PFAS liquid burn trials report v.0

27th & 28 February 2019

Revision register

Revision	Date	Issuer	Recipient	Comment
Draft 1	12/04/2019	H Macready	J Barkla	Draft
v.0	01/05/2019	H Macready	J Barkla	Separate liquid burn trial report including amendments

Executive Summary

PFAS contaminated waste was incinerated in Adelaide under the conditions approved by the EPA and outlined in the burn plans submitted.
The trials were carried out under normal operating conditions with minimum temperatures and emissions to air, water and waste testing requirements.

On the first day of the liquid trial, 410L of PFAS contaminated surface water was injected during 6.53h of operation, an average flow rate of 62.76 L/h. The waters were co-incinerated with 3,829kg of medical waste and 113kg of confidential waste. Several operational challenges as well as an unsuitable computer programme limited the efficiency of the trial. Regardless, the injection of water was compliant with the temperature triggers set in the burn plans and all licensed air emissions were compliant except for a peak in particulate levels around midday. No PFAS was found in the fly ash. PFBA, PFOA and PFPeA were found in the stack. PFPeA was also found in the blank stack samples and the PFOA was identified as a contamination of the sampling train. Some PFAS was detected in the bottom ash and leached into the quench waters. Although the levels were low, the DRE achieved is less than satisfactory. Due to the low flow rate and the number of operational issues encountered, this trial day was not considered as representative but corrective actions were identified and implemented for the following trial day.

On the second day of the liquid trial, 1,990L of PFAS contaminated surface water was injected during 9.67h of operation, an average flow rate of 205.86 L/h. The waters were co-incinerated with 5,533kg of medical waste. The injection PLC programme was modified to suit the trial conditions and resulted in a representative attempt. No PFAS was injected while the temperatures were below the triggers as the minimum temperatures were included in the new programme. All licensed air emissions were compliant. No PFAS was found in the fly ash. PFBA, PFOA and PFPeA were found in the stack, PFPeA was also found in the blank stack samples. Some PFAS was detected in the bottom ash and leached into the quench waters. The destruction and removal efficiency calculated on concentration for all PFAS compounds was 93.06% and 95.77% on mass. The reason for not reaching the 99.9999% DRE under normal operating conditions is assumed to be due to a combination of factors including a potential lack of O_2 in the primary chamber, a possible unsuitable/defective injection nozzle and an unsuitable sampling method.

No complaints from the community were received during the two days of the liquid trial. Options for the treatment and disposal of the contaminated quench waters and ashes are being investigated at the time of writing and will be communicated to the EPA via an Addendum to this report.

Going forward, a number of improvements can be reviewed and implemented in order to reach a higher DRE. One such improvement would be to engage a combustion specialist to advise on the best operating conditions for the trials to ensure complete combustion is ascertained. Another improvement would include a composite sampling programme and the use of two different analytical laboratories therefore increasing the validity of results. A purpose built PLC programme would also allow the injection of PFAS contaminated waters in an almost completely automated way with a controllable flow rate.

Table of contents

Introduction

Incineration trials of waste contaminated with PFAS were carried out at the Veolia high temperature incinerator in Dry Creek, South Australia. Contaminated surface waters were incinerated on the 27th and 28th of February.
Following extensive consultation with the EPA, burn plans were approved and implemented.
This report gives details on the quantities and properties of the waste incinerated each day, summarises operational steps, provides extensive data collected from the Continuous Emissions Monitoring and SCADA systems, laboratory analysis of bottom and fly ashes, quench waters and the results of the stack testing. The analysis of data leads to the identification of potential non compliance with the trial burn plans and actions taken to rectify them. The conclusion includes lessons learnt and if the trials were deemed successful as per criteria approved by the EPA.

Description

The contaminated surface waters were stored at the licensed Kilburn liquid treatment plant and transported to the incinerator before the trial. They were placed in a bunded location in 1,000L IBCs.
On Day 1 of the burn trial, 410L of PFAS contaminated surface water was injected above Step 3 of the incinerator in 6.53h of operation. The average injection flow rate was 62.76 L/h. The waters were co-incinerated with 3,829kg of medical waste and 113kg of confidential waste.
On Day 2 of the burn trial, 1,990L of PFAS contaminated surface water was injected above Step 3 of the incinerator in 9.67h of operation. The average injection flow rate was 205.86 L/h. The waters were co-incinerated with 5,533kg of medical waste.

Day 1 Operational details

The start of the trial on Day 1 was delayed due to operational issues. Once the operational issues were addressed, it became clear that the solvent injection line was blocked. The PFAS sampling on the stack was paused as the time required to rectify the issue was unknown.
The average flow rate for the day was very low as the injection programme was purpose built for solvent injection. As such, many triggers involving high temperatures were preventing the injection of the water. As only medical waste was loaded, the temperatures throughout the incinerator were in general much higher than during normal operation.
The start/stop times as well as the quantity injected were recorded and are tabulated below.

Start time	Stop time	Duration (min)	Reason stopped
10:56	11:12	16	PC chamber temperature too low
11:14	11:51	37	Injection line blocked (PFAS sampling paused)
12:22	15:26	184	Step 3 temperature too high (one load of confidential waste*)
15:35	16:32	57	Filters temperature too high
16:37	18:15	98	End of the trial
	TOTAL	**392 min**	

* A load of 113kg of confidential waste was incinerated to assist the temperatures to drop.

The quantity of wastewater injected was recorded every 30 min. There was no noticeable change in the level of liquid in the IBC until 12:30 due to the injection programme being built for solvent injection.
The recording times are summarised below:

Time recorded	Injected quantity (L)	Level on IBC (L)
12:30	10	1,000
13:00	10	990
13:30	40	950
14:00	30	920
14:30	40	880
15:00	40	840
15:30	10	830
16:00	40	790
16:30	70	720
17:00	50	670
17:30	50	630
18:15	20	600
TOTAL	**410 L**	

The resulting average flow injection rate for Day 1 was 62.76L/h.

Day 2 Operational details

On the second day, adjustments to the solvent injection PLC programme were made to achieve the injection rate of water defined by the trial plan. Minimum temperatures for injection were introduced in the programme and maximum temperatures removed. The modifications to the programme were recorded for future reference.
The start/stop times and quantity injected were recorded and are tabulated below.

Start time	Stop time	Duration (min)	Reason stopped
07:10	08:10	60	Modify injection programme
8:32	9:36	64	Repair air leak on diaphragm pump compressed air supply (PFAS testing paused)
9:45	11:34	109	Change IBC
11:43	16:08	265	Change IBC
16:28	17:50	82	End of the trial
	TOTAL	**580 min**	

Time recorded	Injected quantity (L)	Level on IBC (L)
07:40	90	510
08:10	70	440
09:03	0	440
09:33	110	330
10:03	10	320
10:33	130	190
11:04	140	50
11:34	50	0
11:43	New IBC	1,010
12:13	50	960
12:26	IBC 1 burnt	
12:43	130	830
13:13	150	680
13:44	80	600
14:14	90	510
14:44	160	350
15:14	130	220
15:44	120	100
16:08	100	0
16:28	New IBC	970
16:40	IBC 2 burnt	
16:58	140	830
17:28	130	700
17:50	110	590
TOTAL	**1,990 L**	

The resulting average flow injection rate for Day 2 was 205.86L/h. The injection rate is 3% higher than the 200L/h approved in the burn plans. As it is a stop/start process and the pump wasn't fitted with a flowmeter,

we relied on liquid level measurements against time to calculate the flowrate. Going forward, a system preventing this exceedance would need to be investigated and implemented.
IBCs 1 and 2 were successfully incinerated. After ensuring that the hopper was clear of waste via a visual check in the purpose built mirrors, IBC 1 was placed on the bin lifter. It was then dropped in the hopper. The lifter was used to push the IBC completely in the hopper as per trialled previously. The IBC was then pushed onto step 1 of the incinerator automatically without issues. It should be noted that due to the hopper temperature, the plastic of the IBC becomes softer and therefore easier to fit. The process was successfully repeated with IBC 2. The emissions were closely monitored during the incineration of the IBCs and compliant throughout.

Temperatures from SCADA

All the temperatures on steps 1 to 4 and the PC chamber were recorded during the liquid injection trial. The graphs are included in Appendix 1 and show the actual temperatures against the trigger set in the burn plan. The temperatures were recorded every 10 minutes and will not exactly correspond to injection periods.

Day 1

Several non-compliances were recorded, compared to the injection times and analysed:

Non compliant item	Time of non compliance	Comment
Step 1	12:00	Recorded at 787ºC; <10L PFAS injected, all other steps compliant
Step 1	12:40	Recorded at 777ºC; <10L PFAS injected, all other steps compliant
Step 1	13:20	Recorded at 818ºC; no PFAS injected, all other steps compliant
Step 1	14:40	Recorded at 735ºC; no PFAS injected, all other steps compliant
Step 1	15:20	Recorded at 807ºC; no PFAS injected, all other steps compliant
Step 1	16:00	Recorded at 726ºC; no PFAS injected, all other steps compliant
Step 1	16:10	Recorded at 826ºC; no PFAS injected, all other steps compliant
Step 1	17:30	Recorded at 817ºC; no PFAS injected, all other steps compliant
PC chamber	14:50	Recorded at 1,068ºC; no PFAS injected, all other steps compliant
PC chamber	16:30	Recorded at 1,050ºC; no PFAS injected, all other steps compliant
PC chamber	16:40	Recorded at 1,078ºC; no PFAS injected, all other steps compliant
PC chamber	17:40	Recorded at 1,072ºC; no PFAS injected, all other steps compliant

On Day 1 of the liquid trial, step 1 temperature was the most difficult to control and keep stable due to the full ash push identified during the previous trial days. The delayed start also minimised the heat stored in the incinerator before starting the trial. At 12:00 and 12:40, a maximum of 10L of water had been injected while step 1 temperature was below the trigger. After these occurrences and a better understanding of the injection process, no injection was allowed during the other step 1 non-compliances. As the exact injection times of liquid are not recorded by the system, the operator had to visually ensure that no liquid was injected during the non-compliance periods.

As a corrective action, the injection programme was modified on Day 2 to include a minimum trigger temperature for step 1 to allow injection to occur. Steps 2, 3 and 4 were fully compliant during the trial. Non compliances were also recorded for the post combustion chamber. This could be due to a series of compact medical waste loads (low volume, high weight). The same comments as for step 1 apply with visual control ensuring no injection was happening at the time. The same corrective action was also applied on Day 2.

Day 2

Several non-compliances were recorded, compared to the injection times and analysed:

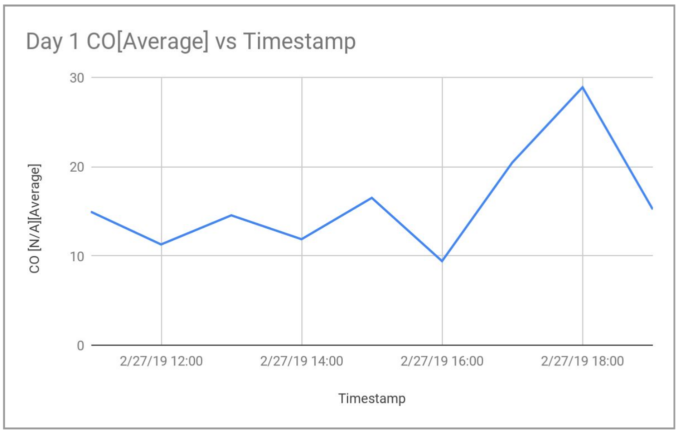
Non compliant item	Time of non compliance	Comment
Step 1	13:10	Recorded at 821ºC, no PFAS injected, all other steps compliant
Step 4	7:20	Recorded at 815ºC, no PFAS injected, all other steps compliant
Step 4	8:30	Recorded at 834ºC, no PFAS injected, PC Chamber non compliant
Step 4	8:40	Recorded at 801ºC, no PFAS injected, all other steps compliant
Step 4	9:00	Recorded at 821ºC, no PFAS injected, all other steps compliant
Step 4	9:20	Recorded at 835ºC, no PFAS injected, all other steps compliant
Step 4	9:30	Recorded at 798ºC, no PFAS injected, all other steps compliant
PC chamber	8:30	Recorded at 911ºC, no PFAS injected, all other steps compliant
PC chamber	15:30	Recorded at 1,033ºC, no PFAS injected, all other steps compliant

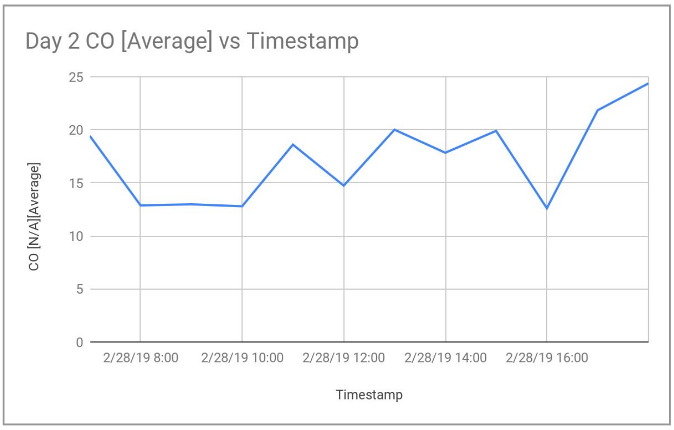
On Day 2, the injection programme was changed and implemented from 8:32 ensuring that no injection of water was occurring during any temperature being non compliant with the trigger set. The temperature on step 1 was generally higher than on the previous day as the incinerator had heat stored in the refractory from its early morning start. Step 4's temperature was less stable in the morning, no obvious reason could be presumed. The PC Chamber's low temperature occurrences could be due to a longer time between two medical waste loads in the morning and a more compact medical load in the afternoon (low volume high weight). No PFAS was injected during any of the non compliances.

Emissions from CEMS

All the emissions were recorded by the CEMS and compared to EPA Licence condition limits as illustrated by the graphs below.

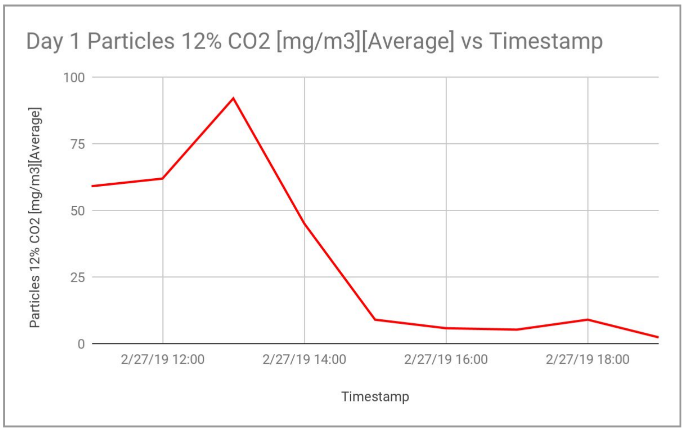
CO (Limit 150 mg/m^3)

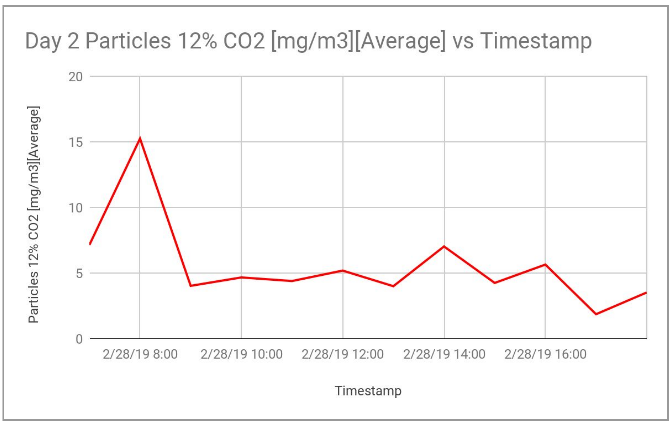




The measured emissions of carbon monoxide during the liquid trial burns were compliant with the EPA licence. No notable peaks could be noticed corresponding to the influence of PFAS injected.

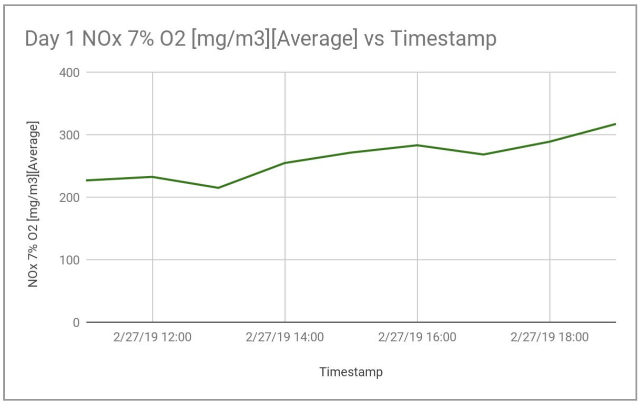
Particles (Limit 70 mg/m^3 corrected)

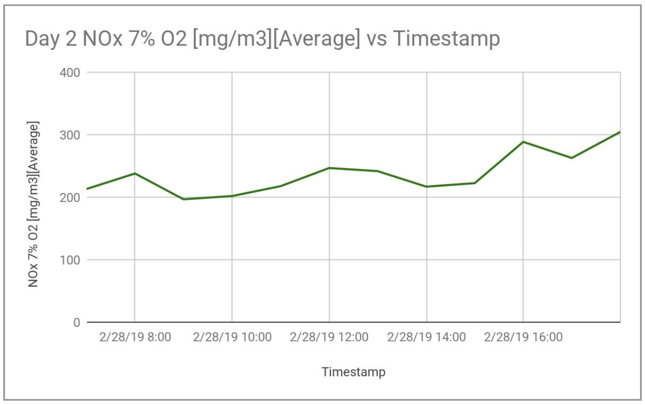




The emissions of particles exceeded the licence limit around 1pm of Day 1 of the liquid trial burn. They were compliant on Day 2 throughout. The Day 1 emissions do not correspond to any notable event relating to the trial, other than a load of confidential waste loaded prior. Moreover, the injection flow rate was much higher on Day 2 so the non-compliance could not easily be attributed to the injection of PFAS liquid.

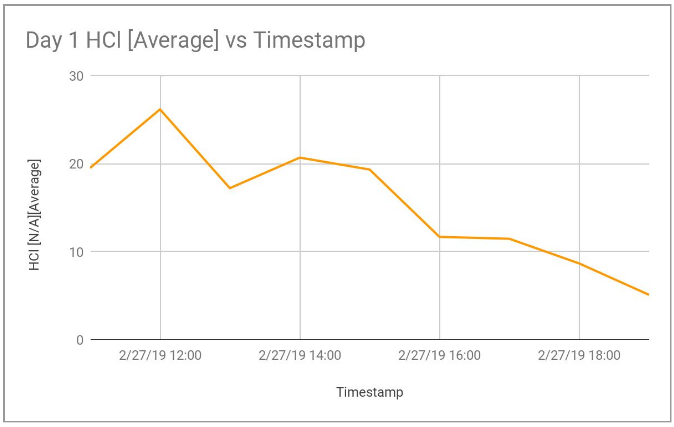
NOx (Limit 500 mg/m^3 corrected)

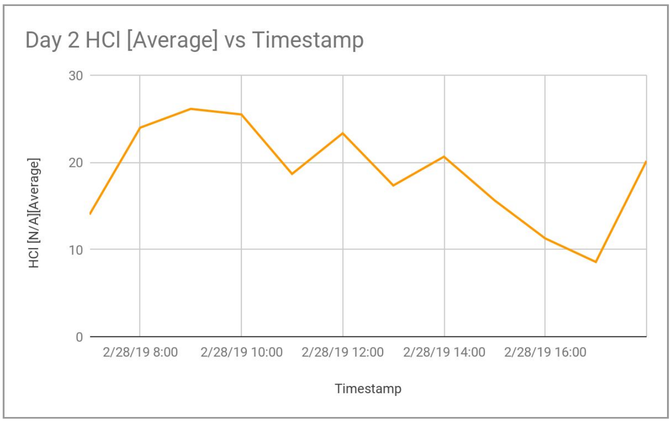




The NOx emissions were compliant with the licence limits during Day 1 and 2 of the trial.

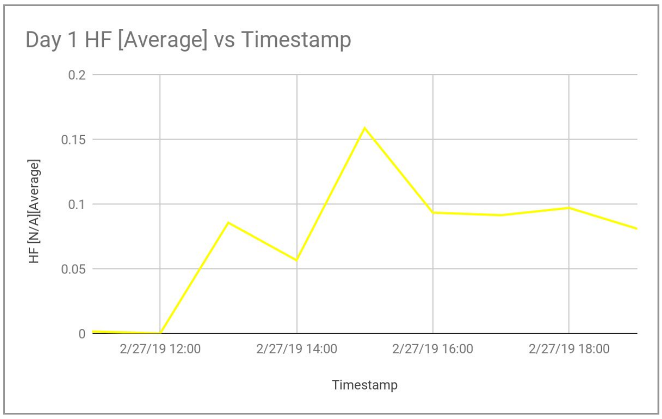
HCl (Limit 50 mg/m^3)

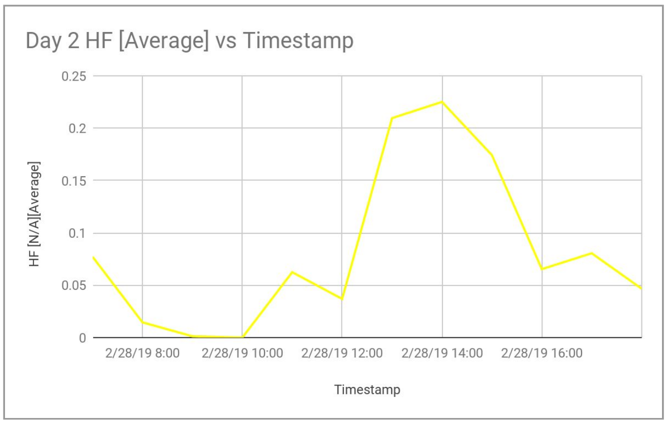




The HCl emissions are compliant with the licence limits with no noticeable differences between the 2 days.

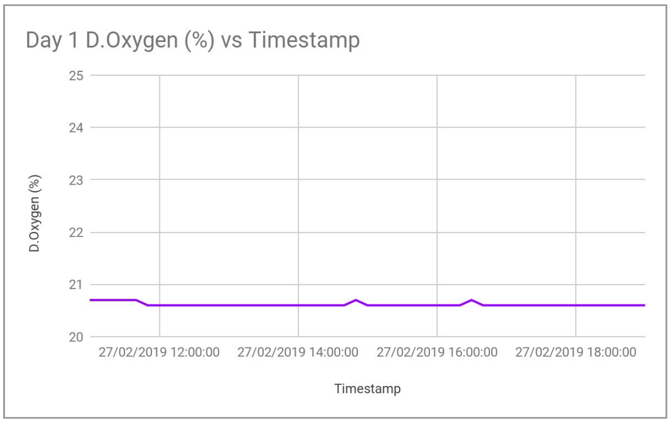
HF (Limit 5 mg/m^3)

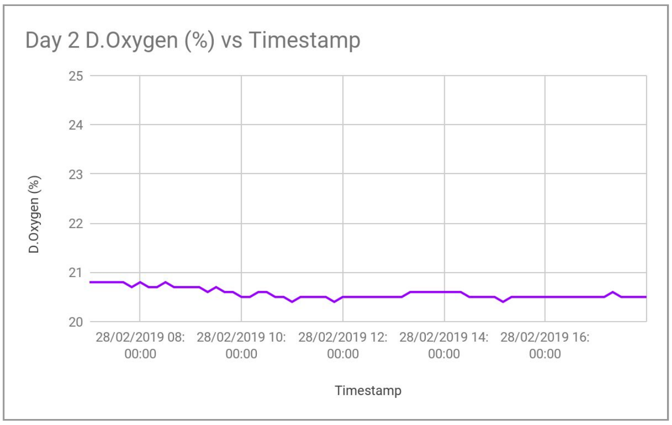




The HF emissions were compliant with the licence limits with a peak on Day 2 corresponding to a peak in flow rate of PFAS liquid injection between 12:45 and 15:45.

O_2 (10% volume in stack)





The level of oxygen in the combustion gases were compliant with the 10% minimum limit.

Bottom/Fly ashes and quench waters analytical results

Samples of bottom/fly ashes and quench waters were taken during the trial. The quench water samples were taken at midday and at the end of the day. The fly ash and bottom ash samples were taken in duplicates at the end of the day. They were all tested for 28 PFAS suite, TOPA 28 PFAS suite and TOF as per trial burn plans. The results are attached in Appendix 2.

The samples IDs were:

- QLIQ 27/02-1 Quench water, liquid trial, 27/02, midday
- QLIQ 27/02-2 Quench water, liquid trial, 27/02, end
- QLIQ 28/02-1 Quench water, liquid trial, 28/02, midday
- QLIQ 28/02-2 Quench water, liquid trial, 28/02, end
- BALIQ 27/02-1 Bottom ashes, liquid trial, 27/02
- BALIQ 27/02-2 Bottom ashes, liquid trial, 27/02, duplicate
- BALIQ 28/02-1 Bottom ashes, liquid trial, 28/02
- BALIQ 28/02-2 Bottom ashes, liquid trial, 28/02, duplicate
- FALIQ 27/02 -1 Fly ashes, liquid trial, 27/02
- FALIQ 27/02 -2 Fly ashes, liquid trial, 27/02, duplicate
- FALIQ 28/02 -1 Fly ashes, liquid trial, 28/02
- FALIQ 28/02 -2 Fly ashes, liquid trial, 28/02, duplicate

No detectable amount of PFAS were found in the fly ash. The quench waters and bottom ashes contained PFAS compounds above the laboratory limit of detection and are summarised in the table below.

Day 1

PFAS	LOR	Unit	Bottom ashes 1 BALIQ 27/02-1	Bottom ashes 2 BALIQ 27/02-2	LOR	Unit	Quench waters 1 QLIQ 27/02-1	Quench waters 2 QLIQ 27/02-2
8:2 FTSA	5	µg/kg	<5	19	0.01	µg/L	0.07	0.12
6:2 FTSA	10	µg/kg	76	110	0.05	µg/L	4.4	3.7
PFBA	5	µg/kg	28	27	0.05	µg/L	5.9	5.3
PFPeA	5	µg/kg	26	30	0.01	µg/L	2	1.9
PFHxA	5	µg/kg	110	140	0.01	µg/L	3.7	4.6
PFHpA	5	µg/kg	9.3	19	0.01	µg/L	0.33	0.62
PFOA	5	µg/kg	39	150	0.01	µg/L	0.98	2.2
PFNA	5	µg/kg	<5	6.3	0.01	µg/L	0.02	0.04
PFBS	5	µg/kg	17	22	0.01	µg/L	0.79	0.96
PFPrS	5	µg/kg	7.6	6.9	0.01	µg/L	0.19	0.23
PFPeS	5	µg/kg	25	69	0.01	µg/L	0.7	1.4
PFHxS	5	µg/kg	180	720	0.01	µg/L	6.5	9.5
PFHpS	5	µg/kg	17	82	0.01	µg/L	0.36	0.64
PFOS	5	µg/kg	170	740	0.01	µg/L	3.1	5.7

Day 2

PFAS	LOR	Unit	Bottom ashes 1 BALIQ 28/02-1	Bottom ashes 2 BALIQ 28/02-2	LOR	Unit	Quench waters 1 QLIQ 28/02-1	Quench waters 2 QLIQ 28/02-2
8:2 FTSA	5	µg/kg	8.1	7.5	0.01	µg/L	0.24	0.32
6:2 FTSA	10	µg/kg	62	52	0.05	µg/L	6.9	8.8
PFBA	5	µg/kg	24	17	0.05	µg/L	7.7	11
PFPeA	5	µg/kg	30	20	0.01	µg/L	4.9	8.4
PFHxA	5	µg/kg	96	73	0.01	µg/L	21	23
PFHpA	5	µg/kg	13	9.9	0.01	µg/L	2.6	4.4
PFNA	5	µg/kg	<5	<5	0.01	µg/L	0.18	0.26
PFOA	5	µg/kg	56	44	0.01	µg/L	9.5	17
PFBS	5	µg/kg	16	15	0.01	µg/L	3.6	5.5
PFPrS	5	µg/kg	<5	<5	0.01	µg/L	0.27	0.34
PFPeS	5	µg/kg	20	19	0.01	µg/L	4.6	5.2

PFAS	LOR	Unit	Bottom ashes 1 BALIQ 28/02-1	Bottom ashes 2 BALIQ 28/02-2	LOR	Unit	Quench waters 1 QLIQ 28/02-1	Quench waters 2 QLIQ 28/02-2
PFHxS	5	µg/kg	160	150	0.01	µg/L	35	41
PFHpS	5	µg/kg	25	<5	0.01	µg/L	1.7	2.9
PFOS	5	µg/kg	210	200	0.01	µg/L	15	25

On both days, the TOP analysis revealed the presence of precursor shorter chain PFAS. The TOF analysis revealed that other non-precursor organofluorine compounds were also present in the ashes and leached in the quench waters. The sample of quench waters on Day 1 was taken after only 10L of PFAS waters were injected. Apart from an analytical error from the lab, it is possible that contamination remained from the prior's day trial. A review of the quench water and ash conveyor belt cleaning procedures should be undertaken prior to any other trial.

Stack testing results

During the 2 days of the liquid burn trial, the stack was tested for total solid particles, CO, NOx, HCl. HF, heavy metals, mercury, lead and dioxins and furans as per EPA licence conditions. PFAS and PFAS TOP were also performed on both days. The full report is attached in Appendix 3.
In summary, the incinerator was compliant with all air emissions listed in the EPA licence.
Some PFAS were detected in the stack on the 2 days as per table below:

Day 1

PFAS	Result (ng/Nm^3)	Blank result (ng/sample)	Reference	Emission rate (g/min)
Perfluorobutanoic acid (PFBA)	2.0	<1.0	STP	5.2E-07
Perfluorooctanoic acid (PFOA)	*46 (sample contamination)*	<0.5	STP	1.2E-05
Perfluoropentanoic acid (PFPeA)	3.0	2.7	STP	7.8E-07

Day 2

PFAS	Result (ng/Nm^3)	Blank result (ng/sample)	Reference	Emission rate (g/min)
Perfluorobutanoic acid (PFBA)	2.7	<1.0	STP	7.8E-07
Perfluorooctanoic acid (PFOA)	0.11	<0.5	STP	3.3E-08
Perfluoropentanoic acid (PFPeA)	3.2	2.7	STP	9.3E-07

The PFAS testing on Day 1 was started at 11:12 and finished at 16:05 during which 220L of waters were

burnt. The PFAS testing on Day 2 started at 8:00 and finished at 12:24 during which about 620L of waters were burnt.
It should be noted that the uncertainty measurement in the stack is +/-30% (Appendix 3, Table 23) and that PFPeA was found in the blank samples throughout the trial. Moreover the result of 46 ng/Nm^3 on Day 1 for PFOA was identified as a contamination of the sampling train (refer to Appendix 3, Section 6).

Destruction Removal Efficiency (DRE)

In order to calculate the trial's DRE, we selected the results of the second day. Indeed, operational parameters were better controlled and a larger quantity of PFAS waters were burnt resulting in a more representative attempt. The samples taken of bottom ash and quench waters returned similar results confirming that no hot spot was detected. The calculations are performed on concentrations (assuming volume of waste in = volume of waste out) and mass of PFAS. The formula used to calculate the DRE is as follows:

DRE= (PFAS content within waste - PFAS content within residual gas/water/ashes)/PFAS content within waste

The calculation table is attached in Appendix 4. The DRE was calculated both on mass and concentrations of PFAS in the waste, bottom ash, quench waters and stack.

1. Taking into account all detected PFAS, the overall destruction rate was 93.06% based on concentrations and 95.77% based on mass.
2. The highest DRE was 100% for 4:2 FTSA, PFDA, PFTrDA and PFTeDA.
3. The lowest DRE was 66.33% on concentration and 78.38% on mass for 8:2 FTSA.
4. The DRE (concentration/mass) for regulated PFAS were 92.19%/95.32% for PFOA with some detected in the stack; 92.28%/95.35% for PFHxS and 90.63%/94.11% for PFOS.

Please note that these calculations are highly sensitive to the PFAS/medical waste ratio.

Conclusion

The first day of the liquid trial burn was challenged by operational issues and a PLC computer programme designed with controlling parameters for flammable solvents with injection regulating times that could be relaxed for the trial waters. It is not therefore considered as a representative and valid test. During the second day, operational issues were addressed and the injection programme changed to better reflect the properties of the waste injected (non flammable solvent). All stack emissions were compliant with the EPA licence limits. No PFAS contaminated waters were injected when the temperatures inside the primary and post combustion chambers were below the triggers approved in the burn plans. The fact that PFAS compounds were found in the bottom ash shows that the primary chamber's normal operating conditions were not optimal for the complete combustion of PFAS compounds. Moreover, a review of the injection nozzle is required ensuring its design supports an optimum vaporisation rate. The calculated overall DRE is above 93% resulting in low level contaminated ash and quench waters but did not reach the targeted 99.9999% destruction rate, therefore the trial was unsuccessful.

Condition U-705 of EPA Licence 2672

Site suitability

The site was suitable for the receipt and storage of the PFAS waters in IBCs. The site was also suitable for the discharge of ashes and quench waters for the trial.

Equipment suitability

- The equipment was able to maintain the temperatures above the triggers except for the occurrences detailed in section"Temperature from SCADA". The co-incineration of medical waste was instrumental in keeping the temperatures in the range specified in the burn plans.
- Although not fitted with a flowmeter, the pump was able to inject the PFAS waters at a rate within 3% of flow rate specified in the burn plans on day 2.
- On the first day of the trial, the equipment was not suitable for PFAS water injection due to an injection programme purposely built for solvents. On the second day, this programme was modified and allowed a better control of injection timing.

The presence of PFAS in the bottom ashes could point towards an unsuitable injection nozzle and/or a lack of oxygen in the primary chamber.

Emissions compliance (conditions U-88 and U-87)

All emissions were compliant except for a high particles reading on day 1 around midday which could be due to a load of co-incinerated confidential waste, demonstrating the suitability of the scrubbing system.

Final Recommendations

The successes and lessons learnt from the trial days are summarised below.

Successes

1. A very small amount of PFAS was injected during step 1 temperature non-compliances on day 1. As the liquid was injected above step 3, it is unlikely to have had a significant impact. All other non-compliances were promptly identified and no PFAS was injected.
2. The injection control programme was successfully modified on the second day of the trial to allow a more representative trial to occur.
3. Line blockage and air leak were repaired in a timely manner.
4. Communication with the stack testing operators was efficient.
5. Air emissions where all compliant with the conditions listed in the current EPA licence, especially HF and dioxins, proving the efficiency of the scrubbing system.
6. Although the DRE of 99.9999% wasn't achieved, PFAS compounds were detroyed with the resulting bottom ashes' PFAS concentration suitable for disposal at a double composite lined landfill (pending leachate concentration confirmation) as per HEPA PFAS NEMP 2.0 landfill acceptance criteria.

Challenges

1. The current solvent injection programme is not suitable for the injection of waters as too many "high temperature" triggers are present. It was successfully modified on the second trial day.
2. Some PFAS compounds were found in the ash and quench waters. The contamination could be a result of a combination of factors:
    a. Poor cleaning procedure for the quench waters on day 1 following the previous day's trial;
    b. Poor vaporisation and mixing due to unsuitable/defective nozzle;
    c. Lack of oxygen in the primary combustion chamber preventing the formation of CO;
    d. Spot sampling not adequate;
    e. Analytical laboratory error.

    The ashes had been tested for PFAS outside of the trial and returned negative results. As the PFAS in the quench water results from ash leaching, it is very unlikely that the quench waters under normal incineration operation would show any PFAS.

Actions

1. The remaining 1,560L of contaminated waters will be stored at the Kilburn liquid plant awaiting decision for a potential second trial;
2. The treatment and disposal of quench waters and ashes is currently being investigated and will be communicated via an Addendum to this report.

Lessons learnt

If another burn trial of liquid was carried out, the following actions would be implemented:

1. Improve labelling;
2. Improve segregation of ash, quench waters and fly ash to allow allow further additional sampling and a more detailed conclusion;
3. Design and implement a PLC programme dedicated to the injection of PFAS contaminated liquid;
4. Improve accuracy of injection flow measurement;
5. Review injection efficiency of current nozzle;
6. Engage a combustion specialist for advice on the optimum O_2 content in the primary and secondary chambers for complete combustion of waters without compromising the licensed air emissions as well as providing a complete assessment of the equipment's suitability to incinerate PFAS contaminated waters;
7. Sample the waste, ash and quench waters using composite samples to better represent the average PFAS contamination throughout the media and engage an analytical lab in the planning process;
8. Ensure the external laboratory analytical method is quality checked by sending duplicate samples to different providers.

Appendix list

Appendix 1: Liquid trial temperature recording
Appendix 2: Ashes and quench waters analytical results
Appendix 3: Stack testing report
Appendix 4: DRE calculation for liquid trials