Flue Gas Treatment

The flue gas treatment systems are installed to reduce levels of acidic flue gas components, particulate matter, heavy metals (including Mercury) and Dioxins/Furans.

To enable the flue gases to be filtered they are first cooled to a temperature necessary for the cleaning within the filter system. For this reason, thermal energy (heat) must be removed from the flue gases.

The flue gases from each cremator enter dedicated flue gas to water coolers (one set per cremator) via a refractory lined duct, and is cooled down to the filter operating temperature of 150°C to 180°C. The heat removed from the flue gas is transferred in the water / glycol circulation system to independent air blast coolers, servicing each set of cremator coolers, located outside the crematorium building. Each cremator is fitted with a draught control damper, downstream of its flue gas cooler, to control combustion chamber suction. The water/glycol system is fitted with a heat exchanger to allow some of the heat recovered from the flue gases to be utilised for heating of the crematorium building or other purposes.

After the Flue Gas Coolers, the gases a metred dose of fresh reagent additive Factivate 20 is added to the flue gases. The flue gases and the reagent are homogeneously mixed within a reaction volume prior to entering a fabric filter where the spent reagent and particulate from the cremator are removed from the waste gas stream.

Within the fabric filter, a cake of additive and dust builds up on the filter bags during the working day. The filter capacity is designed to accommodate a full day's operation without the need to clean the filter media. However, in the event of a build-up of material in the filter, there is an automated online cleaning facility utilising pulsed compressed air.

The adsorption of the mercury, dioxins and furans occurs with the reagents in the flue gas stream and in the dust/reagent cake on the filter bags.

Furthermore, the concentration of acidic gases such as SO_2 and especially HF and HCl is reduced by reaction with the chemical reagent.

During the filter cleaning process, usually at the end of the working day, the released dust cake falls into the filter hopper. A motorised mechanical screw conveyor transports the dust and spent reagent to a container for waste disposal. Typically, the automatic cleaning process occurs once a day – at shutdown, so ensuring that the filter is cleaned of "used additive" at the end of every operational day, and so starts operation the following day using only fresh additive. Such operation dramatically reduces the risk of filter fires, especially as the additive selected has natural fire-retardant capabilities.

An induced draught fan draws the cleaned gas through the fabric filter and passes it to atmosphere through the chimney stack. The control of this fan, via a frequency controller (inverter), ensures the correct suction levels are maintained within the cremator (as measured in the main chamber) at all times. Each cremator is fitted with a draught control damper, downstream of its flue gas cooler, to control combustion chamber suction. The induced draught fan is suitably sized to overcome all the resistances within the cremator(s), flue gas cooling and filter equipment.

Carbon monoxide, particulate matter and oxygen are continuously monitored at the exit of the abatement system and the results are continuously displayed and recorded.

A compressor is included to supply the compressed air requirements of the fabric filter cleaning system and various dampers within the flue gas treatment system.

The premixed chemical reagent additive mixture is supplied in easily manageable, sealed containers, which can be readily introduced into the automatic reagent feeding station with minimal chance of accidental spillage. Under fully controlled conditions, the reagent is fed via a dosing screw into the flue gases in the required amount necessary to ensure compliance with the emissions regulations. Reagent feed rates are controlled by a “loss in weight” metering system incorporated into the feeder station.

During plant start-up the flue gases from the cremator natural gas burners pass through the flue gas coolers but are bypassed around the filter to prevent condensation on the filter media, to the induced draught fan and stack. During this period each day the emissions are the products of combustion from Natural Gas fired burners only. The pollutant content of these flue gases is limited to Carbon Dioxide.

As the flue gas temperature from the cooler(s) rises comfortably above the moisture dew-point, the flue gases are allowed to pass through the filter and its bypass is closed until the plant is closed down.

Once the cremator reaches normal operating temperatures the plant controls allow the first charge of the day to be inserted. During cremations the cremator controls continuously adjust the combustion air levels to ensure optimum combustion conditions and maintain operating temperatures using the burners if required. The Cremator exit flue gas oxygen concentration is continuously monitored and used to control secondary air addition to the process. Carbon Monoxide content is also monitored and used to control the cremator in the event of rising emission levels.

During abated cremations, the stack emissions are comfortably below the limit levels required by PG5/2(12), which are:

Pollutant	**Concentration limits**
Hydrogen Chloride (excluding particulate matter)	**30mg/m^3 averaged over an hour**
Total particulate matter from cremator	**20mg/m^3 averaged over an hour**
Mercury	**50µg/m^3**
Carbon monoxide	**100mg/m^3 reported as 2 × 30 minute averages**
Polychlorinated Dibenzo-p-dioxins and Furans (PCDD/F)	**0.1ng/m^3 as ITEQ**
Organic compounds (excluding particulate matter expressed as carbon)	**20mg/m^3 averaged over an hour of cremation**

Pollutant concentrations are normalised to 273.1K, 101.3kPa, 11% oxygen v/v, dry gas

Flue gas flow rates, during cremations, vary throughout the process. Flow rates of 1500 to 2500 m^3/h (per operating cremator) at 150°C are normal.

As a consequence of normal plant operation, the air blast cooler will heat ambient air up to approximately 80°C. This air is vented directly upwards from the cooler matrix and does not acquire pollutants in this process.

Spent reagent and particulate are collected from the flue gas filter and deposited in a standard drum. When full the drum is collected by a specialist recycling company for Mercury recovery and subsequent disposal.

During closedown all combustion processes are stopped. The equipment runs through a controlled closedown sequence involving the automatic cleaning of the boiler tubes followed by the automatic cleaning of the filter. At the end of the sequence the induced draught fan is stopped, and the plant is left to vent naturally to the chimney. Emissions during this process are limited to hot air vented through the process. The filter remains online until the induced draught fan is closed down.

In the event of a process excursion such as high flue gas temperatures, boiler faults, induced draught fan faults the controls will automatically reduce combustion, within the cremator, until the fault condition is cleared.

In the event of a serious fault within the abatement system, the cremator(s) are capable of operation in unabated mode. The minimum secondary combustion chamber temperature is automatically increased to 850°C in the event of unabated cremator operation, using the bypass flues installed. In this situation flue gases from the cremator(s) are cooled by air dilution and draught control is maintained by a variable speed ejector fan.

In unabated (bypass) operation the cremator(s) will operate in compliance with the PG5/2(12) unabated emissions limits, which are:

Pollutant	**Mass Emission limits**
Hydrogen Chloride (excluding particulate matter)	**300g/h**
Total particulate matter from cremator	**120g/h for 95% of cremations and 240g/h for all cremations**
Mercury	**Unabated**
Carbon monoxide	**150g in the first hour of 95% of cremations and 300g in the first hour for all cremations**
Polychlorinated Dibenzo-p-dioxins and Furans (PCDD/F)	**1.0ng/m^3 as ITEQ**
Organic compounds (excluding particulate matter expressed as carbon)	**30g/h**

As a last resort, for such situations as power failure, to prevent possible dangerous situations or imminent plant damage the plant is able to fully abort operations in which case the cremator(s) will be allowed to vent directly to the chimney. Under these rare conditions pollutant emissions concentrations may exceed guideline limits until the combustion process ceases or normal operation resumes.

PG5/2(12) Emissions Control Techniques

The following pollutants are subject to emission limit values in accordance with "Secretary of States Guidance for Crematoria, Process Guidance Note 5/2(12)":

1. Mercury
2. Hydrogen chloride (excluding particulate matter)
3. Total particulate matter
4. Carbon monoxide
5. Organic compounds
6. PCDD/F

1. Mercury
   Mercury is classed as a heavy metal and has a high toxicity to both man and biota. As an elementary substance, mercury is persistent and cannot be degraded into harmless products. It will therefore be permanently recycled in the physical, chemical and biological processes in the environment. Metallic mercury can be oxidised to mercury ions which have a high affinity to sediments and which are easily transformed in the environment into mercuric ions. Many mercuric salts are very soluble in water. Mercury can also be transformed by biochemical and biological reactions into more toxic organic compounds (e.g. methyl mercury). In the environment, mercury mainly occurs as elemental mercury and as inorganic mercury compounds (chlorides, hydroxides, oxides and sulphides). The origin of mercury emissions from crematoria, in the UK, comes mainly from mercury amalgam fillings in human remains.
   Mercury concentrations, in the cremator(s) flue gases, are reduced by adsorption of the vaporous Mercury compounds on to powdered activated carbon introduced to the abatement system as a component of Factivate 20. The spent product is captured, by filtration, and deposited in drums which are sent off site for Mercury recovery.

2. Hydrogen chloride
   Hydrogen chloride, HCl, is a colourless fuming gas formed during the combustion process as chlorine within the body, mainly as salt, reacts with hydrogen from combustion of the hydrocarbon compounds which make up body tissues. HCl is readily "washed" from the atmosphere by rain forming much diluted hydrochloric acid, which is a component of acid rain.

   The emission of HCl from the process is charge dependent. The levels of HCl from cremators have reduced, over latter years, mainly due to guidelines on materials which may be used in coffin manufacture and avoiding the use of chlorinated materials within the coffin. Further reduction of emissions levels is reduced by the post combustion abatement systems. Hydrogen chloride and other acidic component concentrations are reduced by chemical reaction with sodium bicarbonate introduced to the abatement system as a component of Factivate 20. The chemical reactions produce harmless salts which are captured by filtration and deposited in the drums which are sent off site for Mercury recovery.

3. Total particulate matter
   Many combustion processes generate particulate matter, not necessarily smoke. In the case of the cremation process the dust emitted from the cremator(s) will be mainly wood fly ash and salts. Particulate matter is captured by filtration and deposited in drums which are sent off site for Mercury recovery.

4. Carbon monoxide
   Carbon monoxide, CO, is a colourless and odourless gas.
   Carbon monoxide arises from incomplete fuel combustion and is of concern mainly because of its effect on human health and its role in tropospheric ozone formation. It combines with haemoglobin in the blood to form the compound carboxyhaemoglobin, which prevents the normal transmission of oxygen into the blood stream and can lead to a range of symptoms as the concentration increases.
   Carbon monoxide also contributes to the formation of smog in cold winter conditions.
   Carbon monoxide concentrations from the cremator(s) are very low due to highly turbulent conditions and close control of temperature and oxygen concentration within the secondary combustion chamber.

5. Organic compounds
   Organic compounds, so called because they contain carbon in their molecular structure, are present in cremator flue gases only due to incomplete combustion. Organic compound concentrations from the cremator(s) are very low due to highly turbulent conditions and close control of temperature and oxygen concentration within the secondary combustion chamber.

6. PCDD/F
   Polychlorinated Dibenzo-p-dioxins and Furans (PCDD/F) are common by-products from the combustion of organics in the presence of chlorine, either within the combustible material or the combustion environment. They are substantially destroyed in a properly controlled combustion system, but can be reformed in flue gases during cooling. Dioxins and Furans are not restricted to manmade combustion systems, they are formed during any combustion process where chlorine is present, even in small amounts. Dioxin and dioxin-like compounds are found throughout the environment, in soil, water, and air. Naturally occurring sources include forest fires and even as a by-product of fungal growth. They and are often associated with the production of pesticides, PVC, and other similar chlorinated chemicals.
   Dioxins and furans are known carcinogens. Both classes of compounds are environmentally persistent and are known to bio accumulate.
   PCDD/F concentrations, in the cremator(s) flue gases, are reduced by adsorption on to powdered activated carbon introduced to the abatement system as a component of Factivate 20. The spent product is captured, by filtration, and deposited in drums which are sent off site for Mercury recovery.