Environmental permitting technical guidance PG5/2(23)

Reference document for crematoria

1. Legal status

1.1 This technical guidance applies to the whole of the UK. It is issued by the Secretary of State, the Welsh Ministers, the Scottish Government and the Department of Agriculture, Environment and Rural Affairs in Northern Ireland (DAERA).

1.2 This is issued as guidance in Scotland and as statutory guidance in:

- England and Wales under regulation 65(1) of the Environmental Permitting (England and Wales) Regulations 2016 (EPR).
- Northern Ireland under regulation 41(1) of the Pollution Prevention Control (Industrial Emissions) (Northern Ireland) Regulations 2013 (PPC-NI).

The above regulations along with the Pollution Prevention and Control (Scotland) Regulations 2012 (PPC-S), are referred to collectively as 'the Regulations' in this guidance.

This guidance will be taken into account when determining any appeals against a decision made under this legislation.

The cremation of human remains is an activity listed for regulation as follows:

- England and Wales: EPR, Schedule 1, Section 5.1, Part B, (b)
- Scotland: PPC-S, Schedule 1, Section 5.1, Part B, (c)
- Northern Ireland: PPC-NI, Schedule 1, Section 5.1, Part C, (b)

In England, Wales and Northern Ireland, crematoria are regulated by the relevant local authority and in Scotland by the Scottish Environmental Protection Agency (SEPA).

1.3 This technical guidance supersedes:

- PG5/2(12), Statutory Guidance for Crematoria
- The following AQ Notes are also superseded.
    - AQ1(05)
    - AQ9(06)
    - AQ12(05)
    - AQ19(07)
    - AQ23(05)

2. Scope

2.1 This guidance applies to the cremation of human remains in:

- new cremators
- existing gas fired and electric fired cremators, with or without the abatement of emissions to air
- standby cremators
- temporary cremators
- small-scale cremators

Note: Abatement in this context means flue gas treatment.

2.2 **Available Fuels**

At the time of publication, the overwhelming majority of cremators currently in operation in the UK are fuelled using gas, either natural gas or LPG (liquefied petroleum gas). There are only a few cremators which can use both gas and liquid fuels. Some temporary cremators use only liquid fuels. Also, there are a small number of electric cremators, which with one exception have been installed during the past 3 years.

There is a growing focus on the more efficient use of existing fuels, the use of new fuels e.g., biogas, hydrogen, and liquid biofuels and their environmental impacts. The composition of natural gas could also change with the addition of up to 20% hydrogen into the supply network.

The recent increase in electric cremators is partly motivated by the reducing carbon intensity of the electricity network and it is expected that more will be installed in the next few years.

Thus, in the future, cremators will likely use a more diverse range of fuels and so where reference is made in this guidance to new crematoria, this applies to all new cremators regardless of fuel type. Where reference is made to existing crematoria, this applies to gas fired and electric cremators currently in operation.

2.3 **Cremator Types**

2.3.1 In this guidance a new cremator is one that first comes into operation from 1st January 2024. An existing cremator is one that is not a new cremator.

2.3.2 A stand-by cremator is one that is permanently retained for use in the event of breakdown of the main cremator(s) or other occasional need (excluding small-scale cremators) for additional cremator capacity at the crematoria.

Stand-by cremators, which are not fitted or connected to flue gas treatment, shall operate for no more than 100 hours in any calendar year. In general, stand-by cremators should meet all the standards which apply to unabated cremators. This is described in more detail later in the guidance.

The term stand-by cremator is not to be confused with a temporary cremator.

2.3.3 A temporary cremator is a cremator installed on a temporary basis usually as a replacement for one that has been taken out of service for replacement or major refurbishment.

Where an unabated temporary cremator, replaces a cremator with flue gas treatment and is required to operate for more than 100 hours, an assessment of the impact on local ambient air quality (see Section 4.4.2) shall be made as part of the permit variation application.

From 1st January 2024, if the temporary cremator is installed as additional capacity or is intended to be in service for more than one calendar year, it shall meet the standards for new cremators.

2.3.4 A small-scale cremator is one that is retained specifically to cremate stillbirth, neonatal and foetal remains. Small-scale cremators will have a door opening which is a maximum of 300 x 300 mm and the primary chamber will be no more than 1,000 mm long.

Not all the standards for full scale cremators are appropriate for small-scale cremators because of the relatively small mass of pollutants emitted. This is described in more detail later in the guidance.

2.4 Process Description

2.4.1 Cremators comprise of a primary and a secondary combustion chamber. Both chambers have a refractory lining to retain the heat and to protect temperature sensitive equipment. The coffin containing the deceased is placed into the primary chamber through a doorway at one end of the primary chamber. Loading can be done manually or may be partly automated.

In current gas fired cremators, there is usually a single burner installed within the primary chamber which directs a flame at the coffin. Although cremators can have more than one burner in a range of configurations. The direction of the flame can be controlled to a limited extent by adjusting the injection of the combustion air.

As the fuels used diversify, a key technology will be burners which can utilise a range of different fuels, e.g., biofuels, hydrogen, and natural gas / hydrogen blends.

In electric cremators, there are a number of adjustable electrical heating elements (typically 6), which indirectly heats the primary chamber to above the auto-ignition temperature. No additional fuel is added, but air must be added to sustain combustion.

2.4.2 Cremation is a batch process consisting of (excluding pre-heating and shutdown) the steps shown in Table 2.1.

Indicative timings for existing gas cremators are shown in table 2.1. Total cremation times may vary considerably, ranging from as little as 50 minutes to more than 2 hours, depending upon body size.

Cremation times on recently installed electric cremators are longer, but there is insufficient data to make a direct comparison.

Table 2.1 Steps in the cremation process

Process Step	Typical time required (gas cremators)
brief "flash" caused by volatilisation of the veneer on the outside of the coffin	1 minute
burning of the coffin	20 minutes
after the coffin breaks open, burning of the coffin and cremation of the body	40 minutes
calcination of the remains (when there are no flames from the remains at the end of the cremation)	30 minutes
ashing	2 minutes although times may vary

2.4.3 The purpose of the secondary combustion chamber is to provide sufficient temperature and residence time for the complete oxidation of all the gaseous products of combustion in the primary chamber. In gas cremators, typically a single supplementary burner is installed to maintain the temperature of the secondary chamber if needed, although cremators can have more than one secondary burner. In electric cremators, electrical heating elements are used. In both cases, the retained heat from the primary combustion chamber is often sufficient to maintain temperature. Supplementary air is added to ensure there is sufficient oxygen present to complete the combustion process.

2.4.4 The raking of the ashes into a suitable container can be from either end of the primary chamber based on the design. The remains are then taken to a cremulator where they are processed for return to the family of the deceased. Cremulators are compact pieces of equipment fitted with a small filter which can vent internally or externally to the building. Care is needed when moving the remains from the primary chamber to the cremulator to avoid generating dust.

2.5 Flue Gas Treatment

2.5.1 At the time of publication, approximately 70% of cremations in the UK were carried out in cremators fitted with a flue gas treatment system.

Flue gas treatment was originally introduced to reduce emissions to air of mercury, which arise from dental amalgam. However, the flue gas treatment system is also effective at reducing emissions of dust (particulate matter), acid gases and dioxins.

The principle of the system is the injection of reagents into the flue gas, usually a mixture of sodium bicarbonate or lime and activated carbon. The sodium bicarbonate or lime reacts with the acidic gases and the carbon absorbs mercury and dioxins. The spent reagent is then filtered out of the air stream using a bag or ceramic filter.

Using a different design, the flue gas first passes through a bag or ceramic filter to remove particulates and then the filtered gases pass through a fixed bed of sodium bicarbonate or lime and activated carbon to remove acid gases, mercury and dioxins. In this system, the reagents in the fixed bed need to be replaced before they become fully spent or saturated.

Note: both these forms of flue gas treatment require the combustion gases first to be cooled. This need to cool the exhaust gases is an opportunity to recover heat, usually in the form of hot water, for use, e.g., in heating buildings.

Flue gas treatment is commonly referred to in the industry simply as ‘abatement’. Cremators without flue gas treatment are referred to as ‘unabated cremators’.

2.5.2 However, flue gas treatment does not remove nitrogen oxides (NO_X). More recently, some equipment providers have started to provide a NO_X abatement option using a process of selective non-catalytic reduction (SNCR). The use of this technique is currently quite limited but is becoming more widespread. This is referred to as ‘NO_X abatement’ or ‘SNCR’.

2.6 Not in Scope

The following activities and techniques are not in the scope of the guidance:

- Spreading of the ashes (remains)
- (Alkaline) hydrolysis
- Burials and composting techniques
- Open pyres
- Animal cremation

All the above are outside the scope of the regulated activity “the cremation of human remains” as described in the Regulations – see section 1.2. In the case of alkaline hydrolysis, this is a relatively new technique that does not have emissions to air and therefore does not come within scope of Part B regulation.

The disposal of spent reagent from flue gas treatment equipment, waste dust ash processing and recovered medical implants is not in scope of the guidance as this is covered by other waste regulation.

2.7 Notes on Who is the Operator

2.7.1 Local Authority is both Operator and Regulator

In circumstances, where the local authority is both the operator and regulator of a crematoria, it must have robust processes in place to ensure that the regulatory function is separate from and independent of the operational function.

Local Authorities must carry out their regulatory duties in the same fair, consistent and transparent manner as for any operator of any other permit.

2.7.2 Remote Operation of Crematoria

The Regulations state that the operator is the legal entity who has control over the operation of the regulated facility. The following 5 tests are generally used by National Regulators (e.g., in England, The Environment Agency) to help determine who should be the operator, thereby the permit holder, in cases where this may not be clear cut. Typically, the operator will:

- have day-to-day control of the facility or activity, including the manner and rate of operation
- make sure that permit conditions are complied with
- have managerial responsibility over staff and ensure staff competency
- make investment and financial decisions that affect the facility's performance or how the activity is carried out
- make sure the activities are controlled in an emergency

Since the publication of the previous guidance in 2012, there has been an increasing trend to more detailed remote monitoring by the equipment provider and in some instances, the ability to control remotely some aspects of the cremation process. This has the potential to improve operational control, diagnose and correct problems before they lead to performance issues.

Whilst it is unlikely that the scale and extent of external monitoring by the equipment provider is sufficient to make them the operator, regulators may want to keep this under review. The owner of the permit is ultimately responsible for compliance with the permit. This is regardless of whether any activities at the installation are delegated to second and third parties.

In any event, should an offence committed by the operator be due to the act or default of some other person, that other person may also be guilty of the offence and can be proceeded against by the regulator, whether or not proceedings for the offence are taken against the operator.

3. Using this guidance

3.1 General conditions

3.1.1 This guidance describes what are considered the best available techniques (BAT) for the activities within its scope. This guidance also, where appropriate, gives details of any mandatory requirements affecting emissions to air, such as those contained in other regulations or in Directions from the Government.

In the case of this note, at the time of publication this includes:

- Environmental Protection (England) (Crematoria Mercury Emissions Burden Sharing Certificate) Direction 2010 which came into force on 18th March 2010;
- Environmental Protection (Crematoria Mercury Emissions) (Wales) Direction 2010 which came into force on 19th April 2010.

However, arising from the changes in this guidance, these Directions will cease to have effect from 1st January 2024 for new and replacement cremators, and from 1st January 2027 for all cremators.

Note: there are no Directions in force for Scotland or Northern Ireland.

3.1.2 Unless otherwise stated, the provisions of this guidance are generally applicable.

3.1.3 The techniques in this guidance are neither prescriptive nor exhaustive. Other techniques may be used as long as they ensure at least an equivalent level of environmental protection.

3.1.4 Sections 4 and 5 set out emission limit values and other matters that should be considered for inclusion in environmental permits.

3.1.5 However, in each case the regulator may need to consider variable factors such as the configuration, size and other individual characteristics of the crematoria, as well as the locality (e.g., its proximity to particularly sensitive receptors).

3.1.6 After assessing BAT and the environmental impact of emissions to air, permit conditions, including emission limit values, may need to be tighter than those set out in this guidance. In individual cases, it may be justified to:

- include additional conditions
- include different conditions
- not include conditions relating to some of the matters indicated

3.2 Timetable for compliance and permit reviews

3.2.1 For new crematoria, the permit shall have regard to the full standards of this guidance from the first day of its operation following the completion of commissioning.

Replacement cremators, other than temporary cremators (see Section 2.3.3), shall be designed to meet the standards specified for new crematoria.

3.2.2 For substantially changed crematoria, e.g., replacement of the main cremation unit, or retrofit of flue gas treatment to an unabated cremator, the permit shall have regard to the full standards of this guidance with respect to the parts of the crematoria that have been substantially changed and any part of the crematoria affected by the change, from the first day of operation following the completion of commissioning. Renewing or replacing the refractory lining of the cremator is not a substantial change.

3.2.3 All crematoria permits shall be reviewed no later than 31st December 2025 or earlier where new, replacement or temporary cremators are installed, or where cremators are substantially changed.

In circumstances where the crematoria remains operational during improvement works, the use of stand-by and / or temporary cremators may need to form part of the project plan. The need to vary permit conditions to maintain compliance with the relevant performance standards through all the changes in operation should form part of the project plan.

This guidance contains all the provisions from previous editions which have not been amended or removed. For existing crematoria, the regulator should have already issued or varied the permit having regard to the previous editions of this guidance.

If regulators have not done so, this should be done as soon as possible, without waiting until 31st December 2025, as part of the next permit review.

3.2.4 Where provisions in the preceding guidance note have been deleted or relaxed, permits should be varied as necessary as part of the next permit review.

3.3 Mercury Abatement (Flue Gas Treatment)

3.3.1 Unless meeting one of the exemption criteria in paragraph 3.3.2:

- From 1st January 2024, all new and replacement cremators will be fitted with flue gas treatment that includes mercury abatement.
- From 1st January 2027, all cremators will be fitted with flue gas treatment that includes mercury abatement. Otherwise, their operation will be limited to 100 hours per calendar year.

3.3.2 Flue gas treatment will not be required in the following limited circumstances:

- Standby cremators, whose operation will be limited to 100 hours in any calendar year
- Where, temporary cremators replace an unabated cremator, their operation will be limited to a maximum of one calendar year.
- Small-scale cremators, i.e., cremators designed and built for infants and foetal remains.
- Exceptionally, for existing cremators, where the retrofitting of flue gas treatment is not technically possible due to limitations of space combined with the inability to expand, because development is restricted due to it being a listed building or building an extension would require exhumation.

Where there are technical or logistical problems that might delay completing the retrofit or replacement of an unabated cremator until after 1st January 2027, Operators must raise these problems with their regulator as soon as they become known. Regulators may grant a short delay where these problems are outside the control of the Operator.

3.3.3 Operators of existing cremators intending not to fit flue gas treatment, due to limitations of space combined with the inability to expand, will be required to present evidence that this is not technically possible for assessment by their regulator.

All such crematoria will also be required to carry out an assessment of the impact of emissions to air on local air quality for approval by their regulator.

Where the regulator is satisfied on both counts, the regulator may allow a derogation from the need to fit flue gas treatment for up to 6 years, after which the situation will be reassessed. A condition on reapplication will be included in the permit.

Where the regulator is not satisfied on either count, the regulator may restrict operations or even revoke the permit as necessary.

3.3.4 For existing unabated cremators, the requirement to participate in a burden sharing arrangement will remain in place until 31st December 2026, with a final report made to the regulator no later than 1st April 2027.

3.4 Standby cremators

3.4.1 Standby cremators may be brought into operation subject to the following conditions:

- The standby cremator must be included in the environmental permit and be clearly identified.
- The regulator must be notified, in advance where possible, of the operation of the standby cremator.

- The standby cremator shall not be brought into operation unless there is a clear operational need. All periods of operation and the reason for standby cremator operation must be recorded in the log.
- Standby cremators, which are not fitted with or connected to flue gas treatment equipment, shall operate for no more than 100 hours in any calendar year, i.e., a cremation must not be started once 100 hours have elapsed.
- The number of hours operating standby cremators shall be reported to the regulator.

Note: the calculation of 100 operational hours shall exclude periods of pre-heat prior to the start of operation, and any period needed to complete a cremation begun before the 100-hour operational limit has been reached. However, it will include the period between successive cremations carried out on the same day.

In addition:

- The operator shall make visual and olfactory assessments of emissions at the start and at least once during each cremation cycle; the location and result of the assessment shall be recorded in the log.
- If a standby cremator is in operation when emissions testing takes place, the emissions testing will include the standby cremator. Emissions testing shall not be rescheduled or postponed just because the standby cremator is in operation. Emissions to air from the standby cremator shall not exceed any of the relevant emission limit values.

In all other respects, standby cremators must meet the requirements set out in this guidance. Specifically, the standby cremator must comply with the operational controls described in Section 4.1.2, i.e., for temperature in the secondary combustion chamber, and for oxygen and carbon monoxide at the exit of the secondary combustion chamber.

3.5 **Small-scale cremators**

3.5.1 Small-scale cremators are those developed to cremate stillbirth, neonatal and foetal remains. Some of the requirements of this guidance are not appropriate for such small-scale cremators because of the relatively small mass of pollutants emitted, and the likely absence of mercury.

- Small-scale cremators are not required to fit flue gas treatment.
- Emission limit values for emissions to air do not apply to small-scale cremators.
- Emissions monitoring of small-scale cremators is not required.

In all other respects, small-scale cremators must meet the requirements set out in this guidance. Specifically, the small-scale cremator must comply with the operational controls described in Section 4.1.2.

Where the small-scale cremator is a standalone facility, i.e., not part of an otherwise regulated facility, emissions may be considered trivial and with the agreement of the regulator, will not require a permit.

3.5.2 When stillbirth, neonatal or foetal remains are cremated in other types of cremators (including standby cremators), the guidance for those cremators will still apply. However, because of the shorter cremation times, it is not recommended to carry out emissions monitoring during such cremations.

4. Emission limits, monitoring and other provisions

4.1 Operational Controls

4.1.1 Control over the combustion conditions is of fundamental importance in preventing and controlling emissions to air.

Combustion conditions shall be controlled as described below. The key controls are the combustion temperature and residence time of the combustion gases in the secondary combustion chamber, along with the concentration of carbon monoxide and excess oxygen at the exit of the secondary combustion chamber.

4.1.2 Residence time in the secondary combustion chamber shall be demonstrated by calculation at the design stage and verified at commissioning. Verification may require the temporary installation of additional thermocouples. The residence time requirement should be verified at the operating temperature of the secondary combustion chamber and that temperature must exceed the values set out below.

Table 4.1 Operational Controls

Substance / Parameter	Operating Limit	Cremator Type	Averaging period
Carbon monoxide	< 100 mg/Nm^3 (Note 1)	All	As an average concentration between 2 minutes and 62 minutes from the start of each cremation. (Note 4)
Oxygen content at exit of secondary combustion chamber (Note 2)	Minimum of 6% v/v	All	
	Minimum of 3% v/v	All	5-minute averages throughout the whole of each cremation.
Temperature of secondary combustion chamber	Minimum of 850˚C	Unabated cremators	
	Minimum of 800˚C	All other cremators (Note 3)	
Residence time of secondary combustion chamber (Note 5)	Minimum of 2 seconds	All	

Note 1: Note this is a performance target, not an emission limit value. CO measurement should ideally be made at the exit of the secondary combustion chamber. Modification to existing cremators is not required.
Note 2: Oxygen concentration can be measured wet or dry.
Note 3: In the event of flue gas treatment equipment failure, the minimum temperature must be increased to 850˚C.
Note 4: For small-scale cremators, the averaging period will be between 2 and 32 minutes as the cremation time will be shorter.
Note 5: Without correction for temperature, oxygen, or water vapour.

4.1.3 For cremators fitted with flue gas treatment, conditions different to those set out in Table 4.1 as regards the temperature, residence time and oxygen content at the exit of the secondary combustion chamber may be authorised by the regulator provided all the other requirements of this guidance are met, including all emission limit values. The regulator will then specify those conditions in the permit. The frequency of dioxin monitoring (see Table 4.3) will be increased to annual in all such circumstances.

4.1.4 When re-bricking a cremator, the convolutions of the secondary combustion chamber should be maintained, if it is changed or modified to impact the original design, the volume of the chamber shall be recalculated and reverified.

4.1.5 Some cremators are fitted with an automated shutdown feature, so that the last cremation of the working day can be completed unsupervised. Engaging this function carries a degree of risk that equipment malfunction or unexpected difficulties with the cremation could occur during this period. Therefore, when using this feature, the operator must be satisfied that the cremation has proceeded to a point where this risk is minimal, e.g., the cremation has reached the calcination stage.

4.2 Emissions Monitoring

4.2.1 Emissions of the substances listed in Tables 4.2 and 4.3 must, where relevant, be controlled. The emission limit values and provisions described in this section are achievable using the best available techniques described in Section 5.

4.2.2 Operators shall monitor emissions using the standard specified in Tables 4.2 and 4.3 or an equivalent method agreed by the regulator.

Whilst there are no emission limits for nitrogen oxides or mercury emissions from unabated cremators, operators shall make measurements of emissions and report these to the regulator, to provide emissions data for these substances, e.g., for local air quality purposes and to provide data for future guidance reviews.

Table 4.2 Emission monitoring standards for continuous monitoring

<table>
<tr><th>Substance or Parameter</th><th>Standards</th><th>Calibration Standards (Note 1)</th></tr>
<tr><td>Particulate matter (Note 2)</td><td>EN 15859</td><td rowspan="3">EN 17389</td></tr>
<tr><td>Carbon monoxide</td><td>EN 15058</td></tr>
<tr><td>Oxygen</td><td>EN 14789</td></tr>
<tr><td>Temperature</td><td colspan="2">Calibration shall be traceable to national standards</td></tr>
<tr><td colspan="3">Note 1: Instrument calibration to be carried out by making parallel measurements using the relevant reference methods at least once a year. The operator must inform the regulator about the results.
Note 2: Applies to unabated cremators only.</td></tr>
</table>

For crematoria with flue gas treatment, the operator shall install a filter leak detection device that will operate continuously. The instrument shall detect filter leaks that would be likely to lead to an exceedance of the particulate matter emission limit value in Table 4.5.

Table 4.3 Emission monitoring frequencies and standards for periodic monitoring

Substance or Parameter	Standards	Minimum Monitoring Frequency
Particulate matter	EN 13284-1	Once every year
PCDD/F	EN 1948, Parts 1, 2 and 3	Once every 3 years (Notes 1 and 2)
Mercury	EN 13211	Once every year
HCl	EN 1911	Once every year
TOC	EN 12619	Once every year
NO_X (NO and NO_2 as NO_2) (Note 3)	EN 14792	Once every year
NH_3 (Notes 3 and 4)	EN ISO 21877	Once every year

Note 1: Once every year for unabated cremators and cremators using operating conditions different to those in Table 4.1.
Note 2: The first measurement for a new cremator shall be in the first 12 months of operation.
Note 3: From 1st January 2024.
Note 4: Only where NO_X abatement is installed. To measure ammonia slip associated with the SNCR process.

Where reference is made to a British, European, or International Standard (BS, CEN or ISO) in this section, the standards referred to are correct at the date of publication.

Standards are periodically amended, updated, or replaced so you should check. Further information on monitoring can be found in Environment Agency publications Monitoring stack emissions: measurement locations - GOV.UK (www.gov.uk) and Monitoring stack emissions: techniques and standards for periodic monitoring - GOV.UK (www.gov.uk).

4.2.3 From 1st January 2024, monitoring equipment, techniques, personnel and organisations employed for the emissions monitoring programme shall be accredited to EN ISO/IEC 17025. In England and Wales, accreditation to MCERTs will show this accreditation.

4.2.4 The regulator may require more frequent monitoring than that set out in Table 4.3 or continuous monitoring, based on the impact of emissions on local air quality or other sensitive receptors.

4.2.5 Whether sampling on a continuous or non-continuous basis, care is needed in the design and location of sampling systems to ensure representative samples for all emissions. This means that:

- sampling points on new crematoria should be designed to comply with the relevant standards Monitoring stack emissions: measurement locations - GOV.UK (www.gov.uk).
- the operator should ensure that stacks or ducts are fitted with facilities for sampling that allow compliance with the sampling standards.

- where this is not possible, e.g., in older cremators which were designed to fit into an existing building, deviations from the standard must be reported as well as an estimation of the increased uncertainty in the monitoring results.

A safe and permanent means of access to the test ports shall be provided, to enable the sampling/monitoring specified in Table 4.3 to be carried out.

4.2.6 Where monitoring is not in accordance with the main requirements of the relevant standard, deviations from the standard shall be reported as well as an estimation of any error invoked.

4.2.7 When sampling for polychlorinated dibenzo dioxins and furans, where it is not possible for the sampling point to be located such that the temperature of the flue gases is below 200°C, such as in an unabated cremator – that is, outside the temperature range where reformation or de novo synthesis takes place - and remains so until discharge to atmosphere, the operator should notify the regulator of the minimum temperature at which the measurement can practically be made, and the reason why this cannot be below 200°C before sampling takes place.

4.2.8 Where continuous monitoring is required for any substance or parameter, it should be carried out as follows:

- All continuous monitoring readings should be on display to appropriately trained operating staff.
- Instruments should be fitted with a visual alarm to warn the operator of abatement equipment failure or instrument malfunction. Regulators should decide whether additionally to specify an audible alarm, having regard to, amongst other things, the likelihood of the visual alarm not being noticed, and the intrusiveness of any such alarm for those using the crematorium.
- The activation of alarms should be automatically recorded.

4.3 Emission Limit Values

4.3.1 All activities shall comply with the emission limits in Tables 4.4 and 4.5.

The reference conditions for emission limits are: 273.1K, 101.3kPa, 11% oxygen v/v, dry gas unless otherwise stated.

Compliance will be assessed using an average value of three consecutive measurements of 60 minutes each, as described below unless otherwise stated.

4.3.2 Cremation is a batch process as described in paragraph 2.4.2 and Table 2.1.

Emissions monitoring for compliance purposes should only occur during adult cremation.

A common reference is needed for compliance monitoring across all types of cremators. The initial stage has too short a duration for sampling of emissions. It is also not practical to sample emissions during the ashing phase, as the turbulence caused by the open ash door may bias the results. For cremators with flue gas treatment, the emissions will be strongly influenced by the performance of the abatement equipment. Therefore, for these cremators, emission limits are set on a concentration basis only. For unabated cremators, emission limits for some substances have an alternative mass release limit, which are meant to be broadly equivalent.

Emissions are expected to peak during the first hour of the process. Thus, a common reference of one hour starting approximately 2 minutes following the closure of the cremator door is used for unabated cremations and cremations where the flue gas treatment system serves a single cremator.

In the circumstances where 2 or 3 cremators are served by a common flue gas treatment system, it is not possible to set the emissions monitoring period as described above, as each cremator is likely to be at a different part of the process. In such cases, the monitoring period should commence to coincide with the start of cremation in one of the units with the operating status of the other unit(s) carefully recorded. The other unit(s) should operate as normal during this period.

4.3.3 Emissions monitoring should commence as soon as a stable air flow is established following closure of the cremator door. Typically, this will be 2 minutes into the cremation process. Emissions monitoring shall then continue for a period of one hour. For unabated cremators, if the coffin is breached before emissions monitoring begins, or if the cremation is completed (other than ashing) within one hour from the start of monitoring, then the test shall be void and done again. For cremators with flue gas treatment, if any cremator connected to the flue gas treatment system ceases operation during the monitoring period, then the test will be invalidated and done again.

Table 4.4 Emission Limit Values for unabated cremators

Substance	Emission Limit Value (Note 1)	Averaging period
Particulate matter	80 mg/Nm^3 or 120 g	As an average concentration between 2 minutes and 62 minutes from the start of each cremation or as a total mass emission over the same time period.
HCl	60 mg/Nm^3 or 100 g	
TOC	20 mg/Nm^3	As an average concentration between 2 minutes and 62 minutes from the start of each cremation.
NO_X (NO and NO_2 as NO_2)	No limit applies	

Substance	Emission Limit Value (Note 1)	Averaging period
Mercury	No limit applies	As an average concentration over 3 cremations between 2 minutes and 62 minutes from the start of each cremation.
PCDD/F (Note 2)	1 ng/Nm^3 or 4.5 µg	As an average concentration over 3 cremations between 2 minutes and 62 minutes from the start of each cremation or as a total mass emission over the same time period.

Note 1: Where an emission limit value is expressed both as a concentration or a mass, the operator chooses whether the mass or the concentration limits apply, and the regulator should then specify those limits in the permit.
Note 2: A longer monitoring period may be needed where emissions are very low, and the monitoring uncertainty is high as a proportion of the measured value.

Table 4.5 Emission Limit Values for all other cremators

Substance	Emission Limit Value	Existing or New Cremators	Averaging period
Particulate matter	10 mg/Nm^3	Existing	As an average concentration over 3 x 60 minutes as described in sections 4.3.2 and 4.3.3.
	5 mg/Nm^3	New	
HCl	30 mg/Nm^3	Existing	
	20 mg/Nm^3	New	
TOC	20 mg/Nm^3	Existing	
	10 mg/Nm^3	New	
NO_X (NO and NO_2 as NO_2)	200 mg/Nm^3 (Note 3)	All	
NH_3 (Note 1)	No limit applies		
Mercury	50 µg/Nm^3	Existing	
	30 µg/Nm^3	New	
PCDD/F (Note 2)	0.1 ng/Nm^3	All	

Note 1: Only where NO_X abatement is installed. To measure ammonia slip associated with the SNCR process.
Note 2: A longer monitoring period will be needed. The length of the monitoring period should reflect the expected emission level and the level of the monitoring uncertainty.
Note 3: From 1st January 2027.

4.3.4 Dilution air may be added for waste gas cooling or improved dispersion where this is shown to be necessary because of the operational constraints of the crematoria. Dilution air should have no effect on the assessment of compliance with emission limit values.

4.3.5 For all cremators, the remains in the cremator should only be moved when calcination is completed.

- Particular care is needed in the removal of ash and non-combustible residues from an unabated cremator to prevent dust emissions via the flue.
- Cremated remains should be moved and allowed to cool before they are processed in the cremulator (ash processor). Processed remains must be stored in a covered container.

If an automated shutdown process is used at the end of a working day, this will take place at the start of the next working day.

4.3.6 Cremulators must be fitted with suitable exhaust filters and a gross filter failure detection device, e.g., differential pressure measurement, which must operate continuously when the cremulator is in use.

Particulate emissions from cremulators so equipped should be insignificant and may be vented internally or externally, no emission limits apply.

4.4 Chimney or Stack Height

4.4.1 Pollutants emitted via a chimney or stack require sufficient dispersion and dilution in the atmosphere to ensure that the resultant ground level concentrations are acceptable in terms of their impact on health and environment.

Historically, stack heights have been calculated using HMIP Technical Guidance Note (Dispersion) D1. However, this dates from 1993 and so is 30 years old. In any event, D1 should be viewed as a dated methodology for calculating stack height. It is not a method for assessing pollutant dispersion and its effects on ambient air quality.

Whatever method is used to determine the stack height (and efflux velocity), an assessment of the impact of emissions on local ambient air quality shall be carried out. For new crematoria, this should form part of the permit application. For existing crematoria, this should be done at permit review.

4.4.2 To assess the impact on local ambient air quality, assessment tools such as the Environment Agency's H1 software tool or air dispersion modelling are required. https://www.gov.uk/government/collections/risk-assessments-for-specific-activities-environmental-permits#H1-software-tool

The H1 software tool is a simplified modelling tool which uses a precautionary approach to calculate a predicted maximum ground level pollutant concentration. It can be used to screen out emissions which are insignificant.

To screen out a substance so that you do not need to do any further assessment of it, the Process Contribution (PC) must meet both of the following criteria:

- the short-term PC is less than 10% of the short-term environmental standard

- the long-term PC is less than 1% of the long-term environmental standard

If you meet both criteria no further assessment of the substance is required.

Where this is not the case, a more detailed assessment of those pollutants will be necessary. This will include the use of background data to determine the Predicted Environmental Concentration (PEC) and could include the use of more sophisticated air dispersion modelling.

Assessments should ordinarily be carried out on the basis that emissions to air are at the maximum permitted level. Where there are no ELVs in place emissions monitoring data can be used.

In circumstances where 2 or 3 cremators discharge through a common chimney, the assessment should be based on the operating scenario which results in the highest predicted ground level concentrations.

4.4.3 Previous versions of the crematoria guidance have not included any reference to emissions of nitrogen oxides. As a result, it is likely that the dispersion of NO_X emissions was not considered when designing the stack height of existing crematoria.

Where necessary, the emission limit values in Table 4.4 or 4.5 may need to be reduced by the regulator for existing crematoria to ensure the impact is acceptable. For new crematoria, the stack height may be increased to ensure the impact is acceptable.

4.4.4 For crematoria with flue gas treatment, each treatment unit can have one flue plus an emergency release vent (ERV) for each cremator connected to the system. As the ERV should only be used very infrequently, an air quality impact assessment of the ERV is not needed if the ERV stack is at least the same height as the main stack or greater.

4.4.5 The exit (efflux) velocity from the stack shall be sufficient to prevent aerodynamic downwash of the discharge plume. Dispersion modelling may be used to justify the efflux velocity under normal operating conditions.

To ensure dispersion is not impaired by either low exit velocity at the point of discharge, or deflection of the discharge, a cap, or other restriction, should not be used at the stack exit. However, a cone may sometimes be useful to increase the exit velocity to achieve greater dispersion.

4.4.6 Liquid condensation on internal surfaces of stacks and exhaust ducts might lead to corrosion and ductwork failure or to droplet emission. Adequate insulation will minimise the cooling of waste gases and prevent liquid condensation by keeping the temperature of the exhaust gases above the dewpoint. A leak in a stack/vent and the associated ductwork, or a build-up of material on the internal surfaces may affect dispersion. Flues and ductwork should be cleaned to prevent the accumulation of materials, as part of the routine maintenance programme.

4.5 Visible and Odorous Emissions

4.5.1 Emissions from cremators shall in normal operation be free from visible smoke. All releases to air shall be free from persistent visible emissions, other than condensed water vapour. All releases to air should be free from droplets.

There shall be no odorous emissions as perceived by the regulator.

4.5.2 During other than normal operation, the operator shall make periodic visual and olfactory assessments of emissions, including at the start of and during a cremation cycle, when the location and result of the assessment shall be recorded in the log.

4.6 Energy consumption and carbon emissions

4.6.1 The UK has made a commitment to achieve net zero carbon emissions by 2050.

4.6.2 Carbon emissions at crematoria arise from fuel and electricity use. They also arise from the combustion of the coffin (including fittings) and cremation of the deceased. Small quantities of other greenhouse gases (nitrous oxide, N_2O) can also arise from combustion of coffins and from NO_X abatement.

Carbon emissions can be reduced through improved energy efficiency and through minimising the weight of coffins. To achieve the full potential of these techniques, changes to working practices are likely to be needed. These are explored further in Sections 5.4 to 5.6.

The combination of electrical cremators in combination with decarbonisation of the electricity supply has the potential to reduce carbon emissions at crematoria. The replacement of fossil fuels with sustainable biofuels will also reduce carbon emissions, depending on the accounting methodologies used. Carbon capture or use of hydrogen as a fuel are not currently available techniques for crematoria.

Better data is needed on energy consumption and on carbon emissions to support further work in this area.

4.6.3 Carbon emissions are however a key environmental issue for the sector, and it is important these emissions are measured. Therefore, fuel and electricity consumption shall be measured for each cremator (including all abatement equipment), where there is more than one cremator operating with a shared flue gas treatment system, fuel and electricity consumption shall be measured for the whole system.

- From 1st January 2024, all new and replacement cremators will be fitted with appropriate fuel and electricity metering.

- From 1st January 2027, all cremators will be fitted with appropriate fuel and electricity metering.

Fuel and electricity consumption can be converted into carbon dioxide emissions using standard publicly available emission factors. Carbon intensity data is available for different fuels used; data is also available for electricity drawn from the national grid. Carbon intensity data on electricity is updated from time to time. https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting

Data on the carbon content of coffins may be less freely available. However, data on different coffin materials and types should be available through either the FSA (Funeral Suppliers Association) or DMAG (Deceased Management Advisory Groups). This should include data on carbon from renewable naturally occurring raw materials and embedded carbon arising from the manufacturing process. Funeral directors should pass sufficient information to crematoria operators for them to include in calculations. Where possible data should be referenced to a relevant standard.

Carbon emissions from the deceased shall be excluded from calculations of carbon emissions.

Further work is needed on developing emission factors for N_2O emissions, so these should be excluded from calculations at the present time.

4.6.4 Operators of crematoria shall report on an annual basis their carbon emissions from fuel, electricity consumption, coffins including any fittings, but not including the deceased.

Reports will include a justification of the calculation methodology used and references to relevant sources of data, including emission factors. Emissions will be reported as both total mass emissions (kg) and the average mass of emissions per cremation.

4.7 Consumables and Waste Materials

4.7.1 Waste residues collected from inside the flue gas treatment equipment must be disposed of in accordance with waste legislation.

Dusty materials, dusty wastes and wastes containing mercury shall be contained.

4.7.2 Records shall be kept of all wastes sent for recycling or disposal. Specifically, a record shall be kept of the consumption of flue gas treatment reagents.

4.8 Reporting and notifications

4.8.1 Good communication between the crematoria operator and their regulator is essential for an effectively regulated facility.

4.8.2 The operator shall keep records of all inspections, tests, monitoring and visual assessments. The records should be:

- kept on site
- kept by the operator for at least two years; and
- made available for the regulator to examine on request.

If any records are kept off-site, they shall be made available for inspection within one working week of any request by the regulator.

4.8.3 Where an operator intends to carry out periodic emissions monitoring, they shall notify the regulator in sufficient time, (typically 14 to 21 days) so that they can decide whether to observe the testing.

4.8.4 The operator shall submit the results of all periodic emissions testing to their regulator within a timescale and format agreed with the regulator. This shall be no more than 8 weeks from the date of the test, except if there is a non-compliance, see Section 4.8.6.

Note: DEFRA will produce a recommended format for local authority regulators in England to use.

4.8.5 The operator shall also report operational monitoring data, within a timescale, frequency and format agreed with the regulator. These reports must include:

- the number of occasions on which an operating limit in Section 4.1.2 has not been achieved for any parameter in that table
- the recorded values of all substances and parameters listed in Table 4.1 for each of those occasions.

4.8.6 The operator must restore compliance in the shortest possible time, in the event of any:

- non-compliance with any emission limit value
- malfunctions and breakdown of the plant that leads to abnormal operating conditions, e.g., operation of the flue gas treatment bypass
- complaints about odour or smoke.

To restore compliance, the operator shall:

- notify their regulator within 24 hours of receiving the information
- agree the investigation of the issue with their regulator
- undertake the agreed investigation
- adjust the process or activity to minimise those emissions
- if applicable, re-test to demonstrate compliance as soon as possible
- promptly record the events and actions taken
- submit to the regulator, reports and updates as agreed

4.9 **Failure of Flue Gas Treatment Equipment**

4.9.1 Emergency relief vents (ERV) or bypass systems should not normally be used when cremation is underway, or during maintenance. The ERV/bypass should only be used:

- when the heat removal equipment has failed, and the equipment would otherwise be damaged; or
- during start up and shutdown; or
- due to short term power interruptions.

4.9.2 Where there is a failure of the heat removal equipment during a cremation, that cremation shall be completed operating in bypass mode.

Similarly, where there is an equipment malfunction which does not trigger the ERV or bypass system during a cremation, that cremation shall be completed.

Until the failed system is repaired, the cremator may continue to be operated in bypass mode, provided that:

- It can meet all the operational standards for an unabated cremator.
- The period of such operation does not exceed 100 hours in any calendar year, without the prior agreement of the regulator.

Otherwise, the cremator should not be used until the failed system is repaired.

In unusual and unexpected circumstances, where the use of an ERV is likely to exceed 100 hours, an assessment of the impact on local ambient air quality (see Section 4.4.2) shall be made prior to the 100-hour limit being reached.

4.9.3 The number of hours operating in bypass mode shall be reported to the regulator.

5. Best Available Techniques

5.1 Environmental Management

<table>
<tr><td colspan="2">Name of Technique:</td><td>Environmental Management System (EMS)</td></tr>
<tr><td rowspan="2">Pollutant(s) Targeted:</td><td>Principal pollutant:</td><td>All pollutants</td></tr>
<tr><td>Other pollutants:</td><td></td></tr>
<tr><td colspan="3">Principle of Operation:</td></tr>
<tr><td colspan="3">Effective management is central to environmental performance; it is an important component of BAT and of achieving compliance with permit conditions. All crematoria operators must ensure that the management of environmental performance is embedded within their management system whether by adopting published standards (e.g., ISO 14001) or by setting up an environmental management system (EMS) tailored to the nature and size of the crematorium. As a minimum this will include:

• Commitment, leadership, and accountability for the environmental performance of the facility.
• Procedures and processes in place for achieving full compliance with all environmental permit conditions.
• Setting objectives and setting targets for the continual improvement of environmental performance, measuring progress, and revising the objectives and targets according to results.
• Improving energy and resource efficiency
• Managing risks under normal operating conditions and in accidents and emergencies.
• Proper management, supervision and training of staff.
• Proper use of equipment.
• Effective preventative maintenance of equipment.

Training

Staff at all levels must have the necessary training and instruction in their duties relating to control of the process and emissions to air. As a minimum, this shall include:
• awareness of their responsibilities under the environmental permit
• steps that are necessary to minimise emissions during start up and shutdown
• actions to take when there are abnormal conditions, or accidents.

The Crematorium Technicians Training Scheme operated by the Institute of Cemetery and Crematorium Management should be appropriate for this purpose, as should the Training and Examination Scheme for Crematorium Technicians which is run by the Federation of Burial and Cremation Authorities.

The operator shall maintain a statement of the training requirements for each post and keep a record of the training received by each person. These documents shall be made available to the regulator on request for inspection.

Maintenance

Effective preventative maintenance is a key part in achieving compliance with emission limits and other provisions. All aspects of the process including all plant, buildings and the</td></tr>
</table>

equipment concerned with the control of emissions to air should be properly maintained. A well-maintained cremator will have: • Written inspection, maintenance and cleaning programmes and schedules. This should include regular operator checks (daily, weekly or by number of cremations), maintenance by the service engineer, as well as periodic replacement of some items, e.g., brickwork. Cleaning of cremator ducts and flues are considered part of preventative maintenance. • The inspection and maintenance regime must include all parts of the equipment, instrumentation and control, whose malfunction could have an impact on emissions to air. • Planned and preventative maintenance can be time based or condition based, all maintenance work should be recorded. Maintenance records shall be made available to the regulator on request for inspection.

Achievable Performance:	Implementation of an EMS will support achieving a good level of environmental performance.
Cross Media Effects:	
An EMS provides a good framework for managing environmental impact across all media (i.e., air, water, and land).	
Technical Considerations relevant to applicability:	
Regulators should use their discretion, in consultation with individual operators, in agreeing the appropriate level of environmental management.	
Economic Information:	
Effective management should ensure costs are controlled.	
Driving Force for Implementation:	
Good management control over emissions.	

5.2 Good Combustion Control

Name of Technique:		Good combustion control
Pollutant(s) Targeted:	Principal pollutant:	Volatile organic compounds, Particulates (dust)
	Other pollutants:	Carbon monoxide, Odour, PAHs, PCDD/F
Principle of Operation:		
To minimise and control emissions to air of CO and unburnt substances from crematoria, BAT is to ensure an optimised combustion. Optimised combustion is achieved by good design and operation of the equipment, including: • A primary combustion chamber into which the coffin and deceased are cremated. • A secondary combustion chamber which ensures the complete oxidation of all gaseous compounds passing from the primary combustion chamber.		

The cremator is designed in such a way that the gaseous products of combustion from the primary combustion chamber are held in the secondary combustion chamber at a sufficiently high temperature for a sufficiently long time to ensure they are completely oxidised. The cremator is designed to achieve a minimum residence time in the secondary combustion chamber of 2 seconds at the operating temperature, and this is verified at commissioning. The secondary combustion chamber starts after the last injection of combustion air and ends where the temperature drops below the relevant minimum value set out in Section 4.1.2 of this guidance. The temperature is measured at the start and end of the secondary combustion zone and both values must exceed the minimum value. Residence time in the secondary combustion chamber should be demonstrated at commissioning. This may require the temporary installation of additional thermocouples. The residence time requirement should be verified at the operating temperature of the secondary combustion chamber and that temperature must exceed the relevant minimum value set out in Section 4.1.2 of this guidance. Unabated cremators should also be designed in such a way as to minimise the risk of entrainment of particulate matter by the gas flows.	
Achievable Performance:	The main control is to ensure oxygen concentrations achieve the minimum conditions set out in Table 4.1. Carbon monoxide is a key indicator of incomplete combustion and should also be controlled below the level set out in Table 4.1. Controlling CO emissions will minimise emissions of unburnt organic compounds including PAH and PCDD/F, which are much more difficult to monitor. There is limited data available on PCDD/F emissions. For gas fired cremators fitted with flue gas treatment, emissions in the range 0.0004 to 0.014 ng/Nm^3 were reported (5 data points). For electric cremators, emissions in the range 0.006 to 0.018 ng/Nm^3 were reported. No data was reported for unabated cremators.
Technical Considerations relevant to applicability:	
The cremator should be designed and operated in order to prevent the discharge of smoke or fumes during loading of a coffin into the primary combustion chamber. The charging system shall be interlocked to prevent the loading of a coffin into the primary combustion chamber unless the secondary combustion chamber temperature exceeds that specified for good combustion in the permit. The cremator and all ductwork should be made and maintained gas tight if under positive pressure to prevent the escape of gases from the ductwork or cremator to the air. When re-bricking a cremator, the convolutions of the secondary combustion chamber should be maintained, the volume of the chamber may need to be recalculated and residence time reverified.	
Economic Information:	

Cost effective operation of crematorium equipment.
Driving Force for Implementation:
Good operational control of the cremation process.
Example Plants:
All cremators use this technique.

5.3 Flue Gas Treatment

Name of Technique:		Flue Gas Treatment, Mercury Abatement or Dry Scrubbing Process
Pollutant(s) Targeted:	Principal pollutant:	Mercury
	Other pollutants:	Dioxins and furans, acid gases and particulate matter
Principle of Operation:		
Mercury is highly volatile and therefore almost exclusively passes into the flue-gas stream. Mercury is only partially removed with particulate matter. The rest remains in the flue gases as volatile compounds. This technique involves the injection of activated carbon into the flue gas upstream of a bag filter or another dedusting device. Mercury is adsorbed onto the reagent in the flue gas stream and where barrier filters such as bag filters are used, is retained on the bag surface. Benefits include the reduction of mercury emissions to air by adsorption on activated carbon which also adsorbs dioxins. Bag filters also provide a means of dust and metals removal. It is normal for alkaline reagents to be added with the carbon which then allows the reduction of acid gases in the same process step as a multifunctional device. Alternatively, a fixed bed or cartridge of activated carbon and alkaline reagent can be installed downstream of a bag filter.		
Achievable Performance:	Operational aspects are similar to other situations where bag filters are used. Effective bag filter and reagent injection system maintenance is particularly critical for achieving low emission levels. Where a fixed bed or cartridge is used, reagents must be replaced sufficiently frequently to prevent pollutant breakthrough. Mercury is adsorbed (usually at about 95 % removal efficiency) to result in emissions to air below 30 µg/Nm^3.	
Cross Media Effects:		
The cross-media effects are similar to those for other situations where bag filters are used. The energy consumption of bag filters is a significant aspect. In addition, for this technique		

the most significant cross-media effect is the production of residues contaminated with the removed pollutant (mercury). Cremators should be designed in such a way that the exhaust gases are rapidly cooled prior to flue gas treatment to prevent de novo synthesis (formation) of dioxins.
Technical Considerations relevant to applicability:
The applicability of bag filters is discussed in the section on particulate matter removal. Activated carbon injection is generally applicable to new and existing plants. The fire risk is significant with activated carbon. The adsorbent is normally mixed with either sodium bicarbonate or hydrated lime. The effectiveness of adsorbent materials may be reduced if used after expiry of the shelf life of the material.
Economic Information:
Mercury abatement is normally combined with the abatement of acid gas and particulate matter and so capital, installation and maintenance cost information generally relate to the whole system. Additional operating costs are from reagent consumption and disposal of residues as hazardous waste.
Driving Force for Implementation:
Cost-effective reduction of mercury emissions to air.
Example Plants:
Widely used throughout the UK.
Reference Literature:
References not included as they relate to waste incineration.

5.4 Energy Efficient Operation

Name of Technique:		Efficient Operation
Pollutant(s) Targeted:	Principal pollutant:	CO_2 and NO_X
	Other pollutants:	
Principle of Operation:		
To optimise the consumption of energy: • Record the quantity of fuel and electricity consumed for each cremator or cremator/ flue gas treatment equipment combination. • Carry out as many consecutive cremations as possible. • Operate equipment for the longest possible period between start up and shutdown.		

- Minimise periods of idling, i.e., downtime between cremations when the equipment is kept hot, but is not operational. - Fit and maintain high standards of insulation materials to minimise heat losses. - Fit and maintain flue sealing dampers to minimise heat losses when the cremators are idle. - Fit heat recovery. See technique on energy recovery.	
Achievable Performance:	Industry data indicates that gas consumption drops from around $10m^3$ per cremation for 2 cremations to $<5m^3$ per cremation for 6 or more consecutive cremations in the same operating period. Electric cremators operate differently in that they are maintained in a hot state even when non-operational. However, extended operation will also have energy efficiency benefits.
Cross Media Effects:	
Electricity consumption may reduce emissions of carbon dioxide at the crematoria, depending on the carbon intensity of the supply.	
Technical Considerations relevant to applicability:	
Applicable to all types of cremators. The ability to operate for long / extended periods with minimal down time may be limited locally by customer service needs and demand. All cremators with flue gas treatment will need to cool the exhaust gases for the treatment process to be effective, this is a heat recovery opportunity. At this scale of operation, heat will ordinarily be recovered as hot water.	
Economic Information:	
Efficient use of energy will reduce operating costs.	
Driving Force for Implementation:	
- High cost of energy. - Reducing greenhouse gas and NO_X emissions - Reducing operating costs	
Example Plants:	
The most efficient use of energy will occur where equipment is operated 7 days per week, 24 hour per day, such as may be the case in direct cremation. At traditional crematoria, accepting short delays including overnight, between the funeral service and the cremation can facilitate improved scheduling to improve energy efficiency. Traditional crematoria may include some additional direct cremations within their schedule to improve energy efficiency.	

Note: Direct cremation is where the cremation process takes place separately from the funeral service, e.g., either before or in the absence of a funeral service.

5.5 Energy Recovery

Name of Technique:		Energy Recovery
Pollutant(s) Targeted:	Principal pollutant:	Carbon dioxide
	Other pollutants:	Other combustion related emissions
Principle of Operation:		
In crematoria with flue gas treatment, the energy recovered from cooling of the combustion gases prior to treatment is used, thereby displacing the energy that would otherwise have been needed for that purpose.		
Achievable Performance:	Examples of where recovered heat could be used are: • Preheat of primary and secondary combustion air. • Space heating e.g., hot water central heating of the chapel at the crematoria • Other heating e.g., greenhouses for horticulture • Electricity generation using an Organic Rankine Cycle generator	
Cross Media Effects:		
Improved overall energy efficiency		
Technical Considerations relevant to applicability:		
Secondary air coolers are always likely to be needed which can take the full heat load from the cremator as matching the heat supply with demand will always be problematic.		
Economic Information:		
Reducing energy costs should have economic benefits.		
Driving Force for Implementation:		
Energy saving		
Example Plants:		
• The crematorium at Redditch uses recovered heat to heat the swimming pool in the local Leisure Centre. • The crematorium at Huntingdon uses recovered heat in adjacent greenhouses.		

5.6 Control of Materials

<table>
<tr><td colspan="2">Name of Technique:</td><td>Control of body bag and coffin construction materials (and other materials placed in the cremator)</td></tr>
<tr><td rowspan="2">Pollutant(s) Targeted:</td><td>Principal pollutant:</td><td>Nitrogen Oxides (NO_X), HCl, Dioxins and Furans</td></tr>
<tr><td>Other pollutants:</td><td>Particulate Matter, CO_2 and N_2O</td></tr>
<tr><td colspan="3">Principle of Operation:</td></tr>
<tr><td colspan="3">The operating principle is prevention at source. The range of materials used for coffin or casket construction includes cardboard, wickerwork (made from willow) as well as wood composite board and solid wood. Shrouds are also available and may use natural fibres such as cotton, linen or wool.
• The weight of coffins should generally be optimised so that they provide sufficient strength and integrity to safely convey the deceased but minimise the quantity of additional ‘fuel’ for combustion. Resins with a high nitrogen content should be avoided.
• Materials to be avoided in coffin or casket construction, furnishings and body preparation/embalming include halogenates, metals (except steel screws and staples), wax and more than a thin layer of water based lacquer on wood.
• Where a body bag is used, halogenated polymers and those with a high nitrogen content must not be used in the production of body bags. Double and triple bagging of the deceased should not be carried out. Packaging for stillbirth, neonatal and foetal remains should not include any halogenated plastics.
• Similarly coffin handles, linings, clothing, and any personal effects placed in the coffin with the deceased must not contain polymers with a high halogen or nitrogen content (e.g., PVC or melamine).
• Cardboard coffins should not contain chlorine in the wet strength agent. (e.g., not using polyamidoamine-epichlorhydrin based resin (PAA-E).
• Materials used in coffins shall not produce ashes which may be sticky or cause fouling and slagging within the cremator.
• Coffins containing lead or zinc shall not be cremated

Reducing the additional fuel load to the cremator reduces NO_X formation in a number of ways:
• There is less material to combust, and the combustion is less intense which will reduce flame temperatures and so reduce the amount of thermal NO_X produced.
• There will be less nitrogen embedded in the fuel which is also converted to NO_X during the combustion process, e.g., nitrogen present in the construction materials, e.g., urea formaldehyde resins used in the production of some grades of MDF will be converted into NO or NO_2 during combustion.

Similarly, any chlorinated materials present will result in emissions of HCl during combustion. This will increase the emissions load on the flue gas treatment equipment. High levels of HCl increase the risk of dioxin formation during heat recovery.</td></tr>
<tr><td>Achievable Performance:</td><td colspan="2">The operating principle is prevention at source. Reducing the thermal load and the avoidance of high nitrogen containing construction materials, or at least minimising the amount will reduce the amount of NO_X produced.</td></tr>
</table>

	NO_X reductions of around 66% and N_2O reductions of over 90% are claimed to be achievable by reducing the secondary fuel load at charging of the cremator. NO_X reductions of around 66% are comparable with the performance of SNCR (see Section 5.7.1)

Cross Media Effects:

Reducing the mass of coffins and the use of single body bags will not reduce the ‘fuel load’ to the cremator to the extent that it will result in increased fuel consumption.

Minimising the weight of the coffin will also reduce the emission load of particulates on the flue gas treatment equipment. If the reagent dosing rate needs to be increased to deal with an increased level of HCl, this will result in more spent reagent for disposal.

A small amount of nitrous oxide (N_2O) will also be produced during combustion of the coffin. N_2O is a very potent greenhouse gas (300 times that of CO_2). Minimising the coffin weight will therefore help limit the release of this highly potent greenhouse gas.

Accounting for the carbon content of coffin materials and / or body bags is dependent on factors such as the sustainability of the source materials, accounting for their processing into finished products, any associated transportation along the supply chain and the accounting methodology. This is not considered here, other than to make the obvious comment that whatever CO_2 equivalence is assigned by whatever accounting method, minimising the mass of the coffin will reduce the impact.

Technical Considerations relevant to applicability:

The choice of coffin materials is normally made by the bereaved in consultation with the funeral director and is a matter outside the direct control of the crematoria operator. Operators should advise funeral directors so that they may give appropriate guidance to their customers. Operators are unlikely to refuse to carry out a cremation, except in extreme circumstances.

Loading of coffins: Whilst many models of loaders are suitable for use with lightweight materials, some loaders do not handle the softer, more flexible materials very well and may require modification.

In some circumstances, there could be a risk of flash back when loading the coffin into the cremator if inappropriate materials are used. There is also anecdotal evidence of body bags inflating and bursting on loading into the cremator.

Economic Information:

- The cost of different coffin types and body bags is not a matter for the guidance.
- Coffin choice should not impact on fuel consumption but could lead to a small increase in reagent use.

Driving Force for Implementation:

- Minimising emissions of NO_X, particulates, acid gases, dioxins and furans.
- Reducing the impact of crematoria on local ambient air quality

• Minimising greenhouse gas emissions.	
Example Plants:	
• Applicable to all cremator types • Lightweight coffins are readily sourced and are widely used in the UK.	
Reference Literature:	
1. *Günther, Björn & Gebauer, Kathrin & Barkowski, Robert & Rosenthal, Michael & Bues, Claus-Thomas. (2012). Calorific value of selected wood species and wood products. European Journal of Wood and Wood Products. 70. 755-757. 10.1007/s00107-012-0613-z.* 2. https://epd-australasia.com/wp-content/uploads/2018/04/epd563-Medium-Density-Fibreboard-v1.1.pdf. 3. https://en.wikipedia.org/wiki/Heat_of_combustion 4. *P W Stephenson, P Cimbaly, D Simanovic, J Weber. Date of issue: April 2008 Stack Emission Survey – Casket Combustion Trial LifeArt Australia Pty Ltd Eastern Suburbs Memorial Park Matraville, NSW Project no.: 3868/S11913A/07* 5. *https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-fifth-edition-volume-i-chapter-10-wood-products-0* 6. *Davies & Co.* 7. Nitrogen Oxides (NOx) | Air Pollution Information System (apis.ac.uk)	

5.7 Emerging Techniques

An emerging technique is one which has the potential to provide either a higher level of environmental protection, or the same level of environmental protection in a more cost-effective manner, compared with existing best available techniques.

5.7.1 Selective Non-Catalytic Reduction (SNCR)

Name of Technique:		Selective Non-Catalytic Reduction
Pollutant(s) Targeted:	Principle pollutant:	NO_X – Nitrogen oxides, NO and NO_2
	Other pollutants:	
Principle of Operation:		
Nitrogen oxides arise from combustion (thermal NO_X) and from nitrogen that may form part of the materials being burned in the cremator. In the SNCR process, ammonia or urea is injected into the furnace to reduce NO_X emissions. Ammonia reacts with nitrogen oxide to produce nitrogen and water. Where urea is used, the urea first reacts to produce ammonia and CO_2 with the ammonia then reacting with nitrogen oxide. Nitrogen oxide is a precursor to nitrogen dioxide; thus the technique is effective at reducing emissions of both NO and NO_2. The reaction between ammonia and nitrogen oxide is most effective between 850 ˚C and 950 ˚C which is typically the temperature achieved in the secondary combustion chamber. SNCR is an established technique in other sectors but is included here as an emerging technique because its application to cremation is not yet optimised and not available from all equipment manufacturers.		
Achievable Performance:	SNCR is used as a NO_X abatement technique in combustion processes across a range of industrial sectors and can achieve reductions in emissions of between 60% and 80%.	

	Limited data is available on NO_X emissions because it is not a parameter that has to be monitored in permits. Available data shows NO_X emissions typically from 200 to 350 mg/Nm^3, with some values up to 500 mg/Nm^3. Only one data point for SNCR was obtained showing emissions of 114 mg/Nm^3.
Cross Media Effects:	
Overdosing of ammonia or urea results in ammonia slip, i.e., emissions to air of ammonia. Poor control of the process can also lead to increased emissions of nitrous oxide (N_2O) which is a potent greenhouse gas. On unabated cremators, SNCR can increase particulate emissions.	
Technical Considerations relevant to applicability:	
Cremation is a batch process and thus emissions never achieve a steady state condition. To be fully effective, the injection rate needs to be controlled throughout the process to deliver the optimum dose at each part of the process. Crematoria are small pieces of equipment, and the installation of sophisticated control systems may not be economic.	
Economic Information:	
A simple system for dosing urea solution is relatively inexpensive. In February 2022 installation costs were reported as £20,000 - £25,000 per cremator. More sophisticated control systems would increase these costs. The ongoing supply of reagent will typically add £3.00 - £4.00 per cremation to costs and additional maintenance costs are low. However sophisticated control systems to optimise dosage across the cremation cycle could be expensive and is not used in practice.	
Driving Force for Implementation:	
NOx emissions contribute significantly to poor air quality in urban areas.	
Example Plants:	
One equipment manufacturer supplies a NO_X abatement system for their gas fired cremators using a fixed dosing rate of urea solution based on factory settings.	

6. Cremation standards in the event of mass fatalities

These paragraphs are issued as a precautionary measure in the event of a national emergency giving rise to mass fatalities. These paragraphs are without prejudice to any restrictions or requirements there may be under health and safety legislation.

6.1 The UK or appropriate Devolved Government will alert regulators at the time when an emergency exists which triggers this section of the guidance. There will be a similar alert when the situation is at an end after which this section will no longer apply.

6.2 In the event of mass fatalities, such as could arise from pandemic flu, crematoria may need to operate for sustained or extended periods. This means that there is a greater likelihood of equipment breakdown, including equipment for reducing emissions to air. There could also be implications for staffing of crematoria.

6.3 Regulators and crematoria operators are reminded that it is good practice to ensure that:

- spares and consumables are available at short notice;
- to have an audited list of essential items;
- those spares and consumables subject to continual wear should be held on site or should be available at short notice from guaranteed local suppliers so that plant breakdowns can be rectified rapidly;
- planned and preventative maintenance schedules are adhered to;
- there is a sufficient supply of flue gas treatment reagents;
- staff at all levels need the necessary training and instruction in their duties relating to the control of the process and emissions to air and refer to the Crematorium Technicians Training

6.4 Regulators and crematoria operators should also bear in mind that:

- larger quantities of spares and consumables may be needed in the event of an emergency causing mass fatalities;
- an emergency causing mass fatalities may have implications for the number of trained staff that can be called upon.

To minimise the potential for breakdowns during such an emergency, a simple plan should be drawn up, which should mainly address the holding of additional spares and consumables and the training of suitable numbers of staff.

This plan shall be made available on request to the regulator for inspection.

6.5 If this is done, there might nonetheless be either a breakdown of equipment affecting emissions to air, or a shortage of staff trained on the air pollution aspects of operating the crematorium. There might also be a heightened demand which warrants operating an unabated standby cremator for longer than the 100 hours allowed. In such circumstances, and in the public interest, regulators should take a balanced view of enforcement action in the event of a breach of permit conditions.

6.6 If best endeavours have been taken to reduce the likelihood of a breakdown or staff shortage, it may well be appropriate to allow a crematorium to continue to operate for a period of time, while breaching permit conditions without any enforcement action being taken.

6.7 One consideration may be whether the crematorium in question is located in a local Air Quality Management Area for any of the pollutants emitted from the crematorium. In such cases, steps should be taken to rectify the breaches where practicable and as soon as is feasible.

The UK or Devolved Governments would not expect these allowances to be continued beyond the duration of the emergency.

Appendix

A. Supplementary information on burden sharing for mercury abatement

There is no obligation on those crematoria with mercury abatement to participate in burden sharing arrangements. Note burden sharing arrangements are a cost sharing mechanism so that crematoria with mercury abatement installed are not at a financial disadvantage to those that do not.

For existing unabated cremators, the requirement to participate in a burden sharing arrangement will remain in place until 31st December 2026, with a final report made to the regulator no later than 1st April 2027.

For unabated plant, the options are:

- Membership of the CAMEO scheme, the current performance of the CAMEO scheme is around 70% of cremations carried out in equipment fitted with mercury abatement.
- Forming a different cluster – the percentage of cremations carried out by the cluster in equipment fitted with mercury abatement shall exceed 50%.

The method by which the crematoria comply with the burden sharing requirements should be set out in the permit through appropriate permit conditions, as follows:

The operator shall send the regulator, by no later than 1 April each year, a certificate from the Crematoria Abatement of Mercury Emissions Organisation (CAMEO) or appropriate evidence from a comparable audited burden sharing arrangement or scheme which specifies for the past calendar year:

a) the total number of cremations
b) the number of cremations undertaken in cremators fitted with operational mercury abatement equipment; or
c) the number of cremations undertaken and the proportion of those subject to burden sharing arrangements; or
d) in cases where mercury abatement is fitted but fewer than 50% of cremations at the installation were undertaken in cremators fitted with it, the relevant information in both b) and c).

Arrangements for cost sharing in the CAMEO or any alternate burden sharing scheme do not form part of the permit conditions.