ESCUELA TÉCNICA SUPERIOR DE INGENIERÍA (ICAI)

MÁSTER EN INGENIERÍA INDUSTRIAL

ANALYSIS OF THE THERMAL TREATMENT OF PLASTIC MEDICAL WASTE

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Analysis of the thermal treatment of plastic medical waste

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ANALYSIS OF THE THERMAL TREATMENT OF PLASTIC MEDICAL WASTE

Autor: Álvaro Monedero Álvarez
Director: Maryam Ghodrat

Madrid
Enero 2018

Análisis del tratamiento térmico de residuos plásticos hospitalarios

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Director: Ghodrat, Maryam

Entidad Colaboradora: University of Western Sydney

Resumen del proyecto

Introducción

En una sociedad cada vez más avanzado, la demanda de servicios sanitarios es también cada vez mayor. Los servicios médicos ayudan a superar enfermedades y salvan vidas, pero a su vez, generan una gran cantidad de desechos y subproductos con riesgo de infección que deben ser tratados al convertirse de modo contrario en una amenaza para la salud pública. La búsqueda incesante del bienestar de la sociedad y el aumento continuo de la calidad de vida es el objetivo principal de los avances en gestión y tratamiento de desechos médicos. Estos desechos médicos vienen definidos como "cualquier desecho sólido que se genere en el tratamiento, diagnóstico o inmunización de seres humanos o animales, en investigaciones relacionadas, o en la producción o prueba de productos biológicos" (Congreso de los Estados Unidos, 1988).

La gestión y el tratamiento de estos residuos se ha convertido en uno de los muchos y complejos problemas a los que la humanidad se debe enfrentar a medida que la población mundial crece y con ella la generación de estos residuos médicos. Un tratamiento inadecuado puede generar impactos negativos en el medio ambiente y en la salud pública. Llevar a cabo un tratamiento adecuado es de gran importancia teniendo en cuenta dos de los efectos nocivos principales: el riesgo de infección de los empleados que manejan los residuos, pacientes o la población en general si los residuos no son tratados adecuadamente, y en segundo lugar, los contaminantes liberados al medio ambiente que surgen de un tratamiento inapropiado.

En cuanto a la generación y tratamientos en la actualidad, La Organización Mundial de la Salud estima que en los países desarrollados se generan 3,3 kg de residuos por cama hospitalaria por día, y en los subdesarrollados 1,5 kg. Además, estiman que un 15% de los residuos totales son considerados peligrosos. Existen diversos tratamientos de estos residuos en la actualidad, entre los que se encuentran tratamientos biológicos, químicos, irradiación, mecánicos (complementarios) y térmicos. Entre los térmicos, se distinguen los térmicos que emplean bajas temperaturas, como microondas y autoclaves, que alcanzan una temperatura suficiente para acabar con los patógenos pero no llegan a quemar los residuos y los térmicos que alcanzan temperaturas suficientes para eliminar todos los residuos. En este proyecto, son estos últimos los que resultan más interesantes al reducir el volumen de los residuos al máximo y evitar verter los residuos a vertederos. Como inconveniente aparecen las emisiones de la combustión, las cuales hay que tratar posteriormente de forma adecuada. Existen distintos tipos de hornos, pero el más adecuado y propuesto en el proyecto es el horno rotativo, acompañado de una cámara de post combustión para asegurar una combustión completa de todos los gases.

Objetivos

En primer lugar, es importante hacer un análisis general de los residuos médicos. Esto implica conocer la generación actual, su clasificación y los distintos métodos que se llevan a cabo en la actualidad para tratarlos, con el objetivo de seleccionar el método más adecuado.

En segundo lugar, se selecciona una muestra de residuos plásticos de un hospital europeo, abarcando la generación de 10 días. Con la muestra, se lleva a cabo un análisis en el que se tienen en cuenta distintos aspectos como de que materiales están hechos los distintos tipos de residuos (PP, PE, PVC..) obteniendo de esta forma la composición elemental del material a tratar. Con la composición elemental se calculará el valor calorífico total del material.

En tercer lugar, y considerando una entrada de desechos correspondiente a una población de 2 millones de habitantes, el flujo de residuos a tratar es de 110kg/hora. Se llevarán a cabo los cálculos necesarios para obtener las reacciones, la cantidad de oxígeno estequiométrico y el aire total necesario para la combustión. Con estos resultados, el software HSC Chemistry modelará el proceso de la combustión y se obtendrán los porcentajes en masa y volumen de los gases de salida.

Finalmente, se harán recomendaciones para reducir las emisiones y se propondrá un diseño de planta.

Desarrollo

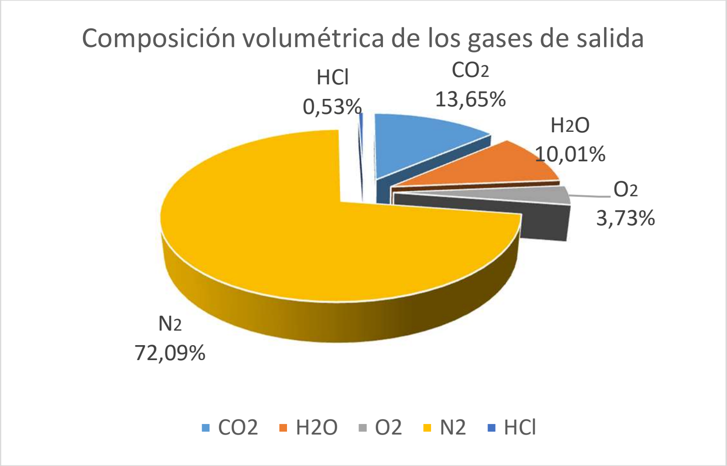
Para encontrar la composición química del material a tratar, se parte de una muestra de 10 días del hospital OLVG de Ámsterdam, en la que se encuentran distintos desechos plásticos con riesgo de infección como guantes, bolsas intravenosas, jeringuillas y accesorios, envases, tubos y accesorios..etc. Conociendo su composición en distintos tipos de plásticos (PP, PE, OVC ..), se obtiene la composición elemental del material en C, H, O, N, S, Cl ,cenizas y agua y con ello el poder calorífico del material, de 8.53kWh.

Conocida la composición, se calcula la cantidad de aire necesario para su combustión, considerando óptimo un 9% de exceso de oxígeno. Es importante resaltar que por normativa los gases deben permanecer en la cámara de combustión al menos dos segundos a 1100°C asegurando así una combustión completa. Para la combustión de 110 kg/hora de residuos se necesitará un flujo de aire de 1207,28 kg/ hora. Con estos datos de entrada, el software HSC Chemistry simula el proceso de combustión, obteniendo las características de los gases de salida (CO_2, H_2O, O_2, N_2, HCl).

Además, debido al alto poder calorífico del material de entrada y la alta temperatura esperada a la salida de los gases de combustión, resulta interesante la idea de la recuperación de energía. Mientras que en muchas plantas los gases son enfriados sin aprovechar su energía, esta energía se puede aprovechar por ejemplo mediante una caldera de recuperación, generando vapor que impulse un ciclo de Rankine cerrado. De esta idea surge hacer un balance de potencias con los datos obtenidos y suposiciones en cuanto a pérdidas tanto en el proceso de combustión como en el ciclo de Rankine. La energía producida en el sistema obtenida es de 208,62kW, siendo el 15% utilizada para el autoconsumo de la planta y el 85% restante (177,32kW) disponible para ser suministrada a la red.

Resultados y recomendaciones

Una vez obtenida la composición del material entrante en el horno rotativo, y la cantidad de aire necesaria para la combustión con el exceso de oxígeno definido, el software HSC Chemistry simula el proceso de combustión, mediante la cual se obtiene la siguiente composición volumétrica del gas resultante.

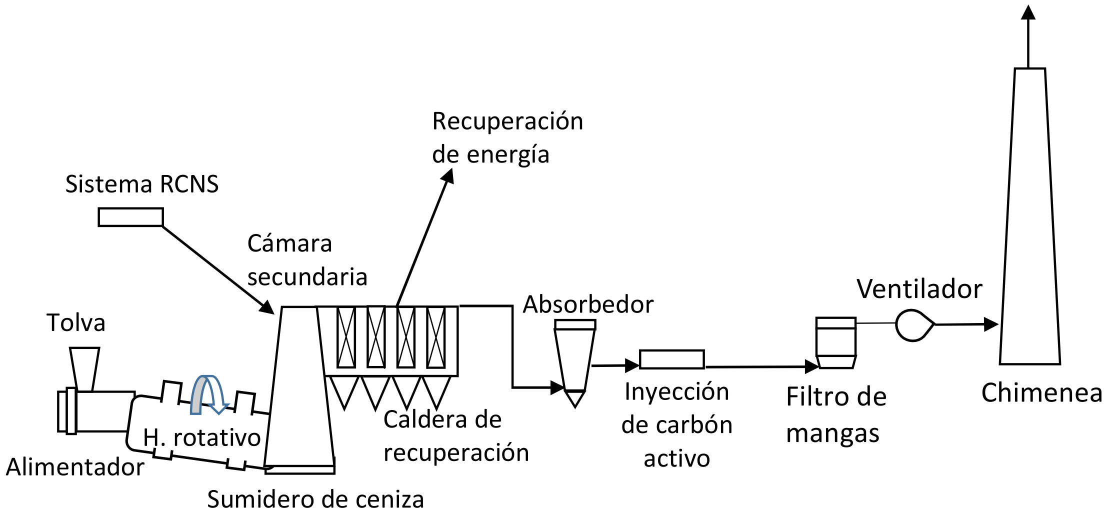


Para cumplir con las Directivas Europeas sobre la incineración de residuos y sus emisiones, es importante incorporar a la planta distintos sistemas para el tratamiento de los gases de salida. El sistema propuesto cuenta con distintos dispositivos.

En primer lugar, para eliminar los posibles óxidos de nitrógeno que se formen durante la combustión y obtener de esta manera solo N_2 y ningún NO_x, la planta cuenta con un sistema de reducción selectiva no catalítica. Para ello se inyecta urea, $CO(NH_2)_2$, en el propio horno rotativo dado que la reacción se produce a una temperatura entre 850°C y 1000°C.

Una vez los gases salen de la cámara de combustión secundaria, pasan por el resto de dispositivos de tratamiento. El primero es un absorbedor encargado de eliminar el gas ácido HCl formado en la combustión. se calcula la cantidad necesaria de cal viva para neutralizar todo el HCl producido con 110kg de residuos por hora. Aplicando un coeficiente de 1,5 para asegurar que todos los gases ácidos reaccionen, la cantidad de cal viva necesaria es de 83,7kg por hora, un valor superior comparado con las plantas de incineración de residuos municipales, debido al mayor contenido de cloro en residuos plásticos hospitalarios. Tras esto, se emplea la inyección de carbón activo para la eliminación de posibles dioxinas y furanos formados. Los gases serán finalmente limpiados en un filtro de mangas, antes de ser impulsados a una chimenea a través de un ventilador inducido.

La siguiente figura representa un diagrama de la planta propuesta.



Analysis of the thermal treatment of plastic medical waste

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Director: Ghodrat, Maryam

Collaborating entity: University of Western Sydney

Abstract

Introduction

In an increasingly advanced society, the demand for medical services is also increasing. Medical services cure illness and save lives, but at the same time generate infectious waste and by-products humanity needs to deal with. The relentless pursuit of well-being and quality of life is the primary objective of the technological development of medical waste management and treatment. Medical waste is generally defined as “any solid waste that is generated in the treatment, diagnosis, or immunization of human beings or animals, in research pertaining thereto, or in the production or testing of biologicals” (United States Congress, 1988).

The management and treatment of medical waste has become one of the many complex problems that humanity must face as the global population increases and with it the generation of this waste. An inappropriate treatment may lead to negative impacts to the environment and to the public health. Medical waste treatment is of considerable importance taking into account two main harmful effects, the risk of infection of employees who handle the waste, patients or general public if not being dealt with properly, and secondly, the pollutants released to the environment (environmental contamination) by an inappropriate treatment or disposal.

Looking at generation of medical waste and its actual treatments, the World Health Organization estimates that in developed countries 3,3kg of waste is generated per hospital bed in one day, while in underdeveloped countries 1,5 kg. From this total waste around 15% is considered hazardous. There are several types of treatment methods for medical waste, such as biological, chemical, irradiation, mechanical (complementary) and thermal treatments. Amongst thermal ones, there are those which use low temperatures, such as microwave treatment or autoclaves, which reach certain temperatures able to eliminate pathogens but not enough to destroy the waste, and those treatments which reach high temperatures enough to destroy the waste. In this project, the high temperature ones are the ones of interest, as they reduce the volume of the waste at its maximum and avoid dumping the waste into landfills. On the other hand, unwanted emissions appear, which should be treated after the combustion. For the incineration, the most adequate and proposed furnace for the project is a rotary kiln, followed by a secondary chamber to ensure combustion of all gases.

Objectives

Firstly, it is important to make a general analysis of medical waste. This implies finding out the current generation, its classification and reviewing the different methods actually used to treat this type of waste, in order to select the most appropriate method.

Secondly, a plastic waste sample from an European average hospital is selected, covering the generated waste for a period of 10 days. With the sample, an analysis is carried out taking into account different aspects such as from what materials are the different types of waste made from (PP, PE, PVC ..) to help obtain the elemental composition of the material to be treated . With the elemental composition, the total calorific value of the material will be calculated.

Thirdly, considering the input waste to proceed from a population of 2 million people, the waste stream to be treated sums up to 110 kg/hour. Calculations will be carried out to obtain the reactions, the amount of stoichiometric oxygen needed and the total air needed for the combustion. With these results, the HSC Chemistry software will model the combustion process and obtain the percentages in mass and volume of the output gases.

Finally, recommendations will be made to reduce emissions and a plant design will be proposed.

Development

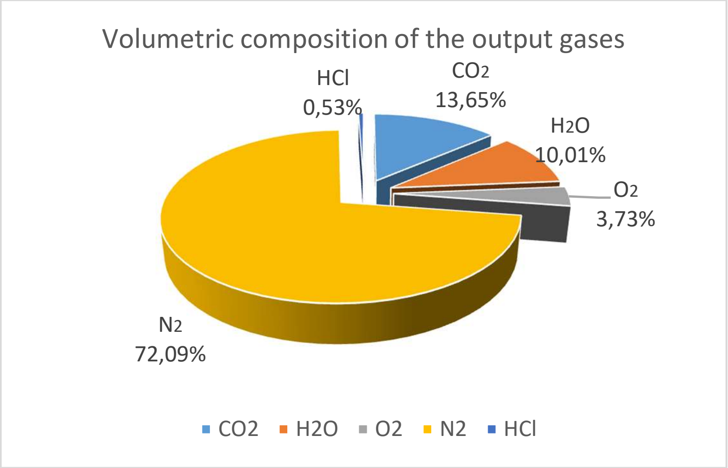
In order to find the chemical composition of the input waste to be treated, a 10 day sample from the OLVG hospital in Amsterdam is analysed. This sample contains different types of waste such as gloves, intravenous bags, syringes and accessories, containers, tubes and accessories..etc. From its composition of different types of plastics (PP, PE, PVC..) the elemental composition in C, H, O, N, S, Cl can be obtained. And with it, the calorific value of the input waste, of 8.53kWh.

Once obtained the composition, the amount of the necessary air for combustion is calculated, considering 9% of excess oxygen as an ideal percentage. It is important to take into account that due to regulation, the gases must remain in the combustion chamber at least for 2 seconds at a temperature of 1100°C to ensure complete combustion. For the combustion of 110 kg/hour of waste an air flow of 1207.28 will be required. With this input data, the software HSC Chemistry simulates the combustion process, obtaining the characteristics of the output gases (CO_2, H_2O, O_2, N_2, HCl).

Moreover, from the high calorific value of the input waste and the high temperature of the output gases expected at the exit of the secondary combustion chamber the idea of energy recovery becomes interesting. While in many actual plants the output gases are cooled down without considering energy recovery, this energy could be recovered by means of a steam boiler, generating steam in a closed Rankine cycle. To calculate the energy that could be produced, an energy balance is made, making assumptions of the losses in both the combustion process and in the Rankine cycle. The total energy produced in the system sums up to 208.62kW, where 15% is used for the own consumption of the plant, and the other 85% (177.32kW) can be supplied to the network.

Results and recommendations

With the elemental composition of the input waste entering the rotary kiln and the amount of air injected defined, the HSC Chemistry software simulates the combustion process, obtaining the volumetric composition of the output gases.



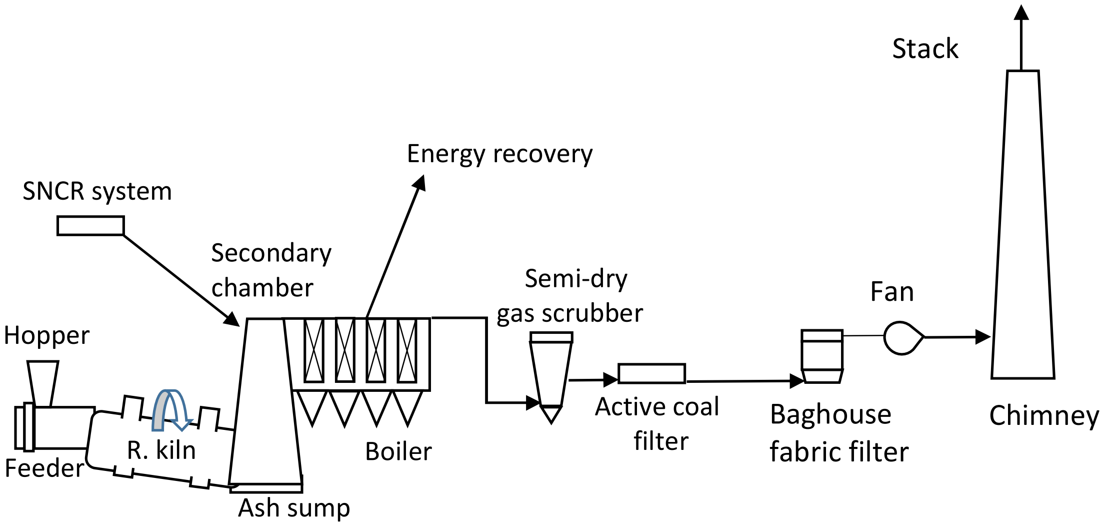
In order to operate under the European Directives on the incineration of waste and its emissions, it is important to incorporate to the plant different systems for the treatment of output gases. The proposed system has different individual devices.

Firstly, to eliminate possible nitrogen oxides formed during the combustion, and to only obtain N_2 and not any NO_x, the plant will count with a selective non-catalytic reduction

First, to eliminate the possible nitrogen oxides that form during combustion and thus obtain only N2 and no NOx, the plant has a non-selective catalytic reduction system. To achieve this, urea, $CO(NH_2)_2$, is injected into the rotary kiln itself, since the reaction takes place at a temperature between 850°C and 1000°C.

Once the gases leave the secondary combustion chamber, they reach the rest of treatment devices. The first one is a semi-dry scrubber (absorber) responsible for eliminating the acidic gases such as the HCl formed during the combustion. The necessary amount of quicklime is calculated to neutralize all the HCl produced in the combustion of the 110kg/hour of input waste. Applying a coefficient of 1.5 to ensure all acidic gases react, the amount of quicklime required is 83.7 kg/hour. Resulting a high value in proportion to that used in incineration plants of municipal solid waste, due to the higher chlorine content in hospital plastic waste. Right after, an injection of active coal is made to eliminate the possible dioxins and furans formed during the combustion. The gases are finally cleaned in a baghouse filter, and sent to the chimney through an induced draft fan.

The following figure represents a diagram of the proposed plant.



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Chapter 1. Introduction and project approach

In an increasingly advanced society, the demand for medical services is also increasing. Medical services cure illness and save lives, but at the same time generate infectious waste and by-products humanity needs to deal with. The relentless pursuit of well-being and quality of life is the primary objective of the technological development of medical waste management and treatment. Medical waste is generally defined as "any solid waste that is generated in the treatment, diagnosis, or immunization of human beings or animals, in research pertaining thereto, or in the production or testing of biologicals" (United States Congress, 1988). Medical waste management and treatment has become one of the many complex problems humanity needs to face as the global population increases, and along with it, the generation of medical waste.

In the whole world, the management of medical waste treatment is an increasing concern. An inappropriate treatment may lead to negative impacts to the environment and to the public health. Medical waste treatment is of considerable importance taking into account two main harmful effects, the risk of infection of employees who handle the waste, patients or general public if not being dealt with properly, and secondly, the pollutants released to the environment (environmental contamination) by an inappropriate treatment or disposal.

At the same time, looking at general waste generation, according to the United Sates Environmental Protection Agency, in 2014, the landfilling as percent of generation for the plastic was significantly higher than the total Municipal Solid Waste landfilling as percent of generation. Also, it revealed that plastic was not as recycled as much as the rest of other MSW. On the other hand, the plastic used in combustion processes was higher than the combustion of the other types of MSW. One of the possible reasons behind this is the high calorific value of plastic compared to the rest of waste, which makes plastic a good material to be treated in a thermal way.

In this project, actual medical waste treatment techniques will be reviewed, and a proposal will be made of what is the best way to treat medical waste. As nearly 50% of the medical waste is plastic, and other materials such as sharps can be more easily re-used, the scope of the present project will be plastic medical waste. Once an appropriate treatment is selected and described, a simulation to obtain the output gases content will be carried out and an analysis of the emissions will be made.

1.1 Context

Medical waste management and treatment became a big society's concern when, in the late 1980's, medical waste items such as used syringes were disposed and were being washed up in beaches of the East Coast of USA. This prompted the US Congress to enact the Biomedical Waste Management Law of 1988 in USA, and soon this seriousness about the management required expanded to the rest of the world.

In a highly developing world, where as well as facilities, waste generated increase, an appropriate management and treatment method for this waste is required. While most plastic and general waste can be easily recycled and treated, it is important to pay especial attention to the infectious waste. From the total amount of medical waste generation, 85% can be classified as general waste, comparable to municipal solid waste while the remaining 15% can be classified as hazardous (infectious, toxic or radioactive). (World Health Organisation, 2015).

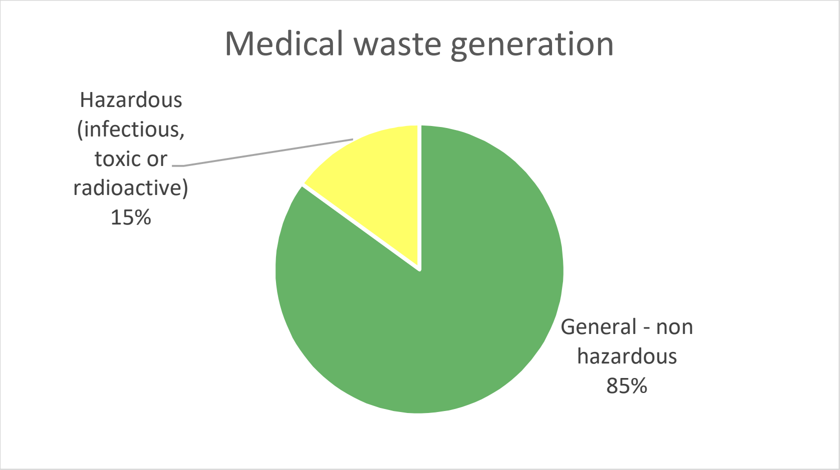


Figure 1: Medical waste generation. Source: World Health Organisation (2015)

With the high world development in the last years, the medical waste generated has also increased. Depending on the country, it can be estimated that developed countries generate around 3.3 kg of waste per bed per day, this is 0.5 kg per bed per day of hazardous waste, while under developed or low-income countries generate 1.33 kg per bed per day, meaning 0.2 kg per bed per day of hazardous waste.

	Waste generated (kg/bed/day)	Hazardous Waste generated (kg/bed/day)
High-income Countries	3,3	0,5
Low-income countries	1,3	0,2

Table 1: Medical waste generation rate in High and low income countries. (World Health Organisation, 2015)

It is important to understand the different types of medical waste. The international Committee of the Red Cross came up with the following classification:

- Sharps (waste entailing risk of injury)
- Anatomical waste (body parts or tissue with risk of contamination)
- Chemical waste (waste with presence of chemical substances)
- Infectious waste (waste contaminated with risk of propagating infectious agents)
- Pharmaceutical waste (Medicines and expired drugs)
- Cytotoxic waste (waste contaminated with cytotoxic substances)
- Radioactive waste (waste containing radioactive substances)

Looking at plastics as a material which represents nearly half of the total medical waste, it is important to review how its generation has also increased in time. The 1940's decade brought with it the first industrial scale production of synthetic polymers (Freinkel, 2011). Since then, plastics production and its associated waste has done nothing but increase in giant steps, bringing with it environmental concerns.

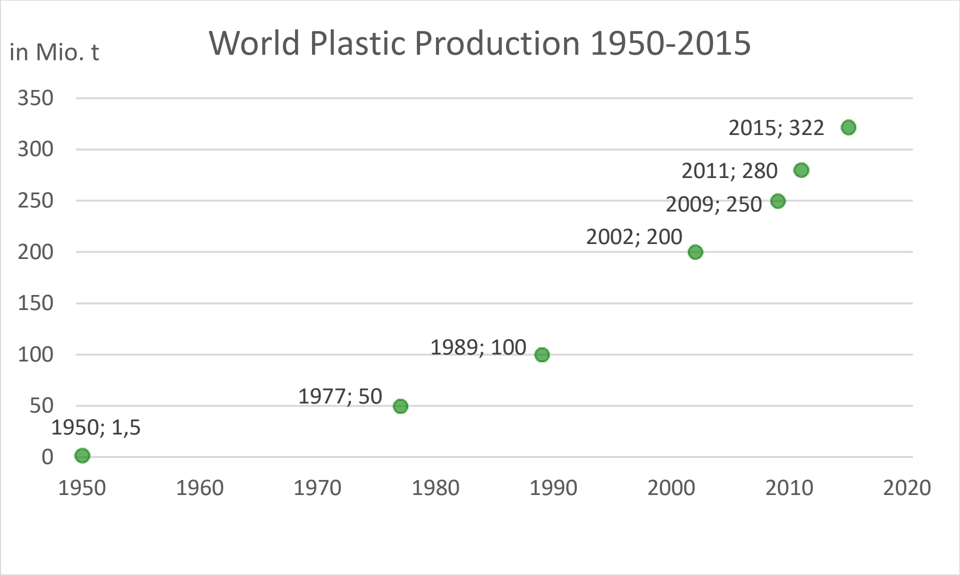


Figure 2: World Plastic Production 1950-2015. Source: PlasticsEurope

There are four main ways to treat plastic solid waste, these are re-extrusion (primary), mechanical (secondary), chemical (tertiary) and energy recovery (quaternary). Firstly, primary recycling involves the re-introduction of clean scrap of single polymer to produce products of similar material. Secondary production is based on the reduction in size of waste, which is converted into other shapes such as pellets or powders. Tertiary treatments produce feedstock chemicals for the chemical industry, although it may lack proper design and kinetic background. Finally energy recovery (quaternary) is an existing and widely used solution to plastic solid waste, which focuses on municipal solid waste (MSW). It involves the complete or partial oxidation of the waste (Troitsch, 1990), while producing heat, power, and/or fuels, chars and by-products such as ash that must be disposed.

While the primary and secondary treatments are widely used and established, the tertiary (chemical recycling) and quaternary (energy recovery) are the ones found more interesting in the development of this project.

Inside thermal treatments, incineration is the treatment of more relevance in this project. Incineration range capacities range over 10 kg/hour to 800kg/hour of waste. There are several types of incinerators. Amongst the most common to treat medical waste, the World Health Organisation declare they are dual-chamber incinerators, multiple-chamber incinerators, and rotary kilns. The process generally involves 4 steps: Charging the waste, combustion process, air pollution control, and ash removal. Normally the first combustion chambers is followed by a second chamber to ensure proper combustion. The output gases are after treated and the system presents an air pollution control system in order to control the emissions.

In order to select an appropriate treatment method, several factors should be taken into account. These factors are the system capacity (kg of waste treated per hour), volume reduction aimed, types of waste to be treated, space available for equipment, costs..etc.

Regarding the emissions, limits of emitted gases are established. The principal pollutants are HCl, SO_2, SO_3, CO, NO_x, organic compounds such as dioxins, furans, chlorophenols and chlorobenzenes and heavy metals. These emissions should tried to be eliminated or at least reduced. Several methods have been developed to eliminate or reduce these pollutants. Some of them are Carbon active filters (used to reduce dioxins and furans), “SNCR” denitrification systems (used to eliminate the NOx), absorbers (minimise emissions of SO2, HCl and HF) and others.

1.2 Motivation

One of the most dangerous types of waste generated in todays world are the hazardous medical waste which can be disposed in a land or anywhere else due to the high risk of infection or diseases transmission it may bring. While most of the actual treatments focus in the disinfection of this waste, the idea of both disinfecting and reducing the volume of waste with one and only treatment seems attractive.

Landfilling is a practice which entails many negative effects (toxins released into soil and groundwater, leachate, greenhouse gas emissions..). It is evident that better ways to treat waste should be carried out. According to the United States Environmental Protection Agency, in 2014, the landfilling of plastic as percent of generation was 75,5%, while around 50% for the rest of Municipal solid waste. Also, the recycled plastic as a percentage of generation was 9,5%, quite lower than that percentage for the rest of Municipal solid waste (25%). In order to try to reduce the landfilling in a world-scale, and therefore reduce its negative effects, high-heat thermal treatment, with the volume reduction of waste they involve, could be a good alternative. Apart from this, the fact that plastics are the waste which result to have a higher calorific value, and therefore make easier its own combustion, sums to define the project scope to plastic medical waste treatment.

Finally, the major inconvenient of the thermal treatment of plastics is the generation of emissions. Analysing these emissions and comparing it to the established limits will help to decide if the chosen technology is effective, and give recommendations for the emission treatments, with the main motivation of reducing these emissions. With more and better pollutant treatments and control, high-heat thermal treatments have potential to be a feasible and environmental-acceptable way of treating plastic medical waste, providing an alternative to landfilling or other methods more commonly used which disinfect the waste but do not reduce its volume.

1.3 Objectives

Four main objectives can be established:

Firstly, a review on medical waste will be carried out. Entailing its generation rate, classification, and deepening the analysis on the different treatment methods in order to select the considered appropriate one.

Secondly, an elemental analysis from plastic medical waste will be carried out. Plastic waste from an average European hospital sample (covering a 10 days) will be selected. This study aims to obtain the input material composition to be treated. From the analysis, the elemental composition of the waste will be obtained by analysing from what materials the different type of waste is made of (PP, PE, PVC). The calorific value of the input will be also calculated.

Thirdly, waste input will be considered to be generated from a population of 2 million people. The required calculations for the reactions, the stoichiometric oxygen and the total air required to treat this waste will be carried out. With these results, the software will calculate the percentage in mass and volume of the output gases from the combustion.

Finally, recommendations to reduce the emissions will be made and a plant design will be proposed.

1.4 Methodology

Regarding the methodology, the scope and deadlines of the Project are defined from August. The blocks will be divided by months, from August 2017 until January 2018. A schedule is made.

During the first 2 months, a literature review on medical waste, heat recovery out of plastic waste, treatment technologies for medical waste, and a reliable generation rate of plastic medical waste will be made. After this review, a comprehensive study on the composition of medical waste will be conducted in order to obtain the input materials of thermal treatment plants. The project scope will be focused on infectious plastic medical waste. A selection of plastic medical waste will be analysed and its elemental composition will be obtained through numeric calculations.

In October, the different expected reaction calculations will be carried out (including the amount of air needed for the defined input waste). Also, during this month the HSC Chemistry software to be used is studied, and the simulation of the combustion process will be carried out obtaining the percentages of the output gases. Finally, during the last three months, an analysis on results will be made. A plant designed will be proposed and recommendations regarding the plant design and the emissions reduction will be given. In January the thesis will be completed and the project presentation prepared.

	August	September	October	November	December	January
Literature Review	🟧					
Input stream Composition		🟧				
Calculations		🟧	🟩			
Simulation (combustión chamber)			🟩			
Results Analysis				▨		
Plant design				▨		
Recommendations					▨	
Thesis Writing + Presentation						▨

Table 2: Schedule

1.5 Resources

Different resources will be used for the development of this project:

- Microsoft Office (Word, Excel, Power point)
- Software HSC Chemistry 8.0
- Internet: articles from different sites such as ScienceDirect will be used.

Chapter 2. Technologies description

2.1 Heat recovery out of Plastic waste

The 1940's decade brought with it the first industrial scale production of synthetic polymers (Freinkel, 2011). Since then, plastics production and its associated waste has done nothing but increase in giant steps, bringing with it environmental concerns. From packaging to wiring, plastics make up a big percentage in the total municipal solid waste generated in the world. There are four main ways to treat plastic solid waste, these are re-extrusion (primary), mechanical (secondary), chemical (tertiary) and energy recovery (quaternary). Firstly, primary recycling involves the re-introduction of clean scrap of single polymer to produce products of similar material. Secondary production is based on the reduction in size of waste which is converted into other shapes such as pellets or powders. Tertiary treatments produce feedstock chemicals for the chemical industry, although it may lack proper design and kinetic background. Finally energy recovery (quaternary) is an existing and widely used solution to plastic solid waste, which focuses on municipal solid waste (MSW). It involves the complete or partial oxidation of the waste (Troitsch, 1990), while producing heat, power, and/or fuels, chars and by-products such as ash that must be disposed.

While the primary and secondary treatments are widely used and established, the tertiary (chemical recycling) and quaternary (energy recovery) are the ones found more interesting in the development of this project, and worthy of additional investigation, therefore a deeper review will take place.

Chemical (tertiary) recycling is based in an alteration of the chemical structure of the polymers. This treatment transforms the plastic waste into smaller molecules, usually liquids or gases, which are suitable to be used as the feedstock chemicals for the chemical industry, such as for the production of new petrochemicals and plastics (Mastellone, 1999). The main interest of this treatment is the possibility of obtaining fuel fractions from plastic solid waste. Polymers such us Polyethylene terephthalate (PET) can be efficiently depolymerised. Polyethylene (PET), the most common thermoplastic polymer resin of the polyester family, is considered as a potential feedstock for fuel producing technologies.

Thermolysis is a non-catalytic thermal cracking treatment of plastic waste in the presence of heat under controlled temperatures. Thermolysis can be divided in 3 technologies: Pyrolysis (thermal cracking in an inert atmosphere), gasification (in the sub-stoichiometric presence of air normally producing CO and CO_2), and hydrogenation (hydrocracking) (Ahrenfeldt, 2007).

In contrast to combustion, pyrolysis is the thermal degradation of a substance in the absence of oxygen. As advantages, it reduces emissions, such as greenhouse gas and CO_2 emissions. Financially, it produces a high calorific value fuel which may be used in gas engines. It also presents disadvantages, such as the handling of the char produced, and the treatment for the final fuel produced.

Moreover, gasification is a process which converts the plastic waste into a syngas (synthesis gas, a mix of carbon monoxide and hydrogen with minor percentages of carbon dioxide and other gaseous hydrocarbons). Air (or oxygen) is used as a gasification agent, being the air around 20-40% of the amount needed. The syngas produced might be used in the chemical industry as feedstock for several chemicals production. In the third place, hydrogenation is defined as the addition of hydrogen (H_2) by chemical reaction through unit operation (March, 1992). It is a process which promotes the removal of atoms such as chlorine (Cl), nitrogen (N) and sulphur in the form of volatile atoms. On the other hand, it presents the disadvantages of the need to operate under high pressures, and the elevated cost of hydrogen.

Energy recovery refers to operations that aim to use the released energy obtained during the combustion of plastics waste. It implies burning waste to produce energy in the form of heat, steam and electricity. It is a widely used treatment for plastic waste due to, amongst other reasons, the high calorific value of plastics.

Incineration is considered by the US EPA (Environmental Protection Agency) as one of the most widely used and better technologies for disposing of several waste streams (US Environmental Protection Agency, 2014). It presents several advantages, as a great reduction in volume (90-99%) of the waste, and a great recovery of heat. Apart from energy and ashes, incineration produces many unwanted pollutants such as CO_2, NO_x and SO_x, which if not treated properly may cause negative impacts to the environment, which the results to be its main disadvantage.

There are many types of incinerators. Looking at modular incinerators there are two types: starved air incinerators and excess air incinerators. Starved air incinerators operate with less than the required stoichiometric amount of air (40-60%), and generate a smoke (off gas) rich in organics, which are to be burnt in a secondary chamber with 100-140% of the stoichiometric air. Excess air incinerators, also has 2 chambers present, and operate with 60-200% of stoichiometric air. These 2 incinerators have the main difference that excess air incinerators are not adaptable to continuous operation, unlike the starved incinerators. Also there are rotary kilns, which are formed by a horizontal cylinder that rotates about its horizontal axes. This rotation is to make sure the waste keeps on moving around and facilitates the process of combustion, making sure every piece of waste gets in contact with the air injected in the chamber.

According to the United Sates Environmental Protection Agency, in 2014, the landfilling as percent of generation for the plastic was 75,5% which is significantly higher than compared to the total Municipal Solid Waste landfilling as percent of generation, which was 52,6% (US Environmental Protection Agency, 2014) . Also, the recycled plastic as percent of generation was 9,5%, quite lower than for the total Municipal Solid Waste (MSW) which rate was 25,7% (US Environmental Protection Agency, 2014). These percentages lead to the thought that there is more to do with plastic, to save space in landfilling and reduce its harmful consequences for the environment.

On the other hand, the plastic combustion as percent of generation was 15%, while for the rest of the Municipal Solid Waste 12,8%, which proves that combustion in plastic waste treatment is quite popular compared to other material sources, both for the efficiency and for the energy generation from the combustion as plastic is a material with a high calorific value (US Environmental Protection Agency, 2014).

2.2 Medical waste

2.2.1 Definition, generation rate and classification

Medical waste is generally defined as "any solid waste that is generated in the treatment, diagnosis, or immunization of human beings or animals, in research pertaining thereto, or in the production or testing of biologicals" (United States Congress, 1988). Medical waste management and treatment has become one of the many complex problems humanity needs to face as the global population increases, and along with it, the generation of medical waste.

From the total amount of medical waste generation, 85% can be classified as general waste, comparable to municipal solid waste while the remaining 15% can be classified as hazardous (infectious, toxic or radioactive). (World Health Organisation, 2015). Depending on the country, it can be estimated that developed countries generate around 3.3 kg of waste per bed per day, this is 0.5 kg per bed per day of hazardous waste, while under developed or low-income countries generate 1.33 kg per bed per day, meaning 0.2 kg per bed per day of hazardous waste. For example, in Australia, looking at both public and private hospitals, in 2015-2016 there was a total of 92,000 beds. 62,000 beds in public hospitals and 33,100 in private ones (Australian Institute of Health and Welfare, 2017). At the same time, looking at statistics of the same year 2015-2016, in private hospitals only 3.152 were available (Australian Bureau of Statistics, 2017), resulting this in a 90% of bed occupation in bed occupancy. From this data, it can be said than in Australia, only in private hospitals, which represent around one third of the total hospitals, 99 tons of medical waste was generated per day, of which 14.85tonns were hazardous. Going even further, sources as the World Health Organisation claims that often health-care waste is not separated into hazardous or non-hazardous wastes in underdeveloped countries making the real quantity of hazardous waste much higher than that quantified (World Health Organisation, 2015).

It is important to distinguish between all the different types of waste generated in health-care facilities. This classification is important in order to separate hazardous waste from non-hazardous or general waste. It helps to have more control over the hazardous waste and separating it makes it easier for future required treatments of each type of waste. The figure below shows a classification of the health-care waste.

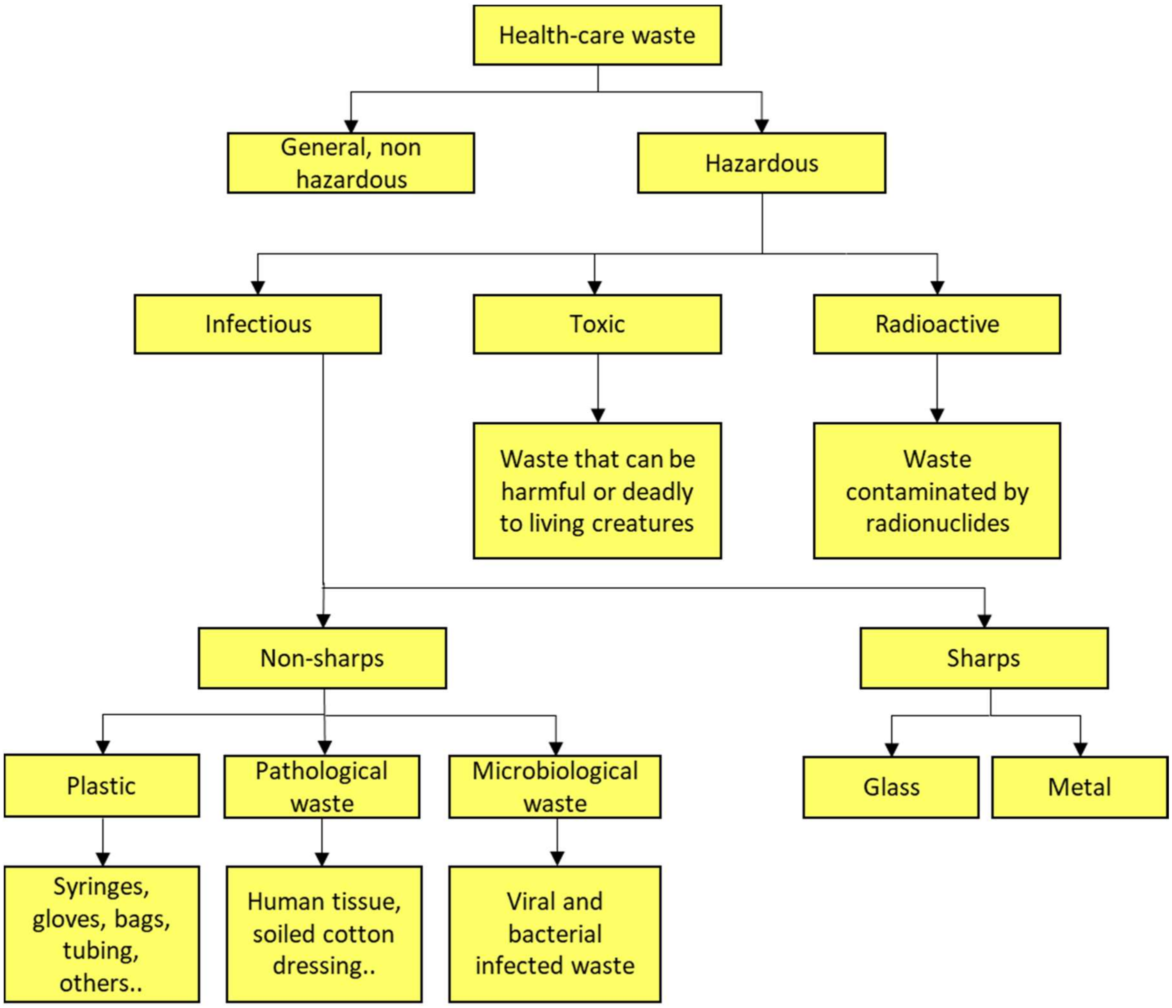


Figure 3: Classification of Health-care waste. Sources: WHO, (Graikos A, 2010)

As many other world-recognised organisms, the International Committee of the Red Cross tried to give a general view of the different types of health-care waste. A brief description of the different types of health-care waste is given in the Table below.

Anatomical waste	Body parts, tissue entailing a risk of contamination.
Chemical waste	Waste containing chemical substances, for example solvents used for laboratory preparations, disinfectants or heavy metals find in medical devices.
Cytotoxic waste	Expired or leftover cytotoxic drugs or equipment contaminated by cytotoxic substances.
Infectious waste	Waste containing large quantities of material or substances entailing the risk of propagating infectious agents. For example, waste contaminated with blood and others. body fluids, infectious agents from laboratories, or waste from patients placed in isolation wards. Eg. Bandages, gloves, swabs.
Microbiological waste	Laboratory waste containing infectious agents (wastes from the production of biologicals and serums, disposable culture dishes, devices used to transfer, inoculate and mix cultures).
Pathological waste	Human tissues, organs or fluids, body parts and contaminated animal carcasses.
Pharmaceuticals	Expired, spilled, unused and contaminated drugs and vaccines.
Pressurized containers	Gas cylinders, aerosol cans.
Radioactive waste	Waste containing radioactive substances: radionuclides used in laboratories or nuclear medicine, radioactive diagnostic material or radiotherapeutic materials, urine or excreta of patients treated.
Sharps	Waste entailing risk of injury. For example needles, syringes, disposable scalpels and blades, etc.

Table 3: Hazardous Medical waste classification. Source: WHO, International Committee of the Red Cross

Regarding the different types of medical waste, a comprehensive study on the composition of medical waste is conducted in order to obtain the composition of the input materials to be treated. The project scope is focused on plastic hazardous waste, which include:

- Plastic syringes & accessories
- Plastic gloves
- IV Bags
- IV Tubing & accessories
- Liquid containers
- Others

The major sources of health-care waste, both general waste and hazardous are:

- Health care facilities (hospitals, clinics, nursing homes for elderly..)
- Laboratories and medical research centres
- Animal laboratories (research and testing)
- Blood banks and collection services
- Animal shelters and animal hospitals
- Mortuary and autopsy centres and funeral homes

2.2.2 Treatment of medical waste

The effective treatment and disposal of healthcare waste is very important nowadays in order to protect both public health and the environment. As well as with other types of waste such as municipal solid waste, the first measure to reduce possible impacts in public health and the environment is to try to reduce the materials used that will result in waste. Once used, it is important to try to re-use them, when possible. After taking this into account and once the material is not in use anymore, it converts into waste that should be treated and disposed.

Different approaches to healthcare waste can be taken depending on the dimensions of the treatment plant and its location. Regarding location, three types of approaches can be distinguished: on-site treatment (where the proper hospital, or healthcare facility treats the waste they generate), Cluster treatment (when a hospital treats both its own waste plus the waste generated in nearby healthcare facilities) and Central treatment, where the waste treated comes from many health care facilities in a determined area.

Also, different processes are used to treat the waste. The process used usually depends on the type of waste to be treated. The United Nations Development Programme describes some of the most common treatment and disposal methods utilized in the management of infectious, hazardous and pathological medical waste as:

- Biological
- Chemical
- Irradiation
- Mechanical (complementary)
- Thermal

Biological treatments imply processes such as composting, biodigestion and natural decomposition. It refers to the degradation and decomposition of organic matter. May involve the use of enzymes to accelerate the process. Most commonly used for placenta and hospital waste generated in the kitchens. (UNDP,GEF,WHO)

The aim of chemical treatments is to disinfect the waste. Chemical desinfectants used range from dissolved chlorine dioxide, bleach (sodium hypochlorite), to peracetic acid, lime solution, ozone gas, or dry inorganic chemicals. (UNDP,GEF,WHO).

Irradiation treatments are used to destroy pathogens. Irradiation comes from electron beams or ultraviolet sources. They require a high investment cost.

Mechanical treatments normally are used as a supplement process in other treatments, for example, to break up the incoming waste before being treated, converting it into smaller pieces for easier handling. Examples are grinding, shredding and compacting the waste, to reduce the volume. They are normally supplementary as by itself it is unable to destroy pathogens. Breaking down waste material will increase the exposed surface, for example to the heat, making the process it complements more efficient. (UNDP,GEF,WHO)

It is important to distinguish between mechanical treatments used in an open system (the waste should be disinfected first, due to the pathogens present in the air during this process), or in a close system (where there is no need to disinfect the waste first).

Thermal treatments are rely on heat to destroy pathogens and in some cases also to reduce the volume of the waste. Thermal treatments can be divided in low-heat thermal systems and high-heat thermal systems.

Low-heat thermal systems use enough thermal energy to destroy pathogens but not enough to burn the waste. The temperature for these systems range between 100°C and 180°C.

Microwave treatment is a steam disinfection system. Water is added to the medical waste and then heat conduction in microwaves is the responsible of destroying the infectious components in the waste.

Regarding its operation, first the waste is loaded to the carts and transported into a hopper, where it is shredded. Once broken down, the waste is exposed to steam and heated at around 100°C. The time inside the microwave is around 20-30 minutes. After this time, the waste is discharged and in many cases transported to a sanitary landfill (Health Care WIthout Harm Europe, 2004).

Autoclaves are low-heat thermal disinfection processes. They are commonly used to sterilize medical equipment that may be reused. They are typically found in hospitals, where they are used to treat high infected materials such as sharps or microbial cultures.

The facility is made of a metal vessel and several valves and pipes to control the steam flow.

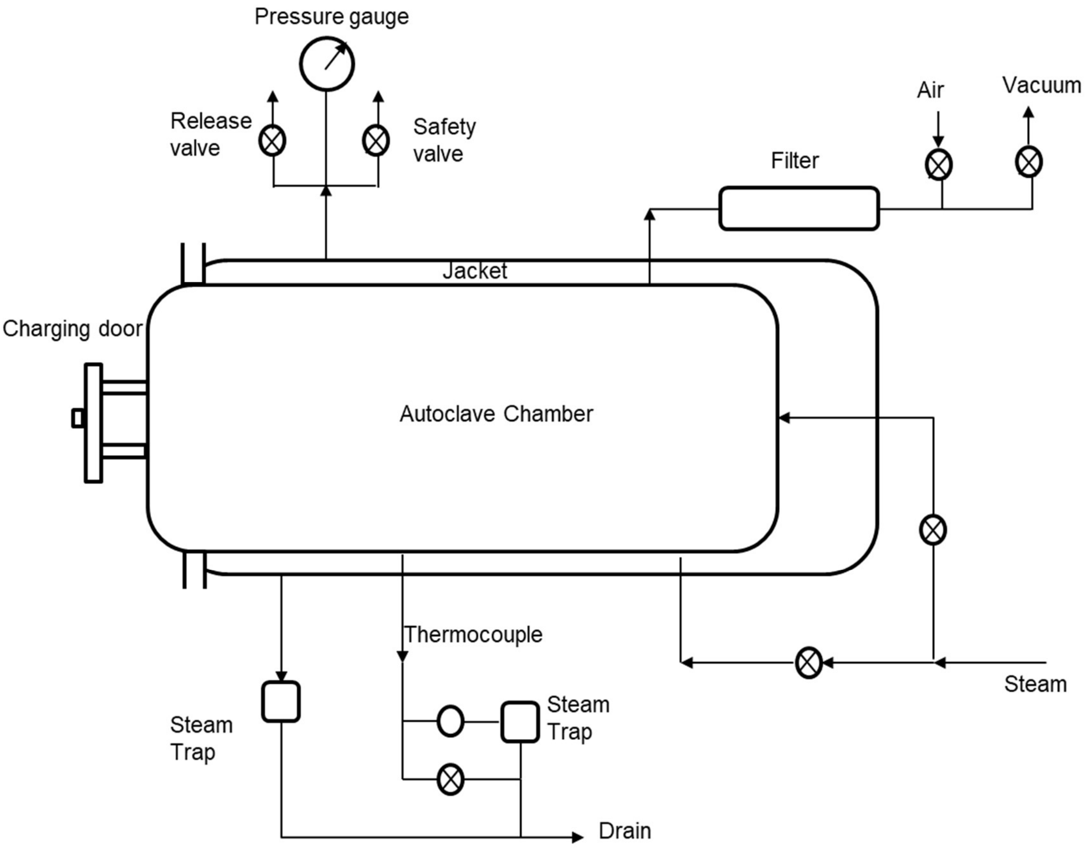


Figure 4: Autoclave chamber. Source (UNDP,GEF,WHO)

Figure 5: Large-Scale Autoclave for Central Treatment Plants. Source: (Gient)

To ensure that the heat reaches the waste in an efficient manner, it is important to remove the air from the metal vessel. Depending on the way the air is removed, classification of autoclaves is made. Between them there are gravity displacement, pre-vacuum, pre- and post- vacuum and pressure pulsing including multiple vacuum autoclaves. The typical operation of these systems imply collecting the waste, pre-heating, loading the waste, evacuating the air in one of the designed way for the specific autoclave, treating and discharging the steam, unloading, and in some cases, a mechanical system, typically used to reduce the volume. (UNDP,GEF,WHO). Regarding their advantages, their emissions are extremely low compared to other high-heat thermal treatments such us incineration. Opposite to incineration, the volume of the final waste remains practically the same. The sizes depend on the location and the capacity the autoclave is designed for.

The figure below represent a complete centralized medical waste treatment system. In includes a washing unit, auto-transfer line, steam boiler, autoclave system and a shredding system for the mechanical treatment of the waste. Each cycle takes around 70 minutes (including the mechanical treatment in the shredder). Stages are: Loading, pre-vacuum, sterilization, post-vacuum, transfer, shredding, and discharging (Gient).

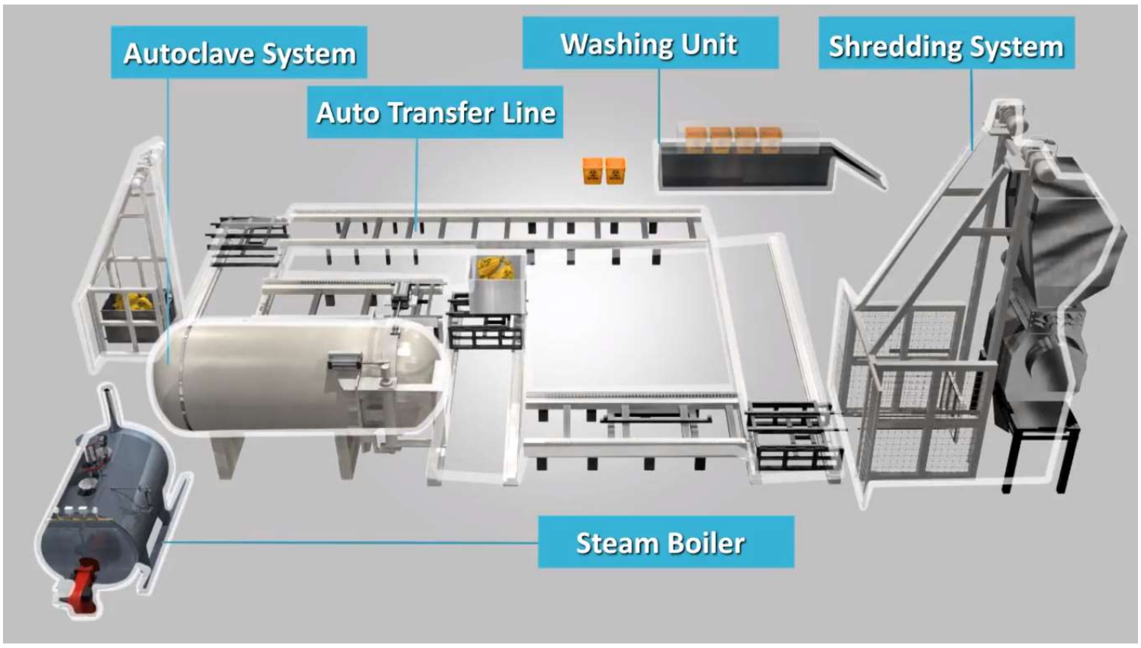


Figure 6: Centralized medical waste treatment system. Source: (Gient)

In high-heat thermal systems organic matter is broken down, reducing its volume significantly through the process of combustion. There are basic requirements for this treatment, refered to the input stream. Most matter should be organic in order for it to be efficient. Also it should have a high calorific value (at least 2000kcal/kg) and present a low content of moisture.

Between high-heat thermal systems, relevant technologies to be reviewed are pyrolysis, gasification, plasma gasification and incineration. Pyrolysis is a process which, in the absence of, or with low amounts of air, degrades waste at temperatures between 400°C to

800°C. As seen before, It becomes interesting as it has the option of generating a fuel which can be later used. Moreover, looking at gasification, it is also carried out with low oxygen, but in this case the temperature of the process is much higher than pyrolysis, ranging from 900°C to 1400°C (Environmental Protection Department, Government of Hong Kong). Combustion does not occur. As well as in pyrolysis, a syngas is produced. As it uses less oxygen, less output gases emissions are generated. On the other hand, both pyrolysis and gasification produce solid residues in form of char and slag, and its treatment might become a problem. Plasma gasification is characterized by being carried out at high temperatures, from 2700°C upwards, up to even 10000°C (Environmental Protection Department, Government of Hong Kong). While it is indicated for hazardous waste and it doesn't generate many emissions, it requires a lot of energy input and the energy recovery rate is lower. (Environmental Protection Department, Government of Hong Kong).

Incineration range capacities range over 10 kg/hour to 800kg/hour of waste (UNDP,GEF,WHO). Incineration process operate with excess air to ensure the maximum volume reduction and a good combustion. Incineration systems normally use an energy recover system to generate steam in order to make the most of the energy given by the combustion process and use it for electricity and/or heat production.

There are several types of incinerators. Amongst the most common to treat medical waste, the World Health Organisation declare there are dual-chamber incinerators, multiple chamber incinerators, and rotary kilns (World Health Organisation, 2015). In order to select an appropriate treatment method, several factors should be taken into account. These factors are the system capacity (kg of waste treated per hour), volume reduction aimed, types of waste to be treated, space available for equipment, costs..etc. The process generally involves 4 steps: Charging the waste, combustion process, air pollution control, and ash removal.

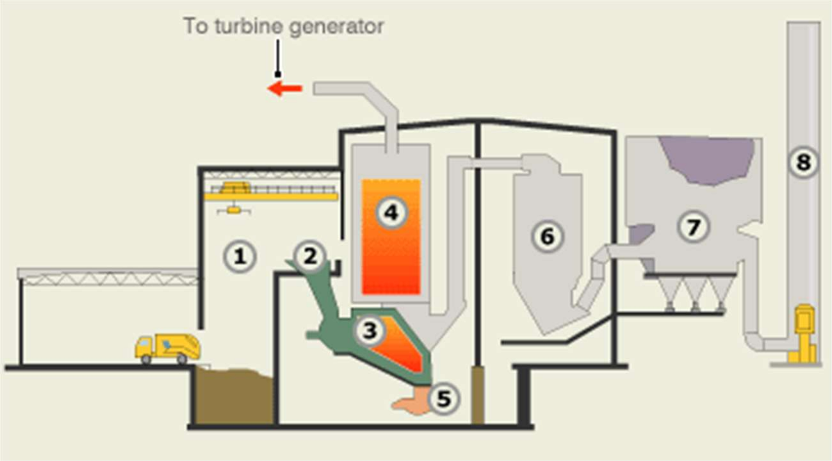


Figure 7: Waste Incineration. Source: (BBC News)

In the figure:

1 – Holding area

2 – Hopper

3 – Incinerator

4 – Boiler

5 – Collection point

6 – Scrubber reactor

7 – particulate removal system

8 – Chimney stack

Normally the first combustion chambers is followed by a second chamber to ensure proper combustion. The output gases are after treated and the system presents an air pollution control system in order to control the emissions. For the gases treatment, different devices can be taken into account (gas scrubbers, fabric filters, Packed-tower demister..etc) (World Health Organization, Global Environment Facility, UNDP, UIC, School of public health). After the gas treatments and the pollutants control systems, the emissions leave the system through a chimney. The figure below shows a rotary kiln with afterburner chamber and different gas treatments.

2.2.3 Emissions and treatments

Regarding the emissions of medical waste, the principal pollutants are:

- Nitrogen oxides (NO_x)
- Hydrochloric acid (HCl)
- Carbon monoxide from incomplete combustion (CO)
- Sulphur oxides (SO_2 and SO_3)
- Organic compounds such as dioxins, furans, chlorophenols and chlorobenzenes.
- Heavy metals
- Solid particles from unburnt waste

It is important to take into consideration that the gas should leave the secondary chamber at a temperature between 1000 and 1200°C (World Health Organization), as it is hazardous waste, to ensure complete combustion. After leaving the secondary chamber, this temperature should be reduced in order to treat the gases.

The gases treatment systems are used to reduce and eliminate the toxic output gases with risk of harming the environment and/or the public health. Gases treatment systems are made of a combination of different independent systems, each focused on treating one or more determined substances, and forming as a whole a gases treatment system for the plant. Some of the most commonly used gases treatment systems are:

- Systems to reduce nitrogen oxides
- Systems to reduce particle emissions
- Systems used as gas washers (reduction and elimination of dioxins, furans..)
- Systems to reduce and eliminate acidic gases (HCl, SO_2, HF..)

Reduction and elimination of nitrogen oxides

During combustion, nitrogen oxides can be formed by two different ways. Firstly, if the waste contains nitrogen, it will oxidize to form nitrogen oxides. Also, the nitrogen contained in the injected air can react with the oxygen forming nitrogen oxides. This reaction of the nitrogen contained in the air with the oxygen will only occur at temperatures above 1300°C. The reaction's speed is directly proportional to the oxygen content, and depends exponentially of the temperature at which the combustion is taking place.

Taking into account how the nitrogen oxides can be formed, two obvious ways to reduce them are avoiding supplying too much air (and therefore too much nitrogen), and don't use unnecessary too high temperatures, as the higher the temperature, the more nitrogen oxides will be formed as the reaction speed will be higher. Therefore an appropriate amount of air injected, which will be enough for complete combustion (to avoid formation of other unwanted substance such as CO), but not too excessive, and a good temperature control are essential techniques to reduce the production of these NO_x.

Looking at secondary techniques, these are used to ensure that the amount of NO_x produced is under the limit of the European legislation (200mg/Nm^3). An efficient technique has been the injection of ammonia or derivatives, such as urea. Reactions in this process are:

$$4NO + 4NH_3 + O_2 = 4N_2 + 6H_2O$$

$$2NO_2 + 4NH_3 + O_2 = 3N_2 + 6H_2O$$

2 different processes can be distinguished for the elimination of nitrogen oxides. These are the Selective Non-Catalytic Reduction (SNCR) and the Selective Catalytic Reduction (SCR).

Moreover, there are different ways to reduce the temperature of the gases. Two of the most common are the use of waste-heat boilers or just spraying water to the output gas. Small units don't usually have heat-recovery boilers, so they normally just use the water-spray technique.

After reducing their temperature, these output products should be eliminated or at least minimised. Several methods have been developed to eliminate or reduce these pollutants.

Regarding air pollution control systems, for flying ash:

- Electrostatic precipitator: One of the most widely used. It is a filtration device which removes fine particles from the output gas by means of an electrostatic charge. An electric current flows between two electrodes, establishing a voltage difference. Free electrons attach to the particles resulting in a negative charge. The particles flow to the positive electrode where they are removed. Efficiency of this device is very high, around 100% for particles bigger than 10µm, and 93% for particles under 2µm.

- Cyclones: Used before the precipitators, are not as efficient. They try to remove bigger particles (>15µm). This system involves generating a cyclone for the gas to be introduced. Particles hit the walls and fall to the ground.

- Fabric Filters (baghouses): A set of fabric bags with different pore sizes (decreasing sizes as the gas goes through the bags). Pollutants are attached to the fabric. To clean them, vibrations or air jet/stream can be used. They are used at temperatures of 140- 200°C.

Gas washers:

- Dry system: An adsorbent in the form of powder is injected with the main aim of capting the gas which will go through the filter described above.
- Semidry system: an absorben slurry is inyected, when it gets in contact with the gas it evaporates and acts as a dry system.

- Wet system: Washing towers in which the washing liquid is pulverized, and the gas flows through it. (alkaline wash for acid gases and acid wash for alkalines)
- Active coal filters: Used in the final stage of the combustion gases depuration. Gas is distributed in an homogenous way in these filters and the dioxins and furans, as well as heavy metals are reduced.

Acids or toxics

Some waste can contain rests of N, S, Cl or F, which may lead to the formation of toxic and corrosive gases in the combustion process. There are 2 possible systems. Firstly, the acids can react with a basic (calcium oxide (CaO), commonly known as quicklime or burnt lime), calcium hydroxide ($Ca(OH)_2$) or sodium hydroxide ($NaOH$). There might be a problem as sludge of difficult treatment could appear. Therefore, it has been substituted for dry depuration in which drops are introduced eliminating the sludge, as the heat from the gas evaporate them transforming them into particles which are held in the filters.

Regarding systems to remove NO_x, the most common nitrogen oxides formed are NO (90%) and NO_2 (10%). It is important that the temperature is at least 870-900°C. At lower temperatures the reaction is too slow and the elimination of NOx would not happen.

The gas output should decrease its temperature. Combustion gases are cooled down/quenched by water sprays atomized into the hot gas flow. This reduction temperature, down to about 350°C is necessary to avoid the formation of dioxins (Manual of waste management).

Also the harmful acids (HCl only in the model) should be treated. For this treatment calcium hydroxide in water (milk of lime) is used. HCl would combine with the calcium hydroxide and precipitate in a dry state as dust. After, the gases enter an adsorption process carried out by active coal injection with the main aim of minimizing emissions of dioxins, which might have appeared. The separation of any solid particle that might have appeared will happen in the baghouse fabric filter which comes ahead. Finally, the gas flows towards the chimney, where it is finally released to the atmosphere through an induced draft fan.

2.3 Thermal treatment technologies

2.3.1 Overview

In order to determine the best thermal treatment method for plastic medical waste which is considered to be hazardous, an analysis of different documents such as the "Mejores técnicas Disponibles de referencia europea para Incineración de Residuos" will be made. The main focus and techniques to be considered will be the different types of incineration, although pyrolysis and gasification will also be slightly reviewed.

For this project, the thermal treatment of bigger interest are the incineration plants, where the volume of waste is reduced at its maximum. Incineration plants are installations where the exothermic process of complete oxidation of combustible materials is produced. The waste is generally composed of organic substances, minerals and water, and also can present metals and other hazardous substances. The process is carried at a high temperature and the waste treated is transformed into gas and some ash. The main purpose of incineration is the volume reduction of the waste, sometimes accompanied by energy recovery. The combustion gases which appear contain the most part of the energy of the waste in the form of heat. The first incineration systems where built for biomass and municipal solid waste. Now a days, incineration is used for a wide range of different waste and applications. Also, the incineration process sometimes represents only one part of a more complex system which is used for the complete treatment of waste, involving reception, handling, storage and further energy recovery and emission treatments. This systems effectively deal with a wide range of waste generated by the whole world.

Incineration can also be problematic due to, mainly, its emissions to the atmosphere. Therefore regulations and legislations are made in order to provide some control regarding these systems. These new legislations have made the incineration sector transform and develop in a quick way in the last decade, becoming every year a more efficient and regulated process. Most of the developments are focused on reducing the emissions control but also to, while maintaining their performance, limit the costs of operation.

The purpose of incineration is to treat waste in order to reduce its volume and its possible risks involving danger to the environment. These risks are eliminated by the destruction of the the potentially harmful substances that are emitted in the output gases leaving the combustion chambers. Also, amongst its purposes, incineration is also used to recover the energy content of the waste burnt, and even the chemical and mineral content. When the calorific value of the waste and the supply of oxygen are high enough, the combustion becomes self-powered, and there is no need of additional fuel.

Looking at the main stages of the incineration process. Firstly, the waste is dried and degassed, in this part of the process, which takes place at temperatures between 100°C and 300°C the volatile content of the waste is released as hydrocarbons and water. After, both pyrolysis and gasification take place. These processes overlap. Pyrolysis is the thermal decomposition of materials at elevated temperatures, involving an irreversible change of the chemical composition. The process takes place between temperatures of

200°C and 750°C. Gasification is a process that converts organic based material into syngas and carbon dioxide. Temperature range from 450°C up to 1600°C. Finally, the oxidation of the combustible gases created takes place. Oxidation takes place between 800°C and 1450°C. These individual stages overlap, and influence each other.

In incineration processes with excess oxygen, where a full oxidative process takes place, the main components of the output gas are nitrogen, carbon dioxide, oxygen and water vapor. Depending on the chemical composition of the waste, other substances might be generated such as HCl, SO_2, NO_x, HF, CO, PCDD/F.. and metal compounds. To achieve an efficient oxidative combustion, an enough supply of oxygen should be introduced into the combustion chambers.

The process of combustion is only one of the stages of a incineration plant. There are many other processes which take place, and as a whole perform the treatment as a whole.

Purpose	Carried out by
Bread down of organic substances	Furnace / Kiln
Water evaporation	
Waste volume reduction	
Energy recovery	Energy recovery system
Gases treatment and emissions diminishment	Gases treatment system

Table 4: Purpose of the different elements of an incineration plant

In Europe, the incineration, as a technique used to treat waste, varies a lot between the member states, between 0 and 62%. Most incineration plants will be found in France, Germany, Denmark and Sweden, while hardly any in countries as Greece or Luxemburg. It is estimated than in Europe the total amount of waste suitable for thermal treatment is over 200 million tonnes. However, the incineration capacity installed will only cover 50 million tonnes.

2.3.2 Applied processes and techniques

There are many different process of incineration proving a great efficiency all around Europe. Although the furnace description, where the combustion of the input waste takes place is the most important part of the process, there are many other stages in the process and techniques used for the complete handling and management of the waste since it arrives to the treatment plant until the final products are sent out and dealt with. An incineration plant normally presents the following stages:

- Reception of input waste
- Storage of input waste
- Pre-treatment of input waste (when required)
- Input waste load
- Thermal treatment
- Energy recovery
- Output gases treatment
- Discharge of combustion gases
- Monitoring and control of emissions;
- Treatment and control of wastewater
- Management of bottom ash

Many of these stages and processes depend on the type of waste to be treated. Control systems and maintenance and monitoring programs ensure an efficient and realiable operation of the plant.

As many of these installations work 24h/day, nearly 365 days/year, the control and maintenance systems result to be very important playing an important role to ensure a good operation of the incineration plant.

The figure below represents a typical incineration plant. It is a very complete plant which apart from burning the input waste has an energy recovery system by means of a boiler. It also has an output gas cleaning system as normally the gases should be treated in order to eliminate toxic compounds and their release to the environment.

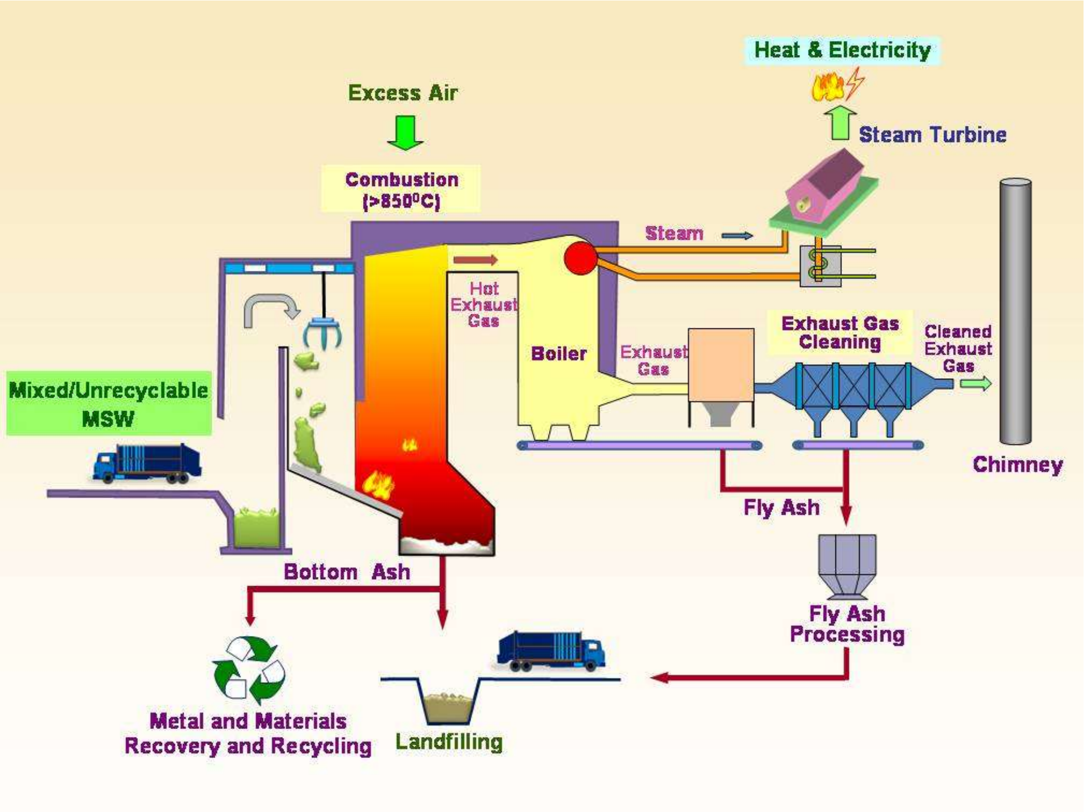


Figure 8: Typical incineration plant diagram. Source: (The Government of Hong Kong Special Administrative Region)

Although incineration is the most applied and common technique, there are other process of thermal treatment of different types of waste. Already being commented before, these two other techniques worth to mention are pyrolysis and gasification.

These 3 process have in common a volume reduction of the input waste, although the most efficient regarding this is the incineration. As a consequence of it, the gases emissions of incineration are the ones which could result more dangerous to the environment, as a complete combustion of the waste takes place and many different output gases are produced in the reactions. Another important difference is the temperature at which these different process take place. While Pyrolysis normally takes place at the lower temperatures, incineration needs high temperatures to ensure complete combustion. These and other differences, as the stoichiometric relation of air needed (excess air in incineration) are shown in the following table:

	Pyrolysis	Gasification	Incineration
Pressure (bar)	1	1-45	1
Process temperature	200°C-750°C	450°C-1600°C	800°C-1450°C
Atmosphere	Inert/Nitrogen	Gasification agent: oxygen/hydrogen	Air
Stoichiometric relation	0	<1	>1
Gas state	H_2, CO, H_2O, N_2 hydrocarbons	H_2, CO, CO_2, CH_4, H2O, N_2	CO_2, O_2, H_2O, N_2
Solid state	Coke and ash	Slag and ash	Slag and ash
Liquid state	Pyrolysis fuel and water	-	-

Table 5: Reaction conditions and products of pyrolysis, gasification and incineration

At a first glance, incineration, with enough air to reach full combustion is the only process where no carbon monoxide is directly formed as a product in the process. Also, although carried out at a higher temperature, does not entail any further treatment of a resultant fuel, as in the case of pyrolysis.

Looking at the plant treatment of hazardous waste, two main type of plants can be distinguished, commercial incineration plants and specific incineration plants. Both deal with the pre-treatment, storage and handling techniques of the hazardous waste. The first step is the assessing of the waste, involving characterization in order to accept it. This is important due to the complex variety of existing waste, presenting uncertainty about its chemical composition and possible risks. Systems aim to identify their origin to prevent unwanted incidents.

Acceptance of the input waste

Depending on the physical and chemical characteristics of the waste, different procedures are used in order to accept and storage the input waste. For the identification of waste, and teherefore decide if a specific treatment is suitable, there is a declaration presented by the producer of the waste, which may indicate data on:

- waste producer
- waste code and other designations of the waste
- origin of the waste
- particular toxic materials
- general characteristics, including combustion parameters, such as:
    - Cl
    - S
    - calorific heat
    - water content

- other information on safety and the environment
- legal firm
- additional data at the request of the receiving plant

It is important to know the approximate chemical composition of the input waste, especially when dealing with hazardous waste, in order to predict the possible pollutants created during the combustion process, and plan an appropriate treatment so the plant operates under the legislation.

After being accepted after several specific controls of admission, the input waste is then assigned to the storage area.

Storage

Storage is particularly important when it comes to hazardous waste, as a bad management can lead to risks and uncertainties. One of the most common decisions is to store the waste in the same drums which were used for the transportation of the waste, avoiding in this way additional handling of the waste. Some aspects to observe regarding the storage and loading options are:

- Normally, incinerators are equipped with a bunker (from around 500m^3 to 2000 m^3) for the storage of hazardous solid waste. The waste is fed to the installation from these bunkers by means of cranes or hoppers.
- Some incinerators use an injection device to introduce certain substances, such as toxi, odorous, reactive and/or corrosive liquids, directly from the transport container to the oven.
- Almost half of commercial incinerators in Europe are equipped with conveyors and elevators to transport and introduce the input waste.

Regarding clinical waste and in order to be able to manage the specific risks this type of waste brings (infectious contamination, needles.. etc.) and its uncertainties in incineration (heat value and moisture content very variable) special attention is required.

Looking at the management of clinical waste, the risks associated can generally be reduced by limiting the contact with the residue and ensuring a safe storage. To achieve this, several techniques are used:

- Use of specific containers and existence of washing / disinfection facilities if needed
- Automatic kiln loading systems
- Isolated areas of transfer and storage

After the transport and storage, the waste will finally reach the combustion chamber. As commented before, not all thermal treatments are suitable for all types of waste. Apart from pyrolysis and gasification systems, some of the more relevant and common thermal treatments to look at are:

- Grill incinerators
- Rotary kilns
- Fluidized beds

Grill incinerators

Grill incinerators are commonly used to treat municipal solid waste. In Europe, around 90% of the installations to treat municipal solid waste use grills. Grills are also sometimes used to treat other types of waste such as commercial, non-hazardous industrial, sewage sludge and some clinical waste.

Although it can slightly vary, waste incinerators are made of the following components:

- Waste feeder
- Incineration grate
- Bottom ash discharger
- Incineration air conduction system
- Incineration chamber
- Auxiliary burners

Figure below shows an example of a grate incinerator with a heat recovery boiler:

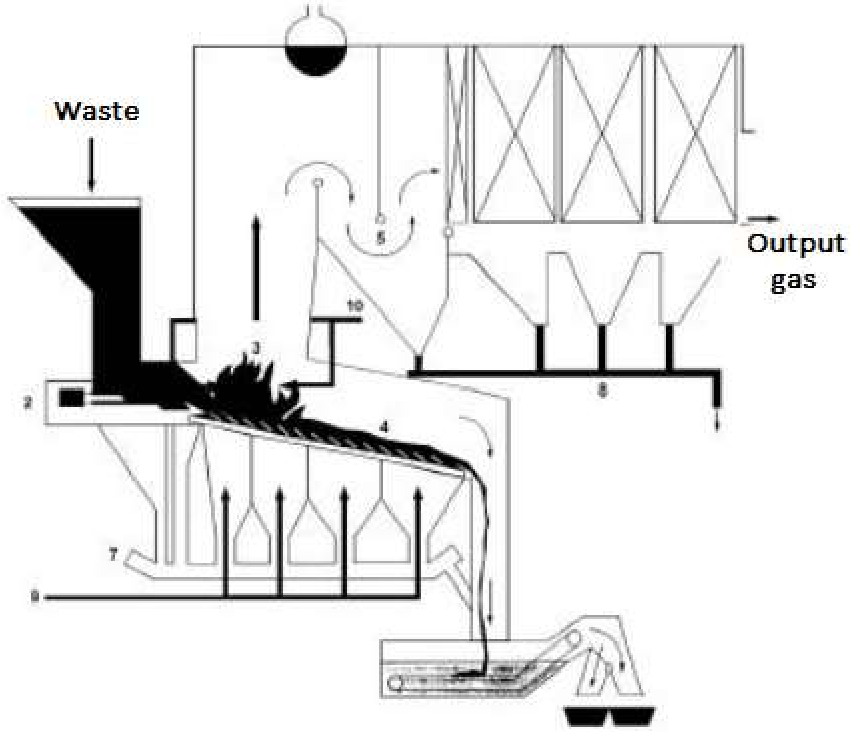


Figure 9: Grill incineration diagram

In the figure:

1. Waste ramp
2. Feeder
3. Incineration area
4. Main incineration area
5. Large grain separator
6. Bottom ash discharge
7. Separation of slag and ash
8. Boiler ash elimination
9. Injection of primary air
10. Injection of secondary air

An incineration grate performs the following functions:

- Transporting the waste through the furnace
- Loading the waste
- Positioning of the main incineration area in the incineration chamber

One of the main objectives of the incineration grid is to distribute well the injected air in the furnace to achieve a good combustion. Normally, the residence time of the waste in the grills is not more than 60 minutes.

There are different types of grills, which differ mainly in the way the waste is transported through the different areas of the combustion chamber. They all have in common several aspects, as ensuring the required speed of transport and inclination, waste mixing, and supply of air.

Mobile grills consist of connecting rods or a continuous metallic belt which move the input waste along the oven. Roller grills have several rollers installed in series, through which the waste is transported inside the chamber. Both types of grills are normally refrigerated with water. The cooling water helps to control the temperature of the grill not relying as much in the injected air. The cooling requirements are normally modified depending on the calorific value changes of the input waste.

One type of oven used for the incineration of hazardous waste are the drum ovens. They are very flexible regarding the waste they can treat, and have proven productivities up to 70000 tons per year. Drum ovens can be protected with refractory bricks (containing Al_2O_3 and SiO_2) to protect themselves from the high temperatures which can be reached inside (up to 1200°C). At the same time, these bricks are protected with a layer of slags such as sand and glass mixes, as they can be attacked by alkali metal compounds.

Drum ovens normally have a slow rotation, between 3 and 40 rotations per hour, and the time residence for solid waste is normally more than half an hour. In order to meet the requirements of minimum residence time for the combustion gases, and so recude the risks of incomplete combustion of the gases, there is normally an afterburner chamber. The minimum residence time, for hazardous waste, are 2 seconds at a temperature of 1100°C for the gases, according to the European legislation.

The following figure shows an incineration plant with a capacity of 45,000 tonnes per year with a drum oven. Three main areas/stages can be distinguished:

- Combustion in the drum oven and secondary (afterburner) chamber
- Energy recovery system (Boiler)
- Gases cleaning system

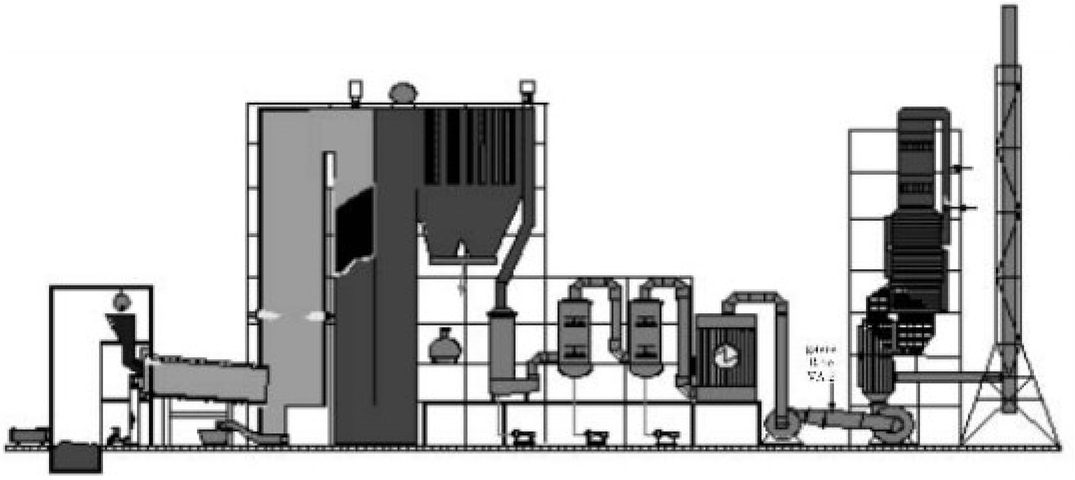


Figure 10: Incineration plant with drum oven for the incineration of hazardous waste

2.3.3 Incineration technology selection

While for municipal solid waste, the most common incineration thermal treatment will involve a grill incinerator, incinerators for hazardous and medical waste normally use rotary kilns. The table below summarises what type of plants are successfully used to treat different types of waste.

Technology	Municipal Solid Waste	Hazardous waste	Clinical waste
Moving grate	**Widely Used**	Rarely used	Sometimes used
Roller grill	**Widely Used**	Rarely used	Sometimes used
Rotary kiln	Sometimes used	**Widely used**	**Widely used**
Fluidized bed	Sometimes used	Very rarely used	Very rarely used
Pyrolysis	Rarely used	Rarely used	Rarely used
Gasification	Rarely used	Rarely used	Rarely used

Table 6: Summary of what type of plants are successfully used to treat different types of waste. Source: (Comisión Europea. Gobierno de España. Ministerio de Medio Ambiente y Medio Rural y Marino)

Rotary kilns are prepared to treat almost any type of waste due to its stockiness. This makes them suitable for the incineration of hazardous waste, were in practice, are widely used. They are also commonly used to treat clinical waste, where the rotary kilns are used to incinerate the considered hazardous clinical waste which need a high combustion temperature. On the other hand, they are rarely used for the incineration of municipal solid waste.

One of their main reasons to be used to treat hazardous and clinical waste is its high operating temperatures. The most common temperatures they operate with are between 900°C and 1200°C, temperatures where a full combustion is generally ensured, although sometimes can reach temperatures up to 1450°C.

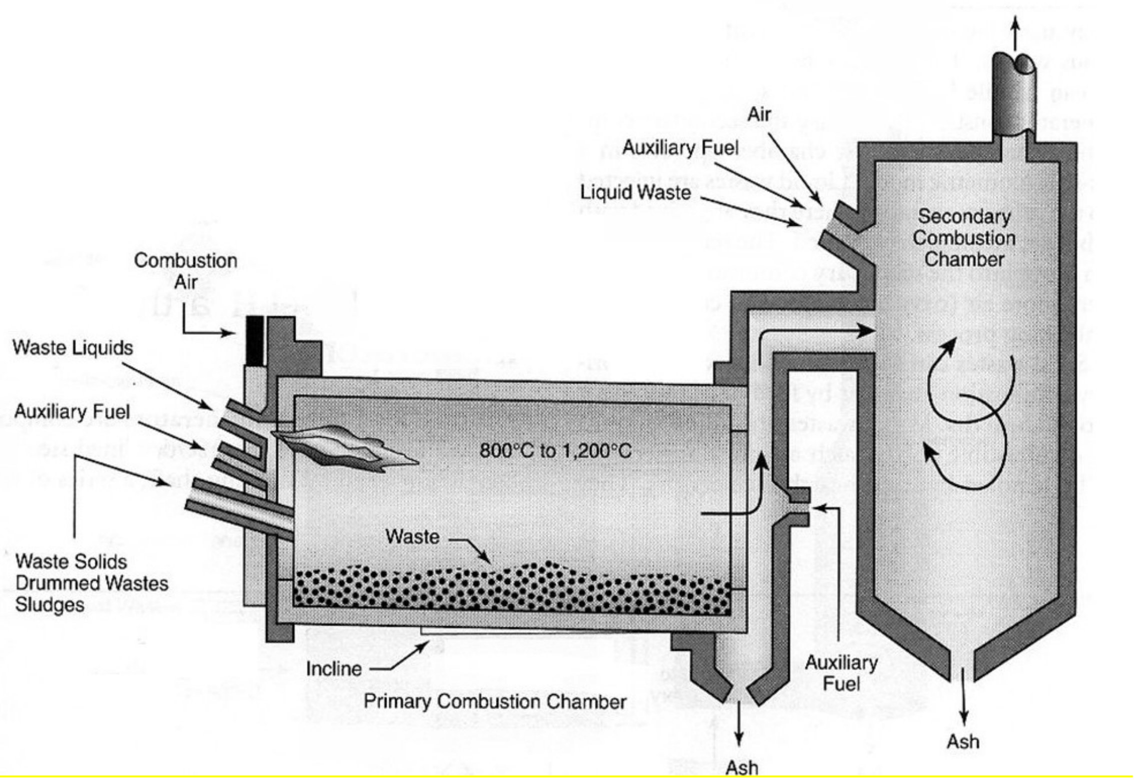


Figure 11: Incineration system with rotary kiln. Source: Kåre Helge Karstensen

The rotary kiln consists of a cilindrical vessel slightly inclined on its horizontal axes. The waste is transported through the furnace by gravity as it rotates. In order to reduce operators exposure, the waste is directly injected.

The inclination of the kiln and its rotation speed determine the residence time of the waste, being normally between 30 to 90 minutes. While solid waste is injected through the hopper, liquids (if any to be treated) can be injected through nozzles. In case of hazardous waste or waste with a risk of emitting toxic compounds, an afterburner chamber is used. Also, if the temperature needs to be raised, additional fuel can be injected, although this is not normally necessary if the calorific value of the input waste is high enough.

When dealing with hazardous waste, the temperature in the combustion process where the waste is burnt normally varies between 850°C and 1300°C. Normally there is an afterburner or secondary chamber (operation temperature between 900°C and 1200°C), ensuring complete combustion.

2.4 Energy recovery

It is very common that new incineration plants are designed with an energy recovery system. Taking into account the high calorific value of the medical plastic waste stream (7337 Kcal/kg), and the expected high temperature at the exit of the secondary combustion chamber, it seems suitable to consider the option of including a boiler in order to make the most of the high energy content present in the output gases leaving the secondary chamber.

The energy recovery system proposed is implemented by a Rankine cycle. The output gases coming out from the secondary combustion chamber will heat up the boiler's water. The generated water steam will go through the Rankine's closed cycle and impulse a turbo-alternator group which will generate electrical energy. After, the steam will be condensed in an air condenser, and after going through a degasser and 2 feeding bombs, the water will go back to the boiler completing a closed Rankine cycle. The produced energy will both be used for the own consumption of the plant and the rest given to the net.

2.5 Emissions limit values

The Directive 2010/75/EU of the European Parliament and of the council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) and the Directive 2000/76/EC of the European Parliament and of the Council, on the incineration of waste, establish:

Daily average values:

Total dust	10 mg/m^3
Gaseous and vaporous organic substances, expressed as total organic carbon	10 mg/m^3
Hydrogen chloride (HCl)	10 mg/m^3
Hydrogen fluoride (HF)	1 mg/m^3
Sulphur dioxide (SO2)	50 mg/m^3
Nitrogen monoxide (NO) and nitrogen dioxide (NO_2) expressed as nitrogen dioxide for existing incineration plants with a nominal capacity exceeding 6 tonnes per hour or new incineration plants	200 mg/m^3 (*)

Table 7: Daily average values. Source: (Directive 2000/76/EC of the European Parliament and of the Council, 2000)

(*) Until 1 January 2007 and without prejudice to relevant (Community) legislation the emission limit value for NOx does not apply to plants only incinerating hazardous waste.

Half-hourly average values:

Total dust	10 mg/m^3
Gaseous and vaporous organic substances, expressed as total organic carbon	10 mg/m^3
Hydrogen chloride (HCl)	10 mg/m^3
Hydrogen fluoride (HF)	2 mg/m^3
Sulphur dioxide (SO2)	50 mg/m^3
Nitrogen monoxide (NO) and nitrogen dioxide (NO_2) expressed as nitrogen dioxide for existing incineration plants with a nominal capacity exceeding 6 tonnes per hour or new incineration plants	200 mg/m^3 (*)

Table 8: Half-hourly average values. Source: (Directive 2000/76/EC of the European Parliament and of the Council, 2000)

(*) Until 1 January 2007 and without prejudice to relevant Community legislation the emission limit value for NO_x does not apply to plants only incinerating hazardous waste.

Average values over the sample period of a minimum of 30 minutes and a maximum of 8 hours

Cadmium and its compounds, expressed as cadmium (Cd)	total 0,05 mg/m^3
Thallium and its compounds, expressed as thallium (Tl)	total 0,05 mg/m^3
Mercury and its compounds, expressed as mercury (Hg)	0,05 mg/m^3
Antimony and its compounds, expressed as antimony (Sb)	total 0,5 mg/m^3
Arsenic and its compounds, expressed as arsenic (As)	total 0,5 mg/m^3
Lead and its compounds, expressed as lead (Pb)	total 0,5 mg/m^3
Chromium and its compounds, expressed as chromium (Cr)	total 0,5 mg/m^3
Cobalt and its compounds, expressed as cobalt (Co)	total 0,5 mg/m^3
Copper and its compounds, expressed as copper (Cu)	total 0,5 mg/m^3
Manganese and its compounds, expressed as manganese (Mn)	total 0,5 mg/m^3
Nickel and its compounds, expressed as nickel (Ni)	total 0,5 mg/m^3
Vanadium and its compounds, expressed as vanadium (V)	total 0,5 mg/m^3

Table 9: Average values over the sample period of a minimum of 30 minutes and a maximum of 8 hours. Source: (European Parliament and the Council, 2010)

Dioxins and furans

Emission limit value for the concentration of dioxins and furans in average values over a sampling period of a minimum of 6 hours and a maximum of 8 hours: 0.1 mg / m^3

The Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste state that incineration plants should be designed, equipped, built and operated in a way so that the gas is raised to a temperature of 850°C, even under the most unfavourable conditions. In case of hazardous waste, implying a content of more than 1% of halogenated organic substances, expressed as chlorine, the gas temperature should reach 1100°C instead of 850°C. (Directive 2000/76/EC of the European Parliament and of the Council, 2000).

Concentrations of carbon monoxide (CO)

The following emission limit values for CO concentrations must not be exceeded in the combustion gases (start-up and stop phases are excluded):

- 50 mg/m^3 of combustion gas calculated as the average daily value
- 150 milligrams/m3 of combustion gas of at least 95 % of all measurements determined as 10-minute average values or 100 mg/m3 of combustion gas of all measurements determined as half-hourly average values taken in any 24-hour period.

Chapter 3. Project development and Calculations

3.1 Generation Rate (MW)

According to the data from the Organisation for Economic Co-operation and Development (OECD) the average number of hospital beds in a number of studied countries (Austria, Belgium, Canada, Chile, China Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Mexico, New Zealand, Norway, Poland, Portugal, Russia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom) is 4,92 beds ~ 5 beds, per 1000 people.

For a population of 2.000.000, the average number of beds sums up to 10.000, and the number of medical waste to 33.000 kg per day. Also, from studies of several hospitals around the world (Italy, China, Turkey..), the percentage of plastics in medical waste is around 50% (World Health Organization) (S. Altin). The total plastic medical waste treated would be 16.500 kg per day. As in the present project only plastic waste with risk of infection is going to be analysed, the total input of infectious plastic medical waste for the incineration plant is estimated to be of 2640kg per day. This estimation has been made from 2 sources. First, a study of plastic medical waste for the OLVG hospital in Amsterdam, where from 7751 kg of plastic medical waste analysed (considered waste of 10 days), only 1268 was considered infectious (16%). Also, according to the WHO, 15% is the percentage of hazardous waste from the total medical waste, which is relative to plastics, and matches this proportion.

Therefore, the input stream of plastic medical waste for the plant will be 110 kg/hour.

3.2 Model description

In order to build the model, it is important to take into account several aspects. Between the main aims, are to maintain an adequate level of emissions and an appropriate level of transformation of ash and slag. Looking at the combustion chambers, an appropriate design of the rotary kiln (volume and design) should be made. Also these parameters should be designed properly for the secondary (afterburner) chamber, where a minimum residence of flue gases should be ensured, and where the outside temperature should be tried to keep at its minimum.

The model will be built based on proven evidence of experimental studies of incineration in Rotary kilns, on energy efficiency of an incinerator for medical waste, and in a mathematical model based on rotary kiln technology of thermal treatment of waste (Bujak, 2009) (Lombardi, 2013), (Bujak, 2015). First, the process will be described, and the input stream of materials will be selected, along with the reactions and product gases. A flow chart will be made to give a more technical idea of the process.

3.3 Input elemental composition calculation

3.3.1 10 day sample from an average European hospital

With the aim of getting a realistic proportion of the different materials generated in an average hospital, a chemical composition study made by Circle Economy is analysed. 9 plastic waste hospital waste from the OLVG hospital in Amsterdam (average hospital with 371 beds) containing a total of 7751g of plastic (calculated to be the total plastic hospital waste from 10 days) were analysed. From it, the materials resulted to be:

Waste material	**Grams**
gloves	100
medical bag	190
plastic cups	60
Medical plastic bottles & accesories	320
Sterile liquid container	225
Syringe & Accesories	75
Trays	500
Tubing & accesories	283
Other (adhesives, food, eyeshields)	15
Bubble wrap	2000
Disposable Packaging	4483

Table 10: Medical plasic waste components. Source: (Circle Economy)

Taking into account that the bubble wrap, trays and disposable packaging can be recycled in other ways as it is not considered infectious, the scope of the materials analysed reduces to:

Waste material	**Nº grams**
gloves	100
medical bag	190
plastic cups	60
Medical plastic bottles & accessories	320
Sterile liquid container	225
Syringe & Accessories	75
Tubing & accessories	283
Other (adhesives, eye shields)	15
Total	1268

Table 11: Medical plastic waste scope components.

3.3.2 Hospital plastic waste composition - Percentages in mass

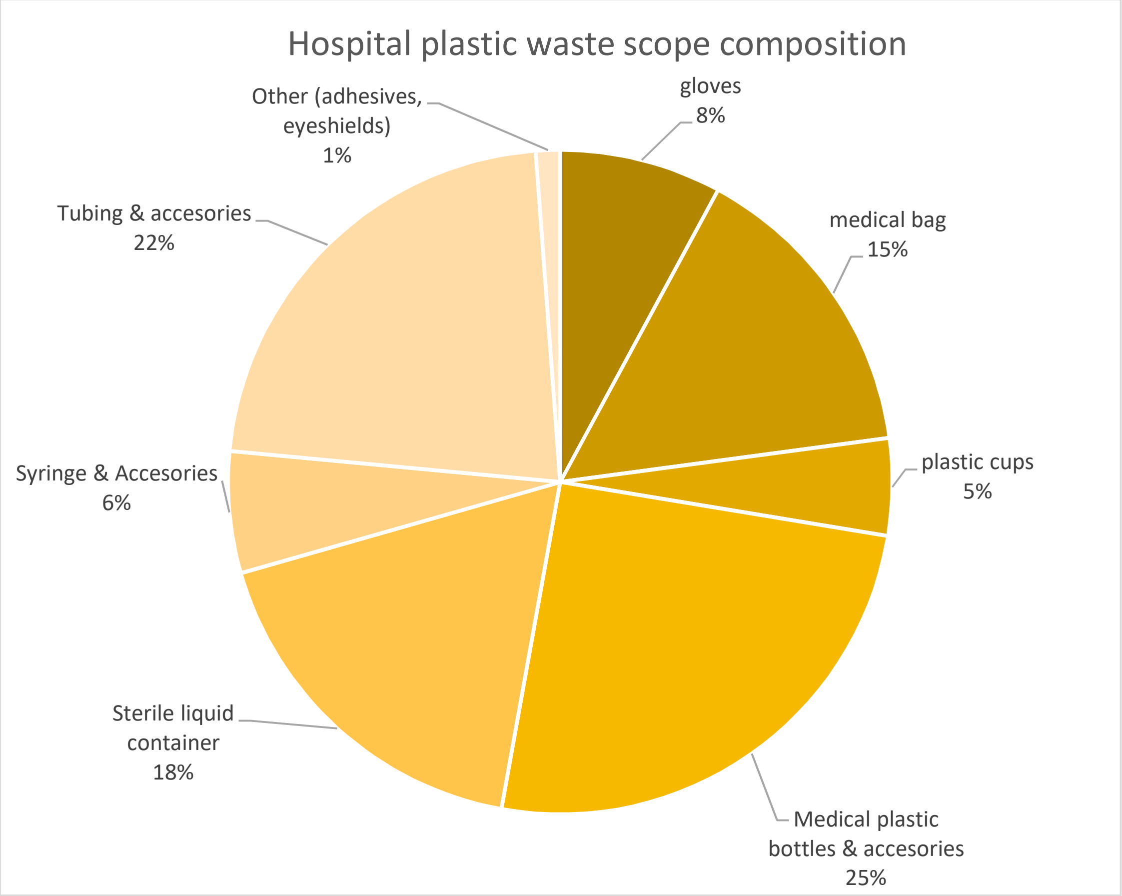


Figure 12:Infectious OLVG hospital plastic waste composition.

The composition of all this plastic waste was identified based on the on the SPI: Plastics Industry Trade Association’s Resin Identification Code (RIC) system2, shown in the Figure below.

Figure 13: Resin identification code

Waste material	**Nº grams**	**Material**	**Nº grams**	**Percentage mass (%)**
gloves	100			
		Nitrile rubber	100	100
medical bag	190			
		LDPE	135	71.05
		PP	55	28.95
plastic cups	60			
		PP	60	100
Medical plastic bottles & accesories	320			
		PP	35	10.94
		PET	275	85.94
		PVC	10	3.13
Sterile liquid container	225			
		PP	25	11.11
		Other plastics	100	44.44
		LDPE	100	44.44
Syringe & Accesories	75			
		PP	50	66.67
		Mixed (PP/HDPE/Rubber)	25	33.33
Tubing & accesories	283			
		PP	30	10.60
		Mixed (Abs/PVC/PP)	25	8.83
		Other plastics	18	6.36
		Mixed (PS/ABS)	25	8.83
		PVC	180	63.60
		LDPE	5	1.77
Other (adhesives, eyeshields)	15			
		PET	10	33.33
		Other plastics	5	16.67
		TOTAL:	1268	

Table 12: Waste input material composition. Source: (Circle Economy)

3.3.3 Elemental composition of the input waste

From the above analysis, the following table presents the elemental composition (%weight) of the sample. Regarding the moisture percentage present, for general hospital waste, the moisture content is set over 30% (Chih-Shan Li). On the other hand, the World health Organization states that the percentage of moisture in plastic medical waste is practically 0%. Also, there is evidence that there is a small percentage of moisture content present in plastics (David H.F. Liu). For the model, therefore, it will be taken into account a 5% of moisture.

Elemental composition, % weight							
C	H	O	N	S	Cl	Ash	Water
64.77	8.26	7.58	1.40	0.00	7.99	<5.00	5.00

Table 13: Elemental composition of input stream

3.4 Calorific value of the input waste

The calorific value refers to the energy contained in a fuel, in this case, the energy contained in the input waste to be burn. It is determined by measuring the heat produced by the complete combustion of a specified quantity.

In order to calculate the calorific values for the input waste, the Dulong equation is used:

$$LCV = 81 \cdot C + 290 \cdot H - 36{,}25 \cdot O + 25 \cdot S - 6 \cdot H_2O$$

$$= 7336{,}995\ \frac{Kcal}{kg} = 30{,}70\frac{MJ}{kg}$$

$$= 8.53 kWh$$

3.5 Combustion calculations

Once obtained the input stream composition and the percentages of the different elements in the input waste (C, H, O, N, Cl..) the next step is to proceed with the calculations to establish what reactions are to occur during the combustion process, the air required for this reactions to happen, and the products obtained.

To proceed, the following simplifications will be made:

- All H_2 present transforms into H_2O (g).
- All Cl_2 into HCl
- All C into CO_2
- All nitrogen present into N_2 (with the addition of urea the NO_x are transformed into N_2)

With this, we obtain the following chemical reactions:

$$C + O_2 = CO_2$$

$$2H_2 + O_2 = 2H_2O$$

$$2N = N_2$$

$$H_2 + Cl_2 = 2HCl$$

The waste will burn using air as the oxidant element. The necessary oxygen for the combustion will become both from the air introduced in the oven, and the oxygen present in the waste itself.

3.5.1 Calculation of air needed for combustion

From the stoichiometric calculation, and considering the excess oxygen required for the complete combustion of the different elements, the necessary air for the combustion and the amount of gases produced are calculated. To proceed, the following table containing the molecular mass values and other required information will be used.

Reactions	%mass	Kg/kmol	Kmol/100kg	Coef O_2	Kmol O_2
$C + O_2 = CO_2$	64,77	12	5,40	1	5,40
$H_2 + \frac{1}{2}O_2 = H_2O$	8,26	2	4,13	0,5	2,07
$O_2 = O_2$	7,58	32	0,24	-1	-0,24
$N_2 = N_2$	1,40	28	0,05	0	0,00
$S + O_2 = SO_2$	0	32	0,00	1	0,00
$H_2 + 2Cl = 2HCl$	7,99	70	0,11	0	0,00
$Ash = Ash$	5	-	-	-	-
$H_2O = H_2O$	5	18	0,27	0	0,00

Table 14: Combustion reactions

Suming up the total moles of O_2:

$$5{,}40 + 2{,}07 - 0{,}24 = 7{,}23\ Kmol\ O_2\ /\ 100kg\ waste$$

It is considered that the plant should work with excess oxygen present in the air introduced in the chambers. It is proved that excess oxygen values below 7% cause high carbon emissions, and excess oxygen over 11% will need further cooling, which increase the possible need of additional fuel. (Bujak, 2015) Therefore, to proceed with the model, an excess oxygen of 9% will be used.

Stoichiometric oxygen	7,23	Kmol/100kg
Excess	0,65	Kmol/100kg
Total Oxygen	7,88	Kmol/100kg
Total Nitrogen	29,631	Kmol/100kg
Total air	37,88	Kmol/100kg
For 1000 kg/h waste	378,85	Kmol/h
Mass flow of required air for 110kg/h waste	1207,28	Kg/h

Table 15: Total air required calculation

3.5.2 Expected output gases composition

The expected theoretical Products from calculations made manually and in Microsoft Excel are:

Reaction	Product gas	Percentage mass (%)
$C + O_2$	CO_2	19,74%
$H_2 + \frac{1}{2}O_2$	H_2O	8,68%
O_2	O_2	1,94%
N_2	N_2	68,97%
$S + O_2$	SO_2	0,00%
$H_2 + Cl_2$	$2HCl$	0,68%

Table 16: Product outputs. Theoretical calculations

3.6 Generic simulation model

Looking at the incineration plant composed by a rotary kiln and a secondary chamber, a generic simulation model can be define. The input parameters are defined as:

Input parameter	Symbol	Unit
Flux of incinerated waste	m_{i-w}	Kg/h
Elemental composition of waste	C, H, O, N, S, Cl, Ash, H_2O	Kg or %
Elemental composition of additional fuel	C, H, O, N, S, Cl, Ash, H_2O	Kg or %
Temperature of the air introduced for combustion	$t_{i-a(rk)}$	°C
Minimum residence time of flue gases outside the afterburner chamber	$\tau_{i-r(secmin)}$	°C
Minimum temperature of flue gases outside the secondary chamber	$t_{i-fg(secmin)}$	°C
Maximum temperature of flue gases outside the secondary chamber	$t_{i-fg(secmax)}$	°C
Concentration of oxygen outside the combustion chamber	O_{2i-sec}	%
Heat transfer coefficient of the outer surfaces of the rotary kiln	U_{i-rk}	W/m^2 K
Heat transfer coefficient of the outer surfaces of the afterburner chamber	U_{i-sec}	W/m^2 K

Table 17: Input parameters. Source: (Bujak, 2015)

*The additional fuel will be used *if necessary* to ensure the designed temperature at the outside of the combustion chambers. A recommended additional fuel to be used would be high methane natural gas. (Bujak, 2015)

A generic simulation model could calculate the following parameters:

Parameters calculated	Symbol	Unit
Volume of the rotary kiln	V_{o-rk}	m^3
Flux of mass of flue gas leaving the Rotary kiln	$m_{o-fg(rk)}$	Kg/h
Chemical composition of flue gas leaving the rotary kiln	CO_2, H_2O, O_2, N_2, SO_2, HCl, Dust	Kg or %
Temperature of the flue gas leaving the rotary kiln	$t_{o-fg(rk)}$	°C

Flux of bottom ash mass leaving the rotary kiln	$m_{o-bash(rk)}$	Kg/h
Volume of the secondary chamber	V_{o-sec}	m^3
Flux of mass of flue gas leaving the Secondary chamber	$m_{o-fg(sec)}$	Kg/h
Chemical composition of flue gas leaving the rotary kiln	CO_2, H_2O, O_2, N_2, SO_2, HCl, Dust	Kg or %
Temperature of the flue gas leaving the secondary chamber	$t_{o-fg(sec)}$	°C
Flux of bottom ash mass leaving the secondary chamber	$m_{o-bash(sec)}$	Kg/h
Fuel flux delivered to the rotary kiln and secondary chamber	m_{i-ff}	m^3/h or kg/h
Calorific value of waste incinerated	$Q(LCV)_{i-w}$	MJ/kg
Calorific value of additional fuel	$Q(LCV)_{i-af}$	MJ/kg
+ enthalpy fluxes		

Table 18: Parameters calculated (Bujak, 2015)

In the energy balance equation, the energy from the medical waste and from the air and additional fuel (if any) injected in both chambers will result/ be transformed into the energy present in the flue gas, and the energy losses in the bottom ash, the dust, and through the external surface of the chambers.

$$\dot{E}_{i-waste} + \dot{E}_{i-air(rk)} + \dot{E}_{i-air(sec)} + \dot{E}_{i-af(rk)} + \dot{E}_{i-af(sec)} = \dot{E}_{o-sur\ \ (rk)} + \dot{E}_{o-surf(sec)} + \dot{E}_{o-f\ \ (sec)} + \dot{E}_{o-dust(sec)} + \dot{E}_{o-bash(rk)} + \dot{E}_{o-bash(sec)}$$

Being:

i = input

o = output

rk = rotary kiln

sec =secondary chamber

af = additional fuel

surf = surface

bash = bottom ash

Being the energy losses:

$$\sum \dot{E}_{loss} = \dot{E}_{o-ba\quad(rk)} + \dot{E}_{o-ba\quad(sec)} + \dot{E}_{o-surf(rk)} + \dot{E}_{o-su\quad(sec)}$$

$$\sum \dot{E}_{loss} = \dot{E}_{o-bash} + \dot{E}_{o-surf}$$

In the diagram of the total combustion process, both mass and energy balance will appear as:

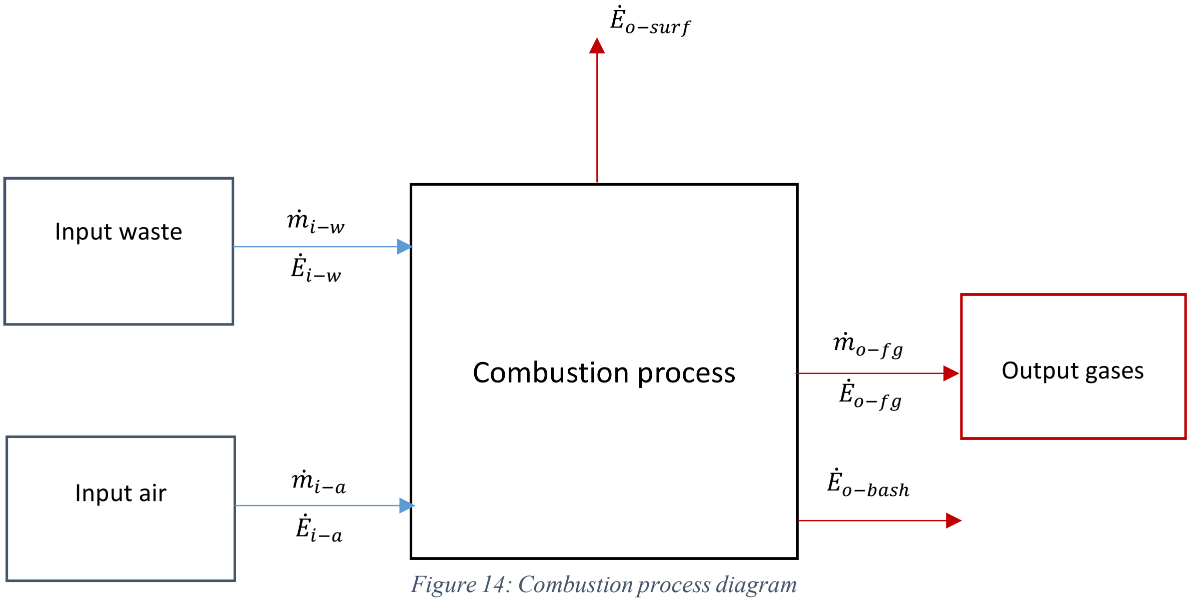
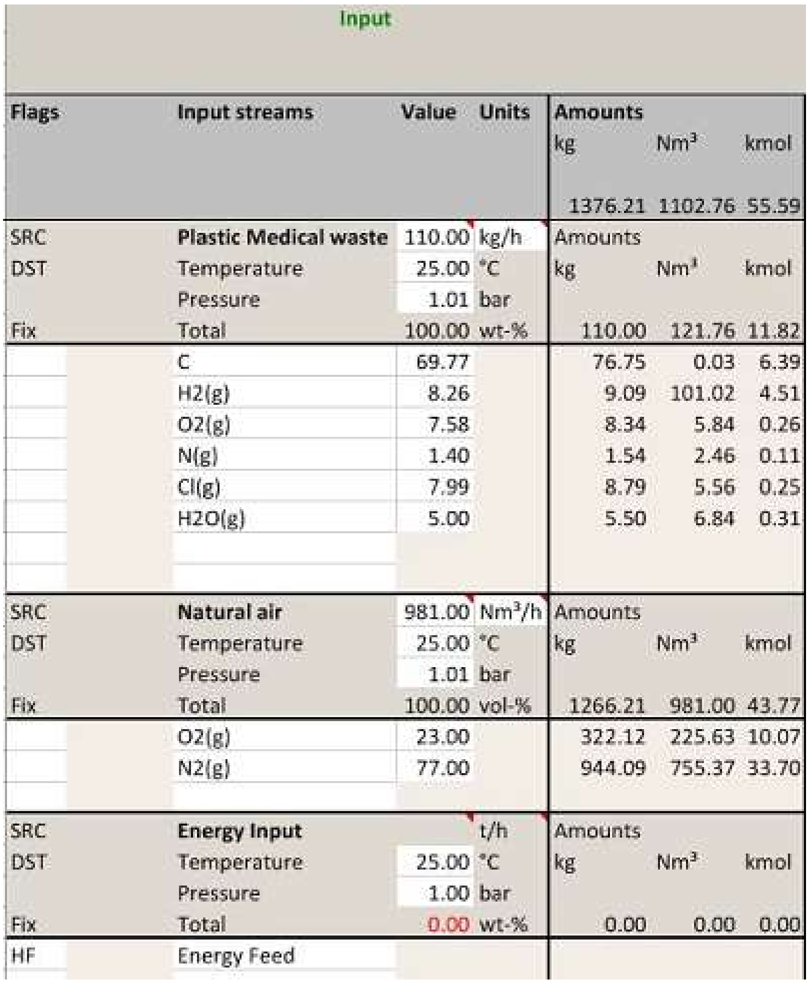


Figure 14: Combustion process diagram

3.7 HSC Chemistry 8

HSC Chemistry is a software for process simulation. In the present project it is used to obtain the volume percentages of the expected output gases, once we introduce the input waste stream and the amount of air the process needs. Also temperatures should be fixed. Input streams will have a temperature of 25°C, and the output gas should leave the combustion process with a temperature of 1100°C to ensure complete combustion. Also, by law, it should be ensured that the gases stay for a minimum of 2 seconds at 1100°C, as the waste to be treated is considered hazardous (Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (German Corporation for International Cooperation)). For the model: it is to be operating in the steady state, and according to research, the additional gas for our characteristics is not necessary (Bujak, 2015).

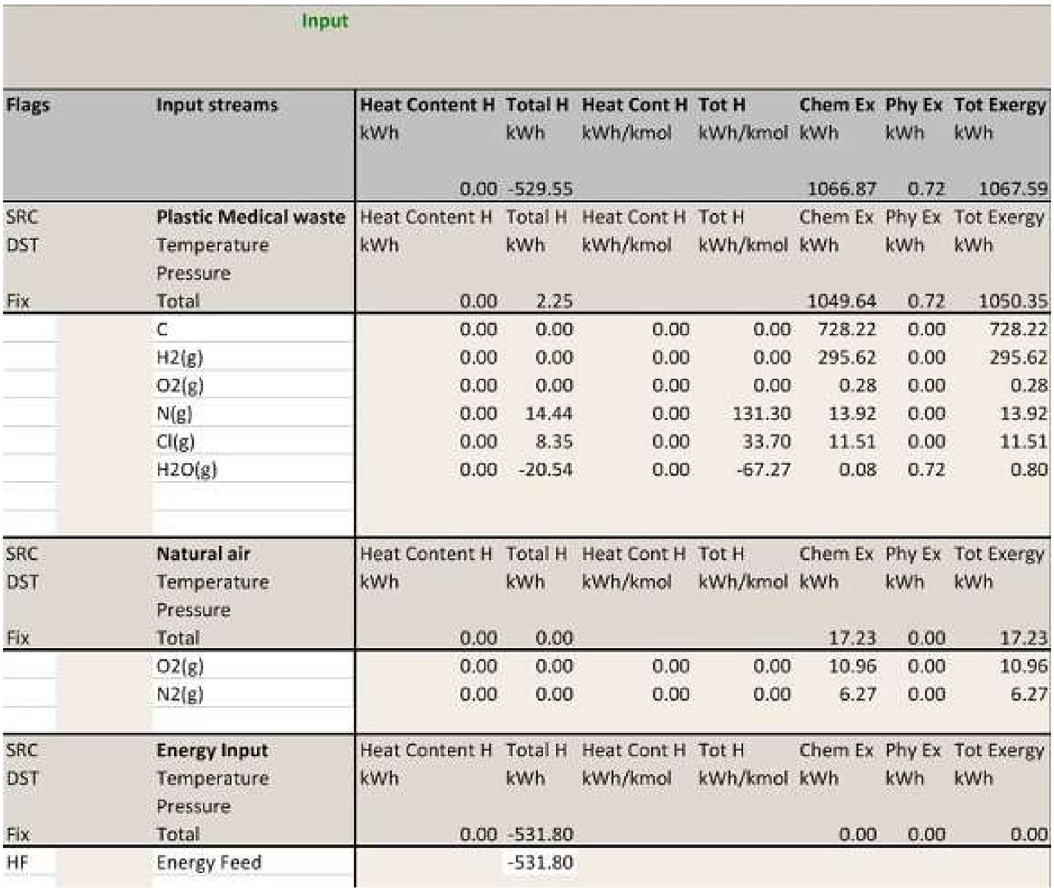
The input stream entered in the software can be seen in the figures below:



Input

Flags	Input streams	Value	Units	Amounts kg	 Nm³	 kmol
				1376.21	1102.76	55.59
SRC	**Plastic Medical waste**	110.00	kg/h	Amounts		
DST	Temperature	25.00	°C	kg	Nm³	kmol
	Pressure	1.01	bar			
Fix	Total	100.00	wt-%	110.00	121.76	11.82
	C	69.77		76.75	0.03	6.39
	H2(g)	8.26		9.09	101.02	4.51
	O2(g)	7.58		8.34	5.84	0.26
	N(g)	1.40		1.54	2.46	0.11
	Cl(g)	7.99		8.79	5.56	0.25
	H2O(g)	5.00		5.50	6.84	0.31
SRC	**Natural air**	981.00	Nm³/h	Amounts		
DST	Temperature	25.00	°C	kg	Nm³	kmol
	Pressure	1.01	bar			
Fix	Total	100.00	vol-%	1266.21	981.00	43.77
	O2(g)	23.00		322.12	225.63	10.07
	N2(g)	77.00		944.09	755.37	33.70
SRC	**Energy Input**		t/h	Amounts		
DST	Temperature	25.00	°C	kg	Nm³	kmol
	Pressure	1.00	bar			
Fix	Total	0.00	wt-%	0.00	0.00	0.00
HF	Energy Feed					

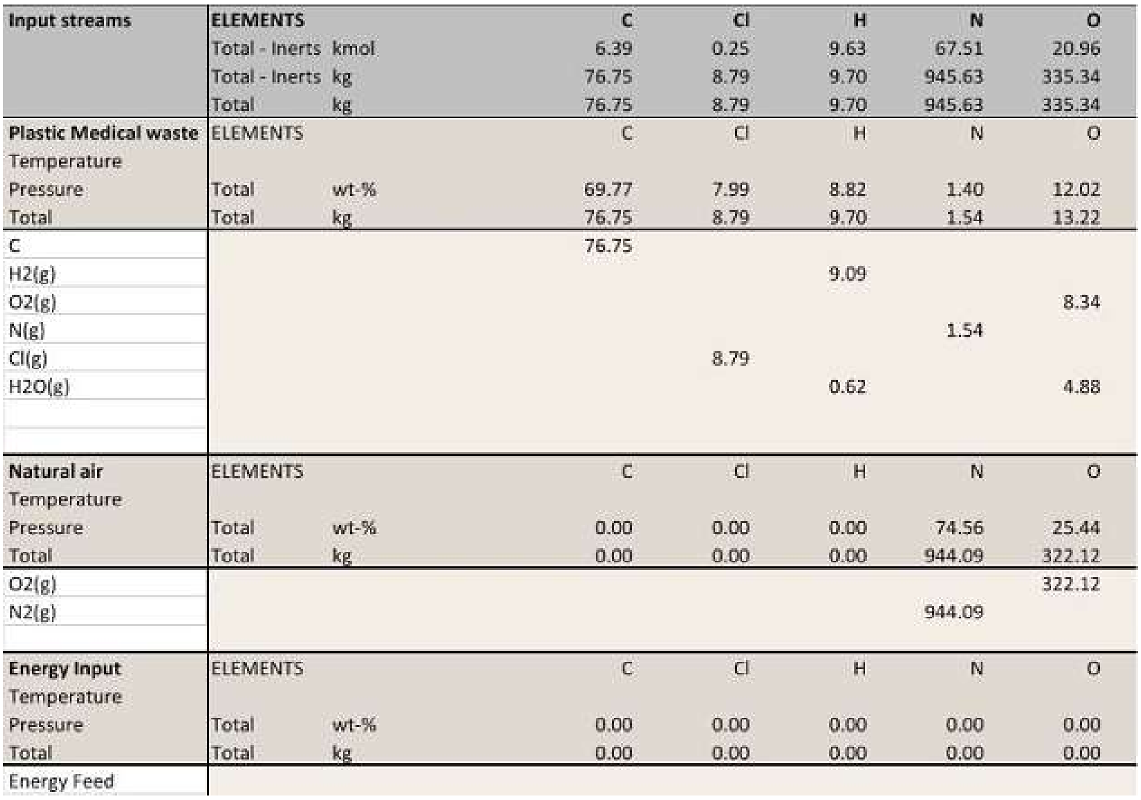
Figure 15: Input stream. HSC Chemistry



Input

Flags	Input streams	Heat Content H kWh	Total H kWh	Heat Cont H kWh/kmol	Tot H kWh/kmol	Chem Ex kWh	Phy Ex kWh	Tot Exergy kWh
		0.00	-529.55			1066.87	0.72	1067.59
SRC	**Plastic Medical waste**	Heat Content H	Total H	Heat Cont H	Tot H	Chem Ex	Phy Ex	Tot Exergy
DST	Temperature	kWh	kWh	kWh/kmol	kWh/kmol	kWh	kWh	kWh
	Pressure							
Fix	Total	0.00	2.25			1049.64	0.72	1050.35
	C	0.00	0.00	0.00	0.00	728.22	0.00	728.22
	H2(g)	0.00	0.00	0.00	0.00	295.62	0.00	295.62
	O2(g)	0.00	0.00	0.00	0.00	0.28	0.00	0.28
	N(g)	0.00	14.44	0.00	131.30	13.92	0.00	13.92
	Cl(g)	0.00	8.35	0.00	33.70	11.51	0.00	11.51
	H2O(g)	0.00	-20.54	0.00	-67.27	0.08	0.72	0.80
SRC	**Natural air**	Heat Content H	Total H	Heat Cont H	Tot H	Chem Ex	Phy Ex	Tot Exergy
DST	Temperature	kWh	kWh	kWh/kmol	kWh/kmol	kWh	kWh	kWh
	Pressure							
Fix	Total	0.00	0.00			17.23	0.00	17.23
	O2(g)	0.00	0.00	0.00	0.00	10.96	0.00	10.96
	N2(g)	0.00	0.00	0.00	0.00	6.27	0.00	6.27
SRC	**Energy Input**	Heat Content H	Total H	Heat Cont H	Tot H	Chem Ex	Phy Ex	Tot Exergy
DST	Temperature	kWh	kWh	kWh/kmol	kWh/kmol	kWh	kWh	kWh
	Pressure							
Fix	Total	0.00	-531.80			0.00	0.00	0.00
HF	Energy Feed		-531.80					

Figure 16: Output Heat and Exergy. HSC Chemistry



Input streams	ELEMENTS		C	Cl	H	N	O
	Total - Inerts	kmol	6.39	0.25	9.63	67.51	20.96
	Total - Inerts	kg	76.75	8.79	9.70	945.63	335.34
	Total	kg	76.75	8.79	9.70	945.63	335.34
Plastic Medical waste	ELEMENTS		C	Cl	H	N	O
Temperature							
Pressure	Total	wt-%	69.77	7.99	8.82	1.40	12.02
Total	Total	kg	76.75	8.79	9.70	1.54	13.22
C			76.75				
H2(g)					9.09		
O2(g)							8.34
N(g)						1.54	
Cl(g)				8.79			
H2O(g)					0.62		4.88
Natural air	ELEMENTS		C	Cl	H	N	O
Temperature							
Pressure	Total	wt-%	0.00	0.00	0.00	74.56	25.44
Total	Total	kg	0.00	0.00	0.00	944.09	322.12
O2(g)							322.12
N2(g)						944.09	
Energy Input	ELEMENTS		C	Cl	H	N	O
Temperature							
Pressure	Total	wt-%	0.00	0.00	0.00	0.00	0.00
Total	Total	kg	0.00	0.00	0.00	0.00	0.00
Energy Feed							

Figure 17: Input stream elemental composition. HSC Chemistry

3.7.1 Combustion process

The flowchart between the input stream and output products of the combustion process is shown in the figure below. The extra fuel has been taking into account as a possible input, and it is only to be considered if the calorific value of the input medical waste is not enough to achieve the desired temperature of the output gases leaving the chamber. It is assumed that the system operates under set conditions, and that the rotary kiln rotates at a constant speed. Also, it has been taken into account that the system has a loss of energy flux in the form of heat flow by the outer wall of the kiln, and the enthalpy (chemical and physical) from the heated bottom ash removed.

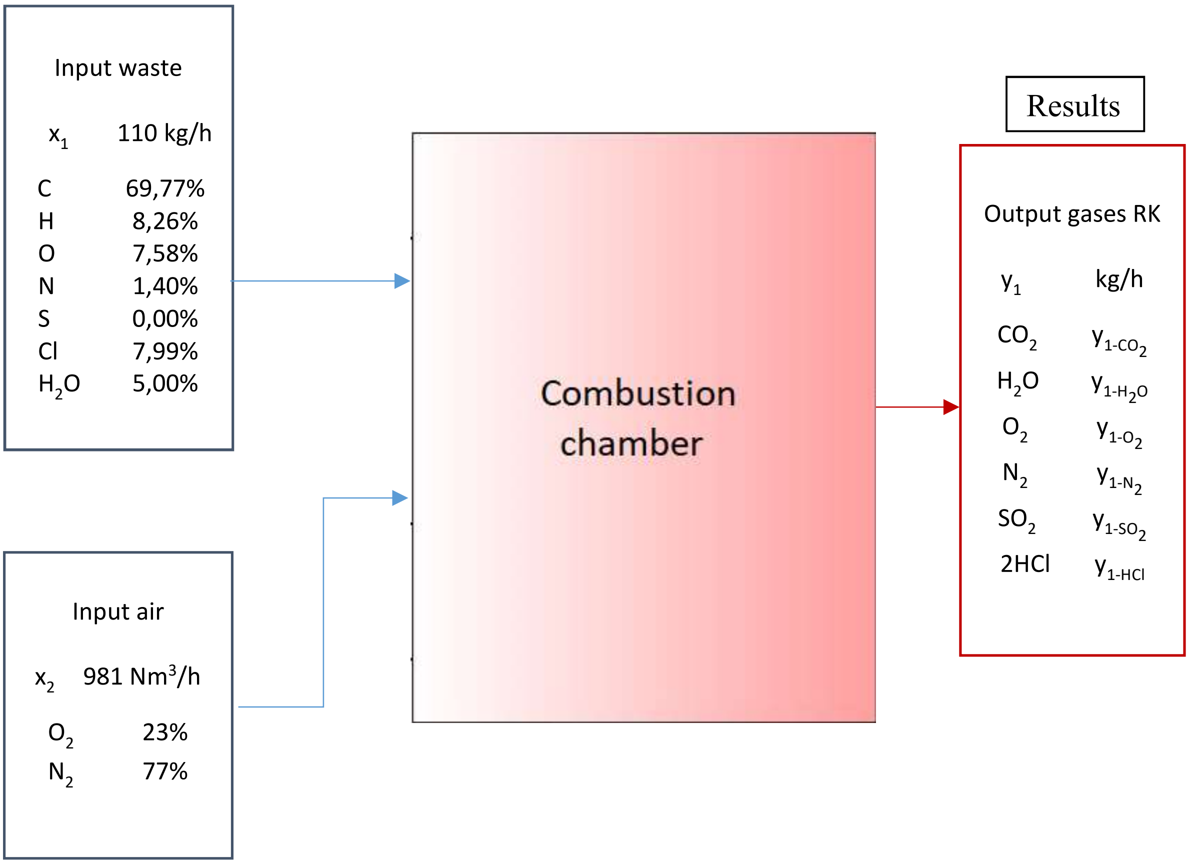


Figure 18: Input and Output stream in the Combustion process

3.8 Energy balance

3.8.1 Energy supplied

The power supplied results from the combustion of the input hospital waste and the input air.

Power supplied by the waste:

$$W_{waste} = PCI * \frac{Capacity}{hour} = 7337 \frac{Kcal}{kg_{waste}} * 110 \frac{kg_{waste}}{h} * \frac{1KW * h}{860Kcal} = 938{,}45Kw$$

Power supplied by the air:

The supplied air is inyected at a temperature of 25°C. At this temperature, the air's enthalpy is 25,13 KJ/Kg. The energy given by the air sums up to:

$$W_{air} = 1207{,}28 \frac{kg_{air}}{h} * \frac{1hour}{3600\ seconds} * 25{,}13 \frac{KJ}{kg} = 8{,}427Kw$$

Total energy supplied:

$$W_{supplied} = W_{waste} + W_{air} = 946{,}88Kw$$

3.8.2 Dissipated Energy

3.8.2.1 Dissipated energy in the combustion process

Dissipated energy due to unburned waste:

It can be estimated that the wasted energy from unburned waste is 1,1% of the total energy supplied. Therefore:

$$W_{unburned} = 946{,}88 * 0{,}011 = 10{,}42\ Kw$$

Dissipated energy due to slag and ash:

It can be estimated that the wasted energy from slag and ash is 1,4% of the total energy supplied. Therefore:

$$W_{slag\ and\ ash} = 946{,}88 * 0{,}014 = 13{,}26\ Kw$$

Dissipated energy due to radiation:

It can be estimated that the wasted energy from radiation is 0,95% of the total energy supplied. Therefore:

$$W_{radiation} = 946{,}88 * 0{,}0095 = 9{,}0\ Kw$$

Total dissipated energy in the combustion process:

$$W_{dis\ combustion} = 32{,}68\ Kw$$

3.8.2.2 Dissipated energy due to output gases

After going through the rotary kiln, the secondary combustion chamber and the energy recovery system (boiler), the gases will then flow until the atmosphere. During this time, they will go through the different emissions treatments of the plant, fan and chimney. Their temperatures will low down from around 200°C when they leave the boiler, to the ambient temperature. This temperature change of the output gases can be seen as energy lost, and therefore in energy lost.

To estimate the dissipated energy from the output gases, a specific heat at 25°C and 1atm will be used. Although this value depends with pressure and temperature, this variation will be despised as this is an approximate estimation.

Gas	C_P [KJ/Kg*K]	Gas flow [Kg/s]
CO_2	0,846	0,078
H_2O	1,8723	0,0235
O_2	0,918	0,0155
N_2	1,039	0,2627
HCl	0,994	0,00251

Table 19: Output gases specific heat and flow

Also, being:

- Temperature of the gases leaving the boiler: 200°C (473 K)
- Ambient temperature: 25°C (298 K)
- Enthalpy difference: $C_p(200-25)$
- Dissipated energy: gas flow(Kg/h) x ΔH

Values obtained:

Gas	Enthalpy difference [KJ/Kg]	Dissipated energy [KW]
CO_2	148,05	11,55
H_2O	327,65	7,70
O_2	160,65	47,77
N_2	181,825	2,49
HCl	173,95	0,44
	Total:	69,94

Table 20: Dissipated energy due to output gases

Total dissipated energy from output gases:

$$W_{output\ gases} = 69{,}94\ Kw$$

3.8.2.3 Dissipated energy in the Rankine cycle:

The Rankine cycle used to recover the energy will also present energy loss. Most of the energy lost would be in the capacitor, being other small losses present in purges, steam auxiliary losses and mechanical ones in the turbine-alternator.

Loss in system purges:

It can be estimated that the losses from system purges are 0,13% of the total energy supplied. Therefore:

$$W_{system\ purges} = 946{,}88 * 0{,}0013 = 1{,}23\ Kw$$

Loss in steam auxiliary losses:

It can be estimated that the losses from steam auxiliary losses are 1% of the total energy supplied. Therefore:

$$W_{steam\ auxiliary\ losses} = 946{,}88 * 0{,}01 = 9{,}47\ Kw$$

Mechanical losses in turbine-alternator:

It can be estimated that the mechanical losses in the turbine-alternator are 1% of the total energy supplied. Therefore:

$$W_{mechanical\ losses\ in\ t-a} = 946{,}88 * 0{,}01 = 9{,}47\ Kw$$

Losses in the capacitor:

It can be estimated that the losses in the capacitor sum up to 65% of the total energy supplied. Therefore:

$$W_{capacitor} = 946{,}88 * 0{,}65 = 615{,}47\ Kw$$

Therefore, the total dissipated energy in the Rankine cycle is estimated to sum up to:

$$W_{Rankine\ cycle} = 635{,}64\ Kw$$

Being therefore the total energy losses of the system:

$$W_{dissipated} = 738{,}26\ Kw$$

3.8.3 Energy produced by the system

The energy produced in the system will be the supplied energy minus the energy losses, both in the combustion process, output gases being released to the atmosphere, and the losses in the Rankine cycle. Therefore:

$$W_{produced} = W_{supplied} - W_{dissipated} = 946{,}88 \ - 738{,}26 = 208{,}62 \ Kw$$

3.8.4 Plant consumption

The proposed plant will be powered from the own energy it produces, in order to be self-sufficient, although it would be more profitable sell all the energy to the system and buying it again, as the plant would receive more premiums, and therefore increase its benefits.

It is considered that the plant will keep 15% of the total energy produced by the system, therefore the plant consumption will be:

$$W_{own\ consumption} = 0{,}15 * W_{produced} = 0{,}15 * 208{,}62 = 31{,}3\ Kw$$

3.8.5 Electric energy produced in the system

It is the energy that is sold and supplied to the network. Therefore it would be all the energy produced except the one consumed to power the plant:

$$W_{network} = 208{,}62 - 31{,}3 = 177{,}32\ Kw$$

3.8.6 Power balance

In order to have a clearer vision of the power balance, a Sankey diagram can represent all the power supplied, lost, used and produced in the plant.

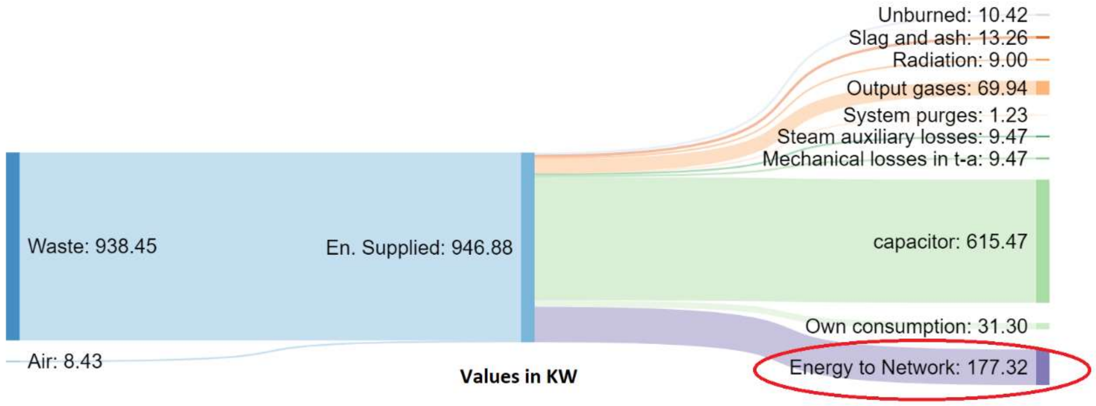


Figure 19: Power balance. Sankey diagram

3.8.7 Performances

Performance of the system combustion chambers – boiler:

$$\eta_{combustion\ ch-boiler} = \frac{W_{supplied} - W_{coombustion\ ch-boiler}}{W_{supplied}}\ x\ 100 = 83{,}1\ \%$$

Performance of the incineration process:

$$\eta_{process} = \frac{W_{produced}}{W_{supplied}}\ x\ 100 = 22{,}0\ \%$$

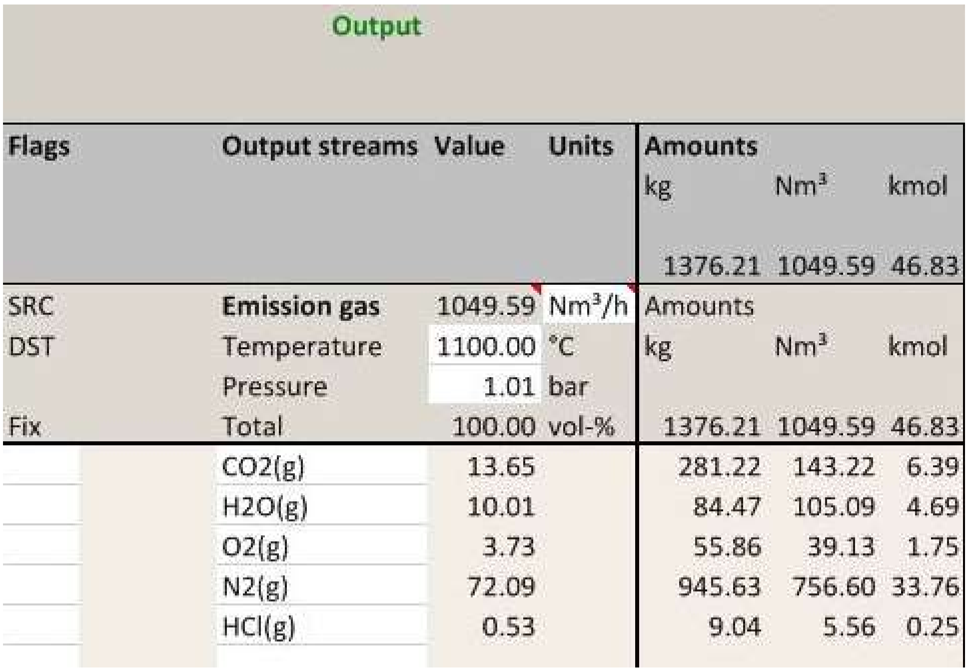
Performance of the cycle as a whole:

$$\eta_{process} = \frac{W_{network}}{W_{supplied}}\ x\ 100 = 18{,}7\ \%$$

Chapter 4. Results and discussion

4.1 Output results

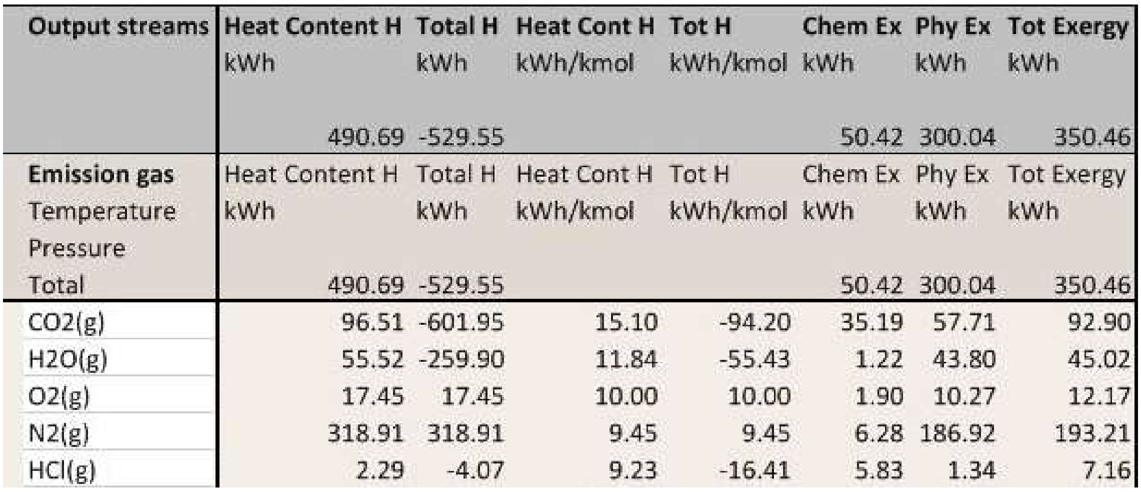
The software HSC Chemistry simulates the combustion process and presents the results of the output stream.



Output

Flags	Output streams	Value	Units	Amounts kg	 Nm³	 kmol
				1376.21	1049.59	46.83
SRC	**Emission gas**	1049.59	Nm³/h	Amounts		
DST	Temperature	1100.00	°C	kg	Nm³	kmol
	Pressure	1.01	bar			
Fix	Total	100.00	vol-%	1376.21	1049.59	46.83
	CO2(g)	13.65		281.22	143.22	6.39
	H2O(g)	10.01		84.47	105.09	4.69
	O2(g)	3.73		55.86	39.13	1.75
	N2(g)	72.09		945.63	756.60	33.76
	HCl(g)	0.53		9.04	5.56	0.25

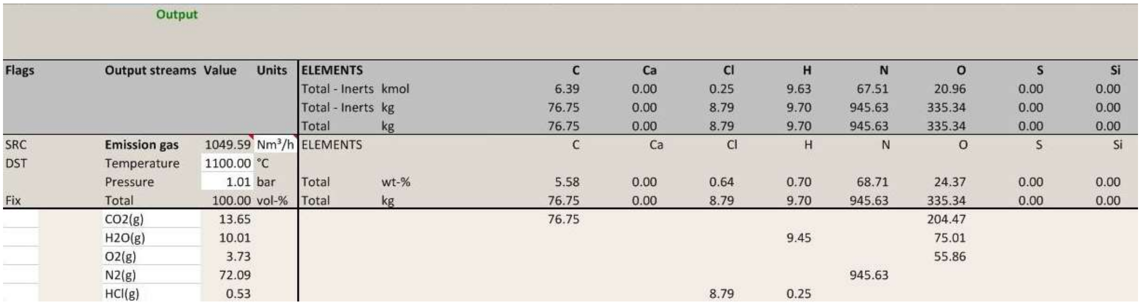
Figure 20: Output stream. HSC Chemistry



Output streams	Heat Content H kWh	Total H kWh	Heat Cont H kWh/kmol	Tot H kWh/kmol	Chem Ex kWh	Phy Ex kWh	Tot Exergy kWh
	490.69	-529.55			50.42	300.04	350.46
Emission gas	Heat Content H	Total H	Heat Cont H	Tot H	Chem Ex	Phy Ex	Tot Exergy
Temperature	kWh	kWh	kWh/kmol	kWh/kmol	kWh	kWh	kWh
Pressure							
Total	490.69	-529.55			50.42	300.04	350.46
CO2(g)	96.51	-601.95	15.10	-94.20	35.19	57.71	92.90
H2O(g)	55.52	-259.90	11.84	-55.43	1.22	43.80	45.02
O2(g)	17.45	17.45	10.00	10.00	1.90	10.27	12.17
N2(g)	318.91	318.91	9.45	9.45	6.28	186.92	193.21
HCl(g)	2.29	-4.07	9.23	-16.41	5.83	1.34	7.16

Figure 21: Output Heat and Exergy. HSC Chemistry

Figure 22: Output stream elemental composition. HSC Chemistry



Output

Flags	Output streams	Value	Units	ELEMENTS		C	Ca	Cl	H	N	O	S	Si
				Total - Inerts	kmol	6.39	0.00	0.25	9.63	67.51	20.96	0.00	0.00
				Total - Inerts	kg	76.75	0.00	8.79	9.70	945.63	335.34	0.00	0.00
				Total	kg	76.75	0.00	8.79	9.70	945.63	335.34	0.00	0.00
SRC	**Emission gas**	1049.59	Nm³/h	ELEMENTS		C	Ca	Cl	H	N	O	S	Si
DST	Temperature	1100.00	°C										
	Pressure	1.01	bar	Total	wt-%	5.58	0.00	0.64	0.70	68.71	24.37	0.00	0.00
Fix	Total	100.00	vol-%	Total	kg	76.75	0.00	8.79	9.70	945.63	335.34	0.00	0.00
	CO2(g)	13.65				76.75					204.47		
	H2O(g)	10.01							9.45		75.01		
	O2(g)	3.73									55.86		
	N2(g)	72.09								945.63			
	HCl(g)	0.53						8.79	0.25				

4.1.1 Mass percentages composition of the output gas

Mass output stream:

$y_1 \longrightarrow$ kg/h = 1376.21 kg/h

$CO_2 \longrightarrow y_{1\text{-}CO_2}$ = 281.22 kg/h

$H_2O \longrightarrow y_{1\text{-}H_2O}$ = 84.47 kg/h

$O_2 \longrightarrow y_{1\text{-}O_2}$ = 55.86 kg/h

$N_2 \longrightarrow y_{1\text{-}N_2}$ = 945.63 kg/h

2HCl $\longrightarrow y_{1\text{-}HCl}$ = 9.04 kg/h

	HSC Chemistry	
Reaction	Product gas	Percentage mass (%)
$C + O_2$	CO_2	20.43
$H_2 + \frac{1}{2}O_2$	H_2O	6.14
O_2	O_2	4.06
N_2	N_2	68.71
$H_2 + Cl_2$	$2HCl$	0.66

Table 21: Output gases percentage mass

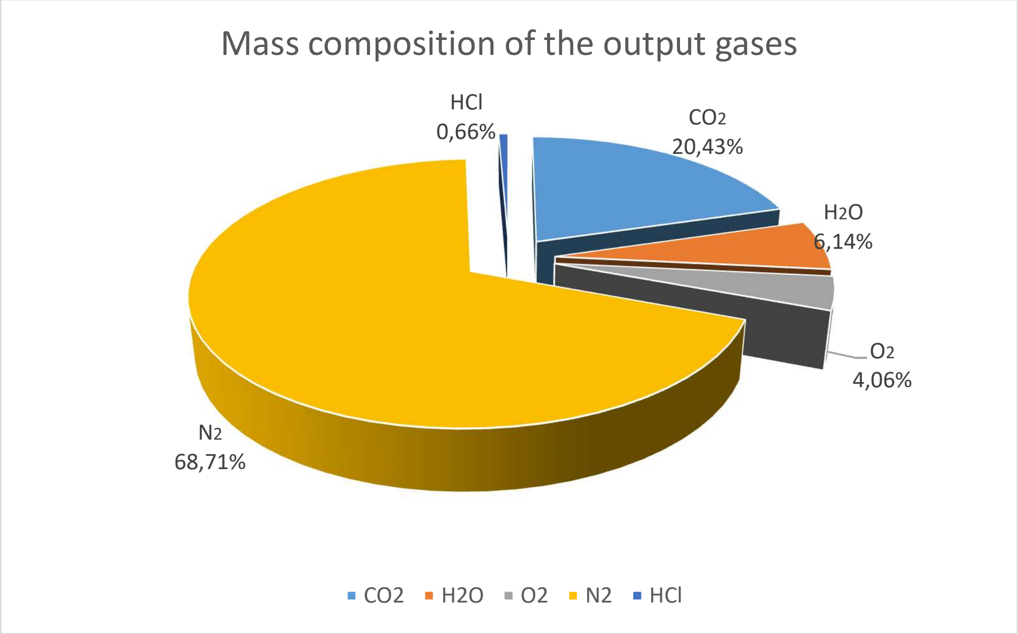


Figure 23: Mass composition of the output gases

4.1.2 Volume composition of the output gas

$y_1 \longrightarrow Nm^3/h = 1049.59\ Nm^3/h$

$CO_2 \longrightarrow y_{1\text{-}CO_2} = 13.65$ %vol

$H_2O \longrightarrow y_{1\text{-}H_2O} = 10.01$ %vol

$O_2 \longrightarrow y_{1\text{-}O_2} = 3.73$ %vol

$N_2 \longrightarrow y_{1\text{-}N_2} = 72.09$ %vol

$2HCl \longrightarrow y_{1\text{-}HCl} = 0.53$ %vol

Volume of output gases	
Product gas	Volume (Nm^3/h)
CO_2	143.27
H_2O	105.06
O_2	39.15
N_2	756.65
$2HCl$	5.56

Table 22: Volume of the output gases

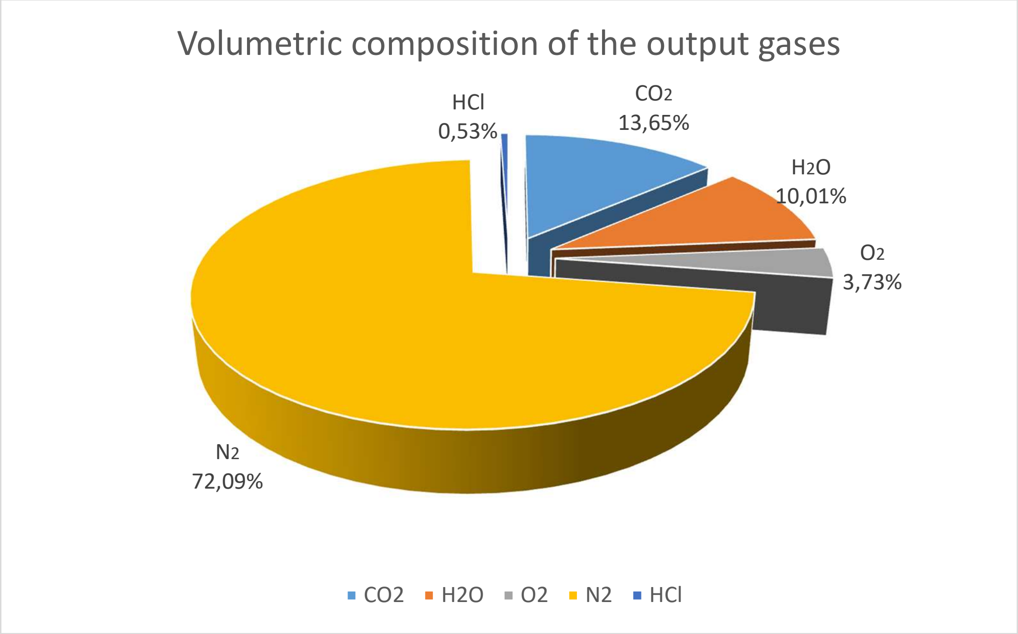


Figure 24: Volumetric composition of the output gases

4.2 Emissions treatment systems

In order to perform under the regulations established in the European Directives already described, it is important to provide the incineration plant with different systems to treat the output gases. This system proposed is selected and designed with the main objection to reduce and eliminate the harmful acid gases, as the HCl present in the results, or others such as HF or SO_2 which may appear in hospital waste with fluorine or sulphur. Also it will consider eliminating possible nitrogen oxides coming from both: reactions between oxygen and the nitrogen present in the combustion air, and the NOx formed in reactions of oxygen and organic nitrogen present in the waste. Also, organic compounds such as dioxins and furans should be eliminated. As well as the heavy metals in the form of gas and particles and the flying dust contained in the combustion gas, in waste with them present. This is why the system proposed is valid both for the plastic medical waste analysed in this project and for other type of medical waste containing other possible chemical elements.

A gases treatment installation for plastic medical waste will consist mainly of the following components:

- SNCR system
- Absorber for neutralization with lime slurry installation
- Filter of sleeves
- Injection of activated carbon
- Installation for the lime slurry
- Induced draft fan
- Chimney

It is important to highlight that in order to obtain N_2 and not any nitrogen oxides (NO or NO_2), previously, an SNCR denitrification system, the Selective non-catalytic reduction system, will be used in the incinerator, in order to eliminate the NOx produced during combustion.

The combustion gases of the plant should be sent to the absorber, where they are released from the harmful substances by atomization of a suspension of lime hydroxide. The noxious gases HCl and SO_2 (if present) combine with the lime hydroxide and dry precipitate as waste mixed with the remaining flying powder. The amount of lime hydroxide has to be calculated. Subsequently, the gases are subjected to an adsorption process by means of active carbon injection in order to minimize emissions of dioxins and furans, with the separation of solid substances taking place in the subsequent bag filter. The combustion gas is sent to the chimney through an induced draft fan.

This system assures that the plant operates under the Directive 2010/75 eu of the European Parliament and of the Council regulations. This regulations can be seen in point 2.6 of the project.

4.2.1 SNCR system

The selective non-catalytic system is used to eliminate the NOx formed in the combustion process. To proceed, urea, $CO(NH_2)_2$,is injected reacting with the NOx, forming N_2, CO_2, and H_2O. The injection is made in the rotary kiln, at a temperature between 850 and 1000°C. This high temperature makes it possible to the reaction to take place without the need of catalysts. The reaction proceed as follows:

$$CO(NH_2)_2 + 2NO + \frac{1}{2}O_2 = 2N_2 + CO_2 + 2H_2O$$

Urea is inyected during the combustion process as an aqueous solution (at 40% urea) using pressurized air. In order to establish the quantity of urea needed, the amount of NOx in the combustion chamber is constantly measured, and regarding it, the amount of urea solution is injected.

There should be a control unit where the quantities of urea solution and water dilution should be established. This is done by the NOx analyser signal and the signal of gas flow. The amount of urea is calculated regarding the amount of NOx present.

4.2.2 Semy-dry scrubber - Absorber

In order to neutralise the acidic gas HCl, calcium hydroxide in water (milk of lime) is atomised at the top of a spray drier. The process carries out at a temperature of 200°C approx. The water evaporates and the reaction takes place.

The neutralization reactions are the following ones:

Firstly, in order to obtain the reactant $Ca(OH)_2$, it can be obtained by making react Calcium oxide (quicklime) with water.

$$CaO + H_2O = Ca(OH)_2$$

After, the reactant $Ca(OH)_2$ reacts with the acidic gas HCl:

$$2HCl + Ca(OH)_2 = CaCl_2 + 2H_2O$$

The reaction product, as well as any calcium hydroxed which hasn't reacted, are collected in the baghouse filter, at a temperature of 120°C approx. This semy-dry scrubbing system removes up to 99% of the HCl formed. (British Lime Association).

4.2.3 Calculation of the Calcium Oxide needed

Reactions	% mass	Kg/kmol	kmol/100Kg	Coef CaO	kmol CaO/100Kg
$CaO + H_2O = Ca(OH)_2$	6,14	18,02	0,3407	1	0,3407
$2HCl + Ca(OH)_2$	0,66	36,47	0,0181	0,5	9,048E(-3)

As every mole of $Ca(OH)_2$ comes from one of CaO, the total number of moles necessary to neutralize the acid HCl are 0,009048 Kmol/100Kg waste.

Now considering that the molecular mass of CaO is 56,08 kg/kmol:

$$CaO\ needed = 0{,}009048\ \frac{kmol\ Cao}{100\ kg\ waste} * 56{,}08\ \frac{kg\ CaO}{kmol\ CaO} * 110\frac{kg\ waste}{1\ hour} = 55{,}82\frac{kg\ CaO}{hour}$$

In practice, the stoichiometric amount is not enough to neutralize the acidic gases as a percentage of it will reach the bottom of the chamber without reacting.

Therefore, a security coefficient to be used to make sure it reacts with all the acidic gases produced is estimated to be 1.5. Therefore:

Calcium oxide needed: 83,7 kg/h.

Moreover, in case other input waste containing other chemical elements such us sulphur (S) the calcium oxide in this process would also be the one used to eliminate the possible output gases these elements could produce during combustion. In the case of sulphur, sulphur dioxide (SO_2) would be produced and therefore needed to be treated.

The reactions would be, similar to before:

$$CaO + H_2O = Ca(OH)_2$$

$$SO_2 + Ca(OH)_2 = CaSO_3 + H_2O$$

Process description

The output gases coming from combustion are sent to the semidry absorber through guide plates and adjustable conducts to create turbulences, in order to create suitable conditions for a good mix between the reactive gases and the pulverized liquids.

The semidry scrubber tower presents a flow from the top downwards. At the entrance of the tower the pulverization takes place. The output gases enter the absorber, where an intense mix between the gases and the drop curtain is made. In a small distance the vaporization process finishes. The average time of the output gases in the absorber is around 15 seconds, which is suitable regarding the efficiency of the acidic gases elimination.

The resting part of the tower ensures that the left particles formed dry. This drying stage occupies the lower half of the tower. The left-over product made is dry.

Process control

The semidry absorber tower is regulated by two regulation circuits.

The mix of calcium oxide and water pulverized is bombed with a constant concentration, being its flow controlled depending of the analysis of the depurated gases.

A second regulation circuit keeps the output temperature constant. This is made by adding to the milk of lime the required amount of water to reach the set temperature. The output gas temperature is kept constant at just above 100°C. This mix of milk of lime and water is previously produced.

4.2.4 Active coal filter

Between the semidry scrubber and the baghouse filter, an active coal filter will be used for the elimination of possible dioxins and furans through the injection of active coal. The adsorbent is capable of attracting to its surface many molecules presents in the output gases, and specially those with a high molecular weight, such as dioxins and furans.

The temperature should not exceed 100°C. To control this, if the temperature exceeds this operation temperature an alarm will ring and the process interrupted.

4.2.5 Baghouse fabric filter

The output gases reach the filter, where their flow speed is rapidly reduced, and therefore, the bigger particles fall inside the hopper. A set of fabric bags with different pore sizes (decreasing sizes as the gas goes through the bags) is displayed. Pollutants attach to the fabric and the resultant clean gas reach the outside towards the induced draft fan.

In the fabric filter, the gases are cleaned from the dust they carry. The filters cover is made of 6mm of a welded steel sheet. The filters are divided into chambers, dividing he gross gas and the clean gas. Each chamber is equipped with fabric filters of 150mm diameter. There are different flaps for raw/gross gas and clean gas, and through them the different chambers can be blocked in order to do maintenance work during operation without problems. The fabric filters are accessible from the clean gas side, through removable covers. The extracted dust is collected in the hoppers, where they are extracted.

The fabric filters are dust extractors which have their cleaning completely automatized in two stages by means of pressure impulses. To clean them, a membrane valve will open so that compressed air coming from the tanks deviated to the corresponding row of the fabric filter. The compressed air comes out at approximately the speed of light, dragging with it the clean gas.

Following the baghouse bag filter, the induced draft fan is used to compensate the pressure loss in the boiler, the gases treatment system and the chimney. After the treatments described, the gases will be emitted to the atmosphere through the chimney, with no ash present and following the current legislation.

4.3 Flowchart

The proposed model consists in 10 blocks. Feeder, Rotary kiln, afterburner chamber (secondary chamber), Boiler for energy recovery, SNCR system, semi-dry scrubber, active coal filter, Baghouse Fabric filter, fan and chimney

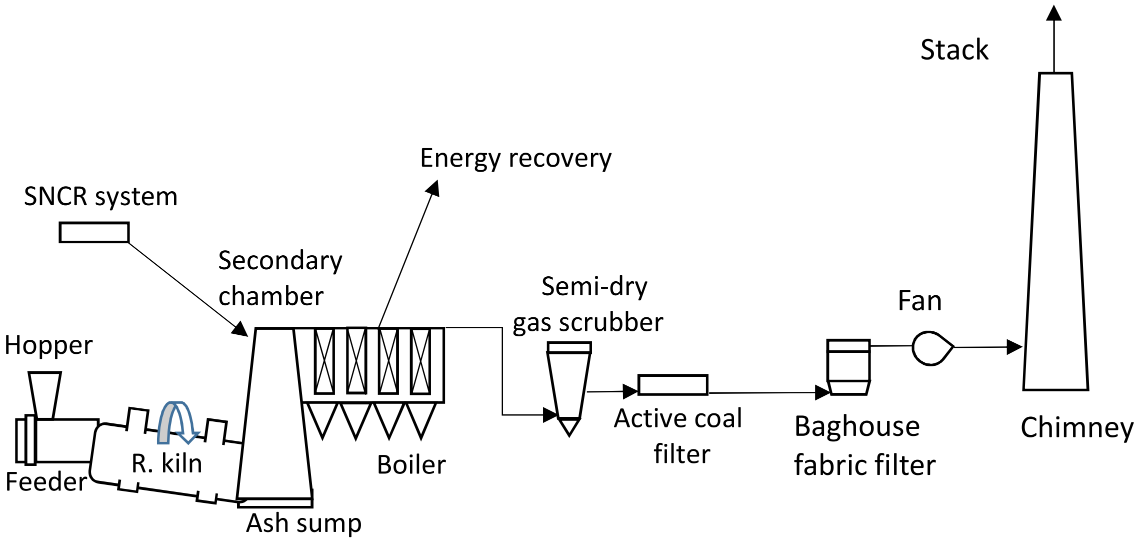


Figure 25: Flowchart. Thermal treatment proposed plant

Chapter 5. Conclusions

5.1 Conclusions regarding methodolody

Firstly, regarding the methodology of the project, the review made on the medical waste, entailing both the focus in plastic medical waste, and the actual thermal treatment technologies and emission treatment systems was considered essential. This review helped to make the decisions on the best treatment method, selecting the waste sample for the simulation, and proposing the considered best emission treatment systems.

Looking at the input waste sample, and at the collection of all the plastic medical waste from an average European hospital, it is important to know that the elemental composition obtained will never be the same in one or another hospital. Not even in the same hospital in different days, therefore, all the results from the simulation are only used to give a general idea. This idea can be completed with the knowledge obtained from the research, from where we know that not only the composition percentages may vary, but that other elements such as sulphur may be present in other samples. Therefore, the emission treatment systems proposed have taken this into account.

Due to the elemental composition of the input, the waste stream selected and proved operation efficiency, a rotary kiln followed by an afterburner chamber seem appropriate for the thermal treatment of medical waste. It is important to analyse the elemental composition of the input stream to anticipate possible emissions, but also to incorporate an emission control system in the plant in order to measure the emissions at every moment.

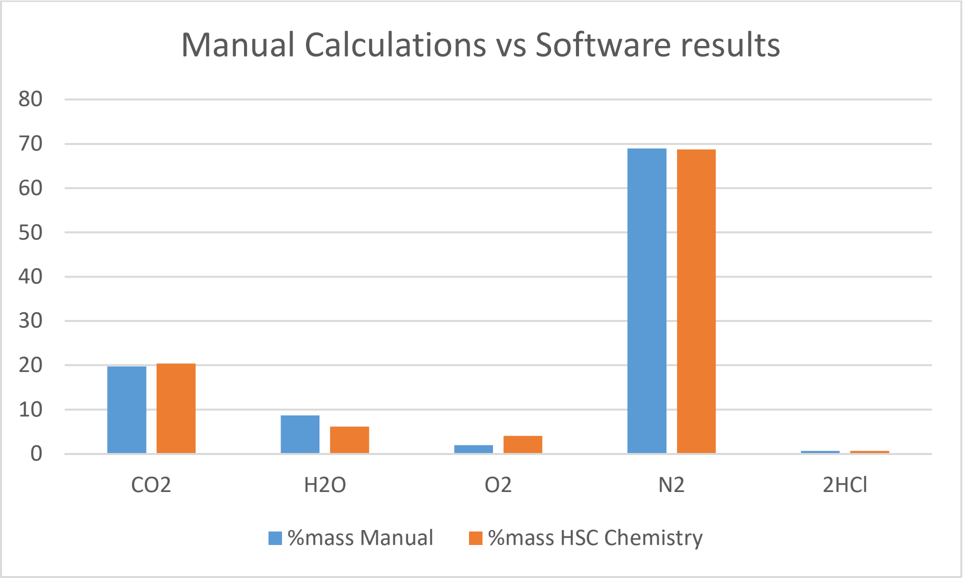
Moreover, during the development of the project one more objective was proposed. The idea of an energy recovery system appeared to be very suitable for this project especially once calculated the high calorific value of the input waste. Although the main objective was to propose treatment for the emissions without getting into costs or energy recovery, the quick analysis made of the energy balance reflected how important it is to make the most of the energy contained in the output gases leaving the secondary chamber. Many operative plants around the world also formed by a rotary kiln with a secondary combustion chamber used to treat hazardous waste send their output gases directly to the scrubber where by the addition of water their temperature decrease from 1200°C to 200°C. The analysis made proves how the plant can not only produce energy for its own consumption but also produce energy to sell to the network.

5.2 Conclusions regarding results

Analysing the results, the output gases composition given through the simulation of the combustion process with the software HSC Chemistry appear as expected. Thermal treatment of plastic medical waste through incineration can be implemented to be an effective way to deal with waste from different health-care facilities. Emissions from incineration can be significantly reduced with the appropriate treatment methods. Although every statement should be proved in an experimental way in a real incineration site, results in this project indicate that with the proper output gases treatment, the emission limits are not exceeded and the plant operates under environmental regulatory constraints. The following table shows the product gases composition coming from the secondary combustion chamber, comparing the results obtained from manual calculations and using the simulation software.

	Manual calculations		HSC Chemistry	
Reaction	Product gas	Percentage mass (%)	Product gas	Percentage mass (%)
$C + O_2$		19.74	CO_2	20.43
$H_2 + \frac{1}{2}O_2$	H_2O	8.68	H_2O	6.14
O_2	O_2	1.94	O_2	4.06
N_2	N_2	68.97	N_2	68.71
$H_2 + Cl_2$	$2HCl$	0.68	$2HCl$	0.66

The results show the model results are very similar to the output composition (%mass) obtained with manual calculations in Excel during the development of the Project.



Moreover, another value obtained of high relevance was the calorific value of the input waste (30,70 MJ/kg). Compared to the calorific waste of other input waste of thermal treatment plants this value is significantly higher. This makes sense as the waste is plastic, with a high content of energy. This result lead to the idea of studying the energy recovery of the plant and the possible energy that could be produced.

Looking at the energy balance, a power of 177,32kW could be supplied to the network. This results interesting when thinking of economic benefits that could be obtained from the plant. The performances from the different cycles and stages calculated make sense comparing them to other operative plants.

Finally, looking at the calcium oxide calculation to treat the acidic gases, the value of calcium oxide needed is relatively high in proportion to other thermal treatment plans, for example of municipal residues. This makes sense as the input waste of this project contains a higher content of chlorine, due to the plastics. It is important to mention that if the input waste also contained sulphur, which could happen in plastic medical waste, the treatment of the acidic gas that would be formed (SO_2) during combustion would be the same, with the injection of urea. The reactions would be:

$$CaO + H_2O = Ca(OH)_2$$

$$SO_2 + Ca(OH)_2 = CaSO_3 + H_2O$$

5.3 Recommendations for future studies

The management and treatment of medical waste requires increased attention and diligence to avoid the possible risks of poor practice. Starting from building a comprehensive system, addressing responsibilities, and establishing handling and disposal good practices. It is important to keep on raising awareness upon society and keep on studying and testing new and improved practices on the treatment.

For future studies related to this project, and to achieve more complete and accurate conclusions, it would be helpful to use a bigger hospital sample, more than just 10 days, and mix samples from different hospitals as this will also affect the composition results.

With an adequate software, it would be interesting to simulate the whole plant, including all the treatment devices operating at their designed pressures and temperatures, and obtaining the characteristics and transformations of all the substances involved.

Giving a bigger step forward, a real life system should be built and monitored, with accurate pollution control systems to monitor the different substances at every stage. Another idea could be designing in-site hospital plants, to be installed individually in hospitals, as many times the transport of waste result to be one of the most expensive parts of the process. Making a realistic economic analysis will also result interesting.

Chapter 6. Bibliography

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Chapter 7. Annexes

Annex I. Directive 2000/76/EC of the European Parliament and of the Council

►B DIRECTIVE 2000/76/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 4 December 2000

on the incineration of waste

(OJ L 332, 28.12.2000, p. 91)

Amended by:

		Official Journal No	page	date
►M1	Regulation (EC) No 1137/2008 of the European Parliament and of the Council of 22 October 2008	L 311	1	21.11.2008

Corrected by:

►C1 Corrigendum, OJ L 145, 31.5.2001, p. 52 (2000/76/EC)

▼B

DIRECTIVE 2000/76/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 4 December 2000

on the incineration of waste

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular Article 175(1) thereof,

Having regard to the proposal from the Commission ([1]),

Having regard to the Opinion of the Economic and Social Committee ([2]),

Having regard to the Opinion of the Committee of the Regions ([3]),

Acting in accordance with the procedure laid down in Article 251 of the Treaty ([4]), and in the light of the joint text approved by the Conciliation Committee on 11 October 2000,

Whereas:

(1) The fifth Environment Action Programme: Towards sustainability — A European Community programme of policy and action in relation to the environment and sustainable development, supplemented by Decision No 2179/98/EC on its review ([5]), sets as an objective that critical loads and levels of certain pollutants such as nitrogen oxides (NO_x), sulphur dioxide (SO_2), heavy metals and dioxins should not be exceeded, while in terms of air quality the objective is that all people should be effectively protected against recognised health risks from air pollution. That Programme further sets as an objective a 90 % reduction of dioxin emissions of identified sources by 2005 (1985 level) and at least 70 % reduction from all pathways of cadmium (Cd), mercury (Hg) and lead (Pb) emissions in 1995.

(2) The Protocol on persistent organic pollutants signed by the Community within the framework of the United Nations Economic Commission for Europe (UN-ECE) Convention on long-range transboundary air pollution sets legally binding limit values for the emission of dioxins and furans of 0,1 ng/m; TE (Toxicity Equivalents) for installations burning more than 3 tonnes per hour of municipal solid waste, 0,5 ng/m; TE for installations burning more than 1 tonne per hour of medical waste, and 0,2 ng/m; TE for installations burning more than 1 tonne per hour of hazardous waste.

(3) The Protocol on Heavy Metals signed by the Community within the framework of the UN-ECE Convention on long-range trans-

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([1]) OJ C 13, 17.1.1998, p. 6 and
OJ C 372, 2.12.1998, p. 11.

([2]) OJ C 116, 28.4.1999, p. 40.

([3]) OJ C 198, 14.7.1999, p. 37.

([4]) Opinion of the European Parliament of 14 April 1999 (OJ C 219, 30.7.1999, p. 249), Council Common Position of 25 November 1999 (OJ C 25, 28.1.2000, p. 17) and Decision of the European Parliament of 15 March 2000 (not yet published in the Official Journal). Decision of the European Parliament of 16 November 2000 and Decision of the Council of 20 November 2000.

([5]) OJ C 138, 17.5.1993, p. 1 and
OJ L 275, 10.10.1998, p. 1.

▼**B**

boundary air pollution sets legally binding limit values for the emission of particulate of 10 mg/m^3 for hazardous and medical waste incineration and for the emission of mercury of 0,05 mg/m^3 for hazardous waste incineration and 0,08 mg/m^3 for municipal waste incineration.

(4) The International Agency for Research on Cancer and the World Health Organisation indicate that some polycyclic aromatic hydrocarbons (PAHs) are carcinogenic. Therefore, Member States may set emission limit values for PAHs among other pollutants.

(5) In accordance with the principles of subsidiarity and proportionality as set out in Article 5 of the Treaty, there is a need to take action at the level of the Community. The precautionary principle provides the basis for further measures. This Directive confines itself to minimum requirements for incineration and co-incineration plants.

(6) Further, Article 174 provides that Community policy on the environment is to contribute to protecting human health.

(7) Therefore, a high level of environmental protection and human health protection requires the setting and maintaining of stringent operational conditions, technical requirements and emission limit values for plants incinerating or co-incinerating waste within the Community. The limit values set should prevent or limit as far as practicable negative effects on the environment and the resulting risks to human health.

(8) The Communication from the Commission on the review of the Community Strategy for waste management assigns prevention of waste the first priority, followed by reuse and recovery and finally by safe disposal of waste; in its Resolution of 24 February 1997 on a Community Strategy for waste management (1), the Council reiterated its conviction that waste prevention should be the first priority of any rational waste policy in relation to minimising waste production and the hazardous properties of waste.

(9) In its Resolution of 24 February 1997 the Council also underlines the importance of Community criteria concerning the use of waste, the need for appropriate emission standards to apply to incineration facilities, the need for monitoring measures to be envisaged for existing incineration plants, and the need for the Commission to consider amending Community legislation in relation to the incineration of waste with energy recovery in order to avoid large-scale movements of waste for incineration or co-incineration in the Community.

(10) It is necessary to set strict rules for all plants incinerating or co-incinerating waste in order to avoid transboundary movements to plants operating at lower costs due to less stringent environmental standards.

(11) The Communication from the Commission/energy for the future: renewable sources of energy/White paper for a Community strategy and action plan takes into consideration in particular the use of biomass for energy purposes.

(12) Council Directive 96/61/EC (2) sets out an integrated approach to pollution prevention and control in which all the aspects of an installations environmental performance are considered in an integrated manner. Installations for the incineration of municipal waste with a capacity exceeding 3 tonnes per hour and installations for the disposal or recovery of hazardous waste with a

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(1) OJ C 76, 11.3.1997, p. 1.

(2) OJ L 257, 10.10.1996, p. 26.

▼**B**

capacity exceeding 10 tonnes per day are included within the scope of the said Directive.

(13) Compliance with the emission limit values laid down by this Directive should be regarded as a necessary but not sufficient condition for compliance with the requirements of Directive 96/61/EC. Such compliance may involve more stringent emissions limit values for the pollutants envisaged by this Directive, emission limit values for other substances and other media, and other appropriate conditions.

(14) Industrial experience in the implementation of techniques for the reduction of polluting emissions from incineration plants has been acquired over a period of ten years.

(15) Council Directives 89/369/EEC (1) and 89/429/EEC (2) on the prevention and reduction of air pollution from municipal waste incineration plants have contributed to the reduction and control of atmospheric emissions from incineration plants. More stringent rules should now be adopted and those Directives should accordingly be repealed.

(16) The distinction between hazardous and non-hazardous waste is based principally on the properties of waste prior to incineration or co-incineration but not on differences in emissions. The same emission limit values should apply to the incineration or co-incineration of hazardous and non-hazardous waste but different techniques and conditions of incineration or co-incineration and different monitoring measures upon reception of waste should be retained.

(17) Member States should take into account Council Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air (3) when implementing this Directive.

(18) The incineration of hazardous waste with a content of more than 1 % of halogenated organic substances, expressed as chlorine, has to comply with certain operational conditions in order to destroy as many organic pollutants such as dioxins as possible.

(19) The incineration of waste which contains chlorine generates flue gas residues. Such residues should be managed in a way that minimises their amount and harmfulness.

(20) There may be grounds to provide for specified exemptions to the emission limit values for some pollutants during a specified time limit and subject to specific conditions.

(21) Criteria for certain sorted combustible fraction of non-hazardous waste not suitable for recycling, should be developed in order to allow the authorisation of the reduction of the frequency of periodical measurements.

(22) A single text on the incineration of waste will improve legal clarity and enforceability. There should be a single directive for the incineration and co-incineration of hazardous and non-hazardous waste taking fully into account the substance and structure of Council Directive 94/67/EC of 16 December 1994 on the incineration of hazardous waste (4). Therefore Directive 94/67/EC should also be repealed.

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(1) OJ L 163, 14.6.1989, p. 32. Directive as last amended by the Accession Act of 1994.

(2) OJ L 203, 15.7.1989, p. 50. Directive as last amended by the Accession Act of 1994.

(3) OJ L 163, 29.6.1999, p. 41.

(4) OJ L 365, 31.12.1994, p. 34.

▼**B**

(23) Article 4 of Council Directive 75/442/EEC of 15 July 1975 on waste (1) requires Member States to take the necessary measures to ensure that waste is recovered or disposed of without endangering human health and without harming the environment. To this end, Articles 9 and 10 of that Directive provide that any plant or undertaking treating waste must obtain a permit from the competent authorities relating, *inter alia*, to the precautions to be taken.

(24) The requirements for recovering the heat generated by the incineration or co-incineration process and for minimising and recycling residues resulting from the operation of incineration or co-incineration plants will assist in meeting the objectives of Article 3 on the waste hierarchy of Directive 75/442/EEC.

(25) Incineration and co-incineration plants treating only animal waste regulated by Directive 90/667/EEC (2) are excluded from the scope of this Directive. The Commission intends to propose a revision to the requirements of Directive 90/667 with a view to providing for high environmental standards for the incineration and co-incineration of animal waste.

(26) The permit for an incineration or co-incineration plant shall also comply with any applicable requirements laid down in Directives 91/271/EEC (3), 96/61/EC, 96/62/EC (4), 76/464/EEC (5), and 1999/31/EC (6).

(27) The co-incineration of waste in plants not primarily intended to incinerate waste should not be allowed to cause higher emissions of polluting substances in that part of the exhaust gas volume resulting from such co-incineration than those permitted for dedicated incineration plants and should therefore be subject to appropriate limitations.

(28) High-standard measurement techniques are required to monitor emissions to ensure compliance with the emission limit values for the pollutants.

(29) The introduction of emission limit values for the discharge of waste water from the cleaning of exhaust gases from incineration and co-incineration plants will limit a transfer of pollutants from the air into water.

(30) Provisions should be laid down for cases where the emission limit values are exceeded as well as for technically unavoidable stoppages, disturbances or failures of the purification devices or the measurement devices.

(31) In order to ensure transparency of the permitting process throughout the Community the public should have access to information with a view to allowing it to be involved in decisions to be taken following applications for new permits and their subsequent updates. The public should have access to

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(1) OJ L 194, 25.7.1975, p. 39. Directive as last amended by Commission Decision 350/96/EC (OJ L 135, 6.6.1996, p. 32).

(2) Council Directive 90/667/EEC of 27 November 1990, laying down the veterinary rules for the disposal and processing of animal waste, for its placing on the market and for the prevention of pathogens in feedstuffs of animal or fish origin and amending Directive 90/425/EEC (OJ L 363, 27.12.1990, p. 51). Directive as last amended by the Accession Act of 1994.

(3) Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment (OJ L 135, 30.5.1991, p. 40). Directive as amended by Directive 98/15/EC (OJ L 67, 7.3.1998, p. 29).

(4) Council Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management (OJ L 296, 21.11.1996, p. 55).

(5) Council Directive 76/464/EEC of 4 May 1976 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community (OJ L 129, 18.5.1976, p. 23). Directive as last amended by the Accession Act of 1994.

(6) Directive 1999/31/EC of 26 April 1999 on the landfill of waste (OJ L 182, 16.7.1999, p. 1).

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reports on the functioning and monitoring of the plants burning more than three tonnes per hour in order to be informed of their potential effects on the environment and human health.

(32) The Commission should present a report both to the European Parliament and the Council based on the experience of applying this Directive, the new scientific knowledge gained, the development of the state of technology, the progress achieved in emission control techniques, and on the experience made in waste management and operation of the plants and on the development of environmental requirements, with a view to proposing, as appropriate, to adapt the related provisions of this Directive.

(33) The measures necessary for the implementation of this Directive are to be adopted in accordance with Council Decision 1999/468/EC of 28 June 1999 laying down the procedures for the exercise of implementing powers conferred on the Commission (1).

(34) Member States should lay down rules on penalties applicable to infringements of the provisions of this Directive and ensure that they are implemented; those penalties should be effective, proportionate and dissuasive,

HAVE ADOPTED THIS DIRECTIVE:

Article 1

Objectives

The aim of this Directive is to prevent or to limit as far as practicable negative effects on the environment, in particular pollution by emissions into air, soil, surface water and groundwater, and the resulting risks to human health, from the incineration and co-incineration of waste.

This aim shall be met by means of stringent operational conditions and technical requirements, through setting emission limit values for waste incineration and co-incineration plants within the Community and also through meeting the requirements of Directive 75/442/EEC.

Article 2

Scope

1. This Directive covers incineration and co-incineration plants.

2. The following plants shall however be excluded from the scope of this Directive:

(a) Plants treating only the following wastes:

  (i) vegetable waste from agriculture and forestry,

  (ii) vegetable waste from the food processing industry, if the heat generated is recovered,

  (iii) fibrous vegetable waste from virgin pulp production and from production of paper from pulp, if it is co-incinerated at the place of production and the heat generated is recovered,

  (iv) wood waste with the exception of wood waste which may contain halogenated organic compounds or heavy metals as a result of treatment with wood-preservatives or coating, and which includes in particular such wood waste originating from construction and demolition waste,

  (v) cork waste,

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(1) OJ L 184, 17.7.1999, p. 23.

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(vi) radioactive waste,

(vii) animal carcasses as regulated by Directive 90/667/EEC without prejudice to its future amendements amendments,

(viii) waste resulting from the exploration for, and the exploitation of, oil and gas resources from off-shore installations and incinerated on board the installation;

(b) Experimental plants used for research, development and testing in order to improve the incineration process and which treat less than 50 tonnes of waste per year.

Article 3

Definitions

For the purposes of this Directive:

1. 'waste' means any solid or liquid waste as defined in Article 1(a) of Directive 75/442/EEC;

2. 'hazardous waste' means any solid or liquid waste as defined in Article 1(4) of Council Directive 91/689/EEC of 12 December 1991 on hazardous waste (1).

   For the following hazardous wastes, the specific requirements for hazardous waste in this Directive shall not apply:

   (a) combustible liquid wastes including waste oils as defined in Article 1 of Council Directive 75/439/EEC of 16 June 1975 on the disposal of waste oils (2) provided that they meet the following criteria:

      (i) the mass content of polychlorinated aromatic hydrocarbons, e.g. polychlorinated biphenyls (PCB) or pentachlorinated phenol (PCP) amounts to concentrations not higher than those set out in the relevant Community legislation;

      (ii) these wastes are not rendered hazardous by virtue of containing other constituents listed in Annex II to Directive 91/689/EEC in quantities or in concentrations which are inconsistent with the achievement of the objectives set out in Article 4 of Directive 75/442/EEC; and

      (iii) the net calorific value amounts to at least 30 MJ per kilogramme,

   (b) any combustible liquid wastes which cannot cause, in the flue gas directly resulting from their combustion, emissions other than those from gasoil as defined in Article 1(1) of Directive 93/12/EEC (3) or a higher concentration of emissions than those resulting from the combustion of gasoil as so defined;

3. 'mixed municipal waste' means waste from households as well as commercial, industrial and institutional waste, which because of its nature and composition is similar to waste from households, but excluding fractions indicated in the Annex to Decision 94/3/EC (4)

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(1) OJ L 377, 31.12.1991, p. 20. Directive as amended by Directive 94/31/EC. (OJ L 168, 2.7.1994, p. 28).

(2) OJ L 194, 25.7.1975, p. 23. Directive as last amended by the Accession Act of 1994.

(3) Council Directive 93/12/EEC of 23 March 1993 relating to the sulphur content of certain liquid fuels (OJ L 74, 27.3.1993, p. 81). Directive as last amended by Directive 1999/32/EC (OJ L 121,11.5.1999, p. 13).

(4) Commission Decision 94/3/EC of 20 December 1993 establishing a list of wastes pursuant to Article 1a of Council Directive 75/442/EEC on waste (OJ L 5, 7.1.1994, p. 15).

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under heading 20 01 that are collected separately at source and excluding the other wastes indicated under heading 20 02 of that Annex;

4. ‘incineration plant’ means any stationary or mobile technical unit and equipment dedicated to the thermal treatment of wastes with or without recovery of the combustion heat generated. This includes the incineration by oxidation of waste as well as other thermal treatment processes such as pyrolysis, gasification or plasma processes in so far as the substances resulting from the treatment are subsequently incinerated.

   This definition covers the site and the entire incineration plant including all incineration lines, waste reception, storage, on site pretreatment facilities, waste-fuel and air-supply systems, boiler, facilities for the treatment of exhaust gases, on-site facilities for treatment or storage of residues and waste water, stack, devices and systems for controlling incineration operations, recording and monitoring incineration conditions;

5. ‘co-incineration plant’ means any stationary or mobile plant whose main purpose is the generation of energy or production of material products and:

   — which uses wastes as a regular or additional fuel; or

   — in which waste is thermally treated for the purpose of disposal.

   If co-incineration takes place in such a way that the main purpose of the plant is not the generation of energy or production of material products but rather the thermal treatment of waste, the plant shall be regarded as an incineration plant within the meaning of point 4.

   This definition covers the site and the entire plant including all co-incineration lines, waste reception, storage, on site pretreatment facilities, waste-, fuel- and air-supply systems, boiler, facilities for the treatment of exhaust gases, on-site facilities for treatment or storage of residues and waste water, stack devices and systems for controlling incineration operations, recording and monitoring incineration conditions;

6. ►**C1** ‘existing incineration or co-incineration plant’ means ◄ an incineration or co-incineration plant:

   (a) which is in operation and has a permit in accordance with existing Community legislation before 28 December 2002, or,

   (b) which is authorised or registered for incineration or co-incineration and has a permit issued before 28 December 2002 in accordance with existing Community legislation, provided that the plant is put into operation not later than 28 December 2003, or

   (c) which, in the view of the competent authority, is the subject of a full request for a permit, before 28 December 2002, provided that the plant is put into operation not later than 28 December 2004;

7. ‘nominal capacity’ means the sum of the incineration capacities of the furnaces of which an incineration plant is composed, as specified by the constructor and confirmed by the operator, with due account being taken, in particular, of the calorific value of the waste, expressed as the quantity of waste incinerated per hour;

8. ‘emission’ means the direct or indirect release of substances, vibrations, heat or noise from individual or diffuse sources in the plant into the air, water or soil;

9. ‘emission limit values’ means the mass, expressed in terms of certain specific parameters, concentration and/or level of an

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emission, which may not be exceeded during one or more periods of time;

10. ‘dioxins and furans’ means all polychlorinated dibenzo-p-dioxins and dibenzofurans listed in Annex I;

11. ‘operator’ means any natural or legal person who operates or controls the plant or, where this is provided for in national legislation, to whom decisive economic power over the technical functioning of the plant has been delegated;

12. ‘permit’ means a written decision (or several such decisions) delivered by the competent authority granting authorisation to operate a plant, subject to certain conditions which guarantee that the plant complies with all the requirements of this Directive. A permit may cover one or more plants or parts of a plant on the same site operated by the same operator;

13. ‘residue’ means any liquid or solid material (including bottom ash and slag, fly ash and boiler dust, solid reaction products from gas treatment, sewage sludge from the treatment of waste waters, spent catalysts and spent activated carbon) defined as waste in Article 1(a) of Directive 75/442/EEC, which is generated by the incineration or co-incineration process, the exhaust gas or waste water treatment or other processes within the incineration or co-incineration plant.

Article 4

Application and permit

1. Without prejudice to Article 11 of Directive 75/442/EEC or to Article 3 of Directive 91/689/EEC, no incineration or co-incineration plant shall operate without a permit to carry out these activities.

2. Without prejudice to Directive 96/61/EC, the application for a permit for an incineration or co-incineration plant to the competent authority shall include a description of the measures which are envisaged to guarantee that:

(a) the plant is designed, equipped and will be operated in such a manner that the requirements of this Directive are taking into account the categories of waste to be incinerated;

(b) the heat generated during the incineration and co-incineration process is recovered as far as practicable e.g. through combined heat and power, the generating of process steam or district heating;

(c) the residues will be minimised in their amount and harmfulness and recycled where appropriate;

(d) the disposal of the residues which cannot be prevented, reduced or recycled will be carried out in conformity with national and Community legislation.

3. The permit shall be granted only if the application shows that the proposed measurement techniques for emissions into the air comply with Annex III and, as regards water, comply with Annex III paragraphs 1 and 2.

4. The permit granted by the competent authority for an incineration or co-incineration plant shall, in addition to complying with any applicable requirement laid down in Directives 91/271/EEC, 96/61/EC, 96/62/EC, 76/464/EEC and 1999/31/EC:

(a) list explicitly the categories of waste which may be treated. The list shall use at least the categories of waste set up in the European Waste Catalogue (EWC), if possible, and contain information on the quantity of waste, where appropriate;

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(b) include the total waste incinerating or co-incinerating capacity of the plant;

(c) specify the sampling and measurement procedures used to satisfy the obligations imposed for periodic measurements of each air and water pollutants.

5. The permit granted by the competent authority to an incineration or co-incineration plant using hazardous waste shall in addition to paragraph 4:

(a) list the quantities of the different categories of hazardous waste which may be treated;

(b) specify the minimum and maximum mass flows of those hazardous wastes, their lowest and maximum calorific values and their maximum contents of pollutants, e.g. PCB, PCP, chlorine, fluorine, sulphur, heavy metals.

6. Without prejudice to the provisions of the Treaty, Member States may list the categories of waste to be mentioned in the permit which can be co-incinerated in defined categories of co-incineration plants.

7. Without prejudice to Directive 96/61/EC, the competent authority shall periodically reconsider and, where necessary, update permit conditions.

8. Where the operator of an incineration or co-incineration plant for non-hazardous waste is envisaging a change of operation which would involve the incineration or co-incineration of hazardous waste, this shall be regarded as a substantial change within the meaning of Article 2(10)(b) of Directive 96/61/EC and Article 12(2) of that Directive shall apply.

9. If an incineration or co-incineration plant does not comply with the conditions of the permit, in particular with the emission limit values for air and water, the competent authority shall take action to enforce compliance.

Article 5

Delivery and reception of waste

1. The operator of the incineration or co-incineration plant shall take all necessary precautions concerning the delivery and reception of waste in order to prevent or to limit as far as practicable negative effects on the environment, in particular the pollution of air, soil, surface water and groundwater as well as odours and noise, and direct risks to human health. These measures shall meet at least the requirements set out in paragraphs 3 and 4.

2. The operator shall determine the mass of each category of waste, if possible according to the EWC, prior to accepting the waste at the incineration or co-incineration plant.

3. Prior to accepting hazardous waste at the incineration or co-incineration plant, the operator shall have available information about the waste for the purpose of verifying, *inter alia*, compliance with the permit requirements specified in Article 4(5). This information shall cover:

(a) all the administrative information on the generating process contained in the documents mentioned in paragraph 4(a);

(b) the physical, and as far as practicable, chemical composition of the waste and all other information necessary to evaluate its suitability for the intended incineration process;

(c) the hazardous characteristics of the waste, the substances with which it cannot be mixed, and the precautions to be taken in handling the waste.

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4. Prior to accepting hazardous waste at the incineration or co-incineration plant, at least the following reception procedures shall be carried out by the operator:

(a) the checking of those documents required by Directive 91/689/EEC and, where applicable, those required by Council Regulation (EEC) No 259/93 of 1 February 1993 on the supervision, and control of shipments of waste within, into and out of the European Community (1) and by dangerous-goods transport regulations;

(b) the taking of representative samples, unless inappropriate, e.g. for infectious clinical waste, as far as possible before unloading, to verify conformity with the information provided for in paragraph 3 by carrying out controls and to enable the competent authorities to identify the nature of the wastes treated. These samples shall be kept for at least one month after the incineration.

5. The competent authorities may grant exemptions from paragraphs 2, 3 and 4 for industrial plants and undertakings incinerating or co-incinerating only their own waste at the place of generation of the waste provided that the requirements of this Directive are met.

Article 6

Operating conditions

1. Incineration plants shall be operated in order to achieve a level of incineration such that the slag and bottom ashes Total Organic Carbon (TOC) content is less than 3 % or their loss on ignition is less than 5 % of the dry weight of the material. If necessary appropriate techniques of waste pretreatment shall be used.

Incineration plants shall be designed, equipped, built and operated in such a way that the gas resulting from the process is raised, after the last injection of combustion air, in a controlled and homogeneous fashion and even under the most unfavourable conditions, to a temperature of 850 °C, as measured near the inner wall or at another representative point of the combustion chamber as authorised by the competent authority, for two seconds. If hazardous wastes with a content of more than 1 % of halogenated organic substances, expressed as chlorine, are incinerated, the temperature has to be raised to 1 100 °C for at least two seconds.

Each line of the incineration plant shall be equipped with at least one auxiliary burner. This burner must be switched on automatically when the temperature of the combustion gases after the last injection of combustion air falls below 850 °C or 1 100 °C as the case may be. It shall also be used during plant start-up and shut-down operations in order to ensure that the temperature of 850 °C or 1 100 °C as the case may be is maintained at all times during these operations and as long as unburned waste is in the combustion chamber.

During start-up and shut-down or when the temperature of the combustion gas falls below 850 °C or 1 100 °C as the case may be, the auxiliary burner shall not be fed with fuels which can cause higher emissions than those resulting from the burning of gasoil as defined in Article 1(1) of Council Directive 75/716/EEC, liquefied gas or natural gas.

2. Co-incineration plants shall be designed, equipped, built and operated in such a way that the gas resulting from the co-incineration of waste is raised in a controlled and homogeneous fashion and even under the most unfavourable conditions, to a temperature of 850 °C for two seconds. If hazardous wastes with a content of more than 1 % of

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(1) OJ L 30, 6.2.1993, p. 1. Regulation as last amended by Commission Regulation (EC) No 2408/98 (OJ L 298, 7.11.1998, p. 19).

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halogenated organic substances, expressed as chlorine, are co-incinerated, the temperature has to be raised to 1 100 °C.

3. Incineration and co-incineration plants shall have and operate an automatic system to prevent waste feed:

(a) at start-up, until the temperature of 850 °C or 1 100 °C as the case may be or the temperature specified according to paragraph 4 has been reached;

(b) whenever the temperature of 850 °C or 1 100 °C as the case may be or the temperature specified according to paragraph 4 is not maintained;

(c) whenever the continuous measurements required by this Directive show that any emission limit value is exceeded due to disturbances or failures of the purification devices.

4. Conditions different from those laid down in paragraph 1 and, as regards the temperature, paragraph 3 and specified in the permit for certain categories of waste or for certain thermal processes may be authorised by the competent authority, provided the requirements of this Directive are met. Member States may lay down rules governing these authorisations. The change of the operational conditions shall not cause more residues or residues with a higher content of organic pollutants compared to those residues which could be expected under the conditions laid down in paragraph 1.

Conditions different from those laid down in paragraph 2 and, as regards the temperature, paragraph 3 and specified in the permit for certain categories of waste or for certain thermal processes may be authorised by the competent authority, provided the requirements of this Directive are met. Member States may lay down rules governing these authorisations. Such authorisation shall be conditional upon at least the provisions for emission limit values set out in Annex V for total organic carbon and CO being complied with.

In the case of co-incineration of their own waste at the place of its production in existing bark boilers within the pulp and paper industry, such authorisation shall be conditional upon at least the provisions for emission limit values set out in Annex V for total organic carbon being complied with.

All operating conditions determined under this paragraph and the results of verifications made shall be communicated by the Member State to the Commission as part of the information provided in accordance with the reporting requirements.

5. Incineration and co-incineration plants shall be designed, equipped, built and operated in such a way as to prevent emissions into the air giving rise to significant ground-level air pollution; in particular, exhaust gases shall be discharged in a controlled fashion and in conformity with relevant Community air quality standards by means of a stack the height of which is calculated in such a way as to safeguard human health and the environment.

6. Any heat generated by the incineration or the co-incineration process shall be recovered as far as practicable.

7. Infectious clinical waste should be placed straight in the furnace, without first being mixed with other categories of waste and without direct handling.

8. The management of the incineration or the co-incineration plant shall be in the hands of a natural person who is competent to manage the plant.

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Article 7

Air emission limit values

1. Incineration plants shall be designed, equipped, built and operated in such a way that the emission limit values set out in Annex V are not exceeded in the exhaust gas.

2. Co-incineration plants shall be designed, equipped, built and operated in such a way that the emission limit values determined according to or set out in Annex II are not exceeded in the exhaust gas.

If in a co-incineration plant more than 40 % of the resulting heat release comes from hazardous waste, the emission limit values set out in Annex V shall apply.

3. The results of the measurements made to verify compliance with the emission limit values shall be standardised with respect to the conditions laid down in Article 11.

4. In the case of co-incineration of untreated mixed municipal waste, the limit values will be determined according to Annex V, and Annex II will not apply.

5. Without prejudice to the provisions of the Treaty, Member States may set emission limit values for polycyclic aromatic hydrocarbons or other pollutants.

Article 8

Water discharges from the cleaning of exhaust gases

1. Waste water from the cleaning of exhaust gases discharged from an incineration or co-incineration plant shall be subject to a permit granted by the competent authorities.

2. Discharges to the aquatic environment of waste water resulting from the cleaning of exhaust gases shall be limited as far as practicable, at least in accordance with the emission limit values set in Annex IV.

3. Subject to a specific provision in the permit, the waste water from the cleaning of exhaust gases may be discharged to the aquatic environment after separate treatment on condition that:

(a) the requirements of relevant Community, national and local provisions are complied with in the form of emission limit values; and

(b) the mass concentrations of the polluting substances referred to in Annex IV do not exceed the emission limit values laid down therein.

4. The emission limit values shall apply at the point where waste waters from the cleaning of exhaust gases containing the polluting substances referred to in Annex IV are discharged from the incineration or co-incineration plant.

Where the waste water from the cleaning of exhaust gases is treated on site collectively with other on-site sources of waste water, the operator shall take the measurements referred to in Article 11:

(a) on the waste water stream from the exhaust gas cleaning processes prior to its input into the collective waste water treatment plant;

(b) on the other waste water stream or streams prior to its or their input into the collective waste water treatment plant;

(c) at the point of final waste water discharge, after the treatment, from the incineration plant or co-incineration plant.

The operator shall take appropriate mass balance calculations in order to determine the emission levels in the final waste water discharge that can be attributed to the waste water arising from the cleaning of exhaust gases in order to check compliance with the emission limit values set out in Annex IV for the waste water stream from the exhaust gas cleaning process.

Under no circumstances shall dilution of waste water take place for the purpose of complying with the emission limit values set in Annex IV.

5. When waste waters from the cleaning of exhaust gases containing the polluting substances referred to in Annex IV are treated outside the incineration or co-incineration plant at a treatment plant intended only for the treatment of this sort of waste water, the emission limit values of Annex IV are to be applied at the point where the waste waters leave the treatment plant. If this off-site treatment plant is not only dedicated to treat waste water from incineration, the operator shall take the appropriate mass balance calculations, as provided for under paragraph 4(a), (b) and (c), in order to determine the emission levels in the final waste water discharge that can be attributed to the waste water arising from the cleaning of exhaust gases in order to check compliance with the emission limit values set out in Annex IV for the waste water stream from the exhaust gas cleaning process.

Under no circumstances shall dilution of waste water take place for the purpose of complying with the emission limit values set in Annex IV.

6. The permit shall:

(a) establish emission limit values for the polluting substances referred to in Annex IV, in accordance with paragraph 2 and in order to meet the requirements referred to in paragraph 3(a);

(b) set operational control parameters for waste water at least for pH, temperature and flow.

7. Incineration and co-incineration plant sites, including associated storage areas for wastes, shall be designed and in such a way as to prevent the unauthorised and accidental release of any polluting substances into soil, surface water and groundwater in accordance with the provisions provided for in relevant Community legislation. Moreover, storage capacity shall be provided for contaminated rainwater run-off from the incineration or co-incineration plant site or for contaminated water arising from spillage or fire-fighting operations.

The storage capacity shall be adequate to ensure that such waters can be tested and treated before discharge where necessary.

8. Without prejudice to the provisions of the Treaty, Member States may set emission limit values for polycyclic aromatic hydrocarbons or other pollutants.

Article 9

Residues

Residues resulting from the operation of the incineration or co-incineration plant shall be minimised in their amount and harmfulness. Residues shall be recycled, where appropriate, directly in the plant or outside in accordance with relevant Community legislation.

Transport and intermediate storage of dry residues in the form of dust, such as boiler dust and dry residues from the treatment of combustion gases, shall take place in such a way as to prevent dispersal in the environment e.g. in closed containers.

Prior to determining the routes for the disposal or recycling of the residues from incineration and co-incineration plants, appropriate tests shall be carried out to establish the physical and chemical characteristics and the polluting potential of the different incineration residues. The analysis shall concern the total soluble fraction and heavy metals soluble fraction.

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Article 10

Control and monitoring

1. Measurement equipment shall be installed and techniques used in order to monitor the parameters, conditions and mass concentrations relevant to the incineration or co-incineration process.

2. The measurement requirements shall be laid down in the permit or in the conditions attached to the permit issued by the competent authority.

3. The appropriate installation and the functioning of the automated monitoring equipment for emissions into air and water shall be subject to control and to an annual surveillance test. Calibration has to be done by means of parallel measurements with the reference methods at least every three years.

4. The location of the sampling or measurement points shall be laid down by the competent authority.

5. Periodic measurements of the emissions into the air and water shall be carried out in accordance with Annex III, points 1 and 2.

Article 11

Measurement requirements

1. Member States shall, either by specification in the conditions of the permit or by general binding rules, ensure that paragraphs 2 to 12 and 17, as regards air, and paragraphs 9 and 14 to 17, as regards water, are complied with.

2. The following measurements of air pollutants shall be carried out in accordance with Annex III at the incineration and co-incineration plant:

(a) continuous measurements of the following substances: NO_x, provided that emission limit values are set, CO, total dust, TOC, HCl, HF, SO_2;

(b) continuous measurements of the following process operation parameters: temperature near the inner wall or at another representative point of the combustion chamber as authorised by the competent authority, concentration of oxygen, pressure, temperature and water vapour content of the exhaust gas;

(c) at least two measurements per year of heavy metals, dioxins and furans; one measurement at least every three months shall however be carried out for the first 12 months of operation. Member States may fix measurement periods where they have set emission limit values for polycyclic aromatic hydrocarbons or other pollutants.

3. The residence time as well as the minimum temperature and the oxygen content of the exhaust gases shall be subject to appropriate verification, at least once when the incineration or co-incineration plant is brought into service and under the most unfavourable operating conditions anticipated.

4. The continuous measurement of HF may be omitted if treatment stages for HCl are used which ensure that the emission limit value for HCl is not being exceeded. In this case the emissions of HF shall be subject to periodic measurements as laid down in paragraph 2(c).

5. The continuous measurement of the water vapour content shall not be required if the sampled exhaust gas is dried before the emissions are analysed.

6. Periodic measurements as laid down in paragraph 2(c) of HCl, HF and SO_2 instead of continuous measuring may be authorised in the

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permit by the competent authority in incineration or co-incineration plants, if the operator can prove that the emissions of those pollutants can under no circumstances be higher than the prescribed emission limit values.

►**M1** 7. The reduction of the frequency of the periodic measurements for heavy metals from twice a year to once every two years and for dioxins and furans from twice a year to once a year may be authorised in the permit by the competent authority provided that the emissions resulting from co-incineration or incineration are below 50 % of the emission limit values determined in accordance with Annex II or Annex V respectively and that criteria for the requirements to be met are available. The Commission shall adopt measures establishing these criteria, based at least on the provisions of points (a) and (d) of the second subparagraph. Those measures, designed to amend non-essential elements of this Directive by supplementing it, shall be adopted in accordance with the regulatory procedure with scrutiny referred to in Article 17(2). ◄

Until 1 January 2005 the reduction of the frequency may be authorised even if no such criteria are available provided that:

(a) the waste to be co-incinerated or incinerated consists only of certain sorted combustible fractions of non-hazardous waste not suitable for recycling and presenting certain characteristics, and which is further specified on the basis of the assessment referred to in subparagraph (d);

(b) national quality criteria, which have been reported to the Commission, are available for these wastes;

(c) co-incineration and incineration of these wastes is in line with the relevant waste management plans referred to in Article 7 of Directive 75/442/EEC;

(d) the operator can prove to the competent authority that the emissions are under all circumstances significantly below the emission limit values set out in Annex II or Annex V for heavy metals, dioxins and furans; this assessment shall be based on information on the quality of the waste concerned and measurements of the emissions of the said pollutants;

(e) the quality criteria and the new period for the periodic measurements are specified in the permit; and

(f) all decisions on the frequency of measurements referred to in this paragraph, supplemented with information on the amount and quality of the waste concerned, shall be communicated on a yearly basis to the Commission.

8. The results of the measurements made to verify compliance with the emission limit values shall be standardised at the following conditions and for oxygen according to the formula as referred to in Annex VI:

(a) Temperature 273 K, pressure 101,3 kPa, 11 % oxygen, dry gas, in exhaust gas of incineration plants;

(b) Temperature 273 K, pressure 101,3 kPa, 3 % oxygen, dry gas, in exhaust gas of incineration of waste oil as defined in Directive 75/439/EEC;

(c) when the wastes are incinerated or co-incinerated in an oxygen-enriched atmosphere, the results of the measurements can be standardised at an oxygen content laid down by the competent authority reflecting the special circumstances of the individual case;

(d) in the case of co-incineration, the results of the measurements shall be standardised at a total oxygen content as calculated in Annex II.

When the emissions of pollutants are reduced by exhaust gas treatment in an incineration or co-incineration plant treating hazardous waste, the

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standardisation with respect to the oxygen contents provided for in the first subparagraph shall be done only if the oxygen content measured over the same period as for the pollutant concerned exceeds the relevant standard oxygen content.

9. All measurement results shall be recorded, processed and presented in an appropriate fashion in order to enable the competent authorities to verify compliance with the permitted operating conditions and emission limit values laid down in this Directive in accordance with procedures to be decided upon by those authorities.

10. The emission limit values for air shall be regarded as being complied with if:

(a) — none of the daily average values exceeds any of the emission limit values set out in Annex V(a) or Annex II;

— 97 % of the daily average value over the year does not exceed the emission limit value set out in Annex V(e) first indent;

(b) either none of the half-hourly average values exceeds any of the emission limit values set out in Annex V(b), column A or, where relevant, 97 % of the half-hourly average values over the year do not exceed any of the emission limit values set out in Annex V(b), column B;

(c) none of the average values over the sample period set out for heavy metals and dioxins and furans exceeds the emission limit values set out in Annex V(c) and (d) or Annex II;

(d) the provisions of Annex V(e), second indent or Annex II, are met.

11. The half-hourly average values and the 10-minute averages shall be determined within the effective operating time (excluding the start-up and shut-off periods if no waste is being incinerated) from the measured values after having subtracted the value of the confidence interval specified in point 3 of Annex III. The daily average values shall be determined from those validated average values.

To obtain a valid daily average value no more than five half-hourly average values in any day shall be discarded due to malfunction or maintenance of the continuous measurement system. No more than ten daily average values per year shall be discarded due to malfunction or maintenance of the continuous measurement system.

12. The average values over the sample period and the average values in the case of periodical measurements of HF, HCl and SO_2 shall be determined in accordance with the requirements of Article 10(2) and (4) and Annex III.

▼M1

13. The Commission shall determine, as soon as appropriate measurement techniques are available within the Community, the date from which continuous measurements of the air emission limit values for heavy metals, dioxins and furans shall be carried out in accordance with Annex III. That measure, designed to amend non-essential elements of this Directive by supplementing it, shall be adopted in accordance with the regulatory procedure with scrutiny referred to in Article 17(2).

▼B

14. The following measurements shall be carried out at the point of waste water discharge:

(a) continuous measurements of the parameters referred to in Article 8(6)(b);

(b) spot sample daily measurements of total suspended solids; Member States may alternatively provide for measurements of a flow proportional representative sample over a period of 24 hours;

▼**B**

(c) at least monthly measurements of a flow proportional representative sample of the discharge over a period of 24 hours of the polluting substances referred to in Article 8(3) with respect to items 2 to 10 in Annex IV;

(d) at least every six months measurements of dioxins and furans; however one measurement at least every three months shall be carried out for the first 12 months of operation. Member States may fix measurement periods where they have set emission limit values for polycyclic aromatic hydrocarbons or other pollutants.

15. The monitoring of the mass of pollutants in the treated waste water shall be done in conformity with Community legislation and laid down in the permit as well as the frequency of the measurements.

16. The emission limit values for water shall be regarded as being complied with if:

(a) for total suspended solids (polluting substance number 1), 95 % and 100 % of the measured values do not exceed the respective emission limit values as set out in Annex IV;

(b) for heavy metals (polluting substances number 2 to 10) no more than one measurement per year exceeds the emission limit values set out in Annex IV; or, if the Member State provides for more than 20 samples per year, no more than 5 % of these samples exceed the emission limit values set out in Annex IV;

(c) for dioxins and furans (polluting substance 11), the twice-yearly measurements do not exceed the emission limit value set out in Annex IV.

17. Should the measurements taken show that the emission limit values for air or water laid down in this Directive have been exceeded, the competent authorities shall be informed without delay.

Article 12

Access to information and public participation

1. Without prejudice to Council Directive 90/313/EEC (1) and Directive 96/61/EC, applications for new permits for incineration and co-incineration plants shall be made available at one or more locations accessible to the public, such as local authority offices, for an appropriate period to enable it to comment on them before the competent authority reaches a decision. That decision, including at least a copy of the permit, and any subsequent updates, shall also be made available to the public.

2. For incineration or co-incineration plants with a nominal capacity of two tonnes or more per hour and notwithstanding Article 15(2) of Directive 96/61/EC, an annual report to be provided by the operator to the competent authority on the functioning and monitoring of the plant shall be made available to the public. This report shall, as a minimum requirement, give an account of the running of the process and the emissions into air and water compared with the emission standards in this Directive. A list of incineration or co-incineration plants with a nominal capacity of less than two tonnes per hour shall be drawn up by the competent authority and shall be made available to the public.

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(1) Council Directive 90/313/EEC of 7 June 1990 on the freedom of access to information on the environment (OJ L 158, 23.6.1990, p. 56). Directive as last amended by the Accession Act of 1994.

▼**B**

Article 13

Abnormal operating conditions

1. The competent authority shall lay down in the permit the maximum permissible period of any technically unavoidable stoppages, disturbances, or failures of the purification devices or the measurement devices, during which the concentrations in the discharges into the air and the purified waste water of the regulated substances may exceed the prescribed emission limit values.

2. In the case of a breakdown, the operator shall reduce or close down operations as soon as practicable until normal operations can be restored.

3. Without prejudice to Article 6(3)(c), the incineration plant or co-incineration plant or incineration line shall under no circumstances continue to incinerate waste for a period of more than four hours uninterrupted where emission limit values are exceeded; moreover, the cumulative duration of operation in such conditions over one year shall be less than 60 hours. The 60-hour duration applies to those lines of the entire plant which are linked to one single flue gas cleaning device.

4. The total dust content of the emissions into the air of an incineration plant shall under no circumstances exceed 150 mg/m^3 expressed as a half-hourly average; moreover the air emission limit values for CO and TOC shall not be exceeded. All other conditions referred to in Article 6 shall be complied with.

Article 14

Review clause

Without prejudice to Directive 96/61/EC, the Commission shall submit a report to the European Parliament and the Council before 31 December 2008 based on experience of the application of this Directive, in particular for new plants, and on the progress achieved in emission control techniques and experience in waste management. Furthermore, the report shall be based on the development of the state of technology, of experience in the operation of the plants, of environmental requirements. This report will include a specific section on the application of Annex II.1.1. and in particular on the economic and technical feasibility for existing cement kilns as referred to in the footnote to Annex II.1.1. of respecting the NO_x emission limit value for new cement kilns set out in that Annex. The report shall, as appropriate, be accompanied by proposals for revision of the related provisions of this Directive. However, the Commission shall, if appropriate, propose an amendment for Annex II.3 before the said report, if major waste streams are directed to types of co-incineration plants other than those dealt with in Annex II.1 and II.2.

Article 15

Reporting

The reports on the implementation of this Directive shall be established in accordance with the procedure laid down in Article 5 of Council Directive 91/692/EEC. The first report shall cover at least the first full three-year period after 28 December 2002 and comply with the periods referred to in Article 17 of Directive 94/67/EC and in Article 16(3) of Directive 96/61/EC. To this effect, the Commission shall elaborate the appropriate questionnaire in due time.

▼**M1**

Article 16

Adaptation to technical progress or new findings

The Commission shall adopt measures designed to amend non-essential elements of this Directive and adapting Articles 10, 11 and 13 and Annexes I and III to technical progress or new findings concerning the health benefits of emission reductions in accordance with the regulatory procedure with scrutiny referred to in Article 17(2).

Article 17

Committee procedure

1. The Commission shall be assisted by a committee.

2. Where reference is made to this paragraph, Article 5a(1) to (4) and Article 7 of Decision 1999/468/EC shall apply, having regard to the provisions of Article 8 thereof.

▼**B**

Article 18

Repeal

The following shall be repealed as from 28 December 2005:

(a) Article 8(1) and the Annex to Directive 75/439/EEC;

(b) Directive 89/369/EEC;

(c) Directive 89/429/EEC;

(d) Directive 94/67/EC.

Article 19

Penalties

The Member States shall determine penalties applicable to breaches of the national provisions adopted pursuant to this Directive. The penalties thus provided for shall be effective, proportionate and dissuasive. The Member States shall notify those provisions to the Commission by 28 December 2002 at the latest and shall notify it without delay of any subsequent amendment affecting them.

Article 20

Transitional provisions

1. Without prejudice to the specific transitional provisions provided for in the Annexes to this Directive, the provisions of this Directive shall apply to existing plants as from 28 December 2005.

2. For new plants, i.e. plants not falling under the definition of ‘existing incineration or co-incineration plant’ in Article 3(6) or paragraph 3 of this Article, this Directive, instead of the Directives mentioned in Article 18, shall apply as from 28 December 2002.

3. Stationary or mobile plants whose purpose is the generation of energy or production of material products and which are in operation and have a permit in accordance with existing Community legislation where required and which start co-incinerating waste not later than 28 December 2004 are to be regarded as existing co-incineration plants.

▼**B**

Article 21

Implementation

1. Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive not later than 28 December 2002. They shall forthwith inform the Commission thereof.

When Member States adopt those measures, they shall contain a reference to this Directive or be accompanied by such reference on the occasion of their official publication. The methods of making such reference shall be laid down by the Member States.

2. Member States shall communicate to the Commission the text of the provisions of domestic law which they adopt in the field governed by this Directive.

Article 22

Entry into force

This Directive shall enter into force on the day of its publication in the *Official Journal of the European Communities*.

Article 23

Addressees

This Directive is addressed to the Member States.

▼B

ANNEX I

Equivalence factors for dibenzo-p-dioxins and dibenzofurans

For the determination of the total concentration (TE) of dioxins and furans, the mass concentrations of the following dibenzo-p-dioxins and dibenzofurans shall be multiplied by the following equivalence factors before summing:

		Toxic equivalence factor
2,3,7,8	— Tetrachlorodibenzodioxin (TCDD)	1
1,2,3,7,8	— Pentachlorodibenzodioxin (PeCDD)	0,5
1,2,3,4,7,8	— Hexachlorodibenzodioxin (HxCDD)	0,1
1,2,3,6,7,8	— Hexachlorodibenzodioxin (HxCDD)	0,1
1,2,3,7,8,9	— Hexachlorodibenzodioxin (HxCDD)	0,1
1,2,3,4,6,7,8	— Heptachlorodibenzodioxin (HpCDD)	0,01
	— Octachlorodibenzodioxin (OCDD)	0,001
2,3,7,8	— Tetrachlorodibenzofuran (TCDF)	0,1
2,3,4,7,8	— Pentachlorodibenzofuran (PeCDF)	0,5
1,2,3,7,8	— Pentachlorodibenzofuran (PeCDF)	0,05
1,2,3,4,7,8	— Hexachlorodibenzofuran (HxCDF)	0,1
1,2,3,6,7,8	— Hexachlorodibenzofuran (HxCDF)	0,1
1,2,3,7,8,9	— Hexachlorodibenzofuran (HxCDF)	0,1
2,3,4,6,7,8	— Hexachlorodibenzofuran (HxCDF)	0,1
1,2,3,4,6,7,8	— Heptachlorodibenzofuran (HpCDF)	0,01
1,2,3,4,7,8,9	— Heptachlorodibenzofuran (HpCDF)	0,01
	— Octachlorodibenzofuran (OCDF)	0,001

▼B

ANNEX II

DETERMINATION OF AIR EMISSION LIMIT VALUES FOR THE CO-INCINERATION OF WASTE

The following formula (mixing rule) is to be applied whenever a specific total emission limit value ‘C’ has not been set out in a table in this Annex.

The limit value for each relevant pollutant and carbon monoxide in the exhaust gas resulting from the co-incineration of waste shall be calculated as follows:

$$\frac{V_{waste} \times C_{waste} + V_{proc} \times C_{proc}}{V_{waste} + V_{proc1}} = C$$

V_{waste}: exhaust gas volume resulting from the incineration of waste only determined from the waste with the lowest calorific value specified in the permit and standardised at the conditions given by this Directive.

If the resulting heat release from the incineration of hazardous waste amounts to less than 10 % of the total heat released in the plant, V_{waste} must be calculated from a (notional) quantity of waste that, being incinerated, would equal 10 % heat release, the total heat release being fixed.

C_{waste}: emission limit values set for incineration plants in Annex V for the relevant pollutants and carbon monoxide.

V_{proc}: exhaust gas volume resulting from the plant process including the combustion of the authorised fuels normally used in the plant (wastes excluded) determined on the basis of oxygen contents at which the emissions must be standardised as laid down in Community or national regulations. In the absence of regulations for this kind of plant, the real oxygen content in the exhaust gas without being thinned by addition of air unnecessary for the process must be used. The standardisation at the other conditions is given in this Directive.

C_{proc}: emission limit values as laid down in the tables of this annex for certain industrial sectors or in case of the absence of such a table or such values, emission limit values of the relevant pollutants and carbon monoxide in the flue gas of plants which comply with the national laws, regulations and administrative provisions for such plants while burning the normally authorised fuels (wastes excluded). In the absence of these measures the emission limit values laid down in the permit are used. In the absence of such permit values the real mass concentrations are used.

C: total emission limit values and oxygen content as laid down in the tables of this annex for certain industrial sectors and certain pollutants or in case of the absence of such a table or such values total emission limit values for CO and the relevant pollutants replacing the emission limit values as laid down in specific Annexes of this Directive. The total oxygen content to replace the oxygen content for the standardisation is calculated on the basis of the content above respecting the partial volumes.

Member States may lay down rules governing the exemptions provided for in this Annex.

II.1. Special provisions for cement kilns co-incinerating waste

Daily average values (for continuous measurements) Sample periods and other measurement requirements as in Article 7. All values in mg/m^3 (Dioxins and furans ng/m^3). Half-hourly average values shall only be needed in view of calculating the daily average values.

The results of the measurements made to verify compliance with the emission limit values shall be standardised at the following conditions: Temperature 273 K, pressure 101,3 kPa, 10 % oxygen, dry gas.

▼B

II.1.1. *C — total emission limit values*

Pollutant	C
Total dust	30
HCI	10
HF	1
NO_x for existing plants	800
NO_x for new plants	500 (1)
Cd + Tl	0,05
Hg	0,05
Sb+As+Pb+Cr+Co+Cu+Mn+Ni+V	0,5
Dioxins and furans	0,1

(1) For the implementation of the NO_x emission limit values, cement kilns which are in operation and have a permit in accordance with existing Community legislation and which start co-incinerating waste after the date mentioned in Article 20(3) are not to be regarded as new plants.

Until 1 January 2008, exemptions for NO_x may be authorised by the competent authorities for existing wet process cement kilns or cement kilns which burn less than three tonnes of waste per hour, provided that the permit foresees a total emission limit value for NO_x of not more than 1200 mg/m^3.

Until 1 January 2008, exemptions for dust may be authorised by the competent authority for cement kilns which burn less than three tonnes of waste per hour, provided that the permit foresees a total emission limit value of not more than 50 mg/m^3.

II.1.2. *C — total emission limit values for SO_2 and TOC*

Pollutant	C
SO_2	50
TOC	10

Exemptions may be authorised by the competent authority in cases where TOC and SO_2 do not result from the incineration of waste.

II.1.3. *Emission limit value for CO*

Emission limit values for CO can be set by the competent authority.

II.2. **Special provisions for combustion plants co-incinerating waste**

II.2.1. *Daily average values*

▼M1

Where, for large combustion plants, more stringent emission limit values are set under Directive 2001/80/EC or will be set under other Community legislation, those emission limit values shall replace, for the plants and pollutants concerned, the emission limit values laid down in the following tables (Cproc). In that case, the Commission shall adapt those tables to the more stringent emission limit values. Those measures, designed to amend non-essential elements of this Directive, shall be adopted in accordance with the regulatory procedure with scrutiny referred to in Article 17(2), without delay.

▼B

Half-hourly average values shall only be needed in view of calculating the daily average values.

C_{proc}:

C_{proc} for solid fuels expressed in mg/Nm^3 (O_2 content 6 %):

▼**B**

Pollutants	< 50 MWth	50-100 MWth	100 to 300 MWth	> 300 MWth
SO_2 general case		850	850 to 200 (linear decrease from 100 to 300 MWth)	200
indigenous fuels		or rate of desulphurisation ≥90%	or rate of desulphurisation ≥92%	or rate of desulphurisation ≥95%
NO_x		400	300	200
Dust	50	50	30	30

Until 1 January 2007 and without prejudice to relevant Community legislation, the emission limit value for NO_x does not apply to plants only co-incinerating hazardous waste.

Until 1 January 2008, exemptions for NO_x and SO_2 may be authorised by the competent authorities for existing co-incineration plants between 100 and 300 MWth using fluidised bed technology and burning solid fuels provided that the permit foresees a C_{proc} value of not more than 350 mg/Nm^3 for NO_x and not more than 850 to 400 mg/Nm^3 (linear decrease from 100 to 300 MWth) for SO_2.

C_{proc} for biomass expressed in mg/Nm^3 (O_2 content 6 %):

'Biomass' means: products consisting of any whole or part of a vegetable matter from agriculture or forestry, which can be used for the purpose of recovering its energy content as well as wastes listed in Article 2(2)(a)(i) to (v).

Pollutants	< 50 MWth	50 to 100 MWth	100 to 300 MWth	> 300 MWth
SO_2		200	200	200
NO_x		350	300	300
Dust	50	50	30	30

Until 1 January 2008, exemptions for NO_x may be authorised by the competent authorities for existing co-incineration plants between 100 and 300 MWth using fluidised bed technology and burning biomass provided that the permit foresees a C_{proc} value of not more than 350 mg/Nm^3.

C_{proc} for liquid fuels expressed in mg/Nm^3 (O_2 content 3 %):

Pollutants	< 50 MWth	50 to 100 MWth	100 to 300 MWth	> 300 MWth
SO_2		850	850 to 200 (linear decrease from 100 to 300 MWth)	200
NO_x		400	300	200
Dust	50	50	30	30

II.2.2. *C — total emission limit values*

C expressed in mg/Nm^3 (O_2 content 6 %). All average values over the sample period of a minimum of 30 minutes and a maximum of 8 hours:

Pollutant	C
Cd + Tl	0,05
Hg	0,05
Sb+As+Pb+Cr+Co+Cu+Mn+Ni+V	0,5

C expressed in ng/Nm^3 (O_2 content 6 %). All average values measured over the sample period of a minimum of 6 hours and a maximum of 8 hours:

▼**B**

Pollutant	C
Dioxins and furans	0,1

II.3. Special provisions for industrial sectors not covered under II.1 or II.2 co-incinerating waste

II.3.1. *C — total emission limit values:*

C expressed in ng/Nm^3. All average values measured over the sample period of a minimum of 6 hours and a maximum of 8 hours:

Pollutant	C
Dioxins and furans	0,1

C expressed in mg/Nm^3. All average values over the sample period of a minimum of 30 minutes and a maximum of 8 hours:

Pollutant	C
Cd + Tl	0,05
Hg	0,05

▼B

ANNEX III

Measurement techniques

1. Measurements for the determination of concentrations of air and water polluting substances have to be carried out representatively.

2. Sampling and analysis of all pollutants including dioxins and furans as well as reference measurement methods to calibrate automated measurement systems shall be carried out as given by CEN-standards. If CEN standards are not available, ISO standards, national or international standards which will ensure the provision of data of an equivalent scientific quality shall apply.

3. At the daily emission limit value level, the values of the 95 % confidence intervals of a single measured result shall not exceed the following percentages of the emission limit values:

Carbon monoxide:	10 %
Sulphur dioxide:	20 %
Nitrogen dioxide:	20 %
Total dust:	30 %
Total organic carbon:	30 %
Hydrogen chloride:	40 %
Hydrogen fluoride:	40 %.

▼**B**

ANNEX IV

Emission limit values for discharges of waste water from the cleaning of exhaust gases

Polluting substances	Emission limit values expressed in mass concentrations for unfiltered samples	
1. Total suspended solids as defined by Directive 91/271/EEC	$\frac{95\%}{30mg/l}$	$\frac{100\%}{45mg/l}$
2. Mercury and its compounds, expressed as mercury (Hg)	0,03 mg/l	
3. Cadmium and its compounds, expressed as cadmium (Cd)	0,05 mg/l	
4. Thallium and its compounds, expressed as thallium (Tl)	0,05 mg/l	
5. Arsenic and its compounds, expressed as arsenic (As)	0,15 mg/l	
6. Lead and its compounds, expressed as lead (Pb)	0,2 mg/l	
7. Chromium and its compounds, expressed as chromium (Cr)	0,5 mg/l	
8. Copper and its compounds, expressed as copper (Cu)	0,5 mg/l	
9. Nickel and its compounds, expressed as nickel (Ni)	0,5 mg/l	
10. Zinc and its compounds, expressed as zinc (Zn)	1,5 mg/l	
11. Dioxins and furans, defined as the sum of the individual dioxins and furans evaluated in accordance with Annex I	►**C1** 0,3 ng/l ◄	

Until 1 January 2008, exemptions for total suspended solids may be authorised by the competent authority for existing incineration plants provided the permit foresees that 80 % of the measured values do not exceed 30 mg/l and none of them exceed 45 mg/l.

▼B

ANNEX V

AIR EMISSION LIMIT VALUES

(a) **Daily average values**

Total dust	10 mg/m^3
Gaseous and vaporous organic substances, expressed as total organic carbon	10 mg/m^3
Hydrogen chloride (HCl)	10 mg/m^3
Hydrogen fluoride (HF)	1 mg/m^3
Sulphur dioxide (SO_2)	50 mg/m^3
Nitrogen monoxide (NO) and nitrogen dioxide (NO_2) expressed as nitrogen dioxide for existing incineration plants with a nominal capacity exceeding 6 tonnes per hour or new incineration plants	200 mg/m^3 (*)
Nitrogen monoxide (NO) and nitrogen dioxide (NO_2), expressed as nitrogen dioxide for existing incineration plants with a nominal capacity of 6 tonnes per hour or less	400 mg/m^3 (*)

(*) Until 1 January 2007 and without prejudice to relevant (Community) legislation the emission limit value for NO_x does not apply to plants only incinerating hazardous waste.

Exemptions for NO_x may be authorised by the competent authority for existing incineration plants:

— with a nominal capacity of 6 tonnes per hour, provided that the permit foresees the daily average values do not exceed 500 mg/m^3 and this until 1 January 2008,

— with a nominal capacity of >6 tonnes per hour but equal or less than 16 tonnes per hour, provided the permit foresees the daily average values do not exceed 400 mg/m^3 and this until 1 January 2010,

— with a nominal capacity of >16 tonnes per hour but <25 tonnes per hour and which do not produce water discharges, provided that the permit foresees the daily average values do not exceed 400 mg/m^3 and this until 1 January 2008.

Until 1 January 2008, exemptions for dust may be authorised by the competent authority for existing incinerating plants, provided that the permit foresees the daily average values do not exceed 20 mg/m^3.

(b) **Half-hourly average values**

	(100 %) A	(97 %) B
Total dust	30 mg/m^3	10 mg/m^3
Gaseous and vaporous organic substances, expressed as total organic carbon	20 mg/m^3	10 mg/m^3
Hydrogen chloride (HCl)	60 mg/m^3	10 mg/m^3
Hydrogen fluoride (HF)	4 mg/m^3	2 mg/m^3
Sulphur dioxide (SO_2)	200 mg/m^3	50 mg/m^3
Nitrogen monoxide (NO) and nitrogen dioxide (NO_2), expressed as nitrogen dixoide for existing incineration plants with a nominal capacity exceeding 6 tonnes per hour or new incineration plants	400 mg/m^3 (*)	200 mg/m^3 (*)

(*) Until 1 January 2007 and without prejudice to relevant Community legislation the emission limit value for NO_x does not apply to plants only incinerating hazardous waste.

▼B

Until 1 January 2010, exemptions for NO_x may be authorised by the competent authority for existing incineration plants with a nominal capacity between 6 and 16 tonnes per hour, provided the half-hourly average value does not exceed 600 mg/m^3 for column A or 400 mg/m^3 for column B.

(c) **All average values over the sample period of a minimum of 30 minutes and a maximum of 8 hours**

Cadmium and its compounds, expressed as cadmium (Cd)	total 0,05 mg/m^3	total 0,1 mg/m^3 (*)
Thallium and its compounds, expressed as thallium (Tl)		
Mercury and its compounds, expressed as mercury (Hg)	0,05 mg/m^3	0,1 mg/m^3 (*)
Antimony and its compounds, expressed as antimony (Sb)	total 0,5 mg/m^3	total 1 mg/m^3 (*)
Arsenic and its compounds, expressed as arsenic (As)		
Lead and its compounds, expressed as lead (Pb)		
Chromium and its compounds, expressed as chromium (Cr)		
Cobalt and its compounds, expressed as cobalt (Co)		
Copper and its compounds, expressed as copper (Cu)		
Manganese and its compounds, expressed as manganese (Mn)		
Nickel and its compounds, expressed as nickel (Ni)		
Vanadium and its compounds, expressed as vanadium (V)		

(*) Until 1 January 2007 average values for existing plants for which the permit to operate has been granted before 31 December 1996, and which incinerate hazardous waste only.

These average values cover also gaseous and the vapour forms of the relevant heavy metal emissions as well as their compounds.

(d) **Average values shall be measured over a sample period of a minimum of 6 hours and a maximum of 8 hours. The emission limit value refers to the total concentration of dioxins and furans calculated using the concept of toxic equivalence in accordance with Annex I.**

Dioxins and furans	0,1 ng/m^3

(e) **The following emission limit values of carbon monoxide (CO) concentrations shall not be exceeded in the combustion gases (excluding the start-up and shut-down phase):**

— 50 milligrams/m^3 of combustion gas determined as daily average value;

— 150 milligrams/m^3 of combustion gas of at least 95 % of all measurements determined as 10-minute average values or 100 mg/m^3 of combustion gas of all measurements determined as half-hourly average values taken in any 24-hour period.

Exemptions may be authorised by the competent authority for incineration plants using fluidised bed technology, provided that the permit foresees an emission limit value for carbon monoxide (CO) of not more than 100 mg/m^3 as an hourly average value.

(f) **Member States may lay down rules governing the exemptions provided for in this Annex.**

▼**B**

ANNEX VI

Formula to calculate the emission concentration at the standard percentage oxygen concentration

$$E_S = \frac{21 - O_S}{21 - O_M} \times E_M$$

E_S = calculated emission concentration at the standard percentage oxygen concentration

E_M = measured emission concentration

O_S = standard oxygen concentration

O_M = measured oxygen concentration

Annex II. Directive 2010/75/EU of the European Parliament and of the Council

DIRECTIVES

DIRECTIVE 2010/75/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 24 November 2010

on industrial emissions (integrated pollution prevention and control)

(Recast)

(Text with EEA relevance)

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty on the Functioning of the European Union, and in particular Article 192(1) thereof,

Having regard to the proposal from the European Commission,

Having regard to the opinion of the European Economic and Social Committee (1),

Having regard to the opinion of the Committee of the Regions (2),

Acting in accordance with the ordinary legislative procedure (3),

Whereas:

(1) A number of substantial changes are to be made to Council Directive 78/176/EEC of 20 February 1978 on waste from the titanium dioxide industry (4), Council Directive 82/883/EEC of 3 December 1982 on procedures for the surveillance and monitoring of environments concerned by waste from the titanium dioxide industry (5), Council Directive 92/112/EEC of 15 December 1992 on procedures for harmonising the programmes for the reduction and eventual elimination of pollution caused by waste from the titanium dioxide industry (6), Council Directive 1999/13/EC of 11 March 1999 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations (7), Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste (8), Directive 2001/80/EC of the European Parliament and of the Council of 23 October 2001 on the limitation of emissions of certain pollutants into the air from large combustion plants (9) and Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 concerning integrated pollution prevention and control (10). In the interests of clarity, those Directives should be recast.

(2) In order to prevent, reduce and as far as possible eliminate pollution arising from industrial activities in compliance with the ‘polluter pays’ principle and the principle of pollution prevention, it is necessary to establish a general framework for the control of the main industrial activities, giving priority to intervention at source, ensuring prudent management of natural resources and taking into account, when necessary, the economic situation and specific local characteristics of the place in which the industrial activity is taking place.

(3) Different approaches to controlling emissions into air, water or soil separately may encourage the shifting of pollution from one environmental medium to another rather than protecting the environment as a whole. It is, therefore, appropriate to provide for an integrated approach to prevention and control of emissions into air, water and soil, to waste management, to energy efficiency and to accident prevention. Such an approach will also contribute to the achievement of a level playing field in the Union by aligning environmental performance requirements for industrial installations.

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(1) OJ C 182, 4.8.2009, p. 46.

(2) OJ C 325, 19.12.2008, p. 60.

(3) Position of the European Parliament of 10 March 2009 (OJ C 87 E, 1.4.2010, p. 191) and position of the Council at first reading of 15 February 2010 (OJ C 107 E, 27.4.2010, p. 1). Position of the European Parliament of 7 July 2010 (not yet published in the Official Journal) and decision of the Council of 8 November 2010.

(4) OJ L 54, 25.2.1978, p. 19.

(5) OJ L 378, 31.12.1982, p. 1.

(6) OJ L 409, 31.12.1992, p. 11.

(7) OJ L 85, 29.3.1999, p. 1.

(8) OJ L 332, 28.12.2000, p. 91.

(9) OJ L 309, 27.11.2001, p. 1.

(10) OJ L 24, 29.1.2008, p. 8.

(4) It is appropriate to revise the legislation relating to industrial installations in order to simplify and clarify the existing provisions, reduce unnecessary administrative burden and implement the conclusions of the Commission Communications of 21 September 2005 on the Thematic Strategy on Air Pollution (hereinafter the Thematic Strategy on Air Pollution), of 22 September 2006 on the Thematic Strategy for Soil Protection and of 21 December 2005 on the Thematic Strategy on the Prevention and Recycling of Waste adopted as a follow-up to Decision No 1600/2002/EC of the European Parliament and of the Council of 22 July 2002 laying down the Sixth Community Environment Action Programme (1). Those Communications set objectives to protect human health and the environment which cannot be met without further reductions in emissions arising from industrial activities.

(5) In order to ensure the prevention and control of pollution, each installation should operate only if it holds a permit or, in the case of certain installations and activities using organic solvents, only if it holds a permit or is registered.

(6) It is for Member States to determine the approach for assigning responsibilities to operators of installations provided that compliance with this Directive is ensured. Member States may choose to grant a permit to one responsible operator for each installation or to specify the responsibility amongst several operators of different parts of an installation. Where its current legal system provides for only one responsible operator for each installation, a Member State may decide to retain this system.

(7) In order to facilitate the granting of permits, Member States should be able to set requirements for certain categories of installations in general binding rules.

(8) It is important to prevent accidents and incidents and limit their consequences. Liability regarding the environmental consequences of accidents and incidents is a matter for relevant national law and, where applicable, other relevant Union law.

(9) In order to avoid duplication of regulation, the permit for an installation covered by Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community (2) should not include an emission limit value for direct emissions of the greenhouse gases specified in Annex I to that Directive except where it is necessary to ensure that no significant local pollution is caused or where an installation is excluded from that scheme.

(10) In accordance with Article 193 of the Treaty on the Functioning of the European Union (TFEU), this Directive does not prevent Member States from maintaining or introducing more stringent protective measures, for example greenhouse gas emission requirements, provided that such measures are compatible with the Treaties and the Commission has been notified.

(11) Operators should submit permit applications containing the information necessary for the competent authority to set permit conditions. Operators should be able to use information resulting from the application of Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment (3) and of Council Directive 96/82/EC of 9 December 1996 on the control of major-accident hazards involving dangerous substances (4) when submitting permit applications.

(12) The permit should include all the measures necessary to achieve a high level of protection of the environment as a whole and to ensure that the installation is operated in accordance with the general principles governing the basic obligations of the operator. The permit should also include emission limit values for polluting substances, or equivalent parameters or technical measures, appropriate requirements to protect the soil and groundwater and monitoring requirements. Permit conditions should be set on the basis of best available techniques.

(13) In order to determine best available techniques and to limit imbalances in the Union as regards the level of emissions from industrial activities, reference documents for best available techniques (hereinafter BAT reference documents') should be drawn up, reviewed and, where necessary, updated through an exchange of information with stakeholders and the key elements of BAT reference documents (hereinafter BAT conclusions') adopted through committee procedure. In this respect, the Commission should, through committee procedure, establish guidance on the collection of data, on the elaboration of BAT reference documents and on their quality assurance. BAT conclusions should be the reference for setting permit conditions. They can be supplemented by other sources. The Commission should aim to update BAT reference documents not later than 8 years after the publication of the previous version.

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(1) OJ L 242, 10.9.2002, p. 1.

(2) OJ L 275, 25.10.2003, p. 32.

(3) OJ L 175, 5.7.1985, p. 40.

(4) OJ L 10, 14.1.1997, p. 13.

(14) In order to ensure an effective and active exchange of information resulting in high-quality BAT reference documents, the Commission should establish a forum that functions in a transparent manner. Practical arrangements for the exchange of information and the accessibility of BAT reference documents should be laid down, in particular to ensure that Member States and stakeholders provide data of sufficient quality and quantity based on established guidance to enable the determination of best available techniques and emerging techniques.

(15) It is important to provide sufficient flexibility to competent authorities to set emission limit values that ensure that, under normal operating conditions, emissions do not exceed the emission levels associated with the best available techniques. To this end, the competent authority may set emission limits that differ from the emission levels associated with the best available techniques in terms of the values, periods of time and reference conditions applied, so long as it can be demonstrated, through the results of emission monitoring, that emissions have not exceeded the emission levels associated with the best available techniques. Compliance with the emission limit values that are set in permits results in emissions below those emission limit values.

(16) In order to take into account certain specific circumstances where the application of emission levels associated with the best available techniques would lead to disproportionately high costs compared to the environmental benefits, competent authorities should be able to set emission limit values deviating from those levels. Such deviations should be based on an assessment taking into account well-defined criteria. The emission limit values set out in this Directive should not be exceeded. In any event, no significant pollution should be caused and a high level of protection of the environment taken as a whole should be achieved.

(17) In order to enable operators to test emerging techniques which could provide for a higher general level of environmental protection, or at least the same level of environmental protection and higher cost savings than existing best available techniques, the competent authority should be able to grant temporary derogations from emission levels associated with the best available techniques.

(18) Changes to an installation may give rise to higher levels of pollution. Operators should notify the competent authority of any planned change which might affect the environment. Substantial changes to installations which may have significant negative effects on human health or the environment should not be made without a permit granted in accordance with this Directive.

(19) The spreading of manure contributes significantly to emissions of pollutants into air and water. With a view to meeting the objectives set out in the Thematic Strategy on Air Pollution and Union law on water protection, it is necessary for the Commission to review the need to establish the most suitable controls of these emissions through the application of best available techniques.

(20) The intensive rearing of poultry and cattle contributes significantly to emissions of pollutants into air and water. With a view to meeting the objectives set out in the Thematic Strategy on Air Pollution and in Union law on water protection, it is necessary for the Commission to review the need to establish differentiated capacity thresholds for different poultry species in order to define the scope of this Directive and to review the need to establish the most suitable controls on emissions from cattle rearing installations.

(21) In order to take account of developments in best available techniques or other changes to an installation, permit conditions should be reconsidered regularly and, where necessary, updated, in particular where new or updated BAT conclusions are adopted.

(22) In specific cases where permit reconsideration and updating identifies that a longer period than 4 years after the publication of a decision on BAT conclusions might be needed to introduce new best available techniques, competent authorities may set a longer time period in permit conditions where this is justified on the basis of the criteria laid down in this Directive.

(23) It is necessary to ensure that the operation of an installation does not lead to a deterioration of the quality of soil and groundwater. Permit conditions should, therefore, include appropriate measures to prevent emissions to soil and groundwater and regular surveillance of those measures to avoid leaks, spills, incidents or accidents occurring during the use of equipment and during storage. In order to detect possible soil and groundwater pollution at an early stage and, therefore, to take appropriate corrective measures before the pollution spreads, the monitoring of soil and groundwater for relevant hazardous substances is also necessary. When determining the frequency of monitoring, the type of prevention measures and the extent and occurrence of their surveillance may be considered.

(24) In order to ensure that the operation of an installation does not deteriorate the quality of soil and groundwater, it is necessary to establish, through a baseline report, the state of soil and groundwater contamination. The baseline report should be a practical tool that permits, as far as possible, a quantified comparison between the state of the site described in that report and the state of the site upon definitive cessation of activities, in order to ascertain whether a significant increase in pollution of soil or groundwater has taken place. The baseline report should, therefore, contain information making use of existing data on soil and groundwater measurements and historical data related to past uses of the site.

(25) In accordance with the polluter pays principle, when assessing the level of significance of the pollution of soil and groundwater caused by the operator which would trigger the obligation to return the site to the state described in the baseline report, Member States should take into account the permit conditions that have applied over the lifetime of the activity concerned, the pollution prevention measures adopted for the installation, and the relative increase in pollution compared to the contamination load identified in the baseline report. Liability regarding pollution not caused by the operator is a matter for relevant national law and, where applicable, other relevant Union law.

(26) In order to ensure the effective implementation and enforcement of this Directive, operators should regularly report to the competent authority on compliance with permit conditions. Member States should ensure that the operator and the competent authority each take necessary measures in the event of non-compliance with this Directive and provide for a system of environmental inspections. Member States should ensure that sufficient staff are available with the skills and qualifications needed to carry out those inspections effectively.

(27) In accordance with the Århus Convention on access to information, public participation in decision-making and access to justice in environmental matters (¹), effective public participation in decision-making is necessary to enable the public to express, and the decision-maker to take account of, opinions and concerns which may be relevant to those decisions, thereby increasing the accountability and transparency of the decision-making process and contributing to public awareness of environmental issues and support for the decisions taken. Members of the public concerned should have access to justice in order to contribute to the protection of the right to live in an environment which is adequate for personal health and well-being.

(28) The combustion of fuel in installations with a total rated thermal input below 50 MW contributes significantly to emissions of pollutants into the air. With a view to meeting the objectives set out in the Thematic Strategy on Air Pollution, it is necessary for the Commission to review the need to establish the most suitable controls on emissions from such installations. That review should take into account the specificities of combustion plants used in healthcare facilities, in particular with regard to their exceptional use in the case of emergencies.

(29) Large combustion plants contribute greatly to emissions of polluting substances into the air resulting in a significant impact on human health and the environment. In order to reduce that impact and to work towards meeting the requirements of Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants (²) and the objectives set out in the Thematic Strategy on Air Pollution, it is necessary to set more stringent emission limit values at Union level for certain categories of combustion plants and pollutants.

(30) The Commission should review the need to establish Union-wide emission limit values and to amend the emission limit values set out in Annex V for certain large combustion plants, taking into account the review and update of the relevant BAT reference documents. In this context, the Commission should consider the specificity of the energy systems of refineries.

(31) Due to the characteristics of certain indigenous solid fuels, it is appropriate to apply minimum desulphurisation rates rather than emission limit values for sulphur dioxide for combustion plants firing such fuels. Moreover, as the specific characteristics of oil shale may not allow the application of the same sulphur abatement techniques or the achievement of the same desulphurisation efficiency as for other fuels, a slightly lower minimum desulphurisation rate for plants using this fuel is appropriate.

(32) In the case of a sudden interruption in the supply of low-sulphur fuel or gas resulting from a serious shortage, the competent authority should be able to grant temporary derogations to allow emissions of the combustion plants concerned to exceed the emission limit values set out in this Directive.

(¹) OJ L 124, 17.5.2005, p. 4.

(²) OJ L 309, 27.11.2001, p. 22.

(33) The operator concerned should not operate a combustion plant for more than 24 hours after malfunctioning or breakdown of abatement equipment and unabated operation should not exceed 120 hours in a 12-month period in order to limit the negative effects of pollution on the environment. However, where there is an overriding need for energy supplies or it is necessary to avoid an overall increase of emissions resulting from the operation of another combustion plant, competent authorities should be able to grant a derogation from those time limits.

(34) In order to ensure a high level of environmental and human health protection and to avoid transboundary movements of waste to plants operating at lower environmental standards, it is necessary to set and maintain stringent operating conditions, technical requirements and emission limit values for plants incinerating or co-incinerating waste within the Union.

(35) The use of organic solvents in certain activities and installations gives rise to emissions of organic compounds into the air which contribute to the local and transboundary formation of photochemical oxidants which causes damage to natural resources and has harmful effects on human health. It is, therefore, necessary to take preventive action against the use of organic solvents and to establish a requirement to comply with emission limit values for organic compounds and appropriate operating conditions. Operators should be allowed to comply with the requirements of a reduction scheme instead of complying with the emission limit values set out in this Directive where other measures, such as the use of low-solvent or solvent-free products or techniques, provide alternative means of achieving equivalent emission reduction.

(36) Installations producing titanium dioxide can give rise to significant pollution into air and water. In order to reduce these impacts, it is necessary to set at Union level more stringent emission limit values for certain polluting substances.

(37) With regard to the inclusion in the scope of national laws, regulations and administrative provisions brought into force in order to comply with this Directive of installations for the manufacturing of ceramic products by firings, on the basis of the characteristics of the national industrial sector, and in order to grant clear interpretation of the scope, Member States should decide whether to apply both the criteria, production capacity and kiln capacity, or just one of the two criteria.

(38) In order to simplify reporting and reduce unnecessary administrative burden, the Commission should identify methods to streamline the way in which data are made available pursuant to this Directive with the other requirements of Union law, and in particular Regulation (EC) No 166/2006 of the European Parliament and of the Council of 18 January 2006 concerning the establishment of a European Pollutant Release and Transfer Register (1).

(39) In order to ensure uniform conditions for implementation, implementing powers should be conferred on the Commission to adopt guidance on the collection of data, on the drawing up of BAT reference documents and on their quality assurance, including the suitability of their content and format, to adopt decisions on BAT conclusions, to establish detailed rules on the determination of start-up and shut-down periods and for transitional national plans for large combustion plants, and to establish the type, format and frequency of information that Member States are to make available to the Commission. In accordance with Article 291 TFEU, rules and general principles concerning mechanisms for the control by Member States of the Commission’s exercise of implementing powers are to be laid down in advance by a regulation adopted in accordance with the ordinary legislative procedure. Pending the adoption of that new regulation, Council Decision 1999/468/EC of 28 June 1999 laying down the procedures for the exercise of implementing powers conferred on the Commission (2) continues to apply, with the exception of the regulatory procedure with scrutiny, which is not applicable.

(40) The Commission should be empowered to adopt delegated acts in accordance with Article 290 TFEU in respect of the setting of the date from which continuous measurements of emissions into the air of heavy metals and dioxins and furans are to be carried out, and the adaptation of certain parts of Annexes V, VI and VII to scientific and technical progress. In the case of waste incineration plants and waste co-incineration plants, this may include, inter alia, the establishment of criteria to allow derogations from continuous monitoring of total dust emissions. It is of particular importance that the Commission carry out appropriate consultations during its preparatory work, including at expert level.

(41) In order to address significant environmental pollution, for example from heavy metals and dioxins and furans, the Commission should, based on an assessment of the implementation of the best available techniques by certain activities or of the impact of those activities on the environment as a whole, present proposals for Union-wide minimum requirements for emission limit values and for rules on monitoring and compliance.

(42) Member States should lay down rules on penalties applicable to infringements of the national provisions adopted pursuant to this Directive and ensure that they are implemented. Those penalties should be effective, proportionate and dissuasive.

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(1) OJ L 33, 4.2.2006, p. 1.

(2) OJ L 184, 17.7.1999, p. 23.

(43) In order to provide existing installations with sufficient time to adapt technically to the new requirements of this Directive, some of the new requirements should apply to those installations after a fixed period from the date of application of this Directive. Combustion plants need sufficient time to install the necessary abatement measures to meet the emission limit values set out in Annex V.

(44) Since the objectives of this Directive, namely to ensure a high level of environmental protection and the improvement of environmental quality, cannot be sufficiently achieved by Member States and can, therefore, by reason of the transboundary nature of pollution from industrial activities, be better achieved at Union level, the Union may adopt measures in accordance with the principle of subsidiarity as set out in Article 5 of the Treaty on European Union. In accordance with the principle of proportionality, as set out in that Article, this Directive does not go beyond what is necessary in order to achieve those objectives.

(45) This Directive respects the fundamental rights and observes the principles recognised in particular by the Charter of Fundamental Rights of the European Union. In particular, this Directive seeks to promote the application of Article 37 of that Charter.

(46) The obligation to transpose this Directive into national law should be confined to those provisions which represent a substantive change as compared with the earlier Directives. The obligation to transpose the provisions which are unchanged arises under the earlier Directives.

(47) In accordance with paragraph 34 of the Interinstitutional agreement on better law-making (1), Member States are encouraged to draw up, for themselves and in the interests of the Union, their own tables, which will as far as possible, illustrate the correlation between this Directive and the transposition measures, and to make those tables public.

(48) This Directive should be without prejudice to the obligations of the Member States relating to the time-limits for transposition into national law and application of the Directives set out in Annex IX, Part B,

HAVE ADOPTED THIS DIRECTIVE:

CHAPTER I

COMMON PROVISIONS

Article 1

Subject matter

This Directive lays down rules on integrated prevention and control of pollution arising from industrial activities.

It also lays down rules designed to prevent or, where that is not practicable, to reduce emissions into air, water and land and to prevent the generation of waste, in order to achieve a high level of protection of the environment taken as a whole.

Article 2

Scope

1. This Directive shall apply to the industrial activities giving rise to pollution referred to in Chapters II to VI.

2. This Directive shall not apply to research activities, development activities or the testing of new products and processes.

Article 3

Definitions

For the purposes of this Directive the following definitions shall apply:

(1) ‘substance’ means any chemical element and its compounds, with the exception of the following substances:

   (a) radioactive substances as defined in Article 1 of Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation (2);

   (b) genetically modified micro-organisms as defined in Article 2(b) of Directive 2009/41/EC of the European Parliament and the Council of 6 May 2009 on the contained use of genetically modified micro-organisms (3);

   (c) genetically modified organisms as defined in point 2 of Article 2 of Directive 2001/18/EC of the European Parliament and of the Council of 12 March 2001 on the deliberate release into the environment of genetically modified organisms (4);

(2) ‘pollution’ means the direct or indirect introduction, as a result of human activity, of substances, vibrations, heat or noise into air, water or land which may be harmful to human health or the quality of the environment, result in damage to material property, or impair or interfere with amenities and other legitimate uses of the environment;

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(1) OJ C 321, 31.12.2003, p. 1.

(2) OJ L 159, 29.6.1996, p. 1.

(3) OJ L 125, 21.5.2009, p. 75.

(4) OJ L 106, 17.4.2001, p. 1.

(3) ‘installation’ means a stationary technical unit within which one or more activities listed in Annex I or in Part 1 of Annex VII are carried out, and any other directly associated activities on the same site which have a technical connection with the activities listed in those Annexes and which could have an effect on emissions and pollution;

(4) ‘emission’ means the direct or indirect release of substances, vibrations, heat or noise from individual or diffuse sources in the installation into air, water or land;

(5) ‘emission limit value’ means the mass, expressed in terms of certain specific parameters, concentration and/or level of an emission, which may not be exceeded during one or more periods of time;

(6) ‘environmental quality standard’ means the set of requirements which must be fulfilled at a given time by a given environment or particular part thereof, as set out in Union law;

(7) ‘permit’ means a written authorisation to operate all or part of an installation or combustion plant, waste incineration plant or waste co-incineration plant;

(8) ‘general binding rules’ means emission limit values or other conditions, at least at sector level, that are adopted with the intention of being used directly to set permit conditions;

(9) ‘substantial change’ means a change in the nature or functioning, or an extension, of an installation or combustion plant, waste incineration plant or waste co-incineration plant which may have significant negative effects on human health or the environment;

(10) ‘best available techniques’ means the most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing the basis for emission limit values and other permit conditions designed to prevent and, where that is not practicable, to reduce emissions and the impact on the environment as a whole:

(a) ‘techniques’ includes both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned;

(b) ‘available techniques’ means those developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced inside the Member State in question, as long as they are reasonably accessible to the operator;

(c) ‘best’ means most effective in achieving a high general level of protection of the environment as a whole;

(11) ‘BAT reference document’ means a document, resulting from the exchange of information organised pursuant to Article 13, drawn up for defined activities and describing, in particular, applied techniques, present emissions and consumption levels, techniques considered for the determination of best available techniques as well as BAT conclusions and any emerging techniques, giving special consideration to the criteria listed in Annex III;

(12) ‘BAT conclusions’ means a document containing the parts of a BAT reference document laying down the conclusions on best available techniques, their description, information to assess their applicability, the emission levels associated with the best available techniques, associated monitoring, associated consumption levels and, where appropriate, relevant site remediation measures;

(13) ‘emission levels associated with the best available techniques’ means the range of emission levels obtained under normal operating conditions using a best available technique or a combination of best available techniques, as described in BAT conclusions, expressed as an average over a given period of time, under specified reference conditions;

(14) ‘emerging technique’ means a novel technique for an industrial activity that, if commercially developed, could provide either a higher general level of protection of the environment or at least the same level of protection of the environment and higher cost savings than existing best available techniques;

(15) ‘operator’ means any natural or legal person who operates or controls in whole or in part the installation or combustion plant, waste incineration plant or waste co-incineration plant or, where this is provided for in national law, to whom decisive economic power over the technical functioning of the installation or plant has been delegated;

(16) ‘the public’ means one or more natural or legal persons and, in accordance with national law or practice, their associations, organisations or groups;

(17) ‘the public concerned’ means the public affected or likely to be affected by, or having an interest in, the taking of a decision on the granting or the updating of a permit or of permit conditions; for the purposes of this definition, non-governmental organisations promoting environmental protection and meeting any requirements under national law shall be deemed to have an interest;

(18) ‘hazardous substances’ means substances or mixtures as defined in Article 3 of Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures (1);

(19) ‘baseline report’ means information on the state of soil and groundwater contamination by relevant hazardous substances;

(20) ‘groundwater’ means groundwater as defined in point 2 of Article 2 of Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (2);

(21) ‘soil’ means the top layer of the Earth’s crust situated between the bedrock and the surface. The soil is composed of mineral particles, organic matter, water, air and living organisms;

(22) ‘environmental inspection’ means all actions, including site visits, monitoring of emissions and checks of internal reports and follow-up documents, verification of self-monitoring, checking of the techniques used and adequacy of the environment management of the installation, undertaken by or on behalf of the competent authority to check and promote compliance of installations with their permit conditions and, where necessary, to monitor their environmental impact;

(23) ‘poultry’ means poultry as defined in point 1 of Article 2 of Council Directive 90/539/EEC of 15 October 1990 on animal health conditions governing intra-Community trade in, and imports from third countries of, poultry and hatching eggs (3);

(24) ‘fuel’ means any solid, liquid or gaseous combustible material;

(25) ‘combustion plant’ means any technical apparatus in which fuels are oxidised in order to use the heat thus generated;

(26) ‘stack’ means a structure containing one or more flues providing a passage for waste gases in order to discharge them into the air;

(27) ‘operating hours’ means the time, expressed in hours, during which a combustion plant, in whole or in part, is operating and discharging emissions into the air, excluding start-up and shut-down periods;

(28) ‘rate of desulphurisation’ means the ratio over a given period of time of the quantity of sulphur which is not emitted into air by a combustion plant to the quantity of sulphur contained in the solid fuel which is introduced into the combustion plant facilities and which is used in the plant over the same period of time;

(29) ‘indigenous solid fuel’ means a naturally occurring solid fuel fired in a combustion plant specifically designed for that fuel and extracted locally;

(30) ‘determinative fuel’ means the fuel which, amongst all fuels used in a multi-fuel firing combustion plant using the distillation and conversion residues from the refining of crude-oil for own consumption, alone or with other fuels, has the highest emission limit value as set out in Part 1 of Annex V, or, in the case of several fuels having the same emission limit value, the fuel having the highest thermal input amongst those fuels;

(31) ‘biomass’ means any of the following:

(a) products consisting of any vegetable matter from agriculture or forestry which can be used as a fuel for the purpose of recovering its energy content;

(b) the following waste:

(i) vegetable waste from agriculture and forestry;

(ii) vegetable waste from the food processing industry, if the heat generated is recovered;

(iii) fibrous vegetable waste from virgin pulp production and from production of paper from pulp, if it is co-incinerated at the place of production and the heat generated is recovered;

(iv) cork waste;

(v) wood waste with the exception of wood waste which may contain halogenated organic compounds or heavy metals as a result of treatment with wood preservatives or coating and which includes, in particular, such wood waste originating from construction and demolition waste;

(32) ‘multi-fuel firing combustion plant’ means any combustion plant which may be fired simultaneously or alternately by two or more types of fuel;

(33) ‘gas turbine’ means any rotating machine which converts thermal energy into mechanical work, consisting mainly of a compressor, a thermal device in which fuel is oxidised in order to heat the working fluid, and a turbine;

(34) ‘gas engine’ means an internal combustion engine which operates according to the Otto cycle and uses spark ignition or, in case of dual fuel engines, compression ignition to burn fuel;

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(1) OJ L 353, 31.12.2008, p. 1.

(2) OJ L 327, 22.12.2000, p. 1.

(3) OJ L 303, 31.10.1990, p. 6.

(35) ‘diesel engine’ means an internal combustion engine which operates according to the diesel cycle and uses compression ignition to burn fuel;

(36) ‘small isolated system’ means a small isolated system as defined in point 26 of Article 2 of Directive 2003/54/EC of the European Parliament and of the Council of 26 June 2003 concerning common rules for the internal market in electricity (1);

(37) ‘waste’ means waste as defined in point 1 of Article 3 of Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste (2);

(38) ‘hazardous waste’ means hazardous waste as defined in point 2 of Article 3 of Directive 2008/98/EC;

(39) ‘mixed municipal waste’ means waste from households as well as commercial, industrial and institutional waste which, because of its nature and composition, is similar to waste from households, but excluding fractions indicated under heading 20 01 of the Annex to Decision 2000/532/EC (3) that are collected separately at source and excluding the other waste indicated under heading 20 02 of that Annex;

(40) ‘waste incineration plant’ means any stationary or mobile technical unit and equipment dedicated to the thermal treatment of waste, with or without recovery of the combustion heat generated, through the incineration by oxidation of waste as well as other thermal treatment processes, such as pyrolysis, gasification or plasma process, if the substances resulting from the treatment are subsequently incinerated;

(41) ‘waste co-incineration plant’ means any stationary or mobile technical unit whose main purpose is the generation of energy or production of material products and which uses waste as a regular or additional fuel or in which waste is thermally treated for the purpose of disposal through the incineration by oxidation of waste as well as other thermal treatment processes, such as pyrolysis, gasification or plasma process, if the substances resulting from the treatment are subsequently incinerated;

(42) ‘nominal capacity’ means the sum of the incineration capacities of the furnaces of which a waste incineration plant or a waste co-incineration plant is composed, as specified by the constructor and confirmed by the operator, with due account being taken of the calorific value of the waste, expressed as the quantity of waste incinerated per hour;

(43) ‘dioxins and furans’ means all polychlorinated dibenzo-p-dioxins and dibenzofurans listed in Part 2 of Annex VI;

(44) ‘organic compound’ means any compound containing at least the element carbon and one or more of hydrogen, halogens, oxygen, sulphur, phosphorus, silicon or nitrogen, with the exception of carbon oxides and inorganic carbonates and bicarbonates;

(45) ‘volatile organic compound’ means any organic compound as well as the fraction of creosote, having at 293,15 K a vapour pressure of 0,01 kPa or more, or having a corresponding volatility under the particular conditions of use;

(46) ‘organic solvent’ means any volatile organic compound which is used for any of the following:

(a) alone or in combination with other agents, and without undergoing a chemical change, to dissolve raw materials, products or waste materials;

(b) as a cleaning agent to dissolve contaminants;

(c) as a dissolver;

(d) as a dispersion medium;

(e) as a viscosity adjuster;

(f) as a surface tension adjuster;

(g) as a plasticiser;

(h) as a preservative;

(47) ‘coating’ means coating as defined in point 8 of Article 2 of Directive 2004/42/EC of the European Parliament and of the Council of 21 April 2004 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products (4).

Article 4

Obligation to hold a permit

1. Member States shall take the necessary measures to ensure that no installation or combustion plant, waste incineration plant or waste co-incineration plant is operated without a permit.

By way of derogation from the first subparagraph, Member States may set a procedure for the registration of installations covered only by Chapter V.

The procedure for registration shall be specified in a binding act and include at least a notification to the competent authority by the operator of the intention to operate an installation.

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(1) OJ L 176, 15.7.2003, p. 37.

(2) OJ L 312, 22.11.2008, p. 3.

(3) Commission Decision 2000/532/EC of 3 May 2000 replacing Decision 94/3/EC establishing a list of wastes pursuant to Article 1(a) of Council Directive 75/442/EEC on waste and Council Decision 94/904/EC establishing a list of hazardous waste pursuant to Article 1(4) of Council Directive 91/689/EEC on hazardous waste (OJ L 226, 6.9.2000, p. 3).

(4) OJ L 143, 30.4.2004, p. 87.

2. Member States may opt to provide that a permit cover two or more installations or parts of installations operated by the same operator on the same site.

Where a permit covers two or more installations, it shall contain conditions to ensure that each installation complies with the requirements of this Directive.

3. Member States may opt to provide that a permit cover several parts of an installation operated by different operators. In such cases, the permit shall specify the responsibilities of each operator.

Article 5

Granting of a permit

1. Without prejudice to other requirements laid down in national or Union law, the competent authority shall grant a permit if the installation complies with the requirements of this Directive.

2. Member States shall take the measures necessary to ensure that the conditions of, and the procedures for the granting of, the permit are fully coordinated where more than one competent authority or more than one operator is involved or more than one permit is granted, in order to guarantee an effective integrated approach by all authorities competent for this procedure.

3. In the case of a new installation or a substantial change where Article 4 of Directive 85/337/EEC applies, any relevant information obtained or conclusion arrived at pursuant to Articles 5, 6, 7 and 9 of that Directive shall be examined and used for the purposes of granting the permit.

Article 6

General binding rules

Without prejudice to the obligation to hold a permit, Member States may include requirements for certain categories of installations, combustion plants, waste incineration plants or waste co-incineration plants in general binding rules.

Where general binding rules are adopted, the permit may simply include a reference to such rules.

Article 7

Incidents and accidents

Without prejudice to Directive 2004/35/EC of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage (1), in the event of any incident or accident significantly affecting the environment, Member States shall take the necessary measures to ensure that:

(a) the operator informs the competent authority immediately;

(b) the operator immediately takes the measures to limit the environmental consequences and to prevent further possible incidents or accidents;

(c) the competent authority requires the operator to take any appropriate complementary measures that the competent authority considers necessary to limit the environmental consequences and to prevent further possible incidents or accidents.

Article 8

Non-compliance

1. Member States shall take the necessary measures to ensure that the permit conditions are complied with.

2. In the event of a breach of the permit conditions, Member States shall ensure that:

(a) the operator immediately informs the competent authority;

(b) the operator immediately takes the measures necessary to ensure that compliance is restored within the shortest possible time;

(c) the competent authority requires the operator to take any appropriate complementary measures that the competent authority considers necessary to restore compliance.

Where the breach of the permit conditions poses an immediate danger to human health or threatens to cause an immediate significant adverse effect upon the environment, and until compliance is restored in accordance with points (b) and (c) of the first subparagraph, the operation of the installation, combustion plant, waste incineration plant, waste co-incineration plant or relevant part thereof shall be suspended.

Article 9

Emission of greenhouse gases

1. Where emissions of a greenhouse gas from an installation are specified in Annex I to Directive 2003/87/EC in relation to an activity carried out in that installation, the permit shall not include an emission limit value for direct emissions of that gas, unless necessary to ensure that no significant local pollution is caused.

2. For activities listed in Annex I to Directive 2003/87/EC, Member States may choose not to impose requirements relating to energy efficiency in respect of combustion units or other units emitting carbon dioxide on the site.

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(1) OJ L 143, 30.4.2004, p. 56.

3. Where necessary, the competent authorities shall amend the permit as appropriate.

4. Paragraphs 1 to 3 shall not apply to installations which are temporarily excluded from the scheme for greenhouse gas emission allowance trading within the Union in accordance with Article 27 of Directive 2003/87/EC.

CHAPTER II

PROVISIONS FOR ACTIVITIES LISTED IN ANNEX I

Article 10

Scope

This Chapter shall apply to the activities set out in Annex I and, where applicable, reaching the capacity thresholds set out in that Annex.

Article 11

General principles governing the basic obligations of the operator

Member States shall take the necessary measures to provide that installations are operated in accordance with the following principles:

(a) all the appropriate preventive measures are taken against pollution;

(b) the best available techniques are applied;

(c) no significant pollution is caused;

(d) the generation of waste is prevented in accordance with Directive 2008/98/EC;

(e) where waste is generated, it is, in order of priority and in accordance with Directive 2008/98/EC, prepared for re-use, recycled, recovered or, where that is technically and economically impossible, it is disposed of while avoiding or reducing any impact on the environment;

(f) energy is used efficiently;

(g) the necessary measures are taken to prevent accidents and limit their consequences;

(h) the necessary measures are taken upon definitive cessation of activities to avoid any risk of pollution and return the site of operation to the satisfactory state defined in accordance with Article 22.

Article 12

Applications for permits

1. Member States shall take the necessary measures to ensure that an application for a permit includes a description of the following:

(a) the installation and its activities;

(b) the raw and auxiliary materials, other substances and the energy used in or generated by the installation;

(c) the sources of emissions from the installation;

(d) the conditions of the site of the installation;

(e) where applicable, a baseline report in accordance with Article 22(2);

(f) the nature and quantities of foreseeable emissions from the installation into each medium as well as identification of significant effects of the emissions on the environment;

(g) the proposed technology and other techniques for preventing or, where this is not possible, reducing emissions from the installation;

(h) measures for the prevention, preparation for re-use, recycling and recovery of waste generated by the installation;

(i) further measures planned to comply with the general principles of the basic obligations of the operator as provided for in Article 11;

(j) measures planned to monitor emissions into the environment;

(k) the main alternatives to the proposed technology, techniques and measures studied by the applicant in outline.

An application for a permit shall also include a non-technical summary of the details referred to in the first subparagraph.

2. Where information supplied in accordance with the requirements provided for in Directive 85/337/EEC or a safety report prepared in accordance with Directive 96/82/EC or other information produced in response to other legislation fulfils any of the requirements of paragraph 1, that information may be included in, or attached to, the application.

Article 13

BAT reference documents and exchange of information

1. In order to draw up, review and, where necessary, update BAT reference documents, the Commission shall organise an exchange of information between Member States, the industries concerned, non-governmental organisations promoting environmental protection and the Commission.

2. The exchange of information shall, in particular, address the following:

(a) the performance of installations and techniques in terms of emissions, expressed as short- and long-term averages, where appropriate, and the associated reference conditions, consumption and nature of raw materials, water consumption, use of energy and generation of waste;

(b) the techniques used, associated monitoring, cross-media effects, economic and technical viability and developments therein;

(c) best available techniques and emerging techniques identified after considering the issues mentioned in points (a) and (b).

3. The Commission shall establish and regularly convene a forum composed of representatives of Member States, the industries concerned and non-governmental organisations promoting environmental protection.

The Commission shall obtain the opinion of the forum on the practical arrangements for the exchange of information and, in particular, on the following:

(a) the rules of procedure of the forum;

(b) the work programme for the exchange of information;

(c) guidance on the collection of data;

(d) guidance on the drawing up of BAT reference documents and on their quality assurance including the suitability of their content and format.

The guidance referred to in points (c) and (d) of the second subparagraph shall take account of the opinion of the forum and shall be adopted in accordance with the regulatory procedure referred to in Article 75(2).

4. The Commission shall obtain and make publicly available the opinion of the forum on the proposed content of the BAT reference documents and shall take into account this opinion for the procedures laid down in paragraph 5.

5. Decisions on the BAT conclusions shall be adopted in accordance with the regulatory procedure referred to in Article 75(2).

6. After the adoption of a decision in accordance with paragraph 5, the Commission shall without delay make the BAT reference document publicly available and ensure that BAT conclusions are made available in all the official languages of the Union.

7. Pending the adoption of a relevant decision in accordance with paragraph 5, the conclusions on best available techniques from BAT reference documents adopted by the Commission prior to the date referred to in Article 83 shall apply as BAT conclusions for the purposes of this Chapter except for Article 15(3) and (4).

Article 14

Permit conditions

1. Member States shall ensure that the permit includes all measures necessary for compliance with the requirements of Articles 11 and 18.

Those measures shall include at least the following:

(a) emission limit values for polluting substances listed in Annex II, and for other polluting substances, which are likely to be emitted from the installation concerned in significant quantities, having regard to their nature and their potential to transfer pollution from one medium to another;

(b) appropriate requirements ensuring protection of the soil and groundwater and measures concerning the monitoring and management of waste generated by the installation;

(c) suitable emission monitoring requirements specifying:

  (i) measurement methodology, frequency and evaluation procedure; and

  (ii) where Article 15(3)(b) is applied, that results of emission monitoring are available for the same periods of time and reference conditions as for the emission levels associated with the best available techniques;

(d) an obligation to supply the competent authority regularly, and at least annually, with:

  (i) information on the basis of results of emission monitoring referred to in point (c) and other required data that enables the competent authority to verify compliance with the permit conditions; and

  (ii) where Article 15(3)(b) is applied, a summary of the results of emission monitoring which allows a comparison with the emission levels associated with the best available techniques;

(e) appropriate requirements for the regular maintenance and surveillance of measures taken to prevent emissions to soil and groundwater pursuant to point (b) and appropriate requirements concerning the periodic monitoring of soil and groundwater in relation to relevant hazardous substances likely to be found on site and having regard to the possibility of soil and groundwater contamination at the site of the installation;

(f) 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;

(g) provisions on the minimisation of long-distance or transboundary pollution;

(h) conditions for assessing compliance with the emission limit values or a reference to the applicable requirements specified elsewhere.

2. For the purpose of paragraph 1(a), emission limit values may be supplemented or replaced by equivalent parameters or technical measures ensuring an equivalent level of environmental protection.

3. BAT conclusions shall be the reference for setting the permit conditions.

4. Without prejudice to Article 18, the competent authority may set stricter permit conditions than those achievable by the use of the best available techniques as described in the BAT conclusions. Member States may establish rules under which the competent authority may set such stricter conditions.

5. Where the competent authority sets permit conditions on the basis of a best available technique not described in any of the relevant BAT conclusions, it shall ensure that:

(a) that technique is determined by giving special consideration to the criteria listed in Annex III; and

(b) the requirements of Article 15 are complied with.

Where the BAT conclusions referred to in the first subparagraph do not contain emission levels associated with the best available techniques, the competent authority shall ensure that the technique referred to in the first subparagraph ensures a level of environmental protection equivalent to the best available techniques described in the BAT conclusions.

6. Where an activity or a type of production process carried out within an installation is not covered by any of the BAT conclusions or where those conclusions do not address all the potential environmental effects of the activity or process, the competent authority shall, after prior consultations with the operator, set the permit conditions on the basis of the best available techniques that it has determined for the activities or processes concerned, by giving special consideration to the criteria listed in Annex III.

7. For installations referred to in point 6.6 of Annex I, paragraphs 1 to 6 of this Article shall apply without prejudice to the legislation relating to animal welfare.

Article 15

Emission limit values, equivalent parameters and technical measures

1. The emission limit values for polluting substances shall apply at the point where the emissions leave the installation, and any dilution prior to that point shall be disregarded when determining those values.

With regard to indirect releases of polluting substances into water, the effect of a water treatment plant may be taken into account when determining the emission limit values of the installation concerned, provided that an equivalent level of protection of the environment as a whole is guaranteed and provided this does not lead to higher levels of pollution in the environment.

2. Without prejudice to Article 18, the emission limit values and the equivalent parameters and technical measures referred to in Article 14(1) and (2) shall be based on the best available techniques, without prescribing the use of any technique or specific technology.

3. The competent authority shall set emission limit values that ensure that, under normal operating conditions, emissions do not exceed the emission levels associated with the best available techniques as laid down in the decisions on BAT conclusions referred to in Article 13(5) through either of the following:

(a) setting emission limit values that do not exceed the emission levels associated with the best available techniques. Those emission limit values shall be expressed for the same or shorter periods of time and under the same reference conditions as those emission levels associated with the best available techniques; or

(b) setting different emission limit values than those referred to under point (a) in terms of values, periods of time and reference conditions.

Where point (b) is applied, the competent authority shall, at least annually, assess the results of emission monitoring in order to ensure that emissions under normal operating conditions have not exceeded the emission levels associated with the best available techniques.

4. By way of derogation from paragraph 3, and without prejudice to Article 18, the competent authority may, in specific cases, set less strict emission limit values. Such a derogation may apply only where an assessment shows that the achievement of emission levels associated with the best available techniques as described in BAT conclusions would lead to disproportionately higher costs compared to the environmental benefits due to:

(a) the geographical location or the local environmental conditions of the installation concerned; or

(b) the technical characteristics of the installation concerned.

The competent authority shall document in an annex to the permit conditions the reasons for the application of the first subparagraph including the result of the assessment and the justification for the conditions imposed.

The emission limit values set in accordance with the first subparagraph shall, however, not exceed the emission limit values set out in the Annexes to this Directive, where applicable.

The competent authority shall in any case ensure that no significant pollution is caused and that a high level of protection of the environment as a whole is achieved.

On the basis of information provided by Member States in accordance with Article 72(1), in particular concerning the application of this paragraph, the Commission may, where necessary, assess and further clarify, through guidance, the criteria to be taken into account for the application of this paragraph.

The competent authority shall re-assess the application of the first subparagraph as part of each reconsideration of the permit conditions pursuant to Article 21.

5. The competent authority may grant temporary derogations from the requirements of paragraphs 2 and 3 of this Article and from Article 11(a) and (b) for the testing and use of emerging techniques for a total period of time not exceeding 9 months, provided that after the period specified, either the technique is stopped or the activity achieves at least the emission levels associated with the best available techniques.

Article 16

Monitoring requirements

1. The monitoring requirements referred to in Article 14(1)(c) shall, where applicable, be based on the conclusions on monitoring as described in the BAT conclusions.

2. The frequency of the periodic monitoring referred to in Article 14(1)(e) shall be determined by the competent authority in a permit for each individual installation or in general binding rules.

Without prejudice to the first subparagraph, periodic monitoring shall be carried out at least once every 5 years for groundwater and 10 years for soil, unless such monitoring is based on a systematic appraisal of the risk of contamination.

Article 17

General binding rules for activities listed in Annex I

1. When adopting general binding rules, Member States shall ensure an integrated approach and a high level of environmental protection equivalent to that achievable with individual permit conditions.

2. General binding rules shall be based on the best available techniques, without prescribing the use of any technique or specific technology in order to ensure compliance with Articles 14 and 15.

3. Member States shall ensure that general binding rules are updated to take into account developments in best available techniques and in order to ensure compliance with Article 21.

4. General binding rules adopted in accordance with paragraphs 1 to 3 shall contain a reference to this Directive or be accompanied by such a reference on the occasion of their official publication.

Article 18

Environmental quality standards

Where an environmental quality standard requires stricter conditions than those achievable by the use of the best available techniques, additional measures shall be included in the permit, without prejudice to other measures which may be taken to comply with environmental quality standards.

Article 19

Developments in best available techniques

Member States shall ensure that the competent authority follows or is informed of developments in best available techniques and of the publication of any new or updated BAT conclusions and shall make that information available to the public concerned.

Article 20

Changes by operators to installations

1. Member States shall take the necessary measures to ensure that the operator informs the competent authority of any planned change in the nature or functioning, or an extension of the installation which may have consequences for the environment. Where appropriate, the competent authority shall update the permit.

2. Member States shall take the necessary measures to ensure that no substantial change planned by the operator is made without a permit granted in accordance with this Directive.

The application for a permit and the decision by the competent authority shall cover those parts of the installation and those details listed in Article 12 which may be affected by the substantial change.

3. Any change in the nature or functioning or an extension of an installation shall be deemed to be substantial if the change or extension in itself reaches the capacity thresholds set out in Annex I.

Article 21

Reconsideration and updating of permit conditions by the competent authority

1. Member States shall take the necessary measures to ensure that the competent authority periodically reconsiders in accordance with paragraphs 2 to 5 all permit conditions and, where necessary to ensure compliance with this Directive, updates those conditions.

2. At the request of the competent authority, the operator shall submit all the information necessary for the purpose of reconsidering the permit conditions, including, in particular, results of emission monitoring and other data, that enables a comparison of the operation of the installation with the best available techniques described in the applicable BAT conclusions and with the emission levels associated with the best available techniques.

When reconsidering permit conditions, the competent authority shall use any information resulting from monitoring or inspections.

3. Within 4 years of publication of decisions on BAT conclusions in accordance with Article 13(5) relating to the main activity of an installation, the competent authority shall ensure that:

(a) all the permit conditions for the installation concerned are reconsidered and, if necessary, updated to ensure compliance with this Directive, in particular, with Article 15(3) and (4), where applicable;

(b) the installation complies with those permit conditions.

The reconsideration shall take into account all the new or updated BAT conclusions applicable to the installation and adopted in accordance with Article 13(5) since the permit was granted or last reconsidered.

4. Where an installation is not covered by any of the BAT conclusions, the permit conditions shall be reconsidered and, if necessary, updated where developments in the best available techniques allow for the significant reduction of emissions.

5. The permit conditions shall be reconsidered and, where necessary, updated at least in the following cases:

(a) the pollution caused by the installation is of such significance that the existing emission limit values of the permit need to be revised or new such values need to be included in the permit;

(b) the operational safety requires other techniques to be used;

(c) where it is necessary to comply with a new or revised environmental quality standard in accordance with Article 18.

Article 22

Site closure

1. Without prejudice to Directive 2000/60/EC, Directive 2004/35/EC, Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration (1) and to relevant Union law on soil protection, the competent authority shall set permit conditions to ensure compliance with paragraphs 3 and 4 of this Article upon definitive cessation of activities.

2. Where the activity involves the use, production or release of relevant hazardous substances and having regard to the possibility of soil and groundwater contamination at the site of the installation, the operator shall prepare and submit to the competent authority a baseline report before starting operation of an installation or before a permit for an installation is updated for the first time after 7 January 2013.

The baseline report shall contain the information necessary to determine the state of soil and groundwater contamination so as to make a quantified comparison with the state upon definitive cessation of activities provided for under paragraph 3.

The baseline report shall contain at least the following information:

(a) information on the present use and, where available, on past uses of the site;

(b) where available, existing information on soil and groundwater measurements that reflect the state at the time the report is drawn up or, alternatively, new soil and groundwater measurements having regard to the possibility of soil and groundwater contamination by those hazardous substances to be used, produced or released by the installation concerned.

Where information produced pursuant to other national or Union law fulfils the requirements of this paragraph that information may be included in, or attached to, the submitted baseline report.

The Commission shall establish guidance on the content of the baseline report.

3. Upon definitive cessation of the activities, the operator shall assess the state of soil and groundwater contamination by relevant hazardous substances used, produced or released by the installation. Where the installation has caused significant pollution of soil or groundwater by relevant hazardous substances compared to the state established in the baseline report referred to in paragraph 2, the operator shall take the necessary measures to address that pollution so as to return the site to that state. For that purpose, the technical feasibility of such measures may be taken into account.

Without prejudice to the first subparagraph, upon definitive cessation of the activities, and where the contamination of soil and groundwater at the site poses a significant risk to human health or the environment as a result of the permitted activities carried out by the operator before the permit for the installation is updated for the first time after 7 January 2013 and taking into account the conditions of the site of the installation established in accordance with Article 12(1)(d), the operator shall take the necessary actions aimed at the removal, control, containment or reduction of relevant hazardous substances, so that the site, taking into account its current or approved future use, ceases to pose such a risk.

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(1) OJ L 372, 27.12.2006, p. 19.

4. Where the operator is not required to prepare a baseline report referred to in paragraph 2, the operator shall, upon definitive cessation of the activities, take the necessary actions aimed at the removal, control, containment or reduction of relevant hazardous substances, so that the site, taking into account its current or approved future use, ceases to pose any significant risk to human health or the environment due to the contamination of soil and groundwater as a result of the permitted activities and taking into account the conditions of the site of the installation established in accordance with Article 12(1)(d).

Article 23

Environmental inspections

1. Member States shall set up a system of environmental inspections of installations addressing the examination of the full range of relevant environmental effects from the installations concerned.

Member States shall ensure that operators afford the competent authorities all necessary assistance to enable those authorities to carry out any site visits, to take samples and to gather any information necessary for the performance of their duties for the purposes of this Directive.

2. Member States shall ensure that all installations are covered by an environmental inspection plan at national, regional or local level and shall ensure that this plan is regularly reviewed and, where appropriate, updated.

3. Each environmental inspection plan shall include the following:

(a) a general assessment of relevant significant environmental issues;

(b) the geographical area covered by the inspection plan;

(c) a register of the installations covered by the plan;

(d) procedures for drawing up programmes for routine environmental inspections pursuant to paragraph 4;

(e) procedures for non-routine environmental inspections pursuant to paragraph 5;

(f) where necessary, provisions on the cooperation between different inspection authorities.

4. Based on the inspection plans, the competent authority shall regularly draw up programmes for routine environmental inspections, including the frequency of site visits for different types of installations.

The period between two site visits shall be based on a systematic appraisal of the environmental risks of the installations concerned and shall not exceed 1 year for installations posing the highest risks and 3 years for installations posing the lowest risks.

If an inspection has identified an important case of non-compliance with the permit conditions, an additional site visit shall be carried out within 6 months of that inspection.

The systematic appraisal of the environmental risks shall be based on at least the following criteria:

(a) the potential and actual impacts of the installations concerned on human health and the environment taking into account the levels and types of emissions, the sensitivity of the local environment and the risk of accidents;

(b) the record of compliance with permit conditions;

(c) the participation of the operator in the Union eco-management and audit scheme (EMAS), pursuant to Regulation (EC) No 1221/2009 (1).

The Commission may adopt guidance on the criteria for the appraisal of environmental risks.

5. Non-routine environmental inspections shall be carried out to investigate serious environmental complaints, serious environmental accidents, incidents and occurrences of non-compliance as soon as possible and, where appropriate, before the granting, reconsideration or update of a permit.

6. Following each site visit, the competent authority shall prepare a report describing the relevant findings regarding compliance of the installation with the permit conditions and conclusions on whether any further action is necessary.

The report shall be notified to the operator concerned within 2 months of the site visit taking place. The report shall be made publicly available by the competent authority in accordance with Directive 2003/4/EC of the European Parliament and of the Council of 28 January 2003 on public access to environmental information (2) within 4 months of the site visit taking place.

Without prejudice to Article 8(2), the competent authority shall ensure that the operator takes all the necessary actions identified in the report within a reasonable period.

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(1) Regulation (EC) No 1221/2009 of the European Parliament and of the Council of 25 November 2009 on the voluntary participation by organisations in a Community eco-management and audit scheme (EMAS) (OJ L 342, 22.12.2009, p. 1).

(2) OJ L 41, 14.2.2003, p. 26.

Article 24

Access to information and public participation in the permit procedure

1. Member States shall ensure that the public concerned are given early and effective opportunities to participate in the following procedures:

(a) the granting of a permit for new installations;

(b) the granting of a permit for any substantial change;

(c) the granting or updating of a permit for an installation where the application of Article 15(4) is proposed;

(d) the updating of a permit or permit conditions for an installation in accordance with Article 21(5)(a).

The procedure set out in Annex IV shall apply to such participation.

2. When a decision on granting, reconsideration or updating of a permit has been taken, the competent authority shall make available to the public, including via the Internet in relation to points (a), (b) and (f), the following information:

(a) the content of the decision, including a copy of the permit and any subsequent updates;

(b) the reasons on which the decision is based;

(c) the results of the consultations held before the decision was taken and an explanation of how they were taken into account in that decision;

(d) the title of the BAT reference documents relevant to the installation or activity concerned;

(e) how the permit conditions referred to in Article 14, including the emission limit values, have been determined in relation to the best available techniques and emission levels associated with the best available techniques;

(f) where a derogation is granted in accordance with Article 15(4), the specific reasons for that derogation based on the criteria laid down in that paragraph and the conditions imposed.

3. The competent authority shall also make available to the public, including via the Internet at least in relation to point (a):

(a) relevant information on the measures taken by the operator upon definitive cessation of activities in accordance with Article 22;

(b) the results of emission monitoring as required under the permit conditions and held by the competent authority.

4. Paragraphs 1, 2 and 3 of this Article shall apply subject to the restrictions laid down in Article 4(1) and (2) of Directive 2003/4/EC.

Article 25

Access to justice

1. Member States shall ensure that, in accordance with the relevant national legal system, members of the public concerned have access to a review procedure before a court of law or another independent and impartial body established by law to challenge the substantive or procedural legality of decisions, acts or omissions subject to Article 24 when one of the following conditions is met:

(a) they have a sufficient interest;

(b) they maintain the impairment of a right, where administrative procedural law of a Member State requires this as a precondition.

2. Member States shall determine at what stage the decisions, acts or omissions may be challenged.

3. What constitutes a sufficient interest and impairment of a right shall be determined by Member States, consistently with the objective of giving the public concerned wide access to justice.

To this end, the interest of any non-governmental organisation promoting environmental protection and meeting any requirements under national law shall be deemed sufficient for the purpose of paragraph 1(a).

Such organisations shall also be deemed to have rights capable of being impaired for the purpose of paragraph 1(b).

4. Paragraphs 1, 2 and 3 shall not exclude the possibility of a preliminary review procedure before an administrative authority and shall not affect the requirement of exhaustion of administrative review procedures prior to recourse to judicial review procedures, where such a requirement exists under national law.

Any such procedure shall be fair, equitable, timely and not prohibitively expensive.

5. Member States shall ensure that practical information is made available to the public on access to administrative and judicial review procedures.

Article 26

Transboundary effects

1. Where a Member State is aware that the operation of an installation is likely to have significant negative effects on the environment of another Member State, or where a Member State which is likely to be significantly affected so requests, the Member State in whose territory the application for a permit pursuant to Article 4 or Article 20(2) was submitted shall forward to the other Member State any information required to be given or made available pursuant to Annex IV at the same time as it makes it available to the public.

Such information shall serve as a basis for any consultations necessary in the framework of the bilateral relations between the two Member States on a reciprocal and equivalent basis.

2. Within the framework of their bilateral relations, Member States shall ensure that in the cases referred to in paragraph 1, the applications are also made available for an appropriate period of time to the public of the Member State likely to be affected so that it will have the right to comment on them before the competent authority reaches its decision.

3. The results of any consultations pursuant to paragraphs 1 and 2 shall be taken into consideration when the competent authority reaches a decision on the application.

4. The competent authority shall inform any Member State which has been consulted pursuant to paragraph 1 of the decision reached on the application and shall forward to it the information referred to in Article 24(2). That Member State shall take the measures necessary to ensure that that information is made available in an appropriate manner to the public concerned in its own territory.

Article 27

Emerging techniques

1. Member States shall, where appropriate, encourage the development and application of emerging techniques, in particular for those emerging techniques identified in BAT reference documents.

2. The Commission shall establish guidance to assist Member States in encouraging the development and application of emerging techniques as referred to in paragraph 1.

CHAPTER III

SPECIAL PROVISIONS FOR COMBUSTION PLANTS

Article 28

Scope

This Chapter shall apply to combustion plants, the total rated thermal input of which is equal to or greater than 50 MW, irrespective of the type of fuel used.

This Chapter shall not apply to the following combustion plants:

(a) plants in which the products of combustion are used for the direct heating, drying, or any other treatment of objects or materials;

(b) post-combustion plants designed to purify the waste gases by combustion which are not operated as independent combustion plants;

(c) facilities for the regeneration of catalytic cracking catalysts;

(d) facilities for the conversion of hydrogen sulphide into sulphur;

(e) reactors used in the chemical industry;

(f) coke battery furnaces;

(g) cowpers;

(h) any technical apparatus used in the propulsion of a vehicle, ship or aircraft;

(i) gas turbines and gas engines used on offshore platforms;

(j) plants which use any solid or liquid waste as a fuel other than waste referred to in point (b) of point 31 of Article 3.

Article 29

Aggregation rules

1. Where the waste gases of two or more separate combustion plants are discharged through a common stack, the combination formed by such plants shall be considered as a single combustion plant and their capacities added for the purpose of calculating the total rated thermal input.

2. Where two or more separate combustion plants which have been granted a permit for the first time on or after 1 July 1987, or the operators of which have submitted a complete application for a permit on or after that date, are installed in such a way that, taking technical and economic factors into account, their waste gases could in the judgement of the competent authority, be discharged through a common stack, the combination formed by such plants shall be considered as a single combustion plant and their capacities added for the purpose of calculating the total rated thermal input.

3. For the purpose of calculating the total rated thermal input of a combination of combustion plants referred to in paragraphs 1 and 2, individual combustion plants with a rated thermal input below 15 MW shall not be considered.

Article 30

Emission limit values

1. Waste gases from combustion plants shall be discharged in a controlled way by means of a stack, containing one or more flues, the height of which is calculated in such a way as to safeguard human health and the environment.

2. All permits for installations containing combustion plants which have been granted a permit before 7 January 2013, or the operators of which have submitted a complete application for a permit before that date, provided that such plants are put into operation no later than 7 January 2014, shall include conditions ensuring that emissions into air from these plants do not exceed the emission limit values set out in Part 1 of Annex V.

All permits for installations containing combustion plants which had been granted an exemption as referred to in Article 4(4) of Directive 2001/80/EC and which are in operation after 1 January 2016, shall include conditions ensuring that emissions into the air from these plants do not exceed the emission limit values set out in Part 2 of Annex V.

3. All permits for installations containing combustion plants not covered by paragraph 2 shall include conditions ensuring that emissions into the air from these plants do not exceed the emission limit values set out in Part 2 of Annex V.

4. The emission limit values set out in Parts 1 and 2 of Annex V as well as the minimum rates of desulphurisation set out in Part 5 of that Annex shall apply to the emissions of each common stack in relation to the total rated thermal input of the entire combustion plant. Where Annex V provides that emission limit values may be applied for a part of a combustion plant with a limited number of operating hours, those limit values shall apply to the emissions of that part of the plant, but shall be set in relation to the total rated thermal input of the entire combustion plant.

5. The competent authority may grant a derogation for a maximum of 6 months from the obligation to comply with the emission limit values provided for in paragraphs 2 and 3 for sulphur dioxide in respect of a combustion plant which to this end normally uses low-sulphur fuel, in cases where the operator is unable to comply with those limit values because of an interruption in the supply of low-sulphur fuel resulting from a serious shortage.

Member States shall immediately inform the Commission of any derogation granted under the first subparagraph.

6. The competent authority may grant a derogation from the obligation to comply with the emission limit values provided for in paragraphs 2 and 3 in cases where a combustion plant using only gaseous fuel has to resort exceptionally to the use of other fuels because of a sudden interruption in the supply of gas and for this reason would need to be equipped with a waste gas purification facility. The period for which such a derogation is granted shall not exceed 10 days except where there is an overriding need to maintain energy supplies.

The operator shall immediately inform the competent authority of each specific case referred to in the first subparagraph.

Member States shall inform the Commission immediately of any derogation granted under the first subparagraph.

7. Where a combustion plant is extended, the emission limit values set out in Part 2 of Annex V shall apply to the extended part of the plant affected by the change and shall be set in relation to the total rated thermal input of the entire combustion plant. In the case of a change to a combustion plant, which may have consequences for the environment and which affects a part of the plant with a rated thermal input of 50 MW or more, the emission limit values as set out in Part 2 of Annex V shall apply to the part of the plant which has changed in relation to the total rated thermal input of the entire combustion plant.

8. The emission limit values set out in Parts 1 and 2 of Annex V shall not apply to the following combustion plants:

(a) diesel engines;

(b) recovery boilers within installations for the production of pulp.

9. For the following combustion plants, on the basis of the best available techniques, the Commission shall review the need to establish Union-wide emission limit values and to amend the emission limit values set out in Annex V:

(a) the combustion plants referred to in paragraph 8;

(b) combustion plants within refineries firing the distillation and conversion residues from the refining of crude-oil for own consumption, alone or with other fuels, taking into account the specificity of the energy systems of refineries;

(c) combustion plants firing gases other than natural gas;

(d) combustion plants in chemical installations using liquid production residues as non-commercial fuel for own consumption.

The Commission shall, by 31 December 2013, report the results of this review to the European Parliament and to the Council accompanied, if appropriate, by a legislative proposal.

Article 31

Desulphurisation rate

1. For combustion plants firing indigenous solid fuel, which cannot comply with the emission limit values for sulphur dioxide referred to in Article 30(2) and (3) due to the characteristics of this fuel, Member States may apply instead the minimum rates of desulphurisation set out in Part 5 of Annex V, in accordance with the compliance rules set out in Part 6 of that Annex and with prior validation by the competent authority of the technical report referred to in Article 72(4)(a).

2. For combustion plants firing indigenous solid fuel, which co-incinerate waste, and which cannot comply with the C_{proc} values for sulphur dioxide set out in points 3.1 or 3.2 of Part 4 of Annex VI due to the characteristics of the indigenous solid fuel, Member States may apply instead the minimum rates of desulphurisation set out in Part 5 of Annex V, in accordance with the compliance rules set out in Part 6 of that Annex. If Member States choose to apply this paragraph, C_{waste} as referred to in point 1 of Part 4 of Annex VI shall be equal to 0 mg/Nm^3.

3. The Commission shall, by 31 December 2019, review the possibility of applying minimum rates of desulphurisation set out in Part 5 of Annex V, taking into account, in particular, the best available techniques and benefits obtained from reduced sulphur dioxide emissions.

Article 32

Transitional National Plan

1. During the period from 1 January 2016 to 30 June 2020, Member States may draw up and implement a transitional national plan covering combustion plants which were granted the first permit before 27 November 2002 or the operators of which had submitted a complete application for a permit before that date, provided that the plant was put into operation no later than 27 November 2003. For each of the combustion plants covered by the plan, the plan shall cover emissions of one or more of the following pollutants: nitrogen oxides, sulphur dioxide and dust. For gas turbines, only nitrogen oxides emissions shall be covered by the plan.

The transitional national plan shall not include any of the following combustion plants:

(a) those to which Article 33(1) applies;

(b) those within refineries firing low calorific gases from the gasification of refinery residues or the distillation and conversion residues from the refining of crude oil for own consumption, alone or with other fuels;

(c) those to which Article 35 applies;

(d) those which are granted an exemption as referred to in Article 4(4) of Directive 2001/80/EC.

2. Combustion plants covered by the plan may be exempted from compliance with the emission limit values referred to in Article 30(2) for the pollutants which are subject to the plan or, where applicable, with the rates of desulphurisation referred to in Article 31.

The emission limit values for sulphur dioxide, nitrogen oxides and dust set out in the permit for the combustion plant applicable on 31 December 2015, pursuant in particular to the requirements of Directives 2001/80/EC and 2008/1/EC, shall at least be maintained.

Combustion plants with a total rated thermal input of more than 500 MW firing solid fuels, which were granted the first permit after 1 July 1987, shall comply with the emission limit values for nitrogen oxides set out in Part 1 of Annex V.

3. For each of the pollutants it covers, the transitional national plan shall set a ceiling defining the maximum total annual emissions for all of the plants covered by the plan on the basis of each plant's total rated thermal input on 31 December 2010, its actual annual operating hours and its fuel use, averaged over the last 10 years of operation up to and including 2010.

The ceiling for the year 2016 shall be calculated on the basis of the relevant emission limit values set out in Annexes III to VII to Directive 2001/80/EC or, where applicable, on the basis of the rates of desulphurisation set out in Annex III to Directive 2001/80/EC. In the case of gas turbines, the emission limit values for nitrogen oxides set out for such plants in Part B of Annex VI to Directive 2001/80/EC shall be used. The ceilings for the years 2019 and 2020 shall be calculated on the basis of the relevant emission limit values set out in Part 1 of Annex V to this Directive or, where applicable, the relevant rates of desulphurisation set out in Part 5 of Annex V to this Directive. The ceilings for the years 2017 and 2018 shall be set providing a linear decrease of the ceilings between 2016 and 2019.

Where a plant included in the transitional national plan is closed or no longer falls within the scope of Chapter III, this shall not result in an increase in total annual emissions from the remaining plants covered by the plan.

4. The transitional national plan shall also contain provisions on monitoring and reporting that comply with the implementing rules established in accordance with Article 41(b), as well as the measures foreseen for each of the plants in order to ensure timely compliance with the emission limit values that will apply from 1 July 2020.

5. Not later than 1 January 2013, Member States shall communicate their transitional national plans to the Commission.

The Commission shall evaluate the plans and, where the Commission has raised no objections within 12 months of receipt of a plan, the Member State concerned shall consider its plan to be accepted.

When the Commission considers a plan not to be in accordance with the implementing rules established in accordance with Article 41(b), it shall inform the Member State concerned that its plan cannot be accepted. In relation to the evaluation of a new version of a plan which a Member State communicates to the Commission, the time period referred to in the second subparagraph shall be 6 months.

6. Member States shall inform the Commission of any subsequent changes to the plan.

Article 33

Limited life time derogation

1. During the period from 1 January 2016 to 31 December 2023, combustion plants may be exempted from compliance with the emission limit values referred to in Article 30(2) and with the rates of desulphurisation referred to in Article 31, where applicable, and from their inclusion in the transitional national plan referred to in Article 32 provided that the following conditions are fulfilled:

(a) the operator of the combustion plant undertakes, in a written declaration submitted by 1 January 2014 at the latest to the competent authority, not to operate the plant for more than 17 500 operating hours, starting from 1 January 2016 and ending no later than 31 December 2023;

(b) the operator is required to submit each year to the competent authority a record of the number of operating hours since 1 January 2016;

(c) the emission limit values for sulphur dioxides, nitrogen oxides and dust set out in the permit for the combustion plant applicable on 31 December 2015, pursuant in particular to the requirements of Directives 2001/80/EC and 2008/1/EC, shall at least be maintained during the remaining operational life of the combustion plant. Combustion plants with a total rated thermal input of more than 500 MW firing solid fuels, which were granted the first permit after 1 July 1987, shall comply with the emission limit values for nitrogen oxides set out in Part 1 of Annex V; and

(d) the combustion plant has not been granted an exemption as referred to in Article 4(4) of Directive 2001/80/EC.

2. At the latest on 1 January 2016, each Member State shall communicate to the Commission a list of any combustion plants to which paragraph 1 applies, including their total rated thermal input, the fuel types used and the applicable emission limit values for sulphur dioxide, nitrogen oxides and dust. For plants subject to paragraph 1, Member States shall communicate annually to the Commission a record of the number of operating hours since 1 January 2016.

3. In case of a combustion plant being, on 6 January 2011, part of a small isolated system and accounting at that date for at least 35 % of the electricity supply within that system, which is unable, due to its technical characteristics, to comply with the emission limit values referred to in Article 30(2), the number of operating hours referred to in paragraph 1(a) of this Article shall be 18 000, starting from 1 January 2020 and ending no later than 31 December 2023, and the date referred to in paragraph 1(b) and paragraph 2 of this Article shall be 1 January 2020.

4. In case of a combustion plant with a total rated thermal input of more than 1 500 MW which started operating before 31 December 1986 and fires indigenous solid fuel with a net calorific value of less than 5 800 kJ/kg, a moisture content greater than 45 % by weight, a combined moisture and ash content greater than 60 % by weight and a calcium oxide content in ash greater than 10 %, the number of operating hours referred to in paragraph 1(a) shall be 32 000.

Article 34

Small isolated systems

1. Until 31 December 2019, combustion plants being, on 6 January 2011, part of a small isolated system may be exempted from compliance with the emission limit values referred to in Article 30(2) and the rates of desulphurisation referred to in Article 31, where applicable. Until 31 December 2019, the emission limit values set out in the permits of these combustion plants, pursuant in particular to the requirements of Directives 2001/80/EC and 2008/1/EC, shall at least be maintained.

2. Combustion plants with a total rated thermal input of more than 500 MW firing solid fuels, which were granted the first permit after 1 July 1987, shall comply with the emission limit values for nitrogen oxides set out in Part 1 of Annex V.

3. Where there are, on the territory of a Member State combustion plants covered by this Chapter that are part of a small isolated system, that Member State shall report to the Commission before 7 January 2013 a list of those combustion plants, the total annual energy consumption of the small isolated system and the amount of energy obtained through interconnection with other systems.

Article 35

District heating plants

1. Until 31 December 2022, a combustion plant may be exempted from compliance with the emission limit values referred to in Article 30(2) and the rates of desulphurisation referred to in Article 31 provided that the following conditions are fulfilled:

(a) the total rated thermal input of the combustion plant does not exceed 200 MW;

(b) the plant was granted a first permit before 27 November 2002 or the operator of that plant had submitted a complete application for a permit before that date, provided that it was put into operation no later than 27 November 2003;

(c) at least 50 % of the useful heat production of the plant, as a rolling average over a period of 5 years, is delivered in the form of steam or hot water to a public network for district heating; and

(d) the emission limit values for sulphur dioxide, nitrogen oxides and dust set out in its permit applicable on 31 December 2015, pursuant in particular to the requirements of Directives 2001/80/EC and 2008/1/EC, are at least maintained until 31 December 2022.

2. At the latest on 1 January 2016, each Member State shall communicate to the Commission a list of any combustion plants to which paragraph 1 applies, including their total rated thermal input, the fuel types used and the applicable emission limit values for sulphur dioxide, nitrogen oxides and dust. In addition, Member States shall, for any combustion plants to which paragraph 1 applies and during the period mentioned in that paragraph, inform the Commission annually of the proportion of useful heat production of each plant which was delivered in the form of steam or hot water to a public network for district heating, expressed as a rolling average over the preceding 5 years.

Article 36

Geological storage of carbon dioxide

1. Member States shall ensure that operators of all combustion plants with a rated electrical output of 300 megawatts or more for which the original construction licence or, in the absence of such a procedure, the original operating licence is granted after the entry into force of Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide (1), have assessed whether the following conditions are met:

(a) suitable storage sites are available,

(b) transport facilities are technically and economically feasible,

(c) it is technically and economically feasible to retrofit for carbon dioxide capture.

2. If the conditions laid down in paragraph 1 are met, the competent authority shall ensure that suitable space on the installation site for the equipment necessary to capture and compress carbon dioxide is set aside. The competent authority shall determine whether the conditions are met on the basis of the assessment referred to in paragraph 1 and other available information, particularly concerning the protection of the environment and human health.

Article 37

Malfunction or breakdown of the abatement equipment

1. Member States shall ensure that provision is made in the permits for procedures relating to malfunction or breakdown of the abatement equipment.

2. In the case of a breakdown, the competent authority shall require the operator to reduce or close down operations if a return to normal operation is not achieved within 24 hours, or to operate the plant using low polluting fuels.

The operator shall notify the competent authority within 48 hours after the malfunction or breakdown of the abatement equipment.

The cumulative duration of unabated operation shall not exceed 120 hours in any 12-month period.

The competent authority may grant a derogation from the time limits set out in the first and third subparagraphs in one of the following cases:

(a) there is an overriding need to maintain energy supplies;

(b) the combustion plant with the breakdown would be replaced for a limited period by another plant which would cause an overall increase in emissions.

Article 38

Monitoring of emissions into air

1. Member States shall ensure that the monitoring of air polluting substances is carried out in accordance with Part 3 of Annex V.

2. The installation and functioning of the automated monitoring equipment shall be subject to control and to annual surveillance tests as set out in Part 3 of Annex V.

3. The competent authority shall determine the location of the sampling or measurement points to be used for the monitoring of emissions.

4. All monitoring results shall be recorded, processed and presented in such a way as to enable the competent authority to verify compliance with the operating conditions and emission limit values which are included in the permit.

Article 39

Compliance with emission limit values

The emission limit values for air shall be regarded as being complied with if the conditions set out in Part 4 of Annex V are fulfilled.

Article 40

Multi-fuel firing combustion plants

1. In the case of a multi-fuel firing combustion plant involving the simultaneous use of two or more fuels, the competent authority shall set the emission limit values in accordance with the following steps:

(a) taking the emission limit value relevant for each individual fuel and pollutant corresponding to the total rated thermal input of the entire combustion plant as set out in Parts 1 and 2 of Annex V;

(b) determining fuel-weighted emission limit values, which are obtained by multiplying the individual emission limit value referred to in point (a) by the thermal input delivered by each fuel, and dividing the product of multiplication by the sum of the thermal inputs delivered by all fuels,

(c) aggregating the fuel-weighted emission limit values.

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(1) OJ L 140, 5.6.2009, p. 114.

2. In the case of multi-fuel firing combustion plants covered by Article 30(2), which use the distillation and conversion residues from the refining of crude-oil for own consumption, alone or with other fuels, the following emission limit values may be applied instead of the emission limit values set according to paragraph 1:

(a) where, during the operation of the combustion plant, the proportion contributed by the determinative fuel to the sum of the thermal inputs delivered by all fuels is 50 % or more, the emission limit value set in Part 1 of Annex V for the determinative fuel;

(b) where the proportion contributed by the determinative fuel to the sum of the thermal inputs delivered by all fuels is less than 50 %, the emission limit value determined in accordance with the following steps:

   (i) taking the emission limit values set out in Part 1 of Annex V for each of the fuels used, corresponding to the total rated thermal input of the combustion plant;

   (ii) calculating the emission limit value of the determinative fuel by multiplying the emission limit value, determined for that fuel according to point (i), by a factor of two, and subtracting from this product the emission limit value of the fuel used with the lowest emission limit value as set out in Part 1 of Annex V, corresponding to the total rated thermal input of the combustion plant;

   (iii) determining the fuel-weighted emission limit value for each fuel used by multiplying the emission limit value determined under points (i) and (ii) by the thermal input of the fuel concerned and by dividing the product of this multiplication by the sum of the thermal inputs delivered by all fuels;

   (iv) aggregating the fuel-weighted emission limit values determined under point (iii).

3. In the case of multi-fuel firing combustion plants covered by Article 30(2), which use the distillation and conversion residues from the refining of crude-oil for own consumption, alone or with other fuels, the average emission limit values for sulphur dioxide set out in Part 7 of Annex V may be applied instead of the emission limit values set according to paragraphs 1 or 2 of this Article.

Article 41

Implementing rules

Implementing rules shall be established concerning:

(a) the determination of the start-up and shut-down periods referred to in point 27 of Article 3 and in point 1 of Part 4 of Annex V; and

(b) the transitional national plans referred to in Article 32 and, in particular, the setting of emission ceilings and related monitoring and reporting.

Those implementing rules shall be adopted in accordance with the regulatory procedure referred to in Article 75(2). The Commission shall make appropriate proposals not later than 7 July 2011.

CHAPTER IV

SPECIAL PROVISIONS FOR WASTE INCINERATION PLANTS AND WASTE CO-INCINERATION PLANTS

Article 42

Scope

1. This Chapter shall apply to waste incineration plants and waste co-incineration plants which incinerate or co-incinerate solid or liquid waste.

This Chapter shall not apply to gasification or pyrolysis plants, if the gases resulting from this thermal treatment of waste are purified to such an extent that they are no longer a waste prior to their incineration and they can cause emissions no higher than those resulting from the burning of natural gas.

For the purposes of this Chapter, waste incineration plants and waste co-incineration plants shall include all incineration lines or co-incineration lines, waste reception, storage, on site pretreatment facilities, waste-, fuel- and air-supply systems, boilers, facilities for the treatment of waste gases, on-site facilities for treatment or storage of residues and waste water, stacks, devices and systems for controlling incineration or co-incineration operations, recording and monitoring incineration or co-incineration conditions.

If processes other than oxidation, such as pyrolysis, gasification or plasma process, are applied for the thermal treatment of waste, the waste incineration plant or waste co-incineration plant shall include both the thermal treatment process and the subsequent incineration process.

If waste co-incineration takes place in such a way that the main purpose of the plant is not the generation of energy or production of material products but rather the thermal treatment of waste, the plant shall be regarded as a waste incineration plant.

2. This Chapter shall not apply to the following plants:

(a) plants treating only the following wastes:

   (i) waste listed in point (b) of point 31 of Article 3;

   (ii) radioactive waste;

   (iii) animal carcasses as regulated by Regulation (EC) No 1774/2002 of the European Parliament and of the Council of 3 October 2002 laying down health rules concerning animal by-products not intended for human consumption (1);

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(1) OJ L 273, 10.10.2002, p. 1.

(iv) waste resulting from the exploration for, and the exploitation of, oil and gas resources from off-shore installations and incinerated on board the installations;

(b) experimental plants used for research, development and testing in order to improve the incineration process and which treat less than 50 tonnes of waste per year.

Article 43

Definition of residue

For the purposes of this Chapter, 'residue' shall mean any liquid or solid waste which is generated by a waste incineration plant or waste co-incineration plant.

Article 44

Applications for permits

An application for a permit for a waste incineration plant or waste co-incineration plant shall include a description of the measures which are envisaged to guarantee that the following requirements are met:

(a) the plant is designed, equipped and will be maintained and operated in such a manner that the requirements of this Chapter are met taking into account the categories of waste to be incinerated or co-incinerated;

(b) the heat generated during the incineration and co-incineration process is recovered as far as practicable through the generation of heat, steam or power;

(c) the residues will be minimised in their amount and harmfulness and recycled where appropriate;

(d) the disposal of the residues which cannot be prevented, reduced or recycled will be carried out in conformity with national and Union law.

Article 45

Permit conditions

1. The permit shall include the following:

(a) a list of all types of waste which may be treated using at least the types of waste set out in the European Waste List established by Decision 2000/532/EC, if possible, and containing information on the quantity of each type of waste, where appropriate;

(b) the total waste incinerating or co-incinerating capacity of the plant;

(c) the limit values for emissions into air and water;

(d) the requirements for the pH, temperature and flow of waste water discharges;

(e) the sampling and measurement procedures and frequencies to be used to comply with the conditions set for emission monitoring;

(f) the maximum permissible period of any technically unavoidable stoppages, disturbances, or failures of the purification devices or the measurement devices, during which the emissions into the air and the discharges of waste water may exceed the prescribed emission limit values.

2. In addition to the requirements set out in paragraph 1, the permit granted to a waste incineration plant or waste co-incineration plant using hazardous waste shall include the following:

(a) a list of the quantities of the different categories of hazardous waste which may be treated;

(b) the minimum and maximum mass flows of those hazardous wastes, their lowest and maximum calorific values and their maximum contents of polychlorinated biphenyls, pentachlorophenol, chlorine, fluorine, sulphur, heavy metals and other polluting substances.

3. Member States may list the categories of waste to be included in the permit which can be co-incinerated in certain categories of waste co-incineration plants.

4. The competent authority shall periodically reconsider and, where necessary, update permit conditions.

Article 46

Control of emissions

1. Waste gases from waste incineration plants and waste co-incineration plants shall be discharged in a controlled way by means of a stack the height of which is calculated in such a way as to safeguard human health and the environment.

2. Emissions into air from waste incineration plants and waste co-incineration plants shall not exceed the emission limit values set out in parts 3 and 4 of Annex VI or determined in accordance with Part 4 of that Annex.

If in a waste co-incineration plant more than 40 % of the resulting heat release comes from hazardous waste, or the plant co-incinerates untreated mixed municipal waste, the emission limit values set out in Part 3 of Annex VI shall apply.

3. Discharges to the aquatic environment of waste water resulting from the cleaning of waste gases shall be limited as far as practicable and the concentrations of polluting substances shall not exceed the emission limit values set out in Part 5 of Annex VI.

4. The emission limit values shall apply at the point where waste waters from the cleaning of waste gases are discharged from the waste incineration plant or waste co-incineration plant.

When waste waters from the cleaning of waste gases are treated outside the waste incineration plant or waste co-incineration plant at a treatment plant intended only for the treatment of this sort of waste water, the emission limit values set out in Part 5 of Annex VI shall be applied at the point where the waste waters leave the treatment plant. Where the waste water from the cleaning of waste gases is treated collectively with other sources of waste water, either on site or off site, the operator shall make the appropriate mass balance calculations, using the results of the measurements set out in point 2 of Part 6 of Annex VI in order to determine the emission levels in the final waste water discharge that can be attributed to the waste water arising from the cleaning of waste gases.

Under no circumstances shall dilution of waste water take place for the purpose of complying with the emission limit values set out in Part 5 of Annex VI.

5. Waste incineration plant sites and waste co-incineration plant sites, including associated storage areas for waste, shall be designed and operated in such a way as to prevent the unauthorised and accidental release of any polluting substances into soil, surface water and groundwater.

Storage capacity shall be provided for contaminated rainwater run-off from the waste incineration plant site or waste co-incineration plant site or for contaminated water arising from spillage or fire-fighting operations. The storage capacity shall be adequate to ensure that such waters can be tested and treated before discharge where necessary.

6. Without prejudice to Article 50(4)(c), the waste incineration plant or waste co-incineration plant or individual furnaces being part of a waste incineration plant or waste co-incineration plant shall under no circumstances continue to incinerate waste for a period of more than 4 hours uninterrupted where emission limit values are exceeded.

The cumulative duration of operation in such conditions over 1 year shall not exceed 60 hours.

The time limit set out in the second subparagraph shall apply to those furnaces which are linked to one single waste gas cleaning device.

Article 47

Breakdown

In the case of a breakdown, the operator shall reduce or close down operations as soon as practicable until normal operations can be restored.

Article 48

Monitoring of emissions

1. Member States shall ensure that the monitoring of emissions is carried out in accordance with Parts 6 and 7 of Annex VI.

2. The installation and functioning of the automated measuring systems shall be subject to control and to annual surveillance tests as set out in point 1 of Part 6 of Annex VI.

3. The competent authority shall determine the location of the sampling or measurement points to be used for monitoring of emissions.

4. All monitoring results shall be recorded, processed and presented in such a way as to enable the competent authority to verify compliance with the operating conditions and emission limit values which are included in the permit.

5. As soon as appropriate measurement techniques are available within the Union, the Commission shall, by means of delegated acts in accordance with Article 76 and subject to the conditions laid down in Articles 77 and 78, set the date from which continuous measurements of emissions into the air of heavy metals and dioxins and furans are to be carried out.

Article 49

Compliance with emission limit values

The emission limit values for air and water shall be regarded as being complied with if the conditions described in Part 8 of Annex VI are fulfilled.

Article 50

Operating conditions

1. Waste incineration plants shall be operated in such a way as to achieve a level of incineration such that the total organic carbon content of slag and bottom ashes is less than 3 % or their loss on ignition is less than 5 % of the dry weight of the material. If necessary, waste pre-treatment techniques shall be used.

2. Waste incineration plants shall be designed, equipped, built and operated in such a way that the gas resulting from the incineration of waste is raised, after the last injection of combustion air, in a controlled and homogeneous fashion and even under the most unfavourable conditions, to a temperature of at least 850 °C for at least two seconds.

Waste co-incineration plants shall be designed, equipped, built and operated in such a way that the gas resulting from the co-incineration of waste is raised in a controlled and homogeneous fashion and even under the most unfavourable conditions, to a temperature of at least 850 °C for at least two seconds.

If hazardous waste with a content of more than 1 % of halogenated organic substances, expressed as chlorine, is incinerated or co-incinerated, the temperature required to comply with the first and second subparagraphs shall be at least 1 100 °C.

In waste incineration plants, the temperatures set out in the first and third subparagraphs shall be measured near the inner wall of the combustion chamber. The competent authority may authorise the measurements at another representative point of the combustion chamber.

3. Each combustion chamber of a waste incineration plant shall be equipped with at least one auxiliary burner. This burner shall be switched on automatically when the temperature of the combustion gases after the last injection of combustion air falls below the temperatures set out in paragraph 2. It shall also be used during plant start-up and shut-down operations in order to ensure that those temperatures are maintained at all times during these operations and as long as unburned waste is in the combustion chamber.

The auxiliary burner shall not be fed with fuels which can cause higher emissions than those resulting from the burning of gas oil as defined in Article 2(2) of Council Directive 1999/32/EC of 26 April 1999 relating to a reduction in the sulphur content of certain liquid fuels (1), liquefied gas or natural gas.

4. Waste incineration plants and waste co-incineration plants shall operate an automatic system to prevent waste feed in the following situations:

(a) at start-up, until the temperature set out in paragraph 2 of this Article or the temperature specified in accordance with Article 51(1) has been reached;

(b) whenever the temperature set out in paragraph 2 of this Article or the temperature specified in accordance with Article 51(1) is not maintained;

(c) whenever the continuous measurements show that any emission limit value is exceeded due to disturbances or failures of the waste gas cleaning devices.

5. Any heat generated by waste incineration plants or waste co-incineration plants shall be recovered as far as practicable.

6. Infectious clinical waste shall be placed straight in the furnace, without first being mixed with other categories of waste and without direct handling.

7. Member States shall ensure that the waste incineration plant or waste co-incineration plant is operated and controlled by a natural person who is competent to manage the plant.

Article 51

Authorisation to change operating conditions

1. Conditions different from those laid down in Article 50(1), (2) and (3) and, as regards the temperature, paragraph 4 of that Article and specified in the permit for certain categories of waste or for certain thermal processes, may be authorised by the competent authority provided the other requirements of this Chapter are met. Member States may lay down rules governing these authorisations.

2. For waste incineration plants, the change of the operating conditions shall not cause more residues or residues with a higher content of organic polluting substances compared to those residues which could be expected under the conditions laid down in Article 50(1), (2) and (3).

3. Emissions of total organic carbon and carbon monoxide from waste co-incineration plants, authorised to change operating conditions according to paragraph 1 shall also comply with the emission limit values set out in Part 3 of Annex VI.

Emissions of total organic carbon from bark boilers within the pulp and paper industry co-incinerating waste at the place of its production which were in operation and had a permit before 28 December 2002 and which are authorised to change operating conditions according to paragraph 1 shall also comply with the emission limit values set out in Part 3 of Annex VI.

4. Member States shall communicate to the Commission all operating conditions authorised under paragraphs 1, 2 and 3 and the results of verifications made as part of the information provided in accordance with the reporting requirements under Article 72.

Article 52

Delivery and reception of waste

1. The operator of the waste incineration plant or waste co-incineration plant shall take all necessary precautions concerning the delivery and reception of waste in order to prevent or to limit as far as practicable the pollution of air, soil, surface water and groundwater as well as other negative effects on the environment, odours and noise, and direct risks to human health.

2. The operator shall determine the mass of each type of waste, if possible according to the European Waste List established by Decision 2000/532/EC, prior to accepting the waste at the waste incineration plant or waste co-incineration plant.

3. Prior to accepting hazardous waste at the waste incineration plant or waste co-incineration plant, the operator shall collect available information about the waste for the purpose of verifying compliance with the permit requirements specified in Article 45(2).

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(1) OJ L 121, 11.5.1999, p. 13.

That information shall cover the following:

(a) all the administrative information on the generating process contained in the documents mentioned in paragraph 4(a);

(b) the physical, and as far as practicable, chemical composition of the waste and all other information necessary to evaluate its suitability for the intended incineration process;

(c) the hazardous characteristics of the waste, the substances with which it cannot be mixed, and the precautions to be taken in handling the waste.

4. Prior to accepting hazardous waste at the waste incineration plant or waste co-incineration plant, at least the following procedures shall be carried out by the operator:

(a) the checking of the documents required by Directive 2008/98/EC and, where applicable, those required by Regulation (EC) No 1013/2006 of the European Parliament and of the Council of 14 June 2006 on shipments of waste (1) and by legislation on transport of dangerous goods;

(b) the taking of representative samples, unless inappropriate as far as possible before unloading, to verify conformity with the information provided for in paragraph 3 by carrying out controls and to enable the competent authorities to identify the nature of the wastes treated.

The samples referred to in point (b) shall be kept for at least 1 month after the incineration or co-incineration of the waste concerned.

5. The competent authority may grant exemptions from paragraphs 2, 3 and 4 to waste incineration plants or waste co-incineration plants which are a part of an installation covered by Chapter II and only incinerate or co-incinerate waste generated within that installation.

Article 53

Residues

1. Residues shall be minimised in their amount and harmfulness. Residues shall be recycled, where appropriate, directly in the plant or outside.

2. Transport and intermediate storage of dry residues in the form of dust shall take place in such a way as to prevent dispersal of those residues in the environment.

3. Prior to determining the routes for the disposal or recycling of the residues, appropriate tests shall be carried out to establish the physical and chemical characteristics and the polluting potential of the residues. Those tests shall concern the total soluble fraction and heavy metals soluble fraction.

Article 54

Substantial change

A change of operation of a waste incineration plant or a waste co-incineration plant treating only non-hazardous waste in an installation covered by Chapter II which involves the incineration or co-incineration of hazardous waste shall be regarded as a substantial change.

Article 55

Reporting and public information on waste incineration plants and waste co-incineration plants

1. Applications for new permits for waste incineration plants and waste co-incineration plants shall be made available to the public at one or more locations for an appropriate period to enable the public to comment on the applications before the competent authority reaches a decision. That decision, including at least a copy of the permit, and any subsequent updates, shall also be made available to the public.

2. For waste incineration plants or waste co-incineration plants with a nominal capacity of 2 tonnes or more per hour, the report referred to in Article 72 shall include information on the functioning and monitoring of the plant and give account of the running of the incineration or co-incineration process and the level of emissions into air and water in comparison with the emission limit values. That information shall be made available to the public.

3. A list of waste incineration plants or waste co-incineration plants with a nominal capacity of less than 2 tonnes per hour shall be drawn up by the competent authority and shall be made available to the public.

CHAPTER V

SPECIAL PROVISIONS FOR INSTALLATIONS AND ACTIVITIES USING ORGANIC SOLVENTS

Article 56

Scope

This chapter shall apply to activities listed in Part 1 of Annex VII and, where applicable, reaching the consumption thresholds set out in Part 2 of that Annex.

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(1) OJ L 190, 12.7.2006, p. 1.

Article 57

Definitions

For the purposes of this Chapter, the following definitions shall apply:

(1) ‘existing installation’ means an installation in operation on 29 March 1999 or which was granted a permit or registered before 1 April 2001 or the operator of which submitted a complete application for a permit before 1 April 2001, provided that that installation was put in operation no later than 1 April 2002;

(2) ‘waste gases’ means the final gaseous discharge containing volatile organic compounds or other pollutants from a stack or abatement equipment into air;

(3) ‘fugitive emissions’ means any emissions not in waste gases of volatile organic compounds into air, soil and water as well as solvents contained in any products, unless otherwise stated in Part 2 of Annex VII;

(4) ‘total emissions’ means the sum of fugitive emissions and emissions in waste gases;

(5) ‘mixture’ means mixture as defined in Article 3(2) of Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) and establishing a European Chemicals Agency (1),

(6) ‘adhesive’ means any mixture, including all the organic solvents or mixtures containing organic solvents necessary for its proper application, which is used to adhere separate parts of a product;

(7) ‘ink’ means a mixture, including all the organic solvents or mixtures containing organic solvents necessary for its proper application, which is used in a printing activity to impress text or images on to a surface;

(8) ‘varnish’ means a transparent coating;

(9) ‘consumption’ means the total input of organic solvents into an installation per calendar year, or any other 12-month period, less any volatile organic compounds that are recovered for re-use;

(10) ‘input’ means the quantity of organic solvents and their quantity in mixtures used when carrying out an activity, including the solvents recycled inside and outside the installation, and which are counted every time they are used to carry out the activity;

(11) ‘re-use’ means the use of organic solvents recovered from an installation for any technical or commercial purpose and including use as a fuel but excluding the final disposal of such recovered organic solvent as waste;

(12) ‘contained conditions’ means conditions under which an installation is operated so that the volatile organic compounds released from the activity are collected and discharged in a controlled way either via a stack or abatement equipment and are, therefore, not entirely fugitive;

(13) ‘start-up and shut-down operations’ means operations excluding regularly oscillating activity phases whilst bringing an activity, an equipment item or a tank into or out of service or into or out of an idling state.

Article 58

Substitution of hazardous substances

Substances or mixtures which, because of their content of volatile organic compounds classified as carcinogens, mutagens, or toxic to reproduction under Regulation (EC) No 1272/2008, are assigned or need to carry the hazard statements H340, H350, H350i, H360D or H360F, shall be replaced, as far as possible by less harmful substances or mixtures within the shortest possible time.

Article 59

Control of emissions

1. Member States shall take the necessary measures to ensure that each installation complies with either of the following:

(a) the emission of volatile organic compounds from installations shall not exceed the emission limit values in waste gases and the fugitive emission limit values, or the total emission limit values, and other requirements laid down in Parts 2 and 3 of Annex VII are complied with;

(b) the requirements of the reduction scheme set out in Part 5 of Annex VII provided that an equivalent emission reduction is achieved compared to that achieved through the application of the emission limit values referred to in point (a).

Member States shall report to the Commission in accordance with Article 72(1) on the progress in achieving the equivalent emission reduction referred to in point (b).

2. By way of derogation from paragraph 1(a), where the operator demonstrates to the competent authority that for an individual installation the emission limit value for fugitive emissions is not technically and economically feasible, the competent authority may allow emissions to exceed that emission limit value provided that significant risks to human health or the environment are not to be expected and that the operator demonstrates to the competent authority that the best available techniques are being used.

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(1) OJ L 396, 30.12.2006, p. 1.

3. By way of derogation from paragraph 1, for coating activities covered by item 8 of the table in Part 2 of Annex VII which cannot be carried out under contained conditions, the competent authority may allow the emissions of the installation not to comply with the requirements set out in that paragraph if the operator demonstrates to the competent authority that such compliance is not technically and economically feasible and that the best available techniques are being used.

4. Member States shall report to the Commission on the derogations referred to in paragraphs 2 and 3 of this Article in accordance with Article 72(2).

5. The emissions of either volatile organic compounds which are assigned or need to carry the hazard statements H340, H350, H350i, H360D or H360F or halogenated volatile organic compounds which are assigned or need to carry the hazard statements H341 or H351, shall be controlled under contained conditions as far as technically and economically feasible to safeguard public health and the environment and shall not exceed the relevant emission limit values set out in Part 4 of Annex VII.

6. Installations where two or more activities are carried out, each of which exceeds the thresholds in Part 2 of Annex VII shall:

(a) as regards the substances specified in paragraph 5, meet the requirements of that paragraph for each activity individually;

(b) as regards all other substances, either:

  (i) meet the requirements of paragraph 1 for each activity individually; or

  (ii) have total emissions of volatile organic compounds not exceeding those which would have resulted had point (i) been applied.

7. All appropriate precautions shall be taken to minimise emissions of volatile organic compounds during start-up and shut-down operations.

Article 60

Monitoring of emissions

Member States shall, either by specification in the permit conditions or by general binding rules, ensure that measurements of emissions are carried out in accordance with Part 6 of Annex VII.

Article 61

Compliance with emission limit values

The emission limit values in waste gases shall be regarded as being complied with if the conditions set out in Part 8 of Annex VII are fulfilled.

Article 62

Reporting on compliance

The operator shall supply the competent authority, on request, with data enabling the competent authority to verify compliance with either of the following:

(a) emission limit values in waste gases, fugitive emission limit values and total emission limit values;

(b) the requirements of the reduction scheme under Part 5 of Annex VII;

(c) the derogations granted in accordance with Article 59(2) and (3).

This may include a solvent management plan prepared in accordance with Part 7 of Annex VII.

Article 63

Substantial change to existing installations

1. A change of the maximum mass input of organic solvents by an existing installation averaged over 1 day, where the installation is operated at its design output under conditions other than start-up and shut-down operations and maintenance of equipment, shall be considered as substantial if it leads to an increase of emissions of volatile organic compounds of more than:

(a) 25 % for an installation carrying out either activities which fall within the lower threshold band of items 1, 3, 4, 5, 8, 10, 13, 16 or 17 of the table in Part 2 of Annex VII or, activities which fall under one of the other items of Part 2 of Annex VII, and with a solvent consumption of less than 10 tonnes per year;

(b) 10 % for all other installations.

2. Where an existing installation undergoes a substantial change, or falls within the scope of this Directive for the first time following a substantial change, that part of the installation which undergoes the substantial change shall be treated either as a new installation or as an existing installation, provided that the total emissions of the whole installation do not exceed those that would have resulted had the substantially changed part been treated as a new installation.

3. In case of a substantial change, the competent authority shall check compliance of the installation with the requirements of this Directive.

Article 64

Exchange of information on substitution of organic solvents

The Commission shall organise an exchange of information with the Member States, the industry concerned and non-governmental organisations promoting environmental protection on the use of organic solvents and their potential substitutes and techniques which have the least potential effects on air, water, soil, ecosystems and human health.

The exchange of information shall be organised on all of the following:

(a) fitness for use;

(b) potential effects on human health and occupational exposure in particular;

(c) potential effects on the environment;

(d) the economic consequences, in particular the costs and benefits of the options available.

Article 65

Access to information

1. The decision of the competent authority, including at least a copy of the permit, and any subsequent updates, shall be made available to the public.

The general binding rules applicable for installations and the list of installations subject to permitting and registration shall be made available to the public.

2. The results of the monitoring of emissions as required under Article 60 and held by the competent authority shall be made available to the public.

3. Paragraphs 1 and 2 of this Article shall apply, subject to the restrictions laid down in Article 4(1) and (2) of Directive 2003/4/EC.

CHAPTER VI

SPECIAL PROVISIONS FOR INSTALLATIONS PRODUCING TITANIUM DIOXIDE

Article 66

Scope

This Chapter shall apply to installations producing titanium dioxide.

Article 67

Prohibition of the disposal of waste

Member States shall prohibit the disposal of the following waste into any water body, sea or ocean:

(a) solid waste;

(b) the mother liquors arising from the filtration phase following hydrolysis of the titanyl sulphate solution from installations applying the sulphate process; including the acid waste associated with such liquors, containing overall more than 0,5 % free sulphuric acid and various heavy metals and including such mother liquors which have been diluted until they contain 0,5 % or less free sulphuric acid;

(c) waste from installations applying the chloride process containing more than 0,5 % free hydrochloric acid and various heavy metals, including such waste which has been diluted until it contains 0,5 % or less free hydrochloric acid;

(d) filtration salts, sludges and liquid waste arising from the treatment (concentration or neutralisation) of the waste mentioned under points (b) and (c) and containing various heavy metals, but not including neutralised and filtered or decanted waste containing only traces of heavy metals and which, before any dilution, has a pH value above 5,5.

Article 68

Control of emissions into water

Emissions from installations into water shall not exceed the emission limit values set out in Part 1 of Annex VIII.

Article 69

Prevention and control of emissions into air

1. The emission of acid droplets from installations shall be prevented.

2. Emissions into air from installations shall not exceed the emission limit values set out in Part 2 of Annex VIII.

Article 70

Monitoring of emissions

1. Member States shall ensure the monitoring of emissions into water in order to enable the competent authority to verify compliance with the permit conditions and Article 68.

2. Member States shall ensure the monitoring of emissions into air in order to enable the competent authority to verify compliance with the permit conditions and Article 69. Such monitoring shall include at least monitoring of emissions as set out in Part 3 of Annex VIII.

3. Monitoring shall be carried out in accordance with CEN standards or, if CEN standards are not available, ISO, national or other international standards which ensure the provision of data of an equivalent scientific quality.

CHAPTER VII

COMMITTEE, TRANSITIONAL AND FINAL PROVISIONS

Article 71

Competent authorities

Member States shall designate the competent authorities responsible for carrying out the obligations arising from this Directive.

Article 72

Reporting by Member States

1. Member States shall ensure that information is made available to the Commission on the implementation of this Directive, on representative data on emissions and other forms of pollution, on emission limit values, on the application of best available techniques in accordance with Articles 14 and 15, in particular on the granting of exemptions in accordance with Article 15(4), and on progress made concerning the development and application of emerging techniques in accordance with Article 27. Member States shall make the information available in an electronic format.

2. The type, format and frequency of information to be made available pursuant to paragraph 1 shall be established in accordance with the regulatory procedure referred to in Article 75(2). This shall include the determination of the specific activities and pollutants for which data referred to in paragraph 1 shall be made available.

3. For all combustion plants covered by Chapter III of this Directive, Member States shall, from 1 January 2016, establish an annual inventory of the sulphur dioxide, nitrogen oxides and dust emissions and energy input.

Taking into account the aggregation rules set out in Article 29, the competent authority shall obtain the following data for each combustion plant:

(a) the total rated thermal input (MW) of the combustion plant;

(b) the type of combustion plant: boiler, gas turbine, gas engine, diesel engine, other (specifying the type);

(c) the date of the start of operation of the combustion plant;

(d) the total annual emissions (tonnes per year) of sulphur dioxide, nitrogen oxides and dust (as total suspended particles);

(e) the number of operating hours of the combustion plant;

(f) the total annual amount of energy input, related to the net calorific value (TJ per year), broken down in terms of the following categories of fuel: coal, lignite, biomass, peat, other solid fuels (specifying the type), liquid fuels, natural gas, other gases (specifying the type).

The annual plant-by-plant data contained in these inventories shall be made available to the Commission upon request.

A summary of the inventories shall be made available to the Commission every 3 years within 12 months from the end of the three-year period considered. This summary shall show separately the data for combustion plants within refineries.

The Commission shall make available to the Member States and to the public a summary of the comparison and evaluation of those inventories in accordance with Directive 2003/4/EC within 24 months from the end of the three-year period considered.

4. Member States shall, from 1 January 2016, report the following data annually to the Commission:

(a) for combustion plants to which Article 31 applies, the sulphur content of the indigenous solid fuel used and the rate of desulphurisation achieved, averaged over each month. For the first year where Article 31 is applied, the technical justification of the non-feasibility of complying with the emission limit values referred to in Article 30(2) and (3) shall also be reported; and

(b) for combustion plants which do not operate more than 1 500 operating hours per year as a rolling average over a period of 5 years, the number of operating hours per year.

Article 73

Review

1. By 7 January 2016, and every 3 years thereafter, the Commission shall submit to the European Parliament and to the Council a report reviewing the implementation of this Directive on the basis of the information referred to in Article 72.

That report shall include an assessment of the need for Union action through the establishment or updating of Union-wide minimum requirements for emission limit values and for rules on monitoring and compliance for activities within the scope of the BAT conclusions adopted during the previous three-year period, on the basis of the following criteria:

(a) the impact of the activities concerned on the environment as a whole; and

(b) the state of implementation of best available techniques for the activities concerned.

That assessment shall consider the opinion of the forum referred to in Article 13(4).

Chapter III and Annex V of this Directive shall be considered to represent the Union-wide minimum requirements in the case of large combustion plants.

The report shall be accompanied by a legislative proposal where appropriate. Where the assessment referred to in the second subparagraph identifies such a need, the legislative proposal shall include provisions establishing or updating Union-wide minimum requirements for emission limit values and for rules on monitoring and compliance assessment for the activities concerned.

2. The Commission shall, by 31 December 2012, review the need to control emissions from:

(a) the combustion of fuels in installations with a total rated thermal input below 50 MW;

(b) the intensive rearing of cattle; and

(c) the spreading of manure.

The Commission shall report the results of that review to the European Parliament and to the Council accompanied by a legislative proposal where appropriate.

3. The Commission shall report to the European Parliament and the Council, by 31 December 2011, on the establishment in Annex I of:

(a) differentiated capacity thresholds for the rearing of different poultry species, including the specific case of quail;

(b) capacity thresholds for the simultaneous rearing of different types of animals within the same installation.

The Commission shall report the results of that review to the European Parliament and to the Council accompanied by a legislative proposal where appropriate.

Article 74

Amendments of Annexes

In order to allow the provisions of this Directive to be adapted to scientific and technical progress on the basis of best available techniques, the Commission shall adopt delegated acts in accordance with Article 76 and subject to the conditions laid down in Articles 77 and 78 as regards the adaptation of Parts 3 and 4 of Annex V, Parts 2, 6, 7 and 8 of Annex VI and Parts 5, 6, 7 and 8 of Annex VII to such scientific and technical progress.

Article 75

Committee procedure

1. The Commission shall be assisted by a committee.

2. Where reference is made to this paragraph, Articles 5 and 7 of Decision 1999/468/EC shall apply, having regard to the provisions of Article 8 thereof.

The period laid down in Article 5(6) of Decision 1999/468/EC shall be set at 3 months.

Article 76

Exercise of the delegation

1. The power to adopt the delegated acts referred to in Article 48(5) and Article 74 shall be conferred on the Commission for a period of 5 years from 6 January 2011. The Commission shall draw up a report in respect of the delegated power at the latest 6 months before the end of the five-year period. The delegation of power shall be automatically extended for periods of an identical duration, unless the European Parliament or the Council revokes it in accordance with Article 77.

2. As soon as it adopts a delegated act, the Commission shall notify it simultaneously to the European Parliament and to the Council.

3. The power to adopt delegated acts is conferred on the Commission subject to the conditions laid down in Articles 77 and 78.

Article 77

Revocation of the delegation

1. The delegation of power referred to in Article 48(5) and Article 74 may be revoked at any time by the European Parliament or by the Council.

2. The institution which has commenced an internal procedure for deciding whether to revoke a delegation of power shall endeavour to inform the other institution and the Commission within a reasonable time before the final decision is taken, indicating the delegated power which could be subject to revocation and possible reasons for a revocation.

3. The decision of revocation shall put an end to the delegation of the power specified in that decision. It shall take effect immediately or on a later date specified therein. It shall not affect the validity of the delegated acts already in force. It shall be published in the *Official Journal of the European Union*.

Article 78

Objections to delegated acts

1. The European Parliament or the Council may object to a delegated act within a period of 2 months from the date of notification.

At the initiative of the European Parliament or the Council that period shall be extended by 2 months.

2. If, on expiry of the period referred to in paragraph 1, neither the European Parliament nor the Council has objected to the delegated act, it shall be published in the *Official Journal of the European Union* and shall enter into force on the date stated therein.

The delegated act may be published in the *Official Journal of the European Union* and enter into force before the expiry of that period if the European Parliament and the Council have both informed the Commission of their intention not to raise objections.

3. If either the European Parliament or the Council objects to the delegated act within the period referred to in paragraph 1, it shall not enter into force. The institution which objects shall state the reasons for objecting to the delegated act.

Article 79

Penalties

Member States shall determine penalties applicable to infringements of the national provisions adopted pursuant to this Directive. The penalties thus provided for shall be effective, proportionate and dissuasive. Member States shall notify those provisions to the Commission by 7 January 2013 and shall notify it without delay of any subsequent amendment affecting them.

Article 80

Transposition

1. Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with Article 2, points (8), (11) to (15), (18) to (23), (26) to (30), (34) to (38) and (41) of Article 3, Article 4(2) and (3), Article 7, Articles 8 and 10, Article 11(e) and (h), Article 12(1)(e) and (h), Article 13(7), point (ii) of Article 14(1)(c), points (d), (e), (f) and (h) of Article 14(1), Article 14(2) to (7), Article 15(2) to (5), Articles 16, 17 and 19, Article 21(2) to (5), Articles 22, 23, 24, 27, 28 and 29, Article 30(1), (2), (3), (4), (7) and (8), Articles 31, 32, 33, 34, 35, 36, 38 and 39, Article 40(2) and (3), Articles 42 and 43, Article 45(1), Article 58, Article 59(5), Article 63, Article 65(3), Articles 69, 70, 71, 72 and 79, and with the first subparagraph and points 1.1, 1.4, 2.5(b), 3.1, 4, 5, 6.1(c), 6.4(b), 6.10 and 6.11 of Annex I, Annex II, point 12 of Annex III, Annex V, point (b) of Part 1, points 2.2, 2.4, 3.1 and 3.2 of Part 4, points 2.5 and 2.6 of Part 6 and point 1.1(d) of Part 8 of Annex VI, point 2 of Part 4, point 1 of Part 5, point 3 of Part 7 of Annex VII, points 1 and 2(c) of Part 1, points 2 and 3 of Part 2 and Part 3 of Annex VIII by 7 January 2013.

They shall apply those measures from that same date.

When Member States adopt those measures, they shall contain a reference to this Directive or be accompanied by such a reference on the occasion of their official publication. The methods of making such reference shall be laid down by Member States.

2. Member States shall communicate to the Commission the text of the main provisions of national law which they adopt in the field covered by this Directive.

Article 81

Repeal

1. Directives 78/176/EEC, 82/883/EEC, 92/112/EEC, 1999/13/EC, 2000/76/EC and 2008/1/EC, as amended by the acts listed in Annex IX, Part A are repealed with effect from 7 January 2014, without prejudice to the obligations of the Member States relating to the time limits for transposition into national law and application of the Directives set out in Annex IX, Part B.

2. Directive 2001/80/EC as amended by the acts listed in Annex IX, Part A is repealed with effect from 1 January 2016, without prejudice to the obligations of the Member States relating to the time limits for transposition into national law and application of the Directives set out in Annex IX, Part B.

3. References to the repealed Directives shall be construed as references to this Directive and shall be read in accordance with the correlation table set out in Annex X.

Article 82

Transitional provisions

1. In relation to installations carrying out activities referred to in Annex I, point 1.1 for activities with a total rated thermal input exceeding 50 MW, points 1.2 and 1.3, point 1.4(a), points 2.1 to 2.6, points 3.1 to 3.5, points 4.1 to 4.6 for activities concerning production by chemical processing, points 5.1 and 5.2 for activities covered by Directive 2008/1/EC, point 5.3 (a)(i) and (ii), point 5.4, point 6.1(a) and (b), points 6.2 and 6.3, point 6.4(a), point 6.4(b) for activities covered by Directive 2008/1/EC, point 6.4(c) and points 6.5 to 6.9 which are in operation and hold a permit before 7 January 2013 or the operators of which have submitted a complete application for a permit before that date, provided that those installations are put into operation no later than 7 January 2014, Member States shall apply the laws, regulations and administrative provisions adopted in accordance with Article 80(1) from 7 January 2014 with the exception of Chapter III and Annex V.

2. In relation to installations carrying out activities referred to in Annex I, point 1.1 for activities with a total rated thermal input of 50 MW, point 1.4(b), points 4.1 to 4.6 for activities concerning production by biological processing, points 5.1 and 5.2 for activities not covered by Directive 2008/1/EC, point 5.3(a)(iii) to (v), point 5.3(b), points 5.5 and 5.6, point 6.1(c), point 6.4(b) for activities not covered by Directive 2008/1/EC and points 6.10 and 6.11 which are in operation before 7 January 2013, Member States shall apply the laws, regulations and administrative provisions adopted in accordance with this Directive from 7 July 2015 with the exception of Chapters III and IV and Annexes V and VI.

3. In relation to combustion plants referred to in Article 30(2), Member States shall, from 1 January 2016, apply the laws, regulations and administrative provisions adopted in accordance with Article 80(1) to comply with Chapter III and Annex V.

4. In relation to combustion plants referred to in Article 30(3), Member States shall no longer apply Directive 2001/80/EC from 7 January 2013.

5. In relation to combustion plants which co-incinerate waste, point 3.1 of Part 4 of Annex VI shall apply until:

(a) 31 December 2015, for combustion plants referred to in Article 30(2);

(b) 7 January 2013, for combustion plants referred to in Article 30(3).

6. Point 3.2 of Part 4 of Annex VI shall apply in relation to combustion plants which co-incinerate waste, as from:

(a) 1 January 2016, for combustion plants referred to in Article 30(2)

(b) 7 January 2013, for combustion plants referred to in Article 30(3).

7. Article 58 shall apply from 1 June 2015. Until that date, substances or mixtures which, because of their content of volatile organic compounds classified as carcinogens, mutagens, or toxic to reproduction under Regulation (EC) No 1272/2008, are assigned or need to carry the hazard statements H340, H350, H350i, H360D or H360F or the risk phrases R45, R46, R49, R60 or R61, shall be replaced, as far as possible, by less harmful substances or mixtures within the shortest possible time.

8. Article 59(5) shall apply from 1 June 2015. Until that date, the emissions of either volatile organic compounds which are assigned or need to carry the hazard statements H340, H350, H350i, H360D or H360F or the risk phrases R45, R46, R49, R60 or R61 or halogenated volatile organic compounds which are assigned or need to carry the hazard statements H341 or H351 or the risk phrases R40 or R68, shall be controlled under contained conditions, as far as technically and economically feasible, to safeguard public health and the environment and shall not exceed the relevant emission limit values set out in Part 4 of Annex VII.

9. Point 2 of Part 4 of Annex VII shall apply from 1 June 2015. Until that date, for emissions of halogenated volatile organic compounds which are assigned or need to carry the hazard statements H341 or H351 or the risk phrases R40 or R68, where the mass flow of the sum of the compounds causing the hazard statements H341 or H351 or the labelling R40 or R68 is greater than, or equal to, 100 g/h, an emission limit value of 20 mg/Nm^3 shall be complied with. The emission limit value refers to the mass sum of the individual compounds.

Article 83

Entry into force

This Directive shall enter into force on the 20th day following its publication in the *Official Journal of the European Union*.

Article 84

Addressees

This Directive is addressed to the Member States.

Done at Strasbourg, 24 November 2010.

For the European Parliament	*For the Council*
The President	*The President*
J. BUZEK	O. CHASTEL

ANNEX I

Categories of activities referred to in Article 10

The threshold values given below generally refer to production capacities or outputs. Where several activities falling under the same activity description containing a threshold are operated in the same installation, the capacities of such activities are added together. For waste management activities, this calculation shall apply at the level of activities 5.1, 5.3(a) and 5.3(b).

The Commission shall establish guidance on:

(a) the relationship between waste management activities described in this Annex and those described in Annexes I and II to Directive 2008/98/EC; and

(b) the interpretation of the term ‘industrial scale’ regarding the description of chemical industry activities described in this Annex.

1. Energy industries

1.1. Combustion of fuels in installations with a total rated thermal input of 50 MW or more

1.2. Refining of mineral oil and gas

1.3. Production of coke

1.4. Gasification or liquefaction of:

(a) coal;

(b) other fuels in installations with a total rated thermal input of 20 MW or more.

2. Production and processing of metals

2.1. Metal ore (including sulphide ore) roasting or sintering

2.2. Production of pig iron or steel (primary or secondary fusion) including continuous casting, with a capacity exceeding 2,5 tonnes per hour

2.3. Processing of ferrous metals:

(a) operation of hot-rolling mills with a capacity exceeding 20 tonnes of crude steel per hour;

(b) operation of smitheries with hammers the energy of which exceeds 50 kilojoule per hammer, where the calorific power used exceeds 20 MW;

(c) application of protective fused metal coats with an input exceeding 2 tonnes of crude steel per hour.

2.4. Operation of ferrous metal foundries with a production capacity exceeding 20 tonnes per day

2.5. Processing of non-ferrous metals:

(a) production of non-ferrous crude metals from ore, concentrates or secondary raw materials by metallurgical, chemical or electrolytic processes;

(b) melting, including the alloyage, of non-ferrous metals, including recovered products and operation of non-ferrous metal foundries, with a melting capacity exceeding 4 tonnes per day for lead and cadmium or 20 tonnes per day for all other metals.

2.6. Surface treatment of metals or plastic materials using an electrolytic or chemical process where the volume of the treatment vats exceeds 30 m^3

3. Mineral industry

3.1. Production of cement, lime and magnesium oxide:

(a) production of cement clinker in rotary kilns with a production capacity exceeding 500 tonnes per day or in other kilns with a production capacity exceeding 50 tonnes per day;

(b) production of lime in kilns with a production capacity exceeding 50 tonnes per day;

(c) production of magnesium oxide in kilns with a production capacity exceeding 50 tonnes per day.

3.2. Production of asbestos or the manufacture of asbestos-based products

3.3. Manufacture of glass including glass fibre with a melting capacity exceeding 20 tonnes per day

3.4. Melting mineral substances including the production of mineral fibres with a melting capacity exceeding 20 tonnes per day

3.5. Manufacture of ceramic products by firing, in particular roofing tiles, bricks, refractory bricks, tiles, stoneware or porcelain with a production capacity exceeding 75 tonnes per day and/or with a kiln capacity exceeding 4 m^3 and with a setting density per kiln exceeding 300 kg/m^3

4. Chemical industry

For the purpose of this section, production within the meaning of the categories of activities contained in this section means the production on an industrial scale by chemical or biological processing of substances or groups of substances listed in points 4.1 to 4.6

4.1. Production of organic chemicals, such as:

(a) simple hydrocarbons (linear or cyclic, saturated or unsaturated, aliphatic or aromatic);

(b) oxygen-containing hydrocarbons such as alcohols, aldehydes, ketones, carboxylic acids, esters and mixtures of esters, acetates, ethers, peroxides and epoxy resins;

(c) sulphurous hydrocarbons;

(d) nitrogenous hydrocarbons such as amines, amides, nitrous compounds, nitro compounds or nitrate compounds, nitriles, cyanates, isocyanates;

(e) phosphorus-containing hydrocarbons;

(f) halogenic hydrocarbons;

(g) organometallic compounds;

(h) plastic materials (polymers, synthetic fibres and cellulose-based fibres);

(i) synthetic rubbers;

(j) dyes and pigments;

(k) surface-active agents and surfactants.

4.2. Production of inorganic chemicals, such as:

(a) gases, such as ammonia, chlorine or hydrogen chloride, fluorine or hydrogen fluoride, carbon oxides, sulphur compounds, nitrogen oxides, hydrogen, sulphur dioxide, carbonyl chloride;

(b) acids, such as chromic acid, hydrofluoric acid, phosphoric acid, nitric acid, hydrochloric acid, sulphuric acid, oleum, sulphurous acids;

(c) bases, such as ammonium hydroxide, potassium hydroxide, sodium hydroxide;

(d) salts, such as ammonium chloride, potassium chlorate, potassium carbonate, sodium carbonate, perborate, silver nitrate;

(e) non-metals, metal oxides or other inorganic compounds such as calcium carbide, silicon, silicon carbide.

4.3. Production of phosphorous-, nitrogen- or potassium-based fertilisers (simple or compound fertilisers)

4.4. Production of plant protection products or of biocides

4.5. Production of pharmaceutical products including intermediates

4.6. Production of explosives

5. Waste management

5.1. Disposal or recovery of hazardous waste with a capacity exceeding 10 tonnes per day involving one or more of the following activities:

(a) biological treatment;

(b) physico-chemical treatment;

(c) blending or mixing prior to submission to any of the other activities listed in points 5.1 and 5.2;

(d) repackaging prior to submission to any of the other activities listed in points 5.1 and 5.2;

(e) solvent reclamation/regeneration;

(f) recycling/reclamation of inorganic materials other than metals or metal compounds;

(g) regeneration of acids or bases;

(h) recovery of components used for pollution abatement;

(i) recovery of components from catalysts;

(j) oil re-refining or other reuses of oil;

(k) surface impoundment.

5.2. Disposal or recovery of waste in waste incineration plants or in waste co-incineration plants:

(a) for non-hazardous waste with a capacity exceeding 3 tonnes per hour;

(b) for hazardous waste with a capacity exceeding 10 tonnes per day.

5.3. (a) Disposal of non-hazardous waste with a capacity exceeding 50 tonnes per day involving one or more of the following activities, and excluding activities covered by Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment (1):

(i) biological treatment;

(ii) physico-chemical treatment;

(iii) pre-treatment of waste for incineration or co-incineration;

(iv) treatment of slags and ashes;

(v) treatment in shredders of metal waste, including waste electrical and electronic equipment and end-of-life vehicles and their components.

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(1) OJ L 135, 30.5.1991, p. 40.

(b) Recovery, or a mix of recovery and disposal, of non-hazardous waste with a capacity exceeding 75 tonnes per day involving one or more of the following activities, and excluding activities covered by Directive 91/271/EEC:

(i) biological treatment;

(ii) pre-treatment of waste for incineration or co-incineration;

(iii) treatment of slags and ashes;

(iv) treatment in shredders of metal waste, including waste electrical and electronic equipment and end-of-life vehicles and their components.

When the only waste treatment activity carried out is anaerobic digestion, the capacity threshold for this activity shall be 100 tonnes per day.

5.4. Landfills, as defined in Article 2(g) of Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste (¹), receiving more than 10 tonnes of waste per day or with a total capacity exceeding 25 000 tonnes, excluding landfills of inert waste

5.5. Temporary storage of hazardous waste not covered under point 5.4 pending any of the activities listed in points 5.1, 5.2, 5.4 and 5.6 with a total capacity exceeding 50 tonnes, excluding temporary storage, pending collection, on the site where the waste is generated

5.6. Underground storage of hazardous waste with a total capacity exceeding 50 tonnes

6. Other activities

6.1. Production in industrial installations of:

(a) pulp from timber or other fibrous materials;

(b) paper or card board with a production capacity exceeding 20 tonnes per day;

(c) one or more of the following wood-based panels: oriented strand board, particleboard or fibreboard with a production capacity exceeding 600 m^3 per day.

6.2. Pre-treatment (operations such as washing, bleaching, mercerisation) or dyeing of textile fibres or textiles where the treatment capacity exceeds 10 tonnes per day

6.3. Tanning of hides and skins where the treatment capacity exceeds 12 tonnes of finished products per day

6.4. (a) Operating slaughterhouses with a carcass production capacity greater than 50 tonnes per day

(b) Treatment and processing, other than exclusively packaging, of the following raw materials, whether previously processed or unprocessed, intended for the production of food or feed from:

(i) only animal raw materials (other than exclusively milk) with a finished product production capacity greater than 75 tonnes per day;

(ii) only vegetable raw materials with a finished product production capacity greater than 300 tonnes per day or 600 tonnes per day where the installation operates for a period of no more than 90 consecutive days in any year;

(iii) animal and vegetable raw materials, both in combined and separate products, with a finished product production capacity in tonnes per day greater than:

— 75 if A is equal to 10 or more; or,

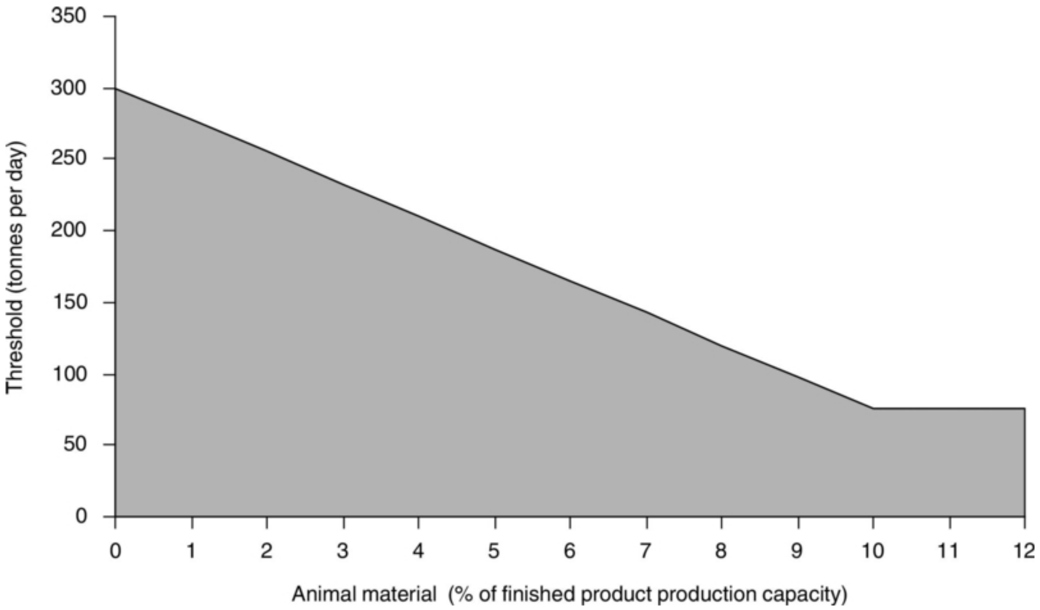
— [300- (22,5 × A)] in any other case,

where ‘A’ is the portion of animal material (in percent of weight) of the finished product production capacity.

Packaging shall not be included in the final weight of the product.

(¹) OJ L 182, 16.7.1999, p. 1.

This subsection shall not apply where the raw material is milk only.



(c) Treatment and processing of milk only, the quantity of milk received being greater than 200 tonnes per day (average value on an annual basis).

6.5. Disposal or recycling of animal carcases or animal waste with a treatment capacity exceeding 10 tonnes per day

6.6. Intensive rearing of poultry or pigs:

(a) with more than 40 000 places for poultry;

(b) with more than 2 000 places for production pigs (over 30 kg), or

(c) with more than 750 places for sows.

6.7. Surface treatment of substances, objects or products using organic solvents, in particular for dressing, printing, coating, degreasing, waterproofing, sizing, painting, cleaning or impregnating, with an organic solvent consumption capacity of more than 150 kg per hour or more than 200 tonnes per year

6.8. Production of carbon (hard-burnt coal) or electrographite by means of incineration or graphitisation

6.9. Capture of CO_2 streams from installations covered by this Directive for the purposes of geological storage pursuant to Directive 2009/31/EC

6.10. Preservation of wood and wood products with chemicals with a production capacity exceeding 75 m^3 per day other than exclusively treating against sapstain

6.11. Independently operated treatment of waste water not covered by Directive 91/271/EEC and discharged by an installation covered by Chapter II

ANNEX II

List of polluting substances

AIR

1. Sulphur dioxide and other sulphur compounds
2. Oxides of nitrogen and other nitrogen compounds
3. Carbon monoxide
4. Volatile organic compounds
5. Metals and their compounds
6. Dust including fine particulate matter
7. Asbestos (suspended particulates, fibres)
8. Chlorine and its compounds
9. Fluorine and its compounds
10. Arsenic and its compounds
11. Cyanides
12. Substances and mixtures which have been proved to possess carcinogenic or mutagenic properties or properties which may affect reproduction via the air
13. Polychlorinated dibenzodioxins and polychlorinated dibenzofurans

WATER

1. Organohalogen compounds and substances which may form such compounds in the aquatic environment
2. Organophosphorus compounds
3. Organotin compounds
4. Substances and mixtures which have been proved to possess carcinogenic or mutagenic properties or properties which may affect reproduction in or via the aquatic environment
5. Persistent hydrocarbons and persistent and bioaccumulable organic toxic substances
6. Cyanides
7. Metals and their compounds
8. Arsenic and its compounds
9. Biocides and plant protection products
10. Materials in suspension
11. Substances which contribute to eutrophication (in particular, nitrates and phosphates)
12. Substances which have an unfavourable influence on the oxygen balance (and can be measured using parameters such as BOD, COD, etc.)
13. Substances listed in Annex X to Directive 2000/60/EC

ANNEX III

Criteria for determining best available techniques

1. the use of low-waste technology;
2. the use of less hazardous substances;
3. the furthering of recovery and recycling of substances generated and used in the process and of waste, where appropriate;
4. comparable processes, facilities or methods of operation which have been tried with success on an industrial scale;
5. technological advances and changes in scientific knowledge and understanding;
6. the nature, effects and volume of the emissions concerned;
7. the commissioning dates for new or existing installations;
8. the length of time needed to introduce the best available technique;
9. the consumption and nature of raw materials (including water) used in the process and energy efficiency;
10. the need to prevent or reduce to a minimum the overall impact of the emissions on the environment and the risks to it;
11. the need to prevent accidents and to minimise the consequences for the environment;
12. information published by public international organisations.

ANNEX IV

Public participation in decision-making

1. The public shall be informed (by public notices or other appropriate means such as electronic media where available) of the following matters early in the procedure for the taking of a decision or, at the latest, as soon as the information can reasonably be provided:

   (a) the application for a permit or, as the case may be, the proposal for the updating of a permit or of permit conditions in accordance with Article 21, including the description of the elements listed in Article 12(1);

   (b) where applicable, the fact that a decision is subject to a national or transboundary environmental impact assessment or to consultations between Member States in accordance with Article 26;

   (c) details of the competent authorities responsible for taking the decision, those from which relevant information can be obtained, those to which comments or questions can be submitted, and details of the time schedule for transmitting comments or questions;

   (d) the nature of possible decisions or, where there is one, the draft decision;

   (e) where applicable, the details relating to a proposal for the updating of a permit or of permit conditions;

   (f) an indication of the times and places where, or means by which, the relevant information will be made available;

   (g) details of the arrangements for public participation and consultation made pursuant to point 5.

2. Member States shall ensure that, within appropriate time-frames, the following is made available to the public concerned:

   (a) in accordance with national law, the main reports and advice issued to the competent authority or authorities at the time when the public concerned were informed in accordance with point 1;

   (b) in accordance with Directive 2003/4/EC, information other than that referred to in point 1 which is relevant for the decision in accordance with Article 5 of this Directive and which only becomes available after the time the public concerned was informed in accordance with point 1.

3. The public concerned shall be entitled to express comments and opinions to the competent authority before a decision is taken.

4. The results of the consultations held pursuant to this Annex must be taken into due account in the taking of a decision.

5. The detailed arrangements for informing the public (for example by bill posting within a certain radius or publication in local newspapers) and consulting the public concerned (for example by written submissions or by way of a public inquiry) shall be determined by the Member States. Reasonable time-frames for the different phases shall be provided, allowing sufficient time to inform the public and for the public concerned to prepare and participate effectively in environmental decision-making subject to this Annex.

ANNEX V

Technical provisions relating to combustion plants

PART 1

Emission limit values for combustion plants referred to in Article 30(2)

1. All emission limit values shall be calculated at a temperature of 273,15 K, a pressure of 101,3 kPa and after correction for the water vapour content of the waste gases and at a standardised O_2 content of 6 % for solid fuels, 3 % for combustion plants, other than gas turbines and gas engines using liquid and gaseous fuels and 15 % for gas turbines and gas engines.

2. Emission limit values (mg/Nm^3) for SO_2 for combustion plants using solid or liquid fuels with the exception of gas turbines and gas engines

Total rated thermal input (MW)	Coal and lignite and other solid fuels	Biomass	Peat	Liquid fuels
50-100	400	200	300	350
100-300	250	200	300	250
> 300	200	200	200	200

Combustion plants, using solid fuels which were granted a permit before 27 November 2002 or the operators of which had submitted a complete application for a permit before that date, provided that the plant was put into operation no later than 27 November 2003, and which do not operate more than 1 500 operating hours per year as a rolling average over a period of 5 years, shall be subject to an emission limit value for SO_2 of 800 mg/Nm^3.

Combustion plants using liquid fuels, which were granted a permit before 27 November 2002 or the operators of which had submitted a complete application for a permit before that date, provided that the plant was put into operation no later than 27 November 2003, and which do not operate more than 1 500 operating hours per year as a rolling average over a period of 5 years, shall be subject to an emission limit value for SO_2 of 850 mg/Nm^3 in case of plants with a total rated thermal input not exceeding 300 MW and of 400 mg/Nm^3 in case of plants with a total rated thermal input greater than 300 MW.

A part of a combustion plant discharging its waste gases through one or more separate flues within a common stack, and which does not operate more than 1 500 operating hours per year as a rolling average over a period of 5 years, may be subject to the emission limit values set out in the preceding two paragraphs in relation to the total rated thermal input of the entire combustion plant. In such cases the emissions through each of those flues shall be monitored separately.

3. Emission limit values (mg/Nm^3) for SO_2 for combustion plants using gaseous fuels with the exception of gas turbines and gas engines

In general	35
Liquefied gas	5
Low calorific gases from coke oven	400
Low calorific gases from blast furnace	200

Combustion plants, firing low calorific gases from gasification of refinery residues, which were granted a permit before 27 November 2002 or the operators of which had submitted a complete application for a permit before that date, provided that the plant was put into operation no later than 27 November 2003, shall be subject to an emission limit value for SO_2 of 800 mg/Nm^3.

4. Emission limit values (mg/Nm^3) for NO$_x$ for combustion plants using solid or liquid fuels with the exception of gas turbines and gas engines

Total rated thermal input (MW)	Coal and lignite and other solid fuels	Biomass and peat	Liquid fuels
50-100	300 450 in case of pulverised lignite combustion	300	450
100-300	200	250	200 (1)
> 300	200	200	150 (1)

Note:

(1) The emission limit value is 450 mg/Nm^3 for the firing of distillation and conversion residues from the refining of crude-oil for own consumption in combustion plants with a total rated thermal input not exceeding 500 MW which were granted a permit before 27 November 2002 or the operators of which had submitted a complete application for a permit before that date, provided that the plant was put into operation no later than 27 November 2003.

Combustion plants in chemical installations using liquid production residues as non-commercial fuel for own consumption with a total rated thermal input not exceeding 500 MW which were granted a permit before 27 November 2002 or the operators of which had submitted a complete application for a permit before that date, provided that the plant was put into operation no later than 27 November 2003, shall be subject to an emission limit value for NO$_x$ of 450 mg/Nm^3.

Combustion plants using solid or liquid fuels with a total rated thermal input not exceeding 500 MW which were granted a permit before 27 November 2002 or the operators of which had submitted a complete application for a permit before that date, provided that the plant was put into operation no later than 27 November 2003, and which do not operate more than 1 500 operating hours per year as a rolling average over a period of 5 years, shall be subject to an emission limit value for NO$_x$ of 450 mg/Nm^3.

Combustion plants using solid fuels with a total rated thermal input greater than 500 MW, which were granted a permit before 1 July 1987 and which do not operate more than 1 500 operating hours per year as a rolling average over a period of 5 years, shall be subject to an emission limit value for NO$_x$ of 450 mg/Nm^3.

Combustion plants using liquid fuels, with a total rated thermal input greater than 500 MW which were granted a permit before 27 November 2002 or the operators of which had submitted a complete application for a permit before that date, provided that the plant was put into operation no later than 27 November 2003, and which do not operate more than 1 500 operating hours per year as a rolling average over a period of 5 years, shall be subject to an emission limit value for NO$_x$ of 400 mg/Nm^3.

A part of a combustion plant discharging its waste gases through one or more separate flues within a common stack, and which does not operate more than 1 500 operating hours per year as a rolling average over a period of 5 years, may be subject to the emission limit values set out in the preceding three paragraphs in relation to the total rated thermal input of the entire combustion plant. In such cases the emissions through each of those flues shall be monitored separately.

5. Gas turbines (including combined cycle gas turbines (CCGT)) using light and middle distillates as liquid fuels shall be subject to an emission limit value for NO$_x$ of 90 mg/Nm^3 and for CO of 100 mg/Nm^3.

Gas turbines for emergency use that operate less than 500 operating hours per year are not covered by the emission limit values set out in this point. The operator of such plants shall record the used operating hours.

6. Emission limit values (mg/Nm^3) for NO_x and CO for gas fired combustion plants

	NO_x	CO
Combustion plants firing natural gas with the exception of gas turbines and gas engines	100	100
Combustion plants firing blast furnace gas, coke oven gas or low calorific gases from gasification of refinery residues, with the exception of gas turbines and gas engines	200 (4)	—
Combustion plants firing other gases, with the exception of gas turbines and gas engines	200 (4)	—
Gas turbines (including CCGT), using natural gas (1) as fuel	50 (2) (3)	100
Gas turbines (including CCGT), using other gases as fuel	120	—
Gas engines	100	100

Notes:

(1) Natural gas is naturally occurring methane with not more than 20 % (by volume) of inerts and other constituents.

(2) 75 mg/Nm^3 in the following cases, where the efficiency of the gas turbine is determined at ISO base load conditions:
- (i) gas turbines, used in combined heat and power systems having an overall efficiency greater than 75 %;
- (ii) gas turbines used in combined cycle plants having an annual average overall electrical efficiency greater than 55 %;
- (iii) gas turbines for mechanical drives.

(3) For single cycle gas turbines not falling into any of the categories mentioned under note (2), but having an efficiency greater than 35 % – determined at ISO base load conditions – the emission limit value for NO_x shall be $50x\eta/35$ where η is the gas turbine efficiency at ISO base load conditions expressed as a percentage.

(4) 300 mg/Nm^3 for such combustion plants with a total rated thermal input not exceeding 500 MW which were granted a permit before 27 November 2002 or the operators of which had submitted a complete application for a permit before that date, provided that the plant was put into operation no later than 27 November 2003.

For gas turbines (including CCGT), the NO_x and CO emission limit values set out in the table contained in this point apply only above 70 % load.

For gas turbines (including CCGT) which were granted a permit before 27 November 2002 or the operators of which had submitted a complete application for a permit before that date, provided that the plant was put into operation no later than 27 November 2003, and which do not operate more than 1 500 operating hours per year as a rolling average over a period of 5 years, the emission limit value for NO_x is 150 mg/Nm^3 when firing natural gas and 200 mg/Nm^3 when firing other gases or liquid fuels.

A part of a combustion plant discharging its waste gases through one or more separate flues within a common stack, and which does not operate more than 1 500 operating hours per year as a rolling average over a period of 5 years, may be subject to the emission limit values set out in the preceding paragraph in relation to the total rated thermal input of the entire combustion plant. In such cases the emissions through each of those flues shall be monitored separately.

Gas turbines and gas engines for emergency use that operate less than 500 operating hours per year are not covered by the emission limit values set out in this point. The operator of such plants shall record the used operating hours.

7. Emission limit values (mg/Nm^3) for dust for combustion plants using solid or liquid fuels with the exception of gas turbines and gas engines

Total rated thermal input (MW)	Coal and lignite and other solid fuels	Biomass and peat	Liquid fuels (1)
50-100	30	30	30
100-300	25	20	25
> 300	20	20	20

Note:

(1) The emission limit value is 50 mg/Nm^3 for the firing of distillation and conversion residues from the refining of crude oil for own consumption in combustion plants which were granted a permit before 27 November 2002 or the operators of which had submitted a complete application for a permit before that date, provided that the plant was put into operation no later than 27 November 2003.

8. Emission limit values (mg/Nm^3) for dust for combustion plants using gaseous fuels with the exception of gas turbines and gas engines

In general	5
Blast furnace gas	10
Gases produced by the steel industry which can be used elsewhere	30

PART 2

Emission limit values for combustion plants referred to in Article 30(3)

1. All emission limit values shall be calculated at a temperature of 273,15 K, a pressure of 101,3 kPa and after correction for the water vapour content of the waste gases and at a standardised O_2 content of 6 % for solid fuels, 3 % for combustion plants other than gas turbines and gas engines using liquid and gaseous fuels and 15 % for gas turbines and gas engines.

   In case of combined cycle gas turbines with supplementary firing, the standardised O_2 content may be defined by the competent authority, taking into account the specific characteristics of the installation concerned.

2. Emission limit values (mg/Nm^3) for SO_2 for combustion plants using solid or liquid fuels with the exception of gas turbines and gas engines

Total rated thermal input (MW)	Coal and lignite and other solid fuels	Biomass	Peat	Liquid fuels
50-100	400	200	300	350
100-300	200	200	300 250 in case of fluidised bed combustion	200
> 300	150 200 in case of circulating or pressurised fluidised bed combustion	150	150 200 in case of fluidised bed combustion	150

3. Emission limit values (mg/Nm^3) for SO_2 for combustion plants using gaseous fuels with the exception of gas turbines and gas engines

In general	35
Liquefied gas	5
Low calorific gases from coke oven	400
Low calorific gases from blast furnace	200

4. Emission limit values (mg/Nm^3) for NO_x for combustion plants using solid or liquid fuels with the exception of gas turbines and gas engines

Total rated thermal input (MW)	Coal and lignite and other solid fuels	Biomass and peat	Liquid fuels
50-100	300 400 in case of pulverised lignite combustion	250	300
100-300	200	200	150
> 300	150 200 in case of pulverised lignite combustion	150	100

5. Gas turbines (including CCGT) using light and middle distillates as liquid fuels shall be subject to an emission limit value for NO_x of 50 mg/Nm^3 and for CO of 100 mg/Nm^3

   Gas turbines for emergency use that operate less than 500 operating hours per year are not covered by the emission limit values set out in this point. The operator of such plants shall record the used operating hours.

6. Emission limit values (mg/Nm^3) for NO_x and CO for gas fired combustion plants

	NO_x	CO
Combustion plants other than gas turbines and gas engines	100	100
Gas turbines (including CCGT)	50 (¹)	100
Gas engines	75	100

Note:

(¹) For single cycle gas turbines having an efficiency greater than 35 % – determined at ISO base load conditions – the emission limit value for NO_x shall be 50xη/35 where η is the gas turbine efficiency at ISO base load conditions expressed as a percentage.

For gas turbines (including CCGT), the NO_x and CO emission limit values set out in this point apply only above 70 % load.

Gas turbines and gas engines for emergency use that operate less than 500 operating hours per year are not covered by the emission limit values set out in this point. The operator of such plants shall record the used operating hours.

7. Emission limit values (mg/Nm^3) for dust for combustion plants using solid or liquid fuels with the exception of gas turbines and gas engines

Total rated thermal input (MW)	
50-300	20
> 300	10 20 for biomass and peat

8. Emission limit values (mg/Nm^3) for dust for combustion plants using gaseous fuels with the exception of gas turbines and gas engines

In general	5
Blast furnace gas	10
Gases produced by the steel industry which can be used elsewhere	30

PART 3

Emission monitoring

1. The concentrations of SO_2, NO_x and dust in waste gases from each combustion plant with a total rated thermal input of 100 MW or more shall be measured continuously.

   The concentration of CO in waste gases from each combustion plant firing gaseous fuels with a total rated thermal input of 100 MW or more shall be measured continuously.

2. The competent authority may decide not to require the continuous measurements referred to in point 1 in the following cases:

   (a) for combustion plants with a life span of less than 10 000 operational hours;

   (b) for SO_2 and dust from combustion plants firing natural gas;

(c) for SO_2 from combustion plants firing oil with known sulphur content in cases where there is no waste gas desulphurisation equipment;

(d) for SO_2 from combustion plants firing biomass if the operator can prove that the SO_2 emissions can under no circumstances be higher than the prescribed emission limit values.

3. Where continuous measurements are not required, measurements of SO_2, NO_x, dust and, for gas fired plants, also of CO shall be required at least once every 6 months.

4. For combustion plants firing coal or lignite, the emissions of total mercury shall be measured at least once per year.

5. As an alternative to the measurements of SO_2 and NO_x referred to in point 3, other procedures, verified and approved by the competent authority, may be used to determine the SO_2 and NO_x emissions. Such procedures shall use relevant CEN standards or, if CEN standards are not available, ISO, national or other international standards which ensure the provision of data of an equivalent scientific quality.

6. The competent authority shall be informed of significant changes in the type of fuel used or in the mode of operation of the plant. The competent authority shall decide whether the monitoring requirements laid down in points 1 to 4 are still adequate or require adaptation.

7. The continuous measurements carried out in accordance with point 1 shall include the measurement of the oxygen content, temperature, pressure and water vapour content of the waste gases. The continuous measurement of the water vapour content of the waste gases shall not be necessary, provided that the sampled waste gas is dried before the emissions are analysed.

8. Sampling and analysis of relevant polluting substances and measurements of process parameters as well as the quality assurance of automated measuring systems and the reference measurement methods to calibrate those systems shall be carried out in accordance with CEN standards. If CEN standards are not available, ISO, national or other international standards which ensure the provision of data of an equivalent scientific quality shall apply.

   The automated measuring systems shall be subject to control by means of parallel measurements with the reference methods at least once per year.

   The operator shall inform the competent authority about the results of the checking of the automated measuring systems.

9. At the emission limit value level, the values of the 95 % confidence intervals of a single measured result shall not exceed the following percentages of the emission limit values:

Carbon monoxide	10 %
Sulphur dioxide	20 %
Nitrogen oxides	20 %
Dust	30 %

10. The validated hourly and daily average values shall be determined from the measured valid hourly average values after having subtracted the value of the confidence interval specified in point 9.

    Any day in which more than three hourly average values are invalid due to malfunction or maintenance of the automated measuring system shall be invalidated. If more than 10 days over a year are invalidated for such situations the competent authority shall require the operator to take adequate measures to improve the reliability of the automated measuring system.

11. In the case of plants which must comply with the rates of desulphurisation referred to in Article 31, the sulphur content of the fuel which is fired in the combustion plant shall also be regularly monitored. The competent authorities shall be informed of substantial changes in the type of fuel used.

PART 4

Assessment of compliance with emission limit values

1. In the case of continuous measurements, the emission limit values set out in Parts 1 and 2 shall be regarded as having been complied with if the evaluation of the measurement results indicates, for operating hours within a calendar year, that all of the following conditions have been met:

   (a) no validated monthly average value exceeds the relevant emission limit values set out in Parts 1 and 2;

   (b) no validated daily average value exceeds 110 % of the relevant emission limit values set out in Parts 1 and 2;

   (c) in cases of combustion plants composed only of boilers using coal with a total rated thermal input below 50 MW, no validated daily average value exceeds 150 % of the relevant emission limit values set out in Parts 1 and 2,

   (d) 95 % of all the validated hourly average values over the year do not exceed 200 % of the relevant emission limit values set out in Parts 1 and 2.

   The validated average values are determined as set out in point 10 of Part 3.

   For the purpose of the calculation of the average emission values, the values measured during the periods referred to in Article 30(5) and (6) and Article 37 as well as during the start-up and shut-down periods shall be disregarded.

2. Where continuous measurements are not required, the emission limit values set out in Parts 1 and 2 shall be regarded as having been complied with if the results of each of the series of measurements or of the other procedures defined and determined according to the rules laid down by the competent authorities do not exceed the emission limit values.

PART 5

Minimum rate of desulphurisation

1. Minimum rate of desulphurisation for combustion plants referred to in Article 30(2)

Total rated thermal input (MW)	Minimum rate of desulphurisation	
	Plants which were granted a permit before 27 November 2002 or the operators of which had submitted a complete application for a permit before that date, provided that the plant was put into operation no later than 27 November 2003	Other plants
50-100	80 %	92 %
100-300	90 %	92 %
> 300	96 % (¹)	96 %

Note:

(¹) For combustion plants firing oil shale, the minimum rate of desulphurisation is 95 %.

2. Minimum rate of desulphurisation for combustion plants referred to in Article 30(3)

Total rated thermal input (MW)	Minimum rate of desulphurisation
50-100	93 %
100-300	93 %
> 300	97 %

PART 6

Compliance with rate of desulphurisation

The minimum rates of desulphurisation set out in Part 5 of this Annex shall apply as a monthly average limit value.

PART 7

Average emission limit values for multi-fuel firing combustion plants within a refinery

Average emission limit values (mg/Nm^3) for SO_2 for multi-fuel firing combustion plants within a refinery, with the exception of gas turbines and gas engines, which use the distillation and conversion residues from the refining of crude-oil for own consumption, alone or with other fuels:

(a) for combustion plants which were granted a permit before 27 November 2002 or the operators of which had submitted a complete application for a permit before that date, provided that the plant was put into operation no later than 27 November 2003: 1 000 mg/Nm^3;

(b) for other combustion plants: 600 mg/Nm^3.

These emission limit values shall be calculated at a temperature of 273,15 K, a pressure of 101,3 kPa and after correction for the water vapour content of the waste gases and at a standardised O_2 content of 6 % for solid fuels and 3 % for liquid and gaseous fuels.

ANNEX VI

Technical provisions relating to waste incineration plants and waste co-incineration plants

PART 1

Definitions

For the purpose of this Annex the following definitions shall apply:

(a) 'existing waste incineration plant' means one of the following waste incineration plants:

  (i) which was in operation and had a permit in accordance with applicable Union law before 28 December 2002,

  (ii) which was authorised or registered for waste incineration and had a permit granted before 28 December 2002 in accordance with applicable Union law, provided that the plant was put into operation no later than 28 December 2003,

  (iii) which, in the view of the competent authority, was the subject of a full request for authorisation before 28 December 2002, provided that the plant was put into operation not later than 28 December 2004;

(b) 'new waste incineration plant' means any waste incineration plant not covered by point (a).

PART 2

Equivalence factors for dibenzo-p-dioxins and dibenzofurans

For the determination of the total concentration of dioxins and furans, the mass concentrations of the following dibenzo-p-dioxins and dibenzofurans shall be multiplied by the following equivalence factors before summing:

	Toxic equivalence factor
2,3,7,8 — Tetrachlorodibenzodioxin (TCDD)	1
1,2,3,7,8 — Pentachlorodibenzodioxin (PeCDD)	0,5
1,2,3,4,7,8 — Hexachlorodibenzodioxin (HxCDD)	0,1
1,2,3,6,7,8 — Hexachlorodibenzodioxin (HxCDD)	0,1
1,2,3,7,8,9 — Hexachlorodibenzodioxin (HxCDD)	0,1
1,2,3,4,6,7,8 — Heptachlorodibenzodioxin (HpCDD)	0,01
Octachlorodibenzodioxin (OCDD)	0,001
2,3,7,8 — Tetrachlorodibenzofuran (TCDF)	0,1
2,3,4,7,8 — Pentachlorodibenzofuran (PeCDF)	0,5
1,2,3,7,8 — Pentachlorodibenzofuran (PeCDF)	0,05
1,2,3,4,7,8 — Hexachlorodibenzofuran (HxCDF)	0,1
1,2,3,6,7,8 — Hexachlorodibenzofuran (HxCDF)	0,1
1,2,3,7,8,9 — Hexachlorodibenzofuran (HxCDF)	0,1
2,3,4,6,7,8 — Hexachlorodibenzofuran (HxCDF)	0,1
1,2,3,4,6,7,8 — Heptachlorodibenzofuran (HpCDF)	0,01
1,2,3,4,7,8,9 — Heptachlorodibenzofuran (HpCDF)	0,01
Octachlorodibenzofuran (OCDF)	0,001

PART 3

Air emission limit values for waste incineration plants

1. All emission limit values shall be calculated at a temperature of 273,15 K, a pressure of 101,3 kPa and after correcting for the water vapour content of the waste gases.

They are standardised at 11 % oxygen in waste gas except in case of incineration of mineral waste oil as defined in point 3 of Article 3 of Directive 2008/98/EC, when they are standardised at 3 % oxygen, and in the cases referred to in Point 2.7 of Part 6.

1.1. Daily average emission limit values for the following polluting substances (mg/Nm^3)

Total dust	10
Gaseous and vaporous organic substances, expressed as total organic carbon (TOC)	10
Hydrogen chloride (HCl)	10
Hydrogen fluoride (HF)	1
Sulphur dioxide (SO_2)	50
Nitrogen monoxide (NO) and nitrogen dioxide (NO_2), expressed as NO_2 for existing waste incineration plants with a nominal capacity exceeding 6 tonnes per hour or new waste incineration plants	200
Nitrogen monoxide (NO) and nitrogen dioxide (NO_2), expressed as NO_2 for existing waste incineration plants with a nominal capacity of 6 tonnes per hour or less	400

1.2. Half-hourly average emission limit values for the following polluting substances (mg/Nm^3)

	(100 %) A	(97 %) B
Total dust	30	10
Gaseous and vaporous organic substances, expressed as total organic carbon (TOC)	20	10
Hydrogen chloride (HCl)	60	10
Hydrogen fluoride (HF)	4	2
Sulphur dioxide (SO_2)	200	50
Nitrogen monoxide (NO) and nitrogen dioxide (NO_2), expressed as NO_2 for existing waste incineration plants with a nominal capacity exceeding 6 tonnes per hour or new waste incineration plants	400	200

1.3. Average emission limit values (mg/Nm^3) for the following heavy metals over a sampling period of a minimum of 30 minutes and a maximum of 8 hours

Cadmium and its compounds, expressed as cadmium (Cd)	Total: 0,05
Thallium and its compounds, expressed as thallium (Tl)	
Mercury and its compounds, expressed as mercury (Hg)	0,05
Antimony and its compounds, expressed as antimony (Sb)	Total: 0,5
Arsenic and its compounds, expressed as arsenic (As)	
Lead and its compounds, expressed as lead (Pb)	
Chromium and its compounds, expressed as chromium (Cr)	
Cobalt and its compounds, expressed as cobalt (Co)	
Copper and its compounds, expressed as copper (Cu)	
Manganese and its compounds, expressed as manganese (Mn)	
Nickel and its compounds, expressed as nickel (Ni)	
Vanadium and its compounds, expressed as vanadium (V)	

These average values cover also the gaseous and the vapour forms of the relevant heavy metal emissions as well as their compounds.

1.4. Average emission limit value (ng/Nm^3) for dioxins and furans over a sampling period of a minimum of 6 hours and a maximum of 8 hours. The emission limit value refers to the total concentration of dioxins and furans calculated in accordance with Part 2.

Dioxins and furans	0,1

1.5. Emission limit values (mg/Nm^3) for carbon monoxide (CO) in the waste gases:

(a) 50 as daily average value;

(b) 100 as half-hourly average value;

(c) 150 as 10-minute average value.

The competent authority may authorise exemptions from the emission limit values set out in this point for waste incineration plants using fluidised bed technology, provided that the permit sets an emission limit value for carbon monoxide (CO) of not more than 100 mg/Nm^3 as an hourly average value.

2. Emission limit values applicable in the circumstances described in Article 46(6) and Article 47.

The total dust concentration in the emissions into the air of a waste incineration plant shall under no circumstances exceed 150 mg/Nm^3 expressed as a half-hourly average. The air emission limit values for TOC and CO set out in points 1.2 and 1.5(b) shall not be exceeded.

3. Member States may lay down rules governing the exemptions provided for in this Part.

PART 4

Determination of air emission limit values for the co-incineration of waste

1. The following formula (mixing rule) shall be applied whenever a specific total emission limit value 'C' has not been set out in a table in this Part.

The emission limit value for each relevant polluting substance and CO in the waste gas resulting from the co-incineration of waste shall be calculated as follows:

$$\frac{V_{waste} \times C_{waste} + V_{proc} \times C_{proc}}{V_{waste} + C_{proc}} = C$$

V_{waste}: waste gas volume resulting from the incineration of waste only determined from the waste with the lowest calorific value specified in the permit and standardised at the conditions given by this Directive.

If the resulting heat release from the incineration of hazardous waste amounts to less than 10 % of the total heat released in the plant, V_{waste} must be calculated from a (notional) quantity of waste that, being incinerated, would equal 10 % heat release, the total heat release being fixed.

C_{waste}: emission limit values for waste incineration plants set out in Part 3

V_{proc}: waste gas volume resulting from the plant process including the combustion of the authorised fuels normally used in the plant (wastes excluded) determined on the basis of oxygen contents at which the emissions must be standardised as set out in Union or national law. In the absence of legislation for this kind of plant, the real oxygen content in the waste gas without being thinned by addition of air unnecessary for the process must be used.

C_{proc}: emission limit values as set out in this Part for certain industrial activities or in case of the absence of such values, emission limit values of plants which comply with the national laws, regulations and administrative provisions for such plants while burning the normally authorised fuels (wastes excluded). In the absence of these measures the emission limit values set out in the permit are used. In the absence of such permit values the real mass concentrations are used.

C: total emission limit values at an oxygen content as set out in this Part for certain industrial activities and certain polluting substances or, in case of the absence of such values, total emission limit values replacing the emission limit values as set out in specific Annexes of this Directive. The total oxygen content to replace the oxygen content for the standardisation is calculated on the basis of the content above respecting the partial volumes.

All emission limit values shall be calculated at a temperature of 273,15 K, a pressure of 101,3 kPa and after correcting for the water vapour content of the waste gases.

Member States may lay down rules governing the exemptions provided for in this Part.

2. Special provisions for cement kilns co-incinerating waste

2.1. The emission limit values set out in points 2.2 and 2.3 apply as daily average values for total dust, HCl, HF, NO_x, SO_2 and TOC (for continuous measurements), as average values over the sampling period of a minimum of 30 minutes and a maximum of 8 hours for heavy metals and as average values over the sampling period of a minimum of 6 hours and a maximum of 8 hours for dioxins and furans.

All values are standardised at 10 % oxygen.

Half-hourly average values shall only be needed in view of calculating the daily average values.

2.2. C – total emission limit values (mg/Nm^3 except for dioxins and furans) for the following –polluting substances

Polluting substance	C
Total dust	30
HCl	10
HF	1
NO_x	500 (1)
Cd + Tl	0,05
Hg	0,05
Sb + As + Pb + Cr + Co + Cu + Mn + Ni + V	0,5
Dioxins and furans (ng/Nm^3)	0,1

(1) Until 1 January 2016, the competent authority may authorise exemptions from the limit value for NO_x for Lepol kilns and long rotary kilns provided that the permit sets a total emission limit value for NO_x of not more than 800 mg/Nm^3.

2.3. C – total emission limit values (mg/Nm^3) for SO_2 and TOC

Pollutant	C
SO_2	50
TOC	10

The competent authority may grant derogations for emission limit values set out in this point in cases where TOC and SO_2 do not result from the co-incineration of waste.

2.4. C- total emission limit values for CO

The competent authority may set emission limit values for CO.

3. Special provisions for combustion plants co-incinerating waste

3.1. C_{proc} expressed as daily average values (mg/Nm^3) valid until the date set out in Article 82(5)

For determining the total rated thermal input of the combustion plants, the aggregation rules as defined in Article 29 shall apply. Half-hourly average values shall only be needed in view of calculating the daily average values.

C_{proc} for solid fuels with the exception of biomass (O_2 content 6 %):

Polluting substances	< 50 MWth	50-100 MWth	100 to 300 MWth	> 300 MWth
SO_2	—	850	200	200
NO_x	—	400	200	200
Dust	50	50	30	30

C_{proc} for biomass (O_2 content 6 %):

Polluting substances	< 50 MWth	50 to 100 MWth	100 to 300 MWth	> 300 MWth
SO_2	—	200	200	200
NO_x	—	350	300	200
Dust	50	50	30	30

C_{proc} for liquid fuels (O_2 content 3 %):

Polluting substances	< 50 MWth	50 to 100 MWth	100 to 300 MWth	> 300 MWth
SO_2	—	850	400 to 200 (linear decrease from 100 to 300 MWth)	200
NO_x	—	400	200	200
Dust	50	50	30	30

3.2. C_{proc} expressed as daily average values (mg/Nm^3) valid from the date set out in Article 82(6)

For determining the total rated thermal input of the combustion plants, the aggregation rules as defined in Article 29 shall apply. Half-hourly average values shall only be needed in view of calculating the daily average values.

3.2.1. C_{proc} for combustion plants referred to in Article 30(2), with the exception of gas turbines and gas engines

C_{proc} for solid fuels with the exception of biomass (O_2 content 6 %):

Polluting substance	< 50 MWth	50-100 MWth	100 to 300 MWth	> 300 MWth
SO_2	—	400 for peat: 300	200	200
NO_x	—	300 for pulverised lignite: 400	200	200
Dust	50	30	25 for peat: 20	20

C_{proc} for biomass (O_2 content 6 %):

Polluting substance	< 50 MWth	50 to 100 MWth	100 to 300 MWth	> 300 MWth
SO_2	—	200	200	200
NO_x	—	300	250	200
Dust	50	30	20	20

C_{proc} for liquid fuels (O_2 content 3 %):

Polluting substance	< 50 MWth	50 to 100 MWth	100 to 300 MWth	> 300 MWth
SO_2	—	350	250	200
NO_x	—	400	200	150
Dust	50	30	25	20

3.2.2. C_{proc} for combustion plants referred to in Article 30(3), with the exception of gas turbines and gas engines

C_{proc} for solid fuels with the exception of biomass (O_2 content 6 %):

Polluting substance	< 50 MWth	50-100 MWth	100 to 300 MWth	> 300 MWth
SO_2	—	400 for peat: 300	200 for peat: 300, except in the case of fluidised bed combustion: 250	150 for circulating or pressurised fluidised bed combustion or, in case of peat firing, for all fluidised bed combustion: 200
NO_x	—	300 for peat: 250	200	150 for pulverised lignite combustion: 200
Dust	50	20	20	10 for peat: 20

C_{proc} for biomass (O_2 content 6 %):

Polluting substance	< 50 MWth	50 to 100 MWth	100 to 300 MWth	> 300 MWth
SO_2	—	200	200	150
NO_x	—	250	200	150
Dust	50	20	20	20

C_{proc} for liquid fuels (O_2 content 3 %):

Polluting substance	< 50 MWth	50 to 100 MWth	100 to 300 MWth	> 300 MWth
SO_2	—	350	200	150
NO_x	—	300	150	100
Dust	50	20	20	10

3.3. C — total emission limit values for heavy metals (mg/Nm^3) expressed as average values over the sampling period of a minimum of 30 minutes and a maximum of 8 hours (O_2 content 6 % for solid fuels and 3 % for liquid fuels)

Polluting substances	C
Cd + Tl	0,05
Hg	0,05
Sb + As + Pb + Cr + Co + Cu + Mn + Ni + V	0,5

3.4. C — total emission limit value (ng/Nm^3) for dioxins and furans expressed as average value measured over the sampling period of a minimum of 6 hours and a maximum of 8 hours (O_2 content 6 % for solid fuels and 3 % for liquid fuels)

Polluting substance	C
Dioxins and furans	0,1

4. Special provisions for waste co-incineration plants in industrial sectors not covered under Points 2 and 3 of this Part

4.1. C — total emission limit value (ng/Nm^3) for dioxins and furans expressed as average value measured over the sampling period of a minimum of 6 hours and a maximum of 8 hours:

Polluting substance	C
Dioxins and furans	0,1

4.2. C – total emission limit values (mg/Nm^3) for heavy metals expressed as average values over the sampling period of a minimum of 30 minutes and a maximum of 8 hours:

Polluting substances	C
Cd + Tl	0,05
Hg	0,05

PART 5

Emission limit values for discharges of waste water from the cleaning of waste gases

Polluting substances	Emission limit values for unfiltered samples (mg/l except for dioxins and furans)	
1. Total suspended solids as defined in Annex I of Directive 91/271/EEC	(95 %) 30	(100 %) 45
2. Mercury and its compounds, expressed as mercury (Hg)	0,03	
3. Cadmium and its compounds, expressed as cadmium (Cd)	0,05	
4. Thallium and its compounds, expressed as thallium (Tl)	0,05	
5. Arsenic and its compounds, expressed as arsenic (As)	0,15	
6. Lead and its compounds, expressed as lead (Pb)	0,2	
7. Chromium and its compounds, expressed as chromium (Cr)	0,5	
8. Copper and its compounds, expressed as copper (Cu)	0,5	
9. Nickel and its compounds, expressed as nickel (Ni)	0,5	
10. Zinc and its compounds, expressed as zinc (Zn)	1,5	
11. Dioxins and furans	0,3 ng/l	

PART 6

Monitoring of emissions

1. Measurement techniques

1.1. Measurements for the determination of concentrations of air and water polluting substances shall be carried out representatively.

1.2. Sampling and analysis of all polluting substances including dioxins and furans as well as the quality assurance of automated measuring systems and the reference measurement methods to calibrate them shall be carried out according to CEN-standards. If CEN standards are not available, ISO, national or other international standards which ensure the provision of data of an equivalent scientific quality shall apply. Automated measuring systems shall be subject to control by means of parallel measurements with the reference methods at least once per year.

1.3. At the daily emission limit value level, the values of the 95 % confidence intervals of a single measured result shall not exceed the following percentages of the emission limit values:

Carbon monoxide:	10 %
Sulphur dioxide:	20 %
Nitrogen dioxide:	20 %
Total dust:	30 %
Total organic carbon:	30 %
Hydrogen chloride:	40 %
Hydrogen fluoride:	40 %.

Periodic measurements of the emissions into air and water shall be carried out in accordance with points 1.1 and 1.2.

2. Measurements relating to air polluting substances

2.1. The following measurements relating to air polluting substances shall be carried out:

(a) continuous measurements of the following substances: NO_x, provided that emission limit values are set, CO, total dust, TOC, HCl, HF, SO_2;

(b) continuous measurements of the following process operation parameters: temperature near the inner wall or at another representative point of the combustion chamber as authorised by the competent authority, concentration of oxygen, pressure, temperature and water vapour content of the waste gas;

(c) at least two measurements per year of heavy metals and dioxins and furans; one measurement at least every 3 months shall, however, be carried out for the first 12 months of operation.

2.2. The residence time as well as the minimum temperature and the oxygen content of the waste gases shall be subject to appropriate verification, at least once when the waste incineration plant or waste co-incineration plant is brought into service and under the most unfavourable operating conditions anticipated.

2.3. The continuous measurement of HF may be omitted if treatment stages for HCl are used which ensure that the emission limit value for HCl is not being exceeded. In that case the emissions of HF shall be subject to periodic measurements as laid down in point 2.1(c).

2.4. The continuous measurement of the water vapour content shall not be required if the sampled waste gas is dried before the emissions are analysed.

2.5. The competent authority may decide not to require continuous measurements for HCl, HF and SO_2 in waste incineration plants or waste co-incineration plants and require periodic measurements as set out in point 2.1(c) or no measurements if the operator can prove that the emissions of those pollutants can under no circumstances be higher than the prescribed emission limit values.

The competent authority may decide not to require continuous measurements for NO_x and require periodic measurements as set out in point 2.1(c) in existing waste incineration plants with a nominal capacity of less than 6 tonnes per hour or in existing waste co-incineration plants with a nominal capacity of less than 6 tonnes per hour if the operator can prove on the basis of information on the quality of the waste concerned, the technologies used and the results of the monitoring of emissions, that the emissions of NO_x can under no circumstances be higher than the prescribed emission limit value.

2.6. The competent authority may decide to require one measurement every 2 years for heavy metals and one measurement per year for dioxins and furans in the following cases:

(a) the emissions resulting from co-incineration or incineration of waste are under all circumstances below 50 % of the emission limit values;

(b) the waste to be co-incinerated or incinerated consists only of certain sorted combustible fractions of non-hazardous waste not suitable for recycling and presenting certain characteristics, and which is further specified on the basis of the assessment referred to in point (c);

(c) the operator can prove on the basis of information on the quality of the waste concerned and the monitoring of the emissions that the emissions are under all circumstances significantly below the emission limit values for heavy metals and dioxins and furans.

2.7. The results of the measurements shall be standardised using the standard oxygen concentrations mentioned in Part 3 or calculated according to Part 4 and by applying the formula given in Part 7.

When waste is incinerated or co-incinerated in an oxygen-enriched atmosphere, the results of the measurements can be standardised at an oxygen content laid down by the competent authority reflecting the special circumstances of the individual case.

When the emissions of polluting substances are reduced by waste gas treatment in a waste incineration plant or waste co-incineration plant treating hazardous waste, the standardisation with respect to the oxygen contents provided for in the first subparagraph shall be done only if the oxygen content measured over the same period as for the polluting substance concerned exceeds the relevant standard oxygen content.

3. Measurements relating to water polluting substances

3.1. The following measurements shall be carried out at the point of waste water discharge:

(a) continuous measurements of pH, temperature and flow;

(b) spot sample daily measurements of total suspended solids or measurements of a flow proportional representative sample over a period of 24 hours;

(c) at least monthly measurements of a flow proportional representative sample of the discharge over a period of 24 hours of Hg, Cd, TI, As, Pb, Cr, Cu, Ni and Zn;

(d) at least every 6 months measurements of dioxins and furans; however, one measurement at least every 3 months shall be carried out for the first 12 months of operation.

3.2. Where the waste water from the cleaning of waste gases is treated on site collectively with other on-site sources of waste water, the operator shall take the measurements:

(a) on the waste water stream from the waste gas cleaning processes prior to its input into the collective waste water treatment plant;

(b) on the other waste water stream or streams prior to its or their input into the collective waste water treatment plant;

(c) at the point of final waste water discharge, after the treatment, from the waste incineration plant or waste co-incineration plant.

PART 7

Formula to calculate the emission concentration at the standard percentage oxygen concentration

$$E_S = \frac{21 - O_S}{21 - O_M} \times E_M$$

E_S = calculated emission concentration at the standard percentage oxygen concentration

E_M = measured emission concentration

O_S = standard oxygen concentration

O_M = measured oxygen concentration

PART 8

Assessment of compliance with emission limit values

1. Air emission limit values

1.1. The emission limit values for air shall be regarded as being complied with if:

(a) none of the daily average values exceeds any of the emission limit values set out in point 1.1 of Part 3 or in Part 4 or calculated in accordance with Part 4;

(b) either none of the half-hourly average values exceeds any of the emission limit values set out in column A of the table under point 1.2 of Part 3 or, where relevant, 97 % of the half-hourly average values over the year do not exceed any of the emission limit values set out in column B of the table under point 1.2 of Part 3;

(c) none of the average values over the sampling period set out for heavy metals and dioxins and furans exceeds the emission limit values set out in points 1.3 and 1.4 of Part 3 or in Part 4 or calculated in accordance with Part 4;

(d) for carbon monoxide (CO):

(i) in case of waste incineration plants:

— at least 97 % of the daily average values over the year do not exceed the emission limit value set out in point 1.5(a) of Part 3; and,

— at least 95 % of all 10-minute average values taken in any 24-hour period or all of the half-hourly average values taken in the same period do not exceed the emission limit values set out in points 1.5(b) and (c) of Part 3; in case of waste incineration plants in which the gas resulting from the incineration process is raised to a temperature of at least 1 100 °C for at least two seconds, Member States may apply an evaluation period of 7 days for the 10-minute average values;

(ii) in case of waste co-incineration plants: the provisions of Part 4 are met.

1.2. The half-hourly average values and the 10-minute averages shall be determined within the effective operating time (excluding the start-up and shut-down periods if no waste is being incinerated) from the measured values after having subtracted the value of the confidence interval specified in point 1.3 of Part 6. The daily average values shall be determined from those validated average values.

To obtain a valid daily average value no more than five half-hourly average values in any day shall be discarded due to malfunction or maintenance of the continuous measurement system. No more than ten daily average values per year shall be discarded due to malfunction or maintenance of the continuous measurement system.

1.3. The average values over the sampling period and the average values in the case of periodical measurements of HF, HCl and SO_2 shall be determined in accordance with the requirements of Articles 45(1)(e), 48(3) and point 1 of Part 6.

2. Water emission limit values

The emission limit values for water shall be regarded as being complied with if:

(a) for total suspended solids 95 % and 100 % of the measured values do not exceed the respective emission limit values as set out in Part 5;

(b) for heavy metals (Hg, Cd, TI, As, Pb, Cr, Cu, Ni and Zn) no more than one measurement per year exceeds the emission limit values set out in Part 5; or, if the Member State provides for more than 20 samples per year, no more than 5 % of these samples exceed the emission limit values set out in Part 5;

(c) for dioxins and furans, the measurement results do not exceed the emission limit value set out in Part 5.

ANNEX VII

Technical provisions relating to installations and activities using organic solvents

PART 1

Activities

1. In each of the following points, the activity includes the cleaning of the equipment but not the cleaning of products unless specified otherwise.

2. Adhesive coating

   Any activity in which an adhesive is applied to a surface, with the exception of adhesive coating and laminating associated with printing activities.

3. Coating activity

   Any activity in which a single or multiple application of a continuous film of a coating is applied to:

   (a) either of the following vehicles:

      (i) new cars, defined as vehicles of category M1 in Directive 2007/46/EC of the European Parliament and of the Council of 5 September 2007 establishing a framework for the approval of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles (1) and of category N1 in so far as they are coated at the same installation as M1 vehicles;

      (ii) truck cabins, defined as the housing for the driver, and all integrated housing for the technical equipment, of vehicles of categories N2 and N3 in Directive 2007/46/EC;

      (iii) vans and trucks, defined as vehicles of categories N1, N2 and N3 in Directive 2007/46/EC, but not including truck cabins;

      (iv) buses, defined as vehicles of categories M2 and M3 in Directive 2007/46/EC;

      (v) trailers, defined in categories O1, O2, O3 and O4 in Directive 2007/46/EC;

   (b) metallic and plastic surfaces including surfaces of airplanes, ships, trains, etc.;

   (c) wooden surfaces;

   (d) textile, fabric, film and paper surfaces;

   (e) leather.

   Coating activities do not include the coating of substrate with metals by electrophoretic and chemical spraying techniques. If the coating activity includes a step in which the same article is printed by whatever technique used, that printing step is considered part of the coating activity. However, printing activities operated as a separate activity are not included, but may be covered by Chapter V of this Directive if the printing activity falls within the scope thereof.

4. Coil coating

   Any activity where coiled steel, stainless steel, coated steel, copper alloys or aluminium strip is coated with either a film forming or laminate coating in a continuous process.

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(1) OJ L 263, 9.10.2007, p. 1.

5. Dry cleaning

Any industrial or commercial activity using volatile organic compounds in an installation to clean garments, furnishing and similar consumer goods with the exception of the manual removal of stains and spots in the textile and clothing industry.

6. Footwear manufacture

Any activity of producing complete footwear or parts thereof.

7. Manufacturing of coating mixtures, varnishes, inks and adhesives

The manufacture of the above final products, and of intermediates where carried out at the same site, by mixing of pigments, resins and adhesive materials with organic solvent or other carrier, including dispersion and predispersion activities, viscosity and tint adjustments and operations for filling the final product into its container.

8. Manufacturing of pharmaceutical products

The chemical synthesis, fermentation, extraction, formulation and finishing of pharmaceutical products and, where carried out at the same site, the manufacture of intermediate products.

9. Printing

Any reproduction activity of text and/or images in which, with the use of an image carrier, ink is transferred onto whatever type of surface. It includes associated varnishing, coating and laminating techniques. However, only the following sub-processes are subject to Chapter V:

(a) flexography – a printing activity using an image carrier of rubber or elastic photopolymers on which the printing areas are above the non-printing areas, using liquid inks which dry through evaporation;

(b) heatset web offset – a web-fed printing activity using an image carrier in which the printing and non-printing area are in the same plane, where web-fed means that the material to be printed is fed to the machine from a reel as distinct from separate sheets. The non-printing area is treated to attract water and thus reject ink. The printing area is treated to receive and transmit ink to the surface to be printed. Evaporation takes place in an oven where hot air is used to heat the printed material;

(c) laminating associated to a printing activity – the adhering together of two or more flexible materials to produce laminates;

(d) publication rotogravure – a rotogravure printing activity used for printing paper for magazines, brochures, catalogues or similar products, using toluene-based inks;

(e) rotogravure – a printing activity using a cylindrical image carrier in which the printing area is below the non-printing area, using liquid inks which dry through evaporation. The recesses are filled with ink and the surplus is cleaned off the non-printing area before the surface to be printed contacts the cylinder and lifts the ink from the recesses;

(f) rotary screen printing – a web-fed printing activity in which the ink is passed onto the surface to be printed by forcing it through a porous image carrier, in which the printing area is open and the non-printing area is sealed off, using liquid inks which dry only through evaporation. Web-fed means that the material to be printed is fed into the machine from a reel as distinct from separate sheets;

(g) varnishing – an activity by which a varnish or an adhesive coating for the purpose of later sealing the packaging material is applied to a flexible material.

10. Rubber conversion

Any activity of mixing, milling, blending, calendering, extrusion and vulcanisation of natural or synthetic rubber and any ancillary operations for converting natural or synthetic rubber into a finished product.

11. Surface cleaning

Any activity except dry cleaning using organic solvents to remove contamination from the surface of material including degreasing. A cleaning activity consisting of more than one step before or after any other activity shall be considered as one surface cleaning activity. This activity does not refer to the cleaning of the equipment but to the cleaning of the surface of products.

12. Vegetable oil and animal fat extraction and vegetable oil refining activities

Any activity to extract vegetable oil from seeds and other vegetable matter, the processing of dry residues to produce animal feed, the purification of fats and vegetable oils derived from seeds, vegetable matter and/or animal matter.

13. Vehicle refinishing

Any industrial or commercial coating activity and associated degreasing activities performing either of the following:

(a) the original coating of road vehicles as defined in Directive 2007/46/EC or part of them with refinishing-type materials, where this is carried out away from the original manufacturing line;

(b) the coating of trailers (including semi-trailers) (category O in Directive 2007/46/EC).

14. Winding wire coating

Any coating activity of metallic conductors used for winding the coils in transformers and motors, etc.

15. Wood impregnation

Any activity giving a loading of preservative in timber.

16. Wood and plastic lamination

Any activity to adhere together wood and/or plastic to produce laminated products.

PART 2

Thresholds and emission limit values

The emission limit values in waste gases shall be calculated at a temperature of 273,15 K, and a pressure of 101,3 kPa.

	Activity (solvent consumption threshold in tonnes/year)	Threshold (solvent consumption threshold in tonnes/year)	Emission limit values in waste gases (mg C/Nm^3)	Fugitive emission limit values (percentage of solvent input)		Total emission limit values		Special provisions
				New installations	Existing installations	New installations	Existing installations	
1	Heatset web offset printing (> 15)	15—25 > 25	100 20	30 (1) 30 (1)				(1) Solvent residue in finished product is not to be considered as part of fugitive emissions.
2	Publication rotogravure (> 25)		75	10	15			
3	Other rotogravure, flexography, rotary screen printing, laminating or varnishing units (> 15) rotary screen printing on textile/cardboard (> 30)	15—25 > 25 > 30 (1)	100 100 100	25 20 20				(1) Threshold for rotary screen printing on textile and on cardboard.
4	Surface cleaning using compounds specified in Article 59(5). (> 1)	1—5 > 5	20 (1) 20 (1)	15 10				(1) Limit value refers to mass of compounds in mg/Nm^3, and not to total carbon.
5	Other surface cleaning (> 2)	2—10 > 10	75 (1) 75 (1)	20 (1) 15 (1)				(1) Installations which demonstrate to the competent authority that the average organic solvent content of all cleaning material used does not exceed 30 % by weight are exempt from application of these values.
6	Vehicle coating (< 15) and vehicle refinishing	> 0,5	50 (1)	25				(1) Compliance in accordance with point 2 of Part 8 shall be demonstrated based on 15 minute average measurements.
7	Coil coating (> 25)		50 (1)	5	10			(1) For installations which use techniques which allow reuse of recovered solvents, the emission limit value shall be 150.

	Activity (solvent consumption threshold in tonnes/year)	Threshold (solvent consumption threshold in tonnes/year)	Emission limit values in waste gases (mg C/Nm^3)	Fugitive emission limit values (percentage of solvent input)		Total emission limit values		Special provisions
				New installations	Existing installations	New installations	Existing installations	
8	Other coating, including metal, plastic, textile (5), fabric, film and paper coating (> 5)	5—15 > 15	100 (1) (4) 50/75 (2) (3) (4)	25 (4) 20 (4)				(1) Emission limit value applies to coating application and drying processes operated under contained conditions. (2) The first emission limit value applies to drying processes, the second to coating application processes. (3) For textile coating installations which use techniques which allow reuse of recovered solvents, the emission limit value applied to coating application and drying processes taken together shall be 150. (4) Coating activities which cannot be carried out under contained conditions (such as shipbuilding, aircraft painting) may be exempted from these values, in accordance with Article 59(3). (5) Rotary screen printing on textile is covered by activity No 3.
9	Winding wire coating (> 5)					10 g/kg (1) 5 g/kg (2)		(1) Applies for installations where average diameter of wire ≤ 0,1 mm. (2) Applies for all other installations.
10	Coating of wooden surfaces (> 15)	15—25 > 25	100 (1) 50/75 (2)	25 20				(1) Emission limit value applies to coating application and drying processes operated under contained conditions. (2) The first value applies to drying processes, the second to coating application processes.
11	Dry cleaning					20 g/kg (1) (2)		(1) Expressed in mass of solvent emitted per kilogram of product cleaned and dried. (2) The emission limit value in point 2 of Part 4 does not apply for this activity.

	Activity (solvent consumption threshold in tonnes/year)	Threshold (solvent consumption threshold in tonnes/year)	Emission limit values in waste gases (mg C/Nm^3)	Fugitive emission limit values (percentage of solvent input)		Total emission limit values		Special provisions
				New installations	Existing installations	New installations	Existing installations	
12	Wood impregnation (> 25)		100 (1)	45		11 kg/m^3		(1) Emission limit value does not apply for impregnation with creosote.
13	Coating of leather (> 10)	10—25 > 25 > 10 (1)				85 g/m^2 75 g/m^2 150 g/m^2		Emission limit values are expressed in grams of solvent emitted per m^2 of product produced. (1) For leather coating activities in furnishing and particular leather goods used as small consumer goods like bags, belts, wallets, etc.
14	Footwear manufacture (> 5)					25 g per pair		Total emission limit value is expressed in grams of solvent emitted per pair of complete footwear produced.
15	Wood and plastic lamination (> 5)					30 g/m^2		
16	Adhesive coating (> 5)	5—15 > 15	50 (1) 50 (1)	25 20				(1) If techniques are used which allow reuse of recovered solvent, the emission limit value in waste gases shall be 150.
17	Manufacture of coating mixture, varnishes, inks and adhesives (> 100)	100—1 000 > 1 000	150 150	5 3		5 % of solvent input 3 % of solvent input		The fugitive emission limit value does not include solvent sold as part of a coatings mixture in a sealed container.
18	Rubber conversion (> 15)		20 (1)	25 (2)		25 % of solvent input		(1) If techniques are used which allow reuse of recovered solvent, the emission limit value in waste gases shall be 150. (2) The fugitive emission limit value does not include solvent sold as part of products or mixtures in a sealed container.

	Activity (solvent consumption threshold in tonnes/year)	Threshold (solvent consumption threshold in tonnes/year)	Emission limit values in waste gases (mg C/Nm^3)	Fugitive emission limit values (percentage of solvent input)		Total emission limit values		Special provisions
				New installations	Existing installations	New installations	Existing installations	
19	Vegetable oil and animal fat extraction and vegetable oil refining activities (> 10)					Animal fat: 1,5 kg/tonne Castor: 3 kg/tonne Rape seed: 1 kg/tonne Sunflower seed: 1 kg/tonne Soya beans (normal crush): 0,8 kg/tonne Soya beans (white flakes): 1,2 kg/tonne Other seeds and other vegetable matter: 3 kg/tonne (1) 1,5 kg/tonne (2) 4 kg/tonne (3)		(1) Total emission limit values for installations processing individual batches of seeds and other vegetable matter should be set by the competent authority on a case-by-case basis, applying the best available techniques. (2) Applies to all fractionation processes excluding de-gumming (the removal of gums from the oil). (3) Applies to de-gumming.
20	Manufacturing of pharmaceutical products (> 50)		20 (1)	5 (2)	15 (2)	5 % of solvent input	15 % of solvent input	(1) If techniques are used which allow reuse of recovered solvent, the emission limit value in waste gases shall be 150. (2) The fugitive emission limit value does not include solvent sold as part of products or mixtures in a sealed container.

PART 3

Emission limit values for installations of the vehicle coating industry

1. The total emission limit values are expressed in terms of grams of organic solvent emitted in relation to the surface area of product in square metres and in kilograms of organic solvent emitted in relation to the car body.

2. The surface area of any product dealt with in the table under point 3 is defined as the surface area calculated from the total electrophoretic coating area, and the surface area of any parts that might be added in successive phases of the coating process which are coated with the same coatings as those used for the product in question, or the total surface area of the product coated in the installation.

   The surface of the electrophoretic coating area is calculated using the following formula:

$$\frac{2 \times \text{total weight of product shell}}{\text{average thickness of metal sheet} \times \text{density of metal sheet}}$$

   This method shall also be applied for other coated parts made out of sheets.

   Computer aided design or other equivalent methods shall be used to calculate the surface area of the other parts added, or the total surface area coated in the installation.

3. The total emission limit values in the table below refer to all process stages carried out at the same installation from electrophoretic coating, or any other kind of coating process, through to the final wax and polish of topcoating inclusive, as well as solvent used in cleaning of process equipment, including spray booths and other fixed equipment, both during and outside of production time.

Activity (solvent consumption threshold in tonnes/year)	Production threshold (refers to annual production of coated item)	Total emission limit value	
		New installations	Existing installations
Coating of new cars (> 15)	> 5 000	45 g/m^2 or 1,3 kg/body + 33 g/m^2	60 g/m^2 or 1,9 kg/body + 41 g/m^2
	≤ 5 000 monocoque or > 3 500 chassis-built	90 g/m^2 or 1,5 kg/body + 70 g/m^2	90 g/m^2 or 1,5 kg/body + 70 g/m^2
		Total emission limit value (g/m^2)	
Coating of new truck cabins (> 15)	≤ 5 000	65	85
	> 5 000	55	75
Coating of new vans and trucks (> 15)	≤ 2 500	90	120
	> 2 500	70	90
Coating of new buses (> 15)	≤ 2 000	210	290
	> 2 000	150	225

4. Vehicle coating installations below the solvent consumption thresholds mentioned in the table under point 3 shall meet the requirements for the vehicle refinishing sector set out in Part 2.

PART 4

Emission limit values relating to volatile organic compounds with specific risk phrases

1. For emissions of the volatile organic compounds referred to in Article 58 where the mass flow of the sum of the compounds causing the labelling referred to in that Article is greater than, or equal to, 10 g/h, an emission limit value of 2 mg/Nm^3 shall be complied with. The emission limit value refers to the mass sum of the individual compounds.

2. For emissions of halogenated volatile organic compounds which are assigned or need to carry the hazard statements H341 or H351, where the mass flow of the sum of the compounds causing the hazard statements H341 or H351 is greater than, or equal to, 100 g/h, an emission limit value of 20 mg/Nm^3 shall be complied with. The emission limit value refers to the mass sum of the individual compounds.

PART 5

Reduction scheme

1. The operator may use any reduction scheme, specially designed for his installation.

2. In the case of applying coatings, varnishes, adhesives or inks, the following scheme can be used. Where the following method is inappropriate, the competent authority may allow an operator to apply any alternative scheme achieving equivalent emission reductions to those achieved if the emission limit values of Parts 2 and 3 were to be applied. The design of the scheme shall take into account the following facts:

   (a) where substitutes containing little or no solvent are still under development, a time extension shall be given to the operator to implement his emission reduction plans;

   (b) the reference point for emission reductions should correspond as closely as possible to the emissions which would have resulted had no reduction action been taken.

3. The following scheme shall operate for installations for which a constant solid content of product can be assumed:

   (a) The annual reference emission is calculated as follows:

      (i) The total mass of solids in the quantity of coating and/or ink, varnish or adhesive consumed in a year is determined. Solids are all materials in coatings, inks, varnishes and adhesives that become solid once the water or the volatile organic compounds are evaporated.

      (ii) The annual reference emissions are calculated by multiplying the mass determined in (i) by the appropriate factor listed in the table below. Competent authorities may adjust these factors for individual installations to reflect documented increased efficiency in the use of solids.

Activity	Multiplication factor for use in item (a)(ii)
Rotogravure printing; flexography printing; laminating as part of a printing activity; varnishing as part of a printing activity; wood coating; coating of textiles, fabric film or paper; adhesive coating	4
Coil coating, vehicle refinishing	3
Food contact coating, aerospace coatings	2,33
Other coatings and rotary screen printing	1,5

   (b) The target emission is equal to the annual reference emission multiplied by a percentage equal to:

      (i) (the fugitive emission limit value + 15), for installations falling within item 6 and the lower threshold band of items 8 and 10 of Part 2,

      (ii) (the fugitive emission limit value + 5) for all other installations.

   (c) Compliance is achieved if the actual solvent emission determined from the solvent management plan is less than or equal to the target emission.

PART 6

Emission monitoring

1. Channels to which abatement equipment is connected, and which at the final point of discharge emit more than an average of 10 kg/h of total organic carbon, shall be monitored continuously for compliance.

2. In the other cases, Member States shall ensure that either continuous or periodic measurements are carried out. For periodic measurements at least three measurement values shall be obtained during each measurement exercise.

3. Measurements are not required in the case where end-of-pipe abatement equipment is not needed to comply with this Directive.

PART 7

Solvent management plan

1. Principles

The solvent management plan shall be used to:

(a) verify compliance as specified in Article 62;

(b) identify future reduction options;

(c) enable provision of information on solvent consumption, solvent emissions and compliance with the requirements of Chapter V to the public.

2. Definitions

The following definitions provide a framework for the mass balance exercise.

Inputs of organic solvents (I):

I1 The quantity of organic solvents or their quantity in mixtures purchased which are used as input into the process in the time frame over which the mass balance is being calculated.

I2 The quantity of organic solvents or their quantity in mixtures recovered and reused as solvent input into the process. The recycled solvent is counted every time it is used to carry out the activity.

Outputs of organic solvents (O):

O1 Emissions in waste gases.

O2 Organic solvents lost in water, taking into account waste water treatment when calculating O5.

O3 The quantity of organic solvents which remains as contamination or residue in products output from the process.

O4 Uncaptured emissions of organic solvents into air. This includes the general ventilation of rooms, where air is released to the outside environment via windows, doors, vents and similar openings.

O5 Organic solvents and/or organic compounds lost due to chemical or physical reactions (including those which are destroyed, by incineration or other waste gas or waste water treatments, or captured, as long as they are not counted under O6, O7 or O8).

O6 Organic solvents contained in collected waste.

O7 Organic solvents, or organic solvents contained in mixtures, which are sold or are intended to be sold as a commercially valuable product.

O8 Organic solvents contained in mixtures recovered for reuse but not as input into the process, as long as not counted under O7.

O9 Organic solvents released in other ways.

3. Use of the solvent management plan for verification of compliance.

The use made of the solvent management plan shall be determined by the particular requirement which is to be verified, as follows:

(a) verification of compliance with the reduction scheme as set out in Part 5, with a total emission limit value expressed in solvent emissions per unit product, or otherwise stated in Parts 2 and 3.

(i) for all activities using the reduction scheme as set out in Part 5, the solvent management plan shall be drawn up annually to determine the consumption (C). The consumption shall be calculated according to the following equation:

$$C = I1 - O8$$

A parallel exercise shall also be undertaken to determine solids used in coating in order to derive the annual reference emission and the target emission each year.

(ii) for assessing compliance with a total emission limit value expressed in solvent emissions per unit product or otherwise stated in Parts 2 and 3, the solvent management plan shall be drawn up annually to determine the emissions (E). The emissions shall be calculated according to the following equation:

$$E = F + O1$$

Where F is the fugitive emission as defined in point (b)(i). The emission figure shall then be divided by the relevant product parameter.

(iii) for assessing compliance with the requirements of point (b)(ii) of Article 59(6), the solvent management plan shall be drawn up annually to determine total emissions from all activities concerned, and that figure shall then be compared with the total emissions that would have resulted had the requirements of Parts 2, 3 and 5 been met for each activity separately.

(b) Determination of fugitive emissions for comparison with the fugitive emission limit values in Part 2:

(i) The fugitive emission shall be calculated according to one of the following equations;

$$F = I1 - O1 - O5 - O6 - O7 - O8$$

or

$$F = O2 + O3 + O4 + O9$$

F shall be determined either by direct measurement of the quantities or by an equivalent method or calculation, for instance by using the capture efficiency of the process.

The fugitive emission limit value is expressed as a proportion of the input, which shall be calculated according to the following equation:

$$I = I1 + I2$$

(ii) Determination of fugitive emissions shall be done by a short but comprehensive set of measurements and needs not be done again until the equipment is modified.

PART 8

Assessment of compliance with emission limit values in waste gases

1. In the case of continuous measurements the emission limit values shall be considered to be complied with if:

   (a) none of the arithmetic averages of all valid readings taken during any 24-hour period of operation of an installation or activity except start-up and shut-down operations and maintenance of equipment exceeds the emission limit values,

   (b) none of the hourly averages exceeds the emission limit values by more than a factor of 1,5.

2. In the case of periodic measurements the emission limit values shall be considered to be complied with if, in one monitoring exercise:

   (a) the average of all the measurement values does not exceed the emission limit values,

   (b) none of the hourly averages exceeds the emission limit value by more than a factor of 1,5.

3. Compliance with Part 4 shall be verified on the basis of the sum of the mass concentrations of the individual volatile organic compounds concerned. For all other cases, compliance shall be verified on the basis of the total mass of organic carbon emitted unless otherwise specified in Part 2.

4. Gas volumes may be added to the waste gas for cooling or dilution purposes where technically justified but shall not be considered when determining the mass concentration of the pollutant in the waste gas.

ANNEX VIII

Technical provisions relating to installations producing titanium dioxide

PART 1

Emission limit values for emissions into water

1. In case of installations using the sulphate process (as an annual average):

   550 kg of sulphate per tonne of titanium dioxide produced.

2. In case of installations using the chloride process (as an annual average):

   (a) 130 kg chloride per tonne of titanium dioxide produced using neutral rutile,

   (b) 228 kg chloride per tonne of titanium dioxide produced using synthetic rutile,

   (c) 330 kg chloride per tonne of titanium dioxide produced using slag. Installations discharging into salt water (estuarine, coastal, open sea) may be subject to an emission limit value of 450 kg chloride per tonne of titanium dioxide produced using slag.

3. For installations using the chloride process and using more than one type of ore, the emission limit values in point 2 shall apply in proportion to the quantity of the ores used.

PART 2

Emission limit values into air

1. The emission limit values which are expressed as concentrations in mass per cubic meter (Nm^3) shall be calculated at a temperature of 273,15 K, and a pressure of 101,3 kPa.

2. For dust: 50 mg/Nm^3 as an hourly average from major sources and 150 mg/Nm^3 as an hourly average from any other source.

3. For gaseous sulphur dioxide and trioxide discharged from digestion and calcination, including acid droplets calculated as SO_2 equivalent:

   (a) 6 kg per tonne of titanium dioxide produced as an annual average;

   (b) 500 mg/Nm^3 as an hourly average for plants for the concentration of waste acid.

4. For chlorine in the case of installations using the chloride process:

   (a) 5 mg/Nm^3 as a daily average;

   (b) 40 mg/Nm^3 at any time.

PART 3

Emission monitoring

The monitoring of emissions into air shall include at least the continuous monitoring of:

(a) gaseous sulphur dioxide and trioxide discharged from digestion and calcination from plants for the concentration of waste acid in installations using the sulphate process;

(b) chlorine from major sources within installations using the chloride process;

(c) dust from major sources.

ANNEX IX

PART A

Repealed Directives with their successive amendments

(referred to in Article 81)

Council Directive 78/176/EEC (OJ L 54, 25.2.1978, p. 19).	
Council Directive 83/29/EEC (OJ L 32, 3.2.1983, p. 28).	
Council Directive 91/692/EEC (OJ L 377, 31.12.1991, p. 48).	only Annex I, point (b)
Council Directive 82/883/EEC (OJ L 378, 31.12.1982, p. 1).	
Act of Accession of 1985	only Annex I, point X.1(o)
Act of Accession of 1994	only Annex I, point VIII.A.6
Council Regulation (EC) No 807/2003 (OJ L 122, 16.5.2003, p. 36).	only Annex III, point 34
Regulation (EC) No 219/2009 of the European Parliament and of the Council (OJ L 87, 31.3.2009, p. 109).	only Annex, point 3.1
Council Directive 92/112/EEC (OJ L 409, 31.12.1992, p. 11).	
Council Directive 1999/13/EC (OJ L 85, 29.3.1999, p. 1).	
Regulation (EC) No 1882/2003 of the European Parliament and of the Council (OJ L 284, 31.10.2003, p. 1).	only Annex I, point 17
Directive 2004/42/EC of the European Parliament and of the Council (OJ L 143, 30.4.2004, p. 87).	only Article 13(1)
Directive 2008/112/EC of the European Parliament and of the Council (OJ L 345, 23.12.2008, p. 68).	only Article 3
Directive 2000/76/EC of the European Parliament and of the Council (OJ L 332, 28.12.2000, p. 91).	
Regulation (EC) No 1137/2008 of the European Parliament and of the Council (OJ L 311, 21.11.2008, p. 1).	only Annex, point 4.8
Directive 2001/80/EC of the European Parliament and of the Council (OJ L 309, 27.11.2001, p. 1).	
Council Directive 2006/105/EC (OJ L 363, 20.12.2006, p. 368).	only Annex, part B, point 2
Directive 2009/31/EC of the European Parliament and of the Council (OJ L 140, 5.6.2009, p. 114).	only Article 33
Directive 2008/1/EC of the European Parliament and of the Council (OJ L 24, 29.1.2008, p. 8).	
Directive 2009/31/EC of the European Parliament and of the Council (OJ L 140, 5.6.2009, p. 114).	only Article 37

PART B

List of time-limits for transposition into national law and application

(referred to in Article 81)

Directive	Time-limit for transposition	Time-limit for application
78/176/EEC	25 February 1979	
82/883/EEC	31 December 1984	
92/112/EEC	15 June 1993	
1999/13/EC	1 April 2001	
2000/76/EC	28 December 2000	28 December 2002 28 December 2005
2001/80/EC	27 November 2002	27 November 2004
2003/35/EC	25 June 2005	
2003/87/EC	31 December 2003	
2008/1/EC	30 October 1999 (1)	30 October 1999 30 October 2007

(1) Directive 2008/1/EC is a codified version of Council Directive 96/61/EC of24 September 1996 concerning integrated pollution prevention and control (OJ L 257, 10.10.1996, p. 26) and the time-limits for transposition and application remain in force.

ANNEX X

Correlation Table

Directive 78/176/EEC	Directive 82/883/EEC	Directive 92/112/EEC	Directive 2008/1/EC	Directive 1999/13/EC	Directive 2000/76/EC	Directive 2001/80/EC	This Directive
Article 1(1)	Article 1	Article 1					Article 66
—	—	—	—	—	—	—	Article 2
Article 1(2), point (a)			Article 2(2)				Article 3(2)
Article 1(2), point (b)					Article 3(1)		Article 3(37)
Article 1(2), points (c), (d) and (e)							—
—	—	—	—	—	—	—	Article 66
Article 2							Article 67
Article 3							Article 11, points (d) and (e)
Article 4			Article 4	Article 3, introductory wording and (1)	Article 4(1)		Article 4(1), first subparagraph
Article 5							Article 11, points (d) and (e)
Article 6							Article 11, points (d) and (e)
Article 7(1)		Article 10					Article 70(1) and 70(2), first sentence
Article 7(2) and (3)							—
—	—	—	—	—	—	—	Article 70(2), second sentence and 70(3)
Article 8(1)							—
Article 8(2)							Article 26(1), second subparagraph
Article 9							—
Article 10							—
Article 11							Article 12
Article 12							—

Directive 78/176/EEC	Directive 82/883/EEC	Directive 92/112/EEC	Directive 2008/1/EC	Directive 1999/13/EC	Directive 2000/76/EC	Directive 2001/80/EC	This Directive
Article 13(1)			Article 17(1), first subparagraph and 17(3), first subparagraph, first sentence	Article 11(1), first sentence and 11(2)			Article 72(1), first sentence
—	—	—	—	—	—	—	Article 72(1), second sentence
Article 13(2), (3) and (4)							—
Article 14							—
Article 15	Article 14	Article 12	Article 21	Article 15	Article 21	Article 18(1) and (3)	Article 80
Article 16	Article 15	Article 13	Article 23	Article 17	Article 23	Article 20	Article 84
Annex I							—
Annex II section A introductory wording and point 1							—
Annex II section A point 2							—
Annex II section B							—
	Article 2						—
	Article 3						—
	Article 4(1) and 4(2), first subparagraph						—
	Article 4(2), second subparagraph						—
	Article 4(3) and (4)						—
	Article 5						—
	Article 6						—
	Article 7						—
	Article 8						—
	Article 9						—
	Article 10						—

Directive 78/176/EEC	Directive 82/883/EEC	Directive 92/112/EEC	Directive 2008/1/EC	Directive 1999/13/EC	Directive 2000/76/EC	Directive 2001/80/EC	This Directive
	Article 11(1)			Article 13(1)	Article 17(1)		Article 75(1)
—	—	—	—	—	—	—	Article 75(2)
	Article 11(2)				Article 17(2)		—
	Article 11(3)						—
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		Article 2(1), introductory wording					—
		Article 2(1)(a), introductory wording					—
		Article 2(1)(a), first indent					Article 67, point (a)
		Article 2(1)(a), second indent					Article 67, point (b)
		Article 2(1)(a), third indent and 2(1)(b), third indent					Article 67, point (d)
		Article 2(1)(a), fourth, fifth, sixth and seventh indent					—

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		Article 2(1)(b), introductory wording and first, fourth, fifth, sixth and seventh indent					—
		Article 2(1)(b), second indent					Article 67, point (c)
		Article 2(1)(c)					—
		Article 2(2)					—
		Article 3					Article 67
		Article 4					Article 67
		Article 5					—
		Article 6, first paragraph, introductory wording					Article 68
		Article 6, first paragraph, point (a)					Annex VIII, Part 1, point 1
		Article 6, first paragraph, point (b)					Annex VIII, Part 1, point 2
		Article 6, second paragraph					Annex VIII, Part 1, point 3
		Article 7					—
		Article 8					—
		Article 9(1) introductory wording					Article 69(2)
		Article 9(1)(a), introductory wording					—
		Article 9(1)(a)(i)					Annex VIII, Part 2, point 2
		Article 9(1)(a)(ii)					Annex VIII, Part 2, point 3, introductory wording, and point 3(a)

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		Article 9(1)(a)(iii)					Article 69(1)
		Article 9(1)(a)(iv)					Annex VIII, Part 2, point 3(b)
		Article 9(1)(a)(v)					—
		Article 9(1)(b)					Annex VIII, Part 2, point 4
		Article 9(2) and (3)					—
		Article 11					Article 11, points (d) and (e)
		Annex					—
			Article 1				Article 1
			Article 2, introductory wording				Article 3, introductory wording
			Article 2(1)	Article 2(14)			Article 3(1)
			Article 2(3)	Article 2(1)			Article 3(3)
			Article 2(4)				—
			Article 2(5)	Article 2(9)	Article 3(8)	Article 2(1)	Article 3(4)
			Article 2(6), first sentence	Article 2(13)	Article 3(9)	Article 2(3), first part	Article 3(5)
			Article 2(6), second sentence				Article 15(1)
			Article 2(7)				Article 3(6)
			Article 2(8)	Article 2(5)			Article 71
			Article 2(9), first sentence	Article 2(7)	Article 3(12)		Article 3(7)
			Article 2(9), second sentence				Article 4(2), first subparagraph
—	—	—	—	—	—	—	Article 4(2), second subparagraph
—	—	—	—	—	—	—	Article 4(3)

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			Article 2(10)				—
—	—	—	—	—	—	—	Article 3(8)
			Article 2(11), first sentence				Article 3(9)
			Article 2(11), second sentence				Article 20(3)
			Article 2(12), first subparagraph and Annex IV, introductory wording				Article 3(10)
			Article 2(12), second subparagraph				Articles 14(5), point (a) and 14(6)
			Article 2(13)	Article 2(6)	Article 3(11)	Article 2(5)	Article 3(15)
			Article 2(14)				Article 3(16)
			Article 2(15)				Article 3(17)
—	—	—	—	—	—	—	Article 3(11) to (14), (18) to (23), (26) to (30) and (34) to (36)
			Article 3(1), introductory wording				Article 11, introductory wording
			Article 3(1), point (a)				Article 11, points (a) and (b)
			Article 3(1), point (b)				Article 11, point (c)
			Article 3(1), point (c)				Article 11, points (d) and (e)
			Article 3(1), point (d)				Article 11, point (f)
			Article 3(1), point (e)				Article 11, point (g)
			Article 3(1), point (f)				Article 11, point (h)
			Article 3(2)				—
			Article 5(1)				—

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			Article 5(2)				Article 80(1), second subparagraph
			Article 6(1), introductory wording				Article 12(1), first subparagraph, introductory wording
			Article 6(1), first subparagraph, points (a) to (d)				Article 12(1), first subparagraph, points (a) to (d)
—	—	—	—	—	—	—	Article 12(1), first subparagraph, point (e)
			Article 6(1), first subparagraph, point (e)				Article 12(1), first subparagraph, point (f)
			Article 6(1), first subparagraph, point (f)				Article 12(1), first subparagraph, point (g)
			Article 6(1), first subparagraph, point (g)				Article 12(1), first subparagraph, point (h)
			Article 6(1), first subparagraph, point (h)				Article 12(1), first subparagraph, point (i)
			Article 6(1), first subparagraph, point (i)				Article 12(1), first subparagraph, point (j)
			Article 6(1), first subparagraph, point (j)				Article 12(1), first subparagraph, point (k)
			Article 6(1), second subparagraph				Article 12(1), second subparagraph
			Article 6(2)				Article 12(2)
			Article 7				Article 5(2)
			Article 8, first paragraph		Article 4(3)		Article 5(1)
			Article 8, second paragraph				—
			Article 9(1), first part of sentence				Article 14(1), first subparagraph

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			Article 9(1), second part of sentence				—
			Article 9(2)				Article 5(3)
			Article 9(3), first subparagraph, first and second sentence				Article 14(1), second subparagraph, introductory wording and points (a) and (b)
			Article 9(3), first subparagraph, third sentence				Article 14(2)
—	—	—	—	—	—	—	Article 14(3), (4), and (7)
—	—	—	—	—	—	—	Article 14(5), introductory wording and point (b) of first subparagraph and Article 14(5), second subparagraph
			Article 9(3), second subparagraph				—
			Article 9(3), third subparagraph				Article 9(1)
			Article 9(3), fourth subparagraph				Article 9(2)
			Article 9(3), fifth subparagraph				Article 9(3)
			Article 9(3), sixth subparagraph				Article 9(4)
—	—	—	—	—	—	—	Article 10
			Article 9(4), first part of first sentence				Article 15(2)
			Article 9(4), second part of first sentence				Article 15(4), first subparagraph
—	—	—	—	—	—	—	Article 15(4), second to fifth subparagraphs and Article 15(5)

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			Article 9(4), second sentence				Article 14(1), second subparagraph, point (g)
—	—	—	—	—	—	—	Article 14(1), second subparagraph, point (h)
—	—	—	—	—	—	—	Article 15(3)
—	—	—	—	—	—	—	Article 16
			Article 9(5), first subparagraph				Article 14(1), second subparagraph, point (c)(i)
—	—	—	—	—	—	—	Article 14(1), second subparagraph, point (c)(ii)
—	—	—	—	—	—	—	Article 14(1), second subparagraph, point (d)
			Article 9(5), second subparagraph				—
—	—	—	—	—	—	—	Article 14(1), second subparagraph, point (e)
			Article 9(6), first subparagraph				Article 14(1), second subparagraph, point (f)
			Article 9(6), second subparagraph				—
			Article 9(7)				—
			Article 9(8)				Article 6 and Article 17(1)
—	—	—	—	—	—	—	Article 17(2), (3) and (4)
			Article 10				Article 18
			Article 11				Article 19
			Article 12(1)				Article 20(1)
			Article 12(2), first sentence				Article 20(2), first subparagraph
			Article 12(2), second sentence				Article 20(2), second subparagraph
			Article 12(2), third sentence				—

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			Article 13(1)				Article 21(1)
—	—	—	—	—	—	—	Article 21(2), (3) and (4)
			Article 13(2), introductory wording				Article 21(5), introductory wording
			Article 13(2)(a)				Article 21(5), point (a)
			Article 13(2)(b)				—
			Article 13(2)(c)				Article 21(5), point (b)
			Article 13(2)(d)				—
—	—	—	—	—	—	—	Article 21(5), point (c)
—	—	—	—	—	—	—	Article 22
—	—	—	—	—	—	—	Article 23(1), first subparagraph
			Article 14, introductory wording and point (a)				Article 8(1)
			Article 14, point (b)				Article 7, point (a) and Article 14(1), point (d)(i)
—	—	—	—	—	—	—	Article 7, introductory wording and points (b) and (c)
—	—	—	—	—	—	—	Article 14(1), point (d)(ii)
			Article 14, point (c)				Article 23(1), second subparagraph
—	—	—	—	—	—	—	Article 23(2) to (6)
			Article 15(1), first subparagraph, introductory wording and points (a) and (b)	Article 12(1), first subparagraph			Article 24(1), first subparagraph, introductory wording and points (a) and (b)
			Article 15(1), first subparagraph, point (c)				Article 24(1), first subparagraph, point (c)

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			Article 15(1), second subparagraph				Article 24(1), second subparagraph
			Article 15(2)				Article 24(3)(b)
			Article 15(3)				Article 24(4)
			Article 15(4)				Article 24(2), introductory wording and points (a) and (b)
—	—	—	—	—	—	—	Article 24(2), points (c) to (f) and Article 24(3), introductory wording and point (a)
			Article 16				Article 25
			Article 17(1), second subparagraph				—
			Article 17(2), first subparagraph				Article 13(1)
—	—	—	—	—	—	—	Article 13(2) to (7)
			Article 17(2), second subparagraph				—
			Article 17(3), first subparagraph, second and third sentence	Article 11(1), second sentence			Article 72(2)
			Article 17(3), first subparagraph, fourth sentence				—
—	—	—	—	—	—	—	Article 72(3) and (4)
			Article 17(3), second subparagraph				—
			Article 17(3), third subparagraph	Article 11(3)			Article 73(1)
—	—	—	—	—	—	—	Article 73(2)
			Article 17(4)				—
—	—	—	—	—	—	—	Article 74
—	—	—	—	—	—	—	Article 27
			Article 18			Article 11	Article 26
			Article 19				—

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			Article 20				—
			Article 21				Article 80(2)
			Article 22		Article 18	Article 17	Article 81
—	—	—	—	—	—	—	Article 82
			Article 23	Article 16	Article 22	Article 19	Article 83
—	—	—	—	—	—	—	Article 2(1)
			Annex I, paragraph 1 of introductory wording				Article 2(2)
			Annex I, paragraph 2 of introductory wording				Annex I, first subparagraph of introductory wording, first sentence
—	—	—	—	—	—	—	Annex I, first subparagraph of introductory wording, second sentence
—	—	—	—	—	—	—	Annex I, second subparagraph of introductory wording
			Annex I, points 1.1 to 1.3				Annex I, points 1.1 to 1.3
			Annex I, point 1.4				Annex I, point 1.4(a)
—	—	—	—	—	—	—	Annex I, point 1.4(b)
			Annex I, point 2				Annex I, point 2
			Annex I, point 3.1				Annex I, point 3.1(a) and (b)
—	—	—	—	—	—	—	Annex I, point 3.1(c)
			Annex I, points 3.2 to 3.5				Annex I, points 3.2 to 3.5
			Annex I, point 4				Annex I, point 4
			Annex I, point 5, introductory wording				—
			Annex I, point 5.1				Annex I, points 5.1(b), (f), (g), (i), (j) and 5.2(b)
—	—	—	—	—	—	—	Annex I, points 5.1(a), (c), (d), (e), (h), (k)

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			Annex I, point 5.2				Annex I, point 5.2(a)
			Annex I, point 5.3				Annex I, point 5.3(a)(i) and (ii)
—	—	—	—	—	—	—	Annex I, point 5.3(a)(iii) to (v) and 5.3(b)
			Annex I, point 5.4				Annex I, point 5.4
—	—	—	—	—	—	—	Annex I, points 5.5 and 5.6
			Annex I, points 6.1(a) and (b)				Annex I, points 6.1(a) and (b)
—	—	—	—	—	—	—	Annex I, point 6.1(c)
			Annex I, points 6.2 – 6.4(b)				Annex I, points 6.2 – 6.4(b)(ii)
—	—	—	—	—	—	—	Annex I, point 6.4 (b)(iii)
			Annex I, points 6.4(c) – 6.9				Annex I, points 6.4(c) – 6.9
—	—	—	—	—	—	—	Annex I, points 6.10 and 6.11
			Annex II				—
			Annex III				Annex II, ‘Air’, and ‘Water’, points 1 to 12
—	—	—	—	—	—	—	Annex II, ‘Water’, point 13
			Annex IV				Annex III
			Annex V				Annex IV
				Article 1			Article 56
				Article 2(2)			Article 57(1)

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				Article 2(3)			—
				Article 2(4)			Article 63(1)
				Article 2(8)			Article 4(1), third subparagraph
				Article 2(10)			Article 57(3)
				Article 2(11)			Article 57(2)
				Article 2(12)			Article 57(4)
				Article 2(15)			Article 57(5)
				Article 2(16)			Article 3(44)
				Article 2(17)			Article 3(45)
				Article 2(18)			Article 3(46)
				Article 2(19)			—
				Article 2(20)			Article 3(47)
				Article 2(21)			Article 57(6)
				Article 2(22)			Article 57(7)
				Article 2(23)			Article 57(8)
				Article 2(24)			Article 57(9)
				Article 2(25)			Article 57(10)
				Article 2(26)			Article 57(11)
				Article 2(27)			—
				Article 2(28)			Article 63(1)
				Article 2(29)			—
				Article 2(30)			Article 57(12)
				Article 2(31)			Annex VII, Part 2, first sentence Annex VIII, Part 2, point 1
				Article 2(32)			—
				Article 2(33)			Article 57(13)
				Article 3(2)			Article 4(1), second subparagraph

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				Article 4(1), (2) and(3)			Article 4(1), first and second subparagraph
				Article 4(4)			Article 63(2)
				Article 5(1)			Article 59(1), first subparagraph, introductory wording
				Article 5(2)			Article 59(1) first subparagraph, points (a) and (b)
				Article 5(3), first subparagraph, point (a)			Article 59(2)
				Article 5(3), first subparagraph, point (b)			Article 59(3)
				Article 5(3), second subparagraph			Article 59(4)
—	—	—	—	—	—	—	Article 59(5)
				Article 5(4)			—
				Article 5(5)			Article 59(6)
				Article 5(6)			Article 58
				Article 5(7)			Annex VII, Part 4, point 1
				Article 5(8) first subparagraph			Annex VII, Part 4, point 2
				Article 5(8) second subparagraph			—
				Article 5(9)			—
				Article 5(10)			Article 59(7)
				Article 5(11), (12) and (13)			—
				Article 6			—
				Article 7(1), introductory wording and first, second, third and fourth indent			Article 64

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				Article 7(1), closing wording			—
				Article 7(2)			—
				Article 8(1)			Article 14(1), point (d), Article 60
—	—	—	—	—	—	—	Article 61
				Article 8(2)			Annex VII, Part 6, point 1
				Article 8(3)			Annex VII, Part 6, point 2
				Article 8(4)			Annex VII Part 6, point 3
				Article 8(5)			—
				Article 9(1), first subparagraph, introductory wording			Article 62, first subparagraph, introductory wording
				Article 9(1), first subparagraph, first, second and third indent			Article 62, first subparagraph, points (a), (b) and (c)
				Article 9(1), second subparagraph			Article 62, second subparagraph
				Article 9(1), third subparagraph			Annex VII, Part 8, point 4
				Article 9(2)			Article 63(3)
				Article 9(3)			Annex VII, Part 8, point 1
				Article 9(4)			Annex VII, Part 8, point 2
				Article 9(5)			Annex VII, Part 8, point 3
				Article 10	Article 4(9)		Article 8(2)
				Article 11(1), third to sixth sentences			—
				Article 12(1), second subparagraph			Article 65(1), first subparagraph
				Article 12(1), third subparagraph			Article 65(1), second subparagraph
				Article 12(2)			Article 65(2)

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				Article 12(3)			Article 65(3)
				Article 13(2) and (3)			—
				Article 14	Article 19	Article 16	Article 79
				Annex I, first and second sentence of introductory wording			Article 56
				Annex I, third sentence of introductory wording and list of activities			Annex VII, Part 1
				Annex IIA			Annex VII, Parts 2 and 3
				Annex IIA, Part II, last sentence of paragraph 6			—
				Annex IIB, point 1, first and second sentences			Article 59(1), first subparagraph, point (b)
				Annex IIB, point 1, third sentence			Article 59(1), second subparagraph
				Annex IIB, point 2			Annex VII, Part 5
				Annex IIB, point 2, second subparagraph (i) and table			—
				Annex III, point 1			—
				Annex III, point 2			Annex VII, Part 7, point 1
				Annex III, point 3			Annex VII, Part 7, point 2
				Annex III, point 4			Annex VII, Part 7, point 3
					Article 1, first paragraph		Article 42
					Article 1, second paragraph		—
					Article 2(1)		Article 42(1), first subparagraph

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—	—	—	—	—	—	—	Article 42(1), second to fifth subparagraphs
					Article 2(2), introductory wording		Article 42(2), introductory wording
					Article 2(2)(a), introductory wording		Article 42(2)(a), introductory wording
					Article 2(2)(a), points (i) to (v)		Article 42(2)(a), point (i)
					Article 2(2)(a), point (vi)		Article 42(2)(a), point (ii)
					Article 2(2)(a), point (vii)		Article 42(2)(a), point (iii)
					Article 2(2)(a), point (viii)		Article 42(2)(a), point (iv)
					Article 2(2)(b)		Article 42(2)(b)
					Article 3(2), first subparagraph		Article 3(38)
					Article 3(2), second subparagraph		—
					Article 3(3)		Article 3(39)
					Article 3(4), first subparagraph		Article 3(40)
					Article 3(4), second subparagraph		Article 42(1), third subparagraph
—	—	—	—	—	—	—	Article 42(1), fourth subparagraph
					Article 3(5), first subparagraph		Article 3(41)
					Article 3(5), second subparagraph		Article 42(1), fifth subparagraph
					Article 3(5), third subparagraph		Article 42(1), third subparagraph

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					Article 3(6)		Annex VI, Part 1, point (a)
					Article 3(7)		Article 3(42)
—	—	—	—	—	—	—	Annex VI, Part 1, point (b)
					Article 3(10)		Article 3(43)
					Article 3(13)		Article 43
					Article 4(2)		Article 44
					Article 4(4), introductory wording and points (a) and (b)		Article 45(1), introductory wording and points (a) and (b)
					Article 4(4), point (c)		Article 45(1), point (e)
					Article 4(5)		Article 45(2)
					Article 4(6)		Article 45(3)
					Article 4(7)		Article 45(4)
					Article 4(8)		Article 54
					Article 5		Article 52
					Article 6(1), first subparagraph		Article 50(1)
					Article 6(1), second subparagraph and 6(2)		Article 50(2)
					Article 6(1), third subparagraph		Article 50(3), first subparagraph
					Article 6(1), first part of fourth subparagraph		—
					Article 6(1), second part of fourth subparagraph		Article 50(3), second subparagraph
					Article 6(3)		Article 50(4)
					Article 6(4), first and second sentences of first subparagraph and Article 6(4), first and second sentences of second subparagraph		Article 51(1)

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					Article 6(4), third sentence of first subparagraph		Article 51(2)
—	—	—	—	—	Article 6(4), third sentence of second subparagraph	—	Article 51(3), first subparagraph
					Article 6(4), third subparagraph		Article 51(3), second subparagraph
					Article 6(4), fourth subparagraph		Article 51(4)
					Article 6(5), first part of sentence		—
					Article 6(5), second part of the sentence		Article 46(1)
					Article 6(6)		Article 50(5)
					Article 6(7)		Article 50(6)
					Article 6(8)		Article 50(7)
					Article 7(1) and Article 7(2), first subparagraph		Article 46(2), first subparagraph
					Article 7(2), second subparagraph		Article 46(2), second subparagraph
					Article 7(3) and Article 11(8), first subparagraph, introductory wording		Annex VI, Part 6, first part of point 2.7
					Article 7(4)		Article 46(2), second subparagraph
					Article 7(5)		—
					Article 8(1)		Article 45(1), point (c)
					Article 8(2)		Article 46(3)
					Article 8(3)		—
					Article 8(4), first subparagraph		Article 46(4), first subparagraph

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					Article 8(4), second subparagraph		Annex VI, Part 6, point 3.2
					Article 8(4), third subparagraph		—
					Article 8(4), fourth subparagraph		—
					Article 8(5)		Article 46(4), second and third subparagraph
					Article 8(6)		Article 45(1), points (c) and (d)
					Article 8(7)		Article 46(5)
					Article 8(8)		—
					Article 9, first subparagraph		Article 53(1)
					Article 9, second subparagraph		Article 53(2)
					Article 9, third subparagraph		Article 53(3)
					Article 10(1) and (2)		—
					Article 10(3), first sentence		Article 48(2)
					Article 10(3), second sentence		—
					Article 10(4)		Article 48(3)
					Article 10(5)		Annex VI, Part 6, second part of point 1.3
					Article 11(1)		Article 48(1)
					Article 11(2)		Annex VI, Part 6, point 2.1
					Article 11(3)		Annex VI, Part 6, point 2.2
					Article 11(4)		Annex VI, Part 6, point 2.3
					Article 11(5)		Annex VI, Part 6, point 2.4

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					Article 11(6)		Annex VI, Part 6, point 2.5, first subparagraph
—	—	—	—	—	—	—	Annex VI, Part 6, point 2.5, second subparagraph
					Article 11(7), first part of first sentence of first subparagraph		Annex VI, Part 6, point 2.6, introductory wording
					Article 11(7), second part of first sentence of first subparagraph		Annex VI, Part 6, point 2.6(a)
					Article 11(7), second sentence of first subparagraph		—
					Article 11(7), second subparagraph		—
					Article 11(7), point (a)		Annex VI, Part 6, point 2.6(b)
					Article 11(7), points (b) and (c)		—
					Article 11(7), point (d)		Annex VI, Part 6, point 2.6(c)
					Article 11(7), points (e) and (f)		—
					Article 11(8), first subparagraph, points (a) and (b)		Annex VI, Part 3, point 1
					Article 11(8), first subparagraph, point (c) and second subparagraph		Annex VI, Part 6, second subparagraph of point 2.7
					Article 11(8), first subparagraph, point (d)		Annex VI, Part 4, point 2.1, second subparagraph
					Article 11(9)		Article 48(4)
					Article 11(10)		Annex VI, Part 8, point 1.1
					Article 11(11)		Annex VI, Part 8, point 1.2
					Article 11(12)		Annex VI, Part 8, point 1.3

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					Article 11(13)		Article 48(5)
—	—	—	—	—	—	—	Article 49
					Article 11(14)		Annex VI, Part 6, point 3.1
					Article 11(15)		Article 45(1), point (e)
					Article 11(16)		Annex VI, Part 8, point 2
					Article 11(17)		Article 8(2), point (a)
					Article 12(1)		Article 55(1)
					Article 12(2), first and second sentence		Article 55(2)
					Article 12(2), third sentence		Article 55(3)
					Article 13(1)		Article 45(1), point (f)
					Article 13(2)		Article 47
					Article 13(3)		Article 46(6)
					Article 13(4)		Annex VI, Part 3, point 2
					Article 14		—
					Article 15		—
					Article 16		—
					Article 20		—
					Annex I		Annex VI, Part 2
					Annex II, first part (without numbering)		Annex VI, Part 4, point 1
					Annex II, point 1, introductory wording		Annex VI, Part 4, point 2.1
					Annex II, points 1.1 and 1.2		Annex VI, Part 4, points 2.2 and 2.3
—	—	—	—	—	—	—	Annex VI, Part 4, point 2.4
					Annex II, point 1.3		—
					Annex II, point 2.1		Annex VI, Part 4, point 3.1

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—	—	—	—	—	—	—	Annex VI, Part 4, point 3.2
					Annex II, point 2.2		Annex VI, Part 4, point 3.3 and 3.4
					Annex II, point 3		Annex VI, Part 4, point 4
					Annex III		Annex VI, Part 6, point 1
					Annex IV, table		Annex VI, Part 5
					Annex IV, final sentence		—
					Annex V, point (a), table		Annex VI, Part 3, point 1.1
					Annex V, point (a), final sentences		—
					Annex V, point (b), table		Annex VI, Part 3, point 1.2
					Annex V, point (b), final sentence		—
					Annex V, point (c)		Annex VI, Part 3, point 1.3
					Annex V, point (d)		Annex VI, Part 3, point 1.4
					Annex V, point (e)		Annex VI, Part 3, point 1.5
					Annex V, point (f)		Annex VI, Part 3, point 3
					Annex VI		Annex VI, Part 7
						Article 1	Article 28, first subparagraph
						Article 2(2)	Annex V, Part 1, point 1 and Part 2, point 1, first subparagraph
—	—	—	—	—	—	—	Annex V, Part 1, point 1 and Part 2, point 1, second subparagraph
						Article 2(3) second part	Annex V, Part 1, point 1 and Part 2, point 1, first subparagraph

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—	—	—	—	—	—	—	Annex V, Part 1, point 1 and Part 2, point 1, second subparagraph
						Article 2(4)	—
						Article 2(6), first part	Article 3(24)
						Article 2(6), second part	Article 28, second subparagraph, point (j)
						Article 2(7), first subparagraph	Article 3(25)
						Article 2(7), second subparagraph, first sentence	—
						Article 2(7), second subparagraph, second sentence and points (a) to (i)	Article 28, second subparagraph and points (a) to (i)
						Article 2(7), second subparagraph, point (j)	—
						Article 2(7), third subparagraph	—
—	—	—	—	—	—	—	Article 29(1)
						Article 2(7), fourth subparagraph	Article 29(2)
—	—	—	—	—	—	—	Article 29(3)
						Article 2(8)	Article 3(32)
						Article 2(9)	—
						Article 2(10)	—
						Article 2(11)	Article 3(31)
						Article 2(12)	Article 3(33)
						Article 2(13)	—
						Article 3	—
						Article 4(1)	—
						Article 4(2)	—

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						Article 4(3)to 4(8)	
						Article 5(1)	Annex V, Part 1, point 2, second subparagraph
							Annex V, Part 1, point 2, first, third and fourth subparagraphs
						Article 5(2)	—
						Article 6	—
						Article 7(1)	Article 37
						Article 7(2)	Article 30(5)
						Article 7(3)	Article 30(6)
						Article 8(1)	Article 40(1)
						Article 8(2), first part of first subparagraph	Article 40(2), first part of first subparagraph
						Article 8(2), second part of first subparagraph	—
—	—	—	—	—	—	—	Article 40(2), second part of first subparagraph
—	—	—	—	—	—	—	Article 40(2), second subparagraph
—	—	—	—	—	—	—	Article 40(3)
—	—	—	—	—	—	—	Article 41
						Article 8(2), second subparagraph	—
						Article 8(3) and (4)	—
						Article 9	Article 30(1)
—	—	—	—	—	—	—	Article 30(2), (3) and (4)
						Article 9a	Article 36
						Article 10, first paragraph, first sentence	Article 30(7), first sentence

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—	—	—	—	—	—	—	Article 30(7), second sentence
—	—	—	—	—	—	—	Article 30(8) and (9)
—	—	—	—	—	—	—	Article 31 to 35
						Article 10, first paragraph, second sentence	—
						Article 10, second paragraph	—
						Article 12, first sentence	Article 38(1)
						Article 12, second sentence	—
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						Article 13	Annex V, Part 3, third part of point 8
						Article 14	Annex V, Part 4
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						Article 15	—
						Article 18(2)	—
						Annex I	—
						Annex II	—
						Annex III and IV	Annex V, point 2 of Part 1 and Part 2
						Annex V A	Annex V, Part 1, point 3
						Annex V B	Annex V, Part 2, point 3
						Annex VI A	Annex V, Part 1, points 4 and 6
—	—	—	—	—	—	—	Annex V, Part 1, point 5
						Annex VI B	Annex V, Part 2, points 4 and 6
—	—	—	—	—	—	—	Annex V, Part 2, point 5

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						Annex VII B	Annex V, Part 2, points 7 and 8
						Annex VIII A point 1	—
						Annex VIII A point 2	Annex V, Part 3, first part of point 1 and points 2, 3 and 5
—	—	—	—	—	—	—	Annex V, Part 3, second part of point 1
—	—	—	—	—	—	—	Annex V, Part 3, point 4
						Annex VIII A point 3	—
						Annex VIII A point 4	Annex V, Part 3, point 6
						Annex VIII A point 5	Annex V, Part 3, points 7 and 8
						Annex VIII A point 6	Annex V, Part 3, points 9 and 10
—	—	—	—	—	—	—	Annex V, Part 3, point 11
—	—	—	—	—	—	—	Annex V, Part 4
						Annex VIII B	—
						Annex VIII C	—
			Annex VI			Annex IX	Annex IX
			Annex VII			Annex X	Annex X