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Integrated Pollution Prevention and Control

Executive Summary of Reference Document on the Best Available Techniques for Waste Incineration

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EXECUTIVE SUMMARY

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

Scope of this document

The scope of this document is based on Sections 5.1 and 5.2 of Annex 1 of the IPPC Directive 96/61/EC, in so far as they deal with incineration of waste. The scope chosen for the work was not restricted by the installation size limitations in the IPPC Directive, nor by the definitions of waste, recovery or disposal included therein. The selected scope therefore intended to provide a pragmatic view across the incineration sector as a whole, with a particular focus upon those installation and waste types that are most common. The scope of the Waste Incineration Directive was also a factor taken into account when deciding on the scope of the BREF document. The final contents of the BREF reflect the information that was submitted during the information exchange by the TWG.

The document deals only with the dedicated incineration of waste and not with other situations where waste is thermally treated, e.g. co-incineration processes such as cement kilns and large combustion plants.

Although incineration provides the main focus of the document, it also includes some information on waste pyrolysis and gasification systems.

This BREF document does not:

- deal with decisions concerning the selection of incineration as a waste treatment option
- compare waste incineration with other waste treatment options.

Waste Incineration (WI)

Incineration is used as a treatment for a very wide range of wastes. Incineration itself is commonly only one part of a complex waste treatment system that altogether, provides for the overall management of the broad range of wastes that arise in society.

The incineration sector has undergone rapid technological development over the last 10 to 15 years. Much of this change has been driven by legislation specific to the industry and this has, in particular, reduced emissions to air from individual installations. Continual process development is ongoing, with the sector now developing techniques which limit costs, whilst maintaining or improving environmental performance.

The objective of waste incineration, in common with most waste treatments, is to treat waste so as to reduce its volume and hazard, whilst capturing (and thus concentrating) or destroying potentially harmful substances. Incineration processes can also provide a means to enable recovery of the energy, mineral and/or chemical content from waste.

Basically, waste incineration is the oxidation of the combustible materials contained in the waste. Waste is generally a highly heterogeneous material, consisting essentially of organic substances, minerals, metals and water. During incineration, flue-gases are created that will contain the majority of the available fuel energy as heat. The organic substances in the waste will burn when they have reached the necessary ignition temperature and come into contact with oxygen. The actual combustion process takes place in the gas phase in fractions of seconds and simultaneously releases energy. Where the calorific value of the waste and oxygen supply is sufficient, this can lead to a thermal chain reaction and self-supporting combustion, i.e. there is no need for the addition of other fuels.

Although approaches vary greatly, the incineration sector may approximately be divided into the following main sub-sectors:

i. Mixed municipal waste incineration – treating typically mixed and largely untreated household and domestic wastes but may sometimes including certain industrial and commercial wastes (industrial and commercial wastes are also separately incinerated in dedicated industrial or commercial non-hazardous waste incinerators).

ii. Pretreated municipal or other pretreated waste incineration – installations that treat wastes that have been selectively collected, pretreated, or prepared in some way, such that the characteristics of the waste differ from mixed waste. Specifically prepared refuse derived fuel incinerators fall in this sub-sector

iii. Hazardous waste incineration - this includes incineration on industrial sites and incineration at merchant plants (that usually receive a very wide variety of wastes)

iv. Sewage sludge incineration – in some locations sewage sludges are incinerated separately from other wastes in dedicated installations, in others such waste is combined with other wastes (e.g. municipal wastes) for its incineration

v. Clinical waste incineration – dedicated installations for the treatment of clinical wastes, typically those arising at hospitals and other healthcare institutions, exist as centralised facilities or on the site of individual hospital etc. In some cases certain clinical wastes are treated in other installations, for example with mixed municipal or hazardous wastes.

Data in this document shows that, at the time of its compilation:

- Around 20 - 25 % of the municipal solid waste (MSW) produced in the EU-15 is treated by incineration (total MSW production is close to 200 million tonnes per year)
- The percentage of MSW treated by incineration in individual Member States of the EU-15 varies from 0 % to 62 %
- The total number of MSW installations in the EU-15 is over 400
- Annual MSW incineration capacity in individual European countries varies from 0 kg to over 550 kg per capita
- In Europe the average MSW incinerator capacity is just under 200000 tonnes per year.
- The average throughput capacity of the MSWI installations in each MS also varies. The smallest plant size average seen is 60000 tonnes per year and the largest close to 500000 tonnes per year
- Around 12 % of the hazardous waste produced in EU-15 is incinerated (total production close to 22 million tonnes per year).

Expansion of the MSW incineration sector is anticipated in Europe over the next 10 – 15 years as alternatives are sought for the management of wastes diverted from landfill by the Landfill Directive and both existing and new Member States examine and implement their waste management strategies in the light of this legislation.

Key environmental issues

Waste and its management are a significant environmental issue. The thermal treatment of waste may therefore be seen as a response to the environmental threats posed by poorly or unmanaged waste streams. The target of thermal treatment is to provide for an overall reduction in the environmental impact that might otherwise arise from the waste. However, in the course of the operation of incineration installations, emissions and consumptions arise, whose existence or magnitude is influenced by the installation design and operation.

The potential impacts of waste incineration installations themselves fall into the following main categories:

- overall process emissions to air and water (including odour)
- overall process residue production
- process noise and vibration
- energy consumption and production
- raw material (reagent) consumption
- fugitive emissions – mainly from waste storage
- reduction of the storage/handling/processing risks of hazardous wastes.

Other impacts beyond the scope of this BREF document (but which can significantly impact upon the overall environmental impact of the whole chain of waste management) arise from the following operations:

- transport of incoming waste and outgoing residues
- extensive waste pretreatment (e.g. preparation of waste derived fuels).

The application and enforcement of modern emission standards, and the use of modern pollution control technologies, has reduced emissions to air to levels at which pollution risks from waste incinerators are now generally considered to be very low. The continued and effective use of such techniques to control emissions to air represents a key environmental issue.

Other than its role in ensuring effective treatment of otherwise potentially polluting unmanaged wastes, many waste incineration installations have a particular role as an energy-from-waste recovery process. Where policies have been implemented to increase the ability of, (most commonly municipal) waste incineration installations to recover the energy value of the waste, this increases the exploitation of this positive environmental contribution. A significant environmental opportunity for the industry is therefore to increase its potential as an energy supplier.

Applied processes and techniques

Chapter 2 of this document provides a description of the processes and techniques that are applied in the waste incineration industry. It focuses upon the most commonly applied thermal treatment of incineration, but also includes information on gasification and pyrolysis. The following main activities and areas are described to varying degrees of detail:

- incoming waste reception
- storage of waste and raw materials
- pretreatment of waste (mainly on-site treatments and blending operations)
- loading of waste into the furnace
- techniques applied at the thermal treatment stage (furnace design etc.)
- the energy recovery stage (e.g. boiler and energy supply options)
- flue-gas cleaning techniques (grouped by substance)
- flue-gas cleaning residue management
- emissions monitoring and control
- waste water control and treatment (e.g. from site drainage, flue-gas treatment, storage)
- ash/bottom ash management and treatment (arising from the combustion stage).

Where techniques are specific to certain types of wastes, relevant sections are subdivided according to waste type.

Consumptions and emissions

The emissions, and material and energy consumptions, that arise from waste incineration installations are described in Chapter 3. Available data are presented on installation emissions to air and water, noise, and residues. Information on raw material consumptions is also provided, along with a section that focuses upon energy consumption and output. Most of the data are whole installation data arising from industrial surveys. Some information about the techniques applied in order to achieve these emission levels is also included.

Although some European installations have yet to be upgraded, the industry is generally achieving operational levels that meet or improve upon the air emission limit values set in Directive 2000/76/EC.

In circumstances where CHP or heat (as heat or steam) can be supplied, it is possible for very large percentages of the energy value of the waste (approx. 80 % in some cases) to be recovered.

Techniques to consider in the determination of BAT

Each technique described in Chapter 4 includes the available relevant information, on: the consumption and emission levels achievable using the technique; some idea of the costs and the cross-media issues associated with the technique, and; information on the extent to which the technique is applicable to the range of installations requiring IPPC permits - for example new, existing, large or small installations, and to various waste types. Management systems, process-integrated techniques and end-of-pipe measures are included.

The techniques that are included are those that are considered to have the potential to achieve, or contribute to, a high level of environmental protection in the waste incineration industry. The final BAT, as agreed by the TWG, is not covered in Chapter 4, but in Chapter 5. The inclusion of a technique in Chapter 4, but not in Chapter 5 should not be taken as an indication that the technique is not and cannot be BAT - the rationale for excluding the technique from Chapter 5 could, for example, be that the TWG felt that the technique not sufficiently widely applicable for it to be described as *BAT in general*. Furthermore, because it is not possible to be exhaustive and because the situation is dynamic, Chapter 4 cannot be considered to be entirely comprehensive. Other techniques may also provide for levels of performance that meet or exceed the BAT criteria later established in Chapter 5, and when applied locally those techniques may provide particular advantages in the situation in which they are used.

The techniques included are grouped in approximately the order in which they would appear in the majority of waste incineration installations. The table below gives the title of the chapter subsections and indicates the grouping to which the techniques are listed.

Chapter 4 section number	Title of section
4.1	General practices applied before thermal treatment
4.2	Thermal processing
4.3	Energy recovery
4.4	Flue-gas treatment
4.5	Process water treatment and control
4.6	Treatment techniques for solid residues
4.7	Noise
4.8	Environmental management tools
4.9	Good practice for public awareness and communication

Table: Organisation chart for the information in Chapter 4

Chapter 4 concentrates on techniques that provide particular advantages at each of the main stages generally seen in waste incineration installations. Dividing the techniques in this way does however mean that, although mentioned in some cases, the important aspect of the overall integration of all of the techniques in an installation (sometimes referred to in the BREF as their "inter-process compatibility") is something which requires careful consideration when reading the individual sections of Chapter 4. The subsections on *operational data* and *applicability* are generally where such matters are given consideration. Overall compatibility was also been given further consideration when finally deriving the BAT conclusions in Chapter 5.

Chapter 4 does not generally describe in detail those techniques that, whilst they provide, or contribute to, a high level of environmental performance, are so common that their use may already be considered as standard. An example of this is that, because the applicability of the main combustor designs to the main waste streams is relatively well established, the techniques considered at this stage concentrate mainly on:

a) the general issue of ensuring the combustion system selected is properly matched to the wastes fed to it, and
b) on some aspects relating to improving combustion performance e.g. waste preparation, air supply control, etc.

BAT for the incineration of waste

The BAT chapter (Chapter 5) identifies those techniques that the TWG considered to be BAT in a general sense, based on the information in Chapter 4, taking into account the Article 2(11) definition of best available techniques and the considerations listed in Annex IV of the Directive.

The BAT chapter does not set or propose emission limit values but suggests the operational consumption and emission values that are associated with the use of BAT. The introduction to Chapter 5 included in this BREF is specifically extended to clarify certain issues that were considered to be of particular relevance to the waste incineration industry, including the links between the Waste Incineration Directive (WID) and IPPC (see the preface of the BREF). These additional specific issues include:

- the difference between WID emission limit values and BAT performance
- the relationship between BAT and site selection
- how to understand and use the BAT described in Chapter 5.

The following paragraphs summarise the key BAT conclusions but **reference must be made to the BAT chapter itself to be comprehensive**. The generic BAT are intended to apply to the whole sector (i.e. waste incineration, waste gasification and waste pyrolysis of whatever type of waste). Other BAT are given that apply to sub-sectors dealing primarily with specific waste streams. It is therefore anticipated that a specific installation would apply a combination of the generic and waste specific BAT, and that installations treating mixtures of waste, or wastes not specifically mentioned, would apply the generic BAT plus a suitable selection of the waste specific BAT. Further comment on the combining of the BAT is included in the introduction to Chapter 5.

Generic BAT

A fundamental BAT stresses the importance of the selecting an installation design that is suited to the characteristics of the waste received at the installation in terms of both its physical and chemical characteristics. This BAT is fundamental to ensuring the installation may treat the waste received with a minimum of process disturbances – which themselves may give rise to additional environmental impacts. To this end there is also a BAT about the minimisation of planned and unplanned shutdowns.

BAT includes establishing and maintaining quality controls over the waste input. This aims to ensure that the waste characteristics remain suited to the design of the receiving installation. Such quality control procedures are compatible with the application of an environmental management system, which is also considered BAT.

There are several BAT regarding the conditions and management of the storage of incoming wastes prior to their treatment, so that this does not give rise to pollution and odour releases. Some specific techniques and conditions of storage are noted. A risk based approach that takes into account the properties of the waste concerned is considered BAT.

Consideration of the demonstrated ability of some installation designs to very efficiently treat highly heterogeneous wastes (e.g. mixed MSW), and the risks and cross-media effects associated with pretreatment, results in a conclusion that it is BAT to pretreat incoming wastes to the degree required to meet the design specification for the receiving installation, noting that to treat wastes beyond this requires balanced consideration of (possibly limited) benefits, operational factors and cross-media effects.

The design and operation of the combustion stage is identified as an important primary pollution prevention aspect, and therefore of great relevance to achieving the aims of the IPPC Directive. It is noted in the BAT chapter that flow modelling at the design stage may assist in ensuring that certain key design decisions are well informed. In operation, it is considered BAT to use various techniques (e.g. control of air supply and distribution) to control combustion. The BAT regarding the selection of a design that suits the waste received is of particular relevance here.

In general the use of the combustion operating conditions specified in Article 6 of Directive 2000/76/EC (WID) are considered to be compatible with BAT. However the TWG noted, that the use of conditions in excess of these (e.g. higher temperatures) could result in an overall deterioration in environmental performance, and that there were several examples of hazardous waste installations that had demonstrated an overall improvement in environmental performance when using lower operational temperatures than the 1100 ^{o}C specified in WID for certain hazardous wastes. The general BAT conclusion was that the combustion conditions (e.g. temperature) should be sufficient to achieve the destruction of the waste but, in order to limit potential cross-media impacts, generally not significantly in excess of those conditions. The provision of auxiliary burner(s) for achieving and maintaining operational conditions is considered to be BAT when waste is being burned.

When gasification or pyrolysis is used, in order to prevent the generation of waste by disposal of the reaction products of these techniques, it is BAT either, to recover the energy value from the products using a combustion stage, or to supply them for use. The BAT associated emission levels for releases to air from the combustion stage of such installations are the same as those established for incineration installations.

The recovery of the energy value of the waste is a key environmental issue for the sector, presenting an area where the sector may make a significant positive contribution. Several BAT cover this aspect, dealing with:

- specific techniques that are considered to be BAT
- the heat transfer efficiencies expected of boilers
- the use of CHP, district heating, industrial steam supply and electricity production
- the recovery efficiencies that may be anticipated.

With CHP and steam/heat supply generally offering the greatest opportunity for increasing energy recovery rates, policies affecting the availability of suitable customers for steam/heat generally play a far greater role in determining the efficiency achievable at an installation than the detail of its design. For mainly policy and economic reasons, electricity generation and supply is often the energy recovery option selected at individual installations. Options for CHP, district heating and industrial steam supply are only well exploited in a few European Member States – generally those that have high heat prices and/or that have adopted particular policies. The supply of energy for the operation of cooling systems and desalination plants is something that is done, but is in general poorly exploited – such an option may be of particular interest in warmer climate zones, and in general expands the options for the supply of waste derived energy.

The flue-gas treatments applied at waste incineration installations have been developed over many years in order to meet stringent regulatory standards and are now highly technically advanced. Their design and operation are critical to ensure that all emissions to air are well controlled. The BAT that are included:

- cover the process of selection of FGT systems
- describe several specific techniques which are considered to be BAT
- describe the performance levels that are anticipated from the application of BAT.

The performance ranges agreed by the wider TWG resulted in some split views. These were mainly from one Member State and the Environmental NGO, who believed that lower emission values than the ranges agreed by the remainder of the TWG could also be considered to be BAT.

The BAT regarding waste water control include:

- the in-process recirculation of certain effluents
- the separation of drainage for certain effluents
- the use of on-site effluent treatment for wet scrubber effluents
- BAT associated performance levels for emissions from scrubber effluent treatment
- the use of specific techniques.

The performance ranges agreed by the wider TWG resulted in some split views from one Member State and the Environmental NGO, who believed that lower emission values than the ranges given could also be considered to be BAT.

BAT regarding residue management include:

- a bottom ash burnout TOC level of below 3 %, with typical values falling between 1 and 2 %
- a list of techniques, which when suitably combined may attain these burnout levels
- the separate management of bottom ash from fly ash and a requirement to assess each stream produced
- the extraction of ferrous and non-ferrous metals from ash for their recovery (where present in ash to sufficient degree to make this viable)
- the treatment of bottom ashes and other residues using certain techniques - to the extent required for them to meet the acceptance criteria at the receiving recovery or disposal site.

In addition to these generic BAT, more specific BAT are identified for those sub-sectors of the industry treating mainly the following wastes:

- municipal wastes
- pretreated or selected municipal wastes
- hazardous wastes
- sewage sludge
- clinical waste.

The specific BAT provide, where it has been possible, more detailed BAT conclusions. These conclusions deal with the following waste stream specific issues:

- in-coming waste management, storage and pretreatment
- combustion techniques
- energy recovery performance.

Emerging techniques

The section on emerging techniques is not comprehensive. A number of the techniques supplied by the TWG and included in earlier drafts of this document were transferred into this section. In the majority of cases the techniques included have only been demonstrated on a pilot or trial scale.

The degree of demonstration (as measured by overall throughput and operational hours) of pyrolysis and gasification on the main European waste streams is low compared with incineration and operational difficulties are reported at some installations. However, both gasification and pyrolysis are applied in the sector and therefore, according to the BREF definition, cannot be considered to be *emerging techniques*. For this reason the information concerning these techniques is included in Chapter 4.

Concluding remarks

Information exchange
This BREF is based on several hundred sources of information, and over 7000 consultation comments supplied by a very large working group. Some of the information was overlapping and therefore, not all of the documents supplied are referenced in the BREF. Both industry and Member States supplied important information. Data quality was generally good, particularly for emissions to air, allowing valid comparisons to be made in some cases. This was not however uniformly the case, and data regarding costs was difficult to compare owing to inconsistencies in data compilation and reporting. The consumption and emissions data given are predominantly for whole installations or groups of techniques, rather than individual ones. This has lead to some important BAT conclusions being expressed as quantitative overall performance targets, with certain technical options presented that when suitably combined, may give rise to that performance.

Level of consensus
There was a very good general level of consensus. There was full agreement, and no split views, in relation to the technique related BAT. There was also generally good consensus upon the quantitative BAT, although the operational emission levels associated with the use of BAT did give rise to some split views, with one Member State and the Environmental NGO recording split views in relation to many of the BAT associated emission levels for releases to both air and water.

Recommendations for future work and R&D projects

The information exchange and its result, i.e. this BREF, provide a step forward in achieving the integrated prevention and control of pollution from waste incineration. Further work could continue the process by providing:

- information regarding the techniques used to, and costs of, upgrading existing installations – such information may be derived from experience of implementing WID in Member States and might usefully be compared with the costs/performance at new installations
- the more detailed cost information that is required to undertake a more precise assessment of variations in technique affordability with plant size and waste type
- information regarding smaller installations – very little information was provided regarding small installations
- information regarding installations that treat industrial non-hazardous wastes and the impact on installations of treating mixtures of wastes e.g. sewage sludge or clinical waste with MSW
- a more detailed evaluation of the impact on pollution prevention of detailed combustion design features e.g. grate design
- further information on emerging techniques.
- ammonia consumption and emission (mainly to air and water) levels for different FGT systems (mainly wet, semi-wet and dry) and their relative NO_X reduction efficiency
- the impact of the dust removal temperature range upon PCDD/F releases to air and residues
- further experiences with continuous emissions monitoring for Hg (to air and water).

Other important recommendations for further work beyond the scope of this BREF but arising from the information exchange are:

- the need for consideration of the overall impact of competition for waste treatment, in particular competition from industries co-incinerating wastes – a study of such might usefully include consideration of: relative reliability of, and risks to, the supply of the total waste management service; overall emissions and energy recovery according to various degrees of diversion, and; consider and identify key risk factors e.g. waste fuel quality assurance.
- it may be useful to assess the impact on adopted waste strategies (i.e. the balance of technologies used on a national scale), and on achieved thermal treatment installation efficiencies, of the degree of integration of energy and waste management policy in EU Member States (and other countries). Such studies may identify how policy on energy and waste interact and give examples, both positive and negative.
- the need to understand in more detail of the impact of absolute and relative energy prices (for electricity and heat) upon the typically achieved energy efficiency of installations, and the role and impact of subsidies and taxation schemes
- the identification of the typical barriers to developing new installations and the approaches that have proved successful
- the development of suitable standards for the use of bottom ash – such standards have proved helpful in improving markets for the use of bottom ash
- the costs and benefits of further reducing emissions from the waste incineration industry when compared to reductions at other industrial and anthropogenic sources of pollution.

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