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Adelaide Brighton Cement Ltd.

Alternative Fuel Post-Trial Report Increasing Plastic Content to 20% in RCD Wood Waste at Birkenhead Plant

Report to the SA Environment Protection Agency

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Contents

List of Tables -

1. Introduction -

This document forms the submission by Adelaide Brighton Cement Limited (ABCL) requesting approval from the SA EPA to increase the plastics content limit to 20% by weight in Recycled Construction and Demolition (RCD) wood waste. RCD wood waste is currently used as an alternative fuel in the ABCL clinker manufacturing operation at Birkenhead, SA displacing a portion of the natural gas usage.

The current Birkenhead site licence allows RCD wood waste burning at a maximum of 15 t/h and specifies a maximum 10% plastics content. The suppliers of this alternative fuel have recently undergone an equipment upgrade, which has led to a significant reduction in the ash content, and a consequent increase in biomass and plastic content. Additionally, construction companies now prefer to source separate at site, and so the plastic content of the RCD wood waste has been increasing. ABCL has been advised by ZeroWaste, SA that mixed plastics streams are very difficult to reprocess and substantial volumes still have to be landfilled. Plastic materials have a very good calorific value and so are ideal fuel sources, provided it can be proven that the higher plastic content does not adversely affect stack emissions.

As a result of the changed conditions for the supply of RCD wood waste, a request was made by ABCL to the SA EPA, and approval was received, to conduct a high plastic content RCD wood waste trial. As the extra plastic will result in lower ash content and hence lower heavy metal inputs, the focus of the trial was to assess indicators of incomplete combustion, in particular carbon monoxide, dioxins/furans, PAH's and VOC's. Unlike previous trial reports, 4A and 4B stack emissions have been reported separately for these organic compounds and for NOx. This is because the RCD wood waste is burned in the calciner vessel and the combustion products of the calciner are vented to atmosphere through the 4B stack stream. Therefore, any change from RCD wood waste will not affect 4A stack.

2. Trial Timing and Fuel Consumption

The RCD wood waste burning trial took place during routine biannual stack testing from 10:00 22nd to 20:02 24th October 2015. Average natural gas fuel consumption was within the range of normal operation. The rate of carbon firing was approximately 1.6 tph and RCD wood waste was fired at up to the licence limit of 15 tph.

3. Storage, Feed Method and Feed Rate

RCD wood waste was delivered to the site in enclosed walking floor trucks and was fed into the kiln process through the existing feed system. The alternative fuel was fired into the calciner with the point of entry into the vessel located above the natural gas burners. In summary, no changes were made to the normal delivery, storage and feed method.

The burning rate of RCD wood waste was up to 15tph. Plastics content averaged 14% by weight. Laboratory records show that historically the plastic content of RCD wood waste has been highly variable, with a standard deviation of 3% by weight. As a result, ABCL estimates that deliveries could contain up to 20% plastic content by weight, and has framed this submission around this percentage as a maximum plastic content the process is likely to receive.

4. Trial Conditions -

4.1. Fuel Value

The calculated calorific value of RCD wood waste was 13.5GJ. At an addition rate of 15t/h this displaces 28% of the total process fuel input. This equates to almost 45% of the calciner fuel and is an excellent result for this relatively low-grade fuel.

4.2. Kiln Operation and Burning Conditions

During the trials the kiln feed rate, natural gas firing rate and RCD wood waste addition rates were held as constant as possible. The small variations in these parameters were considered quite normal for the process. In general the stability of the kiln process during the trial was excellent, although ongoing stability issues with the bypass may have elevated particulate levels on the 4A stack.

5. Stack Emission Tests and Results for Specific Analytes

5.1. Summary

Stack emission sampling was conducted on both stacks during the wood waste trial. Analyte concentration levels were compared to previous stack testing results to observe and comment on any changes that resulted from burning the alternative fuel.

The RCD wood waste trial progressed well with operating parameters within normal operating range and burn rate at up to 15t/h. As mentioned previously, plastic content averaged 14% by weight but this has been highly variable in recent years. Laboratory records show a plastic content standard deviation of 3%. From this ABCL has estimated that deliveries could contain up to 20% plastic content by weight, and has framed this submission around 20% as a maximum. ABCL understands that mixed plastic is a difficult waste to reprocess and so is landfilled. ABCL is willing to increase the plastic content because of the resulting improved calorific value. The following results confirm that excellent burnout is achieved, indicating complete destruction of the plastic material. Additionally, lower NOx emission was measured, probably due to the displacement of more natural gas, and the reduced ash content is also expected to result in lower heavy metals inputs. Through extrapolation of the emission data on organic analytes from this trial and previous tests, ABCL concludes that total destruction of the plastics is occurring in the calciner and emission levels will be no worse, and perhaps slightly better, at the maximum requested plastic content of 20% by weight.

Note: in the following section of tabled stack testing results the superscripts denote the following:

[1]Baseline - refers to results from baseline stack testing conducted on 13/06/2006 Stack report JUN03091.

[2]Nominal - refers to the average of the previous 3 years of stack emissions results for the purpose of this report.

5.2. Dust Emissions

Particulate levels were higher on 4A stack compared to previous stack test results (July '14) but remained within levels of the previous 3 years of testing results. The higher emissions were caused by ongoing instabilities in the bypass system that occurred during the final quarter of 2014. As the plastics are burned in the calciner of the 4B side, the plastics cannot affect this 4A stack result. 4B stack particulate emissions were the lowest compared to the previous three years.

Table 1: Comparative Stack Emissions Test Results for Particulate Matter

Analyte	[1]Baseline 4A stack emissions	[1]Baseline 4B stack emissions	[2]Nominal 4A stack emissions	[2]Nominal 4B stack emissions	4A Stack Emissions Increased Plastics in Wood Trial	4B Stack Emissions Increased Plastics in Wood Trial
Total Particulate Matter (mg/Nm^3)	68	55	19	31	31	9

5.3. NOx Emissions

Emissions of oxides of nitrogen were significantly lower during this trial. NOx levels on both 4A and 4B stack were almost half the level of previous stack test results. Historically, Birkenhead's NOx emissions have been extremely high with GLC results above 85% of the guideline. This is predominantly due to the use of natural gas as a primary fuel. Since commencing the alternative fuel program in 2003, ABCL has been able to significantly reduce NOx emissions. Results for this particular trial show a maximum of 29% of the predicted GLC limit. This is one of the lowest results recorded.

Table 2: Comparative Stack Emissions Test Results for NOx Emissions

Analytes	[1]Baseline 4A stack emissions	[1]Baseline 4B stack emissions	[2]Nominal 4A stack emissions	[2]Nominal 4B stack emissions	4A Stack Emissions Increased Plastics in Wood Trial	4B Stack Emissions Increased Plastics in Wood Trial
Total Oxides of Nitrogen (expressed as mg/Nm^3 of NO_2 @ STP)	480-610	410-520	710	610	420	580

5.4. Carbon Monoxide

As RCD is burned in the calciner vessel on the 4B side, no changes were expected on the 4A stack. This was the observed result during the trial. There was also no significant change in carbon monoxide levels on the 4B stack during the testing period compared to the previous stack testing results. In fact, concentrations were below the average of the last 3 years. Higher than normal carbon monoxide levels on 4B stack could have indicated changes in burning conditions in the

calciner, but it was pleasing to see that this was not the case. This provides confirmation that complete burnout of the higher plastics content is occurring.

Table 6 later in this report shows that the total predicted GLC for carbon monoxide emitted for the whole process during the trial was very low at only 0.1% of the DGLC guideline.

Actual results were as follows:

4A stack: average of 22 mg/Nm^3 during the trial, which is below the last three year average of 35 mg/Nm^3.

4B stack: Average of 231 mg/Nm^3 during the trial, which is below the last three year average of 264 mg/Nm^3.

5.5. Hydrocarbons and Organic Emissions

Polyaromatic hydrocarbons levels showed no significant change on either stack compared to previous results. Overall, the PAH levels are well within EPA licence limits, with a maximum of 0.03% of the predicted GLC limit. Benzene levels were lower on 4B stack whereas on 4A stack they were virtually unchanged. VOCs on both 4A and 4B stack were lower for this trial. These results are further evidence that the plastic is being totally destroyed in the calciner vessel and products of incomplete combustion are not being generated.

Table 3: Comparative Stack Emissions Test Results for Hydrocarbons and Organic Emissions

Analytes	[1]Baseline 4A stack emissions	[1]Baseline 4B stack emissions	[2]Nominal 4A stack emissions	[2]Nominal 4B stack emissions	4A Stack Emissions Increased Plastics in Wood Trial	4B Stack Emissions Increased Plastics in Wood Trial
	(mg/Nm^3)	(mg/Nm^3)	(mg/Nm^3)	(mg/Nm^3)	(mg/Nm^3)	(mg/Nm^3)
Benzene	3	4.4	0.05	0.20	0.06	0.10
PAH	Not measured	Not measured	0.01	0.01	0.01	0.01
VOC	Not measured	Not measured	0.51	0.67	0.21	0.37

5.6. Dioxins and Furans

Even though emission levels of dioxins and furans are not included in the site licence, ABCL wanted to provide evidence that there was no change when burning the increased plastic content RCD wood waste. The dioxins and furans test results are shown below and compared to previous stack test results at different RCD wood waste and plastics content levels. The results show that increased plastic content in RCD wood waste does not increase dioxins and furans concentrations levels in stack emissions. This confirms previous findings at different rates of RCD wood waste firing.

Table 4: Comparison of Dioxins and Furans to Previous Trials

Case	Date of tests	4A STACK	4B STACK	SA EPA Guideline
		ng/Nm^3	ng/Nm^3	ng/Nm^3
		ITEQ	ITEQ	ITEQ
Normal raw materials @ 100% natural gas	30/07/1999	0.04	0.07	0.1
	24/02/2000	0.03	0.05	
	28/08/2001	0.02	0.01	
RCD wood trial – 5 tonnes/hour	14/02/2003	0.02	0.02	0.1
		0.02	0.02	
		0.03	0.02	
RCD wood trial – 10 tonnes/hour + 10% plastics	27/02/2003	0.05	0.05	0.1
		0.04	0.04	
RCD Wood – 15 tonnes/hour	26/05/2005	0.10	0.01	0.1
		0.01	0.01	
		0.01	0.02	
RCD Wood – 15 tonnes/hour Nominal 14% plastics	23/10/2014	<0.01	<0.01	0.1

Dioxin and furan concentration levels were lower than all previous trials. Comparison between RCD wood waste addition rate 15tph 10% plastics (2005) to 14% plastics (2014) showed that dioxins and furans were found to be lower in the latter. The results above infer that increased plastic content in RCD wood waste does not increase dioxin and furan concentration levels in stack emissions. The earlier trials also show that increased wood waste addition rate does not increase dioxin and furan concentration levels. ABCL does not believe there has been a drastic reduction in the levels of dioxins and furans generated, but rather that testing methods have improved over the last decade. All of the above results were generated using the same highly regarded testing company who have published reports on dioxins and furans for the Federal and NSW EPA websites. The measured values from this stack test are considered very low.

5.7. Heavy Metal Emissions

It is important to note that the input of heavy metals reduces through the use of increased plastic content. The supplier has changed processing equipment and, as a direct result, ABCL has seen a drop of 5 to 10% in fuel ash content, which leads to a subsequent reduction in the input of all inorganic elements. As a result it is expected that, directionally, heavy metal emissions will decrease with increased plastics content.

Stack testing and air quality impact assessment showed that heavy metals concentrations continued to remain at extremely low levels of the predicted maximum ground level concentrations. This excellent result can be seen in Table 6 below in section 5.11 where the highest level was observed

with Beryllium which was 1% of the maximum predicted GLC. It is also important to note that the Beryllium emission levels have not increased compared to the previous biannual stack testing and air quality impact assessments.

5.8. Other Analytes

Viewing Table 6 in section 5.11 it can be seen that levels of other analytes of concern such as sulphur dioxide, chloride and fluorine remain at extremely low levels of the maximum predicted GLC.

5.9. Relationship between wood plastics, ash and moisture

The previous section outlines how the increase in plastics content in the RCD wood waste does not have a detrimental effect on stack emissions. As mentioned above, the suppliers of the RCD wood waste have upgraded their waste processing equipment. This has decreased ash content and in turn increased the proportion of plastics, biomass and/or moisture. Extrapolating the data on emission of organic analytes from this trial and previous tests, ABCL concludes that total destruction of the plastics is occurring in the calciner and emission levels will be no worse, and perhaps slightly better, at the maximum requested plastic content of 20% by weight.

5.10. Partitioning and Reporting Streams of Heavy Metals

During the trial various process streams were sampled and tested for heavy metals of concern. The only inputs to the process are from the kiln feed, RCD wood waste ash and carbon ash. The only outputs from the process are in the clinker, the CKD (cement kiln dust) and the two stacks.

Table 5: Mass Balance of the Process Streams

Element	*Kiln Mix Feed	Clinker	Bypass Dust	4A Stack Emission	4B Stack Emission
	(g/h)	*(g/h)*	*(g/h)*	*(g/h)*	*(g/h)*
Antimony	2,974	2,935	38	0.07	0.05
Barium	33,572	33,306	265	0.84	1.02
Chromium	8,199	8,107	90	1.02	0.72
Copper	24,560	24,146	412	1.80	0.50
Mercury	3	1	0	0.59	1.44
Zinc	67,647	65,614	2,010	21.00	1.74
Arsenic	4,185	4,119	65	0.07	0.05
Beryllium	128	126	1	0.04	0.04
Cadmium	142	43	99	0.20	0.02
Lead	5,979	3,447	2,529	3.06	0.50
Nickel	3,857	3,820	36	0.59	0.38

*Where Kiln Mix Feed is composed of Kiln Feed + Carbon Ash + RCD Wood Waste Ash

5.11. Ground Level Concentrations - Schedule Y-1

The Ground Level Concentrations of all analytes of concern were calculated using computer modelling. The Airlabs modelling report is included with this submission as attachment 1.

The predicted maximum concentrations outside the boundary for all pollutants are presented in Table 6. Background levels have not been included in this assessment.

Table 6: Predicted maximum ground-level concentrations from Stacks 4A and 4B

Pollutant	Averaging period	Guideline (µg/m³)	Maximum off-site (µg/m³)	Percentage of guideline (%)
Total solid particles	24-hour	50	0.7	1.5
Benzene	3-minute	53	0.05	0.09
Hydrogen chloride	3-minute	250	0.5	0.2
Chlorine	3-minute	100	0.036	0.036
Fluorides	24-hour	2.9	0.002	0.036
	7 days	1.7	0.001	0.1
	90 days	0.5	0.0008	0.1
Sulphur dioxide	1-hour	450	8	1.8
Carbon monoxide	1-hour	29000	36	0.1
Nitrogen dioxide*	1-hour	113	33	29
Antimony and compounds	3-minute	17	0.0001	0.0006
Barium (soluble compounds)	3-minute	17	0.002	0.0093
Chromium III	3-minute	17	0.0015	0.009
Copper	3-minute	6.7	0.002	0.029
Iron oxide	3-minute	170	0.2	0.14
Magnesium oxide	3-minute	330	0.1	0.026
Manganese	3-minute	33	0.002	0.007
Mercury – organic	3-minute	0.33	0.0017	0.5
Mercury – inorganic	3-minute	3.3	0.00001	0.0004
Lead	Annual	0.5	0.00008	0.015
Zinc oxide	3-minute	170	0.02	0.011
Arsenic	3-minute	0.17	0.0001	0.06
Beryllium	3-minute	0.007	0.0001	1
Cadmium	3-minute	0.033	0.0002	0.6
Chromium VI	3-minute	0.17	0.0004	0.2
Nickel	3-minute	0.33	0.001	0.25
PAH (as benzo(a) pyrene)	Annual	0.0003	9.5E-08	0.03

*as NO_2 Maximum

5.12. Ground Level Concentrations - Schedule Y-1 Conclusion

The emission data from the stacks has been modelled by Airlabs Environmental Pty Ltd, so it can be evaluated against the ground level concentrations for the point source as published in guidelines and in keeping with Schedule Y-1.

Table 6 shows that all ground-level concentrations are predicted to be well below the EPA guidelines. NO_2 was the closest to the SA EPA guideline at 29% but as mentioned earlier in section 5.3, this is one of the lowest results recorded compared to previous years. All other pollutants were predicted to be orders of magnitude lower than the guidelines, which ABCL believes supports the request to allow the burning of RCD wood waste at 15t/h with up to 20 % plastic content by weight.

6. Changes to Plant Pollution Control Equipment, Kiln or Stack Conditions during the Trial

No significant changes in the values or variability of operating conditions were observed during the stack testing trial period of 22nd – 24th of October 2014, other than ongoing tuning to improve the performance of the bypass system (affecting 4A stack) and a short calciner trip on the 22nd of October 2014. This calciner trip would not affect trial results as the 4B stack side itself was actually tested between 23rd and 24th of October 2014.

6.1. Overall Effectiveness of the Trial

From an operational view point the trial was effective in providing an understanding of the effect of burning RCD wood waste with increased plastics content in the calciner. The impacts on process operation, the burner management systems, product quality and the overall pyroprocessing circuit were assessed and no impediments to continuing at this rate were found.

6.2. Complaints and/or Enquiries Received About the Trial

3 dust complaints were logged into the community complaints database during the stack testing period, all of which were referring to 4A stack emissions. As mentioned earlier, some issues were experienced with the bypass system. These emissions were not related to the burning of RCD wood waste with increased plastics. 4B stack emissions remained very low during the stack testing period.

A community consultation program is in place at Birkenhead. The program consists of regular meetings with interested residents, local government and the EPA. Community meetings scheduled will enable feedback to be provided to the residents.

7. Suitability for Continued Use in the Kiln Burner System

The modelling of emissions from ABC's Birkenhead facility during the increased plastics in RCD wood waste trial has shown GLC's to be well below the relevant guidelines. NOx levels continue to reduce when using wood waste as an alternative fuel to natural gas. The findings from this report show that burning RCD with increased plastic content is a viable option to reduce the total natural gas requirement for making clinker. ABCL therefore seeks approval for the maximum permitted plastics content to be increased to 20% by weight in RCD wood waste. The maximum RCD firing rate would remain at 15tph.