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**Boral Cement Limited
Berrima Works**

***Non-Standard Fuels Pollutant
Tracking
First Half Year Report***

October 2021



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1. Introduction

In July 2015, Boral sought approval to modify the consent for the Berrima Cement Works to enable the use of Solid Waste Derived Fuel (SWDF) as an energy source. Modification 9 to the consent DA 401-11-2002 was subsequently approved which included a number of additional monitoring and management conditions covering the use of these alternative fuels. The consent also separated the use of standard fuels, being traditional coal and coal derivatives along with diesel for start-up and non-standard fuels being derived from waste. Non-Standard Fuels (NSF) is the broad term now used to cover the various waste derived fuels approved to be used in the cement plant.

Boral commenced using two types of NSF in August 2018, including Wood Waste (WW) and Refuse Derived Fuels (RDF) known as Solid Waste Derived Fuels (SWDF). Both materials have undergone separation and screening processes to remove contaminants such as, glass and metals. Product specifications have been established and Quality Assurance/Quality Control (QA/QC) procedures implemented.

As per condition 3.22 of the DA, Boral are required to implement a tracking program to undertake:

- a) Batch analysis of non-standard fuels received at the development as provided by suppliers and the results of any check analysis carried out by the applicant as part of the quality control management procedures
- b) A mass inventory of each pollutant entering the process in raw materials, conventional fuels and non-standard fuels, with particular attention to, but not limited to chlorine, mercury cadmium and chromium.
- c) Calculate emission factors for each pollutant based on inputs, outputs and measured air emissions and a variance in the emission factors from period to period.
- d) Any adjustments that may be necessary to non-standard fuel specifications from the tracking analysis.

The initial period of use of SWDF was part of a Proof of Performance Trial which included the submission of monthly reports and a Proof of Performance Trial Consolidated Six Month Report for Solid Waste Derived Fuels on 28 February 2019. On the 23 April 2019 the Department of Planning and Environment approved the ongoing use of SWDF following consultation with the EPA subject to:

- a) Limiting the amount of SWDF to be fired in Kiln 6 to 40%, as a percentage of total fuel
- b) Periodic stack testing being undertaken every three months for the first 12 months of use of SWDF. The monitored pollutants must be consistent with the requirements of the Environment Protection Licence (EPL 1698)
- c) Provision of a monitoring report that outlines the results of quarterly stack testing required in (a) and provides an assessment of compliance against the air emissions limits for the facility, to the satisfaction of the Secretary
- d) Periodic measurements of hydrogen chloride (HCL) taken every 3 months until such time the Secretary agrees the accuracy of the HCL CEMS is confirmed through successful calibration audits undertaken in accordance with USEPA Performance Specification 18.



Condition 3.23 of the DA required Boral Cement to submit a report that assesses the results of the tracking program every 3 months in the first year of operating non-standard fuels under this consent to be synchronised with stack testing and every six months thereafter.

The following report details findings from the non-standard fuels Pollutant Tracking Program for the six monthly testing undertaken on 7 October 2021. This report incorporates the requirements of Condition 3.23.

This report also incorporates the higher use of RDF at 42.5% as approved by the EPA to undertake Proof of Performance above 40%.

As part of the tracking program we consolidate all raw material and fuel specification testing against quantities used and compare this to actual stack testing to determine an emission factor by unit of input by chemical.

1.1 Stack Testing Result

On 07-13 October 2021 stack testing undertaken at Berrima Cement was compliant with the licence limits as summaries in Table 1 below. A copy of the full report numbered R011682 is attached. Metals and Chlorine are outlined in the pollutant tracking discussion. Emissions were in compliance with the Environment Protection Licence 1698.

Parameter	Unit	Limits	07/10/2021 R011682
Mercury	mg/m3	0.05	0.0083
Type 1 and type 2 substances	mg/m3	0.5	<0.031
Solid particles	mg/m3	50	20
Nitrogen oxides	mg/m3	1250	730
Cadmium and Thallium	mg/m3	0.05	<0.0009
Chlorine	mg/m3	50	<0.009
Dioxine and Furans (I-TEQ middle bound)	ng/m3	0.1	0.0029
Hydrogen chloride (HCl)*	mg/m3	10	0.17
Hydrogen fluoride	mg/m3	1	<0.02
Sulfur dioxide	mg/m3	50	<0.021
Sulfuric acid mist and sulfur trioxide	mg/m3	50	0.5
Volatiles organic compounds	mg/m3	40	2.3

*Note that HCl is well below the limit of 10mg/m3.



1.2 Raw Material Inputs

The raw materials used within Kiln 6 include Limestone, Yellow Shale, Blue Shale, Steel Slag and Granulated Blast Furnace Slag. Table 2 summaries the percentage of each raw material input used, the chemical properties of each of the raw material inputs, and the total chemical properties of the raw feed combined in use during the stack testing in October 2021.

Table 2 – Raw Material Input Quantities and Chemical Properties

Raw Material - Input

Chemical Properties		Feed Source1 Limestone	Feed Source2 Yellow Shale	Feed Source3 Blue Shale	Feed Source4 GYP	Feed Source5 Steel Slag	Feed Source3.1 GBFS	Final Feed
	Set Point %	82.05%	2.14%	9.36%	0.00%	3.45%	3.00%	100.00%
Arsenic	As (mg/kg)	1.8	4.8	4.6		1.3	1	2.09
Beryllium	Be (mg/kg)	0.2	1	1.2		0.4	6.9	0.52
Cadmium	Cd (mg/kg)	0.2	0.1	0.1		0.1	0.1	0.18
Chromium	Cr (mg/kg)	2.4	38.2	17.3		1410	20.7	53.67
Cobalt	Co (mg/kg)	4.2	11.4	15.6		1.3	0.3	5.20
Copper	Cu (mg/kg)	2.8	10	43.9		21.1	1.1	7.38
Mercury	Hg (mg/kg)	0.1	0.1	0.1		0.1	0.1	0.10
Manganese	Mn (mg/kg)	450	222	1020		21800	2380	1292.95
Nickel	Ni (mg/kg)	6.1	16.5	22.8		8.5	0.8	7.81
Lead	Pb (mg/kg)	2.8	4.8	20		2.4	0.3	4.36
Antimony	Sb (mg/kg)	0.4	0.3	0.3		0.1	0.1	0.37
Selenium	Se (mg/kg)	1	2	2		1	5	1.24
Tin	Sn (mg/kg)	0.1	2	0.6		1.5	0.2	0.24
Vanadium	V (mg/kg)	2	37	44		2020	73	78.43
Thallium	Th (mg/kg)	0.1	0.1	0.1		0.1	0.1	0.10
Chlorine	Cl (mg/kg)	20	30	10		10	240	25.533
kg mat/kg clinker								1.55

To interpret the table, 82.05% of the raw material is limestone. Within limestone there is 1.8 mg/kg of Arsenic (As), while yellow shale used at 2.14% contained 4.8 mg/kg of As. Combined with the other raw materials of blue shale, steel slag and granulated blast furnace slag, the total As of raw feed is 2.09 mg/kg.

To produce 1 kg of clinker, 1.55 kg of raw materials are required.



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1.3 Kiln Fuel Inputs

The fuel in use at Berrima during normal operating conditions i.e. excluding start-up conditions includes Coal and Solid Waste Derived fuels Wood Waste and Refuse Derived Fuel.

Table 3 – Kiln Fuel Input Quantities and Chemical Properties

Kiln Fuel - Input

Chemical Properties		Fuel Source 1 Coal	Fuel Source 2 Wood Veolia	Fuel Source 3 RDF	Fuel Source 4 Wood Brandown	Final Fuel - Kiln
	Set Point %	57.55%	0.00%	42.45%	0.00%	100.00%
Arsenic	As (mg/kg)	0.8		35		15.3
Beryllium	Be (mg/kg)	0.7		1		0.8
Cadmium	Cd (mg/kg)	0.1		1		0.5
Chromium	Cr (mg/kg)	0.7		58		25.0
Cobalt	Co (mg/kg)	0.5		2		1.1
Copper	Cu (mg/kg)	9.7		40		22.6
Mercury	Hg (mg/kg)	0.1		0.06		0.1
Manganese	Mn (mg/kg)	426		51		266.8
Nickel	Ni (mg/kg)	0.5		3		1.6
Lead	Pb (mg/kg)	9.3		28		17.2
Antimony	Sb (mg/kg)	0.2		4		1.8
Selenium	Se (mg/kg)	1		1		1.0
Tin	Sn (mg/kg)	0.2		3		1.4
Vanadium	V (mg/kg)	3		2		2.6
Thallium	Th (mg/kg)	0.1		1		0.5
Chlorine	Cl (mg/kg)	10		0.24		5.857
kg fuel/kg clinker		0.0960		0.0710		0.167

Table 3 details the inventory of fuel input and the percentage of each fuel used. As can be seen 57.55% of the fuel in use was coal, with Solid Waste Derived Fuels accounting for 42.45% RDF.

Taking As as an example, coal contains 0.8 mg/kg and RDF 35 mg/kg. As makes up 15.3 mg/kg in the total fuel.

To produce 1kg of Clinker a total of 0.167 kg of fuel is consumed.



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1.4 Total Fuel Inputs and Associated Emission Factors

Table 4 collates the raw material and fuel inputs comparing to stack emissions to calculate an emission factor per unit of chemical input.

Table 4 – Emissions Factors per unit of input for raw materials and fuel

	Total Input	Stack Emissions		Emission factor
	Raw material + Fuel			
	mg/kg clk	mg/Nm3	mg/kg clk	from input
Arsenic	5.79	0.0008	0.001872	0.00032
Beryllium	0.94	0.0003	0.000702	0.00074
Cadmium	0.36	0.0002	0.000468	0.00129
Chromium	87.47	0.001	0.00234	0.00003
Cobalt	8.27	0.0004	0.000936	0.00011
Copper	15.22	0.0012	0.002808	0.00018
Mercury	0.17	0.0083	0.019422	0.11488
Manganese	2051.14	0.0078	0.018252	0.00001
Nickel	12.38	0.00072	0.0016848	0.00014
Lead	9.65	0.0012	0.002808	0.00029
Antimony	0.88	0.002	0.00468	0.00534
Selenium	2.08	0.0062	0.014508	0.00696
Tin	0.60	0.0018	0.004212	0.00699
Vanadium	122.15	0.00071	0.0016614	0.00001
Thallium	0.24	0.0009	0.002106	0.00894
Chlorine	40.604	0.009	0.02106	0.00052

Taking As as an example, the total As concentration for inputs into the kiln per kg of clinker produced is calculated by (raw material chemical/kg X kg materials/kg clinker) + (Kiln fuel chemical/kg X kiln fuel kg/kg clinker).

$$(2.09 \times 1.55) + (15.3 \times 0.167) = 5.79 \text{ mg/kg clinker}$$

The emission factor per unit of input for As is calculated by dividing the calculated emissions per kg of clinker by the total As input.

$$0.001872 / 5.79 = 0.00032$$



Table 5 is similar to Table 4 but calculates an emission factor based on the fuel only.

Table 5 – Emissions Factor fuel only

	Total Input	Stack Emissions		Emission factor
	Fuel only			
	mg/kg clk	mg/Nm3	mg/kg clk	from input
Arsenic	2.56	0.0008	0.001872	0.00073
Beryllium	0.14	0.0003	0.000702	0.00508
Cadmium	0.08	0.0002	0.000468	0.00581
Chromium	4.18	0.001	0.00234	0.00056
Cobalt	0.19	0.0004	0.000936	0.00493
Copper	3.77	0.0012	0.002808	0.00075
Mercury	0.01	0.0083	0.019422	1.40086
Manganese	44.56	0.0078	0.018252	0.00041
Nickel	0.26	0.00072	0.0016848	0.00646
Lead	2.88	0.0012	0.002808	0.00098
Antimony	0.30	0.002	0.00468	0.01546
Selenium	0.17	0.0062	0.014508	0.08687
Tin	0.23	0.0018	0.004212	0.01816
Vanadium	0.43	0.00071	0.0016614	0.00386
Thallium	0.08	0.0009	0.002106	0.02616
Chlorine	0.978	0.009	0.02106	0.02153

Any variance to the Emissions Factors in Table 4 & Table 5 can be used to determine the contribution from either raw materials, standard and non-standard fuels.



1.5 Alternate Fuel Inputs and Total Inputs Raw Material and Fuel

Table 6 show the Alternate Fuel inputs against the total raw material and fuel inputs per unit of clinker produced.

Table 6 – Alternate Fuels inputs compared to total inputs from Raw materials and Fuels

	Input		
	Total Input		
	Raw material + Fuel	Alternative Fuels	
	mg/kg clk	mg/kg clk	% input from AF
Arsenic	5.79	2.49	42.89%
Beryllium	0.94	0.07	7.53%
Cadmium	0.36	0.07	19.56%
Chromium	87.47	4.12	4.71%
Cobalt	8.27	0.14	1.72%
Copper	15.22	2.84	18.66%
Mercury	0.17	0.00	2.52%
Manganese	2051.14	3.62	0.18%
Nickel	12.38	0.21	1.72%
Lead	9.65	1.99	20.60%
Antimony	0.88	0.28	32.43%
Selenium	2.08	0.07	3.41%
Tin	0.60	0.21	35.36%
Vanadium	122.15	0.14	0.12%
Thallium	0.24	0.07	30.12%
Chlorine	40.60	0.02	0.04%

Taking As as an example, the total As concentration for inputs into the kiln per kg of clinker produced is 5.79 mg/kg clinker (see calculation for table 4)

The total As concentration for inputs from Alternate fuel is 2.49 mg/kg clinker. This represents 42.89% of the total As input in the process.

$$2.49/5.79 * 100 = 42.89\%$$