Post Trial Report for Fire Fighting Foam Co-processing at Cement Australia's Fisherman's Landing Kiln

Aim: To demonstrate complete destruction of PFAS containing compounds as a result of co-processing fire fighting foam via the clinker kiln main burner at the Gladstone cement manufacturing plant.

Executive Summary

The Cement Australia Gladstone Kiln has completed a trial for the destruction of fire fighting foam concentrate containing PFAS compounds. The trial represented the first stage of the fire fighting foam coprocessing trial, whereby low level fluoride is introduced to the clinker manufacturing kiln through the main burner, as described in the pre-trial notification approved by the Department of Environment and Science on the 30th May 2017.

For a total organic fluoride level of 0.42% and a feed rate of ~1T/hr the prominent PFAS species; PFOS, PFOA and PFHxS had destruction and removal efficiencies of 99.99993%, 99.99975% and 99.99936% respectively. The PCDDs/PCDFs emissions were at 0.00041 ng/Nm^3 compared to the emission limit of 0.1 ng TEQ/Nm^3. All other air pollution emissions were below the required emission limits values.

Negligible PFAS reported to either air emissions or to the clinker. Hydrogen fluoride detected at stack emissions was 0.045mg/Nm^3 compared to the assigned limit of 50mg/Nm^3. Fluorine species liberated from the destruction of PFAS has been bound within the clinker as calcium fluoride consistent with the outcomes of the experimental work of Wang et al and discussed at the pre-trial notification with DEHP. Main burner coal volumes were reduced during the trial indicating the benefits of the fluoride addition into the kiln, which provided lower temperature pathway to the C3S phase of clinker production (i.e. less temperature required to achieve the C3S reaction).

Environmental management of fire fighting foam concentrate was an essential element of the tria:. A method of cleaning PFAS residues from Intermediate Bulk Containers was successfully established and validated with a swab test methodology.

Fire Fighting Foam Background

In July 2016 the Department of Environment and Science released its operational policy for the environmental management of firefighting foams[1].

All fire fighting foams pose a range of hazards to the environment when released during use. The combination of chemicals used in fire fighting foams can have direct and indirect acute and chronic impacts on biota, soils and waterways through their persistence, bioaccumulation, toxicity and their biochemical oxygen demand when they are released and degrade.

Fire fighting foam formulations currently contain complex combinations of many fluorinated organic compounds, principally perfluoroalkyl and fluorotelomer compounds of various carbon chain lengths and with a broad diversity of functional groups. The very strong carbon-fluorine bonding in the perfluoroalkyl chain requires very high energy to break and this contributes to the environmental persistence and limited methods for effective disposal of PFAS containing waste.

Dr. J Seow reported in his 2013 review that the preferred method to dispose and degrade Perfluorochemicals (PFCs) (also referred to as Perfluoroalkyl Substances (PFAS) in order to make them safe for the environment was high temperature thermal incineration at greater than 1100oC due to the stability of the carbon-fluorine bond[2]. A few studies show that PFCs are effectively destroyed at 1100˚C, and the studies available suggest that this may also be the case at a temperature of 850˚C. On the other hand, there are no studies which document clearly that destruction is complete at 850˚C[3].

The main burner at the Gladstone cement kiln typically has a temperature greater than 1200°C and offers a means for the destruction of fire fighting foam containing PFAS. The existing storage systems are designed to receive liquid materials and co-process through to the main burner or calciner of the clinker kiln.

According to the Stockholm Convention on persistent organic pollutants (POPS), PFAS (and other POPs) should be disposed of in such a way that the persistent organic pollutant content is destroyed or irreversibly transformed so that they do not exhibit the characteristics of POPs. Cement kilns are recognised by the Basel Convention for the destruction of POPs.

The Gladstone cement kiln has proven its destruction efficiency for the Polychlorinated biphenyl (PCB) contaminated oil (up to 1000ppm) and Ozone Depleting Substances. The high temperatures achievable at the main burner and the proven capability of the Gladstone cement kiln in regards to POPs provides confidence that PFAS in firefighting foam concentrates will be effectively destroyed. Moreover, the fluorine component liberated will be ultimately captured by scrubbing of the flue gases to remove hydrogen fluoride or immobilised in the cement matrix as inert and environmentally neutral calcium fluoride.

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[1] “Environmental Management of Firefighting Foam”, Department of Environment and Heritage Protection Queensland, July 2016

[2] “Fire fighting Foams with Perfluorochemicals – Environmental Review”, J.Seow, June 2013

[3] “Survey of PFOS, PFOA and other Perfluroalkyl and Polyfluoroalkyl Substances”, Danish Ministry of the Environment, 2013.

Fire fighting Foam Concentrate

Fire fighting foam concentrates are mixed with water and used in the production of streams or blankets of air/gas-filled bubbles to suppress flammable vapours, increase water penetration, reduce static spark generation, control or extinguish fires, and prevent re-ignition by excluding air and cooling the fuel.

A very diverse range of PFAS are now known to occur in fluorinated fire fighting foam including poly- and perfluorinated, fluorotelomers, fluoropolymers and complexes of siloxanes and fluorinated compounds with branches ranging in chain length from C4 to C20.

Foam concentrates are supplied as 1%, 2%, 3% or 6% products to be diluted with 99%, 98%, 97% and 94% water respectively. The 3% and 6% are the most common products available. The foam concentrates are highly water based with the key ingredients being mixtures of hydrocarbon and fluorocarbon surfactants, which act as major surface-active components. Of these, perfluorooctane sulfonate (PFOS) is of major environmental concern because of its known persistence, potential to bioaccumulate, while perfluorooctanoic acid (PFOA) has recently come under scrutiny because of its similarity to PFOS. Table 1 summarises the chemical composition of some fire fighting foam concentrates.

Table 1: Constituents in Common Firefighting Foam Concentrates[4]

Constituent	Ansulite 3%	Ansulite 6%	Light-Water 3%	Light-Water 6%
Water (%)	70 - 80	75 - 85	50 - 60	75 - 85
Diethyleneglycol Monobutylether (%)	14	7.9	30 – 40	10 - 20
Propylene Glycol (%)	2 – 3	1.2		
Amphotoric Perfluoroalkyl Surfactant (%)	<2	<1		
Non-ionic Perfluoroalkyl-thio Surfactant (%)	<0.5	<0.5		
Synthetic Alkylsulfate Surfactants (%)	1 – 2	1 - 2		
Alkyl Polyglycoside Surfactant (%)	1 - 2	1 - 2		
Magnesium Sulfate Heptahydrate (%)	1 - 2	0.5 – 1.5		
Tolytriazole (%)	0.03	0.02		
Fluoroalkyl Surfactants (%)			1 – 7	1 - 5
PFOS	Nil	Nil	Present	Present
PFOA	Nil	Nil	Present	Present
Synthetic Detergents (%)			1 – 6	1 - 5

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[4] "Environmental Fate of new Fire Suppression Products (Ansulite AFFF & 3M RF) compared to Light Water. A Verification of Manufacturer's Claims", University of South Australia, April 2006.

In regards to properties relevant to handling, storage and co-processing at a cement kiln refer to Table 2 (Cement Australia test results). The foam concentrates are low calorific value (high water content) with low viscosity, low total chlorides and sulphur content and low metals content. As expected there is the presence of total fluorides which is elevated above the upper limit of 0.1% specified in Solvent Based Fuel and Industrial Wash Water.

The source material will be a combination of Ansulite and Light-Water fire fighting foam concentrates. This allows the foam concentrate mix to include PFCs, PFOS and PFOA. The actual proportions of substances and total fluoride of the trial mix will depend of availability of suitable material that will be procured by Geocycle (sourced from stocks in either Queensland or Interstate) and with the assistance of EHP.

Table 2: Properties of Fire fighting Foam Concentrates

Parameter	**Ansulite 3%**	**Ansulite 6%**	**Light-Water 3%**	**Light-Water 6%**
Specific Gravity (g/mL @ 20°C)	1.02	1.02	1.03	1.03
pH	5.7			7.8
Viscosity (cps @ 20°C)	85	80	200	150
Ash Content (%)	<0.1	<0.1	<0.1	<0.1
Gross Calorific Value (MJ/kg)	<5	<5	<5	<5
Total Chloride (%)	0.15	0.17	0.03	0.05
Total Fluoride (%)	0.4	0.2	2	1
Total Sulphur (%)	0.39	0.43	0.66	0.76
PCBs (mg/kg)	<0.2	<0.2	<0.2	<0.2
Arsenic (mg/kg)	1	1	1	1
Antimony (mg/kg)	1	1	1	1
Barium (mg/kg)	1	1	45	11
Cadmium (mg/kg)	1	1	1	1
Chromium (mg/kg)	1	1	1	2
Cobalt (mg/kg)	1	1	1	1
Copper (mg/kg)	2	1	3	1
Nickel (mg/kg)	1	1	1	1
Lead (mg/kg)	1	1	1	1
Selenium (mg/kg)	3	1	1	3
Thallium (mg/kg)	1	1	1	1
Vanadium (mg/kg)	1	1	1	1
Zinc (mg/kg)	5	3	2	5

Mercury (mg/kg)	0.02	0.01	0.02	0.0.04

Specification of Fire Fighting Foam to be received at Cement Australia Gladstone

			EHP Permit Requirement	
	Unit	**Reporting Precision**	**Lower Limit**	**Upper Limit**
Physical Properties				
Radioactivity			Not Detected	
Specific Gravity	g/mL	0.01		
Viscosity	Cps	1		
Ash	%	1		
pH		0.1		
Net Calorific Value	MJ/kg	0.1		
Constituent				
PCBs	ppm	n/a	0	0.2
Sulfur as (S)	% w/w	0.01	0	3.0
Total Fluorides	% w/w	0.01	0	2.5
Total Chlorides	% w/w	0.01	0.0	1.0
Heavy Metals				
Antimony (Sb)	ppm	1	0	200
Arsenic (As)	ppm	1	0	200
Cadmium (Cd)	ppm	1	0	14
Chromium (Cr)	ppm	1	0	1000
Cobalt (Co)	ppm	1	0	200
Lead (Pb)	ppm	1	0	1000
Mercury (Hg)	ppm	0.1	0	10.0
Nickel (Ni)	ppm	1	0	1000
Selenium (Se)	ppm	1	0	1000
Thallium (Tl)	ppm	0.1	0	7
Vanadium (V)	ppm	1	0	1000
Sum of Hg+Cd+Tl	ppm	1	0	20
Sum of As+Sb+Co+Ni+Pb+V+Cr	ppm	1	0	2500

Co-processing Trial Report

Condition G23 of the environmental authority EPPR00846713 outlines the requirements of a post alternative fuel trial report.
The following are sections provide the relevant detail to meeting the requirements of conditions G23 a. to j.

Total quantity of waste burnt during the trial

There was 9.62 tonnes of 0.3% F concentration fire fighting foam co-processed during the environmental trial.

Start time	End time	Average flow rate	Total volume of fire fighting foam combusted
28th September 2017 09:20	28th September 2017 16:45	0.96 tph Peak flow rate of 1.08tph	7.03 tonnes
29th September 2017 09:51	29th September 2017 15:24	0.5 tph Peak flow rate 0.9 tph	2.59 tonnes

The remaining material delivered to site was co-processed during process trials.

Dates and time of the trials

The trial was completed during the days of the 28th September and the 29th September 2017. The baseline independant extractive testing was completed on the 5th October and 13th December 2017.

Table 2: Trial dates and times

Trial	Start time	End time	Stack gas parameters sampled
Low Level Fluoride AFFF Trial through main burner	28th September 2017 09:20	28th September 2017 16:45	Polychlorinated Dioxins and Furans Polychlorinated Biphenyls Total Polycyclic Aromatic Hydrocarbons PFAS extended suite of compounds
Low Level Fluoride AFFF Trial through the main burner	29th September 2017 09:51	29th September 2017 15:24	Total Solid Particulates Chlorine Hydrogen Chloride Total Fluorides (as HF) ammonia Carbon Monoxide Sulphur Dioxide Oxides of Nitrogen (as NO2) Hydrogen Sulphide Total Heavy Metals Total Volatile Organic Compounds Total Hydrocarbons
Baseline	5th October 2017 09:16	5th October 2017 14:58	Polychlorinated Dioxins and Furans Polychlorinated Biphenyls Total Polycyclic Aromatic Hydrocarbons PFAS extended suite of compound
Baseline	13th December 2017 10:25	13th December 2017 16:06	Total Solid Particulates Chlorine Hydrogen Chloride Total Fluorides (as HF) ammonia Carbon Monoxide Sulphur Dioxide

			Oxides of Nitrogen (as NO2) Hydrogen Sulphide Total Heavy Metals Total Volatile Organic Compounds Total Hydrocarbons

During the environmental trial independent emission testing was undertaken by Airlabs Environmental Pty Ltd, their full emissions report is appended to this report.

The independent emissions testing was in addition to the continuous emission monitoring for stack gas temperature, stack gas exit velocity and volume flow, particulates, oxides of nitrogen, sulphur dioxide, carbon monoxide, ammonia, hydrogen chloride and volatile organic compounds.

Feed method and feed rate

The fire fighting foam was delivered to the solvent based fuel compound in IBCs, where it was pumped into a dedicated solvent based fuel tank, from here the fire fighting foam was pumped to the kiln 2 main burner firing pipe for co-processing. The fire fighting foam was added at a rate of up to 1.08 tph into the main burner.

Kiln Conditions

During the independant extractive testing conditions for the trial and baseline, both Industrial wash waters (IWW) and Calcined spent cell liner were being used as fuels on the kiln.

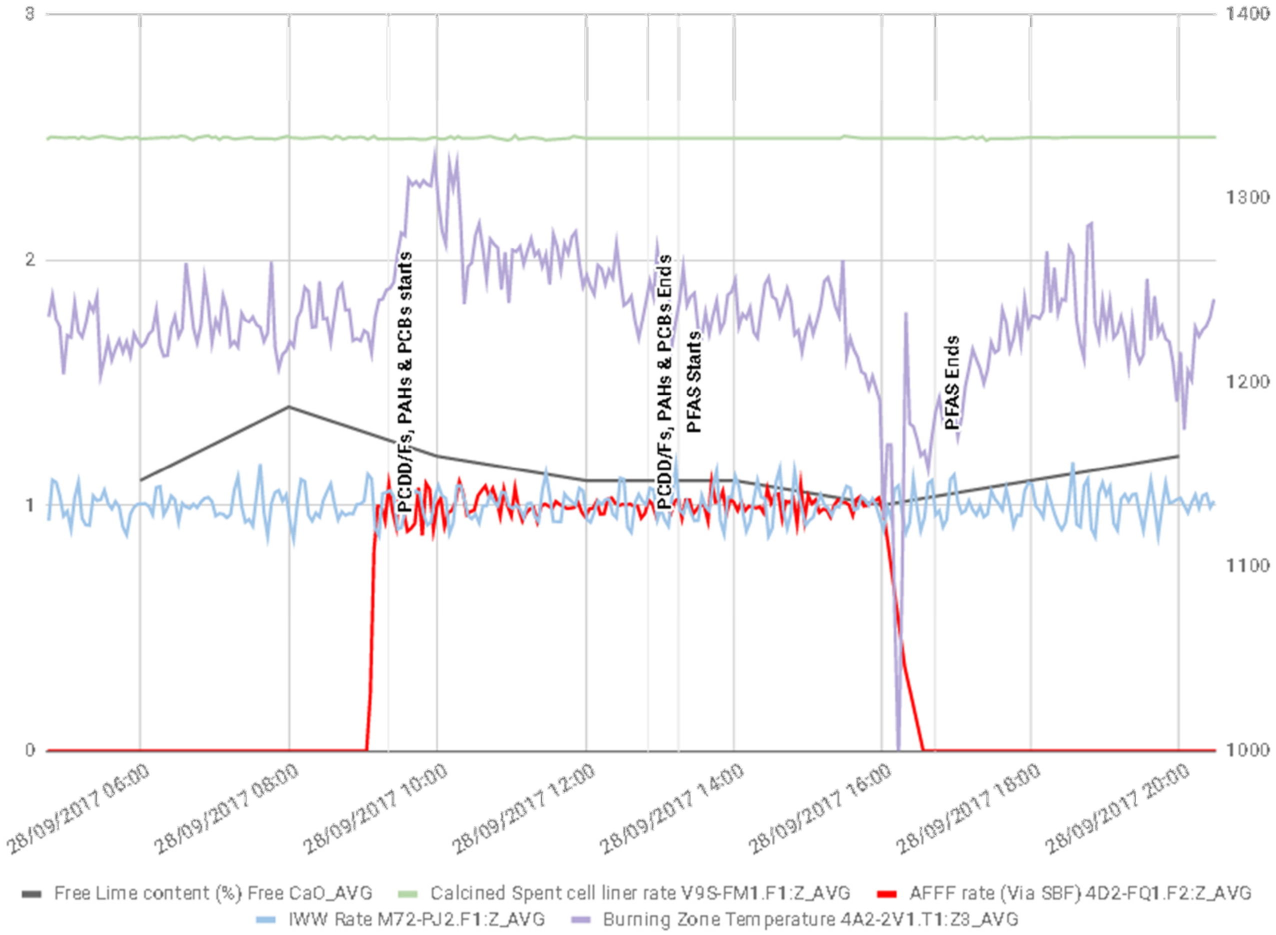


Figure 1: Kiln Conditions - Stack Test 28/9/2017

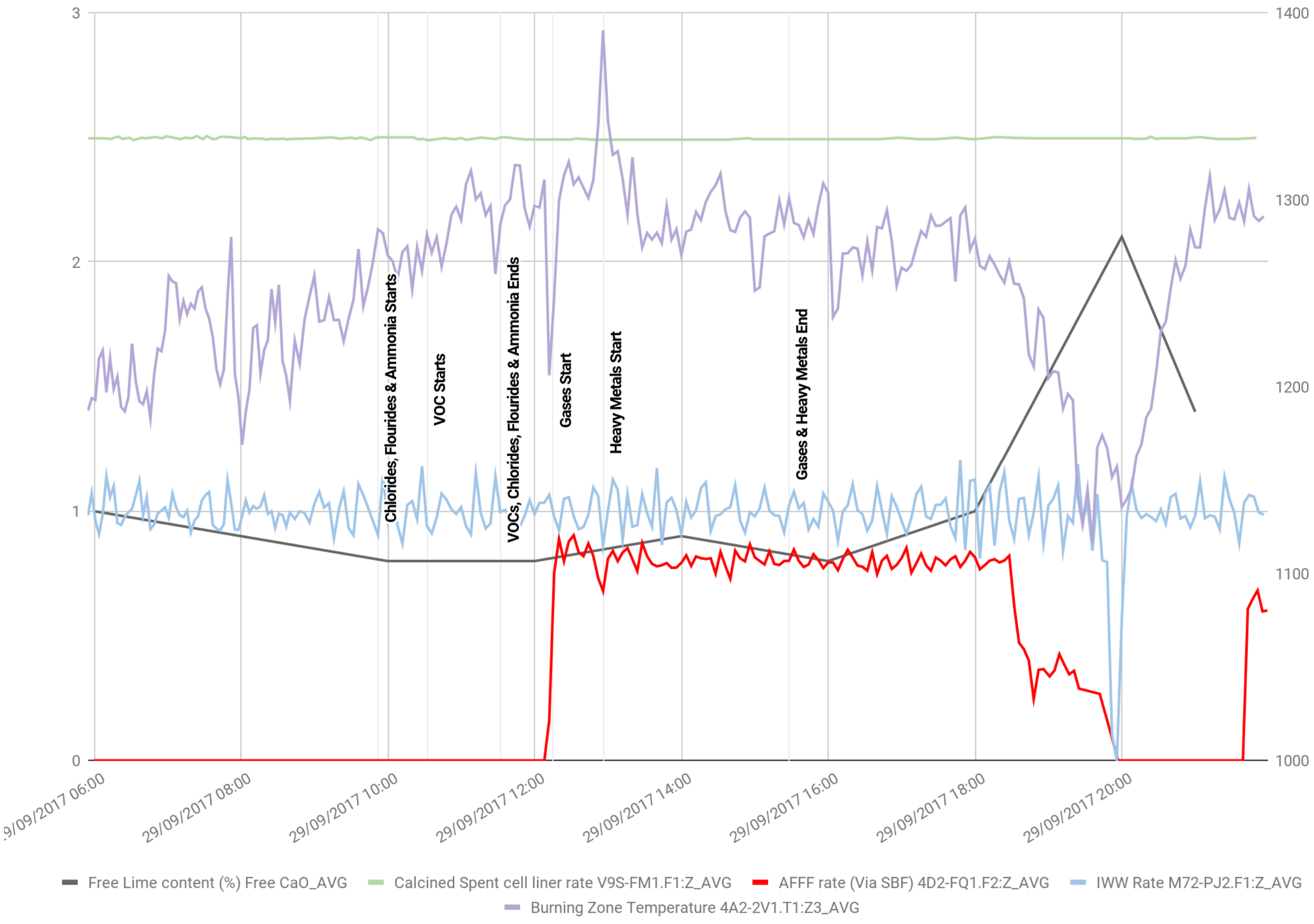


Figure 2: Kiln Conditions - Stack Test 29/9/2017

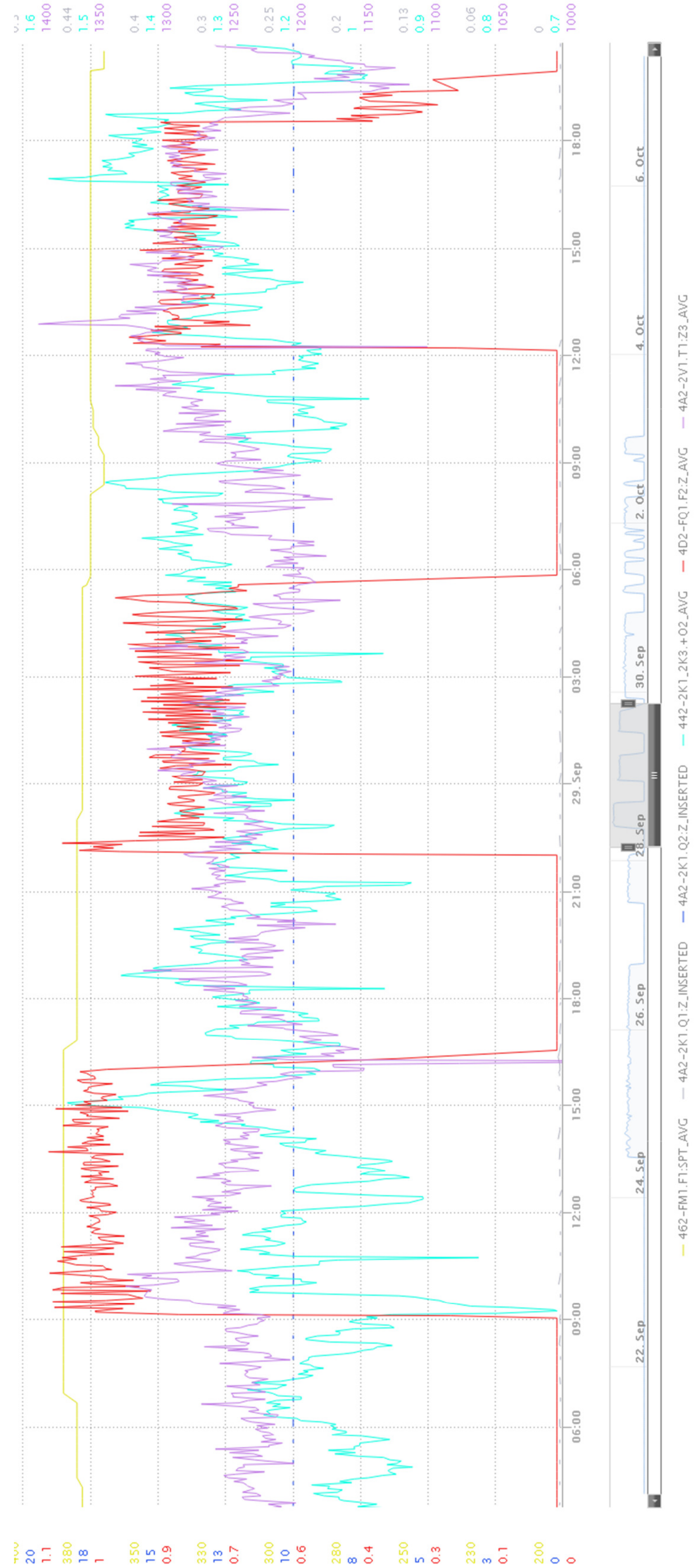


Figure 3: Oxygen and CO profile within the Kiln Inlet & Preheater during Fire fighting foam trial.

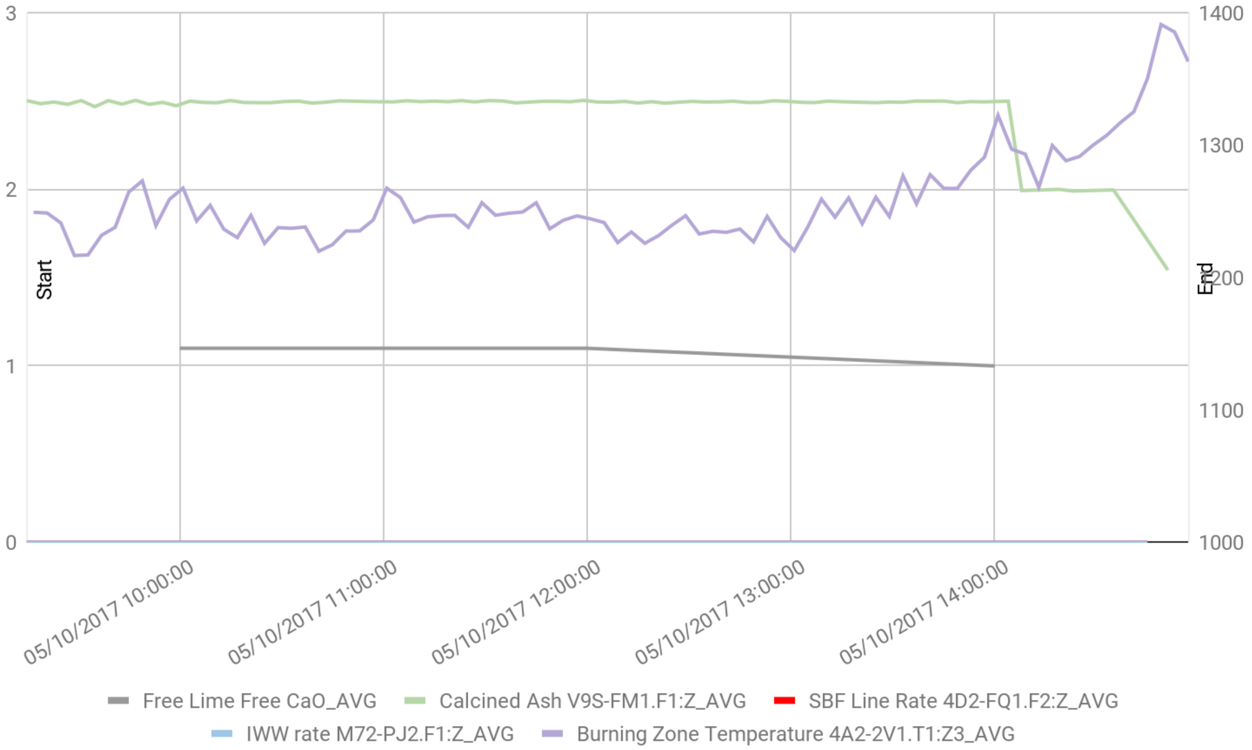


Figure 4: Baseline testing 5/12/2017

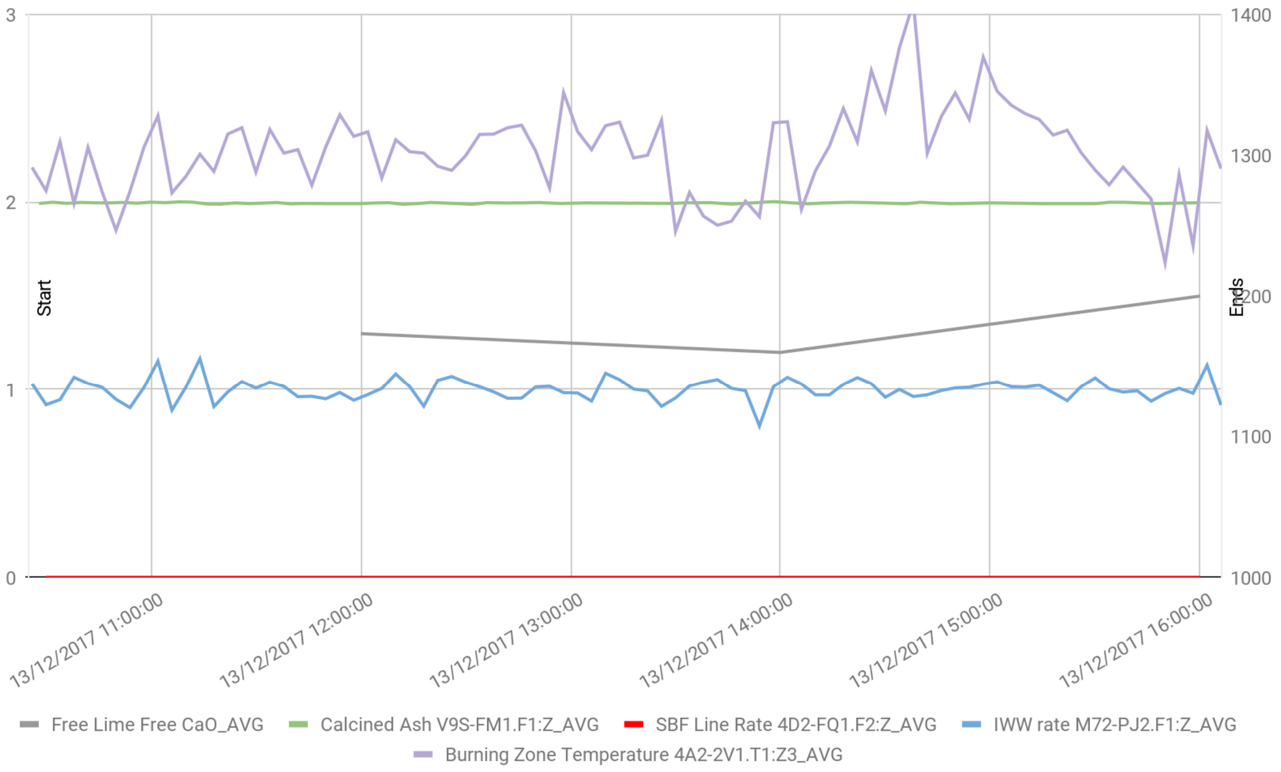


Figure 5: Baseline testing 13/12/2017

The kiln conditions during the trial are depicted in the graphs above . The independent extractive testing start and end time have been added to show the exact timing of the emissions trials by Airlabs Environmental Pty Ltd. The rate of the fire fighting foam addition was 0.99 tonnes per hour during the first stack tests, and 0.807 tonnes per hour during the second stack testing. It should be noted that the VOC, Chloride, Ammonia and Fluoride extractive testing was completed without any fire fighting foam being introduced into the system and therefore are not representative of the system during the destruction of PFAS materials.

During the initial stages of the introduction and cessation of the fire fighting foam addition into the kiln system, there was an initial period of kiln upset conditions. This is due to the large introduction of water into the main flame which rapidly reduced flame temperatures. Once stabilised the kiln performed as normal. It was noted that the amount of coal required at the main burner was higher than that required when no AFFF was utilised, this is due to the cooling effect on the main flame from the increased moisture content. The trial data also suggests that an overall benefit is seen when introducing fire fighting foam at rates of 0.5 TPH.

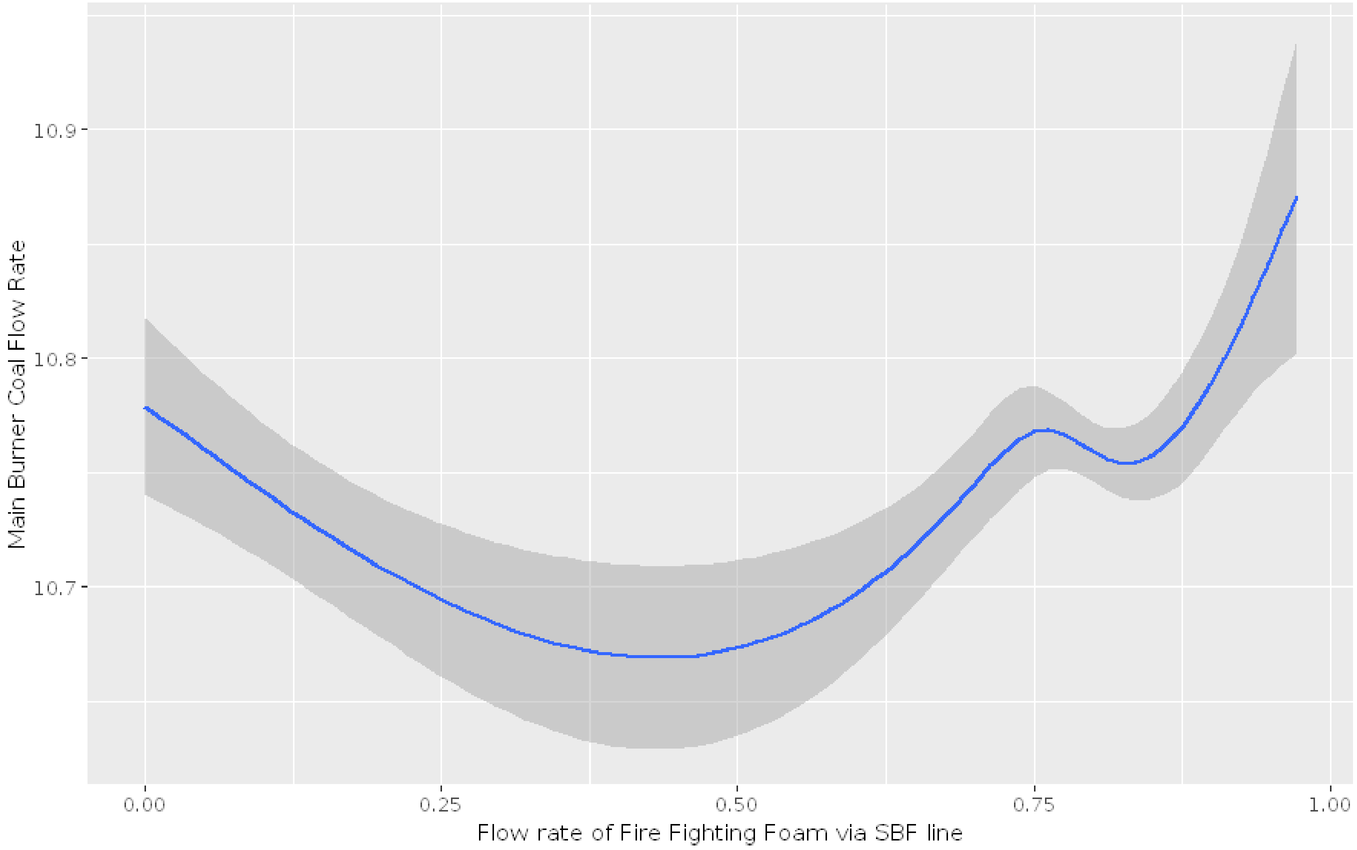


Figure 6. Graph of Fire Fighting Foam Flow rates versus Main Burner coal.

Clinker was sampled prior to the fire fighting foam trial and during and tested for PFAS, Fluoride content, microscopy and grindability.

The PFAS and Fluoride testing was carried out by Eurofins (Report 566485-S). The results , as shown in Appendix 3, showed that the PFAS and Fluoride content were below detectable limits for both samples.

The clinker microscopy and grindability results (see appendix 5) showed that subtle differences in the clinker micro-structure concurrent with the lower free lime content, curtailed dust and reduced porosity demonstrated that slightly harder burning efforts were required to produce the same quality product for the trial sample as the control. That said, from the overall microscopical examinations both products are considered commensurate with a high performance ordinary Portland Cement (OPC) clinker. With the exception of the aforementioned, little or no difference was found between the two materials with respect to the chemistry, hypothetical Bogue calculation values and the clinker moduli.

Overall, the kiln was able to successfully process the firefighting foam via the main burner without any significant changes to process or quality of the clinker produced.

Independent stack emission testing

The following table shows the independent emission results comparing the baseline testing with the fire fighting foam trial trial.

The table also shows the kiln emission limits in Schedule G Table 2 of the Environmental Authority EPPR00846713 and well as the recommended limits for cement kilns co-incinerating waste from the Directive 2000/76/EC on the incineration of waste.

The Waste Incineration directive includes a summation of heavy metals limits as well as an individual species limit, this has been included into the table. The calculation used for this uses the limit of laboratory detection for individual species if no higher rate reported. The emission results from the trial are extremely low compared to either referenced figure.

Emissions Testing Results

Parameter	Trial		Baseline		Environmental Authority Emission Limit Value
Main Stack (mg/Nm3 dry STP 7% O2 (unless stated otherwise))	Independant	CEMS	Independant	CEMS	
Oxides of nitrogen	850	1096.35	970	1084.47	1200
Sulphur Dioxide	<2	0.13	<2	0.12	100
Total particulates	1.9	2.42	3.1	5.58	100
Carbon monoxide	91	98.94	170	160.04	
Total volatile organic compounds (is the summation of individual VOCs as reported by measurement using USEPA method 18)	0.88	6.87	1.5	5.66	20
Ammonia	0.0058	0.33	0.27	0.27	
Hydrogen Chloride	0.28	0.88	3.4	2.37	200
Total fluoride (as HF)	0.045		0.031		50
Total heavy metals (including antimony, cadmium, lead, mercury, beryllium, chromium, cobalt, manganese, nickel, selenium and vanadium and their compounds)	0.017		0.015		1
Polyaromatic hydrocarbons as BaP (BaP-TEQ for PAHs including half LOD) (ug/Sm3 STP 11% O2)	0.006		0.006		0.1
Dioxins and Furans (NATO '89 I-TEQ for PCDDs and PCDFs including half LOD) using the NSW EPATM-18 method (ng/Sm3 STP 11% O2)	0.00041		0.00026		0.1
Total hydrocarbons (C10 - C36)	<0.6		<6		
Hydrogen Sulphide	1.1		1.4		
Chlorine and chlorine compounds; expressed as chlorine for compounds other than HCl	0.13		0.033		
Total polychlorinated biphenyls WHO '05 TEQ for PCBs (inlcuding half LODs) (ng/Sm3 STP 10% O2)	0.000022		0.000023		
Water (%)	6.56		10		
Oxygen (%)	9.72		10.1		
Temperature (deg C)	140		115		

Destruction and Removal Efficiency Calculation for PFAS Compounds

Where analytical detection limits did not restrict the calculation of the Destruction and removal Efficiency Calculation (DRE) then PFAS compounds had a calculated DRE >99.99%. PFAS species of concern such as PFOS, PFOA and PFHxS all had calculated DRE >99.999%.

Publicly available information for PFAS DRE to provide best available practice is not easily identified. The Ministry of Environment Japan has issued a technical guideline that the DRE for PFOS and its salts must be >99.999%.

Air dispersion modelling

Air dispersion modelling was not deemed as a requirement of the trial by the administering authority.

Plant pollution control equipment, kiln or stack conditions

During the trial, the continuous emission monitors were all working correctly with their results shown in the table above. There were no results during the trial that were of concern to the combustion process and that would impact the destruction of the fire fighting foam.

Overall trial effectiveness

According to the Stockholm Convention on persistent organic pollutants (POPS), PFCs (and other POPs) should be disposed of in such a way that the persistent organic pollutant content is destroyed or irreversibly transformed so that they do not exhibit the characteristics of POPs. Cement kilns are recognised by the Basel Convention for the destruction of POPs.

It can be seen from the above table and the demonstration of the Destruction and Removal Efficiency calculation that the co-processing of fire fighting foam through the main burner is very effectively achieved. Further to this, it can be seen that there are fuel efficiency and associated emissions reductions achieved by co-processing fire fighting foam within the clinker manufacturing process. This is demonstrated by the oxides of nitrogen and dioxins and furans emissions reduction when compared to the baseline independant extractive testing.

Complaints &/or Enquiries

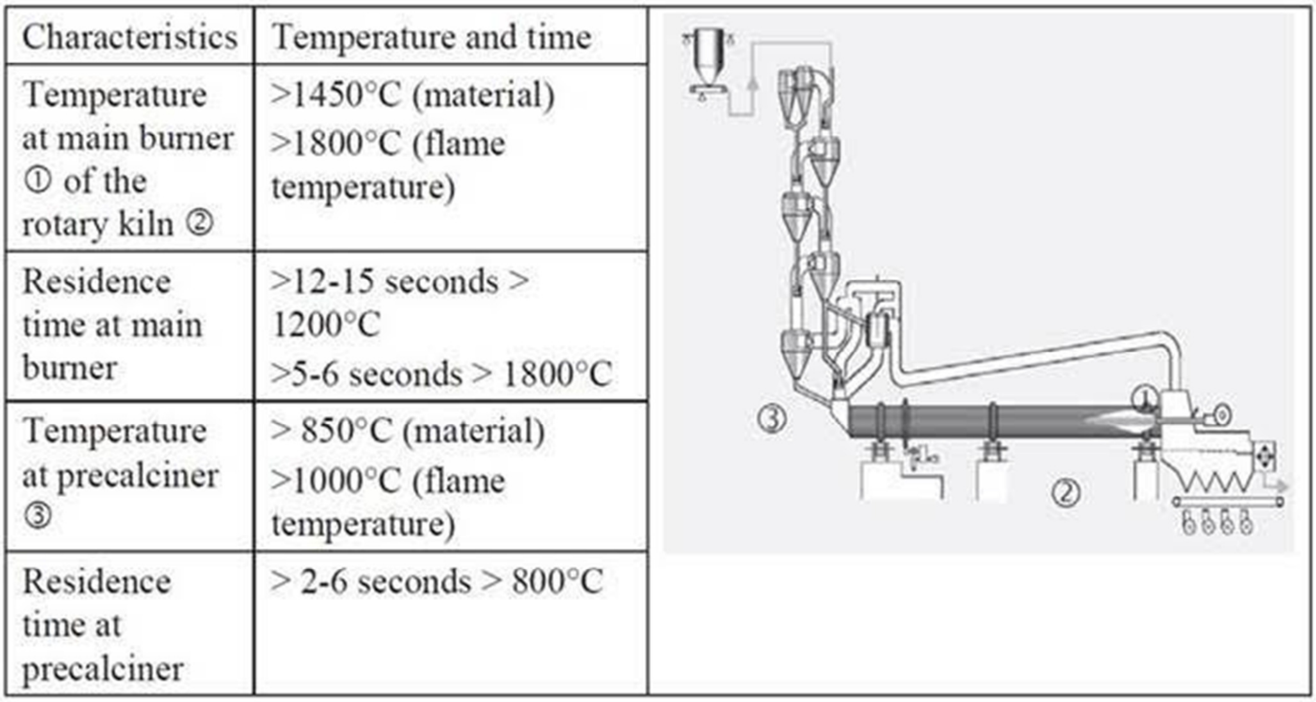
There were no complaints or enquiries about the wastes or the trial that was undertaken.

Suitability of Fire Fighting Foam for Co-processing via the main burner of kiln 2

The kiln process is an extremely effective method of destroying the PFAS containing fire fighting foam, this is due to the gas residence time and gas temperature found within the clinker manufacturing kiln. The trial has proven that the introduction of fire fighting foam via the main burner will destroy the PFAS containing compounds.

As illustrated in the figure below, the temperature and residence times of the precalciner are in excess of 850°C and between 2 and 6 seconds, on this basis it is expected that this same destruction and removal efficiency of PFAS compounds will be achieved by co-processing fire fighting foam via the precalciner of the kiln 2 clinker manufacturing system.

Figure IV
Temperatures and residence times during cement manufacture



Characteristics	Temperature and time
Temperature at main burner ① of the rotary kiln ②	>1450°C (material) >1800°C (flame temperature)
Residence time at main burner	>12-15 seconds > 1200°C >5-6 seconds > 1800°C
Temperature at precalciner ③	> 850°C (material) >1000°C (flame temperature)
Residence time at precalciner	> 2-6 seconds > 800°C

Appendix 1

Airlabs Environmental Pty Ltd
Stack Emission Monitoring conducted on the Main Clinker Stack (RP A4) at Cement Australia Gladstone - Low Fluoride AFFF Destruction Trial (reference SEP17202.2)

Appendix 2

Eurofins Management Certificate of Analysis Fire Fighting Foam (reference 575272-W)

Appendix 3

Eurofins Management Certificate of Analysis Clinker (Reference 566485-S)

Appendix 4 - PFAS Compound Analysis Results and Destruction and Removal Efficiency Calculation Results

PFAS extended suite (applying the total oxidisable precursor analysis (TOPA), to provide analysis of the PFAS extended suite of 28 compounds using the USEPA SW-846 0010 modified method. The modification relates to the modified method 5 sampling train, which requires a different absorbent resin due to the volatility of the compounds. The analysis will be conducted at the Eurofins MGT Brisbane Laboratory.

Individual PFAS Results	**Stack Emissions During Trial**			**Stack Emissions During Baseline**	Fire Fighting Foam Combusted			DRE Calculation
	Concentration of emission	Rate of emission	Mass Emission Rate (MRout)		Sample ID REF 171130-21 WATER (dated 30/11/17)	Amount of each PFAS substance fed to the kiln during PFAS testing per minute (ug/min)	Mass Feed Rate In (MRin)	
	mg/m3	g/min	50% of LOR (where the result is <) (g/min)	mg/m3	ug/litre	50% of LOR (where the result is <) (ug/min)	Volume of PFAS substance fed to kiln per minute (g/min)	%
Perfluorobutanoic acid (PFBA)	<0.000005	<0.00004	0.00002	<0.000005	5300	72408.09524	0.07241	99.97238
Perfluoropentanoic acid (PFPeA)	0.0000001	0.00000079	0.00000079	<0.000005	7600	103830.47619	0.10383	99.99924
Perfluorohexanoic acid (PFHxA)	<0.000005	<0.00004	0.00002	<0.000005	34000	464504.76190	0.46450	99.99569
Perfluoroheptanoic acid (PFHpA)	0.000000048	0.00000039	0.00000039	<0.000005	9100	124323.33333	0.12432	99.99969
Perfluorooctanoic acid (PFOA)	0.0000001	0.00000079	0.00000079	<0.000005	23000	314223.80952	0.31422	99.99975
Perfluorononanoic acid (PFNA)	<0.000005	<0.00004	0.00002	<0.000005	<200	1366.19048	0.00137	98.53608
Perfluorodecanoic acid (PFDA)	<0.000005	<0.00004	0.00002	<0.000005	<200	1366.19048	0.00137	98.53608
Perfluoroundecanoic acid (PFUnA)	0.0000001	0.00000079	0.00000079	<0.000005	<200	1366.19048	0.00137	99.94217
Perfluorododecanoic acid (PFDoA)	<0.000005	<0.00004	0.00002	<0.000005	<200	1366.19048	0.00137	98.53608
Perfluorotridecanoic acid (PFTrDA)	<0.000005	0.00000039	0.00000039	<0.000005	<200	1366.19048	0.00137	99.97145
Perfluorotetradecanoic acid (PFTeDA)	0.000000048	<0.00004	0.00002	<0.000005	<200	1366.19048	0.00137	98.53608

Individual PFAS Results	Stack Emissions During Trial			Stack Emissions During Baseline	Fire Fighting Foam Combusted			DRE Calculation
Perfluorooctane sulfonamide (FOSA) <0.000005	<0.000005	<0.00004	0.00002	<0.000005	<1000	1366.19048	0.00137	98.53608
N-methylperfluoro-1-octane sulfonamide (N-MeFOSA)	<0.000005	<0.00004	0.00002	<0.000005	<1000	1366.19048	0.00137	98.53608
N-ethylperfluoro-1-octane sulfonamide (N-EtFOSA)	<0.000005	<0.00004	0.00002	<0.000005	<1000	1366.19048	0.00137	98.53608
2-(N-methylperfluoro-1-octane sulfonamide)-ethanol (N-MeFOSE)	<0.000005	<0.00004	0.00002	<0.000005	<1000	1366.19048	0.00137	98.53608
2-(N-ethylperfluoro-1-octane sulfonamide)-ethanol (N-EtFOSE)	<0.000005	<0.00004	0.00002	<0.000005	<1000	1366.19048	0.00137	98.53608
N-ethyl-perfluorooctanesulfonamidoacetic acid (N-EtFOSAA)	<0.000005	<0.00004	0.00002	<0.000005	<1000	1366.19048	0.00137	98.53608
N-methyl-perfluorooctanesulfonamidoacetic acid (N-MeFOSAA)	<0.000005	<0.00004	0.00002	<0.000005	<1000	1366.19048	0.00137	98.53608
Perfluorobutanesulfonic acid (PFBS)	<0.000005	<0.00004	0.00002	<0.000005	31000	423519.04762	0.42352	99.99528
Perfluoropentanesulfonic acid (PFPeS)	<0.000005	<0.00004	0.00002	<0.000005	31000	423519.04762	0.42352	99.99528
Perfluorohexanesulfonic acid (PFHxS)	0.00000024	<0.00004	0.00002	<0.000005	230000	3142238.09524	3.14224	99.99936
Perfluoroheptanesulfonic acid (PFHpS)	<0.000005	<0.00004	0.00002	<0.000005	29000	396195.23810	0.39620	99.99495
Perfluorooctanesulfonic acid (PFOS)	<0.000005	<0.00004	0.00002	<0.000005	2090000	28553380.95238	28.55338	99.99993
Perfluorodecanesulfonic acid (PFDS)	<0.000005	<0.00004	0.00002	<0.000005	640	8743.61905	0.00874	99.77126
1H.1H.2H.2H-perfluorohexanesulfonic acid (4:2 FTS)	<0.000005	<0.00004	0.00002	<0.000005	<200	1366.19048	0.00137	98.53608

1H.1H.2H.2H-perfluorooctanesulfonic acid (6:2 FTS)	<0.000005	<0.00004	0.00002	<0.000005	25000	341547.61905	0.34155	99.99414
1H.1H.2H.2H-perfluorodecanesulfonic acid (8:2 FTS)	<0.000005	<0.00004	0.00002	<0.000005	7800	106562.85714	0.10656	99.98123

Appendix 5 -Clinker Microscopy and Grindability Report

Appendix 6 - Department of Environment Response to Request for Information following submission of trial notification

Air Quality Monitoring Programme

EHP Requests

- Heavy metals should be included in the list of parameters required to be monitored.
- Sulphuric dioxide should be corrected to sulphur dioxide.
- Parameter total hydrocarbon should be replaced by total volatile organic compounds (TVOC).
- Continuous measurements for pressure, temperature (preheater, kiln and stack), moisture, oxygen (preheater, kiln and stack), particulates, NO_x, CO and SO_2.
- Continuous measurement of Total fluoride (as HF).
- Periodic monitoring of HCL, PCDD, F, Ammonia, cyanide, H_2S, TVOC, PAH including BaP and PFAS extended suite containing 21 compounds.

Cement Australia Response

Parameter	Environmental Authority Requirement (Schedules B and H)	Environmental Authority - Kiln Burning Trial Requirement (Schedule G)	Cement Australia monitoring requirements
Continuous stack emissions monitoring			
Oxides of nitrogen	✓	✓	✓
Sulphur dioxide	✓	✓	✓
Total particulates	✓	✓	✓
Parameter	Environmental Authority Requirement (Schedules B and H)	Environmental Authority - Kiln Burning Trial Requirement (Schedule G)	Cement Australia monitoring requirements
Carbon monoxide			✓
Volatile organic compounds			✓
Ammonia		✓	✓
Hydrogen Chloride			✓
Water	✓		✓
Oxygen	✓		✓
Temperature	✓		✓
Preheater and Kiln continuous process gas analysis			
Oxygen		✓	✓
Temperature		✓	✓

Independent Extractive Testing			
Total Fluoride (as HF)	✓	✓	
Total heavy metals (including antimony, cadmium, lead, mercury, beryllium, chromium, cobalt, manganese, nickel, selenium and vanadium and their compounds)	✓		
Polyaromatic hydrocarbons as BaP (BaP-TEQ for PAHs including half LOD)	✓	✓	
Dioxins and Furans (NATO ‘89 I-TEQ for PCDDs and PCDFs including half LOD) using the NSW EPATM-18 method	✓	✓	
Total hydrocarbons		✓	
Hydrogen Sulphide		✓	

Parameter	Environmental Authority Requirement (Schedules B and H)	Environmental Authority - Kiln Burning Trial Requirement (Schedule G)	Cement Australia monitoring requirements
Chlorine and chlorine compounds; expressed as chlorine for compounds other than HCl		✓	
Total polychlorinated biphenyls WHO 1998 BaP-TEQ		✓	
Total volatile organic compounds (is the summation of individual VOCs as reported by measurement using USEPA method 18)	✓		

PFAS extended suite (applying the total oxidisable precursor analysis (TOPA), to provide analysis of the PFAS extended suite of 21 compounds using the USEPA SW-846 0010 modified method. The modification relates to the modified method 5 sampling train, which requires a different absorbent resin due to the volatility of the compounds. The analysis will be conducted at the Eurofins MGT Brisbane Laboratory.			✓

Frequency of independent extractive testing

The above suite of independent extractive testing is to be conducted at the maximum fire fighting foam fluoride concentration co-processing condition at least once per each trial scenario: Baseline, combustion of fire fighting foam via the kiln main burner, combustion of fire fighting foam via the calciner.

The sampling time will comply with the relevant sampling standard and will be completed by Airlabs Environmental NATA accredited laboratory.

Quality Assurance and Quality Control

EHP Requests

QA is necessary for ensuring that all data and the decisions resulting from that data are technically sound, statistically valid, and properly documented. QC checks includes blanks, spikes, replicates, and frequency of monitoring. Continuous emission monitoring system (CEMS) must be calibrated and maintained as required by the manufacturer's specification. The raw material including PFAS also needs to be monitored for relevant parameters at a reasonable frequency. This information was not provided in the proposal.

Cement Australia Response

Continuous emissions monitoring quality assurance

Continuous emissions monitoring systems are calibrated and maintained according to the manufacturer's requirements.

Independent extractive emissions testing

The emissions sampling is conducted by Airlabs Environmental who are a NATA accredited laboratory, the sample is then sent to a NATA accredited laboratory for analysis. All testing and analysis is conducted to comply with the relevant standard, including the required quality control checks.

Overall data quality assurance

The data provided by the laboratories and also the process and stack emissions data is validated to ensure that the data is representative of the expected performance parameters of the clinker manufacturing operations, where there are data outliers found, this would be investigated with subsequent follow up sampling and analysis completed where necessary.

Fire Fighting Foam - PFAS Analysis

Fire fighting foam is sampled and analysed to determine the compliance of the material against the agreed quality control specification, in addition the material will be analysed to quantify the degraded compounds of the fire fighting foam into PFAS compounds, applying the total oxidisable precursor analysis (TOPA), to provide analysis of the PFAS extended suite of 21 compounds.

Fire Fighting Foam Feed Rate

EHP Request

According to the Basel Convention guidelines, high levels of fluorine will affect setting time and strength development in clinker, cement and final product. We hope that Cement Australia has used some mass balance method to decide PFAS feed rate of 1 tph. This is to ensure that the quality of the final product meets the standard specifications. Is there any plan to do the trial using variable feed rate?

Cement Australia Response

Cement settling times behaviour only starts to be impacted when the fluoride percentage is greater than 1% within cement, the total percentage of fluoride in the raw material and fuel chemistry will not exceed 1%.

A mass balance calculation has been completed to inform the ideal feedrate for the fire fighting foam trial. The mass balance calculation considers raw material inputs, fuels and the impact on clinker, cement and stack emissions.

Trial Design

During the trial, the only other alternative fuel to be utilised will be calcined ash, as per the trial design plan. Calcined ash will be run in accordance with the plant operating parameters.

The trial of fire fighting foam via the main burner flame will be completed first. This will use the existing Solvent Based Fuel (SBF) delivery system. Once this trial has been proven successful by the Department, the trial via the calciner, using the Industrial Wash Water (IWW) delivery system will be completed. Each trial run will be carried out over a minimum of 24 hours to ensure that production impacts are able to be statistically verified. The stack testing will be used to demonstrate the destruction efficiency of the product, and the variance on coal consumption from baseline will be used to show any process benefits from the CaF_2 formed within the destruction process.

A dedicated tank within the IWW and SBF facilities will be isolated and cleaned out prior to the trials to ensure that there is no mixing of fire fighting foam product with alternative fuels.

The fire fighting foam to be destroyed will be within the following fluoride content bands;

1. 0.2 - 0.4% Fluoride bracket, with a target of 0.3% Fluoride
2. 0.4 - 0.7% Fluoride, with a target of 0.6% Fluoride.

Run Order	Flow rate (t/h)	%F	Calcined Ash
1	0.5	0.3	Off
2	1	0.3	Off
3	1	0.3	On
4	0.5	0.3	On
5	0.5	0.6	On
6	1	0.6	On
7	1	0.6	Off
8	0.5	0.6	Off

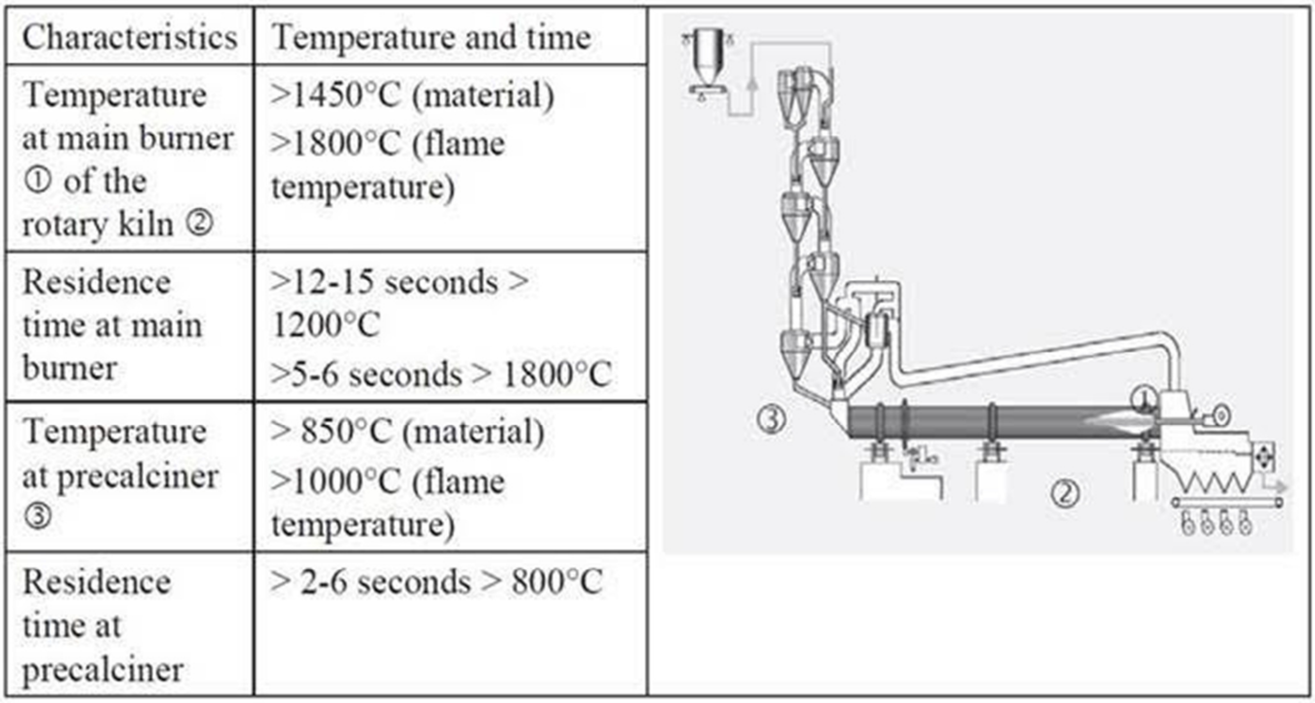
Temperature and Residence Time

EHP Request

According to the Basel Convention guidelines for co-processing of hazardous waste the cement kiln must meet the following temperature and residence time:

Figure IV

Temperatures and residence times during cement manufacture



Characteristics	Temperature and time
Temperature at main burner ① of the rotary kiln ②	>1450°C (material) >1800°C (flame temperature)
Residence time at main burner	>12-15 seconds > 1200°C >5-6 seconds > 1800°C
Temperature at precalciner ③	> 850°C (material) >1000°C (flame temperature)
Residence time at precalciner	> 2-6 seconds > 800°C

We are not sure that the cement kiln meets the above criteria. We are particularly concerned about the third trial when the fire fighting foam injected via the calciner burning system. Is the residence time and temperature sufficient for both second and third trials to meet destruction efficiency criterion of 99.99%.

Cement Australia Response

During the meeting David Darlow presented data from the real-time on line Cement Australia kiln control system and also computerised fluid dynamic modelling completed on the precalciner injection points. Both items demonstrated that the required precalciner and kiln operating temperatures and residence times are achieved. In addition, the control system set points and shut off mechanisms allow full automation of the alternative fuel feed systems, this ensures that waste derived fuels cannot be fed into the kiln, should operating temperatures reduce below the required 850°C within the precalciner vessel.

Further to this, fire fighting foam (PFOS) has been shown to be converted to CaF_2 at temperatures as low as 400°C when in the presence of lime products, such as within the kiln and preheater system. Research has shown (Wang et al. 2011[5]) that whilst PFOS does not decompose below 425° C, in the presence of lime products (such as those within the cyclones and precalciner), the presence of $Ca(OH)_2$ triggered the decomposition of PFOS at temperatures as low as 350° C. They also found that the 80-90% conversion from PFOS to CaF_2 at 900°C at 1:1 Ca:F molar ratio, with a residence time of 1 second. The research also notes that increasing the Ca:F ratio increases the decomposition. Given that the Ca:F ratio within the clinker manufacturing operation will be in the region of 750:1 and that CFD modelling shows that the introduction point achieves >1000°C for 0.3 seconds and 850°C for 1.7s, before being exposed to the gas suspension preheaters (5 stages all above 350°C), Cement

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[5]

Australia is confident that full decomposition within the calciner is possible, and that catalytic decomposition with lime, which allows for lower operating temperatures, will occur.

Best Practice Air Emissions Standards

EHP Request

We understand the caloric value and heavy metal concentration of PFAS are very low. Thus the material does not add value to the combustion process (low heating value) and the product (low mineral composition). The purpose of this trial and the future use is to find alternative safe disposal of hazardous material. Therefore, it is important that the trial must meet the best practice air pollution emission standards. Here is a comparison of some national and international standards for cement kiln main stack:

Contaminant	**NSW EPA POEO Regulation** (see Note 2)	**European Commission (2000/76/EC)** (see Note 3)	**German Standards (mg/N m^3(dry) at 11% O_2)**	**Spanish Standards (mg/N m^3 (dry) at 11% O_2)**
Total solid particulate	50 mg/N m^3 (dry)	30 mg/N m^3 (dry) at 10% O_2	10 – Daily 30 - ½ hourly	10 – Daily 30 - ½ hourly
Oxides of nitrogen as NO_2	400 mg/N m^3(dry)	800 mg/N m^3 (dry) at 10% O_2	200 – Daily 400 - ½ hourly	616 – Daily
Sulphur dioxide	-	50 mg/N m^3 (dry) at 10% O_2	50 – Daily 200 - ½ hourly	50 – Daily 200 - ½ hourly
Chlorine and its compounds	-	-	-	-
Hydrogen chloride (HCl)	-	10 mg/N m^3 (dry) at 10% O_2	10 – Daily 60 - ½ hourly	10 – Daily 60 - ½ hourly
Total fluoride (as HF)	50 mg/N m^3 (dry)	1 mg/N m^3 (dry) at 10% O_2	1 – Daily 4 - ½ hourly	1 – Daily 4 - ½ hourly
Total volatile organic compounds (TVOC)	40 mg/N m^3 (dry)	10 mg/N m^3 (dry) at 10% O_2	10 – Daily 20 - ½ hourly	10 – Daily 20 - ½ hourly
Total Heavy Metals (see Note 1)	1 mg/N m^3 (dry)	0.5 mg/N m^3 (dry) at 10% O_2 sample period of 30 minutes to 8 hours)	0.5 (Average over the sample period of 30 minutes to 8 hours)	0.5 (Average over the sample period of 30 minutes to 8 hours)
Polycyclic	-	Regulator to specify	-	-

Aromatic Hydrocarbons as BαP (BaP-TEQ for PAHs incl. half LOD)		the limit		
Dioxins and furans NATO '89 I-TEQ for PCDDs and PCDFs (incl. half LOD)	0.1 ng/S m^3 (dry) at 11% O_2	0.1 ng/S m^3 (dry) at 10% O_2(averaged over sample period 6 to 8 hours)	0.1 ng/S m^3(dry) at 11% O_2(averaged over sample period 6 to 8 hours)	0.1 ng/S m^3 (dry) at 11% O_2(averaged over sample period 6 to 8 hours)

Note 1: - Total heavy metals limit is for the total of antimony, arsenic, cadmium, lead, mercury, beryllium, chromium, cobalt, manganese, nickel, selenium, and vanadium and their compounds.

Note 2: In NSW, concentration limits for cement kiln except dioxins are reported to measured reference level (no oxygen correction required).

Note 3: According to European Commission directives, all concentrations limits for cement kiln must refer to 10% O_2 reference level.

EHP recommend that the trial should target to meet the above best practice stack emission standards.

Cement Australia Response

The addition of fire fighting foam into the clinker manufacturing process provides a fluoride addition to the raw material chemistry within the preheater tower. Fluoride accelerates the liquid phase within the kiln, known as mineralisation. The mineralization effect has been widely utilised within the cement industry as a means to increase thermal efficiency within the process; through the reduction in the required burning temperatures of 1400°C by up to 150°C. This means that less thermal energy is required to convert the ground limestone into clinker within the kiln, through the formation of lower temperature eutectic melt phases, allowing alite formation at lower temperatures (Yamashita et al 2011[2], Perez Mendes et al 1986[3]) . Since the thermal energy requirement is decreased with an increase of mineralization, there will be less combustion related emissions , as compared to the manufacturing process when fluoride is not added. On this basis, whilst the fire fighting foams do not provide the same direct benefits as "conventional" alternative waste derived fuels in terms of having calorific value, they do have the effect of lowering the overall heat required within the clinker manufacturing process.

It follows that with a fuel consumption benefit the associated stack emissions would be reduced too. The clinker manufacturing process at Gladstone uses best available technologies for oxides of nitrogen and particulate emissions control: A selective non-catalytic reduction system, using ammonia introduced into the gas stream within the preheater, is used to reduce the oxides of nitrogen emissions generated within the kiln. A bag filter is used to abate particulate emissions.

The combustion of fire fighting foams within the kiln presents a significant waste management solution to the community, by co-processing fire fighting foams in a totally enclosed process, that will not generate any subsequent waste, whilst at the same time providing fuel consumption benefits to the clinker manufacturing process. This is an excellent example of a sustainable waste management solution for a waste, where the alternative destruction method is via a highly energy intensive waste incinerator that would require subsequent waste management of the ash generated from the process.

Destruction Efficiency

EHP Request

To better understand where the Fluoride goes, could you provide the following:

1. Feed rate data of Fluoride vs Calcium;
2. CaF_2 in the end product; and
3. Expected PFAS destruction efficiency and proposed measurement methods.

Cement Australia Response

1. Feed rate data of Fluoride vs Calcium

Cement Australia already has experience with processing fluoride containing materials, through the destruction of Calcined Ash in the process, with no detrimental impacts to the environment or the quality of the end products. Calcined ash has high fluoride contents (approx 13% F, in the forms Na_3AlF_6, NaF, CaF_2). The table below shows the balance of fluoride through the system , of which most of the fluoride reports through to the final product.

Sample Date	Clinker produced (T)	Calcined ash Consumed (T)	Fluoride content in clinker (mg/kg)	Total Fluoride in stack (mg/NM^3)
18/3/14	5241.1	56.9	1230	<0.05
18/6/14	5231.5	58.1	1260	
16/9/14	5337.1	51.3	1000	
15/12/14	4644.9	38.2	1020	
23/3/15	5405.1	32.2	730	
11/6/15	5353.3	41.9	1070	<0.2
30/9/15	5296.8	54.0	880	
15/12/15	5015.6	44.0	740	<0.1
15/3/16	5525.9	72	1260	<0.1
1/7/16	5308.2	48	1400	

2. Expected PFAS destruction efficiency and proposed measurement methods

A low level process trial of Industrial Wash Water containing fire fighting foam at a fluoride concentration of 0.1% was completed between October and December 2016. The Industrial Wash Water, containing fire fighting foam was introduced via our Industrial Wash Water system and injected into the precalciner of the kiln. All aspects of the activity fully complied with the requirements of the environmental permit (EPPR00846713) for the cement manufacturing operation, in particular the industrial wash water fully complied with the specification for industrial wash water as per the definitions in table 2.

The process trial consisted of the combustion of four separate loads of Industrial Wash Water containing 0.1% fluoride containing fire fighting foam. For each load independent, NATA accredited analysis was conducted on the Industrial Wash Water and the stack emissions to determine the concentration of polychlorinated dioxins & furans (PCDD/F TEQ) (for the stack emissions) and Polyfluorinated Alkyl Substances (PFAS) (applying the total oxidisable precursor analysis (TOPA), to provide analysis of the PFAS extended suite of 21 compounds) for the Industrial Wash Water and the stack emissions.

By comparing the PFAS analysis of the Industrial Wash Water input and the PFAS analysis of the stack emissions, it was seen that for all four testing rounds, the PFAS analysis results of the stack emissions were below the laboratory limit of reporting of 0.000004mg/Nm^3 for run 1, 0.000006mg/Nm^3 for run 2, 0.000005mg/Nm^3 for run 3 and 0.000005mg/Nm^3 for run 4 for all 21 compounds of the PFAS extended suite. Therefore this demonstrated the complete destruction of the PFAS compounds that were introduced into the preheater calciner via the fire fighting foam containing Industrial Wash Water.

For the purpose of the trial the following measurement methods will be used for PFAS compounds, applying the total oxidisable precursor analysis (TOPA), to provide analysis of the PFAS extended suite of 21 compounds:

USEPA SW-846 0010 (modified): Using the same equipment, sampling & recovery procedures as USEPA SW-846 Test Method 0010 ‘Modified Method 5 Sampling Train’. Requires different adsorbent resin due to the volatility of the compounds

3. CaF2 in the end Product

CaF_2 does not remain in the final product. The CaF_2 undergoes a chemical reaction in the lower temperatures of the process with $CaSO_4$ and $CaCl_2$ to produce low melt products, which go onto further react with the raw material calcium, aluminates and silicates, as shown in the phase diagram below.

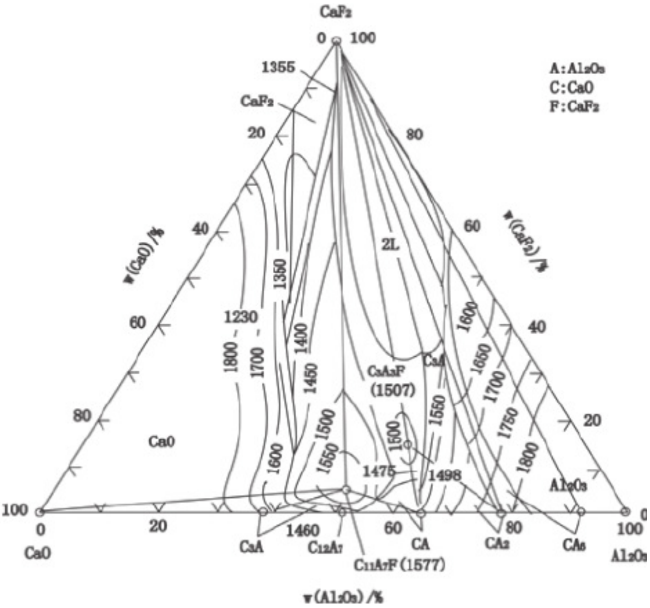
These intermediate products are stable solids and are unlikely to be emitted from the clinker stacks. The CaF_2 will also react with CaO and Al_2O_3 to form Alite with fluorine or $C_{11}A_7CaF_2$ during sintering. Pseudoalite ($3C3S \cdot CaF_2$) and Fluore-Spurrite ($2C2S.CaF_2$) can also be formed. The Fluorine doped Alite, Pseudolalite and Fluore-Spurrites behave in similar ways to that of conventional cementitious mineral products (C4AF, C2S & C3S) and are bound within the clinker matrix and are stable at high temperatures.

0 100

%CaCl2

0

0 100



Other

EHP Request

1. Could you provide justification for needing 200t of concentrate for the trial?

2. How will the remaining material in the solvent based fuel and industrial washwater tanks be managed in the event the trial is stopped?

Cement Australia Response

1. Justification for needing 200t of concentrate for the trial

200 tonnes of material are required in order to ensure a robust process optimisation and subsequent alternative fuel trial to fully understand the impact of the fire fighting foam upon the process.

2. Management of the remaining material in the solvent based fuel and industrial wash water tanks in the event that the trial is stopped

In the unlikely event that there is the requirement to permanently abandon the trial and there is remaining fire fighting foam left in the site storage tanks, the material would be pumped out of the tanks and sent to Geocycle for reprocessing.

Trial Phases

EHP Request

An important requirement when making any decision that can have an impact on environmental values is the appropriate consideration of the Precautionary Principle. This places obligations on management considerations to ensure decisions made are pertinent to any potential or adverse impacts.

It is said in the Operational Policy (Environmental Management of Firefighting Foam) that firefighting foam concentrates are destroyed at temperatures of >1100°C with at least a 2 second residence time. It is noted however that there is some research suggesting that destruction may occur at temperatures around 850°C, being that similar to conditions in the calciner, and that Cement Australia also wishes to conduct trials to determine destruction effectiveness in this part of the process.

In order to assist in controlling risk of harmful air emissions, the department requests Cement Australia to undertake trialling the identified testing scenarios using a staged approach.

The trial scenarios should be undertaken in the following order:

Baseline

No firefighting foam will be added to the clinker manufacturing process.

Main kiln

The addition of firefighting foam via the main kiln burner. The main kiln burner is where destruction success is most likely to occur and as such should be tested first. Failure of destruction at this stage indicates that subjecting PFAS at lower temperatures will likely be unsuccessful.

Calciner

The addition of the firefighting foam via the calciner burning system can only commence where destruction in the main kiln is proven to be successful.

Cement Australia Response

The Department's request is acknowledged and the trial plan reflects the requirements.

HF (Total Hydrogen Fluoride) Monitoring

EHP Request

It's noted that HF monitoring was not reported in the pre-trial analysis.

The Operational Policy recommends that scrubbing of HF from the flue gasses in high temperature destruction of firefighting foam concentrates and contaminated water. EHP also considers monitoring HF levels to be a key component for determining the success of the trial. As such, Cement Australia must conduct HF monitoring when undertaking the trial.

Cement Australia Response

The Department's request is acknowledged and the scope of the emissions monitoring program has been modified to include Hydrogen fluoride (total fluoride) emissions monitoring.

Sampling and Analysis of Emissions

EHP Request

It is recommended that the all sampling and analysis of air emissions be conducted in accordance with the Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales (http://www.epa.nsw.gov.au/resources/legislation/07001amsaap.pdf). If monitoring requirements are not described in the New South Wales sampling manual, monitoring protocols must be in accordance with a method as approved by United States EPA.

It's also noted that there may be a time delay between sampling and receiving analysis results. Please provide details regarding how this will be managed to ensure that unacceptable release of emissions does not occur.

Cement Australia Response

Cement Australia has engaged Airlabs Environmental Pty Ltd. The laboratory is accredited by the National Association of Testing Authorities (NATA) (NATA Accredited Laboratory No. 15463) and accredited for compliance with ISO/IEC 17025:2005.

All stack emissions sampling and analysis will be conducted in accordance with the Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales and where monitoring requirements are not described in the New South Wales sampling manual, monitoring protocols must be in accordance with a method as approved by United States EPA.

There will be continuous emissions monitoring for the following parameters:
Oxides of nitrogen
Particulates
Sulphur dioxide
Carbon monoxide (stack and within the preheater tower)
Ammonia
Hydrogen Chloride
Volatile Organic Compounds
Oxygen (stack, within the preheater tower and within the kiln)

Together with kiln and preheater temperature measurements, the continuous emissions monitoring data will indicate if there are kiln or preheater conditions where combustion and subsequent destruction of the Fire Fighting Foam is unlikely to occur. As with the other alternative fuel feed systems, automatic Fire Fighting Foam feed control loops will be installed to automatically stop the feed of Fire Fighting Foam to the kiln where there is the potential for incomplete destruction to occur.

Operational Management

EHP Request

Please provide information about the management processes and procedures in place to manage the firefighting foam concentrates and contaminated waters (e.g. information about handling, transport, loading/unloading, storage, cleaning empty containers, managing spills, stormwater, etc.).

Cement Australia Response

Handling from supplier to Fishermans Landing

Geocycle will coordinate the collections of the fire fighting foam IBC's from the nominated sites. This will be conducted in accordance with the Australian Dangerous Goods (DG) Code, EHP QLD Guidelines and specific AFFF recommendations from the EHP.

The nominated transporter, will be DG and EHP licenced with all appropriate licences and insurances verified prior to commencement.

A Transport Emergency Response Plan (TERP) has been specifically drafted for the process, along with the engagement of a suitable emergency response provider who has been briefed on the operation and job specifics. A scope of works (SoW) has also been completed for the transportation. A copy of both the TERP and SoW has been supplied to the Emergency Response Provider (ERP), and will be passed on to all transport companies and drivers involved in the collections.

All collections are to be conducted utilising a DG rated, bunded Sidedoor container with a capacity to accommodate up to 20 IBC's or 16 ton per load.

Transport arrangements

Each collection will comply with this procedure:

- The contract transporter will be supplied with collection site specifics such as date required, volume for collection, location, site contacts and all required paperwork. This paperwork will include a manifest, SDS, TERP along with site contacts for delivery at the Fisherman's Landing site.
- Upon arrival at the collection site, the IBC's will be loaded into the sidedoor container and secured in line with national guidelines. The driver will inspect all IBC's at point of loading to ensure they are fit for transportation.
- All paperwork will be completed including (but not limited to) load manifest check and the relevant EHP certificates.
- Once ready to depart the collection site, the driver will contact the nominated ERP to inform of their pending travel and supply information such as volume loaded, route to be taken to the Fisherman's Landing site, time of departure, and estimated time of arrival. Regular ERP check ins are available to track the load when the driver stops for the required breaks.

Unloading and loading procedures

Fire Fighting Foam receival at Fishermans Landing

The fire fighting foam will be received to site in intermediate bulk containers (IBC) stored within a fully bunded transport container. The container will be located as close of possible to the concrete SBF unloading bund, where the intermediate bulk storage will be unloaded into the SBF bund.

Storage arrangements at Fishermans Landing

The full IBCs will be stored within the SBF unloading bund until they are required to be unloaded into the SBF or the Industrial Wash Water tanks. Both the SBF and industrial wash water tanks are fully contained and bunded with concrete bunds.

Cleaning of empty containers

The cleaning of the empty IBC containers will occur within the SBF unloading bund. All rinsate will be pumped into the SBF system (or industrial wash water system, depending upon whether the combustion trial is via the main burner or calciner). Empty IBC containers with potential fire fighting foam residues will be washed using a protocol developed by Geocycle to ensure the IBC container is clean (i..e ∑TOPA analysis <1ug/L).

An IBC screw cap that has been designed to include a spraying head will be fitted onto the empty IBC. Then mains water applied and via a venturi to allow mixing with a cleaning agent. From the advice of Nigel Holmes the cleaning fluid will be a glycol based truck wash which in this case is Auto Klene T2000. The cleaning fluid will be mixed into the water (<10%) and sprayed onto all interior surfaces of the empty IBC. The spraying head has been selected for use with washing IBCs such that all interior surfaces can be washed with water.

Flow rate and time of application for the spraying head have been selected to provide thorough washing of the interior IBC surfaces. Rinsate is vacuumed pumped from the bottom outlet of the IBC. After the first rinse a second final rinsing is also completed. A suitable flow rate and application time has been determined from trials undertaken at Geocycle. Empty IBCs have been washed at different combinations of flow rate and application time with PFAS residues on interior surfaces measured via a swabbing technique advised from Bob Symons (Eurofins). The swabs can be assessed as total organic fluoride and ∑TOPA analysis to determine the PFAS remaining on the interior IBC surfaces.

Management of Spills

In line with the philosophy of the precautionary principle and the hierarchy of controls, thorough risk assessments have been conducted to determine and implement appropriate controls to avoid the spillage of Fire Fighting Foam at the Fishermans Landing site:

- All IBC storage containers are inspected and checked to ensure that they are robust and do not present the risk of split or rupture during the handling processes from the supplier to the SBF unloading bund.
- All unloading activities will be conducted within a fully concrete bunded location using pumping equipment that has been integrity checked to ensure that there is no potential for spillage.
- The storage tanks and associated pipework have been inspected to ensure their integrity to avoid the potential for spillage.
- Injection points on main burner and also the calciner has been checked to ensure their integrity to avoid the potential for spillage.

On this basis, the potential for spillage has significantly reduced. In the unlikely event that a does spillage occur, fully stocked spillage containment kits are deployed across the site, in particular for this project, there is one located in the SBF unloading bund. This is the only point in the storage and handling system, for a small amount of time during the handling activities, that the fire fighting foam is not fully contained, however the activity is conducted within a concrete storage bund, so there is no potential for a spillage to impact upon the ground or surface water. The spillage containment kits contain booms, absorbent pads and kitty litter to contain a spillage. Should a spillage occur within the SBF unloading bund, the spillage would be contained using these materials and cleared up and placed inside a 20 litre plastic bucket for disposal via the “Geopod” system, which feeds waste materials directly into the precalciner. The spill containment material would then be destroyed within the kiln.

Please see GL-AFFF-02 Rev 0 Environmental Controls for Handling of Firefighting Foam Product at Gladstone Kiln for all comprehensive details on the handling procedures for fire fighting foam to prevent environmental impact.

Stormwater Management

The fire fighting foam is fully contained at all stages of the storage and firing systems. During the unloading procedure, the IBCs are stored and unloaded within the SBF unloading bund. The SBF unloading bund is covered, constructed of concrete and has a sump that is connected to the SBF tank, via a pump. In the event that some rainwater falls onto the concrete bund, this water is pumped into the SBF tank via the sump pump. Therefore there is no potential for fire fighting foam contamination of stormwater.

Maintenance Procedures

The equipment associated with the alternative fuel unloading, storage and firing systems are subject to preventative maintenance routines, this ensures that equipment remains in good condition. Prior to the commencement of the trial additional equipment checks will be conducted to ensure that the trial will not be interrupted to allow for maintenance activities to occur.

In the unlikely event that there is an equipment failure, every effort will be made to ensure that the firing system is cleared of fire fighting foam and that the unloading and firing pipelines are flushed with water and a cleaning chemical to remove as much fire fighting foam residue are possible. Once the pipeline and firing system flushing has occurred, a risk assessment will be conducted to ensure that the human and environmental exposure to fire fighting foam is reduced to as low as possible by following the precautionary principle and hierarchy of controls isolate and then contain any potential exposure points.

Procedures for managing employee exposures

The possible human exposure pathways are via inhalation and ingestion of the fire fighting foam, therefore risk assessments are to be developed to include precautions to avoid possible exposures. The principle control is ensuring that where possible, full containment of the fire fighting foam. Potential exposures could occur during the unloading, IBC cleaning and maintenance activities.

Principal controls for unloading:

Eliminate - Seal the connection between the vacuum unit and the IBC

Reduction - Ensure that unloading pump is as efficient as possible to avoid extended periods of exposure and requirement for human intervention

Isolate - Separate the individual from the unloading procedure - once the unloading process has commenced, ensure that the individual can be separated from the process - ie automatic shut off of pump

Containment - IBC and unloading pump are fully contained (sealed)

PPE - Individual unloading IBC is to wear SBF PPE: Chemical resistant gloves, overalls, and footwear and air fed/full face respirator

Administrative controls - Training of individual in the unloading procedure, rotation of task

Principal controls for cleaning of IBCs:

Eliminate - Seal the connection between the cleaning unit and the IBC, seal between discharge of rinsate and container, seal between pump from IBC to SBF/IWW tank. Transfer points to be sealed

Reduction - Ensure that cleaning equipment and procedure is as efficient as possible to avoid extended periods of exposure and requirement for human intervention

Isolate - Separate the individual from the cleaning procedure - Minimise required intervention - once the cleaning/rinsate discharge and transfer to SBF/IWW tank; ensure that the individual can be separated from the process - ie automatic shut off of pumps

Containment - Design the IBC cleaning steps to be as contained as possible. Particularly during transfer of rinsate - design of cleaning, rinsate discharge and pump out.

PPE - Individual cleaning IBC is to wear SBF PPE - Chemical resistant gloves, overalls, and footwear, air fed/full face respirator face

Administrative controls - Training of individual in the cleaning and transfer procedures, rotation of task

Principal controls for maintenance activities:

Eliminate - Flush out pipework, pumps, storage vessels with water and cleaning agent prior to maintenance activities - pump rinsate into SBF/IWW tanks for destruction of rinsate in kiln

Reduction - Where possible, rinse pipework as much as possible, if this is not possible flush remaining fire fighting foam into SBF/IWW tank or if this is not possible into an IBC.

Isolate - No applicable controls

Containment - No applicable controls

PPE - Where there is potential fire fighting foam exposure - Wear SBF PPE - Chemical resistant gloves, overalls, and footwear, air fed/full face respirator

Administrative controls - Comprehensive risk assessment and work procedure, rotation of task

References

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