EUROPEAN COMMISSION

Integrated Pollution Prevention and Control

Reference Document on
Best Available Techniques for

Large Combustion Plants

July 2006

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

Reference Document on Best Available Techniques...	**Code**
Large Combustion Plants	LCP
Mineral Oil and Gas Refineries	REF
Production of Iron and Steel	I&S
Ferrous Metals Processing Industry	FMP
Non Ferrous Metals Industries	NFM
Smitheries and Foundries Industry	SF
Surface Treatment of Metals and Plastics	STM
Cement and Lime Manufacturing Industries	CL
Glass Manufacturing Industry	GLS
Ceramic Manufacturing Industry	*CER*
Large Volume Organic Chemical Industry	LVOC
Manufacture of Organic Fine Chemicals	OFC
Production of Polymers	POL
Chlor – Alkali Manufacturing Industry	CAK
Large Volume Inorganic Chemicals - Ammonia, Acids and Fertilisers Industries	LVIC-AAF
Large Volume Inorganic Chemicals - Solid and Others industry	LVIC-S
Production of Speciality Inorganic Chemicals	SIC
Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector	CWW
Waste Treatments Industries	WT
Waste Incineration	WI
Management of Tailings and Waste-Rock in Mining Activities	MTWR
Pulp and Paper Industry	PP
Textiles Industry	TXT
Tanning of Hides and Skins	TAN
Slaughterhouses and Animals By-products Industries	SA
Food, Drink and Milk Industries	FDM
Intensive Rearing of Poultry and Pigs	ILF
Surface Treatment Using Organic Solvents	STS
Industrial Cooling Systems	CV
Emissions from Storage	ESB
Reference Document...	
General Principles of Monitoring	MON
Economics and Cross-Media Effects	ECM
Energy Efficiency Techniques	ENE

EXECUTIVE SUMMARY

The BAT (Best Available Techniques) Reference Document (BREF) entitled 'Large Combustion Plants' 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, the principal BAT conclusions and the associated emission levels. It can be read and understood as a standalone document but as a summary, it does not present all the complexities of the full BREF text (e.g. full detail of the BAT sections). It is, therefore, not intended as a substitute for the full BREF text as a tool in BAT decision-making and it is strongly recommended to read this summary together with the preface and standard introduction to BAT sections.

More than 60 experts from Member States, industry and environmental NGOs have participated in this information exchange.

Scope
This BREF covers, in general, combustion installations with a rated thermal input exceeding 50 MW. This includes the power generation industry and those industries where 'conventional' (commercially available and specified) fuels are used and where the combustion units are not covered within another sector BREF. Coal, lignite, biomass, peat, liquid and gaseous fuels (including hydrogen and biogas) are regarded as conventional fuels. Incineration of waste is not covered, but co-combustion of waste and recovered fuel in large combustion plants is addressed. The BREF covers not only the combustion unit, but also upstream and downstream activities that are directly associated to the combustion process. Combustion installations which use process-related residues or by-products as fuel, or fuels that cannot be sold as specified fuels on the market as well as combustion processes which is an integrated part of a specific production process are not covered by this BREF.

Submitted Information
A large number of documents, reports and information from Member States, industry, operators and authorities as well as from suppliers of equipment and environmental NGOs have been used to draft the document. Information was further obtained during site visits to different European Member States and by personal communication on selection of technology and on experiences with the application of reduction techniques.

Structure of the document
Electricity (power) and/or heat generation in Europe is a diverse sector. Energy generation is based on a variety of fuels, which can generally be classified by their aggregate state into solid, liquid or gaseous fuels. This document has, therefore, been written vertically, fuel by fuel, but with common aspects and techniques described together in the three introductory chapters.

The European Energy Industry
In the European Union, all available types of energy sources are used for electric and thermal power generation. National fuel resources such as the local or national availability of coal, lignite, biomass, peat, oil and natural gas, largely influence the choice of fuel used for energy generation in each EU Member State. Since 1990, the amount of electric power generated from fossil fuel energy sources increased by about 16 % and demand increased by about 14 %. The amount of electric power generated from renewable energy sources (including hydropower and biomass) shows an above average increase of approximately 20 %.

Combustion plants are operated according to energy demand and requirement, either as large utility plants or as industrial combustion plants providing power (e.g. in the form of electricity, mechanical power), steam, or heat to industrial production processes.

Technologies used
Power generation in general utilises a variety of combustion technologies. For the combustion of solid fuels, pulverised combustion, fluidised bed combustion as well as grate firing are all considered to be BAT under the conditions described in this document. For liquid and gaseous fuels, boilers, engines and gas turbines are BAT under the conditions described in this document.

The choice of system employed at a facility is based on economic, technical, environmental and local considerations, such as the availability of fuels, the operational requirements, market conditions, network requirements. Electricity is mainly generated by producing steam in a boiler fired by the selected fuel and the steam is used to power a turbine which drives a generator to produce electricity. The steam cycle has an inherent efficiency limited by the need to condense the steam after the turbine.

Some liquid and gas fuels can be directly fired to drive turbines with the combustion gas or they can be used in internal combustion engines which can then drive generators. Each technology offers certain advantages to the operator especially in the ability to be operated according to variable power demand.

Environmental Issues
Most combustion installations use fuel and other raw materials taken from the earth's natural resources, converting them into useful energy. Fossil fuels are the most abundant energy source used today. However, their burning results in a relevant and, at times, significant impact on the environment as a whole. The combustion process leads to the generation of emissions to air, water and soil, of which emissions to the air are considered to be one of the main environmental concerns.

The most important emissions to air from the combustion of fossil fuels are SO_2, NO_X, CO, particulate matter (PM_{10}) and greenhouse gases, such as N_2O and CO_2. Other substances such as heavy metals, halide compounds, and dioxins are emitted in smaller quantities.

Conditions
The BAT associated emission levels are based on daily average, standard conditions and an O_2 level of 6 % / 3 % / 15 % (solid fuels / liquid and gasous fuels / gas turbines) which represents a typical load situation. For peak loads, start up and shut down periods as well as for operational problems of the flue-gas cleaning systems, short-term peak values, which could be higher, have to be considered.

Unloading, storage and handling of fuel and additives
Some BAT for preventing releases from the unloading, storage and handling of fuels, and also for additives such as lime, limestone, ammonia, etc. are summarised in Table 1.

	BAT
Particulate matter	• the use of loading and unloading equipment that minimises the height of fuel drop to the stockpile, to reduce the generation of fugitive dust (solid fuels) • in countries where freezing does not occur, using water spray systems to reduce the formation of fugitive dust from solid fuel storage (solid fuels) • placing transfer conveyors in safe, open areas aboveground so that damage from vehicles and other equipment can be prevented (solid fuels) • using enclosed conveyors with well designed, robust extraction and filtration equipment on conveyor transfer points to prevent the emission of dust (solid fuels) • rationalising transport systems to minimise the generation and transport of dust on site (solid fuels) • the use of good design and construction practices and adequate maintenance (all fuels) • storage of lime or limestone in silos with well designed, robust extraction and filtration equipment (all fuels)
Water contamination	• having storage on sealed surfaces with drainage, drain collection and water treatment for settling out (solid fuels) • the use of liquid fuel storage systems that are contained in impervious bunds that have a capacity capable of containing 75 % of the maximum capacity of all tanks or at least the maximum volume of the largest tank. Tank contents should be displayed and associated alarms used and automatic control systems can be applied to prevent the overfilling of storage tanks (solid fuels) • pipelines placed in safe, open areas aboveground so that leaks can be detected quickly and damage from vehicles and other equipment can be prevented. For non-accessible pipes, double walled type pipes with automatic control of the spacing can be applied (liquid and gaseous fuels) • collecting surface run-off (rainwater) from fuel storage areas that washes fuel away and treating this collected stream (settling out or waste water treatment plant) before discharge (solid fuels)
Fire prevention	• surveying storage areas for solid fuels with automatic systems, to detect fires, caused by self-ignition and to identify risk points (solid fuels)
Fugitive emissions	• using fuel gas leak detection systems and alarms (liquid and gaseous fuels)
Efficient use of natural resources	• using expansion turbines to recover the energy content of the pressurised fuel gases (natural gas delivered via pressure pipelines) (liquid and gaseous fuels) • preheating the fuel gas by using waste heat from the boiler or gas turbine (liquid and gaseous fuels).
Health and safety risk regarding ammonia	• for handling and storage of pure liquified ammonia: pressure reservoirs for pure liquified ammonia >100 m^3 should be constructed as double wall and should be located subterraneously; reservoirs of 100 m^3 and smaller should be manufactured including annealling processes (all fuels) • from a safety point of view, the use of an ammonia-water solution is less risky than the storage and handling of pure liquefied ammonia (all fuels).

Table 1: Some BAT for storage and handling of fuel and additives

Fuel pretreatment

Fuel pretreatment of solid fuel mainly means blending and mixing in order to ensure stable combustion conditions and to reduce peak emissions. To reduce the amount of water in peat and biomass, drying of fuel is also considered to be part of BAT. For liquid fuels, the use of pretreatment devices, such as diesel oil cleaning units used in gas turbines and engines, are BAT. Heavy fuel oil (HFO) treatment comprises devices such as electrical or steam coil type heaters, de-emulsifier dosing systems, etc.

EXAMPLE 5.2.3.3 INDUSTRIAL SPREADER-STOKER CHP PLANT WITH SNCR AND FABRIC FILTER

Description: The spreader-stoker technique described here will be illustrated with three examples of almost identical chip board plants operated in France and Germany. In Table 5.12 all substantial parameters for the three plants are summarised. These plants are mainly used for the valorisation of wood residues and wood dust and provide the heat demand for chip board production. Therefore, a high and constant energy demand is ensured.

	Plant A	Plant B	Plant C
Year of implementation	1994	1997	2000
Rated thermal input (MW)	50	73.5	57.7 (grate firing, maximal 28 MW of it delivered by wood dust burners) + 6.7 (Thermo oil boilers: wood dust + extra light fuel oil)
Gross electric power (MW)		16.6 (maximal) 11 (annual mean)	13.3
Availability	Operational life cycle times >5000 h, availability 99.8 %	Operational life cycle times >5000 h	Operational life cycle times >5000 h
Maximal rated thermal input (MW)		63	35 + 6.7
Overall gross energy efficiency (%)		96.6 max.	c. 85 %
Main steam parameters		450 °C, 67 bar	455 °C, 70 bar
Main fuels	Production residues, waste wood, railway sleepers, etc.		

Table 5.12: Technical data for the three example plants

The following description of the technique refers to all three example plants, unless otherwise specified. The spreader-stoker technique is a combustion on an air-cooled travelling-grate stoker, the fuel being evenly spread on the grate by an injection-stoker, which throws the particles in. While the bigger pieces are evenly burned in a fixed bed combustion on the grate, the smaller particles are ignited in a fluidised bed separately above the combustion chamber (this applies to about 50 % of the fuel). This provides good conditions for a high combustion efficiency and residence times of four to five seconds result. Therefore, the air rate can be minimised (O_2 content in the raw gas of less than 3 %), which also reduces NO_X emissions.

The formation of a fluidised bed is possible because the velocity of the flue-gas is similar to the velocity occurring in fluidised bed combustions. The formation of a fluidised bed also means a staging of the fuel, supporting low NO_X combustion. Also the low maximal temperature of 1250 °C supports this effect.

Half of the air is injected by a jet tray, the other half is blown in at a high pressure through nozzles on the walls. Thus, it is a staged combustion with under stoichiometric conditions at the bottom and high turbulence at the same time.

The spreader-stoker plant realises an intensive combustion at high temperatures with a broad spectrum of fuels. The optimised temperature can be sustained by controlled injection of recirculated flue-gas. The ideal adiabatic temperature of the combustion chamber for simultaneous minimisation of CO and NO_X is 1300 to 1400 °C.

The temperature achieved in reality is about 150 °C below this. The lining of the walls with masonry for thermal isolation is not necessary, which also prevents the formation of boiler slag and, therefore, results in high operational life cycle times (>5000 h).

For the combustion of abrasive dust, there are four pulverised-fuel burners installed in plant C. The maximal rated thermal input is 28 MW and contains plug nozzle burners. These can also be driven by extra light fuel oil.

The heat is used mainly for the drying of splints. In plant B, up to 26 t/h are dried in rotary dryers, which means that the moistness is reduced from 60 to 100 % to about 2 %. The drying is realised indirectly by heated tube bundles of 180 °C. Further on, the heat is conducted by thermo oil at 240 °C to a heated end-squeezer in order to dry and consolidate the chip boards. In this process, a mix of air, water and products of degasification occurs, which is returned as combustion air and thus delivers 30 % of the air needed in the boiler. This design provides high energy efficiency and after-burning of the emissions arising from the drying. The exhaust air from the drying of chipping particles is also applied partly to the boiler. All plants are equipped with bag filters to meet the required limit values for particle emissions.

Plant C is fitted with a supplementary SNCR installation. Ammonium hydroxide with 25 mass- % of NH_3 is used as the reducing agent. This is stored aboveground in a tank of stainless steel. Furthermore, plant C is equipped with an adsorption process as a separator. This combined duct sorbent injection (dry adsorption) requires the injection of a ground mix of active carbon/coke and hydrated lime (= adsorbent) in the flue-gas flow which is then separated from it by a fabric filter. During this time, dust, HCl, HF, SO_x, heavy metals, and PCDD/F are adsorbed and thus separated from the flue-gas. Therefore, all types of wood waste can be fired in this plant.

Achieved environmental benefit: By using wood as a biomass fuel, one can achieve an almost neutral CO_2 balance. With the simultaneous utilisation of power and heat, the overall energy efficiency can achieve about 85 to 96.6 %. Only small amounts of waste water arise, coming from the waste water treatment of the water-steam circuit.

At the same time, combustion technology allows low emissions of NO_X and CO to be achieved in the raw gas. Combined with reduction measures like bag filters, SNCR and duct sorption plants, very low concentrations can be achieved for all types of pollutants.

Applicability: The spreader-stoker technique is suitable for a wide range of fuels, exceeds the performance of fluidised bed technology, and is especially used with fuels with highly heterogeneous particle sizes and contaminants (such as metal pieces).

The plants described here are especially designed for applications in the chip board and MDF board industry and are economically viable because of the energetic valorisation of the wood residues and because of the continuous demand for heat. For locations with similar characteristics, the application of this technology is also reasonable.

Cross-media aspects: High amounts of ash result from these plants. Furthermore, water treatment produces waste water. Also, the adsorbent used in the flue-gas cleaning plants has to be deposited.

Operational data: Atmospheric emissions accruing from plant B are shown in Table 5.13.

	Monitoring	Statistics	Measured value (at 11 % O_2)
Dust (mg/Nm^3)	Continuous	Daily mean value	3.4 – 4.3**
CO (mg/Nm^3)	Continuous	Daily mean value	46.7 – 58.3**
NO_X (mg/Nm^3)	Continuous	Daily mean value	183.9 – 190.7**
C total (mg/Nm^3)	Continuous	Daily mean value	1.1 – 1.2**
HCl (mg/Nm^3)	Continuous	Daily mean value	8**
Hg (gas) (mg/Nm^3)	Continuous	Daily mean value out of 2 hour mean values	0.001**
Dioxins/furans (ng TEQ/Nm^3)	Continuous sampling, single values	Mean of 20 days	0.0019
PAH (mg/Nm^3)	Continuous sampling, single values	Mean of 4 days	0.0003
Cd (mg/Nm^3)	Continuous sampling, single values	Mean of 4 days	0.0005
As/Pb/Cu/Ni/Sn (in the particles) (mg/Nm^3)	Continuous sampling, single values	Mean of 4 days	0.053
As (mg/Nm^3)	Continuous sampling, single values	Mean of 4 days	0.0005
Notes: *value for precaution **intervals based on three daily mean values in January 2001			

Table 5.13: Measured atmospheric emissions in 2000/2001

For plant C, a consumption of 120000 t/yr wood is estimated. For plant B, the different types of fuels are used in the amounts listed in Table 5.14.

Fuel	Wood dust	Cardboard pieces	Wood residues out of packaging/loading	Special fuels (railway sleepers)	Timber	Biomass pellets
Contribution to the total fuel consumption	30 %	10 %	10 %	Max. 20 %	Varying	Varying, approx. 15000 t/yr

Table 5.14: Contribution of the different fuel types to the total fuel consumption in plant B

The size of the pieces should be below 100 mm. However, a few pieces can be up to 250 mm. This limit is set by the transport devices, e.g. screw conveyors. For the preparation of all fuels by a hacker, costs of EUR 0.5/t were given for a plant of 60 MW. The accruing boiler ash and fly ash are used in the construction industry.

Economics: The investment for plant B amounted to EUR 36 million.

Driving force for the implementation: The possibility to re-use the by-products and the need to deposit the wood residues in an economically reasonable way.

Reference literature: [98, DFIU, 2001], [101, Vaget, 2001], [102, Fischer, 2000], [78, Finkeldei, 2000].