



Weston Aluminium Pty Ltd

MONITORING AND VERIFICATION REPORT

SPENT POTLINING MATERIAL PROCESSING TRIAL

**ALUMINIUM DROSS PROCESSING FACILITY
KURRI KURRI, NSW**

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1. INTRODUCTION

Since 2005, Weston Aluminium representatives have undertaken extensive research, both domestically and overseas, investigating available technologies for the treatment of SPL from primary aluminium smelters. Weston Aluminium's objective is to offer a sustainable solution to domestic smelters, enabling the cost-effective treatment of SPL and, in conjunction with other treated industrial by-products, formulate the manufacture of a value-added substitute for roadbase and other building and construction products. This particular project was conceived through our Membership in the NSW DECCW Sustainability Advantage Program and our central foundation and ongoing involvement with the NSW Industrial Ecology Network, represented by like-minded industry, academics and Government regulators, eager to encourage the recovery of industrial by-products as valuable resources, and thereby achieve the diversion of large material volumes from landfill.

SPL is a hazardous by-product of primary aluminium production, generated from the periodic de-lining of electrolytic cells. First Cut SPL (originating from the carbon cathode) and Second Cut SPL (refractory lining) contain varying proportions of aluminium, carbon, cyanide, fluorides, sodium and other trace contaminants, and its management and disposal represents a major issue faced by the industry on a worldwide scale. At present, the two primary smelters in NSW (Tomago Aluminium Company and Hydro Aluminium) have not yet attained an effective and sustainable solution for their SPL, and each continue to stockpile surplus SPL and/or export the waste to Europe for treatment. Such treatment is performed at significant expense, and relies on the transport of dangerous and hazardous materials over many jurisdictions and the vagaries of third party countries. This strategy is clearly not sustainable for the domestic industry.

Weston Aluminium proposes to diversify its service provision to the aluminium smelters beyond the reprocessing of aluminium drosses and other aluminium-bearing wastes, to include the treatment and processing of SPL at a local level.

As part of internal research and development programs, Weston Aluminium undertook a series of laboratory-scale SPL processing trials in New Zealand during early 2010 to investigate process design parameters and to assess emission control performance under such small-scale operating conditions. As an extension of these earlier trials, Weston Aluminium subsequently sought Development Modification Approval and a variation to our Environmental Protection Licence for a larger-scale Trial exercise at our Kurri Kurri premises (refer to correspondence by Weston Aluminium dated 26 May 2010). Regulatory approval was granted by the Department of Planning and the Department of Environment, Climate Change & Water, and the Trial subsequently conducted on 14 August 2010. Copies of our Development Consent and Environment Protection Licence are provided as **Attachments 1** and **2** respectively.

The objectives of the current Trial were to verify operations and to demonstrate emission control performance and compliance on the larger-scale.

This report has been prepared in accordance with requirements defined in our Development Consent (DA 86-04-01 Mod 4) and our Environment Protection Licence (EPL No. 6423), and describes processing methodology, monitoring findings and verification of emission control performance assessed during the SPL processing Trial, as conducted on 14 August 2010.

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2. SCOPE OF WORKS

2.1 SPL Processing Trial

The scope of the SPL processing Trial conducted at Weston Aluminium on 14 August, as defined below, is consistent with proposal correspondence to Regulatory Authorities (26 May 2010) and incorporates regulatory approval requirements.

- Preparation of Risk Assessments and Safe Operating Procedures for the safe transport, handling, storage and processing of SPL;
- Sourcing and delivery of 1st and 2nd cut SPL from each of the two local smelters (Tomago Aluminium and Hydro Aluminium) by a licensed Dangerous Goods transport contractor (Note: SPL feedstock could not be obtained from the Hydro Aluminium smelter). Approximately 8 tonnes of SPL was provided by Tomago for the Trial;
- Storage of all SPL materials and treated products within under-cover and bunded areas to prevent the potential contamination of stormwater;
- NATA-certified laboratory analysis to characterise Trial feedstock materials;
- Provision of notification to regulatory bodies prior to, and upon conclusion, of Trial activities;
- Trial processing of the SPL at our Kurri Kurri facility, as follows:
 - Storage of Trial feedstock materials in existing, purpose-built and enclosed bays awaiting Trial use;
 - Preparation of feedstock blends, including an SPL-only feed, and a blend of SPL, cullet, iron oxide and lime;
 - Batch processing of the two discrete blends through an existing natural gas-fired rotary furnace in 2.5 – 3.5 tonne batches and at temperatures exceeding 650°C. Note: SPL processing was performed independently of normal aluminium dross processing activities to thereby permit an assessment of emissions performance attributed to SPL processing only;
 - Maintenance and operation of the existing wet-dry fluoride scrubber and baghouse pollution control systems to control and monitor air emissions to within regulatory requirements. NATA-accredited emissions monitoring were performed concurrently with the Trial program to confirm air emissions performance; and
 - Recovery of the treated product and storage undercover awaiting laboratory assessment.
- Monitoring and recording of Trial operating conditions, including feedstock quantity and characteristics, processing intervals and furnace temperatures;
- NATA-certified laboratory analysis of the treated product to confirm cyanide destruction and contaminant immobilisation. The analytical suite included an assessment of total contaminant loads (including cyanide, fluoride, alkalis and heavy metals) and leachable contaminant loads (including cyanide, fluoride, alkalis and heavy metals) using the Toxicity Characterisation Leaching Procedure (TCLP);

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- NATA-certified emission testing in conjunction with Trial furnace processing works to assess compliance with existing exhaust emission performance requirements for EPL Point 1 (Stack 1). This included an assessment of total and fine particulate, cyanide, oxides of sulfur, oxides of nitrogen, chlorine, hydrogen chloride, particulate and gaseous fluoride, polycyclic aromatic hydrocarbons, volatile organic hydrocarbons, hazardous substances (heavy metals), carbon monoxide, oxygen and flow characteristics (i.e. velocity, volumetric flowrate, temperature and gas density). Real-time, continuous assessment of gaseous fluoride and solid particulates was also performed using existing, on-site monitoring systems;
- Return of any unused SPL materials to the source Smelter; and
- Blending and performance testing of the glassy slag as an integrated aggregate substitute in a roadbase sample matrix (to occur at a later date).

2.2 Reporting

The scope of this monitoring and verification report is defined in Condition 54B of our Development Consent (DA 86-04-01 Mod 4) and Condition U2.2 of our Environment Protection Licence (EPL No. 6423), as reproduced below:

The Monitoring and Verification Report must:

- be submitted to DECCW, Cessnock City Council and the Director-General within 90 days of the completion of the Spent Potlining Material Processing Trial;
- detail the results of the monitoring required by Conditions of the Development Consent and the Environment Protection Licence;
- compare the results of the trial emissions assessment to the laboratory results described in the report dated 30 April 2010 prepared by K2 Environmental Limited (*prepared in relation to earlier NZ trials*), and the limits in the EPL and DECCW's air quality impact assessment criteria specified in the "Approved Methods for the Modelling and Assessment of Air Pollutants in NSW" (DEC 2005);
- describe any anomalies in the monitoring data, and any exceedances of the limits or assessment criteria;
- characterise the trial outputs and describe how these products are to be managed and disposed of;
- summarise the findings of the trial;
- recommend any actions that could be taken to minimise emissions during any future processing; and
- discuss the likely options for any future processing.

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3. FINDINGS

3.1 Feedstock Blends

A summary of feedstock blends and raw material quantities employed in the Trial is presented in **Table 1**. Raw feedstock weight data may be referred to in **Attachment 3**.

Table 1: Trial Raw Material Feedstock Quantities and Blends

Trial Parameters	Trial No.	
	1	3
1st Cut SPL	0.46	-
2nd Cut SPL	0.50	2.00
Iron Oxide	0.69	-
Cullet	0.46	-
Lime	0.14	-
Total	2.25 Mt	2.00 Mt

3.2 Feedstock Analysis

Samples of feedstock materials (as received) were submitted to ALS NATA laboratories for characterisation analyses. A summary of these data is presented in **Table 2**. Analytical Laboratory Certificates may be referred to in **Attachment 4**.

The Trial blends were designed to 1) mimic the batch formulations trialled earlier in New Zealand (i.e. blend of SPL, cullet, iron and lime), and 2) to facilitate as a Control (i.e. SPL only feed). Analyses of inputs were undertaken by ALS NATA Laboratories to characterise the feed, and to assist with refining the blend formulations. The characteristics of SPL sourced for the Trial are considered to be representative of SPL generated at the Tomago Aluminium smelter. Other raw material additives contained suitable quantities of the essential components (i.e. iron oxide, silica and lime), and were considered suitable for the Trial. Should further work be undertaken with the iron-based additive (whilst unlikely), an alternative source may be investigated to limit and minimise heavy metal content.



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Table 2: Analytical Laboratory Analysis Results – Raw Feedstock Materials

Analytical Parameter	Total Contaminant Concentrations (mg/kg, dry wt)					TCLP Leachable Contaminant Concentrations (mg/L)	
	1st Cut SPL	2nd Cut SPL	Iron Oxide	Cullet	Lime	1st Cut SPL	2nd Cut SPL
Aluminium	69,600	79,200	14,500	140	1,030	75.8	9.8
Antimony	6	<5	42	14	<5	<0.1	<0.1
Arsenic	8	8	15	<5	<5	<0.1	<0.1
Barium	410	390	60	<10	<10	2.0	0.6
Beryllium	9	7	1	<1	<1	0.08	<0.05
Cadmium	1	<1	13	<1	<1	<0.05	<0.05
Calcium	360	<10	70	180	3,920	63	21
Chromium	34	26	119	4	0.3	<0.1	<0.1
Cobalt	3	<2	6	<2	<2	<0.1	<0.1
Copper	127	18	168	22	5	0.6	<0.1
Cyanide	319	148	1	<1	<1	4.73	6.83
Fluoride	79,100	47,900	18,400	180	<40	98.0	134
Iron	39,600	14,700	413,000	410	760	20.2	11.3
Lead	42	18	532	109	<5	<0.1	<0.1
Manganese	590	141	7,050	14	78	1.9	<0.1
Mercury	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0010	<0.0010
Nickel	95	28	76	3	<2	0.7	0.1
Phosphorus	210	250	920	<50	120	0.45	0.55
Selenium	<5	<5	<5	3	<5	<0.05	<0.05
Sodium	13,700	68,900	1,880	490	100	2210	2390
Sulfur	1,500	800	700	400	500	40	29
Total Organic Carbon	8,000	<5,000	6,000	<5,000	<5,000	2250	2310
Thallium	<5	<5	8	<5	<5	<0.05	<0.05
Vanadium	104	48	457	<5	<5	0.3	0.3
Zinc	1,140	168	22,400	65	56	0.5	0.3

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3.3 Thermal Operating Conditions

The temperature profile of furnace feedstock material, as a function of time during each Trial batch, is illustrated in **Figure 1**. Raw temperature monitoring data may be referred to in **Attachment 3**.

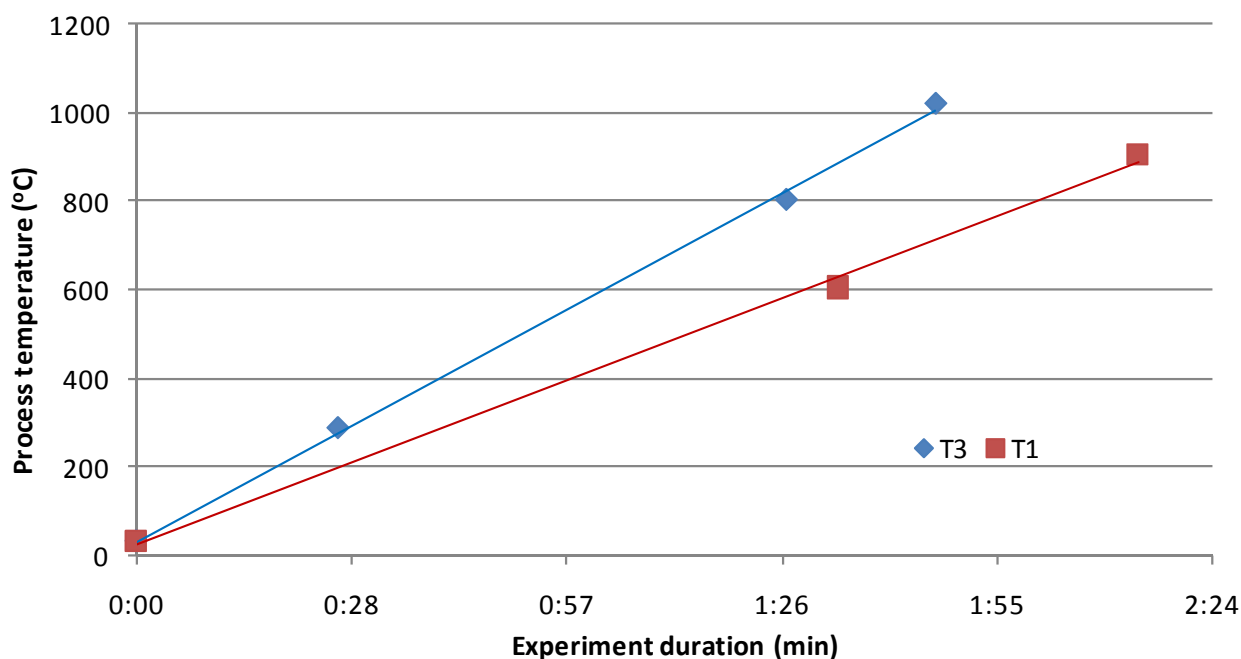


Figure 1: Temperature Profile of Furnace Feedstock Material

Processing of Trial blends was performed in a 5 tonne, refractory lined natural gas-fired rotary furnace. Processing was undertaken over extended periods and at elevated temperatures above 750°C to thereby investigate worst-case exhaust generation (in particular, fluoride evolution), and hence determine air emission control performance (refer to **Section 3.4**).

3.4 Air Emission Monitoring

3.4.1 Real-time Gaseous Fluoride Emissions Monitoring

Continuous emissions monitoring of gaseous fluoride concentrations was performed throughout the Trial to assess compliance with the regulatory limit. Hourly average fluoride data are presented in **Figure 2** for comparison with the regulatory limit of 1.4 mg/m³.



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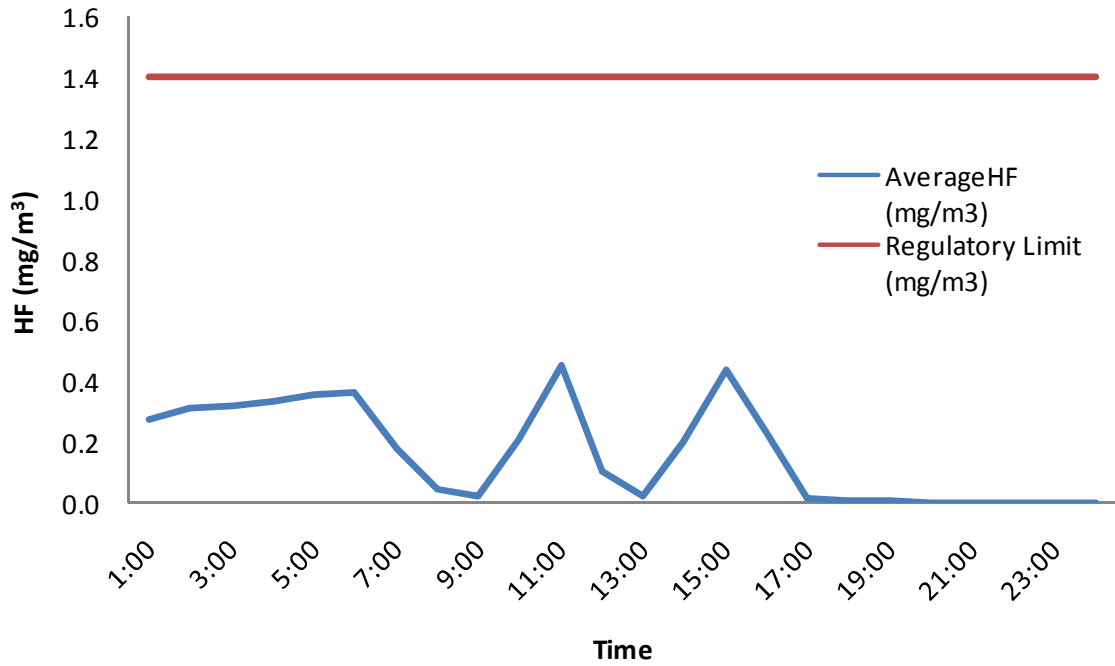


Figure 2: Real-time (Hourly Average) Gaseous Fluoride Emissions Monitoring Data

3.4.2 Real-time Particulate Emissions Monitoring

Continuous emissions monitoring of particulate concentrations was performed throughout the Trial to assess compliance with the regulatory limit of 25 mg/m³. Monitoring data are presented in **Figure 3**.

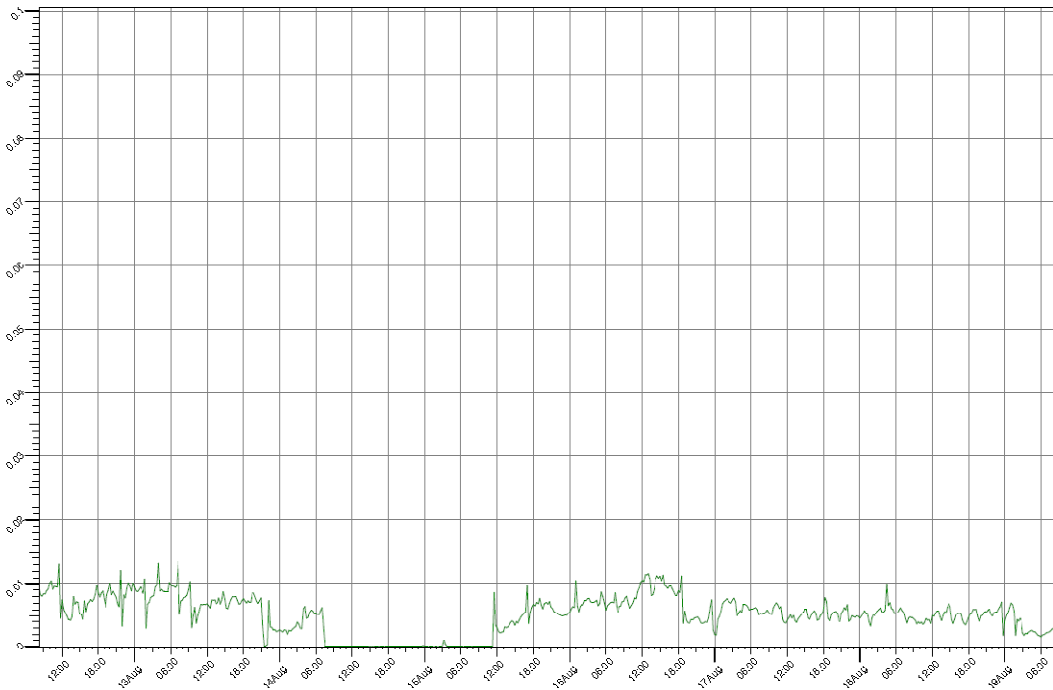


Figure 3: Real-time Particulate Emissions Monitoring Data

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3.4.3 Stack Emission Monitoring

A summary of stack emission monitoring results is presented in **Table 3**. Regulatory compliance limits are also tabulated. A copy of the Air Emissions Monitoring Report may be referred to in **Attachment 5**.

Table 3: Summary of Compliance Stack Emission Testing Results

Emission Monitoring Parameter	Trial Emission Monitoring	Regulatory Compliance Limits	Emission Monitoring (NZ Trial)
Total Particulate Matter	8.9	25	<0.12
Fine Particulate Matter	0.24	NL	ND
Hydrogen Chloride	0.95	400	ND
Chlorine	0.42	NL	ND
Particulate Fluoride	0.027	NL	0.070
Gaseous Fluoride	0.38	2	0.072
Sulfuric Acid Mist	<1.6	100	ND
Sulfur Dioxide	<7.8	NL	ND
Total Hazardous Substances (metals)	0.017	10	ND
Total Polycyclic Aromatic Hydrocarbons	0.74	NL	ND
Volatile Organic Compounds	<0.17	NL	ND
Total Oxides of Nitrogen (as equiv. NO ₂)	4	2500	ND
Carbon Monoxide	5	100	ND
Cyanide	<0.061	NL	0.068
Oxygen (%)	20.7	NL	3.1
Temperature (°C)	52.4	NL	53
Velocity (m/s)	30	NL	5.6
Dry Gas Density (kg/m ³)	1.29	NL	1.31

Notes: All values are expressed in mg/m³ (0°C, 1 atm, dry gas) unless otherwise defined
NL – Not Listed
ND – Not Determined

All air pollutant emission concentrations monitored during the Trial were determined to be very low, and were well below Weston Aluminium's regulatory requirements. **No exceedances of air pollutant concentration limits occurred during the Trial.** This verifies that the air emission monitoring and control systems employed at Weston Aluminium were functioning correctly for the duration of the Trial, and perform more than adequately to maintain environmental compliance during the processing of SPL. Whilst such emission performance was expected, such verification was essential for progression to subsequent Trial and commercial activities relating to future SPL processing.

3.5 Treated Product Analysis

Samples of product materials were submitted to ALS NATA laboratories for characterisation analyses. A summary of these data is presented in **Table 4**. Analytical Laboratory Certificates may be referred to in **Attachment 4**.



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Table 4: Analytical Laboratory Analysis Results – Product Materials

Analytical Parameter	Total Contaminant Concentrations (mg/kg, dry wt)		TCLP Leachable Contaminant Concentrations (mg/L)	
	T1	T3	T1	T3
Aluminium	58,400	117,000	37.2	537
Antimony	14	<5	<0.1	<0.1
Arsenic	9	8	<0.1	<0.1
Barium	260	500	0.7	3.3
Beryllium	4	8	<0.05	0.09
Cadmium	<1	<1	<0.05	<0.05
Calcium	10	<10	270	34
Chromium	66	52	<0.1	<0.1
Cobalt	4	3	<0.1	<0.1
Copper	96	58	<0.1	<0.1
Cyanide	6	4	<0.004	0.007
Fluoride	45,800	62,700	58.0	808.0
Iron	144,000	18,100	288	77.2
Lead	107	19	<0.1	<0.1
Manganese	1910	157	9.7	0.8
Mercury	<0.1	<0.1	<0.0010	<0.0010
Nickel	48	42	<0.1	<0.1
Phosphorus	320	300	0.10	0.38
Selenium	<5	<5	<0.05	<0.05
Sodium	2100	36,100	-	1740
Sulfur	600	900	<1	10
Total Organic Carbon	<5,000	<5,000	2,340	2230
Thallium	<5	<5	<0.05	<0.05
Vanadium	126	63	<0.1	0.1
Zinc	5,160	97	12.5	0.2

Notes: TCLP sodium could not be determined for the T1 product due to background matrix effects

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4. DISCUSSION

- The principal objective of the SPL Processing Trial was to assess emissions and demonstrate the suitability of existing pollution control and monitoring systems at Weston Aluminium's Kurri Kurri facility, thereby verifying that air emissions generated during SPL processing activities could be controlled and maintained to the satisfaction of regulatory requirements. This objective is considered to have been successfully achieved;
- Trials were performed to investigate the emissions-control performance whilst thermally-treating SPL in conjunction with various feedstock additives. The treatment of an SPL-only feed was also investigated as a control. The final blends were determined based upon findings of earlier trials performed in NZ, and were also constrained by raw material availability;
- All SPL raw materials were appropriately stored within purpose-built building and bays throughout the Trial. These facilities are adequately bunded, and prevent the ingress of, and subsequent contact with, stormwater. This is consistent with the current storage, handling and management of aluminium dross on site, for which the same Dangerous Goods classification as SPL applies;
- Temperatures at which cyanide is known to be thermally-destroyed (>750°C) were achieved. The thermal treatment performance is confirmed by the exceptionally low cyanide residuals. Treatment temperatures (over 1000°C attained) and furnace residence times required for SPL treatment are expected to be somewhat less than that explored during the Trial;
- For each Trial batch, the furnace was operated at elevated temperatures to investigate the potential for fluoride evolution and its resultant emission control, and to monitor physical changes to feedstock blends, impacts upon emission control, and other operational issues (findings not reported);
- Emission testing undertaken in conjunction with Trial activities reveal exceptionally low pollutant discharge concentrations, and confirm the performance of the existing lime-scrubber and fabric filter baghouse pollutant control systems. All air emission concentrations were well below regulatory compliance limits. No further assessment of emission performance (including dispersion modelling) is considered warranted. It is considered that the existing pollution control system is suitable for future processing of SPL;
- Real-time, continuous emission monitoring data confirm that gaseous fluoride and particulate emission concentrations satisfied the regulatory compliance limits throughout the Trial interval. Hence, processing activities were not required to cease at any time during the Trial, nor were Regulatory Authorities required to be notified in relation to any exceedance;
- Stack emission data are generally in the same order as those determined by K2 Environmental Limited as part of the earlier NZ Trial exercise (Note: the exceptionally low total particulate concentration determined for the NZ trial is attributed to the relatively low gas volumes and excessively large fabric filter area available for emission control). Given the contrasting scale and technique of processing equipment, and the high sophistication of Weston Aluminium's air emission pollution control and monitoring systems compared with that employed during the laboratory-scale trials in NZ, direct comparison of the present Trial results to that reported by K2 Environmental is considered to be of limited value. Nevertheless, it is noted that in each case,

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that the concentrations of pollutant air emissions were very low and satisfied regulatory requirements. The stack emission data is generally the same as a function of the following:

- Thermal treatment of the feedstock mass exceeded 750°C required for thermal destruction of cyanide. Hence, cyanide was negligible or not detectible in the exhaust streams; and
- Each emission control system is designed for fluoride control (via lime scrubbing) and for particulate matter removal (via fabric filter baghouse) prior to atmospheric discharge. Hence, fluoride emissions were adequately controlled on the scales applied, and similarly, particulate matter emissions (and emissions of those contaminants that may have been particulate-bound) were suitably controlled;
- As expected, cyanide loads and leachability within product slags were dramatically reduced through treatment, and were determined to be negligible within the residual slags. Treatment products exhibit similar heavy metal leachability rates relative to that determined for SPL feedstock materials, whilst fluoride leachability was elevated within the SPL-only (control) treatment product (see further discussion below). Assessment of contaminant loads and leachability rates in accordance with the DECCW's 2009 publication, *Waste Classification Guidelines, Part 1: Classifying Wastes*, revealed that the product slags retain a Hazardous Waste classification due to total fluoride loads and leachability behaviour (control only). Remaining parameters satisfy the General Waste criteria. Further work is to be performed to improve the fixation of fluoride and demonstrate inherent immobilisation;
- Fluoride leachability remains elevated for each Batch product, and depending upon treated product end use application, further work may be required to improve fluoride fixation/immobilisation. Due to the affinity of calcium for fluoride, and the resultant inert and highly insoluble CaF₂ formation, it is proposed that the incorporation of lime as a feedstock additive would be explored during future trial processing. Note: fluoride fixation was significantly greater for the Batch 1 treated product (with only 6% lime addition) compared with that of the Control (no lime addition). Specifically, future Trials may seek to investigate end product fluoride immobilisation principally as a function of lime addition rates;
- No further anomalies in the monitoring data are evident;
- Residual product quantities will be maintained on site for future processing and investigation; and
- Whilst the Trial successfully confirmed the compliant performance of air emissions control, insufficient data is available to determine ideal treatment conditions for product versatility and reuse. Future work may include the trialing and assessment of alternative raw material feedstock materials and blends under various operational conditions and will also focus on the performance and suitability of treatment product slag end uses, including use as roadbase component. Further consultation with regulatory authorities will occur at this time.

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ATTACHMENT 1

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