Air Quality Technical Report

Prepared for

Soul Friend Pet Cremations

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Limitations:

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Executive Summary

Soul Friend Pet Cremations (SFPC) is proposing to establish a pet cremation facility at 94 Mulgrave Street, outside of Ashhurst township. The proposal requires an air discharge consent to operate pet cremators from the Horizons Regional Council (HRC). Pattle Delamore Partners Limited (PDP) has prepared this technical air quality assessment report to support an assessment of environmental effects to be submitted with the consent application.

Discharges to air from the operation of the cremators consist of products of combustion from natural gas, which is used as a fuel in the cremators, and the combustion of animals being cremated. The contaminant discharges include traditional products of combustion (particulate matter, oxides of nitrogen, carbon monoxide) and trace elements that may be present in combusted material.

Contaminant discharge rates for the cremators have been estimated based on a combination of published emission factors, emissions testing, and experience with other cremators in New Zealand and overseas. The assumed emission rates provide an envelope for the maximum effects, and the actual effects are typically expected to be lower than assessed.

Dispersion modelling has been undertaken to assess the effects of contaminant air discharges from the proposed cremators. Dispersion modelling was used to consider two scenarios to represent the maximum and more typical level of operations at the site as follows:

- cremation of a horse (or other large animal up to 600 kg), which would occur over a five-hour period, and with no other cremations being undertaken on that day; and,
- cremation of two lots per day of 200 kg of small animals (e.g. cats and dogs) over a two-hour period, with one lot being cremated in the morning and one lot in the afternoon.

Both scenarios have been separately modelled using air dispersion modelling with cremations occurring daily over a two-year modelling period. This is done to ensure capture of the worst-case meteorological conditions for dispersion. Under normal operations, large animal cremation is currently expected to occur around once per month. Cremation of small animals will normally be undertaken on average five times per week, although SFPC considers this is likely to increase overtime. The maximum operating scenario considered using the dispersion modelling is for up to 600 kg per day, seven-days per week, as represented by the large animal cremation.

Table 1 presents the dispersion modelling results for key contaminants from cremation of 600 kg per day compared to the relevant air quality assessment criteria. The table presents both the maximum concentrations from the cremator operations and the cumulative concentration with the assessed background air quality concentrations.

Table 1: Highest Predicted Off-site MGLCs of Contaminants from the SFPC Discharges

Contaminant	Highest Predicted MGLCs (µg/m³)		Averaging Period	Assessment Criteria (µg/m³)	Source
	Excluding Background	Including Background			
Particulate matter as PM_{10}	4.1	26.1	24-hour	50	NESAQ
	0.3	14.3	Annual	20	MfE
Particulate matter as $PM_{2.5}$	4.1	13.5	24-hour	25	NESAQ (proposed)
	0.3	7.3	Annual	10	NESAQ (proposed)
Carbon monoxide (CO)	13.2	5063	1-hour	30,000	MfE
	12.3	2057	8-hour	10,000	NESAQ
Nitrogen dioxide (NO_2)	13.8	78.8	1-hour	200	NESAQ
	11.1	54.1	24-hour	100	MfE
	0.2	16.2	Annual	30	MfE
Sulphur dioxide (SO_2)	9.8	29.8	1-hour	350	NESAQ
	1.6	9.6	Annual	120	MfE
Dioxins and furans	3.8E-08	3.8E-08	Annual	4.0E-05	California REL
Hydrogen chloride (HCl)	4.3	4.3	1-hour	2,100	California REL
	0.3	0.3	Annual	9	California REL

1. *All particulate matter has been assumed to be $PM_{2.5}$*
2. *NO_2 is assumed to be 20% of total NO_X*

The maximum off-site concentrations of all contaminants are well below all assessment criteria for all relevant averaging periods. The effects of the discharges from the cremation facility are assessed as less than minor, both because the maximum predictions are low compared to the assessment criteria and, in addition, levels at the nearest dwellings will be proportionately lower than the maxima at the site boundary.

Table 1 results are used in this report to represent the worst case for the potential for adverse effects for cremator operating scenarios up to a 600 kg per day maximum.

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1.0 Introduction

Soul Friend Pet Cremations (SFPC) currently operates a facility for the cremation of animals in Palmerston North. SFPC is proposing to relocate the operation to a property at 94 Mulgrave Street, Ashhurst. The proposed site is currently occupied by a cat and dog boarding facility.

SFPC is proposing to develop a purpose-built cremation facility to accommodate four pet cremators. Two cremators are proposed to be transferred from the existing SFPC facility in Palmerston North. An additional two cremators are proposed to be installed at the Ashhurst site to provide additional flexibility with operations.

SFPC requires an air discharge consent from HRC to operate the pet cremators. PDP has been engaged to prepare a technical assessment of potential air quality effects on the environment associated with the operation of the cremation facility.

This technical report provides an assessment of environmental effects resulting from potential air discharges from the cremators to accompany the application for air discharge consent. This report includes a full air dispersion modelling assessment of key air contaminants. This report:

- Sets out the Horizons One Plan consent requirements and the application of the National Environmental Standards for Air Quality (NESAQ) to the local airshed;
- Describes the receiving environment, summarises land uses in the area and characterises the background air quality;
- Describes the cremation process, process controls and air pollution controls;
- Describes the contaminants discharged to air and the potential effects of those contaminants;
- Presents air dispersion modelling for the discharges incorporating local data for building influences, meteorology and terrain with the AERMOD dispersion model;
- Considers the cumulative effects with the existing background air quality and the potential interaction with other sources and relates the modelling results to air quality assessment criteria; and,
- Discusses monitoring and mitigation proposed.

PDP has used contaminant emissions data from a combination of emissions test data from the cremators at their current location in Palmerston North and emissions factors for cremators have been used for contaminants where there is no site-specific test data.

2.0 Description of the Receiving Environment

2.1 Location

The SFPC cremation facility is proposed to be located at 94 Mulgrave Street on the southwestern side of the main residential area of Ashhurst.

The land adjacent to the site is rural with some industrial zoned land. Kilmarnock Nurseries is to the east of the site boundary and a home-kill stock processing facility is directly to the west of the site. Residential dwellings are located to the southeast.

Figure 1 is an aerial image showing the SFPC site at 94 Mulgrave Street. The total site area is approximately 4.0 hectares. The land is legally described as Lot 2 DP 35100, Blk III Gorge SD. A zoning map showing the district plan zone categories is provided as Figure 2. The site and surroundings are zoned Rural and Rural Residential in the Palmerston North City Council District Plan (May 2018).

Figure 1: Aerial Image Showing the Proposed SFPC Site

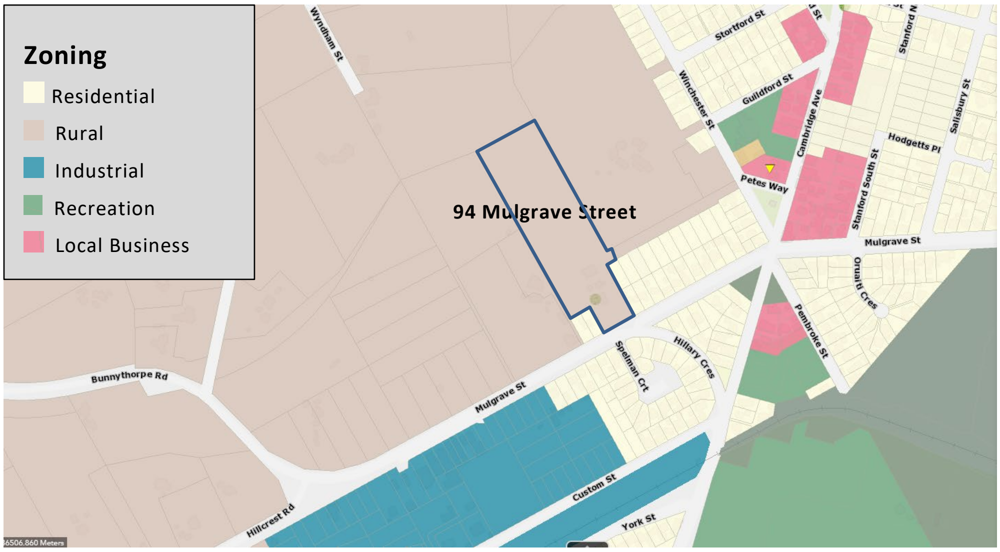

Figure 2: Site - District Plan Zoning

2.2 Topography

The SFPC site and surrounding area is on relatively flat ground which slopes downward to the Pohangina River to the east and upward toward the Ruahine Ranges to the west. The SFPC site is around 75 metres above sea level.

2.3 Meteorology

The nearest full-time meteorological station to the site is located in Palmerston North, approximately 15 kilometres to the southwest of the site, and is operated by NIWA. A wind rose of meteorological data collected at the Palmerston North site for the period 2015 to 2019 is provided as Figure 3, and is expected to be generally representative of winds in the surrounding area including Ashhurst. The winds occur predominantly along the west-northwest and east-southeast axis. The average wind speed during this period was 3.4 m/s, with calms (winds below 0.5 m/s) occurring around 1.4% of the time.

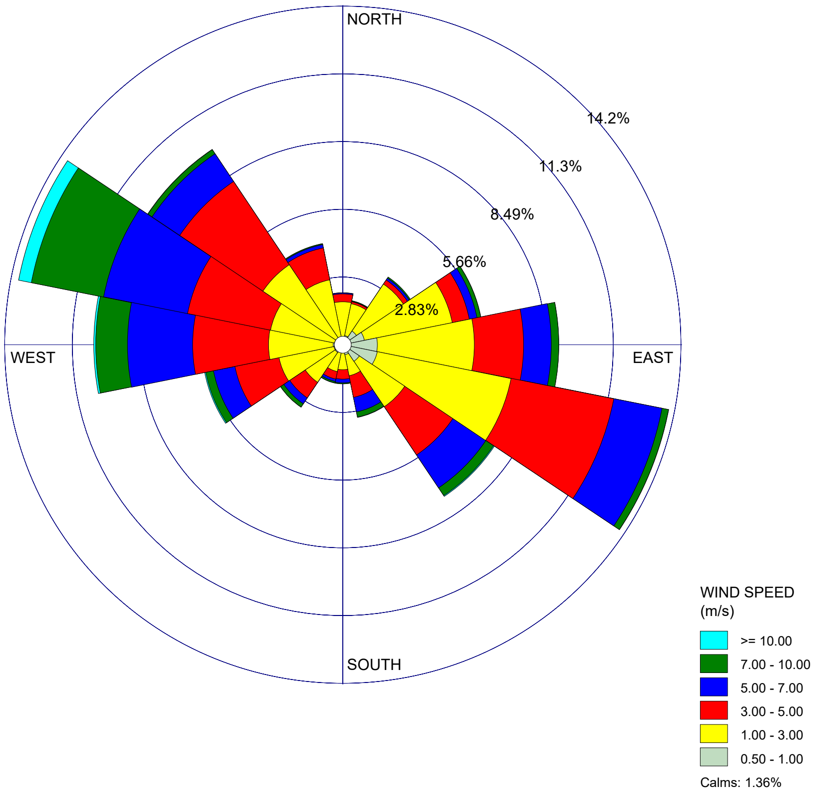

Figure 3: Palmerston North Wind Rose, 2015 – 2019

2.4 Background Air Quality

Background concentrations of some common air contaminants need to be considered when evaluating the effects of discharges from the SFPC site on the air quality of the area.

PDP is not aware of any publicly available ambient monitoring data in the vicinity of the SFPC site. In these circumstances, the *Ministry for Environment* (MfE) *Good Practice Guide*[1] (MfE 2016) recommends using default background air quality values developed by the New Zealand Transport Agency (NZTA 2014) for PM_{10} and NO_2 by census area units (CAU). The maps indicate that the default background values applicable for the site are as for the site are as per the main urban area of Palmerston North of 21.95 µg/m^3 for PM_{10} as a 24-hour average. Default background values for the main urban area of Palmerston North for NO_2 are 65, 43 and 16 µg/m^3 for 1-hour, 24-hour, and annual average concentrations, respectively. These values are expected to be conservative for the rural fringe of Ashhurst. Other values or averaging periods for PM_{10}, CO and SO_2 were obtained

[1] MfE, *Good Practice Guide for Assessing Discharges to Air from Industry*, November 2016.

from default background values provided in the *MfE Good Practice Guide* (2016) and are expected to conservatively represent the semi-rural location of the site's receiving environment.

To estimate the $PM_{2.5}$ background concentrations, it has been assumed that the $PM_{2.5}$ to PM_{10} ratio is 50%, which is consistent with assumptions for rural areas[2]. Table 2 provides the assumed background concentrations for the contaminants of concern at the relevant averaging periods.

Table 2: Summary of Background Air Quality Concentrations

Contaminant	Averaging Period	Background Concentration (µg/m³)	Source
PM_{10}	24-hour	21.95	NZTA
	Annual	14	MfE 2016
$PM_{2.5}$	24-hour	9.4	NZTA[1]
	Annual	7	NZTA[1]
NO_2	1-hour	65	NZTA
	24-hour	43	NZTA
	Annual	16	NZTA
CO	1-hour	5,000	MfE 2016
	8-hour	2,000	MfE 2016
SO_2	1-hour	20	MfE 2016
	24-hour	8	MfE 2016

Notes:

1. Background $PM_{2.5}$ concentrations assumed to be 50% of background PM_{10}.

2.5 Sensitive Receptors

Selected sensitive receptors have been included in the air dispersion modelling to specifically assess potential effects of the SFPC at these locations. The receptors include the closest residential and commercial properties in the vicinity of the SFPC site. Table 3 provides the receptor locations which are also shown on a map in Figure 4 below.

[2] NIWA, *$PM_{2.5}$ in New Zealand Modelling the Current (2018) Levels of Fine Particulate Air Pollution*, December 2019.

Table 3: Closest Sensitive Receivers to SFPC Site

Receptor ID	UTM X	UTM Y	Address	Description
1	393707	5538919.297	102 Mulgrave St	Ashhurst Stock Processing
2	393768	5538822.848	106 Mulgrave St	Residence
3	393792	5538849.407	98 Mulgrave St	Residence
4	393873	5538903.921	88 Mulgrave St	Residence
5	393782	5538779.166	105A Mulgrave St	Residence
6	393802	5538790.698	103 Mulgrave St	Residence
7	393819	5538800.833	101 Mulgrave St	Residence
8	393839	5538815.16	97 Mulgrave St	Residence
9	393870	5538833.332	1 Spelman Court	Residence
10	393922	5538857.095	87 Mulgrave St	Residence
11	393901	5538915.104	86 Mulgrave St	Residence
12	393797	5539115.34	83 Winchester St	Kilmarnock Nurseries
13	393424	5539168.457	167 Wyndham St	Residence

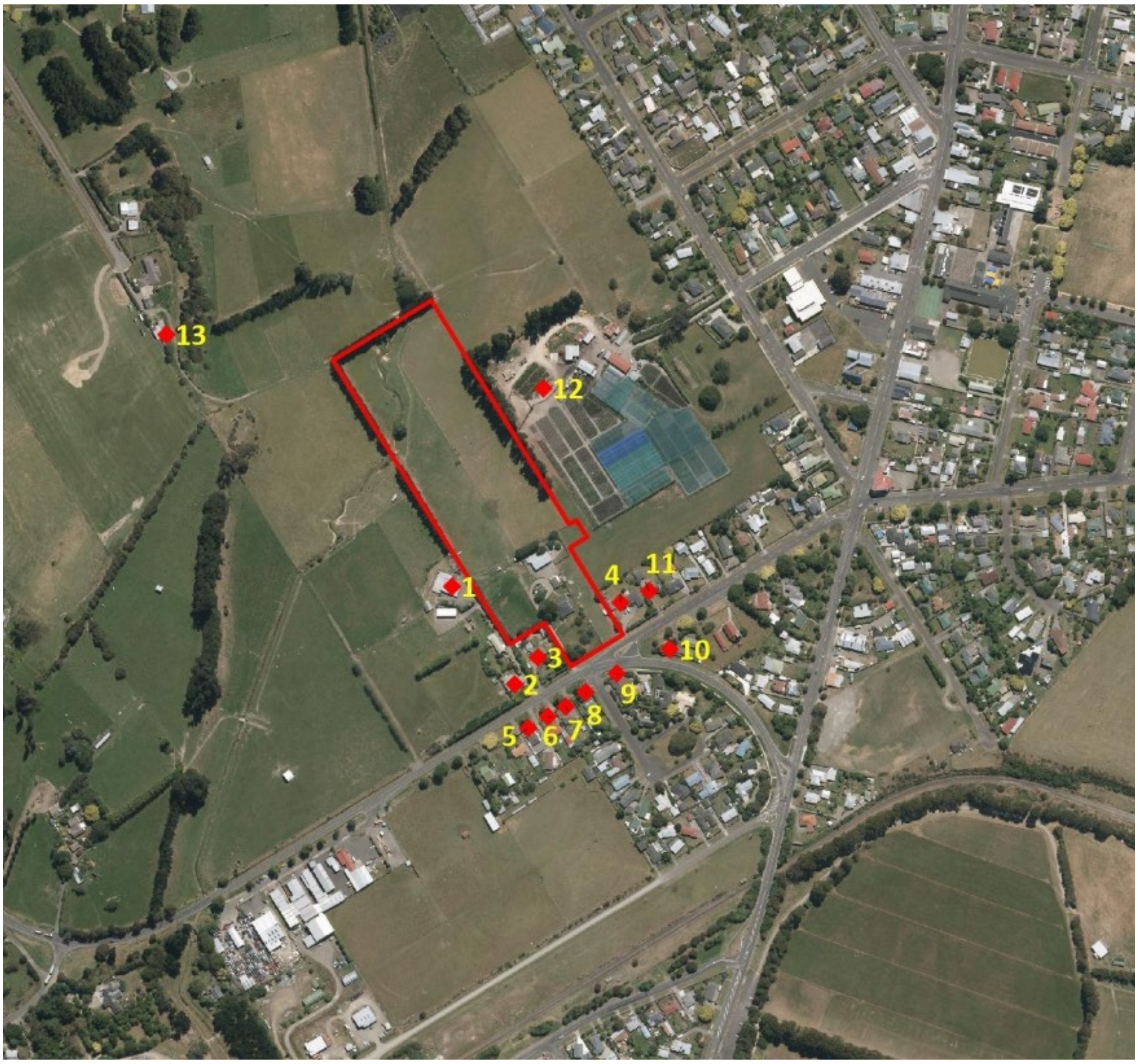

Figure 4: Map of Sensitive Receptors

3.0 Process Overview

SFPC is proposing to move two cremators from an existing cremation facility at 80 Tennant Drive in Palmerston North to the new site in Ashhurst. These two cremators are Model CA30 incinerators manufactured by McDonald Industries Limited. The two cremators have been in operation at the Palmerston North site since 1985 and were refurbished in 2020. SFPC is also proposing to install two additional cremators at the Ashhurst site, one of which is a Therm Tec Model S-27 cremator. The fourth cremator is a McDonalds incinerator that is similar to the existing cremators operating at the Palmerston North site.

The cremators are typical of most pyrolytic incinerators in that they have primary and secondary combustion chambers, each with designated natural gas-fired burners. The primary chamber provides space for the incineration of the animal carcasses. Combustion gases from the primary chamber enter the secondary chamber, which provides a high-temperature, oxygen-rich environment to allow complete combustion of the gases. The primary combustion chambers have two burners, which maintain a temperature in the chamber of around 750°C. The burners in the primary chamber are set to automatically shut off when the temperature reaches 800°C.

The secondary chambers each have a single gas-fired burner to maintain temperatures between 700 and 850°C, with a typical retention time for the gases of 0.5 to 0.6 seconds.

The two McDonalds cremators currently in use at the Palmerston North site have a maximum rating of 350 kg per hour. Typical use of the McDonalds cremators is for the cremation of multiple small animals (cats and dogs) with a total mass of 150 to 200 kg per cremation. Animals for cremation are loaded into the primary chamber and are separated by fire bricks to allow for the ashes of individual animals to be collected afterward. Cremation time for a 150 – 200 kg load is typically 1.5 to 2 hours. Horses are occasionally cremated, and a horse cremation is expected to occur up to once per month on average. A horse cremation takes up to 5 hours for an indicative 600 kg animal.

The Therm Tec unit will be installed to offer single pet cremation services to be attended by the pet owner. The additional McDonalds unit will be used to provide additional capacity and flexibility. The emissions from the single small animal cremations will be proportionately lower than the normal operating scenarios of multiple animals or single large animals with the McDonald's units.

Operation of the cremators will typically occur between the hours of 9 am and 4 pm and will be dependent on demand. The maximum operation of cremating up to 600 kg per day has been assessed using air dispersion modelling.

SFPC has undertaken emissions monitoring of the existing cremators at the Palmerston North facility to obtain data regarding temperatures and flow rates in

December 2020. A copy of the emissions test report for the two current cremator units is provided as Appendix A.

Table 4 summarises the cremator specifications based on measurement data.

Table 4: Cremator Details

Cremator Model	Natural Gas Usage Rate (m^3/hr)	Stack Temperature (°C)	Stack Diameter (m)	Efflux Velocity (m/s)
McDonalds Cold Hearth 1	51.2	739	0.4	19.8[1]
McDonalds Cold Hearth 2	51.2	703	0.4	16.8[1]
Therm Tec	36.7	790[2]	0.3	9[2]
McDonalds Hot Hearth	51.2[3]	700[3]	0.4	17[3]

Notes:

1. *From stack test monitoring report (STNZ, Air Discharge Monitoring of two McDonalds Pyrolytic Crematoriums, December 2020).*
2. *From emissions test report for Therm Tec S-27 located in Vancouver, Washington, USA (Source Evaluation Report, Peaceful Paws Cremation and Memorials, Inc., June 14, 2006).*
3. *Approximated based on the existing McDonald incinerators*

4.0 Nature and Composition of Discharges to Air

Discharges to air from the operation of the proposed pet cremators at the site will consist of products of combustion of both natural gas from the operation of the burners and combustion of the animal carcasses. The key contaminants discharged to air are particulate matter (as PM_{10} and $PM_{2.5}$), sulphur dioxide (SO_2), hydrogen chloride (HCl), oxides of nitrogen or NO_X (as nitrogen dioxide or NO_2) and dioxins and furans.

Particulate matter originates from the combustion of animal remains and fuel burning. SO_2 and HCl are produced from the combustion of sulphur and chlorine content in animal carcasses. Polychlorinated dioxins and furans are produced from the reaction of chlorine contained in the animal carcasses and other material with organic gases in the combustion chambers. NO_X is formed by high temperature combustion processes through the reaction of nitrogen in air with oxygen.

4.1.1 Fine Particulate Matter

Particles with a diameter of less than 10 µm (PM_{10}) are associated with the potential adverse health effects due to their effects on human respiration systems. The inhalation of PM_{10} may cause the aggravation of existing respiratory and cardiovascular disease particularly in the elderly and children. Those suffering from asthma and other respiratory illnesses or cardiovascular diseases are particularly susceptible.

Particles with a diameter of 2.5 micrometres or less ($PM_{2.5}$) present particular risk to health as their size allows them to penetrate deep into the lungs and into the bloodstream. Exposure to $PM_{2.5}$ over long periods can cause adverse health effects.

Particulate matter suspended in the atmosphere can also impact on amenity because of reduced visibility and the deposition of larger particles (dust) can also cause nuisance and adverse effects on amenity values.

4.1.2 Carbon Monoxide

Carbon monoxide is a product of incomplete combustion and will be minimal assuming good combustion conditions are maintained in the cremators' secondary chambers. The toxic effect of CO is characterised by a lowered oxygen-delivery capacity of the blood, even when the partial pressure of oxygen and the rate of blood flow are normal. At a CO concentration of 10 ppm, impairment of judgement and visual perception occur; exposure to 100 ppm causes dizziness, headache, and weariness; loss of consciousness occurs at 250 ppm; and 1000 ppm results in rapid death.

4.1.3 Oxides of Nitrogen

Oxides of nitrogen are generated during high temperature combustion by the thermal oxidation of nitrogen in air and in fuel with oxygen in the atmosphere and consists of nitric oxide (NO) and NO_2. NO is relatively non-toxic, odourless, and colourless, is the primary compound produced during combustion, around 95% of NO_X emitted from most combustion appliances is NO. NO_2 is an acidic gas with a characteristic odour. It is substantially more toxic and more reactive than nitric oxide and is more of concern as an air contaminant if concentrations are excessive. In sufficient concentration, NO_2 damages vegetation.

Up to around 50% of the NO emitted is oxidised to NO_2 over some hours in the presence of atmospheric oxidants at concentrations experienced in urban areas such as over the Auckland metropolitan area. The rate of conversion will be lower in areas such as Ashhurst, which will have considerably lower background oxidant concentrations. Predicted maximum ground level concentrations within 1 km or so from the source are unlikely to have NO_2:NO_X ratios much higher than the initial discharge ratio of around 5% NO_2.

4.1.4 Sulphur Dioxide

SO_2 is generated from the combustion of sulphur-containing fuels. SO_2 can cause respiratory problems, such as bronchitis or irritation of nose, throat and lungs. It can also cause breathing difficulty for those with asthma. SO_2 deposition can damage vegetation and accelerate the decay of building materials and paints if in high enough concentrations.

4.1.5 Hydrogen Chloride

Hydrogen chloride (HCl) is the most common hydrogen halide. Hydrogen chloride may be emitted from the combustion of fuels containing chlorides such as wood and coal, from any fuel contaminated with sea water.

Acute effects of HCl are primarily irritation of eyes and respiratory system. Effects of chronic exposure to HCl at sufficient concentrations can include chronic bronchitis, dermatitis and photosensitisation.

HCl is also of interest due to the role of chlorine in formation of dioxins and furans.

4.1.6 Dioxins and Furans

Dioxins (PCDDs) and furans (PCDFs) are compounds consisting of two benzene rings joined by two oxygen atoms (dioxins) or one oxygen atom (furans). From one to eight chlorine atoms can attach to the benzene rings in a variety of positions (each positional relationship is called a congener). Of the 75 possible dioxin congeners, and the 135 furan congeners, only those that have chlorine (or bromine) substitution in the 2,3,7,8 positions are believed to have dioxin-like toxicity. The most toxic dioxin is 2,3,7,8-TCDD and this is assigned a Toxicity Equivalence Factor (TEF) of 1.0. The remaining dioxins and furans have TEFs less than 1.0 and range down to zero.

These compounds range in toxicity from potentially highly toxic to moderate to low toxicity. They have very low water solubility, are soluble in fats, have low vapour pressure, and tend to bio-accumulate. Most congeners appear to be highly stable under most environmental conditions and show little tendency to leach or volatilise once adsorbed on to particulate matter.

Dioxins and furans are discharged in low concentrations from combustion appliances burning all carbonaceous fuels (e.g. coal or wood). Unless dioxins and furans are already present in the fuel, chloride is a pre-requisite for their generation. Dioxins can be formed from thermal breakdown and chemical re-arrangement of chlorinated aromatic hydrocarbons having a structural similarity to dioxin and furan molecules.

4.2 Elimination of Odour and Smoke Emissions

The cremators proposed to be installed at the site are fitted with high temperature secondary chambers, which are designed to ensure complete combustion of all material. Well operated and maintained secondary chambers eliminate visible smoke and any potentially odorous compounds from the discharges. The secondary chambers are designed to ensure smoke-free and odour-free operation when normally operated under all but the most unusual circumstances.

4.3 Abnormal Operation

Abnormal operation of the cremators could increase the emission of some contaminants into air for a short time. Abnormal operation could occur due to operator error, a malfunction of the equipment, or a failure of electricity or natural gas supply.

Under abnormal operation smoke and possibly odour could be detectable. The discharge of excessive smoke and odour from a cremator could be considered to be objectionable to the average person. The discharge would not, however, pose a physical health risk to the public because of the short-term nature of any such event.

Controls are built into the cremator to reduce the risk of poor operation; and specific instructions are available for undertaking non-standard cremations such as cremation of horses and other large animals. Abnormal operation will be infrequent due to the level of automation and control for the cremators and operation by trained and experienced staff.

Un-programmed electricity and gas outages, and problems due to mechanical or electrical failures are rare.

4.4 Aesthetic Impact

Under nearly all operating conditions, the discharges from the cremator stacks are very similar in appearance and odour to that from commercial natural gas-fired boilers and hot water heaters with no visible smoke. A ‘heat shimmer’ from the top of the stack under some light wind conditions may be observed.

There is appreciably less odour than from combustion emissions of coal and wood-fired appliances.

4.5 Contaminant Emission Rates

Emission rates of total particulate matter and HCl were obtained from the December 2020 emissions test reports (refer Appendix A) for the two existing McDonalds cremators. We have conservatively assumed that all particulate matter measured is $PM_{2.5}$. Emission factors provided by the Australian

Government National Pollutant Inventory (NPI 2011) have been used to estimate the rate of discharge of CO, NOx, SO_2, and dioxins from the cremator operations at the SFPC site. The emission factors include contaminants generated by the combustion of both the animals and fuel. While these emission factors are based on measurements of human cremations, the nature of pet cremations is essentially identical to that of human cremations, and we consider the NPI emission factors for human cremations to be applicable to the SFPC discharges, provided good combustion conditions are achieved and maintained during the cremations. The NPI emission factors are based on average mass of cremation of 70 kg per body and a 20 kg casket. These rates have been adjusted for the somewhat higher loads of the pet cremations on a pro-rata basis assuming a maximum load of 200 kg over a two-hour period and a 600 kg for cremation over a five-hour period.

PDP initially considered the discharges from the cremators using modelling assuming SFPC typical operations of one cremator for two hours in the morning from 10 am to 12 pm, and a second cremator operating from 2 pm to 4 pm daily. SFPC is, however, seeking flexibility to operate the cremators in alternative configurations with a maximum of 600 kg per day for five hours in total as per the maximum scenario modelled.

As modelled, the 600 kg cremation scenario takes place over a five-hour period in one cremator that was assumed to operate daily from 9 am to 2 pm. The impacts on ground level concentrations, in particular, for PM_{10} and $PM_{2.5}$ over a 24-hour averaging period would be comparable to the large animal scenario for any configuration of cremations up to 600 kg per day and five hours of operation.

Table 5 summarises the mass emission rates for PM_{10}, $PM_{2.5}$, NO_X, SO_2, HCl and dioxin/furan as used in the dispersion modelling assessment.

Table 5: Contaminant Discharge Rates

Contaminant	Discharge Rates (kg/cremation)		Discharge Rates (g/s)	
	200 kg 2 hours	600 kg 5 hours	200 kg	600 kg
Particulate matter (PM_{10} and $PM_{2.5}$) discharge rate[1]	0.36	0.89	0.049	0.049
Nitrogen dioxide (NO_X as NO_2)[2]	1.47	6.00	0.21	0.33
Carbon monoxide[2]	0.28	1.15	0.04	0.06
Sulphur dioxide[2]	0.21	0.84	0.03	0.05
Dioxin & furans[2]	1.5E-08	6.0E-08	1.9E-09	3.1E-09
Hydrogen chloride[1]	0.11	0.28	0.015	0.015

Notes:

1. *Emission rates derived from December 2020 emissions test data.*
2. *Emission rates derived from Australian Government, National Pollutant Inventory Emission Estimation Technique Manual for Crematoria, Version 1, March 2011. Emission factors are provided on a per-cremation basis for a 70 kg human body and have been scaled up to reflect the mass of cremations proposed at the SFPC site.*

5.0 Resource Management Act Considerations

5.1 RMA Regulation 15

SFPC's activities are an "industrial and trade premise" as defined in the Resource Management Act (RMA). Section 15(1)(c) prohibits the discharge of any contaminant into air; unless the discharge is allowed by a rule of a regional plan or relevant proposed plan, a resource consent, or by regulations.

5.2 MfE Good Practice Guide

The Ministry for the Environment's (MfE) *Good Practice Guide (GPG) on Assessing Emissions to Air from Industry* (2016) recommends an order of priority when reviewing air quality assessment criteria applicable to assessing effects on air quality in New Zealand as follows:

- National Environmental Standards for Air Quality;

- National Ambient Air Quality Guidelines;
- Regional objectives (unless more stringent than above criteria);
- WHO air quality guidelines;
- California Reference Exposure Levels (acute and chronic RELs) and US EPA inhalation reference concentrations and unit risk factors (chronic);
- Texas Effects Screening Levels (ESLs) if these have been derived from toxicological data in a transparent manner.

Based on this priority list for assessment criteria the following sources have been considered relevant to this activity:

- Ministry for the Environment, *Resource Management (National Environmental Standards for Air Quality) Regulations,* 2004 (NESAQ);
- Ministry for the Environment, *Ambient Air Quality Guidelines* (2002 update) (AAQG); and,
- California Reference Exposure Levels (RELs)

5.3 National Environmental Standards for Air Quality

The New Zealand Government gazetted National Environmental Standards for Air Quality Regulations (NESAQ or "the Regulations") in 2004 and amended these in 2011. The NESAQ are designed to protect public health and the environment by setting concentration limits. The NESAQ differ from the New Zealand Ambient Air Quality Guidelines (NZAAQGs) in that they set an allowable level of exceedance and cover only one time period for averaging per contaminant. The NESAQ includes concentration thresholds and permissible excursions relevant to emissions from the site, which are presented in Table 6.

Table 6: New Zealand Environmental Standards for Air Quality from 1 September 2005 (as Amended 2011)

Contaminant	Threshold Concentration	Averaging Time	Permissible Exceedances
Particulate matter (PM_{10})	50 µg/m^3	24-hour	One in a 12-month period
Nitrogen dioxide (NO_2)	200 µg/m^3	1-hour	9 in a 12-month period
Carbon monoxide	10 mg/m^3	8-hour	One in a 12-month period
Sulphur dioxide (SO_2)	350 µg/m^3	1-hour	9 in a 12-month period
	570 µg/m^3	1 hour	None

The MfE has published proposed amendments to the NESAQ which would establish national air quality standards for $PM_{2.5}$ at 25 µg/m^3 as a 24-hour and

10 µg/m^3 as an annual average. We have therefore included an assessment of the discharges against the proposed NESAQ for $PM_{2.5}$.

The current NESAQ Regulations uses the term "airshed", which defines where air quality must be monitored and for polluted airsheds determines the basis for certain decisions on resource consents. The MfE has gazetted airsheds for managing air quality, which are generally in populated areas where the NESAQ for PM_{10} is being breached or is likely to be breached.

The Regulations currently have an emphasis on managing PM_{10}, with specific provisions for new discharges as follows:

- **Regulation 17(1)** – Applies to an application for resource consent to discharge PM_{10} into a polluted airshed. If the discharge is likely to increase the concentration of PM_{10} by more than 2.5 micrograms per cubic metre in any part of a polluted airshed other than the site on which the consent would be exercised, then the consenting authority must decline the application for resource consent.
- **Regulation 17(2) –** States that Regulation 17(1) does not apply if the proposed consent is for the same activity at the same site (*i.e.* is a renewal of an existing consent), or is a new activity replacing an existing consented activity, and the amount and rate of PM_{10} discharge of the proposed consent is the same as or less than that permitted by the existing consent.
- **Regulation 17(3) –** States that the consenting authority may allow the consent if the applicant can reduce (offset) the PM_{10} discharged from another source or sources into the polluted airshed by the same or greater amount than the amount likely to be discharged by the proposed consent.

Ashhurst is not in a gazetted airshed, nor is it considered polluted under the Regulations. Regulation 17(1) does not therefore restrict granting of a consent for this activity based on PM_{10} discharges.

5.4 Ambient Air Guidelines

The MfE[3] published ambient air guideline values for New Zealand in 2002. The primary purpose of the guidelines is to promote sustainable management of the air resource in New Zealand. The guideline values published are the minimum requirements that outdoor air quality should meet to protect human health and the environment. The guidelines provide values for contaminants that are commonly discharged from combustion sources, such as the proposed cremators.

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[3] MfE, *Proposed amendments to the National Environmental Standards for Air – Particulate Matter and Mercury Emissions -Summary document,* February 2020.

The guideline values relevant to this assessment with their respective averaging times are presented in Table 7.

Table 7: Relevant Ambient Air Quality Guideline Values (MfE, 2002)

Contaminant	Guideline Values (µg/m³)	Averaging Period
Carbon monoxide (CO)	30,000 10,000	1-hour 8-hour
Particulate matter as PM_{10}	50 20	24-hour Annual
Nitrogen dioxide (NO_2)	200 100	1-hour 24-hour
Sulphur dioxide (SO_2)	350 120	1-hour 24-hour

5.5 Other Relevant Assessment Criteria

As discussed above, for contaminants where New Zealand standards and guidelines do not exist, international criteria from a range of sources may be considered and applied to the assessment. Table 8 summarises the relevant assessment criteria for contaminant emissions from the cremator discharges for HCl and dioxins and furans.

Table 8: Other Relevant Assessment Criteria

Contaminant	Threshold Concentration	Averaging Time	Source
Hydrogen chloride (HCl)	2,100 µg/m^3	1 hour	California REL
	9 µg/m^3	Annual	California REL
Dioxins and furans	4 x 10^{-05} µg/m^3	Annual	California REL

5.6 Summary

Table 9 summarises the air quality standards and guidelines relevant to this assessment, which we further consider in Section 6 of this report.

Table 9: Summary of Relevant Air Quality Criteria

Contaminant	NES and NZAAQG values (µg/m³)	Other Relevant Guidelines (µg/m³)	Averaging Period	Number of Exceedances Allowed Each Year
Particulate matter as PM_{10}	50	n/a	24-hour	One 24-hour period
	20	n/a	Annual	n/a
Particulates matter as $PM_{2.5}$	25	n/a	24-hour	Three 24-hour periods
	10	n/a	Annual	n/a
Nitrogen dioxide (NO_2)	200	n/a	1-hour	Nine 1-hour periods
	100	n/a	24-hour	n/a
	30	n/a	Annual	n/a
Sulphur dioxide (SO_2)	570	n/a	1-hour	None
	350	n/a	1-hour	Nine 1-hour periods
	120	n/a	24-hour	n/a
Carbon monoxide (CO)	10,000	n/a	8-hour	One 8-hour period
	30,000	n/a	1-hour	n/a
Dioxins and furans	n/a	4×10^{-05}	Annual	n/a
Hydrogen chloride (HCl)	n/a	2,100 µg/m³	1-hour	n/a
	n/a	9 µg/m³	Annual	n/a

6.0 Atmospheric Dispersion Modelling of Cremator Discharges

6.1 Introduction

Dispersion modelling is an internationally accepted method for predicting concentrations of contaminants in air downwind of a source for use in environmental assessments. Dispersion models account for factors including: the emission rate of the contaminant(s), the height of the discharge, building downwash effects, local topography, and meteorology. The main meteorological aspects considered in modelling are wind speed and direction, ambient temperature, atmospheric mixing height and atmospheric stability.

The accuracy of model predictions depends on factors, including:

- The quality of the input data and assumptions;
- The inherent limitations in the model for predicting plume rise at any point downwind;
- The ability to predict plume dispersion coefficients (plume spread);
- The assumption that meteorological conditions remain constant between the source and receptor; and
- That varying terrain can be accounted for.

6.2 Air Dispersion Modelling Approach

A two-stage modelling approach was taken for modelling emissions from SFPC. First, using the TAPM prognostic meteorological model to provide input data for the AERMOD dispersion model. The Gaussian dispersion model AERMOD Version 7.6 was then used to predict the ground level concentrations likely to result from SFPC's operations. AERMOD is widely accepted internationally as a dispersion model for regulatory purposes.

6.3 Use of 99.9 Percentile Levels for Evaluations

Using percentile values when analysing dispersion modelling predictions, subject to certain criteria, is a statistical method widely accepted and used. For example, the MfE's *Good Practice Guide for Atmospheric Dispersion Modelling* (2004) recommends the 99.9th percentile value of the predicted ground level as the maximum one-hour average ground level concentration be used for comparison with one-hour average assessment criteria. The use of percentiles is linked to the inherent uncertainty (accuracy) of modelling predictions even when input data is appropriate. It has been found that short-term modelling predictions at the 99.9th percentile more closely approximate empirical data as compared with peak predictions. The use of percentiles for analysing dispersion modelling data (and monitoring data) becomes less relevant as averaging times increase.

In this assessment we have reported the predicted concentrations as one-hour averages expressed as the 99.9th percentile. The 24-hour and annual averages are expressed as the 100th percentile.

6.4 Meteorological Data

Comprehensive meteorological data suitable for use with the AERMOD dispersion model was developed using the prognostic model TAPM (Version 4.0.4), CSIRO, Australia[4]. This model predicts all meteorological parameters for the region based on large-scale synoptic information provided by the Australian Bureau of Meteorology.

To produce the meteorological data set to run AERMOD, TAPM was configured with:

- Five nested meteorological grids with a grid spacing of 30, 10, 3, 1, and 0.3 km;
- Default vegetation, topography and soil types as supplied in the TAPM databases for New Zealand;
- Grid centre at 40.29° S, 175.75° E, (393683 E, 5539058 S, UTM Zone 60S);
- Grid dimensions (nx, ny, nz) = 25, 25, 25; and
- Prognostic turbulence scheme and hydrostatic approximation.

Meteorological data collected at the Palmerston North meteorological monitoring station, located about 15 km to the north of the site, for 2018 and 2019 were assimilated into the TAPM model to improve the correlation of the model predictions with actual surface wind measurements. Two meteorological datasets – one surface air data file (**.SFPC) and one upper air data file (**.pfl) were extracted from a pseudo-met station of the modelling grid located at the location of the SFPC site.

A windrose of the surface air data file generated by TAPM for use with AERMOD is provided as Figure 5. The wind profile shows moderately good correlation with the measured winds at the Palmerston North meteorological station as shown in the windrose in Figure 3. Differences between the measured meteorology at the Palmerston North monitoring station and the modelled meteorology at Ashhurst are primarily due to the differences in terrain at Ashhurst as compared to

[4] Peter Hurley. *TAPM V4 User Manual. CSIRO Marine and Atmospheric Research Internal Report No.5*. October 2008. ISBN: 978-1-921424-73-1

Palmerston North in particular proximity to the Ruahine Ranges and the Manawatu Gorge[5].

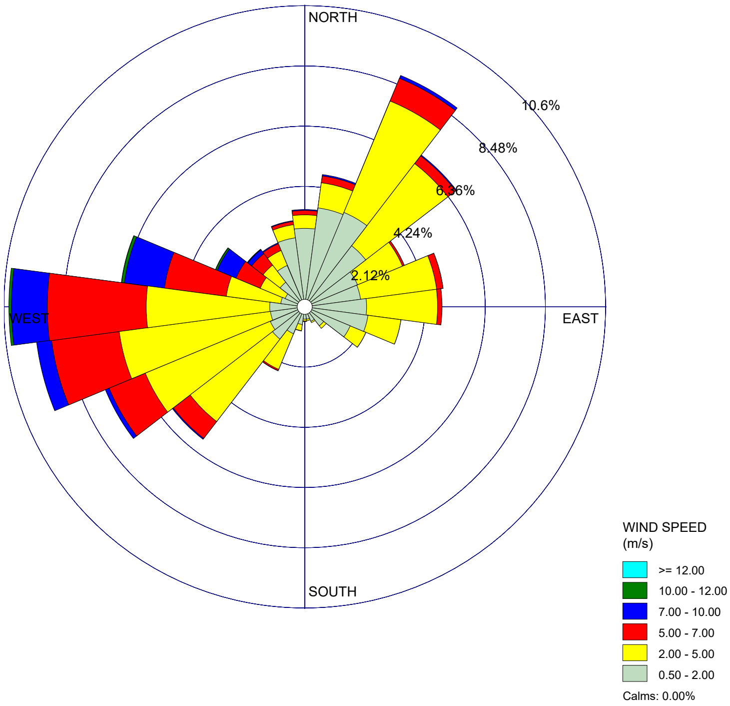


Figure 5: Wind Rose of AERMOD Meteorological Data

6.5 AERMOD Settings and Input Parameters

Dispersion modelling has been undertaken to assess the effects of contaminant air discharges considering two scenarios representing the operation at the site as follows:

- The maximum operation in any one day being cremation of a horse (or combination of smaller cremations up to 600 kg), which would occur over a five-hour period,
- The current typical maximum cremation of two lots of 200 kg of small animals (e.g. cats and dogs) over a two-hour period, with one lot being cremated in the morning and one lot in the afternoon.

Both of these scenarios were modelled as occurring every day over a two-year modelling period in order to capture the worst-case meteorological conditions for dispersion. Under normal operations, the cremation of a large animal is expected to occur around once per month. Cremation of small animals will

[5] https://docs.niwa.co.nz/library/public/NIWAsts66.pdf

normally be undertaken up to five times per week typically with two cremations every second day, although SFPC is seeking to increase from this. The dispersion modelling assessment therefore represents maximum operation up to 600 kg per day.

The Therm Tec unit is intended for use for single-animal cremations (i.e. a single cat or dog) for cases in which the owners wish their animals to be cremated alone. The discharge from the Term Tec will be shorter duration and will result in a less discharge of contaminants as compared to the multiple-small animal or single large animal cremations in the McDonald units. The dispersion modelling undertaken for 600 kg per day creates an envelope of effects within which the additional cremators can operate on any one day.

Table 10 sets out the parameters and settings used in the dispersion modelling for the two scenarios. Air discharge parameters, including efflux temperature and velocity, have been derived from the emissions test data of the existing cremators as currently operating at Palmerston North. Emissions test data for the two existing McDonalds cremators have been used to estimate the discharge parameters (efflux velocity and temperature) and emission rates of particulate matter and hydrogen chloride. Published emission factors from the Australian Government National Pollutant Inventory (NPI)[6] have been used to estimate the discharge rates of other contaminants of concern.

Figure 6 is a site layout diagram of the proposed cremation facility and indicates the locations of each cremator and associated stack within the building. Figure 7 is an aerial image indicating the location of the proposed cremation facility within the overall site.

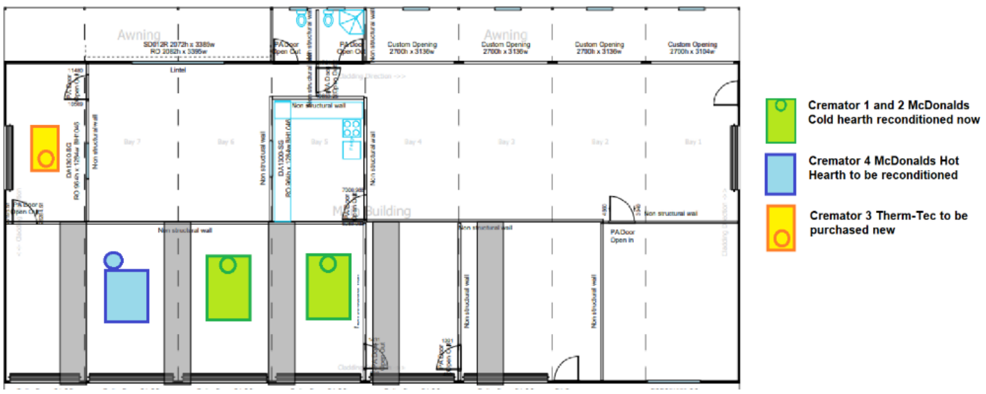


Figure 6: Proposed Cremation Facility with Locations of Cremators and Stacks

[6] Australian Government, *National Pollutant Inventory Emission Estimation Technique Manual for Crematoria, Version 1*, March 2011.

Figure 7: Proposed Cremation Facility within SFPC Site

While variations in contaminant emission rates over the course of a cremation will occur, these variations are not likely to be significant for the averaging periods relevant for the evaluation criteria used in the assessment (i.e. 1-hour, 24-hour and annual averages). Contaminant emissions have therefore been assumed to be constant over the cremation period. Contaminant emission rates from the cremators used in the modelling have been provided in Table 10.

Table 10: SFPC Ashhurst Model Parameters Input Summary

Parameter	Value(s) for Dispersion Modelling	
	Unit 1 – McDonalds Cremator	Unit 2 - McDonalds Cremator
Stack Height	10.5 m	10.5 m
Chimney exit diameter	0.4 m	0.4 m
Chimney efflux temperature	739°C	703°C
Chimney efflux velocity	19.8 m/s	16.8 m/s
Operating hours Scenario 1	9 am to 2 pm (600 kg over 5 hours)	No operation

Table 10: SFPC Ashhurst Model Parameters Input Summary

Parameter	Value(s) for Dispersion Modelling	
	Unit 1 – McDonalds Cremator	Unit 2 - McDonalds Cremator
Operating hours Scenario 2	2 pm to 4 pm (200 kg)	10 am to 12 pm (200 kg)
Terrain effects & roughness height	Digital terrain file – 25 m horizontal resolution	
Modelling domain size	3 x 3 km (9 km^2)	
Receptor locations	Cartesian grid with receptors spaced every 25 m; 107 boundary receptors; 13 sensitive receptors	
Modelling period	1 January 2018 to 31 December 2019	
Averaging time for model predictions	1-hour, 8-hour, 24-hour, and annual	

A copy of the AERMOD input file is provided as Appendix B.

6.6 Dispersion Modelling Results

Table 11 presents the highest predicted maximum ground level concentrations (MGLCs) beyond the site boundary for all contaminants. The highest maxima occur for Scenario 1, the 600 kg cremation, therefore these results are used in this report to represent the worst case for the potential for adverse effects.

Table 12 presents the highest predicted 24-hour average concentrations of PM_{10} and $PM_{2.5}$ at the nearest sensitive receptors. All contaminants are predicted to be at very much lower concentrations as compared to the assessment criteria at sensitive receptor locations, all being proportionately lower than the maximum values as reported in Table 11.

Table 11: Highest Predicted offsite MGLCs of Contaminants from the SFPC Discharges

Contaminant	Highest Predicted MGLCs ($\mu g/m^3$)		Averaging Period	Assessment Criteria ($\mu g/m^3$)	Source
	Excluding Background	Including Background			
Particulate matter as PM_{10}	4.1	26.1	24-hour	50	NESAQ
	0.30	14.3	Annual	20	MfE
Particulate matter as $PM_{2.5}$	4.1	13.5	24-hour	25	NESAQ (proposed)
	0.30	7.3	Annual	10	NESAQ (proposed)
Carbon monoxide (CO)	17.6	5063	1-hour	30,000	MfE
	16.4	2057	8-hour	10,000	NESAQ
Nitrogen dioxide (NO_2)	18.4	83.4	1-hour	200	NESAQ
	14.8	57.8	24-hour	100	MfE
	0.3	16.3	Annual	30	MfE
Sulphur dioxide (SO_2)	13.1	33.1	1-hour	350	NESAQ
	2.1	10.1	Annual	120	MfE
Dioxins and furans	5.1E-08	5.1E-08	Annual	4.0E-05	California REL
Hydrogen chloride (HCl)	5.8	5.8	1-hour	2,100	California REL
	0.3	0.3	Annual	9	California REL

Notes:

1. *All particulate matter has been assumed to be $PM_{2.5}$*
2. *NO_2 is assumed to be 20% of total NO_X*

Table 12: Predicted MGLCs of PM_{10} and $PM_{2.5}$ as 24-hour Averages (µg/m^3)				
Receptor ID	**Description**	**PM_{10} and $PM_{2.5}$ (excluding background)**	**PM_{10} (including background)**	**$PM_{2.5}$ (including background)**
1	102 Mulgrave St	1.6	23.6	11.0
2	106 Mulgrave St	1.3	23.3	10.7
3	98 Mulgrave St	1.4	23.4	10.8
4	88 Mulgrave St	1.5	23.5	10.9
5	105A Mulgrave St	1.2	23.1	10.6
6	103 Mulgrave St	1.1	23.1	10.5
7	101 Mulgrave St	1.1	23.1	10.5
8	97 Mulgrave St	1.0	23.0	10.4
9	1 Spelman Court	1.1	23.1	10.5
10	87 Mulgrave St	1.0	23.0	10.4
11	86 Mulgrave St	1.3	23.2	10.7
12	83 Winchester St	0.9	22.9	10.3
13	167 Wyndham St	1.4	23.3	10.8

Isopleth diagrams showing the spatial distribution of the predicted MGLCs are provided as:

- **Figure 8:** NO_2, 1-hour average at the 99.9th percentile; and,
- **Figure 9** and **Figure 10**: 24-hour and annual average PM_{10}, respectively.

The plots show the areas of highest predicted concentrations as 1-hour and 24-hour averages occur at the western site boundary, and the highest annual average concentrations occur at the eastern site boundary.

The areas of highest predicted concentrations do not coincide with any of the residential or other sensitive receptors. Predicted concentrations are significantly lower at these locations where the general public could be expected to be present.

The MGLCs from the maximum (worst case) operating scenario at SFPC cremators are predicted at a level that is assessed as having less than minor effects. The principal contaminant of concern is particulate matter, which has been assessed assuming 600 kg per day and results in concentrations well below the ambient air standards and guidelines.

The current cremator operations are more likely to be a maximum of two 200 kg cremation in any one day, with a usual maximum of five cremations a week. SFPC is, however, seeking to increase from this. SFPC is seeking consent to provide flexibility to cremate of up to 600 kg per day using the cremators in varying combinations. PDP considers that the predicted ground level concentrations of particulate matter, which is the critical contaminant of concern, will be comparable whether 600 kg is cremated across one unit or several units for up to five hours on any one day.

As demonstrated in the isopleth diagrams, the ground level concentrations at sensitive receptors, in particular at dwellings, are predicted to be significantly less than the highest predicted off-site concentrations and are well below the relevant ambient air standards and guidelines. Consequently, the effects on the surrounding environment are assessed as being at a level that is less than minor for all contaminants assessed.

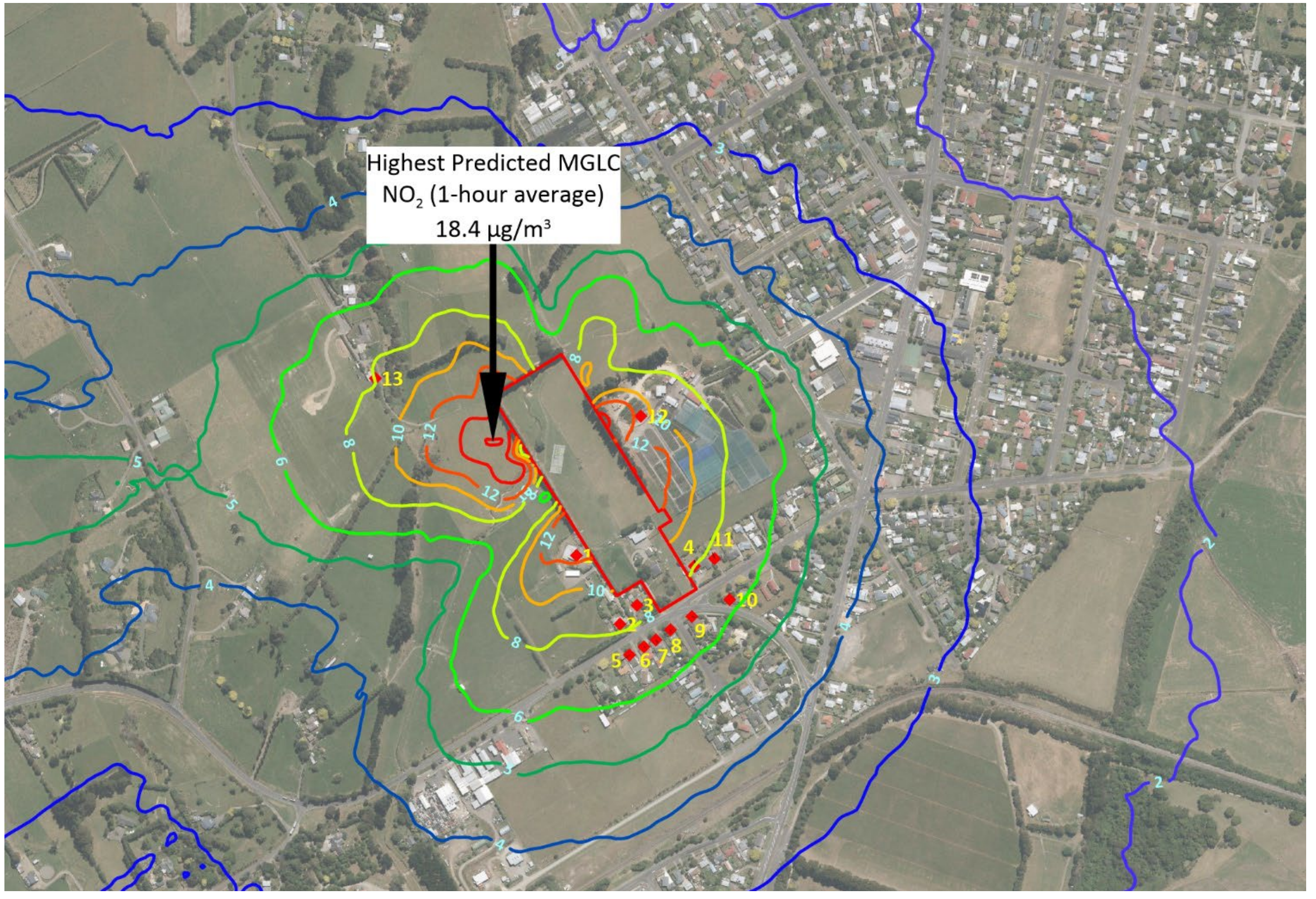


Figure 8: Highest Predicted MGLCs of NO_2 as 1-hour Averages at 99.9th Percentile (µg/m^3)

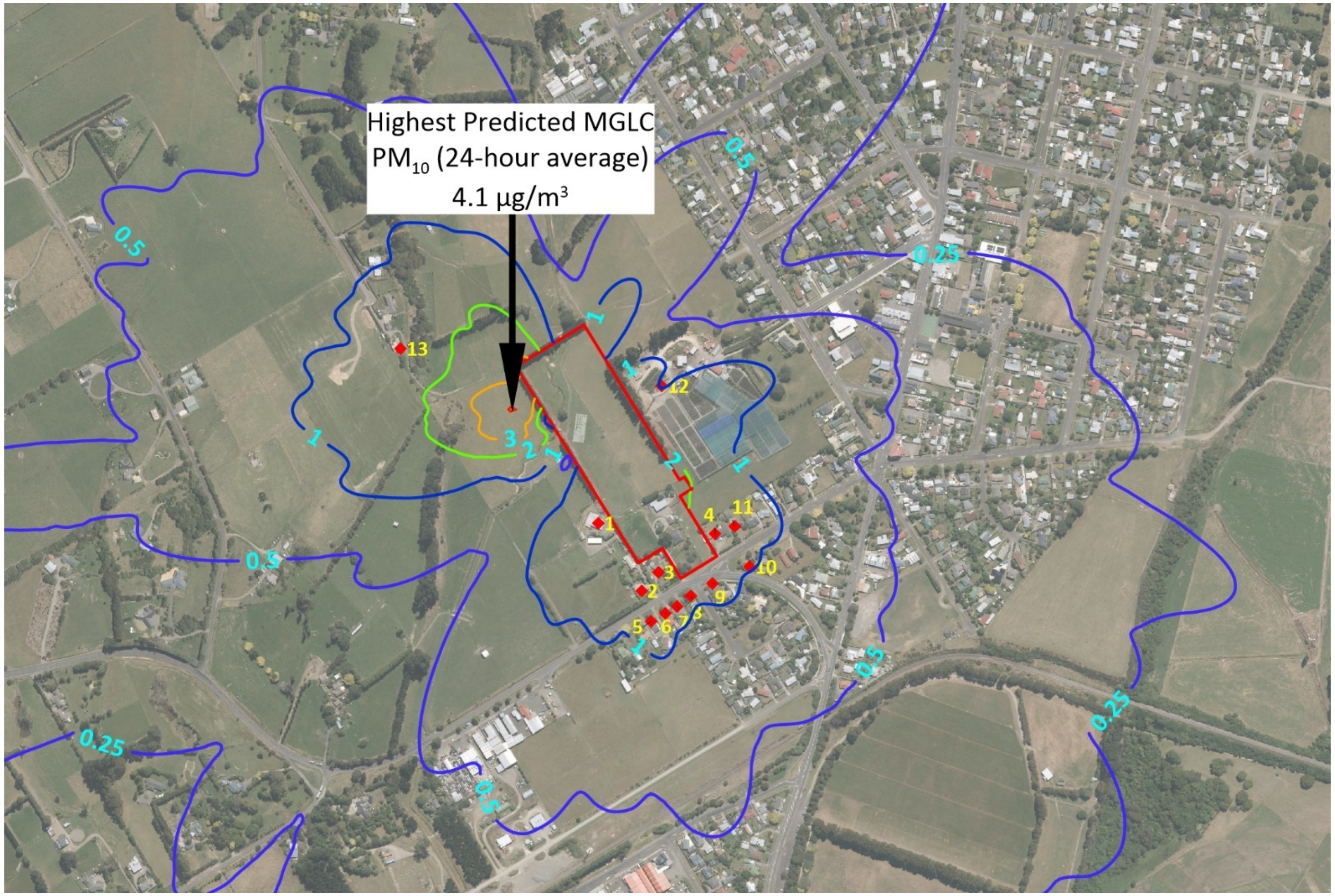


Figure 9: Highest Predicted MGLCs of PM_{10} as 24-hour Averages (µg/m^3)

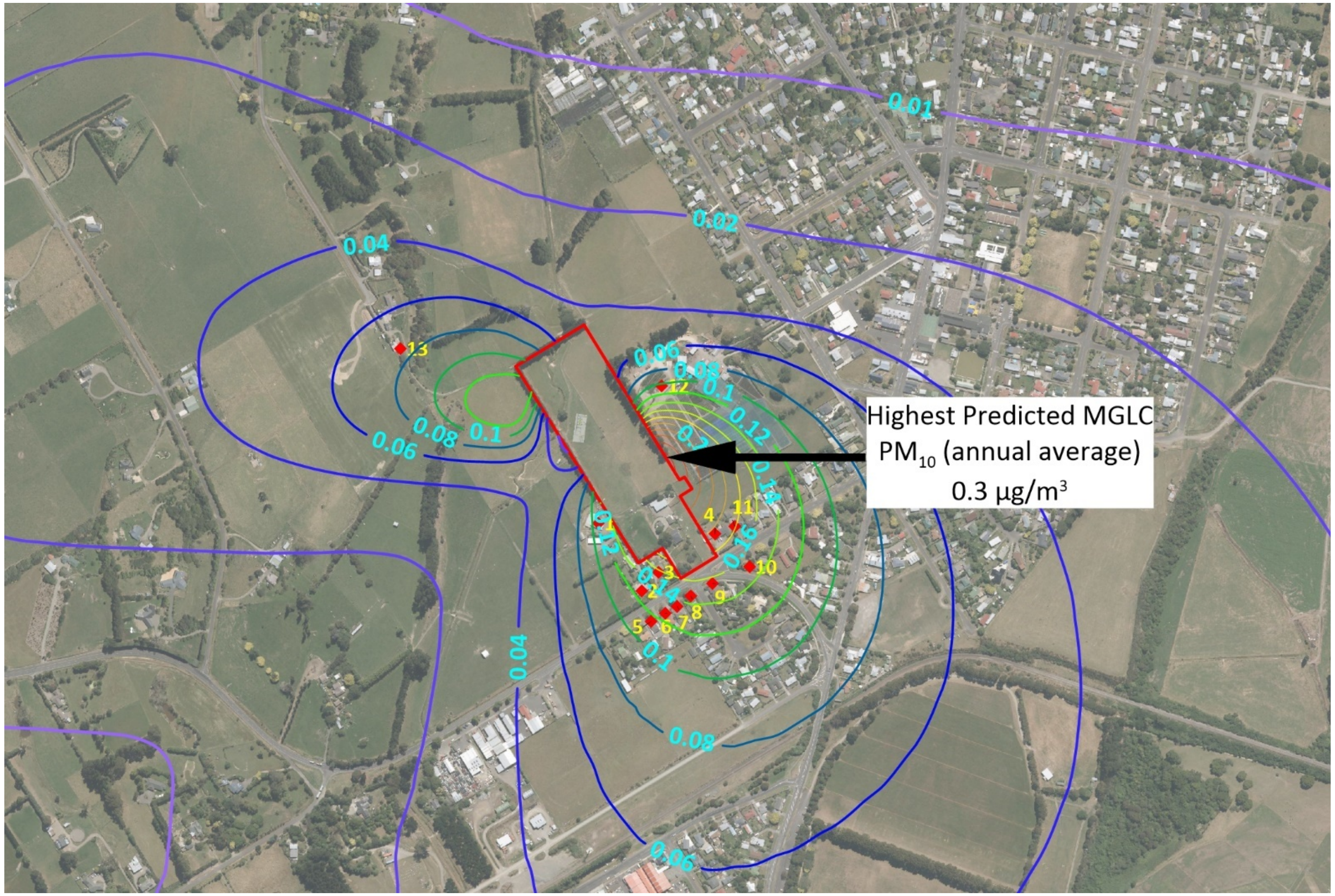


Figure 10: Highest Predicted MGLCs of PM_{10} as Annual Average ($\mu g/m^3$)

7.0 Mitigation and Controls

The pet cremations proposal is the best practicable option as defined in section 2 of the Resource Management Act 1991 when taking into account the sensitivity of the location and the rate of cremations. There are no alternatives to discharging the products of combustion into air through stacks. The stack heights have been considered to achieve low concentrations downwind, while not being overly visually intrusive for the local environment.

We understand that the proposed cremators have secondary combustion chambers that provide an enhanced environment for complete combustion of any unburned gases from the primary chamber. Secondary chambers are designed to control discharges of products of incomplete combustion (PICs) that could otherwise result in smoke and odour from unburned gases from the primary chamber.

For the proposed activity, PVC will not be burned which lowers the potential for formation of dioxins with the absence of chlorine as a precursor. Stack gas discharge temperatures will largely be outside the dioxin reformation window (most significant range 200 – 450°C, with a maximum at about 300°C).

Cremator operators will be trained to appropriately operate the unit and will be thoroughly familiar with operation and maintenance procedures as outlined in the Site Operation Manual. The operations and maintenance procedures as currently in use at the SFPC Palmerston North site are provided as Appendix C of this report and will be updated to represent operations at the proposed site once it has been built and is in operation.

Routine maintenance will be carried out by the operator and/or local firms in accordance with SFPC's management and maintenance documentation.

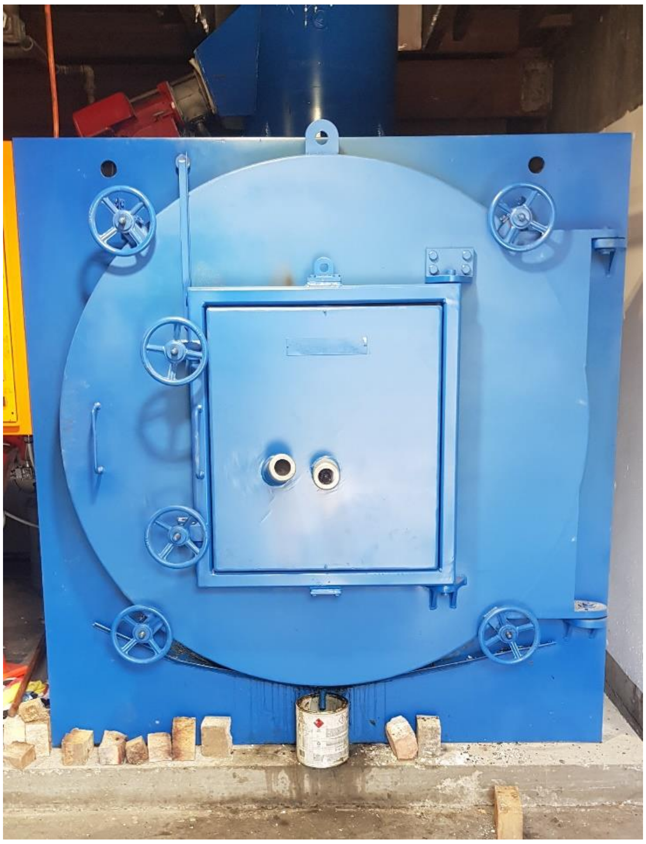
8.0 Conclusion

Considering the assessment in Section 6 of this report, the highest concentrations of contaminants of concern are predicted to occur at the site boundary. All contaminants are well below the relevant assessment criteria and decrease rapidly with distance from the boundary area.

Predicted concentrations at the nearest sensitive receptors are very low compared with assessment criteria; consequently, the air discharges from SFPC are assessed as having effects on the surrounding environment and human health at a level that is less than minor.

Appendix A: December 2020 Air Discharge Monitoring of McDonalds Pyrolytic Cremators

Soul Friends Pet Cremations Limited



AIR DISCHARGE MONITORING OF THE TWO MCDONALD PYROLYTIC CREMATORIUMS, DECEMBER 2020

Issue

February 2021

Soul Friends Pet Cremations Limited

AIR DISCHARGE MONITORING OF THE TWO MCDONALD PYROLYTIC CREMATORIUMS, DECEMBER 2020

Issue

February 2021

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Approved by

Name	Title	Signature
Matthew Newby, CAQP	Senior Air Quality Scientist	

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All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Contents

Executive Summary

Source Testing New Zealand Limited (STNZ) was commissioned by Soul Friends Pet Cremations Ltd to undertake air discharge monitoring of the two McDonald Pyrolytic Crematoriums located in Palmerston North. The objective of the monitoring was to gain emission testing data for inclusion in the Assessment of Environmental Effects for the Company's resource consent application.

Soul Friends Pet Cremations Ltd operate two cremators at the Batchelar Agricultural Centre in Palmerston North for the purpose of cremation of pets. STNZ has been requested to conduct air discharge monitoring for Total Particulate Matter (TPM) and hydrogen chloride (HCl) for each of the cremators. In addition, monitoring for combustion gases (O_2, CO_2, CO, NO_x and SO_2) was also conducted for the duration of each sample.

Table 1 presents a summary of the air discharge monitoring of the two McDonald Pyrolytic Crematoriums operated by Soul Friends Pet Cremations, Palmerston North on 17 and 18 December 2020.

Table 1: McDonalds Pyrolytic Crematoriums Air Discharge Monitoring Results, December 2020

	Cremator 1		Cremator 2	
Contaminant	Range	Average	Range	Average
TPM (mg/m^3)[1]	46.5 & 71.9	59.2	40.6 - 157	94.1
TPM (kg/hr)	0.105 & 0.165	0.135	0.0856 – 0.266	0.178
HCl (mg/m^3)[1]	23.2 & 24.7	24.0	25.8 – 30.7	28.0
HCl (kg/hr)	0.0525 & 0.0568	0.0547	0.0468 – 0.0660	0.0557
O_2 (%)	0.1 – 17.3	9.7	0.4 – 16.1	9.4
CO_2 (%)	2.5 – 15.0	7.8	3.3 – 14.2	7.9
CO (ppmv)[2]	<1 – 5,470	235	<1 – 5,279	92
NO_x (ppmv)[2]	22.5 – 395	137	83.7 – 548	151
SO_2 (ppmv)[2]	<1 – 2,216	104	<1 - 913	53

1. Corrected to 0 ºC, one atmosphere pressure, 11% O_2 on a dry gas basis.
2. ppmv = parts per million by volume

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1. Introduction

Source Testing New Zealand Limited (STNZ) was commissioned by Soul Friends Pet Cremations Ltd to undertake air discharge monitoring of the two McDonald Pyrolytic Crematoriums located in Palmerston North. The objective of the monitoring was to gain emission testing data for inclusion in the Assessment of Environmental Effects for the Company's resource consent application.

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Matthew Newby, Senior Air Quality Scientist with STNZ performed the testing on 17 and 18 December 2020. Matthew has 25 year's air quality monitoring and consulting experience and is designated as a Key Technical Person under STNZ's IANZ accreditation. Matthew is also a Certified Air Quality Professional (CAQP) under the Clean Air Society of Australia and New Zealand (CASANZ) certification programme.

The following report presents the results of the air discharge monitoring of the two McDonald Pyrolytic Crematoriums.

2. Sampling Methodologies

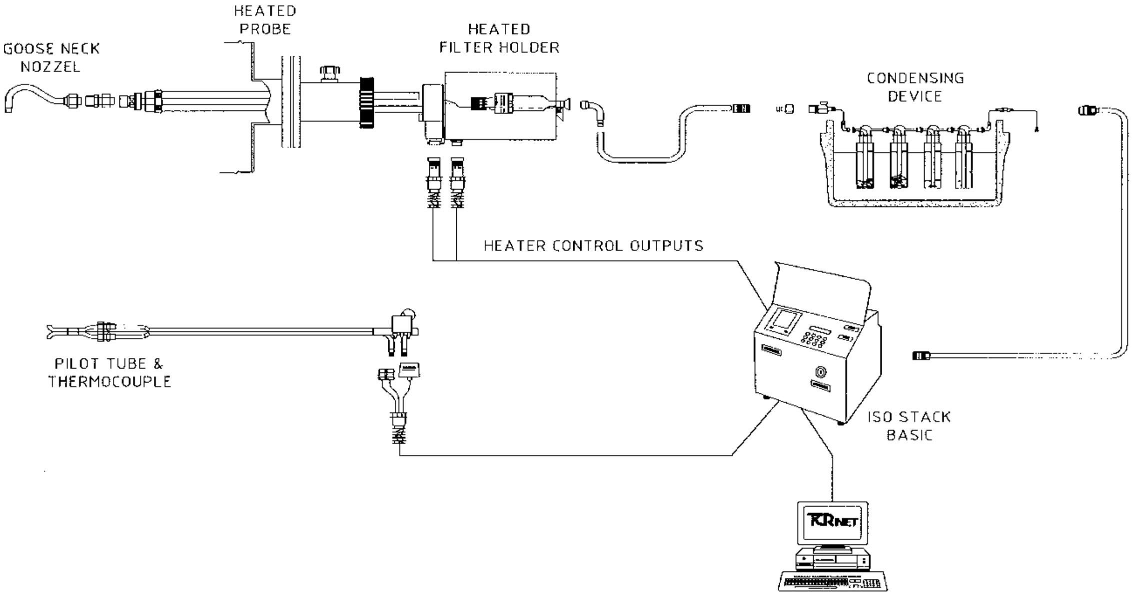
2.1 Isokinetic Stack Sampling Train

STNZ uses a Tecora IsoStack G4 Sampling Train for isokinetic source sampling as depicted in Figures 1 and 2. The IsoStack G4 console incorporates the following components:

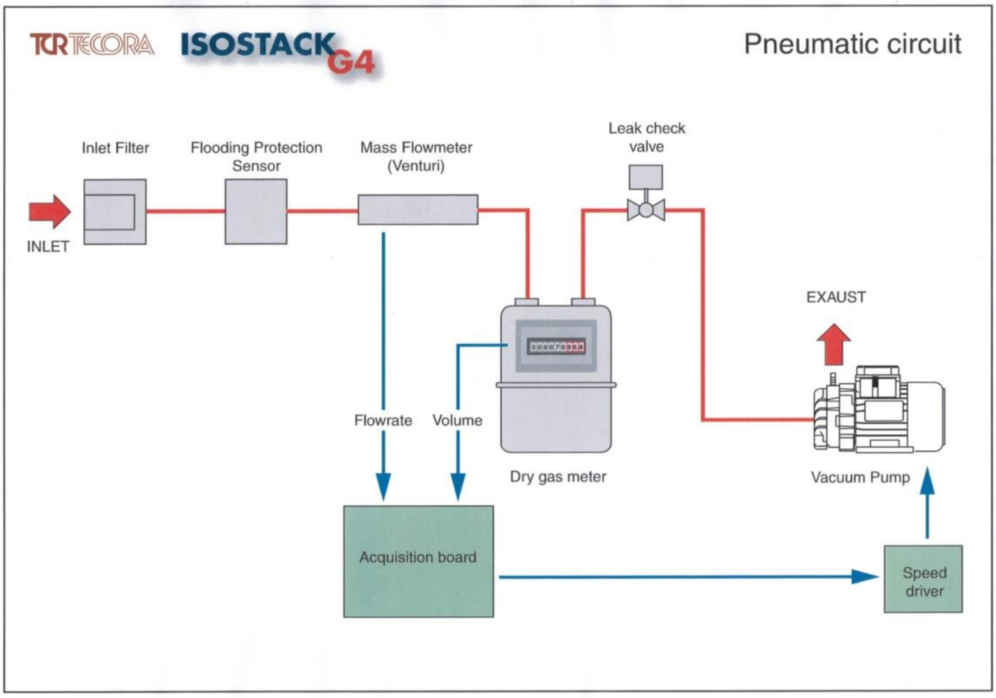
- Leak free rotary sampling pump;
- Electronic mass flow monitor and controller;
- Dry gas meter;
- Stack and dry gas meter temperature indicators;
- Differential and ambient pressure transducers; and
- Electronic data logger and printer.

These components allow for the following parameters to be constantly monitored with automatic adjustment of the sampling rate to isokinetic conditions.

- Stack temperature;
- Pitot differential pressure;
- Stack absolute and ambient pressure;
- Sampling flow rate at standard conditions;
- Sample volume at actual and standard conditions;
- Gas meter temperature;
- Elapsed sampling time; and
- Permanent real time clock and calendar.



- **Figure 1: IsoStack G4 Out-Stack Filter Sampling Train**

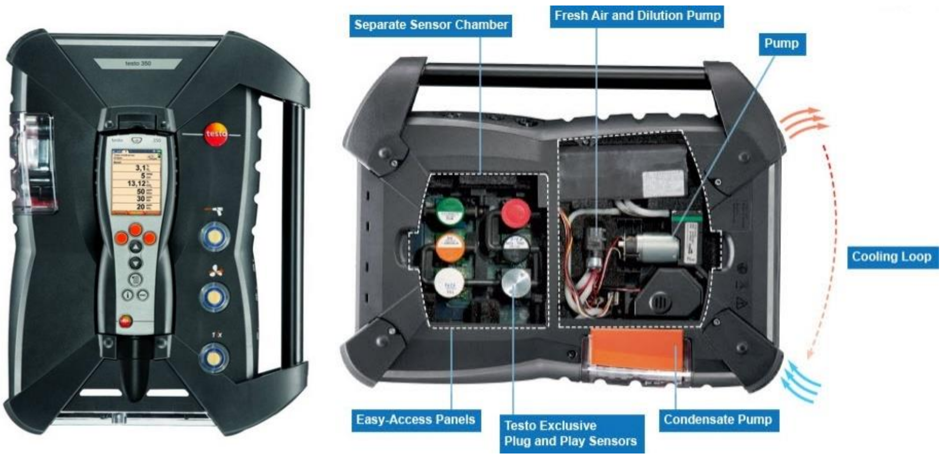


- **Figure 2: Tecora G4 Internal Flow Schematic**

2.2 Testo 350 Portable Combustion Analyser

Gaseous products of combustion were measured using a Testo 350 combustion gas analyser. The Testo 350 utilises electrochemical cells to monitor oxygen (O_2 %), carbon monoxide (CO ppmv), nitric oxide (NO ppmv), nitrogen dioxide (NO_2 ppmv), and sulphur dioxide (SO_2 ppmv). The concentration of carbon dioxide (CO_2 %) was measured using an Infra-Red (IR) cell.

The Testo 350 is a self-contained emission analyser system capable of measuring O_2, CO, CO_2, NO, NO_2, and SO_2 in combustion sources, while capturing data on pressure, temperature, and flow. The unit employs temperature-controlled electrochemical sensors which operate over an ambient temperature range of -5 ºC to +45 ºC and can be calibrated, exchanged, and upgraded in the field without hand tools (see Figure 3). The Model 350 has an automatic sample conditioning system that includes a Peltier cooler, moisture removal pump, and a patented non-heated sample line to provide representative samples from engines, turbines, boilers, burners, and other combustion sources. Table 2 presents the measurement specifications for the Testo 350 combustion gas analyser.



- **Figure 3: Testo 350 Combustion Gas Analyser**

- **Table 2: Testo 350 Cell Specifications**

Cell	Range	Accuracy	Resolution	Response Time
O_2	0 to 25% vol.	±0.8% of f.s.	0.01 vol. %	20 s (t95)
CO_2i	0 to 50% vol.	± 0.3% vol. +1% of m.v. (0 to 25% vol.) ± 0.5% vol. +1.5% of m.v (> 25 to 50% vol.)	0.01% vol. (0 to 25% vol.) 0.1% vol. (> 25% vol.)	10 s (t90)
CO	0 to 10,000 ppm H2 comp.	± 10 ppm of mv (0 to 199 ppm) ± 5% of m.v. (200 to 2,000 ppm) ± 10% of m.v. (2,001 to 10,000 ppm)	1 ppm	40 s (t90)
NO	0 to 4,000 ppm	± 5 ppm (0 to 99 ppm) ± 5% of m.v. (100 to 1,999 ppm) ± 10% of m.v. (2,000 to 3,000 ppm)	1 ppm	30 s (t90)
NO_2	0 to 500 ppm	± 5 ppm (0 to 99.9 ppm) ± 5% of m.v. (100 to 500 ppm)	0.1 ppm	40 s (t90)
SO_2	0 to 500 ppm	± 5 ppm (0 to 99 ppm) ± 5% of m.v. (100 to 2,000 ppm) ± 10% of m.v. (2,001 to 5,000 ppm)	1 ppm	30 s (t90)

2.3 Sampling Methods

Table 3 summarises the testing methodologies used by STNZ for air discharge monitoring of the McDonald Pyrolytic Crematoriums operated by Soul Friends Pet Cremations Ltd. General compliance monitoring generally requires three replicate samples. However, each crematorium normally only does a single burn each day so only two samples were originally scheduled to be collected with each sample collected over the duration of the cremation (approximately 2 hours). However, the for the first sample on Cremator 2, only a single primary burner was operating so a additional sample was collected.

▪ **Table 3: Sampling Methods**

Contaminant	STNZ Standard Test Methods	IANZ Accredited
Sampling Points	Method 1 “Sample and Velocity Traverse for Stationary Sources”	Yes
Velocity & Volumetric Flow Rate	Method 2 “Determination of Stack Gas Velocity and Volumetric Flow rate (Type “S” Pitot Tube)”	Yes
Dry Molecular Weight Determination	Method 3 “Gas Analysis For The Determination Of Dry Molecular Weight	Yes
Moisture Content Determination	Method 4 “Determination of Moisture Content in Stack Gases”	Yes
Total Particulate Matter Determination	Method 5 “Determination of Particulate Emissions From Stationary Sources”	Yes
Determination of HCl	Method 26A “Determination of Hydrogen Halide and Halogen Emissions from Stationary Sources – Isokinetic Method”	Yes
Combustion Gases	Testo 350 Combustion Gas Analyser	No

Due to the high temperature of the source, a water-cooled probe was used to rapidly reduce the gas sample temperature at the filter to 120 ºC ± 14 ºC.

Sample analysis for TPM was performed by STNZ staff in Wellington for which they are IANZ accredited. While STNZ are IANZ accredited for the sampling portion of Method 26A, sample analysis for HCl was performed by R. J. Hill Laboratories Ltd, Hamilton, who are not specifically accredited for this analysis. However, R. J. Hill Laboratories Ltd, Hamilton are a well-respected IANZ accredited laboratory and are included in STNZ’s IANZ accredited Approved Supplier system.

2.3.1 Stack Sampling Locations

Table 4 describes the sampling point characteristics of the McDonald Pyrolytic Crematorium stacks. Two sampling ports at 90 degrees to each other were located approximately 5 m above the afterburner and 4.4 m below the outlet of the stack. The stacks are depicted in Figure 4 and discharge at a height of 15.2 m above ground.

The sampling location meets the requirements of Method 1 provided a minimum of 8 sampling points were selected. Due to the logistics of handling the water-cooled probe in a EWP, only a single sampling port was used as changing ports endangered the sampling equipment. The flow conditions at the sampling ports was uniform allowing for the collection of representative samples.

- **Figure 4: McDonald Pyrolytic Crematoriums Stacks**
- **Table 4: Sampling Locations**

Source	Port	Dimensions	Distance Upstream from Disturbances (in Stack Diameters)		Distance Downstream from Disturbances (in Stack Diameters)		No. of Sampling Lines	No. of Sampling Points	
McDonald Pyrolytic	2 x 4" BSP	Circular 0.379 m	>2	2	>8	8	1	8	8

Note: Shaded cells represent USEPA Method 1 specification.

2.3.2 Stack Gas Velocity

Stack temperatures were measured using a K Type thermocouple connected to a digital thermometer. Stack gas velocities were measured at specific points across the duct in accordance with USEPA Methods 1 & 2 using an S Type Pitot tube connected to a digital manometer. The gas velocities were used to determine volumetric flow rates and mass discharge rates for each sample.

2.3.3 Gaseous Products of Combustion

Gaseous products of combustion were monitored using a Testo 350 combustion gas analyser. The Testo 350 utilises electrochemical cells to monitor oxygen (O_2 %), carbon monoxide (CO ppmv), nitric oxide (NO ppmv), nitrogen dioxide (NO_2 ppmv), and sulphur dioxide (SO_2 ppmv). The concentration of carbon dioxide (CO_2 %) was monitored using an Infra-Red (IR) cell. USEPA Method 3 was subsequently used to determine the molecular weight of the stack gas.

While STNZ are not IANZ accredited for the determination of NOx using their combustion gas analyser, the Testo 350 has been certified by the USEPA under their Environmental Technology Verification Program as applicable for the determination of nitrogen oxides emissions. STNZ carry out three-point calibrations for O_2, CO_2 and CO and two-point calibrations for NO_2 and SO_2 before and after each day's testing.

2.3.4 Total Particulate Matter

Total Particulate Matter (TPM) was determined in accordance with USEPA Method 5 "*Determination of Particulate Emissions From Stationary Sources*". In summary, a sample of stack gas was withdrawn isokinetically from the source and collected on a quartz fibre filter maintained at a temperature of 120 °C ± 14 °C. The particulate mass was determined gravimetrically, after the removal of un-combined water. Particulate analysis was performed by STNZ.

Due to the high stack gas temperature, a water-cooled sampling probe was used. The water-cooled sampling probe was used to rapidly reduce the sampling gas stream to 120 °C ± 14 °C at the outlet of the probe. A continuous quartz sampling probe with an 8 mm button hook nozzle on one end and a 19 mm ball joint on the other end was inserted within the inner tube of the water-cooled probe.

2.3.5 Hydrogen Chloride

Hydrogen chloride discharges were collected using USEPA Method 25A '*Determination of Hydrogen Halide and Halogen Emissions from Stationary Sources"*. Gaseous and particulate pollutants were withdrawn isokinetically from the source. A filter maintained at a temperature of 120 °C ± 14 °C removed particulate matter while acidic absorbing solutions collected gaseous HCl. Sampling was conducted concurrently with TPM.

Analysis for chloride by ion chromatography was performed by R. J. Hill Laboratories Ltd, Hamilton. While STNZ are IANZ accredited for the sampling portion of Method 26A, sample analysis for HCl was performed by R. J. Hill Laboratories Ltd, Hamilton, who are not specifically accredited for this analysis. However, R. J. Hill Laboratories Ltd, Hamilton are a well-respected IANZ accredited laboratory and are included in STNZ's IANZ accredited Approved Supplier system.

3. Plant Operating Conditions

The two McDonald Pyrolytic Crematoriums operated by Soul Friends Pet Cremations Ltd consist of a primary combustion chamber approximately 2 m^3 in volume with two direct fire gas burners. An afterburner is located at the exit of the primary chamber and directed up the stack which acted as the secondary combustion zone. Animal cadavers in thick leak proof plastic bags are placed on the floor of the cremator with bricks used to separate the cadavers. The mass of material cremated ranges from 150 to 250 kg, but the units are capable of cremating horse cadavers which can weigh over 500 kg. It is worth noting that the amount of plastic added will make the cremation process more difficult to control due to the plastic flashing off at the beginning of the cremation.

To commence the cremation, the afterburner was first fired for about 20 minutes to pre-heat the secondary combustion chamber. At this stage, the two primary burners were fired up and allowed to heat the primary chamber to 750°C. A thermocouple located on the wall of the primary chamber was used to monitor the temperature and once the chamber reaches 750°C the burners were supposed to oscillate between high fire and low fire to maintain the temperature in the primary chamber to 750°C. However, it was noted that the location of the thermocouple was not very representative of the actual conditions within the primary chamber which resulted in the cremators over heating at times.

The crematorium on the south side of the building was nominated as Cremator 1 with the North side designated as Cremator 2. Table 5 presents the process data for each of the samples with Appendix A providing the full Burner Logs.

- **Table 5: Process Data Summary, December 2020**

Source	Sample	Date	Weight (kg)
Cremator 1	Run 1	17/12/2020	171
	Run 2	18/12/2020	176
Cremator 2	Run 1	17/12/2020	153
	Run 2	18/12/2020	207
	Run 3	18/12/2020	165

4. Air Discharge Monitoring Results

4.1 Particulate Air Discharge Monitoring Results

Presented below are the results of the TPM air discharge monitoring performed on the Soul Friends Pet two McDonald Pyrolytic Crematoriums on 17 and 18 December 2020. Table 6 presents the results of the TPM emission testing with Table 7 outlining a summary of the relevant stack data. Appendix B presents the raw sampling data with the moisture content and mass determination calculations presented in Appendix C.

- **Table 6: Particulate Matter Discharge Results, December 2020**

Sampling Run	Sampling Period	Sample Volume (m^3)	Stack Flow Rate (m^3/h)[1]	Mass (mg)	Conc. (mg/m^3)[1]	O_2 (%)	Conc. @ 11% O_2 (mg/m^3)[1]	Emission Rate (kg/h)
Cremator 1 Run 1	9:00 - 11:04	1.806	2,119	140.9	78.0	10.1	71.9	0.165
Cremator 1 Run 2	10:47 - 12:45	1.602	1,902	88.7	55.4	9.1	46.5	0.105
Cremator 2 Run 1	12:30 - 14:33	1.626	1,873	74.3	45.7	9.8	40.6	0.0856
Cremator 2 Run 2	7:46 - 9:49	1.494	1,734	157.1	105	8.6	84.7	0.182
Cremator 2 Run 3	14:40 - 16:28	1.165	1,545	200.5	172	10.0	157	0.266

1. Corrected to 0 ºC, 101.3 kPa, dry gas basis.

- **Table 7: Summary of Stack Conditions, December 2020**

Source	Average Temp. (ºC)	Average Moisture Content (% v/v)	Average Velocity (m/s)	Average Volumetric Flow Rate (m^3/hr)
Cremator 1	739	12.2	19.8	8,510
Cremator 2	703	14.5	16.8	7,260

Actual conditions

The results of the TPM air discharge monitoring of Cremator 1 on 17 and 18 December 2020 showed the concentration to be 46.5 and 71.9 mg/m^3 adjusted to 0 ºC, 101.3 kPa, 11% O_2 on a dry gas basis (mg/Sm^3), with an average of 59.2 mg/Sm^3. The mass discharge of TPM were 0.105 and 0.165 kg/hr with an average of 0.135 kg/hr.

The results of the TPM air discharge monitoring for Cremator 2 on 17 and 18 December 2020 showed the concentration to range from 40.6 to 157 mg/m^3 with an average of 94.1 mg/Sm^3. The mass discharge of particulate matter ranged from 0.0856 to 0.266 kg/hr with an average of 0.178 kg/hr.

4.2 Hydrogen Chloride Air Discharge Monitoring Results

Presented below are the results of the HCl air discharge monitoring performed on the Soul Friends Pet two McDonald Pyrolytic Crematoriums on 17 and 18 December 2020. Table 8 presents the results of the HCl emission testing. Appendix B presents the raw sampling data with Appendix C presenting the moisture content and mass determination calculations. Appendix D presents the raw laboratory report.

- **Table 8: Hydrogen Chloride Air Discharge Monitoring Results, December 2020**

Sampling Run	Sampling Period	Sample Volume (m^3)	Stack Flow Rate (m^3/h)[1]	Mass (mg)	Conc. (mg/m^3)[1]	O_2 (%)	Conc. @ 11% O_2 (mg/m^3)[1]	Emission Rate (kg/h)
Cremator 1 Run 1	9:00 - 11:04	1.806	2,119	48.4	26.8	10.1	24.7	0.0568
Cremator 1 Run 2	10:47 - 12:45	1.602	1,902	44.2	27.6	9.1	23.2	0.0525
Cremator 2 Run 1	12:30 - 14:33	1.626	1,873	47.2	29.0	9.8	25.8	0.0544
Cremator 2 Run 2	7:46 - 9:49	1.494	1,734	56.9	38.1	8.6	30.7	0.0660
Cremator 2 Run 3	14:40 - 16:28	1.165	1,545	35.3	30.3	10.0	27.6	0.0468

1. Corrected to 0 ºC, 101.3 kPa, dry gas basis.

The results of the HCl air discharge monitoring of Cremator 1 on 17 and 18 December 2020 showed the concentration to be 23.2 and 24.7 mg/Sm^3 with an average of 24.0 mg/Sm^3. The mass discharge of HCl were 0.0525 and 0.0568 kg/hr with an average of 0.0547 kg/hr.

The results of the HCl air discharge monitoring for Cremator 2 on 17 and 18 December 2020 showed the concentration to range from 25.8 to 30.7 mg/Sm^3 with an average of 28.0 mg/Sm^3. The HCl mass discharge ranged from 0.0468 to 0.0660 kg/hr with an average of 0.0557 kg/hr.

4.3 Quality Control Data

Tables 7 and 8 present the relevant quality control parameters for the particulate emission testing. In addition, all equipment was calibrated and maintained as per the STNZ Air Quality Equipment Manual (available on request).

Table 9: Sampling Quality Control Data, December 2020

Sampling Run	Leak Check Vacuum (bar)	Leak Rate (cc/min)	Leak Check Vacuum (bar)	Leak Rate (cc/min)	Isokinetic Deviation (%)
Method Specs	<70	<570	<70	<570	+/-20
Cremator 2 Run 1	69	0	69	0	1.2
Cremator 2 Run 2	69	0	69	0	3.4
Cremator 1 Run 1	69	0	69	50	3.0
Cremator 1 Run 2	69	50	69	100	6.4
Cremator 1 Run 3	69	0	69	50	2.3

Table 10: Particulate Blank Quality Control Data, 14 July 2020

	Field Blank Mass (g)	Acetone Blank Mass (g)
Method Specs	*<0.0005*	*<0.0005*
Pre	0.5941	100.9506
Post	0.5946	100.9509
Diff	0.0005	0.0003

All quality control parameters met the method specifications.

4.4 Gaseous Products of Combustion Monitoring Results

Tables 11 and 12 present the results of the Testo 350 combustion gas analyser collected on 17 and 18 December 2020 from the Soul Friends Pet Cremations McDonald Pyrolytic Cremator 1 and Cremator 2 respectively. Appendix E presents the raw Testo 350 data in a graphical format.

Table 11: Cremator 1 Products of Combustion Results, December 2020

		O_2 (%)[1]	CO_2 (%)[1]	CO (ppmv)[2]	NO (ppmv)[2]	NO_2 (ppmv)[2]	NO_x (ppmv)[2]	SO_2 (ppmv)[2]
Run 1	Ave.	10.1	7.3	322	129	0.9	130	135
	Max.	0.5	2.4	2	31	<0.1	31.9	<1
	Min.	17.1	14.2	5,470	284	3.6	284	2,216
Run 2	Ave.	9.1	8.2	137	143	1.5	137	70
	Max.	0.1	2.5	<1	22	<0.1	22.5	<1
	Min.	17.3	15.0	4,305	395	13.1	395	657
All Data	Ave.	9.7	7.8	235	136	1.2	145	104
	Max.	0.1	2.5	<1	22	<0.1	22.5	<1
	Min.	17.3	15.0	5,470	395	13.1	395	2,216

1. Dry gas basis
2. parts per million per volume, dry gas basis

In December 2020, the combustion gas monitoring of Cremator 1 showed the O_2 concentration ranged from 0.1 to 17.3 % with an average of 9.7 %; the CO_2 concentration ranged from 2.5 to 15.0 % with an average of 7.8 %; the CO concentration ranged from <1 to 5,470 ppmv with an average of 235 ppmv; the NO_x concentration ranged from 22.5 to 395 ppmv with an average of 137 ppmv; and the SO_2 concentration ranged from <1 to 2,216 ppmv with an average of 104 ppmv.

- **Table 12: Cremator 2 Products of Combustion Results, December 2020**

		O_2 (%)[1]	CO_2 (%)[1]	CO (ppmv)[2]	NO (ppmv)[2]	NO_2 (ppmv)[2]	NO_x (ppmv)[2]	SO_2 (ppmv)[2]
Run 1	Ave.	9.8	7.5	34	130	1.3	131	36
	Max.	5.1	4.7	4	85	<0.1	85.2	4
	Min.	14.2	10.9	435	181	4.5	183	234
Run 2	Ave.	8.6	8.5	79	159	1.1	160	69
	Max.	0.4	3.7	<1	83	<0.1	83.7	3
	Min.	15.4	13.8	4,045	297	3.0	297	618
Run 3	Ave.	10.0	7.6	184	164	1.4	165	53
	Max.	0.7	3.3	1	86	<0.1	85.9	<1
	Min.	16.1	14.2	5,279	547	2.6	548	913
All Data	Ave.	9.4	7.9	92	150	1.3	151	53
	Max.	0.4	3.3	<1	83	<0.1	83.7	<1
	Min.	16.1	14.2	5,279	547	4.5	548	913

1. Dry gas basis
2. parts per million per volume, dry gas basis

In December 2020, the combustion gas monitoring of Cremator 2 showed the O_2 concentration ranged from 0.4 to 16.1 % with an average of 9.4 %; the CO_2 concentration ranged from 3.3 to 14.2 % with an average of 7.9 %; the CO concentration ranged from <1 to 5,279 ppmv with an average of 92 ppmv; the NO_x concentration ranged from 83.7 to 548 ppmv with an average of 151 ppmv; and the SO_2 concentration ranged from <1 to 913 ppmv with an average of 53 ppmv.

4.5 Discussion

The following comments are beyond the scope of STNZ's IANZ Accreditation.

Under normal operating conditions, high temperature combustion sources should reduce the particulate concentration to less than 50 µg/Sm^3, which is normally obtained by control of the combustion conditions to ensure the O_2 concentration does not fall below 6 %. The results of the particulate monitoring showed the first sample collected from Cremator 2 to be less than 50 µg/Sm^3 which was likely due to only a single burner operating.

The second sample from Cremator 1 was also below 50 µg/Sm^3. However, for this test the operation of the burners was determined based on the stack gas O_2 measured during the test as the burners did not appear to oscillate between the high fire/low fire setting.

During the sampling process it was observed, particularly at the beginning of the cremation, that the primary combustion chamber was getting too hot, consuming the O_2 to levels which did not allow for complete combustion of contaminates resulting in elevated particulate emissions. The minimum O_2 concentrations observed for Cremators 1 and 2 was 0.1 and 0.4% respectively. While these low concentrations were observed for relatively short periods of time, thier impact on the emissions was significant.

The low O_2 concentrations observed indicate that the combustion conditions are not being adequately controlled by the temperature sensor used to control the burner firing rates. It is recommended that a suitable control system be installed to maintain the O_2 concentration to ideally above 6 %. Such a system could include an O_2 sensor which shuts down one or both burners when the O_2 falls below optimal levels.

Appendix A Production Data

- This Appendix contains 3 pages including cover.

Burner Log 347

Cancel Print

Burner 1 **Date** 17 Dec 2020
Weight 171.000 kg **Time** 9:00

ID	Clinic	Ref	Pet	Order Type	Weight
11249	Wellington SPCA		Tyson	Pet Cremation, Scatterbox	6.000 kg
11319	Levin and Horowhenua Veterinary Centre	09180 - ARMS	Freddy Arms	Pet Cremation, Scatterbox	7.000 kg
11277	Karori Veterinary Clinic	14473	Lilly Drake	Pet Cremation, Scatterbox	13.000 kg
11386	Wellington After Hours Veterinary Clinic	342792	Poppy Romond	Pet Cremation, Scatterbox	28.000 kg
11464	Hunterville Vet Club	Amber1612	Mata Hainsworth	Pet Cremation, Scatterbox	39.000 kg
11248	Animates Vetcare Paraparaumu	Billy	Billy Jasper	Pet Cremation, Scatterbox	16.000 kg
11201	Upper Hutt Veterinary Hospital and Cattery	BOHAN5A	Syrus Bohan	Pet Cremation, Urn	18.000 kg
11402	Hunterville Vet Club	Sophie15/12	Baby Karatau	Pet Cremation, Urn	5.000 kg
11224	Vetsmart	Vet Smart	Tipsy Millner	Pet Cremation, Urn	39.000 kg

Rows per page: All 1-9 of 9

Burner Log 351

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Burner 1 **Date** 18 Dec 2020
Weight 176.000 kg **Time** 9:30

ID	Clinic	Ref	Pet	Order Type	Weight
11561	Cahill Animal Hospital		Zeke adrian	Pet Cremation, Urn	44.000 kg
11588	Soul Friend Pet Cremations		Stasky Gunn	Pet Cremation, Scatterbox	14.000 kg
11552	Cahill Animal Hospital		Bosco illingworth	Pet Cremation, Urn	37.000 kg
11478	Vet Services Dannevirke	Dannevirke	Smokey Carl McAuley	Pet Cremation, Urn	4.000 kg
11326	South Wairarapa Veterinary Services - Carterton	GREEN50	Tonka Green	Pet Cremation, Scatterbox	25.000 kg
11483	South Wairarapa Veterinary Services - Carterton	HAY8	Jazz Hay	Pet Cremation, Scatterbox	26.000 kg
11325	Pet Doctors Palmerston North	Inv 2661869	Gerogie Murphy	Pet Cremation, Scatterbox	17.000 kg
11405	Pet Doctors Palmerston North	Inv 2662021	Boris Booker	Pet Cremation, Urn	3.000 kg
11452	Totally Vets	REDI31	Ali Reid	Pet Cremation, Urn	6.000 kg

Rows per page: All 1-9 of 9

Burner Log 348

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Burner 2 **Date** 17 Dec 2020
Weight 153.000 kg **Time** 12:10

ID	Clinic	Ref	Pet	Order Type	Weight
11417	Wellington SPCA			Bio Waste Disposal	26.000 kg
11303	Cahill Animal Hospital		Molly thomsen	Pet Cremation, Disposal	10.000 kg
11387	C G Boyce		Dog kauri	Pet Cremation, Disposal	35.000 kg
11337	Rappaw Veterinary Care - Plimmerton	84373	Chicken Ellis-Page	Pet Cremation, Disposal	2.000 kg
11313	Otaki Veterinary Centre	BARRA28	Janey Barraclough	Pet Cremation, Urn	30.000 kg
11109	Otaki Veterinary Centre	DOWLI35	Bro Dowling	Pet Cremation, Disposal	6.000 kg
11120	South Wairarapa Veterinary Services - Carterton	HALFO41	Milly	Pet Cremation, Disposal	4.000 kg
10776	Hunterville Vet Club	Sophie3/12/20	Jonty Strivens	Pet Cremation, Scatterbox	34.000 kg
11184	Vetsmart	Vet Smart	Tandy Geismer	Pet Cremation, Disposal	2.000 kg
11415	Rappaw Veterinary Care - Tawa	wildlife	wildlife	Pet Cremation, Disposal	4.000 kg

Rows per page: All 1-10 of 10

Burner Log 349

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Burner 2 **Date** 18 Dec 2020
Weight 207.000 kg **Time** 7:30

ID	Clinic	Ref	Pet	Order Type	Weight
11542	Vet Services Wairarapa		Remy Sime & Grant	Pet Cremation, Urn	3.000 kg
11555	Cahill Animal Hospital		Rose liu	Pet Cremation, Urn	7.000 kg
11557	Cahill Animal Hospital		Jess arnott	Pet Cremation, Urn	36.000 kg
11563	Cahill Animal Hospital		Tank fieldsend	Pet Cremation, Urn	30.000 kg
11487	Pet Doctors Palmerston North	2662426	Annie Rose Hingston & Howard	Pet Cremation, Urn	7.000 kg
11459	Keinzley AgVet Masterton	andy renton	Rusty	Pet Cremation, Urn	34.000 kg
11501	Vet Services Dannevirke	Dannevirke	Casey Cordell	Pet Cremation, Scatterbox	7.000 kg
11509	Totally Vets	DAVID101	CHARLOTTE Davidson	Pet Cremation, Urn	5.000 kg
11430	South Wairarapa Veterinary Services - Carterton	DOUGBEVAN	Dougal Bevan	Pet Cremation, Scatterbox	57.000 kg
11512	Keinzley AgVet Masterton	kirstan grey	Shippo	Pet Cremation, Scatterbox	6.000 kg
11537	Totally Vets	LIMSO19	Toby Limsowtin	Pet Cremation, Scatterbox	6.000 kg
11443	Valley Vets	Whale	Mack	Pet Cremation, Urn	9.000 kg

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Burner Log 350

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Burner 2 **Date** 18 Dec 2020
Weight 165.000 kg **Time** 14:30

ID	Clinic	Ref	Pet	Order Type	Weight
11601	Soul Friend Pet Cremations		Prince Srhoj	Pet Cremation, Urn	4.000 kg
11449	Totally Vets Taumarunui	2281228	Jax	Pet Cremation, Urn	33.000 kg
11393	South Wairarapa Veterinary Services - Martinborough	HOLLO33	Charlie	Pet Cremation, Scatterbox	22.000 kg
11332	Keinzley AgVet Masterton	jason coffey	kody	Pet Cremation, Urn	34.000 kg
11499	Vet Services Wairarapa	MC EW36	Mac	Pet Cremation, Scatterbox	30.000 kg
11329	South Wairarapa Veterinary Services - Carterton	MCDO42	Luka McDonald	Pet Cremation, Urn	20.000 kg
11299	Vet Services Wairarapa	megleveli	Meg Robinson	Pet Cremation, Scatterbox	22.000 kg

Rows per page: All 1-7 of 7

Appendix B Raw Sampling Data

This Appendix contains 8 pages including cover.

The data presented in the Tecora G4 data sheets are based on assumed moisture contents. The tabulated data presented is based on actual measured moisture content. As a result, the corrected volumetric flow rates may differ between the two data sheets.

Sample Description:	Cremator 1 Run 1	Cremator 1 Run 2	Averages
Sampling Date:	17/12/2020	18/12/2020	
Filter ID:	ST1823	ST1783	
Sampling Period:	9:00 - 11:04	10:47 - 12:45	
Total Sample Time (minutes)	120	116	
Nozzle Diameter (mm)	8	8	
Nozzle Area (m2)	0.0000503	0.0000503	
DGM Calibration Factor	1.0055	1.0055	
Intial DGM Reading	10.2914	17.5876	
Final DGM Reading	12.9185	19.8722	
DGM Sample Volume (m^3):	2.6271	2.2846	
DGM Std. Sample Volume (m^3):	1.8056	1.6018	
Initial Leak Test Vacuum (kPa):	69	69	
Initial Leak Test Flow Rate (cc/min):	0	0	
Final Leak Test Vacuum (kPa):	69	69	
Final Leak Test Flow Rate (cc/min):	0	0	
Moisture Collected (g):	175.6	203.7	
Moisture Content (%):	10.8	13.7	12.2
TCR DGM Sample Volume (m^3):	2.5280	2.2655	
Sampling Plane Mean Velocity (m/s):	20.9	18.7	19.8
TCR Isokinetic Deviation (%):	-0.9	-0.9	
Actual Isokinetic Deviation (%):	1.2	3.4	
Duct Volumetric Flow Rates			
Moist (m^3/h):	8,968	8,051	8,510
Moist Standards (m^3/h):	2,375	2,203	
Dry Standard (m^3/h):	2,119	1,902	
Mean Temperatures			
At Sampling Plane (^oC):	756	723	739
At DGM (^oC):	22.3	27.9	
Ambient Pressure (kPa):	101.067	101.148	
Stack Absolute Pressure (kPa)	101.017	101.088	
Dry Gas Meter Pressure (kPa)	74.904	77.880	

Soul Friends Cremator 1 Run 1

ST0947

Isokinetic sampling 17/12/2020 09:03:49

MACHINE INFORMATION

Master Firmware	v2.0.0001
Master Serial Number	20400114P
Slave Firmware	v0.7.7000
Slave Serial Number	20400114P
Last calibration date	29/09/2020

CV GAMMA [#] CALIBRATION

Point	Flowrate	Gamma
1	0	1

POINT LIST

start ts [timestamp]	Port [###]	Point [###]	Distance [cm]	Elapsed Time [hh:mm:ss]	rw avg [0;1]	t_{fumes} avg [°C]	t_{dgm} avg [°C]	P_{stat} avg [kPa]	P_c avg [kPa]	dP pitot avg [Pa]	P_{line} avg [kPa]	P_{amb} avg [kPa]	v'_a avg [m/sec]	qV_n avg [lt/min]	DI [%]	v'_N avg [m/sec]	Q'Va [m3/h]	Q'Vn [m3/h]	QVn [m3/h]	V_{gn} [lt]	V'_{ga} [lt]	V_{dgm} [lt]
17/12/2020 9:03:52	1	1	1.3	0:15:00	0.1	873.458	18.758	-0.035	101.032	108.532	84.822	101.067	22.958	14.69	-0.7	22.783	9873	2345	2110	213.09	996.64	271.89
17/12/2020 9:18:58	1	2	4.1	0:15:00	0.1	788.053	21.234	-0.043	101.024	111.227	78.635	101.067	22.368	15.47	-0.7	22.195	9619	2468	2221	222.79	964.54	309.26
17/12/2020 9:34:08	1	3	7.6	0:15:00	0.1	760.605	22.132	-0.045	101.022	105.702	76.747	101.067	21.523	15.243	-0.9	21.315	9256	2438	2194	221.38	933.66	315.83
17/12/2020 9:49:13	1	4	12.7	0:15:00	0.1	722.262	22.422	-0.054	101.013	99.522	75.022	101.067	20.486	15.04	-1.1	20.257	8810	2410	2169	219.38	890.95	320.47
17/12/2020 10:04:18	1	5	26.4	0:15:00	0.1	723.533	22.998	-0.062	101.005	93.437	74.513	101.067	19.867	14.628	-0.7	19.724	8543	2334	2100	213.62	868.78	314.82
17/12/2020 10:19:25	1	6	31.5	0:15:00	0.1	722.933	23.084	-0.057	101.01	96.562	71.514	101.067	20.181	14.836	-0.8	20.002	8678	2372	2135	216.69	880.59	332.8
17/12/2020 10:34:28	1	7	35	0:15:00	0.1	725.622	22.919	-0.05	101.017	91.613	70.88	101.067	19.674	14.371	-1.3	19.409	8460	2306	2076	210.92	859.36	326.63
17/12/2020 10:49:36	1	8	37.8	0:15:00	0.1	728.606	23.803	-0.047	101.02	92.34	69.246	101.067	19.779	14.456	-0.9	19.591	8506	2312	2081	211.54	864.45	336.33

NORMALIZATION FACTOR

T_{norm}	[K]	273.15
P_{norm}	[kPa]	101.325

PITOT DATA SPECIFICATION

Name			p0.840
Velocity	[m/sec]	5	0.84
Velocity	[m/sec]	10	0.84
Velocity	[m/sec]	20	0.84
Velocity	[m/sec]	30	0.84
Velocity	[m/sec]	40	0.84

DUCT AND GAS SPECIFICATION

Name			SOUL C1	
Section			Circular	
Diameter		[m]	0.39	
Area		[m^2]	0.119	
Port	B	[#]	1	
Points	P	[#]	8	
Dry gas density	ρn	[kg/m^3]	1.267	[1.267; 1.267]
Carbon dioxide	CO_2	[%]	10	[10.000; 10.000]
Oxygen	O_2	[%]	10	[10.000; 10.000]
Water vapor ratio	rw	[0;1]	0.1	[0.100; 0.100]
Nozzle	nz	[mm]	8	
Turbolence factor	ft	[sec]	5	

DUCT FLOW RATE

Dry actual	QV_a	[m3/h]	8070	[5616; 10079]
Moist actual	$Q'V_a$	[m3/h]	8968	[8460; 9873]
Moist standard [T_{norm} P_{norm}]	$Q'V_n$	[m3/h]	2373	[2306; 2468]
Dry standard [T_{norm} P_{norm}]	QV_n	[m3/h]	21	[21; 22]

AVERAGE VALUES

Total Points		[#]	8	
Velocity	v'_a	[m/sec]	20.854	[14.513; 26.044]
Stack temperature	t_{fumes}	[°C]	755.634	[620.551; 939.691]
Stack Absolute Pressure	P_c	[kPa]	101.017	[100.964; 101.072]
Stack Static Pressure	P_{stat}	[kPa]	-0.05	[-0.103; 0.005]
Isokinetic Deviation	DI	[%]	-0.9	
Velocity at nozzle	v'_N	[m/sec]	20.659	[0.000; 25.361]
Stack Differential Pitot Pressure	dP_{pitot}	[Pa]	99.738	[53.482; 138.410]
Ambient Pressure	P_{amb}	[kPa]	101.067	[101.067; 101.067]

SAMPLED VOLUMES

Elapsed time	et	[hh:mm:ss]	2:00:00	
Total encoder impulses		[#]	25030	
Standard Volume [T_{norm} P_{norm}]	V_{gn}	[m^3]	1.7294	
Moist Volume at stack conditions	V'_{ga}	[m^3]	7.2563	
Volume at dgm conditions	V_{dgm}	[m^3]	2.528	
Gas meter temperature	t_{dgm}	[°C]	22.253	[17.692; 24.237]
Gas Meter Pressure	P_{dgm}	[kPa]	74.904	[65.523; 96.780]

Soul Friends Cremator 1 Run 2

ST0947

Isokinetic sampling 18/12/2020 10:47:30

MACHINE INFORMATION

Master Firmware	v2.0.0001
Master Serial Number	20400114P
Slave Firmware	v0.7.7000
Slave Serial Number	20400114P
Last calibration date	29/09/2020

CV GAMMA [#] CALIBRATION

Point	Flowrate	Gamma
1	0	1

POINT LIST

start ts [timestamp]	Port [###]	Point [###]	Distance [cm]	Elapsed Time [hh:mm:ss]	rw avg [0;1]	t_{fumes} avg [°C]	t_{dgm} avg [°C]	P_{stat} avg [kPa]	P_c avg [kPa]	dP pitot avg [Pa]	P_{line} avg [kPa]	P_{amb} avg [kPa]	v'_a avg [m/sec]	qV_n avg [lt/min]	DI [%]	v'_N avg [m/sec]	Q'Va [m3/h]	Q'Vn [m3/h]	QVn [m3/h]	V_{gn} [lt]	V'_{ga} [lt]	V_{dgm} [lt]
18/12/2020 10:47:32	1	1	1.3	0:15:00	0.1	681.634	28.017	-0.029	101.119	87.629	84.257	101.148	18.815	14.486	-0.5	18.711	8091	2310	2079	211.35	822.63	280.17
18/12/2020 11:02:37	1	2	4.1	0:15:00	0.1	876.58	27.746	-0.046	101.102	96.426	80.831	101.148	21.638	13.799	-1	21.41	9305	2205	1985	200.66	940.38	276.94
18/12/2020 11:17:47	1	3	7.6	0:15:00	0.1	758.302	28.438	-0.048	101.1	92.201	76.57	101.148	20.048	14.266	-0.8	19.883	8621	2278	2050	208.56	877.01	304.62
18/12/2020 11:34:02	1	4	12.7	0:15:00	0.1	733.196	28.157	-0.064	101.084	85.661	75.903	101.148	19.089	13.847	-1.3	18.823	8209	2222	2000	203.71	835.9	299.87
18/12/2020 11:49:10	1	5	26.4	0:15:00	0.1	700.588	28.639	-0.072	101.076	76.324	75.704	101.148	17.711	13.343	-0.7	17.576	7616	2131	1918	196.16	778.88	289.97
18/12/2020 12:04:14	1	6	31.5	0:15:01	0.1	540.525	27.897	-0.074	101.074	71.086	74.814	101.148	15.579	13.992	-0.9	15.438	6699	2243	2019	207.27	687.67	309.26
18/12/2020 12:19:27	1	7	35	0:15:00	0.1	752.819	27.126	-0.073	101.075	79.156	75.56	101.148	18.529	13.209	-1.1	18.323	7968	2116	1904	195.01	815.79	287.35
18/12/2020 12:34:33	1	8	37.8	0:11:17	0.1	742.008	27.292	-0.07	101.078	78.778	75.672	101.148	18.372	13.272	-0.9	18.203	7900	2120	1908	147.6	611.12	217.35

NORMALIZATION FACTOR

T_{norm}	[K]	273.15
P_{norm}	[kPa]	101.325

PITOT DATA SPECIFICATION

Name			p0.840
Velocity	[m/sec]	5	0.84
Velocity	[m/sec]	10	0.84
Velocity	[m/sec]	20	0.84
Velocity	[m/sec]	30	0.84
Velocity	[m/sec]	40	0.84

DUCT AND GAS SPECIFICATION

Name			SOUL C1	
Section			Circular	
Diameter		[m]	0.39	
Area		[m^2]	0.119	
Port	B	[#]	1	
Points	P	[#]	8	
Dry gas density	ρn	[kg/m^3]	1.267	[1.267; 1.267]
Carbon dioxide	CO_2	[%]	10	[10.000; 10.000]
Oxygen	O_2	[%]	10	[10.000; 10.000]
Water vapor ratio	rw	[0;1]	0.1	[0.100; 0.100]
Nozzle	nz	[mm]	8	
Turbolence factor	ft	[sec]	5	

DUCT FLOW RATE

Dry actual	QV_a	[m3/h]	7245	[2436; 9341]
Moist actual	$Q'V_a$	[m3/h]	8051	[6699; 9305]
Moist standard [T_{norm} P_{norm}]	$Q'V_n$	[m3/h]	2203	[2116; 2310]
Dry standard [T_{norm} P_{norm}]	QV_n	[m3/h]	20	[19; 21]

AVERAGE VALUES

Total Points		[#]	8	
Velocity	v'_a	[m/sec]	18.722	[6.297; 24.135]
Stack temperature	t_{fumes}	[°C]	723.206	[296.144; 917.738]
Stack Absolute Pressure	P_c	[kPa]	101.088	[101.000; 101.161]
Stack Static Pressure	P_{stat}	[kPa]	-0.06	[-0.148; 0.013]
Isokinetic Deviation	DI	[%]	-0.9	
Velocity at nozzle	v'_N	[m/sec]	18.545	[0.000; 23.102]
Stack Differential Pitot Pressure	dP_{pitot}	[Pa]	83.216	[12.758; 122.473]
Ambient Pressure	P_{amb}	[kPa]	101.148	[101.148; 101.148]

SAMPLED VOLUMES

Elapsed time	et	[hh:mm:ss]	1:56:18	
Total encoder impulses		[#]	22431	
Standard Volume [T_{norm} P_{norm}]	V_{gn}	[m^3]	1.5703	
Moist Volume at stack conditions	V'_{ga}	[m^3]	6.3793	
Volume at dgm conditions	V_{dgm}	[m^3]	2.2655	
Gas meter temperature	t_{dgm}	[°C]	27.939	[26.996; 29.005]
Gas Meter Pressure	P_{dgm}	[kPa]	77.388	[71.174; 93.824]

The data presented in the Tecora G4 data sheets are based on assumed moisture contents. The tabulated data presented is based on actual measured moisture content. As a result, the corrected volumetric flow rates may differ between the two data sheets.

Sample Description:	Cremator 2 Run 1	Cremator 2 Run 2	Cremator 2 Run 3	Averages
Sampling Date:	17/12/2020	18/12/2020	18/12/2020	
Filter ID:	ST1824	ST1815	ST1818	
Sampling Period:	12:30 - 14:33	7:46 - 9:49	14:40 - 16:28	
Total Sample Time (minutes)	120	115	105	
Nozzle Diameter (mm)	8	8	8	
Nozzle Area (m2)	0.0000503	0.0000503	0.0000503	
DGM Calibration Factor	1.0055	1.0055	1.0055	
Intial DGM Reading	12.9255	15.6025	19.9288	
Final DGM Reading	15.3520	17.5310	21.4952	
DGM Sample Volume (m^3):	2.4265	1.9285	1.5664	
DGM Std. Sample Volume (m^3):	1.6265	1.4937	1.1647	
Initial Leak Test Vacuum (kPa):	69	69	69	
Initial Leak Test Flow Rate (cc/min):	0	50	0	
Final Leak Test Vacuum (kPa):	69	69	69	
Final Leak Test Flow Rate (cc/min):	50	100	50	
Moisture Collected (g):	230	205.7	150.9	
Moisture Content (%):	15.0	14.6	13.9	14.5
TCR DGM Sample Volume (m^3):	2.4074	1.9123	1.5535	
Sampling Plane Mean Velocity (m/s):	18.1	17.7	14.4	16.8
TCR Isokinetic Deviation (%):	-1.0	-0.8	-1.2	
Actual Isokinetic Deviation (%):	3.0	6.4	2.3	
Duct Volumetric Flow Rates				
Moist (m^3/h):	7,797	7,614	6,206	7,206
Moist Standards (m^3/h):	2,203	2,031	1,794	
Dry Standard (m^3/h):	1,873	1,734	1,545	
Mean Temperatures				
At Sampling Plane (^oC):	691	750	669	703
At DGM (^oC):	27.6	22.0	25.8	
Ambient Pressure (kPa):	101.018	101.218	101.035	
Stack Absolute Pressure (kPa)	100.952	101.147	101.005	
Dry Gas Meter Pressure (kPa)	74.378	84.348	82.013	

Soul Friends Cremator 2 Run 1

ST0947

Isokinetic sampling 17/12/2020 12:29:56

MACHINE INFORMATION

Master Firmware	v2.0.0001
Master Serial Number	20400114P
Slave Firmware	v0.7.7000
Slave Serial Number	20400114P
Last calibration date	29/09/2020

CV GAMMA [#] CALIBRATION

Point	Flowrate	Gamma
1	0	1

POINT LIST

start ts [timestamp]	Port [###]	Point [###]	Distance [cm]	Elapsed Time [hh:mm:ss]	rw avg [0;1]	t_{fumes} avg [°C]	t_{dgm} avg [°C]	P_{stat} avg [kPa]	P_c avg [kPa]	dP pitot avg [Pa]	P_{line} avg [kPa]	P_{amb} avg [kPa]	v'$_a$ avg [m/sec]	qV$_n$ avg [lt/min]	DI [%]	v'$_N$ avg [m/sec]	Q'Va [m3/h]	Q'Vn [m3/h]	QVn [m3/h]	V_{gn} [lt]	V'_{ga} [lt]	V_{dgm} [lt]
17/12/2020 12:30:13	1	1	1.3	0:15:00	0.1	629.415	24.285	-0.029	100.989	65.849	82.712	101.018	15.844	12.875	-0.7	15.724	6813	2055	1849	188.82	695.55	251.79
17/12/2020 12:45:19	1	2	4.1	0:15:00	0.1	689.819	25.647	-0.041	100.977	80.009	79.418	101.018	18.049	13.693	-0.9	17.872	7762	2194	1974	199.39	783.66	278.15
17/12/2020 13:00:27	1	3	7.6	0:15:00	0.1	702.185	25.792	-0.045	100.973	82.753	77.757	101.018	18.487	13.879	-0.8	18.322	7950	2218	1996	202.92	807.8	289.26
17/12/2020 13:15:31	1	4	12.7	0:15:00	0.1	708.199	26.742	-0.059	100.959	86.925	74.769	101.018	19.01	14.168	-0.9	18.822	8175	2267	2040	206.65	827.88	307.34
17/12/2020 13:30:40	1	5	26.4	0:15:00	0.1	703.805	28.016	-0.068	100.95	83.698	73.302	101.018	18.611	13.863	-1.5	18.324	8003	2229	2006	202.47	807.56	308.45
17/12/2020 13:45:51	1	6	31.5	0:15:00	0.1	699.696	29.27	-0.08	100.938	83.215	71.4	101.018	18.518	13.879	-1.2	18.292	7963	2227	2004	203.02	806.45	318.86
17/12/2020 14:00:54	1	7	35	0:15:00	0.1	700.307	29.741	-0.094	100.924	82.912	69.502	101.018	18.492	13.877	-1	18.292	7952	2222	2000	203.26	808	328.45
17/12/2020 14:16:01	1	8	37.8	0:15:00	0.1	692.806	30.286	-0.107	100.911	79.665	69.107	101.018	18.051	13.638	-1.1	17.835	7762	2186	1967	199.69	787.81	325.12

NORMALIZATION FACTOR

T_{norm}	[K]	273.15
P_{norm}	[kPa]	101.325

PITOT DATA SPECIFICATION

Name			p0.840
Velocity	[m/sec]	5	0.84
Velocity	[m/sec]	10	0.84
Velocity	[m/sec]	20	0.84
Velocity	[m/sec]	30	0.84
Velocity	[m/sec]	40	0.84

DUCT AND GAS SPECIFICATION

Name			SOUL C2	
Section			Circular	
Diameter		[m]	0.39	
Area		[m^2]	0.119	
Port	B	[#]	1	
Points	P	[#]	8	
Dry gas density	ρn	[kg/m^3]	1.267	[1.267; 1.267]
Carbon dioxide	CO_2	[%]	10	[10.000; 10.000]
Oxygen	O_2	[%]	10	[10.000; 10.000]
Water vapor ratio	rw	[0;1]	0.1	[0.100; 0.100]
Nozzle	nz	[mm]	8	
Turbolence factor	ft	[sec]	5	

DUCT FLOW RATE

Dry actual	QV_a	[m3/h]	7017	[3897; 8532]
Moist actual	$Q'V_a$	[m3/h]	7797	[6813; 8175]
Moist standard [T_{norm} P_{norm}]	$Q'V_n$	[m3/h]	2199	[2055; 2267]
Dry standard [T_{norm} P_{norm}]	QV_n	[m3/h]	20	[18; 20]

AVERAGE VALUES

Total Points		[#]	8	
Velocity	v'_a	[m/sec]	18.132	[10.070; 22.045]
Stack temperature	t_{fumes}	[°C]	690.779	[532.184; 777.853]
Stack Absolute Pressure	P_c	[kPa]	100.952	[100.869; 101.037]
Stack Static Pressure	P_{stat}	[kPa]	-0.066	[-0.149; 0.019]
Isokinetic Deviation	DI	[%]	-1	
Velocity at nozzle	v'_N	[m/sec]	17.935	[0.000; 20.982]
Stack Differential Pitot Pressure	dP_{pitot}	[Pa]	80.509	[51.662; 115.003]
Ambient Pressure	P_{amb}	[kPa]	101.018	[101.018; 101.018]

SAMPLED VOLUMES

Elapsed time	et	[hh:mm:ss]	2:00:00	
Total encoder impulses		[#]	23836	
Standard Volume [T_{norm} P_{norm}]	V_{gn}	[m^3]	1.6062	
Moist Volume at stack conditions	V'_{ga}	[m^3]	6.3181	
Volume at dgm conditions	V_{dgm}	[m^3]	2.4074	
Gas meter temperature	t_{dgm}	[°C]	27.63	[23.718; 30.500]
Gas Meter Pressure	P_{dgm}	[kPa]	74.378	[66.370; 95.687]

Soul Friends Cremator 2 Run 2 ST0947
Isokinetic sampling 18/12/2020 07:46:40

MACHINE INFORMATION

Master Firmware	v2.0.0001
Master Serial Number	20400114P
Slave Firmware	v0.7.7000
Slave Serial Number	20400114P
Last calibration date	29/09/2020

CV GAMMA [#] CALIBRATION

Point	Flowrate	Gamma
1	0	1

POINT LIST

start ts [timestamp]	Port [###]	Point [###]	Distance [cm]	Elapsed Time [hh:mm:ss]	rw avg [0;1]	t_{fumes} avg [°C]	t_{dgm} avg [°C]	P_{stat} avg [kPa]	P_c avg [kPa]	dP pitot avg [Pa]	P_{line} avg [kPa]	P_{amb} avg [kPa]	v'a avg [m/sec]	qV_n avg [lt/min]	DI [%]	v'_N avg [m/sec]	Q'Va [m3/h]	Q'Vn [m3/h]	QVn [m3/h]	V_{gn} [lt]	V'_{ga} [lt]	V_{dgm} [lt]
18/12/2020 7:46:45	1	1	1.3	0:15:01	0.1	767.39	18.711	-0.06	101.158	78.233	89.061	101.218	18.531	13.075	-0.6	18.402	7969	2088	1879	189.14	802.01	229.88
18/12/2020 8:01:49	1	2	4.1	0:15:00	0.1	824.546	20.333	-0.08	101.138	82.046	86.692	101.218	19.511	13.026	-0.9	19.32	8390	2084	1875	187.76	840.05	235.73
18/12/2020 8:16:53	1	3	7.6	0:15:00	0.1	753.708	21.133	-0.067	101.151	77.595	85.036	101.218	18.345	13.068	-1.1	18.135	7889	2094	1885	189.57	793.33	243.31
18/12/2020 8:31:58	1	4	12.7	0:15:00	0.1	749.668	21.933	-0.072	101.146	79.79	82.719	101.218	18.566	13.267	-1.2	18.338	7984	2128	1915	192.76	803.54	255.03
18/12/2020 8:47:03	1	5	26.4	0:15:00	0.1	715.61	21.884	-0.071	101.147	67.529	83.623	101.218	16.786	12.503	-0.5	16.7	7218	1990	1791	182.31	734.69	238.56
18/12/2020 9:02:08	1	6	31.5	0:15:00	0.1	734.097	22.572	-0.065	101.153	66.661	83.11	101.218	16.797	12.217	-0.8	16.66	7223	1955	1760	178.09	731.07	235.03
18/12/2020 9:17:16	1	7	35	0:15:00	0.1	736.654	24.223	-0.069	101.149	67.3	82.225	101.218	16.907	12.316	-0.4	16.832	7270	1963	1767	179.23	737.54	240.38
18/12/2020 9:32:30	1	8	37.8	0:15:00	0.1	717.666	25.383	-0.078	101.14	63.074	82.586	101.218	16.223	12.036	-0.6	16.124	6976	1919	1727	174.86	706.14	234.42

NORMALIZATION FACTOR

T_{norm}	[K]	273.15
P_{norm}	[kPa]	101.325

PITOT DATA SPECIFICATION

Name			p0.840
Velocity	[m/sec]	5	0.84
Velocity	[m/sec]	10	0.84
Velocity	[m/sec]	20	0.84
Velocity	[m/sec]	30	0.84
Velocity	[m/sec]	40	0.84

DUCT AND GAS SPECIFICATION

Name			SOUL C2
Section			Circular
Diameter		[m]	0.39
Area		[m^2]	0.119
Port	B	[#]	1
Points	P	[#]	8
Dry gas density	ρn	[kg/m^3]	1.267 [1.267; 1.267]
Carbon dioxide	CO_2	[%]	10 [10.000; 10.000]
Oxygen	O_2	[%]	10 [10.000; 10.000]
Water vapor ratio	rw	[0;1]	0.1 [0.100; 0.100]
Nozzle	nz	[mm]	8
Turbolence factor	ft	[sec]	5

DUCT FLOW RATE

Dry actual	QV_a	[m^3/h]	6853 [4645; 9002]
Moist actual	$Q'V_a$	[m^3/h]	7614 [6976; 8390]
Moist standard [T_{norm} P_{norm}]	$Q'V_n$	[m^3/h]	2027 [1919; 2128]
Dry standard [T_{norm} P_{norm}]	QV_n	[m^3/h]	18 [17; 19]

AVERAGE VALUES

Total Points		[#]	8
Velocity	v'_a	[m/sec]	17.708 [12.003; 23.260]
Stack temperature	t_{fumes}	[°C]	749.917 [523.820; 910.668]
Stack Absolute Pressure	P_c	[kPa]	101.147 [101.080; 101.208]
Stack Static Pressure	P_{stat}	[kPa]	-0.071 [-0.138; -0.010]
Isokinetic Deviation	DI	[%]	-0.8
Velocity at nozzle	v'_N	[m/sec]	17.563 [0.000; 22.211]
Stack Differential Pitot Pressure	dP_{pitot}	[Pa]	72.615 [32.154; 109.222]
Ambient Pressure	P_{amb}	[kPa]	101.218 [101.218; 101.218]

SAMPLED VOLUMES

Elapsed time	et	[hh:mm:ss]	2:00:01
Total encoder impulses		[#]	18934
Standard Volume [T_{norm} P_{norm}]	V_{gn}	[m^3]	1.4737
Moist Volume at stack conditions	V'_{ga}	[m^3]	6.1435
Volume at dgm conditions	V_{dgm}	[m^3]	1.9123
Gas meter temperature	t_{dgm}	[°C]	22.029 [18.234; 25.924]
Gas Meter Pressure	P_{dgm}	[kPa]	84.348 [78.585; 96.611]

Soul Friends Cremator 2 Run 3

ST0947

Isokinetic sampling 18/12/2020 14:41:34

MACHINE INFORMATION

Master Firmware	v2.0.0001
Master Serial Number	20400114P
Slave Firmware	v0.7.7000
Slave Serial Number	20400114P
Last calibration date	29/09/2020

CV GAMMA [#] CALIBRATION

Point	Flowrate	Gamma
1	0	1

POINT LIST

start ts [timestamp]	Port [###]	Point [###]	Distance [cm]	Elapsed Time [hh:mm:ss]	rw avg [0;1]	t_{fumes} avg [°C]	t_{dgm} avg [°C]	P_{stat} avg [kPa]	P_c avg [kPa]	dP pitot avg [Pa]	P_{line} avg [kPa]	P_{amb} avg [kPa]	v'_a avg [m/sec]	qV_n avg [lt/min]	DI [%]	v'_N avg [m/sec]	Q'Va [m3/h]	Q'Vn [m3/h]	QVn [m3/h]	V_{gn} [lt]	V'_{ga} [lt]	V_{dgm} [lt]
18/12/2020 14:41:50	1	1	1.3	0:15:00	0.1	690.839	25.778	-0.02	101.019	71.227	80.969	101.039	17.017	12.778	-1.7	16.713	7318	2067	1860	187.45	737.32	256.64
18/12/2020 14:56:56	1	2	4.1	0:15:00	0.1	683.327	25.92	-0.02	101.019	64.879	81.207	101.039	16.179	12.346	-1.1	15.988	6957	1981	1782	181.03	706.53	247.25
18/12/2020 15:12:09	1	3	7.6	0:15:00	0.1	643.872	26.324	-0.03	101.009	60.508	80.216	101.039	15.304	12.227	-0.8	15.17	6581	1954	1758	179.74	672.65	248.86
18/12/2020 15:27:12	1	4	12.7	0:15:00	0.1	655.484	25.566	-0.04	100.999	52.018	82.399	101.039	14.255	11.263	-0.7	14.148	6130	1797	1617	165.5	627.24	222.5
18/12/2020 15:42:17	1	5	26.4	0:15:00	0.1	664.39	25.391	-0.042	100.997	51.1	81.207	101.039	14.162	11.053	-0.9	14.03	6090	1768	1591	162.81	623.05	222
18/12/2020 15:57:19	1	6	31.5	0:15:00	0.1	675.375	25.525	-0.032	100.999	38.489	84.943	101.031	12.102	9.278	-1.4	11.921	5204	1493	1344	136.63	529.22	178.27
18/12/2020 16:12:44	1	7	35	0:15:00	0.1	668.759	26.201	-0.031	100.994	37.089	84.74	101.025	12.01	9.267	-1.6	11.806	5164	1492	1343	135.84	522.22	177.96

NORMALIZATION FACTOR

T_{norm}	[K]	273.15
P_{norm}	[kPa]	101.325

PITOT DATA SPECIFICATION

Name			p0.840
Velocity	[m/sec]	5	0.84
Velocity	[m/sec]	10	0.84
Velocity	[m/sec]	20	0.84
Velocity	[m/sec]	30	0.84
Velocity	[m/sec]	40	0.84

DUCT AND GAS SPECIFICATION

Name			SOUL C2	
Section			Circular	
Diameter		[m]	0.39	
Area		[m^2]	0.119	
Port	B	[#]	1	
Points	P	[#]	8	
Dry gas density	ρn	[kg/m^3]	1.267	[1.267; 1.267]
Carbon dioxide	CO_2	[%]	10	[10.000; 10.000]
Oxygen	O_2	[%]	10	[10.000; 10.000]
Water vapor ratio	rw	[0;1]	0.1	[0.100; 0.100]
Nozzle	nz	[mm]	8	
Turbolence factor	ft	[sec]	5	

DUCT FLOW RATE

Dry actual	QV_a	[m^3/h]	5585	[0; 19051]
Moist actual	$Q'V_a$	[m^3/h]	6206	[5164; 7318]
Moist standard [T_{norm} P_{norm}]	$Q'V_n$	[m^3/h]	1793	[1492; 2067]
Dry standard [T_{norm} P_{norm}]	QV_n	[m^3/h]	16	[13; 19]

AVERAGE VALUES

Total Points		[#]	7	
Velocity	v'_a	[m/sec]	14.432	[0.000; 49.224]
Stack temperature	t_{fumes}	[°C]	668.863	[528.403; 779.122]
Stack Absolute Pressure	P_c	[kPa]	101.005	[100.927; 101.245]
Stack Static Pressure	P_{stat}	[kPa]	-0.03	[-0.108; 0.210]
Isokinetic Deviation	DI	[%]	-1.2	
Velocity at nozzle	v'_N	[m/sec]	14.253	[0.000; 20.195]
Stack Differential Pitot Pressure	dP_{pitot}	[Pa]	52.931	[0.000; 609.231]
Ambient Pressure	P_{amb}	[kPa]	101.035	[101.025; 101.039]

SAMPLED VOLUMES

Elapsed time	et	[hh:mm:ss]	1:45:00	
Total encoder impulses		[#]	15381	
Standard Volume [T_{norm} P_{norm}]	V_{gn}	[m^3]	1.149	
Moist Volume at stack conditions	V'_{ga}	[m^3]	4.4175	
Volume at dgm conditions	V_{dgm}	[m^3]	1.5535	
Gas meter temperature	t_{dgm}	[°C]	25.821	[25.303; 26.520]
Gas Meter Pressure	P_{dgm}	[kPa]	82.013	[74.879; 97.500]

Appendix C Moisture Content and Mass Determinations

This Appendix contains 2 pages including cover.

Moisture Content Determinations

Sampling Run	Moisture Mass Collected (g)	Gas Volume Sampled (m^3)[1]	Stack Moisture Content (%)
Cremator 1 Run 1	175.6	1.806	10.8
Cremator 1 Run 2	203.7	1.602	13.7
Cremator 2 Run 1	230.0	1.626	15.0
Cremator 2 Run 2	205.7	1.494	14.6
Cremator 2 Run 3	150.9	1.165	13.9

1. Corrected to 0 °C, one atmosphere, dry gas basis

Particulate Mass Determinations

Sampling Run	Sample ID	Filter ID/ Rinse Vol (ml)	Initial Weight (g)	Final Weight (g)	Mass (g)	Net Mass (g)	Total Mass (g)
Cremator 1 Run 1	ST0947/07	ST1823	0.5947	0.6726	0.0779	0.0774	0.1409
	ST0947/08	100	103.8735	103.9373	0.0638	0.0635	
Cremator 1 Run 2	ST0947/09	ST1783	0.5921	0.6796	0.0875	0.0870	0.0887
	ST0947/10	100	96.9632	96.9652	0.0020	0.0017	
Cremator 2 Run 1	ST0947/11	ST1824	0.5949	0.6599	0.0650	0.0645	0.0743
	ST0947/12	100	104.8487	104.8588	0.0101	0.0098	
Cremator 2 Run 2	ST0947/13	ST1815	0.5938	0.6578	0.0640	0.0635	0.1571
	ST0947/14	100	94.3798	94.4737	0.0939	0.0936	
Cremator 2 Run 3	ST0947/15	ST1818	0.5957	0.6528	0.0571	0.0566	0.2005
	ST0947/16	100	104.5480	104.6922	0.1442	0.1439	
Filter Blank	ST0947/17	ST1817	0.5941	0.5946	0.0005		
Acetone Blank	ST0947/18	100	100.9506	100.9509	0.0003		

HCl Mass Determinations

Sampling Run	Sample ID	Sample Volume (mL)	Chloride Conc. (mg/L)	Chloride Mass (mg)	HCl Mass (mg) Run
Cremator 1 Run 1	ST0954/01	560	84	47.0	48.4
Cremator 1 Run 2	ST0954/02	500	86	43.0	44.2
Cremator 2 Run 1	ST0954/03	540	85	45.9	47.2
Cremator 2 Run 2	ST0954/04	570	97	55.3	56.9
Cremator 2 Run 3	ST0954/05	440	78	34.3	35.3
Blank	ST0954/06	520	<0.5	<0.3	<0.3

Appendix D Laboratory Reports

This Appendix contains 2 pages including cover

Please note that the naming of the cremators ways changed after the lab results were issued so the Sample IDs are slightly out of order.

Hill Laboratories
TRIED, TESTED AND TRUSTED
R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand
T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Certificate of Analysis

Page 1 of 1

SPv1

Client:	Source Testing NZ Limited	**Lab No:**	2502868
Contact:	Matthew Newby	**Date Received:**	06-Jan-2021
	PO Box 32017	**Date Reported:**	19-Jan-2021
	Maungaraki	**Quote No:**	
	Lower Hutt 5050	**Order No:**	
		Client Reference:	ST0947
		Submitted By:	Matthew Newby

Sample Type: Client supplied impinger matrix 0.1N H2SO4

Sample Name:		ST0947/01 17-Dec-2020	ST0947/02 18-Dec-2020	ST0947/03 18-Dec-2020	ST0947/04 17-Dec-2020	ST0947/05 18-Dec-2020
Lab Number:		2502868.1	2502868.2	2502868.3	2502868.4	2502868.5
Total Liquid Volume on Receipt	mL	540	570	440	560	500
Chloride	g/m³	85	97	78	84	86

Sample Name:		ST0947/06 18-Dec-2020				
Lab Number:		2502868.6				
Total Liquid Volume on Receipt	mL	520	-	-	-	-
Chloride	g/m³	< 0.5	-	-	-	-

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Client supplied impinger matrix 0.1N H2SO4

Test	Method Description	Default Detection Limit	Sample No
Total liquid volume on receipt	Sample volume (measuring cylinder).	1.0 mL	1-6
Chloride	Ion Chromatography,. USEPA 26/26A modified.	0.5 g/m³	1-6

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 14-Jan-2021 and 18-Jan-2021. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

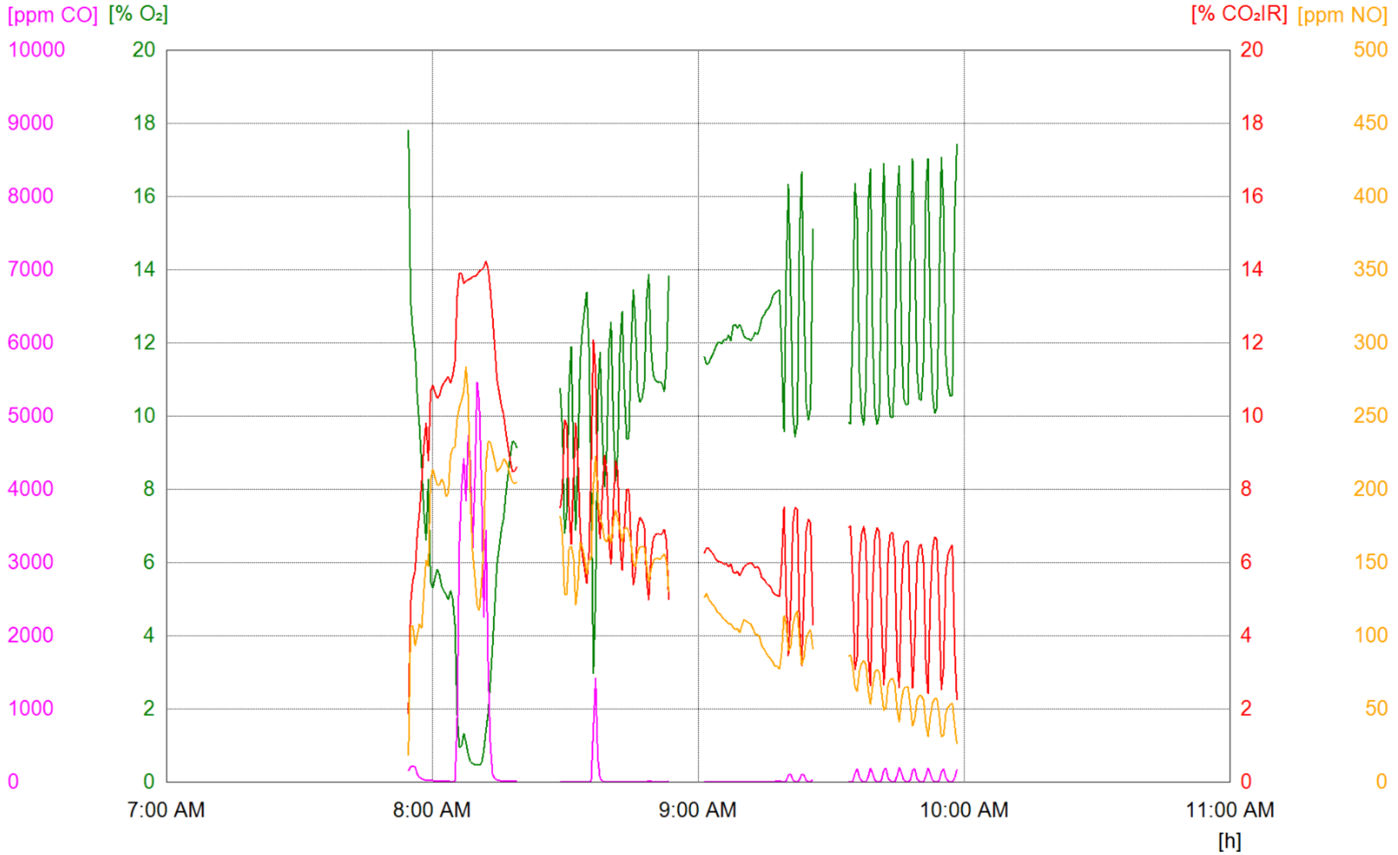
This certificate of analysis must not be reproduced, except in full, without the written consent of the signatory.

Ara Heron BSc (Tech)
Client Services Manager - Environmental

Appendix E Testo 350XL Combustion Gas Graphs

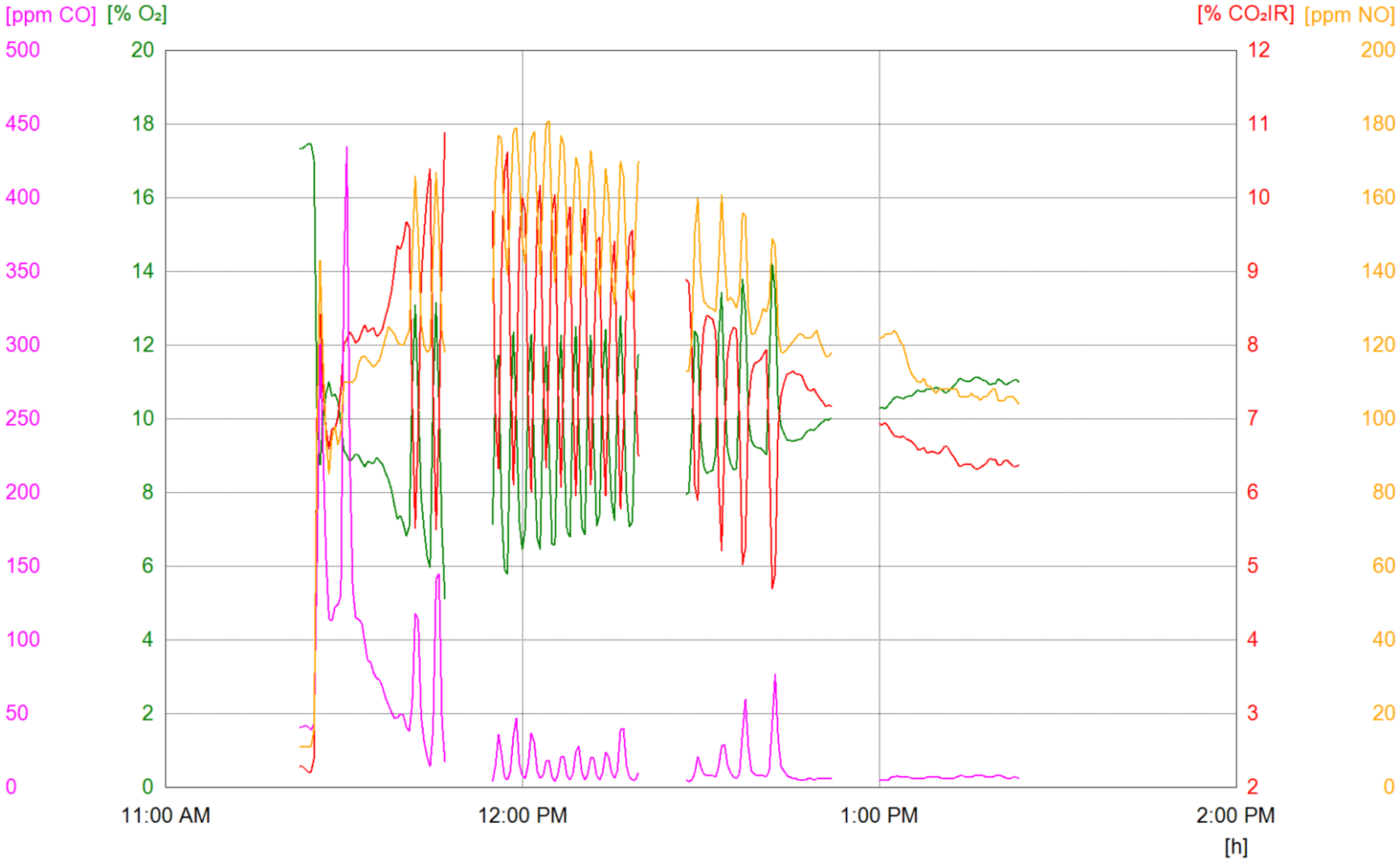
This Appendix contains 6 pages including cover

- **Testo Graph Cremator 1 Run 1, 17 December 2020**



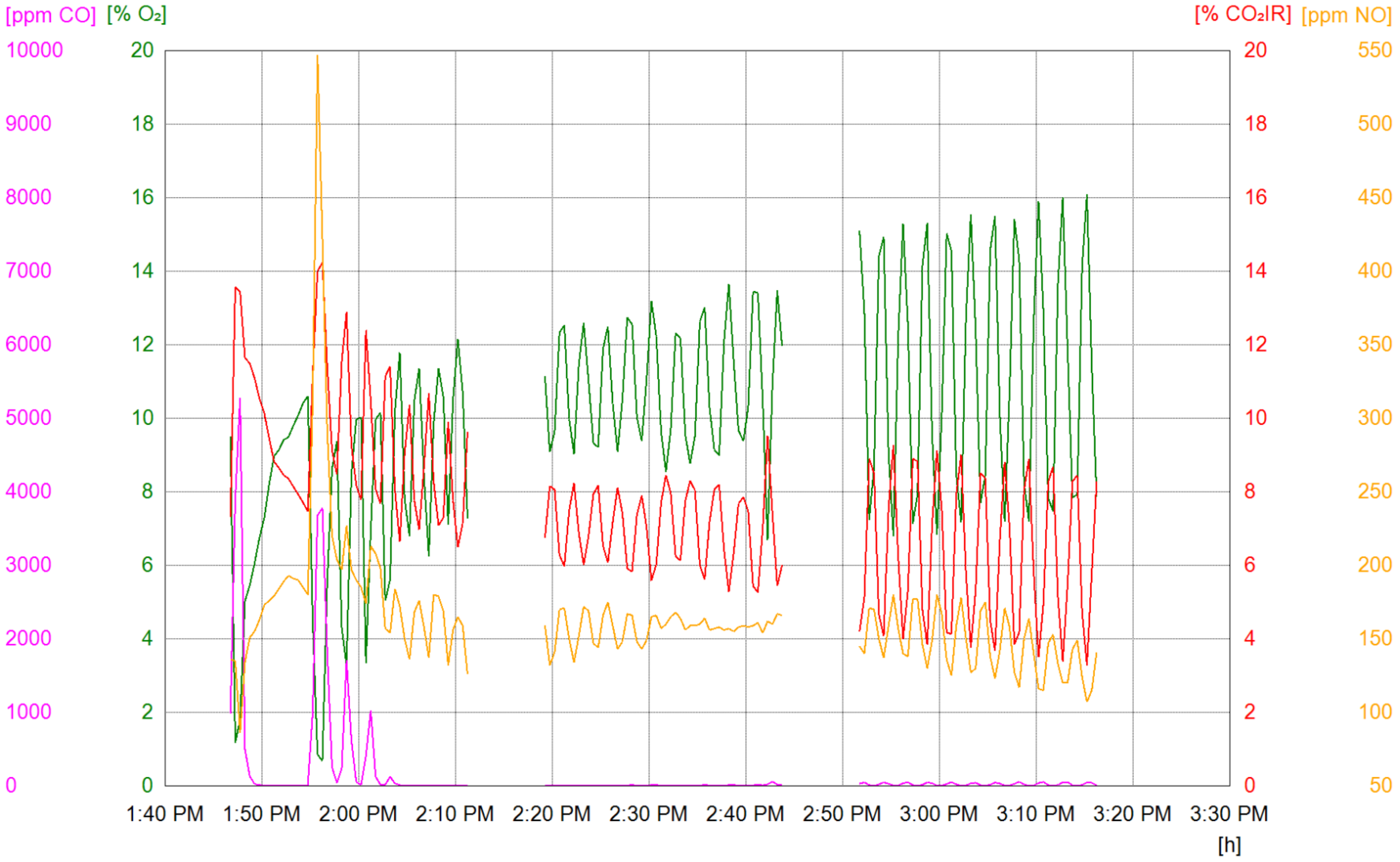
- **Testo Graph Cremator 1 Run 2, 18 December 2020**

- **Testo Graph Cremator 2 Run 1, 17 December 2020**



- **Testo Graph Cremator 2 Run 2, 18 December 2020**

- **Testo Graph Cremator 2 Run 3, 18 December 2020**



Appendix B: AERMOD Input File

```
**
****************************************
**
** AERMOD Input Produced by:
** AERMOD View Ver. 9.8.0
** Lakes Environmental Software Inc.
** Date: 9/04/2021
** File: C:\Modelling\Ashurst\March2021-horse\March2021-horse.ADI
**
****************************************
**
**
****************************************
** AERMOD Control Pathway
****************************************
**
**
CO STARTING
   TITLEONE C:\Modelling\Ashurst\March2021-horse\March2021-horse.isc
   MODELOPT DFAULT CONC
   AVERTIME 1 8 24 ANNUAL
   POLLUTID TSP
   RUNORNOT RUN
   ERRORFIL March2021-horse.err
CO FINISHED
**
****************************************
** AERMOD Source Pathway
****************************************
**
**
SO STARTING
** Source Location **
** Source ID - Type - X Coord. - Y Coord. **
   LOCATION STCK1      POINT     393681.000  5539061.700      75.730
** DESCRSRC Cold hearth 1
   LOCATION STCK2      POINT     393681.700  5539065.800      75.620
** DESCRSRC Cold Hearth 2
   LOCATION STCK3      POINT     393687.300  5539072.500      75.320
** DESCRSRC Thermtec
   LOCATION STCK4      POINT     393682.700  5539070.400      75.490
** DESCRSRC Hot-hearth
** Source Parameters **
   SRCPARAM STCK1          1.0   10.500  1012.150  19.80000    0.400
   SRCPARAM STCK2          0.0   10.500   976.150  16.80000    0.400
   SRCPARAM STCK3          0.0   10.500  1063.150   9.00000    0.300
   SRCPARAM STCK4          0.0   10.500   923.150  12.00000    0.400

** Building Downwash **
   BUILDHGT STCK1       4.16    4.60    4.60    4.60    4.60    4.60
   BUILDHGT STCK1       4.60    4.60    4.60    4.60    4.60    4.60
   BUILDHGT STCK1       4.60    4.60    4.60    4.60    4.60    4.60
   BUILDHGT STCK1       4.16    4.60    4.60    4.60    4.60    4.60
   BUILDHGT STCK1       4.60    4.60    4.60    4.60    4.60    4.60
   BUILDHGT STCK1       4.60    4.60    4.60    4.60    4.60    4.60

   BUILDHGT STCK2       4.16    4.60    4.60    4.60    4.60    4.60
   BUILDHGT STCK2       4.60    4.60    4.60    4.60    4.60    4.60
   BUILDHGT STCK2       4.60    4.60    4.60    4.60    4.60    4.60
```

BUILDHGT STCK2	4.16	4.60	4.60	4.60	4.60	4.60
BUILDHGT STCK2	4.60	4.60	4.60	4.60	4.60	4.60
BUILDHGT STCK2	4.60	4.60	4.60	4.60	4.60	4.60
BUILDHGT STCK3	4.16	4.60	4.60	4.60	4.60	4.60
BUILDHGT STCK3	4.60	4.60	4.60	4.60	4.60	4.60
BUILDHGT STCK3	4.60	4.60	4.60	4.60	4.60	4.60
BUILDHGT STCK3	4.16	4.60	4.60	4.60	4.60	4.60
BUILDHGT STCK3	4.60	4.60	4.60	4.60	4.60	4.60
BUILDHGT STCK3	4.60	4.60	4.60	4.60	4.60	4.60
BUILDHGT STCK4	4.16	4.60	4.60	4.60	4.60	4.60
BUILDHGT STCK4	4.60	4.60	4.60	4.60	4.60	4.60
BUILDHGT STCK4	4.60	4.60	4.60	4.60	4.60	4.60
BUILDHGT STCK4	4.16	4.60	4.60	4.60	4.60	4.60
BUILDHGT STCK4	4.60	4.60	4.60	4.60	4.60	4.60
BUILDHGT STCK4	4.60	4.60	4.60	4.60	4.60	4.60
BUILDWID STCK1	5.37	5.50	10.69	15.54	19.93	23.71
BUILDWID STCK1	26.77	29.02	30.38	30.87	30.45	29.13
BUILDWID STCK1	26.94	23.94	20.21	15.87	11.04	5.88
BUILDWID STCK1	5.37	5.50	10.69	15.54	19.93	23.71
BUILDWID STCK1	26.77	29.02	30.38	30.87	30.45	29.13
BUILDWID STCK1	26.94	23.94	20.21	15.87	11.04	5.88
BUILDWID STCK2	5.37	5.50	10.69	15.54	19.93	23.71
BUILDWID STCK2	26.77	29.02	30.38	30.87	30.45	29.13
BUILDWID STCK2	26.94	23.94	20.21	15.87	11.04	5.88
BUILDWID STCK2	5.37	5.50	10.69	15.54	19.93	23.71
BUILDWID STCK2	26.77	29.02	30.38	30.87	30.45	29.13
BUILDWID STCK2	26.94	23.94	20.21	15.87	11.04	5.88
BUILDWID STCK3	5.37	5.50	10.69	15.54	19.93	23.71
BUILDWID STCK3	26.77	29.02	30.38	30.87	30.45	29.13
BUILDWID STCK3	26.94	23.94	20.21	15.87	11.04	5.88
BUILDWID STCK3	5.37	5.50	10.69	15.54	19.93	23.71
BUILDWID STCK3	26.77	29.02	30.38	30.87	30.45	29.13
BUILDWID STCK3	26.94	23.94	20.21	15.87	11.04	5.88
BUILDWID STCK4	5.37	5.50	10.69	15.54	19.93	23.71
BUILDWID STCK4	26.77	29.02	30.38	30.87	30.45	29.13
BUILDWID STCK4	26.94	23.94	20.21	15.87	11.04	5.88
BUILDWID STCK4	5.37	5.50	10.69	15.54	19.93	23.71
BUILDWID STCK4	26.77	29.02	30.38	30.87	30.45	29.13
BUILDWID STCK4	26.94	23.94	20.21	15.87	11.04	5.88
BUILDLEN STCK1	30.80	30.45	29.13	26.94	23.94	20.21
BUILDLEN STCK1	15.87	11.04	5.88	0.54	5.50	10.69
BUILDLEN STCK1	15.54	19.93	23.71	26.77	29.02	30.38
BUILDLEN STCK1	30.80	30.45	29.13	26.94	23.94	20.21
BUILDLEN STCK1	15.87	11.04	5.88	0.54	5.50	10.69
BUILDLEN STCK1	15.54	19.93	23.71	26.77	29.02	30.38
BUILDLEN STCK2	30.80	30.45	29.13	26.94	23.94	20.21
BUILDLEN STCK2	15.87	11.04	5.88	0.54	5.50	10.69
BUILDLEN STCK2	15.54	19.93	23.71	26.77	29.02	30.38
BUILDLEN STCK2	30.80	30.45	29.13	26.94	23.94	20.21
BUILDLEN STCK2	15.87	11.04	5.88	0.54	5.50	10.69
BUILDLEN STCK2	15.54	19.93	23.71	26.77	29.02	30.38
BUILDLEN STCK3	30.80	30.45	29.13	26.94	23.94	20.21
BUILDLEN STCK3	15.87	11.04	5.88	0.54	5.50	10.69
BUILDLEN STCK3	15.54	19.93	23.71	26.77	29.02	30.38

BUILDLEN	STCK3	30.80	30.45	29.13	26.94	23.94	20.21
BUILDLEN	STCK3	15.87	11.04	5.88	0.54	5.50	10.69
BUILDLEN	STCK3	15.54	19.93	23.71	26.77	29.02	30.38
BUILDLEN	STCK4	30.80	30.45	29.13	26.94	23.94	20.21
BUILDLEN	STCK4	15.87	11.04	5.88	0.54	5.50	10.69
BUILDLEN	STCK4	15.54	19.93	23.71	26.77	29.02	30.38
BUILDLEN	STCK4	30.80	30.45	29.13	26.94	23.94	20.21
BUILDLEN	STCK4	15.87	11.04	5.88	0.54	5.50	10.69
BUILDLEN	STCK4	15.54	19.93	23.71	26.77	29.02	30.38
XBADJ	STCK1	-17.35	-16.80	-15.73	-14.22	-12.27	-9.95
XBADJ	STCK1	-7.33	-4.48	-1.50	1.53	-0.77	-3.11
XBADJ	STCK1	-5.36	-7.44	-9.29	-10.86	-12.11	-12.98
XBADJ	STCK1	-13.45	-13.66	-13.40	-12.73	-11.67	-10.26
XBADJ	STCK1	-8.54	-6.56	-4.38	-2.07	-4.73	-7.57
XBADJ	STCK1	-10.19	-12.49	-14.42	-15.91	-16.91	-17.40
XBADJ	STCK2	-21.51	-20.89	-19.63	-17.81	-15.44	-12.61
XBADJ	STCK2	-9.39	-5.88	-2.20	1.55	-0.03	-1.67
XBADJ	STCK2	-3.26	-4.75	-6.09	-7.25	-8.19	-8.88
XBADJ	STCK2	-9.29	-9.57	-9.50	-9.14	-8.50	-7.61
XBADJ	STCK2	-6.48	-5.16	-3.68	-2.09	-5.47	-9.02
XBADJ	STCK2	-12.29	-15.18	-17.62	-19.52	-20.83	-21.50
XBADJ	STCK3	-29.08	-29.10	-28.24	-26.54	-24.04	-20.80
XBADJ	STCK3	-16.94	-12.56	-7.80	-2.80	-3.00	-3.17
XBADJ	STCK3	-3.24	-3.21	-3.09	-2.87	-2.56	-2.18
XBADJ	STCK3	-1.72	-1.35	-0.89	-0.41	0.10	0.59
XBADJ	STCK3	1.07	1.52	1.92	2.26	-2.50	-7.52
XBADJ	STCK3	-12.30	-16.72	-20.62	-23.90	-26.45	-28.20
XBADJ	STCK4	-26.21	-25.55	-24.12	-21.97	-19.16	-15.77
XBADJ	STCK4	-11.90	-7.67	-3.20	1.36	0.60	-0.23
XBADJ	STCK4	-1.07	-1.86	-2.61	-3.27	-3.83	-4.28
XBADJ	STCK4	-4.59	-4.90	-5.01	-4.97	-4.78	-4.44
XBADJ	STCK4	-3.97	-3.38	-2.68	-1.90	-6.11	-10.45
XBADJ	STCK4	-14.48	-18.07	-21.10	-23.50	-25.18	-26.10
YBADJ	STCK1	-1.69	-1.98	-2.23	-2.42	-2.53	-2.56
YBADJ	STCK1	-2.52	-2.40	-2.21	-1.93	-1.57	-1.17
YBADJ	STCK1	-0.74	-0.30	0.16	0.61	1.04	1.44
YBADJ	STCK1	1.69	1.98	2.23	2.42	2.53	2.56
YBADJ	STCK1	2.52	2.40	2.21	1.93	1.57	1.17
YBADJ	STCK1	0.74	0.30	-0.16	-0.61	-1.04	-1.44
YBADJ	STCK2	-1.71	-2.72	-3.67	-4.52	-5.22	-5.76
YBADJ	STCK2	-6.13	-6.32	-6.31	-6.09	-5.66	-5.07
YBADJ	STCK2	-4.34	-3.47	-2.50	-1.45	-0.36	0.74
YBADJ	STCK2	1.71	2.72	3.67	4.52	5.22	5.76
YBADJ	STCK2	6.13	6.32	6.31	6.09	5.66	5.07
YBADJ	STCK2	4.34	3.47	2.50	1.45	0.36	-0.74
YBADJ	STCK3	2.64	0.25	-2.17	-4.53	-6.75	-8.77
YBADJ	STCK3	-10.52	-11.94	-13.01	-13.66	-13.87	-13.67
YBADJ	STCK3	-13.07	-12.07	-10.70	-9.01	-7.04	-4.86
YBADJ	STCK3	-2.64	-0.25	2.17	4.53	6.75	8.77
YBADJ	STCK3	10.52	11.94	13.01	13.66	13.87	13.67
YBADJ	STCK3	13.07	12.07	10.70	9.01	7.04	4.86
YBADJ	STCK4	-1.52	-3.36	-5.11	-6.71	-8.10	-9.25
YBADJ	STCK4	-10.12	-10.67	-10.91	-10.79	-10.33	-9.55
YBADJ	STCK4	-8.50	-7.19	-5.67	-3.97	-2.15	-0.26

```
   YBADJ   STCK4        1.52    3.36    5.11    6.71    8.10    9.25
   YBADJ   STCK4       10.12   10.67   10.91   10.79   10.33    9.55
   YBADJ   STCK4        8.50    7.19    5.67    3.97    2.15    0.26

   SRCGROUP ALL
SO FINISHED
**
******************************************
** AERMOD Receptor Pathway
******************************************
**
**
RE FINISHED
**
******************************************
** AERMOD Meteorology Pathway
******************************************
**
**
ME STARTING
** Surface File Path: C:\Modelling\Ashurst\March2021-horse\..\Ashurst2\
   SURFFILE ..\Ashurst2\Ashurst2.sfc
** Profile File Path: C:\Modelling\Ashurst\March2021-horse\..\Ashurst2\
   PROFFILE ..\Ashurst2\Ashurst2.pfl
   SURFDATA 1 2018
   UAIRDATA 1 2018
   PROFBASE 68.0 METERS
ME FINISHED
**
******************************************
** AERMOD Output Pathway
******************************************
**
**
OU STARTING
   RECTABLE ALLAVE 1ST
   RECTABLE 1 1ST
   RECTABLE 8 1ST
   RECTABLE 24 1ST
** 1-Hour Binary POSTFILE for the Percentile/Rolling Average Option
   POSTFILE 1 ALL UNFORM C:\Modelling\Ashurst\March2021-horse\March2021-horse.AD\1HGALLUN.POS 31
** Auto-Generated Plotfiles
   PLOTFILE 1 ALL 1ST C:\Modelling\Ashurst\March2021-horse\MARCH2021-HORSE.AD\01H1GALL.PLT 32
   PLOTFILE 8 ALL 1ST C:\Modelling\Ashurst\March2021-horse\MARCH2021-HORSE.AD\08H1GALL.PLT 33
   PLOTFILE 24 ALL 1ST C:\Modelling\Ashurst\March2021-horse\MARCH2021-HORSE.AD\24H1GALL.PLT 34
   PLOTFILE ANNUAL ALL C:\Modelling\Ashurst\March2021-horse\MARCH2021-HORSE.AD\AN00GALL.PLT 35
   SUMMFILE C:\Modelling\Ashurst\March2021-horse\March2021-horse.sum
OU FINISHED
**
**
******************************************
** Percentile/Rolling Average
******************************************
** PERCOPTN ON
** ROLLOPTN OFF
** SKIPCALM OFF
** ROLLPATH C:\Modelling\Ashurst\March2021-horse\March2021-horse.AD\Percentile\
** PERVALUE = 99.90
**
**
******************************************
** Project Parameters
******************************************
```

** PROJCTN CoordinateSystemUTM
** DESCPTN UTM: Universal Transverse Mercator
** DATUM   World Geodetic System 1984
** DTMRGN   Global Definition
** UNITS   m
** ZONE   -60
** ZONEINX 0
**

Appendix C: Operations and Maintenance Procedures

SOUL FRIEND

STANDARD OPERATING PROCEDURE **NUMBER 09-20**

Cremator Operation

Potential Hazards:

- Burn
- Respiratory damage
- Manual handling

Required Personal Protective Equipment (PPE)

Appropriate footwear

Gloves

PROCEDURE

PREPARATION

- Load the Cremator with return animals and separate them with fire bricks. As each pet goes into the Cremator the animals area is drawn on the map on the clip board, and the paper ID tag is kept within the clip board. It is optimal for the load to be 150kg or more. Lighter loads take disproportionatly longer to cremate and are not economic.

- The optimal burn loading to balance fats and reduce emissions is 4 x 30kg dogs and 8 – 10 5 kg cats (or equivalent). Place the cats along the side where the burners come in (left side). This should not obscure the flames entry into the chamber. Dogs are placed along the right hand side.

  A burner filled with only cats will not cremate well. A cremation filled with too many large dogs will need the exhaust slowed to reduce emissions (see Troubleshooting). A horse cremation normally doesn't produce fat fueled emissions as they are often skinny at the time of death or muscularly fit (if they have died by accident). A sea lion is very fatty. Once alight both primary burners will likely cycle off as the cadaver cremates itself.

- Before firing the Cremator up, have one last check of comments in the database to ensure that we don't miss out on taking a paw print or a fur clip.

- Ring fire comms to let them know you are running a cremation and when it will conclude. This stops them sending a fire truck if passerby notice flame from the stack (see process below).

START SEQUENCE

- Turn on the power switch and press the buttons in the sequence shown.

- The hearth fan comes on for 5 minutes to clear the main chamber of any fumes that might ignite. The duration of this is set by the first timer.

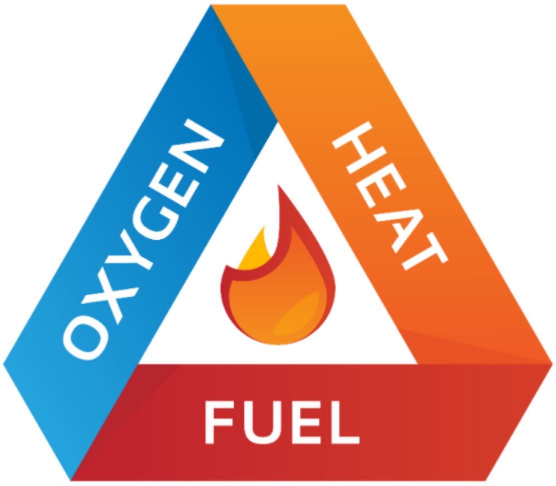
- The after burner in the secondary chamber comes on next. This fires for 20 mins to heat the refractory in the secondary chamber, which burns off emissions leaving the primary chamber. The duration of this is set by the second timer.

- Both burners on the primary chamber fire up next. It is important to observe the stacks at the point that inginition in the primary chamber occurs (aprox 25 mins into the cycle).

- **SMOKE IS NO JOKE!!**

CREMATION

- The key to good combustion is striving for the balance of 3 factors

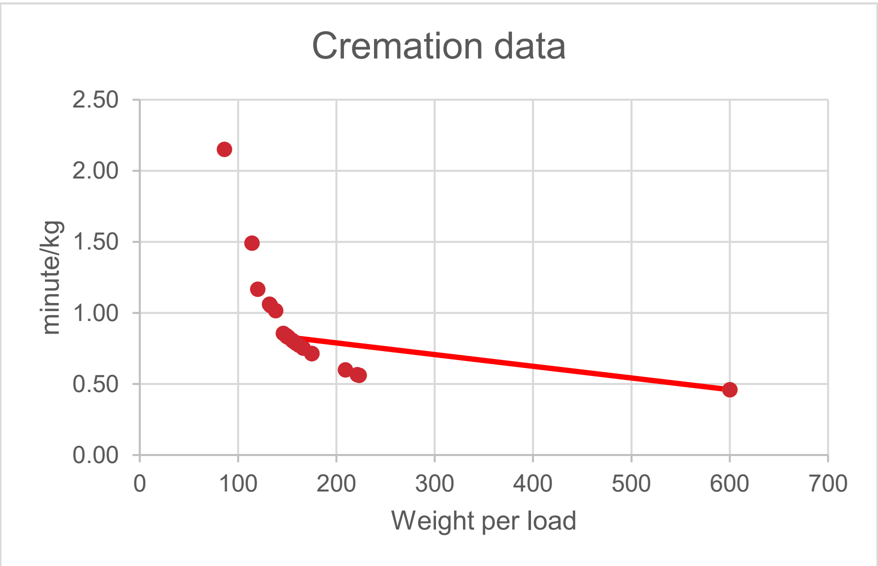


Oxygen is provided via the hearth fan through the breather holes in the floor. This seats the fire down low. When these holes block, the fire wants to climb the chimney to get oxygen. Heat or ignition source is provided by two burners directed downwards into the primary chamber. These also have fans generating oxygen. The gas involved is one fuel input. The bodies themselves are another.

- Once both primary burners are operating they will cycle on and off by themselves without producing a flame failure, as they respond to the temperature probe and the digital display. The cut off is set at 800 degrees Celsius. This stops over fueling with gas making the cremation both safe, economic and kind on equipment.

- Once through the firing up process, the Cremator can consume approximately 100kg per hour. Since our routine cremation full with return animals involves around 150kg, the total cycle should take 2 hrs. Extend the time if you are cremating a larger load. A horse will take somewhere between 4.5 and 5 hours for a 600kg animal.

- Previous cremation data shows that as the weight of the creamtion rises the time to reduce to ash reduces on a per kg basis. (graph does not include the warm up phase of the cycle – see description below).



The Table below indicates suggested cycle times (including warm up phase**)**

Weight (kg)	150	175	200	225	250	275	300	325	350	375
Cycle time	2:30	2:47	3:03	3:18	3:32	3:45	3:57	4:07	4:18	4:26

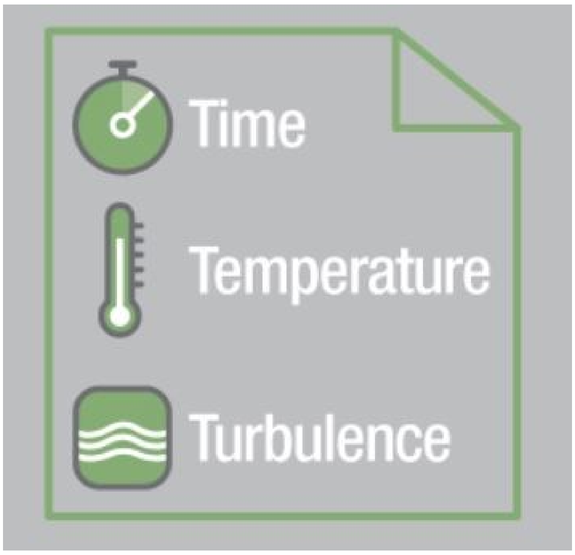
Weight (kg	400	425	450	475	500	525	550	575	600
Cycle time	4:34	4:41	4:48	4:52	4:56	4:58	5:00	5:01	5:01

- The graph and calculation are shown to offer sensible estimate, but always check through the viewing port if there is concern it's not completed.

- Non-return or biological waste loads should be calculated also on a per weight basis.

TROUBLE SHOOTING

- Visible emissions are most likely to occur as the plastic bags surrounding the cadavers or waste ignite. The quality of the exhaust is determined by 3 factors



Turbulence is created by the after burner being aimed diagonally through the after secondary chamber. The temperature will be approximately 1100 degrees if the pre-heat is observed properly. The only other factor we can influence is Time. Visible emissions will occur if the time for the exhaust to travel through the after chamber is too slow or too fast. Previous experience with witches hats over the stacks to prevent rain influx, slowed the exhaust too much and caused emissions to occur through breathing holes in the stack. Now that these have been removed, the reason for visible emissions is the exhaust moving too fast. Turn off the primary burner towards the back of the primary chamber by turning off the gas tap. A flame failure will occur. A light will show on the burner and an alarm will sound. Dismiss the alarm by pushing the yellow button. Monitor the stack, and after 10 minutes reinstate the burner by turn on the gas tap. If emissions are observed repeat the process. Only the early part of a cremation event may be affected in this way, if it occurs at all.

- If the load is large you may notice flame coming out he top of the chimney stack. This means that the bodies are acting as fuel in their own right and we don't need full gas inputs at the beginning. Again turn off the primary burner towards the back of the primary chamber by turning off the gas tap. If flame is still observable out the stack you can also turn off the front primary burner. Observe regularly over the next 10 to 15 minutes. When the flame in the chamber has settled as observed through the viewing ports, you can turn the back onto the burner and clear the flame failure but pressing the lit button on the burner. Within a couple of minutes it should fire again.

- If a flame failure occurs the alarm bell will sound to alert you. The front of the switch board will show you which burner is affected (red light), and there is also a light that will be illuminated on the flame controller visible through the buner maintenance cover. Press this light and reset the alarm (yellow button). Within a couple of minutes the flame controller will attempt ignition again. If you have repeated events of this during a cremation, maintenance should be initiated the following day and documented in the Equipment Log.

- If the digital display shows HHHH and the burner will not start the sequence at all, the temperature probe has burnt out. Maintenance should be initiated the following day and documented in the Equipment Log.

COMPETENCIES		**CREMATOR OPERATION**			**09-20**
Staff member	C1	C2	C3	C4	Trained by
AJ Pehi					
Damien Burns					
Sammy Butler					

Key
C1 = I have read and understood this SOP
C2 = I have received training
C3 = I am competent to manage this task on my own
C4 = I am credentialed to train other staff in this SOP

This document does not replace training; it is provided as a guide to the safe use of this type of equipment or conduct of this task. Refer to referenced documents for further information.

Cremator Maintenance

Potential Hazards:

- Burn
- Respiratory damage
- Manual handling

Required Personal Protective Equipment (PPE)

Appropriate footwear

Gloves

PROCEDURE

- The air holes in the floor need to be cleared each cremation event. Air is essential to seat the fire down low in the chamber, otherwise the flame wants to climb up the chimney to receive oxygen.

- During cremation grease leaves the body and is collected in the trap under the floor. After cremations and during the rake out, some of the cremains also enters the holes and quickly solidify.

- IF THE HOLES ARE NOT CLEARED the grease in the chamber will become super heated, start giving off gases, and create an explosion. The business cannot sustain the consequences of such an explosion.

- Every 12 months the chamber needs to be cleared of grease. JB's environmental are our preferred contractor to do this. The hatch on the site is removed to achieve this and needs to be reinstated before attempting another cremation. This even t needs to be documented in the Equiment log.

- Door seals are to be checked once a month. The bead around the door opening needs to be sealed into the rope seal on the adjoining face. Smoke will leak where this closure does not occur well.

- Door seals need to be replaced once a year as routine. They get clogged with rease and other contaminants reducing their effectiveness. They can be purchased from Pyrotec.

- The flame rods, controllers, ignitors and fan bearings need to be serviced by Windsor Engineering annually. Book 1 unit at a time so the business can continue to function with the remaining cremator.

- From time to time cracks will appear in the refractory. This is an extremely arsh environment in terms of temperature and this will create expansion and contraction in the metal work which will crack refractory over time. When these cracks fill with ash they deepen, and refractory will start to break away. When you see a crack appear, fill it with Mastic sealer. This will cure during the next firing of the cremator holding things in place and reducing wear and tear. Southern Pacific refractories hold a product coloured grey. Heatrite also have tubes of fire cement in black.

- Parts to be kept onsite include
  - Temperature probe
  - Door seals
  - Mastic sealant
  - Flame controllers
  - Fan Bearings

COMPETENCIES **CREMATOR MAINTENANCE** **10-20**

Staff member	C1	C2	C3	C4	Trained by
AJ Pehi					
Damien Burns					
Sammy Butler					

Key
C1 = I have read and understood this SOP
C2 = I have received training
C3 = I am competent to manage this task on my own
C4 = I am credentialed to train other staff in this SOP