Report of : Director & Registrar Item 7
To : Mansfield & District Crematorium Joint Committee

On : 23rd February 2018

Crematorium Abatement System

1. SUMMARY

This report aims to highlight the issues surrounding the abatement equipment at the crematorium and provide options for the future.

2. RECOMMENDATIONS

(I) That the report be noted

(II) It is recommended to schedule the work for 2019/2020 for the order to be placed at the start of the new financial year to allow for manufacturing time and installation prior to 31.12.2019, to ensure that we can legally carry out our function. From 1 .1.2020 we will no longer be able to purchase TMacs through CAMEO as all crematoria will have to abate 100%.

3. BACKGROUND

The purpose of this document is to outline the history of the equipment currently installed at Mansfield and District Crematorium and the associated operational issues. These observations are based on increased problems observed over 2016 to date and form the basis for recommendations for replacement/upgrade of various aspects of the installation with a view to improve the safety, efficiency and profitability of the facility as well as prepare the facility for future changes in legislation which may have an impact on the use of the equipment.

The current installation comprises of four FCC Joule cremators, two of which are serviced by one single line, fixed carbon bed type abatement system via a manual switchover system. A further two cremators are each serviced by a dedicated single line, fixed bed type abatement system.

The current installation at Mansfield and District Crematorium represents Best Available Technology (BAT) at the time of installation the existing equipment is described as below;

4 x FCC Joule Cremator

- Cremator 1 - CF454 FCC Standard width Joule Cremator Installed 1995
- Cremator 2 - CF485 FCC Standard width Joule Cremator Installed 1997
- Cremator 3 - CF521 FCC Standard width Joule Cremator Installed 1998
- Cremator 4 - MCF559 FCC Wide-body Joule Cremator Installed 2011

Cremators 1 is the oldest and it has always been the intention to remove this cremator from service by 2020 (The Oslo-Paris Commission (OSPAR) agreement on eliminating mercury emissions from crematoria, the UK agreed to reduce 50% mercury emissions from crematoria by 2012. But by 2020 **all** crematoria within the UK (roughly 240 facilities) will need to have a zero emissions rate. This means local councils and private organisations which run crematoria will need to either install entirely new cremation equipment, and/or integrate mercury abatement systems.)

The recommended design life of the cremators (20 years) albeit there is no indication of repetitive operational issues related to the cremators themselves as a result of age and effectively the cremators are a box with interchangeable parts so currently there is not a recommendation to look at replacing the other 2 smaller hearthed cremators.

It should be borne in mind that natural evolution of the design of such equipment results in the fact that modern equipment is significantly more efficient and more compact. In turn it can be found to be more easily maintainable and user friendly.

Installation took place in 2010 of the abatement equipment and at this time, it was favourable to adopt the use of a fixed bed containing pelletised activated carbon in order to adsorb mercury from the gas stream. The primary benefit of a fixed bed is the large volume of carbon which has a long service period and requires no intervention from the operators.

However, since 2011, observations of the operation of similar systems, and the alternatives, have identified several negative aspects associated with the use of this technology. This represents one of several aspects to the fundamental design of the installation at the crematorium, which combined, have resulted in operational issues, reduction in system performance, reduced ability to maintain the system, and looking to the future, no scope to develop the installation to suit legislation changes or increased demand on the facility.

The aim is to provide recommendations for upgrades to the existing installation which will be designed utilising knowledge gained from observing the operation of such systems, both good and bad, since the original installation date. The core criteria for the design will be;

- Improved operational performance
- Improved environmental performance and efficiency
- Improved reliability
- Improved maintainability
- Consideration for future changes to legislation and/or demand on the facility

Access for Maintenance purposes.

The 4 existing cremators are serviced by 4 x Hot Gas Transfer Duct incorporating Emergency Relief Vent (ERV)

- In order to fit four sets of hot gas transfer duct above the cremators, including transitional pieces entering each primary heat exchanger it was necessary to route two ducts directly above the other two. This makes long term maintenance of the ductwork extremely difficult and intrusive.

- The ductwork installed is internally lined with ceramic fibre. This makes the ductwork relatively lightweight however the material is not best suited to this high temperature, high abrasion application. Therefore, maintenance intervals are much shorter than they would be if castable refractory material had been used, resulting in high maintenance costs.

- It is necessary for each system to include an Emergency Relief Vent (ERV), which is a route to atmosphere for the waste flue gas in the event that a failure occurs in the abatement system.
- At the time of installation, this was indeed included however, consideration was only taken for failure in the major components of the abatement system itself and not the cooling system associated with reducing the flue gas temperatures suitably to pass through the abatement.
- In the event that a cooling system failure should occur, the abatement system does shutdown and direct the waste flue gases through the emergency relief vent however, the primary heat exchanger, located directly above the cremator, has no means of isolation from the heat.
- The above was considered acceptable as the potential for failure in the cooling system is relatively low and even in the case of such failure, the assumption was that the cremator would only be used to complete the cremation in process and that no further cremations would be completed through the emergency relief vent.
- Since installation, it has been identified at this site, and others, that the above is not practical in this application and that the legislation still currently allows for further cremations to take place.

As such, revising the design of the emergency relief and the control philosophy will reduce health and safety risk as well as maintaining cremator availability.

4 off FCC Continuous CO/O2 Monitoring system

• Comprising cremator mounted, self-contained control cubical housing plus flue mounted sampling probe

• Whilst there are no reported faults or concerns with the current system, they do require a high level of maintenance relative to modern equivalents however it would be recommended to treat these as a separate concern.

Flue gas abatement systems

The flue gas abatement systems were installed in 2010/2011 by Furnace Construction Cremators Ltd. and represent the main area where significant developments have been made in design. In order to fully assess the system, it is necessary to first consider the individual components before then considering how the components integrate and
operate as one complete system.

Primary Heat Exchangers

• Located directly above the abated cremators
• Water tube design – cooling water flows through the tubes whilst the waste flue gas passes through the body. As waste flue gases are passing through a chamber across the outer surface of a tightly spaced bank of tubes, cleaning is more difficult, more so as the particular exchangers used on site have a particularly tightly packed tube bank that limits access. A gas tube heat exchanger on the other hand is easier to clean as the
waste flue gases pass through the tubes with deposits lining the internal surface of the tubes. An industry standard tube cleaning machine can then be used to easily clean the tubes.
• Inspection of the current water tube design is very difficult; in fact, it is almost impossible to identify a leak on the water side of the unit particularly if it is deep in the tube bank making maintenance difficult and expensive.
• No flexibility in design to accommodate cyclic nature of process. The cremation process is a cyclic one whereby the heat load and flue gas flow changes throughout, not to mention differences between individual cremations. It is now common to design flexibility into the primary heat exchanger to accommodate this. Failure to do so has an impact on flue gas conditions downstream and ultimately the impact on both operation and longevity of other components.

Cooling systems

• Pump sets and blast coolers located outside on roof area to the front of the building with no protection and therefore their condition has deteriorated.
• Designed as a low temperature, low pressure system
• Flow/return temperatures in the vicinity of 70-80oC. System operation would benefit from higher temperatures.

Bag House Filters

• Filter housings are of stainless steel construction which is the best practice to ensure longevity in the operating conditions
• Filter area is relatively low for the application. They are adequate for the expected gas loads from the Joule cremator however an increase in size would be more effective such that the speed of the cremation process could be improved.
• Filter housings are of a low design with small capacity ash collection bins. Elevating the filter housings would ease routine maintenance.
• The three filter units are located in the yard area in an orientation which makes maintainability quite a problem.
• Internally the filters are in poor condition. Filter bags have never been changed (the contents have

been removed and re-carbonned) and have gone beyond their design life. Filter cages and blowdown tubes are in poor condition and required replacement.

Fixed Carbon Beds

• A fixed carbon bed system was selected for this installation.
• The carbon beds are located on a mezzanine above the yard area.
• Since the commissioning of this installation, the industry has moved away from the use of carbon beds as a method of abatement in favour of the more compact injected systems which also offer other operational advantages.
• In the interest of operating costs, the main concern with the fixed carbon bed is the increase in pressure loss caused by the volume of carbon that the waste flue gas must pass through. In order to overcome this pressure loss, the induced draught fan must work harder, which consumes more electrical power.
• The design of the fixed carbon beds typically used at the time of this installation is now considered inefficient. The design does not force the gases to travel through the full volume of the bed and as such, saturation of the reagent is inconsistent. It is not feasible to agitate the waste to overcome this issue as it is relatively fragile.
• It is not possible to establish the condition of the carbon within the bed between annual emissions tests without the expense of full non-continuous emissions tests.
• Despite the above, regardless of the status of the carbon with respect to emissions levels, extended periods of use will cause breakdown of the carbon granules. This does not necessarily have a large impact on mercury adsorption, however, the resultant dust will increase pressure loss through the bed.
• Future proofing a fixed carbon bed system is extremely difficult. If for example there is a change of legislation reducing target pollution limits, or targeting additional pollutants the entire volume of carbon would require replacement to suit. This is assuming that suitable grades of reagent could be sourced in a granular or pelletised form. As this design of system is now rare this would be a challenging proposition. However, in the case of a reagent injection system it is easy to source suitable powdered reagents to tackle numerous pollutants and adapting the system only requires a change to the reagent composition being supplied.

Induced Draught Fans

• The fans installed are suitably sized for the maximum gas loads expected from the Joule cremator.
• The fans are industry standard.
• The fans are located on a mezzanine above the yard area and as a result have been installed within acoustic enclosures.

Interconnecting Ductwork

• Industry standard at the time of installation.
• Thin gauge stainless steel inner surround by an insulation and a further stainless steel outer cladding.
• Layout is the result of assessing the best manner to connect the relevant components of the system within the limitations of the surrounding.
• Layout however limits access to key components of the system
• Ducting is in poor condition and in need of replacement. Current industry standard ducting is of better quality and design resulting in much greater longevity.

Compressed Air System

• Compressor is located in an enclosure in the yard area
• The location of the compressor results in poor access for routine maintenance

• The compressor is suitably sized for the site requirements

Servicing and Maintenance

• Servicing and maintenance is currently carried out on an ad hoc basis. By this we mean that the microprocessor on the cremators are, like on a car, provided with an indicator as to when servicing is due and at that point the cremators are serviced – this obviously depends on throughput but servicing is usually ordered once the first cremator indicates it requires it and then completed on all 4. Whilst there is no problem with this, there are significant advantages to us of a long-term service contract. Due to the current system arrangement and component design, access for the purpose of maintenance is extremely difficult and in some cases, causes unnecessary health and safety risk.
• New, modern, compact equipment and a redesign of the duct routes will all but alleviate any access issues.

• The control system of all cremators whilst having been upgraded does not interface reliably with the control system of the corresponding control system. Since the installation of abatement on site, a more effective control system has been developed which controls each abated cremation system as a whole rather than two different systems controlling each aspect of the plant with an interface between the two
• All four cremators utilise an aging FCC CO/O2 monitoring system which is old technology and it would be advisable to replace these with industry standard current equipment which is far more reliable and serviceable.

Hot Gas Transfer Duct incorporating Emergency Relief Vent (ERV)
• the hot gas transfer ductwork consists of ceramic fibre lined steel sections.
• Whilst there is no current outstanding work to the hot gas ductwork, the requirement for maintenance is frequent. The restrictive layout, means that maintenance is intrusive, time consuming, and expensive. Frequent failures of the ceramic fibre cause repeated interruption to operation and regular exposure of the steelwork to excessive heat resulting in premature failure of the steelwork.
• Maintenance of the emergency relief vents is difficult due to restricted access increasing potential for failure.

Primary Heat Exchangers

• Full assessment of this design of heat exchanger is difficult due to restricted access. However, leaks of water/glycol mixture indicate that there is likely failure to welds deep within the tube bank
• Maintenance of the heat exchangers is difficult due to tight access. They can therefore not be cleaned reliably. This is actually favourable in terms of system temperatures as the primary heat exchangers are over-sized and hence, over cool the gases when not fouled. The fouling to the boiler surfaces reduces the capacity to transfer heat which benefits downstream components however, the excessive fouling increases the potential for corrosion within the primary heat exchanger itself.

Bag House Filters

• Despite stainless steel construction, the bag house filters show signs of excessive corrosion. These have been refurbished within the time the systems have been operational however, the lack of ability to change fundamental system parameters means that corrosion will continue. Condensation within the system due to leaks within the heat exchange contributing to the saturation of the gas will dampen the fabric filter bags causing excessive blinding, increased pressure drop, and increased load on the induced draught fan.

• A lack of heat trace system, combined with being located outside compounds the problem of low system temperatures and the ultimate rapid internal corrosion. This matter cannot be resolved without fundamental changes to cooling water system design which are not feasible with the existing equipment.

Fixed Carbon Beds

• The fixed carbon beds are of stainless steel construction and recently underwent repair works. The carbon within was removed and replenished
• The long-term maintenance of these components must be considered. Replenishment of the carbon is a significant task due to the location of the beds, causing excessive disruption to the site, along with cost.
• Fundamental problems associated with heat exchanger and cooling water system design will mean that the carbon beds, and the carbon within remain susceptible to frequent failure and the corresponding maintenance/refurbishment associated with failure.

Induced Draught Fans

• Induced draught fans have been replaced due to excessive corrosion
• These could be replaced with fans utilising higher specification materials however this would not rectify the root cause of the problem
• Without changes to the fundamental design of the system, the fans will continue to fail

prematurely requiring complete replacement. (one fan has been replaced since the last meeting as a result of this)

Interconnecting Ductwork

• Due to low system temperatures, with the temperature profile dropping to the back end of the system, the interconnecting ductwork suffers from corrosion associated with acid condensation.
• Ductwork is of stainless steel construction which resists regular condensation however the acid condensation within the system cannot be resisted by regular grades of stainless-steel.
• Significant areas of the ductwork currently require replacement due to corrosion however, to replace the ductwork without fundamental changes to system design would not be advisable as corrosion would still occur due to the current set up. Corrosion in the ductwork cannot be seen until a section of ductwork fails and has to be removed and replaced.

4. OPTIONS AVAILABLE

4.1 Carry on as we are with continued down time, and failure to meet the current parameters for OSPAR of 50% mercury abatement therefore having to buy in TMacs. It should be noted that come 31.12.2019 comes then if we don't abate we will not be able to operate.
4.2 Schedule the work (to remove no. 1 cremator and utilise the space to install a new abatement plant that is fit for purpose with each of the remaining 3 cremators having their own individual abatement system to ensure that when there is down time we do not have to restrict throughput of funerals due to not being able to abate more than 1 cremator) to be completed as soon as possible so that the situation is resolved and the abatement equipment is removed and replaced thus preventing the need to buy in TMacs and also benefitting from slightly reduced running costs and not having to pay increased costs if the project was deflected for a year.
4.3 Schedule the work for 2019/2020 for the order to be placed at the start of the new financial year to allow for manufacturing time and installation prior to 31.12.2019 to ensure that we can legally carry out our function as CAMEO and the purchase of TMacs by that date will no longer be an option as all crematoria will have to abate 100%

5. RISK ASSESSMENT OF RECOMMENDATIONS AND OPTIONS

Risk	Risk Assessment	Risk Level	Risk Management
To continue to operate with failing equipment	To do so would mean postponing the inevitable option of having to carry out the work and increased maintenance in the meantime.	High	Can mitigate the risk by buying in TMac's for a limited period.
To carry out the work 2018/2019	To do so would reduce maintenance costs long term and reduce the risk of not meeting the	High	Whilst there is money for the works nothing has been budgeted for the resources to

	OSPAR recommendations		pay for additional expenditure which will possibly be caused if the 5% partial exemption calculation is breached.
To carry out the work 2019/2020	To do so would reduce maintenance costs long term and reduce the risk of not meeting the OSPAR recommendations but scheduling would be key as compliance is required by 31.12.2019 However it would still require increased troubleshooting until that point and buying of TMacs	High	Whilst there is money for the works nothing has been budgeted for the resources to pay for additional expenditure which will possibly be caused if the 5% partial exemption calculation is breached. A delay to this period would potentially give time for this to be resolved.

6. IMPLICATIONS

Relevant Legislation –

- The Oslo-Paris Commission (OSPAR) agreement on eliminating mercury emissions from crematoria, the UK agreed to reduce 50% mercury emissions from crematoria by 2012. But by 2020 **all** crematoria within the UK (roughly 240 facilities) will need to have a zero emissions rate.
- Environmental Permitting (England and Wales) Regulations 2010 which are made under the Pollution, Prevention and Control Act 1999 and cascaded down to crematoria under the Process Guidance Notes PG5/2(12) which sets out how we operate to control odour, particulate matter, hydrogen chloride, carbon monoxide, volatile organic compounds, mercury compounds and dioxins.

Human Rights – none

Equality and Diversity – none

Climate change and environmental sustainability – as detailed in 'relevant legislation'

Crime and Disorder – none

Budget/Resource – implications to budget/resource are a potential £750,000 outlay which could be found within reserves however there would be a potential impact on the Local Authority's partial exemption calculation. There are CAMEO revenue costs incurred if the 50% mercury abatement targets are not met. Due to continuing abatement issues the payments to CAMEO have been £26,364 for 2016 and forecasted as £33,770 for 2017. There is currently no set budget provision for un-abated CAMEO costs in the 2018/2019, 2019/2020 or 2020/2021 budgets, so if the 50% target continues not to be reached then any costs would need to be met from either existing budgets or surpluses.

7. CONSULTATION

The matter has been discussed at length with The Treasurer, Clerk, Finance Officers and Head of

Place and Wellbeing for Mansfield District Council.