Rules, regulations and recommendations on combustion and incineration related to the emission of dioxins

There are numerous international agreements and EU-regulations that are or could directly or indirectly limit emissions of dioxins, furans and dioxin like PCBs. These regulations cover products, waste (management, transport and disposal), industrial emissions, heat and power production and product standards for residential combustion.

There are new EU-regulations entering into force that will reduce emissions of dust from industry and large combustion plants (that indirectly could reduce emissions of dioxins, furans and PCBs) – namely the Industry emission directive (IED). Regulations under the IED directly limiting missions of dioxins and furans to air for specific industrial sectors could be decided, by the EU-commission, in the form of so called BAT-conclusions. However, such emission limit values for dioxins and furans will only be included in the BAT-conclusions if the member states or other relevant parties participating in the process of revising the so called BREF-documents (Best available technique reference documents) with relevant information. These regulations on industry mainly focus on normal operating conditions. Start-up and shut-down procedures as well as abnormal operating conditions are not covered by emission limit values in the IED. The EU leaves this to the competent authority to introduce in individual permits.

Potential weaknesses in the current and proposed legislation for industry could be insufficient regulation of other than normal operating conditions such as start-up and shut-down operations, leaks, malfunctions and momentary stoppages. During such conditions emissions of dioxins, furnace and PCBs could be high due to insufficient combustion, improper temperature in the waste gas flow, or abatement techniques such as filters are not in full operation.

Regarding small scale combustion (residential and commercial) there are proposed regulations under the Eco-design directive. These regulations will introduce product standards for new installations put on the market. It will not cover existing installations, nor will it cover the actual daily performance of the installation.

Potential weaknesses in the current and proposed regulations for small scale combustion could be that it does not cover actual emissions.

Below is a summary of identified regulations limiting emissions of unintentionally formed dioxins, furans and dioxin like PCBs from combustion of fuels and waste. The summary covers regulations that limit the emissions from combustion and incineration in technical units/plants, e.g. industry, production of heat and power (public and residential), waste incineration (on land and offshore), as well as intentional and unintentional outdoor/open fires, combustion and incineration.

Emissions of dioxins and furans from combustion can be correlated to a combination of the fuel (or waste) that is combusted/incinerated, conditions under which the fuel (or waste) is combusted/ incinerated, temperature and cooling of flue gas and flue gas treatment (for example dust-filters). In this summary focus has been on general process requirements and limit values or recommendations for concentration of pollutants in air-emissions from combustion (CO, TOC, PAH, dust and dioxins and furans).
EU-REGULATIONS

Directive 2010/75/EU on industrial emissions (IED)

The IED covers the majority of the largest industrial activities in the EU (about 52 000 installations). It is a compilation revision of the IPPC-directive and six sectorial EU-directives for industrial activities.

According to the EU-commission impact assessment, the industrial activities covered by the IPPC Directive emit about 43% of the EU’s anthropogenic particulate matter and 25% of dioxin emissions to air. Large combustion plants (LCP) within the EU covers a large fraction of the emissions of particulate matters from the industry. The new requirements are expected to reduce these emissions of particulate matter from the LCP-sector by roughly 20% (http://ec.europa.eu/environment/air/pollutants/stationary/ippc/pdf/recast/ia_en.pdf).

As regards emissions of dioxins, furans and dioxin like PCBs the following revised directives are most important:
- Directive 2008/1/EC concerning integrated pollution prevention and control (IPPC-d) – replaced by chapter II of the IED
- Directive 2001/80/EC on the limitation of emissions of certain pollutants from large combustion plants (LCPD) – replaced by chapter III of the IED.
- Directive 2000/76/EC on waste incineration (WID) – replaced by chapter IV of the IED

The revision of the existing EU-directives was mainly aiming at reducing pollution from various industrial sources throughout the European Union.

The IPPC-directive and chapter II of the IED covers the bulk of the large industrial installations within the EU. It requires permitting of these installations and that best available technique are applied to these installations to avoid or minimize emissions from the plants, considering all aspects of the environmental impact of the installation.

One of the most important changes, expected to reduce emissions from the bulk of the industrial installations, is that the conclusions on best available techniques (BAT-conclusions) derived from the reference documents on best available techniques (BREF-documents) will be binding minimum requirements throughout the EU. The BREFs are based on a consensus between technical experts from Member States and from industrial and environmental NGOs. Under the IPPC-directive the BAT-conclusions was only a reference for setting emission limit values or other conditions in the permit for the industrial installation. The emission values presented in the conclusions on best available techniques (decided by the EU-commission) will, under the IED, be mandatory for all installations covered by that BAT-conclusion four years after publication of that BAT-conclusion in the Official Journal.

The BREF-documents will be revised regularly (optimistically every 8th year). About four BREF-documents and BAT-conclusions should be published every year.

The following BAT-conclusions have up to now been published:
- Iron and Steel Production (2012)
Six BREF-documents are in a late stage in the revision process expected to be published in 2013 or 2014. Another three BREF-documents are currently under revision for publication in 2014-2016.


Comment: The BAT associated emission levels in the BAT-conclusions covers normal operating conditions. According to article 14 (1) (f) of the directive, Member States shall ensure that a permit includes all measures necessary to limit pollution also taking into consideration measures relating to conditions other than normal operating conditions such as start-up and shut-down operations, leaks, malfunctions, momentary stoppages and definitive cessation of operations. It could be worth while discussing if such conditions actually are included in the permits and if those are designed to minimise emissions of dioxins and furans.

Below follows brief summaries of a number of BREF:s and BAT-conclusions

The Large combustion plants BREF (Not yet binding BAT-conclusions)
The LCP BREF covers to a large extent the same installations as the LCP-directive and to some extent the Waste Incineration (WI)-directive. The current LCP-BREF contains among others recommendations on combustion temperature and waste and fuel management, as well as BAT associated emission levels for several pollutants: among others Dust, CO, Dioxins and furans. The emission-levels for dust described in the current LCP-BREF are by a large extent in line with the requirements of the LCP –chapter of IED.

The LCP BREF was published in 2006. It is currently (since 2011) undergoing a revision. A first draft is expected to be published in May 2013 and BAT-conclusions is expected to be published in 2014-2015. The conclusions of the BREF will be “mandatory” four years after it is published (i.e. year 2018-2019).

Comment: There are currently no BAT associated emission level for dioxins and furans in the chapter on coal and lignite. Combustion of coal and lignite might result in higher emissions of dioxins and furans than biomass.

Comment: The conclusions of the revised LCP-BREF may perhaps result in BAT associated emissions levels on dioxins and furans as well as stricter emission levels on dust than is currently in the LCP-chapter of the IED. However, the levels might just as well end up at the same level as the requirements of chapter III and IV of the IED, depending on the input to the revision process.

Comment: The BREF-on large combustion plants (LCP) that are currently under revision will to an extent be covering co-incineration of waste. The information in the current BREF on co-incineration is limited.

The Waste incineration BREF (No binding BAT-conclusions)
The WI-BREF covers incineration and co-incineration of waste – the main part of the installations that are covered by the WI-directive. However use of waste as fuel in industrial processes and in heat and power plants might be covered by the BREF-documents for that sector. It contains among others recommendations on combustion temperature and waste and fuel management, as well as BAT
associated emission levels for several pollutants: among others Dust, TOC, CO, Dioxins and furans. The emission-levels and measures/techniques described in the WI-BREF are by and large in line with the requirements of the WI-directive (and chapter IV of the IED). However dust levels are a bit stricter than the WI-directive.

The WI BREF was published in 2005. According to the plan of the IPPC-bureau a revision will start in 201X (2014??). The revision is expected to take 1-2 years. The conclusions of the BREF will be “mandatory” four years after it is published (i.e. around year 2020).

*Comment:* The conclusions of the revised WI-BREF may perhaps result in stricter BAT associated emissions levels than the WI-directive or just as well at the same level as the requirements of chapter IV of the IED depending on the input to the revision process. *(The BREF-on large combustion plants (LCP) that are currently under revision will to an extent be covering co-incineration of waste.)*

**Cement and lime BREF BAT-conclusions**

A number of requirements similar to the ones in the waste incineration directive are introduced (even though the Waste incineration directive and the chapter on waste incineration is already applicable to the combustion of waste in cement and lime kilns).

Examples of techniques to prevent emissions of PCDD/F or to keep the emissions of PCDD/F from the flue-gases of the kiln firing processes low, is:

- Carefully selecting and controlling of kiln inputs (raw materials and fuels),
- Limiting/avoiding the use of wastes which contain chlorinated organic materials
- Avoid feeding fuels with a high content of halogens in secondary firing,
- Quick cooling of kiln flue-gases to lower than 200 °C and minimising residence time of flue-gases and oxygen content in zones where the temperatures range between 300 and 450 °C and stop co-incinerating waste for operations such as start-ups and/or shutdowns

The BAT-associated emission levels for the emissions of PCDD/F from the flue-gases of the kiln firing processes is <0,05 – 0,1 ng PCDD/ F I-TEQ/Nm³, as the average over the sampling period (6 – 8 hours).

*Comment:* thus 0,1 ng/Nm³ should be the least strict emission limit value (under normal operating conditions) set out in operational/environmental permits for cement and lime kilns within the EU.

The BAT-associated emission levels for dust emissions from flue-gases of kiln firing processes is <10 – 20 mg/Nm³, as the daily average value. When applying fabric filters or new or upgraded ESPs, the lower level is achieved.

*Comment:* thus 20 mg/Nm³ should be the least strict emission limit value (under normal operating conditions) set out in operational/environmental permits for cement and lime kilns within the EU

**Directive 2000/76/EU (WID) and chapter IV of directive 2010/75/EU (IED).**
The WID and chapter IV of the IED covers all combustion of waste in any installation (no lower capacity or production threshold). Exempted is combustion of “clean” vegetable wastes, radioactive waste, animal carcases, and waste incinerated on board off-shore installations for oil and gas as well as experimental plants meeting specific requirements.

All plants should have a permit regulating measures which are envisaged to guarantee that the plant is designed, equipped and will be operated in such a manner that the requirements are taking into account the categories of waste to be incinerated. There are a number of possible derogations from these general requirements that can be granted by competent authorities.

Comment: In the questionnaire for implementation of the WI-directive sent out to the EU-member-states the commission asked for information on such derogations. The EU-commission has not yet published a compilation on the replies from the member states. It might be interesting to enquire the number of derogations from these requirements.

The directives consist of requirements on among others lowest combustion temperature as well as emission limit values for dioxins and furans (0,1 ngTEQ/Nm³), dust, total organic carbon, and CO. There are a number of possibilities for derogations from the main requirements.

There are also requirements to be met during malfunction or breakdown of abatement equipment or other abnormal operation - for example, longest period of burning waste under abnormal conditions.

Comment: Limit values dioxins and furans is 0,1 ng (TE) per normal cubic meter (6-8 hour samples two times a year). In most cases sampling/monitoring is conducted under normal operating conditions. Emissions in-between samples might be higher, especially during abnormal operating conditions as well as start-up and shut-down of the plant.

Large combustion plants

The LCP-directive (replaced by chapter III of the IED) regulates emissions of NOX, SO2, Dust (and in the IED also CO for gas fired units/plants). Limiting emissions of dust reduces emissions of dioxins, furans and dioxin like PCBs.

The LCP regulations also to some extent regulates abnormal operating conditions (malfunction or breakdown of the abatement equipment) to limit the time when the plant is not operating with all abatement techniques in full operation. The directives require that the total operational hour during malfunction or breakdown of the abatement equipment should be limited to 120 hours during a 12 month period. The competent authorities should also (according to a decision by the EU-commission in 2012) set out conditions to minimize emissions for start-up and shut down procedures.

Comment: The concentrations of dioxins and furans as well as dioxin like PCBs can be significantly higher (factor 10-10 000) during abnormal operation or start-up and shut-down procedures. If dust filters with a dust reduction rate at >99 % is failing, emissions of dust and dioxins during a day could be more than what is emitted over a three month period at normal operating conditions. How many countries have regulated start-up and shut-down procedures?

The new emission limit values for dust will become more strict for LCP:s due to the requirements of chapter III of the IED. The dust emissions from LCP:s are expected to be reduced by about 20 % according to the EU-commission impact assessment.
Proposal on combustion plants smaller than large combustion plants

According to article 73(3) of the IED there is need to control emissions from the combustion of fuels in installations with a total rated thermal input below 50 MW.

A study was conducted by the consultant “amec” to support the Commission in the examination of different options for including these combustion plants into the IED was finalized in July 2012. The study covers options for controlling emission of SO2, NOx, and dust to air from combustion plants in the range 1-50 MWth. The study shows that all options examined were cost effective.

The commission is expected to report the results of the review to the European Parliament and to the Concil accompanied by a legislative proposal where appropriate.

The Commission has indicated that a report and if appropriate a proposal will be presented in May 2013.


The framework directive does not directly introduce binding requirements for specific products, but defines conditions and criteria for setting, through subsequent implementing measures, requirements regarding environmentally relevant product characteristics.

According to the directive, the implementing measures can be proposed for product categories which meet the following criteria:

- Significant volume of products placed on the EU market (indicatively >200 000 units per year)
- Significant environmental impact
- Significant potential for improvement

The implementing measures are to be based on an environmental assessment taking into account products characteristics and functionality. Technologies available on the market should be taken as a reference.

Currently two proposals for ecodesign requirements of smaller solid fuel combustion units/installations are under preparation (presented by the EU-commission in April and May 2013). Those are ecodesign requirements for the placing on the market and/or putting into service of:

- solid fuel boilers with a rated heat output ≤ 1,000 kW, including those integrated in packages of solid fuel boilers, supplementary heater, temperature control and solar device (Lot-15) and,
- domestic local space heaters with a nominal heat output equal or below 50 kW and commercial local space heaters with a nominal heat output equal or below 70 kW (Lot-20)

These two proposals consist of requirements to limit emissions of particulate matter (PM/Dust), organic gaseous compounds (OGC), carbon monoxide (CO), and nitrogen oxides (NOx).

The EU-commission hopes to have an approval on these proposals in 2013 or 2014. The regulations is then put into force four years after the decision (i.e. around year 2018)
Comment: Dust concentrations in these regulations are at the same magnitude as for existing large combustion plants 30-40 mg/m³. However, these regulations are stating minimum performance requirements to be contained at specified testing conditions. Actual performance under daily usage is not regulated. Poor operation of these appliances must be avoided to limit emissions of dioxins, furans and dioxin like PCBs. These regulations do not cover re-use of boilers or space heaters through for example the second-hand market.

Regulation (EC) No 850/2004 on persistent organic pollutants

The objective of this Regulation is to protect human health and the environment from persistent organic pollutants by prohibiting, phasing out as soon as possible, or restricting the production, placing on the market and use of substances subject to the Stockholm Convention on Persistent Organic Pollutants, or the 1998 Protocol to the Convention on Long-Range Transboundary Air Pollution on Persistent Organic Pollutants, and by minimising, with a view to eliminating where feasible as soon as possible, releases of such substances, and by establishing provisions regarding waste consisting of, containing or contaminated by any of these substances.

Waste consisting of, containing or contaminated by any substance listed shall be disposed of or recovered, in such a way as to ensure that the persistent organic pollutant content is destroyed or irreversibly transformed so that the remaining waste and releases do not exhibit the characteristics of persistent organic pollutants.

Incineration on land, and use principally as a fuel or other means to generate energy (excluding waste containing PCBs) are permitted when applied in such a way as to ensure that the persistent organic pollutant content is destroyed or irreversibly transformed.

Waste framework directive (2008/98/EC)

The directive sets the basic concepts and definitions related to waste management, such as definitions of waste, recycling, recovery. It explains when waste ceases to be waste and becomes a secondary raw material (so called end-of-waste criteria), and how to distinguish between waste and by-products. The Directive lays down some basic waste management principles: it requires that waste be managed without endangering human health and harming the environment, and in particular without risk to water, air, soil, plants or animals, without causing a nuisance through noise or odours, and without adversely affecting the countryside or places of special interest. Waste legislation and policy of the EU Member States shall apply as a priority order the waste management hierarchy.

The directive requires that member states shall take the necessary measures to ensure that waste management is carried out without endangering human health, without harming the environment and, without risk to water, air, soil, plants or animals.

Member States shall also require any establishment or undertaking intending to carry out waste treatment to obtain a permit from the competent authority.

The directive states that measures shall be taken to minimise nuisances and hazards arising from the landfill through among others fires.

**REGULATION (EC) No 1069/2009 laying down health rules as regards animal by-products and derived products not intended for human consumption (Animal by-products Regulation)**

These regulations are laying down health rules. However some regulations are introduced for the protection of the environment. For example rules regarding incineration of carcasses.

Animal carcasses shall be disposed of as waste by incineration, with or without prior processing or recovered or disposed of by co-incineration, with or without prior processing.

According the regulation it shall be ensured that incineration and co-incineration of animal by-products and derived products shall only take place in in incineration plants and co-incineration plants which have been granted a permit in accordance with the Waste Incineration directive or in incineration and co-incineration plants which have been approved by the competent according to the requirements stated in annex III of the COMMISSION REGULATION (EU) No 142/2011.

These regulations do not cover emission limit values for emissions to air. There are regulations on combustion temperature and the level of total organic carbon content in the slag and bottom ashes similar to the requirement of the Waste incineration directive and chapter IV of the IED.

Comment: In these installations it is not uncommon that straw or other fuels are used for heating of stables or other buildings.

**CONVENTIONS**

**The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal**

The overarching objective of the Basel Convention is to protect human health and the environment against the adverse effects of hazardous wastes. The provisions of the Convention center around the following principal aims:

- the reduction of hazardous waste generation and the promotion of environmentally sound management of hazardous wastes, wherever the place of disposal;
- the restriction of transboundary movements of hazardous wastes except where it is perceived to be in accordance with the principles of environmentally sound management; and
- a regulatory system applying to cases where transboundary movements are permissible.
A number of technical guidelines on environmentally sound disposal of hazardous waste is published under the Basel convention that are relevant for directly or indirectly limiting emissions of dioxins, furans and dioxin like PCBs. For example:

- Technical guidelines on the environmentally sound co-processing of hazardous wastes in cement kilns (adopted at COP10)
- Technical guidelines for the environmentally sound management of used and waste pneumatic tires (adopted at COP10)
- Updated general technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants (POPs).
- Technical guidelines on the environmentally sound management of wastes containing or contaminated with unintentionally produced PCDDs, PCDFs, HCB or PCBs
- Technical guidelines for the environmentally sound management of the full and partial dismantling of ships
- Basel Convention Technical Guidelines on Incineration on Land (D10)
- Technical Guidelines for the Environmentally Sound Management of Waste Lead-acid Batteries
- Technical Guidelines on the Environmentally Sound Management of Biomedical and Healthcare Wastes (Y1; Y3)
- Technical guidelines on the environmentally sound recycling/reclamation of metals and metal compounds (R4)

These recommendations covers among others, recommendations on if and how to combust or incinerate different types of hazardous wastes. Some of them consist of examples of emission levels for dioxins and furans as well as dust and CO that could or should be met.

**Stockholm convention**

Under the Stockholm Convention on Persistent Organic Pollutants, Parties shall promote in some cases and require in others the use of best available techniques, and promote the application of best environmental practices. In short, each Party shall:

- Develop, within two years of the date of entry into force of the Convention for it, an action plan (national or regional) where releases of chemicals listed in Annex C of the Convention are identified, characterized and addressed; the plan shall include source inventories and take into consideration the source categories listed in Parts II and III of Annex C (subparagraph (a) of Article 5);

- For new sources:

  Promote and, in accordance with the implementation schedule of its action plan, require the use of best available techniques within source categories identified as warranting such action, with particular initial focus on source categories identified in Part II of Annex C; the requirement to use best available techniques for Part II source categories shall be phased in as soon as practicable, but no later than four years after entry into force of the Convention for the Party (subparagraph (d) of Article 5);
Promote, for those categories identified above, the use of best environmental practices (subparagraph (d) of Article 5); Promote, in accordance with its action plan, best available techniques and best environmental practices within source categories such as those listed in Part III of Annex C which a Party has not addressed above (subparagraph (e) (ii) of Article 5);

• For existing sources:

Promote, in accordance with its action plan, the use of best available techniques and best environmental practices for source categories listed in Part II of Annex C and such sources as those in Part III of the Annex (subparagraph (e) (i) of Article 5).

When applying best available techniques and best environmental practices, Parties should take into consideration the general guidance on prevention and release reduction measures in Annex C and guidelines on best available techniques and best environmental practices.

A number of extensive technical guidelines on combustion of fuels and waste as well as other processes are published under the Stockholm convention that are relevant for directly or indirectly limiting emissions of dioxins, furans and dioxin like PCBs. These are assembled in the “Guidelines on best available techniques and provisional guidance on best environmental practices relevant to Article 5 and Annex C of the Stockholm convention on Persistent Organic Pollutants”

**Comment: Table 2 of section VI C of “Guidelines on best available techniques and provisional guidance on best environmental practices relevant to Article 5 and Annex C of the Stockholm convention on Persistent Organic Pollutants” that coal gives arise to significantly higher emissions of dioxins than firing wood and coke. It might be useful to discuss limitations to the use of coal for domestic heating and cooking. See table 1-3 below on residential combustion copied from that guideline.**
The aim of the Convention is that Parties shall endeavor to limit and, as far as possible, gradually reduce and prevent air pollution including long-range transboundary air pollution. Parties develop policies and strategies to combat the discharge of air pollutants through exchanges of information, consultation, research and monitoring.

The Convention, has 51 Parties in Europe, North America and Caucasus.

Under the convention there are three newly revised protocols (to be ratified by the parties before entering into force) that are directly or indirectly relevant for limiting emissions of dioxins, furans and dioxin like PCBs in the northern hemisphere:

- The 1998 Protocol on Heavy Metals; limiting emissions of, among others, dust.
- For parties outside North America there are limit values on dust for Large combustion plants, Primary and secondary iron and steel industry, Iron foundries, Production and processing of...
copper, zinc and silico- and ferro-manganese alloys, Production and processing of lead, Cement industry, Glass industry, as well as Waste incineration.
- The 1998 Aarhus Protocol on Persistent Organic Pollutants (POPs)
  According to the protocol each party shall:
  - reduce its total annual emissions of PAH, Dioxins and furans, HCBs and PCBs in relation to a country specific reference year.
  - apply best available techniques, taking into consideration what is stated in an annex to the protocol, to each new stationary source within the major stationary source categories.
  - apply limit values for dioxins for incinerators (municipal and medical solid waste, hazardous waste and non-hazardous industrial waste) as well as sinter-plants and electric arc furnaces.

**Comment:** Emission limit values and BAT-guidance relates to normal operating conditions (except for batch processes). A Party may, as an alternative, apply different emission reduction strategies that achieve equivalent overall emission reductions Consist of a number of emission limit values for dioxin.

- The revised 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (Gothenburg protocol)
  - The protocol regulates emissions of NOx, SO2, NH3, NMVOC and particulate matters.
  - It consist of emission ceilings for NOx, SO2, NH3 and NMVOC and emission reduction commitments for PM 2,5 from 2005 to 2020. The reduction commitment for 2020 on PM2,5 for the EU is proposed to be 22% of the emissions in 2005 (equivalent to approximately 300 000 tonnes).
  - It consist emission limit values for NOx, SO2, NH3, NMVOC and particulate matters
  - It consist of emission limit values on dust for industrial activities.

  **Comment:** those are in line with the requirements in current EU-legislation (IED, LCPD, WID, IPPCD)

- It consists of recommended emission limit values on dust for new residential small scale combustion to be used with product standards (< 500 kWth).
- It consist of recommended emission limit values on dust for new and existing not residential boilers and process preheaters (100 kWth – 1000 kWth).

**Comment:** The emission levels are for normal operating conditions (not during start-up, shut-down or abnormal operation). Recommended emission limit values are just recommendations. Recommendations for new residential combustion units cover performance under test conditions.