Environment Protection Authority

Audit report

Crematoria industry sector (2016)

EPA South Australia

Audit report – Crematoria industry sector (2016)

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ISBN 978-1-921495-80-9

December 2016

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Abbreviations

Air Quality Policy	Environment Protection (Air Quality) Policy
BAT	best available techniques
BEP	Best Environmental Practice
EPA	South Australian Environment Protection Authority
EP Act	*Environment Protection Act 1993*
PCBs	polychlorinated biphenyls
PCDD/Fs (or PCDD/DFs)	dioxins and furans
PeCB	pentachlorobenzene
POPs	persistent organic pollutants

Summary

This report presents the findings of an audit conducted by the South Australian Environment Protection Authority (EPA) of the crematoria industry sector. This audit was carried out in 2016, and comprised a desktop review, literature review and on-site inspections of each licensed crematorium in the state.

The audit assessed compliance with EPA licence conditions for the sector and suitability of current licence conditions. The audit also reviewed the current operating methods and pollution control equipment utilised at each site. This review was considered timely due to Australia's planned ratification of the latest tranche of chemicals listed in the *Stockholm Convention on Persistent Organic Pollutants* (POPs), including pentachlorobenzene which can be emitted during the cremation process.

The audit found general compliance with EPA conditions regarding the minimisation of smoke and odour. The main non-compliances noted were related to record keeping, and poor maintenance of pollution control and/or cremator equipment.

The audit also found that all cremators designed after 2006 were operated in line with best available techniques and best environmental practice (BAT/BEP) guidance to minimise pentachlorobenzene and other POPs. Some cremators constructed before 2006 are also currently operating in line with this guidance. These sites are not expected to be affected by the planned ratification. There are other remaining cremators not operating in line with this guidance for part or all of the cremation process. These sites may be affected by the planned ratification of the latest tranche of chemicals listed in the Stockholm Convention.

A review of mercury emissions from this sector was also undertaken because of previous media interest and Australia's planned ratification of the *Minamata Convention on Mercury*. The audit found that no sites in this sector are currently utilising equipment or methods to minimise mercury emissions. It was concluded that mercury emissions from this sector are not currently a high priority risk when compared to other emitting industries, such as coal-fired power stations.

Finally, recommendations for future work have been made. This includes the development of new standard licence conditions for this sector, preparation of position statements and an information sheet to better communicate the EPA's requirements to industry, and further investigation into whether operational changes or significant equipment upgrade works would be needed for older sites (pre-2006) in order to meet BAT/BEP guidance, or if alternatives (such as stack testing) would instead be warranted.

1 Audit objectives

The objectives of the audit were to:

- Assess compliance with EPA licence conditions, and determine suitability of these conditions for their operations.
- Gain a better understanding of the operations of crematoria licensees. Specific information included the secondary chamber temperature and residence time, and types of pollution control equipment in place.
- Notify licensees of the planned ratification by the Commonwealth Government of the *Stockholm Convention on Persistent Organic Pollutants* (POPs), and to explain the new EPA licence conditions and format.
- Conduct a desktop review of the potential risk of mercury emissions from crematoria, and to update licensees about the planned ratification of the *Minamata Convention on Mercury* by the Commonwealth (which at this stage is understood to have excluded Mercury emissions from crematoria due to the low relative risk).

2 Background

2.1 EPA licensed crematoria

The South Australian Environment Protection Authority (EPA) requires persons undertaking the Schedule 1 activity – *3(1)c Incineration: cremation of bodies* to hold an environmental authorisation, or 'licence'. The requirement to hold an authorisation for this activity covers both human and animal crematoria.

As at June 2016, 13 facilities hold an EPA licence across the state, which were audited between March and May 2016 (Table 1 and Figure 1).

Table 1 Facilities licensed for Schedule 1 Activity – 3(1)c Incineration: Cremation of Bodies

	SA EPA Authorisation	Name	Location	Human/animal
1	1237	Adelaide Cemeteries Authority	Clearview	Human
2	12908	Aldekerk	Port Adelaide	Human
3	63	Animal Welfare League	Wingfield	Animal
4	1234	Centennial Park	Pasadena	Human
5	29883	McKessar, AM & D	Port Lincoln	Animal
6	2914	Mount Gambier Cemetery Trust	Mt Gambier	Human
7	14532	Paws to Reflect	Waitpinga	Animal
8	26525	SA Cremation Services	Seaford	Human
9	14529	Sweet, JD & VE	Berri	Human
10	2445	Taylor & Forgie	Gawler	Human
11	2672	Veolia Environmental Services[1]	Dry Creek	Animal
12	2843	Watkins, RW & JL	Port Lincoln	Human
13	1522	Whyalla Cremation	Whyalla	Human

[1] Veolia Environmental Services is primarily a medical waste incineration facility.

Figure 1 Sites of licensed crematoria in South Australia

2.2 Previous audit of the sector

This sector was last audited in 2008. The main finding of the audit was that the highest environmental nuisance risk factors were visible smoke and odour from premises. Subsequently, standard licence conditions were applied to all authorisations to ensure consistent management across the sector. These conditions focused on:

1 the minimisation of visible smoke and odour, where 'visible smoke' equated to a measure of Level One (1) on the Ringelmann Chart[2].

2 keeping a register to record any visible smoke events. The cause of such an event and corrective actions taken must also be recorded in this register.

3 keeping a register to record any maintenance to pollution control equipment. In the event of equipment failure, the cause of the failure and corrective actions taken must also be recorded in this register.

Since this time there has been work undertaken at the local, federal and international level (which is discussed in further detail in later sections). An audit was determined as the best way to verify and update known information about licensed crematoria, as well as to fill any data gaps and determine the potential impacts of the regulatory changes.

[2] The Ringelmann Chart, as defined in the *Environment Protection (Air Quality) Policy 1994*. Note that this policy was revoked in July 2016 and has been replaced with the *Environment Protection (Air Quality) Policy 2016*.

2.3 The cremation process

To provide context of what the EPA are auditing, it is important to understand the process of cremation. The cremators used in South Australia are of varying ages, models and types. However, each cremator has a primary and a secondary chamber (Figure 2). The chambers are lined with refractory bricks, which are able to withstand the high temperatures (up to 1,100°C) required for the cremation process.

The primary chamber is where the cremation of the body occurs. The secondary chamber (also known as an afterburner) incinerates the waste gases from the primary chamber, ensuring that smoke, odour and other potential air emissions are minimised. The secondary chamber may be in line with the primary chamber, or directly beneath the primary chamber. The 'residence time' is the term given to the length of time the waste gases are held at the set-point temperature of the secondary chamber. The residence time is a function of the flow rate of the waste gas, and the volume of the secondary chamber.

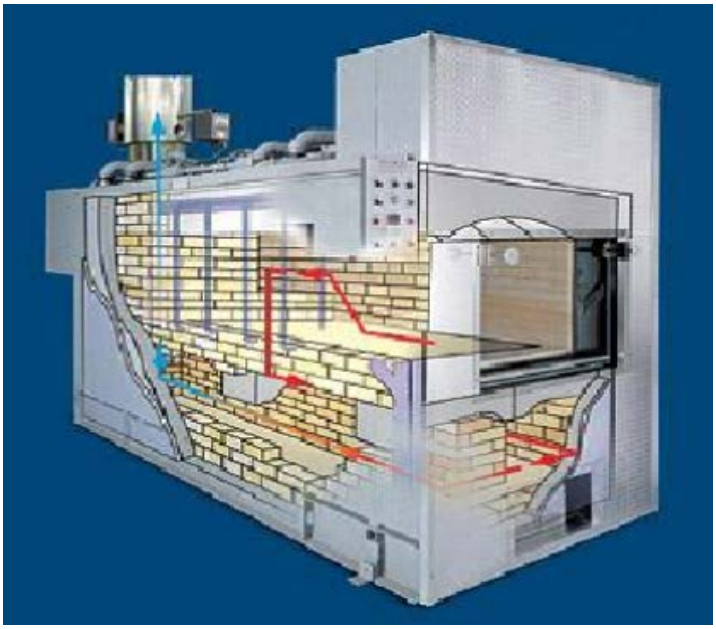

Figure 2 **Gas flow path through a cremator (secondary chamber directly beneath the primary).** ***Picture courtesy of Matthews Environmental Solutions***

Prior to the cremation commencing, devices such as pacemakers are removed as they may explode due to the high temperatures inside the cremator and damage the refractories. The primary and secondary chambers are preheated before the coffin is transferred into the primary chamber.

During incineration, the body is exposed to furnace flames, generally fueled by natural gas or LPG. The first stage of the cremation is the burning of the coffin and other effects such as clothing and the coffin lining. Once the coffin collapses, the heat removes all moisture from the body before the fats begin to burn. Calcification of the bones occurs once all fats, soft tissues, muscles and organs are cremated, until only non-combustibles such as metal residues, ash and bone fragments remain. These are then collected in a tray and allowed to cool. Any metal residues from the cremation, such as screws, nails, hip joints, or metal plates are removed prior to ash reduction.

It generally takes between one to four hours to cremate a human body. Factors affecting the cremation time include the weight of the body, ratio of body fat to muscle mass, performance of the cremation equipment used, operating temperature of the cremation chamber and type of casket in which the body is placed.

2.4 The Stockholm Convention: pentachlorobenzene emission control

The Stockholm Convention on Persistent Organic Pollutants is an international environmental treaty, signed in 2001 (and effective from May 2004) that aimed to eliminate or restrict the production and use of 12 persistent organic pollutants

(POPs) such as dioxins and furans, polychlorinated biphenyls (PCBs) and some types of pesticides. Australia ratified this convention in 2004.

In 2009, 2011 and 2013 additional chemicals were added to the Convention's Annexes. In 2014, the Federal government outlined the planned ratification of these additional POPs. The ratification has not yet occurred, but is expected in the medium term.

Pentachlorobenzene (C_6HCl_5; CAS: 608-93-5) is included in this list of additional POPs. Pentachlorobenzene (PeCB) is an unintentionally produced compound arising from waste incineration, cremation and other industrial processes. The chemical structure of PeCB is presented in Figure 3.

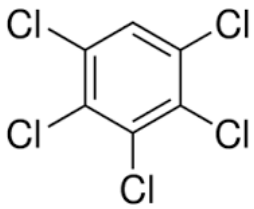

Figure 3 Chemical structure of pentachlorobenzene (C_6HCl_5; CAS: 608-93-5)

It has been indicated that the current measures (as also outlined in the *National Action Plan for Addressing Dioxins in Australia 2005*) to control unintentional production of previously ratified POPs, including dioxins and furans are expected to also be effective in reducing unintentional production of PeCB (van der Zande 2007, Secretariat of the Stockholm Convention on Persistant Organic Pollutants 2008).

These measures outline the use of best available techniques and best environmental practices (BAT/BEP) to reduce the risk of unintentional PeCB generation to as low as reasonably practicable. In particular, ensuring that cremation is undertaken in the presence of excess oxygen while the secondary chamber is held at a temperature of 850°C for a residence time of at least 2 seconds. Some variations on this temperature and residence time combination are known to the EPA, such as a secondary chamber temperature of 1,000°C for a residence time of 1 second. Refer to Appendix A.1 for an outline of these variations.

The National Action Plan for Addressing Dioxins in Australia (EPHC 2005) outlined that all new cremators and any existing cremators were to be upgraded according to the recommendations outlined in the Stockholm Convention BAT/BEP guidance. In particular, that the secondary chamber temperature during the cremation process is at least 850°C for a minimum residence time of 2 seconds in the presence of excess oxygen. This was to ensure the emission limits for dioxins and furans (0.1 ng TEQ/m^3) would be met. This recommendation was endorsed on 29 October 2005 as the guiding document for addressing dioxins in Australia.

All cremators designed and constructed from approximately 2006 onwards will not be affected by the ratification of the latest tranche of POPs, as they should already be operating in line with BAT/BEP guidance. However, it was unclear as to whether cremators constructed prior to this date (without major upgrade works) were operating in line with this guidance, ie if the secondary chamber temperature during the cremation process was at least 850°C for a minimum residence time of 2 seconds in the presence of excess oxygen for part or all of the cremation process. It was then determined that an assessment the current operations of all crematoria was required as part of the audit.

2.5 Potential mercury emission assessment

At the federal level, Australia has signed the Minamata Convention on Mercury, which is an agreement to minimise mercury emissions (via air, water and soil) from a number of industrial and other (eg dental practices) sources. It is expected that this convention will be ratified in the medium term. As there has been previous media and licensee interest in mercury emissions from the cremation of bodies, a desktop review of the potential risk of mercury emissions from crematoria was included as part of this audit. This forms part of the literature review summary (Appendix A.2). This audit

also aimed to determine if any licensees in this sector are currently managing potential mercury emissions from their operations through the use of specific pollution control equipment.

2.6 Other regulatory changes

The EPA has recently introduced a new licence format, including changes to the structure and coding of licence conditions. The aim of these changes was to make the conditions of licence easier to understand. This audit was considered a good opportunity to outline these changes to licensees, and to also determine where new conditions should be considered for this industry sector.

3 The audit process

The audit process comprised the following steps:

1 **A desktop review** of each licensee's operations. The information used in this review included previous site inspection notes, audit notes, online and inhouse mapping software, and/or development applications to determine known information about the site, cremators, pollution control equipment and compliance history. The desktop review template used for each licensee is found in Appendix B.

2 **Correspondence** with the licensee, to notify them of the planned on-site audit and the information we were seeking during this process. Notification to interested third parties (SA Health, Federal Government) of our intended audits were also sent.

3 A **site inspection** to verify known information, and fill information gaps. The template used for each audit is found in Appendix C.

4 **Follow up** with the licensee following up regarding licence compliance and requesting any information that was not accessible during the audit.

5 A **review** of all gathered information in Steps 1–4, including a literature review (Appendix A) and recommendations for future work based on the information gathered throughout the audit process.

4 Results

4.1 Licence condition compliance

Figure 4 illustrates non-compliances identified during the audit. The most common was the non-maintenance of registers, in line with conditions 330–162 and 330–229 or S–2 and S–199 of EPA licences. The second most common non-compliance was poor maintenance of equipment, which included either pollution control equipment (eg opacity meters), or the cremator itself (eg door seals), which constituted breaches of Part 4 (7)(a)–(d) of the Air Quality Policy 1994[3] and general environmental duty, as defined by section 25 of the *Environment Protection Act 1993*.

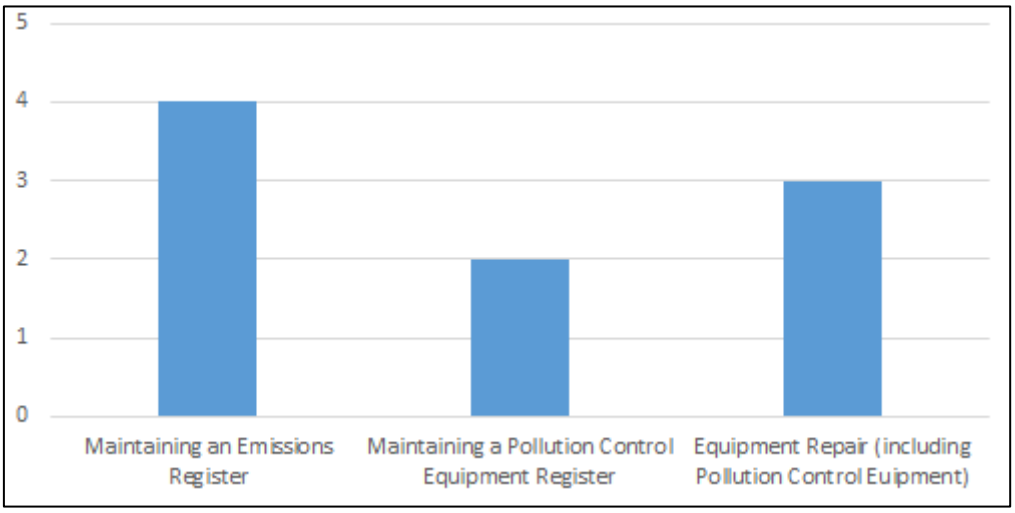

Figure 4 Non-compliances Identified during the audits

In a review of responses as to why licensees were not keeping registers, authorised officers noted that licensees required further guidance as to what was expected in terms of the content and the format of these registers. It was noted that many licensees were confused as to what was expected by the EPA in order to comply with these conditions.

4.2 Cremator technology and pollution control equipment

As previously outlined, the cremators across South Australia are of varying ages, makes and models. There are some cremators which have been operating for over 30 years, and others for less than five years. Ideally, in order to comply with BAT/BEP guidance, the secondary chamber should be pre-heated to at least 850°C (or equivalent) prior to the coffin insertion, and then maintained at or above this temperature for the entire cremation process. Figure 5 illustrates the secondary chamber settings and calculated residence times for licensed crematoria across the state once the coffin has been inserted into the primary chamber.

[3] Since the time of the audit, the Air Quality Policy 1994 has been revoked and replaced with the Air Quality Policy 2016. The requirement to maintain equipment, in line with Part 4 (7)(a)–(d) of the 1994 Policy has been replaced with Division 4, (15)(1)(a)–(d) of the 2016 Policy.

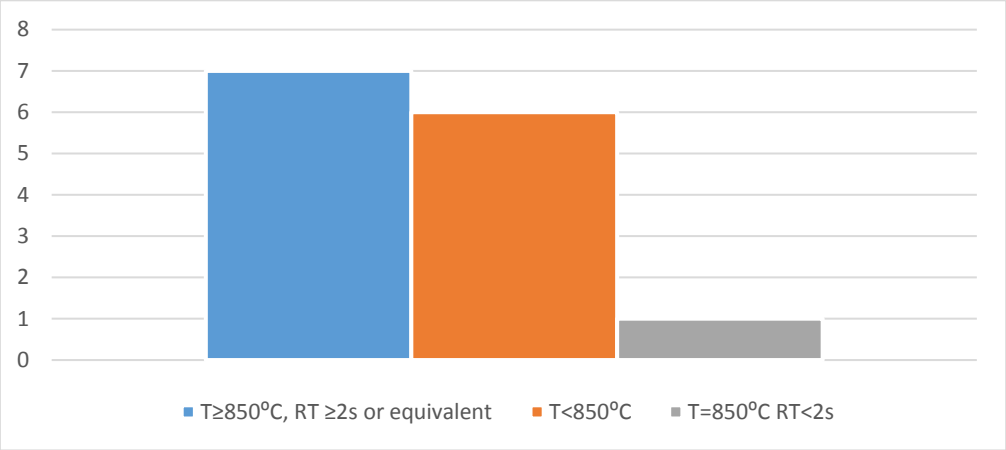

Figure 5 Secondary chamber temperature settings (T) and residence time (RT)[4, 5]

All licensees with a secondary chamber set-point of 850°C or greater once the coffin was inserted were also noted as keeping the temperature setting of the secondary chamber the same, or above 850°C for the remainder of the cremation. Others were also noted as having variable temperature settings throughout the process after insertion, or a constant set-point less than 850°C (or equivalent).

It was also found that a number of licensees operated the secondary chamber of their cremators at a temperature lower than 850°C (or equivalent) in the pre-heat stage (ie up until the time of coffin or cadaver insertion), and the temperature setting was then increased as soon as the coffin was placed in the primary chamber. One licensee pre-heated their secondary chamber to 850°C prior to insertion, then reduced the temperature set-point after the coffin was inserted. Figure 6 illustrates the secondary chamber temperature settings of cremators prior to the insertion of the coffin into the primary chamber.

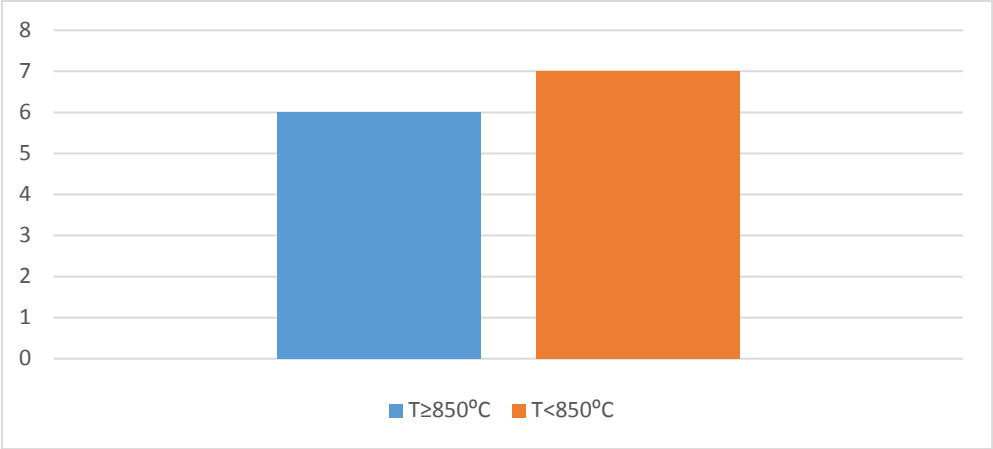

Figure 6 Secondary chamber temperature setting prior to coffin insertion

The audit questions also covered the types of pollution control equipment in use. Smoke detection devices (such as opacity meters) were common for licensed crematoria. Back-up generators with sufficient capacity to complete any in-process cremation/s in the case there was an issue with electricity supply were also common across licensees. These

[4] Since the time of the inspection, one licensee has confirmed that the secondary chamber temperature setting was increased to 850°C, and has been included in the number of licensees operating above this temperature (with a residence time of at least two 2 seconds).

[5] One licensee unable to achieve an equivalent temperature of 850°C and residence time of 2 seconds has advised that they are planning to discontinue use of their current cremators, and have since submitted a development application for a new cremation system which is able to operate in accordance with BAT/BEP guidance.

are both used to assist with meeting EPA licence requirements with minimising smoke and/or odour, and have often been specified as required at the planning approval stage of any crematorium application.

Other pollution control equipment or monitoring equipment noted at some sites during the audit included:

- In-stack temperature measurement and control (to prevent stack fires and/or protect in-stack monitoring probes)
- In-line monitoring of analytes aside from particulates (HCl, O_2, CO, CO_2)

No licensee had specific pollution control or monitoring equipment for heavy metals such as mercury. However, at least two licensees had previously tested via stack measurements for mercury emissions, and the resulting risk from the industry, when compared to other industries such as power generation or smelting is considered to be low (Appendix A.2).

5 Discussion

5.1 Licence condition compliance and suitability

With regards to maintaining registers, in keeping with the EPA's spectrum of compliance (see below), it was determined that 'educate' and 'enable' were the appropriate compliance measures in the instances where registers were not being kept.

Subsequently, an Information Sheet with details on how the EPA expect maintenance registers to be kept was developed specifically for those licensees conducting this activity (Appendix D).

Poor pollution control and equipment maintenance was followed up through the standard EPA compliance management system, and compliance dates for the repair and/or upgrade of equipment were set. Repairs have either been completed or are underway. One operator has undertaken repairs of their equipment, but due to the age of the cremators and other market factors, has advised that these cremators will be replaced with those which will be able to meet BAT/BEP guidance, and the EP Act requirements. The EPA has since received a development application for the planned replacement, and expects the replacement cremators will be installed in the medium term.

This audit identified the majority of licences did not contain conditions requiring a minimum secondary chamber temperature or residence time. Nor did they contain conditions specifying a dioxin limit of 0.1 ng TEQ/m^3. Secondary chamber temperatures and residence times were assessed during the 2008 audit, and the finding was that the requirements for licensees were varied and inconsistent. The determination was that a standardising of requirements for the sector was needed. This was on the basis that *de novo* synthesis of dioxins occurred in the 200–450°C temperature range. It then concluded that theoretically, temperatures above this will minimise dioxin formation—provided sufficient residence time in the secondary chamber equivalent to this temperature is maintained, and that complete combustion occurs.

Upon review of the literature for the 2016 audit, it was clear that in practice dioxins and furans are formed at temperatures well above 450°C, and subsequently afterburner temperatures at or above 800°C is recommended, and is the basis for the BAT/BEP guidance to minimise POPs. Subsequent further work considering standard EPA licence conditions for secondary chamber temperatures in line with this guidance is considered timely due to the imminent ratification of PeCB as an additional POP.

Following the audit, it was also identified that the current standard conditions for the sector require revision due to the introduction of the Air Quality Policy 2016. This version replaced the Air Quality Policy 1994, which was revoked in July 2016. The new version has removed references to the Ringelmann Chart. In line with the new version of the Policy, revisions of the standard conditions will specify a percentage opacity in place of 'Ringelmann 1' (eg 20% opacity as measured by an opacity meter or an approved equivalent) are required. These revised conditions will then be applied to new and renewed authorisations conducting activity – 3(1)c Incineration: Cremation of Bodies. During this transition period, the existing standard conditions which currently reference Ringelmann 1 will be updated to include a definition of the Ringelmann Chart and Ringelmann Level 1.

5.2 Ability to comply with BAT/BEP guidelines for temperature and residence time based on cremator technology

Residence time

The residence time is essentially fixed at the time of the design and construction of the cremation system, as it is a number based on the volume of the secondary chamber and flow rate of gases from the primary chamber. A residence time of at least 2 seconds was met by nine out of the 13 licensees. Cremators where the residence time specified was less than 2 seconds were designed and approved prior to 2006.

However, the residence time cannot be taken in isolation, and the secondary chamber temperature must also be considered. For example, a secondary temperature of 1,000°C, and a residence time of 1 second is accepted by the literature as sufficient to destroy POPs was also considered equivalent to the 850°C and 2-second combination (refer to Appendix A.1).

Options to increase residence time include replacing the secondary chamber, or adding another chamber in series. These options involve significant capital costs, and in the case where temperature and residence time are not the equivalent to 850°C and 2 seconds, the more feasible approach would be to increase the operating temperature of the secondary chamber.

Operating temperature of the secondary chamber

A total seven out of 13 licensees are operating their secondary chambers equivalent to a temperature of 850°C and 2 seconds from the commencement of charging a coffin. However, a number of licensees with cremators constructed prior to 2006 are currently operating secondary chambers at temperatures less than the equivalent of 850°C and 2 seconds for part or for all of a cremation. One licensee was noted as having had significant upgrade works to their cremator, such that their residence time was now greater than 2 seconds, but had not increased their operating temperatures in order to meet BAT/BEP guidance.

Theoretically, an increase in temperature is feasible based on the general physical properties of the chambers themselves as these are designed to withstand high temperatures (although wear and tear may decrease the lifespan of the refractory bricks, seals and doors). Factors that will need to be considered when seeking to increase the secondary chamber temperature throughout the cremation process:

1 **Larger or higher fat percentage cadavers:** It has been observed that during the fat-burning stage of the cremation period, in particular with cadavers which contain a relatively high percentage of fat, the temperature in the cremators may get so high that out of control smoke and fire events occur. This is becoming a more prevalent problem not only within Australia, but also internationally (Kroboth 2016, Shak 2009). Increasing the set-point of these temperatures may affect the handling of higher-risk cadavers, and different handling and operating procedures will need to be in place to manage these risks.

2 **Cremator design:** The cremator itself may be designed for a ‘cold- start’, ie insertion at or around 400°C. The potential impacts of operating at higher temperatures will need to be investigated, and different handling and operating procedures will need to be in place to manage any identified risks.

3 **Impacts of not meeting BAT/BEP guidance:** If it is not economically feasible for older cremators to comply with these requirements, potential health impacts and alternative risk management strategies will need to be considered in accordance with the EPA risk-based approach to regulation. Alternatives or risk-reduction strategies include whether there a plan in place to move towards an upgrade of equipment (at which point the BAT/BEP guidance requirements will apply), and whether stack testing for potential POP emissions would be warranted.

4 **Fuel/gas usage:** The consumption of gas will increase with high temperatures in the secondary chamber leading to a rise in the cost of operations.

6 Conclusions and recommendations

From the information obtained and assessed as part of this audit process, the following conclusions have been made:

1 All cremators operating at the time of the audit were noted as emitting minimal smoke and odour, in line with licence conditions. The main licence non-compliances were the non-maintenance of registers. Three instances of poor equipment (including pollution control equipment) maintenance were also identified. These have been or are currently being addressed.

2 Crematoria designed and approved since 2006 are able to meet the requirements of BAT/BEP guidance with regards to temperature and residence time in the secondary chamber. These facilities are not envisaged to be affected by the planned ratification of the latest tranche of POPs.

3 Some crematoria constructed pre-2006 are operating at or below the BAT/BEP recommended 850°C and 2 seconds (or equivalent) for some or all of the cremation process. One licensee has since submitted development approval for a new cremator that meets these requirements. Another will need to increase their secondary chamber temperature as they have had significant upgrade works since 2006. Other licensees have advised that they are now assessing whether increasing the secondary chamber temperature is achievable.

4 None of the cremators audited use pollution control equipment or other methods to minimise potential mercury emissions. Based on the literature review (Appendix A.2), the EPA does not consider potential mercury emissions from this sector to be a high-risk priority, when considering population, cremation rates, other emitting industries and the phasing down of the use of mercury amalgam fillings in the dental industry.

Recommendations for further work over 2017

- Investigate whether crematoria which do not currently operate in line with BAT/BEP will be able to come into compliance with this guidance, or if alternatives will need to be considered. This includes whether these licensees are able to increase their secondary chamber temperatures, or if alternatives to implement a testing regime for potential emissions of POPs would be feasible and warranted.
- Development of new standard licence conditions for the sector. Identified potential conditions include a specified minimum secondary chamber operating temperatures and opacity requirements (in place of Ringelmann 1).
- The development of a crematoria operations position statement to outline what the EPA expects of new proponents who are applying to install and operate a crematorium.
- An information sheet providing examples of how licensees can set out and complete their registers in compliance with EPA licence conditions requiring the maintenance of registers (action completed at the time of this report).

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Appendix A Literature review summary

A.1 Minimisation of persistent organic pollutants (POPs) from crematorium operations

Guidance (van der Zande 2007, Secretariat of the Stockholm Convention on Persistent Organic Pollutants 2008) suggests that the minimisation of PeCB will be achieved by using BAT/BEP techniques already used to minimise previously ratified POPs such as dioxins and furans (PCDD/Fs). The literature review has focused on two areas relating to general POPs generation:

1 When are POPs generated during the cremation process and under what conditions?

2 What operating factors influence their destruction and minimisation?

As already outlined in previous sections, there are a number of stages during the cremation. Once inserted, the coffin and effects burn before the coffin collapses. The heat removes all moisture from the body before the body fats begin to burn. Fats, organs and muscles are cremated prior to calcification of the bones.

A review of literature regarding pollutants generated during the cremation process identified that PCDD/Fs can be formed or be present from the time of coffin insertion, up until the point that calcification of the bones occurs (Mari and Domingo 2010) outline that PCDD/Fs are:

> formed during combustion processes when chlorinated products such as plastic are burned. In crematories these plastics may be present as prosthetics or as part of the container. The body also contains a percentage of chlorine, and thus cremation produces PCDD/Fs … even non-treated wood contains small amounts of chlorine.

Takeda *et al* (2001) found that PCDD/Fs generation was greatest during the combustion of the coffin and effects, and that they were also:

> generated from the combustion of the dead body and that controlling the temperature [of the main/secondary chambers] was needed during a whole cremation time

and that:

> In crematories without [a] dust collector…total concentration of PCDDs/DFs decreased with the rise of average temperature in the secondary combustion chamber. This fact indicates that raising the temperature in the secondary chamber is the only measure to prevent PCDDs/DFs emissions.

BAT/BEP recommend that any cremation is undertaken in the presence of excess oxygen while the secondary chambers are held at a temperature of 850°C for a residence time of at least 2 seconds for the entire cremation. Some variations on this temperature and residence time requirement were found during this literature review, and were considered 'equivalent' to the standard temperature and residence time combination of 850°C and 2 seconds. The most common alternative combination found was a secondary chamber temperature of 1000°C for a residence time of 1 second (Baukal *et al* 2003, Startec 2002, Lima & Bachman 2002, Takeda *et al* 2001 and McKay 2002).

A secondary chamber temperature of 950°C, with a residence time of 1 second in the presence of excess oxygen (<7%) was also put forward (Miller & Marklund *et al* 1989). Takeda *et al* (2001) alternatively recommended that existing crematoria without a dust collector should be 'keeping the temperature of 800°C in [both] the main/secondary chambers during a whole cremation'.

In the *Statutory Guidance for Crematoria* (DEFRA UK 2012) for unabated cremators, a temperature and residence time combination of 850°C and 2 seconds with oxygen at a minimum of 6% (measured wet) is required. In the absence of meeting this requirement, periodic testing for PCDD/Fs is required. In the case of abated cremators, a temperature and residence time combination of 800°C and 2 seconds with oxygen at a minimum of 6% (measured wet) is mandated.

A.2 Mercury emissions from crematorium operations

Mercury can be present in the human body, usually in the form of fillings made with dental amalgam. During the cremation process, if fillings are present, these will volatilise and release mercury to the atmosphere (Mari and Domingo 2010).

Australia has recently signed the Minamata Convention, which is an agreement to minimise mercury emissions (via air, water and soil) from a number of industrial and other (eg dental practices) sources. At this stage, the EPA understands that this proposed ratification does not consider the cremation industry a high-risk industry in Australia, when compared to the power generation, mining and metal works industries.

This is supported by the data from the National Pollutant Inventory. In the 2014–15 reporting period, the highest mercury air emissions in South Australia were from coal-fired power stations at 200 kg for the reporting period. The largest crematorium operation in the state estimated an emission level of 5.7 kg. No other crematoria in South Australia reached the reporting threshold for mercury.

This is not to say that the literature does not discuss or highlight potential mercury air emission risks in other countries. Rates of mercury emissions to air in the UK were between 400 kg and 1,340 kg in 2000, which is expected to increase to up to 2,200 kg in 2020 (Mari and Domingo 2010). However, when considering the significantly lower population density of South Australia, which is four times greater in land area than the UK, with about 1/40th of the population (Shrosbee E 2016, ABS 2016), and the comparable emissions (an estimated 5–15 kg across the state, compared to approximately 2,000 kg), the potential load and exposure risk factors are not considered to be equivalent.

In recent times there has also been a 'phasing down' of mercury amalgam use for restorative services by dental practices. The Australian Dental Industry Association's submission to the Commonwealth Government's planned ratification of the Minamata Convention outlined that alternatives such as resin composites and glass ionomer products make up 75% of dental restorations. The response also outlined that:

> dental amalgam restorations are now a minority of all restorations provided and total numbers of dental amalgam restorations or surfaces restored with dental amalgam have decreased dramatically in children and young adults and somewhat less in middle-aged adults … [though] dental amalgam continues to be a material of choice in certain circumstances]. (ADIA 2014)

Similar statements were also made by the Australian Dental Association in their submission. The phasing down of mercury amalgam use in Australia since the 1980's is also supported by studies conducted between 1983 through to 2004. Between 1983 and 1997, (Spencer AJ 2000) noted:

> the use of dental amalgam had decreased [from 57.9% in 1983] to 28 percent of all restorative services. The use of other restorative materials increased….fewer dental amalgam fillings are being placed in children, adolescents and young adults – this reflects both the overall decline in caries activity in these age groups and a movement away from dental amalgam towards composite resins and glass ionomer cements.

More recent data collected and compared in the *Practice activity patterns of dentists in Australia* study (Brennan and Spencer 2006) outlined that between 1993 and 2004:

> Rates of amalgam restoration services tended to increase across successively older age groups of patients to peak around patients aged 25–44 years in 1993–94 and 1998–99, and patients aged 45–64 years in 2003–04. Significant differences were observed over time for all groups of patients, involving a decrease in the rate of amalgam restorations per visit between 1993–94 and 2003–04.

and that:

> The rate of composite resin restorations per visit tended to increase across successively older age groups of patients to peak among patients aged 18–24 years. All age groups of patients aged over 5 years exhibited a significant increase in the rate of composite resin restorations at each time of the study.

There is currently no requirement for crematoria within South Australia to test for, or to utilise pollution control equipment or abatement methods such as selenium (Hogland 1994) to control mercury emissions. This being said, there have been instances where licensees have previously tested and/or modelled potential mercury emissions from their operations.

The EPA has assessed these reports in light of this audit, and in combination with the above information, concluded that the potential mercury emission levels are of low environmental risk. In line with the risk-based approach to regulation, the EPA do not foresee the need to change the current regulatory approach at this point in time.

Appendix B Crematoria desktop audit checklist

Licensee name	
Licensee number	
Site address	
Postal address	
Company contact name	
Company contact phone	
Company contact email	
Licence coordinator	

You will need to review existing records, for available information, including:

- The electronic (S drive) and hard copy licence files
- LAMP (for previous inspection notes)
- CARES
- Maps and possibly Section 7

	Action	**Record/Notes**			**Completed (Date/Initial)**
1	Confirm site address via maps and Section 7				
2	Based on confirmed site address, estimate the separation distance to closest sensitive receiver				
3	Verify the predominant surrounding land-use	Light industry	Heavy industry	Commercial	
		Residential	Rural	Other (provide detail)	
4	Licensed activities [including 3(1)]	3(1)			
5	Licence conditions current (new format?)				
6	Licence expiry				
7	Number of years operating at current address				
8	Compliance history				

	Action	Record/Notes	Completed (Date/Initial)
9	Number and details of CARES complaints or enquiries over past three years.		
10	Process description, including number/type of burners, dust and ash collection, primary/ planning steps prior to cremation process		
11	Temperature and residence time settings for primary and secondary chambers (include date this information was received/noted)		
12	Type of cremation (animal/human)		
13	Throughput and maximum capacity (include date this information was received/noted)		
14	Pollution control qquipment (eg opacity meters, dust collection systems)		
15	Information gaps identified/ additional notes		

Appendix C Crematoria audit checklist

Licensee name		Licensee number	
Site address			
Company representative/s name/s & contact detail/s	Name/s	Tel	Email
EPA authorised officers			
Time & date			

Pre-Inspection meeting

Background and purpose

- The Environment Protection Authority (EPA) last conducted an audit of the crematoria industry sector in 2008–09. Since then, there have been changes to regulations, nationally and internationally. These include;
  - Australia's planned ratification of the Stockholm Convention (PeCBs)
  - The Minamata Convention relating to mercury emissions
  - EPA licence conditions – these have been reviewed and reformatted to make them more enforceable and clear, so that they are more easily understood by licensees. We will be reviewing licence conditions for the sector with a view to updating these to the new format.
- The EPA has conducted a desktop audit of licensed crematorium facilities. The purpose of this audit is to verify/update these details, fill any data gaps and to discuss the potential impacts of the regulatory changes with Licensees.

The audit will cover

- An overview of the process (start to finish) from receipt and preparation, to ash collection and inspection of maintenance records.
- Compliance with current licence conditions, including a review of pollution control equipment maintenance registers and complaints register.

Site environment

	Action	Record/notes		
	Physically validate site location and estimate separation distance to closest sensitive receiver.			
	Verify the predominant surrounding land-use	Light industry	Heavy industry	Commercial
		Residential	Rural	Other (provide detail)
	Circle any of the following sensitive receivers in the vicinity (200 m)	Residential	Nursing home	Hotel
		Childcare centre/school	Offices	Other (provide detail)

General details

	How many cremators on site, and maximum capacity and throughput	
	Current throughput (per day)	
	Maximum throughput (per day)	
	Once the deceased is received, what are the preparation steps prior to cremation? (Removal of items, coffin handles, etc)	
	Cremator start up/shut down process and frequency	

Operational details

	Question/prompt	Record/notes
	If operating at time of inspection: • What is the size of the cadaver? • At (approx) 10 minutes into the cremation, sight smoke stack – are there any visible emissions? Take a photo of the stack.	
	What is the set-point temperature of the primary chamber prior to commencing a cremation?	
	What is the set point temperature of the secondary chamber prior to commencing a cremation?	
	What are the temperature settings for the primary chamber while the cadaver is being cremated? Does the temperature vary throughout the cremation?	

	Question/prompt	Record/notes
	What are the temperature settings for the secondary chamber while the cadaver is being cremated? Does the temperature vary throughout the cremation?	
	What is the residence time in the secondary chamber?	
	How are non-combustible products in the coffin during the final stages of the cremation managed?	
	Pollution control equipment – what type of smoke detection is used? Check to see if any of the following is used, and write down details.	Opacity meters: Particulate collection system: Temperature protection in flue: Any other pollution control measures, eg metals, particulates, air emissions:
	How is ash from each cremation collected from the cremator?	
	Is the cremator cooled prior to the insertion of the next cadaver? Details as to temperatures and reasons for these temperatures.	

Records required by EPA licence conditions

	Action	Record/notes
	Pollution control equipment register	Frequency of maintenance: Date of last recorded maintenance & type: Equipment fault or failure noted: YES/NO If yes, were actions taken, and repairs undertaken recorded, dated and signed:
	Register of emissions – smoke & odour	Sight emissions register: YES/NO Frequency of recorded black smoke emissions: Were the following details recorded: • Date/time & duration: • Cause • Actions taken & future prevention

	Action	Record/notes
	What processes are in place to ensure smoke and odour during operations are minimised, in accordance with EPA licence conditions?	
	Details of other site-specific licence conditions	

Follow-up actions

	Note any actions requiring follow up during the audit	Who	Date
1			
2			
3			

Additional notes

Appendix D Maintaining registers information sheet

Licensing

Information Sheet

MAINTAINING REGISTERS

Issued May 2016

This information sheet provides guidance to licensees on how to comply with conditions relating to the maintenance of registers. Examples specific to licensees undertaking the activity 3(1)c: Incineration - works for the cremation of bodies pursuant to Schedule 1 of the Environment Protection Act,1993 are provided.

Introduction

Conditions (330-162) and (330-229) or (S-2) and (S-199) are standard conditions for licensees conducting the Schedule 1 activity *3(1)c: Incineration - works for the cremation of bodies.* Under these conditions, licensees are obliged to maintain 1) a register for each inspection of Pollution Control Equipment, and 2) a register of emissions.

What each licensee is required to document in these registers is outlined in the above conditions – please refer to the licence for details.

These registers can be kept electronically or as a hard copy, but must be accessible and produced upon request by an EPA authorised officer. It can be as simple as an A4 notebook with lined columns for each category, an electronic spreadsheet, or it can form part of an electronic quality control software system.

Examples of what the EPA would consider acceptable registers for this purpose can be found below:

EMISSIONS REGISTER – (EXAMPLE ONLY)

Date:	Time:	Duration:	Cause:	Immediate Action(s) Taken:	Action(s) taken to Prevent Recurrence:	Recorded by:
3 Apr 2016	10:15am	90s (approx)	Dark smoke from cremation due to heavily lacquered casket	Increased throat air	Assess potential for casket finish to create smoke	J Smith
25 Apr 2016	12:15pm	30min (approx)	Dark smoke from cremation due to extremely large deceased	Reduced cremation rate	Modified the cremator control system to allow for future cremations of this type	J Smith

Environment Protection Authority

EPA South Australia

POLLUTION CONTROL EQUIPMENT REGISTER – (EXAMPLE ONLY)

Date:	Equipment Inspected:	Equipment Status – Noted Fault/Failure?	Immediate Action(s) Taken if Fault Noted:	Planned Action(s):	Follow up to Planned Action(s):	Recorded by:
02 Jan 2016	Opacity Meter on "Cremator 2"	Not operating correctly – invalid readings.	"Crem 2" taken out of service until repair	Await service provider for repair	24 Jan 2016 – opacity meter repaired	J Smith
13 Mar 2016	Thermocouple on afterburner "Cremator 3"	Not operating correctly – temperature reading 9999	Replaced thermocouple 13/3/2016	Not applicable	Not applicable	J Smith

Disclaimer

This publication is a guide only and does not necessarily provide adequate information in relation to every situation. This publication seeks to explain your possible obligations in a helpful and accessible way. In doing so, however, some detail may not be captured. It is important, therefore, that you seek information from the EPA itself regarding your possible obligations and, where appropriate, that you seek your own legal advice.

Further information

Legislation

Online legislation is freely available. Copies of legislation are available for purchase from:

Service SA Government Legislation Outlet
Adelaide Service SA Centre
108 North Terrace
Adelaide SA 5000

Telephone: 13 23 24
Facsimile: (08) 8204 1909
Website: <shop.service.sa.gov.au>
Email: <ServiceSAcustomerservice@sa.gov.au>

General information

Environment Protection Authority
GPO Box 2607
Adelaide SA 5001

Telephone: (08) 8204 2004
Facsimile: (08) 8124 4670
Freecall: 1800 623 445 (country)
Website: <www.epa.sa.gov.au>
Email: <epainfo@epa.sa.gov.au>
