Section VI.B.4.

Guidance by source category: Annex C, Part III Source Categories

Secondary steel production

Coordinated by Mr. Patrick Finlay (Canada)

Draft Guidelines on Best Available Techniques (BAT) for Secondary Steel Production

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1 Process Description

The use of electric arc furnaces (EAFs) in the production of steel provides three major benefits - lower capital cost for an EAF steelmaking shop, significantly less energy required to produce steel by the EAF process versus the coke oven/blast furnace/basic oxygen furnace method of the integrated steelmakers, and avoidance of coke ovens.

Production of steel from scrap consumes considerably less energy than production of steel from iron ores.[1] EAF steel manufacturing is an important recycling activity which contributes to the recovery of steel resources and waste minimization.

The EAF melts and refines a metallic charge of scrap steel to produce carbon, alloy, and stainless steels at non-integrated mills.

An EAF is a cylindrical vessel with a dish-shaped refractory hearth and electrodes that lower from the dome-shaped, removable roof. Refractory brick form the lining of the furnace. The walls typically contain water-cooled panels that are covered to minimize heat loss. The electrodes may also be equipped with water cooling systems.

EAF steelmaking consists of scrap charging, melting, refining, deslagging, and tapping. In addition to scrap steel, the charge may include pig iron, and alloying elements. As the steel scrap is melted, additional scrap may be added to the furnace. The EAF generates heat by passing an electric current between electrodes through the charge in the furnace. This energy is supplemented by natural gas, oxygen, and other fuels.

Fluxing materials are added to combine with unwanted materials and form a slag. Slag removes the steel impurities (e.g., silicon, sulfur, and phosphorus) from the molten steel. Oxygen may be added to the furnace to speed up the steelmaking process. At the end of a heat, the furnace tips forward and the molten steel is poured off.

Direct-reduced iron (DRI) is also increasingly being used as a feedstock due to both its low gangue content and variable scrap prices. [2]

Many of the steel plants increase productivity by using the EAF for the melting phase and a ladle metallurgy facility for the final refining and alloying phase. In

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[1] *Understanding Electric Arc Furnace Operations*, EPRI Centre for Materials Production, February 1997.

[2] *Best available techniques reference document on the production of iron and steel,* Integrated Pollution Prevention and Control (IPPC), European Commission, December 2001.

some cases the steel ladle is taken to a vacuum degassing station where the gas content of the molten steel is reduced for quality requirements.
The molten steel from the EAF or the ladle metallurgical facility is cast in a continuous casting machine to produce cast shapes including slabs, billets, or beam blanks. In some processes, the cast shape is torch cut to length and transported hot to the hot rolling mill for further processing. Other steel mills have reheat furnaces. Steel billets are allowed to cool, then are reheated in a furnace prior to rolling the billets into bars or other shapes.

EAF steelmaking is a dynamic batch process with steel tap-to-tap times of one hour or less for a heat except for stainless and specialty steel producers. The process is constantly changing from the removal of the furnace roof for charging the steel scrap to the meltdown of the steel scrap with the resultant emissions from scrap contaminants such as oils and plastics, to the refining period, and finally tapping of the steel. The conditions within the EAF and the combustion processes vary throughout the heat production cycle.

In recent years, more new and existing EAFs have been equipped with a system for preheating the scrap in the off-gas in order to recover energy. The so-called shaft technology and the Consteel Process are the two proven systems which have been introduced. The shaft system can be designed to reheat 100 percent of the scrap.[3]

Some EAFs also use a water spray or evaporative cooling system to cool the hot off-gases and some use heat exchangers ahead of the emission control device. EAFs may be equipped with dry, or semi-wet or wet air pollution controls. Semidry and wet gas cleaning systems may be sources of waste water.

Figure F-1 shows the EAF and a generic fabric filter emission control system.

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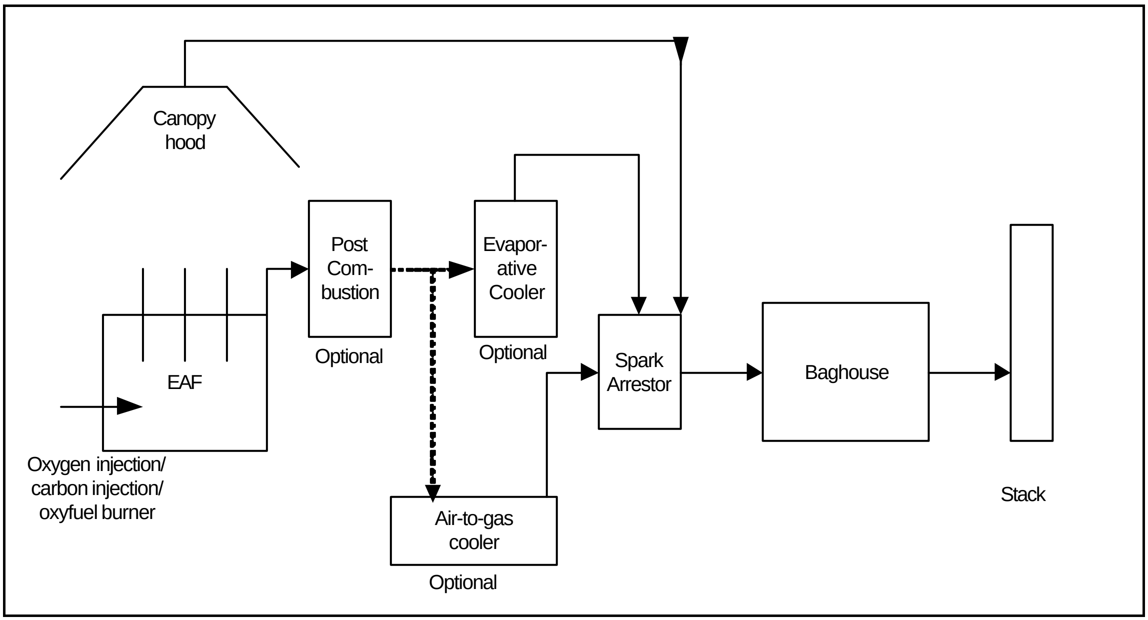
[3] European Commission IPPC. Best Available Techniques Reference Document on the Production of Iron and Steel, December 2001; http://eippcb.jrc.es/pages/FActivities.htm



Source: William Lemmon and Associates Ltd. *Research on Technical Pollution Prevention Options for Steel Manufacturing Electric Arc Furnaces*, Prepared for the Canadian Council of Ministers of the Environment (CCME), Final Report: March 24, 2004, CCME Contract No. 283-2003

Figure 1-1: Generic Electric Arc Furnace Emission Control System

2 Sources of Unintentional Persistent Organic Pollutants (UPOPs)

2.1 Emissions

2.1.2 PCDD/F Formation

EAF steelmaking is a batch process which can result in fluctuating emissions during heating of the charge and from heat to heat. Gas handling systems vary from facility to facility, both in configuration and design. These factors contribute to a varying concentration in process off-gases.

As a high temperature metallurgical process, particulate matter that contains a fine fume of metal and metal oxides is generated. High efficiency pollution control systems are required to remove the fine particulate matter in the off-gases.

Aromatic organohalogen compounds including PCDD/F, chlorobenzenes and polychlorinated biphenyls may be formed as a consequence of the thermal process and have been detected in EAF off-gas. The most important member of this group of compounds is PCDD/F. Scrap preheating may result in higher emissions of aromatic organohalogen compounds.

A recent (2003) United Nations Environment Programme (UNEP) document, *Formation of PCDD/PCDF – An Overview*, is helpful in providing an understanding of the basic formation mechanism of PCDD/F.[4] Information from this report is summarized below:

- The processes by which dioxins/furans are formed are not completely understood nor agreed upon. Most information about these substances in combustion processes has been obtained from laboratory experiments, pilot-scale systems, and municipal waste incinerators.

- Dioxins/furans appear to be most likely formed in the EAF steelmaking process via *de novo* synthesis by the combustion of non-chlorinated organic matter such as polystyrene, coal, and particulate carbon in the presence of chlorine donors. Many of these substances are contained in trace concentrations in the steel scrap or are process raw materials such as injected carbon.

- There is an inherent dualism of formation and de-chlorination of dioxins/furans which occurs in the same temperature range and especially under the conditions present in the EAF. In general, de-chlorination of dioxins/furans appears to take place at temperatures above 750^{o}C in the presence of oxygen. As the temperature increases above 750^{o}C, the rate of de-chlorination increases and the required residence time decreases.

- Increasing the oxygen concentrations results in increasing formation of dioxins/furans. It is unknown whether this continues at elevated oxygen concentrations (e.g. above 10 percent O_2). Under pyrolytic conditions (oxygen deficiency) de-chlorination of dioxins/furans occurs at temperatures above 300^{o}C.

- Some metals act as catalysts in the formation of dioxins/furans. Copper is a strong catalyst and iron is a weaker one.

- Condensation starts in the 125-60 ^{o}C range with the higher chlorinated dioxins and increases very rapidly as the temperature drops. The lower chlorinated furans are the last to condense, which explains why the tetra and penta furans constitute the majority of the dioxins/furans in EAF emission tests.

- Emission test results had higher dioxin/furan emission concentrations when the gas temperature exiting the gas conditioning system gas cooling device was consistently above 225 ^{o}C indicating that *de novo* synthesis had taken place in the gas conditioning system.

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[4] *Formation of PCCD/PCDF – An Overview*, UNEP/POPS/EGB.1/INF/5, Prepared by UNEP Chemicals, Geneva, Switzerland, January 2003 Draft, www.pops.int/documents/meetings/.

- Furans consistently accounted for 60 to 90 percent of the dioxin/furan I-TEQ concentration EAF emission tests.

- Two furan congenors, 2378-T4CDF and 23478-T5CDF, consistently accounted for 60 to 75 percent of the dioxin/furan I-TEQ concentration in EAF emission tests. These results are comparable to the theoretical condensation calculations for dioxins/furans since these two congenors would be the last to condense as the gas temperature decreases.

- These latter findings indicate that there is a predominant dioxin/furan formation mechanism, *de novo* synthesis, for the EAF steelmaking process. It appears likely that variations in the dioxin/furan fingerprint for the EAF steelmaking process are due to variations in the constituents of the scrap charge, varying conditions in the EAF resulting from changes in EAF operating practices from heat to heat and plant to plant, varying conditions in the gas conditioning and cleaning system, and differences in baghouse collection efficiencies.

2.1.2 PCDD/F Research on EAFs

Most of the research on PCDD/F formation and control has been carried out for EAFs in Europe. The earliest reported work was by Badische Stahlwerke GmbH (BSW) in Kehl/Rheim, Germany, in the early 1990s.[5] Other European steel companies followed BSW's lead under regulatory pressure from national environmental agencies.

A summary of the EAF operational findings follows:

- The Badische Stahlwerke GmbH research project confirmed that a high concentration of hydrocarbon material in the steel scrap significantly increased the VOC and PCDD/F emissions.

- Emission test results from the Badische Stahlwerke GmbH, ProfilARBED, Differdange, and Gerdau Ameristeel Cambridge emission testing programs had higher PCDD/F emission concentrations when the gas temperature exiting the gas conditioning system gas cooling device was consistently above 225 °C indicating that *de novo* synthesis had taken place in the gas conditioning system.

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[5] *Emittlung und Verminderung der Emissionen von Dioxinen und Furanen aus thermischen Prozessen; Untersuchung der Zusammenhange der Dioxin-/Ruanemissionen in Abhangigkeit von Einsatzstoffen und Minderungstechniken bei Elektro-Lichtbogenofen*, Dietmar Weiss and Andreas Karcher, prepared for BSW, February 1996. (English translation: *Evaluation and reduction of dioxin and furan emissions from thermal processes: Investigation of the effect of electric arc furnace charge materials and emission control technologies on the formation of dioxin and furan emissions*).

- PCDF consistently accounted for 60 to 90 percent of the PCDD/F I-TEQ concentration in the Canadian EAF emission tests. Similar results have been reported in European emission tests of EAFs.

- Two PCDF congenors, 2378-T4CDF and 23478-T5CDF, consistently accounted for 60 to 75 percent of the PCDD/F I-TEQ concentration in the Canadian EAF emission tests. Similar results have been reported in European emission tests of EAFs. These results are comparable to the theoretical condensation calculations for PCDD/F since these two congenors would be the last to condense as the gas temperature decreases.

- The congenor I-TEQ concentration distributions in the Canadian EAF emission tests were similar regardless of the total PCDD/F I-TEQ concentrations.

- The findings indicate that *de novo* synthesis is the predominant PCDD/F formation mechanism for the EAF steelmaking process.

- It appears likely that variations in the PCDD/F emission fingerprint for the EAF steelmaking process are due to variations in the constituents of the scrap charge, varying conditions in the EAF resulting from changes in EAF operating practices from heat to heat and plant to plant, varying conditions in the gas conditioning and cleaning system, and differences in baghouse collection efficiencies. There is insufficient publicly available information to determine the relative importance of these factors.

A review of the relationship of EAF combustion chemistry with PCDD/F formation in the EAF may be summarized as follows:

- PCDD/F can be formed from related chlorinated precursors such as polychlorinated biphenyls (PCB), chlorinated phenols, and chlorinated benzenes.

- The environment inside a steelmaking EAF is very complex and is constantly varying. The combustion chemistry produces conditions that are amenable to PCDD/F formation. The hydrocarbons entering the EAF in the scrap may be vaporized, cracked, partially combusted, or completely combusted depending on the conditions in the furnace or parts of the furnace during or after charging. Other sources of carbon include injected carbon and the graphite electrodes. The dual processes of PCDD/F formation and de-chlorination may be proceeding at the same time if the oxygen concentration and temperature are such that some PCDD or PCDF congeners are being formed while other congeners are being de-chlorinated.

- The research on optimization of internal post-combustion indicates that under normal steelmaking operations conditions – oxygen-rich atmosphere, reactive carbon particles, and temperatures under 800°C - are present in parts of the furnace during the meltdown phase and possibly for some time afterwards. Given that metals that act as catalysts are present and that trace amounts of chlorine may be present in some of the charge materials and fluxes, the conditions appear to be present for *de novo* synthesis to occur. Since ideal mixing conditions are not present, it appears that a portion of the PCDD/F that are formed will leave the EAF in the off-gas without encountering sufficiently high temperatures for de-chlorination to take place.

- Most of the research on combustion chemistry and internal post-combustion in EAF steelmaking has been to increase EAF productivity by taking advantage of fuels within the EAF - such as hydrocarbons, carbon monoxide, and hydrogen - to replace electric energy with chemical energy thus reducing the total energy input, which results in lower production costs per tonne of product.

- Scrap preheating may result in elevated emissions of chlorinated aromatic compounds such as PCDD/F, chlorobenzenes, polychlorinated biphenyls, as well as polycyclic aromatic hydrocarbons, and other products of incomplete combustion from scrap contaminated with paints, plastics, lubricants, or other organic compounds. The formation of these pollutants may be minimized by post-combustion within the furnace (as opposed to external post-combustion of the off-gas) by additional oxygen burners developed for burning the carbon monoxide and hydrocarbons, which recovers chemical energy.

- Indications are that internal post-combustion may be a more attractive option than external post-combustion for PCDD/F formation prevention.

2.2 PCDD/F Releases in Solid Waste and Waste Water Sources

Most mills worldwide operate EAFs with dry off-gas cleaning systems (i.e., fabric filter dust collectors), which produce no process wastewater that would require treatment.

Some existing EAFs may be equipped with semi-wet air pollution control systems.[6] Semi-wet systems apply water to the furnace off-gases to partially cool and condition the off-gases prior to particulate removal in an electrostatic precipitator. Sites are able to achieve zero wastewater discharge from semi-wet systems by balancing the applied water with water that evaporates in the

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[6] European Commission IPPC. Best Available Techniques Reference Document on the Production of Iron and Steel, December 2001; http://eippcb.jrc.es/pages/FActivities.htm

conditioning process. Non-contact cooling water is the predominant water source; however, some facilities may use treated process water and plant service water.[7]

Standards of some jurisdictions identify zero discharge as the best available technique for semi-dry gas cleaning systems.

In some European Union countries wet scrubbers are used to clean the off-gases from EAFs at some mills. However, no information from these facilities is available on wastewater quantities and methods of treatment.[8] Consequently, no findings were concluded as the best available techniques for treating and minimizing PCDD/F releases from wastewater from wet air pollution control systems.

Residues in the form of dust collected by the dry air pollution control system may contain trace levels of PCDD/F.

3 EAF Process Improvements and Alternate Processes for Electric Steelmaking

3.1 Process Improvements

The EAF steelmaking process has been undergoing change over the past decades. Research and development for EAF steelmaking, especially in Europe, is focused on EAF design improvements to increase productivity and energy efficiency, and to reduce steelmaking costs.

There are two major driving forces – reduction of steelmaking costs as exemplified by increased productivity and increased product quality as exemplified by quality demands from the automotive industry - and a third – environmental pressures. Productivity improvements have resulted in shorter tap-to-tap times, increased energy efficiency, and increased use of chemical energy.

Quality demands have been met through selection of scrap, furnace operating practices, and increased use of ancillary processes such as ladle metallurgy and vacuum degassing. Environmental pressures include the requirements for PCDD/F emission reduction and smog precursor reduction of substances such

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[7] U.S. EPA. *Development Document for Final Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category*, April 2002; http://epa.gov/waterscience/ironsteel/pdf/tdd/complete.pdf

[8] European Commission IPPC. Best Available Techniques Reference Document on the Production of Iron and Steel, December 2001; http://eippcb.jrc.es/pages/FActivities.htm

as fine particulate. One option for these producers is to use higher quality scrap with lower contaminant levels.[9]

A second option is to replace part of the scrap charge by direct reduced iron (DRI) or similar products that are produced from iron ore and have contaminant concentrations lower than the lower quality scrap steel grades. Merchant DRI production is increasing and the international market for merchant DRI is growing, so the availability is increasing and some EAF steelmakers may have the option of buying DRI rather than on-site production. There is very limited available information on PCDD/F emissions from the DRI process but, given the characteristics of the process, PCDD/F emissions are likely to be very small. Information on the formation and emissions of PCDD/F from the use of DRI in EAF steelmaking is not available.

A third option is the use of hot metal in EAF steelmaking. This is forecast to increase as EAF steelmakers strive for shorter heat cycles and higher productivity.[10] Information on the impact of this option on PCDD/F emissions is not available. With scrap preheating of part of the scrap about 60 kWh/t can be saved, in case of preheating the total scrap amount up to 100 kWh/t liquid steel can be saved. The applicability of scrap preheating depends on the local circumstances and has to be proved on a plant by plant basis.

Advances in the EAF steelmaking process often has collateral benefits including the reduction of particulate matter and PCDD/F emissions, except for scrap preheating as noted above. Usually the objective of advanced operating practices is improved operational and energy efficiency to increase productivity and thus increase production and reduce operating costs.

3.2 Alternate Processes

No alternate steelmaking technology would replace the EAF for the high production operations of steel plants. While other electrode materials have been used for a few EAFs in the past, there are no alternatives to the graphite electrode at the present time.

4 Primary and Secondary Measures

Primary and secondary measures for reducing emissions of PCDD/F from EAFs are outlined in the ensuing section.

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[9] Lemmon, W., William Lemmon and Associates Ltd. *Research on Technical Pollution Prevention Options for Steel Manufacturing Electric Arc Furnaces*, Prepared for the Canadian Council of Ministers of the Environment (CCME), Final Report: March 24, 2004, CCME Contract No. 283-2003

[10] *The Making, Shaping and Treating of Steel, 11th Edition Steelmaking and Refining Volume*, Richard J. Fruehan, Ph.D., Editor, The AISE Steel Foundation, Pittsburgh, PA, 1998.

The extent of emission reductions possible with implementation of primary measures only is not readily known. Implementation of both primary and secondary measures at existing and new plants is most likely necessary to achieve the desired emission levels.

It should be feasible for all plants to implement some or all of the pollution prevention practices identified below.

4.1 Primary Measures for Emissions

Primary measures, often called pollution prevention techniques, are able to avoid, suppress, or minimize the formation of PCDD/F or de-chlorinate PCDD/F in the EAF steelmaking process.

As a general measure, an integral part of a facility's pollution prevention program should include best environmental, operating, and maintenance practices for all operations and aspects of the EAF steelmaking process.

The following list presents a range of options as primary measures; some may not be applicable to all plants, and some may require further investigation:

- Raw Material Quality:
  The major raw material used in the EAF steelmaking process is steel scrap. Contaminants including oil, plastics, and other hydrocarbons are often present in the scrap. Pollution prevention practices to prevent or minimize the entry of contaminants into EAF steelmaking include changes in material specifications, improved quality control programs, changes in the types of raw materials (such as avoidance of oily scrap or cleaning oily scrap), and programs to prevent the entry of contaminants.

- EAF Operation:
  Recent changes in EAF operational practices that have been adopted to improve operational and energy efficiency appear to have collateral benefits to reduce PCDD/F or in certain conditions to de-chlorinate PCDD/F. Pollution prevention practices which appear to reduce PCDD/F emissions include minimizing the duration of the roof being open for charging, reduction of air infiltration into the EAF, and avoiding or minimizing operational delays. Condensation of PCDD/F increases rapidly at temperatures below 125°C starting with the higher chlorinated dioxins.

- Off-gas conditioning system design: Off-gas conditioning includes the collection, cooling, and ducting of EAF off-gases prior to cleaning in a baghouse:
  Off-gas conditioning system conditions may be conducive to *de novo* synthesis formation of PCDD/F unless care is taken to avoid conditions

leading to *de novo* synthesis. Pollution prevention techniques include adequately sized system, maximization of off-gas mixing, rapid cooling of off-gas, and development and implementation of good operating and maintenance practices.

- Continuous Parameter Monitoring System:
  A continuous parameter monitoring system based on optimizing the appropriate parameters for the operation of the gas conditioning system and documented operating and maintenance procedures should minimize the formation of dioxins/furans by *de novo* synthesis in the gas conditioning system.

4.2 Secondary Measures for Emissions

Secondary measures, often called pollution control techniques, may be summarized as follows:

- Off-Gas Dust Collection:
  Capturing all of the off-gas, including fugitive emissions, from the EAF area is an important part of the control system. Dust collection efficiency of primary and secondary emissions from the EAF should be maximized by a combination off-gas and hood system, or dog-house and hood system, or building air evacuation.

- Fabric filter dust collectors (or baghouses):
  Some of the PCDD/F in the EAF off gases adsorb onto fine particulate matter. As the gas temperature decreases through the PCDD/F condensation temperature of the various congenors more of the PCDD/F either adsorb onto the fine particulate matter or condense and form fine particulate matter. Well-designed fabric filter achieve less than 5 mg dust/Nm^3 for new plants and less than 15 mg dust/Nm^3 for existing plants. Minimizing dust levels also minimizes PCDD/F emissions.

- External post-combustion system coupled with a rapid water quench:
  This technique was the early PCDD/F emission control technique applied to EAF steelmaking. External post-combustion systems were originally developed to combust CO and H_2 in the EAF off-gas in a refractory lined combustion chamber, usually with supplementary fuel. Subsequently a number of European EAF steelmaking plants adopted the external post-combustion technology to de-chlorinate PCDD/F emissions by maintaining the post-combustion temperature above 800^{o}C. This emission control technique is not able to consistently meet the CWS standard of 100 pg/Nm^3. It may not be feasible for some plants to install external post-combustion and improvements to gas conditioning systems due to site-specific space considerations.

- Adsorbent Injection:
  This control technique was originally developed to control PCDD/F emissions from waste incinerators. Sized lignite coke (activated carbon is a similar adsorbent) injection technology is used in a number of European EAF steelmaking plants to supplement the fabric filter baghouse technology to achieve low PCDD/F emission concentrations consistently. Reported emission test results from EAF steelmaking plants in Europe indicate that this technique in combination with a high efficiency fabric filter baghouse consistently achieves PCDD/F emission concentrations of less than 100 pg/Nm^3. It should be feasible for all plants to install an activated carbon injection system. There may be site-specific constraints such as lack of available space, configuration of existing emission control systems. It should be feasible for all plants to install an activated carbon injection system. There may be site-specific constraints such as lack of available space, configuration of existing emission control systems, and financial costs.

Selective catalytic reduction (SCR) technology used for NOx removal in other industrial sectors has been shown to reduce PCDD/F emissions to significantly less than 100 pg I-TEQ/Nm^3. This technology has not been applied to steelmaking EAFs but may be in the future.

4.3 Primary and Secondary Measures for Solid Wastes and Waste Water

With respect to solid wastes, EAF slag and filter dust should be recycled to the extent possible. Filter dust from high-alloy steel production, where possible, may be treated to recover valuable metals. Excess solid waste should be disposed in an environmentally sound manner.

With respect to wastewater, closed loop water cooling systems for EAF components avoid waste water being generated, or recycled to the maximum extent possible to minimize waste volume for treatment.

Semi-dry emission control systems may be used at some plants. While replacement with dry dust collectors would be the desirable option, semi-dry systems can be designed to avoid the generation of wastewater.

Wastewater may originate at EAF facilities that use wet scrubbing systems. The desired approach is the replacement of existing systems with dry dust collectors. If replacement of existing emission control systems is not feasible, the wastewater would need treatment. However, standards for treated wastewater quality concerning PCDD/F discharge levels or other parameters were not found.

5 Summary of Measures

The following tables present a summary of the measures discussed in previous sections.

Table 5.3.1 Measures for New Electric Arc Furnaces

Measure	Description	Considerations	Other comments
New Electric Arc Furnaces			
Process Design	Priority consideration should be given to the latest proven process design based on process and emissions performance.	An example is internal post-combustion design for a new electric arc furnace.	
Performance Requirements	New electric arc furnaces should be required by the applicable jurisdiction to achieve stringent performance and reporting requirements associated with best available techniques.	Consideration should be given to the primary and secondary measures listed in Table 4.3.2 below.	Achievable emission limits should be specified as follows: • <0.1 ng TEQ/Rm^3 for PCDD/PCDF, and • <5 mg/Rm^3 for particulate matter

Table 5.3.2 Measures for New and Existing Electric Arc Furnaces

Measure	Description	Considerations	Other comments
Primary Measures			
General Operating Practices	An integral part of a facility’s pollution prevention program should include best environmental, operating, and maintenance practices for all operations and aspects of the EAF steelmaking process.	Generally applicable; part of an integrated concept for pollution prevention	
Raw Material Quality	A review of feed materials and identification of alternate inputs and/or procedures to minimize unwanted inputs should be conducted. Documented procedures should be developed and implemented to carry out the appropriate changes.	Generally applicable. Measures include changes in material specifications, improved quality control programs, changes in the types of raw materials (such as avoidance of oily scrap), and programs to prevent the entry of contaminants	
EAF Operation	Minimizing the duration of the roof being open for charging, reduction of air infiltration into the EAF, and avoiding or minimizing operational delays.	Collateral benefit is reduced PCDD/F.	Other pollutants are reduced including aromatic organhalogen compounds, carbon monoxide, hydrocarbons, and greenhouse gases.

Table 5.3.2 Measures for New and Existing Electric Arc Furnaces, continued

Measure	Description	Considerations	Other comments
Primary Measures			
Off-Gas Conditioning	Design and installation of an adequately sized gas conditioning system based on optimum system parameters should prevent or minimize formation of PCDD/F in the gas conditioning system. Development and implementation of documented operating and maintenance procedures should be developed to assist in optimizing the operation of the gas conditioning system.	A reduction in de novo synthesis in the gas conditioning system has been linked to the rapid cooling of the furnace off-gases to below a range of 225 to 200°C.	
Continuous Parameter Monitoring	A continuous parameter monitoring system (CPMS) should be employed to ensure optimum operation of the sinter strand and off-gas conditioning systems. Operators should prepare a site-specific monitoring plan for the continuous parameter monitoring system and keep records that document conformance with the plan.	Correlations between parameter values and stack emissions (stable operation) should be established. Parameters are then continuously monitored in comparison to optimum values.	System can be alarmed and corrective action taken when significant deviations occur.

Table 5.3.2 Measures for New and Existing Electric Arc Furnaces, continued

Measure	Description	Considerations	Other comments
Secondary Measures			
The following secondary measures can effectively reduce releases of PCDD/PCDF and serve as examples of best available techniques.			
Off-Gas Collection	Dust collection efficiency of primary and secondary emissions from the electric arc furnace should be maximized by a combination off-gas and hood system, or dog-house and hood system, or building air evacuation.		98 percent efficiency or more of dust collection is achievable.
Fabric Filters	Well-designed fabric filters achieve low dust emissions. Procedures should be developed for the operation and maintenance of the fabric filter dust collector to optimize and improve collection performance, including optimization of fabric bag cleaning cycles, improved fabric bag material, and preventive maintenance practices. A continuous temperature monitoring and alarm system should be provided to monitor the off-gas inlet temperature to the emission control device. A bag leak detection system should be provided with documented operating and maintenance procedures for responding to monitoring system alarms.	There is close correlation between the PCDD/F content in collected dust of a fabric filter and dust concentration. Lower exhaust PCDD/F levels accompany lower dust levels.	Maintaining the off-gases in the baghouse to below 60^{o}C will prevent PCDD/F evaporation in the baghouse and collected dust. Enclosing the filter dust collection areas and transfer points minimize fugitive dust.
Post-Combustion of Off-Gas	PCDD/F formation may be minimized by post-combustion within the off-gas duct system or in a separate post-combustion chamber. Indications are that internal post-combustion may be a more attractive option than external post-combustion for dioxin/furan formation prevention.		PCDD/F that have been formed in the process undergo de-chlorination reactions as the off-gas is burned by the additional oxygen burners. This technique with a rapid water quench has been an early PCDD/F emission control technique applied to electric arc furnace steelmaking.

Table 5.3.2 Measures for New and Existing Electric Arc Furnaces, continued

Measure	Description	Considerations	Other comments
Secondary Measures			
Adsorbent Injection	Injection of activated carbon or similar adsorptive material into the off-gas upstream of high efficiency fabric filters in electric arc furnaces at European steelmaking plants has consistently achieved low levels of PCDD/F emissions according to data from demonstration projects.		
Minimize Solid Waste Generation	electric arc furnace slag and filter dust should be recycled to the extent possible. Filter dust from high-alloy steel production, where possible, may be treated to recover valuable metals. Best management practices should be developed and implemented for hauling and handling dust-generating solid wastes. Excess solid waste should be disposed of in an environmentally sound manner.		
Minimize Waste Water	Closed loop water cooling systems for electric arc furnace components avoid waste water being generated. Recycle waste water to the maximum extent possible. Residual waste water should be treated. Semi-dry air pollution control systems can be designed to have zero discharge of excess waste water. Waste water from wet gas cleaning systems should treated before discharging to the environment.	These measures would be primarily associated with general pollution prevention and control practices rather than being applied specifically, or only, for the purpose of PCDD/F.	No standards were found on PCDD/F limits for treated waste water discharged as final effluent from wet off-gas cleaning systems. **(PLEASE PROVIDE ANY ADDITIONAL INFORMATION ON WASTEWATER RELEASE LIMITS.)**

6.0 Achievable Levels

6.1 PCDD/PCDF Achievable Levels

A PCDD/PCDF emission limit less than 100 pg ITEQ/Rm3 is achievable by steel manufacturing EAFs that incorporate best available techniques and best environmental practices.

6.2 Country Emission Limits for Steel Manufacturing EAFs

The following provides a brief overview of emission concentration limits that have been established for or are applicable to steel electric arc furnace operations.

Country	Emission Limit	Comment
Canada	<0.1 ng I-TEQ/Rm^3	For new plants
	<0.1 ng I-TEQ/Rm^3	For existing plants, to be achieved by 2010
Germany	0.1 ng I-TEQ/m^3 0.25 µg/h	General limit for industrial processes and large combustion sources
Japan	0.5 ng WHO-TEQ/m^3	For new plants
	5 ng WHO-TEQ/m^3	For existing plants
Other	**(PLEASE PROVIDE ANY ADDITIONAL INFORMATION ON EMISSION LIMITS)**	

7.0 Performance Reporting

Performance reporting is recommended as follows:

Annual isokinetic emission testing should be conducted at electric arc furnaces for:

- Polychlorinated dibenzoparadioxin (PCDD);
- Polychlorinated dibenzofuran (PCDF);
- Hexachlorobenzene (HCB); and
- Polychlorinated biphenyls (PCB).

Test data should be reported to the appropriate national or sub-national authority. Annual emission testing could be reduced (i.e., frequency) or suspended once emissions are shown to be 'eliminated' [11] on a continued and consistent basis.

These are considered as best available techniques for performance reporting.

Where isokinetic stack sampling for the above substances is not possible (e.g., analytical capacity is not readily available), emission factors associated with a similar plant type and operation is suggested as an interim performance reporting requirement until such time as annual emissions testing and analysis is available. Emission factors for releases of PCDD/PCDF from electric arc furnaces are presented in the *UNEP Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases*, May 2003 (URL: www.pops.int).

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[11] Consideration should be given to appropriate emission levels associated with 'elimination' of PCDD, PCDF, HCB and PCB. The Government of Canada has established levels of quantification (LOQ) for 'virtual elimination' of PCDD/PCDF, HCB and PCB in air as follows: <32 pg TEQ/Rm^3, <6 ng HCB/Rm^3, and <2 ng PCB/Rm^3, respectively.