

DATE OF REPORT: 18TH JUNE 2018



TEST REPORT No. APR18054.1

**AIR EMISSIONS MONITORING OF
RELEASE POINTS 4A & 4B AT
ADELAIDE BRIGHTON CEMENT LTD
IN BIRKENHEAD**

DATE OF TESTING: 23RD – 25TH APRIL 2018

ACCREDITATION:



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INTRODUCTION

Airlabs Environmental Pty Ltd was commissioned by Adelaide Brighton Cement Ltd to conduct air emissions testing of the Dry Process Kiln 4 Main Stack (Release Point 4A) and the Precalciner Plant Stack (Release Point 4B) at their Birkenhead Plant. The following parameters were monitored in replicate on each stack:

- Gas velocity and volume flow rate
- Temperature
- Moisture concentration
- Concentration of oxygen & carbon dioxide
- Dry molecular weight and dry gas density
- Concentration and mass emission rate of:
 - Total solid particulates;
 - PM₁₀ (Particulate matter with a nominal aerodynamic diameter $\leq 10 \mu\text{m}$);
 - PM_{2.5} (Particulate matter with a nominal aerodynamic diameter $\leq 2.5 \mu\text{m}$);
 - Carbon monoxide;
 - Nitrogen oxides (NO, NO₂, NO_x);
 - Sulphur dioxide;
 - Antimony and its compounds (as Sb);
 - Arsenic and its compounds (as As);
 - Barium and its compounds (as Ba);
 - Beryllium and its compounds (as Be);
 - Cadmium and its compounds (as Cd);
 - Chromium trivalent and its compounds (as Cr(III));
 - Chromium hexavalent and its compounds (as Cr(VI))
 - Copper Oxide fume (as CuO);
 - Iron oxide fume (as Fe₂O₃);
 - Lead and its compounds (as Pb);
 - Magnesium oxide fume (as MgO);
 - Manganese and its compounds (as Mn);
 - Mercury and its compounds - organic and inorganic (as Hg);
 - Nickel and its compounds (as Ni);
 - Zinc oxide fume (as ZnO);
 - Hydrogen chloride;
 - Fluoride (as HF);
 - Chlorine;
 - PAHs (as BaP toxic equivalent);
 - Polychlorinated Dibenzo-*p*-Dioxins & Polychlorinated Dibenzofurans (Dioxins & Furans);
 - Total Volatile Organic Compounds (TVOCs);
 - Benzene.

Combustion gases (O₂, CO, CO₂, SO₂ and NO_x) were monitored semi-continuously and the average values reported. Average normalised flow rates were used to calculate the mass emission rates. The Precalciner Plant Stack (4B) and the Dry Process Kiln 4 Main Stack (4A) were tested between 23rd to 25th April 2018.

QUALITY STATEMENT

Airlabs Environmental is committed to providing the highest quality data to all our clients, as reflected in our ISO 17025 (NATA) accreditation. This requires strict adherence to, and continuous improvement of, all our processes and test work. Our goal is to exceed the QA/QC requirements as set by our clients and appropriate governmental entities and to ensure that all data generated is scientifically valid and defensible.

Airlabs Environmental is NATA accredited for all sampling undertaken for this project. Analysis was undertaken by the National Measurement Institute (NATA Accreditation No. 198) and Airlabs Environmental in accordance with our terms of accreditation.

OPERATING CONDITIONS



TEST METHODS

All sampling was undertaken by Airlabs Environmental. Airlabs Environmental is NATA accredited for all sampling undertaken for this project (NATA Accredited Laboratory No. 15463). Analysis was undertaken by Airlabs Environmental and the National Measurement Institute (NMI, NATA Accreditation No. 198) in accordance with our terms of accreditation. Specific details of the test methods used are available upon request.

Table 2: Summary of Test Methods

Test Parameter	Test Method	Method Detection Limit	Estimated Measurement Uncertainty	NATA Accredited	
				Sampling	Analysis
Sample plane criteria	AS 4323.1	NA	NA	✓	NA
Gas velocity	US EPA Method 2	3 m/s	± 10%	✓	NA
Temperature	US EPA Method 2	273K (0°C)	± 1%	✓	NA
Moisture content	US EPA Method 4	0.2%	± 5%	✓	✓
Oxygen & carbon dioxide	US EPA Method 3A	0.1%	± 2%	✓	✓
Dry molecular weight & gas density	US EPA Method 3	NA	± 5%	✓	✓
Total solid particulates ¹	AS 4323.2	1 mg/Nm ³	± 15%	✓	✓
PM ₁₀ & PM _{2.5}	US EPA Method 201A	1 mg/Nm ³	± 15%	✓	✓
Sulfur dioxide	US EPA Method 6C	3 mg/Nm ³	± 5%	✓	✓
Carbon monoxide	US EPA Method 10	1 mg/Nm ³	± 5%	✓	✓
Nitrogen oxides (as NO ₂)	US EPA Method 7E	2 mg/Nm ³	± 5%	✓	✓
Chlorine, Chloride (as HCl) & Fluoride (as HF)	US EPA Method 26	0.1 mg/Nm ³	± 17%	✓	✓ ¹
Total VOCs	US EPA Method 25A	0.1 mg/Nm ³	± 10%	✓	✓
Benzene	US EPA Method 18 / NSW EPA TM-34	0.05 mg/Nm ³	± 17%	✓	✓
Multi-Metals	US EPA Method 29	0.05 mg/Nm ³ (total metals)	± 17%	✓	✓ ²
Chromium VI	US EPA Method 0061	0.0001 mg/Nm ³	± 17%	✓	✓ ³
PAHs (as BaP-TEQ _{PAH})	US EPA SW-846 Method 0010 & CARB 429	0.000005 mg/Nm ³ (total BaP-TEQ _{PAH})	± 20%	✓	✓ ⁴
Dioxins and Furans (PCDD/Fs)	USEPA Method 23	0.0004 ng/Nm ³ as I-TEQ	± 25%	✓	✓ ⁵

¹. Total solid particulates were determined in conjunction with multi-metals, as the sampling procedure for the particulate phase of the metals train by USEPA 29 is identical to AS 4323.2. US EPA 29 states that 'This method may be used to determine particulate emissions in addition to the metals emissions if the prescribed procedures and precautions are followed'.

¹. Chloride and fluoride analyses were performed by NMI, with results included in their Report No. RN1196783.

². Multi-metal analysis was performed on the various sample components by NMI, with results included in their Report No. RN1196783.

³. Hexavalent chromium analysis was performed by NMI, with results included in their Report No. RN1196783.

⁴. PAH analysis was performed by NMI, with results included in their Analytical Certificate No. ORG18_023.

⁵. Dioxin & furan analysis was performed by NMI, with results included in their Analytical Certificate No. DAU18_084.

DEFINITIONS

'SA EPA'	South Australian Environment Protection Authority.
'US EPA'	United States Environmental Protection Agency.
'NSW EPA'	New South Wales Environment Protection Authority.
'NMI'	National Measurement Institute (Australian Government), North Ryde, NSW.
'K'	Absolute temperature in Kelvin ($^{\circ}\text{C} + 273$).
'mB'	Pressure in millibars.
'STP'	Standard temperature and pressure (273K and 101.3 kPa).
'm ³ '	Actual gas volume in cubic metres at stack conditions.
'Nm ³ '	Gas volume in dry cubic metres at STP.
'Sm ³ '	Gas volume in dry cubic metres at STP and referenced to 11% oxygen concentration.
'<'	Less than. The value stated is the limit of detection.
'g'	Grams.
'mg'	Milligrams (10^{-3} grams).
' μg '	Micrograms (10^{-6} grams).
'ng'	Nanograms (10^{-9} grams).
'min'	Minute.
'NA'	Not applicable.
'PM ₁₀ '	Particulate matter with a nominal aerodynamic diameter $\leq 10 \mu\text{m}$.
'PM _{2.5} '	Particulate matter with a nominal aerodynamic diameter $\leq 2.5 \mu\text{m}$.
'LOD'	Limit of detection.
'FIA'	Flame ionisation analyser.
'VOC'	Volatile organic compound. A VOC is defined as any chemical compound based on carbon chains or rings with a vapour pressure greater than 2 mm of mercury (0.27 kPa) at 25 $^{\circ}\text{C}$. These compounds may contain hydrogen, oxygen, nitrogen and other elements, but specifically excluded are methane, carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonate salts.
'PAHs'	Polycyclic aromatic hydrocarbons.
'CARB'	California Air Resources Board.
'OEHHA'	Office of Environmental Health Hazard Assessment (US).
'BaP-PEF'	Benzo(a)pyrene Potency Equivalent Factor, as defined in "Benzo(a)pyrene as a Toxic Air Contaminant", CARB/OEHHA Executive Summary, July 1994.
'BAP-TEQ _{PAH} '	Benzo(a)pyrene Toxic Equivalents.
'PCDDs'	Polychlorinated Dibenzo-p-Dioxins.
'PCDFs'	Polychlorinated Dibenzofurans.
'TCDF'	Tetrachlorodibenzofuran.
'TCDD'	Tetrachlorodibenzo-p-dioxin.
'PeCDF'	Pentachlorodibenzofuran.
'PeCDD'	Pentachlorodibenzo-p-dioxin.
'HxCDF'	Hexachlorodibenzofuran.
'HxCDD'	Hexachlorodibenzo-p-dioxin.
'HpCDF'	Heptachlorodibenzofuran.
'HpCDD'	Heptachlorodibenzo-p-dioxin.
'OCDF'	Octachlorodibenzofuran.
'OCDD'	Octachlorodibenzo-p-dioxin.
'NATO'	North Atlantic Treaty Organisation.
'WHO'	World Health Organisation.
'NATO ₈₉ I-TEF'	International Toxic Equivalency Factor for PCDDs & PCDFs (NATO 1989 basis).
'NATO ₈₉ I-TEQ'	International Toxic Equivalent for PCDDs & PCDFs, based on the 2,3,7,8-TCDD congener (NATO 1989 basis).
'WHO ₀₅ TEF'	International Toxic Equivalency Factor for PCDDs & PCDFs (WHO 2005 basis).
'WHO ₀₅ TEQ'	International Toxic Equivalent for PCDDs & PCDFs, based on the 2,3,7,8-TCDD congener (WHO 2005 basis).

SUITABILITY OF SAMPLING PLANE

The criteria for sampling planes as specified in AS4323.1-1995 'Stationary Source Emissions, Method 1: Selection of Sampling Provisions' states that, in the absence of cyclonic flow activity, ideal sampling plane conditions are found to exist at the positions given in Table 3 below:

Table 3: Criteria for the Selection of Sampling Planes

Type of flow disturbance	Minimum distance upstream from disturbance, diameters (D)	Minimum distance downstream from disturbance, diameters (D)
Bend, connection, junction, direction change	>2D	>6D
Louvre, butterfly damper (partially closed or closed)	>3D	>6D
Axial fan	>3D	>8D (see Note)
Centrifugal fan	>3D	>6D

NOTE: The plane should be selected as far as practicable from a fan. Flow straighteners may be required to ensure the position chosen meets the check criteria listed in Items (a) to (f) below.

Section 4.1 of AS 4323.1-1995 (Ideal Sampling Positions) states that the location of the sampling plane shall be such that it meets the following criteria:

- The gas flow is basically in the same direction at all points along each sampling traverse.
- The gas velocity at all sampling points is greater than 3 m/s.
- The gas flow profile at the sampling plane shall be steady, evenly distributed and not have a cyclonic component which exceeds an angle of 15° to the duct axis, when measured near the periphery of a circular sampling plane.
- The temperature difference between adjacent points of the survey along each sampling traverse is less than 10% of the absolute temperature, and the temperature at any point differs by less than 10% from the mean.
- The ratio of the highest to lowest pitot pressure difference shall not exceed 9:1 and the ratio of highest to lowest gas velocities shall not exceed 3:1. For isokinetic testing with the use of impingers, the gas velocity ratio across the sampling plane should not exceed 1.6:1.
- The gas temperature at the sampling plane should preferably be above the dewpoint.

The gas characteristics determined for the Dry Process Kiln 4 Main Stack (Release Point 4A) and the Precalciner Plant Stack (Release Point 4B) satisfied the requirements of AS 4323.1-1995 Section 4.1 (a) - (f), and as such the sampling location is considered to be ideal. The sampling plane details and required number of sampling points are given in Tables 4 and 5 below:

SUITABILITY OF SAMPLING PLANE Continued

Table 4: Sampling Plane Details for the Kiln 4 Main Stack

Parameter	
Stack Shape	Circular
Actual Stack Internal Diameter (m)	3.23
Stack Exit Diameter (m)	3.23
Direction of Discharge to Air	Vertical
Type of Disturbance, Upstream	Centrifugal Fan
Distance from Upstream Disturbance	> 6 D
Type of Disturbance, Downstream	Stack Exit
Distance to Downstream Disturbance	> 2 D
Compliance with AS4323.1, Ideal Conditions	Yes
Stack Height Above Ground Level (m)	75.5
Standard No. of Sampling Points per Traverse	12
Number of Traverses	2
Correction Factor	N/A
Corrected No. of Sampling Points per Traverse	N/A
Total No. of Sampling Points	24
Stratified	No
Cyclonic	No (< 15°)
Velocity Difference	1.2:1 (< 1.6:1)
Absolute Temperature Difference (K)	< 10%
Minimum Velocity at any Sample Point (m/s)	> 3

Figure 1: Kiln 4 Main Stack (RP 4A)



Table 5: Sampling Plane Details for the Precalciner Plant Stack

Parameter	
Stack Shape	Circular
Actual Stack Internal Diameter (m)	3.00
Stack Exit Diameter (m)	3.00
Direction of Discharge to Air	Vertical
Type of Disturbance, Upstream	Centrifugal Fan
Distance from Upstream Disturbance	> 6 D
Type of Disturbance, Downstream	Stack Exit
Distance to Downstream Disturbance	> 2 D
Compliance with AS4323.1, Ideal Conditions	Yes
Stack Height Above Ground Level (m)	96
Standard No. of Sampling Points per Traverse	12
Number of Traverses	2
Correction Factor	N/A
Corrected No. of Sampling Points per Traverse	N/A
Total No. of Sampling Points	24
Stratified	No
Cyclonic	No (< 15°)
Velocity Difference	1.1:1 (< 1.6:1)
Absolute Temperature Difference (K)	< 10%
Minimum Velocity at any Sample Point (m/s)	> 3

Figure 2: Precalciner Plant Stack (RP 4B)



RESULTS – RELEASE POINT 4A – RUN 1

Company	Adelaide Brighton Cement
Site	Elder Rd, Birkenhead
Source Tested	Dry Process Kiln 4 Main Stack - Release Point 4A
Date of Tests	23 rd April 2018
Sampling Period	10:35 – 21:26
Testing Officers	C. Clunies Ross
Sampling Position	Four 4" BSP sample ports in circular stack

Table 6: Release Point 4A (Run 1) - Gas Flow Conditions

Sampling Conditions	Average
Stack diameter at sampling plane (m)	3.23
Average stack gas temperature (K)	382 (109°C)
Average barometric pressure (mB)	1007.8
Average static pressure (mB)	- 3.0 (negative pressure)
Average stack pressure (mB)	1004.8
Average velocity at sampling plane (m/s)	18.9
Average velocity at sampling plane expressed at STP (m/s)	12.3
Actual gas flow rate (m ³ /min)	9,290
Average moisture content (%v/v)	8.49
Gas flow rate at STP, dry (Nm ³ /min)	6,070
Gas flow rate at STP, dry and referenced to 11% O ₂ (m ³ /min)	2,450
Average carbon dioxide concentration, dry basis (%v/v)	4.40
Average oxygen concentration, dry basis (%v/v)	16.9
Dry molecular weight of stack gas (g/g mole)	29.38
Dry gas density of stack gas (kg/m ³)	1.311

RESULTS – RELEASE POINT 4A – RUN 1 Continued

Table 7: Release Point 4A (Run 1) - Summary of Test Results

Parameter	Sampling Period	Concentration (mg/Nm ³)	Emission Rate (g/min)
Total Solid Particulates	13:17 – 15:21 (23/04/18)	15	91
PM ₁₀ Particles	10:40 – 12:43 (23/04/18)	10	61
PM _{2.5} Particles		4.1	25
Sulphur Dioxide		< 3	< 20
Carbon Monoxide	18:22 – 19:22 (23/04/18)	77	470
Oxides of Nitrogen (as NO ₂) <i>Actual at STP</i>		680	4,130
Hydrogen Chloride	15:50 – 16:50 (23/04/18)	1.6	9.7
Chlorine		4.5	28
Fluoride (as HF)		<0.04	<0.2
Total Volatile Organic Compounds (by FIA, as n-propane equivalent)	10:35 – 11:35 (23/04/18)	0.25	1.5
Benzene (by activated carbon adsorption and GC/MS analysis)		< 0.09	< 0.5
Total Multi-Metals ^a	13:17 – 15:21 (23/04/18)	0.46	2.8
Chromium VI and Compounds	15:54 – 17:57 (23/04/18)	0.00078	0.0045
Polycyclic Aromatic Hydrocarbons <i>Total BaP-TEQ_{PAH}</i> ^b		0.000013	0.000079
<i>Polychlorinated Dioxins and Furans</i> ^c Total tetra to octa PCDDs/Fs ^d WHO ₀₅ TEQ for PCDDs/Fs ^d NATO ₈₉ I-TEQ for PCDDs/Fs ^d	18:23 – 21:26 (23/04/18)	0.57 ng/Nm ³ 0.0068 ng/Nm ³ 0.0072 ng/Nm ³	0.71 µg/min 0.017 µg/min 0.018 µg/min

Table 8: Comparison of Dioxin & Furan Concentration in 4A Stack (Run 1) with International Guideline

Parameter	Concentration in Stack Gas Emissions (ng/Nm ³)	Oxygen (O ₂) Reference Condition (%)	Concentration at O ₂ Reference Condition (ng/Sm ³)	International Guideline (ng/Sm ³) ^e	Compliance with International Guideline
Polychlorinated Dioxins & Furans (NATO ₈₉ I-TEQ)	0.0029	11	0.0072	0.1	YES

^a Individual metals and their compounds are provided in Table 9. Total solid particulates were determined in conjunction with multi-metals, as the sampling procedure for the particulate phase of the metals train by USEPA 29 is identical to AS 4323.2 (refer to Table 2 'Summary of Test Methods').

^b Individual BaP-TEQ_{PAH} contributions are given in Table 10, and the total BaP-TEQ_{PAH} in Table 12. This result includes half LOD values.

^c Tetra-octa chlorinated dioxin & furan congener profile, homologue groups and toxic equivalents are given in Table 13.

^d Result includes half LOD values.

^e The International Guideline for the Concentration of Polychlorinated Dioxins & Furans in Stack Gas Emissions is 0.1 ng/Sm³ I-TEQ referenced to 11% O₂.

RESULTS – RELEASE POINT 4A – RUN 1 Continued

Table 9: Release Point 4A (Run 1) - Metals and their Compounds

Metal	Concentration (mg/Nm³)	Emission Rate (g/min)
Antimony and its compounds	0.000070	0.00042
Arsenic and its compounds	0.00055	0.0033
Barium (soluble compounds)	0.0068	0.041
Beryllium and its compounds	< 0.0002	< 0.001
Cadmium and its compounds	0.0012	0.0071
Chromium (III) and its compounds	0.016	0.097
Copper oxide fume (as CuO)	0.013	0.080
Iron oxide fume (as Fe ₂ O ₃)	0.20	1.2
Lead and its compounds	0.0098	0.060
Magnesium oxide fume (as MgO)	0.17	1.0
Manganese and its compounds	0.018	0.11
Mercury and its compounds (as Hg)		
Organic:	< 0.00001	< 0.00006
Inorganic:	0.000025	0.00016
Total:	0.000025	0.00015
Nickel and its compounds	0.0049	0.030
Zinc oxide fume (as ZnO)	0.015	0.088
TOTAL METALS		
Excluding LOD values	0.46	2.8
Including half LOD values	0.46	2.8

RESULTS – RELEASE POINT 4A – RUN 1 Continued

Table 10: Release Point 4A (Run 1) - Individual USEPA Priority Pollutant PAHs

Individual USEPA Priority Pollutant PAHs	Concentration of PAHs ($\mu\text{g}/\text{Nm}^3$)	BaP-PEF value	BaP-TEQ _{PAH} Contribution	Emission Rate of PAHs (mg/min)
Naphthalene	8.2	0.0	0.0	50
2-Methylnaphthalene	0.76	0.0	0.0	4.6
Acenaphthylene	0.030	0.0	0.0	0.18
Acenaphthene	<0.01	0.0	0.0	<0.1
Fluorene	0.023	0.0	0.0	0.14
Phenanthrene	0.050	0.0	0.0	0.30
Anthracene	<0.01	0.0	0.0	<0.08
Fluoranthene	0.049	0.0	0.0	0.30
Pyrene	0.047	0.0	0.0	0.29
Benz(a)anthracene	0.016	0.1	0.0016	0.10
Chrysene	0.023	0.01	0.00023	0.14
Benzo(b)fluoranthene	<0.01	0.1	0.00063	<0.08
Benzo(k)fluoranthene	<0.01	0.1	0.00063	<0.08
Benzo(e)pyrene	<0.01	0.0	0.0	<0.08
Benzo(a)pyrene	<0.01	1.0	0.0063	<0.08
Perylene	<0.01	0.0	0.0	<0.08
Indeno(123-cd)pyrene	<0.01	0.1	0.00063	<0.08
Dibenz(ah)anthracene	<0.01	0.4	0.0025	<0.08
Benzo(ghi)perylene	<0.01	0.0	0.0	<0.08

Table 11: Release Point 4A (Run 1)- Total USEPA Priority Pollutant PAHs

Total USEPA Priority Pollutant PAHs	Concentration ($\mu\text{g}/\text{Nm}^3$)	Emission Rate (mg/min)
<i>Excluding LOD values</i>	9.3	56
<i>Including half LOD values</i>	9.3	56

Table 12: Release Point 4A (Run 1) - Total PAH Toxic Equivalents (BaP-TEQ_{PAH})

Total PAH Toxic Equivalents (BaP-TEQ _{PAH}) ^f	Concentration ($\mu\text{g}/\text{Nm}^3$)	Emission Rate (mg/min)
<i>Excluding LOD values</i>	0.0018	0.011
<i>Including half LOD values</i>	0.013	0.079

^f Calculated using benzo(a)pyrene potency equivalency factors (BaP-PEF values).

RESULTS – RELEASE POINT 4A – RUN 1 Continued

Table 13: Release Point 4A (Run 1) - PCDD/F Congener Profile

PCDD/F Congeners	Concentration (ng/Nm ³)	WHO ₀₅ TEF	WHO ₀₅ TEQ contribution (ng/Nm ³)	NATO ₈₉ I-TEF	NATO ₈₉ I-TEQ contribution (ng/Nm ³)
2378 TCDF	0.0029	0.1	0.00029	0.1	0.00029
2378 TCDD	<0.0013	1	0.00066	1	0.00066
12378 PeCDF	0.0055	0.03	0.00017	0.05	0.00028
23478 PeCDF	0.0054	0.3	0.0016	0.5	0.0027
12378 PeCDD	0.0017	1	0.0017	0.5	0.00086
123478 HxCDF	0.0051	0.1	0.00051	0.1	0.00051
123678 HxCDF	0.0075	0.1	0.00075	0.1	0.00075
234678 HxCDF	0.0055	0.1	0.00055	0.1	0.00055
123789 HxCDF	<0.0011	0.1	0.000053	0.1	0.000053
123478 HxCDD	<0.0013	0.1	0.000066	0.1	0.000066
123678 HxCDD	<0.0013	0.1	0.000066	0.1	0.000066
123789 HxCDD	<0.00092	0.1	0.000046	0.1	0.000046
1234678 HpCDF	0.012	0.01	0.00012	0.01	0.00012
1234789 HpCDF	<0.00079	0.01	0.0000040	0.01	0.0000040
1234678 HpCDD	0.011	0.01	0.00011	0.01	0.00011
OCDF	<0.0013	0.0003	0.00000020	0.001	0.00000066
OCDD	<0.26	0.0003	0.000040	0.001	0.00013
PCDD/F Homologue Groups				Concentration (ng/Nm³)	
Total TCDF isomers				0.073	
Total TCDD isomers				< 0.0092	
Total PeCDF isomers				0.087	
Total PeCDD isomers				0.015	
Total HxCDF isomers				0.069	
Total HxCDD isomers				0.013	
Total HpCDF isomers				0.013	
Total HpCDD isomers				0.022	
Polychlorinated Dioxins & Furans Results Summary				Concentration (ng/Nm³)	Emission Rate (µg/min)
Sum of PCDD/F congeners (Total of all Tetra to Octa congeners)					
Total PCDD/F (Excluding LOD values)				0.29	0.71
Total PCDD/F (Including half LOD values)				0.57	1.4
WHO ₀₅ TEQ (Total of WHO ₀₅ TEQ contribution for 17 toxic congeners)					
WHO ₀₅ TEQ (Excluding LOD values)				0.0058	0.014
WHO ₀₅ TEQ (Including half LOD values)				0.0068	0.017
NATO ₈₉ I-TEQ (Total of NATO ₈₉ I-TEQ contribution for 17 toxic congeners)					
NATO ₈₉ I-TEQ (Excluding LOD values)				0.0062	0.015
NATO ₈₉ I-TEQ (Including half LOD values)				0.0072	0.018

RESULTS – RELEASE POINT 4A – RUN 2

Company	Adelaide Brighton Cement
Site	Elder Rd, Birkenhead
Source Tested	Dry Process Kiln 4 Main Stack - Release Point 4A
Date of Tests	24 th & 25 th April 2018
Sampling Period	08:33 – 17:00 (24/04/18) & 07:42 – 10:47 (25/04/18)
Testing Officers	C. Clunies Ross
Sampling Position	Four 4" BSP sample ports in circular stack

Table 14: Release Point 4A (Run 2) - Gas Flow Conditions

<i>Sampling Conditions</i>	<i>Average (24/04/18)</i>	<i>Average (25/04/18)</i>
Stack diameter at sampling plane (m)	3.23	3.23
Average stack gas temperature (K)	381 (108°C)	382 (109°C)
Average barometric pressure (mB)	1012.7	1012.0
Average static pressure (mB)	- 2.9 (negative pressure)	- 3.0 (negative pressure)
Average stack pressure (mB)	1009.8	1009.0
Average velocity at sampling plane (m/s)	18.8	19.0
Average velocity at sampling plane expressed at STP (m/s)	12.3	12.4
Actual gas flow rate (m ³ /min)	9,250	9,340
Average moisture content (%v/v)	8.25	8.32
Gas flow rate at STP, dry (Nm ³ /min)	6,080	6,120
Gas flow rate at STP, dry and referenced to 11% O ₂ (m ³ /min)	2,580	2,530
Average carbon dioxide concentration, dry basis (%v/v)	5.02	4.93
Average oxygen concentration, dry basis (%v/v)	16.7	16.8
Dry molecular weight of stack gas (g/g mole)	29.47	29.46
Dry gas density of stack gas (kg/m ³)	1.315	1.315

RESULTS – RELEASE POINT 4A – RUN 2 Continued

Table 15: Release Point 4A (Run 2) - Summary of Test Results

Parameter	Sampling Period	Concentration (mg/Nm ³)	Emission Rate (g/min)
Total Solid Particulates	08:33 – 10:35 (24/04/18)	24	150
PM ₁₀ Particles	12:46 – 14:47 (24/04/18)	15	91
PM _{2.5} Particles		6.7	41
Sulphur Dioxide	16:20 – 17:20 (24/04/18)	< 3	< 20
Carbon Monoxide		64	390
Oxides of Nitrogen (as NO ₂) <i>Actual at STP</i>		460	2,800
Hydrogen Chloride		1.3	8.0
Chlorine	15:32 – 16:32 (24/04/18)	0.83	5.1
Fluoride (as HF)		<0.03	<0.2
Total Volatile Organic Compounds (by FIA, as n-propane equivalent)		0.31	1.9
Benzene (by activated carbon adsorption and GC/MS analysis)	07:42 – 08:42 (25/04/18)	< 0.09	< 0.5
Total Multi-Metals ^g	08:33 – 10:35 (24/04/18)	0.53	3.2
Chromium VI and Compounds	14:59 – 17:00 (24/04/18)	< 0.0008	< 0.005
Polycyclic Aromatic Hydrocarbons <i>Total BaP-TEQ_{PAH}</i> ^h	07:45 – 10:47 (25/04/18)	0.000018	0.00011
<i>Polychlorinated Dioxins and Furans</i> ⁱ		0.31 ng/Nm ³ 0.0066 ng/Nm ³ 0.0073 ng/Nm ³	0.46 µg/min 0.017 µg/min 0.018 µg/min
Total tetra to octa PCDDs/Fs ^j			
WHO ₀₅ TEQ for PCDDs/Fs ^d			
NATO ₈₉ I-TEQ for PCDDs/Fs ^d			

Table 16: Comparison of Dioxin & Furan Concentration in 4A Stack (Run 2) with International Guideline

Parameter	Concentration in Stack Gas Emissions (ng/Nm ³)	Oxygen (O ₂) Reference Condition (%)	Concentration at O ₂ Reference Condition (ng/Sm ³)	International Guideline (ng/Sm ³) ^k	Compliance with International Guideline
Polychlorinated Dioxins & Furans (NATO ₈₉ I-TEQ)	0.0030	11	0.0073	0.1	YES

^g Individual metals and their compounds are given in Table 17. Total solid particulates were determined in conjunction with multi-metals, as the sampling procedure for the particulate phase of the metals train by USEPA 29 is identical to AS 4323.2 (refer to Table 2 'Summary of Test Methods').

^h Individual BaP-TEQ_{PAH} contributions are given in Table 18, and the total BaP-TEQ_{PAH} in Table 20. This result includes half LOD values.

ⁱ Tetra-octa chlorinated dioxin & furan congener profile, homologue groups and toxic equivalents are given in Table 21.

^j Result includes half LOD values.

^k The International Guideline for the Concentration of Polychlorinated Dioxins & Furans in Stack Gas Emissions is 0.1 ng/Sm³ I-TEQ referenced to 11% O₂.

RESULTS – RELEASE POINT 4A – RUN 2 Continued

Table 17: Release Point 4A (Run 2) - Metals and their Compounds

Metal	Concentration (mg/Nm³)	Emission Rate (g/min)
Antimony and its compounds	0.000068	0.00042
Arsenic and its compounds	0.00058	0.0035
Barium (soluble compounds)	0.0069	0.042
Beryllium and its compounds	< 0.0002	< 0.001
Cadmium and its compounds	0.0012	0.0076
Chromium (III) and its compounds	0.016	0.096
Copper oxide fume (as CuO)	0.017	0.10
Iron oxide fume (as Fe ₂ O ₃)	0.23	1.4
Lead and its compounds	0.011	0.065
Magnesium oxide fume (as MgO)	0.20	1.2
Manganese and its compounds	0.020	0.12
Mercury and its compounds (as Hg)		
Organic:	< 0.00001	< 0.00006
Inorganic:	0.000024	0.00015
Total:	0.000024	0.00015
Nickel and its compounds	0.0054	0.033
Zinc oxide fume (as ZnO)	0.022	0.13
TOTAL METALS		
Excluding LOD values	0.53	3.2
Including half LOD values	0.53	3.2

RESULTS – RELEASE POINT 4A – RUN 2 Continued

Table 18: Release Point 4A (Run 2) - Individual USEPA Priority Pollutant PAHs

Individual USEPA Priority Pollutant PAHs	Concentration of PAHs ($\mu\text{g}/\text{Nm}^3$)	BaP-PEF value	BaP-TEQ _{PAH} Contribution	Emission Rate of PAHs (mg/min)
Naphthalene	8.4	0.0	0.0	51
2-Methylnaphthalene	1.6	0.0	0.0	9.7
Acenaphthylene	<0.02	0.0	0.0	<0.1
Acenaphthene	<0.02	0.0	0.0	<0.1
Fluorene	<0.02	0.0	0.0	<0.1
Phenanthrene	0.063	0.0	0.0	0.38
Anthracene	<0.02	0.0	0.0	<0.1
Fluoranthene	<0.02	0.0	0.0	<0.1
Pyrene	<0.02	0.0	0.0	<0.1
Benz(a)anthracene	<0.02	0.1	0.0010	<0.1
Chrysene	<0.02	0.01	0.00010	<0.1
Benzo(b)fluoranthene	<0.02	0.1	0.0010	<0.1
Benzo(k)fluoranthene	<0.02	0.1	0.0010	<0.1
Benzo(e)pyrene	<0.02	0.0	0.0	<0.1
Benzo(a)pyrene	<0.02	1.0	0.010	<0.1
Perylene	<0.02	0.0	0.0	<0.1
Indeno(123-cd)pyrene	<0.02	0.1	0.0010	<0.1
Dibenz(ah)anthracene	<0.02	0.4	0.0040	<0.1
Benzo(ghi)perylene	<0.02	0.0	0.0	<0.1

Table 19: Release Point 4A (Run 2) - Total USEPA Priority Pollutant PAHs

Total USEPA Priority Pollutant PAHs	Concentration ($\mu\text{g}/\text{Nm}^3$)	Emission Rate (mg/min)
<i>Excluding LOD values</i>	10	61
<i>Including half LOD values</i>	10	63

Table 20: Release Point 4A (Run 2) - Total PAH Toxic Equivalents (BaP-TEQ_{PAH})

Total PAH Toxic Equivalents (BaP-TEQ _{PAH}) ¹	Concentration ($\mu\text{g}/\text{Nm}^3$)	Emission Rate (mg/min)
<i>Excluding LOD values</i>	0.0	0.0
<i>Including half LOD values</i>	0.018	0.11

¹ Calculated using benzo(a)pyrene potency equivalency factors (BaP-PEF values).

RESULTS – RELEASE POINT 4A – RUN 2 Continued

Table 21: Release Point 4A (Run 2) - PCDD/F Congener Profile

PCDD/F Congeners	Concentration (ng/Nm ³)	WHO ₀₅ TEF	WHO ₀₅ TEQ contribution (ng/Nm ³)	NATO ₈₉ I-TEF	NATO ₈₉ I-TEQ contribution (ng/Nm ³)
2378 TCDF	0.0024	0.1	0.00024	0.1	0.00024
2378 TCDD	<0.0028	1	0.0014	1	0.0014
12378 PeCDF	0.0053	0.03	0.00016	0.05	0.00026
23478 PeCDF	0.0053	0.3	0.0016	0.5	0.0026
12378 PeCDD	<0.0019	1	0.00093	0.5	0.00046
123478 HxCDF	0.0053	0.1	0.00053	0.1	0.00053
123678 HxCDF	0.0076	0.1	0.00076	0.1	0.00076
234678 HxCDF	0.0045	0.1	0.00045	0.1	0.00045
123789 HxCDF	<0.00093	0.1	0.000046	0.1	0.000046
123478 HxCDD	<0.0028	0.1	0.00014	0.1	0.00014
123678 HxCDD	<0.0019	0.1	0.000093	0.1	0.000093
123789 HxCDD	<0.00093	0.1	0.000046	0.1	0.000046
1234678 HpCDF	0.014	0.01	0.00014	0.01	0.00014
1234789 HpCDF	<0.0028	0.01	0.000014	0.01	0.000014
1234678 HpCDD	<0.0046	0.01	0.000023	0.01	0.000023
OCDF	<0.0046	0.0003	0.00000070	0.001	0.0000023
OCDD	<0.093	0.0003	0.000014	0.001	0.000046
PCDD/F Homologue Groups				Concentration (ng/Nm³)	
Total TCDF isomers				0.036	
Total TCDD isomers				< 0.019	
Total PeCDF isomers				0.067	
Total PeCDD isomers				< 0.0093	
Total HxCDF isomers				0.058	
Total HxCDD isomers				< 0.0065	
Total HpCDF isomers				0.014	
Total HpCDD isomers				0.0065	
Polychlorinated Dioxins & Furans Results Summary				Concentration (ng/Nm³)	Emission Rate (µg/min)
Sum of PCDD/F congeners (Total of all Tetra to Octa congeners)					
Total PCDD/F (Excluding LOD values)				0.18	0.46
Total PCDD/F (Including half LOD values)				0.31	0.78
WHO ₀₅ TEQ (Total of WHO ₀₅ TEQ contribution for 17 toxic congeners)					
WHO ₀₅ TEQ (Excluding LOD values)				0.0039	0.010
WHO ₀₅ TEQ (Including half LOD values)				0.0066	0.017
NATO ₈₉ I-TEQ (Total of NATO ₈₉ I-TEQ contribution for 17 toxic congeners)					
NATO ₈₉ I-TEQ (Excluding LOD values)				0.0050	0.013
NATO ₈₉ I-TEQ (Including half LOD values)				0.0073	0.018

RESULTS – RELEASE POINT 4B – RUN 1

Company	Adelaide Brighton Cement
Site	Elder Rd, Birkenhead
Source Tested	Precalciner Plant Stack - Release Point 4B
Date of Tests	23 rd April 2018
Sampling Period	10:29 – 21:19
Testing Officers	I. Brash
Sampling Position	Four 4” BSP sample ports in circular stack

Table 22: Release Point 4B (Run 1) - Gas Flow Conditions

Sampling Conditions	Average
Stack diameter at sampling plane (m)	3.00
Average stack gas temperature (K)	384 (111°C)
Average barometric pressure (mB)	1005.9
Static pressure (mB)	-2.7 (negative pressure)
Average stack pressure (mB)	1003.2
Average velocity at sampling plane (m/s)	19.3
Average velocity at sampling plane expressed at STP (m/s)	11.0
Actual gas flow rate (m ³ /min)	8,210
Average moisture content (%v/v)	18.7
Gas flow rate at STP, dry (Nm ³ /min)	4,750
Gas flow rate at STP, dry and referenced to 11% O ₂ (m ³ /min)	5,340
Average carbon dioxide concentration, dry basis (%v/v)	21.3
Average oxygen concentration (%v/v), dry basis	9.77
Dry molecular weight of stack gas (g/g mole)	31.80
Dry gas density of stack gas (kg/m ³)	1.419

RESULTS – RELEASE POINT 4B – RUN 1 Continued

Table 23: Release Point 4B (Run 1) - Summary of Test Results

Parameter	Sampling Period	Concentration (mg/Nm ³)	Emission Rate (g/min)
Total Solid Particulates	16:31 – 18:34 (23/04/18)	4.1	19
PM ₁₀ Particles	19:16 – 21:19	3.0	14
PM _{2.5} Particles	(23/04/18)	1.8	8.6
Sulphur Dioxide	19:08 – 20:08 (23/04/18)	< 3	< 10
Carbon Monoxide		390	1,850
Oxides of Nitrogen (as NO ₂) <i>Actual at STP</i>		580	2,760
Hydrogen Chloride	15:34 – 16:34 (23/04/18)	12	55
Chlorine		2.6	12
Fluoride (as HF)		<0.05	<0.2
Total Volatile Organic Compounds (by FIA, as n-propane equivalent)	13:55 – 14:55 (23/04/18)	0.27	1.3
Benzene (by activated carbon adsorption and GC/MS analysis)		0.16	0.77
Total Multi-Metals ^m	16:31 – 18:34 (23/04/18)	0.61	2.9
Chromium VI and Compounds	13:58 – 16:02 (23/04/18)	0.00045	0.0021
Polycyclic Aromatic Hydrocarbons <i>Total BaP-TEQ_{PAH}</i> ⁿ	10:29 – 13:32 (23/04/18)	0.00010	0.00048
<i>Polychlorinated Dioxins and Furans</i> ^o		0.91 ng/Nm ³ 0.011 ng/Nm ³ 0.013 ng/Nm ³	4.9 µg/min 0.060 µg/min 0.070 µg/min
Total tetra to octa PCDDs/Fs ^p WHO ₀₅ TEQ for PCDDs/Fs ^j NATO ₈₉ I-TEQ for PCDDs/Fs ^j			

Table 24: Comparison of Dioxin & Furan Concentration in 4B Stack (Run 1) with International Guideline

Parameter	Concentration in Stack Gas Emissions (ng/Nm ³)	Oxygen (O ₂) Reference Condition (%)	Concentration at O ₂ Reference Condition (ng/Sm ³)	International Guideline (ng/Sm ³) ^q	Compliance with International Guideline
Polychlorinated Dioxins & Furans (NATO ₈₉ I-TEQ)	0.015	11	0.013	0.1	YES

^m Individual metals and their compounds are given in Table 25. Total solid particulates were determined in conjunction with multi-metals, as the sampling procedure for the particulate phase of the metals train by USEPA 29 is identical to AS 4323.2 (refer to Table 2 'Summary of Test Methods').

ⁿ Individual BaP-TEQ_{PAH} contributions are given in Table 26, and the total BaP-TEQ_{PAH} in Table 28. This result includes half LOD values.

^o Tetra-octa chlorinated dioxin & furan congener profile, homologue groups and toxic equivalents are given in Table 29.

^p Result includes half LOD values.

^q The International Guideline for the Concentration of Polychlorinated Dioxins & Furans in Stack Gas Emissions is 0.1 ng/Sm³ I-TEQ referenced to 11% O₂.

RESULTS – RELEASE POINT 4B – RUN 1 Continued

Table 25: Release Point 4B (Run 1) – Metals and their Compounds

Metal	Concentration (mg/Nm³)	Emission Rate (g/min)
Antimony and its compounds	0.00014	0.00064
Arsenic and its compounds	0.00048	0.0022
Barium (soluble compounds)	0.0059	0.028
Beryllium and its compounds	< 0.0001	< 0.0005
Cadmium and its compounds	0.000036	0.00017
Chromium (III) and its compounds	0.0011	0.0052
Copper oxide fume (as CuO)	0.0090	0.042
Iron oxide fume (as Fe ₂ O ₃)	0.21	0.97
Lead and its compounds	0.00076	0.0036
Magnesium oxide fume (as MgO)	0.34	1.6
Manganese and its compounds	0.018	0.082
Mercury and its compounds (as Hg)		
Organic:	< 0.00001	< 0.00005
Inorganic:	< 0.00001	< 0.00005
Total [†] :	< 0.00001	< 0.00005
Nickel and its compounds	0.00074	0.0035
Zinc oxide fume (as ZnO)	0.025	0.12
TOTAL METALS		
Excluding LOD values	0.61	2.9
Including half LOD values	0.61	2.9

[†] Total does not include 'less than limit of detection' value for organic mercury.

RESULTS – RELEASE POINT 4B – RUN 1 Continued

Table 26: Release Point 4B (Run 1) – Individual USEPA Priority Pollutant PAHs

Individual USEPA Priority Pollutant PAHs	Concentration of PAHs ($\mu\text{g}/\text{Nm}^3$)	BaP-PEF value	BaP-TEQ Contribution	Emission Rate of PAHs (mg/min)
Naphthalene	52	0.0	0.0	248
2-Methylnaphthalene	2.7	0.0	0.0	13
Acenaphthylene	0.26	0.0	0.0	1.2
Acenaphthene	<0.02	0.0	0.0	<0.1
Fluorene	<0.02	0.0	0.0	<0.07
Phenanthrene	0.47	0.0	0.0	2.2
Anthracene	0.062	0.0	0.0	0.29
Fluoranthene	0.51	0.0	0.0	2.4
Pyrene	0.51	0.0	0.0	2.4
Benz(a)anthracene	0.11	0.1	0.011	0.50
Chrysene	0.17	0.01	0.0017	0.79
Benzo(b)fluoranthene	0.074	0.1	0.0074	0.35
Benzo(k)fluoranthene	0.075	0.1	0.0075	0.36
Benzo(e)pyrene	0.057	0.0	0.0	0.27
Benzo(a)pyrene	0.064	1.0	0.064	0.30
Perylene	<0.02	0.0	0.0	<0.1
Indeno(123-cd)pyrene	0.066	0.1	0.0066	0.32
Dibenz(ah)anthracene	<0.02	0.4	0.0030	<0.1
Benzo(ghi)perylene	0.11	0.0	0.0	0.50

Table 27: Release Point 4B (Run 1) – Total USEPA Priority Pollutant PAHs

Total USEPA Priority Pollutant PAHs	Concentration ($\mu\text{g}/\text{Nm}^3$)	Emission Rate (mg/min)
Excluding LOD values	57	270
Including half LOD values	57	270

Table 28: Release Point 4B (Run 1) – Total PAH Toxic Equivalents (BaP-TEQ_{PAH})

Total PAH Toxic Equivalents (BaP-TEQ _{PAH}) ^s	Concentration ($\mu\text{g}/\text{Nm}^3$)	Emission Rate (mg/min)
Excluding LOD values	0.098	0.47
Including half LOD values	0.10	0.48

^s Calculated using benzo(a)pyrene potency equivalency factors (BaP-PEF values).

RESULTS – RELEASE POINT 4B – RUN 1 Continued

Table 29: Release Point 4B (Run 1) – PCDD/F Congener Profile

PCDD/F Congeners	Concentration (ng/Nm ³)	WHO ₀₅ TEQ	WHO ₀₅ TEQ contribution (ng/Nm ³)	NATO ₈₉ I-TEQ	NATO ₈₉ I-TEQ contribution (ng/Nm ³)
2378 TCDF	0.0067	0.1	0.00067	0.1	0.00067
2378 TCDD	<0.0013	1	0.00067	1	0.00067
12378 PeCDF	0.012	0.03	0.00036	0.05	0.00060
23478 PeCDF	0.012	0.3	0.0036	0.5	0.0060
12378 PeCDD	0.0019	1	0.0019	0.5	0.00097
123478 HxCDF	0.010	0.1	0.0010	0.1	0.0010
123678 HxCDF	0.013	0.1	0.0013	0.1	0.0013
234678 HxCDF	0.0081	0.1	0.00081	0.1	0.00081
123789 HxCDF	<0.00047	0.1	0.000024	0.1	0.000024
123478 HxCDD	0.0023	0.1	0.00023	0.1	0.00023
123678 HxCDD	0.0015	0.1	0.00015	0.1	0.00015
123789 HxCDD	<0.00067	0.1	0.000034	0.1	0.000034
1234678 HpCDF	0.021	0.01	0.00021	0.01	0.00021
1234789 HpCDF	0.00067	0.01	0.0000067	0.01	0.0000067
1234678 HpCDD	0.011	0.01	0.00011	0.01	0.00011
OCDF	0.0037	0.0003	0.0000011	0.001	0.0000037
OCDD	0.20	0.0003	0.000060	0.001	0.00020
PCDD/F Homologue Groups				Concentration (ng/Nm³)	
Total TCDF isomers				0.19	
Total TCDD isomers				0.018	
Total PeCDF isomers				0.25	
Total PeCDD isomers				0.036	
Total HxCDF isomers				0.13	
Total HxCDD isomers				0.028	
Total HpCDF isomers				0.028	
Total HpCDD isomers				0.021	
Polychlorinated Dioxins & Furans Results Summary				Concentration (ng/Nm³)	Emission Rate (µg/min)
Sum of PCDD/F congeners (Total of all Tetra to Octa congeners)					
Total PCDD/F (Excluding LOD values)				0.91	4.9
Total PCDD/F (Including half LOD values)				0.91	4.9
WHO ₀₅ TEQ (Total of WHO ₀₅ TEQ contribution for 17 toxic congeners)					
WHO ₀₅ TEQ (Excluding LOD values)				0.010	0.056
WHO ₀₅ TEQ (Including half LOD values)				0.011	0.060
NATO ₈₉ I-TEQ (Total of NATO ₈₉ I-TEQ contribution for 17 toxic congeners)					
NATO ₈₉ I-TEQ (Excluding LOD values)				0.012	0.066
NATO ₈₉ I-TEQ (Including half LOD values)				0.013	0.070

RESULTS – RELEASE POINT 4B – RUN 2

Company	Adelaide Brighton Cement
Site	Elder Rd, Birkenhead
Source Tested	Precalciner Plant Stack - Release Point 4B
Date of Tests	24 th & 25 th April 2018
Sampling Period	08:31 – 16:59 (24/04/18) & 07:40 – 10:50 (25/04/18)
Testing Officers	I. Brash
Sampling Position	Four 4" BSP sample ports in circular stack

Table 30: Release Point 4B (Run 2) - Gas Flow Conditions

Sampling Conditions	Average (24/04/18)	Average (25/04/18)
Stack diameter at sampling plane (m)	3.00	3.00
Average stack gas temperature (K)	382 (109°C)	383 (110°C)
Average barometric pressure (mB)	1009.4	1008.5
Static pressure (mB)	-2.2 (negative pressure)	-2.1 (negative pressure)
Average stack pressure (mB)	1007.2	1006.4
Average velocity at sampling plane (m/s)	18.9	19.1
Average velocity at sampling plane expressed at STP (m/s)	11.0	11.0
Actual gas flow rate (m ³ /min)	8,030	8,100
Average moisture content (%v/v)	18.1	18.4
Gas flow rate at STP, dry (Nm ³ /min)	4,700	4,710
Gas flow rate at STP, dry and referenced to 11% O ₂ (m ³ /min)	5,330	5,330
Average carbon dioxide concentration, dry basis (%v/v)	21.3	21.4
Average oxygen concentration (%v/v), dry basis	9.67	9.70
Dry molecular weight of stack gas (g/g mole)	31.79	31.81
Dry gas density of stack gas (kg/m ³)	1.419	1.420

RESULTS – RELEASE POINT 4B – RUN 2 Continued

Table 31: Release Point 4B (Run 2) - Summary of Test Results

Parameter	Sampling Period	Concentration (mg/Nm ³)	Emission Rate (g/min)
Total Solid Particulates	12:46 – 14:48 (24/04/18)	4.9	23
PM ₁₀ Particles	14:58 – 16:59	3.2	15
PM _{2.5} Particles	(24/04/18)	2.1	9.9
Sulphur Dioxide	07:40 – 08:40 (25/04/18)	< 3	< 10
Carbon Monoxide		620	2,910
Oxides of Nitrogen (as NO ₂) <i>Actual at STP</i>		490	2,300
Hydrogen Chloride	08:31 – 09:31 (24/04/18)	7.4	35
Chlorine		2.2	10
Fluoride (as HF)		<0.04	<0.2
Total Volatile Organic Compounds (by FIA, as n-propane equivalent)	14:05 – 15:05 (24/04/18)	0.24	1.1
Benzene (by activated carbon adsorption and GC/MS analysis)		0.13	0.60
Total Multi-Metals ^t	12:46 – 14:48 (24/04/18)	0.69	3.2
Chromium VI and Compounds	08:39 – 10:42 (24/04/18)	0.00046	0.0022
Polycyclic Aromatic Hydrocarbons <i>Total BaP-TEQ_{PAH}</i> ^u	07:46 – 10:50 (25/04/18)	0.000038	0.00018
<i>Polychlorinated Dioxins and Furans</i> ^v		0.88 ng/Nm ³ 0.011 ng/Nm ³ 0.013 ng/Nm ³	4.7 µg/min 0.057 µg/min 0.068 µg/min
Total tetra to octa PCDDs/Fs ^w WHO ₀₅ TEQ for PCDDs/Fs ^j NATO ₈₉ I-TEQ for PCDDs/Fs ^j			

Table 32: Comparison of Dioxin & Furan Concentration in 4B Stack (Run 2) with International Guideline

Parameter	Concentration in Stack Gas Emissions (ng/Nm ³)	Oxygen (O ₂) Reference Condition (%)	Concentration at O ₂ Reference Condition (ng/Sm ³)	International Guideline (ng/Sm ³) ^x	Compliance with International Guideline
Polychlorinated Dioxins & Furans (NATO ₈₉ I-TEQ)	0.014	11	0.013	0.1	YES

^t Individual metals and their compounds are given in Table 33. Total solid particulates were determined in conjunction with multi-metals, as the sampling procedure for the particulate phase of the metals train by USEPA 29 is identical to AS 4323.2 (refer to Table 2 'Summary of Test Methods').

^u Individual BaP-TEQ_{PAH} contributions are given in Table 34, and the total BaP-TEQ_{PAH} in Table 36. This result includes half LOD values.

^v Tetra-octa chlorinated dioxin & furan congener profile, homologue groups and toxic equivalents are given in Table 37.

^w Result includes half LOD values.

^x The International Guideline for the Concentration of Polychlorinated Dioxins & Furans in Stack Gas Emissions is 0.1 ng/Sm³ I-TEQ referenced to 11% O₂.

RESULTS – RELEASE POINT 4B – RUN 2 Continued

Table 33: Release Point 4B (Run 2) - Metals and their Compounds

Metal	Concentration (mg/Nm³)	Emission Rate (g/min)
Antimony and its compounds	0.00033	0.0016
Arsenic and its compounds	0.00053	0.0025
Barium (soluble compounds)	0.0070	0.033
Beryllium and its compounds	< 0.0001	< 0.0005
Cadmium and its compounds	0.000041	0.00019
Chromium (III) and its compounds	0.0013	0.0061
Copper oxide fume (as CuO)	0.0087	0.041
Iron oxide fume (as Fe ₂ O ₃)	0.25	1.2
Lead and its compounds	0.00088	0.0041
Magnesium oxide fume (as MgO)	0.36	1.7
Manganese and its compounds	0.023	0.11
Mercury and its compounds (as Hg)		
Organic:	< 0.00001	< 0.00005
Inorganic:	< 0.00001	< 0.00005
Total ^y :	< 0.00001	< 0.00005
Nickel and its compounds	0.00071	0.0033
Zinc oxide fume (as ZnO)	0.030	0.14
TOTAL METALS		
Excluding LOD values	0.69	3.2
Including half LOD values	0.69	3.2

^y Total does not include 'less than limit of detection' value for organic mercury.

RESULTS – RELEASE POINT 4B – RUN 2 Continued

Table 34: Release Point 4B (Run 2) – Individual USEPA Priority Pollutant PAHs

Individual USEPA Priority Pollutant PAHs	Concentration of PAHs ($\mu\text{g}/\text{Nm}^3$)	BaP-PEF value	BaP-TEQ Contribution	Emission Rate of PAHs (mg/min)
Naphthalene	29	0.0	0.0	134
2-Methylnaphthalene	2.5	0.0	0.0	12
Acenaphthylene	<0.02	0.0	0.0	<0.1
Acenaphthene	<0.02	0.0	0.0	<0.1
Fluorene	<0.02	0.0	0.0	<0.1
Phenanthrene	0.074	0.0	0.0	0.35
Anthracene	<0.02	0.0	0.0	<0.07
Fluoranthene	0.090	0.0	0.0	0.42
Pyrene	0.11	0.0	0.0	0.53
Benz(a)anthracene	0.025	0.1	0.0025	0.12
Chrysene	0.038	0.01	0.00038	0.18
Benzo(b)fluoranthene	<0.02	0.1	0.00075	<0.1
Benzo(k)fluoranthene	<0.02	0.1	0.00075	<0.1
Benzo(e)pyrene	0.033	0.0	0.0	0.16
Benzo(a)pyrene	0.028	1.0	0.028	0.13
Perylene	<0.02	0.0	0.0	<0.1
Indeno(123-cd)pyrene	0.029	0.1	0.0029	0.13
Dibenz(ah)anthracene	<0.02	0.4	0.0030	<0.1
Benzo(ghi)perylene	0.055	0.0	0.0	0.26

Table 35: Release Point 4B (Run 2) – Total USEPA Priority Pollutant PAHs

Total USEPA Priority Pollutant PAHs	Concentration ($\mu\text{g}/\text{Nm}^3$)	Emission Rate (mg/min)
Excluding LOD values	31	150
Including half LOD values	32	150

Table 36: Release Point 4B (Run 2) – Total PAH Toxic Equivalents (BaP-TEQ_{PAH})

Total PAH Toxic Equivalents (BaP-TEQ _{PAH}) ^z	Concentration ($\mu\text{g}/\text{Nm}^3$)	Emission Rate (mg/min)
Excluding LOD values	0.034	0.16
Including half LOD values	0.038	0.18

^z Calculated using benzo(a)pyrene potency equivalency factors (BaP-PEF values).

RESULTS – RELEASE POINT 4B – RUN 2 Continued

Table 37: Release Point 4B (Run 2) – PCDD/F Congener Profile

PCDD/F Congeners	Concentration (ng/Nm ³)	WHO ₀₅ TEF	WHO ₀₅ TEQ contribution (ng/Nm ³)	NATO ₈₉ I-TEF	NATO ₈₉ I-TEQ contribution (ng/Nm ³)
2378 TCDF	0.0049	0.1	0.00049	0.1	0.00049
2378 TCDD	<0.00066	1	0.00033	1	0.00033
12378 PeCDF	0.011	0.03	0.00034	0.05	0.00056
23478 PeCDF	0.012	0.3	0.0036	0.5	0.0060
12378 PeCDD	0.0017	1	0.0017	0.5	0.00083
123478 HxCDF	0.011	0.1	0.0011	0.1	0.0011
123678 HxCDF	0.015	0.1	0.0015	0.1	0.0015
234678 HxCDF	0.0086	0.1	0.00086	0.1	0.00086
123789 HxCDF	<0.00040	0.1	0.000020	0.1	0.000020
123478 HxCDD	0.0018	0.1	0.00018	0.1	0.00018
123678 HxCDD	0.0019	0.1	0.00019	0.1	0.00019
123789 HxCDD	0.0011	0.1	0.00011	0.1	0.00011
1234678 HpCDF	0.021	0.01	0.00021	0.01	0.00021
1234789 HpCDF	<0.00046	0.01	0.0000023	0.01	0.0000023
1234678 HpCDD	0.012	0.01	0.00012	0.01	0.00012
OCDF	0.0027	0.0003	0.00000081	0.001	0.0000027
OCDD	0.30	0.0003	0.000091	0.001	0.00030
PCDD/F Homologue Groups				Concentration (ng/Nm³)	
Total TCDF isomers				0.12	
Total TCDD isomers				0.017	
Total PeCDF isomers				0.19	
Total PeCDD isomers				0.030	
Total HxCDF isomers				0.14	
Total HxCDD isomers				0.031	
Total HpCDF isomers				0.027	
Total HpCDD isomers				0.022	
Polychlorinated Dioxins & Furans Results Summary				Concentration (ng/Nm³)	Emission Rate (µg/min)
Sum of PCDD/F congeners (Total of all Tetra to Octa congeners)					
Total PCDD/F (Excluding LOD values)				0.88	4.7
Total PCDD/F (Including half LOD values)				0.88	4.7
WHO ₀₅ TEQ (Total of WHO ₀₅ TEQ contribution for 17 toxic congeners)					
WHO ₀₅ TEQ (Excluding LOD values)				0.010	0.055
WHO ₀₅ TEQ (Including half LOD values)				0.011	0.057
NATO ₈₉ I-TEQ (Total of NATO ₈₉ I-TEQ contribution for 17 toxic congeners)					
NATO ₈₉ I-TEQ (Excluding LOD values)				0.012	0.066
NATO ₈₉ I-TEQ (Including half LOD values)				0.013	0.068