installed at two pusher-type furnaces used to reheat cold charged slabs at BS, Teeside, resulted in energy savings of 15 % for both furnaces. The formerly manually adjusted temperature zones switched to computer-controlled (using on-line mathematical models) to provide optimal heating profiles.

Implementation of computerised furnace control at a German pipe production site led to energy savings of 5 % and a reduction of scale generation during reheating of up to 30 %. [StuE-116-11]

Example: Roller hearth furnaces

In roller hearth furnaces, selected furnace zones can be switched to standby mode when no slab is present inside the furnace by using computerised furnace control. Additionally, depending on the actual slab temperature, the temperature of the zones and the duration of slab heating are adjusted. [EUROFER 23-7-18]

TWG to provide updated information for the following table or it will be deleted.

Table 8.1: Typically achievable reductions and cost data for furnace automation

| | Reduction [%] | | Investment cost [M ECU] | |
|---|---------------|---------------------|-------------------------|---------------------|
| | NOX | Energy ¹ | New facilities | Existing facilities |
| Furnace automation² | 10 | 10 | 2.0 | 2.0 |
| <p>Note: Source of data [EUROFER HR]. Basis is a furnace with a yearly capacity of 1.5 Mt fired with natural gas with standard burners and without air preheat. Investment costs can be site specific (available room, layout of the existing furnace, number of side and bottom burners)</p> <p>¹In percentage terms, the energy reduction is matched by the reduction in SO₂, CO and CO₂ emissions</p> <p>²With furnace automation is meant all measures that allow a quick adaptation of the furnace parameters to changes in the production and a tight control of the air excess</p> | | | | |

Cross-media effects

No negative effects on other media are known.

Technical considerations relevant to applicability

- ~~New and existing continuous reheating furnaces.~~

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

Economics

TWG, please provide information.

Driving force for implementation

- Reduced energy consumption – energy savings.
- Improved product quality and reduced maintenance costs.

Example plants

Roundwood Coil Bar Mill, Rotherham Engineering Steels Ltd, UK.

British Steel, Teesside, UK.

Benteler AG, Dinslaken, Germany [StuE-116-11].

SSAB Special Steels, Oxelösund, Sweden.

Reference literature

[ETSU-FP15] [ETSU-G77] [ETSU-G76] [JF-D799] [EUROFER 23-7-18] [StuE-116-11]

8.5.3.4 Process gas management system

Description

A system that enables iron and steel process gases to be directed to the reheating and/or heat treatment furnaces, depending on their availability. The calorific value of the iron and steel process gases is used.

See the LCP BREF for more information.

Reference literature

[LCP BREF]

8.5.3.5 Batch annealing with 100 % hydrogen

Description

Batch annealing is carried out in furnaces using 100 % hydrogen as protective gas with increased thermal conductivity.

Technical description

Conventional batch annealing in annealing furnaces is carried out under a hydrogen/nitrogen atmosphere (e.g. HN) consisting of about 5 % H₂ and 95 % N₂. In some cases, up to 7 % H₂ may be used. High-Performance Hydrogen (e.g. HPH) annealing of steel coils consists of using 100 % hydrogen and results in better productivity, improved mechanical properties, surface and product quality. [EUROFER 10-7-18]

The changeover to an atmosphere with 100 % H₂ has the following effects on the heating and cooling process:

- 1) The heat transfer by convection between the gas and the steel surface will increase owing to the relatively higher thermal conductivity of hydrogen gas. The effect is approximately a 60 % higher convective heat transfer rate.
- 2) The smaller size of H₂ molecules compared to N₂ enables easier penetration of the gas into the small gap between the layers of the coiled strip. Since H₂ also has a higher ability to absorb heat, it will increase the axial thermal conductivity in a coil, by approximately a factor of 7.
- 3) The lower specific weight of H₂ also allows a higher circulation of the gas for the heat transfer.

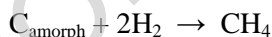
Pure hydrogen bell furnaces can be equipped with gaseous fuel burners, allowing the surplus/leftover of the reduction gases (mainly H₂, but also the residuals from oil, CH₄, C_nH_m, CO and H₂O) to be burned together with the main fuel in order to maximise the use of hydrogen. The method of using the off-gases in the burners for heating the process allows to treat and eliminate the oil and other organic materials from the product.

The benefits of higher heat transfer to and within the coil enables an increased production rate with a lower heating and cooling time as well as lower specific energy consumption. A faster heating rate means less specific consumption of gases and electrical energy.

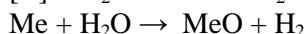
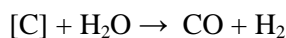
H₂ reacts very quickly and intensively with air. Using a 100 % hydrogen atmosphere, process safety actions are put in place to avoid reactions with air, including continuous supervision of the annealing process.

A higher amount of H₂ provides the possibility to penetrate better between the layers of a coil, facilitating decarbusising reactions between hydrogen and oil contamination products on the coil. The decarbusising power of pure hydrogen is significantly higher than that obtained in a protective atmosphere composed of nitrogen and 5 % hydrogen. [Scheuermann et al., 1995]

This results in a cleaning effect when the following reactions take place:



In addition, a higher H₂:H₂O ratio helps preserve the structure of the steel surface by preventing to a certain extent the following reactions from taking place:

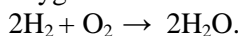


Where:

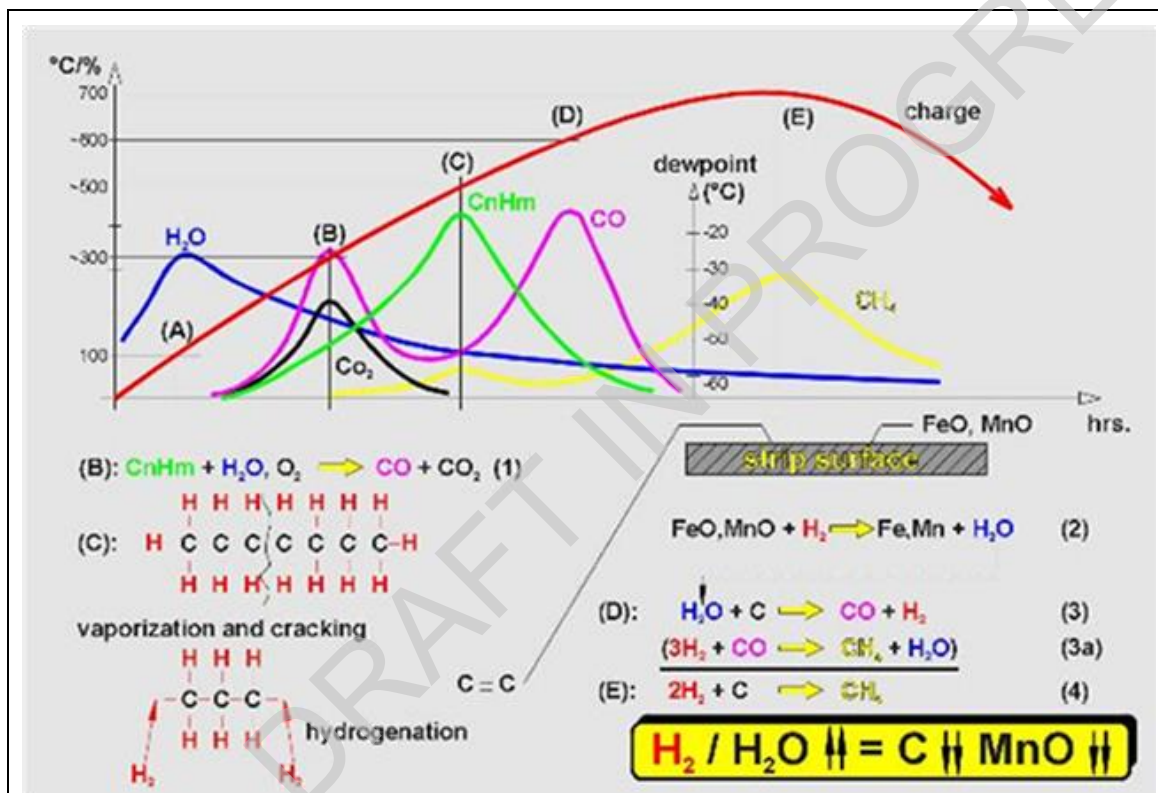
Me = any kind of metal;

MeO = any kind of metal oxide.

Figure x shows the chemical reactions taking place during the heating up of the charge in a 100 % hydrogen bell annealing furnace. Reaction A (blue line) is the reduction of any free oxygen:



From B to E, the consecutive chemical reactions taking place during the annealing process are detailed. Overall, a high concentration of H_2 helps the reduction of any oxides and the hydrogenation of heavy hydrocarbons; these reactions are only limited when using a conventional HN annealing furnace.



Achieved environmental benefits

Reduced energy consumption.

Environmental performance and operational data

At SSAB Borlänge site, there are five HPH bell furnaces operating with 100 % hydrogen and four electrically heated HN furnaces. For these furnaces, operational data are given in Table 8.2. These data are aggregated over a three-year period from the actual plant production. In this exercise, the fact that different annealing cycles could have been used in the different furnaces was not taken into consideration. [EUROFER 10-7-18]

Regarding the data reported, it should be noted that the energy savings figures are related to the time of process. No data were available for the energy savings from the base fans and electrical heating component separately. Also, product grade (and hence annealing cycles) as well as loading (tonne/batch), strip thickness which can have an influence on data such as annealing time and energy efficiency (per tonne) were not considered. [EUROFER 10-7-18]

Table 8.2: Productivity rate, energy and gas consumption and NOX emissions data at SSAB Borl nge annealing furnaces (HN and HPH) [EUROFER 10-7-18]

| | Electrical HNL furnace | HPH (100 % H ₂) furnace | Difference |
|---|------------------------|-------------------------------------|------------|
| Productivity (tonne/h) | 0.5 | 2.0 | 200 % |
| Energy [kWh/tonne] (electricity and LPG) | 427 | 253 | -41 % |
| N ₂ gas [m ³ /tonne] | 83 | 8.7 | -90 % |
| H ₂ gas [m ³ /tonne] | 2.9 | 6 | 107 % |
| NOX [kg/tonne] | NI | 0.21 | NI |
| NB: NI = No information provided. | | | |

At SSAB, only the H₂ bell furnaces emit NOX because the other HN furnaces are electrically heated.

Cross-media effects

Compared with electrically heated furnaces, the use of HPH furnaces may result in higher emissions to air. In order to fully utilise the H₂, efficiency increases can be achieved if using a combustion technology for heating the bell where the surplus of H₂ can be combusted together with natural gas or another fuel.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

- Productivity, surface quality, cost savings depending on fuel prices.
- High product quality standards can be met.

Example plants

SSAB Borl nge.

Reference literature

[EUROFER 10-7-18]

[Scheuermann et al., 1995]

W. Scheuermann, D. Boing, P. Witter, M. Bock, T. Bovalina, 1995. New developments in hydrogen annealing of steel coils. MPT International 2, 90-98.

[Wendt et al., 2015]

P. Wendt, F. Gerwin, F. Maschler, G. Freber, H. Meyer, S. Bothen, 2015. Modernisation of existing industrial furnace plants. Heat processing, 81-90.

8.5.3.6 Optimum galvanising kettle and furnace design

Description

This includes techniques such as:

- uniform heating of the galvanising kettle walls (e.g. by using high-velocity burners or radiant design);

- minimisation of heat losses from the furnace using insulated outer walls (e.g. ceramic lining);
- minimisation of heat losses from the galvanising kettle using enclosures.

Technical description

Furnace heating efficiency should be considered in two parts. They are firstly the efficiency with which heat is transferred from the prime heat source to the galvanising bath and, secondly, the efficiency with which the transferred heat is employed in maintaining the zinc temperature.

The efficiency of heat transfer to the kettle is governed by basic principles of heat transfer and combustion engineering. Combustion of gases and oils results in a flow of flue-gas products which carries away sensible and latent heat. This amounts typically to 45 – 55 % of the gross calorific input of the fuel at maximum input. A small amount of electrical energy is used to drive the combustion air fan, and the pump or compressor used in oil heating. Use of electricity for heating involves energy loss owing to reactance effects and often also to cooling of temperature-sensitive parts of the heating system. Losses may be around 15 % of the metered power. For all energy sources, there is additional heat loss from the furnace case, although for a well-insulated furnace this is small, typically 2 % of the energy input. All losses in this category increase as the heat input increases.

Losses from the system are also due to radiation and convection from the molten metal surface and from exposed parts of the top of the bath, such as the top flange on a steel kettle. The extent of these losses depends on the surface areas, conditions and temperatures, but is typically 15 to 25 % of the heat originally transferred to the bath.

Flue-gas heat losses may be reduced by optimising the combustion process, by optimising excess air for combustion and by reducing air ingress to the furnace casing. The low-temperature operation of the galvanising process implies that there are limited opportunities for energy saving by reduction of losses. The burner system must be capable of accommodating a turn down ratio of approximately 15:1.

Surface losses may be reduced during working (subject to adequate ventilation) by use of an enclosure over the bath, or limiting the open part of the surface to that required for the type of galvanising in progress. When the kettle is on hot standby, reductions in heat loss can be obtained by the use of insulated covers which extend over the furnace top. Reducing the bath temperature during hot standby periods rarely saves significant amounts of energy and, with steel kettles, cycling of the bath temperature adversely affects the protective zinc-iron alloy, thus reducing the kettle's working life. In some cases, furnaces can be lined with high-temperature ceramic fibre to minimise heat losses from the outer walls of the furnace. The kettles are insulated using enclosures and the top flange is also insulated in order to reduce heat losses from the flange surface.

Furnace efficiency is also affected by the control system. Higher efficiencies are obtained with control systems which most closely match the heat input to the heat demand. Determination of heat input is based on the molten zinc temperature, measured by thermocouples either immersed in the zinc or – for steel kettles – possibly by contact with the external kettle wall. Depending on the flexibility of the heating system the controller often uses PID (Proportional, Integral, Derivative) or other control logic to keep the zinc temperature as constant as possible. In some cases, a two-zone temperature control can be installed where the heating system can be divided in two zones, the upper and the lower zone. This can also help to control and minimise the formation of top dross.

Combustion systems include High/Low (either maximum or minimum heat is delivered for a period), Modulating (the heat input varies constantly over a range between maximum and minimum), or Pulsing (a continual succession of maximum and minimum heat inputs is delivered equating to a net intermediate heat input).

In the case of gas-fired burners, high velocity burners are employed to ensure an optimal heat transfer towards the galvanising kettle. In the case of induction heating, heating panels with a radiant design are used for uniform heating of the kettle walls.

Achieved environmental benefits

Reduced energy consumption.

Environmental performance and operational data

Losses from the system are also due to radiation and convection from the molten metal surface and from exposed parts of the top of the bath, such as the top flange on a steel kettle. The extent of these losses depends on the surface areas, conditions and temperatures, but is typically 15 % to 25 % of the heat originally transferred to the bath.

Cross-media effects

None.

Technical considerations relevant to applicability

Only applicable to new plants and major plant upgrades.

Economics

TWG, please provide information.

Driving force for implementation

Reduced energy consumption – energy savings.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

8.5.4 General heat recovery techniques from flue-gases

8.5.4.1 Feedstock preheating

Description

Feedstock is preheated by blowing hot flue-gases directly onto the slabs.

Technical description

The heat in the waste gas of heating furnaces can be used to preheat the feedstock by blowing the hot waste gas from above and below onto the slab. Even after regenerative burners and a waste heat boiler, the waste gas can have enough energy to heat the slabs up to 400 °C. Figure 8.8 shows the example of a slab preheater installed upstream of a pusher-type heating furnace.

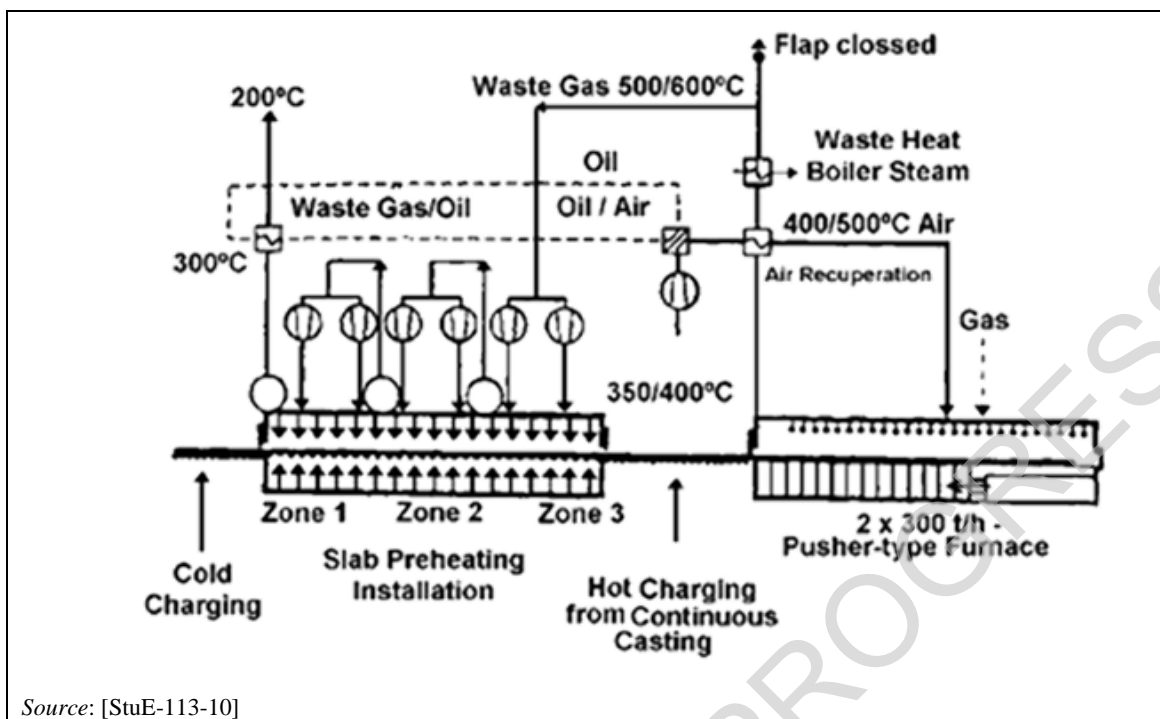


Figure 8.8: Principle of slab preheating by waste gas

As an alternative to preheaters, the heat of waste gas can be used in very long walking beam furnaces in the unfired long preheating zone. [StuE-113-10]

Achieved environmental benefits

Reduced energy consumption in the heating furnace (20 %).

Environmental performance and operational data

The preheater shown in Figure 8.8 is installed upstream of two pusher-type furnaces. The furnaces have capacities of 300 t/h and are fired by regenerative burners. The heat from the waste gas of the furnace is first used for heat recovery in a waste heat boiler. After that it still has a temperature of 500–600 °C and is used in the preheater to heat the slabs to up to 400 °C. The waste gas leaving the preheater still has a temperature of 300 °C and is used to preheat the combustion air for the regenerative burners of the heating furnace to about 150 °C (by means of an oil heat exchanger). The waste gas is discharged at a temperature of 200 °C. [StuE-113-10]

Cross-media effects

No negative effects on other media are known.

Technical considerations relevant to applicability

~~New and existing continuous reheating furnaces. (for cases where stock recuperation is not already incorporated in the furnace).~~

Only applicable to continuous reheating furnaces.

Economics

TWG, please provide information.

Driving force for implementation

Increased energy efficiency.

Example plants

Preussag Stahl, Salzgitter

Reference literature

[StuE-113-10]

8.5.4.2 Feedstock drying

Description

The heat from flue-gases is used to dry the feedstock, e.g. after fluxing.

Technical description

Galvanising kettles may be fired either by gaseous or liquid fuels. The method most commonly used for heat recovery from combustion gas is transfer to air or water. Heat exchangers typically fabricated from banks of stainless steel tubes are used to recover heat from flue-gas to air. The flue products are normally on the tube side. Flue products may be introduced at 500–700 °C when the furnace is operating at full production rate. The heat exchanger may be placed directly in the furnace flue duct but, in the absence of forced extraction of flue-gases, only a small flue-gas pressure drop can be tolerated. This limits the rate of heat transfer.

Shell and tube heat exchangers can be used to transfer heat from flue products to water or steam, with flue-gas on the shell side. Another common type of exchanger is a bank of finned tubes placed in the flue duct. In this case, water is on the tube side.

Gases may be drawn through the heat exchanger using a fan downstream of the exchanger in order to increase the overall coefficient. This is a common arrangement for gas-to-water heat exchange. Both the heat exchanger and fan are located in a branch parallel to the main flue duct, thus avoiding any back-pressure effect on the furnace. The fan consumes a small amount of power.

In a few cases, flue-gases are in direct contact with the outer surface of a pretreatment tank, transferring heat by radiation and convection.

Heat exchangers for oil fuels and for surface-heated baths require special design due to the presence of SO₂ and ash in the flue-gases. [Com2 EGGA]

Achieved environmental benefits

Reduced energy consumption.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

- ~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.
- In principle, the technique can be applied to any installation subject to economic analysis, which depends on the fuel price, the thermal rating of the furnace and the demand for waste heat.
- It is not normally worthwhile in two-burner systems (small kettles) because there is not enough heat available to be useful. Heat recovery systems are very frequently installed on four- and six-burner systems.

Economics

Energy reductions in the range of 15–45 kWh/t of black steel.

Driving force for implementation

Fuel costs.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[Com2 EGGA]

8.5.4.3 Heating of baths**Description**

The heat from flue-gases is used to heat baths (e.g. for fluxing and pickling).

Technical description

Heat of waste gas from kettle firing is recovered by use of heat exchangers to heat air for drying of steel items after fluxing.

See Section 8.5.4.3 for more details.

Achieved environmental benefits

Reduced energy consumption.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

Generally applicable

Economics

TWG, please provide information.

Driving force for implementation

Increased energy efficiency.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

8.5.4.4 Preheating of combustion air**Description**

Reuse of part of the heat recovered from the combustion flue-gas to preheat the air used in combustion. This may be achieved for example by using regenerative or recuperative burners.

Technical description

To improve the thermal efficiency of furnaces, the exhaust gases from the furnace may be used to preheat the combustion air. Thermal efficiency increases with increasing preheated air temperature and decreasing waste gas temperature. The diagram in Figure 8.9 shows potential fuel savings achieved by combustion air preheating. Actual values might differ from these theoretical figures as they are subject to a number of other influences.

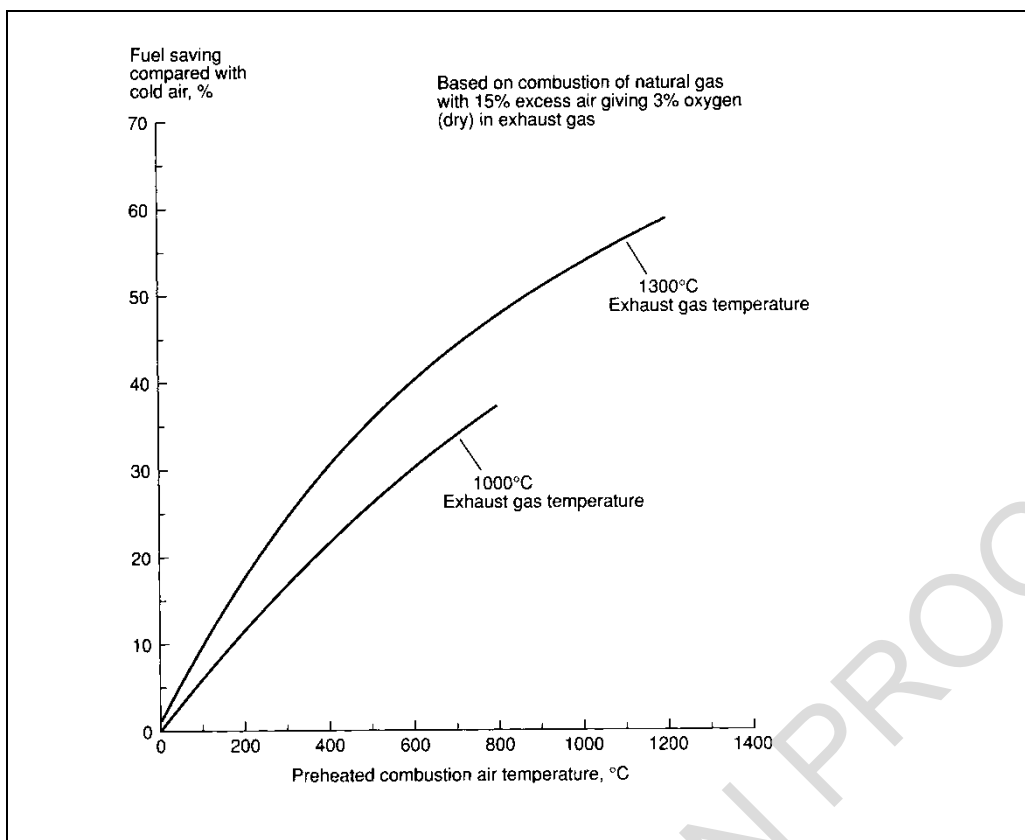


Figure 8.9: Potential fuel savings with preheated combustion air [ETSU-G76]

In general, two systems exist: the regenerative and the recuperative burner.

Regenerative burners

Regenerative systems use two sets of heat exchangers, containing for example brick chequer material or ceramic balls. Figure 8.10 shows an example of such a regenerative burner system in a continuous reheating furnace. When one burner is fired, the furnace gases are channelled via the other burner. The exhaust gases pass through a regenerator which contains a bed of refractory or ceramic materials. The refractory materials are heated by the exhaust gases and store the energy, which is then used to preheat the combustion air. When the refractory materials are fully heated, the firing burner is turned off and the regenerated burner is put into operation. Typical reversal times are in the range of 20 s to 100 s.

New regenerative low-NOX burners have been developed, combining the regeneration with coupled gas and air staging, internal POC (products of combustion) recirculation and flameless technologies. [EUROFER 10-7-18]

TWG, Figure D.1-2: "Schematic of a regenerative burner system" in the old BREF has been deleted and replaced by Figure 8.10 below

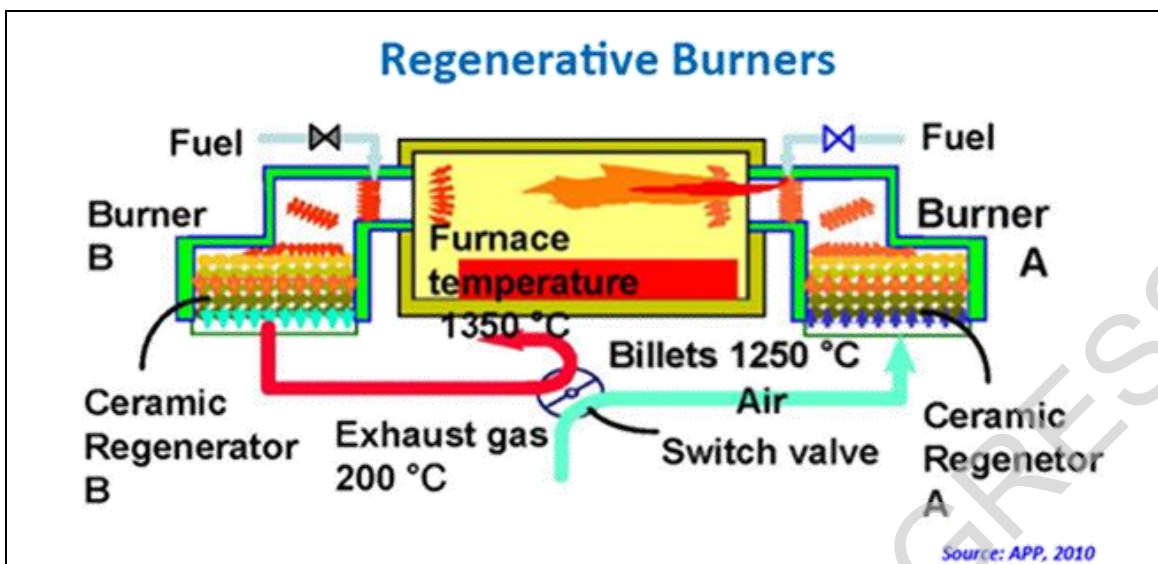


Figure 8.10: Schematic of a regenerative burner system [EUROFER 31-3-17]

A special type of regenerative burner is the integral bed burner which has a more compact design as the regenerative bed is incorporated in the body of the burner. These types of burners are especially suitable for retrofitting furnaces where space constraints may be a problem and for small furnaces.

Recuperative burners

A recuperator is a heat exchanger fitted in the exhaust gas outlet, which allows heat to be transferred continuously through the heating surfaces to the incoming combustion air. Various equipment designs are available. Self-recuperative burners have integral heat exchangers for preheating combustion air. Figure 8.11 shows the schematic of a self-recuperative burner where the hot combustion products preheat the combustion air.

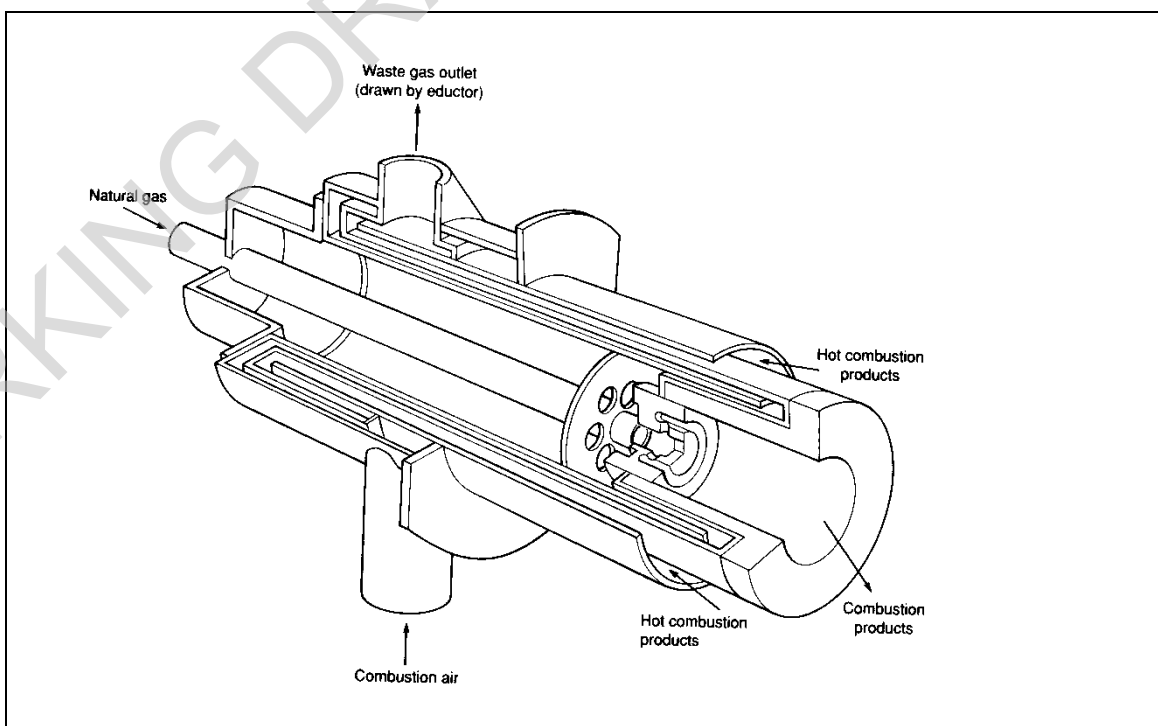


Figure 8.11: Schematic of a self-recuperative burner [ETSU-G76]

There are several types of recuperators:

- the radiation recuperator incorporates a cylindrical alloy steel tube bundle suspended within a refractory-lined outer shell (see Figure 8.12). These recuperators have proven reliable under adverse corrosion and fouling conditions. [EUROFER 10-7-18]
- a convection recuperator is comprised of tube bundles with the tubes welded to the tube sheets to assure gas-tightness (see Figure 8.12). The tube arrangement, tube material and flow pattern are based on the specifics of each individual application, including temperatures, compositions, pressure drop limits and space availability. In a typical design, the hot waste gas from the furnace flows horizontally through the recuperator, passing outside of vertical tubes. Combustion air flowing to the burners makes two or more passes inside the tubes in a counter cross-flow pattern. [EUROFER 10-7-18]

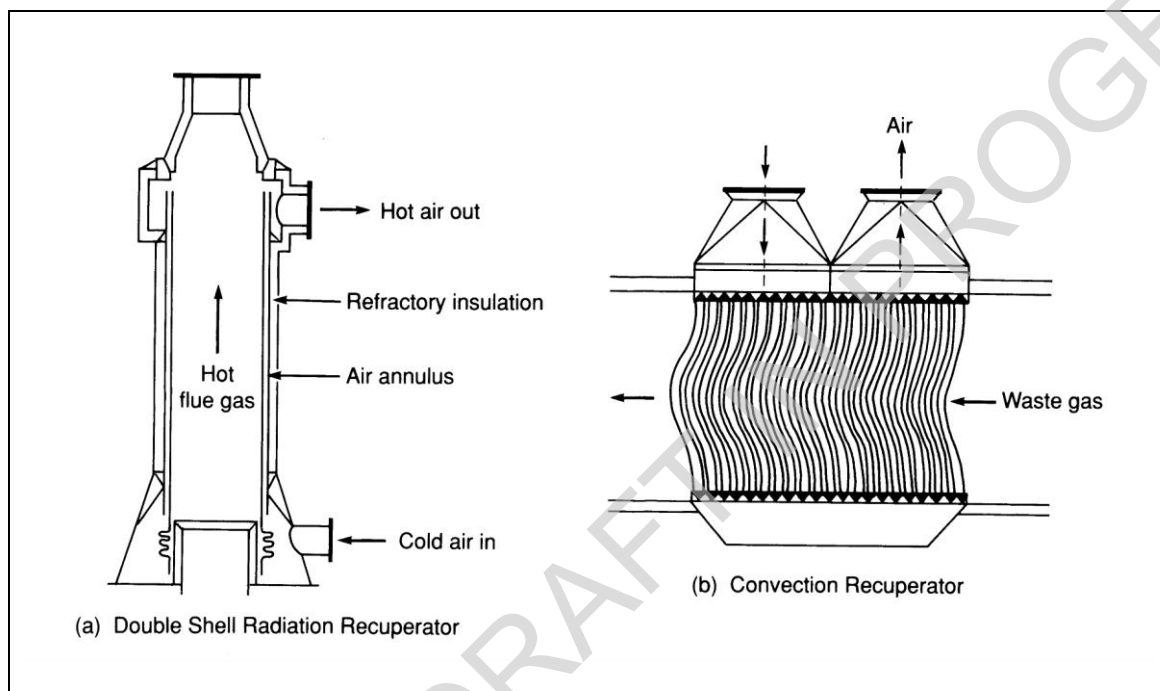


Figure 8.12: Typical exhaust gas recuperators
[ETSU-G76]

More complex designs of a recuperator can enlarge the heat exchange surface by creating a more compact heat transfer surface geometry. Figure 8.13 shows the schematic of a typical compact recuperator. [EUROFER 10-7-18]

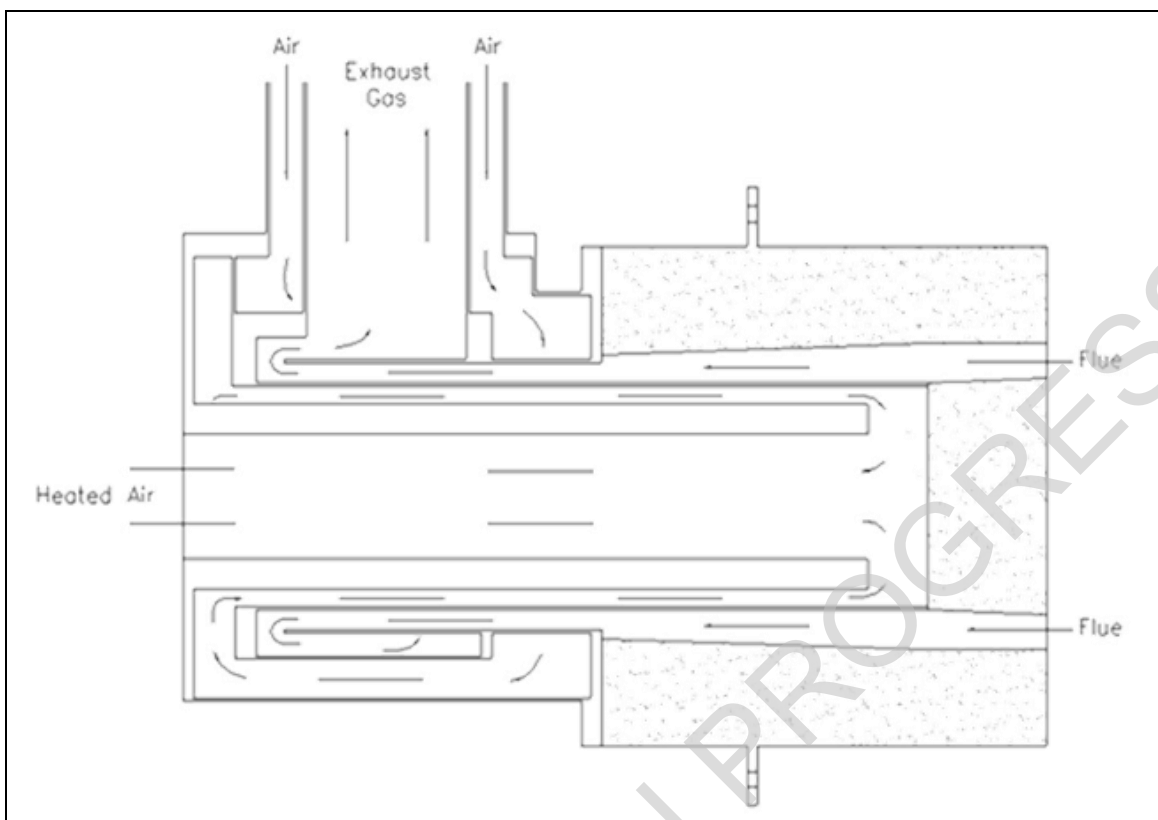


Figure 8.13: Typical compact recuperator [EUROFER 31-3-17]

Achieved environmental benefits

Reduced energy consumption.

Environmental performance and operational data

Regenerative burners

Regenerative burners Such systems can achieve air preheating temperatures of up to 1 100 °C but actual temperatures are dependent on the waste gas inlet temperature. Based on the air preheat temperatures, NOX emissions can be as high as 3 000 mg/m³. [CITEPA]

Regenerative systems are preferred for high waste gas temperatures to achieve air preheat temperatures above 600 °C. The air preheat temperature is limited by the process temperature and is generally 150–200 °C below the process temperature. A thermal efficiency of the furnace of 80 % and fuel savings of up to 60 % can be achieved. [EUROFER HR] [EUROFER CR]

A regenerative system is particularly attractive for batch processes because batch processes do not generally contain a preheat zone. In continuous furnaces equipped with a central recuperator system, a similar thermal efficiency is reached by means of a long unheated (preheat) zone, where the heat of the flue-gases is transmitted by convection to the cold stock. [EUROFER HR]

A specific design of compact regenerative burners has been developed for radiant tubes (Figure 8.14), with specific application for continuous annealing lines or the heating zones of galvanising lines. [EUROFER 10-7-18]

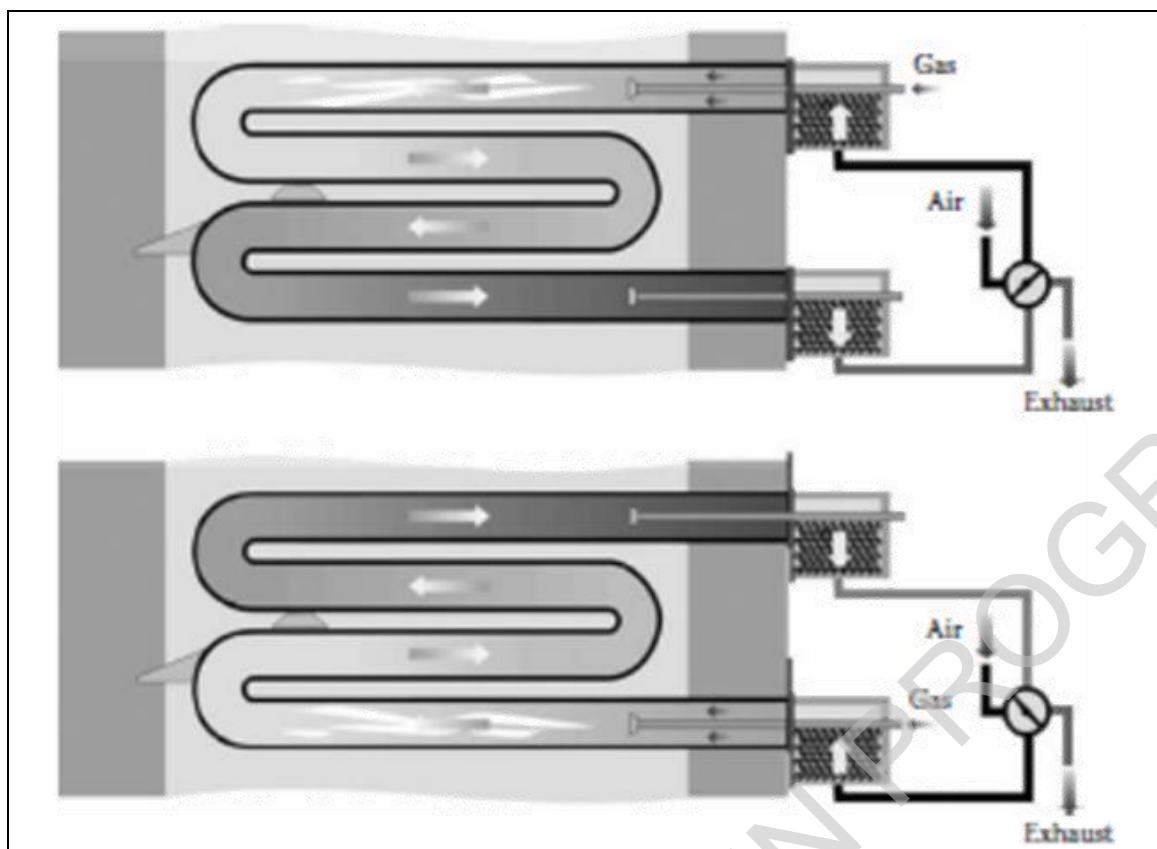


Figure 8.14: Schematic of a regenerative burner system in radiant tubes [EUROFER 31-3-17]

Recuperative burners

Recuperating the heat of flue-gases allows an air preheat temperature up to 550 °C or 620 °C depending on the process temperature. Higher air preheat temperatures are technically possible, but entail excessive additional costs due to the heat-resistant construction materials that would be required. A thermal efficiency of approximately 65 % can be reached. [EUROFER HR]

Recuperative burners can be used in high-temperature processes (700–1 300 °C). [EUROFER 10-7-18]

Recuperation combined with additional techniques results in advanced burner designs with effects on emissions. A recuperative radiant tube burner used for indirect heating of the load is shown in Figure 8.15. The high velocity of the combustion gases generates a pressure at the outlet of the ceramic burner tube, resulting in the recirculation of the flue-gases. This leads to the reduction of NOX emissions and a uniform radiant tube temperature. The maximum air preheat temperature is approximately 700 °C. A recuperative burner using staged combustion can lead to low NOX emissions. [EUROFER 10-7-18]

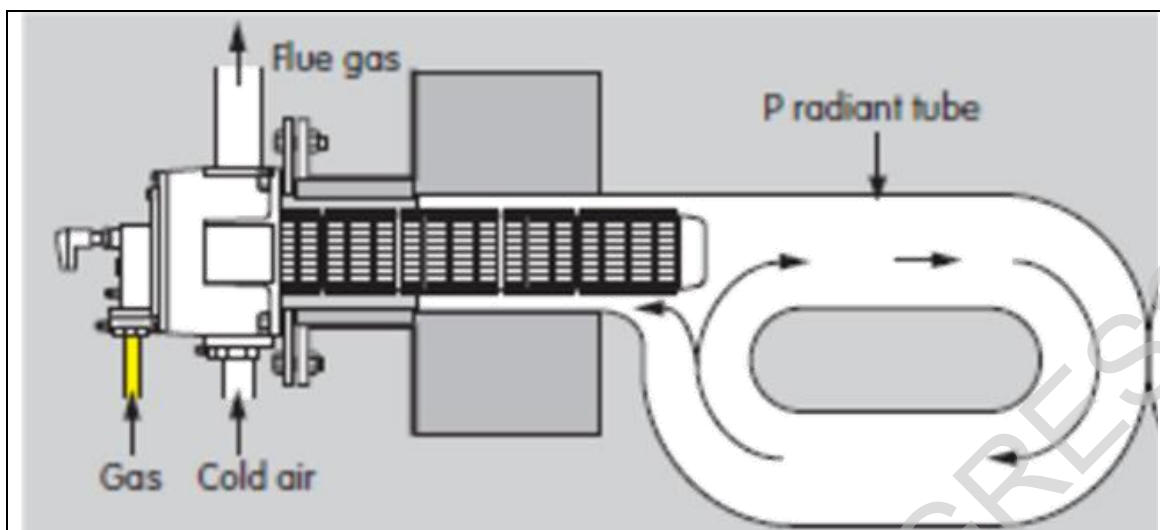


Figure 8.15: Typical recuperative burner in radiant tubes [EUROFER 31-3-17]

Cross-media effects

Thermal NOX generation can be increased.

Technical considerations relevant to applicability

Generally applicable within the constraints related to the need to control NOX emissions.

Economics

TWG, please provide information.

Driving force for implementation

Increased energy efficiency.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[CITEPA] [EUROFER 10-7-18] [EUROFER HR]

8.5.4.5 Waste heat recovery boiler

TWG, this section has been revised based on new information received by the TWG.

Description

Heat from hot flue-gases is used to generate steam that is used in other processes, for district heating or for generating electricity.

Technical description

The waste heat recovery boiler can be installed directly after the furnace exit or after a recuperator unit. With this technique, the heat content of the hot exhaust gases is used to generate steam (Figure 8.16). Hot exhaust gases pass through several heat exchanger units and heat is transferred to the water/steam cycle. The economiser and evaporiser are used to heat up the condensate and generate steam. Additional overheater units can be installed to generate overheated steam. Depending on the operation conditions, the exhaust gas can be cooled down to around 200 °C, but lower temperatures would lead to condensation in the chimney and therefore must be avoided. [EUROFER 23-7-18]

The generation of steam by this method at this point saves generating this energy elsewhere (e.g. in the power plant or heating station). As a result, considerable energy and emission reductions can be achieved, providing that there is a need for the quantity of steam produced and over the time period when it is produced. [EUROFER 23-7-18]

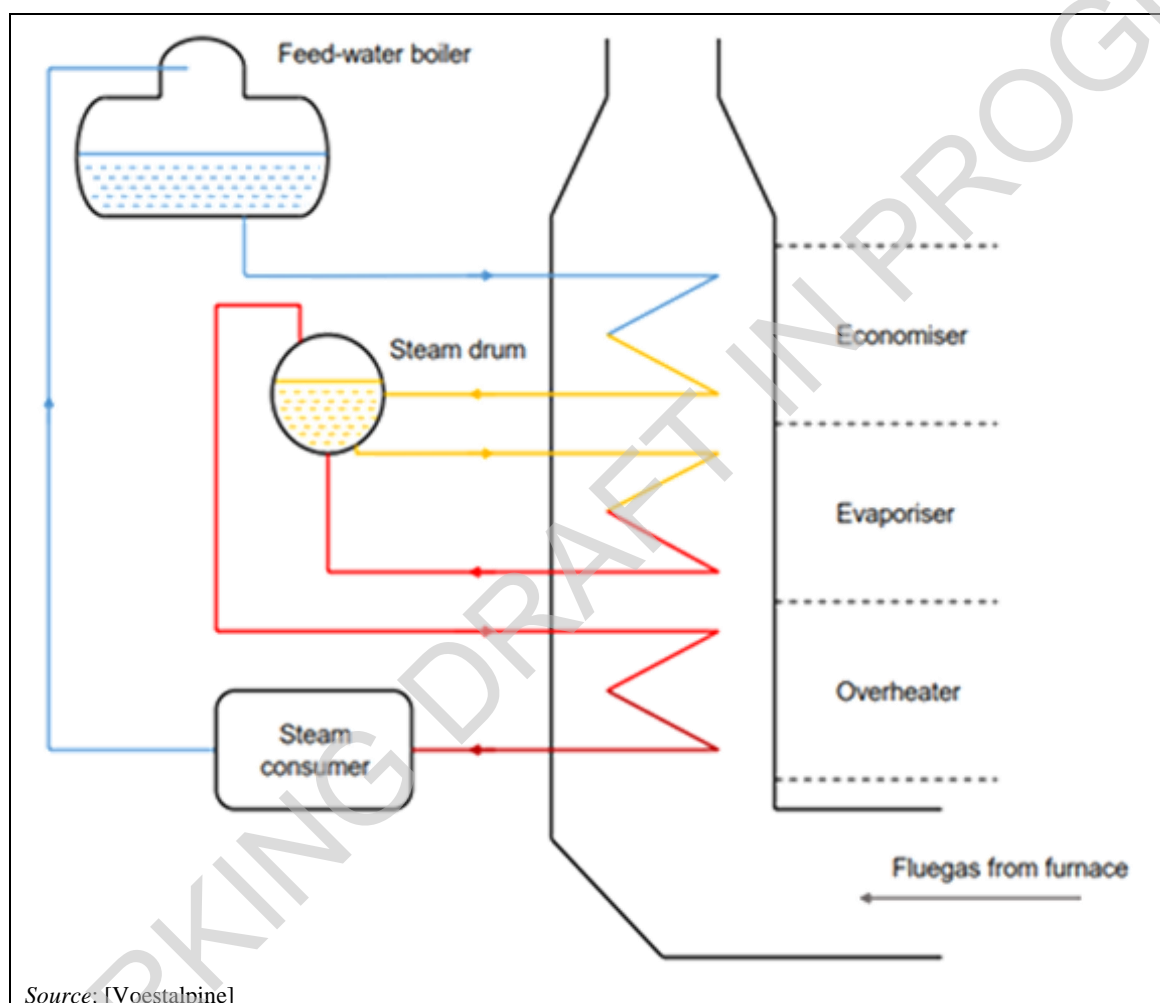


Figure 8.16: Basic schematic of a waste heat recovery boiler

The steam generated can be used within the rolling mill for heating systems or outside the rolling mill to produce electrical energy in the power plants and for municipal long-distance heating systems. [EUROFER HR]

Achieved environmental benefits

- Efficient energy use.
- Saves resources, as no fuel is consumed at other stages for producing the steam and emissions are reduced.

By generating steam, the thermal potential of the waste heat stream can be used to supply other processes in the plant and therefore decrease the overall primary fuel consumption. [EUROFER 23-7-18]

Environmental performance and operational data

TWG, This example is to be deleted and replaced by new information provided by the TWG below.

Example Voest:

| | |
|---|--------------------------------------|
| Steam temperature: | 320 °C |
| Steam pressure: | 18 bar |
| Waste gas temperature behind water heat boiler: | 200 °C |
| Energy recovery: | 0.17 GJ/t (12 % of fuel consumption) |
| Investment costs: | 4.5 M Euro/ heat boiler (65t/h) |

Table 8.3: Typically achievable reductions and cost data for waste heat boilers

| Waste heat boiler | Reduction ¹ [%] | | Investment cost [M ECU] | |
|-------------------|----------------------------|---------------------|-------------------------|---------------------|
| | NOX | Energy ² | New facilities | Existing facilities |
| | 15 | 15 | 4.0 | 4.0 |

Notes: Source of data [EUROFER HR]. Basis is a furnace with a yearly capacity of 1.5 Mt fired with natural gas with standard burners and without air preheat. Investment costs can be site specific (available room, layout of the existing furnace, number of side and bottom burners)

¹ Waste heat boilers have a negligible effect when combined with recuperators or with regenerative systems

² The energy reduction in terms of percentage has an equal effect on the reduction in SO₂, CO and CO₂ emissions

Installation of a waste heat boiler is only sensible when there is a special requirement for steam, i.e. some users. Only a marginal effect can be expected from the installation of a waste heat boiler when it is combined with effective recovery of the waste heat by the use of recuperators or of a regenerative system and with the proper furnace design. [EUROFER HR]

Table 8.4: Operational data of the waste heat recovery boiler at reference plant Voestalpine Stahl GmbH (hot strip rolling mill)

| | |
|---------------------------|--|
| Location | Steam generator producing overheated steam using the exhaust gases from two pusher-type furnaces |
| Steam pressure | 18 bar |
| Steam temperature | 320 °C |
| Capacity | 65 t/h |
| Investment costs: | EUR 4.5 million |
| Energy recovery | (8 % of fuel consumption) |
| Use of steam | Steam network |
| Source: [EUROFER 23-7-18] | |

The steam-generating process is applied between points of high thermodynamic potential. In the hot rolling process, only the heat treatment furnaces provide a sufficient thermal gradient to operate a practical waste heat steam boiler. [EUROFER 23-7-18]

The effectiveness of the waste heat boiler and recuperator decreases when they are installed for the same exhaust gas stream. [EUROFER 23-7-18]

Cross-media effects

None.

Technical considerations relevant to applicability

- New plants.
 - Existing plants, provided required space is available.
- Applicability to existing plants may be restricted by a lack of space.

Economics

With heat recovery systems, fuels can be substituted, which leads to a monetary advantage.

The installation of a waste heat recovery boiler is only practical when there is a significant and continuous demand for steam. In an integrated steel plant, there is mostly a surplus of heat and a fast amortisation of the investment cannot be expected.

Investment costs depend on the heat capacity, location and accessibility of the furnaces, the type of steam requirements and the existing steam network. Long distances to the purchaser or the steam network significantly increase the investment and maintenance costs for transportation.

Additional expenses for maintenance, process control and operating costs must be taken into account. Possible further costs may be needed for the transport of steam to users (if not already available). [EUROFER 23-7-18]

Driving force for implementation

- ~~reduced energy consumption, monetary advantage.~~

Energy savings.

Example plants

- ~~Voest Alpine (2 boilers), Svenskt Stål AB~~

Voestalpine Stahl GmbH hot strip rolling mill.

Reference literature

[EUROFER 23-7-18] [EUROFER HR]

8.5.4.6 Organic Rankine Cycle (ORC) system

TWG, This is a new section based on information provided by the TWG.

Description

Low-grade heat is converted into electricity using high-molecular-weight fluids.

Technical description

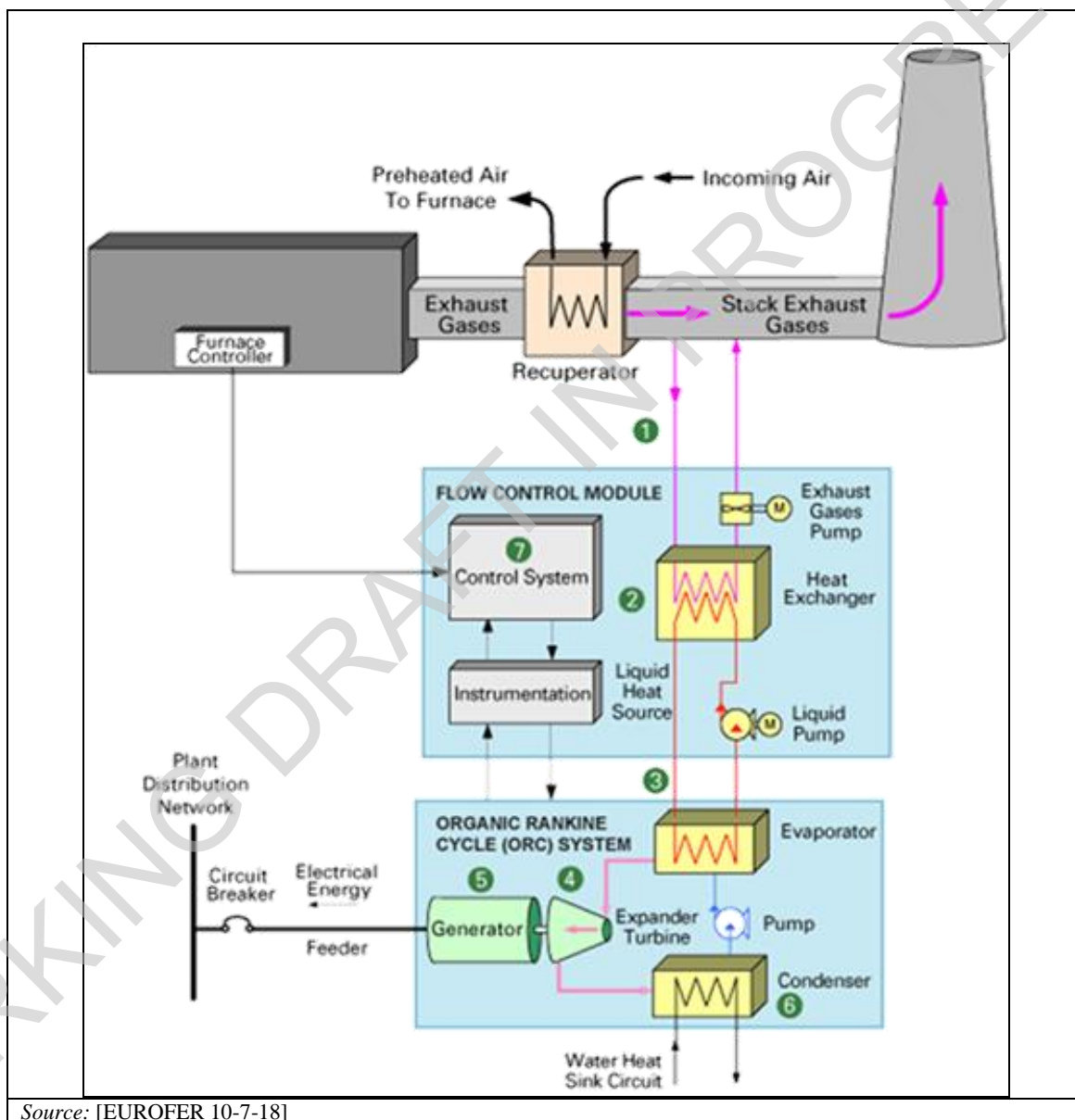
In a conventional Rankine Cycle, a working fluid (usually water) is heated to saturation in a boiler, the water vapour expands through a turbine while producing work, returns to the liquid state in a condenser, and is pumped back into the boiler to repeat the cycle.

In an Organic Rankine Cycle (ORC), high-molecular-mass organic fluids are used instead of water as the working fluid. In general, the types of working fluids used are siloxanes or hydrocarbons. These fluids exhibit much lower boiling points than water. The working fluid is vaporised in a heat exchanger using the heat from waste flue-gases. The working fluid changes into a gaseous state and expands in a turbine directly connected to a generator to produce electricity. The working fluid is condensed in a water-cooled condenser and pumped back to the heat exchanger. ORC are used to generate electrical power using low- to medium-temperature heat sources (e.g. low-grade heat), typically in the range of 80 °C to 350 °C.

The process to capture the waste heat and generate electrical power in an ORC system is depicted in Figure 8.17. The different steps are: [EUROFER 10-7-18]

- hot exhaust gases are passed through the heat exchanger;
- in the heat exchanger, heat is transferred from the hot exhaust gases to the organic working fluid such as silicone oil (hexamethyldisiloxane), hydrocarbons or fluorinated refrigerants [Foresti, 2015];
- the hot working fluid is pumped to the heat recovery evaporator in the ORC system;

- the working fluid is boiled in the ORC evaporator and fed to an expander turbine which drives the electrical generator;
- the turbine generator generates electrical power which is fed to the plant distribution network;
- the exhaust refrigerant is condensed using plant water as a heat sink and pumped back to the evaporator to repeat the cycle;
- the master controller monitors all the relevant parameters and variables of the ORC process including flow, pressure, temperature and electrical power, but also controls the variable speed pumps for optimum thermal efficiency.



Source: [EUROFER 10-7-18]

Figure 8.17: Schematic of an Organic Rankine Cycle

Achieved environmental benefits

- Efficient energy use.
- Saves resources, as no fuel is consumed at other stages for producing the steam and emissions are reduced.

Environmental performance and operational data

A total of 1.44 million kWh per year of electrical energy are produced at NatSteel rolling mill reheating furnace in Singapore after the installation of an ORC plant with a 700 kW nominal capacity. [Wong, 2013]

Cross-media effects

None identified.

Technical considerations relevant to applicability

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

Economics

Globally, a potential recovery of 310 MW of energy was estimated if ORC plants were installed at 209 rolling mills across the EU-27. [Campana, 2013]

At NatSteel rolling mill plant reheating furnace, the ORC plant installation costs were USD 3.7 million with net annualised energy savings ranging between USD 650 000 and USD 750 000 per year. [Wong, 2013]

Driving force for implementation

- Increased energy efficiency.
- Supply of electricity to the plant distribution network.

Example plants

Voestalpine (two boilers), Svenskt Stål AB.

NatSteel rolling mill reheating furnace in Singapore. [Foresti, 2015] [Wong, 2013]

Reference literature

[EUROFER 10-7-18]

[Campana, 2013]

Campana, F., Bianchi, M., Branchini, L., De Pascale, A., Peretto, A., Baresi, M., Fermi, A., Rossetti, N., Vescoso, R., 2013. ORC waste heat recovery in European energy intensive industries: Energy and GHG savings. *Energy Conversion and Manage* 76, 244-252.

[Foresti, 2015]

Foresti, A., Archetti, A., April 2015. Energy efficient electric steelmaking. In *Steel Times Magazine*, 49-51.

[Wong, 2013]

Wong, E., 2013. Organic Rankine Cycle (ORC) waste heat recovery system at rolling mill reheating furnace. Technical presentation at the 2013 National Energy Efficiency Conference, October 9-10, Singapore.

8.6 Material efficiency

8.6.1 Techniques to increase material efficiency in degreasing

8.6.1.1 ~~Minimisation of oil and grease input~~ Use of feedstock with low oil and grease contamination

Description

The use of feedstock with low oil and grease contamination prolongs the lifetime of the degreasing solution.

Technical description

Customers of galvanising plants are informed ~~should be persuaded~~ to oil and grease their items as little as possible. Reducing the oil/grease input is a cheap, easy and effective technique ~~measure~~ to prolong the lifetime of degreasing baths and thus reduce the amount of waste generated (spent bath and oily sludge).

Achieved environmental benefits

- ~~Reduced spent degreasing baths~~ Increased material efficiency.
- Reduced waste water and sludge.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

~~New and existing plants~~. The influence of the ~~galvanizer~~ plant on the state of the input material may be limited in job galvanising.

Economics

TWG, please provide information.

Driving force for implementation

Reduced costs due to increased material efficiency.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

8.6.1.2 Use of a direct-flame furnace in the case of hot dip coating of steel sheets

Description

The oil on the surface of the steel sheet is burnt in a direct-flame furnace. Degreasing before the furnace may be necessary for some high-quality products or in the case of steel sheets with high residual oil levels.

Technical description

Annealing furnaces on galvanising lines equipped with a DFF (direct-flame furnace) have the additional function of cleaning the strip of surface contaminants (this occurs in the DFF section). In this specific furnace configuration, most of the heating occurs in the DFF where the

gas is a mixture of natural gas and air with a super-stoichiometric air/gas ratio ($\text{Lambda} < 1$). The gas burners in the DFF are normally arranged asymmetrically to ensure uniform heating of the strip surface (See Figure 8.18). The strip enters the DFF at room temperature or higher if there is a preheating section (normally preheating is achieved by counter flow of combustion fumes) and exits the DFF at temperatures in the range of 500–800 °C.

In summary:

- carbon residues are burnt (atmosphere even oxidising for iron);
- chemical degreasing can be used to ensure constant surface carbon; variable surface carbon may change the Fe oxidation kinetic, affecting the emissivity differently, and so the way the furnace is operating.

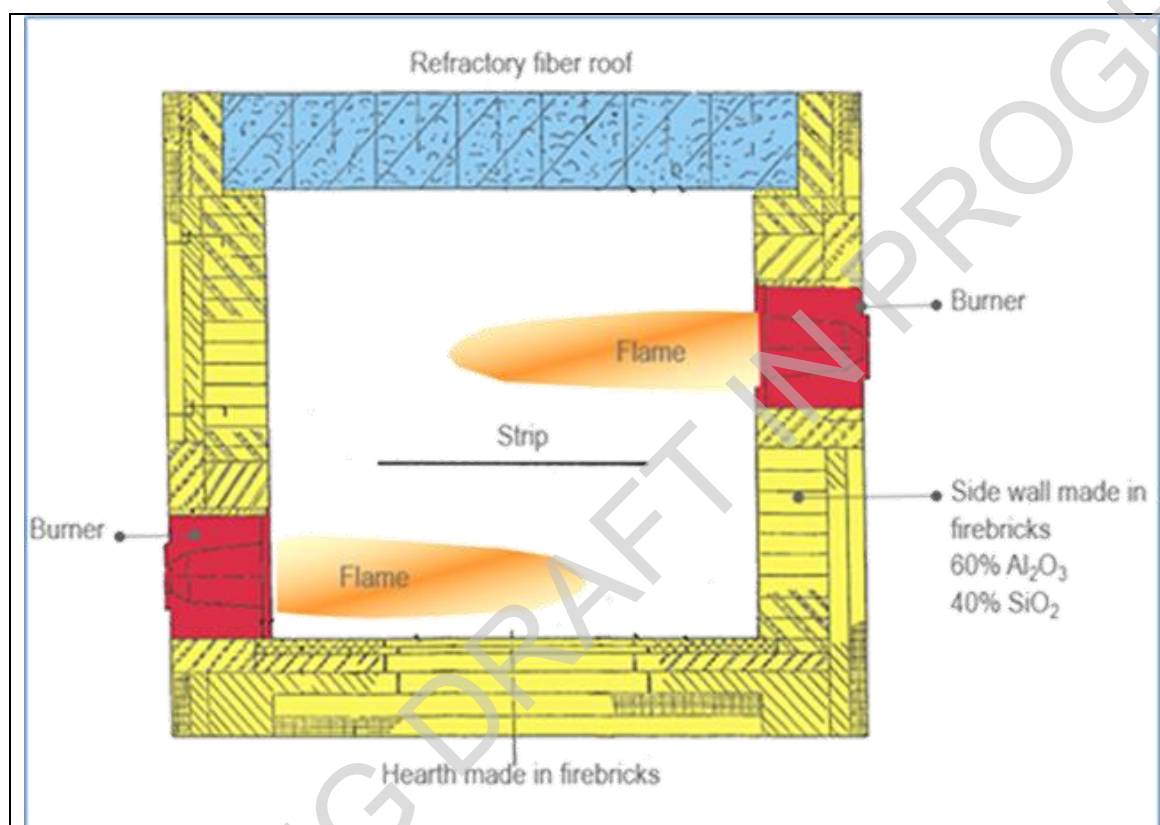


Figure 8.18: Schematic of a direct-flame furnace

Achieved environmental benefits

- No emissions to water [Com-CC-2].
- No generation of waste [Com-CC-2].

Environmental performance and operational data

In some cases, it might still be necessary to have a degreasing section before the furnace for some high-quality appliances or in the case of incoming coils with a high residual level of oil. The furnace is not as easy to control as a radiant tube furnace. Fumes from the furnace are normally used to preheat incoming gas and combustion air with a dedicated heat exchanger. [Com-CC-2]

Cross-media effects

Emissions to air through the burning of oil [Com-CC-2].

Technical considerations relevant to applicability

~~New and existing installations.~~ Only applicable to new plants and major plant upgrades.

- ~~When requirements for surface cleanliness and zinc adhesion are not very high).~~ [Com-CC-2]

Economics

Investment and operating costs are reduced because there is no need for preceding sections. [Com E]

~~It is cheap to operate and install.~~ [Com-CC-2]

Driving force for implementation

Cost (see economics above).

Example plants

- Galtec 1 [Com-CC-2].
- Voestalpine Stahl GmbH HDC line 1 (HDC line 2-5 include also an alkaline degreasing section).
- ArcelorMittal: Piombino 4, Aviles 1, Krakow HDG2, Montataire HDGs.

Reference literature

[Com-CC-2]

8.6.1.3 General techniques for increased degreasing efficiency**Description**

This includes techniques such as:

- monitoring and optimising the temperature and the concentration of degreasing agents in the solution;
- enhancing the interaction of the degreasing solution with the feedstock (e.g. by moving the feedstock, agitating the degreasing solution or by using ultrasound to create cavitation of the solution on the surface to be degreased).

Technical description

~~General measure to control degreasing bath operations by~~ Monitoring of bath parameters such as temperature and concentration of degreasing agent can be used for optimising degreasing activities and thus make efficient use of the degreasing bath. Furthermore, degreasing efficiency can be improved by enhancing the contact of liquor and workpiece: e.g. by moving the workpiece, by moving the bath (agitation) or by using ultrasound.

Achieved environmental benefits

- ~~Reduced spent degreasing baths.~~ Increased material efficiency.
- Reduced waste water and sludge.

Environmental performance and operational data

Plants 166, 167 and 168 report analysing the degreasing bath parameters every month. [FMP data collection 2018]

Cross-media effects

Increased energy consumption for moving the feedstock, agitating the solution or ultrasonic cleaning.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Reduced costs due to increased material efficiency.

Example plants

Plants 166, 167 and 168 in the FMP data collection.

Reference literature

[FMP data collection 2018]

8.6.1.4 Minimisation of carry-over of degreasing solution

Description

This includes techniques such as:

- using squeeze rolls (see Section 5.4.1.3.3);
- slow lifting of workpieces to allow for a sufficient dripping time (see Section 6.4.1.1).

8.6.1.5 Reverse cascade degreasing in the case of continuous degreasing

Description

Degreasing is carried out in two or more steps in series where the flow of degreasing solution is countercurrent to the feedstock flow.

More information on the technique

See Sections 3.4.3.1 and 5.4.1.3.1.

8.6.1.6 Cleaning and reuse of the degreasing solution

Description

Physical treatment (e.g. magnetic separation, oil separation, micro- or ultrafiltration) or biological treatment is used to clean the degreasing solution for reuse.

Technical description

High oil contents make degreasing solutions unusable and cleaning measures are applied to extend the lifetime of the bath using different types of cleaning circuits employing mechanical cleaning, magnetic separators/filters, adsorption of surfactants and oils, membrane filtration.

Mechanical cleaning

Usually the emulsions of degreasing agents and oil/grease from the metal surface are unstable and after some time they float on the surface of the bath in calm areas. Calm areas can be achieved by special design features of the degreasing tank or if this is not possible, e.g. when the degreasing solution is sprayed, by introducing a special calm tank where the solution can settle. The floating oil and grease can be removed by **skimmers, discharge launders, weirs** etc.

With these measures, simply using natural gravity (separating time: a couple of hours), the lifetime of degreasing baths can be prolonged by two or four times. Sludge withdrawn contains oils, grease, degreasing agent, scale, rust, dust, etc. and is usually disposed of. [ABAG] [Fichtner]

Separation is more effective using **centrifuge separators** or hydrocyclones, which split the oil and water phases within seconds. Very small oil and grease drops are separated more easily; the oil-rich part contains only 5–10 % water and unwanted carry-over of degreasing chemicals is prevented. The lifetime of the baths can be prolonged by up to 16 times. [ABAG]

Magnetic separators/filters

Magnetic separators can be used to remove the mixture of iron fines and oil from degreasing baths.

Membrane filtration

In **micro- and ultrafiltration** (see also Figure 8.65) the degreasing bath is pumped through membranes (at a pressure of 3–8 bar) in which oil, grease and spent surfactants are held back due to the size of the molecules. To protect the membranes, the degreasing liquid is usually cleaned from particles in a settling tank or by other means first. Micro- and ultrafiltration increase the lifetime of the bath by 10 to 20 times. [ABAG]

Figure 8.19 shows the flow sheet of such a filtration plant; in regular production the degreasing liquid is pumped out of the bath into a standard plate filter where all solid particles are removed. The filtrate then goes on to a storage vessel, also known as a circulation vessel. The vessel contains the concentrated degreasing solution. [Sprang-IG-97]

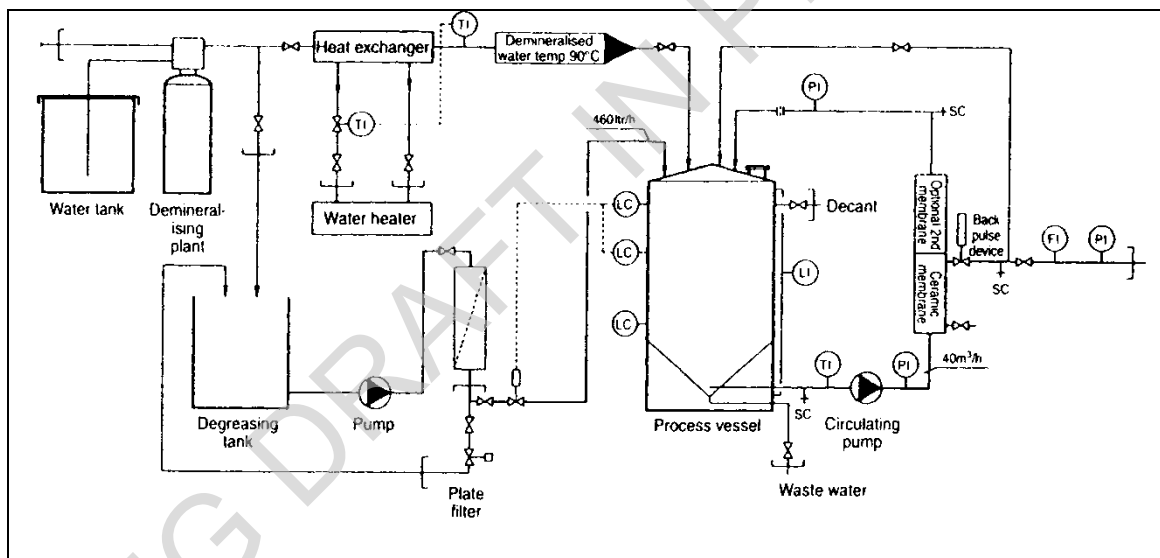


Figure 8.19: Example flowsheet for ceramic filtration of degreasing solution
[Sprang-IG-97]

A second pump forces degreasing solution through the membrane section at high speed and pressure (approximately 2.5 bar). The free oil and oil dissolved by the surfactant are filtered out by the membrane while the clear liquid and free surfactants flow through it and back into the degreasing bath. Thus, any oil that forms is removed during the course of normal production. Liquid circulates through the storage vessel and concentrates over time. When the oil concentration is high enough the unit is turned off and the liquid (oil and water) in the storage vessel allowed to settle. After a period of time, a two-stage process takes place; the oil is separated from the water phase and, to recycle the active surfactants, a thermal treatment is employed in the second stage. This thermal treatment causes the surfactant to release the oil trapped in it and to separate into two phases. Separation is highly effective and high-grade oil is recovered. [Sprang-IG-97]

Achieved environmental benefits

- Reduced spent degreasing baths. Increased material efficiency.

- Reduced waste water and sludge.

Environmental performance and operational data

Table 8.5 presents input/output data and effluent data for degreasing solution cycle of a continuous annealing line, which is maintained by cleaning via **ultrafiltration**.

Table 8.5: Operational and effluent data for degreasing bath cleaning by ultrafiltration

| Input / Consumption Level | | | | |
|--|-------------------------|------------------------------------|------------------------------------|-----------------------|
| Degreasing solution | | 50 - 60 | | kg/t |
| Demineralised water | | 0.3 - 0.4 | | kg/t |
| Degreaser | | 0.04 - 0.05 | | kg/t |
| Tempering fluid concentrate | | 0.15 - 0.2 | | kg/t |
| Electrical energy | | 4 -5 | | MJ/t |
| Output / Emission Level | | | | |
| Cleaned degreasing solution | | 40 - 50 | | kg/t |
| Sludge | | 0.4 - 0.5 | | kg/t |
| | Concentration [mg/l] | Specific Emission [g/t product] | Reduction rate ¹ [%] | Method of analysis |
| Suspended solids (filterable) | 20 - 40 | 2.35 - 4.7 E -4 | > 90 | DIN 38409-H2 |
| Σ Hydrocarbons (oil, grease) | 5 - 8 | 5.9 - 9.4 E -5 | > 90 | DIN 38409-H18 |
| Fe total | 1 -2 | 1.2 - 2.4 E -5 | > 90 | DIN 38406 |
| Temperature | 30 °C | NI | NI | Thermometer |
| pH | 6.5 - 9.5 | NI | NI | NI |
| Source of data [EUROFER CR]. Data based on weekly, volume proportional 24-h sampling | | | | |
| ¹ Based on mass flow of constituent | | | | |
| NB: NI = No information provided. | | | | |

All techniques described above to prolong the lifetime of degreasing baths can be used in the case of alkaline or acidic degreasing baths, but the efficiency in acidic degreasing baths is reduced due to the more stable emulsions formed- [ABAG]

Cross-media effects

Increase in energy consumption when using centrifuges, micro- or ultrafiltration.

Oil and grease arise as waste in the cleaning of degreasing solutions. This waste may be used for energy recovery or has to be disposed of by incineration.

Technical considerations relevant to applicability

~~New and existing plants:~~ Generally, there are no technical restrictions to the applicability of this technique.

The membranes (pore size) have to be adjusted to the characteristic of the degreasing bath and have to match the cleaning requirements for each individual bath. With the ever changing conditions usually observed in job galvanising (i.e. variations in contents, surfactants, oils, grease etc.), operational problems occur, like clogging, fouling and damage to the membrane. [ABAG] Appropriate membranes and specific bath chemistry have yet to be developed to allow application in batch hot dip galvanising. [Com2 D]

TWG, please provide updated cost information.

Economics

The investment costs for micro-/ultrafiltration with the appropriate capacity for galvanising plants are estimated at 80000 to 100000 DM. [ABAG]

Driving force for implementation

Reduced costs due to increased material efficiency.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[ABAG] [Com2 D] [Fichtner] [FMP data collection 2018] [Sprang-IG-97]

8.6.2 Techniques to increase material efficiency in pickling**8.6.2.1 Acid heating with heat exchangers or by submerged combustion****Description**

The direct injection of steam to heat the pickling acid is avoided. Acid heating is carried out with heat exchangers or by submerged combustion:

- Corrosion-resistant heat exchangers are immersed in the pickling acid for indirect heating with steam;
- Combustion gases pass through the pickling acid, releasing the energy via direct heat transfer.

Technical description

Heating of process liquors may be necessary at several stages in ferrous metals processing, e.g. for heating acid baths, for emulsion splitting or for reducing/evaporating waste water. In principle two techniques are available: **heat exchangers** and **submerged combustion** (immersion gas burner). The formerly applied technique of steam injection (e.g. for heating acid baths), is not considered here as it leads to unnecessary dilution of process baths. The principles of both, heat exchanger and submerged combustion, are shown in Figure 8.20 and Figure 8.21.

In heat exchangers the heating media and the liquid to be heated are separated by a partition and no mixing (or contamination) takes place. With immersion gas burners the heating media, hot flue-gas, is blown directly into the liquid to be heated and both are mixed. Either heating technique has advantages and disadvantages and application depends to some extent on the individual situation of a plant.

Where waste heat is available in the form of steam or in the form of another heating medium with a lower temperature, heat exchangers are commonly used. Several designs of heat exchangers exist, tube or plate, and depending on the chemical properties of the product to be heated and/or the heating media, high quality material has to be used. Heat exchangers need large surfaces to achieve the heat transfer.

If fuel gas is readily available or steam has to be produced first, it might be sensible to use a burner to heat the liquid directly and thus increase the thermal efficiency. Disadvantages are that the product may be contaminated with CO₂, SO₂, NO_x etc., which could cause problems, and that portions of the product (e.g. acid vapour, droplets) may be carried out with the flue-gas, making a waste gas treatment necessary. [VOEST]

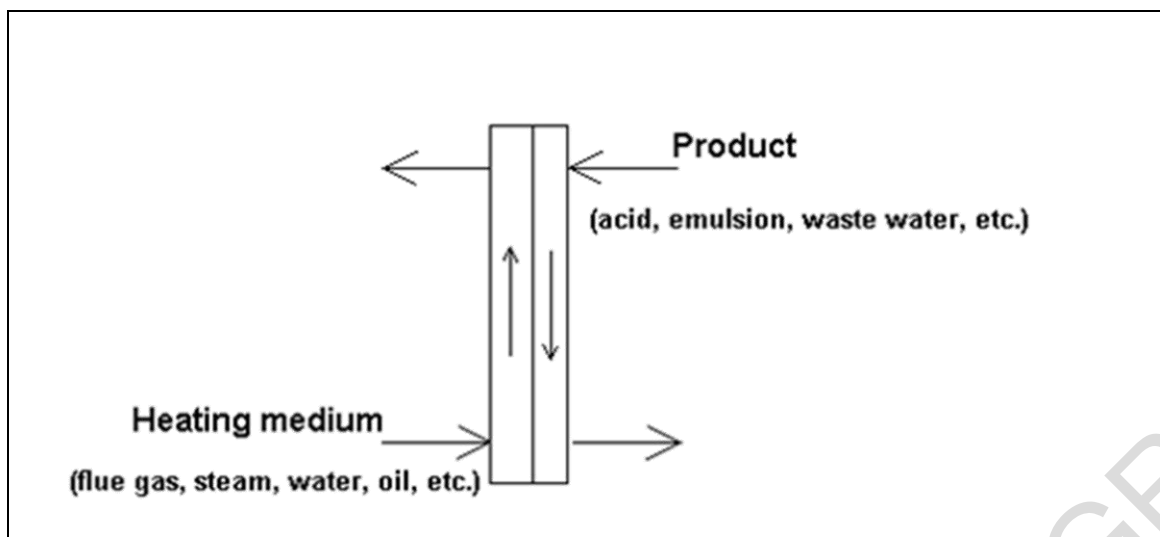


Figure 8.20: Principle of heat exchangers
[VOEST]

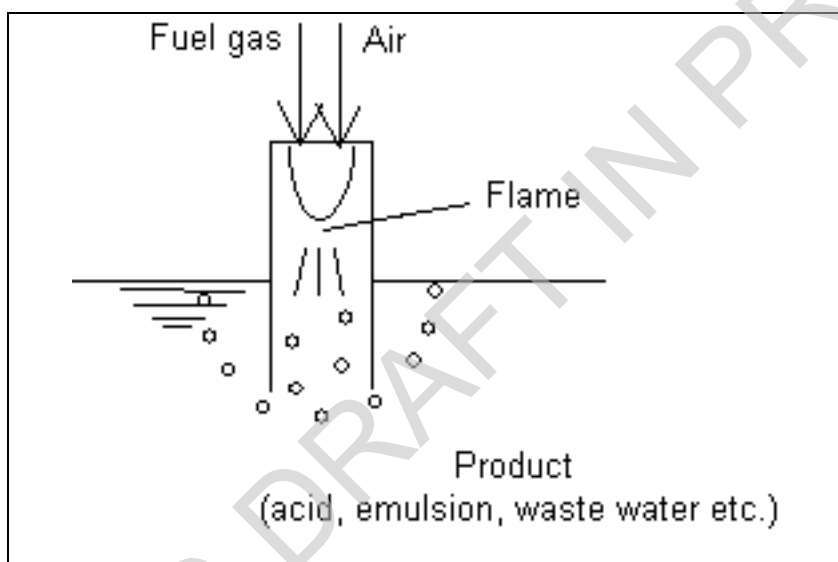


Figure 8.21: Principle of submerged combustion
[VOEST]

Some advantages of submerged combustion were reported, beside financial savings, reduced energy consumption and acid consumption were claimed.

Achieved environmental benefits

Increased material efficiency.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

- Savings in acid consumption.
- Increased effectiveness of pickling operations.

Example plants

Widely used.

Reference literature

[VOEST]

8.6.2.2 Minimisation of steel corrosion

Description

This includes techniques such as:

- cooling the hot rolled steel as fast as possible depending on product quality requirements or specifications;
- storing the feedstock in roofed areas;
- limiting the storage duration of the feedstock.

Technical description

General techniques are employed to minimise steel corrosion of the hot rolled product and reduce or avoid the need for pickling. Indeed, the acid consumption during pickling is proportional to the amount of iron oxide removed from the steel surface. These techniques include the following:

- Reduction of iron oxide formation during hot rolling and steel handling (e.g. by high-pressure descaling, fast cooling).
- Short storage time of the feedstock in corrosion-free storage areas.
- The acid consumption during pickling is proportional to the amount of iron oxide removed from the steel surface. Although the potential for a reduction in oxide formation is limited, control of the cooling rate can modify the structure of the scale. This can influence the pickling speed and thus reduce energy consumption for the process. Fast cooling of the hot rolled strip may be limited however for quality reasons.

Achieved environmental benefits

Reduce the generation of spent pickling acid.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

Reduced costs due to increased material efficiency.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

8.6.2.3 Mechanical (pre-)descaling**Description**

This includes techniques such as:

- shot blasting;
- bending;
- sanding;
- brushing;
- stretching and levelling.

Technical description

Mechanical (pre-)descaling techniques, like shot blasting, stretcher leveller, temper mill or leveller, are used to break and remove the major portion of the hot rolling scale. As the amount of iron oxide that has to be removed from the steel surface in the chemical pickling section is reduced, the acid consumption is reduced. Mechanical descaling facilities are equipped with extraction systems and abatement devices (generally fabric filters) to control the release of particulate material.

Achieved environmental benefits

Reduction of acid consumption.

Environmental performance and operational data

Table 8.6: Dust emission levels achieved at shot blasting units using fabric filters

| | Concentration [mg/Nm ³] | Specific Emission [kg/t product] | Reduction rate ¹ [%] | Waste Gas Volume | Method of analysis |
|---|--|-------------------------------------|------------------------------------|--|-----------------------|
| Example A: shot blasting unit of stainless steel plant | | | | | |
| Dust | 15 – 25 ¹ | 0.01 - 0.02 | > 95 | 350 – 450 m ³ /t | BS 3405 |
| Cr, Mn, Ni | reliably below the limit of 5 mg/m ³ ² | NI | NI | NI | NI |
| Example B: shot blasting unit of the annealing and pickling line for hot rolled steelbands | | | | | |
| | 4.5/≤1/2.6 NI | NI | NI | 13 800/15 200/18 200 Nm ³ /h | NI |
| Note: example B [FIN 28.3] ¹ [CITEPA] reports below 20 mg/m ³ for V=135 000 m ³ /h and max capacity of 225 t/h. ² Source of data [Met-Plant-Int-1-94] NI = No information provided. Source: [EUROFER 23-7-18] [CITEPA] [FIN 28.3] | | | | | |

- Due to increased effectiveness of the pickling operations, pickling bath temperatures can be lowered, resulting in lower evaporation losses. Reducing the loading on the acid pickling and hence the consumption of acids decreases the generation of acidic wastes.
- Mechanical descaling for stainless steel grades can only be applied prior to the initial pickling step. In later pickling steps this would influence the surface quality of the finished product.

Cross-media effects

- Increased energy consumption.
- Generation of particulate emissions which have to be captured and abated.
- Generation of waste (filter dust).

Technical considerations relevant to applicability

~~New plants and with limitations due to available space for existing plants.~~

- In existing plants, there may be a lack of space.
- Applicability may be restricted due to product quality requirements or specifications.

Economics

TWG, please provide information.

Driving force for implementation

- Savings in acid consumption.
- Increased effectiveness of pickling operations.

Example plants

Thyssen Stahl, Krefeld, Germany (horizontal shot blasting for hot and cold strip, fabric filter).
[Met-Plant-Int-1-94]

Reference literature

[Met-Plant-Int-1-94] [CITEPA][EUROFER CR] [FIN 28.3]

8.6.2.4 Electrolytic prepickling for high-alloy steel**Description**

Use of an aqueous solution of sodium sulphate (Na_2SO_4) to pretreat high-alloy steel before pickling with mixed acid, in order to speed up and improve the removal of the surface oxide scale. The waste water containing hexavalent chromium is treated by chemical reduction (see Section 8.9.4).

Technical description

In the production of stainless steel, electrolytic pre-pickling with a neutral electrolytic solution of sodium sulphate (Na_2SO_4) is used as a pre-processing technique, at a maximum processing temperature of 80 °C, prior to mixed acid pickling (with HF/HNO_3) in order to speed up the removal of the surface oxide scale which develops during annealing. This process provides fast pickling rates and reduces over-pickling. [Ipek, 2005]

~~Pre pickling is done in an initial neutral electrolyse tank using an aqueous solution of sodium sulphate (Na_2SO_4), at a maximum processing temperature of 80 °C, prior to the mixed acid baths.~~

Other developments include alkaline electrolytic pre-pickling in combination with neutral pre-pickling and acidic pickling / acidic electrolysis. [Hitachi]

Achieved environmental benefits

- Reduction of the load on the mixed acid pickling line and hence a reduction in NOX and nitrate releases.
- Wet scrubbing techniques using packed towers are generally employed to reduce the emissions to air from pre-pickling facilities.

Environmental performance and operational data

Electrolytic pre-pickling facilities are fully sealed; fumes are extracted and led to a scrubber unit before release. [Hitachi]

During the pickling process, insoluble salts and metallics are formed and must be removed from the electrolytic sodium sulphate solution to maintain proper operation. Accordingly, a small side stream of the electrolyte is cleaned. Particulates in the solution are removed in inclined plate clarifiers by gravity settling. The clarified solution is returned to the electrolysis tank while the sludge stream is sent to a chromium reduction unit.

Cross-media effects

Emissions to air and to water.

Technical considerations relevant to applicability

~~New pickling lines and existing in case of major revamps provided sufficient space is available.~~

- Only applicable to cold rolling.
- In existing plants, there may be a lack of space.

Economics

TWG, please provide information.

Driving force for implementation

Reduction of pickling time at the mixed acid pickling line.

Example plants

Allegheny Ludlum, USA

Reference literature

[Ipek, 2005]

N. Ipek, B. Hol., R. Pettersson, G. Runnsjo, M. Karlsson, 2005. Electrolytic pickling of duplex stainless steel. *Materials and Corrosion* 56, 521 – 532.

8.6.2.5 Rinsing after degreasing

Description

Carry-over of degreasing solution to the pickling solution is reduced by rinsing feedstock after degreasing.

Technical description

The amount of solution carried out of degreasing baths and into the following pickling process can be minimised by allowing enough time for the solution to drip off, but especially by implementing a rinse step ~~(more detailed information on rinsing see Chapter C.4.4).~~

Achieved environmental benefits

- ~~Reduced consumption of degreasing solution.~~
~~Prolonged lifespan of pickling baths, thus reduced acid consumption.~~ Reduction of the generation of spent pickling acid.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

Generation of waste water.

Technical considerations relevant to applicability

~~New plants and existing plants.~~ In existing plants, there may be a lack of space.

Economics

TWG, please provide information.

Driving force for implementation

Reduced costs due to increased material efficiency.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

8.6.2.6 General techniques for increased pickling efficiency**Description**

These include techniques such as:

- optimisation of pickling temperature for maximising pickling rates while minimising emissions of acids;
- optimisation of the pickling bath composition (e.g. acid and iron concentrations);
- optimisation of the pickling time to avoid over-pickling;
- avoiding drastic changes in the pickling bath composition by frequently replenishing it with fresh acid.

Technical description

From ex-Sections A.4.2.2.1 and C.4.3.1.

~~Reduction of~~ The acid concentration can be reduced by using high pickling temperatures. ~~Although a balance has to be reached between acid concentration and pickling temperature. The optimum is a function of acid losses, pickling efficiency and energy consumption. Increasing the pickling temperature leads to a rise in NOX generation for stainless steel pickling and therefore avoiding excessive NOX formation needs to be considered in the balance.~~

The pickling efficiency, and thereby the necessary pickling time, changes during the lifetime of the bath. As the bath gets older, the iron concentration increases significantly ~~quite a lot~~, and less free acid is needed to keep the same pickling velocity as initially. Drastic changes in the pickle liquor, e.g. by replacing large volumes of the bath, may lead to unknown pickle conditions which may result in over-pickling. Discharge of spent pickle liquor and addition of fresh acid in more frequent but small doses avoids drastic changes in bath characteristics and allows for smooth operation.

Achieved environmental benefits

- ~~Reduced acid consumption.~~ Reduction of the generation of spent pickling acid.
- Less over-pickling (associated with less waste).

Environmental performance and operational data

Careful monitoring of bath parameters (acid concentration, iron content etc.), can help in optimising the operation ~~by raising the awareness of changes in the bath and allowing for changed operating procedures, such as~~, e.g. by shortening the pickling time to avoid over-pickling.

Cross-media effects

None.

Technical considerations relevant to applicability

~~New and existing installations.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Reduced costs due to increased material efficiency.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

8.6.2.7 Cleaning and reuse of pickling acid

Description

A cleaning circuit, e.g. with filtration, is used to clean the pickling acid for reuse.

Technical description

Side-stream mechanical filtering, acid recovery and internal recycling can be used for cleaning and extending the lifetime of the pickling liquor. The liquor is filtered, e.g. in deep bed media filters, to remove particulates. Cooling of the acid by means of heat exchangers might be necessary prior to the adsorption unit in which a physico-chemical adsorbent (like a resin) removes free acid from the waste stream. Once the unit is saturated, the free acid is desorbed by a fresh water stream and recycled to the pickling process.

Achieved environmental benefits

Reduced acid consumption (waste water volume and sludge).

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

Increased energy consumption.

Technical considerations relevant to applicability

• ~~New and existing plants.~~

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

Economics

TWG, please provide information.

Driving force for implementation

Reduced consumption of pickling acid.

Example plants

Allegheny Ludlum, USA.

Reference literature

TWG, please provide information.

8.6.2.8 Reverse cascade pickling

Description

Pickling is carried out in two or more baths in series where the pickling acid flow is countercurrent to the feedstock flow.

Technical description

Cascade pickling is performed in two or more baths in series. The acid flows (continuously or discontinuously) countercurrently from one bath to the next. This allows a very efficient use of the acid while still achieving good pickling quality. [CET-BAT]

Achieved environmental benefits

- Reduced consumption of fresh acid.
- Reduced spent acid (waste).

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

- ~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.
- In existing plants, there may be a lack of space.

Economics

Costs include:

- larger building, including larger acid-proof floor surface and larger secondary containment;
- extra tank, circulation pump, and possibly extra exhaust system;
- more complex process control software for follow-up of pickling bath composition and level;
- often, different types of wire rod require different contact times; if this is the case, specific process control software for scheduling and follow-up of the movements of the different rolls is also required.

Estimation: EUR 0.2–0.4 million depending on capacity.

Driving force for implementation

Reduced consumption of pickling acid.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[CET-BAT]

8.6.2.9 Minimisation of carry-over of pickling acid

Description

This includes techniques such as:

- using squeeze rolls;
- slow lifting of workpieces to allow for a sufficient dripping time;
- vibrating wire rod coils.

Technical description

Minimising carry-over requires sufficient time for the acid to drip off the wire rod coils. This can be done by lifting the wire rod coil slowly from the last acid bath of the cascade and then allowing several seconds of dripping time above the acid bath before moving the wire rod coil to the first bath of the rinsing cascade. Dripping off can be enhanced for example by vibrating the wire rod coil.

Achieved environmental benefits

- Reduced ~~carry-out of acid~~, reduced fresh acid consumption.
- Reduced spent acid (waste).
- Reduced pickling loss.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

Energy needed for squeeze rolls and vibrating wire rod coils.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Reduced consumption of pickling acid.

Example plants

Reduced consumption of pickling acid.

Reference literature

TWG, please provide information.

8.6.2.10 Turbulence pickling

Description

This includes techniques such as:

- injection of the pickling acid at high pressure via nozzles;
- agitation of the pickling acid using an immersed turbine.

More information on the technique

See Sections 3.4.1.2 and 6.4.2.1.

8.6.2.11 Use of pickling inhibitors

Description

Pickling inhibitors are added to the pickling acid to protect clean metallic parts of the feedstock from over-pickling.

Technical description

To protect parts of the workpieces from over-pickling, pickling inhibitors are added to the pickling solution.

Achieved environmental benefits

- Reduced acid consumption.
- Less waste acid.

Environmental performance and operational data

~~Estimated reduction in acid consumption 10–20 %. [EGGA8/99]~~

Pickling inhibitors can reduce the material loss of the workpieces by up to 98 % and can reduce acid consumption by 10–20 %. [EGGA8/99]

However, these organic inhibitors could have a negative influence on subsequent acid recycling processes and reducing acid consumption by use of pickling inhibitors should be considered carefully. Inhibitors can also have a detrimental effect on the surface quality (due to the formation of rust). [ABAG]

Cross-media effects

Some pickling inhibitors may reduce the recycling options for waste acid.

Technical considerations relevant to applicability

~~New and existing installations.~~

~~Reduction of acid consumption and regeneration costs by adding adequate chemicals (inhibitors) for pickling of low alloy and alloy steel~~

- Not applicable to high-alloy steel.
- Applicability may be restricted due to product quality requirements or specifications.

Economics

~~Positive,~~ Cost savings. [EGGA7/99]

Driving force for implementation

- Enhanced quality of product.
- Reduced operational costs.

Example plants

The vast majority (> 90 %) of all batch galvanising plants ~~galvanisers~~ use pickling inhibitors. [EGGA8/99]

Reference literature

[ABAG] [EGGA7/99] [EGGA8/99]

8.6.2.12 Activated pickling with hydrochloric acid

Description

Pickling is carried out with a low hydrochloric acid concentration (i.e. around 4–6 wt-%), a high iron concentration (i.e. around 120–180 g/l), at temperatures of 20–25 °C.

Technical description

Pickling in hydrochloric acid with a low acid percentage and high iron content is referred to as activated pickling. For pickling steel with hydrochloric acid, the acid content is normally 10–12 % in order to achieve a reasonably quick pickling. However, at this acid percentage, the formation of hydrogen chloride is rather high. When using activated pickling, the acid percentage may be halved without affecting the pickling rate negatively, provided that the iron concentration is kept within 120–180 g/l. The temperature of the pickling bath needs to be maintained at 20–25 °C.

Achieved environmental benefits

- Reduced acid consumption.
- Prolonged lifetime of pickling baths and reduced generation of spent pickling liquor (liquid waste).

- Reduction of HCl emissions to air.

Environmental performance and operational data

Example Ferritslev Jernvarefabrik (FJ)

This system is used at Ferritslev Jernvarefabrik (FJ) where the pickling bath is kept almost free of zinc. The discarded baths can be utilised as precipitation agent at the municipal sewage treatment plant. FJ Varmforzinkning only has to pay the transport costs. [DK-EPA-93]

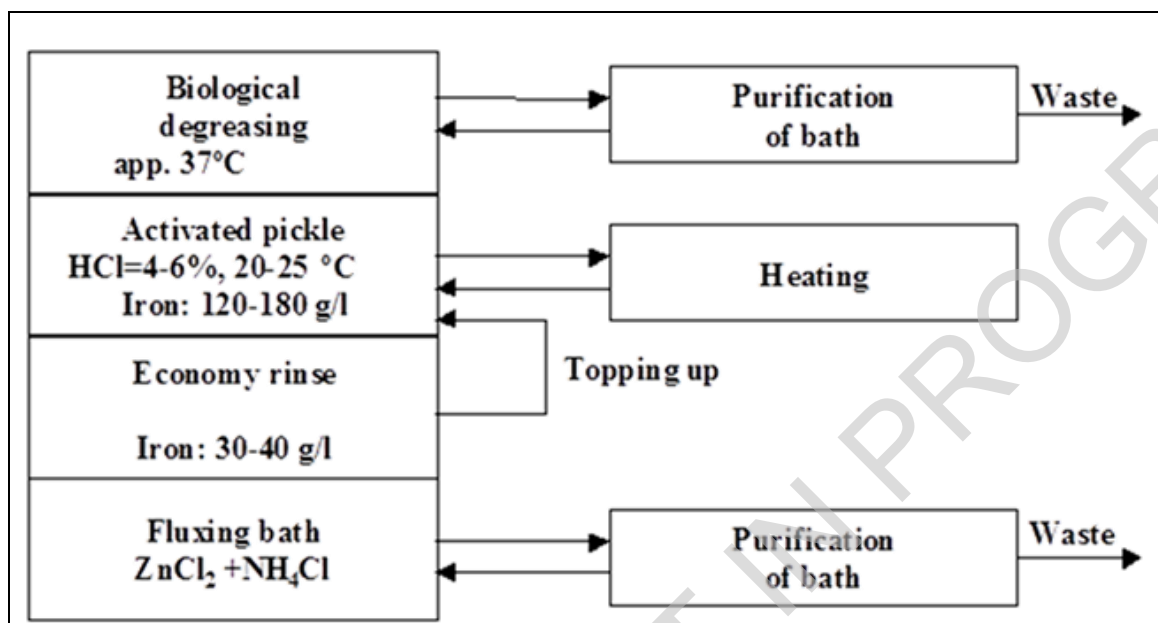


Figure 8.22: Flowsheet for activated pickling
[DK-EPA-93]

After biological degreasing, the items are immersed directly into an activated pickling bath with 4–6 % hydrochloric acid and an iron content of 120–180 g/l. The items are suspended in black steel wires which are used only once. By doing so, zinc-coated suspension devices are prevented from entering the pickling bath. Furthermore, in a special stripping acid (4–7 % hydrochloric acid) zinc is stripped off items to be regalvanised. Thus, the zinc concentration in the pickling bath is kept at a very low level. [DK-EPA-93]

There are four pickling tanks of 100 m³ each. From each tank 10 m³/h are circulated by means of a pump. The circulated volumes of water are mixed and pass through a heat exchanger before the water is returned to the individual tanks via a distribution system. In this manner, they take care of both heating and circulation in the pickling baths. [DK-EPA-93]

It is important not to rinse between the biological degreaser and the pickler, since carry-over chemicals from the degreaser act as an inhibitor in the pickler, thereby preventing acid attack on the base material. [DK-EPA-93]

After the pickling bath, rinsing is carried out in a so-called economy rinse which is used to dilute the pickling bath when part of it is to be discarded. Typically, the economy rinse has an iron content of 30–40 g/l and, consequently, it significantly reduces the carry-over of iron into the flux bath. [DK-EPA-93]

Discarded stripping acid is delivered to Kommunekemi in the usual way. Discarded pickling acid is delivered to a firm which utilises it as precipitation agent in municipal sewage treatment plants. When they change the bath, they typically drain off 20 m³ of bath which is replaced by 10 m³ of hydrochloric acid and 10 m³ of water from the economy rinse. [DK-EPA-93]

The production of hydrogen chloride in the acid hall is so low that even without extraction the hydrogen chloride content is 11–20 times below the occupational health and safety threshold value. Occupational environment measurements in the acid hall show hydrogen chloride concentrations in the air of 0.32–0.65 mg/m³. This is only 5–9 % of the threshold value for hydrogen chloride of the Danish Working Environment Service which is 7 mg/m³.

As activated pickling is introduced at the same time as biological degreasing and fluxing bath regeneration, it is difficult to quantify the financial advantages. In principle, extraction in the acid hall may be dispensed with. If they had extraction, air purification might be required. Their solution means that they can do without such equipment.

The service lifetime of the pickling baths increases by about 50 % when using activated pickling, because the bath is not discarded until it has an iron content of 180 g/l compared with the usual 120 g/l. It is cheap to get rid of the discarded pickling bath when it does not contain substantial quantities of zinc. The plant only has to pay for the transport to Kemira Miljø in Esbjerg where the discarded bath is reprocessed into precipitation agent. [DK-EPA-93]

A heating system for the pickling baths is necessary when activated pickling is used, which means additional expense as compared with conventional pickling baths.

Cross-media effects

Increased energy consumption.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Increased lifetime of the pickling baths.

Example plants

FJ Varmforzinkning A/S, (period of experience: 5 years) [DK-EPA-93].

Reference literature

[DK-EPA-93]

8.6.3 Techniques to increase material efficiency in fluxing

8.6.3.1 Rinsing of workpieces after pickling

Description

Carry-over of iron to the fluxing solution is reduced by rinsing workpieces after pickling.

Technical description

From ex-Sections B.4.3.2.1, C.4.4.1 and C.4.4.2.

An excessive iron concentration in the flux bath causes drag-in of iron into the zinc bath. Each kg of Fe entering the zinc bath causes the loss of 25–30 kg Zn by formation of dross. Therefore, the iron content should be kept at a low level (~~e.g. by sufficient rinsing and wiping in the rinsing step~~) and be controlled carefully. [CET-BAT]

After pickling and ensuring the minimisation of carry-over of pickling solution (see Section 8.6.2.9), the ~~steel items are~~ feedstock is rinsed in water using a static rinse tank or

reverse cascade rinsing (the same procedure can be applied after degreasing). When the water becomes too contaminated to secure efficient rinsing, the water is reused in the preceding process bath as make-up water for evaporation losses and drag-out. With the proper design and operational practice all rinsing water can be used the galvanizing plant.

Achieved environmental benefit

- Reduction of the generation of spent fluxing solution.
- Reduced waste (dross) and emissions in the subsequent galvanising step.

Environmental performance and operational data

Example Herning Varmforzinkning:

3-step closed rinsing system after pickling

At As an example, the Herning Varmforzinkning plant uses they have started using 3 rinsing tanks without outlet after the pickling process (see Figure 8.23). Here, the pollution of the fluxing bath is reduced by 85–90 % resulting in a longer lifetime of the fluxing bath and less fluxing waste. The rinsing water flows countercurrent to the feedstock and is finally used as make-up water in the pickling baths. The rinsing tanks are used for diluting new pickling baths by which procedure the 3 rinsing tanks are evenly diluted. The first tank is used for diluting the pickling bath, after which the first tank is then diluted with water from the second tank, which again is diluted with water from the third tank, which is diluted with tap water. [DK-EPA-93]

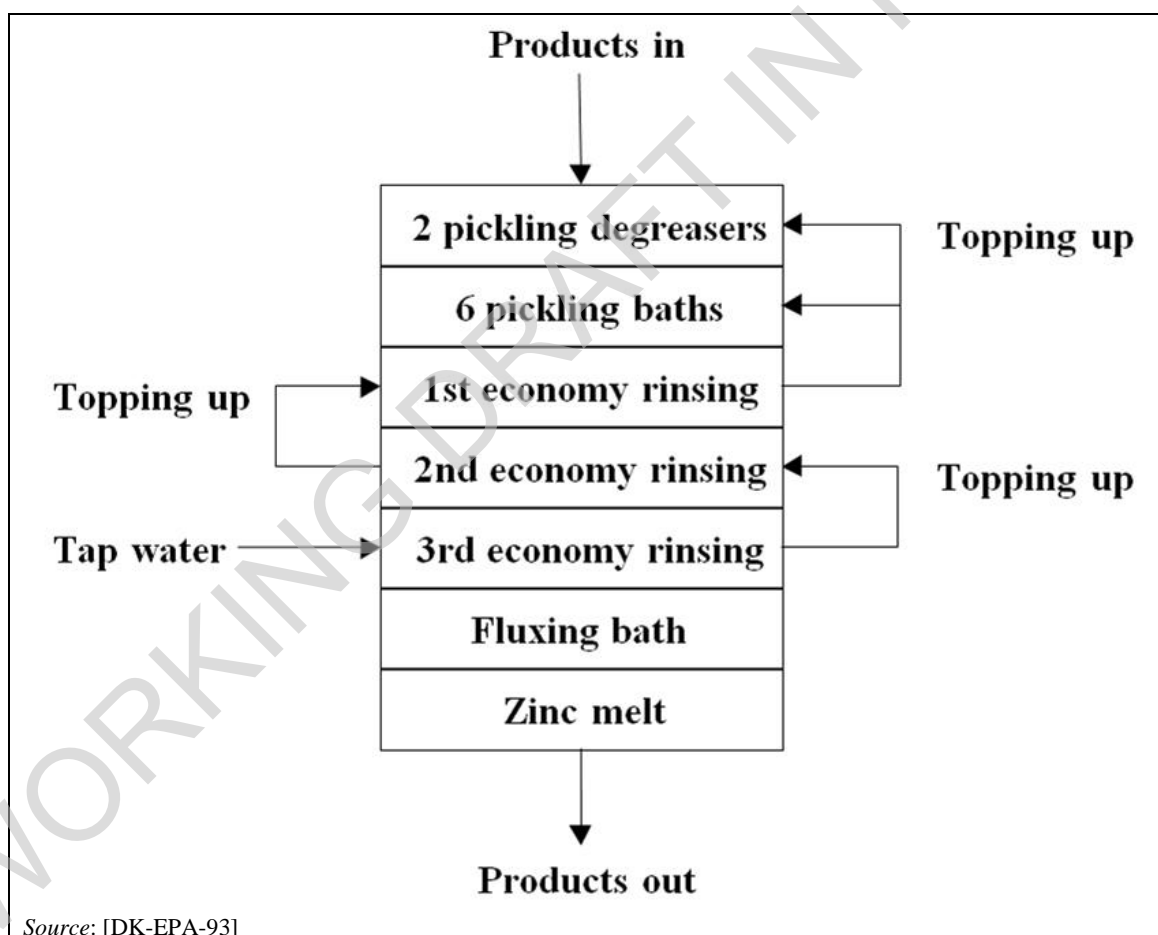


Figure 8.23: Reverse cascade rinsing at a batch galvanising plant

All items are pickled for a minimum of 10 minutes in a so-called pickle degreaser acting as degreaser and pickler at the same time. It is a 10 % hydrochloric acid with degreasing chemicals admixed to it. After this they pickle for somewhat longer in a purer hydrochloric

acid. After the final pickling they rinse in three consecutive economy rinses after which the items are immersed in the fluxing bath and finally the zinc melt. [DK-EPA-93]

There are 2 pickling degreasers of 23 m³ in which the liquid is changed when iron content has reached 129 g/l, which takes about 6 months. Then a new pickling degreaser batch is mixed from 12–15 m³ of water from the 1st economy rinse and 8–11 m³ 30 % hydrochloric acid. [DK-EPA-93]

There are 6 tanks of 23 m³ of pure hydrochloric acid pickling liquid with approximately 10 % free acid. These pickling baths are not changed until the iron content reaches more than 100 g/l, which has not happened yet (the system was introduced on December 1st, 1991). These pickling baths have a somewhat longer life than the pickling degreasers, because coarse pickling takes place in the pickling degreasers which are soon saturated with iron. The clean pickling baths are expected to have a service life of 1.5–2.0 years. New pickling baths are started with half economy rinse and half 30 % hydrochloric acid. [DK-EPA-93]

The following average iron values have been measured in pickling baths, rinsing tanks and fluxing baths: [DK-EPA-93]

- Pickling bath: Iron = 75–85 g/l
- 1st economy rinse: Iron = 40–50 g/l
- 2nd economy rinse: Iron = 25–35 g/l
- 3rd economy rinse: Iron = approximately 10 g/l
- Fluxing bath: Iron = approx. 5 g/l

When the iron concentration in the fluxing bath reaches 10 g/l the bath is discharged into a road tanker and brought to the Vildbjerg factory where they have a purification and regeneration system for fluxing baths. The road tanker returns with 23 m³ of purified fluxing bath so that production can immediately be continued at the Herning factory. [DK-EPA-93]

From the beginning the company had hoped that the clean pickling baths could be kept free of zinc, but this has proved impossible in practice. The zinc content in the pickling degreaser is so high that the carry-over to the clean pickling baths results in considerable zinc pollution in these pickling baths. [DK-EPA-93]

Cross-media effects

The rinsing water can be partially or completely used as make-up water for the pickling bath. In the case of a partial use, waste water is generated.

Technical considerations relevant to applicability

- New plants.

Existing plants provided that space for rinsing tanks is available. In existing plants, the applicability may be limited by a lack of space.

Economics

At the Herning plant the system requires 3 rinsing tanks of 23 m³ as opposed to going direct from the pickling bath to the fluxing bath. The advantage is that the fluxing bath does not get polluted nearly as soon. The fluxing bath is purified in their own fluxing bath purification plant at the company's other factory at nearby Vildbjerg. It is difficult to quantify the savings achieved. [DK-EPA-93]

Driving force for implementation

Reduced costs due to increased material efficiency.

Example plants

Herning Varmforzinkning A/S, Denmark [DK-EPA-93]

Reference literature

8.6.3.2 Monitoring and adjustment of the chemical composition of the fluxing solution

Description

The chemical composition of the fluxing solution is monitored frequently. Fluxing agents (e.g. ZnCl_2 , NH_4Cl) and water are added on a regular basis to maintain the quality of the fluxing solution.

Technical description

To make up for entrainment losses and to keep the concentration of flux baths constant, fluxing agents and water are added on a regular basis. ~~To prevent carry over of iron chlorides from pickling baths, the pickled workpieces should be rinsed thoroughly before fluxing.~~

Achieved environmental benefits

Reduction of waste and avoidance of premature discarding of flux baths.

Environmental performance and operational data

Close monitoring of the iron content is necessary. Nevertheless, a build-up of iron chloride cannot be prevented completely, so the flux solution has to be exchanged or regenerated periodically.

Cross-media effects

None.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Increased lifetime of the fluxing baths.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

8.6.3.3 Iron removal and reuse of the fluxing solution

Description

Iron is removed from the fluxing solution by:

- electrolytic oxidation;
- oxidation using air or H_2O_2 ;
- ion exchange.

After iron removal, the fluxing solution is reused.

Technical description

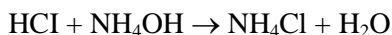
During operation, the iron concentration in a fluxing solution ~~is~~ increases. At a certain level, the flux solution becomes unusable. In order to be able to recirculate the solution, the iron content needs to be removed. This can be done continuously or in batch operation.

Iron removal from the flux bath by aeration and precipitation of iron

The flux solution is aerated to assist iron precipitation and then the solution is decanted in order to remove the resulting sludge from the bottom of the tank. This operation has the advantage of reducing iron levels, albeit not to very low levels. [Com2 Wedge]

Iron removal using ammonia and H₂O₂ oxidation

By means of addition of ammonia (for pH adjustment) and H₂O₂ (oxidant), iron is precipitated as Fe(OH)₃ and NH₄Cl is produced according to the reactions:



The precipitated iron hydroxide sludge is withdrawn and disposed of.

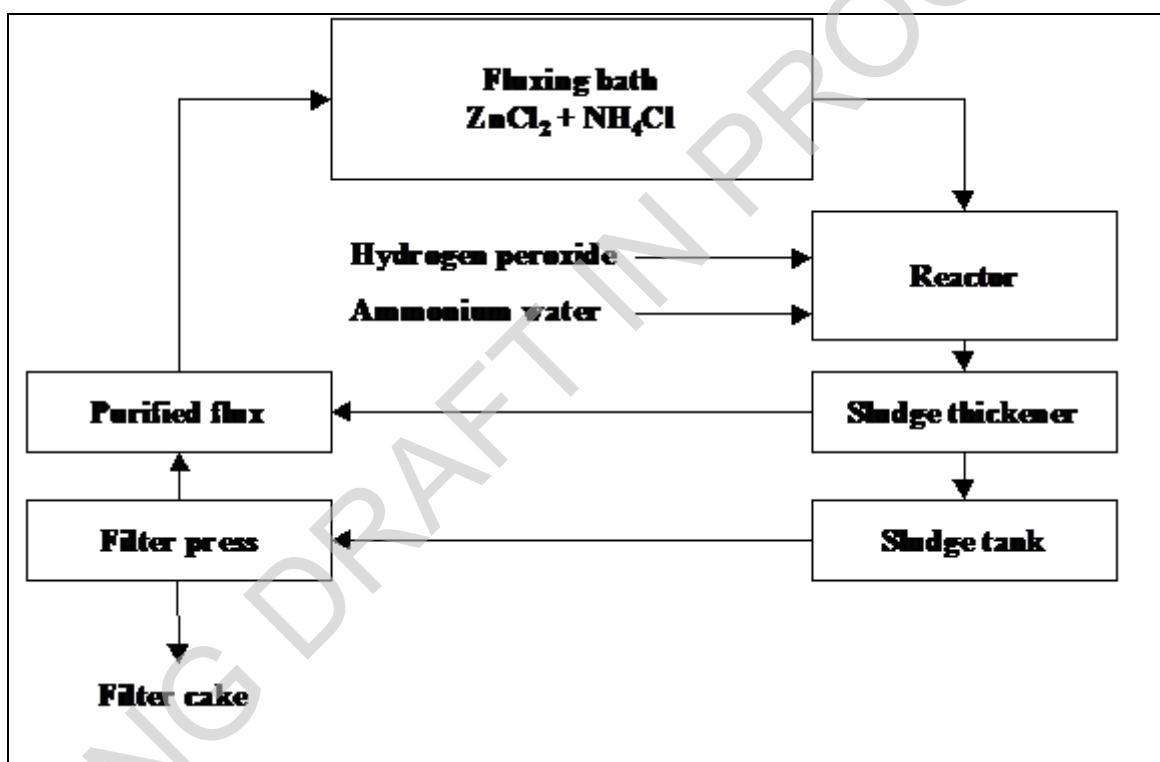
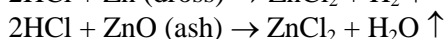
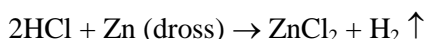


Figure 8.24: Flow sheet for flux regeneration
[DK-BAT-93]

Zinc, initially present in solution or introduced by the workpieces impregnated with solution from the rinsing or pickling baths, remains as ZnCl₂.

Normally, the ratio of NH₄Cl/ZnCl₂ produced is higher than the ratio required by most galvanisers and the amount of salt produced is not sufficient to compensate for the consumption of flux. This can be corrected by addition of depleted pickling or de-zincing solution, which increases the production of fluxing salts. Another option to influence the NH₄Cl/ZnCl₂ ratio of salts produced is to pre-react the depleted pickling or the de-zincing solution with dross or ash, thus producing ZnCl₂ instead of NH₄Cl:



Automated pH and redox controls allow for a selective iron precipitation (about 50 % iron in the solids) and a low oxidising potential, avoiding the destruction of any organic additive in the flux. To obtain maximum thickening and filtration efficiency, a selective flocculant is added to the pulp in the flocculator, resulting in a high settling rate of solids, excellent clarity of the overflow and improved filtration characteristics of the underflow. A solid content of the press filter cake of around 50 % is achievable.

It is possible to generate flux solution with a composition required by the galvaniser. For an optimum composition of the flux, zinc chloride or ammonium chloride additions may be required. [DK-BAT-93]

Iron removal using electrolytic oxidation

The electrolytic oxidation process consists of a reactor module or series of reactor modules for the electrolytic oxidation of dissolved iron and a set of sedimentation tanks for the removal of precipitate from the process stream. A schematic flow diagram is shown in Figure 8.25.

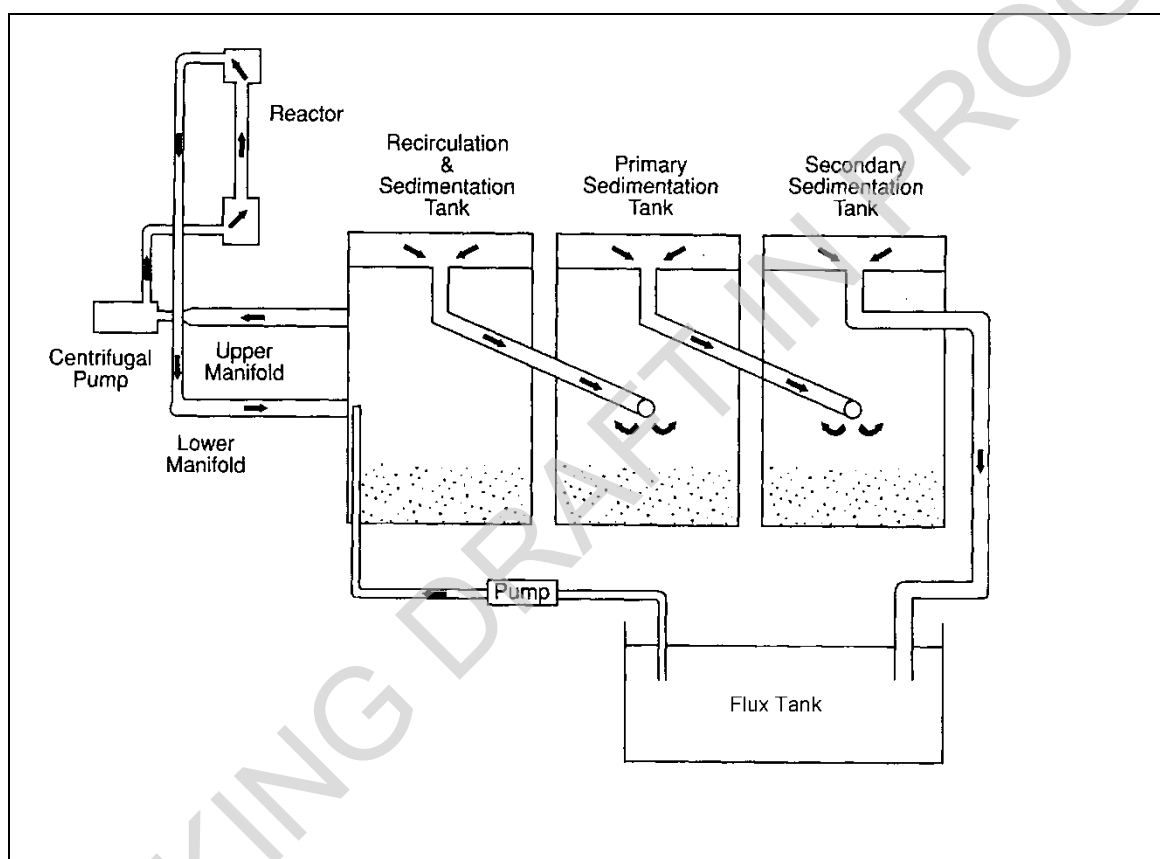


Figure 8.25: Schematic of the electrolytic oxidation process
[Choice/Barr-IG-94]

As flux solution passes through the reactor, ferrous iron (II) is oxidised to ferric iron (III). The ferric iron (III) is precipitated as hydroxide. This is accompanied by the generation of acid. As a result of these changes, the concentrations of dissolved iron and acid capacity in the stream leaving the reactor are lower than in the entering stream. Because of this, and because work continues to import rinse water or pickle solution to the main flux tank, the iron and acid capacity in the recirculation tank are lower than in the main flux tank. The relationship between the iron concentrations in the two tanks depends on a number of factors but, in practice, the concentration in the recirculation tank can be brought down to near zero grams per litre and steady concentrations in the main tank of less than 2 grams per litre can be achieved easily, while concentrations of 1 gram per litre or lower can be achieved with careful operation. [Choice/Barr-IG-94]

Briefly, the main benefits of this technique are:

- The system is based on a chloride balance and all the chloride carried over from the rinse tank to the flux tank is utilised in the generation of zinc ammonium chloride make-up.
- Iron is removed.
- No waste water treatment is necessary.
- Promotion of the rinse water to the acid tanks allows a significant saving in acid costs.
- Water input and costs are minimised [Choice/Barr-IG-94].

Sourcing spare parts for the equipment was reported as a potential problem as the supplier is based in Australia. [Com2 EGGA]

Iron removal using ion exchange columns

The ion exchange process uses resin to absorb the iron. As this process is sensitive to solid particles, the flux solution is filtered first. This can be done with a standard plate filter. By adding concentrated NaOH, the pH is set to the required pH value. The neutralisation unit is continuously stirred to create a homogeneous solution. The solution is then pumped through the ion exchange column where iron is absorbed by the resin. After leaving the column, the liquid is returned to the rinse/flux bath. When the resin is saturated with iron, it must be stripped and regenerated. The stripping/regeneration solution is pumped from a storage vessel through the column into another vessel. An exchange of iron and acid takes place in the column. Iron is dissolved in the HCl, while the acid is absorbed by the resin. [Sprang-IG-97]

Achieved environmental benefits

Reduction of waste (spent flux).

Environmental performance and operational data

Iron removal using ammonia and H₂O₂ oxidation

Example CM Jernvarer AIS

CM Jernvarer AIS has established a regeneration system for their fluxing bath enabling them continuously to remove iron pollution from their bath. In the purifying process the hydrochloric acid is neutralised, thus generating ammonium chloride which is one of the two components of the bath. The optimum composition of the fluxing bath is maintained by dosing extra zinc chloride and ammonium chloride calculated on the basis of routine chemical analyses. [DK-EPA-93]

The system has been designed for continuous purification of the fluxing bath, and about 5 000 litres are purified daily. With this capacity, the system is actually capable of purifying a fluxing bath being polluted by iron corresponding to a production of at least 10 000 tonnes of products per year. The bath is pumped through a reactor to which hydrogen peroxide and ammonia water are dosed by a redox and pH controller. The iron is oxidised and precipitated as iron hydroxide sludge. The sludgy fluxing bath is collected in a sludge thickener where the sludge is separated. The sludge is then dewatered in a filter press, the filtrate and decanting water from the thickener being collected in a storage tank from where it is reused in the fluxing bath. Discarded fluxing bath with a high iron content may also be purified by the system. It is either fed slowly together with the lightly polluted fluxing liquid from the fluxing tank or it may be purified separately by several successive treatments. Discarded stripping acid may be treated too. In this case a reduced dose is required to avoid getting too high sludge concentrations in the liquid. The stripping acid contains great volumes of zinc chloride which are admixed to the fluxing bath in this process. However, since a certain ratio between ammonium chloride and zinc chloride has to be maintained in the fluxing bath, there is an upper limit to the volume of stripping acid that may be taken into the system if the zinc chloride concentration is to be kept at the optimum value. [DK-EPA-93]

In the purification of old fluxing baths, no ammonium water was dosed because the pH value remained at the desired value of 4.5. Normally the consumption of ammonia is 2.4 g of 25 % ammonium water per g of iron II (dissolved iron). This corresponds to an expected consumption of 1 800 kg of ammonium water for the regeneration of fluxing baths of 50 m³. There were no major problems during the running-in period, and after some minor adjustments the system is today running as planned with minimum time spent on operation and maintenance. After purification of the old fluxing baths, the system is today linked to the fluxing bath used in the production so they are continuously keeping the iron concentration as low as possible. They have not yet started treating discarded stripping acid in the system. [DK-EPA-93]

Example Galva 45

Results (January-April 1993) of the flux regeneration process in operation at Galva 45, France are shown below:

| | | First line (7m bath) | New automated line (3.5m bath) |
|--|-------|-------------------------|-----------------------------------|
| Total salt content | (g/l) | 461 | 450 |
| ZnCl ₂ % - NH ₄ Cl% | | 55 - 45 | 57 - 43 |
| Temperature | (°C) | 46 | 50 |
| Fe | (g/l) | 0.9 | 0.38 |
| ZnCl ₂ or NH ₄ Cl addition | | 0 | NI |
| NB: NI = No information provided. | | | |

Advantages in purifying fluxing baths

- Quality improvement: by maintaining acid and iron in the flux at very low levels (below 1 g/l), there would be a sharp reduction in dross formation and, consequently, fewer coating defects due to dross inclusion in the zinc. The zinc coating would have a more regular thickness and hence a shiny appearance. The reduction in the number of workpieces with surface defects would lead to a reduction in the workpieces having to be recycled.
- Reduction in zinc consumption: there would be reductions in zinc pick-up and of ash and dross formation, leading to valuable reductions in total zinc consumption.
- Increased internal profitability, thanks to the flux production and the reduction of effluent solution, which compensated for reagent costs and for iron solid residue disposal costs. Direct savings were approximately 1.7 ECU per tonne of galvanised workpieces.
- Ecological process: there was a marked reduction in residue production since the tonnage of effluent solutions used to produce the flux was higher than the production of the new iron solid residue.

Iron removal using electrolytic oxidation

Example Industrial Galvanizers Corporation

The galvanising plant is processing 10 000–12 000 tonnes per year of general workpieces which includes a reasonable proportion of tube and manufactured products. The average steel section thickness processed by this plant is approximately 3 mm. [CEPT]

The three identifiable plant operating costs associated with iron contamination of flux are: effluent disposal, zinc usage cost and chemical usage cost. The costs will vary from plant to plant and vary within a plant depending on the method used to control the composition of the preflux solution. In the case studied, a rinse system was used to avoid carry-over of acid and iron into the preflux solution. [CEPT]

An examination of the operating costs of the plant before and after introduction of regeneration has shown the following cost savings:

- effluent disposal 20.2 %;
- dross production 27.6 %;
- chemicals 10.5 %;
- ash production 39.0 %;
- zinc 10.4 % [CEPT].

Advantages

- Eliminating the need for rinse overflow or rinse treatment.
- Minimising the sludge for disposal from conventional flux treatment.

Savings have far exceeded our expectations. These savings were in effluent disposal, zinc usage and chemicals usage and, in this case study, exceeded AUD 12.50 per tonne of dipped steel. The original cost-benefit analysis, on which the units were justified, predicted payback periods of 12 to 24 months. In operation, this prediction has been significantly bettered and recovery of capital expenditure was achieved in 6 to 9 months. [CEPT]

It is believed that the additional savings have been a result of improvements in plant management that were not included in the original estimation, but have been achieved through greater attention to detail in work practice. This greater attention to detail has been a direct result of the implementation of the technology. The regeneration system, together with monitoring of the condition of the preflux bath, has thus proven to be a very useful management tool for monitoring metal preparation line performance. [CEPT]

Disadvantages

It was commented that the system requires considerable operator input, and that problems of sourcing spare parts (from Australia) have been reported. [Com2 EGGA]

Iron removal using ion exchange columns

TWG, please specify which plant is the Dutch plant mentioned below, if possible.

Example Dutch plant

Advantages

- Decrease in zinc pick-up from 9.5 % to < 7 %.
- Higher production rate - increase of over 10 %.
- Lower production of zinc ash.
- Lower production of fume.
- Lower dross production from 8 t every 2 weeks to 2 t every 6 weeks.
- Higher quality product [Sprang-IG-97].

Cross-media effects

Generation of iron hydroxide sludge (60 % water, 6.5 % zinc, 20 % iron) requiring disposal in the case of iron removal using ammonia and H₂O₂ oxidation.

Technical considerations relevant to applicability

- Generally applicable to new plants.
- For existing plants, applicability may be restricted by a lack of space.

Economics

TWG, please provide updated economic data (see below highlighted in yellow) if possible.

Example CM Jernvarer AIS

The system has cost DKK 310 000 including equipment, installation, commissioning, and consulting, but exclusive of two storage tanks for purified and non-purified fluxing baths. The system is located in existing buildings. During the first three months, 50 m³ of old fluxing bath with a high content of iron (14–15 g/l) have been purified. The costs have been:

| | |
|---|----------|
| • 270 l of 35 % hydrogen peroxide at DKK 7.00 | DKK 1890 |
| • 4 tonnes of filter cake at DKK 1500 | DKK 6000 |
| • Electricity | DKK 1000 |
| • Total | DKK 8890 |

Direct savings compared with shipping to Kommunekemi:

| | |
|--|------------|
| • 50 m ³ of old fluxing bath to Kommunekemi | DKK 75000 |
| • Fluxing chemicals: 20 tonnes at DKK 8800 | DKK 176000 |
| • Total | DKK 251000 |

In practice, the savings amounted to about DKK 100 000 only, because the plant would have cleaned the fluxing bath manually if they had not had a regeneration system. When cleaning manually they only ship the bottom sludge to Kommunekemi. There will also be very great indirect savings which are difficult to quantify. The consumption of zinc will drop substantially (5–10 %) when a fluxing bath with a low iron content is used, and the production of hard zinc and zinc ash will be reduced too. The payback period is probably less than 1 year. [DK-EPA-93]

Example Galva 45

Operating costs might change from one plant to another. They also depend on the production level of each galvanising plant and especially on the chemical composition of the pickling and rinsing solutions, the temperature and required composition of the fluxing bath. Nevertheless, the estimated benefits which would be expected using flux regeneration in a conventional galvanising plant are shown in Table 8.7 and Table 8.8.

The savings due to production of flux salts, reduction of zinc consumption and of workpieces for recycling and to suppression of spoiled fluxing bath treatment cost is estimated at 13.79 ECU per tonne galvanised. With an estimated labour cost of 0.74 ECU/ton, the net profit would be about 13.0 ECU/tonne. For a galvanising plant that produced 20 000 tonnes a year, the estimated annual saving would be 261 000 ECU.

Table 8.7: Typical specific consumption/production and cost/saving for flux regeneration

| | Unit | Specific consumption or production (unit/tonne Fe) | Specific saving (+) or cost (-) (ECU/unit) | Specific saving (+) or cost (-) (ECU/tonne Fe) |
|---|------|--|--|--|
| <i>Consumptions</i> | | | | |
| NH ₄ OH | l | 0.920 | -0.183 | -0.168 |
| H ₂ O ₂ | l | 0.345 | -0.731 | -0.252 |
| Dross | kg | 0.310 | -0.519 | -0.161 |
| Spent pickling solution | kg | 8.330 | +0.094 | +0.783 |
| <i>Productions</i> | | | | |
| Flux | kg | 1800 | +0.926 | +1.667 |
| Fe filtration cake | kg | 0.770 | -0.192 | -0.148 |
| TOTAL | | | | +1.721 |
| Source of data. These figures are based on January to April 1993 operation data for the Galva 45 galvanising line. The specific consumption/production figures as reagent costs may change somewhat from plant to plant | | | | |

The savings in spent pickling solution disposal costs used for this calculation take into account a temporary 30 % French authority subsidy. In normal conditions, without subsidy, the savings would be higher.

Table 8.8: Summary of savings and costs

| Savings | ECU/tonne |
|---|------------------|
| (1) Flux salts production including reagent cost and effluent reduction | 1.72 |
| (2) Zinc consumption reduction | 9.11 |
| (3) Reduction in reglvanising of workpieces | 2.28 |
| (4) Suppression of spoiled fluxing bath treatment cost | 0.68 |
| TOTAL: | 13.79 |
| Costs: | |
| (5) Labour | 0.74 |
| Net Profit | 13.05 |
| Source of data [PURIFLUX]. The savings are estimated values to be expected by the introduction of the regeneration process in a conventional 20000 tonnes/year galvanising plant. They will vary from one plant to another. | |

Driving force for implementation

Reduced costs due to increased material efficiency.

Example plants

CM Jernvarer A/S (period of experience: 0.5 year)

Reference literature

[CEPT] [Choice/Barr-IG-94] [Com2 Wedge] [DK-EPA-93] [DK-BAT-93] [Com2 EGGA]

8.6.3.4 Recovery of salts from the spent fluxing solution for production of fluxing agents

Description

Spent fluxing solution is used to recover the salts contained therein to produce fluxing agents.

Technical description

~~Spent flux baths are sent off site, usually to flux agent producers, for recycling.~~ The salts in the spent fluxing solution can be reused for fluxing agent production. This is usually carried out off site by fluxing agent producers.

Achieved environmental benefits

Reduced amount of waste sent for disposal.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

Reduced costs due to increased material efficiency.

Example plants

Th. Goldschmidt, Germany.

Reference literature

TWG, please provide information.

8.6.4 Techniques to increase material efficiency in hot dipping

8.6.4.1 Reduction of the generation of hard zinc

Description

The generation of hard zinc is reduced by sufficient rinsing after pickling, continuously removing the iron from the fluxing solution, using fluxing agents with a mild pickling effect and avoiding local overheating in the galvanising kettle.

Technical description

The following techniques ~~measures~~ reduce the generation of hard zinc:

- Sufficient rinsing following pickling.
- Continuous regeneration of the flux bath.
- Use of fluxing agents with a low ~~in~~-ammonium chloride content which have a low pickling effect (removal of iron).
- Avoiding local overheating in the externally heated galvanising kettles (reaction with the boiler walls) [Com D] [Com2 EGGA].

Achieved environmental benefits

Less waste, more efficient use of raw material (no need to recycle hard zinc).

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

Rinsing generates waste water.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Reduced costs due to increased material efficiency.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[Com D] [Com2 EGGA]

8.6.4.2 Prevention, collection and reuse of zinc splashes

Description

The generation of zinc splashes from the galvanising kettle is reduced by minimising carry-over of the fluxing solution. Zinc splashes out of the kettle are collected and reused. The area surrounding the kettle is kept clean to reduce contamination of the splashes.

Technical description

The following techniques ~~measures~~ reduce the generation of splashes:

- Sufficient drying after the flux bath.

- Areas surrounding the galvanising kettles is kept clean to obtain recoverable zinc containing a minimum of impurities. [Com D]

Achieved environmental benefits

Less waste, more efficient use of raw material (no need to recycle splashes for zinc recovery).

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

Energy needed for drying the workpieces.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Reduced costs due to increased material efficiency.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[Com D]

8.6.5 Techniques to recover spent pickling acids

Description

Techniques to recover spent pickling acids include:

- spray roasting or using fluidised bed reactors for the recovery of hydrochloric acid;
- crystallisation of ferric sulphate for the recovery of sulphuric acid;
- spray roasting, evaporation, ion exchange or diffusion dialysis, for the recovery of mixed acid;
- use of spent pickling acid as a secondary raw material (e.g. for the production of iron chloride or pigments).

Technical description

Crystallisation (H_2SO_4)

~~The sulphuric acid recovery process by crystallisation is based on the decreasing solubility relations of water, sulphuric acid and iron sulphate. Iron sulphate is more soluble at increasing temperatures and crystallises out of saturated solutions when being cooled. For the recovery of free sulphuric acid from spent pickle from H_2SO_4 pickling lines, the heptahydrate crystallisation process, yielding $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$, is usually applied in industry.~~ Sulphuric acid recovery by crystallisation is based on the decreasing solubility of iron sulphate with decreasing temperatures. By cooling spent pickling acid (e.g. to temperatures of 6–10 °C), iron sulphate heptahydrate ($\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$) crystallises and is removed from the acid by sedimentation followed by centrifugation. The regenerated sulphuric acid is recycled back to the pickling tank while the iron sulphate can be sold [IT 18-4-17] [BG Q 198].

With respect to the type of cooling, the following heptahydrate crystallisation processes for regeneration are available: crystallisation with indirect cooling, cyclone crystallisation and vacuum cooling crystallisation. The treatment of spent pickle solution by crystallisation avoids the need to neutralise free acid; furthermore the iron is precipitated as heptahydrate and does not have to be neutralised either. With crystallisation processes a significant enhancement of the waste water releases and a reduction of the salt load can be achieved. As an example, Figure 8.26 shows the vacuum cooling crystallisation process.

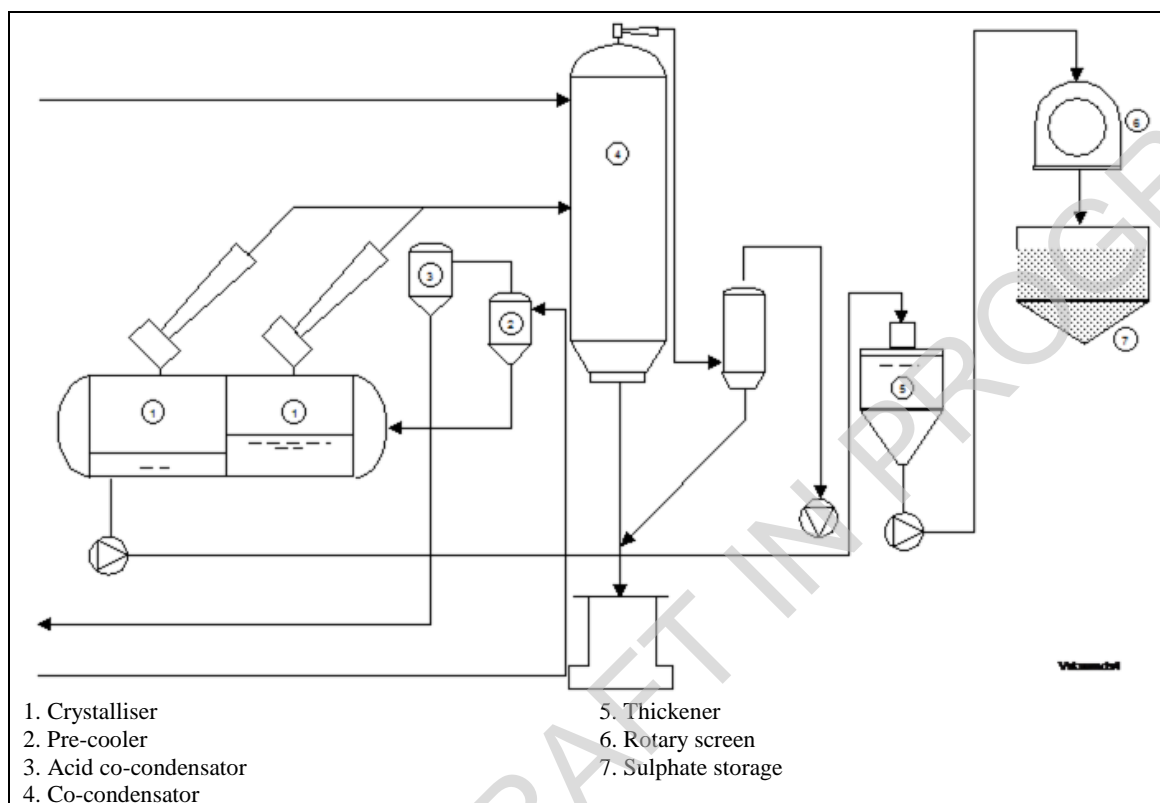


Figure 8.26: Vacuum cooling crystallisation process for H_2SO_4 [DFIU98]

Evaporative recovery (HCl)

The evaporative hydrochloric acid recovery system is a forced circulation flash evaporator with controlled two-stage condensation/separation. The spent acid solution is aggressively heated to extract the acid and water from the spent pickling acid. Only a concentrated ferrous chloride solution remains.

The spent acid solution is led to the recovery unit via a filter and a preheat exchanger, utilising the remaining heat of the acid and water vapours generated in the evaporative process (See Figure 8.27). The preheated spent acid solution then enters the evaporation section where it quickly loops through the main heat exchanger and into the separator vessel where water and acid vaporise. Acid and water vapour are continuously driven from the waste solution until the solution temperature reaches about 110 °C. At that temperature, the solution has reached saturation and is ready for removal from the evaporator. A PLC (programmable logic controller) automatically adjusts the rate of spent acid fed into the process and the volume of ferrous chloride concentrate removed from the loop and stored in a holding tank. [Cullivan-IG-97]

Forced by the expanding vapours in the separator, the acid and water vapours are driven through the feed exchanger and into the acid condenser. The condensing acid vapour combines with some of the condensing water vapour as it descends through the acid condenser. The concentration of the acid is controlled in this step to return the right quality to the pickling

process. The remaining water vapour is led into the water condenser where it is cooled and scrubbed of any residual acid vapour. No vapours leave the system because the process cools any remaining vapour to a condensate. The final condensate can be reused, e.g. as rinse water in the pickling process.

An optional heating loop added to the acid condensing section can provide a precise pickling acid concentration. Since the recovered acid concentration typically ranges from 5 % to 15 %, this additional cost is usually not warranted. The recovered acid is strong enough for pickling and is combined with a more concentrated mix of HCl when fresh make up acid is added. [Cullivan-IG-97]

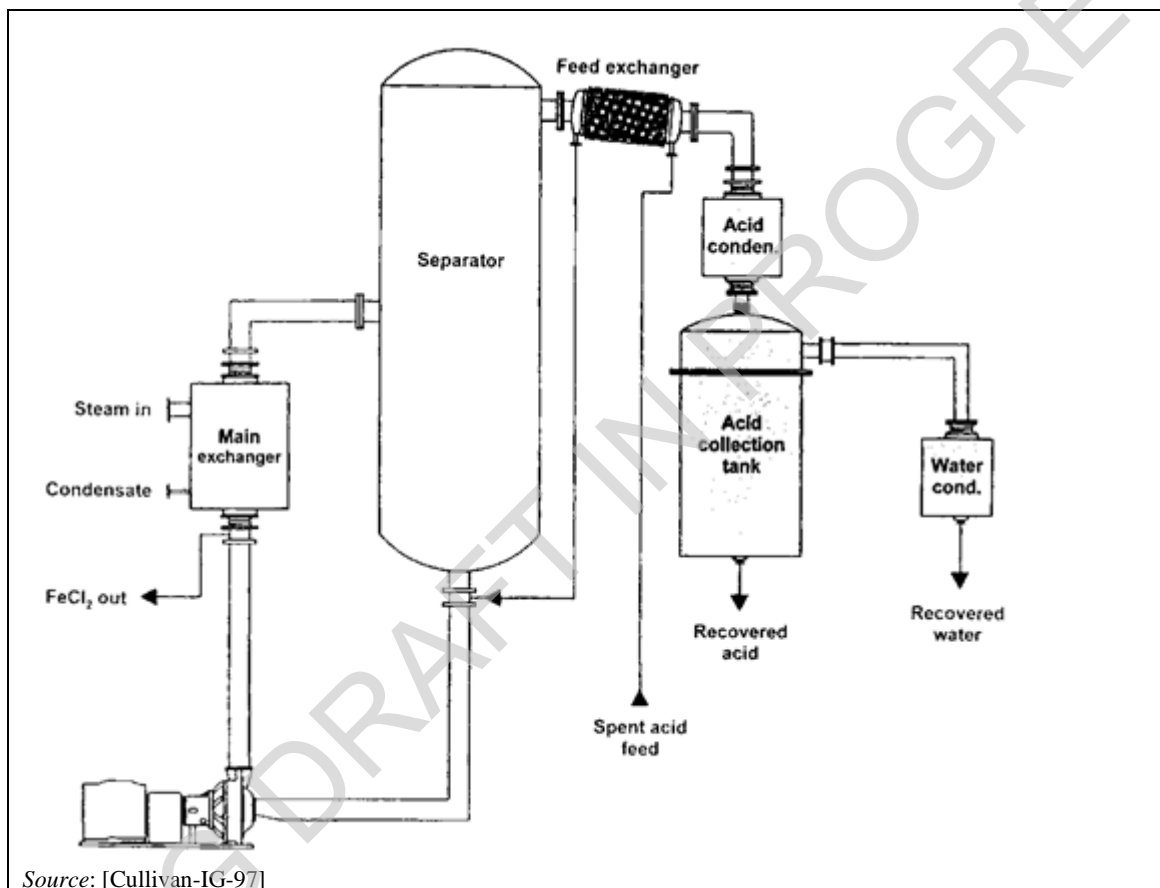


Figure 8.27: Evaporative acid recovery

The process is easy to operate. Since it has only a few moving parts and the acid vapours essentially clean the system while it operates, downtime for maintenance of heat exchangers and reactors has proven minimal. Normal maintenance includes changing filters, attending to pumps and checking the boiler and cooling tower loops to ensure optimum performance. [Cullivan-IG-97]

Acid retardation (HCl, H₂SO₄, HF/HNO₃)

The principle of the retardation process is based on the adsorption of free, undissociated acid to ion-exchange resins as the dissolved metals pass through the resin bed. In backwashing with water, the adsorbed acid is re-released because of the difference in osmotic pressure. Free-acid recovery rates are about 80–90 % for hydrochloric acid and sulphuric acid. The advantages of the process are that it requires little apparatus and space. The energy requirement for the regeneration process is confined to electrical energy. Electricity consumption varies between approximately 0.25 kWh/kg and 0.40 kWh/kg of iron depending on throughput. The requirement for demineralised water is approximately 1 m³/m³ of regenerated pickling solution. [Com D] [Fichtner]

The use of the retardation process is feasible when acid consumption is at least about 40 l/h. The average metal content in the pickling solution should not exceed 50–60 g/l. The resulting waste consists of a metallic salt solution which, depending upon composition, can be utilised. [Com D] [Fichtner]

Diffusion dialysis (HCl, H₂SO₄, HF/HNO₃)

Diffusion dialysis is a membrane separation process where an anion exchange membrane is placed between a rinse water stream (water side) and the flowing spent pickle liquor containing dissolved metals in solution (feed side). The anion exchange membrane exhibit a positive charge on its surface which attracts the negatively charged anions in solution. Hence, the chloride (or sulphate / nitrate / fluoride) ions which are negatively charged are flowing from the feed side to the water side (See Figure 8.28). The dissolved metals positively charged (e.g. Fe²⁺) present in the feed side will not be able to pass through the positively charged membrane and will remain in the feed side. However, the H⁺ ions despite being positively charged will flow through the membrane together with the chloride ions because of their smaller size and higher mobility allowing electrical neutrality in the water side. [Luo et al., 2011]

~~The diffusion dialysis process uses ion exchange membranes, which separate two different liquids: the used acid and demineralised water. The concentration difference between the two solutions is the motive power of this process. The special anion exchange membranes, having a positive surface charge in their polymer structure, make the diffusion of dissociated acid (anions) through the membrane possible, while the cations (metals) are held back by their positive charge. The hydrogen ion is an exception in this case. Owing to its small size, it diffuses together with the anions through the membrane. [OSMOTA]~~

The membranes are assembled in a membrane stack similar to a filter press with a usual specific capacity of 0.5–2 l/hm². The demineralised water and the used acid are led in countercurrent through the cells in an alternating manner. The demineralised water adopts the free acid and the resulting diffusate is recycled to the pickling process. The other part-stream - dialysate - is mostly led to the neutralisation. In certain cases this part stream can also be recycled or retreated. [OSMOTA]

For years, the process of diffusion dialysis has been used successfully for recovery of H₂SO₄, HCl, HNO₃ and HF. It is possible to extract 80–85 % of free acids from used pickling solutions and to recycle it in a purified form with about 5 % metal pollution. [OSMOTA]

The membrane lifetime is normally 3–5 years, but it can be reduced by oxidising substances such as hydrogen peroxide, chromic acid, nitric acid with concentrations of over 20 % as well as temperatures over 45 °C and organic substances such as tensides, oils, grease, solvents or cleaners. In most cases in which organic substances cause membrane fouling, a pretreatment of the raw solution with activated carbon does help. [OSMOTA]

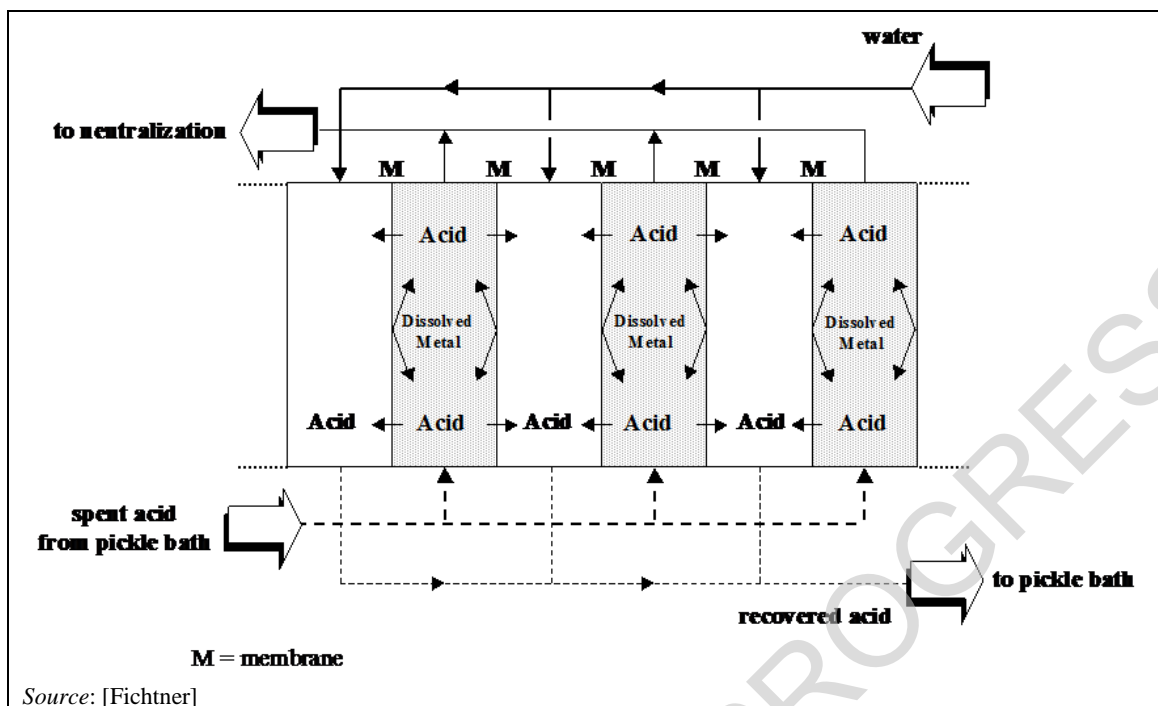


Figure 8.28: Principle of diffusion dialysis

The advantages of the process are that it requires little apparatus and space and has low operating costs. The energy requirement for diffusion dialysis is confined to electricity to run the pumps. Electricity consumption per kg of removed iron varies between 0.1 kWh and 0.23 kWh. The requirement for demineralised rinse water is approximately 1 m³/m³ regenerated pickling solution. Diffusion dialysis can be used when acid consumption is at least about 60 l/h. The average metal content in the pickling solution should not exceed 50–60 g/l. [Com D] [Fichtner]

Further reported advantages of the process:

- Small energy requirement.
- Considerable reduction of fresh acid requirement, of neutralisation and deposition costs.
- Very low maintenance costs.
- Long membrane life.
- Short amortisation time [OSMOTA].

Pyrohydrolysis: Fluidised bed process (HCl)

The basis of the process is the thermal decomposition of spent pickle liquor, which is converted at high temperature in the presence of water vapour and oxygen into hydrochloric acid and iron oxide:

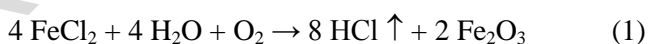


Figure 8.29 shows the main subprocesses of the fluidised bed acid regeneration process. The spent pickle liquor is pumped into a separating vessel and then concentrated in a Venturi loop by hot gases from the reactor. A share of the concentrated pickle from this loop is continuously fed into the fluidised bed of the reactor. Within the fluidised bed, which consists of iron oxide granulate, acid and water are evaporated at a temperature of about 850 °C and iron chloride is converted into iron oxide and hydrochloric gas according to equation (1).

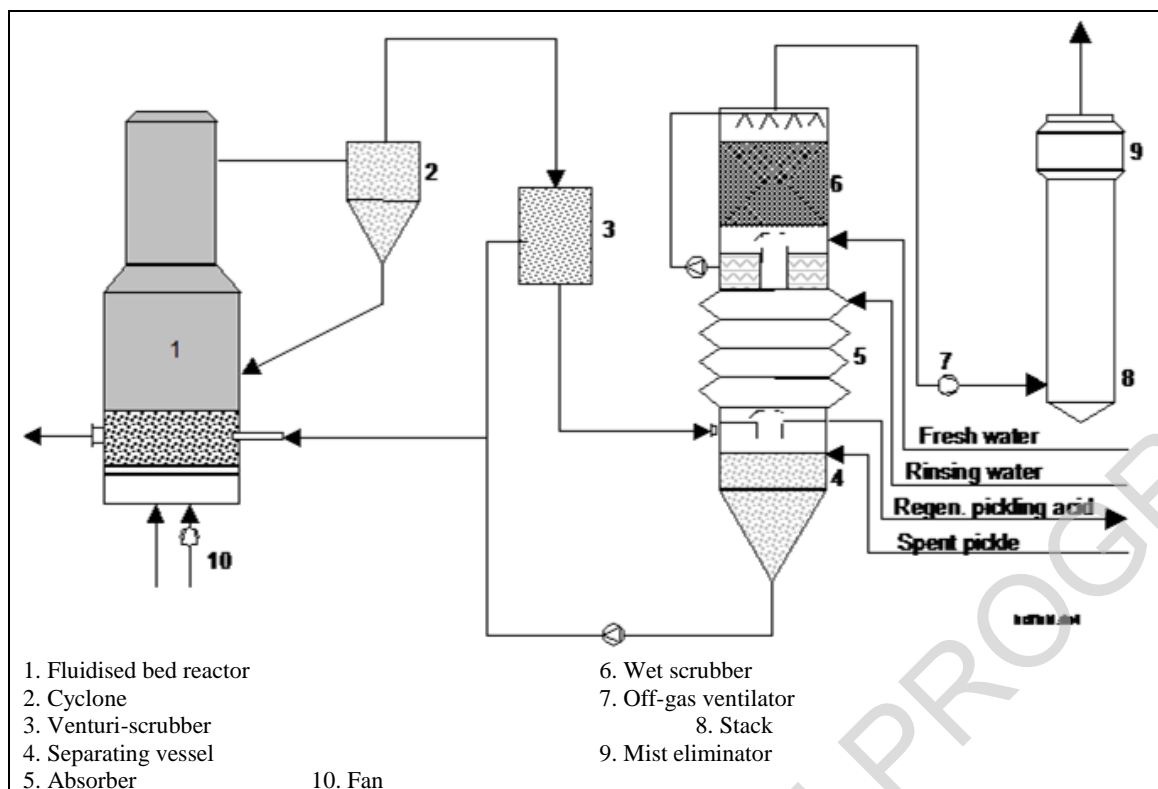


Figure 8.29: Fluidised bed HCl acid regeneration process [DFIU98]

Growth and new formation of iron oxide grains in the fluidised bed are controlled so that a dust-free granulated product is obtained with a grain size of 1–2 mm and a bulk density of about 3.5 t/m^3 . The granular product is discharged continuously from the bottom of the reactor, and transported by a vibrating cooling chute and vibrating spiral conveyor to the oxide storage bin.

The hot off-gas from the reactor contains hydrochloric gas, overheated steam, combustion products and small amounts of iron oxide dust, which is separated from the gas in a cyclone and recycled to the fluidised bed. The off-gas is then cooled to a temperature of about 100°C in the Venturi scrubber. The thermal energy of the hot off-gases is used to concentrate the spent pickling liquor by evaporation before it is fed to the reactor. Very fine dust particles in the gas stream are removed by scrubbing.

From the venturi scrubber, the cooled gas stream goes to the absorber, where hydrogen chloride is absorbed adiabatically with rinse liquor from the pickling line and fresh water. The hydrochloric acid thus produced has a concentration of approximately 18 wt-%. It is recycled to the pickling plant or held in a storage tank. After passing through a scrubbing stage and a mist collector, the off-gas is virtually free of hydrochloric acid and is released to the atmosphere.

The iron oxide granular product can be used as raw material in various industries. The most important options are the production of magnetic materials (eg, hard and soft ferrites), iron powder for the fabrication of sintered parts and welding electrodes, and as an additive for the production of magnetic tapes, abrasives, tiles, glass, cosmetics and pigments.

The described fluidised bed hydrochloric acid regeneration can process spent pickle liquor of any iron concentration. Even at the high iron concentration of preconcentrated pickle liquor, up to 250 g/l , the pipes do not block. Furthermore, spent pickle liquor with a high content of sludge (eg, from the pickling of high silicon steel) can be utilised without difficulty because of a special design of injection equipment.

As the recovered acid is nearly Fe^{++} free, the recovery efficiency is considerably higher than 99 %, contrary to other regeneration processes, where up to 10 g/l Fe^{++} can be expected. [Rituper-1]

Pyrohydrolysis: spray roasting (HCl , HF/HNO_3)

The regeneration of hydrochloric acid pickling solutions can be done using the spray roasting process. An example is shown in Figure 8.30. The pyrohydrolytic separation of iron chloride and water is carried out at a temperature of about 450 °C (temperature of reaction ArcelorMittal Ghent: 600 °C) in the spray roasting reactor. The spent acid is fed to a venturi recuperator where the hot gases coming from the reactor are cooled and the acid is pre-concentrated. The concentrate is then sprayed into the directly fired reactor from above. Hot burn gases cause the fine droplets to evaporate as they descend. The ferrous chloride is separated into hydrochloric gas and iron oxide by means of steam and oxygen in the air according to the following reaction:



The iron oxide thus formed is collected at the bottom of the reactor and conveyed pneumatically to an oxide bin. The piled weight of the powder is about 0.3–0.4 t/m³. (0.48–0.6 t/m³ ArcelorMittal Ghent). This oxide is a valuable raw material for the production of magnetic materials, i.e. hard and soft ferrites. The generated iron oxide can be used for different purposes according to its quality.

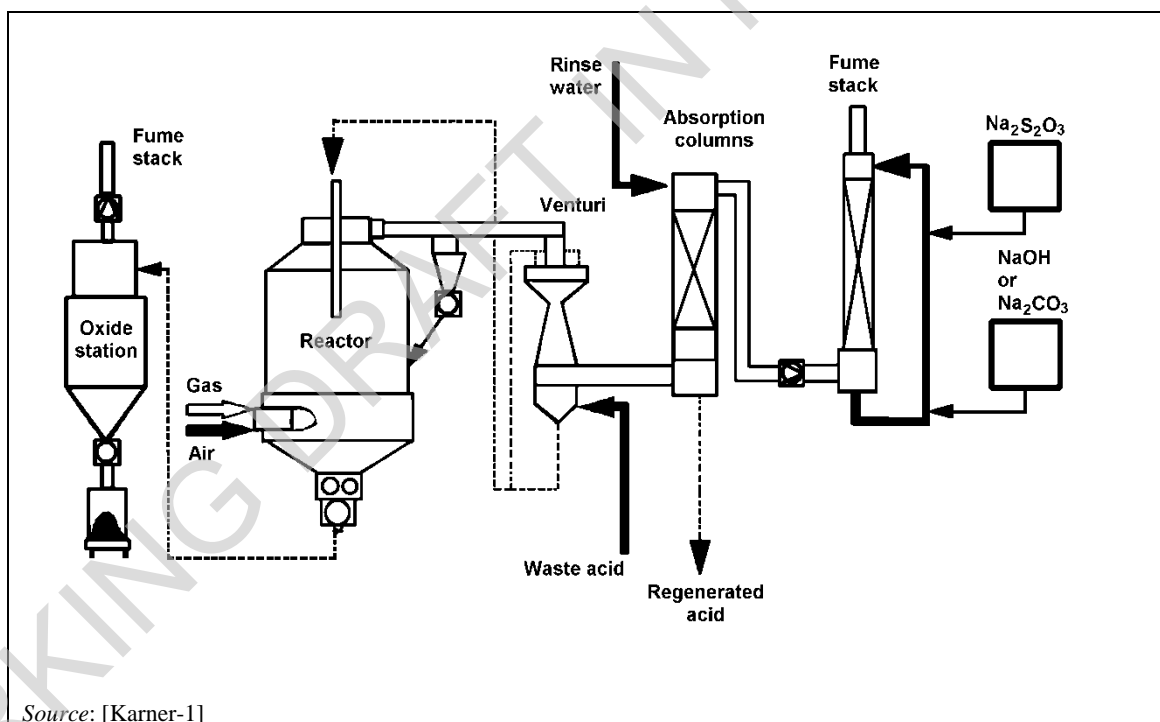


Figure 8.30: Spray roasting HCl acid regeneration process

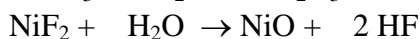
The hydrochloric gas, steam and combustion gases are ducted via the pre-vaporiser to an absorber. The resulting off-gas is subsequently cleaned by alkaline washing and is released via a stack into the atmosphere.

The gases containing HCl are absorbed in an adiabatic column where rinse water from the pickling line can be used as absorption water. The generated hydrochloric acid (about 18 %) can be returned to the pickling process. The off-gas from the absorption unit is subsequently cleaned in a caustic scrubber with the addition of sodium thiosulphate, which results in pollutant concentrations of less than 2 mg/m³ of HCl and free Cl₂.

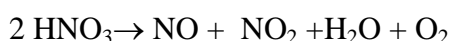
-
- The diagram illustrates the production process for ammonium sulfate. It begins with a **Leaching column** where **Scrap** is added, and **Waste acid** is introduced from the bottom. **Steam** is also supplied to the column. **Exhaust fume** exits from the top. The leached material moves to an **NH₃ bin**, which also receives **Demineralized water** and **Flocculant** from the **Flocculant preparation bin**. The mixture then goes to an **Oxidation bin** where **Air** is added. The resulting slurry is transferred to a **Reaction bin**. The output of the reaction bin goes to a **Sedimentation bin**. The **Sedimentation bin** has two outlets: one for **Treated acid** (which is recycled back to the leaching column) and another for **Sludge** (which goes to a **Filter press**). The **Filter press** produces **Sludge** and a stream that goes to a **Collecting bin**. The **Collecting bin** feeds into an **NH₃ Storage tank**, which provides **NH₃** to the **NH₃ bin**. The **Collecting bin** also feeds into the **Flocculant preparation bin**, which also receives **Flocculant** from a **Flocculant storage bin**. The **Flocculant storage bin** receives material from the **Sedimentation bin**.

Figure 8.31: Process flowsheet for the production of high-purity oxides

The spray roasting process for the regeneration of **mixed acids** from stainless steel pickling is quite similar to the one for hydrochloric acid, but it also includes an isothermal absorption step and a tail-gas cleaning system using a catalytic converter for NOX. The spent pickle liquor containing the fluoride complexes of iron, chromium, nickel and minor metals as well as free hydrofluoric and nitric acid is first led to a pre-evaporiser, where it is partly evaporated by the contact with hot gases from the reactor. The preconcentrated pickle liquor is fed into the reactor via nozzles. Inside the reactor, the following decomposition reactions are taking place:



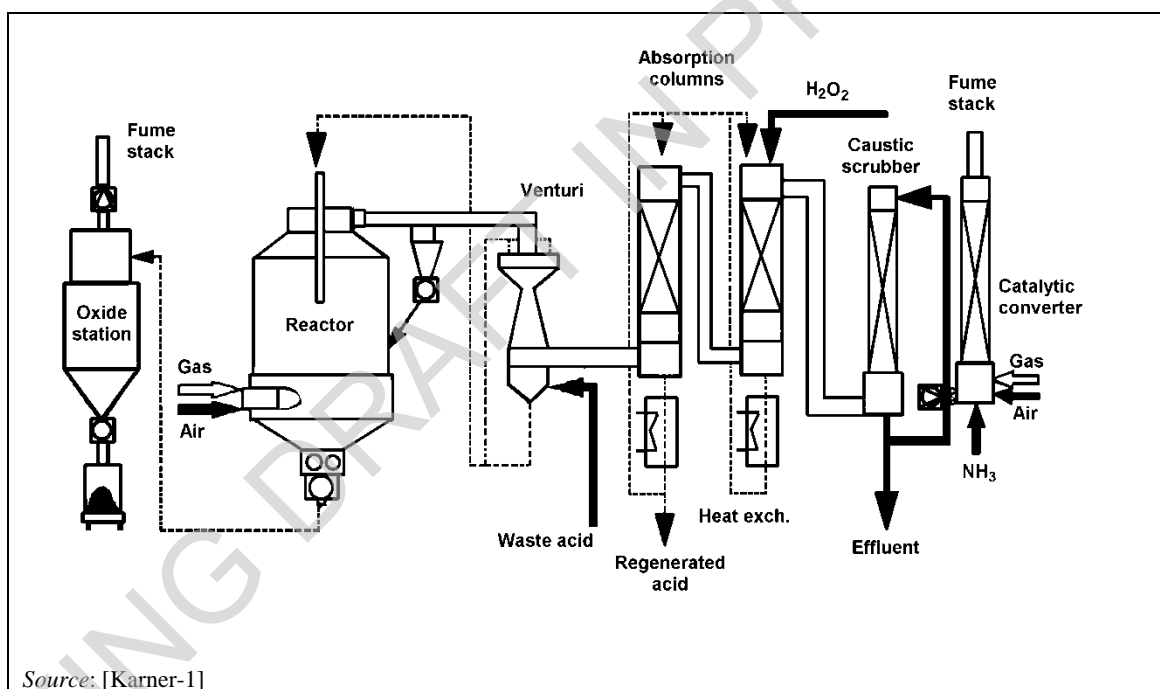
In addition, nitric acid is partly decomposed into nitrogen oxides:



The reactor is directly heated with burners using natural or other gases. The mixed metal oxide is collected at the bottom of the reactor. The oxide is kept at 500 °C to 600 °C at the flat bottom of the reactor to reduce the fluoride content below 1.5 %. This oxide is usually pelletised and can be recycled to the EAF. [Karner-1] [Com-Karner]

The reactor off-gases, which contain water vapour, combustion gases, HF, HNO₃ and NO_x are led to a two-stage absorption unit, where cooled recirculated acid is used for absorption. Hydrogen peroxide is added to the second column in order to oxidise NO to NO₂, which can be absorbed more easily. Contrary to the hydrochloric acid regeneration, the absorption is carried out isothermally, i.e. the liquid in the two columns is recycled and cooled in external heat exchangers. In the columns, regenerated acid is produced which contains free and bound hydrofluoric acid and up to 85 % of the nitric acid. The regenerated acid is reused in the pickling process. [Karner-1] [Com-Karner]

The off-gas after the absorption columns is first cleaned in an (alkaline) wet scrubber to remove traces of HF and the tail gases, which still contain NO_x from nitric acid are cleaned by a selective catalytic reduction using NH₃ or urea or ammonium compounds as a reducing agent. The NO_x is thus converted to harmless nitrogen and water. Figure 8.32 shows the flowsheet of such a spray roasting process for mixed acids (Pyromars process). [Karner-1] [Com-Karner]



Source: [Karner-1]

Figure 8.32: Spray roasting mixed acid regeneration process

Electrolytic regeneration (HCl, H₂SO₄)

The electrolytic regeneration of acid is based on iron precipitation at the cathode of the electrolytic cell and water splitting and acid reformation at the anode.

For HCl a recovery of free and iron-bound acid is possible but, simultaneously with the water splitting at the anode, chloride gas is formed. This requires a waste gas extraction and waste gas cleaning unit.

In regenerating H₂SO₄ an additional electrolyte (ammonia sulphate) is used and cathode and anode are separated by an ion exchange membrane. Iron is precipitated on cathodic stainless steel plates while sulphate ions in the anodic part reform H₂SO₄ which can be recycled to the pickling operation.

Bipolar membrane (HF/HNO₃)

Acid regeneration using bipolar membranes comprises a combination of processing steps. First, the free acid is recovered, e.g. by diffusion dialysis. Then the remaining spent acid solution is neutralised with potassium hydroxide (KOH), thus generating metal hydroxides and salts such as potassium chloride (KCl) or -with mixed acids- potassium fluoride (KF). The metal hydroxides are precipitated as sludge and further processed, e.g. dewatered. By thoroughly washing the metal hydroxide sludge, virtually all chloride and fluoride is transferred into solution. The KCl/KF-containing salt solution is then further concentrated by electrodialysis. The generated water can be used for metal hydroxide sludge washing. [Fichtner]

The bipolar membrane process is an electrically driven membrane process similar to electrodialysis in that it employs ion exchange membranes to selectively separate charged ions in solution, but distinguished by the water splitting characteristics of a bipolar membrane. [EC Haskoning]

The membranes are composed of two distinct layers of oppositely charged ion exchange materials. Subjected to an electrical current, the cations in the salt solution (potassium) pass through the cation exchange membrane into a parallel water flow (See Figure 8.33); the anions (chloride, fluoride) pass through the anion exchange membrane into another parallel water flow. Due to the bipolar membrane, the water is continuously dissociated (split) into H⁺ and OH⁻. With the anions and cations of the salt solution, acid and base, in this case KOH, are generated. The acid is recycled to the pickling process; the KOH is recycled to the neutralisation step. [Fichtner]

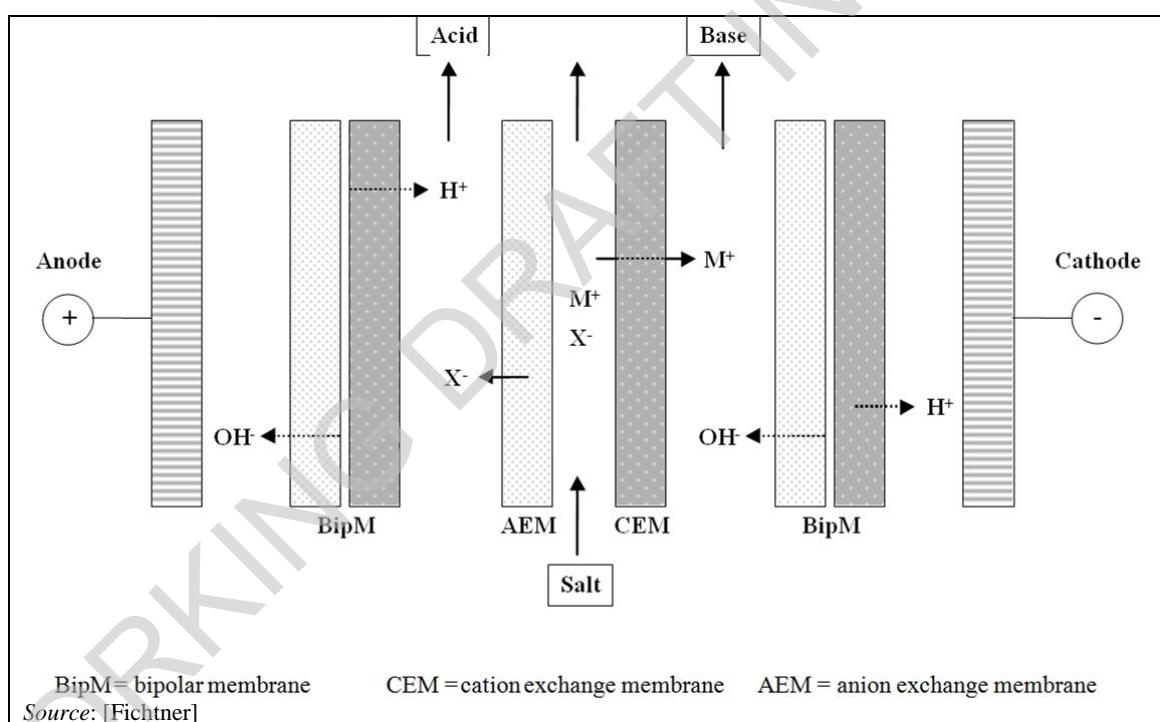
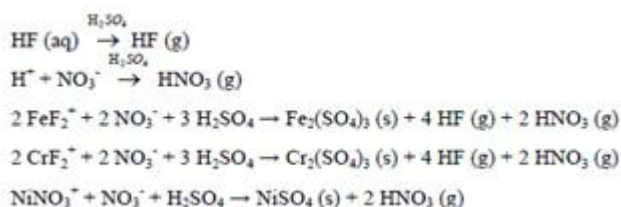


Figure 8.33: Principle of salt splitting by bipolar membranes

Evaporation process (HF/HNO₃)

The spent pickling acid is fed to a vacuum evaporator together with circulating sulphuric acid. In the vacuum evaporator the mixed acid is heated at about 90 °C. Make-up sulphur acid is added to such an extent that a concentration of at least 60 % is reached. This concentration ensures a high yield of recovered pickling acids. Metal fluorides and nitrates forms metal sulphates while the acid is liberated. These reaction products are formed according to the following reactions:



In the evaporation process, the following steps are taking place. First, the combustion gases generated in the vacuum evaporator are ducted down below the acid liquor surface through a dip tube. At this point, a sulphuric acid concentration of 80 % is reached at 150 °C. The underflow of the submerged combustion evaporator is led to the crystalliser tank. The combustion gases are washed in two steps to recover HF and HNO₃ acids from the gas. First, the gas is washed using a venturi scrubber. In addition, a general gas scrubber is included in the regeneration process. Gases from the venturi scrubber, from crystallisation and from other process steps are treated together. The acid solution washed from the gases is combined with the product acid from the evaporation and condensing part of the process. [EUROFER 23-7-18]

Long enough residence time in the evaporation-crystallisation circuit improves the filtering properties of the sulphate salt formed. The sulphate slurry from the crystalliser tank is pumped to a cone thickener. The underflow of the thickener is led to a press filter to separate the metal sulphates from the acid liquor. The filtrate is returned to the crystalliser. The metal sulphate cake from the press filter is neutralised in a separate process to form metal hydroxides. [EUROFER 23-7-18]

The evaporation process is also applicable to three-acid pickling (HF, HNO₃ and H₂SO₄) – (See Section 3.4.1.14). [EUROFER 23-7-18]

A flowsheet of the evaporation process for mixed acid recovery is shown in Figure 8.34.

~~The heat treatment is done in a submerged combustion evaporator. The combustion gases are ducted down below the liquor surface through a dip tube. The sulphur acid concentration of 80 % is reached at 150 °C. The combustion gases are washed using a venturi scrubber to recover HF and HNO₃ acids. This solution is combined with the main pickling acid stream, which is condensed in the vacuum evaporator stage. The underflow of the submerged evaporator is led to the crystallizer tank.~~

~~A very positive fact is that the process barely changes the fluoride and nitrate concentration levels in the recovered acids. A slight increase of the concentrations is obtained, which ensures a proper water balance of pickling lines.~~

~~The process equipment has to be constructed using high quality materials. Special corrosion-resistant steel grades and fluorocarbon polymers have found extensive use as construction materials for the process equipment. The flowsheet of the Outokumpu Pickling Acid Recovery process is presented in Figure D.5-18.~~

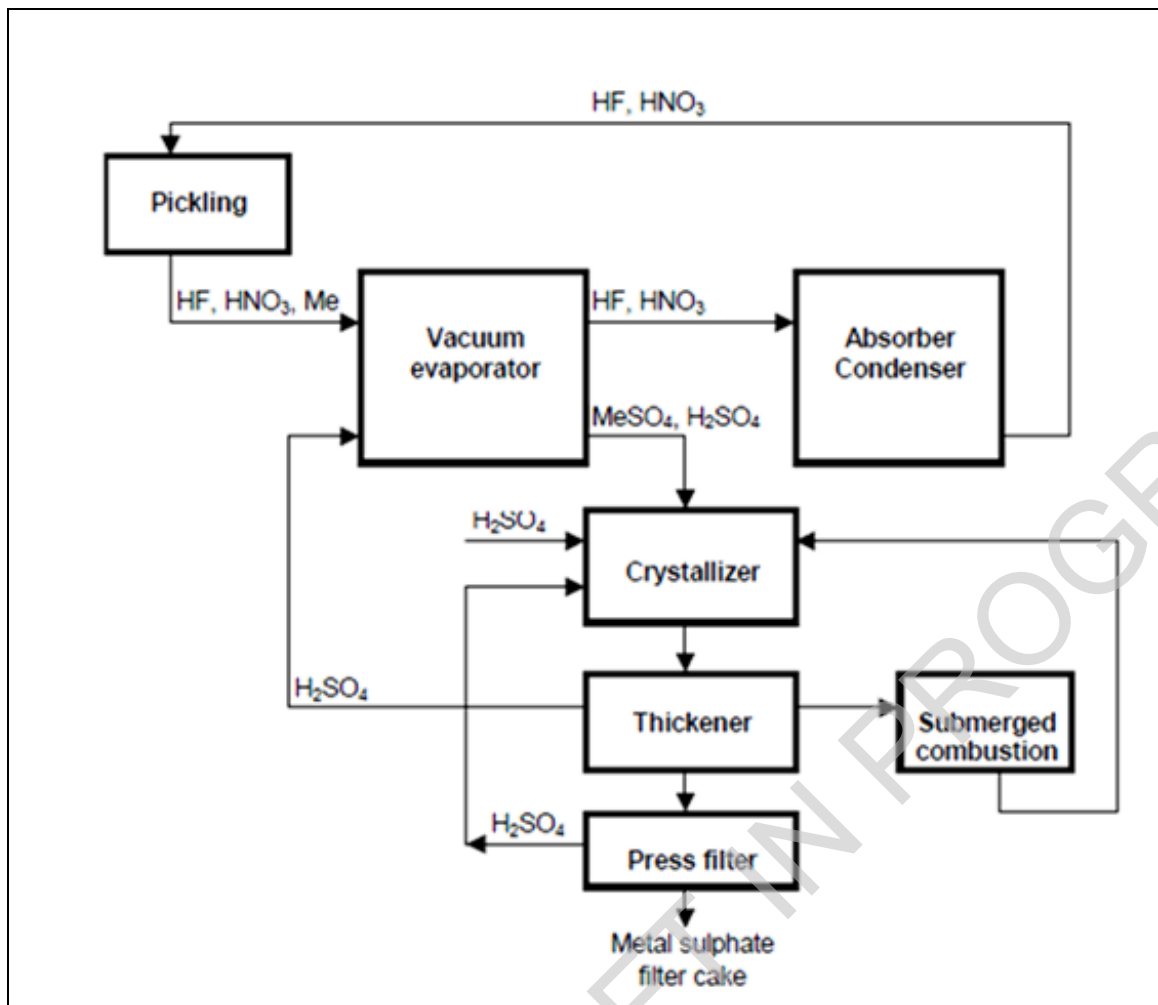


Figure 8.34: Evaporation process for mixed acid regeneration [Com2-Fin] [EUROFER 23-7-18]

Achieved environmental benefits

- Increased material efficiency.
- Reduction of pickling acid sent for disposal.

Environmental performance and operational data

Table 8.9 gives an overview of the available acid regeneration and acid reclamation techniques.

Table 8.9: Overview of regeneration and reclamation processes

(as submitted by [DFIU99])

| Processes for recovery and regeneration of spent acids from HCl pickling plants | | | | | | | |
|--|--|---|---|--|--|---|---|
| | Pyrohydrolysis | Retardation | Dialysis | Electrolytic oxidation | Electrolytic Fe-precipitation | Chemical oxidation | Ion exchange |
| 1. Principle of process. | Regeneration | Recovery of free HCl | Recovery of free HCl | Transformation of FeCl ₂ to FeCl ₃ | Regeneration of HCl Electrolysis | Transformation of FeCl ₂ to FeCl ₃ | Recovery of free HCl acid |
| 2. Other products | Iron-oxides | - | - | FeCl ₃ | Ferrous shots | FeCl ₃ | FeCl ₃ |
| Waste for disposal | - | Acidic FeCl ₂ solution | Acidic FeCl ₂ solution | - | - | - | - |
| 3. Regeneration rate total acid | > 99 % | For neutralisation | For neutralisation | > 95 % | > 95 % | > 95 % | |
| free acid | | 75 - 90 % | 75 - 90 % | | | | 50 - 70 % |
| 4. Input for regeneration | - Electrical energy - Natural gas - Fresh- and waste-water | - Electrical energy - VE-water | - Electrical energy - VE-water | - Electrical energy - muriatic acid | - Electrical energy | - Electrical energy - HCl + air or Cl ₂ or HCl + H ₂ O ₂ | - Electrical energy - VE-water - Oxidation agents as for chemical oxidation |
| 5. Field of application l/h | > 300 | > 40 | > 60 | > 20 | > 20 | > 20 | > 40 |
| 6. Complexity of installation | High | Low | Medium | Low | Medium | Medium | High |
| 7. Required space | Big | Small | Medium | Small | Small | Medium | Medium |
| 8. Benefit / cost ratio | High | Medium | Medium | Medium | Medium | Low | Low |
| 9. # plants ¹ | ca. 250 | ca. 15 | ca. 5 | 2 | ??? | ??? | 1 |
| Processes for recovery and regeneration of spent acids from H ₂ SO ₄ pickling plants | | | | | | | |
| | Crystallisation (indirect cyclone- or vacuum-cooling) | Retardation | Dialysis | Electrolytic oxidation | Process with HCl and pyrolysis | Crystallisation and roasting | Precipitation with solvents |
| 1. Principle of process | Recovery of free H ₂ SO ₄ | Recovery of free H ₂ SO ₄ | Recovery of free H ₂ SO ₄ | Regeneration | Regeneration | Regeneration | Recovery of free H ₂ SO ₄ |
| 2. Other products | FeSO ₄ ; 7H ₂ O | - | - | Ferrous shots | Iron-oxide | Iron-oxide | Iron-oxide |
| Waste for disposal | (If Cr, Ni, Zn present) | Acidic FeSO ₄ for neutralisation | Acidic FeSO ₄ for neutralisation | - | - | - | (If Cr, Ni, Zn present) |
| 3. Regeneration rate total acid | | | | > 99 % | > 95 % | > 95 % | |
| free acid | > 99 % | 80 - 90 % | 75 - 85 % | | | | > 99 % |
| 4. Input for regeneration | - Electrical energy - Steam - Cooling water | - Electrical energy - VE-water | - Electrical energy - VE-water | - Electrical energy - Additional electrolyte in loop | - Electrical energy - Natural gas - Cooling water - HCl in loop by fresh- and rinsing water | - Electrical energy - Steam - Natural gas - Cooling water - Fresh and waste water | - Electrical energy - Steam - Cooling water - Solvent in loops |
| 5. Field of application l/h | > 200 | > 40 | > 60 | > 20 | > 500 | > 500 | > 200 |
| 6. Complexity of installation | Medium/ high | Low | Medium | Medium | High | High | High |
| 7. Required space | Medium/ big | Small | Medium | Medium | Big | Big | Medium |
| 8. Benefit / cost ratio | Medium | Medium | Medium | Medium | Low | Low | Low |
| 9. # plants ¹ | ca. 80 | ca. 30 | ca. 5 | 2 | 1 | 1 | n.a. |

| Processes for recovery and regeneration of spent acids from HNO ₃ / HF pickling plants | | | | | | | | |
|---|---|--|--|--|---|--|--|--|
| | Solvent extraction | Retardation | Dialysis | Crystallisation | Pyrohydrolysis | Bipolar membranes | Outokumpu process ² | Kawasaki process |
| 1. Principle of process | Total regeneration | Regeneration of free acids | Regeneration of free acids | Regeneration of free acids | Total regeneration | Total regeneration | Total regeneration | Total regeneration |
| 2. Regenerate / reg. acid | Total HNO ₃ and HF | Free HNO ₃ and HF | Free HNO ₃ and HF | Free HNO ₃ and HF | Total HNO ₃ and HF | Total HNO ₃ and HF | Total HNO ₃ and HF | Total HNO ₃ and HF |
| 3. Other products | - | | | Metal fluorides | Metal oxide | Metal hydroxides | Ni(OH) ₂ | Iron oxide |
| Waste for disposal | Metallic salt solution | Metallic salt solution | Metallic salt solution | | | | Metal hydroxides | Metallic salt solution |
| 3. Regeneration rate total acid | HNO ₃ 80 - 95 % HF 50 - 65 % | | | | HNO ₃ 80 - 90 % HF 90 - 99 % | HNO ₃ 90 - 95 % HF 90 - 97 % | HNO ₃ > 97 % HF 99 % | HNO ₃ 75 - 90 % HF 85 - 95 % |
| free acids | | HNO ₃ 80 - 95 % HF 80 - 90 % | HNO ₃ 85 - 95 % HF 80 - 90 % | HNO ₃ 80 - 95 % HF 50 - 55 % | | | | |
| 4. Input for regeneration | - Electrical energy - H ₂ SO ₄ - Cooling water - TBP in loop - Activated carbon | - Electrical energy - VE-water | - Electrical energy - VE-water | - Electrical energy - Cooling water | - Electrical energy - Natural gas - Cooling water - Fresh- and waste water - H ₂ O ₂ or similar | - Electrical energy - Caustic potash solution in loop - Diatom earth | - Electrical energy - H ₂ SO ₄ in loop- - Propane - Limestone - Steam - Cooling water | - Electrical energy - Extraction agents TBP and D2EHPA in loop - NH ₄ HF ₂ in loop - Natural gas, - Freshwater |
| 5. Field of application l/h | >300 | >40 | >60 | >300 | >500 | >100 | 4500 | >1000 |
| 6. Complexity of installation | Medium | Low | Medium | Medium | High | High | Medium | Very high |
| 7. Required space | Medium | Small | Medium | Medium | Large | Medium | Medium | Very large |
| 8. Benefit / cost ratio | Medium | Medium | Medium | Low | Medium | Medium | Medium | Medium |
| 9. # plants¹ | 2 | ca. 30 | ca. 5 | 1 | 2 | 2 | 2 | 1 |
| ¹ world-wide, as at 1990, production and pilot plants | | | | | | | | |
| ² Source of data [Com2 FIN] | | | | | | | | |

Technical considerations relevant to applicability

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

From ex-Section C.4.3.5.1 "Fluidised Bed Process and Spray Roasting"

The fluidised bed and spray roasting processes for HCl recovery are useful only for liquors which contain iron but no zinc. If zinc enters the feedstock there is a strong possibility of process upset.

Driving force for implementation

Reduced costs due to increased material efficiency.

Reference literature

[Fichtner] [Karner-1] [EC Haskoning] [Com-Karner] [Rituper-1] [DFIU98] [OSMOTA] [EUROFER 23-7-18] [Cullivan-IG-97] [IT 18-4-17] [BG Q 198] [Luo et al., 2011]

Luo, J., Wu, C., Xu, T., Wu, Y., 2011. Diffusion dialysis-concept, principle and applications. Journal of Membrane Science 366, 1-16.

More information on the techniques

More information on the techniques presented above, namely about environmental performance and operational data, cross-media effects, economics and example plants, is available in Sections 3.4.1.3, 3.4.1.4, 3.4.1.6 to 3.4.1.10, and 6.4.2.3.

8.7 Water use and waste water generation

8.7.1 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;
- establishment of water efficiency objectives;
- implementation of water optimisation techniques (e.g. control of water usage, recycling, detection and repair of leaks).

Water audits are carried out at least annually to increase the reliability of controls and to ensure the objectives of the water management plan are met.

Achieved environmental benefits

Reduction in water consumed and waste water discharged.

Environmental performance and operational data information

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

The level of detail of the water management plan and water audits will generally be related to the nature, scale and complexity of the plant. The technique may not be applicable if the FMP activity is carried out within a larger installation, provided that the water management plan and the water audits of the larger installation sufficiently cover the FMP activity.

The technique is not applicable to batch galvanising.

Economics

- Staff time.
- Cost of any additional metering required.

Driving force for implementation

Cost reduction depending on pricing of water and availability.

Example plants

Widely used.

Reference literature

TWG, please provide information.

8.7.2 Segregation of water streams

Description

Each water stream (e.g. surface run-off water, process water) is collected and treated separately, based on the pollutant content and on the required combination of treatment techniques. In particular, uncontaminated waste water streams are segregated from waste water streams that require treatment.

Technical description

A detailed technical description of a waste water collection and segregation system can be found in the CWW BREF

Achieved environmental benefits

Reduction in water consumed and waste water discharged.

Environmental performance and operational data information

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

- Applicability to existing plants may be limited by the layout of the water collection system.
- The technique is not applicable to batch galvanising.

Economics

Retrofitting costs associated with the separation/segregation of waste waters can be significant at existing plants. Waste water separation/segregation systems can be installed efficiently at new plants. Savings may be made from the reduction in the water holding capacity needed on the site.

Driving force for implementation

Cost reduction depending on pricing of water and availability.

Example plants

Widely used.

Reference literature

[CWW BREF]

8.7.3 Minimisation of hydrocarbon contamination of process water

Description

The contamination of process water by oil and lubricant losses is minimised by using techniques such as:

- oil-tight bearings and bearing seals for working rolls;
- leakage indicators;
- regular inspections and preventive maintenance of pump seals, piping and working rolls.

Technical description

Reduction of oil and lubricant losses is a preventive measure against the contamination of process waters and the included scale. The use of **modern design bearings** and **bearing seals** for work-up and back-up rolls and the installation of **leakage indicators** in the lubricant lines (pressure monitoring equipment, e.g. at hydrostatic bearings) can reduce the hydrocarbon content (oil) of scale and waste water and reduces the oil consumption by 50–70 %. [EUROFER HR]. In addition, preventive periodic checks and maintenance of seals, gaskets, pumps and piping reduce the chance of equipment failures and oil leakages.

Contaminated drainage water at the various consumers (hydraulic aggregates) is collected and pumped into intermediate storage tanks. The waste oil, after separation from water, can be used as a reducing agent in the blast furnace or can be recycled off site. The separated water may be

further processed either in the water treatment plant or in dressing plants with ultrafiltration or a vacuum evaporator. [Com2 HR]

Complete prevention of water and scale contamination by hydrocarbons (oils and grease) is, even by applying precautionary measures, almost impossible.

Achieved environmental benefits

- Prevention of oil (hydrocarbon) contamination of water and scale.
- Reduced amount of oily scale.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

~~New plants and existing plants in case of major revamps (less applicable to older plants).~~
Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Optimisation of water consumption.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[EUROFER HR] [Com2 HR]

8.7.4 Adequate drainage infrastructure

Description

The process areas are connected to drainage infrastructure. Contaminated process water is collected in the drainage infrastructure along with washing water and occasional spillages and sent to further treatment (see Section 8.9).

Technical considerations relevant to applicability

Applicability to existing plants may be limited by the layout of the water collection system.

8.7.5 Reuse and/or recycling of water

Description

Water streams (e.g. effluents from wet scrubbing or quench baths) are reused and/or recycled, if necessary after treatment (see Section 8.9). The degree of water reuse and/or recycling is limited by the water balance of the plant, the content of impurities and/or the characteristics of the water streams.

Technical description

In order to reduce costs, plants will strive to reuse and/or recycle water as much as possible. However, the recycling of certain water streams may only be partially possible. For example, to reduce waste water generation, quenching water is often used to prepare and refresh pickling

~~acids-pickle solutions. However, quenching water-this could add large amounts of zinc to the acid which would hamper its recovery-pickling baths. Careful acid management can achieve zinc contents of 5-10 g/l in iron pickling baths. [ABAG]~~

Achieved environmental benefits

- Reduction of water consumption.
- Reduction of the volume of waste water generated.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

Reduced costs due to reduced water consumption and reduced waste water generation.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[ABAG]

8.7.6 Efficient (multiple) Use of Rinsing Water Reverse cascade rinsing

Description

Rinsing is carried out in two or more baths in series where the flow of the rinsing water is countercurrent to the feedstock flow.

Technical description

From ex-Sections A.4.2.2.4 and D.8.1.

~~An optimised rinsing operation aims at reducing the waste water generated and at minimising contamination of the rinsing water. A common method to reduce the volume of waste water and sludge from waste water treatment is to install a (counter current) cascading flow system in combination with squeegee rolls in the rinsing plant. Furthermore, spent rinsing water can be reused in the plant, e.g. for make up water in pickling baths. Squeeze rolls and wiper rolls are installed behind the pickling baths, as well as before and behind the rinsing baths. Adhering bath liquor from the strip surface is removed to reduce carry over of pickle liquor from the pickling bath and of concentrated rinsing water from one cascading flow step to the next.~~

A typical reverse cascade rinsing system utilises three to six compartments with wringer rolls to reduce carry-over between compartments. Fresh or condensate water to be added to the last compartment is allowed to cascade countercurrently over a weir to the preceding compartment. The excess (e.g. drag-out) overflows from the first compartment to a storage tank from where it is usually passed to the regeneration plant. Portions from the intermediate tanks are taken for acid vapour absorption in the absorption columns of the regeneration plant or for fresh acid dilution in the pickling tanks.

Figure 8.35 shows a variety of rinsing techniques available; ranging from the simplest single rinse flow method to more sophisticated combined rinsing systems. Multiple (cascade) use of rinse water and static rinse tanks result in sufficiently high concentrations in the rinse water to allow for the **reuse in preceding process baths** or to allow for **regeneration or reclamation measures** applied to the process baths to be applied to the rinse water as well.

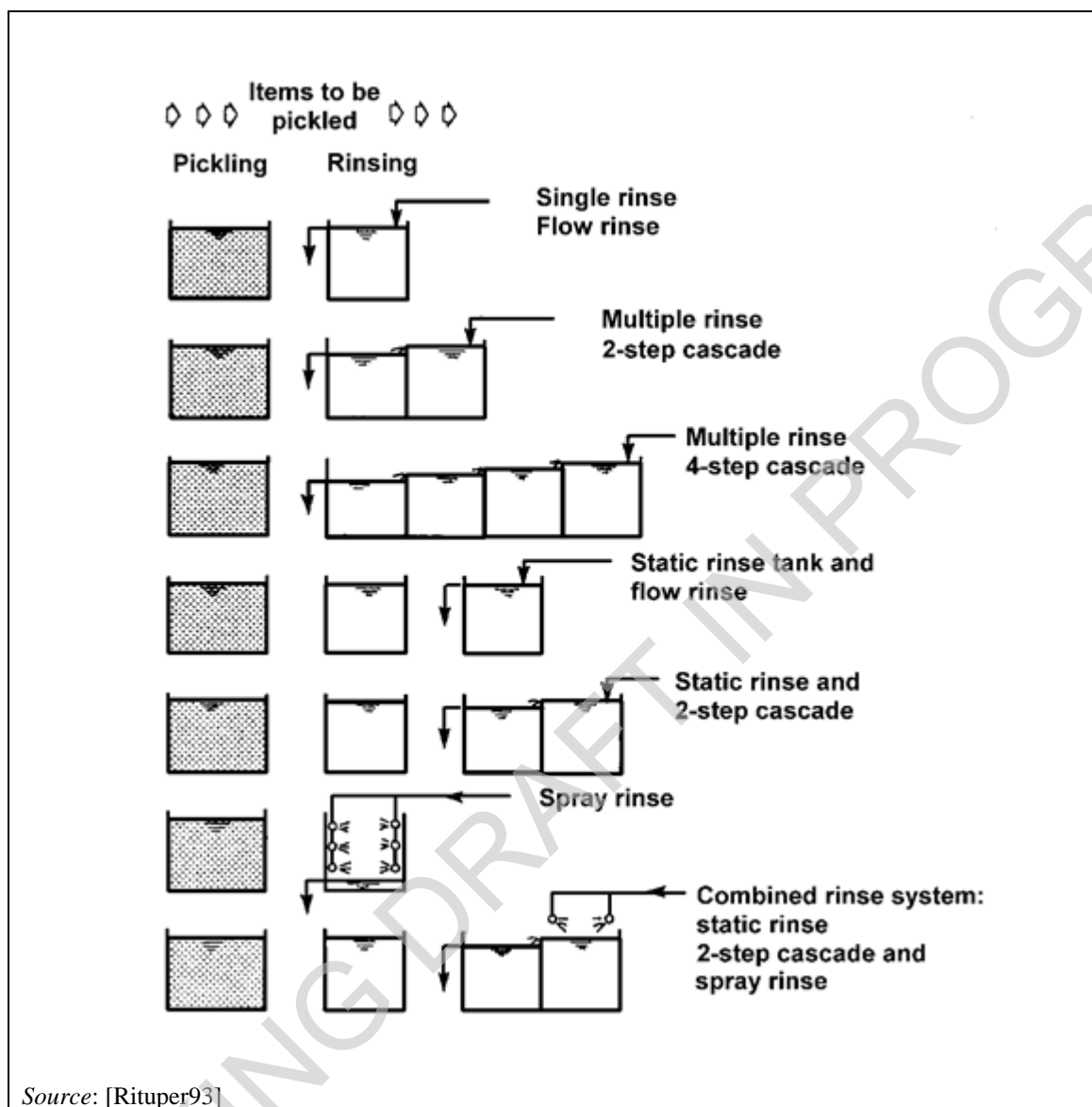


Figure 8.35: Rinsing systems

Achieved environmental benefits

- Reduction of water consumption.
- Reduction of the volume of waste water generated.

Environmental performance and operational data

The associated Water consumption levels associated with different rinsing systems are listed in Table 8.10. Due to the high water consumption of flow rinsing, this technique is no longer acceptable. Rinsing systems with a single flow rinse step (i.e. 'Flowrinse' and 'Static and flow rinse')) show by far the highest water consumption levels.

Table 8.10: Comparison of water consumption levels for different rinsing systems

| Concentration in pickling bath [g/l] | | 100 | | | | 200 | | | | 600 | | | |
|--|-----------------|---|--------|----------------|----------------|---|----------------|--------|----------------|---|----------------|----------------|------------------|
| Residual concentration in last rinse bath [mg/l] | | 5 | 10 | 20 | 50 | 5 | 10 | 20 | 50 | 5 | 10 | 20 | 50 |
| Rinse criteria | | $2 \cdot 10^4$ | 10^4 | $5 \cdot 10^3$ | $2 \cdot 10^3$ | $4 \cdot 10^4$ | $2 \cdot 10^4$ | 10^4 | $4 \cdot 10^3$ | $1.2 \cdot 10^5$ | $6 \cdot 10^4$ | $3 \cdot 10^4$ | $1.2 \cdot 10^4$ |
| Rinse system | Number of Baths | Rinse water consumption [m ³ /h] | | | | Rinse water consumption [m ³ /h] | | | | Rinse water consumption [m ³ /h] | | | |
| Flowrinse | 1 | 2000 | 1000 | 500 | 200 | 4000 | 2000 | 1000 | 400 | 12000 | 6000 | 3000 | 1200 |
| 2-step cascade | 2 | 14.1 | 10 | 7.1 | 4.5 | 20 | 14.1 | 10 | 6.3 | 34.6 | 24.5 | 17.3 | 11 |
| 3-step cascade | 3 | 2.7 | 2.1 | 1.7 | 1.3 | 3.4 | 2.7 | 2.1 | 1.6 | 5.0 | 4.0 | 3.1 | 2.3 |
| 4-step cascade | 4 | 1.2 | 1.0 | 0.9 | 0.7 | 1.4 | 1.2 | 1.0 | 0.8 | 1.9 | 1.6 | 1.3 | 1.0 |
| Static and flow rinse | 2 | 400 | 200 | 100 | 40 | 800 | 400 | 200 | 80 | 2400 | 1200 | 600 | 240 |
| Static rinse 2-step cascade | 3 | 6.3 | 4.5 | 3.2 | 2.0 | 9.0 | 6.3 | 4.5 | 2.9 | 15.5 | 11.0 | 7.7 | 4.9 |
| Static rinse 3-step cascade | 4 | 1.6 | 1.3 | 1.0 | 0.7 | 2.0 | 1.6 | 1.3 | 0.9 | 2.9 | 2.3 | 1.8 | 1.3 |
| Spray rinse Efficiency 100 % | 1 | 9.9 | 9.2 | 8.5 | 7.6 | 10.6 | 9.9 | 9.2 | 8.3 | 11.7 | 11.0 | 10.3 | 9.4 |
| Spray rinse Efficiency 30 % | 1 | 3.3 | 3.1 | 2.9 | 2.6 | 3.6 | 3.3 | 3.1 | 2.8 | 4.0 | 3.7 | 3.5 | 3.2 |
| Note: carry-over 100 l/h | | | | | | | | | | | | | |
| Source: [Rituper93] | | | | | | | | | | | | | |

Cross-media effects

None.

Technical considerations relevant to applicability

- ~~New installations.~~
- ~~Existing if space is available (due to requirement of more than 1 additional tank, very limited).~~

In existing plants, there may be a lack of space.

Economics

TWG, please provide information.

Driving force for implementation

Reduced costs due to reduced water consumption and reduced waste water generation.

Example plants

Reverse cascade rinsing is widely used. Example plants include Jenn Ann, Taiwan and Herning Varmforzinkning A/S, Denmark (see Section 8.6.3.1).

Reference literature

[Rituper93]

8.7.7 Recycling of rinsing water

Description

Rinsing water after pickling or degreasing is recycled to the preceding process baths as make-up water or, if appropriate, for acid recovery.

Technical description

When the water in rinsing tanks becomes too contaminated to secure efficient rinsing, the water is reused in the preceding process bath as make-up water for evaporation losses and drag-out.

Achieved environmental benefits

~~Waste water free operation.~~

- Reduction of water consumption.
- Reduction of the volume of waste water generated.

Environmental performance and operational data

With ~~the~~ a proper design and operational practice, all rinsing water can be ~~used~~ recycled in batch galvanising plants.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

- ~~New plants.~~
- ~~Existing plants provided that space for rinsing tanks is available.~~

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

Economics

TWG, please provide information.

Driving force for implementation

Reduced costs due to reduced water consumption and reduced waste water generation.

Example plants

Basically all galvanising plants recycle rinsing water. An example plant is described in Section 8.6.3.1.

Reference literature

TWG, please provide information.

8.7.8 Treatment and reuse of scale- and oil-bearing process water in hot rolling

Description

Scale- and oil-bearing waste water from hot rolling mills is treated separately using a sequence of cleaning steps including scale pits, settling tanks, cyclones and filtration to separate oil and scale and to recycle a large proportion of the treated water back to the process. Recirculation rates higher than 95 % can be achieved.

Technical description

Scale- and oil-bearing waste water from hot rolling (and often from continuous casting) is treated by a sequence of cleaning steps, for example scale pits, settling tanks, cyclones, filtration, etc., creating relatively complex waste water treatment systems. The first step is usually a scale pit to remove the coarse scale by sedimentation. This is followed by several secondary or fine cleaning steps aiming at separating and abating oil and the remaining scale. Treated water is recirculated to the various processes and reused, at rates that can be over 95 %.

As there are numerous options for combining the individual cleaning steps, the treatment of scale- and oil-bearing process waters and the achievable emission levels are described by means of examples of water treatment systems implemented in hot rolling mills.

In most cases, coarse scale is captured close to the spot where it arises by **scale pits**, small gravity separators, to prevent installations from damage, e.g. if it is necessary to transport the scale-loaded water by pumps. Scale pits can reduce the content of suspended solids in the waste water (load of 20–40 m³/(m²h)) from 200–800 mg/l to 60–100 mg/l. The advantage of decentralised scale arresting is that there is no sedimentation in the flume channels and less corrosion takes place.

For further coarse cleaning (intermediate cleaning), the water is usually physically treated in settling tanks to separate coarse scale and hydrocarbons. Different designs are available, e.g. vertical and horizontal flow **settling tanks**. Figure 8.36 and Figure 8.37 depict examples of gravity separators.

The basic principle of these separators is that coarse particles settle on the bottom of the basin by gravity, while the major part of the oil dispersed in the water rises to the surface. The water is discharged via an outlet equipped with a submerged barrier in front to prevent the oil floating on the surface from being discharged with the purified water. The deposited sediments are usually conveyed to a sump by scrapers where they can be removed by excavators or pumps.

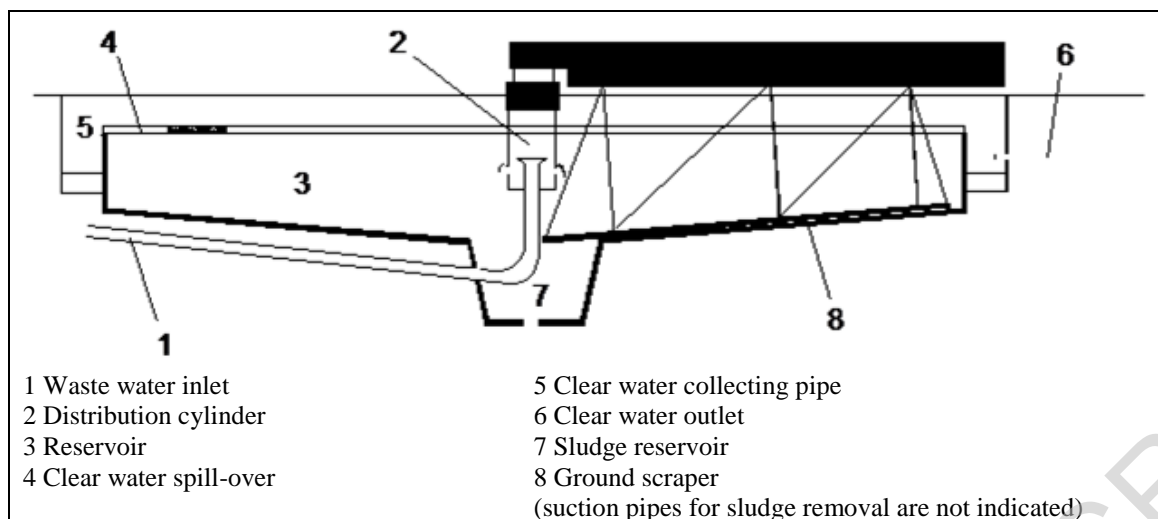


Figure 8.36: Circular settling tank (vertical)

Figure D.9-1: Rinsing systems
[DFIU98]

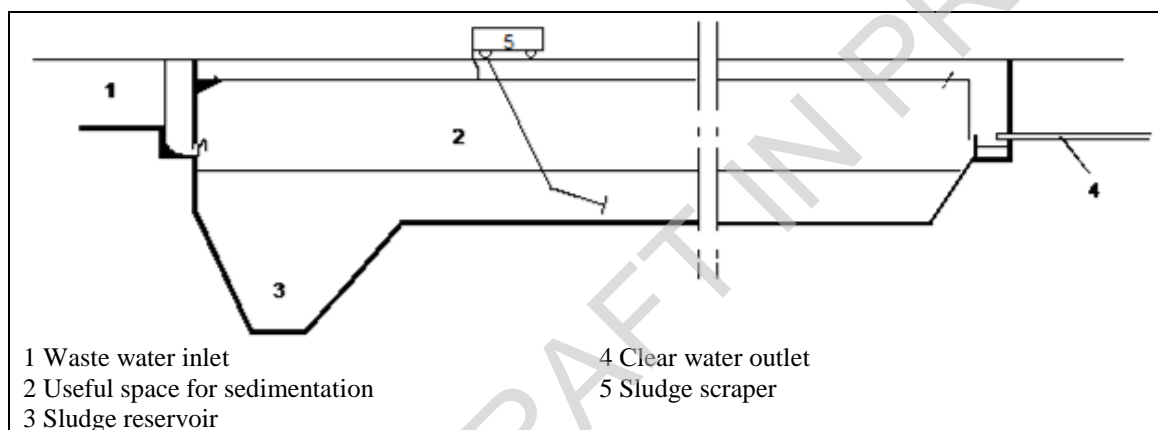


Figure 8.37: Horizontal flow settling tank
[DFIU98]

The achievable reduction depends on tank size, particle size distribution, addition of flocculating agents and oil content. Settling tanks can reduce suspended solids from 40–80 mg/l down to 20–35 mg/l (load 4–15 m³/(m²h)).

Other types of gravity separators are **screw-type clarifier (or screw-type dewaterer)** and **lamella separator**. Compared to settling basins, they have a more compact construction. In lamella separators (Figure 8.38), the incoming water is led over a number of inclined plates (lamellas). The settling distance is much shorter. The settlements are forced down along the plates by gravity, while the oils move upwards along the underside of the plates and can be collected by skimming mechanisms. The purified water is discharged through an outlet, which is separated from the basin by a submerged barrier. The sediment is discharged from the bottom e.g. via a screw, which is also separated from the main basin by a submerged barrier.

Screw-type clarifiers (see Figure 8.39) are basically settling tanks with an inclined bottom. The solids settling by gravity are transported out of the separator by a rotating screw, partially submerged in the sediment.

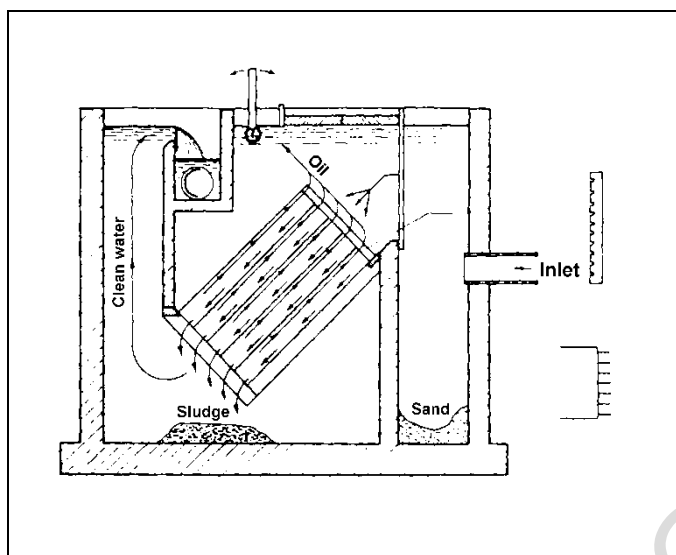


Figure 8.38: Schematic of a lamella separator
[Fichtner]

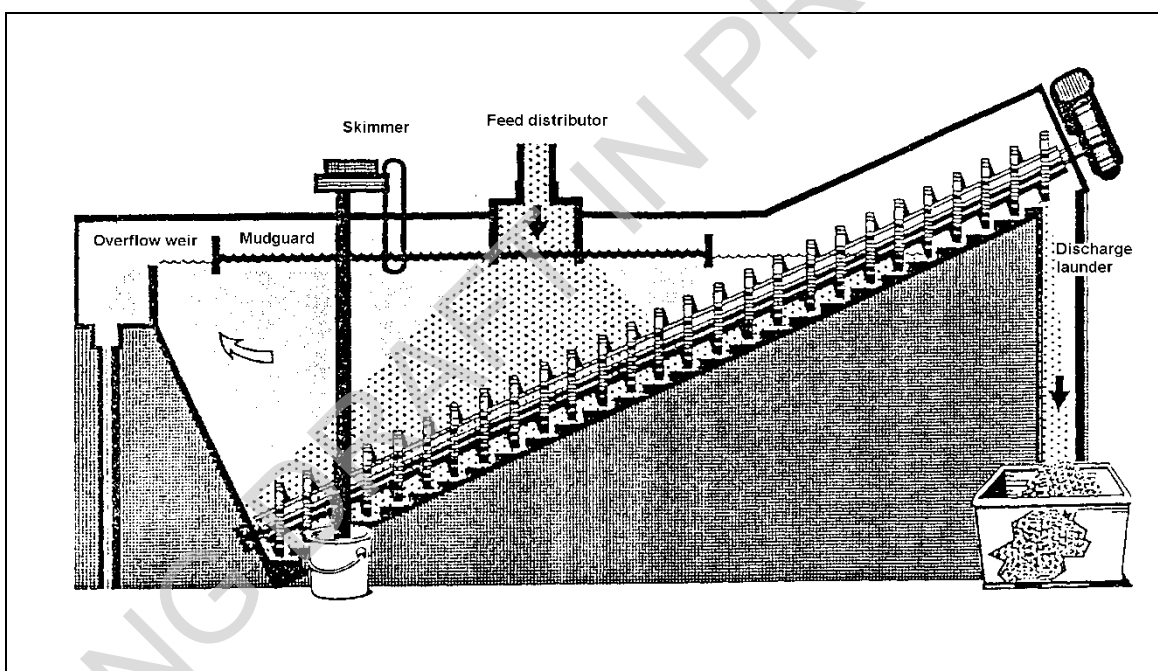


Figure 8.39: Screw-type clarifier
[BSW-WWT-90]

In **centrifugal separators** the scale particles are pressed to the wall by the flow. On the wall of the separation chamber, the scale particles glide slowly downward to the collecting chamber. When the collecting chamber is full, automatic elutriation starts. A disadvantage of this method is the fact that oil separation is not possible.

Oil floating on water surfaces is removed by **oil skimmers**. The oil adheres to an endless strip or hose, which is immersed in the basin. Together with this strip or hose the oil is transferred to a funnel outside of the basin where it is skimmed from the strip. A wheel can also be used instead of the endless strip.

Fine cleaning can be carried out in **gravel** or **sand filters** (Figure 8.40). The water flows through the filter medium from the top to the bottom. Thus large amounts of scale, sludge and oil are retained. Depending on the cleaning system these filters can remove all particles carried

by the water down to a grain size of 1 micron. The cleaned but still thermally loaded water is cooled in cooling towers in order to achieve the right temperature for recirculation. Gravel and sand filters need to be cleaned in order to remove particles and hydrocarbons. The filters are backwashed after a fixed period or when a defined filter resistance has been reached. Backwashing is performed with water or air. The required volume of backwash water amounts to about 1–3 % of the cleaned water.

Some sand filters are operated with continuous backwashing. Here the water flows through the filter medium from the bottom to the top. The sand is continuously transported upwards and constantly washed. The purified sand falls on top of the clean sand bed.

The backwash water is usually highly contaminated and is either treated in the pre-cleaning units, if necessary under addition of flocculating agents; or is treated separately in special sludge treatment units.

For **treatment of backwashing water** from the sand filters, the water is thickened in a thickener by adding flocculents and applying sedimentation techniques. The flocculent is added and mixed with the backwash water in a pre-reaction chamber. In the central chamber the sludge settles down. The purified water is discharged through an indented weir and is returned to a sand filter system. By means of a scraper the sludge is transported to the sludge sluice, where it is discharged.

If the arising sludge contains too much water, a press can be used for further dewatering. Such a press can be designed as a chamber filter press, a membrane filter press or a solid bowl centrifuge. The filtered water is recirculated to the thickener. [EUROFER HR]

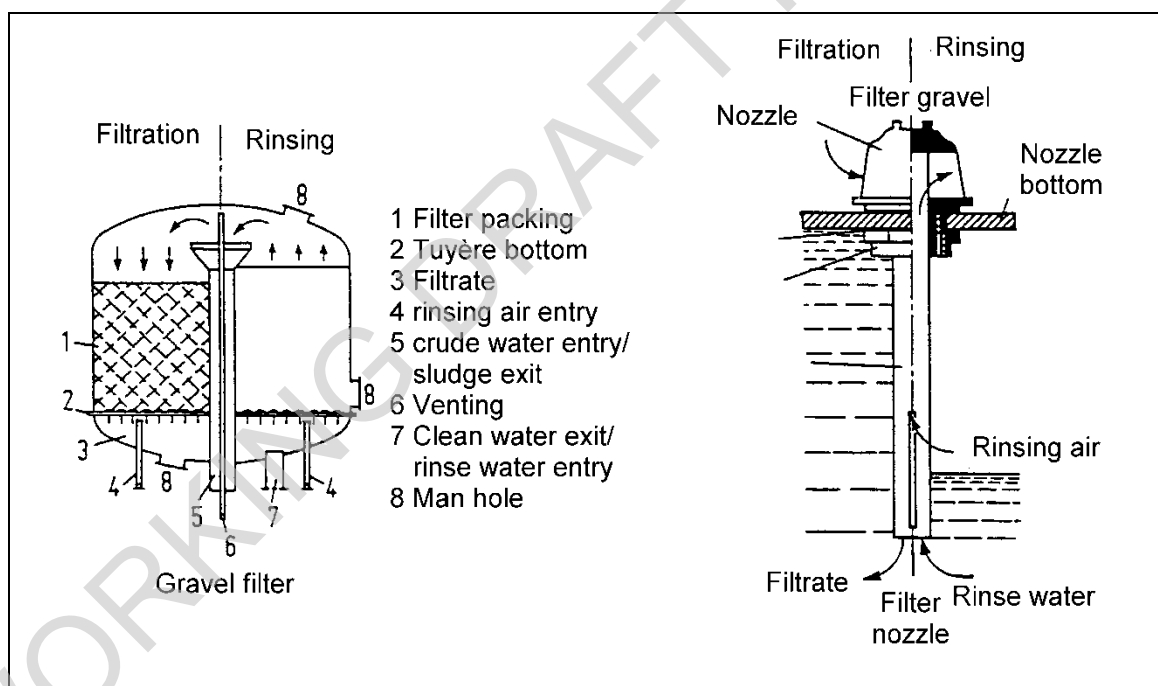


Figure 8.40: Example of a gravel filter showing in detail the backwash operation
[Theobald]

Another option for fine cleaning the pre-cleaned waste water is filters that consist of **cylindrical, wire-netting filtering elements** (see Figure 8.41).

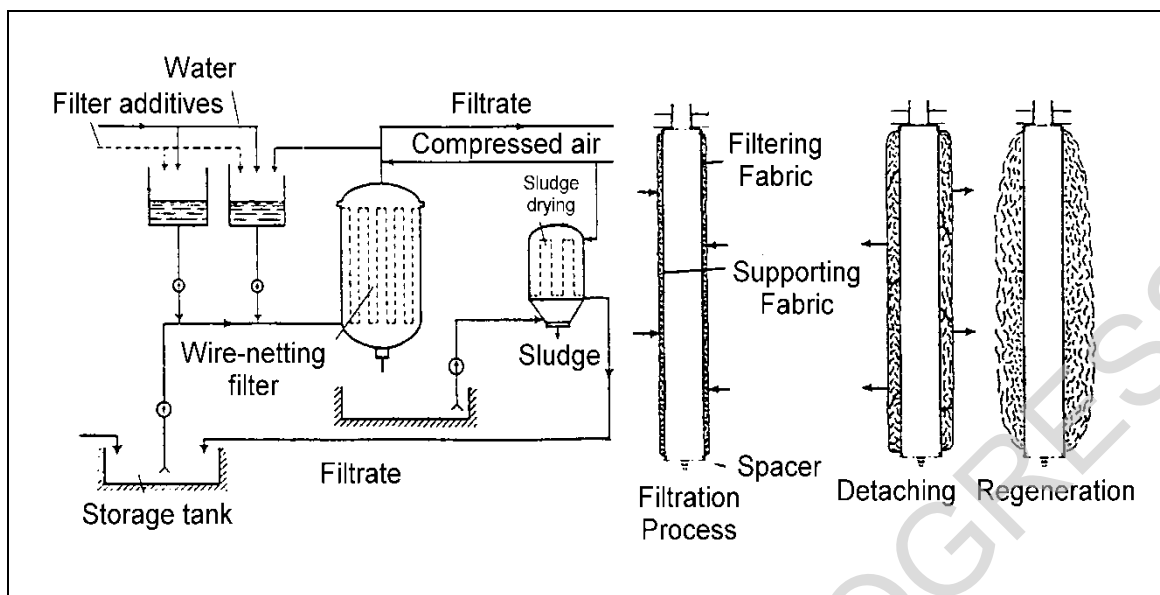


Figure 8.41: Example of wire-netting filters showing in detail the backwash operation [Theobald]

Operation cycles of these filters are divided into:

- starting phase during which a layer of filtration aid is built up on the fine meshed filters;
- filtering phase during which further filtration aid is added to keep the filtrate and sludge layer permeable;
- backwashing phase during which the filters are cleaned by reversing the flow direction.

Sludges obtained from backwashing can be dewatered directly and require special treatment prior to reuse (e.g. in the sinter plant) only if they have a high oil content. [Theobald]

For a more efficient intermediate cleaning and enhanced separation of scale and oil, so-called **aerated fine scale-traps** have been developed as shown in Figure 8.42. These combine the principles of sedimentation and flotation. The solids settle on the bottom and are removed by scrapers, while the air blown in (air bubbles) enhances the flotation of the oil.

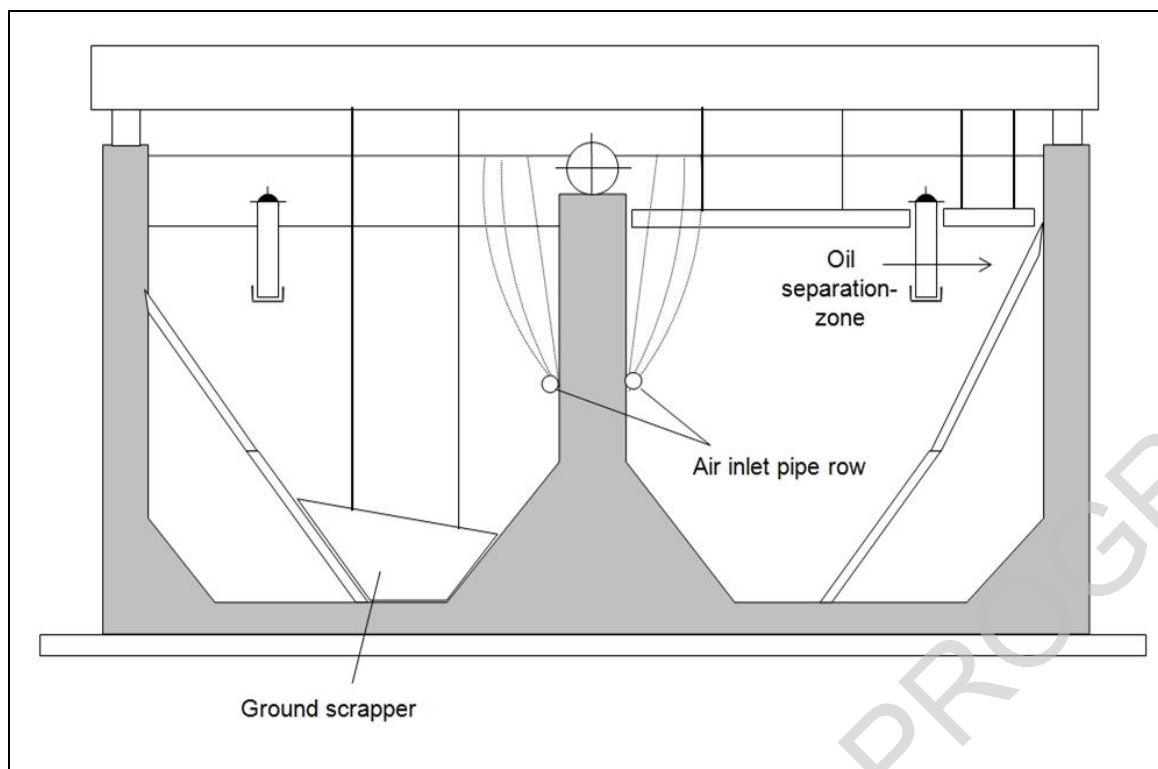


Figure 8.42: Aerated fine scale-trap
[DFIU 98]

Furthermore, the oil adsorbed by the fine scale is 'washed off' by agitation. Due to the better separation of oil and scale and the lowered oil content of the scale, the recycling options are improved. With retaining times of 15 to 30 minutes and loads of $15\text{--}20 \text{ m}^3/(\text{m}^2\text{h})$, aerated fine scale-traps can achieve reduction rates of 99 % for particles $> 63 \mu\text{m}$ and 20–80 % for particles sized $31\text{--}63 \mu\text{m}$ (depending on the particle size distribution). [DFIU98] [Theobald]

Table 8.11: Example of achieved emission levels for aerated fine scale-traps

| | Inlet [mg/l] | Outlet [mg/l] | Reduction [%] |
|----------------------------------|-----------------|------------------|------------------|
| Suspended solids | 32.3 | 25.8 | 20.1 |
| Settleable solids | 95.5 | 44.2 | 53.7 |
| Fe total | 43.5 | 24.6 | 43.4 |
| Hydrocarbons ¹ | 2.0 | 1.3 | 35.0 |

Source of data [StuE-111-3]
¹ Determined according to DIN 38 409, part 18, 1981

Reducing oil and grease content by using aerated fine scale-traps as a precleaning device upstream of gravel or sand filters can improve the operation of the filters. The backwashing intervals are increased as the particle load is reduced and clogging of filters due to oil and grease is minimised. [UBA-Kloeckner-82]

Mill scale has a high magnetic susceptibility and can thus be removed by **magnetic filtration** (see example in Figure 8.43). A coil creates a magnetic field in which the steel casing of the filter and a matrix of filament material are also magnetised (amplification); due to the high gradients, small ferromagnetic particles such as mill scale fines are attracted.

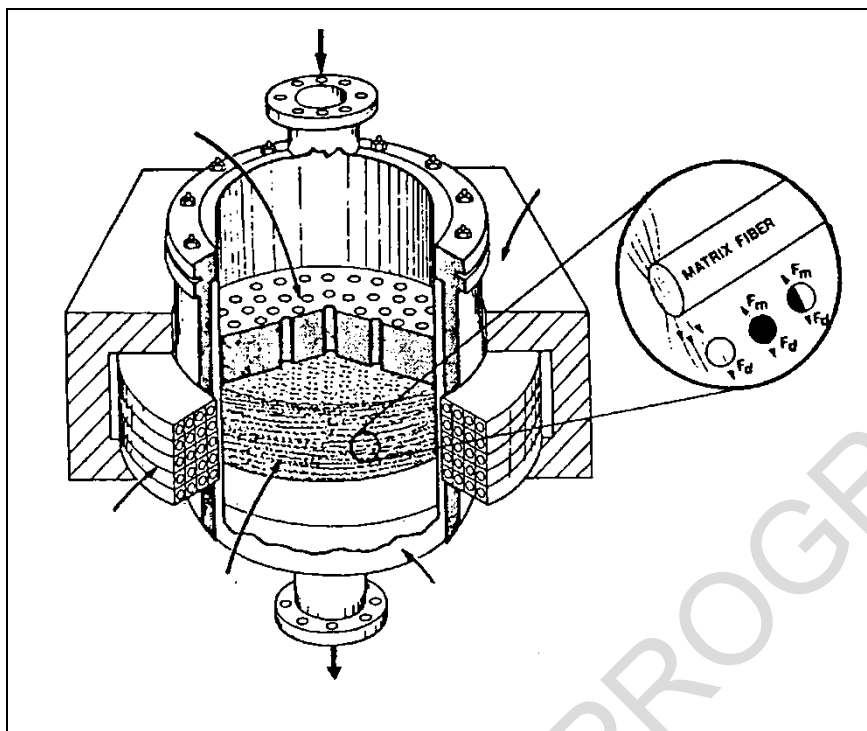


Figure 8.43: Magnetic filtration (example high gradient MF)
[Svedala]

Achieved environmental benefits

Reduction of pollutant discharge to water, especially suspended solids, oil and grease.

Environmental performance and operational data

Example A: SSAB

The major portion of scale and oil is separated in two scale pits near the rolling mill. The water treatment plant has three basins for gravimetric separation of scale and surface separation of oil and grease. The final cleaning is done in 10 sand filters. The rate of water circulation has gradually been increased over the past years to reduce water discharge to the river to below 200 m³/h (previously: 3 500 m³/h, recirculation rate approximately > 95 %). Additionally, primary measures have been taken to reduce leakage of, for example, grease, lubricants and hydraulic oils from machine equipment. Hoses have been changed, better couplings have been installed and routine inspections are carried out. [SSAB]

Achieved discharge values are 0.4 mg/l for oil (0.7 t/yr) and 3.8 mg/l for suspended solids (6 t/yr) (reference year 1994, monthly mean value). [SSAB]

Example B: ArcelorMittal Bremen

Figure 8.44 shows the water circuit and the water treatment system installed at ArcelorMittal Bremen. The system treats an average water flow of 18 000 m³/h including 3 500 m³/h from the roughing mill and 14 500 m³/h from the finishing train (including water from the delivery roller table, the coiler and the mist extraction system). The coarse scale is removed from the roughing mill process water in scale pits before it is treated together with the stream from the finishing train in aerated fine scale traps followed by settling tanks. Before the water is recirculated and split into different quality streams, it is cleaned in sand filters. These consist of three groups of pressure filters; operating at full production capacity, the filtering speed is 21.4 m³/h. The reduced concentration of suspended solids, iron and hydrocarbons is shown in Table 8.12. [Damman] [UBA-Kloekner-82]

Table 8.12: Pollutant concentration in the water circuit

| Substance | Scale pits, aerated fine scale trap, settling tank | Sand/Gravel filter | | |
|------------------|--|--------------------|-----------|-----------|
| | Outlet | Inlet ¹ | Outlet | Reduction |
| | [mg/l] | [mg/l] | [mg/l] | [%] |
| Suspended solids | 40 – 70 | 36 | 3.5 ~ 3.8 | 90 |
| Iron | 10 – 20 | 7.7 | 0.85 | 90 |
| Hydrocarbons | 1 – 2 | 1.7 | 0.5 ~ 0.6 | 65 |

¹ Average inlet concentration.

Source: [UBA- Kloeckner -82]

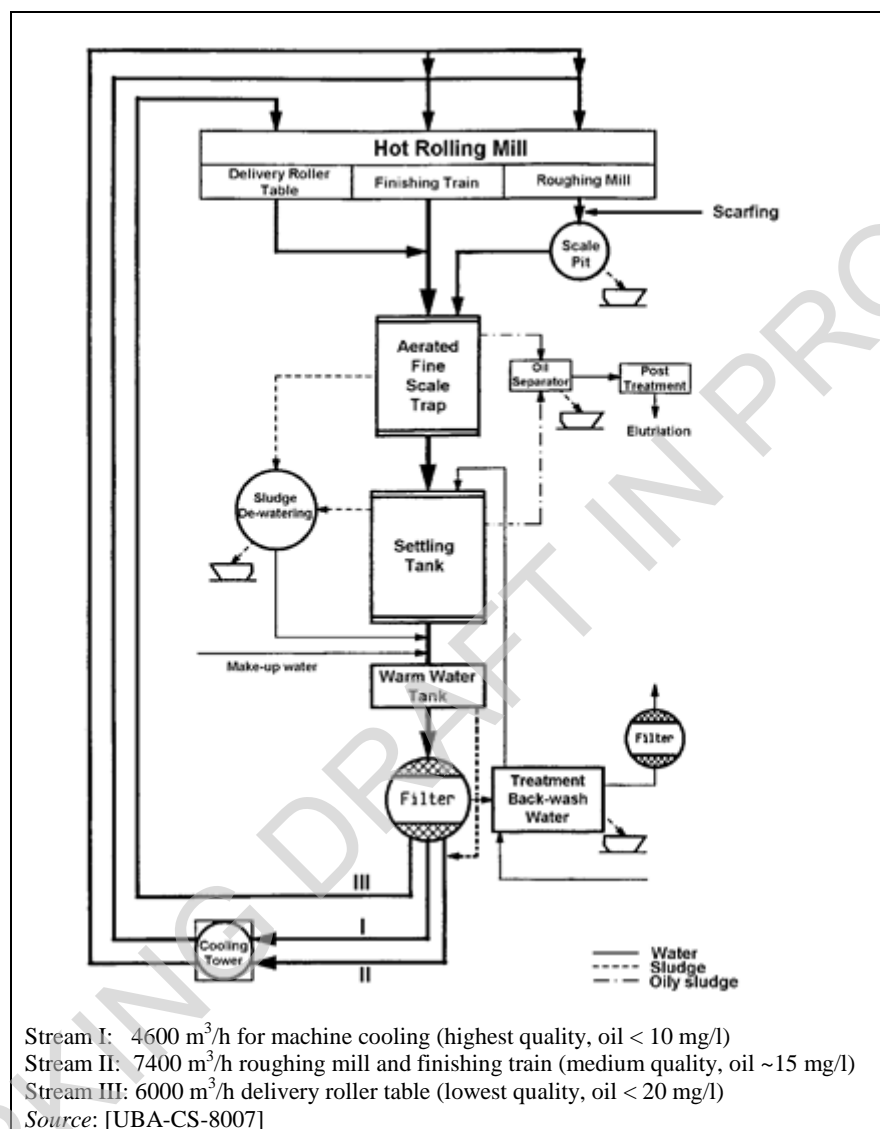


Figure 8.44: Example of a water recirculation system for a hot rolling mill

To make up for evaporation losses and elutriation water, water from the LD steel plant or – in case of production stop - roughly filtered water from a river is added to the system. The amount of elutriation water, which needs to be withdrawn from the system to avoid salt built-up, is minimised by reuse for backwashing sand filters and by partial reuse in slag processing. [Dammann] [UBA-Kloeckner-82]

From filter backwashing, about 750 m³/h arise which are treated as shown in Figure 8.45. About 92 % of the solids settle in the sedimentation step; the remaining suspended solids (approximately 50 mg/l) and the hydrocarbons (average 1.5 mg/l) are treated by flocculation and flotation. The water is then recirculated to the water system. The partial stream which has to be

discarded is treated in two-layer filters. The concentration of suspended solids and hydrocarbons are well below the emission limit values set by authorities (10 mg/l SS and 1 mg/l HC). Achieved emission levels are shown in Table 8.13.

For maintaining the water circuit, biocides, corrosion inhibitors and dispersing agents are added. When needed (e.g. once a day), flash chlorination is carried out.

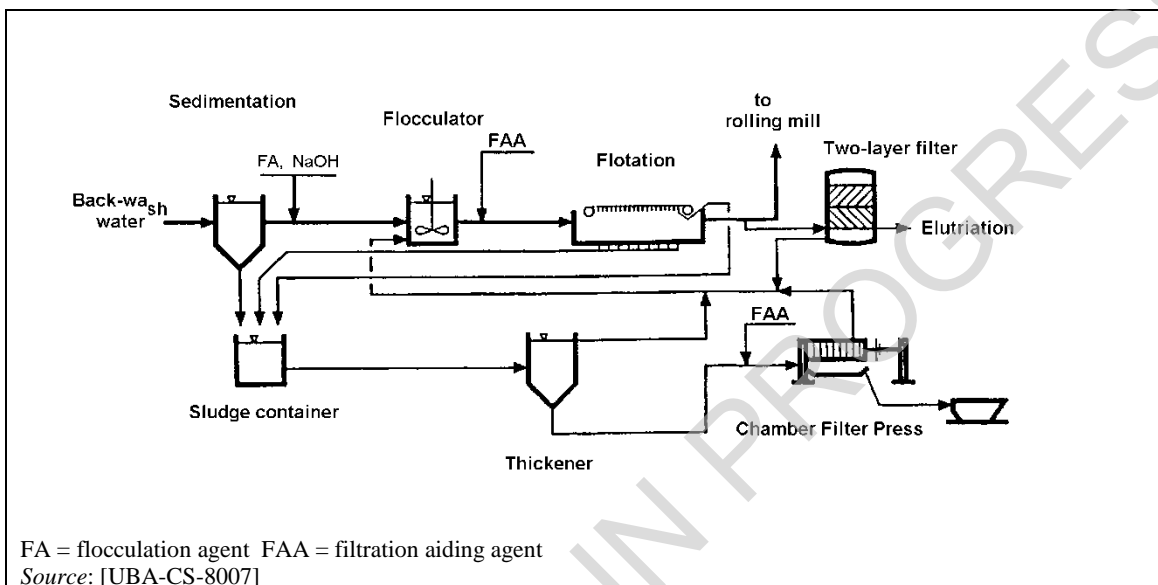


Figure 8.45: Treatment of backwashing water

Table 8.13: Concentration of effluents from treatment of backwashing water

| Substance | Concentration in mg/l | Type of sampling | Measurements in 1998 Operator/Comp. authority |
|------------------|-----------------------|-------------------------|--|
| Fe | 0.13 | Qualified random sample | 12/6 |
| Oil | < 0.1 | Qualified random sample | 12/6 |
| Suspended solids | < 3 | Qualified random sample | 12/6 |
| Cr | < 0.01 | Qualified random sample | 12/6 |
| Ni | 0.02 | Qualified random sample | 12/6 |
| Zn | 0.03 | Qualified random sample | 12/6 |

Note:
Mean values of the qualified random samples from 1998. Waste water volume: 1620404 m³
Source: Senator für Bau und Umwelt Bremen. Plant: Stahlwerke Bremen.[Com2 D]

Example C: ArcelorMittal Ghent

The water circuit installed at ArcelorMittal Ghent basically consists of three systems: the 3-bar system for cooling the supporting rolls, the roll table and the motors; the 12-bar system for cooling of the work rolls and for feeding of the descaling pump system and the 150-bar system for descaling at the furnace exits and in the roughing and finishing mill. The total flow is up to 13 000 m³/h.

Oil- and scale-bearing water from the 150-bar system is cleaned in a first step by scale pits followed by gravity sand filters. The process water from the roughing mill contains mainly large scale, less than 20 % of the oil and grease consumed, does not require cooling and can be reused in the 3-bar system without further treatment. Water from the finishing mill contains fine scale and over 80 % of the oil and grease consumed. Following the decanters and the sand filters, this

water needs to be cooled before it is reused in the 3-bar system. The reused channel water contains less than 5 mg/l suspended solids and less than 0.2 mg/l hydrocarbons.

Due to evaporation losses and high contents of Na, Cl, etc., about 500 m³/h of refreshing water is needed, which is taken from the cold rolling mill. The elutriated water exits to the steel mill.

The reutilisation rate of the system described is over 95 %.

The efficiency of the waste water treatment and thus the pollutant concentration discharged depend among others on the combination of individual cleaning operations. Table 8.14 lists more example water treatment sequences and achieved emission levels.

Table 8.14: Pollutant reduction for several waste water treatments

| Results of waste water treatment | | |
|---|--|--|
| Before Treatment | Treatment | After treatment [mg/l] |
| Oil/Grease: 10 -200 mg/l 0.7 - 2.73 kg/t Suspended solids (SS): 120 – 2000 mg/l 0.13 - 4.57 kg/t | Example E Sedimentation + flocculation, flotation + sand filter | Oil: 50 SS: 50 |
| | Example F Sedimentation + flocculation + cooling + sand filter | SS: < 10 Oil: <5 Fe: 12 Ni, Cr, Cu, Zn, Pb, Cd: < 0.1 |
| | Example G Sedimentation + flocculation + cooling + magnetic filtration ¹ | Reduction: SS: 90 % (down to 3 - 9 mg/l) Oil: 50 - 90 % |
| | Example B' Sedimentation + aerated sinter removal + flotation + sand filter, blow down: biological polishing | Reduction: SS (>63 µm): > 99 % 31 < SS <63 µm): 20 - 80 %: |
| | Example H Cyclones, settling basin, sand filter, cooling towers | Oil: 50 (= 20 g/t) SS: 50 (= 20 g/t) COD: 100 |
| ¹ Concentration before treatment: 30 - 100 mg suspended solids/l Source: [EC Haskoning] | | |

Cross-media effects

Oil and sludge arise as waste in waste water treatment. [Com D]

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Environmental legislation.

Example plants

ArcelorMittal Bremen, ArcelorMittal Ghent, SSAB (S), BSW (D).

Reference literature

[EUROFER HR] [DFIU98] [Theobald] [UBA-Kloekner-82] [SSAB] [Dammann] [Com D]

8.7.9 Cooling water systems

Description

Separate and closed cooling water systems with recooling of the water by evaporative towers or plate heat exchangers (cooling media can also be seawater or other available media). In order to operate closed cooling water cycles, the cooling water has to be re-cooled and treated, depending on the type of cooling system. Cooling water may be recirculated to minimise consumption by rejecting the heat via evaporative cooling towers or secondary cooling circuits. [EUROFER 23-7-18]

Technical description

In order to run cooling water in closed loops and thus reduce the water consumption, the cooling water has to be re-cooled and treated.

Cooling is carried out either by evaporation in cooling towers, heat exchangers using a secondary cooling system or hybrid cooling towers. In pressure-cooled counterflow **cooling towers**, the water to be cooled is sprayed on grids in the cooling tower cells and trickles over blocks into the cooling tower tray. Fans arranged laterally or on top draw in ambient air which passes the water in counterflow. Thus cooling is achieved by evaporation of water. The cooling efficiency is controlled by means of the air volume. Desalting is controlled via a measurement of the electrical conductivity. If required, the necessary amount of dispersants, sodium hypochlorite and biocide (prevention of growth of bacteria and fungi) and acid or alkali (pH value) is added. [EUROFER HR] [EUROFER 23-7-18]

In **plate heat exchangers**, plates with through-flow channels are stacked up. Between the plates, alternately warmed up water and secondary cooling water is pumped through, enabling heat exchange between the two fluids via the plate walls. Sources for secondary cooling water are mostly open water sources like rivers, lakes or sea, and it can be pretreated to decrease fouling in the system. [EUROFER HR]-[EUROFER 23-7-18]

In **hybrid cooling towers**, a plate heat exchanger is installed in the upper part of the tower. In the lower part, the water is cooled by evaporation. Due to the heat exchanger, the air with 100 % moisture is heated and condenses as fog some time later and with less intensity.

In the planning and installation of circuit-type water treatment plants with cooling towers, the geographical situation of the respective mill has to be taken into consideration. Due to the water evaporation in the recooling process, climatic conditions can be affected by the constant formation of fog and by so-called industrial snow, especially in central Europe. [EUROFER HR]

Achieved environmental benefits

Reduced water consumption as water can be reused in the process.

Environmental performance and operational data

Cold rolling (example of a tandem mill)

Table 8.15: Consumption and emission levels for the cooling water system of a tandem mill

| Input / Consumption Level | | |
|---|----------------------------|-------------------|
| Cooling water (re-circulating) | 8400 | m ³ /t |
| River water | 7000 | m ³ /t |
| Soft water ¹ | 2.5 E -4 | m ³ /t |
| NaOH | 1.25 E -8 | m ³ /t |
| Inhibitor | 2.5 E -7 | m ³ /t |
| Energy: | | |
| Electrical | 0.004 | GJ/t |
| Caloric ² | 0.282 | GJ/t |
| Output / Emission Level | | |
| | Specific Emission | Concentration |
| Cooling water (re-circulating) | 8400 m ³ /t | |
| Waste water (system drain water) | 2.5 E -4 m ³ /t | |
| Settleable solids (volume) | 2 - 5 ml/l | |
| Hydrocarbons (oil, grease) | 2 - 5 mg/l | 0.5 - 1.25 mg/t |
| Chlorides | 50 mg/l | 12.5 mg/t |
| Fe total | 2 mg/l | 0.5 mg/t |
| Temperature | 35 °C | |
| pH | 6.5 - 9.5 | |
| Electric conductivity | 1.1 mS/cm | |
| Notes: Source of data [EUROFER CR] | | |
| Data based on weekly, volume proportional 24-h sampling | | |
| ¹ only in case of system drainage | | |
| ² energy removed from tandem mill by cooling water | | |

Example of annealing furnaces

The annealing furnaces (e.g. batch annealing in a controlled atmosphere of 75 % H₂, 25 % N₂ (or sometimes 100 % H₂) are equipped with a water cooling system in order to maintain both the fan motors brackets situated at the base of the furnaces and the furnace bell at low temperature. The cooling circuit has a water tank that is reintegrated every time a minimum level is reached. The frequency of reintegration of the water tank is dependent on production. The water is cooled by evaporative towers and then reused. [EUROFER 31-5-17]

Cross-media effects

- Addition of dispersants and of biocides for cooling water treatment [Com HR].
- Increased energy consumption as a result of recirculation pumping requirements. [Com2 HR]
- Due to the water evaporation in the recooling process, the climatic conditions can be affected by the constant formation of fog and by the so-called industrial snow, especially in central Europe. [EUROFER 23-7-18]

Technical considerations relevant to applicability

- Applicability to existing plants may be limited by a lack of space [EUROFER 23-7-18]
- Depending on local conditions, in some plants once-through water cooling systems are applied (see Section 2.2.17 and BAT conclusions in the IS BREF and ICS BREF). [EUROFER 23-7-18]
- Once-through systems are commonly applied to large-capacity installations, e.g. iron and steel integrated works in locations where sufficient cooling water and receiving surface water are available. Using a once-through system has the advantage of avoidance of industrial snow and ice formation during winter time in cold climatic European regions, resulting from condensating steam emissions from cooling towers. If a reliable water source is not available, recirculating systems (cooling towers) are used (see the IS BREF and ICS BREF). [EUROFER 23-7-18]

Economics

Beside the costs for installing and operating a cooling water system, the expenditure for maintenance needs to be considered. Micro- and macro-fouling inside the heat exchangers and cooling water pipes increases the pressure loss and decreases the heat transfer, causing higher energy consumption for recirculation. Periodic maintenance is necessary to preserve the efficiency of the system. [EUROFER 23-7-18]

Driving force for implementation

Reduced water consumption.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[ICS BREF] [IS BREF] [Com2 HR] [Com HR] [EUROFER 23-7-18]

8.8 General techniques to reduce emissions to air

8.8.1 End-of-pipe techniques

8.8.1.1 Demister

Description

Demisters are filter devices that remove entrained liquid droplets from a gas stream. They consist of a woven structure of metal or plastic wires, with a high specific surface area. Through their momentum, small droplets present in the gas stream impinge against the wires and coalesce into bigger drops.

Reference literature

[WT BREF] [CWW BREF]

8.8.1.2 Electrostatic precipitator (ESP)

Description

Electrostatic precipitators (ESPs) operate such that particles are charged and separated under the influence of an electrical field. Electrostatic precipitators are capable of operating under a wide range of conditions. The abatement efficiency may depend on the number of fields, residence time (size), and upstream particle removal devices. They generally include between two and five fields. Electrostatic precipitators can be of the dry or the wet type depending on the technique used to collect the dust from the electrodes. Wet ESPs are typically used at the polishing stage to remove residual dust and droplets after wet scrubbing.

Reference literature

[WT BREF] [CWW BREF]

8.8.1.3 Fabric filter

Description

Fabric filters, often referred to as bag filters, are constructed from porous woven or felted fabric through which gases are passed to remove particles. The use of a fabric filter requires the selection of a fabric suitable for the characteristics of the waste gas and the maximum operating temperature.

Reference literature

[WT BREF] [CWW BREF]

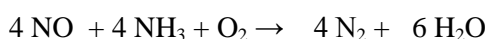
8.8.1.4 Selective catalytic reduction (SCR)

Description

The SCR technique is based on the reduction of NO_x to nitrogen in a catalytic bed by reaction with urea or ammonia at an optimum operating temperature of around 300–450 °C. Several layers of catalyst may be applied. A higher NO_x reduction is achieved with the use of several catalyst layers.

Technical description

The SCR process is the most highly developed and widely used method for NO_x removal from exhaust gases. The process involves the reduction of NO and NO₂ to N₂ of ammonia over a catalyst bed. The overall reactions are:





The optimum temperature window for these reactions is 300–400 °C. Usually, ammonia is added slightly sub-stoichiometrically (0.9–1.0 mole per mole of NOX) to suppress carry-over. [HMIP-95-003] [ETSU-45] [HMIP-95-003]

The most effective and widely used catalyst is vanadium pentoxide (V_2O_5) supported on TiO_2 . Other substances exhibiting catalytic activity are Fe_2O_3 and CuO ; the noble metals (Pt, Pd, Ru, Rh); oxides of the metals W, Mo, Cr, Co and Ni; certain zeolites and activated carbon. The catalyst may be employed in a variety of structures and configurations to alleviate the problem of blockage by particulates depending on the severity of the problem. A honeycomb-shaped catalyst is suitable in a fixed bed configuration because it permits the particles to pass through without clogging. A moving bed configuration allows a deactivated or clogged catalyst to be constantly regenerated. A parallel-flow arrangement is also suitable. [HMIP-95-003]

Deactivation by poisoning (Na, K, As), erosion or solids contamination may limit the lifetime of the catalyst. [EUROFER HR]

The efficiency of NOX reduction by SCR depends on the catalyst used and the initial NOX concentration. Values up to 95 % have been reported, with a typical range being 70–90 % [HMIP-95-003] [ETSU-gir-45]

Reference literature

[HMIP-95-003] [EUROFER HR] [ETSU-45] [ETSU-gir-45]

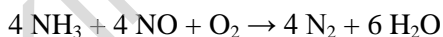
8.8.1.5 Selective non-catalytic reduction (SNCR)

Description

SNCR is based on the reduction of NOX to nitrogen by reaction with ammonia or urea at a high temperature. The operating temperature window is maintained between 800 °C and 1 000 °C for optimal reaction.

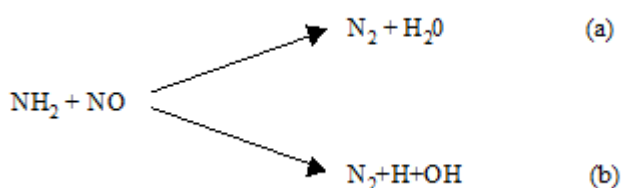
Technical description

In this process, also known as the thermal De-NOX process, ammonia or urea is injected directly into the flue-gas at higher temperatures than SCR, to reduce NO to N_2 , without the aid of a catalyst. To ensure the maximum possible reduction of NOX, it is necessary to inject ammonia or urea at a point in the process where the exhaust gas temperature is within an optimum range. For ammonia, the range is between 850 °C and 1 000 °C and for urea the range is from 950 °C to 1 100 °C. The overall reaction is:



The presence of excess O_2 in the exhaust gas is thus required, as well as a residence time of 0.1 to 0.4 seconds. A feature of this process is that it is only effective over a narrow temperature window. [HMIP-95-003]

The reaction mechanism is a homogeneous gas phase one, the key step being:



The chain-branching channel (b), producing radicals, is crucial to sustaining the reaction; without it, the reaction would quickly terminate. This reaction is in competition with reactions of NH_2 with oxidising radicals (O, OH) which lead to the formation of NO. This competition explains the existence of the temperature window. At temperatures below the low temperature limit, NO reduction is limited by radical chain termination steps in the mechanism competing effectively with chain-branching steps; at temperatures above the high temperature limit, NH_3 oxidation dominates over NO reduction, leading to net NO formation. Additives influence this window by altering the balance between these processes. [HMIP-95-003]

Ammonia is potentially explosive and its safe storage would be a significant consideration with cost implications. [HMIP-95-003]

Reference literature

[HMIP-95-003]

8.8.1.6 Wet scrubbing**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.

Reference literature

[WT BREF]

8.8.2 Emissions to air from heating**8.8.2.1 Use of a fuel or a combination of fuels with low dust or ash content****Description**

Fuels with low dust and ash content include natural gas, liquefied petroleum gas, dedusted blast furnace gas and dedusted basic oxygen furnace gas.

Technical considerations relevant to applicability

Applicable within the constraints associated with the availability of different types of fuel, which may be impacted by the energy policy of the Member State.

More information on the technique

See Section 2.4.2.1.

8.8.2.2 Use of a fuel or a combination of fuels with low sulphur content**Description**

Fuels with low sulphur content include natural gas, liquefied petroleum gas, blast furnace gas, basic oxygen furnace gas and desulphurised coke oven gas.

Technical considerations relevant to applicability

Applicable within the constraints associated with the availability of different types of fuel, which may be impacted by the energy policy of the Member State.

More information on the technique

See Section 2.4.2.1.

8.8.2.3 Use of a fuel or a combination of fuels with low nitrogen content

Description

Fuels with low nitrogen content include natural gas, liquefied petroleum gas, blast furnace gas, basic oxygen furnace gas and desulphurised coke oven gas.

Technical considerations relevant to applicability

Applicable within the constraints associated with the availability of different types of fuel, which may be impacted by the energy policy of the Member State.

More information on the technique

See Section 2.4.2.1.

8.8.2.4 Furnace automation and control

See Section 8.5.3.3.

8.8.2.5 Combustion optimisation

More information on the technique

See Section 8.5.3.2.

8.8.2.6 Low-NOX burner

Description

The technique (including ultra-low-NOX burners) is based on the principles of reducing peak flame 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 NOX and the formation of thermal NOX, while maintaining high combustion efficiency.

Technical description

Low-NOX burner is a general term for a series of burners that combine several design features to reduce the NOX emission level. The main principles of these burners are the reduction in peak flame temperature, the reduction in residence time in the high-temperature zone and the reduction in oxygen availability in the combustion zone. This is generally achieved by air staging, fuel staging and/or internal flue-gas recirculation. [HMIP-95-003] As there is a multitude of different burner designs, also varying from supplier to supplier, Figure 8.46 and Figure 8.47 show only a selection of the different low-NOX burners available.

The **recirculation of the flue-gases** from the furnace into the flame can be favoured by burner design as shown in Figure 8.46. This lowers the O₂ concentration in the air/fuel mixture and creates a quiet flame with a lower temperature. The recirculation also achieves a chemical reduction of the NOX in the flue-gases by the hydrocarbons in the fuel. [EUROFER HR]

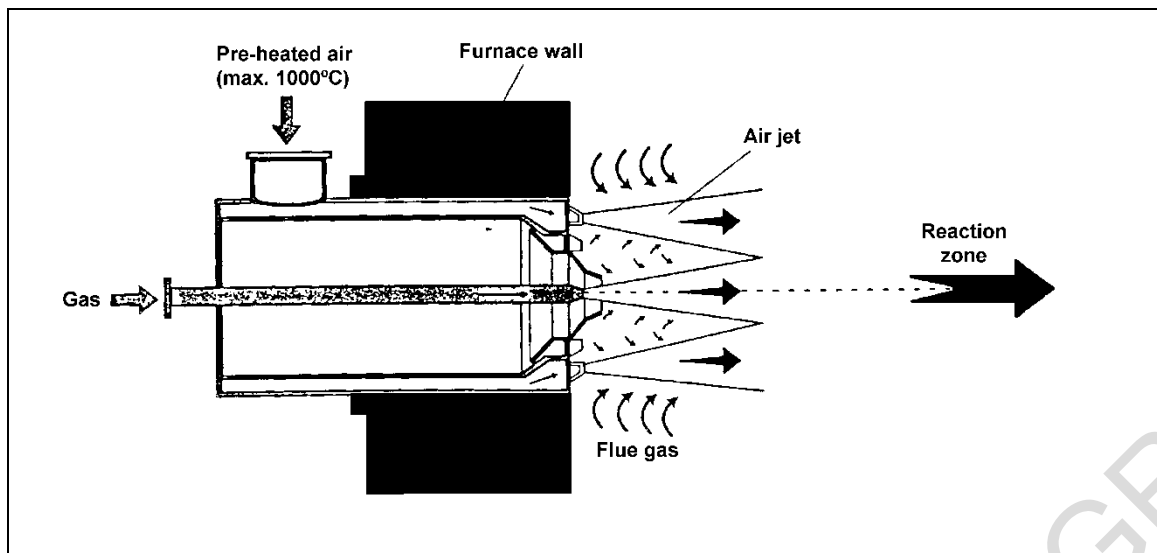


Figure 8.46: Schematic of a low-NOX burner with internal flue-gas recirculation [ETSU-45]

A further reduction of the NOX level and of the dependency of the NOX level on the air preheat temperature can be achieved by burners with an increased jet flow, where the flame in some cases is not anchored to the tile of the burner or where the gas and combustion air inlets are separated. [EUROFER HR]

A common mode of operation of low-NOX burners is the creation of a fuel-rich zone within the flame. This favours the conversion of fixed nitrogen, chemically bound fuel-nitrogen, to N_2 . It also has the effect of reducing the peak flame temperature. Both fuel and thermal NOX mechanisms are retarded and the formation of NOX is reduced. There are two main types of low-NOX burners which both involve the use of staged combustion to achieve the desired effect. These are air-staged and fuel-staged burners.

In **air-staged burners**, the first stage of combustion occurs in a slightly fuel-rich zone, at an optimum fuel to air ratio (1.1–1.3) for conversion of the fuel nitrogen to N_2 . A second stage of combustion is operated fuel-lean by addition of secondary air in such a way as to complete the fuel burnout, with careful temperature control to minimise the formation of thermal NO in this zone.

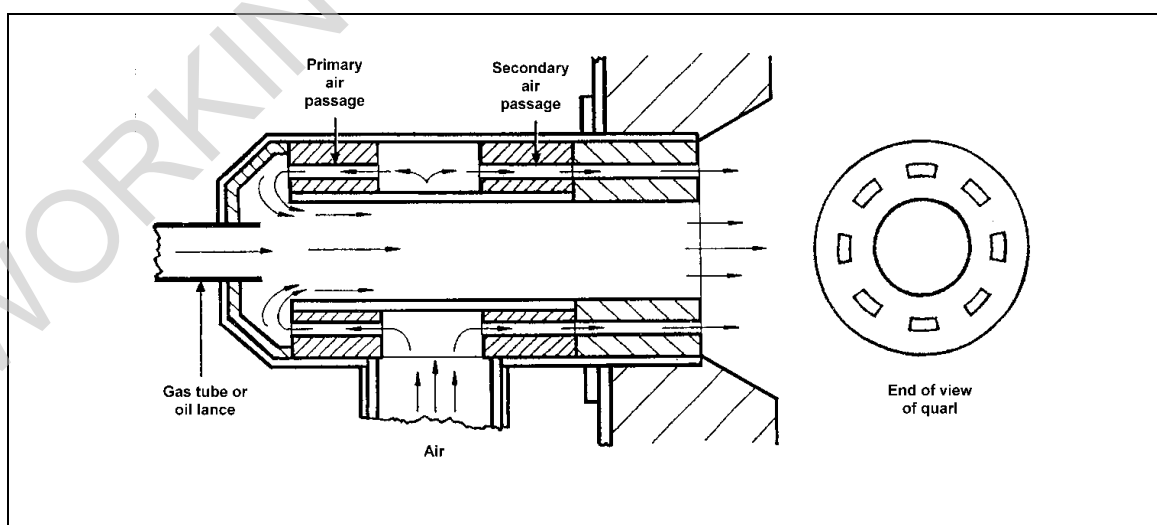


Figure 8.47: Schematic example of an air-staged low-NOX burner [HMIP-95-003]

There are various designs of air-staged burners which differ in the way the two combustion zones are created. In aerodynamically air-staged burners, all the combustion air flows through the same burner opening, in such a way that aerodynamics is used to create the first fuel-rich zone. External air-staged burners use a separate air stream to complete burnout. In air-staged pre-combustor burners, the fuel-rich zone is established in a separate pre-combustor section. Key design factors controlling the effectiveness of air-staged burners are the temperature and residence time in each stage. ~~Manufacturers generally claim a reduction in uncontrolled NOX emissions on gas firing of 50–60 % by means of air staging.~~ [HMIP-95-003]

In **fuel-staged burners**, NO is allowed to be formed in the primary combustion zone, but fuel is injected downstream to create a secondary fuel-rich, or 'reburn' zone where the NO is reduced to N₂. Further air is added downstream to complete combustion of the excess fuel in a tertiary combustion zone, again with careful control of temperature to minimise thermal NO formation. Reburn fuels can be natural gas or coal.

The key reactions responsible for conversion of NO to N₂ in the fuel-rich zones of both types of low-NOX burners are those between NO and small hydrocarbon- and nitrogen-containing radicals (such as CH, CH₂, NH, NH₂, NCO) which are present under these conditions. The mechanisms of NOX chemistry are complex and the effectiveness of the methods described here to reduce NOX formation depends on a number of factors including burner design, operation, fuel quality (particularly the volatile and fuel-nitrogen content), particle size (especially for liquid and solid fuels) and scale of operation.

Low-NOX staged combustors are the most applicable of control techniques for industrial furnaces and do not present many difficulties of installation. Some, but not all, designs of staged combustor result in lower burner exit velocities and this reduction in momentum may cause changes in furnace aerodynamics and hence problems with heat transfer distribution. Similarly, flames will tend to lengthen which may necessitate increases in excess air levels to avoid direct flame contact with the material being heated. [HMIP-95-003]

Low-NOX burners can be more complex and/or bulky than conventional burners and may give rise to problems in furnace design or in retrofitting existing furnaces. The investment cost for retrofit depends on the type and size of furnace and to what degree the new burners are compatible with the existing combustion equipment. No increase of operating costs is connected with low-NOX burners. [ETSU-45]

Ultra-low-NOX burner

For ultra-low-NOX burners, a high gas flow is required. The complete mixing of the fuel and the combustion air (and the flue-gases) takes place in the furnace, which has the effect that there is no anchoring of the flame to the burner. As a result, this type of burners can only be used at furnace temperatures beyond the spontaneous ignition temperature of the fuel/air mixture.

~~NOX levels of 100–200 mg/Nm³ can be achieved. The NOX levels are less dependent of the air preheat temperature.~~ [HR]

By injecting fuel away from the immediate vicinity of the combustion air, mixing between reactants and products of combustion is enhanced. As a consequence, the peak flame temperature is lowered, reducing the formation of thermal NOX. In the case of high injection momentum (e.g. high velocities), the entrainment of flue-gases is increased, resulting in mild or flameless combustion. The temperature profile achieved is much smoother, with very low NOX emissions. In order to achieve combustion under such conditions, the furnace temperature must be above the self-ignition temperature. External flue-gas recirculation can be also used to lower the NOX emissions, with the goal of reducing the peak flame temperature by dilution with the flue-gases. [EUROFER 10-7-18]

Combustion optimisation is a key method to reduce NOX emissions by means of reducing the excess air. By controlling the oxygen level in the furnace atmosphere (flues), efficiency is increased and NOX emissions are reduced (less oxygen available to react with the nitrogen). Air

ingress should also be avoided (e.g. furnace pressure control during door openings). Furthermore, excess air control provides additional benefits since process yield is increased (less steel oxidation). [EUROFER 10-7-18]

Fuel switching is another effective way to reduce NOX emissions. Use of natural gas leads to lower NOX levels. Other fuels such as process gases from iron and steel production contain nitrogen and can therefore contribute to the formation of fuel NOX (e.g. NH_3 in coke oven gas). In addition to the standard practice of replacing N-bound fuels (coals or fuel oils) with gaseous fuels, the use of blast furnace gas reduces NOX formation, taking into account its lower peak flame temperature. Also, fuel conditioning is important (e.g. NH_3 removal from COG which is described in the IS BREF). [EUROFER 10-7-18]

Reference literature

[HMIP-95-003] [EUROFER HR] [ETSU-45] [HR]

8.8.2.7 Flue-gas recirculation

Description

Recirculation of part of the flue-gas to the combustion chamber to replace part of the fresh combustion air, with the dual effect of cooling the temperature and limiting the O_2 content for nitrogen oxidation, thus limiting the NOX generation. It implies the supply of flue-gas from the furnace into the flame to reduce the oxygen content and therefore the temperature of the flame.

Technical description

Flue-gas recirculation (FGR) is a technique for limiting peak flame temperatures. Recirculating flue-gases into the combustion air will reduce the oxygen to 17–19 % and lower flame temperatures, hence limiting the formation of thermal NOX. [HMIP-95-003] [HR]

Figure 8.48 shows schematically the principle of FGR. The simplest method consists of recirculating the flue-gases by withdrawing them from the exhaust duct using the burner fan and mixing them with combustion air. The recirculation flow rate can be adjusted using a servo-controlled throttle valve managed by the electronic equipment of the burner. The NOX emission reduction obtained with this method with natural gas as fuel is significant and is a function of the percentage of recirculated fumes and the type of burner used. [EUROFER 23-7-18]

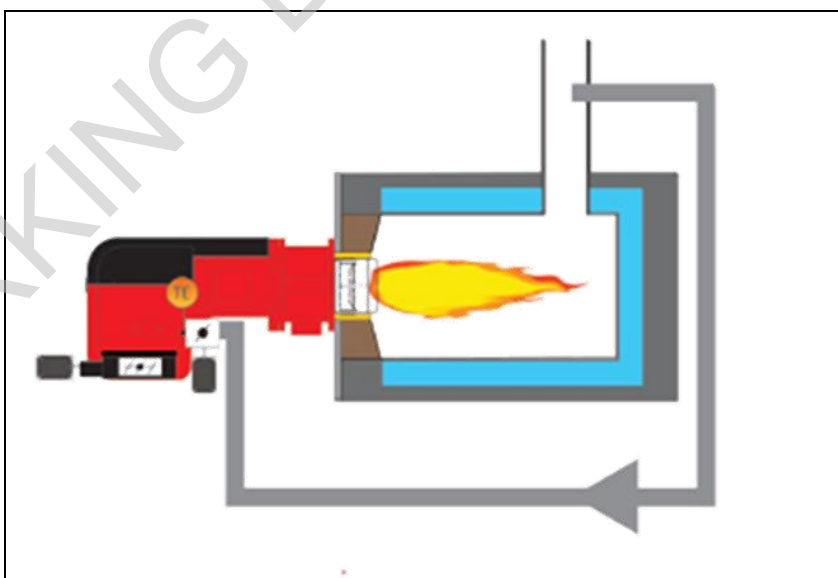


Figure 8.48: Schematic of a burner equipped with FGR [EUROFER 23-7-18]

For instance, the NOX emissions reduction achieved with FGR is shown in Figure 8.49. The diagram is based on a range of test data.

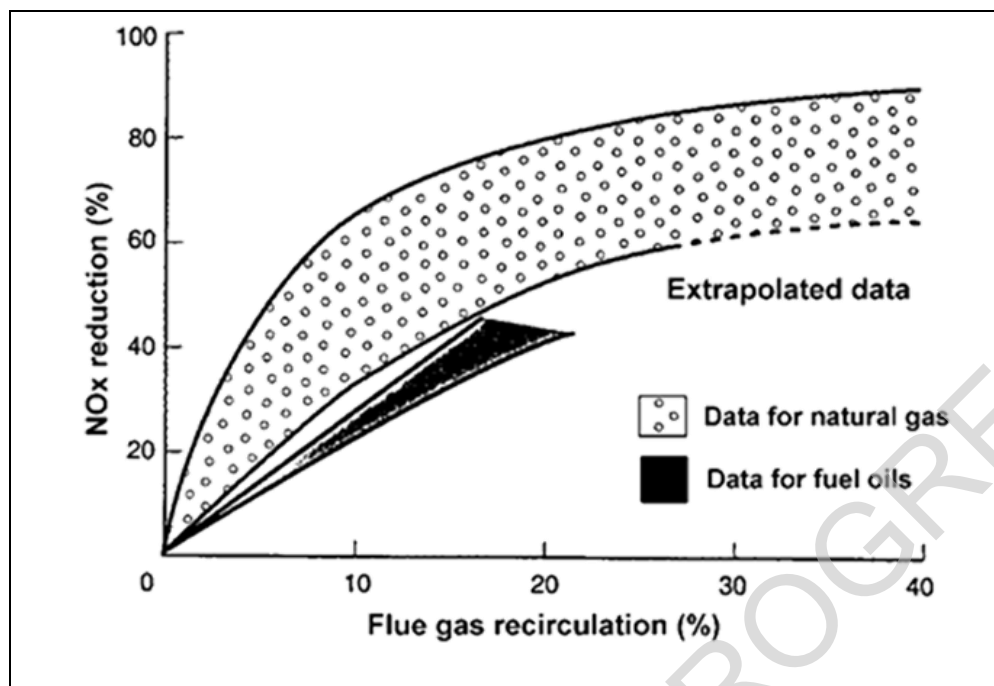


Figure 8.49: Effect of flue-gas recirculation on NOX emission [ETSU-45]

Data obtained with several different test rigs showed that FGR can achieve NOX reductions approaching 70–80 % depending on the fraction of the flue-gas that is recirculated (FGR 20–30 %), the temperature of the recirculated gases and whether or not the FGR is to be applied to a low-NOX burner system. Fractional reductions compared directly to a staged combustion burner should be somewhat less, but the overall reductions with respect to the baseline should still be greater, although there are insufficient experimental results to quantify this for high-temperature industrial burners. [HMIP-95-003]

~~At least one manufacturer offers FGR in conjunction with its low NOX burner range and there may well be others.~~

~~Regarding operational problems, there is some concern that there may be flame stability problems at 'turndown' and that increased water vapour contents in the combustion products can increase for example the scaling of the steel that is being heated. [HMIP-95-003]~~

~~Some doubts exist about how FGR is actually done in a multiburner combustion system. Variable composition fuels (and hence variable waste gas volumes) could also result in combustion control problems. [EUROFER HR]~~

Reference literature

[HMIP-95-003] [HR] [EUROFER 23-7-18]

8.8.2.8 Limiting the temperature of air preheating

Description

Limiting the air preheating temperature leads to a decrease of NOX emissions. A choice has to be made between maximising heat recovery from the flue-gas and minimising NOX emissions.

Technical description

Emission levels of NOX increase with increasing preheating temperatures of combustion air as is shown in Figure 8.50 and Figure 8.51. Thus limiting air preheating can be a measure to limit NOX emissions.

On the other hand, the preheating of combustion air is a commonly applied measure to increase the energy efficiency of furnaces and to decrease fuel consumption. The increase in fuel consumption to be expected from reducing air preheating temperatures can be seen in Table 8.16.

Generally, plant operators are interested in reducing the fuel consumption as this implies a monetary benefit, but the reduction of fuel consumption can additionally reduce other air pollutants, such as CO₂, SO₂ and particulates. Thus a balance has to be struck between energy efficiency and decreasing SO₂ and CO₂ emissions on one hand and increasing NO_x emissions on the other. When keeping air preheating temperatures high, the application of secondary NO_x reduction measures might be necessary.

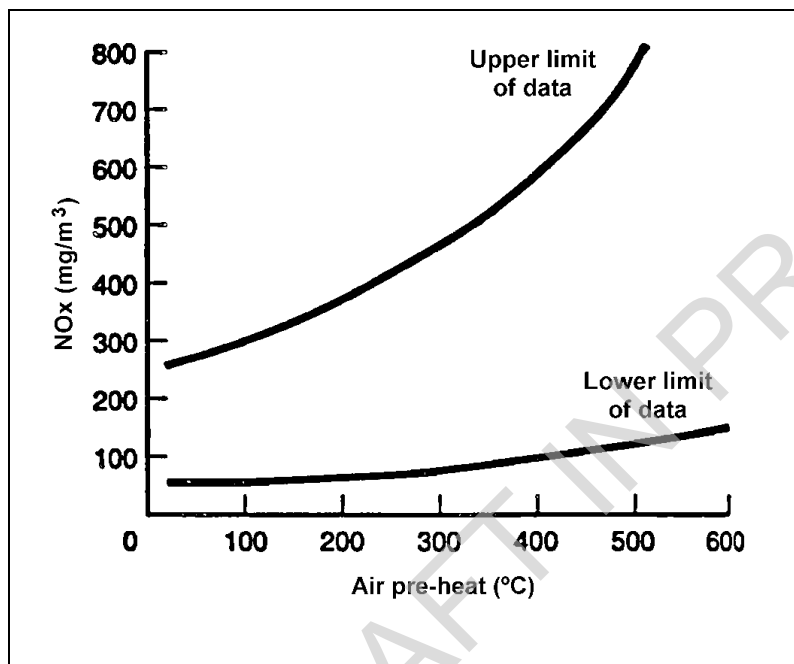


Figure 8.50: Influence of air preheating temperatures (low range) on NO_x emissions [ETSU-45]

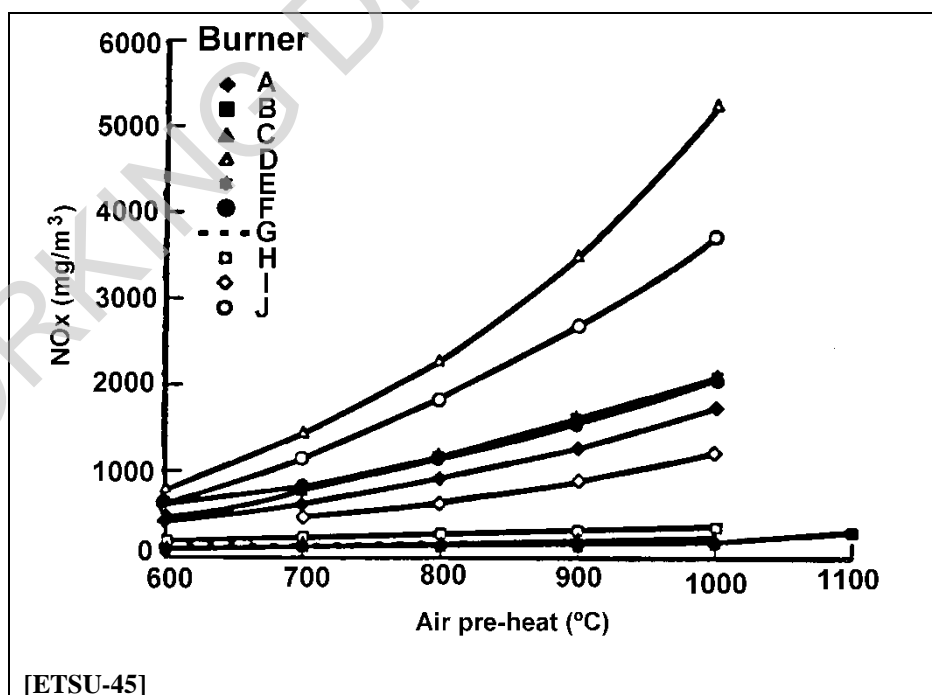


Figure 8.51: Influence of air preheating temperatures (high range) on NO_x emissions [ETSU-45]

Table 8.16: Calculated percentage increase in fuel consumption from reduced air preheat

| Initial air pre-heat [°C] | Final air pre-heat [°C] | | | | | | | | | |
|---------------------------|-------------------------|------|-----|------|------|------|------|------|------|------|
| | | 1000 | 900 | 800 | 700 | 600 | 500 | 400 | 300 | 200 |
| | 1000 | 0.0 | 6.0 | 12.6 | 19.9 | 28.3 | 37.7 | 48.6 | 60.4 | 74.5 |
| | 900 | | 0.0 | 6.3 | 13.1 | 21.1 | 30.0 | 40.3 | 51.4 | 64.7 |
| | 800 | | | 0.0 | 6.4 | 13.9 | 22.2 | 31.9 | 42.3 | 54.9 |
| | 700 | | | | 0.0 | 7.0 | 14.9 | 24.0 | 33.8 | 45.6 |
| | 600 | | | | | 0.0 | 7.4 | 15.9 | 25.0 | 36.0 |
| | 500 | | | | | | 0.0 | 7.9 | 16.4 | 26.7 |
| | 400 | | | | | | | 0.0 | 8.4 | 17.4 |
| | 300 | | | | | | | | 0.0 | 8.8 |
| 200 | | | | | | | | | 0.0 | |

[ETSU-45]

8.8.2.9 Flameless combustion

See Section 2.4.2.6.

8.8.2.10 Oxy-fuel combustion

See Section 2.4.2.5.

8.8.2.11 Selective catalytic reduction (SCR)**More information on the technique**

See Section 8.8.1.4.

8.8.2.12 Selective non-catalytic reduction (SNCR)**More information on the technique**

See Section 8.8.1.5.

8.8.2.13 Comparison of NOX reduction methods for furnaces

Table 8.17: Comparison of NOX reduction methods [EUROFER 23-7-18]

(as reported by [ETSU-gir-45])

| Technique | Advantages | Disadvantages |
|--|---|--|
| Low-NOX burners | <ul style="list-style-type: none"> - Moderate to high level of NOX reduction - Fuel consumption unchanged - Low or zero operating cost penalty | <ul style="list-style-type: none"> - High capital cost - Longer flame - Different flame shape than existing - Reduced flame velocity (?) No - Uncertain furnace temperature uniformity - Reduced flame stability – safety risk at temperatures below self-ignition - Larger burners (?) - Some cases poor turndown |
| Limiting air preheat | <ul style="list-style-type: none"> - Can be simple, with low or zero capital cost - Moderate to high level of NOX reduction | <ul style="list-style-type: none"> - Increased fuel costs - Downrating of combustion equipment - Reduced flame stability - Reduced burner velocity therefore furnace temperature uniformity |
| Flue-gas recirculation | <ul style="list-style-type: none"> - Moderate to high level of NOX reduction - Improved temperature uniformity(?) - Medium capital costs (if no uprating required) | <ul style="list-style-type: none"> - High capital cost (if uprating required) - Increased fuel and electricity costs - More space required (especially if uprating required) - Reduced flame stability - Downrating of existing combustion system |
| SCR | <ul style="list-style-type: none"> - High level of NOX removal - Combustion system not downrated | <ul style="list-style-type: none"> - Very high capital costs - Increased energy and operating costs - Ammonia slip - Ammonia storage problems - Sensitive to changes in temperature/flowrates - Requires specific waste gas temperature - Less effective when the NOX concentration is low |
| SNCR | <ul style="list-style-type: none"> - Moderate to high level of NOX reduction - Combustion system not downrated | <ul style="list-style-type: none"> - High capital cost - Increased energy and operating costs - Ammonia slip - Ammonia storage problems (unless urea is used) - Sensitive to changes in temperature/flowrates/ stoichiometry - Requires specific furnace temperature - Less effective when the NOX concentration is low |
| Note Source [ETSU-gir-45] (?) Indicates a possible or likely effect | | |

8.8.3 Emissions to air from degreasing

8.8.3.1 Emissions to air from degreasing (fume collection and treatment)

Description

In the case of batch degreasing, air extraction is carried out as close as possible using for example lateral hood or lip extraction or the tanks are located in enclosed areas equipped with

roof or wall extraction. In the case of continuous degreasing, degreasing is carried out in closed tanks and emissions are extracted. In both cases, emissions are treated by wet scrubbing followed by a demister.

Technical description

Fumes generated by degreasing operations are collected and extracted by commonly known measures, namely:

- in the case of batch degreasing, extraction using for example lateral lip or hood extraction or the tanks are located in enclosed areas equipped with roof or wall extraction;
- in the case of continuous degreasing, degreasing is carried out in closed tanks and emissions are extracted.

~~closed degreasing tanks, enclosures extraction hoods, etc. The extracted air is can then be cleaned by means of wet scrubbing followed by a or demister. For the latter, the separation is based on mass inertia. Particles (liquids or solids) with a certain mass and speed follow their original direction. When they collide with obstacles, because of their mass inertia they are separated from the carrier gas stream. Obstacles are created by means of simple walls, fillings (i.e. mesh wire), labyrinths etc. [Com-CC-2]~~

See Sections 8.8.1.1 and 8.8.1.6 the descriptions of demister and wet scrubbing, respectively.

Achieved environmental benefits

- Reduction of fugitive emissions.
- Reduction of degreasing fume emissions.

Environmental performance and operational data

A total of 5 m³/h of recirculated water (evaporate) is needed for a production yield of 66 t/h [Com-CC-2].

Cross-media effects

- Scrubber: water consumption (evaporation) and sludge generation in water treatment plant [Com-CC-2].
- Demister: depending on the cleaning technique used, treatment of spraying water or solvents [Com-CC-2].

Technical considerations relevant to applicability

- ~~New and existing plants with degreasing devices [Com-CC-2].~~
- ~~Existing plants with no space problems [Com-CC-2].~~

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

Economics

~~medium [Com-CC-2]~~

No information provided.

Driving force for implementation

~~Local conditions or requirements from local authorities that lead to implementation. [Com-CC-2]~~

Environmental legislation.

Example plants

Several [Com-CC-2] Jenn An, Taiwan [Danieli].

AceriNOX Europe [EUROFER 23-7-18].

Reference literature

[Com-CC-2] [Danieli] [EUROFER 23-7-18]

8.8.4 Emissions to air from pickling

8.8.4.1 Restricted operating range in the case of batch pickling using hydrochloric acid

Description

The pickling acid temperature and HCl concentration in the pickling bath(s) are strictly controlled so that both of the following conditions are met:

- a) $4\text{ }^{\circ}\text{C} < T < (80 - 4w)\text{ }^{\circ}\text{C}$;
- b) $2\text{ wt-}\% < w < (20 - T/4)\text{ wt-}\%$;

where T is the pickling acid temperature expressed in $^{\circ}\text{C}$ and w the HCl concentration expressed in wt-%.

Technical description

Emissions of acid fumes to air are limited by keeping the temperature and the concentration of the acid bath within a defined range. For any given acid concentration a maximum allowed bath temperature and for any acid bath temperature a maximum allowed acid concentration are defined by the thermodynamic equilibrium and the vapour pressure of the acid.

The hydrogen chloride content in the gaseous phase above a hydrochloric acid pickling bath depends to a large degree on bath temperature and concentration and is determined by thermodynamic equilibrium and the vapour pressure of the acid.

Figure 8.52 shows the (simplified) limiting curve for the operation of open HCl pickling baths given in the [VDI-RL-2579].²

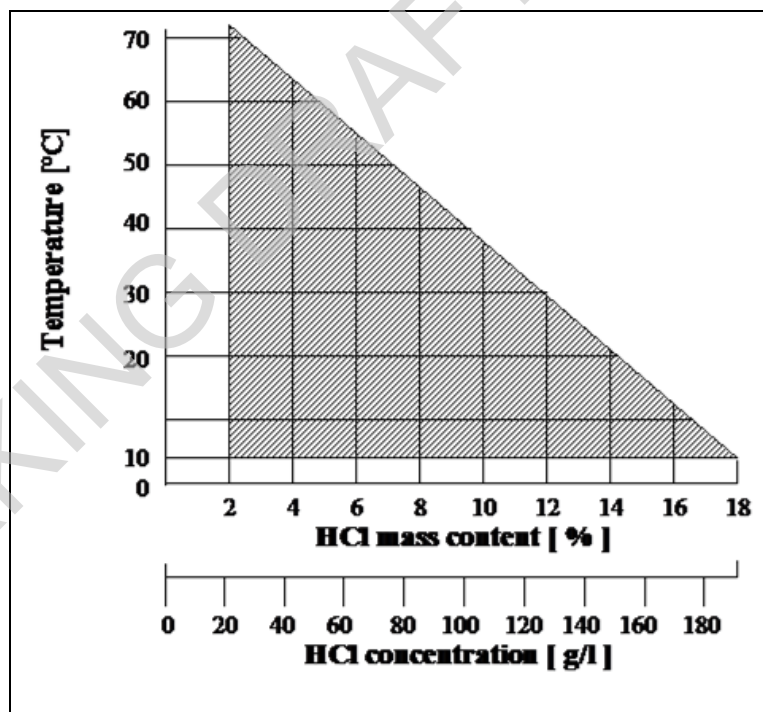


Figure 8.52: Limiting curve for the operation of open HCl pickling baths [VDI-RL-2579] [Galv-BAT-E]

² Emission Control Guideline for Hot-dip Zinc Galvanizing Plants of the German Engineers Association, (Verein Deutscher Ingenieure)

The equation given in the description corresponds to the shaded area of the diagram.

Achieved environmental benefits

Reduction of ~~air~~-acid emissions to air, ~~especially acid fumes~~.

Environmental performance and operational data

Emissions from pickling baths are below 10 mg/m^3 when the operating point (temperature and HCl concentration) of the baths is within the shaded area of this diagram. [VDI-RL-2579]

By close control of process parameters (temperature, concentration) and by ensuring that bath operating conditions are within these given limits, vapour extraction systems and subsequent abatement techniques may become redundant.

TWG input is required on the practise of monitoring bath parameters, e.g. how often is the temperature and the acid concentrations measured ? what about ferrous chloride concentrations ? What measures are taken e.g. if temperature are too high for given concentration?

During operation the ferrous chloride concentration in the pickling baths rises. This results in an increased pickle effect. At the same time, ferrous chloride in hydrochloric acid affects the vapour pressure of the acid in the same way as if the acid concentration was increased: the vapour pressure is increased. Comparing a pickle liquor with 1 % HCl and 6 % iron at 140°F (60°C) with a straight 10 % acid solution, the vapour pressure is increased five times. [Esco 3]

So, in determining the optimum operating range with respect to emission reduction, the ferrous chloride content should be taken into account.

Another aspect influencing the amount of acid vapour emitted is the air flow rate over the pickling bath. Assuming an absolutely still atmosphere over the bath, the evaporation of acid would come to a halt as the equilibrium, determined by the vapour pressure, is reached. A more or less strong and constant air flow over the pickling tank sweeps away the acid vapour and keeps the evaporation process going. The result is not only increased acid consumption, but also higher acid emissions. Air movement and, in the case of extraction systems, the extraction rate should be kept as low as possible.

Cross-media effects

The acid concentration chosen according to the VDI guideline is lower than typically used in the case of wire rod pickling. This results in the following:

- Lower conversion of the acid from HCl to FeCl_2 , which implies a higher consumption of fresh HCl. [Com2 BG]
- Reuse of spent acid as secondary raw material becomes very difficult. For reuse for the production of FeCl_3 , a minimum concentration of 10 % Fe is requested; this high Fe concentration can only be achieved with a high conversion of HCl and with a high initial concentration of HCl. [Com2 BG]
- Increased pickling time, which implies investment in more and/or bigger pickling tanks. Increased bath surface leads to more g/h HCl evaporation. [Com2 BG]

Technical considerations relevant to applicability

~~New and existing plants~~. Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Environmental legislation.

Example plants

Wire drawing: Plant 24 (Data collection)

Reference literature

[VDI-RL-2579] [Esco 3] [Galv-BAT-E] [Com2 BG]

8.8.4.2 Air extraction as close as possible to the source in the case of batch pickling**Description**

Air from the pickling tanks is extracted, for example using lateral hood or lip extraction, or the tanks are located in enclosed areas equipped with roof or wall extraction.

Technical description

Emissions to air from pickling lines with high acid concentrations and high temperatures are dangerous for the health of the operators and can cause corrosion to nearby installations and equipment such as building and cranes. Emissions are captured, collected and treated to protect the environment and reduce workers' exposure. Pickling of hot strip where the hot rolling oxides are removed using high acid concentration and process temperatures (e.g. $> 60^{\circ}\text{C}$) will generate high concentrated acid emissions that need to be collected and treated. On the other hand, batch treatment processes are usually carried out in open accessible tanks at low temperature with pickle liquor exhibiting low acid concentration. For this type of treatment, if the temperature and acid concentrations are kept low, generally emissions to air are minimised (see Section 8.8.4.1). [EUROFER 23-7-18]

In order to extract emissions to air from pickling and/or other process baths, a variety of different designs and techniques are available. Figure 8.53 shows a collection of possible extraction designs applied in conventional open pickling tank operations.

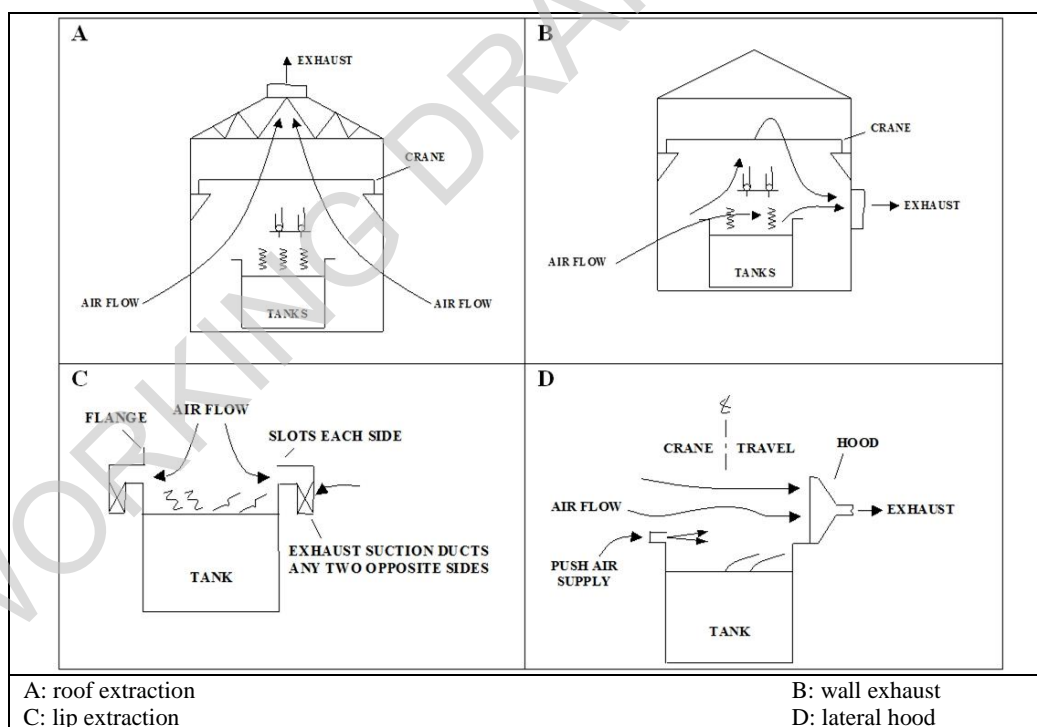


Figure 8.53: Different extraction systems used in open pickling tank operations based on [Stone]

Achieved environmental benefits

Reduction of dust, acids (HCl, HF, H₂SO₄) and SO₂ emissions.

Environmental performance and operational data information

The more open and the further away the extraction device is from the actual emission source, the smaller the capture efficiency and the larger the volumes that need to be extracted to achieve acceptable emission capture efficiency. Roof and wall exhaust systems are usually easy to install and cheaper, but the resulting large air flows require large fans and emission abatement devices. Furthermore, the building itself and the roofs act as collection hoods for acidic emissions and deteriorate accordingly. Also any equipment, such as cranes and hoists, close to the pickling tanks or in the building will corrode rapidly.

Lip extraction and lateral hoods are designed to extract only emissions from the surrounding area of the pickling tank, thus the resulting volume flows are much smaller.

Batch processes usually require open accessible tanks for loading and removing the items to be pickled; therefore only the former measures are applicable.

Cross-media effects

None

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

Environmental legislation.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[EUROFER 23-7-18] [ESCO x] [Stone]

8.8.4.3 Closed pickling tanks combined with air extraction in the case of continuous pickling

Description

Pickling is carried out in closed tanks and emissions are extracted.

Technical description

Completely closed/sealed tanks where the material enters the pickling tank through small openings are used in continuous processes to pickle hot strips and wires. This is the most effective way to capture the emissions from pickling in completely closed/sealed tanks as shown in Figure 8.54. The material enters the pickling tank through small openings. The whole process section including the rinse section is kept under slight negative pressure to avoid the escape of fumes. The collected emissions/vapours are treated using wet scrubber systems followed by a demister (see Section 8.8.1.1). [EUROFER 23-7-18]

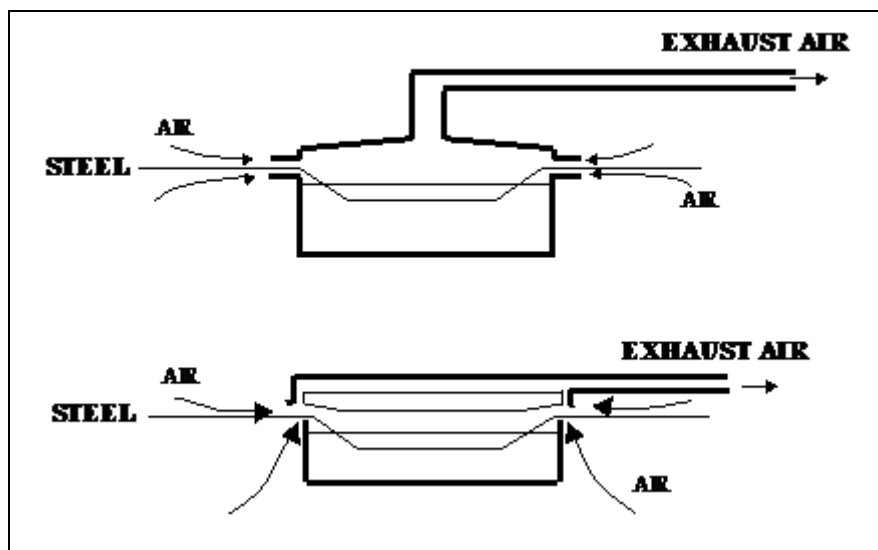


Figure 8.54: Design principles for closed pickling tanks
[ESCO x]

Achieved environmental benefits

Reduction of dust, acids (HCl, HF, H₂SO₄) and SO₂ emissions.

Environmental performance and operational data information

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

Environmental legislation.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[ESCO x]

8.8.4.4 Wet scrubbing followed by a demister

Description

See Sections 8.8.1.6 and 8.8.1.1.

Technical description

Wet scrubbing systems are used to remove acid gas, aerosols or vapour from waste gases. The principle of wet scrubbing is absorption of gas or liquid in the scrubbing medium by close gas-liquid contact. Absorption systems can have either aqueous or non-aqueous liquid phases. The selection of the appropriate reagents depends upon the properties of the pollutant to be removed from the gas stream.

Water is suitable for absorbing soluble acidic gases such as hydrogen chloride and hydrogen fluoride and also for absorbing ammonia. Alkaline solutions are suitable for absorbing less soluble acidic gases such as sulphur dioxide, hydrogen sulphide and chlorine. [Martin]

The gas absorber needs a liquid/gas interface of high surface area across which mass transfer can occur. This is usually achieved using packing materials which are coated with liquid or by droplet/bubble formation. The absorber design also has to provide a means for renewing the liquid absorbent so that a high driving force for mass transfer is maintained.

Gas absorption is a rate process and consequently the concentration gradient (driving force for the reaction) and the surface area of contact between the liquid and gaseous phase are crucial design parameters. The surface area is determined by the packing material or droplet size. Gas and liquid flow rates and pressure drop across the absorber influence the driving force, the efficiency and, in some cases, the surface area (droplet formation). In the following sections the principal wet scrubbing systems used in connection with scrubbing of waste gas from acid pickling are described.

Packed scrubbers (Figure 8.55) consist of an outer shell containing a bed of packing material on support grids, liquid distributors, gas and liquid inlets and outlets, and a mist eliminator.

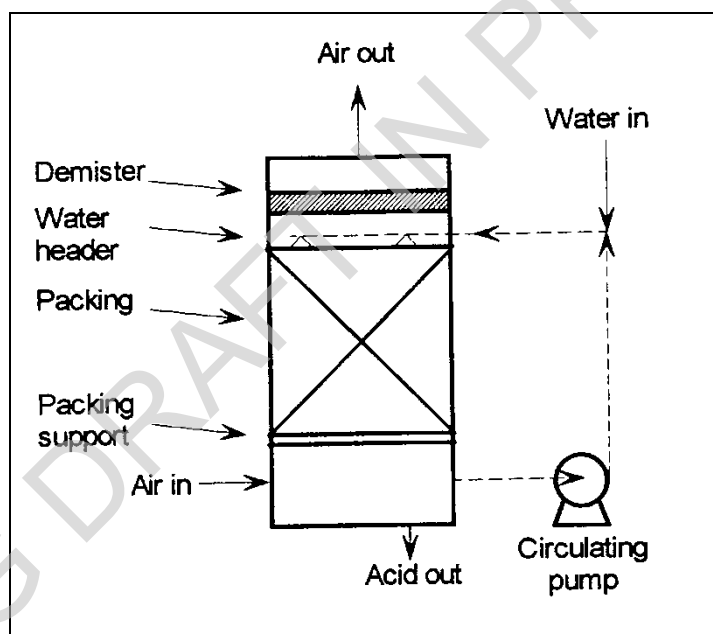


Figure 8.55: Principle of packed scrubbers
[ESCO 2]

The water is usually delivered to the top of the packing bed, and runs down, by gravity, flowing over the packing, while the waste gas enters the bottom of the scrubber, and is washed by the water as it passes upwards through the bed. With this *countercurrent flow* design, the most contaminated gas contacts the most contaminated water at the bottom of the scrubber, and the cleanest gas contacts the cleanest water at the top of the scrubber. Other designs are possible in which the liquid and gas flows may be cocurrent or cross-current. [ESCO 2]

To get an even flow and good contacting of air and water, the water has to be distributed evenly over the top of the packing bed. This is usually done by a distribution header, equipped with spray nozzles. In addition, to ensure that the gas can flow through the whole bed, the packing is held up by a packing support. This packing support has to be open enough to allow the water and air to pass through without creating too much pressure drop, while still being strong enough to hold the packing up, even when it is dirty, and flooded with water. [ESCO 2]

A disadvantage of packed scrubbers is that, in order to function properly, the packing needs quite a high water flow rate - about 200 gpm of water for 20 000 cfm of air (equals 1.34 l/m³). So, instead of using fresh water, most packed scrubbers have recirculation pumps, which pump the water from the bottom of the scrubber to the top of the packing. A small, continuous flow of water has to be added to the scrubber to purge the acid removed from the gas stream, through the overflow. The disadvantages of this practice are: [ESCO 2]

- the pump requires maintenance;
- the water at the top of the packing is now contaminated, so the advantages of countercurrent flow are no longer obtained;
- any dirt in the water is pumped back into the packing, where it may separate and block the distribution header or the packing. [ESCO 2].

Still, in comparison to plate scrubbers, packed scrubbers allow processing of high volume at a good rate. [EUROFER 23-7-18]

Higher scrubbing efficiency can be obtained in packed scrubbers by increasing the depth of the packing bed. [ESCO 2]

The advantages of packed scrubbers are ~~strengths~~:

- simple construction;
- the ability to operate over a wide range of gas flow rates. [EUROFER 23-7-18]

However, to keep a packed scrubber running at the most efficient level (~~as opposed to just "running" i.e. having the air flow through it~~) requires a significant maintenance effort to keep the circulating pump going, ensuring that the water distribution on to the packing is ~~even~~ consistent, and keeping the packing clean. [ESCO 2]

The conventional packed scrubber is a vertical tower, with the air flowing up, and the water running down. A variation on this is the **cross-flow scrubber** (Figure 8.56). In a cross-flow scrubber, the waste gas flows horizontally through the packing, while the liquid still flows down, across the flow of the waste gas. The basic set-up is the same as for conventional packed scrubbers, and a circulating pump is still needed to keep the packing wet. [ESCO 2]

The advantage of the cross-flow scrubber is that it needs less head room, and the ducting is usually simpler and less expensive than for a vertical scrubber. However, cross-flow scrubbers are slightly less efficient than vertical counterflow at removing soluble gases. [ESCO 2]

An advanced type of cross-flow scrubber emulates the multi-stage scrubbing of a plate scrubber. In this version there are several packed beds in series. Each bed has a separate water supply, or circulation system, and may use a structured packing, rather than a random one. This advanced type of scrubber has quite a high pressure drop, and is not currently used in pickling applications. Random packed cross-flow units are widely used. [ESCO 2]

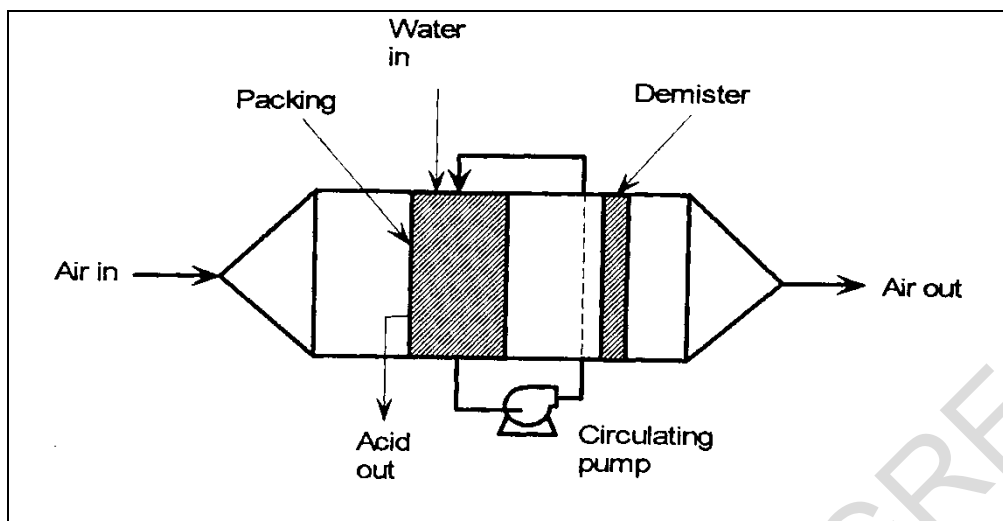


Figure 8.56: Principle of a cross-flow scrubber
[ESCO 2]

Plate scrubbers (Figure 8.57) consist of a vertical tower with several horizontal perforated trays (sieve plates) stacked in it. Baffles are situated a short distance above the apertures in the plates. Scrubbing liquid enters the top of the tower and flows along each of the trays successively. The waste gas enters the bottom of the tower and flows upwards, passing through the perforations in the plates. The velocity of the gas is sufficient to prevent liquid seeping through the perforations. [Martin]

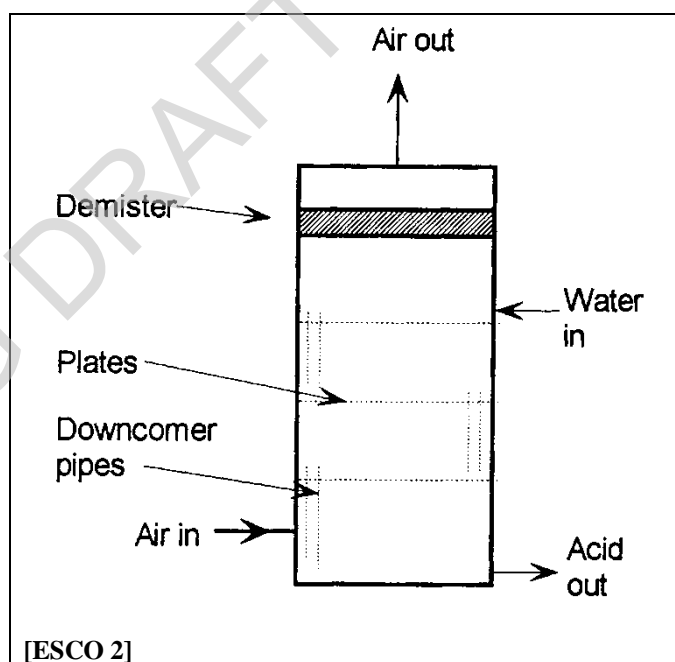


Figure 8.57: Principle of plate scrubbers

The absorption efficiency can be increased by adding more plates to the absorber (increasing the tower height) and by increasing the liquid flow rate. [Martin]

Because the water forms a pool on each plate, smaller water flow rates are sufficient for the exchange of substances ~~is needed for efficient contact~~. A constant flow is necessary to flush out dissolved fumes, and also to offset weeping that occurs through the holes, due to surface tension

effects. In general, recirculation pumps are unnecessary on plate scrubbers, and these scrubbers operate in true countercurrent flow. [ESCO 2] [EUROFER 23-7-18]

Plate scrubbers are simple and have no moving parts, but require careful installation, to ensure the plates are level, and steady air flow. [ESCO 2] They can be susceptible to plugging and scaling, and are not suitable for foaming liquids. [Martin]

The plate scrubber advantages are its low maintenance requirements, and once-through flow of water, which is useful in making high-strength solutions suitable for recycling into the pickling tank. However, a plate scrubber needs careful installation (to level the plates), and has a limited range of air flow variation. [ESCO 2]

All that is needed to keep a plate scrubber operating at design efficiency is the proper flow rate of water to the top tray, and an air flow rate within the designed range. Reported water consumption levels ranged from 0.06 l/m³ to 0.13 l/m³. [ESCO 2]

A key element of scrubbers - as shown above - is the **demister** (entrainment separator, mist eliminator). This is a device that ensures that the air leaving the scrubber is free of water droplets. [ESCO 2]

The principle of all demisters is the same. The inertia of fluid droplets allows the separation from the carrier gas stream by guiding the loaded air through a channel or maze with several changes of direction. The water droplets are forced to impact on a solid surface, where they create larger drops, which are too heavy to be carried by the air. [ESCO 2] [EUROFER 23-7-18]

There are two main types of demister: *knitted mesh* and *chevron baffles*.

The knitted mesh type is simple to handle and install, and separates the water by agglomerating it on fine plastic fibres. Its disadvantages are that it also tends to remove dust, besides water, and the fine plastic fibres deteriorate in time. Eventually, after 3 to 5 years, the accumulated dust and fibre debris plug up the demister, and it has to be replaced. [ESCO 2]

The chevron type of demister consists of a bank of parallel, S-shaped blades, through which the gas passes - the water is removed by impact on the blade surface. This type of demister is not susceptible to plugging, and has an almost unlimited lifetime. [ESCO 2]

Both types of demister will remove over 99.99 % of the droplets created in wet scrubbers. [ESCO 2]

In a **fume filter** (Figure 8.58), the air passes at low velocity through a compacted fibrous bed. As it flows through, the droplets impact on the fibres, agglomerate, and eventually become large enough to drain away by gravity. As this kind of filter also removes dust from the air, it requires washing at regular intervals for cleaning. However, while packed and plate scrubbers usually use several gpm of water on a continuous basis, the filter only uses 30–50 gal/day (114–190 l/d) for rinsing, and this water can be returned to the pickling tank ('no-effluent' scrubber). [ESCO 2]

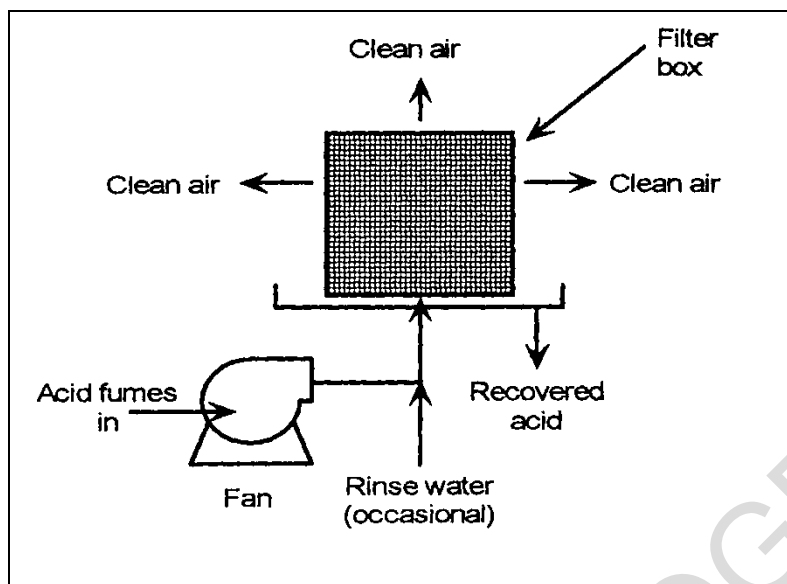


Figure 8.58: Principle of fume filter
[ESCO 2]

Technical aspects specific to mixed acid pickling

Stainless steel is pickled in a mixture of nitric and hydrofluoric acid. Nitric acid is a low-boiling liquid whereas hydrogen fluoride (HF) is a gas, like HCl. As a result, these pickling tanks emit vapours. In addition, they produce droplets which are generated by the bursting of nitrogen oxide (NOX) bubbles. However, in the case of mixed acid pickling, these droplets are not as fine as the sulphuric acid droplets observed in steel pickling, and are less problematic to collect. [ESCO 2]

The nitric and HF vapours and droplets are easily removed in a packed or plate scrubber, using a small throughput of water. [ESCO 2] However, if aerosols are present, the operation of an intensive spraying zone may be required for an efficient aerosol precipitation. [DFIU]

The NOX gases are not easily removed because they are not very soluble in water (refer to Sections 8.8.5 for NOX abatement). [ESCO 2]

A problem that can occur in HF scrubbers is scaling, caused by the deposit of insoluble calcium fluoride. This is produced by the reaction of hard (calcium-bearing) water with the hydrofluoric acid, and can plug up the packing, the outlet pipes, downcomers or recirculation piping. The best way to avoid this problem is to install a water softener to remove the calcium from the supply to the scrubber. [ESCO 2]

Achieved environmental benefits

Reduction of dust, acids (HCl, HF, H₂SO₄) and SO₂ emissions.

Environmental performance and operational data information

TWG, this heading will be updated at a later stage based on the data collection.

[Rituper] reported emission levels $< 10 \text{ mg/m}^3$.

USA [EPA 453]

Packed scrubber + mesh demister:

HCl emission values: 2.7 / 2.8 / 21.2 mg/m^3 , respectively 99.5 / 97.8 / 97.0 % efficiency.

Plate scrubber + mesh demister:

HCl emission values: 3.5 mg/m^3 , respectively 99.96 % efficiency.

Plate scrubber + chevron demister:

HCl emission values: 12.9 / 13.4 mg/m³, respectively 99.0 % efficiency.

[Co or] reported HCl emission values as low as 1 mg/m³, with an average of 15.4 mg/m³ and a maximum of 30 mg/m³

HCl Pickling

Table 8.18: Emission levels achieved for HCl pickling by absorption towers

| | HCl Pickling | |
|---|--------------|--|
| | Dust | HCl |
| Specific Waste Gas Volume [m ³ /t] | 25–400 | |
| Energy Consumption [MJ/t] | 0.5–1.5 | |
| Concentration [mg/Nm ³] | 10–20 | 10–30 ¹ |
| Specific Emission [g/t] | | 0.258 |
| Reduction rate ² | | ≥ 98 % |
| Method of analysis | EPA | Ion chromatography (ASTM D 4327 84) Potentiometric titration (NEN 6476) |
| Note: Source of data [EUROFER CR] | | |
| ¹ [EUROFER 6.9] reports upper level of 30 mg/Nm ³ when including continuous measurements. | | |
| ² Reduction rate based on mass flow of constituent before/after abatement measure | | |

H₂SO₄ PicklingTable 8.19: Emission levels achieved for HCl H₂SO₄ pickling by absorption towers

| | H ₂ SO ₄ Pickling | |
|---|---|--------------------------------|
| | SO ₂ | H ₂ SO ₄ |
| Specific Waste Gas Volume [m ³ /t] | 50–110 | |
| Energy Consumption [MJ/t] | 1–2 | |
| Concentration [mg/Nm ³] | 8–20 | 1–2 |
| Specific Emission [g/t] | 0.4 | 0.05 |
| Reduction rate ¹ | ≥ 95 % | ≥ 95 % |
| Method of analysis | Infrared | Titration |
| Note: Source of data [EUROFER CR] | | |

[CITEPA]:

Water wall + mist arrestor:

HCl emissions 10–15 mg/m³, investment costs: 450 kECU, operating costs: 14 kECU/a, electricity hourly consumption: 100 kWh.

Counter current water packed scrubbing: HCl emissions 10–15 mg/m³, investment costs: 625 kECU, operating costs: 14 kECU/a, electricity 80 kWh.

Cross-media effects

- Increased energy consumption.
- Generation of acidic waste water, which can be reused in the process, e.g. as rinse water for HCl regeneration, or require neutralisation followed by water treatment (associated with consumption of chemicals and generation of water treatment sludges), or has to be disposed of externally. [EUROFER 23-7-18]

Technical consideration relevant to applicability

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

Economics

TWG, please provide updated information for this section. The data presented in the Table below are old.

Table 8.20: Estimated costs for countercurrent water scrubbing in packed columns

[CITEPA]

| Countercurrent water scrubbing in packed columns | | |
|---|--------|--------------------|
| Production capacity | 900000 | t/a |
| Energy consumption (electrical) | 0.68 | kWh/t |
| Volume flow | 10.6 | Nm ³ /s |
| Investment cost | 625 | EUR '000 |
| Operating costs | 14 | EUR '000 |

Driving force for implementation

- Collection and treatment of acidic vapour fumes from pickling tanks. [EUROFER 23-7-18]
- Reduction of the potential exposure of workers to acidic fumes in the workplace. [EUROFER 23-7-18]

Example plants

Jenn An, Taiwan [Danieli].

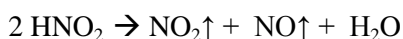
Voestalpine, Austria. [EUROFER 23-7-18]

Reference literature

[EPA-453] [Rituper] [Danieli] [EUROFER 23-7-18] [ESCO 2]

8.8.5 NOX reduction techniques in mixed acid pickling

When stainless steel is pickled in mixed acid, the nitric acid reacts with the metal or metal oxides and is reduced to nitrous acid (HNO₂), which is, in turn, in equilibrium with a mixture of nitrogen oxides.



In the case of batch pickling operations (e.g. for stainless steel tube), pickling is carried out at ambient temperature. Batch processes usually apply open tanks, where a lower temperature and longer pickling times (e.g. 60–90 minutes) reduce the rate of emission of NOX fumes.

Coil, sheet or wire pickling, if carried out continuously, requires higher acid temperatures in order to maintain an effective pickling result in short pickling times (i.e. usually 2–4 minutes).

As higher acid temperatures generate higher emissions of NOX fumes, closed tanks are installed. Specific techniques employed for NOX suppression and reduction are described in the following sections.

8.8.5.1 Nitric-acid-free pickling of high-alloy steel**Description**

Pickling of high-alloy steel is carried out by fully substituting nitric acid with a strong oxidising agent (e.g. hydrogen peroxide).

Technical description

In mixed acid pickling of high-alloy steel, the nitric acid ~~contributes an~~ acts both as an acid and an oxidant in the metal pickling process. Theoretically, the replacement of the acid contribution by another acid, for example sulphuric acid, and the oxidant contribution with hydrogen peroxide shall result in a nitric-acid-free metal pickling solution.

Trials have been carried out at various steel mills in Europe where this technology has been successfully used for stainless steel pickling techniques. [WireInd-10-97]

These processes rely on the oxidising nature of the ferric ion; the ferric ion content of the pickling liquor is maintained at a minimum concentration of 15 g/l. This is achieved by the introduction of an oxidising agent to oxidise the ferrous iron (Fe^{2+}) formed during the pickling reaction to ferric iron (Fe^{3+}).

The oxidising agent chosen is normally hydrogen peroxide, as this does not introduce any foreign ions into the pickling bath and the method of addition is essentially the same as that used in NOX suppression techniques. This treatment can be used on all types of production facilities, i.e. continuous or batch pickling. [WireInd-10-97]

The actions of $\text{HF}/\text{H}_2\text{O}_2$ mixtures on high-alloy steel are considerably less aggressive than that of HF/HNO_3 at high pickling temperatures (around 50–60 °C), although the reverse of this has been shown when pickling has been carried out at ambient temperatures of approximately 20–25 °C. [WireInd-10-97]

Additives, such as nonionic surfactants and corrosion accelerators, are also added to the pickling bath, to maintain pickling efficiency. Stabilisers are added, to prolong the lifetime of the hydrogen peroxide in the pickling bath. [WireInd-10-97]

Achieved environmental benefits

Reduction of NOX.

Environmental performance and operational data

Pilot trials which have been carried out have shown that the nitric-acid-free pickling process has a number of advantages when compared with the conventional nitric acid/hydrofluoric acid process. [WireInd-10-97]

The reported advantages of hydrogen-peroxide-based nitric-acid-free pickling are:

- in certain cases, shorter pickling times;
- reduced sludge formation;
- longer bath life;
- greatly reduced intergranular corrosion;
- less aggressive pickling resulting in reduced attack on the metal surface and reduced weight loss of the steel;
- reduced NOX emissions and nitrate effluent discharges (in fact, there is an overall reduction in the volume of effluent per tonne of product per bath);
- all effluents can be precipitated by lime treatment;
- no major modifications are required to use the process at existing pickling plants; with no major equipment required except for a simple control system;
- there is a reduction in product dissolution and potential for an improvement in product quality.

Cross-media effects

None identified.

Technical considerations relevant to applicability

~~New plants and major modernisation of existing plants.~~

- Only applicable to new plants and major plant upgrades.
- Not applicable for pickling of strip [Com2 CR].

Economics

The hydrogen-peroxide-based nitric-acid-free pickling process can operate effectively at low temperatures, therefore saving on heating costs compared with the conventional nitric acid/hydrofluoric acid process, which is usually required to operate at approximately 60 °C to be effective. [WireInd-10-97]

Driving force for implementation

Environmental legislation.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[WireInd-10-97] [Com2 CR]

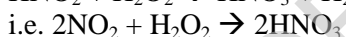
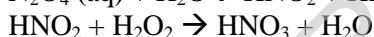
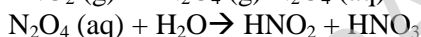
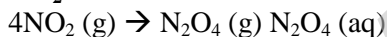
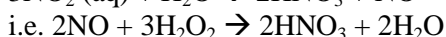
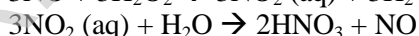
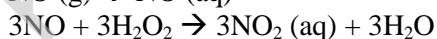
8.8.5.2 Addition of hydrogen peroxide or urea to the pickling acid**Description**

Hydrogen peroxide or urea is added directly to the pickling acid to reduce the generation of NOX emissions.

Technical description

Hydrogen peroxide or urea is added directly to the pickling acid to reduce the generation of NOX emissions or is added to the scrubbing solution. When using hydrogen peroxide, the nitric acid formed can be recycled to the pickling tanks.

The reaction between hydrogen peroxide (H₂O₂) and NOX occurs in the aqueous phase, in which NOX reacts with water to form nitrous acid (HNO₂). The HNO₂ is relatively unstable and will readily decompose back to NO₂, NO and H₂O. The NOX would ultimately be emitted from the process. However, the presence of H₂O₂ rapidly oxidises HNO₂ to the more stable HNO₃, thus preventing the re-formation and emission of NOX. This behaviour is detailed in the following chemical reaction equations:

NO₂**NO/NO₂****NO**

The key to the efficient usage of hydrogen peroxide in NOX suppression, by addition to the pickling bath, lies in effective mixing.

When hydrogen peroxide is added to the pickling liquor containing both oxides of nitrogen and transition metal ions, it will either oxidise the NOX, according to the chemistry outlined above, or will itself undergo catalytic decomposition by reaction with the metal ions.

NOX suppression by H₂O₂ injection into a recirculation loop

Austenitic steels are generally endothermic in pickling character, while ferritic steels are exothermic due to the differences in chemical composition. Therefore, some form of

temperature control is installed. The normal method is to incorporate a recirculation loop, whereby the bath liquor is recirculated through either a heater or a cooler.

One method of effective mixing of H_2O_2 and the bath liquor is to inject the hydrogen peroxide into the recirculated pickle liquor. The bath contents are pumped around a recirculation loop at a rate of up to ten bath changes per hour. Hydrogen peroxide (35 %) is dosed into this loop at up to 1 litre per minute, dependent upon the process conditions pertaining. A schematic diagram of this operation is shown in Figure 8.59.

Trials carried out have shown that NOX suppression efficiencies in excess of 90 % have been achieved using this technique.

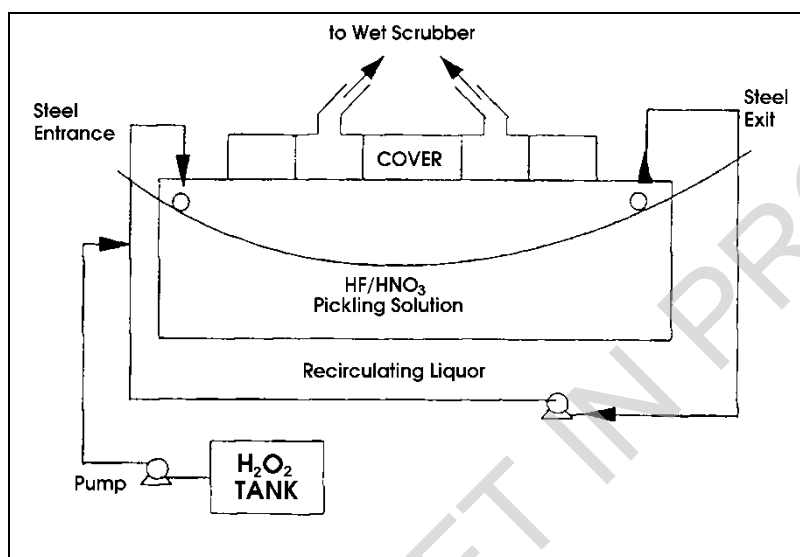


Figure 8.59: Schematic for injecting H_2O_2 into pickling acid recirculation loop [WireInd-10-97]

NOX suppression by H_2O_2 injection into the pickling bath via a sparge pipe

The capital cost of a new installation of a recirculation loop to a pickling bath can be high if a static pickling bath is in operation. Therefore, an alternative method of H_2O_2 addition to the pickling bath is to directly inject H_2O_2 into the pickling bath via a bifurcated sparge located in the pickling bath. A simple sparge pipe, made from 30 mm diameter polypropylene tubing, with 3 mm holes drilled at 150 mm intervals, is inserted into the bath. [WireInd-10-97]

Due to the large amount of insoluble scale which builds up in the pickling bath, the sparge pipe is arranged with the holes pointing at 45° downwards to the horizontal to minimise blockages. The sparge pipe is positioned at the steel entry end of the bath, just beneath the moving steel sheet, to prevent accidental collision with the sheet and also to use the constant movement of the steel sheet as a method of effectively mixing the H_2O_2 into the pickling bath. A schematic diagram of the sparge pipe system is shown in Figure 8.60.

Trials carried out have shown that NOX suppression efficiencies in excess of 90 % have been achieved using this technique. [WireInd-10-97]

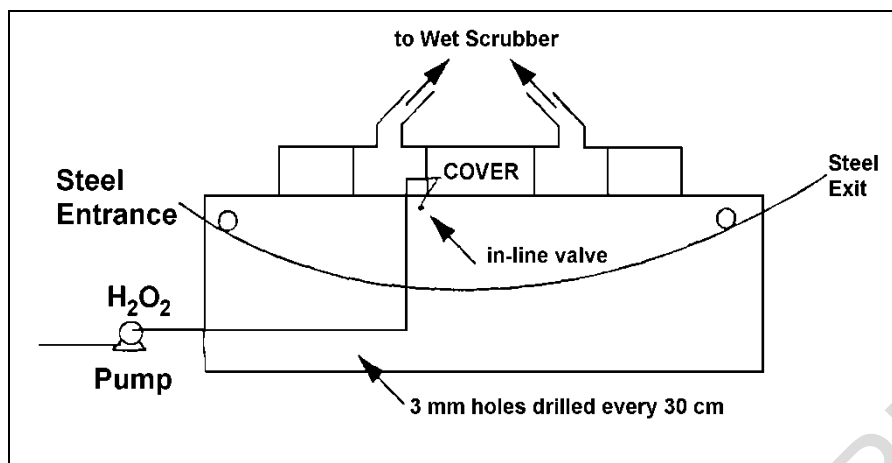


Figure 8.60: Schematic for injecting H_2O_2 into pickling baths via a sparge pipe [WireInd-10-97]

NOX suppression by H_2O_2 injection into a spray pickling facility

An additional example of NOX suppression using hydrogen peroxide is the one used for pickling of stainless steel plate in a spray chamber. The nitric acid/hydrofluoric acid pickling liquor is sprayed onto both sides of the stainless steel plate; the pickling liquor is then returned from the spray chamber to the pickling holding tank, from where it is recycled to the spray chamber. [WireInd-10-97]

A pilot trial was carried out at a facility by injecting hydrogen peroxide into the liquor recirculation line immediately before it splits into two branches. It was found that more than 90 % of NOX emissions were suppressed within ten minutes after the introduction of hydrogen peroxide, indicating that the NOX suppression reaction took place at the site of NOX generation. [WireInd-10-97] Other sources report NOX reduction by up to 70 % [fmp012].

NOX suppression by hydrogen peroxide has no adverse affect on stainless steel product quality. [WireInd-10-97]

Advantages of NOX suppression by hydrogen peroxide

- Hydrogen peroxide converts NOX to nitric acid *in situ*, and therefore reduces nitric acid consumption, in some cases by 20–30 %.
- No major plant change is required.
- Existing hydrofluoric acid scrubber can be used with no neutralisation of the scrubber liquor required, as the weak hydrofluoric acid solution formed can be returned to the process.

Achieved environmental benefits

Reduction of NOX.

Environmental performance and operational data

TWG, this heading will be updated at a later stage based on the data collection.

~~Addition of hydrogen peroxide suppresses the formation of gaseous NOX emissions by reforming HNO_3 in the pickling tank. Thus it is possible to reuse the acid part, leading to a reduction of acid consumption of up to 25 %.~~

Table 8.21: Achievable emission levels by H₂O₂ injection

| | Concentration [mg/Nm ³] | Specific Emission [g/t product] | Reduction rate [†] [%] | Method of analysis |
|-----|--|------------------------------------|------------------------------------|--------------------|
| NOX | 350–600 | 80–300 | 75–85 | Chemiluminescence |
| HF | 2–7 | 1–1.5 | 70–80 | Titration |

[†] Reduction rate is a combination of H₂O₂ injection and exhaust absorber system.
Source: [EUROFER CR]

For NOX suppression using urea addition to the pickling bath (plus gas washer), it was reported that emissions were reliably below the NOX emission limit value of 850 mg/m³. Higher ammonia contents in the waste water were reduced by aeration. [Met Plant Int 1 94]

Cross-media effects

- Reduction in acid consumption.
- Consumption of hydrogen peroxide (3–10 kg/t).

Technical considerations relevant to applicability

- New and existing plants.

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

Economics

TWG, please provide updated cost information for this technique (See below).

For a 70 % reduction of NOX, hydrogen peroxide addition costs of 4 kECU/kg NOX reduced were reported. [CITEPA]

For shallow bath turbulent pickling, the required dose rate of hydrogen peroxide may increase dramatically. [Com2 CR] Hence for large pickling installations where the dose rate for hydrogen peroxide would be excessive, other NOX reduction measures, e.g. SCR system, may be more appropriate

Driving force for implementation

Environmental legislation.

Example plants

Thyssen Krupp Stahl, Krefeld, Germany (urea addition). [Met-Plant-Int-1-94]

Reference literature

[WireInd-10-97] [fmp012] [Met-Plant-Int-1-94] [EUROFER CR] [Com2 CR] [CITEPA]

8.8.5.3 Wet scrubbing with addition of an oxidising agent (e.g. hydrogen peroxide)

Description

An oxidising agent (e.g. hydrogen peroxide) is added to the scrubbing solution to reduce NOX emissions. When using hydrogen peroxide, the nitric acid formed can be recycled to the pickling tanks.

Technical description

Wet absorbers/scrubbers are used to abate NOX fumes from mixed acid pickling. As NO and NO₂ are insoluble or only partially soluble in water, other washing media, such as NaOH, H₂O₂ or urea, are used.

The efficiency of NaOH scrubbers depends on the NOX concentration and on the NO:NO₂ ratio in the waste gas. To achieve satisfactory reductions, long oxidation times or multi-stage scrubbers are necessary.

To enhance the efficiency of NOX abatement, two or more packed columns may be installed; one part operated as a reduction column, the other as an oxidation column. The reduction columns are operated countercurrently with NaOH and a reductant: sodium hydrosulphide solution (NaHS). The reductant along with high pH reduces the NO₂ entering the column bottom to nitrogen and washes and neutralises any free acid that may be entrained in the gas stream. Fresh NaOH and NaHS are added to the washing liquid based on pH value and the oxidation reduction chemical potential (ORP). [LUDL]

The gas stream from the reduction column then enters the oxidation column where NO is oxidised to NO₂. The gas enters the column at the top and flows cocurrently with the oxidising solution (e.g. sodium chlorite - NaClO₂) at low pH. The sodium chlorite forms chlorine dioxide (ClO₂) that oxidises the NO. Fresh acid and NaClO₂ are added based on pH and ORP. The cycle of reduction and oxidation may be repeated to achieve sufficient NOX abatement rates. [LUDL]

When H₂O₂ is used for scrubbing, the scrubbing liquor usually consists of a mixture of HNO₃ and H₂O₂ at typical concentrations of 20 wt-% and 0.5 wt-% respectively. A benefit of using H₂O₂ is that the by-product of the scrubbing process is nitric acid, instead of sodium nitrate when using sodium hydroxide. This acid is recovered in usable concentrations and recycled back to the pickling process. Thus not only is the sodium nitrate waste disposal cost eliminated but the overall nitric acid consumption is reduced. [CITEPA]

Achieved environmental benefits

- Reduction of NOX.
- Scrubbing with H₂O₂ results in a nitric acid by-product with a concentration that allows recycling to the pickling process.
- Reduction of nitric acid consumption.
- Reduced waste water volume and waste water treatment sludge.
- In the case of H₂O₂ or urea injection in the pickling bath, scrubbing water can be reused as make-up water in the pickling tanks.

Environmental performance and operational data

TWG, this heading will be updated at a later stage based on the data collection.

- ~~[CITEPA] reported emission between 0.2 mg/m³ and 2 mg/m³ (maximum reported value: 17 mg/m³) for HF and 5 mg/m³ and 1 000 mg/m³ for NOX.~~
- ~~Industry reported the lower end of the emission range to be 350 mg/Nm³ for NOX.~~
~~[Com2 CR]~~

Cross-media effects

Scrubbing with sodium hydroxate results in a sodium nitrate waste which requires disposal.

Technical considerations relevant to applicability

- ~~New and existing plants.~~

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

Economics

TWG, please provide information.

Driving force for implementation

Environmental legislation.

Example plants

Thyssen Krupp Stahl, Krefeld, Germany [Met-Plant-Int-1-94]

Allegheny Ludlum, USA

AceriNOX Europa, Spain [EUROFER 23-7-18]

Reference literature

[LUDL] [EUROFER 23-7-18] [Com2 CR] [CITEPA] [Met-Plant-Int-1-94]

8.8.5.4 Selective catalytic reduction (SCR) in mixed acid pickling

Description

See Section 8.8.1.4.

Technical description

For a full technical description, see Section 8.8.1.4.

More specifically, concerning mixed pickling acid plants, lime treatment can be used in combination with SCR for HF reduction. The gas flow is first heated and inserted into a reactor packed with CaO tiles. Inside the reactor, HF reacts with CaO to form CaF₂ according to the following equation:



Achieved environmental benefits

- Reduction of NOX (reduction efficiency of up to 95 % with a typical range of 70–90 %. The achieved NOX level depends on the initial concentration).
- If coupled with lime treatment, reduction of HF emissions.

Environmental performance and operational data

Cross-media effects

- Energy consumption to heat the exhaust gas to operating temperature for SCR. [EUROFER 23-7-18]
- NH₃ consumption in the process. [EUROFER 23-7-18]
- New CaO tiles every few years. [EUROFER 23-7-18]

Technical considerations relevant to applicability

- ~~New plants and major modernisation of existing plants.~~

Only applicable to new plants and major plant upgrades [EUROFER 23-7-18]

Economics

TWG, please provide information.

Driving force for implementation

Environmental legislation.

Example plants

Outokumpu Tornio, Outokumpu Krefeld, AceriNOX Europe

Reference literature

[EUROFER 23-7-18]

8.8.5.5 Comparison of NOX reduction methods for mixed acid pickling

Table 8.22 compares the different NOX reduction measures and gives an overview of cost.

Table 8.22: Comparison of different NOX reduction measures for mixed acid pickling

(as reported in [CITEPA])

| | NOX Supression by Injection | | Nitric Acid-free Stainless Steel Pickling ² | Absorptive Scrubbing | | Selective Catalytic Reduction | Selective Non-Catalytic Reduction |
|------------------------------------|-------------------------------|---------------------|--|------------------------|-------------------------------|-------------------------------|-----------------------------------|
| | H ₂ O ₂ | Urea ¹ | | NaOH | H ₂ O ₂ | | |
| Capital Costs | low | low | NI | high | high | very high | NI |
| Variable costs | high | low | NI | low | high | low | NI |
| HNO₃ Consumption | lower | higher | NI | no influence | lower | no influence | NI |
| NOX Reduction | very high | very high | NI | low | very high | very high | NI |
| By-products | recovered | no problem | NI | difficult to discharge | recovered | no problem | NI |
| Steel Surface Quality | better ³ | better ³ | NI | no influence | no influence | no influence | NI |

1 Comment: urea injection can lead to ammonia compounds in the effluent [Com2 CR]

2 Comment: only limited application [Com2 CR]

3 Comment: neither urea nor hydrogen peroxide injection give rise to better surface finish [Com2 CR]

NB: NI = No information provided.

8.8.6 Emissions to air from hot dipping

8.8.6.1 Smoke-reducing fluxing agent

Description

Ammonium chloride in fluxing agents is partly substituted with other alkali chlorides (e.g. potassium chloride) to reduce smoke formation.

Technical description

The 'normal' flux used in batch galvanizing consists of a mixture of zinc chloride and ammonium chloride. A 'triple' salt flux contains approximately 45 % zinc chloride and 55 % ammonium chloride. An alternative 'double' salt flux contains approximately 55 % zinc chloride and 45 % ammonium chloride. [EGGA 18-3-19]

Ammonium chloride is a component of the fluxing agent that has a sublimation temperature below the zinc bath temperature which causes fumes to be generated during hot dipping. To reduce the environmental impact of ammonium chloride during dipping, 'smoke-reducing' fluxing agents in which ammonium chloride has partly or completely been substituted by other alkali chlorides (e.g. potassium chloride) are employed. [ABAG]

When steelwork is dipped into the galvanizing bath a fume is given off that can contain total particulate above 50 mg/m³. This fume is usually captured within an enclosure situated over the galvanising bath and extracted to a bag filter. The fume consists mainly of ammonium chloride and, after being extracted through an efficient bag filter, emission levels can be reduced to very low levels. [EGGA 18-3-19]

Achieved environmental benefits

- Reduced emissions to air.
- Reduced hard zinc.

Environmental performance and operational data

Fluxing agents based on zinc chloride/alkali chloride do not result in an additional pickling effect during hot dipping and therefore do not dissolve more iron. This reduces the generation of hard zinc on one hand, but also requires optimum pickling in the pretreatment section to achieve high quality coatings. [ABAG]

Table 8.23: Emission comparison of normal and smoke-reducing fluxing agents

| Fluxing agent | Emission | Work piece | Zinc ash |
|---|----------|------------|----------|
| ZnCl ₂ : 89 % NH ₄ Cl: 11 % Salt content: 170 g/l | 33 % | 2 % | 65 % |
| ZnCl ₂ : 32 % KCl: 68 % Salt content: 170 g/l | 19 % | 1 % | 80 % |
| Source of data [ABAG] | | | |

A typical (commercially available) low fume flux has replaced the majority of the ammonium chloride content with potassium chloride that releases far less fume during the dipping operation. The consistency of a low fume flux can be in the range of 60 % zinc chloride, 30 % potassium chloride and 10 % ammonium chloride. This type of flux still produces fume during dipping but at a much more reduced level than a traditional flux, giving emission levels of total particulate of less than 15 mg/m³. [EGGA 18-3-19]

Cross-media effects

- Zinc ash may be increased (reported by some sources).

- Smoke-reducing fluxing agents produce less visible fumes. The visibility of fumes is a function of particle size. Accordingly, there is a potential for smaller size particles with smoke-reducing fluxing agents which could give rise to adverse health effect of respirable dust. [Com2 UK Galv]. Results from occupational exposure surveys, however, state no health concerns between the different flux types and no concerns over the size of the airborne particulate. [Piat 19.9]

Technical considerations relevant to applicability

~~New and existing~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

TWG, please provide information.

Example plants

South East Galvanizers Ltd., Witham, Essex, UK (Installation Number - 252)

Reference literature

[ABAG] [Piat 19.9] [EGGA 18-3-19] [Com2 UK Galv]

8.8.6.2 Minimisation of carry-over of the fluxing solution

Description

The carry-over of the fluxing solution to the hot dipping bath is minimised by allowing enough time for the fluxing solution to drip off, and/or by drying.

Technical description

After withdrawing the workpieces from the flux bath, some of the water from the adhering fluxing fluid evaporates. The extent of evaporation depends on the temperature of the flux bath and, if the bath is hot, the rate of removal of workpieces from the bath (slower removal gives more evaporation). Further drying is sometimes achieved in dedicated drying. Exhaust gases from the galvanising kettle can sometimes be a useful indirect source of heat to such a drying unit, although ancillary burners are often also used. Drying of the workpiece helps reduce splashing and ejection of metal from the zinc bath as the workpiece is dipped, a benefit which is increased if the workpiece retains heat after leaving the dryer, i.e. if preheating is applied. [Com2 EGGA]

Achieved environmental benefits

Reduced emissions of zinc in hot dipping.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

Environmental legislation.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[Com2 EGGA]

8.8.6.3 Air extraction as close as possible to the source

Description

Air from the kettles is extracted for example using lateral hood or lip extraction or the kettles are located in enclosed areas equipped with roof or wall extraction.

Technical description

The galvanising kettle is equipped with lateral hood or lip extraction to collect emissions. The emissions are treated using scrubbers (See Section 8.8.1.6) or fabric filters (see Section 8.8.1.3). Figure 8.60 and Figure 8.61 show bilateral and lip extraction systems at galvanising plants

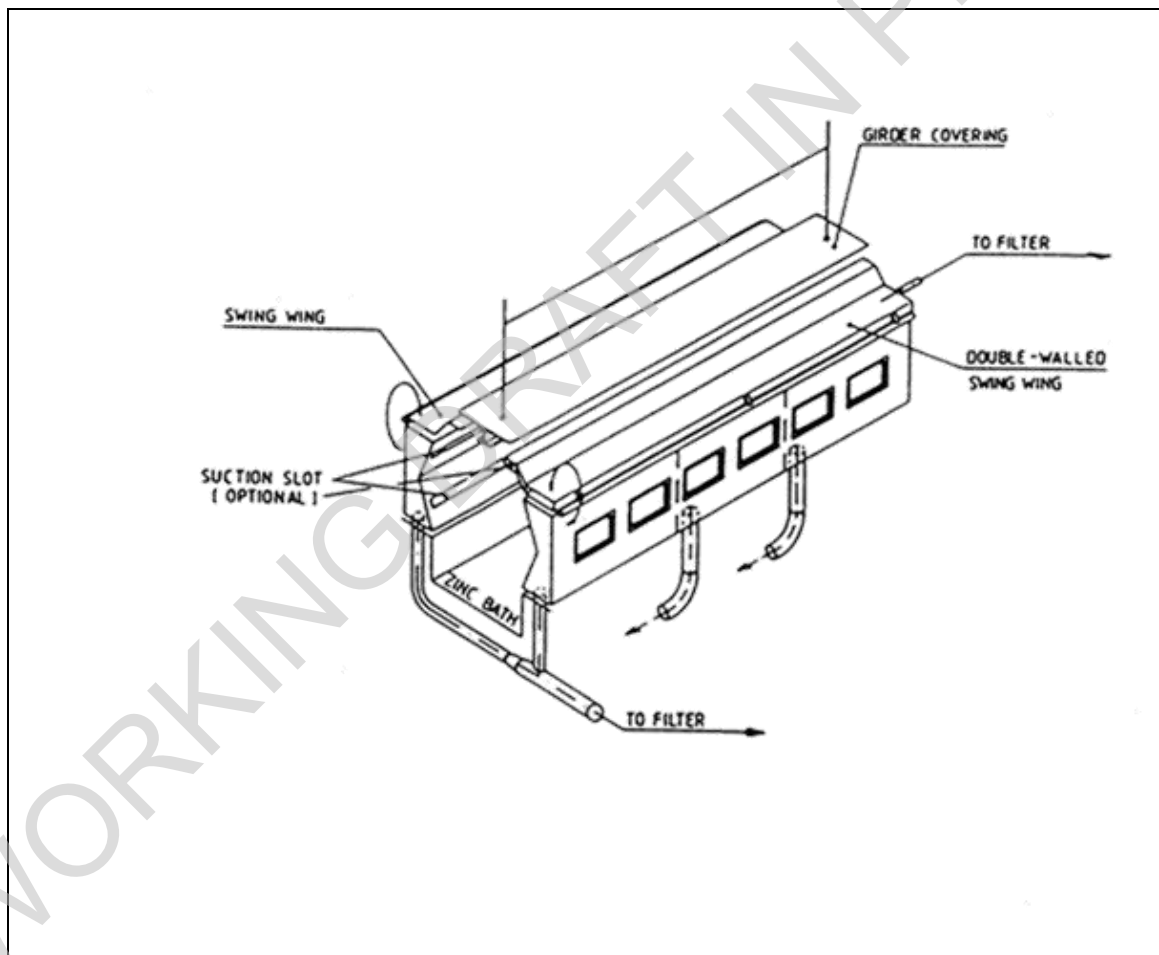


Figure 8.61: Bilateral peripheral exhaust with auxiliaries
[Galva-94-1]

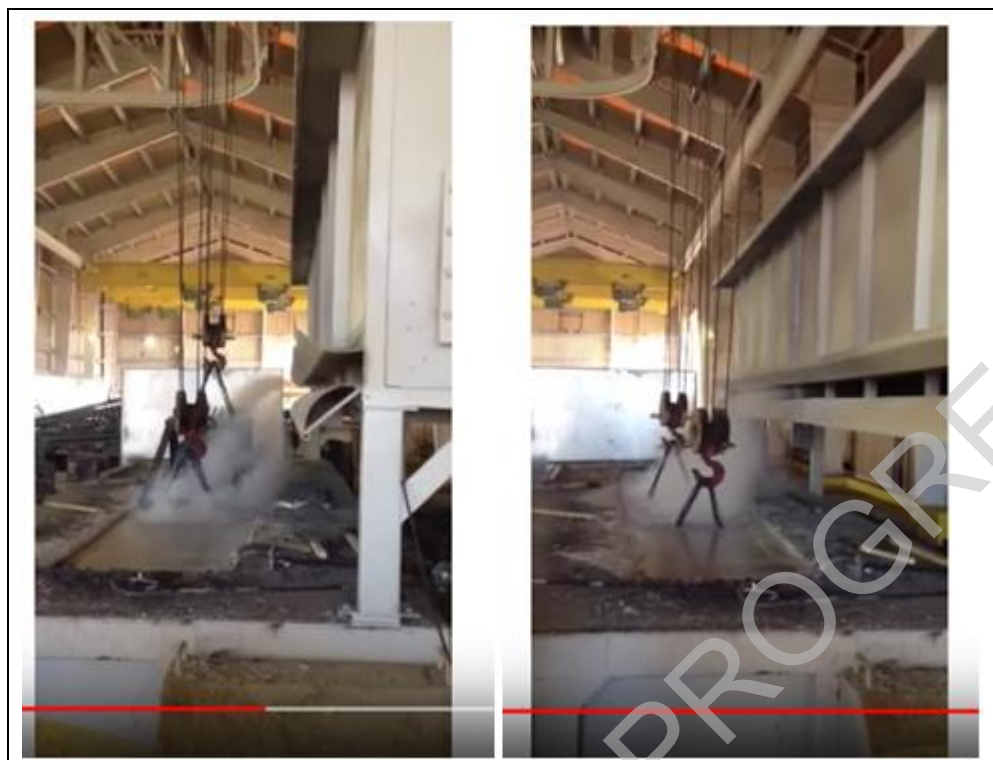


Figure 8.62: Lip extraction at a galvanising plant

Achieved environmental benefits

Reduced emissions of dust and metals.

Environmental performance and operational data

Example Wilhelm Hähn, Germany

Table 8.24 gives some examples of emissions from a galvanising kettle under different conditions.

Table 8.24: Examples for emissions from a galvanising kettle

| Point of measurement | As ³⁺ [µg/m ³] | Cd ³⁺ [µg/m ³] | Pb ²⁺ [µg/m ³] | Zn ²⁺ [mg/m ³] | NH ₄ ⁺ [mg/m ³] | Cl ⁻ [mg/m ³] | Dust [mg/m ³] |
|---|--|--|--|--|--|---|------------------------------|
| Above zinc surface without air extraction | 106.9 | 117.2 | 125.3 | 44.5 | 197.9 | 14.3 | 384.6 |
| Above zinc surface with air extraction | 1.4 | 2.9 | 53.1 | 0.9 | 0.2 | 1.2 | 0.5 |
| Crude gas | 3.6 | 5.1 | 49.0 | 6.2 | 17.5 | 7.4 | 24.1 |
| Cleaned gas | 0.1 | 0.1 | 1.8 | 0.017 | 9.0 | 2.7 | 0.1 |
| Source of data [UBA-Hähn-83] Based on case study: lip extraction, 3380 m ³ /m ² h = 32958 m ³ /h, abatement: bag filter | | | | | | | |

The emissions data are mean values from six individual measurements with an average measuring period of 18 minutes, calculated as absolute immersion period with two to four dipping operations each. Repeat measurements conducted in 1996 confirm these data and showed the following results: dust < 0.13 mg/m³ and HCl 0.9 mg/m³. These values are mean values from four individual measurements with an average measuring period of 28 minutes, calculated as absolute immersion period with three to four dipping operations each.

Fabric filters show reduction efficiencies of 99.6 %.

Cross-media effects

- Energy consumption (electrical energy is used for extraction fans, filter cleaning, and possibly filter heating).
- Wet scrubbers: generate waste water, requiring treatment, less recycling potential than for dry filter dust.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

The burden on the product due strictly to pollution abatement measures, such as venting during degreasing, hot rinsing, flux bath and zinc bath as well as fabric filter for dust removal, averaged DM 32/t product in 1983. [UBA-Hähn-83]

Driving force for implementation

Environmental legislation.

Example plants

Fa. Wilhelm Hähn, Kreuztal-Ferndorf, Germany.

Reference literature

[UBA-Hähn-83]

8.8.6.4 Closed kettles combined with air extraction

Description

Hot dipping is carried out in closed kettles and air is extracted.

Technical description

The galvanising kettle is equipped with an enclosing hood. The emissions are treated using scrubbers (See Section 8.8.1.6) or fabric filters (See Section 8.8.1.3).

The hood is a steel structure that is built on top of the galvanising kettle. In this case it is equipped with sliding horizontal doors or short end doors to allow access to the zinc bath. In some cases the hood is designed as mobile hood that is attached to overhead crane systems and can be lifted. This design is usually applied when the racks enter the galvanising bath from one of the two long sides.

Figure 8.63 and Figure 8.64 show some examples of enclosure designs.

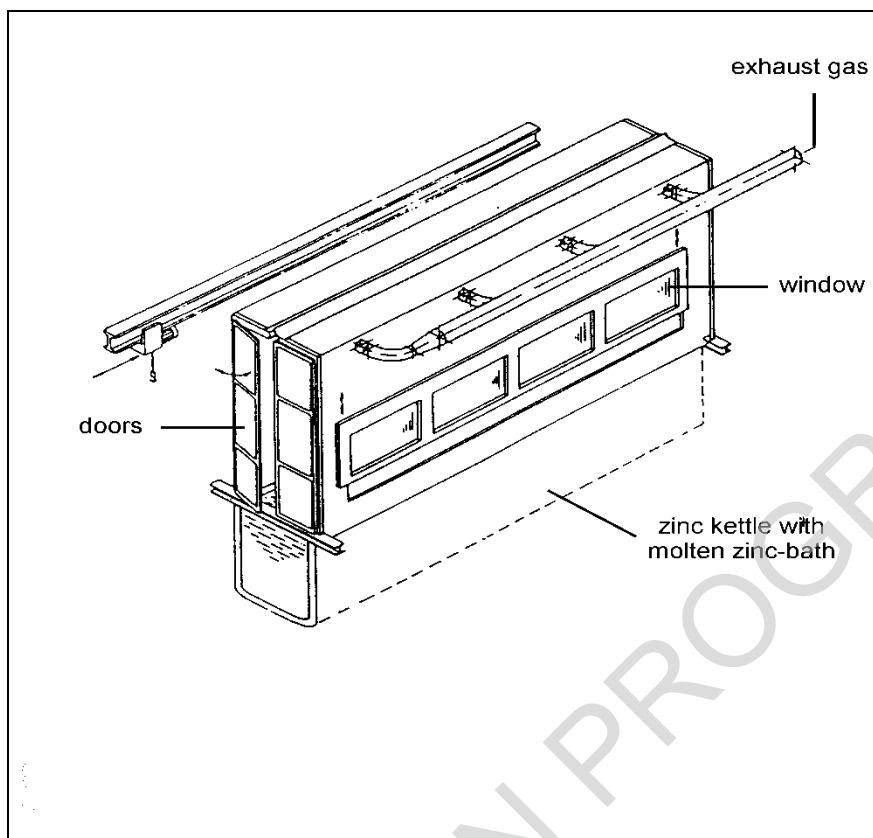


Figure 8.63: Stationary enclosure
[Galva-94-1]

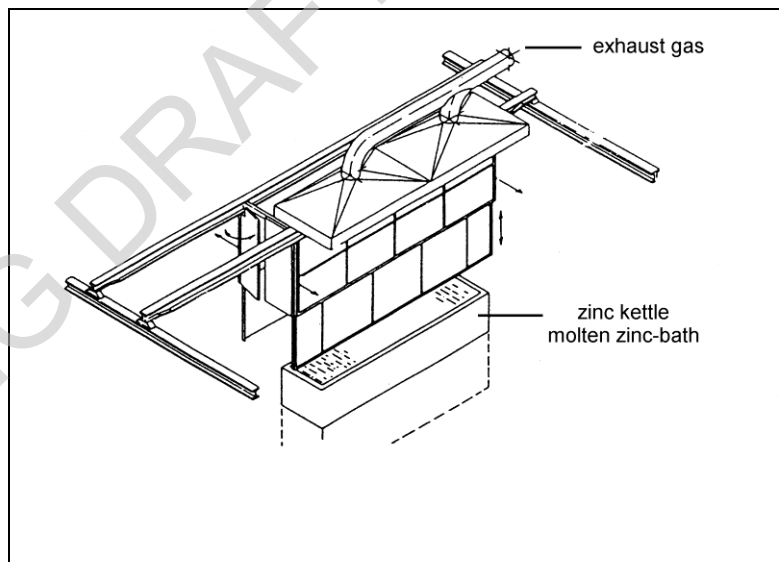


Figure 8.64: Moveable enclosure with vertical moving side walls
[Galva-94-1]

Achieved environmental benefits

- Reduction of fugitive air emissions (reported 95–98 % capture of dust and other emissions [Com2 B]).
- Reduction of squirts.
- Energy savings due to reduced surface heat loss from the galvanising bath. [Com2 EGGA]

Environmental performance and operational data

Table 8.25 compares examples of particulates and fume from galvanising kettles for different abatement techniques.

Table 8.25: Concentrations in emissions from galvanising kettles

| Component | Emission [mg/m ³] No abatement | Emission [mg/m ³] Wet scrubber ^(1,2) | Emission [mg/m ³] Bag filter ⁽³⁾ |
|--------------------|---|--|--|
| Dust | 20 | < 1.7 | 4.2 - 4.6 |
| Zinc | 2.3 | 0.11 - 0.38 | 0.49 - 0.52 |
| ZnCl | n.a. | 0.16 - 0.34 | n.a. |
| NH ₄ Cl | 7.4 | 0.02 - 0.05 | n.a. |
| NH ₃ | 2.6 | n.a. | n.a. |
| HCl | 23 | n.a. | n.a. |

Source of data [Dan-EPA]
¹ Volume flow = 39500 m³
² Pb content: 0.005 - 0.007 mg/m³
Cd content: < 0.0002 mg/m³
³ Volume flow = 13400 m³

Example Verzinkerei Rhein-Main GmbH

Table 8.26: Concentrations in emissions from galvanising kettles

| Component | Emission ¹⁾ in mg/m ³ |
|--------------------|---|
| Dust | < 1 |
| Zinc | 0.03 |
| ZnCl | 0.1 |
| NH ₄ Cl | 32 |
| HCl | < 10 |

Source of data [UBA-Hoesch-87]; volume flow = 23400 m³/h; removal system: fabric filter
1) Mean values from 8 individual measurements; average measuring period 32 minutes, calculated as absolute period of immersion with 5 to 8 dipping operations each

Other sources reported dust emissions from hot dipping of 1–3 mg/m³ using fabric filters. [Flatt/Knupp]

Cross-media effects

- Energy consumption (electrical energy is used for extraction fans, filter cleaning and possibly filter heating), but, compared to other suction systems, weaker suction is required (meaning less energy is needed). [Com2 B]
- Wet scrubbers: generate waste water, requiring treatment, less recycling potential than for dry filter dust.

Technical considerations relevant to applicability

- ~~New and existing plants~~: Generally, there are no technical restrictions to the applicability of this technique.
- Loading in longitudinal direction of bath.

Economics

At Verzinkerei Rhein-Main, investment costs of DM 1 634 167 and operating costs of DM 309 000 were incurred in 1985 for enclosure in combination with a fabric filter. The operating costs include DM 259 000 for service of capital [UBA-Hoesch-87].

Driving force for implementation

Environmental legislation.

Example plants

Verzinkerei Rhein-Main GmbH, Groß-Rohrheim, Germany

Reference literature

[Com2 EGGA] [Flatt/Knupp] [Com2 B] [UBA-Hoesch-87]

8.8.7 Emissions to air from oiling**8.8.7.1 Electrostatic oiling****Description**

Oil is sprayed on the metal surface through an electrostatic field, which ensures homogeneous oil application and optimises the quantity of oil applied.

Technical description

Oiling machines are used for the purpose of applying a uniform preservation oil film on the strip surface. There are several technologies for oiling the finished products: roll coaters, conventional spraying systems and electrostatic oiling. Electrostatic oiling is employed more and more in cold rolling plants. This oiling process is based on the electrostatic spraying of preservation oil on one side or on both sides of the strip. Oiling must guarantee a uniform coating with the required oil volume on the sheet surface, while the maximum allowable tolerance range between individual measurements is 0.5 g/m².

The operation principle of the electrostatic oiler is based on the use of electrostatic forces that concentrate on the edge of the blade which supplies the oil. The electrostatic forces interact with the oil which is an electrically resistive liquid and cause its dispersion in droplets of small diameter. As a result, a finely air-sprayed product cloud is obtained. The droplets of oil that have the same electrical charge repel each other and are attracted by the ribbon which has a charge of the opposite sign. The so-called inductor bars can be used in order to improve the stability of the electrostatic field and the homogeneity of oil distribution over the strip width.

The oiling machine is covered and the oil emissions are collected and reused. Electrostatic application is a more efficient and effective method of coating to minimise the amount of oil used within the system.

Recent developments in electrostatic oiling have focused on introducing new types of oil and in-line controlling thickness and thickness distribution systems of the oil film applied onto the steel surface. [EUROFER 19-6-17]

Achieved environmental benefits

- Reduced consumption of strips preservation oil. [EUROFER 19-6-17]
- Reduced oil emissions. [EUROFER 19-6-17]

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

Increased energy consumption.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

- Reduced costs due to increased material efficiency.
- Environmental legislation.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[EUROFER 19-6-17]

8.8.7.2 Enclosed oiling machine with air extraction followed by a demister

Description

The entire oiling machine is enclosed in order to avoid dispersion of oil mist and air is extracted. The oil which does not deposit on the metal surface is recovered and reused. Emissions are treated using a demister.

Technical description

Covered electrostatic coating machines are used on galvanising lines for the purpose of applying a uniform preservation oil film on the surface of cut material.

The covering of the strip oiling machine is necessary to avoid the dispersion of oil fumes in the working environment and to avoid contact with parts in electrostatic oilers. The cover encloses the entire oiling machine completely. The oil is present in a tank where it is pumped out and electrostatically sprinkled onto the tape surface. The oil that does not deposit on the tape is collected and returned to the delivery tank together with the replenishing oil. Other systems (working more like a coater-type, not electrostatic) can be open.

The oiling process is based on electrostatic spraying of oil on one side or on both sides using preservation oil. [EUROFER 31-5-17]

Oil mist emissions are extracted and treated using a demister (see Section 8.8.1.1)

Achieved environmental benefits

- Reduced preservation oil consumption.
- Reduction of the release of oil mists into the environment [EUROFER 31-5-17].

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

~~New and existing plants:~~ Generally applicable in plants equipped with this strip oiling device. [Com-CC-2].

Economics

The investment cost is medium and the operating costs are low. [Com-CC-2]

Driving force for implementation

Environmental legislation.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[EUROFER 31-5-17] [Com-CC-2]

8.8.8 Emissions to air from acid recovery**8.8.8.1 Use of a fuel or a combination of fuels with low sulphur and/or nitrogen content****Description**

Fuels with low sulphur content include natural gas, liquefied petroleum gas, blast furnace gas, basic oxygen furnace gas and desulphurised coke oven gas.

Fuels with low nitrogen content include natural gas, liquefied petroleum gas, blast furnace gas and basic oxygen furnace gas.

Technical considerations relevant to applicability

Applicable within the constraints associated with the availability of different types of fuel, which may be impacted by the energy policy of the Member State.

More information on the technique

See Section 2.4.2.1.

8.8.8.2 Furnace automation and control**More information on the technique**

See Section 8.5.3.3.

8.8.8.3 Combustion optimisation**More information on the technique**

See Section 8.5.3.2.

8.8.8.4 Low-NOX burners**More information on the technique**

See Section 8.8.2.6.

8.8.8.5 Wet scrubbing followed by a demister**More information on the technique**

See Sections 8.8.1.6 and 8.8.1.1.

8.9 General techniques to reduce emissions to water

This section gives a short overview of the techniques used in the FMP sector to reduce emissions to air. All these techniques are extensively described in the CWW BREF.

8.9.1 Adsorption

Description

The removal of soluble substances (solutes) from the waste water by transferring them to the surface of solid, highly porous particles (typically activated carbon).

Reference literature

[CWW BREF]

8.9.2 Aerobic treatment

Description

The biological oxidation of dissolved organic pollutants with oxygen using the metabolism of microorganisms. In the presence of dissolved oxygen, injected as air or pure oxygen, the organic components are mineralised into carbon dioxide and water or are transformed into other metabolites and biomass.

Reference literature

[CWW BREF]

8.9.3 Chemical precipitation

Description

The conversion of dissolved pollutants into an insoluble compound by adding chemical precipitants. The solid precipitates formed are subsequently separated by sedimentation, air flotation or filtration. If necessary, this may be followed by microfiltration or ultrafiltration. Multivalent metal ions (e.g. calcium, aluminium, iron) are used for phosphorus precipitation.

Reference literature

[CWW BREF]

8.9.4 Chemical reduction

Description

Chemical reduction is the conversion of pollutants by chemical reducing agents into similar but less harmful or hazardous compounds.

Reference literature

[CWW BREF]

8.9.5 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.

Reference literature

[CWW BREF]

8.9.6 Equalisation**Description**

Balancing of flows and pollutant loads at the inlet of the final waste water treatment by using central tanks. Equalisation may be decentralised or carried out using other management techniques.

Reference literature

[CWW BREF]

8.9.7 Filtration**Description**

The separation of solids from waste water by passing them through a porous medium, e.g. sand filtration, microfiltration and ultrafiltration.

Reference literature

[CWW BREF]

8.9.8 Flotation**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.

Reference literature

[CWW BREF]

8.9.9 Nanofiltration**Description**

A filtration process in which membranes with pore sizes of approximately 1 nm are used.

Reference literature

[CWW BREF]

8.9.10 Neutralisation**Description**

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 (H₂SO₄), hydrochloric acid (HCl) or carbon dioxide (CO₂) is generally used to decrease the pH. The precipitation of some substances may occur during neutralisation.

Reference literature

[CWW BREF]

8.9.11 Physical separation

Description

The separation of gross solids, suspended solids, metal particles from the waste water using, for example, screens, sieves, grit separators, grease separators, hydrocyclones, oil-water separation or primary settlement tanks.

Reference literature

[CWW BREF]

8.9.12 Reverse osmosis

Description

A membrane process in which a pressure difference applied between the compartments separated by the membrane causes water to flow from the more concentrated solution to the less concentrated one.

Reference literature

[CWW BREF]

8.9.13 Sedimentation

Description

The separation of suspended particles and suspended material by gravitational settling.

Reference literature

[CWW BREF]

8.9.14 Treatment of water contaminated with oil or grease

Description

Water contaminated with oil or grease (e.g. from oil spillages or from the cleaning of rolling or tempering emulsions, degreasing solutions and wire-drawing lubricants) are treated to reduce the load of organic pollutants. The organic phase is separated from the aqueous phase, e.g. by skimming or by emulsion splitting with suitable agents, evaporation or membrane filtration. The organic phase may be used for other purposes (e.g. as a fuel).

Technical description

Rolling or tempering emulsions from the mill stands and wire drawing lubricants pick up particulate matter, steel slivers, scale and dust during operation. As the degree of contamination rises, these impurities affect the quality of the product and lead to process failure. To enable emulsion systems to be run as circulation systems and to extend the lifetime of the emulsions, the cleanliness is controlled closely.

Solids can be removed from emulsions by gravity in **settling tanks, separators, mesh filters, magnetic filters, etc.**

To remove solids, a **centrifuge** utilises centrifugal forces. Dirty liquid is fed into the spinning rotor or bowl, whereby the liquid is accelerated and distributed onto the internal walls of the

bowl. The solids separate and compact at the perimeter of the bowl. The solids remain in the bowl while the liquid exits, as it is displaced by the incoming liquid.

Once the bowl fills to the maximum allowable capacity with waste solids, the automatic cleaning cycle is activated. At this point, the feed of dirty liquid is shut off and the rotor comes to a complete stop. The internal scraping blades then rotate back and forth against the rotor while removing the solids, which are dumped into a collection hopper. [El-Hindi]

Depending on the particle size of the solids, **mesh filters** or **media filtration** using disposable paper can be used. The liquid is forced through the filter medium which extracts the fines, by gravity, pressure or vacuum.

However, a partial flow of the emulsion may need to be withdrawn from the system to maintain quality.

The partial flow discarded from the emulsion circuit systems requires treatment prior to discharge. This treatment basically constitutes the separation of the water and the oil phase (emulsion splitting). The purified water is discharged. The separated oil or oil-containing sludge may be reused, e.g. thermally by incineration.

Treatments available comprise:

- thermal: by evaporation and splitting with chemical additions;
- chemical: acid splitting, salt splitting, combined dosage of coagulants and polyelectrolytes;
- flotation;
- adsorption;
- electrolytical;
- membrane filtration (ultrafiltration, reverse osmosis).

Thermal breaking / Thermal emulsion splitting / Evaporation

Thermal breaking utilises a heat source, e.g. an internal heating tube or immersion gas burner, to raise the emulsion temperature to accelerate the evaporation rate, driving away the water content. The water exits as vapour, leaving the increasingly concentrated oil as a separate discharge. [El-Hindi]

The air saturated with water vapour is passed through coalescing elements to retain any possible droplets of coolant in the air stream prior to discharge. As an option, a condenser unit using a water-cooled coil can be installed in the discharge stack to retrieve the water as condensate. This water stream can then be used as make-up water to be reintroduced to the emulsion system. [El-Hindi]

The concentrated oil left in the chamber is subjected to a cook-down cycle to drive out more water. By thermal breaking, an emulsion with an initial concentration of 5–7 % oil can ultimately be reduced to 90 % oil and 10 % water. With more water removed, the disposal volume and cost are much less. With the greater concentration of oil, the reuse option of incineration is more feasible. [El-Hindi]

Chemical breaking of emulsions

In splitting with acid/salt, the emulsified oil will mostly be adsorbed to sludge and will not be separated as an oil phase. The addition of acids, iron/aluminium salts or polyelectrolytes causes the oil emulsion to destabilise due to the neutralisation of the charged colloidal oil particles. Splitting of oil-containing emulsions with acids or salts is not a state-of-the-art technique, due to the generation of large amounts of oil-containing neutralisation sludges and the contamination of waste water by salt. Acids/salts can be used as after-treatment in combined processes if only small amounts of residual oil need to be removed.

Polyelectrolytes soluble in the oil phase (so-called organic splitters, e.g. tertiary and quaternary polyamines) do not produce sludge during the splitting process itself, but generate a liquid oil phase which can be removed and utilised. This process can be used to treat emulsions with a high content of emulsified oil (a well-suited pretreatment technique when a combination of processes is applied). Polyelectrolytes (often used in combination with absorbents) through which the proportion of emulsified oil is bound within flocs and which produce a removable sludge (flotation or sedimentation) should only be used when the oil content is low (less than 300 mg/l), in order to reduce flocculant consumption, sludge volume and, thereby, costs. When a combination of processes is applied, flocculation can be used as an after-treatment. [Com2 D]

Flotation

Flotation is a gravity separation process using different density of two media. The lighter medium (e.g. oil) is collected at the surface of the heavier medium (e.g. water) in a tank with low turbulence. Even heavier media (e.g. flocs) can be collected at the water surface if flocs are made lighter by gas bubbles sticking to the flocs. Gas bubbles must be smaller than the flocs, otherwise they will not stick. Small bubbles are usually produced by pressurising water and gas together (dissolved air flotation), electrolytically (water split into hydrogen and oxygen gas bubbles) or by high shear forces (mechanical dispersing of gas into water). [Com2 A]

Flotation emulsion breaking usually means a two-step process consisting firstly of chemical emulsion breaking (by dosing acid, flocculents and polyelectrolyte or electrochemically by dissolving the anode) and secondly of flotation for separating the flocs from water. [Com2 A]

The layer of floating sludge forming at the water surface (flotate) is removed mechanically. In general, flotation techniques can be distinguished *inter alia* by the way the gas bubbles are produced:

- pressure relief flotation (introduction of air-saturated pressurised water);
- electroflotation (electrolytical decomposition of water with formation of hydrogen and oxygen bubbles);
- dispersion flotation (generation of microbubbles through injection of air via a hollow shaft).

No additional solids arise in the flotatate sludge when polyelectrolytes are used for emulsion splitting instead of acids/salts. [Com2 D]

Adsorption

Adsorption means adhering the oil particles to the surface of a solid or semisolid adsorbent. The adsorbent may either be a fixed bed of solids (e.g. activated carbon) through which the emulsion is flowing or may be a powdered solid (e.g. activated carbon) or semisolid flocs (e.g. iron hydroxide) distributed into the liquid. Powder or flocs have to be finally separated from liquid by settling, flotation or filtering. [Com2 A]

Oil-contaminated adsorbent has to be discharged when exhausted and treated as sludge or has to be burnt (or sometimes regenerated in case of fixed beds).

Fixed bed adsorbers and powder-type adsorbers are only usable for very low oil concentrations; otherwise adsorbent is exhausted too fast and is therefore too expensive. It is not common as basic emulsion treatment but it is sometimes used as a final polishing step of other types of emulsion breaking. Adsorption to semisolid flocs is part of the chemical emulsion breaking. [Com2 A]

A special kind of adsorbers are coalescing filters. These filters are filled with regular or irregular wire mesh, plastic or ceramic filling and will cause small oil droplets to collect and adhere to this filling. If collected oil volume increases, oil droplets (now bigger in size) will escape and rise up to the water surface from where they are skimmed off. Coalescing filters are sometimes used as emulsion pretreatment to remove free oil droplets from an emulsion. [Com2 A]

Use of adsorbents for treating spent emulsions consumes large amounts of chemicals and generates considerable quantities of oil-containing waste sludge. [Com2 D]

Electrolytic emulsion splitting

In electrolytic emulsion splitting, aluminium anodes are dissolved; the resulting sludge flakes bond to the oil and float. To improve the separation effect, polyelectrolyte can be added. In addition, control of the pH value and the electrical conductivity is maintained.

All of the oil contained in the emulsion has to be removed as sludge. The process does not produce an oil phase fit for use. [Com2 D]

Ultrafiltration

A successful alternative for emulsion with low initial oil concentration ($< 2\%$) is the use of ultrafiltration (UF) (see Figure 8.65) to mechanically split out the oils or soaps. The oil is separated at the molecular level, as the emulsion is forced through membrane filters. The membranes block oil molecules, while the water molecules pass through. The water, which passes through, is called permeate, while the restrained oil is called concentrate. Typically, the concentration of the concentrate (oil) does not exceed 25 % and is limited by the plugging of the membranes. As membranes are plugged, the ultrafilter cartridges must be periodically backwashed. [El-Hindi]

The average separation efficiency of UF, related to normal industrial water, is approximately 40 l/h per m² of filter surface. [EUROFER HR]

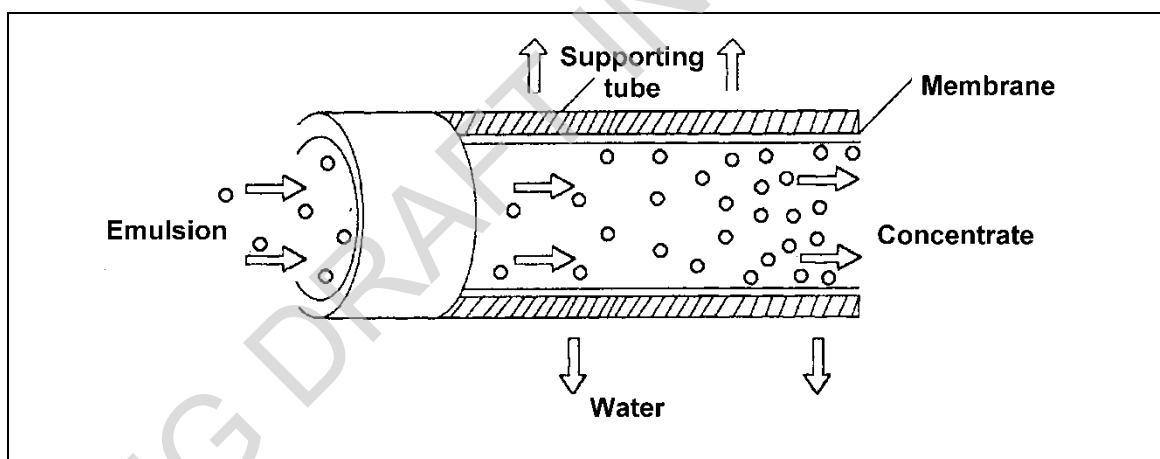


Figure 8.65: Principle of ultrafiltration
[Fichtner]

Figure 8.66 provides an example of the treatment of spent degreasing bath solutions and alkaline waste water solutions in a continuous annealing line. Partial flows from the degreasing solution cleaning circuit, rinsing water from the electrolytic degreasing and waste water from the skin pass mill stand, which cannot be reused in the mills, have to be treated prior to discharge. Prior to treatment of the waste water with flocculants, the oil content has to be removed, e.g. by oil-water separation or ultrafiltration. [Com2 D] [EUROFER 23-7-18] Then, the waste water is usually neutralised with lime or HCl in a neutralisation plant, passed through filters and finally discharged. The sludge is dewatered in filter presses and discharged for landfill deposit. The oil sludge from the ultrafiltration plants can be used in the blast furnaces. [EUROFER CR]

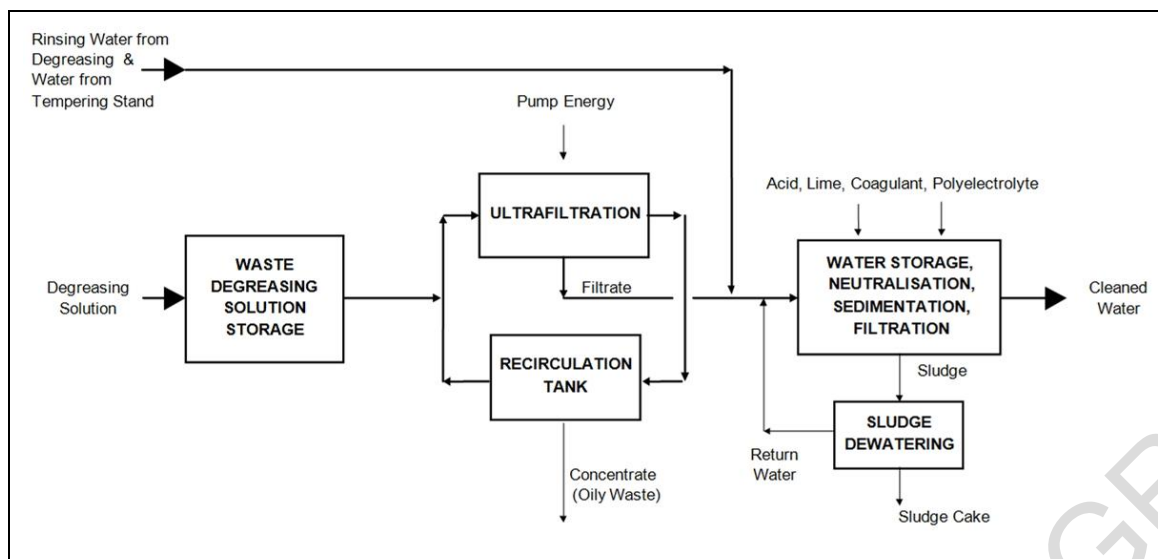


Figure 8.66: Spent degreasing solution flow (example of a continuous annealing line)
[EUROFER CR]

Achieved environmental benefits

Reduction of TOC, COD, TSS, HOI and metal emissions.

Environmental performance and operational data

Figure 8.66 provides an example of the treatment of spent degreasing bath solutions and alkaline waste water solutions in a continuous annealing line. Partial flows from the degreasing solution cleaning circuit, rinsing water from the electrolytic degreasing and waste water from the skin pass mill stand, which cannot be reused in the mills, have to be treated prior to discharge. Prior to treatment of the waste water with flocculants, the oil content has to be removed, e.g. by oil-water separation or ultrafiltration. [Com2 D] [EUROFER 23-7-18] Then, the waste water is usually neutralised with lime or HCl in a neutralisation plant, passed through filters and finally discharged. The sludge is dewatered in filter presses and discharged for landfill deposit. The oil sludge from the ultrafiltration plants can be used in the blast furnaces. [EUROFER CR]

Table 8.27 presents input/output data and effluent data for alkaline (degreasing) waste water treatment by ultrafiltration (continuous annealing line).

Table 8.27: Operational and effluent data for alkaline waste water treatment

| Input / Consumption Level | | | | |
|--|-------------------------|------------------------------------|------------------------------------|-----------------------|
| Raw waste water | | 12 - 15 | kg/t | |
| Citric acid | | occasionally | kg/t | |
| Electrical energy | | 1 - 1.5 | MJ/t | |
| Output / Emission Level | | | | |
| Purified waste water | | 12 - 15 | kg/t | |
| Sludge | | | kg/t | |
| | Concentration [mg/l] | Specific Emission [g/t product] | Reduction rate ¹ [%] | Method of analysis |
| Suspended solids (filterable) | 20 - 40 | 2.35 - 4.7 E -4 | > 90 | DIN 38409-H2 |
| Σ Hydrocarbons (oil, grease) | 5 - 8 | 5.9 - 9.4 E -5 | > 90 | DIN 38409-H18 |
| COD | 5000 - 6000 | 5.9 - 7.1 E -5 | > 50 | DIN 38409-H44 |
| Temperature | 30 °C | | | Thermometer |
| pH | 6.5 - 9.5 | | | |
| Note: Source of data [EUROFER CR]. Data based on weekly, volume proportional 24-h sampling | | | | |
| ¹ Reduction rate based on mass flow of constituent | | | | |

Cross-media effects

Energy and raw material consumption.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

Environmental legislation.

Example plants

Aviles 2, Florange, Sagunto. [EUROFER 23-7-18]

AceriNOX Europe. [EUROFER 23-7-18]

Reference literature

[Fichtner] [EUROFER HR] [El-Hindi] [Com2 D] [Com2 A] [EUROFER 23-7-18]

8.10 General techniques to reduce noise and vibrations

8.10.1 Noise and vibration management plan

Description

Implementation of a noise and vibration management plan as part of the environmental management system (EMS) (see Section 8.1.1).

Technical considerations relevant to applicability

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

Reference literature

[WT BREF]

8.10.2 Appropriate location of equipment and buildings

Description

Noise levels can be reduced by increasing the distance between the emitter and the receiver, by using buildings as noise screens and by relocating the exits or entrances of the buildings.

Technical considerations relevant to applicability

For existing plants, the relocation of equipment and the exits or entrances of the buildings may not be applicable due to a lack of space and/or excessive costs.

Reference literature

[WT BREF]

8.10.3 Operational measures

Description

These include techniques such as:

- improved 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, traffic and handling.

Technical considerations relevant to applicability

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

Reference literature

[WT BREF]

8.10.4 Low-noise equipment

Description

This includes direct drive motors, low-noise compressors, pumps and fans.

Technical considerations relevant to applicability

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

Reference literature

[WT BREF]

8.10.5 Noise and vibration control equipment

Description

This includes techniques such as:

- noise reducers;
- acoustic and vibrational insulation of equipment;
- enclosure of noisy equipment (e.g. scarfing and grinding machines, wire drawing machines, air jets);
- soundproofing of buildings.

Technical considerations relevant to applicability

In existing plants, there may be a lack of space.

Reference literature

[WT BREF]

8.10.6 Noise abatement

Description

Inserting obstacles between emitters and receivers (e.g. protection walls, embankments and buildings).

Technical considerations relevant to applicability

Only applicable to existing plants, as the design of new plants should make this technique unnecessary. In existing plants, there may be a lack of space to insert obstacles.

Reference literature

[WT BREF]

8.11 Residues

8.11.1 General techniques for residues management

8.11.1.1 Residues management plan

Description

A residues management plan is part of the EMS (see Section 8.1.1) and is a set of measures aiming to 1) minimise the generation of residues, 2) optimise the reuse, recycling and/or recovery of residues, and 3) ensure the proper disposal of waste.

Technical considerations relevant to applicability

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

Reference literature

[WT BREF]

8.11.1.2 Pretreatment of oily scale for recycling

Description

This includes techniques such as:

- briquetting or pelletising;
- reducing the oil content of oily scale, e.g. by thermal treatment, washing, flotation.

Technical description

Hot rolling generates valuable oily mill scale residues which are recycled either towards the sinter plant or other iron- and steel-making furnaces. If recycled to the sinter plant, oily mill scale exhibiting a high oil content (fine scale sludge) is pretreated to reduce its oil content in order to prevent glow fires in the waste gas abatement system and emissions of organic pollutants (i.e. dioxins/VOCs). If recycled to other iron- and steel-making furnaces, oily mill scale is either directly injected or pretreated using briquetting or pelletising techniques prior to charging. [EUROFER 10-7-18]

Techniques for recycling oily mill scale to the sinter plant

The direct utilisation of oily mill scale in sinter plants is restricted depending on the oil content. Coarse scale with a particle size of 0.5–5 mm and an oil content below 1 wt-% can be directly recycled to the sinter plant without any pretreatment. [IS BREF - Section 3.1.2]

However, fine scale sludge which is composed of small scale particles (< 0.1 mm) and exhibiting a very high oil content (5–20 wt-%) cannot be directly recycled towards the sinter plant. Indeed, high oil content residues (> 3 wt-%) result in increased emissions of VOCs and potentially dioxins and can lead to significant safety issues for the waste gas abatement systems (i.e. electrostatic precipitators) with potential occurrence of glow fires when oil vapour formation takes place as a result of incomplete burning.

A non-exhaustive list of techniques used for pretreatment of mill scale and recycling at the sinter plant is provided below:

- Washing method for de-oiling mill scale
Fine scale sludge is mixed with water containing washing reagents to produce slurry which is charged into a high-shear stirring device. After stirring and rinsing, a phase separation between the de-oiled mill scale and the oily water emulsion occurs. The de-oiled mill scale (≤ 0.2 wt-% oil content) is recovered and dried prior to recycling to the sinter plant.

- Flotation method for de-oiling mill scale
Fine scale sludge is conditioned using water and chemical reagents and de-oiled in a three-stage flotation process.
 - Revolving tubular furnace (thermal treatment for de-oiling)
Oily mill scale is dewatered and thermally de-oiled using a directly or indirectly heated furnace at temperatures between 450 °C and 470 °C. The product is an oil-free ferrous material exhibiting less than 0.1 wt-% oil content.
 - Top-layer sintering technology
The top-layer sintering process principles are described in more detail in the IS BREF (Section 3.3.2.5.2). Briefly, the top-layer sintering process uses a second ignition hood which ignites a second layer of materials deposited on top of the main sinter layer. The process consists of charging the oily mill sludge after the first ignition and the oil emulsion on the first flame front.
- The main process steps are:
- pre-straining of the charge (mill scale, flue dust, etc.);
 - charging the waste mixture - approximately 10 m behind ignition - onto the already sintered primary charge, resulting in a secondary ignition.
- Thermal treatment of oily mill scale using rotary kilns
After dewatering and homogenisation, the oily mill scale is transported by a screw conveyor through a heating chamber to a rotary kiln where the material is continuously processed at temperatures between 400 °C and 550 °C. Both the moisture and the oil content are thermally driven off and subsequently burned in a combustion chamber. De-oiled residues are reused at the sinter plant.

Figure 8.68 depicts the schematic of a rotary kiln installation at an ArcelorMittal integrated site for treatment of oily mill scale. The rotary kiln has a diameter of 2 m and a length of 10 m (Figure 2.48) and is heated by gas to 500–550 °C. The distilled moistness with oil is burnt in a combustion chamber heated by gas to 780 °C. The waste gas is cooled using a water scrubber below 250 °C and cleaned using a cyclone and a fabric filter. The collected dust (fine scale) is mixed together with the processed scale, ensuring that all residues are fully recycled (i.e. zero waste). [EUROFER 31-3-17]

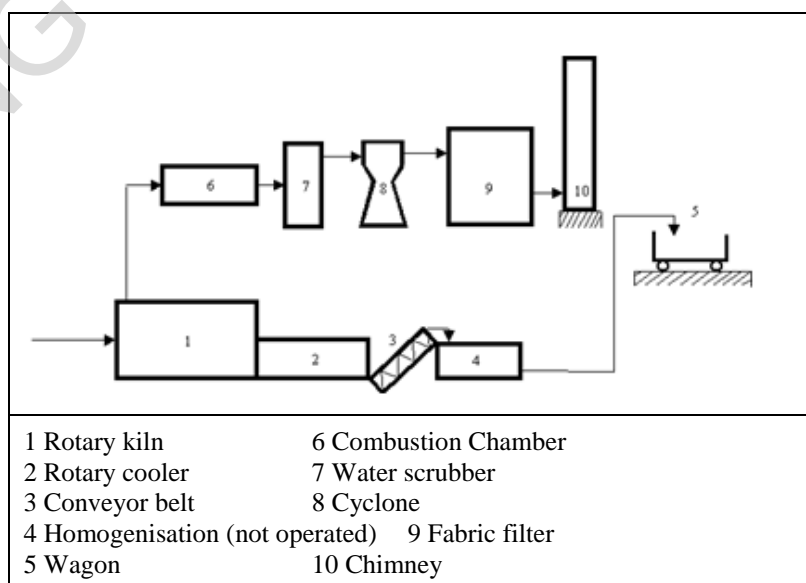


Figure 8.67: Schematic of a rotary kiln plant for thermal treatment of oily mill scale.



Source: [EUROFER 31-3-17]

Figure 8.68: Picture of a rotary kiln for thermal treatment of oily mill scale at an ArcelorMittal integrated plant.

Techniques for recycling oily mill scale in other iron- and steel-making furnaces

A non-exhaustive list of techniques used for pretreatment of mill scale and recycling at iron- and steel-making furnaces is provided below:

- **Briquetting and converter charging**
Fine scale sludge is transformed into briquettes with the addition of binders (e.g. lime, molasses). The produced moulded bodies are of adequate consistency to be charged in the converter. The briquettes' cooling effect is sufficient for converter charging. Additives such as anthracite can be included to make the briquettes thermally neutral.
- **Blast furnace charging**
Several options are available to integrate the oily mill scale to the blast furnace charge including briquetting and top charging; injection via coal grinder through the tuyeres; pelletising and mixing with coal; injection as slurry directly into the tuyeres. However, all these practices are limited by the moisture and the oil content of the sludge as well as the process requirements.
- **Direct utilisation in the blast furnace (Voestalpine Stahl method)**
Scale is shot into the bottom of the blast furnace via a sludge burning lance. This is a very economical way to utilise the energy of the hydrocarbons and to reduce the iron oxide (scale) without needing an extra furnace and without producing additional environmental pollution, but it is only possible for blast furnaces equipped with a sludge or waste oil burning lance. It is important to inject the sludge at the bottom and not at the top of the furnace to ensure that the hydrocarbons are burnt and not only evaporated. Special care is required to ensure that all the hydrocarbons are effectively burnt in the process to prevent higher emissions in the blast furnace.
- **Carbofer**
Oily mill scale sludge is mixed with lime and coal dust and, optionally, iron- or carbon-bearing flue dust to obtain a dry mixture that is suitable for pneumatic injection into a reactor of the iron- and steel-making process, such as the blast furnace or the electric arc furnace. The blend is injected into the steel-making furnace either through a retractable consumable lance or via a water-cooled sidewall lance. Injection of the Carbofer mixture into the slag bath produces a good foaming slag. A full recovery of the injected materials can be expected. [Com HR]

Achieved environmental benefits

The environmental benefits resulting from the implementation of recycling technologies for oily mill scale residues are:

- reduction of raw materials used, e.g. decrease of the coke rate in the blast furnace (see Section 6.3.12.5 of the IS BREF), or reduction of primary raw materials in the sinter plant (see Section 3.3.4 of the IS BREF); [EUROFER 10-7-18]
- reduction of the amount of waste and the disposal rate. [EUROFER 10-7-18]

Environmental performance and operational data

The capacity of the thermal rotary kiln de-oiling installation (at one of the ArcelorMittal integrated sites in Europe) is 20 000 t/yr. The processed scale from the rotary kiln has ≤ 0.1 wt-% oil content. [EUROFER 10-7-18]

Cross-media effects

- De-oiling methods consume detergents or flocculating agents and result in oily waste water or residues from flotation.
- Thermal treatments result in emissions to air and increased energy consumption.
- The recycling of certain residues can contribute to an increase of metal emissions in the waste gas of the sinter plant. [EUROFER 10-7-18]

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

The costs and benefits associated with this technique are summarised below:

- cost benefits obtained by reducing the use of virgin raw materials (i.e. iron ores) and reducing the coke rate;
- cost benefits obtained due to reduced quantities of waste sent for disposal;
- investment, operation and maintenance costs associated with the installation of de-oiling facilities for processing oily mill scales.

For most integrated steelworks, the financial benefits of recycling oily mill scale outweigh the costs of operating the de-oiling and waste water treatment facilities.

Driving force for implementation

- Reduction of costs due to reduced quantities of raw materials used.
- Reduction of costs due to reduced quantities of waste sent for disposal.
- Limited availability of options for waste disposal.

Example plants

Almost all sinter plants around the world utilise oily mill scale (after treatment) arising from integrated steelworks.

One example is Voestalpine Stahl GmbH (direct utilisation of oil residues in the blast furnace and reuse of scale in the sinter plant).

Reference literature

[EUROFER 10-7-18]

IS BREF Section 3.1.2: Blending and mixing of raw materials

IS BREF Section 3.3.4: Use of production residues such as waste and by-products in the sinter plant

IS BREF Section 6.3.12.5: Direct injection of used oils, fats and emulsions as reducing agents and of solid residues

IS BREF Section 3.3.2.5.2: Top layer sintering

8.11.1.3 Recycling of scale

Description

Scale is collected and used in a sinter plant (in the case of scale with a low oil content) or in iron- and steel-making furnaces (in the case of scale with a high oil content).

Technical description

Oil-free scale and low-oil-content ($< 1\%$) scale is fed directly back into the metallurgical process, usually via the sinter plant or the iron- and steel-making furnaces.

More information on the technique

Additional information on the technique may be found in Section 4.4.1.1.

8.11.1.4 Recycling of metallic scrap

Description

Metallic scrap from mechanical processes (e.g. from trimming and finishing) is recycled to iron and steel production.

Technical description

Metallic by-products including scrap, downgrades, crop ends arising mostly from hot rolling are usually relatively clean and can easily be recycled back into metallurgical processes (e.g. BOF).

Achieved environmental benefits

Increased material efficiency.

Environmental performance and operational data

In hot rolling, the amounts of metallic scrap generated range between 70 kg/t and 150 kg/t of steel produced. [Com A]

Cross-media effects

None.

Technical considerations relevant to applicability

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

Economics

Cost savings.

Driving force for implementation

Recover the iron content and reduce the consumption of primary raw materials.

Example plants

Widely used.

Reference literature

[Com A]

8.11.1.5 Recycling of metal and metal oxides from dry waste gas cleaning

Description

The coarse fraction of metal and metal oxides originating from dry cleaning (e.g. fabric filters) of waste gases from mechanical processes (e.g. scarfing or grinding) are selectively isolated using mechanical techniques (e.g. sieves) or magnetic techniques and recycled to iron and steel production.

Technical description

Dry or drained oxides that are mostly originating from dry air abatement cleaning systems (e.g. bag filters) in the rolling mills (including from grinding or scarfing operations) are recycled. The coarse fraction of oxides can be selectively isolated using magnetic or mechanical separation (sieves). This fraction can be directly reused in the sinter plant, in the blast furnace or in the steel plant to recover the iron content.

Achieved environmental benefits

- Reduced waste.
- Use of iron content.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

In some cases, oxides can contain oil requiring pretreatment for de-oiling the material prior to recycling (refer to Section 2.4.13.2). [EUROFER 23-7-18]

Technical considerations relevant to applicability

~~Certain recycling options require pretreatment by briquetting [Com D].~~
Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Reduction of waste disposal costs. [EUROFER 23-7-18]

Example plants

Most integrated steelworks have facilities to recycle oxides. [EUROFER 23-7-18]

Reference literature

[EUROFER 23-7-18]

8.11.1.6 Use of oily sludge**Description**

Residual oily sludge, e.g. from degreasing, is dewatered to recover the oil contained therein for further use (e.g. as fuel). Alternatively, if the water content is low, the sludge can be directly used as fuel.

Technical description

A variety of methods is used to remove oily sludge from the degreasing bath. This sludge contains solids together with a range of grease and oils. Depending on contaminant loading and calorific value, it can be used for other purposes ~~energy recovery by incineration as fuel~~, if necessary after dewatering. For example, the oily sludge ~~is~~ may be removed from the site by a specialised contractor ~~either for controlled disposal or~~ for the recovery of the oil contained therein ~~in it~~. In some cases, if the water content is low, the sludge can be directly used as ~~part of the fuel requirement for steam raising or heating plant~~. [Com EGGA]

Achieved environmental benefits

Reduction of oil-containing waste sent for disposal.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

Reduced disposal costs.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

[Com EGGA]

TWG, The following section has been added – New BAT candidate provided by the TWG.

8.11.1.7 Thermal treatment of hydroxide sludge from the recovery of mixed acid

Description

Sludge generated from the recovery of mixed acid is thermally treated in order to produce a material rich in calcium fluoride that can be used in argon oxygen decarburisation converters.

Technical description

This technique consists of processing the hydroxide sludge obtained as by-product in a stainless steel mixed acid pickling line in order to reuse it as a slag former in AOD converters because of its high content in calcium fluoride (as a substitute for the commercial powder – CaF_2).

In mixed acid pickling plants, a pickling sludge is produced after neutralisation with $\text{Ca}(\text{OH})_2$ (see Section 3.4.1.10). Typically, this pickling sludge after the filter press contains about 40–50 % CaF_2 , 5–30 % $\text{Ca}(\text{OH})_2$, 20–30 % $\text{Fe}(\text{OH})_3$, 5–9 % $\text{Cr}(\text{OH})_3$, 2–4 % $\text{Ni}(\text{OH})_2$ and 2–4 % SiO_2 . Using a thermal treatment in a rotary kiln, the hydroxide sludge is converted into a dark and strong material, designated as Hydroflus, consisting mainly of CaF_2 , as well as chromium and nickel oxides. This product constitutes an excellent substitute for the fluorspar powder normally used as a slag former in the AOD process. [World Patent, 2005]

The method is currently employed as a standard practice in Outokumpu Avesta in Sweden with some restrictions regarding the sulphur content of the sludge. [Schneiker et al., 2008]

Achieved environmental benefits

- Reduced landfill of hydroxide sludge.
- Reduced usage of fluorspar in AOD converters.

Environmental performance and operational data

Landfill is reduced by > 80 %.

Cross-media effects

- The Hydroflus product contains 5–8 % Cr of which small amounts, less than 0.1 %, is Cr(VI). [Lindfors and Kostamo, 2006]
- The use of the Hydroflus product can increase the load of reducing elements (e.g. Si) in AOD converters and consequently increase slag volume. [EUROFER 23-7-18]

Technical considerations relevant to applicability

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

Economics

The landfill costs for the hydroxide sludge is about EUR 2 500 per tonne. The consumption of fluorspar in a mixed acid pickling line is usually higher than the amounts of hydroxide sludge produced in the mixed acid pickling line meaning that significant cost savings can be achieved by partially substituting the fluorspar used in AOD converters with the processed hydroxide sludge.

Driving force for implementation

- Reduction/elimination of the landfill of hydroxide sludge in mixed acid pickling plants.
- Significant reduction of the quantities of fluorspar used in AOD converters.

Example plants

Outokumpu Avesta (Sweden).

Reference literature

[EUROFER 23-7-18]

[World Patent, 2005]

S-E., Lunner, and G., Ye, 2005. Method in Connection with Steel Production. World Patent No. WO2005/098054.

[Schneiker et al., 2008]

T., Schneiker, S., Lille, P., Strandberg, 2008. Hydrofluss - Recycled Hazardous waste - Proceedings of SCANMET III – In the proceedings of the 3rd International Conference on Process Development in Iron and Steelmaking, Lulea, Sweden, 8-11 June, 539-546.

[Lindfors and Kostamo, 2006]

N.O., Lindfors, P. Kostamo, 2006. BAT examples from the Nordic iron and steel industry. ISBN 92-893-1286-6

8.11.2 Techniques for residues management in galvanising**8.11.2.1 ~~Reuse of filter dust~~ Recycling of fabric filter dust****Description**

Dust from fabric filters containing zinc is collected and used to produce fluxing agents.

Technical description

Precipitated dust from bag filters consists basically of ammonium chloride and zinc chloride (fluxing agent). The dust is collected, packed in bags and periodically sent for recycling to fluxing agent producers. ~~Recycling might be limited by oil and grease content (less than 3 % is required) or by dioxin content.~~

Achieved environmental benefits

- Increased material efficiency.
- Reduction of waste sent for disposal.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

TWG, please provide information.

Technical considerations relevant to applicability

~~New and existing plants with fabric filters.~~ Recycling might be limited by the oil and grease content (less than 3 wt-% are required).

Economics

Savings result from reduced costs for waste disposal.

Driving force for implementation

Reduced costs for waste disposal.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

8.11.2.2 Reuse-Recycling of zinc ash

Description

Metallic zinc is recovered from zinc ash by melting in recovery furnaces. The remaining zinc-containing residue is used for zinc oxide production.

Technical description

~~Zinc grains can be melted from the zinc ash and recycled back to the galvanizing pot. The reduction grade is 60–70 %. The remaining zinc oxide ash is refined further in specialised industry. [Com FIN]~~

~~— Special melting pots are used to collect the zinc ash.~~

~~— Melting pot is put to the Zinkof furnace, in which zinc ash is melted at temperature of about 520 °C with a rotating movement. The molten zinc (60–65 wt %) is returned to the molten zinc kettle. The remaining oxide zinc ash is ground and sold to the secondary zinc industry.~~

Metallic zinc that is trapped in zinc ash (i.e. zinc oxide) as a result of the skimming process is recovered by melting in zinc recovery furnaces (at around 520 °C). The residual zinc ash floats on top of the molten zinc. The molten zinc (60–65 wt-%) is tapped and returned to the galvanising kettle. The remaining zinc-containing residue is sold to plants producing zinc oxide. [Com FIN]

Achieved environmental benefits

- Increased material efficiency.
- Reduction of waste sent for disposal.

Environmental performance and operational data

~~With described technique~~ The recycled zinc amount is 11.5 kg/t of galvanised steel.

Cross-media effects

Increased energy consumption due to the heating of the recovery furnace.

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

The costs ~~price~~ of the equipment ~~is about~~ were reported to be approximately FIM 200 000. In addition ~~to that, grinding equipment for grinding zinc ash also has to be provided and it was~~ purchased at costs of about FIM 60 000. The net profit, when all the costs, except investment

costs, ~~are~~ were included, ~~is~~ was reported to be about FIM 2.20–2.80/kg recycled zinc depending upon the market price of zinc. [Com 2 FIN]

Driving force for implementation

Cost savings due to the recovery of zinc.

Example plants

Four galvanising plants in Finland, including KS-Sinkki Oy, Lievestuore. [Com2 FIN]

Reference literature

[Com FIN] [Com2 FIN]

8.11.2.3 Recycling of hard zinc

Description

Hard zinc is used, e.g. in the non-ferrous metals industries to produce zinc.

Technical description

Hard zinc (dross) is a zinc-iron alloy that builds up in the bath. It results from the reaction of molten zinc with iron originating from the preceding pickling and fluxing baths, from the feedstock that is galvanised or from the kettle itself. Zinc may be recovered from this residue, e.g. in the non-ferrous metals industries to produce zinc.

Achieved environmental benefits

- Increased material efficiency.
- Reduction of waste sent for disposal.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

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

Economics

Savings result from the recovery of zinc.

Driving force for implementation

Cost savings due to the recovery of zinc.

Example plants

A list of the relevant example plants from the data collection will be inserted here by the EIPPCB after Draft 1.

Reference literature

TWG, please provide information.

8.11.2.4 Environmental risk prevention from the storage of zinc-containing residues

Description

Zinc-containing residues from galvanising baths are stored separately from each other on impermeable surfaces and in enclosed areas.

Technical description

Zinc-containing residues originate from galvanising baths (e.g. zinc ash, hard zinc, splashes, fabric filter dust). These residues are stored separately from each other on impermeable surfaces and protected from rain and wind in enclosed areas.

Achieved environmental benefits

Prevention of contamination from the storage of residues.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

Environmental legislation.

Example plants

Widely used.

Reference literature

TWG, please provide information.

8.11.3 Techniques for residues management in wire drawing

8.11.3.1 Environmental risk prevention from the storage of lead-containing residues

Description

Lead-containing residues from lead baths are stored separately from each other on impermeable surfaces and in enclosed areas.

Technical description

Lead-containing residues originate from the lead baths used in the wire drawing industry (e.g. protective layer materials and lead oxides). These residues are stored separately from each other on impermeable surfaces and protected from rain and wind in enclosed areas.

Achieved environmental benefits

Prevention of contamination from the storage of residues.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None.

Technical considerations relevant to applicability

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

Economics

TWG, please provide information.

Driving force for implementation

Environmental legislation.

Example plants

Widely used.

Reference literature

TWG, please provide information.

8.11.3.2 Recycling of lead-containing residues from wire drawing**Description**

Lead-containing residues are recycled, e.g. to the non-ferrous metals industries to produce lead.

Technical description

Pb-containing residues originate from the Pb bath (waste bath cover material, lead oxides, etc.). The wire industry depends on subcontractors for the final disposal or recycling of these residues. Normally, Pb-containing waste is recycled by the non-ferrous metals industry (Pb smelters). [CET-BAT]

Achieved environmental benefits

Reduced waste disposal.

Environmental performance and operational data

TWG, please provide information.

Cross-media effects

None

Technical considerations relevant to applicability

~~New and existing plants.~~ Generally, there are no technical restrictions to the applicability of this technique.

Economics

TWG, please provide information.

Driving force for implementation

Reduced costs due to increased material efficiency.

Example plants

Widely used.

Reference literature

[CET-BAT]

WORKING DRAFT IN PROGRESS

9 BEST AVAILABLE TECHNIQUES (BAT) CONCLUSIONS FOR FERROUS METALS PROCESSING

Scope

These BAT conclusions concern the following activities specified in Annex I to Directive 2010/75/EU:

- 2.3 Processing of ferrous metals:
 - (a) operation of hot rolling mills with a capacity exceeding 20 tonnes of crude steel per hour;
 - (c) application of protective fused metal coats with an input exceeding 2 tonnes of crude steel per hour. This includes hot dip coating and batch galvanising.
- 2.6 Surface treatment of metals using electrolytic or chemical processes where the volume of the treatment vats exceeds 30 m³, provided that cold rolling, wire drawing or batch galvanising are directly associated to the surface treatment.
- 6.11 Independently operated treatment of waste water not covered by Directive 91/271/EEC, provided that the main pollutant load originates from the activities covered by these BAT conclusions.

These BAT conclusions also cover:

- cold rolling and wire drawing if directly associated with hot rolling and/or hot dip coating;
- the combined treatment of waste water from different origins, provided that the waste water treatment is not covered by Directive 91/271/EEC and that the main pollutant load originates from the activities covered by these BAT conclusions.

These BAT conclusions do not cover the following:

- production of welded tubes;
- production of seamless tubes by extrusion;
- metal coating by thermal spraying;
- electroplating and electroless plating. This may be covered by the BAT conclusions for Surface Treatment of Metals and Plastics (STM).

Other BAT conclusions and reference documents which could be relevant for the activities covered by these BAT conclusions include the following:

- Iron and Steel Production (IS);
- Large Combustion Plants (LCP);
- Surface Treatment of Metals and Plastics (STM);
- Surface Treatment using Organic Solvents (STS);
- Waste Treatment (WT);
- 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).

Definitions

For the purposes of these BAT conclusions, the following definitions apply:

| General terms | |
|---------------------------------------|---|
| Term used | Definition |
| Batch galvanising | Discontinuous immersion of steel workpieces in a bath containing molten zinc to coat their surface with zinc. This also includes any directly associated pre- and post-treatment processes (e.g. degreasing and passivation). |
| Carbon steel | Steel in which the content of each alloy element is less than 5 wt-%. |
| Channelled emissions | Emissions of pollutants into the environment through any kind of duct, pipe, stack, etc. |
| Cold rolling | Compression of steel by rollers at ambient temperatures to change its characteristics (e.g. size, shape and/or metallurgical properties). This also includes any directly associated pre- and post-treatment processes (e.g. pickling, annealing and oiling). |
| Continuous measurement | Measurement using an automated measuring system permanently installed on site. |
| Hot dip coating | Continuous immersion of steel sheets or wires through a bath containing molten metal(s), e.g. zinc and/or aluminium, to coat the surface with metal(s). This also includes any directly associated pre- and post-treatment processes (e.g. pickling and phosphating). |
| Direct discharge | Discharge to a receiving water body without further downstream waste water treatment. |
| Existing plant | A plant that is not a new plant. |
| High-alloy steel | Steel in which the content of one or more alloy elements is 5 wt-% or more. This includes stainless steel, which contains 10 wt-% chromium or more. |
| Hot rolling | Compression of heated steel by rollers at temperatures typically ranging from 1 050 °C to 1 300 °C to change its characteristics (e.g. size, shape and/or metallurgical properties). This includes hot ring rolling and hot rolling of seamless tubes as well as any directly associated pre- and post-treatment processes (e.g. scarfing, finishing, pickling and oiling). |
| Indirect discharge | A discharge that is not a direct discharge. |
| Intermediate heating | Heating of the feedstock between the hot rolling stages. |
| Iron and steel process gases | Blast furnace gas, basic oxygen furnace gas, coke oven gas or mixtures thereof originating from iron and steel production. |
| Major plant upgrade | A major change in the design or technology of a plant with major adjustments or replacements of the process and/or abatement technique(s) and associated equipment. |
| Mixed acid | A mixture of hydrofluoric acid and nitric acid. |
| 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. |
| Periodic measurement | Measurement at specified time intervals using manual or automated methods. |
| Plant | All parts of an installation covered by the scope of these BAT conclusions and any other directly associated activities which have an effect on consumption and/or emissions. |
| Post-heating | Heating of the feedstock after hot rolling. |
| Recovery | Recovery as defined in Article 3(15) of Directive 2008/98/EC. The recovery of spent acids includes their regeneration, reclamation and recycling. |
| Reheating | Heating of the feedstock before hot rolling. |
| Residue | Substance or object generated by the activities covered by the scope of these BAT conclusions as waste or by-product. |
| Sensitive receptor | Areas which need special protection, such as: - residential areas; - areas where human activities are carried out (e.g. neighbouring workplaces, schools, day-care centres, recreational areas, hospitals or nursing homes). |
| Valid hourly (or half-hourly) average | An hourly (or half-hourly) average is considered valid when there is no maintenance or malfunction of the automated measuring system. |

| | |
|--------------|--|
| Wire drawing | Drawing of steel rods or wires through dies to reduce their diameter. This also includes any directly associated pre- and post-treatment processes (e.g. wire rod pickling and feedstock heating after drawing). |
|--------------|--|

| Pollutants and parameters | |
|--------------------------------|---|
| Term used | Definition |
| Cd | The sum of cadmium and its compounds, expressed as Cd. |
| CO | Carbon monoxide. |
| COD | Chemical oxygen demand. 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. |
| Cr | The sum of chromium and its compounds, expressed as Cr. |
| Cr(VI) | Hexavalent chromium, expressed as Cr(VI), includes all chromium compounds where the chromium is in the oxidation state +6. |
| Dust | Total particulate matter (in air). |
| Fe | The sum of iron and its compounds, expressed as Fe. |
| F ⁻ | Dissolved fluoride, expressed as F ⁻ . |
| HCl | Hydrogen chloride. |
| HF | Hydrogen fluoride. |
| Hg | The sum of mercury and its compounds, expressed as Hg. |
| HOI | Hydrocarbon oil index. The sum of compounds extractable with a hydrocarbon solvent (including long-chain or branched aliphatic, alicyclic, aromatic or alkyl-substituted aromatic hydrocarbons). |
| H ₂ SO ₄ | Sulphuric acid. |
| NH ₃ | Ammonia. |
| Ni | The sum of nickel and its compounds, expressed as Ni. |
| NO ₂ | Nitrogen dioxide. |
| NOX | The sum of nitrogen monoxide (NO) and nitrogen dioxide (NO ₂), expressed as NO ₂ . |
| Pb | The sum of lead and its compounds, expressed as Pb. |
| Sn | The sum of tin and its compounds, expressed as Sn. |
| SO ₂ | Sulphur dioxide. |
| SO _x | The sum of sulphur dioxide (SO ₂), sulphur trioxide (SO ₃) and sulphuric acid aerosols, expressed as SO ₂ . |
| TOC | Total organic carbon, expressed as C (in water); includes all organic compounds. |
| Total P | Total phosphorus, expressed as P, includes all inorganic and organic phosphorus compounds. |
| TSS | Total suspended solids. Mass concentration of all suspended solids (in water), measured via filtration through glass fibre filters and gravimetry. |
| TVOC | Total volatile organic carbon, expressed as C (in air). |
| Zn | The sum of zinc and its compounds, expressed as Zn. |

Acronyms

For the purposes of these BAT conclusions, the following acronyms apply:

| Acronym | Definition |
|---------|--|
| BG | Batch galvanising |
| CR | Cold rolling |
| EMS | Environmental management system |
| HDC | Hot dip coating |
| HR | Hot rolling |
| OTNOC | Other than normal operating conditions |
| SCR | Selective catalytic reduction |
| SNCR | Selective non-catalytic reduction |
| WD | Wire drawing |

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.

[NOTE: Whilst cross-references are provided to other parts of this document in order to aid the work of the TWG, they will not be included in the final BAT conclusions themselves. Such cross-references are consequently displayed in italics in square brackets.]

[NOTE: In order to avoid repetition, this section contains general considerations that are essential to the understanding of the BAT conclusions taken as a stand-alone document, such as:

- *reference conditions for emissions to air (e.g. dry gas, standard temperature/pressure, oxygen concentration);*
- *averaging periods;*
- *sampling times;*
- *conversions to reference conditions;*
- *units in which environmental performance levels are expressed.]*

BAT-AELs and indicative emission levels for emissions to air

Emission levels associated with the best available techniques (BAT-AELs) and indicative emission levels for emissions to air given in these BAT conclusions refer to concentrations (mass of emitted substances per volume of waste gas) under the following standard conditions: dry gas at a temperature of 273.15 K and a pressure of 101.3 kPa, and expressed in mg/Nm³.

The reference oxygen levels used to express BAT-AELs and indicative emission levels in these BAT conclusions are shown in the table below.

| Source | Reference oxygen level (O_R) |
|---|------------------------------------|
| Feedstock heating and drying; heating of the galvanising kettle | 3 dry vol-% |
| All other sources | 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-%.

For averaging periods of BAT-AELs for emissions to air, the following definitions apply.

| Type of measurement | Averaging period | Definition |
|--|----------------------------------|--|
| Continuous | Daily average | Average over a period of one day based on valid hourly or half-hourly averages. |
| Periodic | Average over the sampling period | Average value of three consecutive measurements of at least 30 minutes each ⁽¹⁾ . |
| ⁽¹⁾ For any parameter where, due to sampling or analytical limitations and/or due to operational conditions, a 30-minute sampling/measurement and/or an average of three consecutive measurements is inappropriate, a more representative sampling/measurement procedure may be employed. | | |

When the waste gases of two or more sources (e.g. furnaces) are discharged through a common stack, the BAT-AELs apply to the combined discharge from the stack.

BAT-AELs for emissions to water

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 or µg/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;
- 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.

Time-proportional composite samples can be used provided that sufficient flow stability is demonstrated.

The BAT-AELs apply at the point where the emission leaves the plant.

Other environmental performance levels associated with the best available techniques (BAT-AEPLs)

BAT-AEPLs for specific energy consumption (energy efficiency)

The BAT-AEPLs for specific energy consumption refer to yearly averages calculated using the following equation:

$$\text{specific energy consumption} = \frac{\text{energy consumption}}{\text{activity rate}}$$

where:

energy consumption: total amount of heat (generated by primary energy sources) and electricity consumed by the specific process(es), expressed in MJ/year or kWh/year; and

activity rate: yearly process throughput, expressed in t/year.

BAT-AEPLs for specific water consumption

The BAT-AEPLs for specific water consumption refer to yearly averages calculated using the following equation:

$$\text{specific water consumption} = \frac{\text{water consumption}}{\text{production rate}}$$

where:

water consumption: total amount of water consumed by the plant excluding recycled and reused water, cooling water used in once-through cooling systems, as well as water for domestic-type usage, expressed in m³/year; and

production rate: yearly amount of products manufactured by the plant, expressed in t/year.

BAT-AEPLs for specific waste water discharge

The BAT-AEPL for specific waste water discharge refers to a yearly average calculated using the following equation:

$$\text{specific waste discharge} = \frac{\text{waste water consumption}}{\text{production rate}}$$

where:

waste water discharge: total amount of waste water discharged (as direct discharge or indirect discharge) by the plant excluding any indirect cooling water and surface run-off water that is discharged separately, expressed in m³/year; and

production rate: yearly amount of products manufactured by the plant, expressed in t/year.

BAT-AEPLs for specific material consumption

The BAT-AEPLs for specific material consumption refer to yearly averages calculated using the following equation:

$$\text{specific material consumption} = \frac{\text{material consumption}}{\text{activity rate}}$$

where:

material consumption: total amount of material consumed by the specific process(es), expressed in kg/year; and

activity rate: yearly process throughput, expressed in t/year or m²/year.

9.1 General BAT conclusions for ferrous metals processing

9.1.1 Environmental management systems

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:

- xxvii. commitment, leadership, and accountability of the management, including senior management, for the implementation of an effective EMS;
- xxviii. 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;
- xxix. development of an environmental policy that includes the continuous improvement of the environmental performance of the installation;
- xxx. establishing objectives and performance indicators in relation to significant environmental aspects, including safeguarding compliance with applicable legal requirements;
- xxxi. planning and implementing the necessary procedures and actions (including corrective and preventive actions where needed), to achieve the environmental objectives and avoid environmental risks;
- xxxii. determination of structures, roles and responsibilities in relation to environmental aspects and objectives and provision of the financial and human resources needed;
- xxxiii. 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);
- xxxiv. internal and external communication;
- xxxv. fostering employee involvement in good environmental management practices;
- xxxvi. establishing and maintaining a management manual and written procedures to control activities with significant environmental impact as well as relevant records;
- xxxvii. effective operational planning and process control;
- xxxviii. implementation of appropriate maintenance programmes;
- xxxix. emergency preparedness and response protocols, including the prevention and/or mitigation of the adverse (environmental) impacts of emergency situations;
 - xl. 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;
 - xli. 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;
 - xl. application of sectoral benchmarking on a regular basis;
 - xl. 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;
 - xl. 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;
 - xl. periodic review, by senior management, of the EMS and its continuing suitability, adequacy and effectiveness;
 - xl. following and taking into account the development of cleaner techniques.

Specifically for the ferrous metals processing sector, BAT is to also incorporate the following features in the EMS:

- xlvi. an inventory of waste water and waste gas streams (see BAT 2);
- xlvi. a plan for the prevention and control of leaks and spillages (see BAT 6 (a));
- xlix. an OTNOC management plan (see BAT 7);
 - 1. an energy efficiency plan (see BAT 9 (a));
 - li. a water management plan (see BAT 17 (a));
 - lii. a noise and vibration management plan (see BAT 29);
 - liii. a residues management plan (see BAT 31 (a)).

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 8.1.1]

BAT 2. In order to facilitate the reduction of emissions to water and air, BAT is to establish, maintain and regularly review (including when a significant change occurs) an inventory of waste water and waste gas streams, as part of the EMS (see BAT 1), that incorporates all of the following features:

- (i) information about the production processes, 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 at source including their performances;
- (ii) information about the characteristics of the waste water streams, such as:
 - (a) average values and variability of flow, pH, temperature and conductivity;
 - (b) average concentration and load values of relevant substances (e.g. total suspended solids, TOC or COD, hydrocarbon oil index, phosphorus, metals, fluoride) and their variability;
- (iii) information about the characteristics of the waste gas streams, such as:
 - (a) average values and variability of flow and temperature;
 - (b) average concentration and load values of relevant substances (e.g. dust, NOX, SO₂, CO, metals, acids) and their variability;
 - (c) presence of other substances that may affect the waste gas treatment system or plant safety (e.g. oxygen, nitrogen, water vapour).

Applicability

The level of detail of the inventory will generally be related to the nature, scale and complexity of the plant, and the range of environmental impacts it may have.

9.1.2 Monitoring

BAT 3. BAT is to monitor at least once per year:

- the annual consumption of water, energy and materials,
- the annual generation of residues and waste water,
- the annual amount of waste sent for disposal.

Description

Monitoring includes direct measurements, calculations or recording, e.g. using suitable meters or invoices. The monitoring is broken down to the most appropriate level (e.g. to process or plant/installation level) and considers any significant changes in the plant/installation.

BAT 4. 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 | Specific process(es) | Sector | Standard(s) | Minimum monitoring frequency ⁽¹⁾ | Monitoring associated with |
|-------------------------|--|-----------------------------|--|---|----------------------------------|
| CO | Feedstock heating | HR | EN 15058 ⁽²⁾ | Once every six months | BAT 20 |
| | | CR, WD, HDC | | Once every year | |
| | Heating of the galvanising kettle and feedstock drying | HDC, BG | | Once every year | |
| | Hydrochloric acid recovery by spray roasting and by using fluidised bed reactors | All sectors | | Once every year | BAT 26 |
| Dust | Feedstock heating | HR | EN 13284-1 ⁽²⁾ ⁽³⁾ | Once every six months | BAT 18 |
| | | CR, WD, HDC, BG | | Once every year | |
| | Pickling | All sectors | | Once every year ⁽⁴⁾ | BAT 22 |
| | Hot dipping | Coating of wires in HDC, BG | | Once every year | BAT 24 |
| | Hydrochloric acid recovery by spray roasting and by using fluidised bed reactors | All sectors | | Once every year | BAT 26 |
| | Mechanical processing, scarfing and welding | HR | | Once every year | BAT 40 |
| | Mechanical processing and welding | CR | | Once every year | BAT 43 |
| | Lead baths | WD | | Once every year | BAT 48 |

| | | | | | | |
|--------------------------------|----|--|----------------------------------|---|--------------------------------|--------|
| | | Dry drawing | | | Once every year | BAT 48 |
| HCl | | Pickling with hydrochloric acid | All sectors | EN 1911 ⁽²⁾ | Once every year | BAT 22 |
| | | Hydrochloric acid recovery by spray roasting and by using fluidised bed reactors | All sectors | | Once every year | BAT 26 |
| | | Stripping with hydrochloric acid | BG | | Once every year | BAT 60 |
| HF | | Pickling with mixed acid | HR, CR | No EN standard available ⁽²⁾ | Once every year | BAT 22 |
| | | Recovery of mixed acid by evaporation | HR, CR | | Once every year | BAT 26 |
| Metals | Ni | Mechanical processing, scarfing and welding | HR | EN 14385 | Once every year ⁽⁴⁾ | BAT 40 |
| | | Mechanical processing and welding | CR | | Once every year ⁽⁴⁾ | BAT 43 |
| | Pb | Mechanical processing, scarfing and welding | HR | | Once every year ⁽⁴⁾ | BAT 40 |
| | | Mechanical processing and welding | CR | | Once every year ⁽⁴⁾ | BAT 43 |
| | | Lead baths | WD | | Once every year ⁽⁴⁾ | BAT 48 |
| | Zn | Hot dipping | HDC, BG | | Once every year ⁽⁴⁾ | BAT 24 |
| NH ₃ | | When SNCR and/or SCR is used | All sectors | No EN standard available ⁽²⁾ | Once every year | — |
| NOX | | Feedstock heating | HR | EN 14792 ⁽²⁾ | Once every six months | BAT 20 |
| | | | CR, WD, HDC | | Once every year | |
| | | Heating of the galvanising kettle and feedstock drying | HDC, BG | | Once every year | |
| | | Pickling with mixed acid | HR, CR | | Once every year | BAT 23 |
| | | Hydrochloric acid recovery by spray roasting and by using fluidised bed reactors | All sectors | | Once every year | BAT 26 |
| SO ₂ ⁽⁵⁾ | | Feedstock heating | HR | EN 14791 ⁽²⁾ | Once every six months | BAT 19 |
| | | | CR, WD, Coating of sheets in HDC | | Once every year | |
| | | Hydrochloric acid recovery by spray roasting and by using fluidised bed reactors | All sectors | | Once every year | BAT 26 |
| SO _x | | Pickling with sulphuric acid | All sectors | | Once every year | BAT 22 |
| TVOC | | Degreasing | All sectors | EN 12619 ⁽²⁾ | Once every year ⁽⁴⁾ | BAT 21 |
| | | Oiling | All sectors | | Once every year ⁽⁴⁾ | BAT 25 |

| | | | | | |
|--|--------------------------------------|----|--|--------------------------------|--------|
| | Rolling, wet tempering and finishing | CR | | Once every year ⁽⁴⁾ | BAT 45 |
| | Lead baths | WD | | Once every year ⁽⁴⁾ | — |
| | Oil quench baths | WD | | Once every year ⁽⁴⁾ | BAT 50 |

⁽¹⁾ The measurements are carried out at the highest expected emission state under normal operating conditions.
⁽²⁾ If measurements are continuous, the following generic EN standards apply: EN 15267-1, EN 15267-2, EN 15267-3, and EN 14181.
⁽³⁾ If measurements are continuous, EN 13284-2 also applies.
⁽⁴⁾ If the emission levels are proven to be sufficiently stable, a lower monitoring frequency can be adopted but in any case at least once every 3 years.
⁽⁵⁾ The monitoring does not apply if only natural gas is used as a fuel.

[This BAT conclusion is based on information given in Section 8.2.3]

BAT 5. 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 | | Specific process(es) (¹) | Standard(s) | Minimum monitoring frequency (²) (³) | Monitoring associated with |
|--|---|---|--|---|----------------------------|
| Total suspended solids (TSS) (⁴) | | All processes | EN 872 | Once every week | BAT 28 |
| Total organic carbon (TOC) (⁴) (⁵) | | All processes | EN 1484 | Once every month | |
| Chemical oxygen demand (COD) (⁴) (⁵) | | All processes | No EN standard available | | |
| Hydrocarbon oil index (HOI) (⁶) | | All processes | EN ISO 9377-2 | Once every month | |
| Metals/ elements (⁶) | Boron | Processes where borax is used | Various EN standards available (e.g. EN ISO 11885, EN ISO 17294-2) | Once every month | |
| | Cadmium | All processes | Various EN standards available (e.g. EN ISO 11885, EN ISO 15586, EN ISO 17294-2) | Once every month | |
| | Chromium | All processes | | | |
| | Iron | All processes | | | |
| | Nickel | All processes | | | |
| | Lead | All processes | | | |
| | Tin | Coating with tin | | | |
| | Zinc | All processes | | | |
| | Mercury | All processes | Various EN standards available (e.g. EN ISO 12846, EN ISO 17852) | | |
| Hexavalent chromium | Pickling of high-alloy steel and passivation with hexavalent chromium compounds | Various EN standards available (e.g. EN ISO | | | |

| | | | |
|---|--------------------------|--|------------------|
| | | 10304-3, EN ISO 23913) | |
| Total phosphorus (Total P) ⁽⁴⁾ | Phosphating | Various EN standards available (e.g. EN ISO 6878, EN ISO 11885, EN ISO 15681-1 and -2) | Once every month |
| Fluoride (F) ⁽⁶⁾ | Pickling with mixed acid | EN ISO 10304-1 | Once every month |

⁽¹⁾ For batch galvanising, the monitoring only applies if waste water is discharged.
⁽²⁾ Monitoring frequencies may be reduced if the emission levels are proven to be sufficiently stable.
⁽³⁾ In the case of batch discharge less frequent than the minimum monitoring frequency, monitoring is carried out once per batch.
⁽⁴⁾ The monitoring applies only in the case of a direct discharge to a receiving water body.
⁽⁵⁾ Either COD or TOC is monitored. TOC monitoring is the preferred option because it does not rely on the use of very toxic compounds.
⁽⁶⁾ In the case of an indirect discharge to a receiving water body, the monitoring frequency may be reduced if the downstream waste water treatment plant is designed and equipped appropriately to abate the pollutants concerned.

[This BAT conclusion is based on information given in Section 8.2.2]

9.1.3 General environmental performance

BAT 6. In order to prevent or reduce the environmental risk associated with the storage and handling of liquids, BAT is to use all of the techniques given below.

| Technique | Description | Applicability |
|--|---|--|
| a Set-up and implementation of a plan for the prevention and control of leaks and spillages | <p>A plan for the prevention and control of leaks and spillages is part of the EMS (see BAT 1) and includes, but is not limited to:</p> <ul style="list-style-type: none"> – site incident plans for small and large spillages; – identification of the roles and responsibilities of persons involved; – ensuring staff are environmentally aware and trained to prevent/deal with spillage incidents; – identification of areas at risk of spillage and/or leaks of hazardous materials and ranking them according to the risk; – identification of suitable spillage containment and clean-up equipment and regularly ensuring it is available, in good working order and close to points where these incidents may occur; – waste management guidelines for dealing with waste arising from spillage control; – regular (at least on an annual basis) inspections of storage and handling areas, testing and calibration of leak detection equipment and prompt repair of leaks from valves, glands, flanges, etc. | The level of detail of the plan will generally be related to the nature, scale and complexity of the plant, as well as to the type and quantity of liquids used. |
| b Use of oil-tight trays or cellars | Hydraulic stations and oil- or grease-lubricated equipment are situated in oil-tight trays or cellars. | Generally applicable. |
| c Prevention and handling of acid spillages | Storage tanks for both fresh and spent acid are equipped with sealed secondary containment protected with an acid-resistant coating which is | Generally applicable. |

| | | | |
|--|--|--|--|
| | | regularly controlled for potential damage and cracks. Loading and unloading areas for the acids are designed in such a way that any potential leak is sent directly to treatment (see BAT 28). | |
|--|--|--|--|

[This BAT conclusion is based on information given in Sections 8.3.1, 8.3.2 and 8.3.3]

BAT 7. 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:

- 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 a preventive maintenance plan for critical equipment (see BAT 1 xii);
- monitoring 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.

[This BAT conclusion is based on information given in Section 8.3.5]

9.1.4 Hazardous substances

BAT 8. In order to avoid the use of hexavalent chromium compounds in passivation, BAT is to use chromium (III) solutions or chromium-free solutions including other metal-containing solutions (e.g. containing manganese, zinc, titanium fluoride, phosphates and/or molybdates) or organic polymer solutions (e.g. containing polyurethanes or polyesters).

Applicability

Applicability may be restricted due to product quality requirements or specifications.

[This BAT conclusion is based on information given in Section 8.4.1]

9.1.5 Energy efficiency

BAT 9. In order to increase energy efficiency, BAT is to use both of the techniques given below.

| Technique | Description | Applicability |
|--------------------------|---|--|
| a Energy efficiency plan | An energy efficiency plan is part of the EMS (see BAT 1) and entails defining and monitoring the specific energy consumption of the activity/processes (see BAT 3), setting key performance indicators on an annual basis (e.g. MJ/t of product) and planning the periodic improvement targets and related actions. The plan is adapted to the specificities of the plant in terms of process(es) carried out, materials, products, etc. | |
| b Energy balance record | Drawing up on an annual basis of an energy balance record which provides a breakdown of the energy consumption and generation (including energy export) by the type of energy source (e.g. electricity, natural gas, iron and steel process gases, renewable energy, imported heat and/or cooling). This includes: (i) defining the energy boundary of the processes; (ii) information on energy consumption in terms of delivered energy; (iii) information on energy exported from the plant; (iv) energy flow information (e.g. Sankey diagrams or energy balances) showing how the energy is used throughout the processes. The energy balance record is adapted to the specificities of the plant in terms of processes carried out, materials, products etc. | The level of detail of the energy efficiency plan and of the energy balance record will generally be related to the nature, scale and complexity of the plant and the energy types used. |

[This BAT conclusion is based on information given in Sections 8.5.1 and 8.5.2]

BAT 10. In order to increase energy efficiency in heating (including heating and drying of feedstock as well as heating of kettles and baths), BAT is to use a combination of the techniques given below.

| Technique | Description | Applicability |
|------------------------------------|-------------|---------------|
| <i>Design and operation</i> | | |

| | | | |
|--------------------------------------|---|--|---|
| a | Optimum furnace design for feedstock heating | <p>This includes techniques such as:</p> <ul style="list-style-type: none"> – Optimisation of key furnace characteristics (e.g. number and type of burners, airtightness and furnace insulation using suitable refractory materials). – Minimisation of heat losses from furnace door openings, e.g. by using several liftable segments instead of one in continuous reheating furnaces. – Minimisation of the number of feedstock supporting structures inside the furnace (e.g. beams, skids) and the use of suitable insulation to reduce the heat losses from water cooling of the structures in continuous reheating furnaces. | Only applicable to new plants and major plant upgrades. |
| b | Optimum galvanising kettle and furnace design | <p>This includes techniques such as:</p> <ul style="list-style-type: none"> – Uniform heating of the galvanising kettle walls (e.g. by using high-velocity burners or radiant design). – Minimisation of heat losses from the furnace using insulated outer walls (e.g. ceramic lining). – Minimisation of heat losses from the galvanising kettle using enclosures. | Only applicable to new plants and major plant upgrades. |
| c | Combustion optimisation | See Section 9.7.1. | Generally applicable. |
| d | Furnace automation and control | See Section 9.7.1. | Generally applicable. |
| e | Process gas management system | See Section 9.7.1. The calorific value of the iron and steel process gases is used. | Only applicable to plants adjacent to iron and steel production. |
| f | Batch annealing with 100 % hydrogen | Batch annealing is carried out in furnaces using 100 % hydrogen as protective gas with increased thermal conductivity. | Generally applicable. |
| Heat recovery from flue-gases | | | |
| g | Feedstock preheating | Feedstock is preheated by blowing hot flue-gases directly onto the slabs. | Only applicable to continuous reheating furnaces. |
| h | Feedstock drying | The heat from flue-gases is used to dry the feedstock, e.g. after fluxing. | Generally applicable. |
| i | Heating of baths | The heat from flue-gases is used to heat baths (e.g. for fluxing and pickling). | Generally applicable. |
| j | Preheating of combustion air | See Section 9.7.1. This may be achieved for example by using regenerative or recuperative burners. | Generally applicable within the constraints related to the need to control NOX emissions. |
| k | Waste heat recovery boiler | The heat from hot flue-gases is used to generate steam that is used in other processes, for district heating or for generating electricity. | Applicability to existing plants may be restricted by a lack of space. |
| l | Organic Rankine Cycle (ORC) system | Low-grade heat is converted into electricity using high-molecular-weight fluids. | Generally applicable. |

[This BAT conclusion is based on information given in Sections 8.5.3.1, to 8.5.3.6 and Sections 8.5.4.1 to 8.5.4.6]

Further sector-specific techniques to increase energy efficiency are given in Sections 9.2.1, 9.3.1 and 9.4.1 of these BAT conclusions.

9.1.6 Material efficiency

BAT 11. In order to increase material efficiency in degreasing and to reduce the generation of spent degreasing solution, BAT is to use a combination of the techniques given below.

| Technique | | Description | Applicability |
|--|--|--|---|
| <i>Avoiding or reducing the need for degreasing</i> | | | |
| a | Use of feedstock with low oil and grease contamination | The use of feedstock with low oil and grease contamination prolongs the lifetime of the degreasing solution. | Not applicable if the feedstock quality cannot be controlled. |
| b | Use of a direct-flame furnace in the case of hot dip coating of sheets | The oil on the surface of the sheet is burnt in a direct-flame furnace. Degreasing before the furnace may be needed for some high-quality products or in the case of sheets with high residual oil levels. | Only applicable to new plants and major plant upgrades. |
| <i>Degreasing optimisation</i> | | | |
| c | General techniques for increased degreasing efficiency | These include techniques such as: <ul style="list-style-type: none"> – monitoring and optimising the temperature and the concentration of degreasing agents in the solution; – enhancing the interaction of the degreasing solution with the feedstock (e.g. by moving the feedstock, agitating the degreasing solution or by using ultrasound to create cavitation of the solution on the surface to be degreased). | Generally applicable. |
| d | Minimisation of carry-over of degreasing solution | This includes techniques such as: <ul style="list-style-type: none"> – using squeeze rolls; – slow lifting of workpieces to allow for a sufficient dripping time. | Generally applicable. |
| e | Reverse cascade degreasing in the case of continuous degreasing | Degreasing is carried out in two or more steps in series where the flow of degreasing solution is countercurrent to the feedstock flow. | Generally applicable. |
| f | Cleaning and reuse of the degreasing solution | Physical treatment (e.g. magnetic separation, oil separation, micro- or ultrafiltration) or biological treatment is used to clean the degreasing solution for reuse. | Generally applicable. |

[This BAT conclusion is based on information given in Sections 8.6.1.1 to 8.6.1.6]

BAT 12. In order to increase material efficiency in pickling and to reduce the generation of spent pickling acid, BAT is to avoid the direct injection of steam to heat the pickling acid by using one of the techniques given below.

| Technique | | Description |
|-----------|--------------------------------------|--|
| a | Acid heating with heat exchangers | Corrosion-resistant heat exchangers are immersed in the pickling acid for indirect heating with steam. |
| b | Acid heating by submerged combustion | Combustion gases pass through the pickling acid, releasing the energy via direct heat transfer. |

[This BAT conclusion is based on information given in Sections 8.6.2.1 and 8.6.2.2]

BAT 13. In order to increase material efficiency in pickling and to reduce the generation of spent pickling acid, BAT is to use a combination of the techniques given below.

| Technique | | Description | Applicability |
|---|--|--|--|
| Avoiding or reducing the need for pickling | | | |
| a | Minimisation of steel corrosion | This includes techniques such as: <ul style="list-style-type: none"> – cooling the hot rolled steel as fast as possible depending on product quality requirements or specifications; – storing the feedstock in roofed areas; – limiting the storage duration of the feedstock. | Generally applicable. |
| b | Mechanical (pre)descaling | This includes techniques such as: <ul style="list-style-type: none"> – shot blasting; – bending; – sanding; – brushing; – stretching and levelling. | Applicability to existing plants may be limited by a lack of space. Applicability may be restricted due to product quality requirements or specifications. |
| c | Electrolytic prepickling for high-alloy steel | Use of an aqueous solution of sodium sulphate (Na_2SO_4) to pretreat high-alloy steel before pickling with mixed acid, in order to speed up and improve the removal of the surface oxide scale. The waste water containing hexavalent chromium is treated using technique BAT 28 (f). | Only applicable to cold rolling. Applicability to existing plants may be limited by a lack of space. |
| Pickling optimisation | | | |
| d | Rinsing after degreasing | Carry-over of degreasing solution to the pickling solution is reduced by rinsing feedstock after degreasing. | Applicability to existing plants may be restricted by a lack of space. |
| e | General techniques for increased pickling efficiency | These include techniques such as: <ul style="list-style-type: none"> – optimisation of pickling temperature for maximising pickling rates while minimising emissions of acids; – optimisation of the pickling bath composition (e.g. acid and iron concentrations); – optimisation of the pickling time to avoid over-pickling; – avoiding drastic changes in the pickling bath composition by frequently replenishing it with fresh acid. | Generally applicable. |

| | | | |
|---|---|--|--|
| f | Cleaning and reuse of pickling acid | A cleaning circuit, e.g. with filtration, is used to clean the pickling acid for reuse. | Generally applicable. |
| g | Reverse cascade pickling | Pickling is carried out in two or more baths in series where the pickling acid flow is countercurrent to the feedstock flow. | Applicability to existing plants may be limited by a lack of space. |
| h | Minimisation of carry-over of pickling acid | This includes techniques such as: – using squeeze rolls; – slow lifting of workpieces to allow for a sufficient dripping time; – vibrating wire rod coils. | Generally applicable. |
| i | Turbulence pickling | This includes techniques such as: – injection of the pickling acid at high pressure via nozzles; – agitation of the pickling acid using an immersed turbine. | Generally applicable. |
| j | Use of pickling inhibitors | Pickling inhibitors are added to the pickling acid to protect metallurgically clean parts of the feedstock from over-pickling. | Not applicable to high-alloy steel. Applicability may be restricted due to product quality requirements or specifications. |
| k | Activated pickling with hydrochloric acid | Pickling is carried out with a low hydrochloric acid concentration (i.e. around 4–6 wt-%), a high iron concentration (i.e. around 120–180 g/l), at temperatures of 20–25 °C. | Generally applicable. |

[This BAT conclusion is based on information given in Sections 8.6.2.3 to 8.6.2.12]

Table 9.1: BAT-associated environmental performance levels (BAT-AEPLs) for specific pickling acid consumption

| Pickling acid | Sector | Unit | BAT-AEPL (Yearly average) |
|----------------------------|-------------------|-------------------|---------------------------|
| Hydrochloric acid, 33 wt-% | Hot rolling | kg/m ² | 0.005–0.03 |
| | Cold rolling | kg/m ² | 0.05–0.5 |
| | Wire drawing | kg/m ² | 0.03–0.06 |
| | Hot dip coating | kg/m ² | 0.02–0.09 |
| | Batch galvanising | kg/t | 10–30 |
| Sulphuric acid, 96 wt-% | Hot rolling | kg/m ² | 0.02–0.2 |
| | Cold rolling | kg/m ² | 0.1–0.75 |
| Nitric acid, 70 wt-% | Hot rolling | kg/m ² | 0.25–2.6 |
| | Cold rolling | kg/m ² | 0.4–1.6 |
| Hydrofluoric acid, 49 wt-% | Hot rolling | kg/m ² | 0.2–1.6 |
| | Cold rolling | kg/m ² | 0.2–0.6 |

The associated monitoring is given in BAT 3.

BAT 14. In order to increase material efficiency in fluxing and to reduce the quantity of spent fluxing solution sent for disposal, BAT is use both of the techniques (a) and (b), in combination with technique (c) or in combination with technique (d) given below.

| Technique | | Description | Applicability |
|-----------|--|---|--|
| a | Rinsing of workpieces after pickling | Carry-over of iron to the fluxing solution is reduced by rinsing workpieces after pickling. | Applicability to existing plants may be restricted by a lack of space. |
| b | Monitoring and adjustment of the chemical composition of the fluxing solution | The chemical composition of the fluxing solution is monitored frequently. Fluxing agents (e.g. ZnCl_2 , NH_4Cl) and water are added on a regular basis to maintain the quality of the fluxing solution. | Generally applicable. |
| c | Iron removal and reuse of the fluxing solution | Iron is removed from the fluxing solution by: <ul style="list-style-type: none"> - electrolytic oxidation; - oxidation using air or H_2O_2; - ion exchange. After iron removal, the fluxing solution is reused. | Generally applicable. |
| d | Recovery of salts from the spent fluxing solution for production of fluxing agents | Spent fluxing solution is used to recover the salts contained therein to produce fluxing agents. | Generally applicable. |

[This BAT conclusion is based on information given in Sections 8.6.3.1 to 8.6.3.4]

BAT 15. In order to increase the material efficiency of hot dipping in the coating of wires and in batch galvanising, and to reduce the generation of waste, BAT is to use both of the techniques given below.

| Technique | | Description |
|-----------|---|--|
| a | Reduction of the generation of hard zinc | The generation of hard zinc is reduced by sufficient rinsing after pickling (see BAT 14 (a)), continuously removing the iron from the fluxing solution (see BAT 14(c)), using fluxing agents with a mild pickling effect and avoiding local overheating in the galvanising kettle. |
| b | Prevention, collection and reuse of zinc splashes | The generation of zinc splashes from the galvanising kettle is reduced by minimising carry-over of the fluxing solution (see BAT 24 (b)). Zinc splashes out of the kettle are collected and reused. The area surrounding the kettle is kept clean to reduce contamination of the splashes. |

[This BAT conclusion is based on information given in Sections 8.6.4.1 and 8.6.4.2]

BAT 16. In order to increase material efficiency and to reduce the quantity of spent pickling acids sent for disposal, BAT is to recover spent pickling acids. The neutralisation of spent pickling acids or the use of spent pickling acids for emulsion splitting is not BAT.

Description

Techniques to recover spent pickling acids include:

- spray roasting or using fluidised bed reactors for the recovery of hydrochloric acid;
- crystallisation of ferric sulphate for the recovery of sulphuric acid;
- spray roasting, evaporation, ion exchange or diffusion dialysis, for the recovery of mixed acid;

- use of spent pickling acid as a secondary raw material (e.g. for the production of iron chloride or pigments).

[This BAT conclusion is based on information given in Section 8.6.5]

Further sector-specific techniques to increase material efficiency are given in Sections 9.2.2, 9.3.2, 9.4.2, 9.5.2 and 9.6.2 of these BAT conclusions.

9.1.7 Water use and waste water generation

BAT 17. In order to optimise water consumption and to reduce the volume of waste water generated, BAT is to use all of the techniques given below.

| Technique | | Description | Applicability |
|-----------|--|---|--|
| a | Water management plan and water audits | A water management plan and water audits are part of the EMS (see BAT 1) and include: <ul style="list-style-type: none"> – 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, water recycling, detection and repair of leaks). Water audits are carried out at least annually. | The level of detail of the water management plan and water audits will generally be related to the nature, scale and complexity of the plant. Not applicable to batch galvanising. |
| b | Segregation of water streams | Each water stream (e.g. surface run-off water, process water) is collected and treated separately, based on the pollutant content and on the required treatment techniques. In particular, uncontaminated waste water streams are segregated from waste water streams that require treatment. | Applicability to existing plants may be limited by the layout of the water collection system. Not applicable to batch galvanising. |
| c | Minimisation of hydrocarbon contamination of process water | The contamination of process water by oil and lubricant losses is minimised by using techniques such as: <ul style="list-style-type: none"> – oil-tight bearings and bearing seals for working rolls; – leakage indicators; – regular inspections and preventive maintenance of pump seals, piping and working rolls. | Generally applicable. |
| d | Adequate drainage infrastructure | The process areas are connected to drainage infrastructure. Contaminated process water is collected in the drainage infrastructure along with washing water and occasional spillages and sent to treatment (see BAT 27 and BAT 28). | Applicability to existing plants may be limited by the layout of the water collection system. |
| e | Reuse and/or recycling of water | Water streams (e.g. effluents from wet scrubbing or quench baths) are reused and/or recycled, if necessary after treatment (see BAT 27 and BAT 28). The degree of water reuse and/or recycling is limited by the water balance of the plant, the content of impurities and/or the characteristics of the water streams. | Generally applicable. |
| f | Reverse cascade rinsing | Rinsing is carried out in two or more baths in series where the flow of the rinsing water is countercurrent to the feedstock flow. | Applicability to existing plants may be limited by a lack of space. |
| g | Recycling of rinsing water | After pickling or degreasing, rinsing water is recycled to the preceding process baths as | Generally applicable. |

| | | | |
|---|--|--|-----------------------|
| | | make-up water or, if appropriate, for acid recovery. | |
| h | Treatment and reuse of oil- and scale-bearing process water in hot rolling | Oil- and scale- bearing waste water from hot rolling mills is treated separately using a sequence of cleaning steps including scale pits, settling tanks, cyclones and filtration to separate oil and scale and to reuse a large proportion of the treated water in the process. | Generally applicable. |

Table 9.2: BAT-associated environmental performance levels (BAT-AEPLs) for specific water consumption

| Sector | Unit | BAT-AEPL (Yearly average) |
|-----------------|-------------------|------------------------------|
| Hot rolling | m ³ /t | 1–5 |
| Cold rolling | m ³ /t | 2–10 |
| Wire drawing | m ³ /t | 5–20 |
| Hot dip coating | m ³ /t | 2–10 |

Table 9.3: BAT-associated environmental performance level (BAT-AEPL) for specific waste water discharge

| Sector | Unit | BAT-AEPL (Yearly average) |
|-------------------|-------------------|------------------------------|
| Batch galvanising | m ³ /t | 0 ⁽¹⁾ |

⁽¹⁾ In batch galvanising, no waste water is generated by the processes.

The associated monitoring is given in BAT 3.

[This BAT conclusion is based on information given in Sections 8.7.1 to 8.7.8]

Further sector-specific techniques to optimise water consumption and to reduce the volume of waste water generated are given in Section 9.2.3 of these BAT conclusions.

9.1.8 Emissions to air

9.1.8.1 Emissions to air from heating

BAT 18. In order to reduce dust emissions to air from heating, BAT is to use a fuel or a combination of fuels with low dust or ash content.

Description

Fuels with low dust and ash content include natural gas, liquefied petroleum gas, dedusted blast furnace gas and dedusted basic oxygen furnace gas.

Applicability

Applicable within the constraints associated with the availability of different types of fuel, which may be impacted by the energy policy of the Member State.

Table 9.4: BAT-associated emission levels (BAT-AELs) for channelled dust emissions to air from feedstock heating

| Parameter | Sector | Unit | BAT-AEL (Daily average or average over the sampling period) |
|-----------|-----------------|--------------------|--|
| Dust | Hot rolling | mg/Nm ³ | < 2–10 |
| | Cold rolling | | < 2–5 |
| | Wire drawing | | < 2–10 |
| | Hot dip coating | | < 2–10 |

The associated monitoring is given in BAT 4.

[This BAT conclusion is based on information given in Sections 8.8.2.1 and 2.4.2.1]

BAT 19. In order to reduce SO₂ emissions to air from heating, BAT is to use a fuel or a combination of fuels with low sulphur content.

Description

Fuels with low sulphur content include natural gas, liquefied petroleum gas, blast furnace gas, basic oxygen furnace gas and desulphurised coke oven gas.

Applicability

Applicable within the constraints associated with the availability of different types of fuel, which may be impacted by the energy policy of the Member State.

Table 9.5: BAT-associated emission levels (BAT-AELs) for channelled SO₂ emissions to air from feedstock heating

| Parameter | Sector | Unit | BAT-AEL (Daily average or average over the sampling period) |
|-----------------|---|--------------------|--|
| SO ₂ | Hot rolling | mg/Nm ³ | 50–200 ⁽¹⁾ ⁽²⁾ |
| | Cold rolling, wire drawing, hot dip coating of sheets | | 20–100 ⁽¹⁾ |

⁽¹⁾ The BAT-AEL does not apply to plants using 100 % natural gas or 100 % electrical heating.
⁽²⁾ The higher end of the BAT-AEL range may be exceeded when using a high share of coke oven gas (e.g. > 50 %). In this case, the higher end of the BAT-AEL range is 300 mg/Nm³.

The associated monitoring is given in BAT 4.

[This BAT conclusion is based on information given in Sections 8.8.2.2 and 2.4.2.1]

BAT 20. In order to reduce NOX emissions to air from heating while limiting CO emissions, BAT is to use a combination of the techniques given below.

| Technique | | Description | Applicability |
|---|---|---|--|
| Reduction of generation of emissions | | | |
| a | Use of a fuel or a combination of fuels with low nitrogen content | Fuels with low nitrogen content include natural gas, liquefied petroleum gas, blast furnace gas and basic oxygen furnace gas. | Applicable within the constraints associated with the availability of different types of fuel, which may be impacted by the energy policy of the Member State. |
| b | Furnace automation and control | See Section 9.7.2. | Generally applicable. |

| | | | |
|----------------------------|--|--|--|
| c | Combustion optimisation | See Section 9.7.2. Generally used in combination with other techniques. | Generally applicable. |
| d | Low-NOX burners | See Section 9.7.2. | Generally applicable. |
| e | Flue-gas recirculation | See Section 9.7.2. | Generally applicable. |
| f | Limiting the temperature of air preheating | See Section 9.7.2. | Generally applicable. |
| g | Flameless combustion | See Section 9.7.2. | Applicability to existing plants may be limited by a lack of space. Not applicable to furnaces operating at a temperature lower than the auto-ignition temperature required for flameless combustion. |
| h | Oxy-fuel combustion | See Section 9.7.2. | Generally applicable. |
| Waste gas treatment | | | |
| i | Selective catalytic reduction (SCR) | See Section 9.7.2. | Applicability to existing plants may be limited by a lack of space. |
| j | Selective non-catalytic reduction (SNCR) | See Section 9.7.2. | Generally applicable. |

Table 9.6: BAT-associated emission levels (BAT-AELs) for channelled NOX emissions to air and indicative emission levels for channelled CO emissions to air from feedstock heating in hot rolling

| Parameter | Type of fuel | Specific process | Unit | BAT-AEL (Daily average or average over the sampling period) | Indicative emission level (Daily average or average over the sampling period) |
|-----------|-------------------|---|--------------------|--|--|
| NOX | 100 % natural gas | Reheating | mg/Nm ³ | 100–300 | No indicative level |
| | | Intermediate heating | mg/Nm ³ | 100–250 | |
| | | Post-heating | mg/Nm ³ | 100–200 | |
| | Other fuels | Reheating, intermediate heating, post-heating | mg/Nm ³ | 100–350 ⁽¹⁾ | |
| CO | 100 % natural gas | Reheating | mg/Nm ³ | No BAT-AEL | 10–50 |
| | | Intermediate heating | mg/Nm ³ | | 10–100 |
| | | Post-heating | mg/Nm ³ | | 10–100 |
| | Other fuels | Reheating, intermediate heating, post-heating | mg/Nm ³ | | 10–50 |

⁽¹⁾ The higher end of the BAT-AEL range may be exceeded when using a high share of coke oven gas (e.g. > 50 %). In this case, the higher end of the BAT-AEL range is 550 mg/Nm³.

Table 9.7: BAT-associated emission levels (BAT-AELs) for channelled NOX emissions to air and indicative emission levels for channelled CO emissions to air from feedstock heating in cold rolling

| Parameter | Type of fuel | Unit | BAT-AEL (Daily average or average over the sampling period) | Indicative emission level (Daily average or average over the sampling period) |
|-----------|-------------------|--------------------|--|--|
| NOX | 100 % natural gas | mg/Nm ³ | 100–250 | No indicative level |
| | Other fuels | mg/Nm ³ | 100–300 | |
| CO | 100 % natural gas | mg/Nm ³ | No BAT-AEL | 10–50 |
| | Other fuels | mg/Nm ³ | | 10–100 |

Table 9.8: BAT-associated emission level (BAT-AEL) for channelled NOX emissions to air and indicative emission level for channelled CO emissions to air from feedstock heating in wire drawing

| Parameter | Unit | BAT-AEL (Daily average or average over the sampling period) | Indicative emission level (Daily average or average over the sampling period) |
|-----------|--------------------|--|--|
| NOX | mg/Nm ³ | 10–120 | No indicative level |
| CO | mg/Nm ³ | No BAT-AEL | 10–100 |

Table 9.9: BAT-associated emission level (BAT-AEL) for channelled NOX emissions to air and indicative emission level for channelled CO emissions to air from feedstock heating in hot dip coating

| Parameter | Unit | BAT-AEL (Daily average or average over the sampling period) | Indicative emission level (Daily average or average over the sampling period) |
|-----------|--------------------|--|--|
| NOX | mg/Nm ³ | 100–250 | No indicative level |
| CO | mg/Nm ³ | No BAT-AEL | 10–100 |

Table 9.10: BAT-associated emission level (BAT-AEL) for channelled NOX emissions to air and indicative emission level for channelled CO emissions to air from heating the galvanising kettle and from feedstock drying

| Parameter | Unit | BAT-AEL (Daily average or average over the sampling period) | Indicative emission level (Daily average or average over the sampling period) |
|-----------|--------------------|--|--|
| NOX | mg/Nm ³ | 70–150 | No indicative level |
| CO | mg/Nm ³ | No BAT-AEL | 10–100 |

The associated monitoring is given in BAT 4.

[This BAT conclusion is based on information given in Sections 8.8.2.3, 2.4.2.1, 8.5.3.3, 8.5.3.2, 8.8.2.6, 8.8.2.7, 8.8.2.8, 2.4.2.5, 2.4.2.6, 8.8.1.4 and 8.8.1.5]

9.1.8.2 Emissions to air from degreasing

BAT 21. In order to reduce emissions to air of oil mist, acids and/or alkalis from degreasing, BAT is to collect emissions by using technique (a) or technique (b), and to treat the waste gas by using technique (c) given below.

| Technique | | Description |
|--------------------------------|---|---|
| Collection of emissions | | |
| a | Air extraction as close as possible to the source in the case of batch degreasing | Air from the degreasing tanks is extracted, for example using lateral hood or lip extraction, or the tanks are located in enclosed areas equipped with roof or wall extraction. |
| b | Closed degreasing tanks combined with air extraction in the case of continuous degreasing | Degreasing is carried out in closed tanks and air is extracted. |
| Waste gas treatment | | |
| c | Wet scrubbing followed by a demister | See Section 9.7.2. |

Table 9.11: BAT-associated emission level (BAT-AEL) for channelled TVOC emissions to air from degreasing

| Parameter | Unit | BAT-AEL (Daily average or average over the sampling period) |
|-----------|--------------------|--|
| TVOC | mg/Nm ³ | < 3–10 |

The associated monitoring is given in BAT 4.

[This BAT conclusion is based on information given in Sections 8.8.3.1, 8.8.1.1 and 8.8.1.6]

9.1.8.3 Emissions to air from pickling

BAT 22. In order to reduce emissions to air of dust, acids (HCl, HF, H₂SO₄) and SO₂ from pickling, BAT is to use technique (a), or to use technique (b) in combination with technique (d), or to use technique (c) in combination with technique (d) given below.

| Technique | | Description |
|---|---|---|
| Reduction of generation of emissions | | |
| a | Restricted operating range in the case of batch pickling using hydrochloric acid | The pickling acid temperature and HCl concentration in the pickling bath(s) are strictly controlled so that both of the following conditions are met: a) $4\text{ }^{\circ}\text{C} < T < (80 - 4w)\text{ }^{\circ}\text{C}$; b) $2\text{ wt-\%} < w < (20 - T/4)\text{ wt-\%}$. where T is the pickling acid temperature expressed in $^{\circ}\text{C}$ and w the HCl concentration expressed in wt-%. |
| Collection of emissions | | |
| b | Air extraction as close as possible to the source in the case of batch pickling | Air from the pickling tanks is extracted, for example using lateral hood or lip extraction, or the tanks are located in enclosed areas equipped with roof or wall extraction. |
| c | Closed pickling tanks combined with air extraction in the case of continuous pickling | Pickling is carried out in closed tanks and air is extracted. |
| Waste gas treatment | | |
| d | Wet scrubbing followed by a demister | See Section 9.7.2. |

Table 9.12: BAT-associated emission levels (BAT-AELs) for channelled emissions of dust, HCl, HF and SO_x to air from pickling in hot rolling, cold rolling and hot dip coating

| Parameter | Unit | BAT-AEL (Daily average or average over the sampling period) |
|---|--------------------|--|
| Dust | mg/Nm ³ | < 2–6 ⁽¹⁾ |
| HCl | mg/Nm ³ | < 2–8 ⁽¹⁾ ⁽²⁾ |
| HF | mg/Nm ³ | < 1 ⁽³⁾ |
| SO _x | mg/Nm ³ | < 1–3 ⁽⁴⁾ |
| ⁽¹⁾ The BAT-AEL does not apply when technique (a) is used. ⁽²⁾ This BAT-AEL only applies to pickling with hydrochloric acid. ⁽³⁾ This BAT-AEL only applies to pickling with mixed acid. ⁽⁴⁾ This BAT-AEL only applies to pickling with sulphuric acid. | | |

Table 9.13: BAT-associated emission level (BAT-AEL) for channelled HCl emissions to air from pickling with hydrochloric acid in wire drawing

| Parameter | Unit | BAT-AEL (Daily average or average over the sampling period) |
|---|--------------------|--|
| HCl | mg/Nm ³ | < 2–10 ⁽¹⁾ |
| ⁽¹⁾ The BAT-AEL does not apply when technique (a) is used. | | |

Table 9.14: BAT-associated emission level (BAT-AEL) for channelled HCl emissions to air from pickling and stripping with hydrochloric acid in batch galvanising

| Parameter | Unit | BAT-AEL (Daily average or average over the sampling period) |
|---|--------------------|--|
| HCl | mg/Nm ³ | < 2–5 ⁽¹⁾ |
| ⁽¹⁾ The BAT-AEL does not apply when technique (a) is used. | | |

The associated monitoring is given in BAT 4.

[This BAT conclusion is based on information given in Sections 8.8.4.1 to 8.8.4.4]

BAT 23. In order to reduce NO_x emissions to air from pickling with mixed acid, BAT is to use one or a combination of the techniques given below.

| Technique | Description | Applicability |
|--|---|---|
| Reduction of generation of emissions | | |
| a Nitric-acid-free pickling of high-alloy steel | Pickling of high-alloy steel is carried out by fully substituting nitric acid with a strong oxidising agent (e.g. hydrogen peroxide). | Only applicable to new plants and major plant upgrades. |
| b Addition of hydrogen peroxide or urea to the pickling acid | Hydrogen peroxide or urea is added directly to the pickling acid to reduce NO _x emissions. | Generally applicable. |
| Waste gas treatment | | |
| c Wet scrubbing with addition of an oxidising agent (e.g. hydrogen peroxide) | See Section 9.7.2. An oxidising agent (e.g. hydrogen peroxide) is added to the scrubbing solution to reduce NO _x emissions. When using hydrogen peroxide, the nitric acid formed can be recycled to the pickling tanks. | Generally applicable. |
| d Selective catalytic reduction (SCR) | See Section 9.7.2. | Only applicable to new plants and major plant upgrades. |

Table 9.15: BAT-associated emission level (BAT-AEL) for channelled NOX emissions to air from pickling with mixed acid

| Parameter | Unit | BAT-AEL (Daily average or average over the sampling period) |
|-----------|--------------------|--|
| NOX | mg/Nm ³ | 10–200 |

The associated monitoring is given in BAT 4.

[This BAT conclusion is based on information given in Sections 8.8.5.1 to 8.8.5.4 and Section 8.8.1.4]

9.1.8.4 Emissions to air from hot dipping

BAT 24. In order to reduce emissions to air of dust and zinc from hot dipping in hot dip coating of wires and in batch galvanising, BAT is to use both of the techniques (a) and (b), together with one of the techniques (c) or (d), and in combination with one of the techniques (e) or (f) given below.

| Technique | | Description |
|---|--|--|
| Reduction of generation of emissions | | |
| a | Smoke-reducing fluxing agent | Ammonium chloride in fluxing agents is partly substituted with other alkali chlorides (e.g. potassium chloride) to reduce smoke formation. |
| b | Minimisation of carry-over of the fluxing solution | The carry-over of the fluxing solution to the hot dipping bath is minimised by allowing enough time for the fluxing solution to drip off, and/or by drying. |
| Collection of emissions | | |
| c | Air extraction as close as possible to the source | Air from the kettles is extracted, for example using lateral hood or lip extraction, or the kettles are located in enclosed areas equipped with roof or wall extraction. |
| d | Closed kettles combined with air extraction | Hot dipping is carried out in closed kettles and air is extracted. |
| Waste gas treatment | | |
| e | Wet scrubbing | See Section 9.7.2. |
| f | Fabric filter | See Section 9.7.2. |

Table 9.16: BAT-associated emission level (BAT-AEL) for channelled dust emissions to air from hot dipping in hot dip coating of wires and in batch galvanising

| Parameter | Unit | BAT-AEL (Daily average or average over the sampling period) |
|-----------|--------------------|--|
| Dust | mg/Nm ³ | < 2–5 |

The associated monitoring is given in BAT 4.

[This BAT conclusion is based on information given in Sections 8.8.6.1 to 8.8.6.4 and in Sections 8.8.1.3 and 8.8.1.6]

9.1.8.5 Emissions to air from oiling

BAT 25. In order to reduce oil mist emissions to air from oiling, BAT is to use all of the techniques given below.

| Technique | | Description |
|---|--|---|
| Reduction of generation of emissions | | |
| a | Electrostatic oiling | Oil is sprayed on the metal surface through an electrostatic field, which ensures homogeneous oil application and optimises the quantity of oil applied. |
| Collection of emissions | | |
| b | Enclosed oiling machine combined with air extraction | The entire oiling machine is enclosed in order to avoid dispersion of oil mist and air is extracted. The oil which does not deposit on the metal surface is recovered and reused. |
| Waste gas treatment | | |
| c | Demister | See Section 9.7.2. |

Table 9.17: BAT-associated emission level (BAT-AEL) for channelled TVOC emissions to air from oiling

| Parameter | Unit | BAT-AEL (Daily average or average over the sampling period) |
|-----------|--------------------|--|
| TVOC | mg/Nm ³ | < 3–10 |

The associated monitoring is given in BAT 4.

[This BAT conclusion is based on information given in Sections 8.8.7.1, 8.8.7.2 and 8.8.1.1]

9.1.8.6 Emissions to air from acid recovery

BAT 26. In order to reduce emissions to air of dust, acids (HCl, HF), SO₂ and NO_x from the recovery of spent acid while limiting CO emissions, BAT is to use a combination of the techniques given below.

| Technique | | Description | Applicability |
|-----------|--|--|--|
| a | Use of a fuel or a combination of fuels with low sulphur and/or nitrogen content | See BAT 19 and BAT 20 (a). | Applicable within the constraints associated with the availability of different types of fuel, which may be impacted by the energy policy of the Member State. |
| b | Combustion optimisation | See Section 9.7.2. Generally used in combination with other techniques. | Generally applicable. |
| c | Low-NO _x burners | See Section 9.7.2. | Generally applicable. |
| d | Wet scrubbing followed by a demister | See Section 9.7.2. In the case of mixed acid recovery, an alkali is added to the scrubbing solution to remove traces of HF. | Generally applicable. |
| e | Fabric filter | See Section 9.7.2. | Generally applicable. |

Table 9.18: BAT-associated emission levels (BAT-AELs) for channelled emissions of dust, HCl, SO₂ and NOX to air from the recovery of spent hydrochloric acid by spray roasting and by using fluidised bed reactors

| Parameter | Unit | BAT-AEL (Daily average or average over the sampling period) |
|-----------------|--------------------|--|
| Dust | mg/Nm ³ | < 2–15 |
| HCl | mg/Nm ³ | < 2–15 |
| SO ₂ | mg/Nm ³ | < 1–8 |
| NOX | mg/Nm ³ | 50–150 |

Table 9.19: BAT-associated emission level (BAT-AEL) for channelled HF emissions to air from the recovery of mixed acid by evaporation

| Parameter | Unit | BAT-AEL (Daily average or average over the sampling period) |
|-----------|--------------------|--|
| HF | mg/Nm ³ | < 1 |

The associated monitoring is given in BAT 4.

[This BAT conclusion is based on information given in Sections 8.8.8.1, 2.4.2.1, 8.5.3.3, 8.5.3.2, 8.8.2.6, 8.8.1.6 and 8.8.1.1]

9.1.9 Emissions to water

BAT 27. In order to reduce the load of organic pollutants in water contaminated with oil or grease (e.g. from oil spillages or from the cleaning of rolling and tempering emulsions, degreasing solutions and wire-drawing lubricants) that is sent to further treatment (see BAT 28), BAT is to separate the organic and the aqueous phase.

Description

The organic phase is separated from the aqueous phase, e.g. by skimming or by emulsion splitting with suitable agents, evaporation or membrane filtration. The organic phase may be used for other purposes (e.g. as a fuel).

[This BAT conclusion is based on information given in Section 8.9.14]

BAT 28. In order to reduce emissions to water, BAT is to treat waste water using a combination of the techniques given below.

| Technique (1) | | Typical pollutants targeted |
|---|--|--|
| Preliminary, primary and general treatment, e.g. | | |
| a | Equalisation | All pollutants |
| b | Neutralisation | Acids, alkalis |
| c | Physical separation, e.g. screens, sieves, grit separators, grease separators, hydrocyclones, oil-water separation or primary settlement tanks | Gross solids, suspended solids, oil/grease |
| Physico-chemical treatment, e.g. | | |
| d | Adsorption | Adsorbable dissolved non-biodegradable or inhibitory pollutants, e.g. hydrocarbons, mercury |
| e | Chemical precipitation | Precipitable dissolved non-biodegradable or inhibitory pollutants, e.g. metals, phosphorus, fluoride |
| f | Chemical reduction | Reducible dissolved non-biodegradable or inhibitory pollutants, e.g. hexavalent chromium |

| | | |
|--|---|---|
| g | Nanofiltration/reverse osmosis | Soluble non-biodegradable or inhibitory pollutants, e.g. salts, metals |
| Biological treatment, e.g. | | |
| h | Aerobic treatment | Biodegradable organic compounds |
| Solids removal, e.g. | | |
| i | Coagulation and flocculation | Suspended solids and particulate-bound metals |
| j | Sedimentation | |
| k | Filtration (e.g. sand filtration, microfiltration, ultrafiltration) | |
| l | Flotation | |
| (1) The descriptions of the techniques are given in Section 9.7.3. | | |

Table 9.20: BAT-associated emission levels (BAT-AELs) for direct discharges to a receiving water body

| Substance/Parameter | | Unit | BAT-AEL ⁽¹⁾ | Process(es) to which the BAT-AEL applies ⁽²⁾ |
|--|--------|------|-------------------------|---|
| Total suspended solids (TSS) | | mg/l | 5–30 | All processes |
| Total organic carbon (TOC) ⁽³⁾ | | mg/l | 10–30 | All processes |
| Chemical oxygen demand (COD) ⁽³⁾ | | mg/l | 30–90 | All processes |
| Hydrocarbon oil index (HOI) | | mg/l | 0.5–4 | All processes |
| Metals | Cd | µg/l | 1–5 | All processes |
| | Cr | mg/l | 0.01–0.1 ⁽⁴⁾ | All processes |
| | Cr(VI) | µg/l | 10–50 | Pickling of high-alloy steel and passivation with hexavalent chromium compounds |
| | Fe | mg/l | 1–5 | All processes |
| | Hg | µg/l | 0.1–1 | All processes |
| | Ni | mg/l | 0.01–0.2 ⁽⁵⁾ | All processes |
| | Pb | µg/l | 10–50 | All processes |
| | Sn | mg/l | 0.01–0.2 | Coating with tin |
| | Zn | mg/l | 0.1–1 ⁽⁶⁾ | All processes |
| Total phosphorus (P) | | mg/l | 0.2–1 | Phosphating |
| Fluoride (F) | | mg/l | 5–25 | Pickling with mixed acid |
| ⁽¹⁾ The averaging periods are defined in the General considerations. ⁽²⁾ For batch galvanising, the BAT-AELs only apply if waste water is generated. ⁽³⁾ Either the BAT-AEL for COD or the BAT-AEL for TOC applies. TOC monitoring is the preferred option because it does not rely on the use of very toxic compounds. ⁽⁴⁾ The higher end of the BAT-AEL range is 0.3 mg/l in the case of high-alloy steels. ⁽⁵⁾ The higher end of the BAT-AEL range is 0.5 mg/l in the case of high-alloy steels. ⁽⁶⁾ The higher end of the BAT-AEL range is 2 mg/l in the case of hot dip coating. | | | | |

Table 9.21: BAT-associated emission levels (BAT-AELs) for indirect discharges to a receiving water body

| Substance/Parameter | | Unit | BAT-AEL (¹) (³) | Process(es) to which the BAT-AEL applies (²) |
|-----------------------------|--------|------|--|---|
| Hydrocarbon oil index (HOI) | | mg/l | 0.5–4 | All processes |
| Metals | Cd | µg/l | 1–5 | All processes |
| | Cr | mg/l | 0.01–0.1 (⁴) | All processes |
| | Cr(VI) | µg/l | 10–50 | Pickling of high-alloy steel and passivation with hexavalent chromium compounds |
| | Fe | mg/l | 1–5 | All processes |
| | Hg | µg/l | 0.1–1 | All processes |
| | Ni | mg/l | 0.01–0.2 (⁵) | All processes |
| | Pb | mg/l | 10–50 | All processes |
| | Sn | mg/l | 0.01–0.2 | Coating with tin |
| | Zn | mg/l | 0.1–1 (⁶) | All processes |
| Fluoride (F ⁻) | | mg/l | 5–25 | Pickling with mixed acid |

(¹) The averaging periods are defined in the General considerations.
 (²) For batch galvanising, the BAT-AELs only apply if waste water is generated.
 (³) 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.
 (⁴) The higher end of the BAT-AEL range is 0.3 mg/l in the case of high-alloy steels.
 (⁵) The higher end of the BAT-AEL range is 0.5 mg/l in the case of high-alloy steels.
 (⁶) The higher end of the BAT-AEL range is 2 mg/l in the case of hot dip coating.

The associated monitoring is given in BAT 5.

[This BAT conclusion is based on information given in Sections 8.9.1 to 8.9.13]

9.1.10 Noise and vibrations

BAT 29. In order to prevent or, where that is not practicable, to reduce noise and vibration emissions, BAT is to set up, implement and regularly review a noise and vibration management plan, as part of the EMS (see BAT 1), that includes all of the following elements:

- a protocol containing appropriate actions and timelines;
- a protocol for conducting noise and vibration monitoring;
- a protocol for response to identified noise and vibration events, e.g. complaints;
- a noise and vibration reduction programme designed to identify the source(s), to measure/estimate noise and vibration exposure, to characterise the contributions of the sources and to implement prevention and/or reduction measures.

Applicability

The applicability is restricted to cases where a noise or vibration nuisance at sensitive receptors is expected and/or has been substantiated.

[This BAT conclusion is based on information given in Section 8.10.1]

BAT 30. In order to prevent or, where that is not practicable, to reduce noise and vibration emissions, BAT is to use one or a combination of the techniques given below.

| Technique | | Description | Applicability |
|-----------|---|---|---|
| a | 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 the exits or entrances of the buildings. | For existing plants, the relocation of equipment and the exits or entrances of the buildings may not be applicable due to a lack of space and/or excessive costs. |
| b | Operational measures | These include techniques such as: <ul style="list-style-type: none"> – improved 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, traffic and handling. | Generally applicable. |
| c | Low-noise equipment | This includes direct drive motors, low-noise compressors, pumps and fans. | |
| d | Noise and vibration control equipment | This includes techniques such as: <ul style="list-style-type: none"> – noise reducers; – acoustic and vibrational insulation of equipment; – enclosure of noisy equipment (e.g. scarfing and grinding machines, wire drawing machines, air jets); – soundproofing of buildings. | Applicability to existing plants may be limited by a lack of space. |
| e | Noise abatement | Inserting obstacles between emitters and receivers (e.g. protection walls, embankments and buildings). | Only applicable to existing plants, as the design of new plants should make this technique unnecessary. For existing plants, the insertion of obstacles may not be applicable due to a lack of space. |

[This BAT conclusion is based on information given in Sections 8.10.2 to 8.10.6]

9.1.11 Residues

BAT 31. In order to increase material efficiency and to reduce the quantity of waste sent for disposal, BAT is to avoid the disposal of metals, metal oxides, oily sludge and hydroxide sludge by using all of the techniques given below.

| Technique | | Description |
|-----------|--------------------------------|--|
| a | Residues management plan | A residues management plan is part of the EMS (see BAT 1) and is a set of measures aiming to 1) minimise the generation of residues, 2) optimise the reuse, recycling and/or recovery of residues, and 3) ensure the proper disposal of waste. |
| b | Pretreatment of oily scale for | This includes techniques such as: |

| | | |
|---|---|---|
| | recycling | <ul style="list-style-type: none"> - briquetting or pelletising; - reducing the oil content of oily scale, e.g. by thermal treatment, washing, flotation. |
| c | Recycling of scale | Scale is collected and used in a sinter plant (in the case of scale with a low oil content) or in iron- and steel-making furnaces (in the case of scale with a high oil content). |
| d | Recycling of metallic scrap | Metallic scrap from mechanical processes (e.g. from trimming and finishing) is recycled to iron and steel production. |
| e | Recycling of metal and metal oxides from dry waste gas cleaning | The coarse fraction of metal and metal oxides originating from dry cleaning (e.g. fabric filters) of waste gases from mechanical processes (e.g. scarfing or grinding) are selectively isolated using mechanical techniques (e.g. sieves) or magnetic techniques and recycled to iron and steel production. |
| f | Use of oily sludge | Residual oily sludge, e.g. from degreasing, is dewatered to recover the oil contained therein for further use (e.g. as fuel). Alternatively, if the water content is low, the sludge can be directly used as fuel. |
| g | Thermal treatment of hydroxide sludge from the recovery of mixed acid | Sludge generated from the recovery of mixed acid is thermally treated in order to produce a material rich in calcium fluoride that can be used in argon oxygen decarburisation converters. |

[This BAT conclusion is based on information given in Sections 8.11.1.1 to 8.11.1.7]

BAT 32. In order to increase material efficiency and to reduce the quantity of waste sent for disposal from galvanising, BAT is to avoid the disposal of zinc-containing residues by using all of the techniques given below.

| Technique | | Description |
|-----------|---------------------------------|--|
| a | Recycling of fabric filter dust | Dust from fabric filters containing zinc is collected and used to produce fluxing agents. |
| b | Recycling of zinc ash | Metallic zinc is recovered from zinc ash by melting in recovery furnaces. The remaining zinc-containing residue is used for zinc oxide production. |
| c | Recycling of hard zinc | Hard zinc is used, e.g. in the non-ferrous metals industries to produce zinc. |

[This BAT conclusion is based on information given in Sections 8.11.2.1 to 8.11.2.3]

BAT 33. In order to prevent or reduce the environmental risk associated with the storage of zinc-containing residues from galvanising (e.g. zinc ash, hard zinc and fabric filter dust), BAT is to store them separately from each other on impermeable surfaces and in enclosed areas.

[This BAT conclusion is based on information given in Section 8.11.2.4]

BAT 34. In order to increase material efficiency and to reduce the quantity of waste sent for disposal from texturing of working rolls, BAT is to use both of the techniques given below.

| Technique | | Description |
|-----------|---------------------------------|--|
| a | Treatment of grinding sludge | Treatment of grinding sludge by magnetic separation for recovery of metal particles and recycling to iron and steel production. |
| b | Recycling of worn working rolls | Worn working rolls which are unsuitable for texturing are recycled to iron and steel production or returned to the manufacturer for refabrication. |

[This BAT conclusion is based on information given in Section 2.4.10.1]

Further sector-specific techniques to reduce the quantity of waste sent for disposal are given in Section 9.4.4 of these BAT conclusions.

WORKING DRAFT IN PROGRESS

9.2 BAT conclusions for hot rolling

The BAT conclusions in this section apply in addition to the general BAT conclusions given in Section 9.1.

9.2.1 Energy efficiency

BAT 35. In order to increase energy efficiency in feedstock heating, BAT is to use a combination of the techniques given in BAT 10 together with a combination of the techniques given below.

| Technique | | Description | Applicability |
|-----------|---|--|--|
| a | Near net shape casting for thin slabs and beam blanks | Thin slabs and beam blanks are produced by combining casting and rolling in one process step. The need to reheat the feedstock before rolling and the number of rolling passes are reduced. | Only applicable to plants adjacent to continuous casting and within the limitations of plant layout and customer demand. |
| b | Hot charging or direct rolling | Continuous-cast steel products are directly charged in the reheating furnaces or directly transferred to the rolling mill in hot conditions. | Only applicable to plants adjacent to continuous casting and within the limitations of plant layout and customer demand. |
| c | Heat recovery from skids cooling | Steam produced when cooling the skids supporting the feedstock in the reheating furnaces is extracted and used in other processes of the production plant. | Generally applicable. |
| d | Heat conservation during transfer of feedstock before the roughing mill | Insulated chambers or insulated shields are used between the source of feedstock and the reheating furnace and/or between the furnace and the roughing mill. | Generally applicable. |
| e | Heat conservation during transfer of feedstock after the roughing mill | Insulated shields are used on feedstock transfer tables between the roughing mill and the finishing mill. | Generally applicable. |
| f | Coil boxes | Coil boxes are installed between the roughing mill and the finishing mill to minimise temperature losses from transfer bars during coiling/uncoiling processes and allow for lower rolling forces. | Generally applicable. |
| g | Coil recovery furnaces | Coil recovery furnaces are used as an addition to coil boxes to restore the rolling temperature of coils and return them to a normal rolling sequence in the event of rolling mill interruptions. | Generally applicable. |

Table 9.22: BAT-associated environmental performance levels (BAT-AEPLs) for specific energy consumption in feedstock heating

| Specific process(es) | Unit | BAT-AEPL (Yearly average) |
|--------------------------------|------|------------------------------|
| Feedstock reheating | MJ/t | 1 400–3 200 |
| Feedstock intermediate heating | MJ/t | 100–900 |
| Feedstock post-heating | MJ/t | 3 000–10 000 |

The associated monitoring is given in BAT 3.

[This BAT conclusion is based on information given in Sections 2.4.2.14 to 2.4.2.18 and Sections 2.4.6.1 to 2.4.6.3]

BAT 36. In order to increase energy efficiency in rolling, BAT is to use a combination of the techniques given below.

| Technique | | Description | Applicability |
|-----------|-------------------------------------|---|---|
| a | Sizing press | Using a sizing press before the roughing mill enables an efficient width reduction of slabs together with a uniform increase of the slab thickness both at the edges and centre of the product. The shape of the final slab is nearly rectangular, reducing significantly the number of rolling passes necessary to reach product specifications. | Only applicable to new plants and major plant upgrades for the production of flat products. |
| b | Computer-aided rolling optimisation | The thickness reduction is controlled using a computer to minimise the number of rolling passes. | Generally applicable. |
| c | Reduction of the rolling friction | Rolling oils are carefully selected and emulsion systems are operated to reduce the friction between the working rolls and the feedstock and to ensure minimal oil consumption. | Generally applicable. |
| d | Coil boxes | Coil boxes are installed between the roughing mill and the finishing mill to minimise temperature losses from transfer bars during coiling/uncoiling processes and allow for lower rolling forces. | Generally applicable. |

Table 9.23: BAT-associated environmental performance level (BAT-AEPL) for specific energy consumption in rolling

| Specific process(es) | Unit | BAT-AEPL (Yearly average) |
|--|------|------------------------------|
| Rolling (including roughing and finishing) | MJ/t | 100–600 |

The associated monitoring is given in BAT 3.

[This BAT conclusion is based on information given in Sections 2.4.4.1, 2.4.5.1, 2.4.7.2 and 2.4.6.1]

9.2.2 Material efficiency

BAT 37. In order to increase material efficiency, to prevent emissions to air, and to reduce the quantity of waste sent for disposal from feedstock conditioning, BAT is to avoid or, where that is not practicable, to reduce the need for conditioning by applying one or a combination of the techniques given below.

| Technique | | Description | Applicability |
|-----------|--|---|---|
| a | Computer-aided quality control | The quality of slabs is controlled by a computer which allows the adjustment of the casting conditions to minimise surface defects and enables manual scarfing of the damaged area(s) only rather than scarfing of the entire slab. | The adjustment of the casting conditions is only applicable to plants with adjacent continuous casting. |
| b | Slab slitting | The slabs (often cast in multiple widths) are slit before hot rolling by means of slitting devices, slit rolling or torches either manually operated or mounted on a machine. | Generally applicable. |
| c | Edging or trimming of wedge-type slabs | Wedge-type slabs are rolled under special settings where the wedge is eliminated by edging (e.g. using automatic width control or a sizing press) or by trimming. | Only applicable to new plants and major plant upgrades. |

[This BAT conclusion is based on information given in Sections 2.4.1.3 to 2.4.1.5]

BAT 38. In order to increase material efficiency in rolling, BAT is to reduce the generation of metallic scrap by using both of the techniques given below.

| Technique | | Description |
|-----------|---|--|
| a | Crop optimisation | The cropping of the feedstock after roughing is controlled by a shape measurement system (e.g. camera) in order to minimise the amount of metal cut off. |
| b | Control of the feedstock shape during rolling | Any deformations of the feedstock during rolling are monitored and controlled in order to ensure that the rolled steel has as rectangular a shape as possible and to minimise the need for trimming. |

[This BAT conclusion is based on information given in Sections 2.4.7.1 and 2.4.7.10]

9.2.3 Water use and waste water generation

BAT 39. In order to optimise water consumption, to reduce the volume of waste water generated and to increase energy efficiency in descaling, BAT is to use sensors to trigger the spraying of descaling water according to the position of the feedstock.

[This BAT conclusion is based on information given in Section 2.4.3.1]

9.2.4 Emissions to air

BAT 40. In order to reduce emissions to air of dust, nickel and lead from mechanical processing, scarfing and welding, BAT is to collect the emissions by using techniques (a) and (b) and to treat the waste gas by using one or a combination of the techniques (c) to (e) given below.

| Technique | | Description |
|--------------------------------|---|--|
| Collection of emissions | | |
| a | Enclosed scarfing and grinding combined with air extraction | Scarfing and grinding operations are carried out completely enclosed (e.g. under closed hoods) and air is extracted. |
| b | Air extraction as close as possible to the emission source | Emissions from slitting, descaling, roughing, rolling, finishing, levelling and welding are collected, for example using hood or lip extraction. |
| Waste gas treatment | | |
| c | Electrostatic precipitator | See Section 9.7.2. |
| d | Fabric filter | See Section 9.7.2. |
| e | Wet scrubbing | See Section 9.7.2. |

Table 9.24: BAT-associated emission levels (BAT-AELs) for channelled emissions of dust, lead and nickel to air from mechanical processing, scarfing and welding

| Parameter | Unit | BAT-AEL (Daily average or average over the sampling period) |
|-----------|--------------------|--|
| Dust | mg/Nm ³ | < 2–5 |
| Ni | | 0.01–0.1 |
| Pb | | 0.01–0.04 |

The associated monitoring is given in BAT 4.

[This BAT conclusion is based on information given in Sections 2.4.1.1, 2.4.1.2, 8.8.1.2, 8.8.1.3 and 8.8.1.6]

9.3 BAT conclusions for cold rolling

The BAT conclusions in this section apply in addition to the general BAT conclusions given in Section 9.1.

9.3.1 Energy efficiency

The environmental performance level for specific energy consumption in annealing after rolling given in the table below is associated with BAT 10.

Table 9.25: BAT-associated environmental performance level (BAT-AEPL) for specific energy consumption in annealing after rolling

| Specific process(es) | Unit | BAT-AEPL (Yearly average) |
|-------------------------|------|------------------------------|
| Annealing after rolling | MJ/t | 600–1 200 |

The associated monitoring is given in BAT 3.

BAT 41. In order to increase energy efficiency in rolling, BAT is to use a combination of the techniques given below.

| Technique | | Description | Applicability |
|-----------|--|---|---|
| a | Continuous rolling for low-alloy and alloy steel | Continuous rolling is employed instead of conventional discontinuous rolling, allowing for stable feed and less frequent start-ups and shutdowns. | Only applicable to new plants and major plant upgrades. |
| b | Reduction of the rolling friction | Rolling oils are carefully selected and emulsion systems are operated to reduce the friction between the working rolls and the feedstock and to ensure minimal oil consumption. | Generally applicable. |

Table 9.26: BAT-associated environmental performance level (BAT-AEPL) for specific energy consumption in rolling

| Specific process(es) | Unit | BAT-AEPL (Yearly average) |
|----------------------|------|------------------------------|
| Rolling | MJ/t | 100–600 |

The associated monitoring is given in BAT 3.

[This BAT conclusion is based on information given in Sections 3.4.2.1 and 3.4.2.3]

9.3.2 Material efficiency

BAT 42. In order to increase material efficiency and to reduce the quantity of waste sent for disposal from rolling, BAT is to use all of the techniques given below.

| Technique | | Description |
|-----------|---|--|
| a | Monitoring and adjustment of the rolling emulsion quality | Important characteristics of the rolling emulsion (e.g. oil concentration, pH, emulsion particle size, saponification value, viscosity) are monitored regularly or continuously to detect anomalies in the emulsion quality and take corrective action, if needed. |
| b | Inspection and maintenance of the emulsion system | Regular inspections and preventive maintenance of the emulsion system (e.g. pump seals, piping and filters) are carried out to reduce oil leakages and thus contamination of the rolling emulsion. |
| c | Cleaning and reuse of the rolling emulsion | Particulate matter (e.g. dust, steel slivers and scale) contaminating the rolling emulsion is removed in a cleaning circuit (usually based on sedimentation combined with filtration and/or magnetic separation) in order to maintain the emulsion quality. |

[This BAT conclusion is based on information given in Sections 3.4.2.4, 3.4.2.5 and 3.4.2.7]

9.3.3 Emissions to air

BAT 43. In order to reduce emissions to air of dust, nickel and lead from mechanical processing and welding, BAT is to use both of the techniques given below.

| Technique | | Description |
|--------------------------------|--|---|
| Collection of emissions | | |
| a | Air extraction as close as possible to the emission source | Emissions from decoiling, mechanical predescaling, levelling and welding are collected, for example using hood or lip extraction. |
| Waste gas treatment | | |
| b | Fabric filter | See Section 9.7.2. |

Table 9.27: BAT-associated emission levels (BAT-AELs) for channelled emissions of dust, nickel and lead to air from mechanical processing and welding

| Parameter | Unit | BAT-AEL (Daily average or average over the sampling period) |
|-----------|--------------------|--|
| Dust | mg/Nm ³ | < 2–5 |
| Ni | | 0.01–0.1 |
| Pb | | ≤ 0.003 |

The associated monitoring is given in BAT 4.

[This BAT conclusion is based on information given in Sections 3.4.1.1, 3.4.5.2 and 8.6.2.3]

BAT 44. In order to prevent or reduce oil mist emissions to air from tempering, BAT is to use one of the techniques given below.

| Technique | | Description | Applicability |
|-----------|---|---|--|
| a | Dry tempering | No water or lubricants are used for tempering. | Not applicable to tinplate packaging products. |
| b | Low-volume lubrication in wet tempering | Low-volume lubrication systems are employed to supply precisely the amount of lubricants needed for reducing the friction between the working rolls and the feedstock. Liquid nitrogen is used to clean the working rolls and improve the strip surface finish. | Not applicable to stainless steel. |

BAT 45. In order to reduce oil mist emissions to air from rolling, wet tempering and finishing, BAT is to use both of the techniques given below.

| Technique | | Description |
|--------------------------------|--|--|
| Collection of emissions | | |
| a | Air extraction as close as possible to the emission source | Emissions from rolling, wet tempering and finishing are collected, for example using hood or lip extraction. |
| Waste gas treatment | | |
| b | Demister | See Section 9.7.2. |

Table 9.28: BAT-associated emission level (BAT-AEL) for channelled TVOC emissions to air from rolling, wet tempering and finishing

| Parameter | Unit | BAT-AEL (Daily average or average over the sampling period) |
|-----------|--------------------|--|
| TVOC | mg/Nm ³ | < 3–10 |

The associated monitoring is given in BAT 4.

[This BAT conclusion is based on information given in Sections 3.4.2.9, 3.4.4.2, 3.4.4.4 and 8.8.1.1]

9.4 BAT conclusions for wire drawing

The BAT conclusions in this section apply in addition to the general BAT conclusions given in Section 9.1.

9.4.1 Energy efficiency

BAT 46. In order to increase the energy and material efficiency of lead baths, BAT is to use a floating protective layer on the surface of the lead baths and tank covers.

Description

Floating protective layers and tank covers minimise heat losses and lead oxidation.

[This BAT conclusion is based on information given in Section 4.4.6.1]

9.4.2 Material efficiency

BAT 47. In order to increase material efficiency and to reduce the quantity of waste sent for disposal from wet drawing, BAT is to clean and reuse the wire-drawing lubricant.

Description

A cleaning circuit, e.g. with filtration and/or centrifugation, is used to clean the wire-drawing lubricant for reuse.

[This BAT conclusion is based on information given in Section 4.4.4.2]

9.4.3 Emissions to air

BAT 48. In order to reduce emissions to air of dust and lead from lead baths, BAT is to use all of the techniques given below.

| Technique | | Description |
|---|--|---|
| Reduction of generation of emissions | | |
| a | Minimisation of carry-over of lead | Techniques include the use of anthracite gravel to scrape off lead and the coupling of the lead bath with in-line pickling. |
| Collection of emissions | | |
| b | Air extraction as close as possible to the emission source | Emissions from the lead bath are collected, for example using hood or lip extraction. |
| Waste gas treatment | | |
| c | Fabric filter | See Section 9.7.2. |

Table 9.29: BAT-associated emission levels (BAT-AELs) for channelled emissions of dust and lead to air from lead baths

| Parameter | Unit | BAT-AEL (Daily average or average over the sampling period) |
|-----------|--------------------|--|
| Dust | mg/Nm ³ | < 2–5 |
| Pb | mg/Nm ³ | ≤ 0.5 |

The associated monitoring is given in BAT 4.

[This BAT conclusion is based on information given in Sections 4.4.6.2, 4.4.6.3 and 8.8.1.3]

BAT 49. In order to reduce dust emissions to air from dry drawing, BAT is to use both of the techniques given below.

| Technique | | Description |
|--------------------------------|---|---|
| Collection of emissions | | |
| a | Enclosed drawing machine combined with air extraction | The entire drawing machine is enclosed in order to avoid dispersion of dust and air is extracted. |
| Waste gas treatment | | |
| b | Fabric filter | See Section 9.7.2. |

Table 9.30: BAT-associated emission level (BAT-AEL) for channelled dust emissions to air from dry drawing

| Parameter | Unit | BAT-AEL (Daily average or average over the sampling period) |
|-----------|--------------------|--|
| Dust | mg/Nm ³ | < 2–5 |

The associated monitoring is given in BAT 4.

[This BAT conclusion is based on information given in Sections 4.4.3.1 and 8.8.1.3]

BAT 50. In order to reduce oil mist emissions to air from oil quench baths, BAT is to use both of the techniques given below.

| Technique | | Description |
|--------------------------------|--|--|
| Collection of emissions | | |
| a | Air extraction as close as possible to the emission source | Emissions from oil quench baths are collected, for example using lateral hood or lip extraction. |
| Waste gas treatment | | |
| b | Demister | See Section 9.7.2. |

[This BAT conclusion is based on information given in Sections 4.4.9.2 and 8.8.1.1]

9.4.4 Residues

BAT 51. In order to increase material efficiency and to reduce the quantity of waste sent for disposal, BAT is to avoid the disposal of lead-containing residues by recycling them, e.g. to the non-ferrous metals industries to produce lead.

[This BAT conclusion is based on information given in Section 8.11.3.2]

BAT 52. In order to prevent or reduce the environmental risk associated with the storage of lead-containing residues from lead baths (e.g. protective layer materials and lead oxides), BAT is to store lead-containing residues separately from other residues, on impermeable surfaces and in enclosed areas.

[This BAT conclusion is based on information given in Section 8.11.3.1]

9.5 BAT conclusions for hot dip coating of sheets

The BAT conclusions in this section apply in addition to the general BAT conclusions given in Section 9.1.

9.5.1 Energy efficiency

The environmental performance level for specific energy consumption of feedstock heating before hot dipping given in the table below is associated with BAT 10.

Table 9.31: BAT-associated environmental performance level (BAT-AEPL) for specific energy consumption of feedstock heating before hot dipping

| Specific process(es) | Unit | BAT-AEPL (Yearly average) |
|--|------|------------------------------|
| Feedstock heating before hot dipping | MJ/t | 700–1 100 ⁽¹⁾ |
| ⁽¹⁾ In the case of coating with a zinc-aluminium alloy, the higher end of the BAT-AEPL range is 1 800 MJ/t. | | |

The associated monitoring is given in BAT 3.

9.5.2 Material efficiency

BAT 53. In order to increase material efficiency in hot dipping, BAT is to avoid excess coating with metals or alloys.

Description

After hot dipping, the coating thickness is measured by a gauge and controlled by air jets which blow the surplus coating metal or alloy from the steel surface back into the galvanising kettle. The efficiency of the surplus removal can be improved when the oscillations of the steel sheet are limited by applying an electromagnetic field.

Applicability

Electromagnetic stabilisation is applicable only to new plants and major plant upgrades.

[This BAT conclusion is based on information given in Sections 5.4.1.5.1 and 5.4.1.5.2]

BAT 54. In order to increase material efficiency and to reduce the quantity of waste sent for disposal from phosphating and passivation, BAT is to use technique (a) and one of the techniques (b) and (c) given below.

| Technique | | Description |
|-----------|---|--|
| a | Cleaning and reuse of the spent phosphating or passivation solution | A cleaning circuit, for example with filtration, is used to clean the spent phosphating or passivation solution for reuse. |
| b | Use of roll coaters | Roll coaters are used to apply a passivation or a phosphate-containing layer on the metal surface. This allows better control of the layer thickness and thus the reduction of the consumption of chemicals. |
| c | Minimisation of carry-over of chemical solution | The carry-over of chemical solution into the following process step is minimised by passing the sheet through squeeze rolls. |

[This BAT conclusion is based on information given in Sections 5.4.1.7.1, 5.4.1.7.2, 5.4.1.7.4 and 5.4.1.7.5]

9.5.3 Emissions to air

BAT 55. In order to reduce emissions to air from chemical storage tanks and chemical baths in post-treatment (phosphating and passivation), BAT is to use both of the techniques given below.

| Technique | | Description | Applicability |
|--------------------------------|---|---|--|
| Collection of emissions | | | |
| a | Air extraction as close as possible to the source | Air from the chemical storage tanks and chemical baths is extracted, for example using lateral hood or lip extraction, or the tanks or baths are located in enclosed areas equipped with roof or wall extraction. | Not applicable when the storage temperature is low. Only applicable when the treatment is carried out by spraying or when the treatment temperature is high. |
| Waste gas treatment | | | |
| b | Wet scrubbing followed by a demister | See Section 9.7.2. | Not applicable when the storage temperature is low. Only applicable when the treatment is carried out by spraying or when the treatment temperature is high. |

[This BAT conclusion is based on information given in Section 5.4.1.7.3, 8.8.1.1 and 8.8.1.6]

9.6 BAT conclusions for batch galvanising

The BAT conclusions in this section apply in addition to the general BAT conclusions given in Section 5.1.

9.6.1 Energy efficiency

The environmental performance level for specific energy consumption in the heating of the galvanising kettle given in the table below is associated with BAT 10.

Table 9.32: BAT-associated environmental performance level (BAT-AEPL) for specific energy consumption in the heating of the galvanising kettle

| Specific process(es) | Unit | BAT-AEPL (Yearly average) |
|-----------------------------------|-------|------------------------------|
| Heating of the galvanising kettle | kWh/t | 300–800 |

The associated monitoring is given in BAT 3.

9.6.2 Material efficiency

BAT 56. In order to facilitate the recycling of spent pickling acid, BAT is to carry out pickling separately from stripping.

Applicability

Applicability to existing plants may be restricted by a lack of space.

[This BAT conclusion is based on information given in Section 6.4.2.2]

BAT 57. In order to increase material efficiency in stripping and to reduce the quantity of spent pickling acids with high zinc concentrations sent for disposal, BAT is to recover the spent pickling acids and/or the metals contained therein.

Description

Techniques to treat spent pickling acids with high zinc concentrations include the following:

- Zinc removal by ion exchange. The treated acid can be used in pickling, while the zinc-containing solution resulting from the stripping of the ion-exchange resin can be used for fluxing.
- Iron removal by oxidation and precipitation. The resulting liquid can be used for fluxing.
- Zinc removal by solvent extraction. The treated acid can be used in pickling, while the zinc-containing concentrate resulting from stripping and evaporation can be used for other purposes.

[This BAT conclusion is based on information given in Sections 6.4.2.4 to 6.4.2.6]

BAT 58. In order to increase material efficiency in hot dipping, BAT is to use both of the techniques given below.

| Technique | | Description |
|-----------|---|--|
| a | Optimised dipping time | The dipping time is optimised to achieve the coating thickness specifications. |
| b | Slow withdrawal of workpieces from the bath | By withdrawing the galvanised workpieces slowly from the galvanising kettle, the drain-off is improved and zinc splashes are reduced. |
| c | Modified fluxing solution to increase the aluminium content of the bath | By means of a modified fluxing solution, the aluminium content of the bath can be increased to 0.03–0.05 wt-%. This reduces the coating thickness of steels with a high silicon and/or phosphorus content. |

[This BAT conclusion is based on information given in Sections 6.4.5.1 to 6.4.5.3]

BAT 59. In order to increase material efficiency and to reduce the quantity of waste sent for disposal from blowing off excess zinc from galvanised tubes, BAT is to recover zinc-containing particles and to reuse them in the galvanising kettle or to send them for zinc recovery.

[This BAT conclusion is based on information given in Section 6.4.5.4]

9.6.3 Emissions to air

BAT 60. In order to reduce emissions of HCl to air from stripping, BAT is to use technique (a) or both of the techniques (b) and (c) given below.

| Technique | | Description |
|---|---|--|
| Reduction of generation of emissions | | |
| a | Restricted operating range | The stripping acid temperature and HCl concentration in the stripping bath(s) are strictly controlled so that both of the following conditions are met: a) $4\text{ }^{\circ}\text{C} < T < (80 - 4w)\text{ }^{\circ}\text{C}$; b) $2\text{ wt-\%} < w < (20 - T/4)\text{ wt-\%}$. where T is the stripping acid temperature expressed in $^{\circ}\text{C}$ and w the HCl concentration expressed in wt-%. |
| Collection of emissions | | |
| b | Air extraction as close as possible to the source | Air from the stripping tanks is extracted, for example using lateral hood or lip extraction, or the tanks are located in enclosed areas equipped with roof or wall extraction. |
| Waste gas treatment | | |
| c | Wet scrubbing followed by a demister | See Section 9.7.2. |

The BAT-associated emission level (BAT-AEL) is given in Table 9.15.

The associated monitoring is given in BAT 4.

[This BAT conclusion is based on information given in Sections 8.8.4.1, 8.8.4.2, 8.8.1.6 and 8.8.1.1]

9.7 Descriptions of techniques

9.7.1 Techniques to increase energy efficiency

| Technique | Description |
|--------------------------------|--|
| Combustion optimisation | Measures taken to maximise the efficiency of energy conversion in the furnace while minimising emissions (in particular of CO). This is achieved by a combination of techniques including good design of the furnace, optimisation of the temperature (e.g. efficient mixing of the fuel and combustion air) and residence time in the combustion zone, and use of furnace automation and control. |
| Furnace automation and control | The heating process is optimised by using a computer system controlling in real time key parameters such as furnace and feedstock temperature, the air to fuel ratio and the furnace pressure. |
| Process gas management system | A system that enables iron and steel process gases to be directed to the feedstock heating furnaces, depending on their availability. |
| Regenerative burner | Regenerative burners consist of two burners which are operated alternately and which contain beds of refractory or ceramic materials. While one burner is in operation, the heat of the flue-gas is absorbed by the refractory or ceramic materials of the other burner and then used to preheat the combustion air. |
| Preheating of combustion air | Reuse of part of the heat recovered from the combustion flue-gas to preheat the air used in combustion. |
| Recuperative burner | Recuperative burners employ different types of recuperators (e.g. heat exchangers with radiation, convection, compact or radiant tube designs) to directly recover heat from the flue-gases, which are then used to preheat the combustion air. |
| Waste heat recovery boiler | Heat from hot flue-gases is used to generate steam using a waste heat recovery boiler. The generated steam is used in other processes of the production plant, for supplying a steam network or for generating electricity in the power plant. |

9.7.2 Techniques to reduce emissions to air

| Technique | Description |
|--|---|
| Combustion optimisation | See Section 9.7.1. |
| Demister | Demisters are filter devices that remove entrained liquid droplets from a gas stream. They consist of a woven structure of metal or plastic wires, with a high specific surface area. Through their momentum, small droplets present in the gas stream impinge against the wires and coalesce into bigger drops. |
| Electrostatic precipitator | Electrostatic precipitators (ESPs) operate such that particles are charged and separated under the influence of an electrical field. Electrostatic precipitators are capable of operating under a wide range of conditions. Abatement efficiency may depend on the number of fields, residence time (size), and upstream particle removal devices. They generally include between two and five fields. Electrostatic precipitators can be of the dry or of the wet type depending on the technique used to collect the dust from the electrodes. Wet ESPs are typically used at the polishing stage to remove residual dust and droplets after wet scrubbing. |
| Fabric filter | Fabric filters, often referred to as bag filters, are constructed from porous woven or felted fabric through which gases are passed to remove particles. The use of a fabric filter requires the selection of a fabric suitable for the characteristics of the waste gas and the maximum operating temperature. |
| Flameless combustion | Flameless combustion is achieved by injecting fuel and combustion air separately into the combustion chamber of the furnace at high velocity to suppress flame formation and reduce the formation of thermal NOX while creating a more uniform heat distribution throughout the chamber. Flameless combustion can be used in combination with oxy-fuel combustion. |
| Flue-gas recirculation | Recirculation of part of the flue-gas to the combustion chamber to replace part of the fresh combustion air, with the dual effect of cooling the temperature and limiting the O ₂ content for nitrogen oxidation, thus limiting the NOX generation. It implies the supply of flue-gas from the furnace into the flame to reduce the oxygen content and therefore the temperature of the flame. |
| Furnace automation and control | See Section 9.7.1. |
| Limiting the temperature of air preheating | Limiting the air preheating temperature leads to a decrease of NOX emissions. A choice has to be made between maximising heat recovery from the flue-gas and minimising NOX emissions. |
| Low-NOX burner | The technique (including ultra-low-NOX burners) is based on the principles of reducing peak flame 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 NOX and the formation of thermal NOX, while maintaining high combustion efficiency. |
| Oxy-fuel combustion | Combustion air is replaced fully or partially with pure oxygen. Oxy-fuel combustion can be used in combination with flameless combustion. |
| Selective catalytic reduction (SCR) | The SCR technique is based on the reduction of NOX to nitrogen in a catalytic bed by reaction with urea or ammonia at an optimum operating temperature of around 300–450 °C. Several layers of catalyst may be applied. A higher NOX reduction is achieved with the use of several catalyst layers. |
| Selective non-catalytic reduction (SNCR) | SNCR is based on the reduction of NOX to nitrogen by reaction with ammonia or urea at a high temperature. The operating temperature window is maintained between 800 °C and 1 000 °C for optimal reaction. |
| Wet scrubbing | 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. |

9.7.3 Techniques to reduce emissions to water

| Technique | Description |
|------------------------------|---|
| Adsorption | The removal of soluble substances (solutes) from the waste water by transferring them to the surface of solid, highly porous particles (typically activated carbon). |
| Aerobic treatment | The biological oxidation of dissolved organic pollutants with oxygen using the metabolism of microorganisms. In the presence of dissolved oxygen, injected as air or pure oxygen, the organic components are mineralised into carbon dioxide and water or are transformed into other metabolites and biomass. |
| Chemical precipitation | The conversion of dissolved pollutants into an insoluble compound by adding chemical precipitants. The solid precipitates formed are subsequently separated by sedimentation, air flotation or filtration. If necessary, this may be followed by microfiltration or ultrafiltration. Multivalent metal ions (e.g. calcium, aluminium, iron) are used for phosphorus precipitation. |
| Chemical reduction | The conversion of pollutants by chemical reducing agents into similar but less harmful or hazardous compounds. |
| 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 at the inlet of the final waste water treatment by using central tanks. Equalisation may be decentralised or carried out using other management techniques. |
| Filtration | The separation of solids from waste water by passing them 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. |
| Nanofiltration | A filtration process in which membranes with pore sizes of approximately 1 nm are used. |
| 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. |
| Physical separation | The separation of gross solids, suspended solids, metal particles from the waste water using for example screens, sieves, grit separators, grease separators, hydrocyclones, oil-water separation or primary settlement tanks. |
| Reverse osmosis | A membrane process in which a pressure difference applied between the compartments separated by the membrane causes water to flow from the more concentrated solution to the less concentrated one. |
| Sedimentation | The separation of suspended particles and suspended material by gravitational settling. |

10 ANNEXES

WORKING DRAFT IN PROGRESS

GLOSSARY

TWG, the glossary from the previous BREF has been deleted, and replaced with the updated one below.

This glossary is meant to facilitate the understanding of the information contained in this document. The definitions of terms in this glossary are not legal definitions (even if some of them may coincide with definitions given in European legislation), they are meant to help the reader understand some key terms in the context of their use in the specific sector covered by this document.

This glossary is divided up into the following sections:

- I. ISO country codes
- II. Monetary units
- III. Unit prefixes, number separators and notations
- IV. Units and measures
- V. Acronyms
- VI. Abbreviations used in the graphs

I. ISO country codes

| ISO code | Member State |
|---|----------------|
| <i>Member States (*)</i> | |
| AT | Austria |
| BE | Belgium |
| BG | Bulgaria |
| CZ | Czech Republic |
| CY | Cyprus |
| DE | Germany |
| DK | Denmark |
| EE | Estonia |
| EL | Greece |
| ES | Spain |
| FI | Finland |
| FR | France |
| HU | Hungary |
| IE | Ireland |
| IT | Italy |
| LT | Lithuania |
| LU | Luxembourg |
| LV | Latvia |
| MT | Malta |
| NL | Netherlands |
| PL | Poland |
| PT | Portugal |
| RO | Romania |
| SE | Sweden |
| SI | Slovenia |
| SK | Slovakia |
| UK | United Kingdom |
| <i>Non-member countries</i> | |
| US | United States |
| (*) The protocol order of the Member States is based on the alphabetical order of their geographical names in the original language(s). | |

II. Monetary units

| Code ⁽¹⁾ | Country/territory | Currency |
|--|--------------------------|--------------------------------------|
| Member State currencies | | |
| EUR | Euro area ⁽²⁾ | euro (pl. euros) |
| GBP | United Kingdom | pound sterling (pl. pounds sterling) |
| Other currencies | | |
| SEK | Sweden | krona (pl. kronor) |
| USD | United States | US dollar |
| ⁽¹⁾ ISO 4217 codes. | | |
| ⁽²⁾ Includes Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia and Spain. | | |

III. Unit prefixes, number separator and notations

Numbers in this document are written using the '.' character as the decimal separator and the space as the separator for thousands.

The following table contains the frequently used prefixes:

| Symbol | Prefix | 10 ⁿ | Word | Decimal Number |
|--------|--------|------------------|------------|----------------|
| k | kilo | 10 ³ | Thousand | 1 000 |
| h | hecto | 10 ² | Hundred | 100 |
| da | deca | 10 ¹ | Ten | 10 |
| ----- | ----- | 1 | One | 1 |
| d | deci | 10 ⁻¹ | Tenth | 0.1 |
| c | centi | 10 ⁻² | Hundredth | 0.01 |
| m | milli | 10 ⁻³ | Thousandth | 0.001 |

IV. Unit and measurements

| TERM | MEANING |
|----------------------|--|
| atm | normal atmosphere (1 atm = 101325 N/m ²) |
| bar | bar (1.013 bar = 1 atm) |
| billion | thousand million (10 ⁹) |
| °C | degree Celsius |
| cm | centimetre |
| d | day |
| °C/W | thermal resistance |
| dB | Decibel. The unit of measuring noise emission levels |
| dB(A) | Noise is measured in decibels (dB). To address the way the human ear responds to sound of different frequencies (pitches), an A-weighting is commonly applied, and the measurements are expressed in dB(A). Every 3 dB(A) reduction is equivalent to halving the noise emission level. |
| eV | electron volt |
| g | gram |
| GJ | gigajoule |
| Hz | hertz |
| h | hour |
| ha | hectare (10 ⁴ m ²) (=2.47105 acres) |
| hl | hectolitre |
| hPa | hectopascal (1hPa = 100 Pa) |
| J | joule |
| K | kelvin (0 °C = 273.15 K) |
| kcal | kilocalorie (1 kcal = 4.19 kJ) |
| kg | kilogramme (1 kg = 1000 g) |
| kJ | kilojoule (1 kJ = 0.24 kcal) |
| kPa | kilopascal |
| kt | kilotonne |
| kW | kilowatt |
| kW _e | kilowatt in the form of electrical energy |
| kWh | kilowatt-hour (1 kWh = 3600 kJ = 3.6 MJ = 0.0036 GJ) |
| kWh _e | kilowatt-hour in the form of electrical energy |
| l | litre |
| m | metre |
| m ² | square metre |
| m ³ | cubic metre |
| m ² .°C/W | thermal resistance unit |
| mg | milligram (1 mg = 10 ⁻³ gram) |
| MJ | megajoule (1 MJ = 1000 kJ = 10 ⁶ joule) |
| nm | nanometre (1 nm = 10 ⁻⁹ m) |
| mm | millimetre (1 mm = 10 ⁻³ m) |
| m/min | metres per minute |
| Mt | megatonne (1 Mt = 10 ⁶ tonne) |
| Mt/yr | megatonnes per year |
| mV | millivolts |
| MW _e | megawatts electric (energy) |
| MW _{th} | megawatts thermal (energy) |
| ng | nanogram (1 ng = 10 ⁻⁹ gram) |
| Nm ³ | normal cubic metre (101.325 kPa, 273 K) |
| OU _E | European odour unit |
| Pa | pascal |

| TERM | MEANING |
|---------------|--|
| ppb | parts per billion |
| ppm | parts per million (by weight) |
| ppmv | parts per million (by volume) |
| s | second |
| t | metric tonne (1000 kg or 10^6 gram) |
| t/d | tonnes per day |
| t/yr | tonne(s) per year |
| V | volt |
| vol-% | percentage by volume |
| W | watt (1 W = 1 J/s) |
| wt-% | percentage by weight |
| yr | Year |
| ~ | around; more or less |
| μm | micrometre ($1 \mu\text{m} = 10^{-6} \text{ m}$) |

V. Acronyms

| | |
|-----------------|--|
| BAT | Best Available Technique(s), as defined in Article 3(10) of the IED |
| BAT-AEL | Best Available Techniques - associated emission level, as defined in Article 3(13) of the IED |
| BAT-AEPL | Best Available Techniques - associated performance emission level, as described in Section 3.3.2 of Commission Implementing Decision 2012/119/EU |
| BFG | Blast furnace gas |
| BG | Batch galvanising |
| BOD | Biochemical oxygen demand |
| BOF | Basic oxigene furnace |
| BREF | Best available techniques (BAT) reference document |
| CEN | The European Committee for Standardisation |
| CHP | Cogeneration of heat and power (combined heat and power) |
| CLM BREF | BAT Reference Document for for the Production of Cement, Lime and Magnesium Oxide |
| COD | Chemical oxygen demand |
| COG | Coke oven gas |
| CR | Cold rolling |
| CWW BREF | BAT Reference Document in the Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector |
| EC | European Commission |
| EFS BREF | BAT Reference Document on Emissions from Storage |
| EIPPCB | European IPPC Bureau |
| EMAS | Eco-Management and Audit Scheme |
| EMS | Environmental management system |
| EN | European Norming (EN standards) |
| EP | Electrostatic precipitator |
| ENE BREF | BAT Reference Document for Energy Efficiency |
| ESP | Electrostatic precipitator |
| EU | European Union |
| FMP | Ferrous metals processing |
| ISO | International Organisation for Standardisation |
| IPPC | Integrated pollution prevention and control |
| LCP BREF | BAT Reference Document for Large Combustion Plants |
| LPG | Liquefied petroleum gas |
| MS | Member State(s) of the European Union |
| NGO | Non-governmental organisation |
| NOX | Nitrous oxides |
| OTNOC | Other than normal operating conditions |
| PAH | Polyaromatic hydrocarbon |
| PM | Particulate matter |
| SCR | Selective catalytic reduction |
| SNCR | Selective non-catalytic reduction |
| SO _x | Sulphur oxides |
| TDS | Total dissolved solids |
| TN | Total nitrogen |
| TOC | Total organic carbon |
| TP | Total phosphorus |
| TSS | Total suspended solids |
| TVOC | Total volatile organic carbon, expressed as C (in air) |
| TWG | Technical working group |
| UV | Ultraviolet |
| VOC | Volatile organic compound |
| WD | Wire drawing |
| WT BREF | BAT Reference Document for Waste Treatment |
| WWTP | Waste water treatment plant |

VI. Abbreviations

Abbreviations used in the figures of air emissions to air

Abbreviations used to express the concentrations and number of measurements

| Sector | Abbreviations / Term used | Information |
|---------------|--|--|
| HR, CR plants | Max for year 1/2016 | Maximum value of all reported measurements for year 2016 or the first year of reporting data |
| | Max for year 2/2015 | Maximum value of all reported measurements for year 2015 or the second year of reporting data |
| | Max for year 3/2014 | Maximum value of all reported measurements for year 2014 or the third year of reporting data |
| | Average for 3 years | The average value of all reported measurements for the three reporting years (either the period 2014-2016, or the last three years with available data). |
| | Number of measurements | The number of measurements over the three reporting years. For continuous monitoring, the letter 'C' is denoted. |
| WD, HDC, BG | Pollutant (unit), MxYx e.g. Dust (mg/Nm ³) M1Y1 | Name of the pollutant, measurement unit, number of measurement and year of three reporting years |
| All sectors | CO at max NOX value | CO concentration corresponding to the maximum NOX value over the reporting period |
| | Reference O ₂ level (%) | O ₂ reference value at the maximum concentration of the parameter plotted in the graph |
| | % Ref O ₂ (max) | |
| | O ₂ reported (%) | O ₂ value as reported at the maximum concentration of the parameter plotted in the graph |
| | O ₂ (%) (parameter) e.g. O ₂ (%) NOX | |

Abbreviations used for monitoring frequency

| Abbreviations | Monitoring frequency |
|---------------|----------------------|
| C | Continuous |
| 4/y | 4 times per year |
| 3/y | 3 times per year |
| 2/y | 2 times per year |
| 1/y | Once per year |
| 2y | Every 2 years |
| 3y | Every 3 years |
| 5y | Every 5 years |

Abbreviations used for fuels

| Abbreviations | Fuel |
|---------------|-------------------------|
| NG | Natural gas |
| COG | Coke oven gas |
| BFG | Blast furnace gas |
| BOF | Biomass oil fuel |
| LPG | Liquefied petroleum gas |

Abbreviations used for the type of product

| Abbreviations | Type of product |
|---------------|---------------------------|
| bi | Billets |
| ra | Rails |
| ro | Rods/Wire Rods |
| ba | Bars |
| tu | Tubes |
| st | Strips (hot rolled coils) |
| pl | Plates |
| be | Beams |
| ot | Other profiles |
| ri | Rings |

Abbreviations used for the steel grade in hot rolling figures

| Abbreviations | Steel categories |
|---------------|--|
| CS-El | CS-Electrical steel Grain-Oriented |
| CS-O | CS-Other (non-alloy/low-alloy) |
| SS-F | SS-Ferritic |
| SS-A | SS-Austenitic |
| SS-M | SS-Martensitic |
| SS-D | SS-Duplex (mixed ferritic and austenitic) |
| O-HA | Other high-alloy steels |
| CS | CS-not specified, otherwise with CS>90% |
| M | Mix of products with 10%<CS<90% |
| SS | SS-not specified, otherwise with SS>90% |
| CS-CR | CS-Cold rolled products automotive |
| CS-OA | CS-Cold rolled products others than automotive |
| CS-P | CS-Products for packaging |

Abbreviations used for steel grade in cold rolling figures

| Abbreviations | Steel categories |
|---------------|--|
| CS-P | CS-Products for packaging |
| CS-GO | CS-Electrical steel Grain Oriented |
| CS-GO | CS-Electrical steel Grain Oriented (GO) |
| CS-NO | CS-Electrical steel Non Oriented (NONO) |
| CS-HS | CS-High strength steels with yield strength Re > 420 MPa, mainly used for automotive |
| CS-MH | CS-Medium and high carbon steels (C>0.3%) |
| CS-O | CS-Other (non alloy/low alloy) |
| SS-F | SS-Ferritic |
| SS-A | SS-Austenitic |
| SS-M | SS-Martensitic |
| SS-D | SS-Duplex (mixed ferritic and austenitic) |
| O-HA | Other high alloy steels |

Abbreviations used for steel grade in hot dip coating figures

| Abbreviations | Steel categories |
|---------------|--|
| CS-CR | CS-Cold rolled products automotive |
| CS-OA | CS-Cold rolled products others than automotive |

Abbreviations used for hot rolling furnace types

| Abbreviations | Furnace type |
|---------------|-----------------------|
| Batch | Batch furnace |
| Push | Pushing furnace |
| Roll hth | Roller hearth furnace |
| Rot hth | Rotary hearth furnace |
| Tunn | Tunnel furnace |
| Walk | Walking beam furnace |

Abbreviations used in the techniques for hot rolling figures

| Abbreviation | Equipment contributing to emissions |
|------------------------|--|
| Regen | Regeneration |
| Dry ESP | Dry electrostatic precipitator |
| Wet ESP | Wet electrostatic precipitator |
| Acid gas Abate | Acid gas Abatement |
| Encl Grind WGC | Enclosed Grinding Operation with Waste Gas Cleaning |
| External FGR | External Flue-Gas Recirculation (FGR) |
| Oscil comb for low NOX | Oscillating combustion for NOX emission reduction |
| Sequent Impulse Firing | Sequential impulse firing burner technology for reheating furnaces |

Abbreviations for type of pickling line

| Abbreviations | Pickling line type |
|---------------|---------------------|
| pul psh | push pull |
| cont. | continuous pickling |
| batch | batch pickling |

Abbreviations used for the type of acid regeneration systems

| Abbreviations | Acid regeneration systems |
|---------------|-------------------------------|
| Flu Bed | Fluidized bed regeneration |
| Spray Roast | Spray roasting regeneration |
| Cryst | Crystallization recovery |
| Ion Exch | Ion exchange recovery |
| Diff Dial | Diffusion dialysis recovery |
| Evap | Evaporation recovery |
| Neutr | Neutralization |
| Retard | Retardation |
| El Oxid | Electrolytic oxidation |
| El Fe Precip | Electrolytic Fe precipitation |
| Chem Oxid | Chemical oxidation |
| Precip Solv | Precipitation with solvents |

Abbreviations used for the type of tanks in pickling figures

| Abbreviations | Type of tanks |
|---------------|--------------------|
| deep | deep-type tanks |
| shall | shallow-type tanks |
| turb | turbulence tanks |
| trbfl | turboflow tanks |

Abbreviations used for lubrication and oiling type

| Abbreviations | Type rolling lubrication/oiling type |
|---------------|--------------------------------------|
| Dir App | direct application |
| Em Rec | emulsion recirculation |
| Pur Oil Rec | pure oil recirculation |
| E static | Electrostatic |
| Spray | Spray oiling |
| Rolls | Oiling rolls |
| Other | Other |
| None | None |

Abbreviations used in the techniques for cold rolling figures

| Abbreviation | Equipment contributing to emissions |
|-----------------------------------|--|
| Decoiler D Red | Reduction of Dust Emission at the Decoilers |
| Pickl Emission Control/collection | Emission Control/Collection from Pickling |
| Wet ESP | Wet electrostatic precipitator |
| Regen/Recup burners | Preheating Combustion Air/Use of Regenerative or Recuperative Burners for Annealing Furnace |
| Acid gas Abate | Acid gas Abatement |
| External FGR | External Flue-Gas Recirculation (FGR) |
| Closed Tank EGS | Reduction of Emissions from Pickling/Closed HCl and H ₂ SO ₄ Pickling Tanks with Exhaust Gas Scrubbing |
| Closed Mix Acid EGS | Reduction of Emissions from Pickling/Closed Mixed Acid Pickling Tanks with Exhaust Gas Scrubbing |
| Oil Mist Abate | Capture and Abatement of Oil Mists from Oiling Operation |
| Oil Mist Separation | Extraction of Oil Mist Emissions and Oil Separation |
| Oil Mist & Dust Red | Reduction of Oil Mist and Dust |

Abbreviations used for the type of descaling in wire drawing figures

| Abbreviations | Type of descaling |
|---------------|---------------------|
| Chem | Chemical (Pickling) |
| Mech | Mechanical |

Abbreviations used for the processes hot dip coating figures

| Abbreviations | Process |
|---------------|---|
| SC-Heat | Sheet Coating - Heat treatment before dipping |
| SC-Galva | Sheet Coating - Galvannealing |
| WC-Kettle | Wire Coating - Kettle heating |

Abbreviations used for preheating and annealing equipment in hot dip coating figures

| Abbreviation | Preheating equipment |
|---------------------|-------------------------------------|
| WG | Waste gas |
| RHF | Recover heat in fumes |
| DF&RTF | Direct flame & radiant tube furnace |
| HNx conv | HNx convection |
| RTF | Radiant tube furnace |
| DF | Direct Flame |
| eDFF | Energy from DFF fumes |
| DFF | Direct flame furnace |
| eRF | Energy recover in the fumes |
| HEF | Hot exhaust fumes |
| DFnO | Direct flame non oxidizing |
| RTs&IC | Radiant tubes and induction coils |
| RT&I | Radiant tube and induction |
| EGHR | Exhaust gas heat recovery |
| annAB | Annealing atmosphere blowing |
| IH | Induction heating |
| HSG | Hot smoke gases |

Abbreviations used for the soaking equipment in hot dip coating figures

| Abbreviation | Soaking equipment |
|---------------------|--------------------------|
| NH | not heated |
| RTF | Radiant tube furnace |
| Elect | Electricity |
| ElectRT | Electrical radiant tube |
| ElectH | Electrical Heater |
| ElectR | Electrical resistances |

Abbreviations used for the cooling equipment in hot dip coating figures

| Abbreviation | Cooling equipment |
|---------------------|---|
| GJ | Gas jet |
| CB | Cooling by blower |
| JC | Jet cool |
| Ex | Exchangers |
| CS | Cooling System |
| CHNX | Cooling through HNX jets cooled by water exchanger. |
| AJ | Air jets |
| None | No additional heat input |
| SCF&JCF | Slow Cool Furnace and Jet Cooling furnace. |
| H2/N2 | H2/N2 |
| RTF | Radiant tube furnace |
| HEWG | Heat exchanger water/gas |
| annAB | Annealing atmosphere blowing |
| AC&WC | Air cooling & water cooling |

Abbreviations used for the equipment contributing to emissions in hot dip coating figures

| Abbreviation | Equipment contributing to emissions |
|--------------|---|
| Ann f | Annealing furnace |
| Preh. Sec | Preheating section |
| HTF | Heat treatment furnace |
| All zones | Combined emission from all zones |
| Ann. Sec | Annealing section |
| HTbd | Heat treatment before dipping |
| F | Furnace (vent called four coté Meuse) |
| Galv f | Galvannealing furnace |
| Preh. F/NOF | Pre Heating Furnace / Non Oxidising Furnace |
| RTF | Radiant Tube Furnace |
| Preh. FDF | Pre Heating furnace Direct Flame |

Abbreviations used in the figures of water emissions**Abbreviations used for origin of streams**

| Abbreviations | Origin of stream |
|---------------|---|
| N | The waste water is not treated in the FMP plant before entering the common WWTP (where N is repeated, additional non-treated streams enter the plant) |
| T | The waste water is pretreated in the FMP plant before entering the common WWTP (where T is repeated, additional treated streams enter the plant) |
| WT | Waste treatment sector |
| LCP | Large combustion plants |
| STS | Surface treatment using organic solvents sector |
| STM | Surface treatment of metals and plastics sector |
| I&S | Iron and steel production sector |
| BG | Batch galvanising |
| HDC | Hot dip coating |
| WD | Wire drawing |
| CR | Cold rolling |
| HR | Hot rolling |

Abbreviations used for the lay-out of the treatment lines involved

| Abbreviation | Treatment lines involved |
|-------------------|---|
| 1,2 (in parallel) | More than one lines treated in parallel |
| 1->2 (in series) | Lines is treated in series |

Abbreviations used for the destination of discharge

| Abbreviations | Destination of discharge |
|---------------|--------------------------|
| DD | Direct discharge |
| ID | Indirect discharge |

Abbreviations for the expression of metals concentration measured

| Abbreviations | Expression of metal concentration |
|---------------|-----------------------------------|
| t | Total metal concentrations |
| d | Dissolved metal concentrations |

WORKING DRAFT IN PROGRESS

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