ERA
Environment & Resources Authority

Crematoria

Supporting Document for the Control of Emissions into the Air from the Cremation Processes in Malta

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Revision of the Guidance

This publication is updated from time to time with new or amended guidance. The table below is an index to these changes.

Rev/version	Date of amendment	Change Details

More information is available at era.org.mt

ISBN: 978-9918-628-22-3

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1. INTRODUCTION

1.1 The objective of this supporting document is to give guidance on the conditions appropriate for the control of emissions into the air from the cremation of human remains in Malta.

1.2 This document is aimed at providing a framework for consistent and transparent regulation of installations regulated under the Environment Protection Act (CAP 549). This document will be treated as one of the material considerations when determining any proposal for crematoria in Malta.

1.3 The information is based on the state of knowledge and understanding, at the time of writing, of what constitutes Best Available Techniques (BAT) for this sector. The information may be amended from time to time to keep up with developments in BAT, including improvements in techniques, changes to the economic parameters, and new understanding of environmental impacts and risks. The updated version will replace the previous version on the ERA website and will include an index to the amendment. Reasonable steps will be taken to keep the document up-to-date to ensure that those who need to know about changes are informed of any published revisions. However, because there can be rapid changes to matters referred to in the document – the reader should ascertain that the latest version is referred to.

ACTIVITY DESCRIPTION

1.4 This document applies to fixed installations for cremation of human remains in:

i. Gas fired and electric fired cremators;
ii. Standby cremators;
iii. Small-scale cremators.

1.5 Cremation is a batch process consisting (excluding pre-heating and shut-down) of:

i. The brief “flash” caused by volatilization of the veneer on the outside of the coffin;
ii. Burning of the coffin;
iii. After the coffin breaks open, burning of the coffin and cremation of the body;
iv. Calcination of the remains; and
v. Ashing.

1.6 Total cremation times vary considerably, ranging from 50 minutes up to in excess of 2 hours, depending upon body size and cause of death. Indicative timescales involved for processes i - v. are typically:

i. 1 minute;
ii. 20 minutes;
iii. 40 minutes;
iv. 30 minutes;
v. 2 minutes although times may vary.

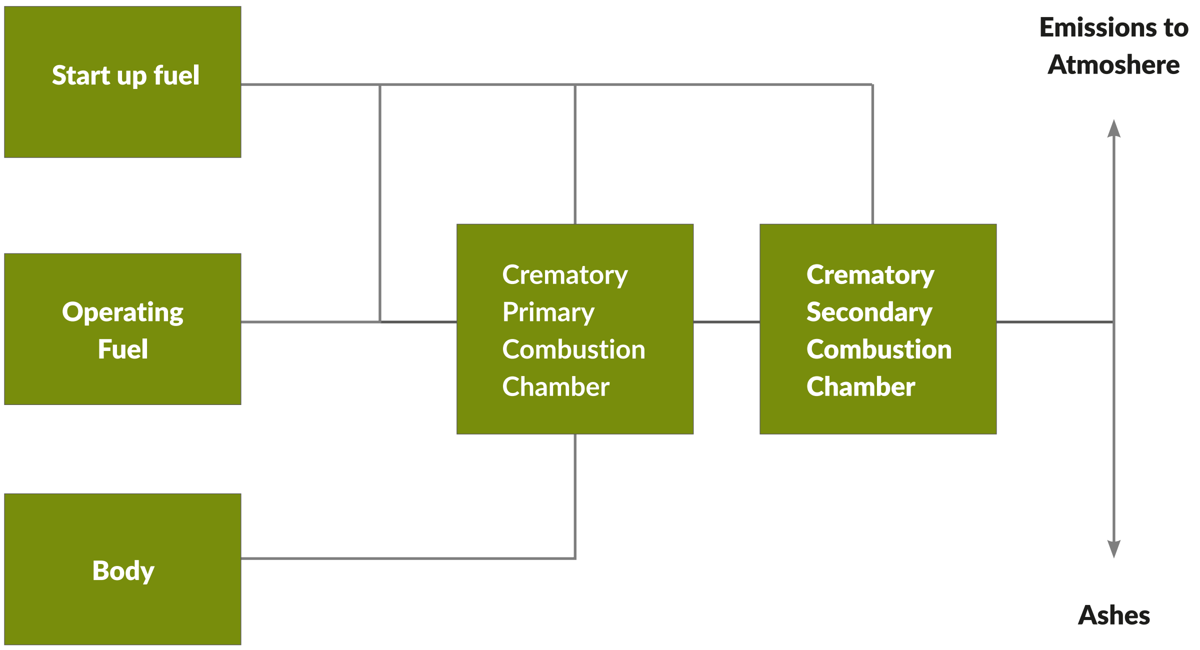

Figure 1 Schematic of a typical cremation process

2. EMISSION LIMITS, MONITORING AND OTHER PROVISIONS

EMISSION LIMITS VALUES (ELVS)

2.1 Potential pollutants from cremations consist of;

i. Particulate matter (PM)
ii. Hydrogen chloride (HCL)
iii. Nitrogen oxides (NOx)
iv. Carbon monoxide (CO)
v. Volatile organic compounds (from methane to polyaromatic hydrocarbons (PAH)
vi. Mercury compounds
vii. Dioxins [Polychlorinated dibenzo-p-dioxins and furans (PCDD/F)]

2.2 Flue gases from abated cremations may also include particulate matter from:

i. Alkali compounds added to the flue gases to control acid gas (ex. HCl) emissions;
ii. Activated carbon powder used to control dioxin and mercury emissions;
iii. Incompletely combusted char and soot particles.

2.3 All activities should comply with the emission limit values (ELVs) and provisions in Table 1 and Table 2[1]. The ELVs and provisions described in this section are achievable using the best available techniques described in Section 3.

2.4 Monitoring of emissions should be carried out according to the method specified in this section or by an equivalent method agreed by the Authority. Where reference is made to a European, or International standard (CEN or ISO) in this section, the standards referred to are correct at the date of publication.

2.5 All analysis shall be conducted by a laboratory accredited to at least EN ISO 17025:2017. In the case of in-situ monitoring, analysis shall be conducted via appropriately calibrated instrumentation.

2.6 The reference conditions for limits in **Table 1** are: 273.1K, 101.3kPa, 11% oxygen v/v, dry gas unless otherwise stated.

1 The measured value of each concentration or parameter required herein shall be electronically recorded, including the time and date corresponding to each recorded measured value. Periodic checks of such continuously monitored equipment for the listed parameters in Table 1 shall take place on an annual basis

Table 1 - cremators - emission limits, monitoring and other provisions

Row	Substance	Mass emission limits per cremator	Concentration limits	Type of monitoring	Monitoring frequency	Standard
1	Mercury	n/a	50 µg/m³	Periodic monitoring	Annual	EN 13211
2	Hydrogen chloride (excluding particulate matter)	n/a	30 mg/m³ hourly average	Periodic monitoring	Annual	EN 1911
3	Total particulate matter	n/a	20 mg/m³ hourly average	Continuous monitoring	Continuous	EN 15859
				Periodic monitoring Set reference levels for continuous emission monitor (CEM) (i.e.set levels at which alarms will activate	Every 3 years	EN 17389
4a[1]	Carbon monoxide	n/a	100 mg/m³ reported as 2 x 30-minute averages	Continuous monitoring	Continuous	EN 15267-3
				Periodic test: Validation of continuous emissions monitor (CEM) output through comparison with periodic test results	Annual	EN 15058
4b	Carbon monoxide	150g in the first hour of cremation for 95% of cremations **and**	n/a	Continuous monitoring	Continuous	EN 15267-3
		300g in the first hour of cremation for all cremations		Instrument health check – i.e. service according to manufacturer's instructions	Annual	
				Periodic monitoring Validation of continuous emissions monitor (CEM) output through comparison with periodic test results		EN 15058
5	Oxides of Nitrogen NOX (NO and NO² expressed as NO²)	n/a	200 mg/m³	Periodic monitoring	Once every year from 1 month	EN 14792
6	Organic compounds (excluding particulate matter) expressed as carbon	n/a	20 mg/m³ averaged over an hour of cremation.	Periodic monitoring	Annual	EN 12619
7[2]	PCDD/F (on abated processes, for crematoria that don't meet the combustion provisions below)	n/a	0.1 nanogram/m³ as ITEQ	Periodic monitoring • Continuous monitoring of an temperature, oxygen and flow parameters that apply during the dioxin tests should be required by the permit • Interlock to prevent cremator loading unless those parameters are met	Upon commissioning of new or replacement cremators	EN 1948-1, EN 1948-2, EN 1948-3

1 For crematoria with a "**multiple cremators/single abatement plant**" configuration, the provisions of Row 4a apply.
For crematoria with a "**single cremator/single abatement plant**" configuration, the provisions of either Row 4a **OR** Row 4b can apply but should be specified to the Authority at the earliest opportunity.

2 If combustion provisions in Rows 8 – 10 in Table 2 are not met, then the dioxin emission limit and monitoring provision in Row 7 should be applied

Table 2: Monitoring of flue gas conditions

Row	Parameter	Combustion Provision	Type of monitoring	Monitoring frequency	Monitoring standard	Other specifications
8	Temperature	• Minimum of 800°C (1073K) in the secondary combustion chamber; • Minimum of 850°C (1123K) in the secondary combustion chamber when operating under emergency conditions without abatement; • Measuring point should be at the last measuring thermocouple.	• Measure at the exit of the secondary combustion zone; measuring point should be at the last measuring thermocouple; • Automatically record temperatures; • Visual alarm when temperature falls below 1073K (800°C); • Record alarm activations; • Interlock to prevent cremator loading below 800°C.	Continuous	–	–
9	Residence time	• 2 seconds residence time (minimum) in the secondary combustion chamber without correction for temperature, oxygen or water vapour	• Measurement and calculation of the volume rate of the flue gases throughout the cremation cycle at the cremator exit.	Upon commissioning of new or replacement cremators	–	–
10	Exhaust gas oxygen content	• measured wet or dry, minimum average 6% and minimum 3%	• Record of concentration at outlet of secondary combustion zone; • Visual alarm and record alarm activations; • During discontinuous tests, continuous reference oxygen measurements should be at the same sampling location as the parameters tested.	Continuous	EN 14181 EN 15267-3	EN 14789
11	Exhaust gas flow				EN 16911-2	

CONTINUOUS EMISSIONS MONITORING

2.7 Where continuous emissions monitoring (CEMs) is required for any parameter, it should be carried out as follows:

i. All readings from CEMs should be on display to appropriately trained operating staff.
ii. Instruments should be fitted with a visual alarm to warn the Operator of abatement equipment failure.
iii. The activation of alarms should be automatically recorded.
iv. All continuous monitors should be operated, maintained and calibrated in accordance with the manufacturers' instructions, which should be made available for inspection by the Authority. The relevant maintenance and calibration (or referencing) should be recorded.
v. Emission concentrations may be reported as zero when the plant is off and there is no flow from the stack. If required a competent person should confirm that zero is more appropriate than the measured stack concentration if there is no flow.
vi. Any CEMs used should provide reliable data >95% of the operating time, (i.e. availability >95%). A manual or automatic procedure should be in place to detect instrument malfunction and to monitor instrument availability.

2.8 Exhaust flow rates should be consistent with efficient capture of emissions, good operating practice.

2.9 The introduction of dilution air to achieve ELVs should not be permitted. Dilution air may be added for waste gas cooling or improved dispersion where this is shown to be necessary because of the operational requirements of the plant, but this additional air should be discounted when determining the mass concentration of the pollutant in the waste gases.

2.10 Where periodic monitoring is required, the frequency may be varied. Where consistent compliance is demonstrated with emission limits, the Authority may consider reducing the frequency. However, any significant process changes that might have affected the monitored emission should be taken into account in making the decision. The Authority may amend the frequency, locations, and methods and scope of monitoring, sampling and analyses, as set out in the permit, following the evaluation of the test results.

Notwithstanding the monitoring requirements specified in this document (Table 1), the Authority may approve alternative monitoring arrangements where it is satisfied that the proposed approach provides an equivalent level of environmental protection and sufficient information to demonstrate compliance with permit conditions and applicable emission limit values.

2.11 Where a new or substantially changed process is being commissioned, or where emission levels are near to or approach the ELVs, the Authority may consider increasing the frequency of testing.

All continuous monitoring equipment should be operated, maintained and calibrated in accordance with the manufacturers' instructions, which should be made available for inspection by the Authority

SAMPLING & MONITORING PROVISIONS

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

2.13 The Operator shall maintain and implement an emissions monitoring programme which ensures that that monitoring is carried out under an appropriate range of operating conditions, and that measurements for the determination of concentrations of substances specified in this document shall be carried out representatively. Methods complying with harmonised CEN standards shall be presumed to satisfy this requirement. All analysis shall be conducted by a laboratory accredited to at least EN ISO 17025:2017. In the case of in-situ monitoring, analysis shall be conducted via appropriately calibrated instrumentation.

2.14 Whether sampling on a continuous or a periodic basis, care is needed in the design and location of sampling systems in order to obtain representative samples for all release points.

i. Sampling points on new plant should be designed to comply with the equivalent standards

ii. The Operator should ensure that relevant stacks or ducts are fitted with facilities for sampling which allow compliance with the sampling standards.

MINIMUM VOLUME OF GAS SAMPLED

2.15. The volume of gas sampled will depend on the size of the charge, the standard used for the testing, the type of machine (i.e. electric cremators will have a smaller volumetric flow rate) and whether sampling is performed before or after the introduction of dilution air. European standards, state that the sample time is calculated by the limit of detection of the analysis method employed.

CONCURRENT OXYGEN READINGS

2.16 Oxygen readings will be required, which are concurrent with the monitoring of the other pollutants, in order to make the correction to standard conditions.

2.17 These readings should be made in the same sampling plane in which the other samples are being taken; if not, extra dilution air could be introduced into the flue, changing the oxygen concentration at a point downstream. Care should be taken, however, that any probe used to extract the sample of gas for oxygen analysis does not cause interference to other sampling equipment in the flue, and vice-versa.

ABATE MERCURY EMISSIONS

2.18 All crematoria shall be fitted with mercury abatement.

3. BEST AVAILABLE TECHNIQUES

3.1 **Table 3** provides a summary of the best available techniques that can be used to control the process in order to meet the emission limits and provisions in Section 2. Provided that it is demonstrated to the satisfaction of the Authority that an equivalent level of control will be achieved, then other techniques may be used.

The abatement provisions in this document are based on an abatement system of cool, capture, collect. The hot exhaust gases are cooled, using for example water tube coolers. Typical abatement equipment may include, for example, selective non-catalytic reduction for NOx control, lime injection for acid gas control (SO_2 and HCl), carbon injection for mercury and PCDD/PCDF control and fabric filtration for particulate matter control.

Best available techniques are those that consider both technology and management. Control of pollutants would comprise the following items and consideration:

i. ”A cremator meeting the minimum temperature, residence time and oxygen requirements indicated in Table 2;

ii. Air emissions should be controlled at all stages of the process, including material handling, combustion and material transfer points, to control the emission of persistent organic pollutants. Sealed furnaces are essential to contain fugitive emissions while permitting heat recovery and collecting off-gases for abatement or discharge. Proper design of hooding and ductwork is essential to minimize fugitive discharge;

iii. Suitable air pollution control equipment (for control of persistent organic pollutants this would need to include temperature management to control residence time in reformation window, carbon injection and fabric filtration or equivalent);

iv. Combustion chambers and casings should be made as airtight as possible and operate under reduced pressure to minimize release of furnace gases;

v. Gas temperatures should be monitored to allow control systems to maintain minimum;

vi. Temperature criteria (through use of support fuel burners) and provide interlocking to stop charge when temperature falls below minimum;

vii. Flue gas oxygen and carbon monoxide levels should be monitored and linked to the control system to ensure adequate control of air supplies and address any combustion problems;

vii. Mechanized loading and handling of coffins to minimize exposure to Operators;

ix. Coffin storage facilities to be refrigerated, lockable and rodent and bird proof and have odour control;

x. Coffin and coffin fittings should be made of combustible material. Avoid use, or inclusion, of articles containing PVC, metals and other chlorinated compounds;

xi. Effective operation control, inspection and preventive maintenance of components whose failure could impact on the environment by releasing persistent organic pollutants;

xii Operator competencies to be identified and met by suitable training;

xiii. Application of emission limit values and monitoring of emissions to demonstrate emission compliance for pollutants.

SUMMARY OF BEST AVAILABLE TECHNIQUES

3.2 Table 3 provides a summary of the best available techniques that can be used to control the process in order to meet the emission limits and provisions in Section 2. Provided that it is demonstrated to the satisfaction of the Authority that an equivalent level of control will be achieved, then other techniques may be used.

Table 3 - Summary of control techniques

Release source	Substance	Control techniques
Flue gas	NOx	SNCR is an established technique in many industrial sectors as a NOx abatement technique in combustion processes and can achieve reductions in emissions of between 60% and 80% when required
	Odour	Good combustion and a secondary combustion zone
	CO	
	VOCs	
	PAH	
	Hg (and its compounds)	Abatement
	PM	Good combustion, slow gas velocities and a secondary combustion zone. Abatement further minimizes emissions
	Hydrogen chloride	Minimize halogens combusted, avoid excessive temperature in primary chamber. Abatement further minimizes emissions
	PCDD/F	Minimize chlorine combusted and particulate matter emitted, good combustion and a secondary combustion zone, Abatement further minimizes emissions
	CO_2	Measure gas consumption, good cremator design
Cremated remains size reduction machine	PM	Filter on machine or external dispersion and filter if needed.
Spent flue gas-abatement materials	PM, Hg	Keep containers tightly enclosed

TECHNIQUES TO CONTROL EMISSIONS

3.3 Particulate matter (PM)

Particulate matter is controlled by good combustion and by gas flows that do not carry particles out of the cremator. Mercury abatement further lessens emissions of particulate matter.

3.4 Hydrogen chloride

Hydrogen chloride mostly arises from the salt content of bodies. Chlorine should be avoided by careful control of coffin materials, contents, shrouds, clothing and items other than the body itself. Condensation is prevented by dilution and preheating stacks. Mercury abatement further lessens emissions of hydrogen chloride.

3.5 Mercury

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. Where activated carbon is used as part of the abatement technique, Operators should be aware of potential health and safety risks arising from spontaneous combustion.

3.6 Volatile organic compounds

Volatile organic compounds are controlled by good combustion.

3.7 Dioxins

PCDD/PCDF are formed through incomplete combustion or by de novo synthesis when organic and chlorine compounds are present in the feed material or flue gas matrix. Although it is considered that PCDD/PCDF, PCB and HCB will be destroyed at high temperature (minimum 850°C) in the presence of oxygen, the de novo process of PCDD/PCDF synthesis is still possible if the combustion gases are cooled over an extended period through the reformation temperature window (between 200°C and 400°C). This window can be present in abatement systems, energy recovery equipment and in cooler parts of the furnace, for example the feed area. Care taken in the design of cooling systems to minimize the residence time in the reformation window is practiced to prevent de novo synthesis Good combustion and low particulate matter emissions minimize the emission of PCDD/F. Mercury abatement further lessens emissions of dioxins.

Cremators should be designed to address the requirement for a minimum furnace temperature of 850°C, a 2-second residence time for the combustion gases and sufficient excess air to ensure combustion. The use of designs that cannot achieve these criteria should be discouraged unless demonstrated to be capable of operating without significant emissions of persistent organic pollutants.

3.8 Nitrogen oxides

Thermal NOx is minimal due to the secondary chamber temperature and because combustion is staged over primary and secondary chambers.

3.9 Carbon monoxide

Carbon monoxide is a pollutant but is also the prime indicator of incomplete combustion that would emit un-burnt hydrocarbons, PAH and PCDD/F, which are much more difficult to monitor. Abatement of CO is not BAT but good combustion minimizes emissions.

3.10 Carbon dioxide

With reference to emissions of carbon dioxide, Operators may be required to contact the Climate Action Authority (CAA) in view of reporting requirements in terms of greenhouse gas emissions.

3.11 Odour

Odour is prevented by good combustion.

3.12 Failure of Abatement Plant

The process will be designed that will allow the emergency release of unabated gases in the event of a breakdown of the abatement equipment. Where there is more than one air emission abatement system and one system fails, that system should not be used until it is repaired.

Where there is only one air emission abatement system then cremations should be allowed to continue for up to 48 hours to provide an opportunity for the necessary repairs to be completed. The Authority should be notified immediately.

Emergency relief vents (ERV) or bypass systems should not normally be used when cremation is underway. Occasions when the ERV/bypass is used during a cremation should be notified to the Authority. Use of the ERV/ bypass during cremation more than once a year should be investigated and remedial action taken.

i. In the event of the use of a ERV/ bypass during cremation:

a. The failure, its cause and cure should be entered in the log; and

b.The Authority should be notified immediately

ii. ERV/bypass should only be used:

a. When the heat removal plant has failed and the abatement plant would be damaged; or

b. During warm-up and shutdown, provided that compliance be demonstrated with the CO limit.

3.13 Waste Materials

Any Waste materials resulting from the operations of the cremator shall be managed in accordance with waste legislation. Waste consisting of fine-particles and waste containing mercury should be kept tightly contained to prevent dispersal and/or leakages.

The Operator shall ensure to put in place a system in which implants and foreign materials in the deceased are declared to the cremation process.

3.14 Coffin materials and cremator design

The ELVs and provisions specified in section 2 may be achieved by careful use of materials in coffin construction and furnishing and by cremator design and operation (including abatement). 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. 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.

i. PVC and melamine should not be used in coffin construction or furnishings;
ii. Cardboard coffins should not contain chlorine in the wet- strength agent. (e.g. not using polyamidoamine-epichlorhydrin based resin (PAA-E));
iii. Packaging for stillbirth, neonatal and fetal remains should not include any chlorinated plastics:
iv. Coffins containing lead or zinc should not be cremated;
v. The cremator should be designed and operated in order to prevent the discharge of smoke or fumes during charging;
vi The charging system should be interlocked to prevent the introduction of a coffin to the primary combustion zone unless the secondary combustion zone temperature exceeds that specified for good combustion in the permit;
vii. 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.

3.15 **Good combustion**

The secondary combustion zone starts after the last injection of combustion air. Air injected at support burners in the secondary combustion chamber is ignored, as long as there is no more than about 6% excess oxygen for the fuel burnt.

i. All cremators should be designed to ensure complete combustion and should be fitted with a secondary combustion zone;
ii. The manufacturer should state the volume of the secondary combustion zone;
iii. When re-bricking a cremator, the convolutions of the secondary combustion chamber should be maintained and the volume of the chamber recalculated and restated.

It is technically feasible for oxygen levels to be less than 6% but any minimum oxygen levels proposed by Operators should be fully justified to the Authority and backed up with monitoring data to show that compliance with emission limit values for all pollutants listed in Table 1 is fully met.

i. Residence time in the secondary combustion zone should be demonstrated at commissioning or by calculation.

Re-lining or re-bricking of a cremator is likely to improve emission control rather than have a significant negative effect on human beings or the environment, and therefore this activity alone is unlikely to justify classification as a substantial change such that residence time requires demonstrating again.

3.16 **Visible and Odorous Emissions**

The aim should be to prevent any visible airborne and odorous emissions from any part of the process, as perceived by the Authority. This aim includes all sites regardless of location. Emissions from cremations should in normal operation be free from visible smoke:

i. All other releases to air, other than condensed water vapour, should be free from persistent visible emissions.
ii. All emissions to air should be free from droplets

3.17 **Cremated remains**

i. For all cremators, the remains in the cremator should only be moved when calcination is completed.
ii. The removal of ash and non-combustible residues from the cremator should be undertaken carefully so as to prevent dust emissions via the flue.
iii. Cremated remains should be moved and stored in a covered container.
iv. Many cremated remains treatment plants have an internal filter and discharge inside the building and for them an emission limit and testing are unlikely to be needed.
v. Cremated remains treatment plant venting externally should be abated to meet the particulate matter limit in Table 1.

3.18 **Standby cremators**

Some crematoria may wish to retain a stand-by cremator for use in the event of breakdown of the main cremator or other occasional need for additional cremator capacity. Such plant should be permitted and is to be operated in compliance with all the following criteria:

i. With the aggregate periods of emission of dark smoke not exceeding 5 minutes during any period of eight hours;
ii. With no single emission of dark smoke exceeding two minutes; and
iii. Without any emission of black smoke.

The following conditions and also the management requirements listed should also be complied with:

i. The standby cremator should be clearly identified.
ii. Stand-by plant should operate for no more than 100 hours in any 12-month period.

iii. All periods of operation and the reason for standby plant operation should be recorded in the log.
iv. The Authority should be notified, in advance if possible, of the operation of standby plant.
v. Visual and olfactory assessments of emissions should be made at the start and at least once during each cremation cycle in standby plant, the location and result of the assessment should be recorded in the log.[4]
vi. Remedial action should be taken immediately in the case of abnormal emissions.
vii. PVC and melamine should not be used in coffin construction and furnishings
viii. Cardboard coffins should not contain chlorine in the wet-strength agent (i.e. not using polyamidoamine-epichlorhydrin based resin (PAA-E).
ix. Packaging for stillbirth, neonatal and fetal remains should not include any chlorinated plastics.
x. Coffins containing lead or zinc should not be cremated.
xi The remains in the cremator should only be moved when calcination is completed.

3.19 Small-scale cremators

i. Small-scale cremators may be developed in order to cremate stillbirth, neonatal and fetal remains. Not all the standards for full- scale cremators are appropriate for such small-scale cremators because of the relatively small mass of pollutants emitted. For these purposes “small-scale cremators” should be taken to mean cremators with a maximum door opening of 300 x 300 mm and with a maximum length of primary chamber of 1,000 mm.
ii. When stillbirth, neonatal or fetal remains are cremated in full-scale cremators, the guidance for those cremators should apply.

4 The frequency of assessments can be reduced if a continuous particulate matter monitor is operating

3.20 Cremation standards in the event of mass fatalities

This section is issued as a precautionary measure in the event of a national emergency giving rise to mass fatalities. In the event of mass fatalities, such as could arise from pandemics, crematoria may need to operate for sustained periods. This means that there is a greater prospect of breakdown of equipment, including equipment for reducing air emissions. There could also be implications for staffing of crematoria.

The Operator should consider that:

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

In order to minimize the potential for breakdowns during such an emergency, it is important that all crematoria plan for such an eventuality, taking account of above. A plan should be in place for dealing with emergencies which give rise to mass fatalities, which should mainly address the holding of additional spares and consumables and the training of suitable numbers of staff.

This supporting document is without prejudice to any restrictions or requirements there may be under health and safety legislation.

3.21 Management

The management of the facility is the key to ensuring safe and environmentally benign operation. All personnel operating the facility should be fully conversant with their duties, in particular with regard to routine operation, maintenance, process upset conditions and local environmental legislation. The competency of Operators should be addressed by suitable training at an appropriate level for the facility.

Important elements for effective control of emissions include:

i. Proper management, supervision and training for process operations;
ii. Proper use of equipment;
iii. Effective preventative maintenance on all plant and equipment concerned with the control of emissions to the air; and
iv. Ensuring that spares and consumables

It is good practice to ensure that:

i. Spares and consumables are available at short notice;
ii. To have an audited list of essential items;
iii. 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; This is important with respect to arrestment plant and other necessary environmental controls. It is useful to have an audited list of essential items.

3.22 **Appropriate management systems**

Effective management is central to environmental performance; it is an important component of BAT and of achieving compliance with permit conditions. It requires a commitment to establishing objectives, setting targets, measuring progress and revising the objectives according to results. This includes managing risks under normal operating conditions and in accidents and emergencies. It is therefore desirable that installations put in place some form of structured environmental management approach, whether by adopting published standards (ISO 14001 or the EU Eco Management and Audit Scheme [EMAS]) or by setting up an environmental management system (EMS) tailored to the nature and size of the particular process. Operators may also find that an EMS will help identify business savings.

3.23 **Training**

Staff at all levels need the necessary training and instruction in their duties relating to control of the process and emissions to air. In order to minimize risk of emissions, particular emphasis should be given to control procedures during start-up, shut down and abnormal conditions. All staff whose functions could impact on air emissions from the activity should receive appropriate training on those functions. This should include:

i. Awareness of their responsibilities under the permit;
ii. Steps that are necessary to minimize emissions during start up and shut down;
iii. Actions to take when there are abnormal conditions, or accidents or spillages that could, if not controlled, result in emissions.
iv. The Operator should maintain a statement of training requirements for each post with the above-mentioned functions and keep a record of the training received by each person. These documents should be made available to the Authority on request.

3.24 **Maintenance**

Effective preventative maintenance plays a key part in achieving compliance with emission limits and other provisions. All aspects of the process including all plant, buildings and the equipment concerned with the control of emissions to air should be properly maintained. In particular, the Operator should have the following available for inspection by the Authority:

i. A written maintenance programme for all pollution control equipment; and
ii. A record of maintenance that has been undertaken.

3.25 **Cremator maintenance**

A well-maintained cremator should have:

i. Written maintenance and cleaning programmes available to the Authority with respect to pollution control equipment, including control instrumentation and the cremator secondary chamber, ducts and flues, and on any abatement;
ii. Cleaning of cremator ducts and flueways is considered part of preventative maintenance e.g. raking out twice a year;
iii. Maintenance of an existing crematorium will need to include at least the following:
    - Inspecting, repairing and replacing brick, flue, control software and hardware, monitoring equipment etc.;
    - Regular maintenance and inspection by service engineer;
    - Operator maintenance - daily, weekly, monthly, by number of cremations.

All aspects of the process including all plant, buildings and the equipment concerned with the control of emissions to air should be properly maintained.

4. AIR QUALITY

4.1 **Dispersion & Dilution**

For all crematoria, the chimney height is calculated at a suitable height for the release of emissions during normal operation.

Pollutants that are emitted via a stack require sufficient dispersion and dilution in the atmosphere to ensure that they ground at concentrations that are deemed harmless. The stack height should be determined in line with the modeling provisions outlined in point 4.4

In order to maintain maximum advantage from thermal buoyancy and momentum, emissions should take place from the minimum practicable number of chimneys. Each cremator should have its own flue in a multi-flue stack. For crematoria with abatement plant, each abatement plant can have one flue plus an emergency release vent (ERV). As the ERV should only be used infrequently, the ERV stack height can be the same as the abated stack height. An Operator may choose to meet tighter emission limits in order to reduce the required main stack height, but the ERV stack height may not be reduced.

4.2 **Ambient air quality management**

In areas where air quality standards or objectives are being breached or are in serious risk of breach and it is clear from the detailed review and assessment work under Local Air Quality Management that the permitted process itself is a significant contributor to the problem, it may be necessary to impose tighter emission limits.

4.3 **Stacks, vents and process exhausts**

Liquid condensation on internal surfaces of stacks and exhaust ducts might lead to corrosion and ductwork failure or to droplet emission. Adequate insulation will minimize 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 buildup of material on the internal surfaces may effect dispersion:

- Flues and ductwork should be cleaned to prevent accumulation of materials, as part of the routine maintenance programme.
- When dispersion of pollutants discharged from the stack (or vent) is necessary, the target exit velocity should be 15m/s during peak operating conditions to achieve adequate dispersal.

In order 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 Terms of reference for the modelling of crematoria emissions

Part A: Stack height and Effect of Stack emissions on deposition rates & Emission Loads

Scope

To use dispersion modelling suites, in order to assess for the likelihood of significant effects on ambient air quality (including exceedances of the ambient limit values in SL.549.59) as well as on the deposition levels of particular components, due to the operation of a crematorium. The analysis should focus on the area of influence of the plant, and should include the sensitive receptors in this area. For the deposition levels the sensitive receptors shall include, amongst others, all farms within this area.

The study shall be repeated at predetermined intervals and using in-stack emissions data from the plant.

Technical specifications.

Point Source modelling.

The modelling suite used throughout this exercise shall be capable of incorporating all the substances included in these terms of reference. Any emission factors used shall be European Emission factors preferably based on plants similar (same manufacturer and operating conditions) to the one under study. The model must be capable of predicating the dispersion and deposition of pollutants under variable meteorological conditions ranging from the most favorable to the least favorable.

The modelling suite shall model annual levels of the required parameters.

Acceptable dispersion models are e.g. ADMS, AERMOD, and IMMIS. Other dispersion models may be accepted provided that the requirements in this document are met. The spatial resolution achievable by the model shall be 5 × 5 m^2, to enable the identification of impacts at sensitive receptors.

The model shall include a meteorological processor and a terrain processor (capable of modelling dispersion over a complex terrain).

Rather than using the Pasquill-Gifford stability classes, the model shall rely on the use of the Monin-Obukov lengths.

The model shall be capable of modelling the effect of the interaction of the pollutant(s) from the plant with natural or man-made structures e.g. (aerodynamic downwash, cavity and wake effects, etc.).

The model shall be capable of modelling the effect of complex winds, different fumigation mechanisms and stagnation on pollutant dispersion. The consultants shall provide documentation that the chosen model in any one of the 28 EU member states, for regulatory applications involving the local scale effects of point sources on air quality.

For particulate matter both primary and secondary particulate shall be modelled.
In addition, the total deposition of certain pollutants shall be modelled.

The consultants shall be obliged to follow industry best practice standards in respect of quality assurance requirements of the dispersion model and in order to ensure that the final report satisfies its intended objectives in respect of resolution, accuracy and reliability.

The dispersion modelling study shall assume that the cremator always operates at full capacity, and the reference conditions are 273.15 K, 101.3kPa, 0% water and 11% oxygen.

Specific requirements

The dispersion modelling study shall establish the AOI.

The dispersion modelling study shall establish the combination of chimney height and abatement measures required in order to ensure that the contribution of the plant to annual levels of $PM_{2.5}$, PM_{10}, NO_2 and benzo(α) pyrene in PM_{10} within the AOI is nowhere higher than the value indicated in table 4 below. These values represent 3% of the respective annual limit or target values, where these are available.

The model shall also be used in order to determine the likelihood of exceedances of the limit values for $PM_{2.5}$, PM_{10}, NO_2 at the sensitive receptors within the AOI, due to the operation of the plant. In this context the consultants will be required to carry out at their own expense any baseline monitoring studies for these pollutants. The sites used for these studies as well as the monitoring methods are to be agreed with ERA. For PM_{10}, the consultants shall also estimate the 90.4th percentile of the daily readings using the following equation $P = (1.46 \times A) + 0.03$; where P = the 90.4th percentile of the daily readings and A is the annual average of the daily readings.

In addition, the dispersion model shall establish a chimney height and abatement measures required in order to ensure that ambient levels of pollutants within the AOI are kept below the level indicated in Table 4.

Furthermore, the dispersion model shall establish the chimney height and abatement measures required to ensure that annual bulk deposition rate for metals, particularly in any nearby farms and these shall be below the limit in table 5.

The dispersion model shall establish the points at which the annual averaged daily bulk deposition rates are the highest.

The model shall determine the appropriate in-stack limit values, which would enable the achievement of the limits in Tables 4 and 5 below and those set out in Table 1 in Section 2 of this document whichever is the strictest. These concentrations shall be expressed at the reference conditions above.

Table 4: Pollutant limit values to be referred to when establishing stack heights from dispersion modelling.

Pollutant	Limit
$PM_{2.5}$	0.75 µg/m^3
PM_{10}	1.2 µg/m^3
NO_2	1.2 µg/m^3
Pb in PM_{10}	15 ng/m^3
Cd in PM_{10}	0.15 ng/m^3
As in PM_{10}	0.18 ng/m^3
Ni in PM_{10}	0.60 ng/m^3
Cr in PM_{10}	0.50 ng/m^3
Cr (VI) in PM_{10}	51 pg/m^3
Hg total	1.5 ng/m^3

Table 5: Pollutant limit values to be referred to when establishing stack heights in relation to bulk deposition rates for metals.	
Pollutant	**Limit**
Cd	2 µg/m².day (bulk deposition)
As	4 µg/m².day (bulk deposition)
Hg	1 µg/m².day (bulk deposition)
Pb	100 µg/m².day (bulk deposition)

The model used shall incorporate terrain, land coverage and wind speed and wind direction (at least a year's data) ideally from the site and if this is not possible from a weather station nearby.

Different meteorological scenarios including the most frequently occurring, to the most unfavorable shall be modelled for both ambient air quality levels and deposition levels.

Submission of report

The final report shall as a minimum contain the following sections:

1. Non-technical summary.
2. Introduction.
3. Scope of work.
4. Site description.
5. Methodology.
6. Identification of sensitive receptors.
7. Dispersion models.
8. Comparison with limits in legislation.
9. Limitations of study.
10. Conclusions and recommendations.
11. Appendices.

A draft report shall be submitted to ERA for comments prior to finalisation of the final report.

Part B: Further requirements

Should any other auxiliary infrastructure falling within scope of the Medium Combustion Plants Regulations (S.L 549.122), be considered, the air dispersion model should take into consideration such equipment.

Part C: Effect of traffic emissions

This part of the study is required if the plant will increase HGV traffic flows by 200 AADT or else passenger car traffic flows by 1000 AADT.

The consultants will have to delineate the area of influence of the traffic from the plant. The terms of reference for this part of the study are found in:

https://era.org.mt/wp-content/uploads/2020/03/TORs-Air-Quality-Study.pdf

Part D: Effect of stack and traffic emissions on compliance with the air quality limit values.

This part of the study should be carried out once the AOI for emissions from the stack has been determined. Once this is done the consultants should revert back to ERA for direction.

Part E: Qualifications of the person carrying out the Dispersion study.

Experts carrying out the dispersion modelling shall possess the educational qualification as outlined hereunder:

- At least an MQF level 7 in Atmospheric Physics/Chemistry, Environmental Engineering, Air Quality Modelling or similar with 7 years' experience in modelling for regulatory applications.
- Should have a demonstrable knowledge of the requirements of Directive 2008/50/EC.

Modelling experience to be specifically related to the modelling of such installations of similar and their effect on air quality and on deposition rates and should be accompanied by a list of completed projects.

The modeller working on the traffic effects should have the same qualifications as per above and should have at least 7 years experience in the modelling of the effect of traffic flows on air quality. This should be accompanied by a list of completed projects.

The experts assigned to the project shall submit his/her curriculum vitae to ERA prior to the commencement of the study, and shall not commence such study until such time that ERA deems the expert suitable for the role.

All experts must be independent and free from conflicts of interest in the responsibilities accorded to them.

5. INFORMATION REQUIRED BY THE AUTHORITY

Monitoring, investigating and reporting

5.1 The Operator shall monitor emissions and carry out checks and tests in accordance with the permit requirements. The need, scope, frequency, and timing of sampling and testing shall be determined based on local circumstances.

5.2 The Operator should keep records of inspections, tests and monitoring, including all non-continuous monitoring, inspections and visual assessments. The records should be:

i. Kept on site
ii. Kept by the Operator for at least two years; and
iii. Made available for the Authority to examine

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

Monitoring Data

5.3 The Operator should report monitoring data as follows:

i. A one-time screening exercise to establish the concentration of the following metals in the flue gases:

Table 6: Monitoring of metals in flue gases		
Metal	**Limit of detection[5] in µg/m³**	**Test methods**
Mercury (Hg)	0.04	EN14885:2005
Arsenic (As)	0.04	EN14385:2004
Cadmium (Cd)	$9x10^{-5}$	
Chromium (Cr)	0.0003	
Nickel (Ni)	0.0002	
Lead (Pb)	0.005	
Zinc (Zn)	0.0005	

ii. Every 12 months a report should be submitted containing the following continuous monitoring data for carbon monoxide and, in respect of unabated cremators, particulate matter.[6] The data should be submitted covering each period of either four weeks or a calendar month:

a. Values that exceed the 95% limit for CO (and PM if appropriate) in that period;
b. 60-minute mean emission values that exceed the 100% limit for CO and PM, if appropriate) in that period;
c. A list of the highest 60-minute mean emission value for each period;
d. The 95th-percentile value for each period.

iii. For temperature and oxygen, the Operator should report the following continuous monitoring values to the Authority every 6 months:

a. Secondary chamber entrance temperature, 4- weekly/monthly maximum and minimum (of 5-minute averages);
b. Secondary chamber exit temperature, 4-weekly/monthly maximum and minimum (of 5-minute averages);
c. Oxygen concentration, 4-weekly/monthly minimum (of 5- minute averages).

iv. Where any values have been exceeded in any 4- weekly/monthly or 6-monthly reporting period, records should be kept that identify the number of times that the limit was exceeded during the reporting period, the levels of the exceedance, and the time, date and cremation reference. This data should be kept available.

5 Normalisation parameters are T=273.15k, P=101.3kPa, 0% water, 3% O_2. The limits were derived assuming a sampling time of 6hrs.
6 The report specified in paragraph 5.4 should be presented in a format that enables the Authority to check compliance.

Where the combustion provisions in Table 1, as appropriate are not met continuously, more detailed reporting may be needed.

Exceedance of Emission Limit Values

5.4 Adverse results from any monitoring activity (both continuous and periodic) should be investigated by the Operator as soon as the monitoring data has been obtained. The Operator should:

i. Identify the cause and take corrective action;
ii. Clearly record as much detail as possible regarding the cause and extent of the problem, and the remedial action taken;

5.5 Re-test to demonstrate compliance as soon as possible; and inform the Authority of the steps taken and subsequent re-testing results.

Visible and Odorous Emissions

5.6 In the event of visible and odorous emissions, the Operator should inspect in order to find out which operation(s) is the cause. Whilst problems are ongoing, visual and olfactory boundary checks should also be made once per day when an installation is being operated. The time, location and result of these checks, along with weather conditions such as indicative wind direction and strength, should be recorded. Once the source of the emission is known, corrective action should be taken without delay and where appropriate the Authority may want to vary the permit in order to add a condition requiring the particular measure(s) to be undertaken. If inspection does not lead to correction of the problem then the Operator should inform the Authority in order to determine whether ambient air monitoring is necessary.

Abnormal Events

5.7 The Operator should respond to problems which may have an adverse effect on emissions to air.

i. In the case of abnormal emissions, malfunction or breakdown leading to abnormal emissions the Operator should:

   a. Investigate and undertake remedial action immediately
   b. Adjust the process or activity to minimise those emissions; and
   c. Promptly record the events and actions taken

ii. The Authority should be informed without delay, whether or not there is related monitoring showing an adverse result:

   a. If there is an emission that is likely to have an effect on the local community; or
   b. In the event of the failure of key arrestment plant, for example, bag filtration plant or scrubber units; or in the event of the use of the bypass or emergency relief vent.

5.8 The Operator should provide a list of key abatement technology and should have a written procedure (OTNOC management plan) for dealing with its failure, in order to minimise any adverse effects.

6. ABBREVIATIONS AND ACRONYMS AND DEFINITIONS

Area of influence - AOI	means the contour around the plant in which the contribution of the plant to the annual ambient levels of NO_2, PM_{10} or $PM_{2.5}$ is 0.3 µg/m³ for NO_2 or 0.3 µg/m³ for PM_{10} or 0.19 µg/m³ for $PM_{2.5}$, whichever results in the largest AOI. If the area of the AOI is < 11.3 km² then the AOI shall be assumed to be a circle of radius 6 km centered on the chimney
BAT	Best Available Technique
CEN	Comité Européen de Normalisation
Continuous measurement	Measurement using an automated measuring system permanently installed on site
ERA	Environment & Resources Authority
ERV	Emergency Release Vent
ISO	International Organization for Standardization
Operating hours	The time, expressed in hours, during which a crematoria, in whole or in part, is operated and is discharging emissions to air, excluding start-up and shutdown periods
NOx	The sum of nitrogen monoxide (NO) and nitrogen dioxide (NO_2), expressed as NO_2
PCDD/F	Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans often referred to as ‘dioxins and furans "or even just dioxins"
“The Authority” or “the Competent Authority” or “ERA”	means the Environment and Resources Authority or such other body or person as the Minister responsible for the environment may by order in the Gazette prescribe
Valid (hourly average)	An hourly average is considered valid when there is no maintenance or malfunction of the automated measuring system