TEST PROGRAMME REPORT

For The Co-Firing of

Solid Recovered Fuel (SRF)

at

Irish Cement Limerick Works

January 2024

TABLE OF CONTENTS

LIST OF APPENDICES

1. EXECUTIVE SUMMARY

Irish Cement Limited, Limerick Works (ICL) commenced co-firing of Solid Recovered Fuel (SRF) in May 2023 under the conditions of the P0029-06 IE licence. A Test Programme with the EPA was agreed prior to firing of SRF. The introduction of SRF as an alternative fuel, is intended to reduce the fossil-based carbon emissions in the cement clinker manufacturing process and reduce reliance on unsustainable fossil fuel sources of thermal energy.

In January 2023, ICL applied to the EPA to enter into a Test Programme to demonstrate full compliance with the IE licence and test programme conditions. This application was approved by the EPA on the 25th April 2023 subject to 13 conditions including a duration length of up to 8 months and a maximum SRF addition rate of 7 tonnes per hour. This Test Programme report includes information relating to compliance to conditions of the test programme as well as results, commentary and analysis for the testing in order for ICL to request the approval of the Agency to continue to use SRF as an Alternative Fuel.

ICL's strategy throughout the Test Programme period was predicated on pursuing an orderly ramp up in SRF substitution rates in order to ensure the delivery of its dual objectives, namely:
(i) assuring environmental emissions compliance with IE licence and test programme conditions; and
(ii) ensuring product quality consistency and compliance with applicable product quality standards. The ramp up schedule of SRF was agreed with the Agency in advance of the programme and was followed throughout.

ICL has operated with SRF as a fuel since the 30th of May 2023 and with an orderly ramp up approach, ICL has achieved a progressive increase in thermal substitution. The maximum level of thermal substitution achieved over the test program period was ~40% and the maximum hourly rate of SRF throughput achieved to date is 7 t/hr. Since commencing the test programme, ICL has successfully consumed SRF during the Test Programme period thereby reducing the equivalent amount of waste going to landfill.

Throughout the Test Programme, ICL has complied with all of the conditions of its IE licence and Test Programme requirements and has maintained consistent product quality performance in accordance with applicable product standards, all of which is detailed in this report and the associated Appendices.

Furthermore, data generated from the external kiln stack testing of non-continuously monitored parameters, coupled with continuous monitoring of multiple prescribed parameters over the course of the Test Programme, clearly illustrate that:

1. **No relationship exists between SRF input rates and emission measurements; and**
2. **Emission levels are unaffected by SRF input rates**

ICL's AF strategy is to continue to pursue the highest possible SRF substitution rates achievable within the industry so as to maximise the sustainability benefits in the immediate term whilst also investigating the feasibility of using other alternative fuels over the medium term. Whilst this Test

Programme report demonstrates full compliance with IE and Quality Standards requirements, ICL is targeting thermal substitution rates of ~80% in line with best practice cement kilns across Europe. The maximum substitution of SRF yields a wide range of sustainability benefits such as underpinning local employment, diverting waste from landfill to energy recovery and reducing fossil-based carbon emissions.

The test programme report demonstrates a varied input of SRF over the time period including a maximum of 7 t/hr as approved in the test programme proposal. All conditions within the test programme approval have been complied with in order to demonstrate that the equipment can operate at these tonnages, that cement quality is unaffected and especially that kiln stack emissions remain unchanged. ICL has tested SRF additions at all stages including external stack testing at the three main stages – 3 t/hr, 5 t/h and 7 t/hr. ICL has carried out testing up to and including 7 t/hr and has satisfied the approval conditions for the test programme at this addition rate and have demonstrated that there is no effect to kiln stack emissions or kiln operation at any of the SRF tonnages used during the programme. Through this test program report ICL is able to demonstrate that no relationship exists between SRF input rates and emission measurements and that emission levels are unaffected by SRF at the various input rates. Furthermore, any limitation on the use of SRF arising from the agreed conditions of the test program would limit the ability of ICL to achieve:

- maximum SRF substitution that the test programme allows for;
- less favourable overall environmental outcomes where the unintended consequence of a limit in SRF hourly / daily input rate results in the unnecessary usage of fossil fuels;
- the improvements in CO2 emissions that an increase in the use fossil would not allow for;
- and the potential landfilling of material by our SRF suppliers that would otherwise be supplied as SRF for energy recovery.

In conclusion, ICL believes that the extensive information provided in this test programme report demonstrates that the IE licence P0029-06 as granted by the Agency contains all the necessary operational control and emission limitations necessary to assure acceptable environmental outcomes from the operation of Limerick Works.

2. BACKGROUND

The alternative fuels project at Limerick is a critical part of ICL's sustainability strategy which includes reducing CO_2 emissions and dependency on imported fossil fuels. Fundamental to ICL's ability to deliver on this strategy has been the multi-million Euro investment in the process technology required to substitute a proportion of the fossil fuels used in its Kiln 6 cement kiln at Limerick Works with Solid Recovered Fuel (SRF). SRF is the clean dry blend of fragments of plastics, paper, cardboard and textiles which arises once recycling of waste materials through mechanical and / or biological treatment has been completed. This fuel is produced to defined chemical and physical standards specifically suited for use within the cement industry.

Approximately 40% of the Carbon Dioxide (CO_2) generated in the production of cement clinker arises from the carbon content of the fuels used. Due to the traditional reliance on fossil fuels within the industry, the European cement industry has been progressively introducing Alternative Fuels (AF) for the past 40 years. This strategy has seen a significant displacement of the reliability on fossil fuel sources with greater than 90% of energy used in firing cement kilns in some plants within the EU now accounted for by the use of lower carbon intensity alternative fuels. In many countries this practice is considered an integral component of a national waste management infrastructure where high recycling rates are achieved in tandem with high levels of energy recovery from residual wastes thereby reducing the dependency on landfill as a waste disposal option.

There are many sustainability advantages that arise from the use of AF in the cement manufacturing process, some of which are summarised below:

- Complete recovery of the energy value of the material due to the efficiency of the combustion process in the cement kilns
- Reduction in CO_2 emissions
  - Directly due to lower carbon emissions arising from the lower carbon intensity of the fuels
  - Indirectly by diverting material from landfill thereby reducing the potential for landfill gas production; and by eliminating the need for dedicated incineration capacity
- The biomass fraction of the fuels is considered renewable and CO_2 free
- Reduction in the dependency on imported fossil fuels
- No residual wastes are produced from the cement manufacturing process. The organic fraction contributes to the combustion process and the inorganic components are incorporated into the cement product thereby eliminating the requirement for additional landfill capacity
- Complete destruction of the fuels and full compliance with Industrial Emissions Directive (IED) requirements due to the high temperatures, long residence times and high thermal inertia
- Reduction in the input of raw materials and additives due to the mineral contribution from AF
- Contribution to achieving Ireland's international obligations by providing the most efficient energy recovery option and contributing to the achievement of national landfill diversion targets
- Reduction in transport effects by indigenously sourcing fuel supply
- Development of jobs in Irish companies producing and supplying SRF

2.1 ICL SRF Project

In order to facilitate the SRF project a full review of the Limerick Works IE licence was completed by the EPA and a new IE licence (Registration Number P0029-06) was issued on the 18th May 2021. New compliance conditions and emission limit values were included in the revised licence to ensure compliance with both IE and the IED.

In accordance with Condition 6.3 Co-incineration – Test Programme of IE Licence P0029-06, a Test Programme was prepared and submitted by Irish Cement. This was subsequently approved by the Agency on the 25th April 2023 permitting the co-firing of Solid Recovered Fuel (SRF), EWC Code 19 12 10, at Irish Cement Limited, Limerick Works under Test Programme conditions.

This Test Programme report contains additional conditions from the IE licence in relation to the use of Alternative Fuels and conditions from the EPA on approval of the Test Programme. An initial Interim test programme report was submitted by Irish Cement to the EPA in July 2023, which was one of the approval conditions.

The report contained herein constitutes as the final report for the period from May 2023 to December 2023 and includes results, commentary and analysis for the testing undertaken therein.

2.2 Key Objectives

The core objectives of the SRF Project for Irish Cement are based on following three key pillars:

Figure 1: Key Pillars of ICL's Alternative Fuel Strategy

- ***Maximise Thermal Substitution…*** reduce CO2 emissions per tonne and reduce dependency and usage on imported fossil fuels;
- ***Environmental Compliance…*** demonstrating compliance with the IE licence and agreed additional Test Programme conditions; and
- ***Product Quality Compliance…*** demonstrating conformity with relevant cement standards and maintaining product quality assurance.

This report documents the operational outcomes of the test programme period (e.g., SRF throughput and thermal substitution rates achieved) against each of these three objectives.

2.3 ICL Approach

In order to achieve the desired sustainability benefits from the SRF project, a deliberate and orderly ramp-up of SRF substitution for fossil fuel was necessary from the outset of the Test Programme. A progressive ramp-up was designed to ensure that each targeted step change in SRF substitution rate was adequately assessed to:

- Demonstrate environmental compliance with the requirements of the IE licence and agreed Test Programme conditions; and
- Assure consistent cement product quality performance and compliance with EN197-1, the Harmonised European standard for cement products.

Due to the nature of the cement production process and quality assurance testing, the rate of SRF ramp-up was dictated by the product quality performance testing requirements as well as the agreed ramp up timeline with the EPA. This is best understood by considering the steps taken for each targeted SRF substitution rate as outlined in **Figure 2** below:

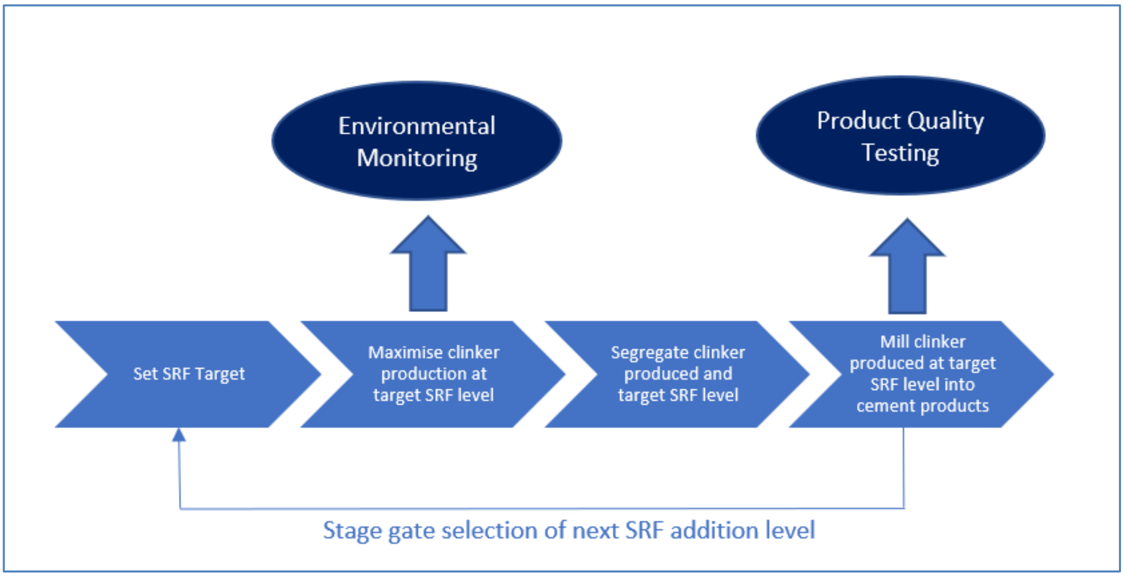


Figure 2: Key Pillars of SRF Test Programme Approach

Environmental monitoring was conducted in accordance with the conditions of IE licence P0029-06 and additional Test Programme conditions agreed with the EPA.

Product quality assurance included sampling, testing and analysis of the cement performance in mortar and concrete applications for a variety of quality characteristics including strength development, workability, durability and setting time. As the primary performance characteristic for cement product is a measurement of compressive strength after 28 days, the timing of the stage-gate decision to move onto the next SRF substitution rate (and repeat the quality assurance process) was dictated by the availability of this cement performance data as long as on-going environmental compliance was evident from emissions monitoring results.

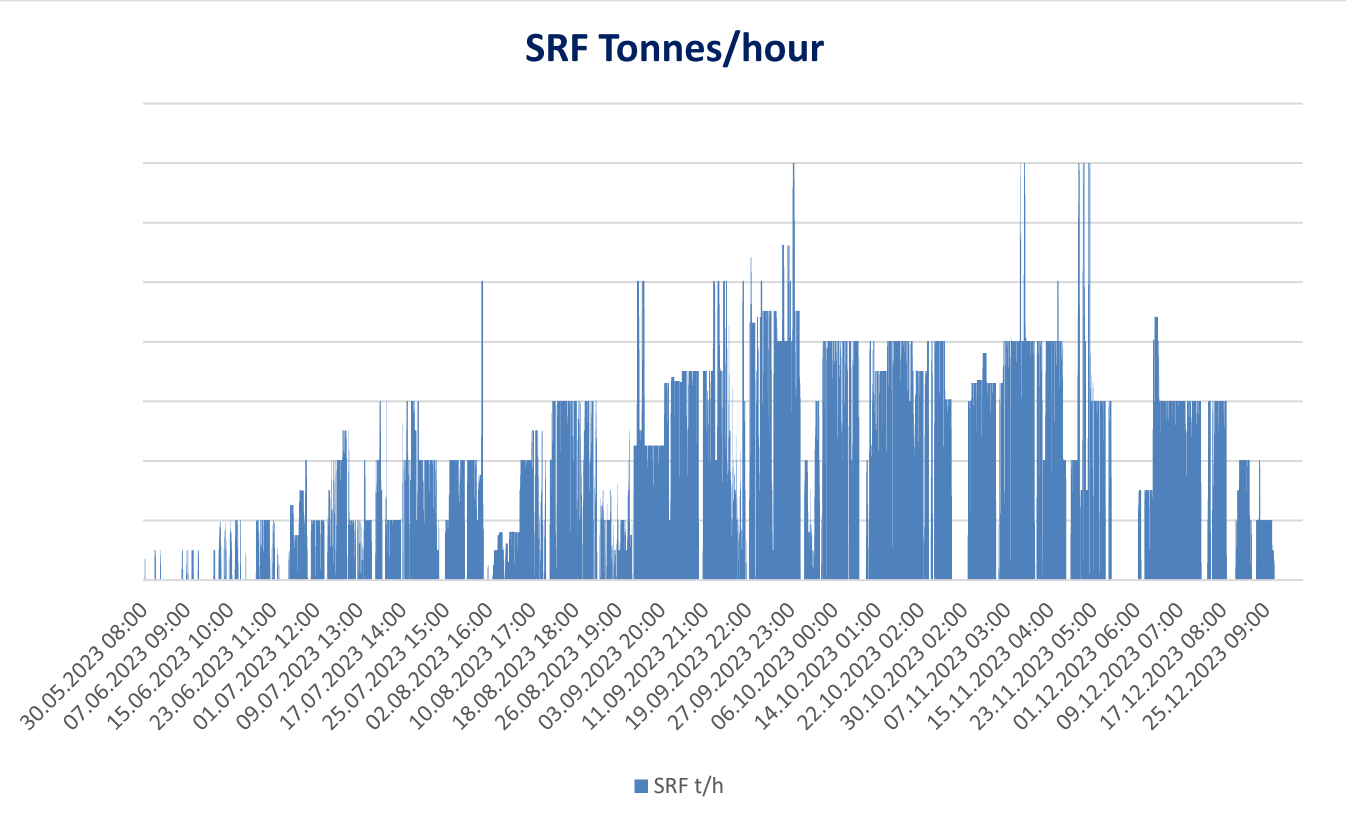
In addition, as the SRF usage ramp-up progressed, the orderly ramp-up of the SRF supply chain was also necessary to ensure continued supply of SRF at increasing levels of substitution. To this end, Irish Cement has worked closely with their supplier to be able to attain SRF to the technical specification required to ensure consistently high thermal substitution rates. Only one SRF supplier, Thorntons Recycling, who have been involved in SRF processing for over 10 years and have supplied other cements plants prior to Limerick, has been used to date, as approved by the Agency.

3. THERMAL SUBSTITUTION

3.1 SRF Usage Rates

SRF has been used as a fuel alongside pet coke since the 30th May 2023.

As is evident from the following graph, the hourly substitution rate steadily increased as equipment commissioning, supply chain development and compliance with environmental monitoring and product quality was demonstrated throughout the period.

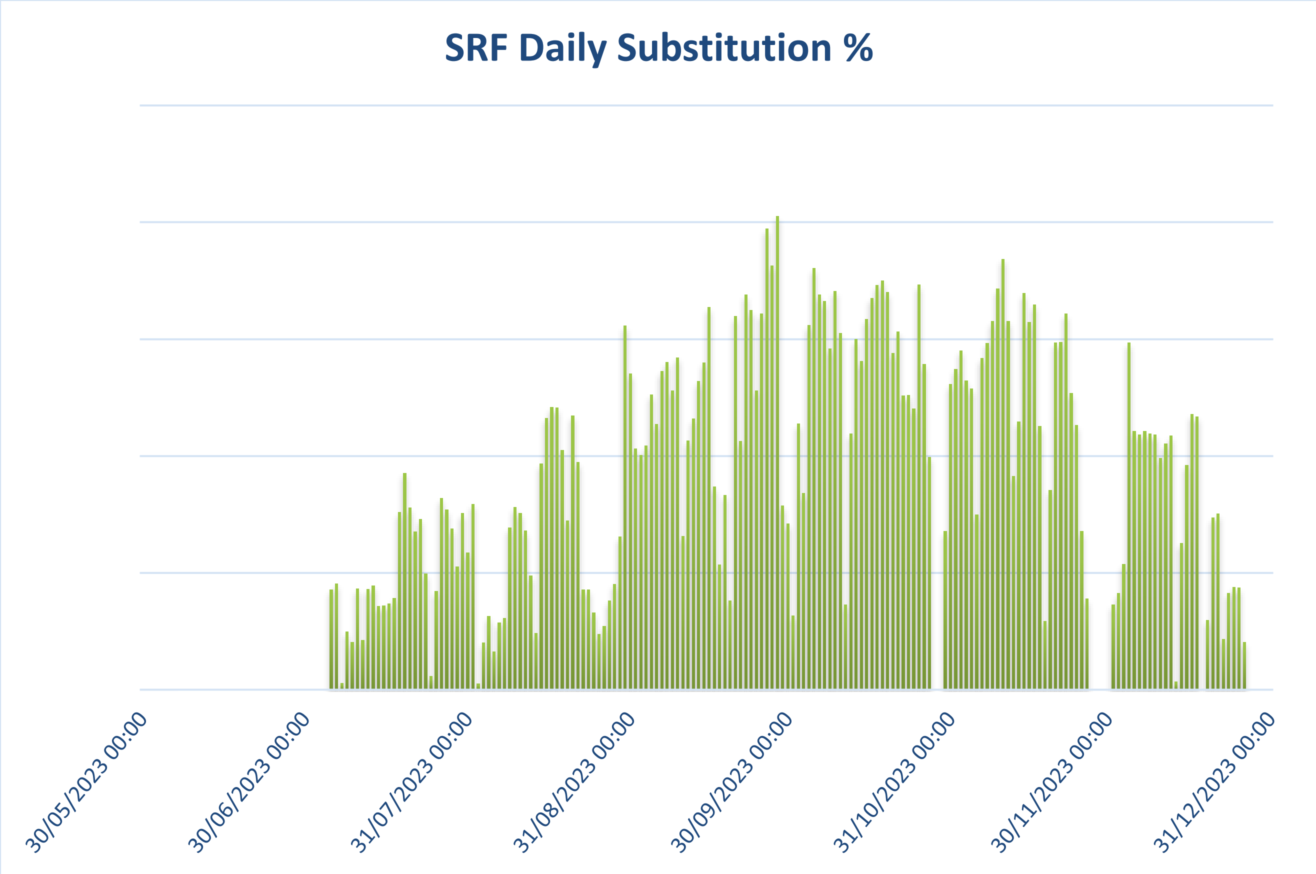


Graph 1: SRF t/h Rates May to December 2023

The maximum hourly rate of SRF consumption achieved to date is c.7 t/hr. This has progressively increased since as per the agreed ramp up timeline.

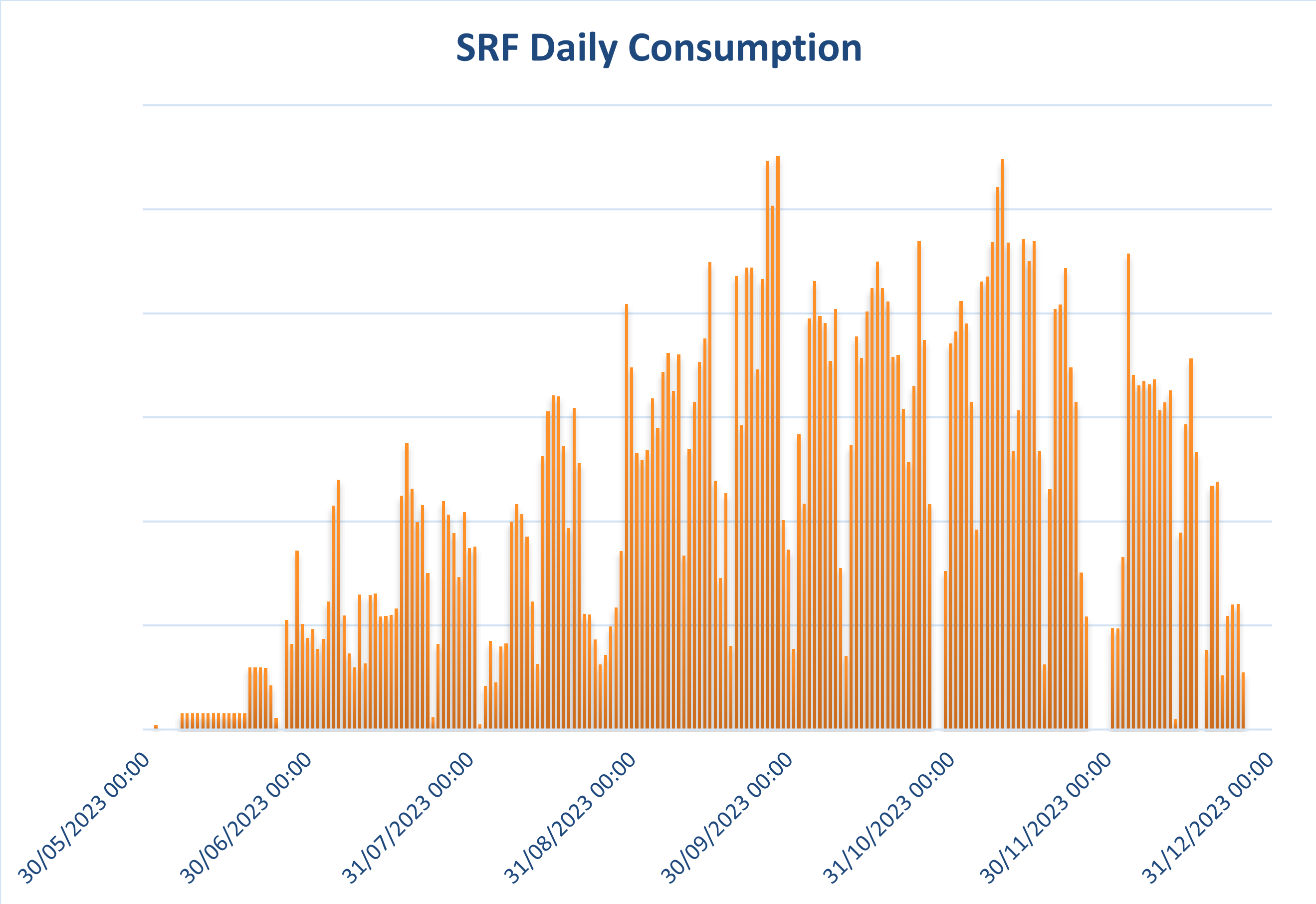
3.2 Thermal Substitution Performance

The following graphs depict the daily thermal substitution of SRF achieved throughout the Test Programme period and the daily consumption of SRF in tonnes from May 2023 to December 2023. The highest instantaneous hourly SRF substitution rate achieved by ICL is ~40%. The graph illustrates an increasing trend in the thermal substitution rates. It is worth noting that 7 t/h SRF was achieved towards the end of the test program. With future upgrades to equipment, including the addition of a chloride bypass in 2024, higher levels of SRF addition will be achievable.



Graph 2: SRF Substitution Rates May to December 2023

SRF substitution was increased in a gradual and controlled manner over the course of the test programme. A maximum SRF t/h limit was set for each month to ensure that the ramp up of SRF was done on a monthly basis and in a controlled manner. A maximum SRF t/h limit is currently in place.



Graph 3: SRF Daily Tonnes Consumed May to December 2023

3.3 Summary of Key Points

- The average SRF substitution rate has increased gradually over the course of the test programme.
- The max hourly rate of SRF loading achieved to date is c.7t/hr.
- The SRF substitution has been achieved with full environmental compliance

4. ENVIRONMENTAL COMPLIANCE

4.1 IE Licence Conditions

The following conditions of IE licence P0029-06 refer specifically to aspects of Alternative Fuel firing:

> ***6.3.4 The test programme shall as a minimum:***
> *(1) Verify the residence time, the minimum temperature and the oxygen content of the exhaust gas which will be achieved during normal operation and under the most unfavourable operating conditions anticipated.*
> *(2) Establish all criteria for operation, control and management of the abatement equipment to ensure compliance with the emission limit values specified in this licence.*
> *(3) Assess the performance of any monitors on the abatement system and establish a maintenance and calibration programme for each monitor.*
> *(4) Establish criteria for the control of all waste input; and*
> *(5) Confirm that all measurement equipment or devices (including thermocouples) used for the purpose of establishing compliance with this licence have been subjected, in situ, to normal operating temperatures to prove their operation under such conditions.*

> ***Condition 6.3.4.1: Verification of the Control Parameters***
> "*Verify the residence time, the minimum temperature and the oxygen content of the exhaust gas which will be achieved during normal operation and under the most unfavourable operating conditions anticipated.*"

Limerick Works will comply with EU Directive 2000/76/EC, referred to as the Industrial Emissions Directive (IED). The principal operating conditions established in the IED are that material must be processed within the system for at least 2 seconds (residence time) at 850°C (temperature).

In the main burner, the flame temperature exceeds 2000°C (as shown on the schematic diagram in below). This high temperature is necessary to ensure that the raw materials reach temperatures of 1450°C in order to form clinker, the primary ingredient in the production of cement. The stability of the kiln burner flame is monitored using the burning zone temperature along with the preheater tower temperature probes and preheater tower exit analyser to ensure correct conditions are maintained for clinker formation. The oxygen content of the kiln gas is controlled and is verified by changes in gas concentration observed at the Preheater Exit Analyser (644XQ02) and the Secondary Analyser (644XQ06). The locations of the monitoring points are indicated on the schematic shown in Figure 3.

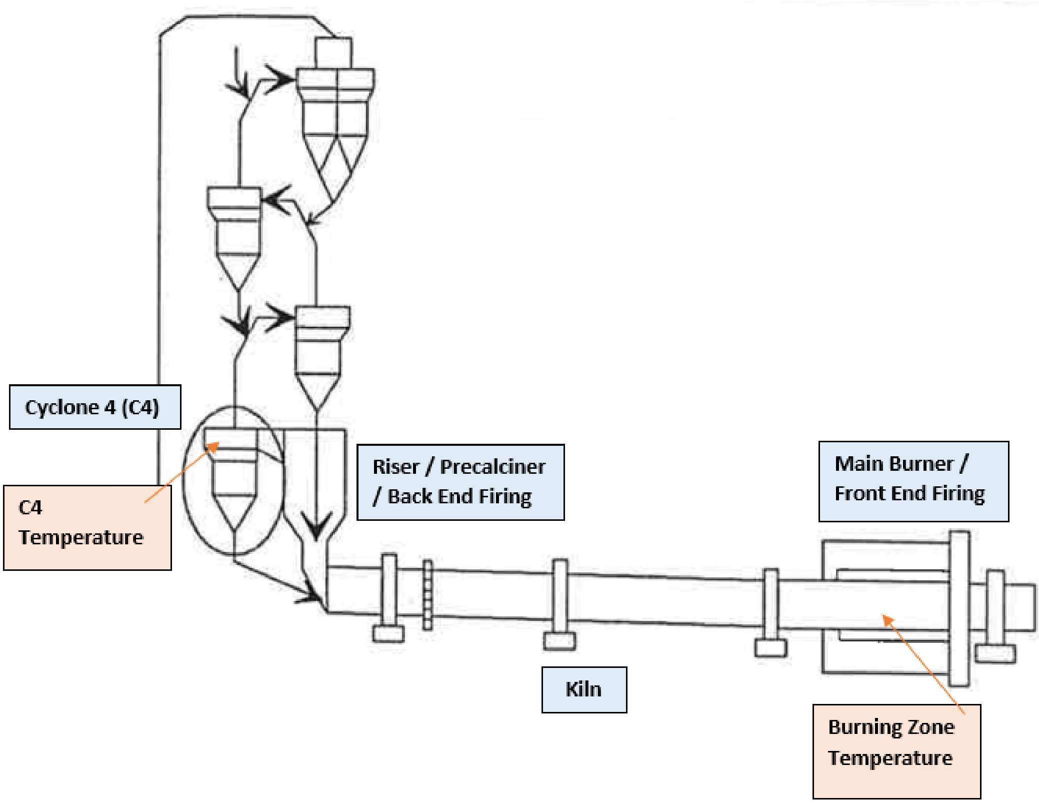


Figure 3: Schematic of Kiln 6 process

In order to verify the residence time, a range of scenarios were modelled to simulate expected operating conditions. The original equipment designer and manufacturer of Kiln 6, FLSmidth, were employed to model this data. A copy of the FLSmidth memo is provided for reference in Appendix I.
The fuel injection is interlocked with the temperature in the burning zones to ensure stable specific heat consumption. A stable specific heat consumption is paramount to the formation of good quality Clinker and in turn good quality cement. Therefore, if this is not correct, there may be an effect on Clinker quality. There are two temperature measurements: one in Cyclone 4 also known as Stage 4 and the main kiln burning zone. The FLSmidth modelling indicates that the minimum gas residence time under even the worst-case scenario (simulated with complete substitution of SRF) is 5.72 seconds, which is far in excess of 2 seconds required under the IED.

The table below summarises the residence time when operating at a minimum temperature of 855°C:

Scenario	Main Burner Fuel Mix	Back End Fuel Mix	Back End Residence Time (s)	Residence Time from Main Burner (s)	Total Residence Time
1	80% Pet Coke	20% Pet Coke	3.74	3.39	7.13
2	20% SRF+60% Pet Coke	20% Pet Coke	3.72	3.33	7.05
3	40% SRF+40% Pet Coke	20% Pet Coke	3.70	3.22	6.92
4*	80% SRF	20% SRF	3.13	2.59	5.72

Table 1: Summary for Operating Scenarios as modelled by FLSmidth

**Scenario 4 is to show the worst-case scenario*

Condition 6.3.4.2: Abatement Equipment Operation

"Establish all criteria for operation, control and management of the abatement equipment to ensure compliance with the emission limit values specified in this licence."

Emission abatement is an integral part of the cement manufacturing process. The Kiln 6 investment includes the Best Available Technology (BAT) fabric filters and ensures that Limerick can abate emissions to BAT emission levels. Limerick also installed a Selective Non-Catalytic Reduction (SNCR) for NOx abatement and has lime injection for SOx abatement.

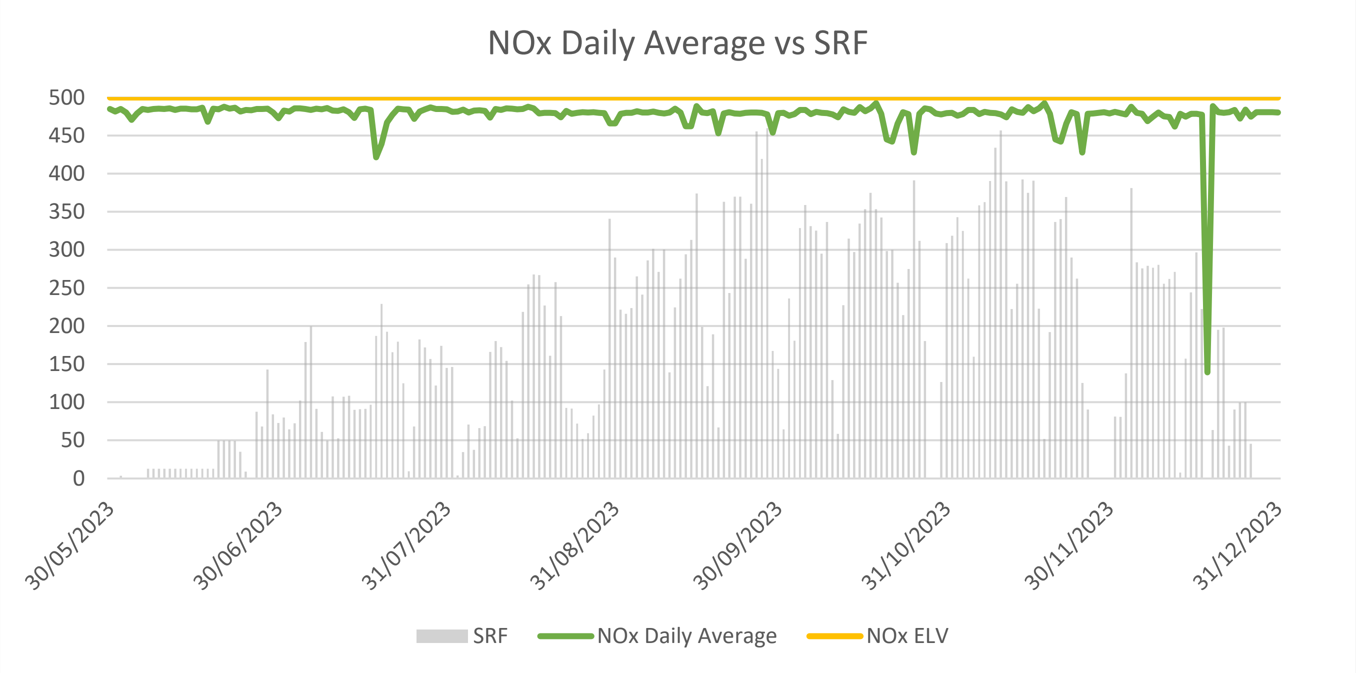
Assessment of SNCR abatement compliance with NOx ELV during co-firing of SRF

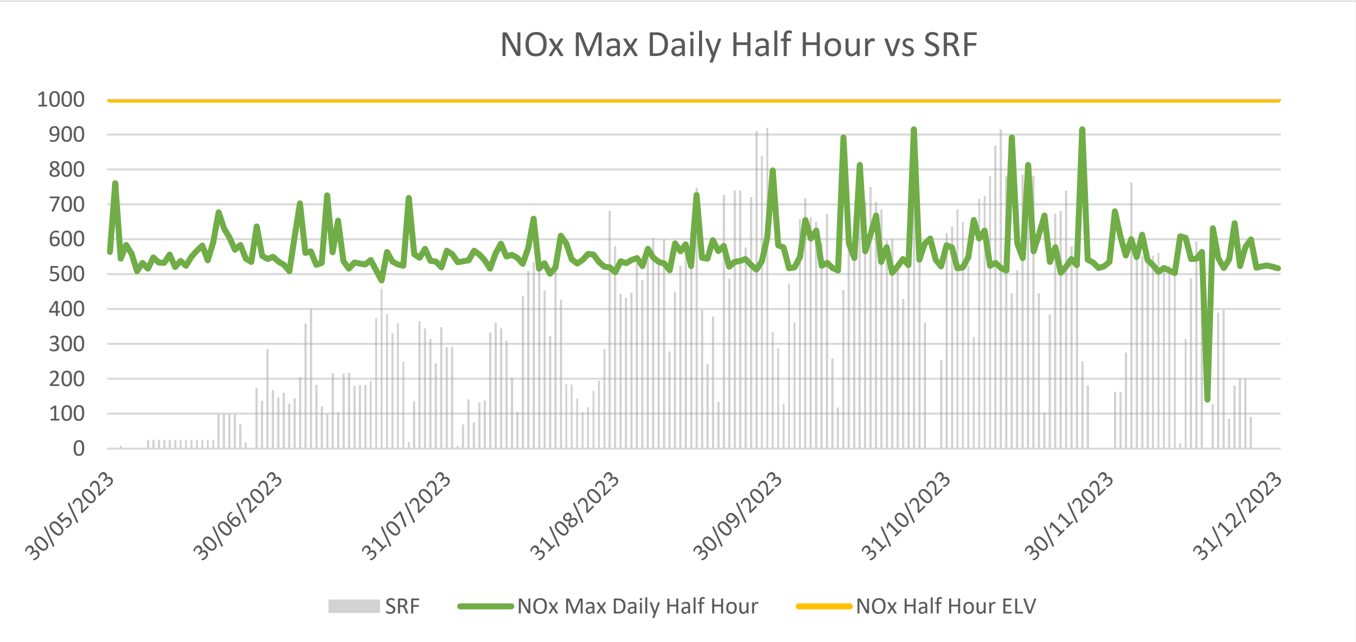
The NOx abatement equipment installed on Kiln 6 is primarily ABC&I Selective Non-Catalytic Reduction (SNCR) technology. The SNCR technology was commissioned in a test programme and was commissioned in 2007. Limerick Works monitored the performance of the SNCR abatement system and the ABB ACF5000 Continuous NOx Analyser in the Kiln 6 Stack to ensure compliance with the Emission Limit Value.

The co-firing of SRF has a positive impact on the SNCR system, as under co-firing conditions there is a reduction in the amount of Ammonia Water required to target a set-point showing that SRF as a fuel creates less NOx emissions than when firing with pet-coke solely.

During the test programme period the SNCR NOx abatement system successfully maintained stack NOx emissions below the licence emission limit values of 500mg/Nm3 and 1000mg/Nm3 for 24-hour average and half hour average respectively in accordance with the conditions of the IE licence P0029-06.

No NOx non-compliances occurred over the course of the test programme period as illustrated in the charts below, detailing the max 24 hour and max half hourly results for each day of production from the 30th May 2023 to the 31st December 2023. All external testing NOx emissions results were also compliant with the licence. Additionally, to this, control system interlocks are in place so as to prevent breaches in any emission limit value that is continuously monitored.





The effectiveness of the system with achieving compliance with the NOx ELV is also demonstrated by compliance with Condition 4.1.1 (ii) of the licence. This states that '97% of all 30-minute mean values taken continuously over an annual period (excluding start-up and shutdown) shall not exceed 1.2 times the ELV'. For the Test Programme period the compliance of this condition is summarised below. It demonstrates the effectiveness of the SNCR system in the achievement of NOx reduction during co-firing of SRF.

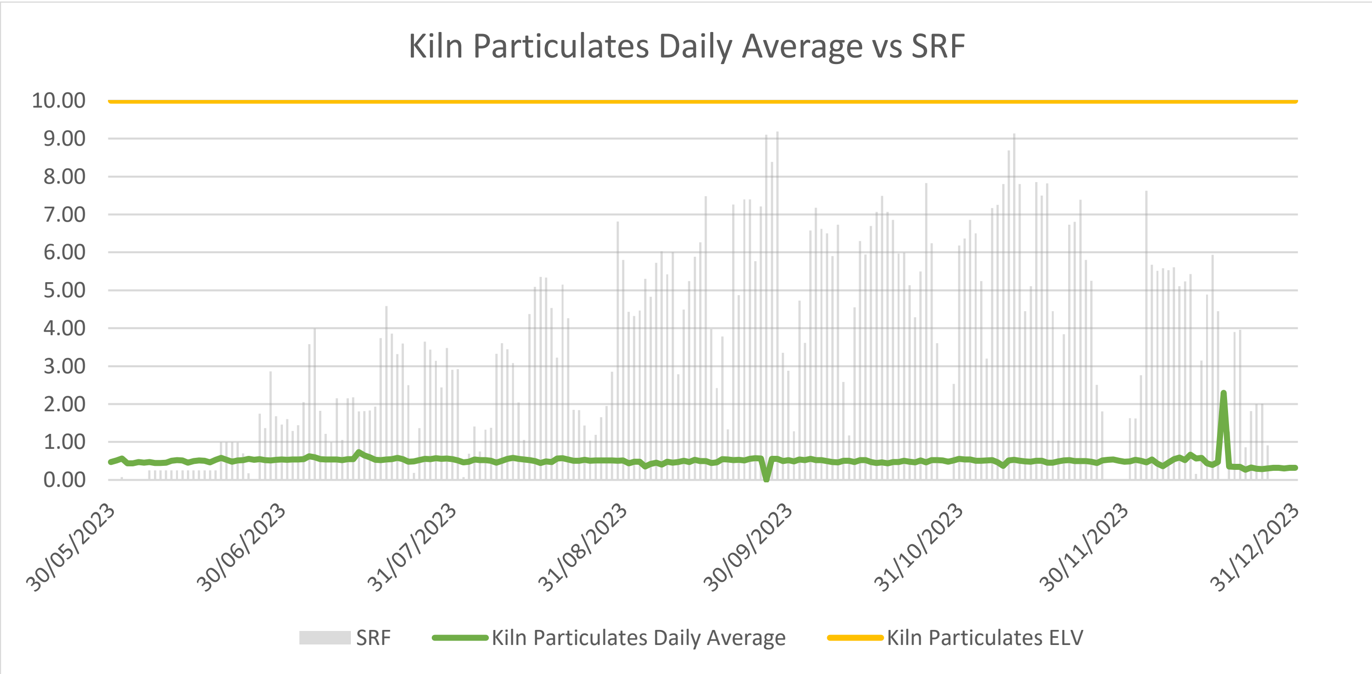
NOx Reduction	
Month	**% of Half Hourly Average Values within 1.2 times the NOx ELV**
	%
June	99.6
July	99.5
August	99.8
September	99.6
October	99.3
November	98.5
December	99.2

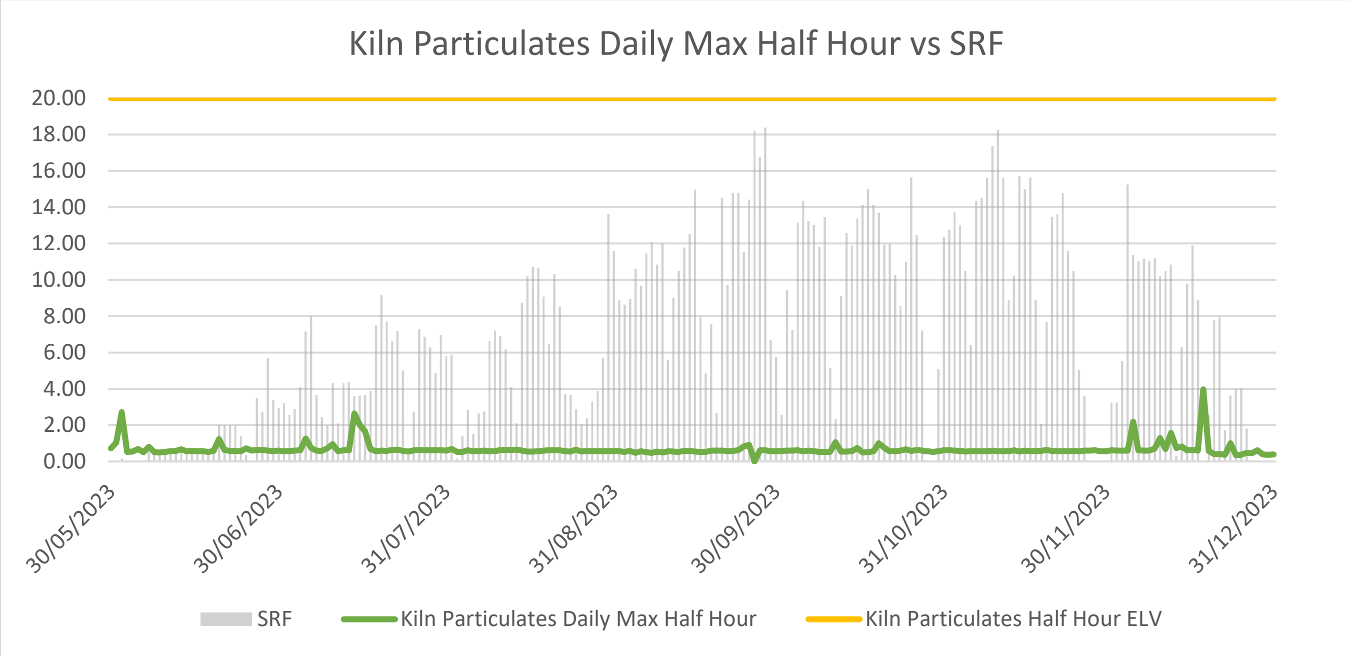
Table 2: % of Half Hourly Average Values within 97% of 1.2 times the NOx ELV

Assessment of Kiln 6 bag filter abatement compliance with dust ELV during co-firing of SRF

Limerick Works installed an FLS Fabric Filter for Kiln 6 in 2010 for the abatement of particulates. Limerick Works monitored the performance of the bag filter using the differential pressure monitor installed and the PCME QAL 181 dust monitor on the Kiln 6 stack to ensure continued compliance with the Emission Limit Values for particulate emissions.

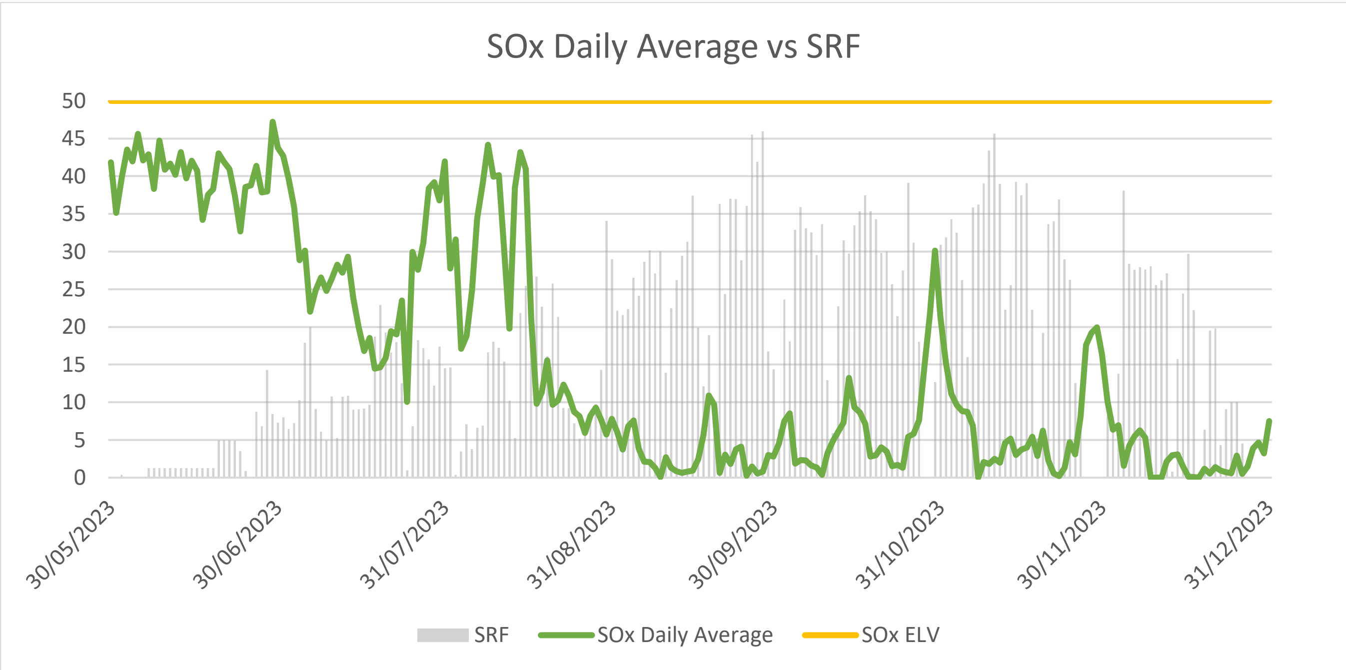
The co-firing of SRF does not affect the control of the filter, as there is no impact of SRF co-firing on the filter integrity as seen by the chart below of the daily average and max half hourly data during the co-firing period from the 30th May to the 31st December 2023.

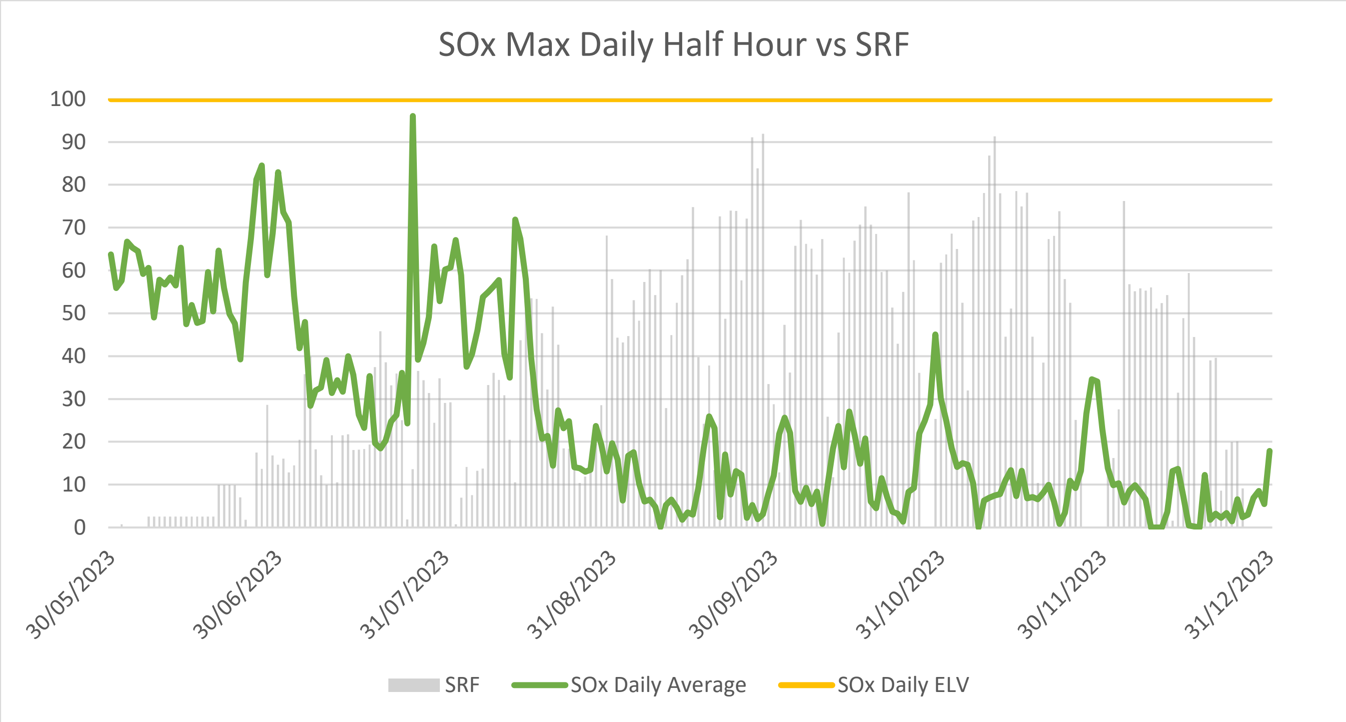




__Assessment of SO_2 abatement compliance with dust ELV during co-firing of SRF__

In 2021 Limerick Works commissioned a lime injection system for the abatement of SO_2 following a significant reduction in the SO_2 ELV in the P0029-06 licence in May 2021. A high-quality lime powder is injected into the kiln gas stream before the gas enters the cooling tower to reduce emissions of SO_2. Hydrated lime is used to neutralise the acidic gases and remove sulphur dioxide from flue gases. The lime system is used dependent on the SO_2 emission which is determined by the raw materials. Co-firing SRF has no influence on the SO2 emission. All SO2 emissions during the test programme were compliant and can be seen by the chart below of the daily average and max half hourly data during the co-firing period from the 30th May to the 31st December 2023.



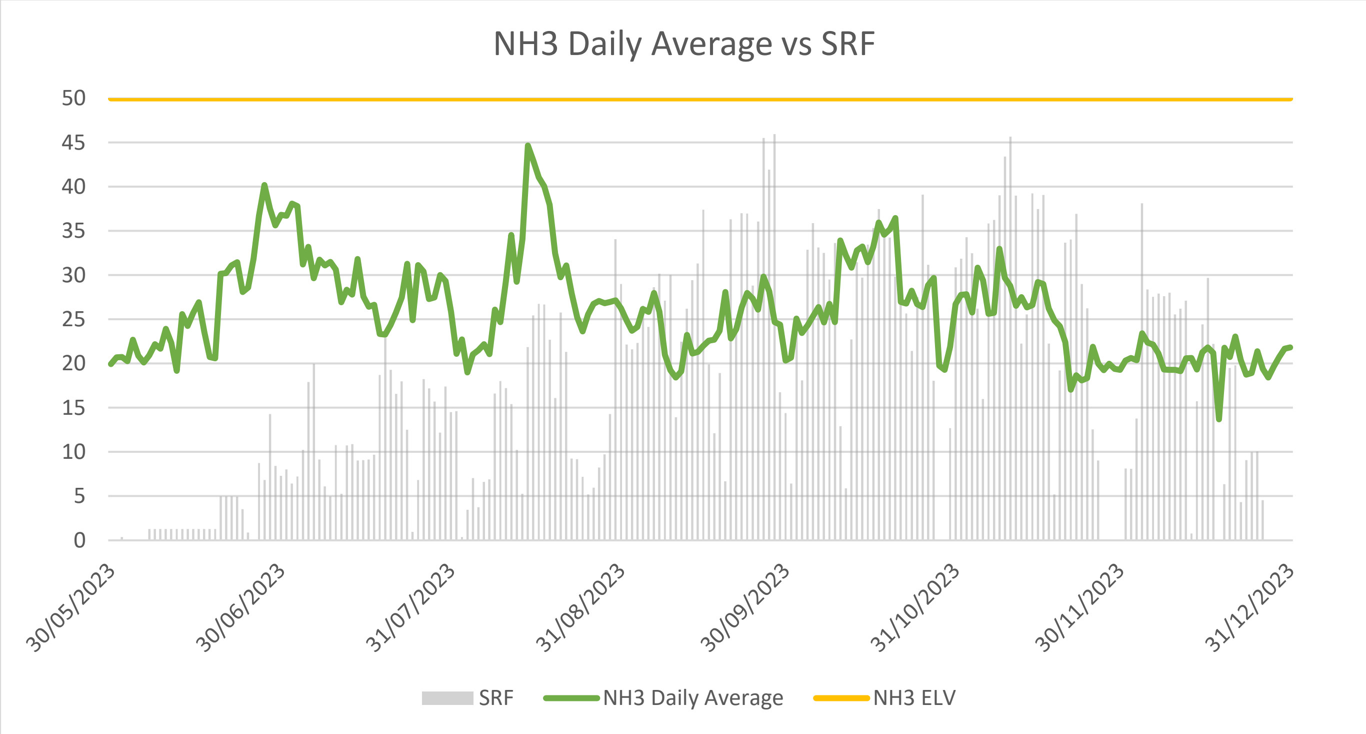


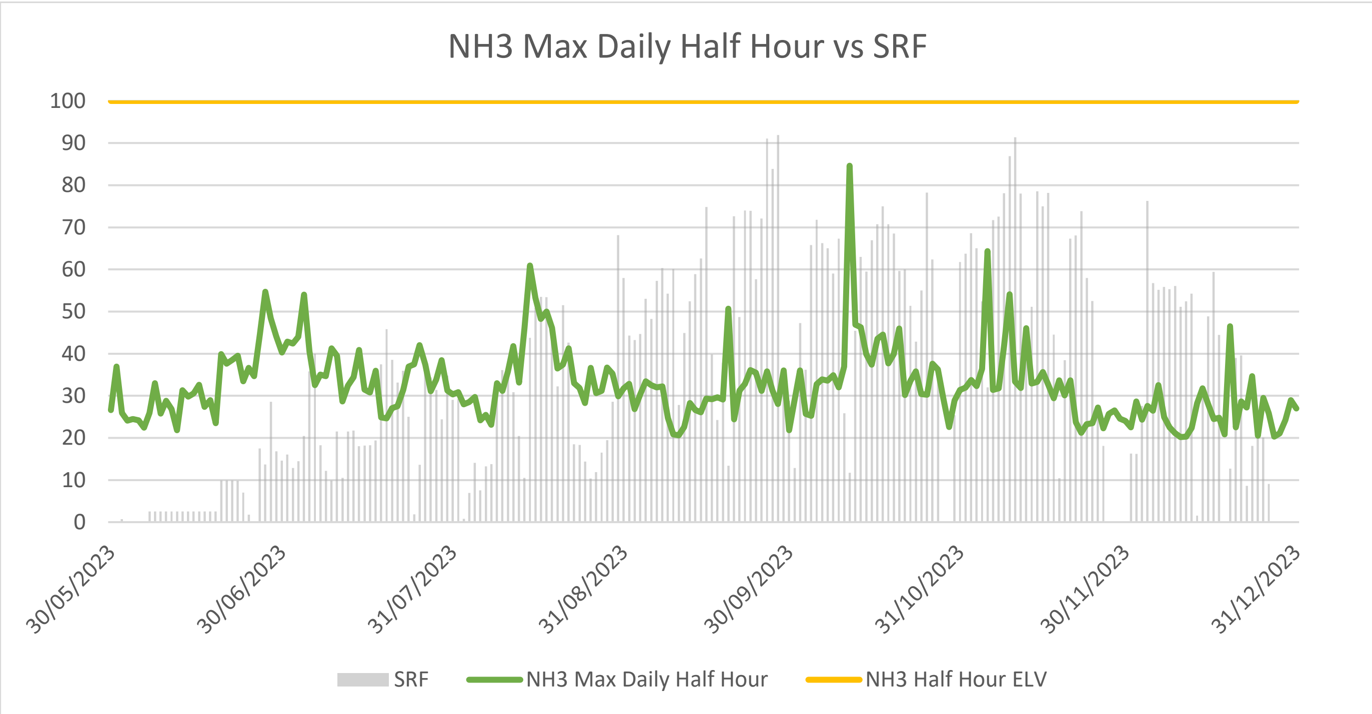
The other parameters which are subject to ELV's include:

- Ammonia Slip (NH3)
- Hydrogen Chloride (HCl)
- Hydrogen Fluoride (HF)
- Total Organic Carbon (TOC)
- Carbon Monoxide (CO)

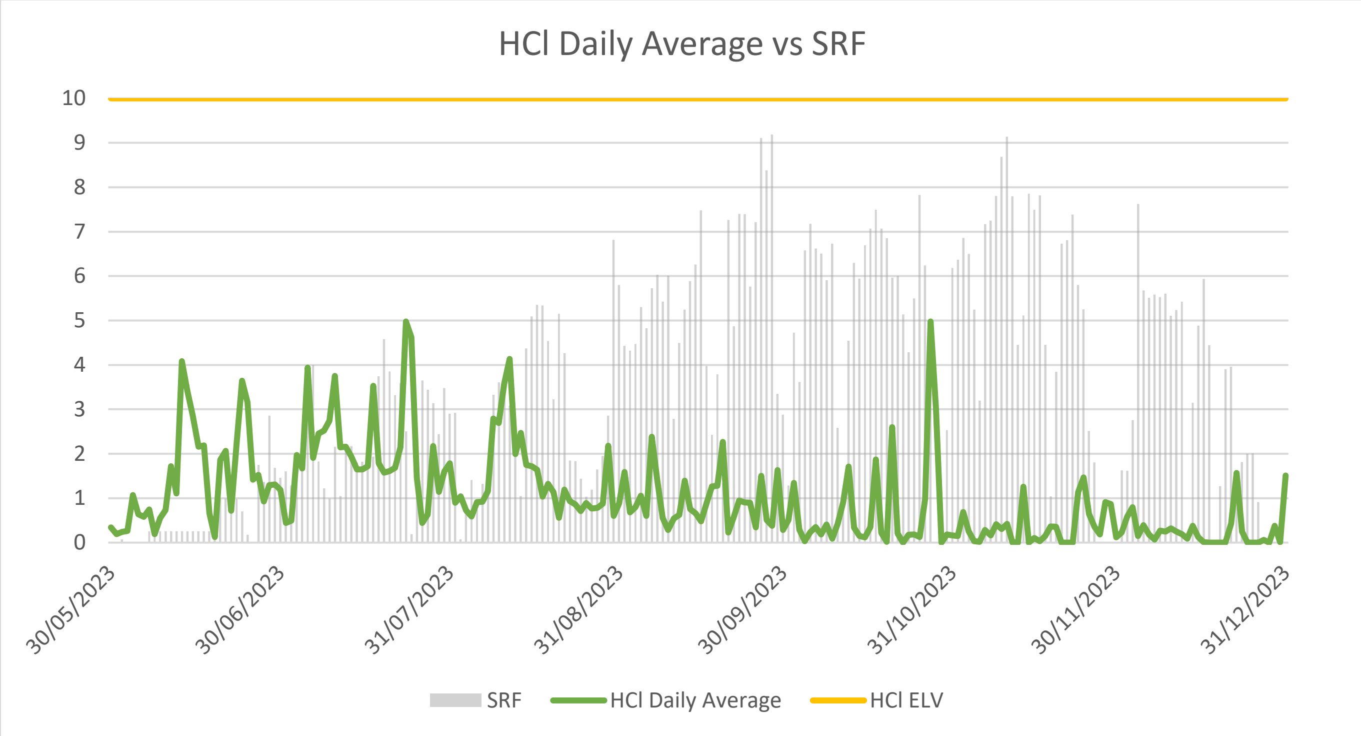
The following graphs demonstrate the daily average and max half hourly data during the co-firing period from the 30th May to the 31st December 2023 as well as the ELV's for the individual parameters.

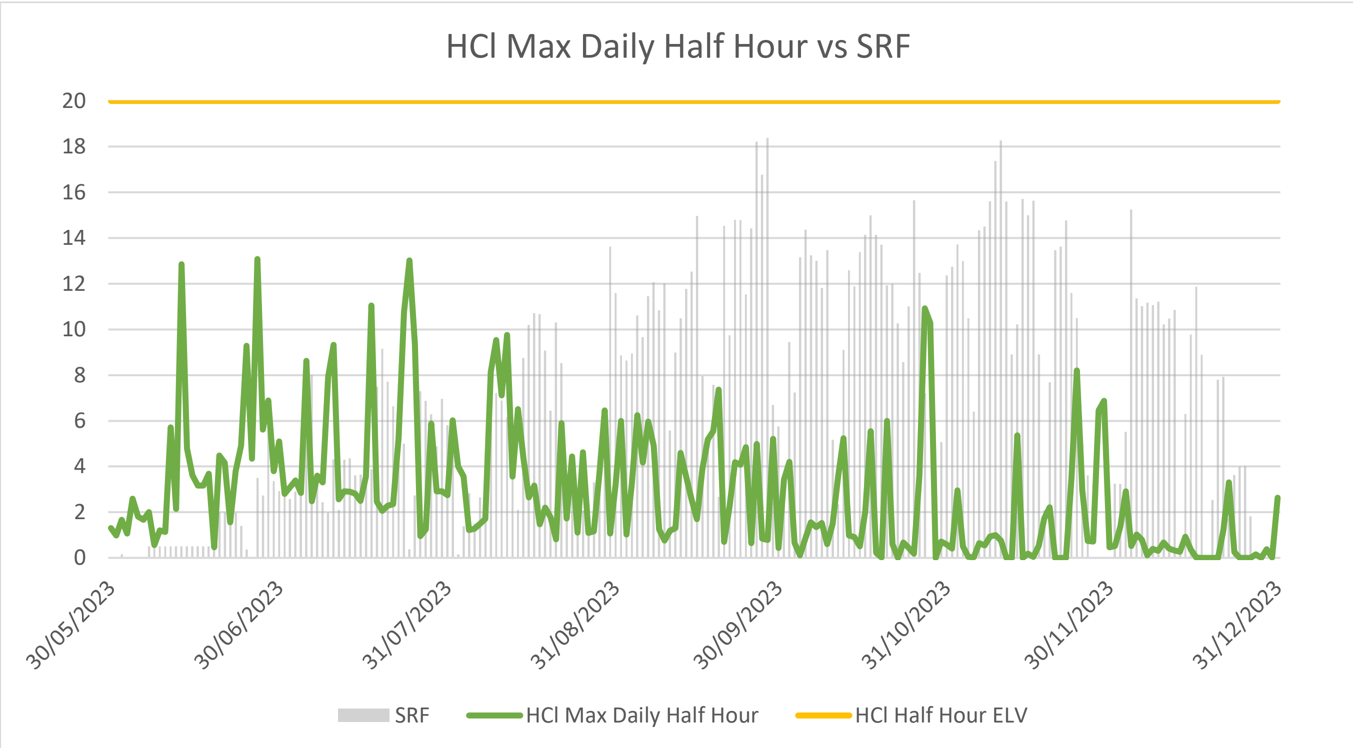
Ammonia (NH3):


NH3 Daily Average vs SRF
50
45
40
35
30
25
20
15
10
5
0
30/05/2023
30/06/2023
31/07/2023
31/08/2023
30/09/2023
31/10/2023
30/11/2023
31/12/2023
SRF
NH3 Daily Average
NH3 ELV

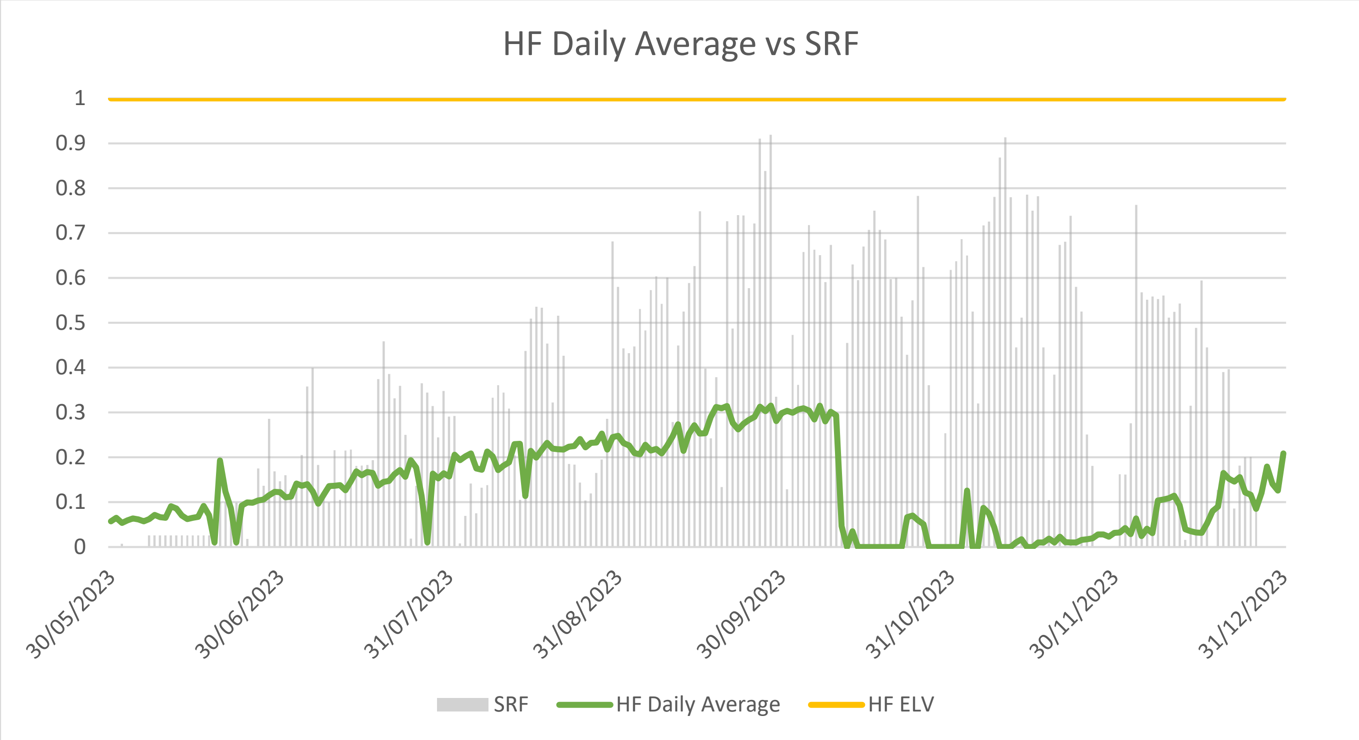

NH3 Max Daily Half Hour vs SRF
100
90
80
70
60
50
40
30
20
10
0
30/05/2023
30/06/2023
31/07/2023
31/08/2023
30/09/2023
31/10/2023
30/11/2023
31/12/2023
SRF
NH3 Max Daily Half Hour
NH3 Half Hour ELV

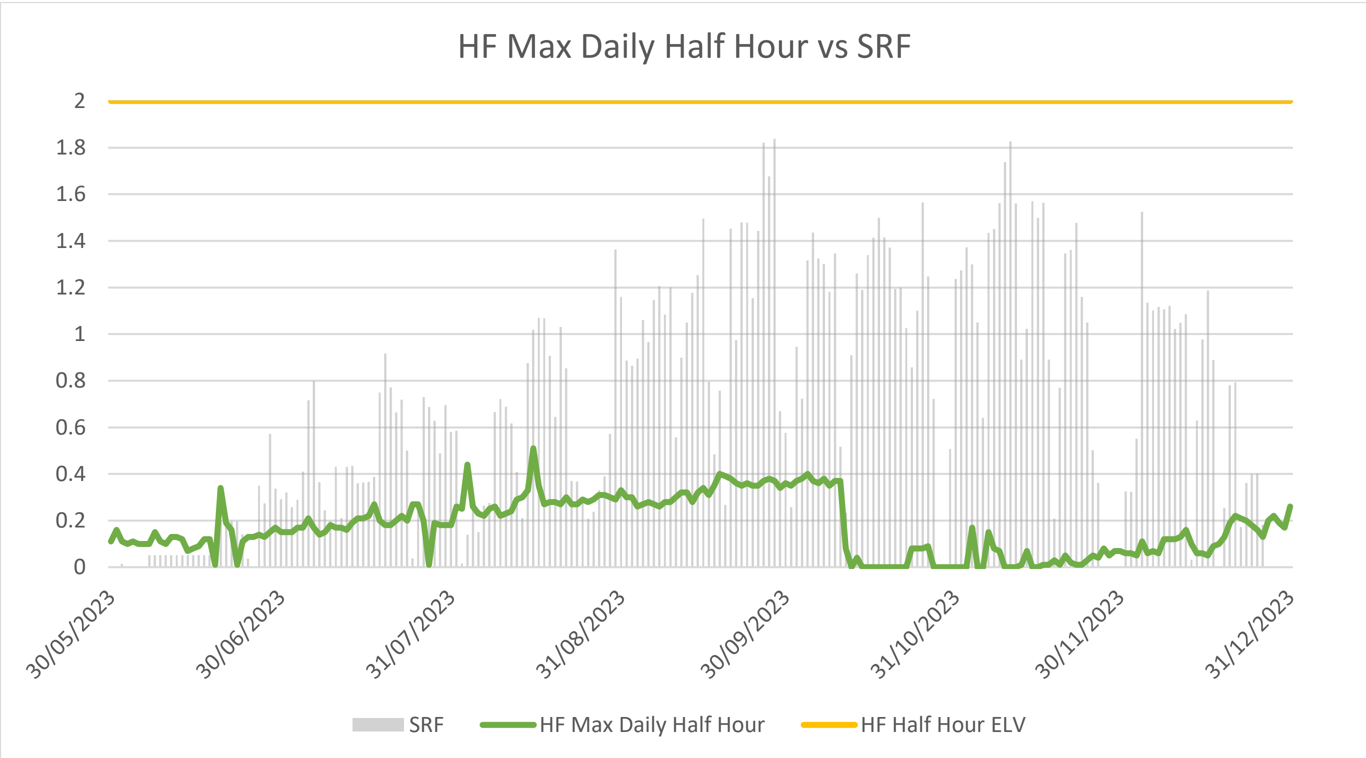
Hydrogen Chloride (HCl):



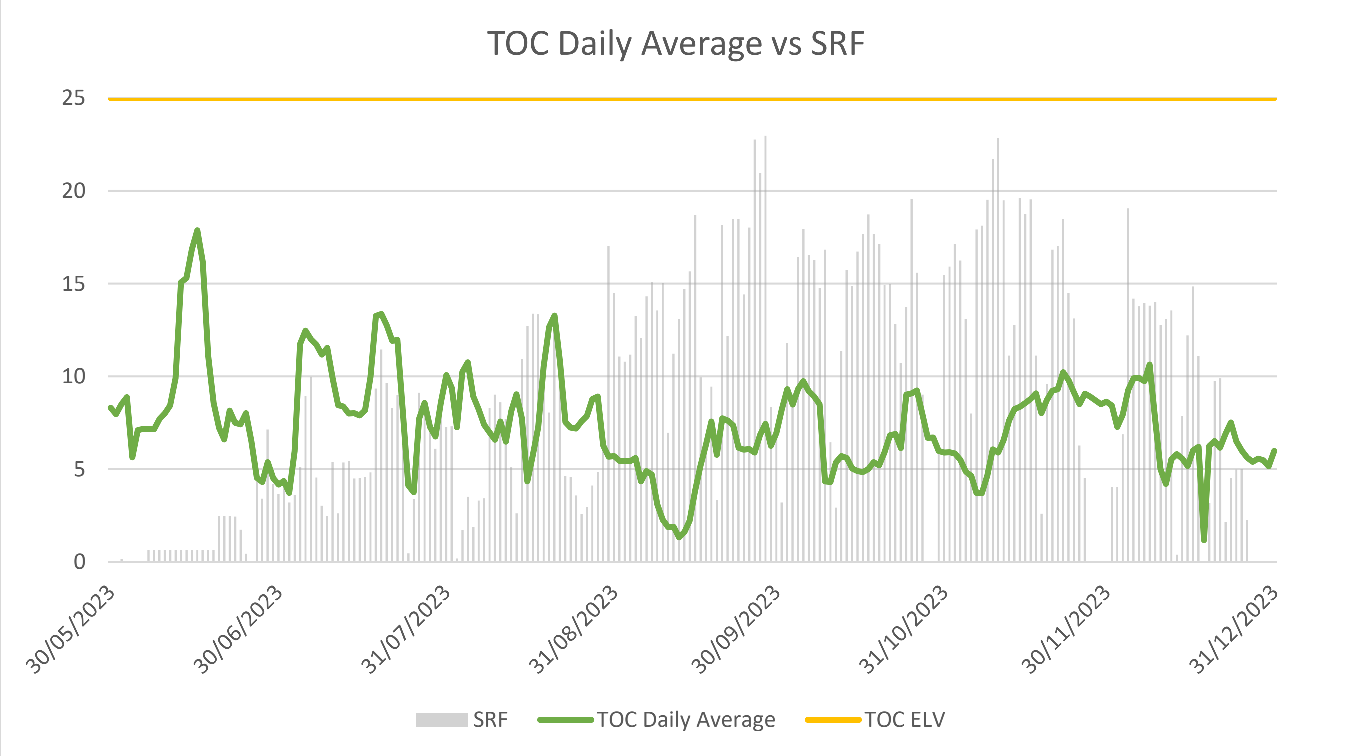


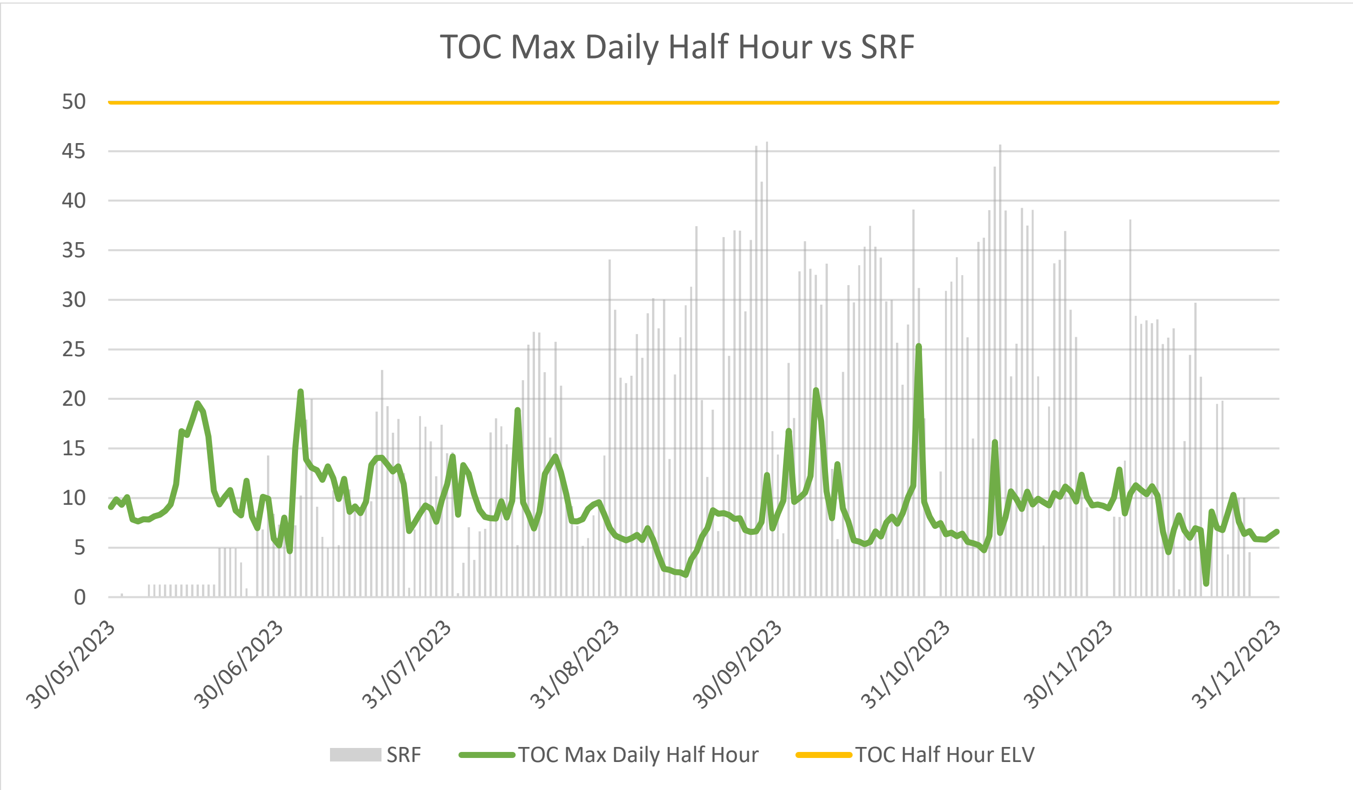
Hydrogen Fluoride (HF):



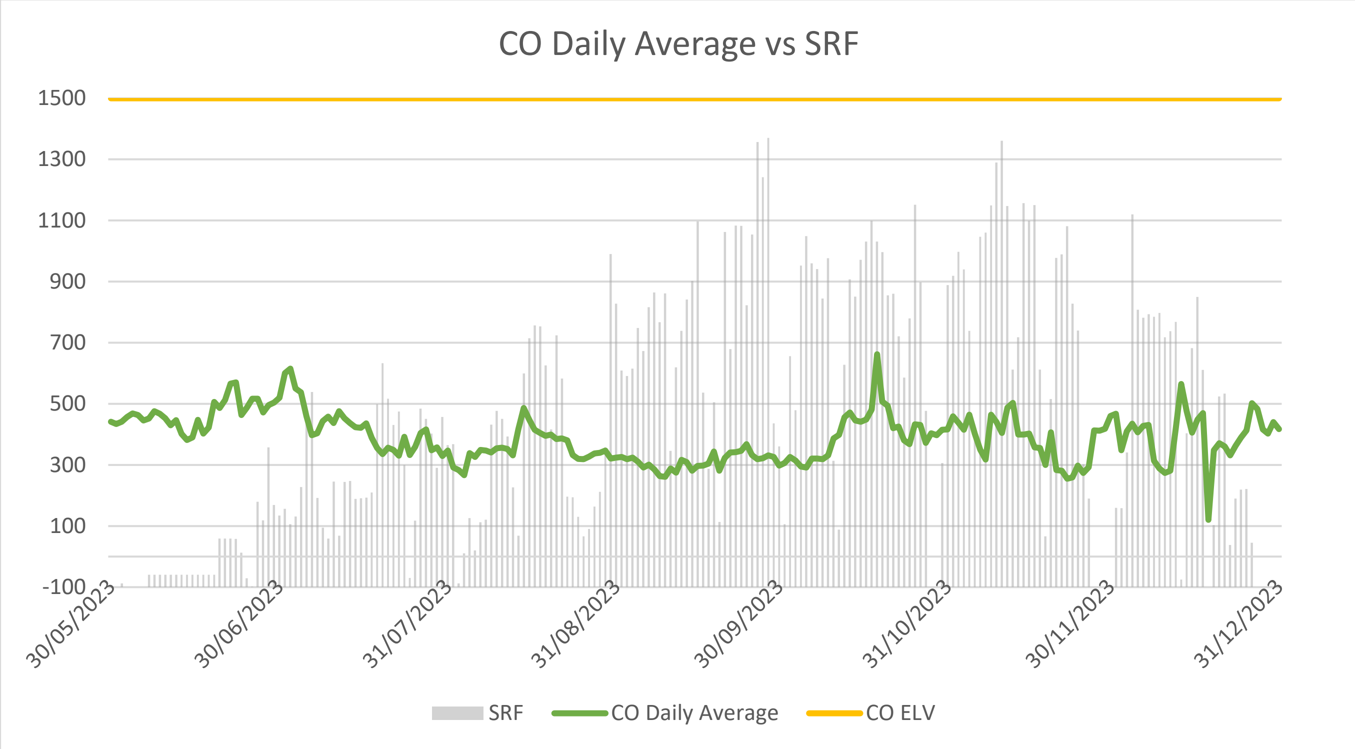


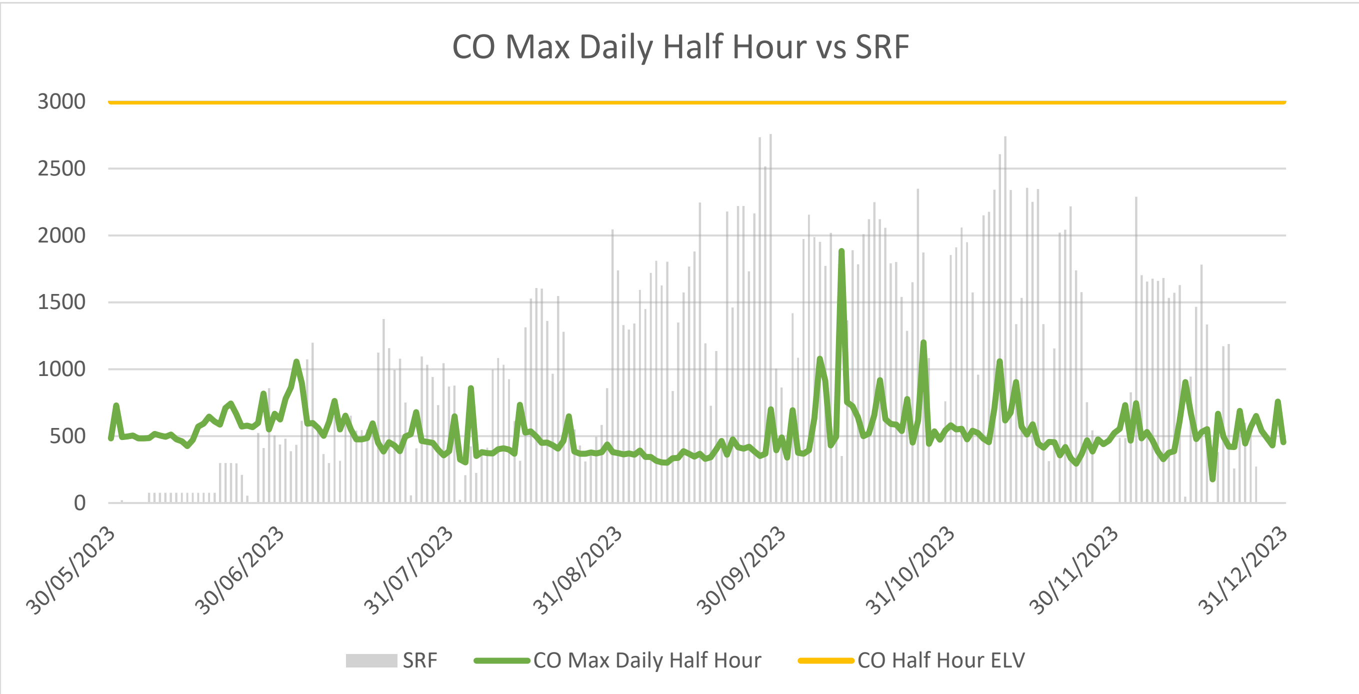
Total Organic Carbon (TOC):





Carbon Monoxide (CO):





All continuously monitored parameters were compliant during the test programme and were also not affected by the use of SRF. The trends show that the use of SRF did not change these emissions. Emissions can change due to various reasons but mainly due to raw materials.

Non-Continuously Monitored Parameters

IE Licence P0029-06 requires the discrete monitoring of several parameters over defined sampling periods. As per the test programme these parameters were required to be tested in triplicate on separate days at various SRF addition rates. The full reports for the testing external testing are included in Appendix V.

The following emissions parameters were monitored during SRF co-firing:

- Dioxins & Furans
- Mercury
- Cadmium & Thallium
- Heavy metals

The following tables detail the results of the testing data available:

Dioxins and Furans				
Run	**Date**	**SRF Addition**	**P0029-06 ELV**	**External Testing Result**
		t/h	***ng/m3***	***ng/m3***
Run 1	18/07/2023	3	0.1	0.0014
Run 2	19/07/2023	3	0.1	0.0016
Run 3	11/12/2023	3	0.1	<0.0019
Run 4	30/08/2023	5	0.1	<0.0004
Run 5	13/09/2023	5	0.1	0.0020
Run 6	15/09/2023	5	0.1	0.0029
Run 7	20/11/2023	7	0.1	0.0014
Run 8	21/11/2023	7	0.1	0.0147
Run 9	22/11/2023	7	0.1	0.0177

Table 3: Dioxin and Furans Results

Mercury				
Run	**Date**	**SRF Addition**	**P0029-06 ELV**	**External Testing Result**
		t/h	***mg/m3***	***mg/m3***
Run 1	20/07/2023	3	0.05	0.0110
Run 2	07/12/2023	3	0.05	0.0082
Run 3	09/12/2023	3	0.05	0.0104
Run 4	30/08/2023	5	0.05	<0.0020
Run 5	13/09/2023	5	0.05	0.0060
Run 6	14/09/2023	5	0.05	0.0070
Run 7	20/11/2023	7	0.05	0.0070
Run 8	21/11/2023	7	0.05	0.0120
Run 9	22/11/2023	7	0.05	0.0100

Table 4: Mercury Results

Cadmium and Thallium				
Run	**Date**	**SRF Addition**	**P0029-06 ELV**	**External Testing Result**
		t/h	***mg/m3***	***mg/m3***
Run 1	20/07/2023	3	0.05	0.0018
Run 2	07/12/2023	3	0.05	0.0021
Run 3	09/12/2023	3	0.05	<0.0012
Run 4	30/08/2023	5	0.05	<0.0010
Run 5	13/09/2023	5	0.05	0.0010
Run 6	14/09/2023	5	0.05	<0.0010
Run 7	20/11/2023	7	0.05	0.0020
Run 8	21/11/2023	7	0.05	0.0010
Run 9	22/11/2023	7	0.05	0.0010

Table 5: Cadmium and Thallium Results

Heavy Metals				
Run	**Date**	**SRF Addition**	**P0029-06 ELV**	**External Testing Result**
		t/h	***mg/m3***	***mg/m3***
Run 1	20/07/2023	3	0.5	0.0120
Run 2	07/12/2023	3	0.5	0.0459
Run 3	09/12/2023	3	0.5	<0.3308
Run 4	30/08/2023	5	0.5	<0.0110
Run 5	13/09/2023	5	0.5	0.0060
Run 6	14/09/2023	5	0.5	0.0120
Run 7	20/11/2023	7	0.5	0.2440
Run 8	21/11/2023	7	0.5	0.0140
Run 9	22/11/2023	7	0.5	0.0170

Table 6: Heavy Metals Results

All results were compliant with the licence and have shown no correlation to the use of SRF.

Limerick Works dedicate significant time and resources to ensure the continued management of the abatement systems. The operation and performance of these systems are monitored on an ongoing basis. In addition, emission values are assessed on a daily basis using data from the data acquisition and handling system (DAHS) at Limerick Works. This practice will continue as it has before and during the test programme as per the relevant schedule under IEL P0029-06.

Standard Operating Procedures for the abatement system, including operating with the co-firing of SRF, form part of Limerick's controlled documented procedures. These procedures have been reviewed as part of the SRF test programme. A copy of this procedure is included in appendix IV.

Condition 6.3.4.3: Performance of Abatement Systems

The test programme shall as a minimum:

Assess the performance of any monitors on the abatement system and establish a maintenance and calibration programme for each monitor.

As required under the Industrial Emissions Directive (IED), Limerick Works complies with the requirements of the International Standard EN 14181:2004 “Stationary Source Emissions – Quality Assurance of Automated Measuring Systems”. There are 3 Quality Assurance Levels (QAL) associated with this Standard. In accordance with the agreed Test Programme QAL 1, 2 and 3 have all been completed as appropriate and where technically feasible during the Test Programme period.
All CEM’s equipment are MCert equipment and therefore qualify for QAL 1. Two ABB ACF5000 analysers are in place for continuous monitoring (one as a standby), two PCME dust monitors are in place for monitoring dust and a DURAG flowmeter is in place for motoring the Volumetric Flow. All analysers underwent QAL 2 testing during the test programme while using SRF. QAL 2 reports have been submitted to the EPA via EDEN for approval. Limerick Works performed QAL3 tests for both ACF5000 analysers during the test programme for SRF in accordance with the “Air Guidance Note on the Implementation of I.S. EN 14181 (AG3)” issued by the EPA and to meet the requirements of Condition 4.1.3 of IE Licence P0029-06.
All QAL’s and AST’s, as appropriate, for the necessary monitors will continue going forward as per EN14181.

Condition 6.3.4.4: Control of SRF Input

“Establish criteria for the control of all waste input”

Kiln control systems are designed to monitor and control a range of variables to produce stable operating conditions. These controls allow for the increase or decrease of fuel or raw meal inputs as required. Under normal operating conditions alternative fuels are the final input to be added once stable kiln operation has been established. For all shutdowns the alternative fuels will be the first input to be stopped. The high thermal inertia or heat load of the kiln system means that even after the kiln is ‘shutdown’ the system maintains temperature for an extended period of time and all fuel will be fully combusted.

The fuel injection to the kiln is controlled to maintain a stable temperature and constant specific heat consumption. The alternative fuel injection is interlocked with the temperature probe in the fuel burning zone to maintain a minimum temperature of 855°C. A fuel control loop is in place in the control system which operates to a fuel energy target and regulates the balance of fossil fuel and SRF injection to the kiln to ensure constant specific heat consumption. A detailed description of the control interlock is provided under clause 3.19.6.2 below. Fossil fuel (coal or pet coke) will remain the primary control fuel for the kiln to maintain this temperature (855°C). A minimum input of fossil fuel will be maintained at all times. SRF was incrementally increased throughout the test programme as per an agreed timeline with the Agency. A maximum setpoint for SRF injection was interlocked at each stage so as to limit the SRF maximum tonnes/hour which can be fired into the kiln. The maximum set point allowed for a controlled ramp up of SRF t/h each month. Control of the temperature is ensured by

control of the gas analysis at the Preheater Exit Analyser (644XQ02) and Secondary Analyser (644XQ06). The kiln camera and Burning Zone Temperature (pyrometer) provides further temperature information.
The maximum calorific value of the fuel input, including SRF, is established by controlling the energy input to the kiln and ensuring a minimum temperature for the combustion of SRF. These temperatures are used in control system interlocks to limit the maximum flow of SRF. A copy of the control logic and evidence of the limits on SRF is provided in Appendix II.

Condition 6.3.4.5: Measurement Devices

> *"Confirm that all measurement equipment or devices (including thermocouples) used for the purpose of establishing compliance with this licence have been subjected, in situ, to normal operating temperatures to prove their operation under such conditions."*

All measurement equipment devices, including thermocouples, installed are specified with accuracy in accordance with the International Standard for a Type K Thermocouple. Independent temperature and pressure measurements, where possible, were taken to verify that measurement devices are reading correctly.

In addition, the following requirements under the IE licence P0029-06 have been addressed as part of this test programme below.

5. CO-INCINERATION – OPERATIONAL CONTROLS

The following sub-sections address how full compliance with the relevant parts of Clause 3.19 of IE licence P0029-06 will be demonstrated during the proposed test programme period.

5.1 Standard Operating Procedures

Condition 3.19.1:

> *The licensee shall maintain standard operating procedures for the operation of the co-incineration plant.*

Standard Operating Procedures for kiln operation, including operating with the co-firing of SRF, form part of Limerick's controlled documented procedures. These procedures have been reviewed and revised as necessary during the commissioning and ramp up of SRF. Full copies of these procedures are available to the Agency upon request.

5.2 Co-incineration

Condition 3.19.2:

The installation, when co-incinerating waste, shall be operated in such a way that the gas resulting from the process is raised, after the last injection of combustion air, in a controlled and homogeneous fashion and even under the most unfavourable conditions, to a temperature of 850°C, as measured near the inner wall or at another representative point of the combustion chamber as may be authorised by the Agency, for two seconds.

Condition 3.19.3:

Waste shall be charged into the plant only when these operating conditions are being complied with and when the emission limit values which are subject to continuous monitoring are not being exceeded.

The SRF fuel injection is interlocked with the temperature in the fuel burning zone to ensure stable specific heat consumption in the kiln. The minimum residence time and temperature required to burn alternative fuels is 2 seconds and 850°C respectively. Injection of SRF will only be possible if the temperature is in excess of 855°C. This is controlled automatically by a fuel control loop.
SRF is not used as a start-up fuel and use in the kiln is not possible until the kiln is no longer in start up or shut down mode and interlocks are in place to ensure this. SRF cannot be fired until the kiln temperatures have reached the interlocked temperature limit of 855°C for the co-firing of SRF.
Furthermore, injection of SRF is not possible unless the emission limit values, which are subject to continuous monitoring, are not being exceeded. Interlocks are in place within the control system to stop the kiln before any emission limit value is exceeded. The SRF will be stopped automatically when the kiln stops.

5.3 Provision for Auxiliary firing

Condition 3.19.4:

The burner and kiln shall be equipped with at least one auxiliary burner. The auxiliary burner shall be switched on automatically when the temperature of the combustion gases after the last injection of combustion air falls below 850°C. The auxiliary burners shall also be used during plant start-up and shut-down operations in order to ensure the temperature of >850°C is maintained at all times during the co-incineration of waste and as long as there is unburned waste in the combustion chamber.

Introduction and continued firing of alternative fuels into the kiln process is interlocked with stable process conditions and as such can only occur when the following conditions exist:

- Pet coke (or Coal) is being fed to the Kiln
- Raw meal is being fed to the Kiln system
- A minimum temperature of 855°C

During the start-up sequence SRF is not be permitted until the same conditions specified above, as a minimum, have been achieved. SRF is not used as a start-up fuel and interlocks are in place to ensure this.
In effect, the kiln system is only started up and stable operation established using Diesel Oil, Pet coke or Coal as the fuel input. Only when the kiln is normal production mode (i.e. out of start-up and/or shut down mode and temperature >855°C) is SRF introduced. As the volume of alternative fuels increases, the volume of fossil fuels can be gradually reduced, maintaining stable plant operation at all times. The fuel input in the Kiln is a function of both clinker quality and achieving the correct quality targets for product optimisation. This is achieved by means of a fuel control loop. The fuel control loop is described in detail under clause 3.19.6.2.

SRF injection stops automatically should the kiln become unstable, the temperature in the fuel burning zone is below 855°C or the kiln stops. This is controlled by means of a control system interlock. Should the kiln stop, whether it be planned or unplanned, SRF is automatically shut off immediately.

5.4 Start-Up and Shut-Down Scenarios

Condition 3.19.5:

During start up or shut down or when the temperature of the combustion gas falls below 850°C, the auxiliary burner shall be fed with coal, oil or gas.

Condition 3.19.6:

The licensee shall maintain and operate an automatic system to prevent waste feed:
3.19.6.1 at start-up, until a temperature of ≥850°C has been reached;
3.19.6.2 whenever the temperature falls below 850°C;
3.19.6.3 whenever the continuous measurements show that any emission limit value is exceeded;
3.19.6.4 whenever stoppages, disturbances or failure of the purification devices or the measurement devices may result in the exceedance of the emission limit values; or
3.19.6.5 in the case of a breakdown or incident.

As described above, the introduction and continued firing of SRF is interlocked with stable process conditions and a minimum temperature of 855°C maintained. For all shutdowns or other kiln stops, the alternative fuels are the first input to be stopped. The high thermal inertia or heat load of the kiln system means that even after the kiln is 'shutdown' the system maintains temperature for an extended period of time and all fuel will be fully combusted. Additionally in the event of a kiln stop, SRF injection will automatically stop. This will be controlled by means of a control system interlock.

ICL Limerick has a fuel control loop in place for controlling the addition of SRF. The fuel control loop operates by inputting a specific energy value which is necessary for the formation of Clinker by ensuring sufficient temperature. In order to meet the specific energy value, the correct proportion of fuel is added to the kiln and can be in the form of pet coke solely or pet coke with SRF. When two fuels are being used there is balance between the energy from each fuel to meet the specific energy value. If SRF is not being used in the kiln for any reason, this reduction in energy is immediately replaced by the required amount of pet coke to ensure a stable input of energy into the kiln and maintaining the burning zone temperature. An interlock is in place to ensure a minimum temperature is in place for the combustion of the alternative fuels and if this temperature reduces below this limit for any reason, the alternative fuels are immediately stopped and cannot be restarted until the threshold of temperature has been met.

Furthermore, injection of SRF is not possible unless the emission limit values are not being exceeded. A control system interlock has been implemented to ensure these conditions are met. ICL has put in place safety measures and interlocking systems which will result in the Kiln being automatically shut down prior to the exceeding the ELV.
Emission limit values are monitored on a daily and half hourly basis. In the event of the parameter that is continuously monitored approaching the ELV, the SRF firing is stopped. Prior to a breach of the ELV, the kiln is stopped at a point below the relevant ELV so as not to breach the ELV. This takes place automatically. As per licence P0029-06, schedule C.1.1 lists the parameters that have 24-hour limits (NOx, SOx, Dust, TOC, CO, NH3, HCl, HF). There are also ½ hour average limits for these parameters. In addition, an automatic interlock for half hour average limits is present such that the kiln is stopped at a point below the relevant ELV so as not to breach the ELV. This is also true for SRF firing. From a programming point of view technically SRF can be re-started when either the half hourly or daily average drops below the automatic stop points. However, in practice SRF would not be re-started until the emission trend is understood by the production team.

Condition 3.19.7:

There shall be no bypass of any electrostatic precipitator and/or bag filter

All gas flow leaving the preheater tower is taken through the cooling tower and a bag filter by a fan before it can leave the kiln system through the kiln stack, which is monitored continuously by an ABB ACF5000, particulates monitor, gas flowrate monitor and also for temperature and pressure. There are no facilities in place to allow for the bag filter to be bypassed and the kiln cannot operate unless it complies with the licenced ELV for particulates and all other licensed parameters at the kiln stack.

6. ADDITIONAL REQUIREMENTS RELATING TO SRF

The following sub-sections address how full compliance with other relevant Clauses of IE licence P0029-06 have been demonstrated during the test programme period.

6.1 Spillage and Containment

> ***Condition 3.11:***
>
> *Prior to the acceptance of waste at the installation, the licensee shall provide dedicated unloading and, where appropriate, storage areas*

All alternative fuels used on site are sourced from pre-approved suppliers. Thorntons Recycling have been the sole SRF supplier to date and are very experienced in the use of SRF. All safety, environmental and unloading procedures have been agreed and discussed with the supplier prior to coming to site. The SRF facility is a distinguished area where access is only possible with unique swipe cards, therefore only trained and pre-approved drivers can access the area. A dedicated unloading area is in place adjacent to the storage facilities for the SRF. A unique swipe card is required to be able to unload at the unloading bay and several safety and access steps need to be completed in order to offload. Each area is clearly marked and has been communicated with the SRF suppliers.

6.2 Continuous Operational Parameter Monitoring

> ***Condition 6.4:***
>
> *The licensee shall ensure that the following operating parameters are continuously monitored and recorded when co-incinerating waste:*
>
> *(i) the temperature near the inner wall of the combustion chamber (or other representative location agreed by the Agency);*
>
> *(ii) the exhaust gas oxygen concentration;*
>
> *(iii) the exhaust gas temperature;*
>
> *(iv) the exhaust gas pressure; and*
>
> *(v) if the gases are not dried prior to analysis, the exhaust gas water vapour content.*

Continuous monitoring of the temperature and the oxygen content, as well as temperature, pressure and humidity of the exhaust gas in the kiln 6 stack have been applied. These values are automatically transferred to the Siemens Process Control System (PCS7). Thereafter the data is transferred and recorded on the data acquisition and handling system (DAHS).

6.3 Dust and Odour

> ***Condition 6.18.5:***
>
> *The licensee shall within one month of acceptance of each individual or combination of waste as the installation, undertake an odour assessment in accordance with the EPA guidance. An odour impact assessment shall thereafter be undertaken at a frequency to be approved by the agency and in any case no less than annually. The assessment shall be undertaken by the appropriate qualified professional and shall identify and quantify all significant odour sources at the installation, in particular the waste storage buildings and hardstanding areas, and shall include an assessment of the suitability and adequacy of the odour control system. Recommendations for improvement arising from the odour impact assessment shall be implemented.*

An odour impact assessment was carried out by an approved contractor as per EPA Guidance and is in place at the site.

Odour assessments have also been carried out during the test programme. These assessments were carried out by an approved contractor. The assessments were carried out along the boundary of the site and there were no odour issues found.

6.4 Materials Handling

> ***Condition 8.9:***
>
> *No waste imported from outside Ireland shall be accepted for co-incineration at the installation*

Only alternative fuels sourced from the Republic of Ireland will be used in Irish Cement Limerick.

> ***Condition 8.11:***
>
> *No waste that contains more than 1% halogenated organic compounds, expressed as chlorine, shall be accepted for co-incineration, or otherwise introduced to the kiln*

All alternative fuels accepted into site have been from a pre-approved supplier where specifications for the fuel’s chlorine, moisture and NCV, as a minimum, have been agreed. The supplier has been approved by the Agency and any future suppliers will be sent to the Agency for approval prior to use. When agreeing specification with suppliers, ICL will take note of this condition.

Regular testing is carried out on the fuel to ensure that all agreed specifications are complied with.

6.5 Acceptance of Waste

> ***Condition 8.12:***
>
> *No waste other than the List of Waste codes listed in Schedule A: Limitations of this licence shall be accepted at the installation*

This test programme report is for the use of SRF only. No other alternative fuels other than those listed in licence P0029-06 in Schedule A and until the test programmes have been agreed with the agency will be accepted to site.

Condition 8.13:
The acceptance of waste at the installation for co-incineration shall be for the purposes of:
• Waste fuels with significant calorific value;
• Waste materials without significant calorific values but with mineral components used as raw materials that contribute to the intermediate product clinker; and
• Waste materials that have both a significant calorific value and mineral components

All alternative fuels accepted into site are from a pre-approved supplier where specifications for the fuel's chlorine, moisture and NCV, at a minimum, have been agreed.
Regular testing will be carried out on the fuel to ensure that all agreed specifications are complied with.

Condition 8.14.1:
Waste accepted at the installation shall be subject to a technical specification agreed between the licensee and the supplier. The technical specification shall set out criteria to be met in order that combustion or use of the material will not lead to failure to comply with the conditions of this licence. The technical specification shall have regard to any published or, as appropriate, Irish or international standard relevant to the supply of that material and any departure from such a standard shall be approved by the Agency. The technical specification shall conform to relevant best available techniques in Commission Implementation Decision 2013/163/EU for the production of cement, lime and magnesium oxide.

All alternative fuels accepted into site are from a pre-approved supplier where technical specifications for the fuels have been agreed. This will include at a minimum chlorine, moisture and NCV. SRF is only accepted to site once it complies with specifications from the standard EN 15359 for Solid Recovered Fuels.
Classification of the SRF was carried out during the test programme and was done in accordance with EN 15359.
The classification for the SRF for ICL Limerick is:
Class Code: NCV 4; Cl 4; Hg 3

Table 1 — Classification system for solid recovered fuels

Classification characteristic	Statistical measure	Unit	Classes				
			1	2	3	4	5
Net calorific value (NCV)	Mean	MJ/kg (ar)	≥ 25	≥ 20	≥ 15	≥ 10	≥ 3
Classification characteristic	**Statistical measure**	**Unit**	**Classes**				
			1	**2**	**3**	**4**	**5**
Chlorine (Cl)	Mean	% (d)	≤ 0,2	≤ 0,6	≤ 1,0	≤ 1,5	≤ 3
Classification characteristic	**Statistical measure**	**Unit**	**Classes**				
			1	**2**	**3**	**4**	**5**
Mercury (Hg)	Median	mg/MJ (ar)	≤ 0,02	≤ 0,03	≤ 0,08	≤ 0,15	≤ 0,50
	80th percentile	mg/MJ (ar)	≤ 0,04	≤ 0,06	≤ 0,16	≤ 0,30	≤ 1,00

Regular testing is carried out on the fuel to ensure that all agreed specifications are complied with. Continuous quality checks are also carried out during the cement manufacturing process as well as on the final cement product to ensure that all standards are continued to be complied with when using alternative fuels.

Condition 8.14.2:

The quantity of waste to accepted at the installation on a daily basis shall not exceed the storage capacity available.

Only waste which can be stored in the purpose-built SRF storage areas are accepted to site. No other location on site is permitted to store the material.

Condition 8.14.3:

The licensee shall maintain a record of the quantity of each waste type co-incinerated at the installation, introduced into the kiln or otherwise used in the manufacture of cement.

All material accepted to site is weighed over calibrated and certified weigh bridges and recorded on the material data base.
Any material used in the kiln is recorded on a weighted basis and is stored on the data acquisition and handling system (DAHS).

Condition 8.14.4:

Waste shall only be accepted at the installation from known suppliers or new suppliers subject to initial waste profiling, analysis, characterisation off site and demonstration of compliance with the technical specification

Commercial contracts for the supply of these fuels to defined specifications will continue to be adjudicated through the Irish Cement ISO 9001 quality control system in a similar manner to the supply of other raw materials or fossil fuels. The contracts require that all suppliers' material must conform to the agreed specifications and are produced in compliance with the relevant environmental requirements. Sampling and testing are performed by both the supplier and Irish Cement (or an approved contractor on behalf of Irish Cement).

Details of each fuel is entered into the site material database and full safety reviews and risk assessments have been performed in accordance with standard materials handling procedures.
Independent analysis of the SRF in an ISO 17025 laboratory was carried out prior to accepting the material to site to ensure that it met the technical specification for SRF. In addition, the SRF was tested for trace elements and heavy metals to ensure that the conditions of the IE licence can be complied with when using of the material. This testing will continue going forward.

Condition 8.14.5:

Alternative fuel shall only be accepted if delivered in appropriate sealed, leakproof, covered containers

All deliveries are scheduled in advance and are only permitted on site in sealed, covered containers.

Condition 8.14.6:

Prior to commencement of the acceptance of each waste at the installation, the licensee shall establish and maintain detailed written procedures for the acceptance and handling of each. These procedures shall at least include the following:

a) inspection and sampling at the point of entry to the installation;
b) criteria to be met prior to acceptance;
c) rejection criteria and procedures;
d) material characterisation and profiling s from known customers or new customers prior to acceptance at the installation;
e) frequency of technical testing and analysis and methods to be employed by the licensee to demonstrate compliance with the technical specification;
f) recording of each load of material on arrival at the installation in accordance with Condition 1 1.10 of this licence;
g) handling procedures including unloading, transfer and cleaning of all plant.

The requirements necessary for acceptance of the fuel deliveries are as follows:

- Confirmation of conformity to the fuel specification is provided by the supplier for all fuel supplied. This is a requirement of the supply contract in place between Irish Cement and the selected supplier. This confirmation will declare that the material delivered meets the supply specification as contracted.
- Each delivery must be made by an approved driver. All drivers have been provided with appropriate safety training which will be refreshed on a regular basis. Each qualifying driver has been issued with a unique identification card. This identification card must be presented

before the delivery can gain entry to the site. Deliveries of other externally sourced raw materials are controlled in ICL Limerick using this system at present.

- On arrival at the Irish Cement entrance, all deliveries are verified by the automated delivery acceptance system.
- Characterisation of the fuel was carried out prior to SRF arriving to site and will continue during the full extent of the contract with the supplier. The process involved site visits to the SRF supplier processing plant and a defined sampling procedure. During the test programme, sampling frequency and procedures were put in place. Sampling is carried out per each individual load. These samples are then composited into a fortnightly sample and sent to an accredited ISO 17025 laboratory for the necessary testing. Attempts to deliver incompatible material will result in more frequent and onerous sampling and testing.
- Sampling/visual inspection will be carried out as per the sampling procedures. Testing of the samples can be carried out both in the internal Irish Cement laboratories and also at off-site accredited laboratories.

Subject to all of the foregoing steps being in order, unloading of the material will be commence and the offloading will be visually monitored using CCTV.
Detailed Material acceptance procedures are now in place for SRF in Limerick Works and a copy of this procedure is included in Appendix III.

Condition 8.14.7:

Waste arriving at the installation shall have its documentation checked at the point of entry to the installation and, subject to this verification, weighed, recorded and directed to the appropriate storage area or quarantine area as appropriate.

Each delivery is made by an approved driver. All drivers have been provided with appropriate safety training which will be refreshed in line with site safety policy. Each qualifying driver has been issued with a unique identification card. This identification card must be presented before the delivery will be permitted entry to the site. Deliveries of other externally sourced raw materials are controlled in ICL Limerick using this system at present. Unloading procedures have been provided to drivers as to the appropriate unloading location on site and how to carry out the unloading of the SRF.

All deliveries are scheduled in advance. Detailed delivery plans will be established with all suppliers in advance of arrival onsite. Vehicle and driver details along with supplier information is stored on the automated delivery acceptance system and unique swipe cards for each driver will be pre loaded with this information. All hauliers delivering alternative fuels to site have been given full training in accordance with the CRH Code of Practice for Hauliers, as occurs for hauliers of other materials currently.

Condition 8.14.8:

Any waste deemed unsuitable for processing at the installation or in contravention of this licence or the technical specification shall be immediately separated and returned to the location supply within 48 hours or a longer time period as may be agreed by the Agency due to weekend and bank/public holiday closures. Secure storage of such waste shall be provided in a dedicated waste quarantine area. Waste stored in the quarantine area shall be stored under appropriate conditions to avoid loss to the environment, putrefaction, odour generation, the attraction of vermin and other nuisances or objectionable condition. If the original supplier of rejected waste cannot take the material back, an appropriate alternative destination for the rejected waste shall be approved by the agency.

Non-conforming loads will be rejected where they fail to satisfy the fuel acceptance procedures. There have been no non-conforming SRF loads during the test programme. If this was to occur in the future, any such rejected loads will be stored in the designated, signed areas adjacent to the SRF store until it can be returned directly to the supplier. Material will be quarantined for no longer than 48 hours on site. Following a non-conforming load, a more onerous sampling and testing requirements for SRF will be imposed on suppliers until demonstration of sustained compliance with the agreed fuel specifications is evident.

Condition 8.14.9:

The rejection of waste and any failure to demonstrate compliance with the technical specification shall be recorded and reported in the AER.

At any stage in the process a delivery can be rejected and returned to the supplier. The supplier will be contacted immediately to determine the status of other planned deliveries. A notification of non-conformance stating the details of the delivery and the reason/s for rejection will be forwarded to the supplier. Copies of sample analysis results, if available, will be provided to the supplier.

Details of non-conforming loads will be recorded and reported to the Agency in the AER.

Condition 8.14.10:

Waste shall not be accepted from a supplier of rejected material until such time as the reasons for rejection have been investigated and corrective actions agreed in writing between the licensee and the supplier have been implemented to the licensee's satisfaction. All such correspondence shall be provided to the Agency upon request.

Following a rejected or returned load to a supplier, Limerick Works will not accept further deliveries of SRF from the supplier until a report detailing the cause of the non-conformance and the corrective actions taken by the supplier to ensure that it is not repeated has been received and is to the satisfaction of Limerick Works.

Condition 8.15 (a):

Waste shall only be introduced to the kiln when the appropriate operating conditions have been achieved. There conditions shall, as a minimum, meet those set out in Schedule C: Emissions, Monitoring and Control of this licence.

Condition 8.15 (b):

Waste shall only be introduced to the kiln when cement clinker is being manufactured.

Introduction and continued firing of alternative fuels into the kiln process is interlocked with stable process conditions and as such can only occur when the following conditions exist:

- Pet coke (or Coal) is being fed to the Kiln
- Raw meal is being fed to the Kiln system
- A minimum temperature of 855°C

During the start-up sequence, the use of SRF is not permitted until the same conditions specified above have been achieved and there are interlocks in place to ensure this.

In effect, the kiln system will only be started up and stable operation established using Diesel Oil, Pet coke or Coal as the fuel input. Only when stable operation has been established can SRF be introduced. As the volume of alternative fuels increases, the volume of fossil fuels can be gradually reduced, maintaining stable plant operation at all times. Should the kiln become unstable, the temperature in the fuel burning zone decrease below 855°C or the kiln stop, SRF injection stops automatically. This is controlled by the previously discussed control system interlock.

Condition 8.16:

No odour-forming wastes shall be accepted at the installation

An odour assessment was carried out on the SRF facility as well as odour assessments around the site boundary. Only non-odour forming materials will be accepted to the site.

7. CONCLUSIONS

The Test Programme period has successfully demonstrated that it is possible to continue to pursue maximisation of the SRF substitution rate at Limerick Works whilst complying with the conditions of IE licence P0029-06 and thus assuring environmental performance as well as maintaining compliance with all relevant product quality requirements. This report demonstrates:

1. **Compliance of all IE licenced environmental emissions parameters;**
2. **No relationship exists between SRF input rates and emission measurements of non-continuously monitored parameters;**
3. **Quality assurance of the CEMs equipment in use for compliance monitoring of continuously monitored parameters;**
4. **The co-firing of SRF does not result in any adverse impact on the Kiln or the associated Abatement equipment; and**
5. **The establishment of robust standard operating procedures, standards, checks and balances for operational control of SRF usage and control of SRF input quality.**

ICL proposes that the outcomes from the Test programme period have met the objective of assuring environmental performance whilst using SRF as an alternative fuel on Kiln 6 at progressively rising thermal substitution rates.

As such ICL believes that IE licence P0029-06 and test programme conditions as granted by the Agency contains all the necessary operational control and emission limitations necessary to assure acceptable environmental outcomes from the operation of Limerick Works whilst using SRF as an alternative fuel.

APPENDICES

APPENDIX I
MEMO FROM FLSMIDTH REGARDING GAS RESIDENCE TIME MODELLING

Memo

To Eve Howard (enviromental manager, Irish Cement Limerick Works),
Seamus Breen (Environmental Manager, Irish cement)

Copies to Pat Robinson (Plant manager, Irish Cement, Limerick works),
Shane McCarthy (Production manager, Irish cement Limerik works)

From PRos (FLS)

Filing Report-33/ICL/Limerick/PRos/2022/12/05

Subject **Kiln system – resume of estimated gas and material retention times when firing SRF (in the complete kiln, kiln riser duct, ILC-E calciner and bottom stage cyclone) for an outlet temperature on 855ºC from the bottom stage cyclone.**

The simulations are only made for the scenarios where the kiln system is fired with petroleum coke and/or SRF .

Resume of simulations with SRF only

Irish Cement Ltd. Limerick works has been considering burning different alternative fuels in there ILC-E calciner kiln system. This memo resumes the estimated retention time in the kiln and in the kiln riser duct, the ILC-E calciner and the fourth stage cyclone.

The estimated retention times in the kiln, the calciner and total for the revised operational conditions are for the considered scenarios shown in the following table:

Based on Kiln output on 3000t /day when co-firing with Solid refuse derived fuel (SRF)							
Total retention time in kiln, calciner			Kiln heat	FE - whole kiln	Pre-calciner + C4	Pre-calciner + C4	
Scenario	Fuel Mix		Consumption	Residence time	Temperature	Residence Time	Total
	FE	BE	Kcal/kg Clinker	Seconds	deg.C	Seconds	seconds
2A	80% PC	20% PC	842	3.74	855	3.39	7.13
2.3A	80% PC	20% SRF	849	3.74	855	3.33	7.07
3A	40% PC + 40% SRF	20% PC	858	3.70	855	3.22	6.92
3.1A	80% SRF	20% PC	877	3.48	855	3.04	6.52
3.4A	80% SRF	20% SRF	887	3.44	855	2.96	6.40
3.5A	75% PC + 5% SRF	20% PC	843	3.78	855	3.39	7.17
3.6A	70% PC + 10% SRF	20% PC	845	3.77	855	3.38	7.15
3.7A	60% PC + 20% SRF	20% PC	849	3.72	855	3.33	7.05
5A	80% SRF BE	20% SRF BE	925	3.13	855	2.59	5.72

The considered scenarios are made for estimating the corresponding retention times of the combustion gases at a production level on 3000 tpd clinker. The retention times (RT) at lower production levels (X) can be estimated as:

RT(@X tpd clinker) = RT(@3000 tpd clinker)*((3000 tpd)/(X tpd)

APPENDIX II
FUEL CONTROL LOGIC

Irish Cement		Alternative Fuels Interlocks
Revision: See Revision History in Sharepoint	**Form No.:** *PRO_AF_01*	Irish Cement Ltd
	Compiled by: E. Scanlan	*(Limerick Works)*

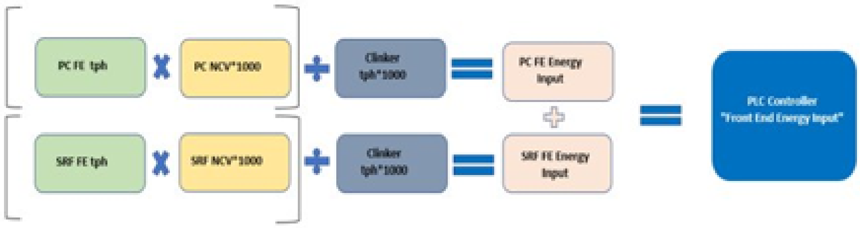
Alternative Fuel Interlocks

1. SRF Fuel Control Loop

The main burner operates with two fuels during normal operation (outside of start up), pet coke and SRF. In order to use the correct amount of fuel to create sufficient heat for both the formation of clinker and a stable kiln operation, a fuel firing logic has been developed which ensures the correct balance of energy is being inputted at all times.

A specific amount of energy is required to create sufficient heat in the kiln. To do this, the logic inputs this specific energy requirement with both SRF and pet coke. If the SRF is lost for any reason, the correct balance of pet coke will be added in its place to ensure the heat in the kiln is maintained.

Should the pet coke in the main burner be lost, SRF will be automatically stopped and the kiln will also stop because we cannot operate without pet coke on the front burner during normal operation. The kiln is interlocked to keep a minimum t/h of pet coke on at all times. The main burner cannot operate with just SRF. The diagram below shows how this fuel ratio will be calculated:



2. SRF Main burner on interlocks

Introduction and continued firing of alternative fuels into the kiln process will be interlocked with stable process conditions and as such can only occur when the following conditions exist;

- Petcoke (or Coal) is being fed to the main burner
- Raw meal is being fed to the Kiln system
- A minimum temperature of 870°C in the burning zone
- If Burning Zone Temperature (642XT01) < 870°C or 'kiln stop' then SRF main burner group "645/G03 -> SRF_TO_BURNER" stops

- During the start-up sequence the use of SRF will not be permitted until the same conditions specified above, as a minimum, have been achieved. SRF will not be used as a start-up fuel and interlocks will be in place to ensure this.
- The kiln system will only be started up and stable operation established using Diesel Oil, Petcoke or Coal as the fuel input. Only when the kiln is normal production mode (i.e. out of start up and / or shut down mode) will SRF be introduced.

Irish Cement A CRH COMPANY		Alternative Fuels Interlocks
Revision: See Revision History in Sharepoint	**Form No.:** *PRO_AF_01* **Compiled by:** E. Scanlan	Irish Cement Ltd *(Limerick Works)*

- As the volume of alternative fuels increases, the volume of fossil fuels can be gradually reduced, maintaining stable plant operation at all times. This will be achieved by means of a fuel control loop.
- There is currently maximum SRF t/h limit of 3 t/h. This limit will be modified as require throughout the test programme by the Environmental Manager or Production Manager.

3. <u>SRF Main burner off interlocks</u>

- SRF injection will stop automatically should the kiln become unstable, the temperature in the burning zone is below 1000°C or the kiln stops. This will be controlled by means of a control system interlock.
- Should the kiln stop, whether it be planned or unplanned, SRF will automatically be shut off immediately.

4. <u>Minimum injection of fossil fuels main burner -> if 'kiln on' and SRF burning</u>

Main burner SRF group "645/G03 -> SRF_TO_BURNER" can only run if Fossil Fuel to Kiln group "646G05/05" is running.

A fossil fuel set point of < 0.5 T/hr cannot be entered for the main burner fossil fuel to ensure fossil fuel firing is always on.

APPENDIX III
MATERIAL ACCEPTANCE PROCEDURE

Irish Cement		SRF Delivery and Handling Procedure
Revision: See Revision History on Sharepoint	**Form No.:** *PRO_AF_02*	Irish Cement Ltd
	Compiled by: Eve Howard	*(Limerick Works)*

Contents

Irish Cement		SRF Delivery and Handling Procedure
Revision: See Revision History on Sharepoint	Form No.: *PRO_AF_02*	Irish Cement Ltd
	Compiled by: Eve Howard	*(Limerick Works)*

1 Purpose

The purpose of this SOP is to define the procedure for accepting and handling Solid Recovered Fuel (SRF) onsite at Limerick Works.

2 Scope

This document applies to ICL employees or contractors who are involved in the delivery, handling and sampling of SRF.

3 Responsibilities

3.1 Environmental Manager

To ensure compliance with this SOP

3.2 Process Manager

Manage deliveries and material handling onsite

3.3 Delivery drivers

To ensure that they are aware of the details of this procedure and comply with the instructions contained within.

4 Delivery of SRF to Limerick Works.

Irish Cement will only contract with suppliers licensed to produce SRF (EPA waste licence, Local Authority permits) for the supply of ready-to-use fuels with the EWC code 19 12 10. The fuels will arrive on site prepared to specification and no further processing of fuels will take place on the site in Limerick.

All deliveries will be scheduled in advance and will only be permitted on site in sealed, covered containers.

- The supplied SRF will be produced to a strict supply specification so as to assure of environmental compliance to the licensed emission parameters and quality compliance to the harmonised cement product standard.

It is policy that all waste disposed of off-site is traceable via the relevant paperwork e.g. disposal Cert, and in the case of hazardous wastes, CI and TFS forms.

5 Onsite SRF Acceptance procedure

Vehicle and driver details along with supplier information will be entered into the automated delivery acceptance system. Individual driver identification tags will be provided.

Irish Cement		SRF Delivery and Handling Procedure
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All hauliers delivering alternative fuels to site will be given full training in accordance with the CRH Code of Practice for Hauliers, as occurs for hauliers of other materials currently.

The unloading procedure for unloading of SRF into the intake system should be followed. See separate unloading procedure.

Confirmation of conformity to the fuel specification will be provided by the supplier for all fuel supplied. This confirmation will declare that the material delivered meets the supply specification as contracted.

Each delivery must be made by an approved driver. Each qualifying driver will be issued with a unique identification card. This identification card must be presented before the delivery will be permitted entry to the site.

On arrival at the Irish Cement entrance, all deliveries will be verified by the automated delivery acceptance system. Offloading of each load will be observed via CCTV from the central control room.

SRF will conform to the requirements of the EN 15359 standard an SRF in Limerick has been classed as:

Class Code: NCV 4; Cl 4; Hg 3

6 Onsite sampling procedure

Sampling procedures on site will be in compliance with the on-site ISO 9001 Quality System. Fortnightly composite samples from each supplier will be analysed to determine compliance with fuel specification. Regular internal testing will be carried out by Limerick Works to determine compliance of the following parameters with the relevant alternative fuels specification;

SRF	
Calorific value	Chloride
Moisture	Ash Content

Testing of a composite sample is carried out to confirm that the fuels supplied are in compliance with the agreed specification. Testing frequency will be greater during initial evaluations and be adjusted as compliance confidence increases.

Samples will be taken using the sampling system at the SRF intake. Each load must be sampled and a compositive fortnightly sample is to be sent to an ISO 17025 lab for analysis.

Irish Cement		SRF Delivery and Handling Procedure
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	Compiled by: Eve Howard	*(Limerick Works)*

7 Analysis

Analysis will be completed in either the internal Irish Cement laboratories or at off-site accredited laboratories.

Specifically, the following parameters will be closely monitored:

- Particle size and moisture content so as to optimise handling and processing
- Calorific or heat value of SRF (Megajoule per kilogram (MJ/kg)) so as to ensure adequate heat/energy content of the fuel.

8 Handling of rejected material

At any stage in the process a delivery can be rejected and returned to the supplier in compliance with Irish cement and Supplier procedures.

The criteria for accepting / rejecting is as follows:

- Size
- Not meeting specifications
- Not meeting visual inspection

The supplier will be contacted immediately to determine the status of other planned deliveries. A notification of non-conformance stating the details of the delivery and the reason/s for rejection will be forwarded to the supplier. Copies of sample analysis results, if available, will be provided to the supplier.

Rejected loads will be stored adjacent to the SRF store within the SRF facility until it can be returned directly to the supplier. Material will be quarantined for no longer than 48 hours on site.

Following a rejected or returned load to a supplier, Limerick Works will not accept further deliveries of SRF from the supplier until a report detailing the cause of the non-conformance and the corrective actions taken by the supplier to ensure that it is not repeated has been received and is to the satisfaction of Limerick Works. A more onerous sampling and testing requirement for SRF will be imposed on suppliers until demonstration of sustained compliance with the agreed fuel specifications is evident. Details of non-conforming loads will be recorded and reported to the Agency in the AER.

9 Oversize material

Oversize material will be removed from the system via a screening plant at the exit of the storage bay tunnel. This material will be removed from site by an approved waste contractor.

APPENDIX IV
ABATEMENT SYSTEM PROCEDURE

<table>
<tr><td colspan="2">Irish Cement A CRH COMPANY</td><td>Abatement Procedures during SRF Firing to Kiln 6</td></tr>
<tr><td rowspan="2">Revision: See Version History SharePoint</td><td>Form No: PRO_AF_09</td><td rowspan="2">Irish Cement Ltd
(Limerick Works)</td></tr>
<tr><td>Compiled by: D Curran (Chemical Engineer)</td></tr>
</table>

Abatement Procedures during SRF Firing to Kiln 6

Document Revision Number	Date	Production Manager	Signature

Irish Cement A CRH COMPANY		Abatement Procedures during SRF Firing to Kiln 6
Revision: See Version History SharePoint	**Form No:** *PRO_AF_09* **Compiled by:** D Curran (Chemical Engineer)	Irish Cement Ltd *(Limerick Works)*

Summary

The purpose of this document is to provide shift personnel with a guide on the abatement procedures to be followed while SRF is fired to Kiln 6 at ICL Limerick.

Operating Principles

Multiple interlocks have been implemented at ICL Limerick in order to stop the firing of SRF to Kiln 6 if any of the below scenarios occur:

- Kiln stack emission interlocks – SRF off first when approaching an emission ELV and followed by a kiln stop if emissions continue to increase
- Temperature interlock to burning zone temperature - if temperature in the burning zone drops below 1000 degrees Celsius, SRF firing is automatically stopped by the control system.
- SRF firing cannot be commenced until out of “start-up” conditions and into “normal” conditions.
- Maximum SRF t/h limit is set at 7tph – thereby preventing the system from running at >7tph.
- A fuel control loop has been implemented which allows the system to automatically adjust the required petcoke feed to Kiln 6 in the event that the SRF feed is stopped.

Irish Cement (A CRH COMPANY)		Abatement Procedures during SRF Firing to Kiln 6
Revision: See Version History SharePoint	**Form No:** *PRO_AF_09* **Compiled by:** D Curran (Chemical Engineer)	Irish Cement Ltd *(Limerick Works)*

Emission Control

The table below highlights new emission limits implemented to stop SRF feed to Kiln 6 when approaching an emission ELV - emission limits for Kiln 6 stoppages are also shown below.

		SRF Interlock		Kiln Interlock	
Emission Control	Units	30 Minute Average	24 Hour Average	30 Minute Average	24 Hour Average
NOx	Mg/Nm³	965	485	975	495
SO_2	Mg/Nm³	88	45	90	48
NH_3	Mg/Nm³	92	45	95	48
CO	Mg/Nm³	2700	1400	2900	1450
HCL	Mg/Nm³	18	9	18.5	9
HF	Mg/Nm³	1.8	0.9	1.9	0.95
TOC	Mg/Nm³	45	22	47	25
DUST	Mg/Nm³	18	9	19	9

Kiln 6 Process Related Interlocks

In order for SRF to be fired to the kiln, the following requirements must be met at all times. If any of the below parameters fall out of accepted ranges – the SRF feed will automatically stop. These interlocks ensure that the kiln is steady before SRF can be fired.

- Kiln burning zone temperature must be greater than 1000°C (measured using 642XT01S BZT)
- Kiln feed must be greater than 100tph.
- Temperatures in the stage 4 cyclone must be greater than 800°C (measured using 641XT04 and 641XT04A).
- 64402 ID Fan must be on for SRF feed to be enabled.

		Abatement Procedures during SRF Firing to Kiln 6
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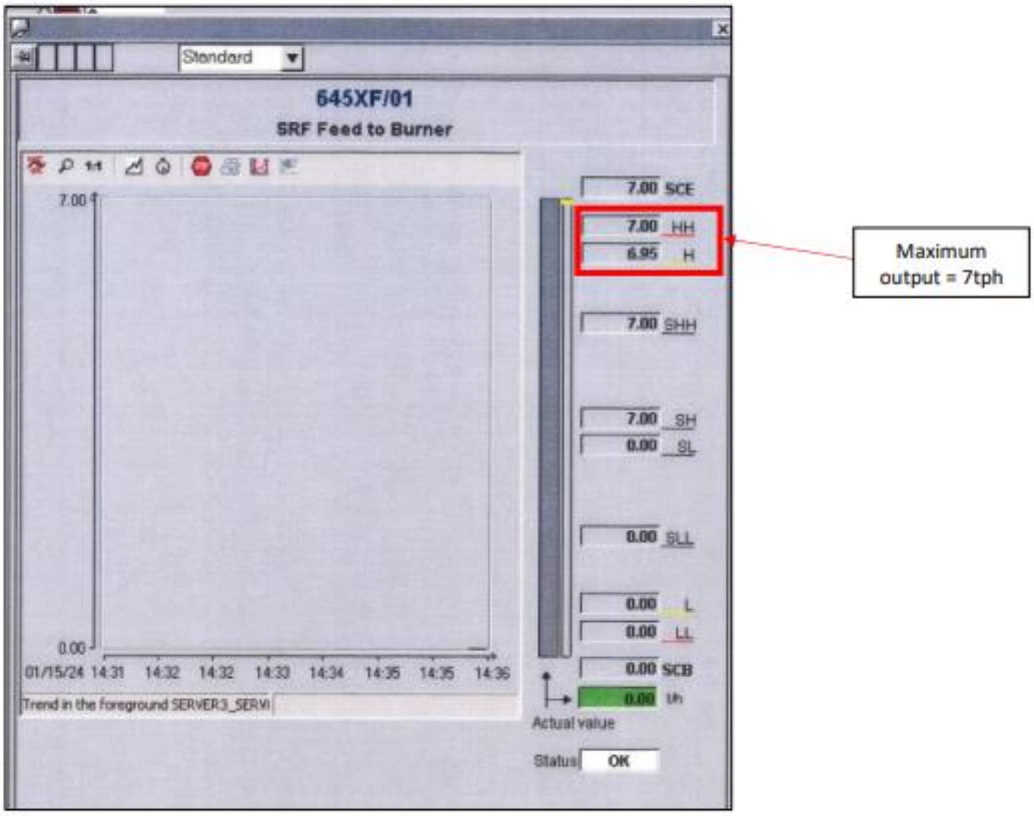
SRF Process Related Interlocks

SRF Pfister Feeder is set at a maximum output of 7tph in the control system. Therefore, a controller input >7tph will cause the SRF feed to be shut off.



		Abatement Procedures during SRF Firing to Kiln 6
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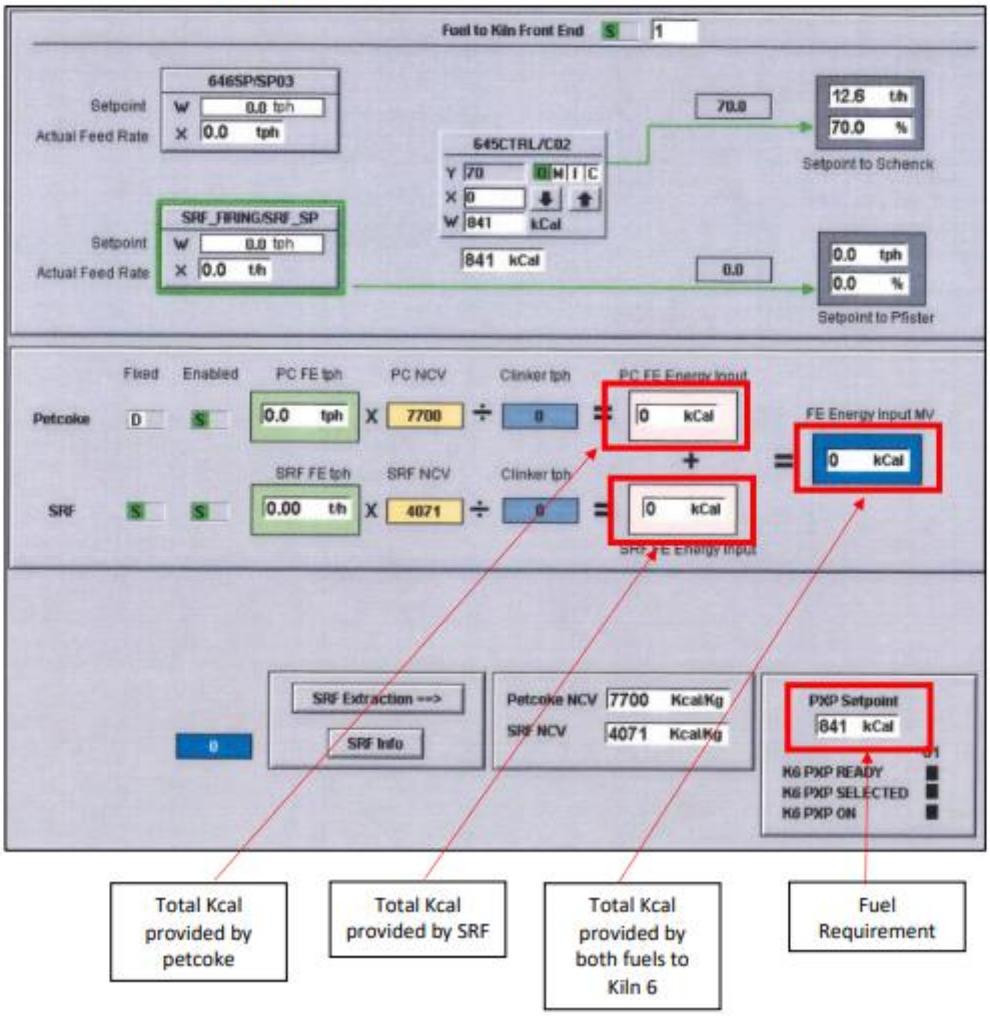
Kiln Fuel Control and Stability

A fuel control loop is integrated into the plant control system to ensure that kiln fuel demands are met in the event of an SRF feed stoppage or adjustment.
The loop utilises a kilocalorie target in order to establish total heat required for the kiln.

- SRF feed is maintained at a constant value, while the petcoke feed is adjusted in order to meet the exact fuel demands for Kiln 6.
- In the event that SRF is stopped, the petcoke feed is increased to provide the entire fuel requirements to Kiln 6 instantly.



Irish Cement A CRH COMPANY		Abatement Procedures during SRF Firing to Kiln 6
Revision: See Version History SharePoint	**Form No:** *PRO_AF_09* **Compiled by:** D Curran (Chemical Engineer)	Irish Cement Ltd *(Limerick Works)*

NOx Abatement Procedure during SRF Firing

1. Objective

The objective of this procedure is to outline the principle of NOx abatement using the ABC&I SNCR system, the major equipment involved in the system as well as the operation and monitoring of the system to reduce NOx emissions to below emission limits set out in Environmental license issued by the EPA to Irish Cement Limerick Works.

2. Operating Principle

The reduction agent used to reduce NOx formation is 25% water-soluble ammonia.

After the injection of the reagent into the main PHT gas duct, the following chemical reactions takes place where ammonia reacts with nitrous oxide and oxygen to produce nitrogen and water.

$$4NH_3 + 4NO + O_2 \rightarrow 4N_2 + 6H_2O$$

$$4NH_3 + 2NO + 2O_2 \rightarrow 3N_2 + 6H_2O$$

The SNCR system is required to maintain NOx emissions below our current EPA licence limits with adjusted figures for SRF to run.

- 30-min: 965 mg/Nm3
- 24-hr: 485 mg/Nm3

*Both limits come into account until kiln is in "Normal Production Mode" which is defined as; Stage 4 temperature (XT04) above 800 degrees Celsius.

3. Equipment

The SNCR system consists of four major parts: storage tanks, pump cabinet, process cabinet and injectors.

Storage Tanks: Ammonia is offloaded and stored here in stainless steel single-sheeted tanks that are enclosed by a concrete bund to prevent leakage in the event of a spillage.

Pump Cabinet: Located at the tanks is a pump/filter module contained in a stainless-steel case. It contains pumps, filters, pressure transmitters, valves and ammonia piping. The pump is a centrifugal pump with a capacity of 6 bars and 3 m3/h.

Ammonia Piping: From the pump cabinet to the process cabinet located just below the 2nd floor of the PHT.

Process Cabinet: In the process cabinet there are pressure and flow transmitters for both ammonia and softened water. Via 7 injectors ammonia is sprayed into the NOx reaction/reduction zone at a pressure of 3-4 bar. Regulating valve 64125 controls the overall flow to the 7 injectors.

Irish Cement A CRH COMPANY		Abatement Procedures during SRF Firing to Kiln 6
Revision: See Version History SharePoint	**Form No:** *PRO_AF_09* **Compiled by:** D Curran (Chemical Engineer)	Irish Cement Ltd *(Limerick Works)*

Injectors: 2 of the injectors are located at the PHT 2nd floor while 5 injectors are located at the kiln backend close to the petcoke backend firing pipes. Barrier air surrounds the injectors and nozzles which is produced by a central fan 64128.

4. Operation

Starting/Stopping the SNCR System

The SNCR system should be running when the kiln is in production to mitigate high NOx generation.

To start the system, go to the control system and under the Plant Services drop down menu select SNCR tanks. Next to SNCR System Running select the Start Button in order to bring in 64123 or 64124 pump. Flow can be verified under the SNCR Injectors page when a flowrate is recorded at FT5005 as well as a flow indication at the individual injectors FT5034. A corresponding reduction in NOx should be recorded shortly after with at both the ground floor analysers and ACF5000 stack analysers.

The SNCR system is interlocked to stop if the kiln is to stop for any reason.

Running the SNCR System in Automatic

The SNCR system should be selected to run in automatic (Closed Loop Control) unless for operational reasons it cannot be.

To run in automatic (CLC) select the Auto button next to SV50001 on the SNCR injectors page. The NOx setpoint (SP/NOX_SETPOINT) is typically set to 480 mg/m3 just below the 24 hour interlock limit of 495 mg/m3. This activates a PID control loop that opens or closes 64125 regulator valve to increase or decrease ammonia flowrate to the injectors to control live NOx readings taken at the kiln stack by the ACF5000 (644XQ/NOx EPA)

The 24-hour NOx Average is good indication of whether the automatic control loop is working correctly with this value here should be within 5 mg/m3 of the current NOx Setpoint.

Running the SNCR System in Manual

On occasion it may be required to run the SNCR system in manual (Open Loop Control) i.e. a flow rate setpoint is input by the Process Controller and the regulator valve opens or closes to achieve the target flowrate setpoint.

To run in manual (OLC) select the Auto button next to SV50001 on the SNCR injectors page and input the required flow rate setpoint.

Care should be taken by the Process Controller to monitor closely NOx emissions when in manual control (OLC) as setpoint will need to be increased or decreased based on current NOx readings.

Irish Cement A CRH COMPANY		Abatement Procedures during SRF Firing to Kiln 6
Revision: See Version History SharePoint	**Form No:** *PRO_AF_09* **Compiled by:** D Curran (Chemical Engineer)	Irish Cement Ltd *(Limerick Works)*

5. Operating Controls

In the computers in the CCR the mimics for the SNCR system are found under plant services, there are four mimics:

Figure 1 - SNCR Tanks

A. This box is where the NOX setpoint is inputted, the system then regulates the quantity of ammonia to the injectors to achieve this.

B. This is the level or quantity of ammonia in the tank in percentage form.

C. These are the two pumps, pump 1 and pump 2. Pump 1 gives slightly more pressure / flow than pump 2. To change from one pump to the other, it must be done manually and the group needs to be given a new start command.

D. These buttons will bring up the list of a) all alarms and b) critical alarms on the SNCR system.

E. This is a reading for the differential pressure across the filter, this will identify when the filter is blocking and therefore when it needs to be changed.

F. This is the button that starts the SNCR system.

G. This button will allow maintenance to be carried out on the NOX analyser and the SNCR system will continue to dose ammonia using the flow rates that were used before the NOX signal was removed due to maintenance of the analyser.

H. These are pop up boxes that allow the controller to move from one SNCR screen to another.

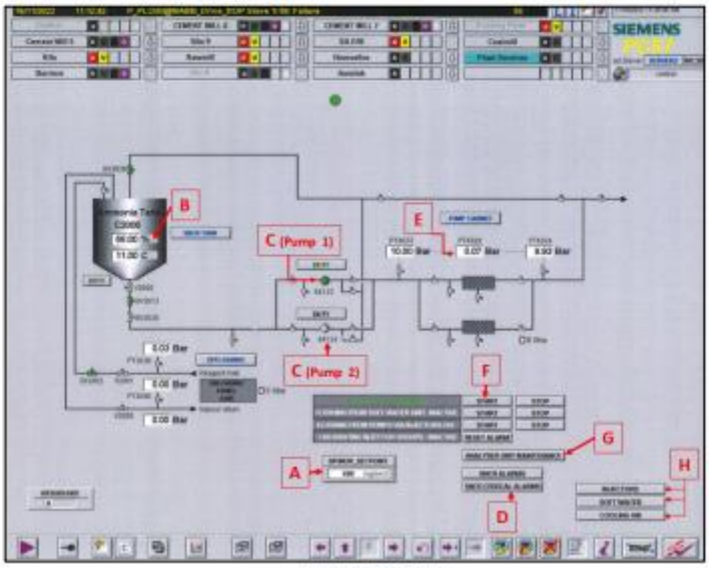


Figure 1: SNCR Tanks

Irish Cement A CRH COMPANY		Abatement Procedures during SRF Firing to Kiln 6
Revision: See Version History SharePoint	**Form No:** *PRO_AF_09* **Compiled by:** D Curran (Chemical Engineer)	Irish Cement Ltd *(Limerick Works)*

Figure 2 - SNCR Injectors

A. This is the total amount of softened water (litres/hr) being added to the ammonia going to the injectors in the preheater.
B. This is the valve that regulates the quantity of ammonia being injected to the preheater.
C. This is the total ammonia flow rate going to the preheater.
D. This is the differential pressure across the filter, therefore identifying when the filter needs to be changed.
E. This box is used by the CCR when manipulating injector control.
F. This box is used by the CCR when adjusting flow measurement.
G. Toggled flow meter that will change from injector to injector periodically as a check of ammonia addition through each injector, therefore helping to identify blockages or leaks in the system.
H. Cooling fan which supplies cooling air to the injectors, to protect same from burning in the very high preheater temperatures.

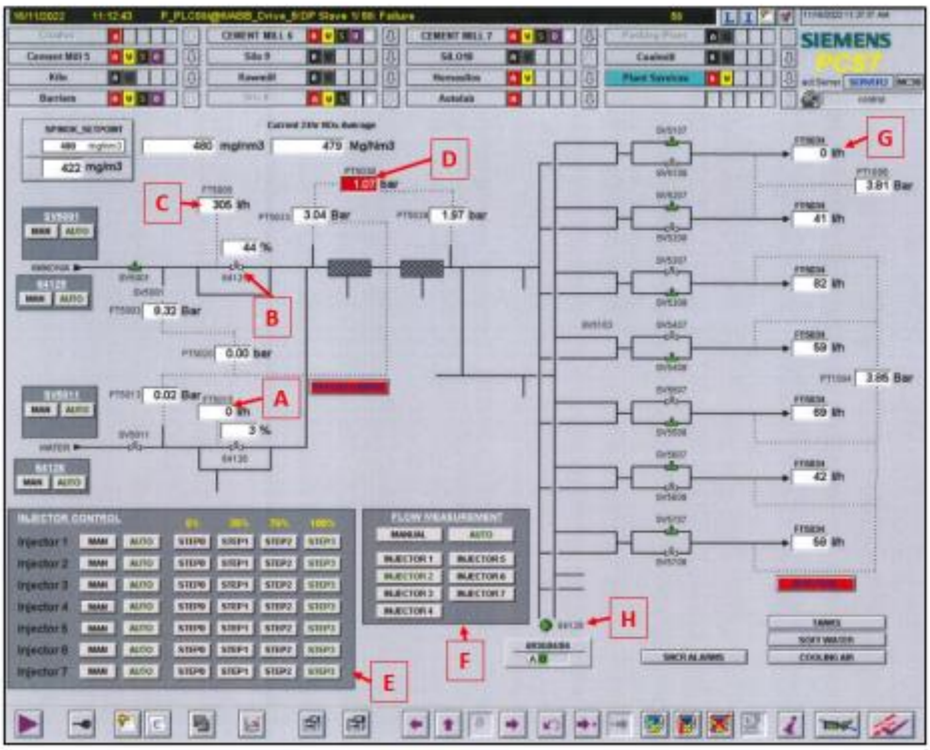


Figure 2: SNCR Injectors

		Abatement Procedures during SRF Firing to Kiln 6
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Lime Feed System Operation for SOx Abatement during SRF Firing

1. Objective

The objective of this procedure is to outline the principle of SOx abatement using the Lime Feed system, the major equipment involved in the system as well as the operation and monitoring of the system to reduce SOx emissions to below emission limits set out in Environmental license issued by the EPA to Irish Cement Limerick Works.

2. Operating Principle

Hydrated Lime Powder is fed into the Pre-Heater Tower Exhaust Gas stream by means of a pressure blower.
After the injection of the reagent into the main PHT exhaust gas duct a proportion of the SO2 portion of the gas stream will react with the lime to form CaSO3 and CaSO4 which is captured by the main kiln bag filter incorporated in the dust returns and eventually exits the kiln system incorporated as clinker.
The Lime Feed system is required to maintain SOx emissions below our current EPA licence limits with SRF firing to Kiln 6:

- 30-min: 88 mg/Nm3
- 24-hr: 45 mg/Nm3

*Both limits come into account until kiln is in "Normal Production Mode" which is defined as; Stage 4 temperature (XT04) above 800 degrees Celsius.

3. Equipment

The Lime Feed system consists of: a storage silo, loss in weight feeder, VSD controlled sluice, screw conveyor, air seal sluice and high pressure blower.

4. Operation

The Lime Feed system should be started and running when SO2 emissions are high (>45 mg/m3) while the rawmill is running or if the rawmill is likely to be down for an extended period of time (>8hrs). When the rawmill is running the gas diverted to the rawmill circuit comes in contact with limestone which acts as a scrubber for SO2 gas reducing SO2 stack emissions.

To start the Lime Feed System, go to the PCS7 control system. Under the Rawmill drop down menu select Rawmill Feed. On the Rawmill Feed page of PCS7 select "Lime to Kiln Gas". This starts 631G11/G11 the Lime to Kiln Gas group. Open the 631CTRL/C09 and select CLC with a setpoint of 40 mg/m3 (or lower if required).

644XQ/166 "Predicted 24hr SO2 Average" can be monitored to ensure that the setpoint is sufficient to reduce SO2 emissions so that the 24hr average interlock is not activated.
644XQ/92 "10s CO Value" can be monitored to ensure that the setpoint is sufficient to reduce SO2 emissions so that the 30-minute average interlock in not activated.

Irish Cement A CRH COMPANY		Abatement Procedures during SRF Firing to Kiln 6
Revision: See Version History SharePoint	**Form No:** *PRO_AF_09* **Compiled by:** D Curran (Chemical Engineer)	Irish Cement Ltd *(Limerick Works)*

Dust Abatement Procedure during SRF Firing

Under no circumstances should the Kiln be operated without adequate filter performance. The indicators of filter performance are the continuous dust monitor levels and differential pressure levels. A visual inspection will also confirm if the filter is operating satisfactorily. Under no circumstances should dust from the Kiln bag filter be run to the ground.

If the filter is not operating satisfactorily the Kiln should be stopped and all necessary repairs need to be carried out.

The operation of the kiln is interlocked with dust levels in the kiln stack. A breach of the dust levels will be prevented by these interlocks and the kiln will not be able to run until dust levels are below the ELV.

Alternative fuels will be stopped from firing to kiln 6 as per the following ELV's:

- 30-min: 18 mg/Nm3
- 24-hr: 9 mg/Nm3

APPENDIX V
KILN STACK EXTERNAL MONITORING REPORTS

4279

Element, Unit C6, Emery Court, The Embankment Business Park, Heaton Mersey, Stockport, SK4 3GL
Your Element Contact: Scott Pilkington (07825 991 537)
E: scott.pilkington@element.com

Stack Emissions Testing Report Commissioned by
Irish Cement Ltd

Installation Name & Address
Irish Cement Ltd
Castlemungret
County Limerick

Industrial Emissions Licence: P0029-06

Stack Reference
A2-01 Kiln 6

Dates of the Monitoring Campaign
18th to 20th July 2023

Job Reference Number
EMT06515

Report Written by
Keith Miller Team Leader MCERTS Level 2 MM 02 135 TE1 TE2 TE3 TE4

Report Approved by
John McBride Senior Team Leader MCERTS Level 2 MM 04 515 TE1 TE2 TE3 TE4

Report Date
14th August 2023

Version
Version 1

Signature of Report Approver

CONTENTS

Opinions and interpretations expressed herein are outside the scope of Element's ISO 17025 accreditation.

4279

Executive Summary

MONITORING OBJECTIVES

Irish Cement Ltd, County Limerick
A2-01 Kiln 6
18th to 20th July 2023

Overall Aim of the Monitoring Campaign

Element were commissioned by Irish Cement Ltd to carry out stack emissions testing on the A2-01 Kiln 6 at County Limerick.

The aim of the monitoring campaign was to demonstrate compliance with a set of emission limit values (ELVs) as specified in the Site's Permit.

Special Requirements

There were no special requirements.

Target Parameters

Total Particulate Matter, Sulphur Dioxide, Cadmium & Thallium, Heavy Metals, Mercury, Dioxins & Furans, PCBs, Hydrogen Fluoride, Ammonia, Hydrogen Chloride, Total VOCs (as Carbon), Oxides of Nitrogen (as NO_2), Carbon Monoxide

MONITORING RESULTS

Irish Cement Ltd, County Limerick
A2-01 Kiln 6
18th to 20th July 2023

where MU = Measurement Uncertainty associated with the Result

Parameter		Concentration					Mass Emission			
	Units		Result	MU +/-	Limit	Units	Result	MU +/-	Limit
Total Particulate Matter [1]	mg/m³		0.16	0.46	10	g/hr	43.8	125	-
Sulphur Dioxide [1]	mg/m³		7.7	0.56	50	g/hr	2093	196	-
Cadmium & Thallium [1]	mg/m³		0.0048	0.00079	0.05	g/hr	1.2	0.21	-
Heavy Metals [1]	mg/m³		0.012	0.0024	0.5	g/hr	3.1	0.64	-
Mercury	mg/m³		0.013	0.0030	0.05	g/hr	3.4	0.84	-
Dioxins & Furans Upper Limit (worst case where <LOD = LOD)									
Dioxins & Furans (NATO I-TEQ) [1]	ng/m³		0.0014	0.00030	0.1	µg/hr	0.39	0.084	-
Dioxins & Furans (WHO TEQ Humans / Mammals) [1]	ng/m³		0.0017	0.00036	-	µg/hr	0.47	0.10	-
Dioxins & Furans (WHO TEQ Fish) [1]	ng/m³		0.0019	0.00039	-	µg/hr	0.51	0.11	-
Dioxins & Furans (WHO TEQ Birds) [1]	ng/m³		0.0033	0.00069	-	µg/hr	0.90	0.20	-
Dioxins & Furans Lower Limit (best case where <LOD = 0)									
Dioxins & Furans (NATO I-TEQ) [1]	ng/m³		0.000073	0.000015	-	µg/hr	0.020	0.0043	-
Dioxins & Furans (WHO TEQ Humans / Mammals) [1]	ng/m³		0.000071	0.000015	-	µg/hr	0.019	0.0042	-
Dioxins & Furans (WHO TEQ Fish) [1]	ng/m³		0.000037	0.000008	-	µg/hr	0.010	0.0022	-
Dioxins & Furans (WHO TEQ Birds) [1]	ng/m³		0.00067	0.00014	-	µg/hr	0.18	0.039	-
PCBs Upper Limit (worst case where <LOD = LOD)									
PCBs (WHO TEQ Humans / Mammals) [1]	ng/m³		0.00017	0.000035	-	µg/hr	0.045	0.0098	-
PCBs (WHO TEQ Fish) [1]	ng/m³		0.000013	0.0000026	-	µg/hr	0.0034	0.00073	-
PCBs (WHO TEQ Birds) [1]	ng/m³		0.0016	0.00034	-	µg/hr	0.44	0.095	-
PCBs Lower Limit (best case where <LOD = 0)									
PCBs (WHO TEQ Humans / Mammals) [1]	ng/m³		0.000068	0.000014	-	µg/hr	0.019	0.0040	-
PCBs (WHO TEQ Fish) [1]	ng/m³		0.0000077	0.0000016	-	µg/hr	0.0021	0.00045	-
PCBs (WHO TEQ Birds) [1]	ng/m³		0.0015	0.00032	-	µg/hr	0.41	0.089	-
Hydrogen Fluoride [1]	mg/m³		0.051	0.0066	1	g/hr	12.8	1.8	-
Ammonia [1]	mg/m³		25.7	4.7	50	g/hr	6497	1259	-
Hydrogen Chloride [1]	mg/m³		1.9	0.12	10	g/hr	475	40.9	-
Total VOCs (as Carbon) [1]	mg/m³		19.9	0.89	25	g/hr	5040	376	-
Oxides of Nitrogen (as NO_2) [1]	mg/m³		412	15.3	500	g/hr	104224	7322	-
Carbon Monoxide [1]	mg/m³		348	12.8	1500	g/hr	87916	6171	-
Carbon Dioxide	% v/v	Dry	20.1	0.49					
Oxygen	% v/v	Dry	9.7	0.23					
Water Vapour	% v/v		10.9	0.52					
Stack Gas Temperature	°C		145						
Stack Gas Velocity	m/s		22.2	0.87					
Volumetric Flow Rate (ACTUAL)	m³/hr		425270	25399					
Volumetric Flow Rate (REF) [1]	m³/hr		252768	15096					

NOTE: VOLUMETRIC FLOW RATE & VELOCITY DATA TAKEN FROM THE PRELIMINARY VELOCITY TRAVERSE.

[1] Reference Conditions (REF) are: 273K, 101.3kPa, dry gas, 10% oxygen.

Executive Summary

MONITORING DATE(S) & TIMES

Irish Cement Ltd, County Limerick
A2-01 Kiln 6
18th to 20th July 2023

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
Total Particulate Matter	R1	mg/m³	0.16	g/hr	43.8	18/07/2023	16:20 - 17:25	60
Total Particulate Matter	R2	mg/m³	0.16	g/hr	43.8	18/07/2023	17:45 - 18:50	60
Total Particulate Matter	R3	mg/m³	0.16	g/hr	43.8	19/07/2023	06:00 - 07:05	60
Sulphur Dioxide	R1	mg/m³	5.6	g/hr	1521	18/07/2023	16:20 - 17:25	60
Sulphur Dioxide	R2	mg/m³	10.7	g/hr	2911	18/07/2023	17:45 - 18:50	60
Sulphur Dioxide	R3	mg/m³	6.8	g/hr	1845	19/07/2023	06:00 - 07:05	60
Cadmium & Thallium	R1	mg/m³	0.010	g/hr	2.5	20/07/2023	06:00 - 07:05	60
Cadmium & Thallium	R2	mg/m³	0.0025	g/hr	0.64	20/07/2023	07:15 - 08:20	60
Cadmium & Thallium	R3	mg/m³	0.0018	g/hr	0.47	20/07/2023	09:50 - 10:55	60
Heavy Metals	R1	mg/m³	0.012	g/hr	3.0	20/07/2023	06:00 - 07:05	60
Heavy Metals	R2	mg/m³	0.010	g/hr	2.5	20/07/2023	07:15 - 08:20	60
Heavy Metals	R3	mg/m³	0.015	g/hr	3.7	20/07/2023	09:50 - 10:55	60
Mercury	R1	mg/m³	0.011	g/hr	3.1	20/07/2023	11:05 - 12:10	60
Mercury	R2	mg/m³	0.015	g/hr	4.0	20/07/2023	12:20 - 13:25	60
Mercury	R3	mg/m³	0.012	g/hr	3.2	20/07/2023	13:35 - 14:40	60
Dioxins & Furans (NATO)	R1	ng/m³	0.0014	µg/hr	0.38	18/07/2023	10:00 - 16:10	360
Dioxins & Furans (NATO)	R2	ng/m³	0.0016	µg/hr	0.42	19/07/2023	07:15 - 13:20	360
Dioxins & Furans (NATO)	R3	ng/m³	0.0014	µg/hr	0.37	19/07/2023	13:35 - 19:40	360
PCBs	R1	ng/m³	0.00014	µg/hr	0.037	18/07/2023	10:00 - 16:10	360
PCBs	R2	ng/m³	0.00019	µg/hr	0.052	19/07/2023	07:15 - 13:20	360
PCBs	R3	ng/m³	0.00017	µg/hr	0.047	19/07/2023	13:35 - 19:40	360
Hydrogen Fluoride	R1	mg/m³	0.090	g/hr	22.7	18/07/2023	11:00 - 12:00	60
Hydrogen Fluoride	R2	mg/m³	< 0.032	g/hr	< 8.0	18/07/2023	12:15 - 13:15	60
Hydrogen Fluoride	R3	mg/m³	< 0.031	g/hr	< 7.8	18/07/2023	13:30 - 14:30	60
Ammonia	R1	mg/m³	24.4	g/hr	6165	19/07/2023	11:00 - 12:00	60
Ammonia	R2	mg/m³	25.0	g/hr	6329	19/07/2023	12:15 - 13:15	60
Ammonia	R3	mg/m³	27.7	g/hr	6998	19/07/2023	13:30 - 14:30	60
Hydrogen Chloride	R1	mg/m³	3.1	g/hr	785	19/07/2023	07:00 - 08:00	60
Hydrogen Chloride	R2	mg/m³	1.3	g/hr	327	19/07/2023	08:15 - 09:15	60
Hydrogen Chloride	R3	mg/m³	1.2	g/hr	314	19/07/2023	09:30 - 10:30	60
Total VOCs (as Carbon)	R1	mg/m³	19.9	g/hr	5040	18/07/2023	14:00 - 22:00	480
Oxides of Nitrogen (as NO_2)	R1	mg/m³	412	g/hr	104224	18/07/2023	14:00 - 22:00	480
Carbon Monoxide	R1	mg/m³	348	g/hr	87916	18/07/2023	14:00 - 22:00	480
Carbon Dioxide	R1	% v/v	20.1			18/07/2023	14:00 - 22:00	480
Oxygen	R1	% v/v	9.5			18/07/2023	14:00 - 22:00	480
Velocity Traverse	R1					18/07/2023	09:00 - 09:45	

All results are expressed at the respective reference conditions.

Executive Summary

PROCESS DETAILS

Irish Cement Ltd, County Limerick
A2-01 Kiln 6
18th to 20th July 2023

Standard Operating Conditions

Parameter	Value
Process Status	Normal Operation
Capacity (of 100%) and Tonnes / Hour	180te/hr
Continuous or Batch Process	Continuous
Feedstock (if applicable)	Raw Meal
Abatement System	Bag Filter / SNCR
Abatement System Running Status	Normal Operation
Fuel	Pet Coke
Plume Appearance	White Cloud

MONITORING & ANALYTICAL METHODS

Irish Cement Ltd, County Limerick
A2-01 Kiln 6
18th to 20th July 2023

Parameter	Monitoring				Analysis				Overall Status	LOD (Average)
	Standard	Technical Procedure	Sampling Status	Testing Lab	Analytical Procedure	Analytical Technique	Analysis Status	Analysis Lab		
Total Particulate Matter	EN 13284-1	MD 001	MCERTS	EET	MD 103	Gravimetric	MCERTS	EET	MCERTS	0.16 mg/m³
Sulphur Dioxide	EN 14791	MD 009	MCERTS	EET	CAT-AP-01	IC	MCERTS	EET	MCERTS	0.015 mg/m³
Cadmium & Thallium	EN 14385	MD 006	MCERTS	EET	CAT-AP-07	ICP-MS	MCERTS	EET	MCERTS	0.001 mg/m³
Heavy Metals	EN 14385	MD 006	MCERTS	EET	CAT-AP-07	ICP-MS	MCERTS	EET	MCERTS	0.004 mg/m³
Mercury	EN 13211	MD 006	MCERTS	EET	CAT-AP-08	CV-AFS	MCERTS	EET	MCERTS	0.00017 mg/m³
Dioxins & Furans	EN 1948	MD 007	MCERTS	EET	PM137, TM201	GC-HRMS	MCERTS	ELD	MCERTS	0.0014 ng/m³
PCBs	EN 1948	MD 007	MCERTS	EET	PM137, TM201	GC-HRMS	MCERTS	ELD	MCERTS	0.00015 ng/m³
Hydrogen Fluoride	CEN/TS 17340	MD 010	MCERTS	EET	CAT-AP-01	IC	MCERTS	EET	MCERTS	0.031 mg/m³
Ammonia	ISO 21877	MD 014	MCERTS	EET	A6	IC	MCERTS	RPS	MCERTS	0.067 mg/m³
Hydrogen Chloride	EN 1911	MD 011	MCERTS	EET	CAT-AP-01	IC	MCERTS	EET	MCERTS	0.032 mg/m³
Water Vapour	EN 14790	MD 005	MCERTS	EET	MD 105	Gravimetric	MCERTS	EET	MCERTS	0.10 % v/v
Total VOCs (as Carbon)	EN 12619:2013	MD 020	MCERTS	EET	Flame Ionisation Detection by Sick 3006				MCERTS	0.32 mg/m³
Oxides of Nitrogen (as NO_2)	EN 14792	MD 039	MCERTS	EET	Chemiluminescence by Horiba PG-350E				MCERTS	0.41 mg/m³
Carbon Monoxide	EN 15058	MD 039	MCERTS	EET	NDIR by Horiba PG-350E				MCERTS	0.76 mg/m³
Carbon Dioxide	CEN/TS 17405	MD 039	MCERTS	EET	NDIR by Horiba PG-350E				MCERTS	0.1 %
Oxygen	EN 14789	MD 039	MCERTS	EET	Dry Paramagnetic Cell by Horiba PG-350E				MCERTS	0.1 %
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	MD 041	MCERTS	EET	Pitot Tube and Thermocouple				MCERTS	1.8 m/s

ANALYSIS LABORATORIES

(with short name reference as appears in the table above)

Element (Stockport Lab - EET)	ISO 17025 Accreditation Number: 4279
Element (Deeside Lab - ELD)	ISO 17025 Accreditation Number: 4225
RPS Laboratories Ltd (RPS)	ISO 17025 Accreditation Number: 0605

SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
All	All	There are no deviations associated with the sampling employed.

Executive Summary

SUITABILITY OF SAMPLING LOCATION

Duct Characteristics

Parameter	Units	Value
Type	-	Circular
Depth	m	2.60
Width	m	-
Area	m^2	5.31
Port Depth	cm	21
Orientation of Duct	-	Vertical
Number of Ports	-	2
Sample Port Size	-	4" BSP

Location of Sampling Platform

General Platform Information	Value
Permanent / Temporary Platform	Permanent
Inside / Outside	Inside

Platform Details

EA Technical Guidance Note M1 / EN 15259 Platform Requirements	Value
Sufficient working area to manipulate probe and operate the measuring instruments	Yes
Platform has 2 levels of handrails (approx. 0.5m & 1.0m high)	Yes
Platform has vertical base boards (approx. 0.25m high)	Yes
Platform has chains / self closing gates at top of ladders	Yes
There are no obstructions present which hamper insertion of sampling equipment	Yes
Safe Access Available	Yes
Easy Access Available	Yes

Sampling Location / Platform Improvement Recommendations

The sampling location meets all the requirements specified in EA Guidance Note M1 and EN 15259, and therefore there are no improvement recommendations.

EN 15259 Homogeneity Test Requirements

There is no requirement to perform a EN 15259 Homogeneity Test on this Stack.

Sampling Plane Validation Criteria (from EN 15259)

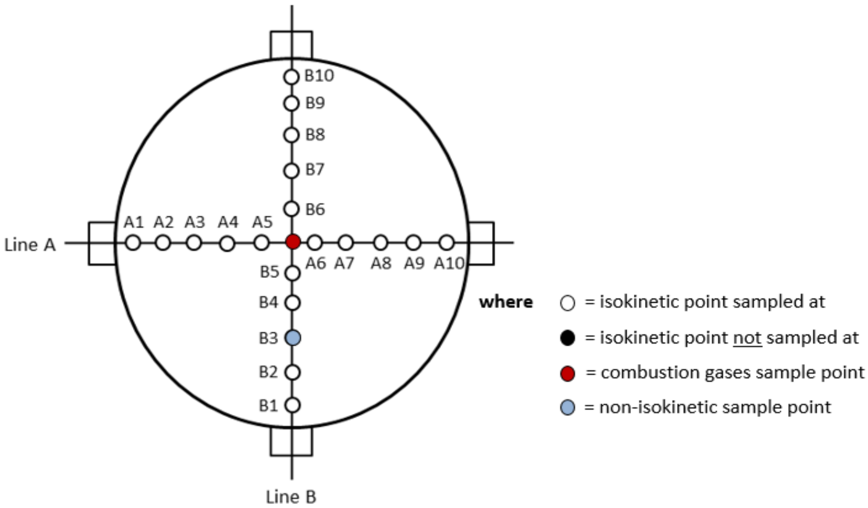
Criteria in EN 15259	Units	Traverse 1	Required	Compliant
Lowest Differential Pressure	Pa	294	> 5 Pa	Yes
Mean Velocity	m/s	22.2	-	-
Lowest Gas Velocity	m/s	21.8	-	-
Highest Gas Velocity	m/s	23.5	-	-
Ratio of Above	: 1	1.1	< 3 : 1	Yes
Maximum Angle of Swirl	°	10.0	< 15°	Yes
No Local Negative Flow	-	Yes	-	Yes

PLANT PHOTOS

Photo 1

Photo 2

SAMPLE POINTS



APPENDIX CONTENTS

STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	Keith Miller	MCERTS Level 2	MM02 135	TE1 TE2 TE3 TE4
Technician	Mark Riches	MCERTS Level 1	MM02 063	None

LIST OF EQUIPMENT

Extractive Sampling

Equipment Type	Equipment I.D.
Control Box DGM (1)	CAT 7.63
Control Box DGM (2)	-
Box Thermocouples (1)	-
Box Thermocouples (2)	-
Umbilical (1)	-
Umbilical (2)	-
Oven Box (1)	CAT 12.127
Oven Box (2)	-
Heated Probe (1)	CAT 5.164
Heated Probe (2)	CAT 5.168
Heated Probe (3)	CAT 5.172
S-Pitot (1)	CAT 21P.0004
S-Pitot (2)	-
L-Pitot	-
Site Balance	CAT 17.55
500g / 1Kg Check Weights	CAT 17.55
Last Impinger Arm	CAT 4.1225
Callipers	CAT 23.79
Tubes Kit Thermocouple	-

Instrumental Analysers

Equipment Type	Equipment I.D.
Horiba PG-350E	CAT 39.16
Horiba PG-350E	-
Servomex 4900	-
Eco Physics CLD 822Mh	-
ABB AO2020-URAS26	-
Testo 350 XL	-
JCT JCC P1 Cooler	CAT 4.0103
Gasmet DX4000	-
Gasmet Sampling System	-
Sick 3006	CAT 8.30
M&C PSS	CAT 12.120
Mass Flow Controller (1)	CAT 6.45
Mass Flow Controller (2)	CAT 6.86
Mass View (1)	CAT 25.116
Mass View (2)	CAT 25.55
Hioki 5043 (V)	CAT 11.100
Hioki 5043 (V)	-
Bioaerosols Temperature Logger	-
Electronic Refrigerator	-

Miscellaneous Items

Equipment Type	Equipment I.D.
Digital Manometer (1)	CAT 3.176
Digital Manometer (2)	CAT 3.181
Digital Temperature Meter	CAT 3.180
Stopwatch	CAT 14.103
Barometer	CAT 13.49
Stack Thermocouple (1)	CAT 4.1363
Stack Thermocouple (2)	CAT 4.1379
Stack Thermocouple (3)	-
1m Heated Line (1)	-
1m Heated Line (2)	-
1m Heated Line (3)	-
5m Heated Line (1)	CAT 20.198
15m Heated Line (1)	CAT 20.158
20m Heated Line (1)	CAT 20.173
20m Heated Line (2)	-
Dual Channel Heater Controller	CAT 3.187
Single Channel Heater Controller	-
Laboratory Balance	CAT 1.18, 1.18a, 1.18b
Tape Measure	CAT 16.77

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
Total Particulate Matter	EN 13284-1	MD 001
Sulphur Dioxide	EN 14791	MD 009
Cadmium & Thallium	EN 14385	MD 006
Heavy Metals	EN 14385	MD 006
Mercury	EN 13211	MD 006
Dioxins & Furans	EN 1948	MD 007
PCBs	EN 1948	MD 007
Hydrogen Fluoride	CEN/TS 17340	MD 010
Ammonia	ISO 21877	MD 014
Hydrogen Chloride	EN 1911	MD 011
Water Vapour	EN 14790	MD 005
Total VOCs (as Carbon)	EN 12619:2013	MD 020
Oxides of Nitrogen (as NO_2)	EN 14792	MD 039
Carbon Monoxide	EN 15058	MD 039
Carbon Dioxide	CEN/TS 17405	MD 039
Oxygen	EN 14789	MD 039
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	MD 041

PRELIMINARY STACK SURVEY: CALCULATIONS

General Stack Details

Stack Details (from Traverse)	Units	Value
Stack Diameter / Depth, D	m	2.60
Stack Width, W	m	-
Stack Area, A	m²	5.31
Average Stack Gas Temperature, T_a	°C	145.3
Average Stack Gas Pressure	mmH_2O	31.3
Average Stack Static Pressure, P_{static}	kPa	-0.118
Average Barometric Pressure, P_b	kPa	100.7
Average Pitot Tube Calibration Coefficient, C_p	-	0.84

Stack Gas Composition & Molecular Weights

Component	Conc ppm	Conc Dry % v/v	Conc Wet % v/v	Volume Fraction r	Molar Mass M	Density kg/m³ p	Conc kg/m³ p_i
CO_2	-	20.09	17.90	0.2009	44.01	1.9635	0.39447
O_2	-	9.68	8.63	0.0968	32.00	1.4277	0.13820
N_2	-	70.23	62.59	0.7023	28.01	1.2498	0.87776
Moisture (H_2O)	-	-	10.88	0.1088	18.02	0.8037	0.08746

Where: p = M / 22.41

p_i = r x p

Calculation of Stack Gas Densities

Determinand	Units	Result
Dry Density (STP), P_{STD}	kg/m³	1.410
Wet Density (STP), P_{STW}	kg/m³	1.344
Dry Density (Actual), P_{Actual}	kg/m³	0.914
Average Wet Density (Actual), $P_{ActualW}$	kg/m³	0.871

Where: P_{STD} = sum of component concentrations, kg/m³ (not including water vapour)

P_{STW} = sum of all wet concentrations / 100 x density, kg/m³ (including water vapour)

$P_{Actual} = P_{STD} \times (T_{STP} / (P_{STP})) \times ((P_{static} + P_b) / T_a)$

$P_{ActualW}$ (at each sampling point) = $P_{STW} \times (T_s / P_s) \times (P_a / T_a)$

Calculation of Stack Gas Volumetric Flowrate, Q

Duct gas flow conditions	Units	Actual	REF [1]
Temperature	°C	145.3	0.0
Total Pressure	kPa	100.6	101.3
Moisture	%	10.88	0.00
Oxygen (Dry)	%	9.7	10.0

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m³/hr	425270
Gas Volumetric Flowrate (STP, Wet)	m³/hr	275614
Gas Volumetric Flowrate (STP, Dry)	m³/hr	245624
Gas Volumetric Flowrate REF [1]	m³/hr	252768

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID)

(1 of 1)

Parameter	Units	Value
Date of Survey	-	18/07/2023
Time of Survey	-	09:00 - 09:45
Atmospheric Pressure	kPa	100.7
Average Stack Static Pressure	Pa	-118
Result of Pitot Stagnation Test	-	Pass
Are Water Droplets Present?	-	Yes
Device Used	S-Type Pitot with Liquid Incline Manometer	

Parameter	Units	Value
Initial Pitot Leak Check	-	Pass
Final Pitot Leak Check	-	Pass
Orientation of Duct	-	Vertical
Pitot Tube, C_p	-	0.84
Number of Lines Available	-	2
Number of Lines Used	-	2

		Sampling Line A					Sampling Line B				
Traverse Point	**Depth m**	**ΔP mmH_2O**	**Temp °C**	**Wet Density kg/m³**	**Velocity m/s**	**Swirl °**	**ΔP mmH_2O**	**Temp °C**	**Wet Density kg/m³**	**Velocity m/s**	**Swirl °**
STATIC (Units: Pa)		*-117*					*-119*				
Mean		**30.8**	**145**	**0.87**	**22.1**		**31.8**	**145**	**0.87**	**22.4**	
1	0.07	30.0	145	0.87	21.8	8.0	32.0	145	0.87	22.5	8.0
2	0.21	30.0	145	0.87	21.8	9.0	33.0	145	0.87	22.8	9.0
3	0.38	32.0	145	0.87	22.5	7.0	35.0	143	0.88	23.5	10.0
4	0.59	32.0	145	0.87	22.5	9.0	32.0	146	0.87	22.5	8.0
5	0.89	32.0	146	0.87	22.5	8.0	32.0	145	0.87	22.5	9.0
6	1.71	30.0	146	0.87	21.8	9.0	30.0	145	0.87	21.8	5.0
7	2.01	30.0	145	0.87	21.8	5.0	30.0	146	0.87	21.8	8.0
8	2.22	30.0	145	0.87	21.8	8.0	32.0	146	0.87	22.5	9.0
9	2.39	30.0	146	0.87	21.8	7.0	32.0	145	0.87	22.5	7.0
10	2.53	32.0	146	0.87	22.5	10.0	30.0	145	0.87	21.8	9.0

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID) - MEASUREMENT UNCERTAINTY

(1 of 1)

Performance characteristics (Uncertainty Components)	Uncertainty	Value	Units
Standard Uncertainty on the coefficient of the Pitot Tube	u(k)	0.005	-
Standard Uncertainty associated with the mean local dynamic pressures	u(Δpi)	5.480	Pa
- Resolution	u(res)	0.52154	
- Calibration	u(cal)	9.810	
- Drift	u(drift)	1.096	
- Lack of Fit	u(fit)	17.604	
- Overall corrections to dynamic measurements	u(Cf)	29.032	
Standard uncertainty associated with the molar mass of the gas	u(M)	0.00011	-
- φO_2,w	-	8.627	
- φCO_2,w	-	17.904	
- Oxygen, dry	u(ϕO_2,d)	0.296	
- Carbon Dioxide, dry	u(ϕCO_2,d)	0.615	
- Water Vapour	u(ϕH_2O)	0.555	
- Oxygen, wet	u(ϕO_2,w)	0.269	
- Carbon Dioxide, wet	u(ϕCO_2,w)	0.559	
Standard uncertainty associated with the stack temperature	u(Tc)	2.134	K
Standard uncertainty associated with the absolute pressure in the duct	u(pc)	175.735	Pa
- Atmospheric Pressure	u(patm)	175.692	
- Static Pressure	u(pstat)	3.875	
Standard uncertainty associated with the density in the duct	u(ρ)	0.00470	-
Standard uncertainty associated with the local velocities	u(vi)	1.951	Pa
Standard uncertainty associated with the mean velocity	u(v)	0.442	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	Uc(v)	0.867	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	Uc,rel(v)	3.90	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	Uc(qV,w)	25398.7	m^3/hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00093	
- $u^2(qV,w)$	-	167922597	
- u(qV,w)	-	12958.5	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	Uc,rel(qV,w)	6.0	%

TOTAL PARTICULATE MATTER: RESULTS SUMMARY

Irish Cement Ltd, County Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	mg/m³	0.16	0.16	0.16		0.16
Uncertainty	±mg/m³	0.46	0.46	0.46		0.46
Mass Emission	g/hr	43.8	43.8	43.8		43.8
Uncertainty	±g/hr	125	125	125		125

NOTE: Where the maximum Blank concentration is higher than the Sample concentration, the maximum Blank concentration has been reported.

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	11.3	11.6	11.1		11.3
Uncertainty	±% v/v	0.63	0.65	0.60		0.63

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	0.16		0.16

NOTE: Where the Balance Uncertainty / Limit of Detection is higher than the Blank concentration, the Balance Uncertainty / Limit of Detection concentration has been reported.

General Sampling Information

Parameter	Value	
Standard	EN 13284-1	
Technical Procedure	MD 001	
Probe Material	Titanium	
Filter Housing Material	Titanium	
Positioning of Filter	In Stack	
Filter Size and Material	47mm Glass Fibre	
Number of Sampling Lines Used	2 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	20 / 20	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10 - B1, B2, B3, B4, B5, B6, B7, B8, B9, B10	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

TOTAL PARTICULATE MATTER: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	Run 2	Run 3
Absolute pressure of stack gas, P_s				
Barometric pressure, P_b	mmHg	755.3	755.3	759.8
Stack static pressure, P_{static}	mmH_2O	11.9	11.9	11.9
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	756.2	756.2	760.7
Volume of water vapour collected, V_{wstd}				
Total mass collected in impingers (liquid trap)	g	127.1	122.2	140.2
Total mass collected in impingers (silica trap)	g	8.1	13.0	7.8
Total mass of liquid collected, V_{lc}	g	135.2	135.2	148.0
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.1685	0.1685	0.1844
Volume of gas metered dry, V_{mstd}				
Volume of gas sample through gas meter, V_m	m^3	1.6000	1.5600	1.7500
Gas meter correction factor, Y_d	-	0.9610	0.9610	0.9610
Average dry gas meter temperature, T_m	°C	45.6	45.6	39.8
Average pressure drop across orifice, ΔH	mmH_2O	66.9	68.0	90.0
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	1.3179	1.2853	1.4804
Moisture content, B_{wo} & R_{wv}				
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.1133	0.1159	0.1108
B_{wo} as a percentage	% v/v	11.33	11.59	11.08
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	11.33	11.59	11.08
Volume of gas metered wet, V_{mstw}				
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	1.4864	1.4537	1.6648
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$				
IED & Incinerates Hazardous Material? (Yes = no positive O_2 correction)	-	No	No	No
% wet oxygen measured in gas stream, $ACT\%O_{2w}$	% v/v	10.30	8.60	8.95
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	9.34	9.35	9.74
% oxygen reference condition, $REF\%O_2$	% v/v	10.00	10.00	10.00
O_2 Reference Factor wet $(O_{2REFw}) = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$	-	1.03	0.89	0.91
O_2 Reference Factor dry $(O_{2REFd}) = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$	-	0.94	0.94	0.98
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	1.4464	1.6394	1.8231
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	1.3966	1.3608	1.5148
Molecular weight of dry gas stream, M_d				
CO_2	% v/v	20.00	20.00	20.00
O_2	% v/v	9.34	9.35	9.74
Total	% v/v	29.34	29.35	29.74
N_2	% v/v	70.66	70.65	70.26
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	31.57	31.57	31.59
Molecular weight of stack gas (wet), M_s				
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	30.04	30.00	30.08
Velocity of stack gas, V_s				
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97
Velocity pressure coefficient, C_p	-	0.84	0.84	0.84
Average of velocity heads, ΔP_{avg}	mmH_2O	29.60	30.60	41.20
Average square root of velocity heads, $\sqrt{\Delta P}$	$\sqrt{mmH_2O}$	5.44	5.53	6.42
Average stack gas temperature, T_s	°C	148.2	155.6	155.0
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{(M_s)(P_s)})$	m/s	21.76	22.33	25.78
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})				
Area of stack, A_s	m^2	5.31	5.31	5.31
$Q_a = (60)(A_s)(V_s)$	m^3/min	6933.9	7115.8	8214.6
Conversion factor (K/mm.Hg), C_f	-	0.3592	0.3592	0.3592
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	4471.5	4509.6	5244.9
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	3964.7	3987.0	4664.0
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	4351.2	5085.5	5743.6
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	4201.6	4221.3	4772.4
Percent isokinetic, %I				
Nozzle diameter, D_n	mm	6.02	6.02	6.02
Nozzle area, A_n	mm^2	28.47	28.47	28.47
Total sampling time, q	min	60	60	60
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	103.3	100.2	98.7

TOTAL PARTICULATE MATTER: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	16:20 - 17:25	17:45 - 18:50	06:00 - 07:05
Sampling Dates	-	18/07/2023	18/07/2023	19/07/2023
Sampling Device	-	ISO	ISO	ISO
Volume Sampled (REF)	m^3	1.3966	1.3608	1.5148
Filter I.D. Number	-	47-96586	47-94678	47-97924
Start Filter Mass	g	0.14838	0.15152	0.14758
End Filter Mass	g	0.14787	0.15139	0.14726
Total Mass on Filter	g	-0.00051	-0.00013	-0.00032
Probe Rinse I.D. Number	-	PR-47-96586	PR-47-94678	PR-47-97924
Start Probe Rinse Mass	g	2.93650	3.00000	3.06607
End Probe Rinse Mass	g	2.93660	3.00013	3.06626
Total Mass in Probe Rinse	g	0.00010	0.00013	0.00019
Total Mass Collected	mg	-0.41	0.00	-0.13
Calculated Concentration	mg/m^3	-0.29	0.00	-0.09
Balance Uncertainty / LOD	mg/m^3	0.16	0.17	0.15

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	13/07/2023
Average Volume Sampled (REF)	m^3	1.4241
Filter I.D. Number	-	47-96585
Start Filter Mass	g	0.14554
End Filter Mass	g	0.14527
Total Mass on Filter	g	-0.00027
Probe Rinse I.D. Number	-	PR-47-96585
Start Probe Rinse Mass	g	2.51665
End Probe Rinse Mass	g	2.51650
Total Mass in Probe Rinse	g	-0.00015
Total Mass Collected	mg	-0.42
Calculated Concentration	mg/m^3	-0.29
Balance Uncertainty / LOD	mg/m^3	0.16

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	25.6	25.0	28.0
Pre-Sampling Leak Rate	l/min	0.20	0.30	0.20
Post-Sampling Leak Rate	l/min			
Allowable Leak Rate	l/min	0.40	0.40	0.40
Leak Test Acceptable	-	Yes	Yes	Yes

Water Droplets	Units	Run 1	Run 2	Run 3
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Measurement Uncertainty (MU)	%	5.5	5.6	5.4
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Less than 50% Faded	%	Yes	Yes	Yes

Isokinetic Criterion Compliance	Units	Run 1	Run 2	Run 3
Isokinetic Variation	%	103.3	100.2	98.7
Allowable Isokinetic Range	%	95 - 115	95 - 115	95 - 115
Isokineticity Acceptable	-	Yes	Yes	Yes

Weighing Uncertainty Criteria	Units	Run 1	Run 2	Run 3
Overall Weighing Uncertainty	± mg	0.33	0.33	0.33
Overall Weighing Uncertainty	± mg/m³	0.23	0.24	0.21
ELV [Daily ELV for IED]	mg/m³	10.00	10.00	10.00
Allowable Weighing Uncertainty	mg/m³	0.50	0.50	0.50
Weighing Uncertainty Acceptable	-	Yes	Yes	Yes

Filter Temperatures	Units	Run 1	Run 2	Run 3
Pre-Conditioning Temperature	°C	180	180	180
Post-Conditioning Temperature	°C	160	160	160
Maximum Filter Temperature	°C	150	158	156

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	20.0
Pre-Sampling Leak Rate	l/min	0.20
Post-Sampling Leak Rate	l/min	
Allowable Leak Rate	l/min	N/A
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m³	1.0
Blank Acceptable	-	Yes

Acetone / Water Rinse Blank	Units	Blank
Acetone / Water Rinse Value	mg/l	2.7
Allowable Blank	mg/l	10
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	Run Number 2	Run Number 3
There are no deviations associated with the sampling employed.	wx	wx	wx

TOTAL PARTICULATE MATTER: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value				Standard uncertainty				
	Symbol	Run 1	Run 2	Run 3	Symbol	Units	Run 1	Run 2	Run 3
Sampled Volume (Actual)	V_m	1.6000	1.5600	1.7500	uV_m	m^3	0.0320	0.0312	0.0350
Sampled Gas Temperature	T_m	318.6	318.6	312.8	uT_m	K	2.00	2.00	2.00
Sampled Gas Pressure	ρ_m	100.8	100.8	101.4	$u\rho_m$	kPa	0.50	0.50	0.50
Sampled Gas Humidity	H_m	0.00	0.00	0.00	uH_m	% v/v	1.00	1.00	1.00
Leak	L	0.78	1.20	0.71	uL	%	-	-	-
Mass of Particulate	m	0.23	0.23	0.23	um	mg	0.23	0.23	0.23
Uncollected Mass	UCM	-0.42	-0.42	-0.42	uUCM	mg	-	-	-

Measured Quantities	Uncertainty as a Percentage				Requirement of Standard
	Units	Run 1	Run 2	Run 3	
Sampled Volume (Actual)	%	2.00	2.00	2.00	≤2%
Sampled Gas Temperature	%	0.63	0.63	0.64	≤1%
Sampled Gas Pressure	%	0.50	0.50	0.49	≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00	≤1%
Leak	%	0.78	1.20	0.71	≤2%
Mass of Particulate	%	1.62	1.62	1.62	-
Uncollected Mass	%	-	-	-	-

Measured Quantities	Uncertainty in Measurement Units					Sensitivity Coefficient		
	Symbol	Units	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	m^3	1.3179	1.2853	1.4804	0.12	0.13	0.11
Leak	L	mg/m^3	0.001	0.001	0.001	1.00	1.00	1.00
Mass of Particulate	L_r	mg	0.230	0.230	0.230	0.70	0.70	0.70
Uncollected Mass	UCM	mg	-0.24	-0.24	-0.24	0.70	0.70	0.70

Measured Quantities	Uncertainty in Result			
	Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	mg/m^3	0.004	0.004	0.004
Leak	mg/m^3	0.0007	0.0011	0.0007
Mass of Particulate	mg/m^3	0.1615	0.1615	0.1615
Uncollected Mass	mg/m^3	-0.1703	-0.1703	-0.1703

Measured Quantities	Oxygen Correction Part of MU Budget			
	Units	Run 1	Run 2	Run 3
O_2 Correction Factor	-	0.94	0.94	0.98
Stack Gas O_2 Content	% v/v	9.34	9.35	9.74
MU for O_2 Correction	-	0.04	0.04	0.04
Overall MU For O_2 Measurement	%	4.29	4.29	4.44

Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	mg/m^3	0.23	0.23	0.23
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.46	0.46	0.46
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	0.46	0.46	0.46
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.46	0.46	0.46
Reported Uncertainty	mg/m^3	0.46	0.46	0.46
Expanded uncertainty (95% confidence), without Oxygen Correction	%	285	285	285
Expanded uncertainty (95% confidence), with Oxygen Correction	%	285	285	285
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	285	285	285
Reported Uncertainty	%	285	285	285

APPENDIX 2

SULPHUR DIOXIDE: RESULTS SUMMARY

Irish Cement Ltd, County Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	mg/m³	5.6	10.7	6.8		7.7
Uncertainty	±mg/m³	0.40	0.78	0.49		0.56
Mass Emission	g/hr	1521	2911	1845		2093
Uncertainty	±g/hr	142	273	172		196

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	11.3	11.6	11.1		11.3
Uncertainty	±% v/v	0.63	0.65	0.60		0.63

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 0.011		< 0.011

General Sampling Information

Parameter	Value	
Standard	EN 14791	
Technical Procedure	MD 009	
Name of Analytical Laboratory	EET	
Analytical Laboratory's Procedure	CAT-AP-01	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	27/07/2023	
Probe Material	Titanium	
Filter Housing Material	Titanium	
Impinger Material	Polyethylene	
Absorption Solution	0.3% Hydrogen Peroxide	
Positioning of Filter	In Stack	
Filter Size and Material	47mm Glass Fibre	
Number of Sampling Lines Used	2 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	20 / 20	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10 - B1, B2, B3, B4, B5, B6, B7, B8, B9, B10	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

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APPENDIX 2

SULPHUR DIOXIDE: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	Run 2	Run 3
Absolute pressure of stack gas, P_s				
Barometric pressure, P_b	mmHg	755.3	755.3	759.8
Stack static pressure, P_{static}	mmH_2O	11.9	11.9	11.9
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	756.2	756.2	760.7
Volume of water vapour collected, V_{wstd}				
Total mass collected in impingers (liquid trap)	g	127.1	122.2	140.2
Total mass collected in impingers (silica trap)	g	8.1	13.0	7.8
Total mass of liquid collected, V_{lc}	g	135.2	135.2	148.0
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.1685	0.1685	0.1844
Volume of gas metered dry, V_{mstd}				
Volume of gas sample through gas meter, V_m	m^3	1.6000	1.5600	1.7500
Gas meter correction factor, Y_d	-	0.9610	0.9610	0.9610
Average dry gas meter temperature, T_m	°C	45.6	45.6	39.8
Average pressure drop across orifice, ΔH	mmH_2O	66.9	68.0	90.0
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	1.3179	1.2853	1.4804
Moisture content, B_{wo} & R_{wv}				
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.1133	0.1159	0.1108
B_{wo} as a percentage	% v/v	11.33	11.59	11.08
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	11.33	11.59	11.08
Volume of gas metered wet, V_{mstw}				
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	1.4864	1.4537	1.6648
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$				
IED & Incinerates Hazardous Material? (Yes = no positive O_2 correction)	-	No	No	No
% wet oxygen measured in gas stream, $ACT\%O_{2w}$	% v/v	10.30	8.60	8.95
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	9.34	9.35	9.74
% oxygen reference condition, $REF\%O_2$	% v/v	10.00	10.00	10.00
O_2 Reference Factor wet $(O_{2REFw}) = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$	-	1.03	0.89	0.91
O_2 Reference Factor dry $(O_{2REFd}) = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$	-	0.94	0.94	0.98
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	1.4464	1.6394	1.8231
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	1.3966	1.3608	1.5148
Molecular weight of dry gas stream, M_d				
CO_2	% v/v	20.00	20.00	20.00
O_2	% v/v	9.34	9.35	9.74
Total	% v/v	29.34	29.35	29.74
N_2	% v/v	70.66	70.65	70.26
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	31.57	31.57	31.59
Molecular weight of stack gas (wet), M_s				
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	30.04	30.00	30.08
Velocity of stack gas, V_s				
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97
Velocity pressure coefficient, C_p	-	0.84	0.84	0.84
Average of velocity heads, ΔP_{avg}	mmH_2O	29.60	30.60	41.20
Average square root of velocity heads, $\sqrt{\Delta P}$	$\sqrt{mmH_2O}$	5.44	5.53	6.42
Average stack gas temperature, T_s	°C	148.2	155.6	155.0
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{(M_s)(P_s)})$	m/s	21.76	22.33	25.78
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})				
Area of stack, A_s	m^2	5.31	5.31	5.31
$Q_a = (60)(A_s)(V_s)$	m^3/min	6933.9	7115.8	8214.6
Conversion factor (K/mm.Hg), C_f	-	0.3592	0.3592	0.3592
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	4471.5	4509.6	5244.9
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	3964.7	3987.0	4664.0
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	4351.2	5085.5	5743.6
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	4201.6	4221.3	4772.4
Percent isokinetic, %I				
Nozzle diameter, D_n	mm	6.02	6.02	6.02
Nozzle area, A_n	mm^2	28.47	28.47	28.47
Total sampling time, q	min	60	60	60
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	103.3	100.2	98.7

SULPHUR DIOXIDE: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	16:20 - 17:25	17:45 - 18:50	06:00 - 07:05
Sampling Dates	-	18/07/2023	18/07/2023	19/07/2023
Sampling Device	-	ISO	ISO	ISO
Volume Sampled (REF)	m^3	1.3966	1.3608	1.5148
Laboratory Result for Front Impingers	µg/ml	26.75	35.48	24.19
Laboratory Result for Back Impinger	µg/ml	< 0.05		
Volume in Front Impingers	ml	293.0	412.2	426.6
Volume in Back Impinger	ml	107.3		
Mass in Front Impingers	µg	7837.8	14624.9	10319.5
Mass in Back Impinger	µg	< 5.4		
Total Mass Collected	µg	7843.1	14624.9	10319.5
Calculated Concentration	mg/m^3	5.6	10.7	6.8

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	13/07/2023
Average Volume Sampled (REF)	m^3	1.4241
Laboratory Result for Impingers	µg/ml	< 0.05
Volume in Impingers	ml	306.2
Total Mass Collected	µg	< 15.3
Calculated Concentration	mg/m^3	< 0.011

SULPHUR DIOXIDE: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	25.6	25.0	28.0
Pre-Sampling Leak Rate	l/min	0.20	0.30	0.20
Post-Sampling Leak Rate	l/min	N/A	N/A	N/A
Allowable Leak Rate	l/min	N/A	N/A	N/A
Leak Test Acceptable	-	No	No	No

Absorption Efficiency	Units	Run 1
Absorption Efficiency	%	100.0
Allowable Absorption Efficiency	%	N/A [2]
Absorption Efficiency Acceptable	-	Yes [2]

[2] The concentration is less than 30% of the ELV, therefore no assessment against an allowable efficiency is required.

Water Droplets	Units	Run 1	Run 2	Run 3
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Measurement Uncertainty (MU)	%	5.5	5.6	5.4
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Less than 50% Faded	%	Yes	Yes	Yes

Isokinetic Criterion Compliance	Units	Run 1	Run 2	Run 3
Isokinetic Variation	%	103.3	100.2	98.7
Allowable Isokinetic Range	%	95 - 115	95 - 115	95 - 115
Isokineticity Acceptable	-	Yes	Yes	Yes

Filter Temperatures	Units	Run 1	Run 2	Run 3
Maximum Filter Temperature	°C	150	158	156

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

SULPHUR DIOXIDE: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	20.0
Pre-Sampling Leak Rate	l/min	0.20
Post-Sampling Leak Rate	l/min	
Allowable Leak Rate	l/min	N/A
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m^3	5.0
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	2	3
There are no deviations associated with the sampling employed.	wx	wx	wx

SULPHUR DIOXIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value				Standard uncertainty				
Measured Quantities	**Symbol**	**Run 1**	**Run 2**	**Run 3**	**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (Actual)	V_m	1.6000	1.5600	1.7500	uV_m	m^3	0.0320	0.0312	0.0350
Sampled Gas Temperature	T_m	318.6	318.6	312.8	uT_m	K	2.00	2.00	2.00
Sampled Gas Pressure	ρ_m	100.8	100.8	101.4	$u\rho_m$	kPa	0.50	0.50	0.50
Sampled Gas Humidity	H_m	0.00	0.00	0.00	uH_m	% v/v	1.00	1.00	1.00
Leak	L	0.78	1.20	0.71	uL	%	-	-	-
Laboratory Result	L_r	0.90	0.90	0.90	uL_r	%	-	-	-

	Uncertainty as a Percentage				
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**	**Requirement of Standard**
Sampled Volume (Actual)	%	2.00	2.00	2.00	≤2%
Sampled Gas Temperature	%	0.63	0.63	0.64	≤1%
Sampled Gas Pressure	%	0.50	0.50	0.49	≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00	≤1%
Leak	%	0.78	1.20	0.71	≤2%
Laboratory Result	%	0.90	0.90	0.90	No Requirement

	Uncertainty in Measurement Units					Sensitivity Coefficient		
Measured Quantities	**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (STP)	V_m	m^3	1.3179	1.2853	1.4804	4.26	8.36	4.60
Leak	L	mg/m^3	0.025	0.075	0.028	1.00	1.00	1.00
Laboratory Result	L_r	mg/m^3	0.051	0.097	0.061	1.00	1.00	1.00

	Uncertainty in Result			
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (STP)	mg/m^3	0.154	0.295	0.183
Leak	mg/m^3	0.0253	0.0745	0.0281
Laboratory Result	mg/m^3	0.0505	0.0967	0.0613

	Oxygen Correction Part of MU Budget			
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**
O_2 Correction Factor	-	0.94	0.94	0.98
Stack Gas O_2 Content	% v/v	9.34	9.35	9.74
MU for O_2 Correction	-	0.04	0.04	0.04
Overall MU For O_2 Measurement	%	4.29	4.29	4.44

Parameter	**Units**	**Run 1**	**Run 2**	**Run 3**
Combined uncertainty	mg/m^3	0.16	0.32	0.20
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.32	0.63	0.38
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	0.40	0.78	0.49
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.40	0.78	0.49
Reported Uncertainty	mg/m^3	0.40	0.78	0.49
Expanded uncertainty (95% confidence), without Oxygen Correction	%	5.7	5.8	5.6
Expanded uncertainty (95% confidence), with Oxygen Correction	%	7.2	7.2	7.2
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	7.2	7.2	7.2
Reported Uncertainty	%	7.2	7.2	7.2

CADMIUM & THALLIUM: RESULTS SUMMARY

Irish Cement Ltd, County Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	mg/m³	0.010	0.0025	0.0018		0.0048
Uncertainty	±mg/m³	0.0017	0.00041	0.00030		0.00079
Mass Emission	g/hr	2.5	0.64	0.47		1.2
Uncertainty	±g/hr	0.44	0.11	0.082		0.21

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	10.9	9.7	9.3		10.0
Uncertainty	±% v/v	0.59	0.53	0.50		0.54

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 0.00069		< 0.00069

General Sampling Information

Parameter	Value	
Standard	EN 14385	
Technical Procedure	MD 006	
Name of Analytical Laboratory	EET	
Analytical Laboratory's Procedure	CAT-AP-07	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	27/07/2023	
Probe Material	Titanium	
Filter Housing Material	Titanium	
Impinger Material	Borosilicate Glass	
Absorption Solution	Nitric Peroxide	
Positioning of Filter	Out Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	2 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	20 / 20	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10 - B1, B2, B3, B4, B5, B6, B7, B8, B9, B10	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

CADMIUM & THALLIUM: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	Run 2	Run 3
Absolute pressure of stack gas, P_s				
Barometric pressure, P_b	mmHg	759.8	759.8	759.8
Stack static pressure, P_{static}	mmH_2O	11.9	11.9	11.9
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	760.7	760.7	760.7
Volume of water vapour collected, V_{wstd}				
Total mass collected in impingers (liquid trap)	g	132.0	113.5	119.8
Total mass collected in impingers (silica trap)	g	10.2	8.2	7.6
Total mass of liquid collected, V_{lc}	g	142.2	121.7	127.4
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.1772	0.1516	0.1587
Volume of gas metered dry, V_{mstd}				
Volume of gas sample through gas meter, V_m	m^3	1.7000	1.6800	1.8600
Gas meter correction factor, Y_d	-	0.9610	0.9610	0.9610
Average dry gas meter temperature, T_m	°C	37.1	42.8	43.4
Average pressure drop across orifice, ΔH	mmH_2O	82.9	81.1	81.5
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	1.4496	1.4062	1.5540
Moisture content, B_{wo} & R_{wv}				
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.1089	0.0973	0.0927
B_{wo} as a percentage	% v/v	10.89	9.73	9.27
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	10.89	9.73	9.27
Volume of gas metered wet, V_{mstw}				
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	1.6268	1.5579	1.7128
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$				
IED & Incinerates Hazardous Material? (Yes = no positive O_2 correction)	-	No	No	No
% wet oxygen measured in gas stream, $ACT\%O_{2w}$	% v/v	7.47	7.40	7.49
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	9.85	9.76	9.87
% oxygen reference condition, $REF\%O_2$	% v/v	10.00	10.00	10.00
O_2 Reference Factor wet (O_{2REFw}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2w}$)	-	0.81	0.81	0.81
O_2 Reference Factor dry (O_{2REFd}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2d}$)	-	0.99	0.98	0.99
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	2.0004	1.9257	2.1039
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	1.4691	1.4371	1.5722
Molecular weight of dry gas stream, M_d				
CO_2	% v/v	20.00	20.00	9.00
O_2	% v/v	9.85	9.76	9.87
Total	% v/v	29.85	29.76	18.87
N_2	% v/v	70.15	70.24	81.13
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	31.59	31.59	29.83
Molecular weight of stack gas (wet), M_s				
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	30.11	30.27	28.74
Velocity of stack gas, V_s				
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97
Velocity pressure coefficient, C_p	-	0.84	0.84	0.84
Average of velocity heads, ΔP_{avg}	mmH_2O	37.70	37.00	37.05
Average square root of velocity heads, √ΔP	$\sqrt{mmH_2O}$	6.14	6.08	6.09
Average stack gas temperature, T_s	°C	148.5	158.2	155.6
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{(M_s)(P_s)})$	m/s	24.46	24.45	25.03
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})				
Area of stack, A_s	m^2	5.31	5.31	5.31
$Q_a = (60)(A_s)(V_s)$	m^3/min	7794.3	7790.1	7975.9
Conversion factor (K/mm.Hg), C_f	-	0.3592	0.3592	0.3592
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	5053.3	4936.9	5085.4
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	4502.9	4456.4	4614.1
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	6213.9	6102.7	6246.6
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	4563.5	4554.3	4668.1
Percent isokinetic, %I				
Nozzle diameter, D_n	mm	6.02	6.02	6.02
Nozzle area, A_n	mm^2	28.47	28.47	28.47
Total sampling time, q	min	60	60	60
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	100.1	98.1	104.7

CADMIUM & THALLIUM: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	06:00 - 07:05	07:15 - 08:20	09:50 - 10:55
Sampling Dates	-	20/07/2023	20/07/2023	20/07/2023
Sampling Device	-	ISO	ISO	ISO
Volume Sampled (REF)	m^3	1.4691	1.4371	1.5722
Cadmium				
Mass on Filter / in Rinse	µg	< 0.50	< 0.50	< 0.50
Mass in Front Impingers	µg	< 0.07	< 0.06	< 0.06
Mass in Back Impinger	µg	< 0.02	< 0.03	< 0.02
Total Mass Collected	µg	< 0.59	< 0.59	< 0.59
Calculated Concentration	mg/m^3	< 0.0004	< 0.0004	< 0.0004
Reported Concentration	mg/m^3	< 0.0004	< 0.0004	< 0.0004
Mass Emission	g/hr	< 0.10	< 0.10	< 0.10
Thallium				
Mass on Filter / in Rinse	µg	14.10	2.94	2.22
Mass in Front Impingers	µg	< 0.07	< 0.06	< 0.06
Mass in Back Impinger	µg	< 0.02	< 0.03	< 0.02
Total Mass Collected	µg	14.19	3.03	2.31
Calculated Concentration	mg/m^3	0.0097	0.0021	0.0015
Reported Concentration	mg/m^3	0.0097	0.0021	0.0015
Mass Emission	g/hr	2.44	0.53	0.37
Cadmium & Thallium Combined				
Total Mass Collected	µg	14.78	3.61	2.89
Calculated Concentration	mg/m^3	0.0101	0.0025	0.0018
Reported Concentration	mg/m^3	0.0101	0.0025	0.0018

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	20/07/2023
Average Volume Sampled (REF)	m^3	1.4928
Cadmium		
Mass on Filter / in Rinse	µg	< 0.50
Mass in Front Impingers	µg	< 0.04
Mass in Back Impinger	µg	< 0.02
Total Mass Collected	µg	< 0.56
Calculated Concentration	mg/m^3	< 0.0004
Reported Concentration	mg/m^3	< 0.0004
Thallium		
Mass on Filter / in Rinse	µg	< 0.40
Mass in Front Impingers	µg	< 0.04
Mass in Back Impinger	µg	< 0.02
Total Mass Collected	µg	< 0.46
Calculated Concentration	mg/m^3	< 0.0003
Reported Concentration	mg/m^3	< 0.0003
Cadmium & Thallium Combined		
Total Mass Collected	µg	< 1.03
Calculated Concentration	mg/m^3	< 0.00069
Reported Concentration	mg/m^3	< 0.00069

CADMIUM & THALLIUM: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	27.2	26.9	29.8
Pre-Sampling Leak Rate	l/min	0.20	0.20	0.10
Post-Sampling Leak Rate	l/min	N/A	N/A	N/A
Allowable Leak Rate	l/min	0.40	0.40	0.40
Leak Test Acceptable	-	Yes	Yes	Yes

Absorption Efficiency	Units	Run 1	Run 2	Run 3
Cadmium	%	100.0	100.0	100.0
Thallium	%	100.0	100.0	100.0
Allowable Absorption Efficiency	%	N/A	N/A	N/A
Absorption Efficiency Acceptable	-	Yes	Yes	Yes

Where the emissions are < 30% of the ELV, MID 14385 does not require the absorption efficiency requirement to be applied

Detection Limit	Units	Run 1	Run 2	Run 3
Cadmium	µg/m³	0.4	0.4	0.4
Thallium	µg/m³	0.3	0.3	0.3
Allowable Detection Limit	µg/m³	5	5	5
Detection Limit Acceptable	-	Yes	Yes	Yes

Water Droplets	Units	Run 1	Run 2	Run 3
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Measurement Uncertainty (MU)	%	5.4	5.5	5.4
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Less than 50% Faded	%	Yes	Yes	Yes

Isokinetic Criterion Compliance	Units	Run 1	Run 2	Run 3
Isokinetic Variation	%	100.1	98.1	104.7
Allowable Isokinetic Range	%	95 - 115	95 - 115	95 - 115
Isokineticity Acceptable	-	Yes	Yes	Yes

Filter Temperatures	Units	Run 1	Run 2	Run 3
Maximum Filter Temperature	°C	180	180	180

Impingers Exit Temperature	Units	Run 1	Run 2	Run 3
Maximum Temperature Recorded	°C	10	10	11
Maximum Allowable Temperature	°C	30	30	30
Exit Temperature Acceptable	-	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

CADMIUM & THALLIUM: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	20.0
Pre-Sampling Leak Rate	l/min	0.20
Post-Sampling Leak Rate	l/min	N/A
Allowable Leak Rate	l/min	0.40
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m^3	0.0
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	2	3
There are no deviations associated with the sampling employed.	wx	wx	wx

CADMIUM & THALLIUM: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value: Symbol	Run 1	Run 2	Run 3	Standard uncertainty: Symbol	Units	Run 1	Run 2	Run 3
Sampled Volume (Actual)	V_m	1.7000	1.6800	1.8600	uV_m	m^3	0.0340	0.0336	0.0372
Sampled Gas Temperature	T_m	310.1	315.8	316.4	uT_m	K	2.00	2.00	2.00
Sampled Gas Pressure	ρ_m	101.4	101.4	101.4	$u\rho_m$	kPa	0.50	0.50	0.50
Sampled Gas Humidity	H_m	0.00	0.00	0.00	uH_m	% v/v	1.00	1.00	1.00
Leak	L	0.73	0.74	0.34	uL	%	-	-	-
Laboratory Result	L_r	7.60	7.60	7.60	uL_r	%	-	-	-

Measured Quantities	Uncertainty as a Percentage: Units	Run 1	Run 2	Run 3	Requirement of Standard
Sampled Volume (Actual)	%	2.00	2.00	2.00	≤2%
Sampled Gas Temperature	%	0.65	0.63	0.63	≤1%
Sampled Gas Pressure	%	0.49	0.49	0.49	≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00	≤1%
Leak	%	0.73	0.74	0.34	≤2%
Laboratory Result	%	7.60	7.60	7.60	No Requirement

Measured Quantities	Uncertainty in Measurement Units: Symbol	Units	Run 1	Run 2	Run 3	Sensitivity Coefficient: Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	m^3	1.4496	1.4062	1.5540	0.01	0.00	0.00
Leak	L	mg/m^3	0.000	0.000	0.000	1.00	1.00	1.00
Laboratory Result	L_r	mg/m^3	0.001	0.000	0.000	1.00	1.00	1.00

Measured Quantities	Uncertainty in Result: Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	mg/m^3	0.000	0.000	0.000
Leak	mg/m^3	0.0000	0.0000	0.0000
Laboratory Result	mg/m^3	0.0008	0.0002	0.0001

Measured Quantities	Oxygen Correction Part of MU Budget: Units	Run 1	Run 2	Run 3
O_2 Correction Factor	-	0.99	0.98	0.99
Stack Gas O_2 Content	% v/v	9.85	9.76	9.87
MU for O_2 Correction	-	0.04	0.04	0.04
Overall MU For O_2 Measurement	%	4.49	4.45	4.49

Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	mg/m^3	0.0008	0.0002	0.0001
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.0016	0.0004	0.0003
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	0.0017	0.0004	0.0003
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.0017	0.0004	0.0003
Reported Uncertainty	mg/m^3	0.0017	0.0004	0.0003
Expanded uncertainty (95% confidence), without Oxygen Correction	%	15.8	15.8	15.8
Expanded uncertainty (95% confidence), with Oxygen Correction	%	16.4	16.5	16.4
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	16.4	16.5	16.4
Reported Uncertainty	%	16.4	16.5	16.4

HEAVY METALS: RESULTS SUMMARY

Irish Cement Ltd, County Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	mg/m³	0.012	0.010	0.015		0.012
Uncertainty	±mg/m³	0.0024	0.0020	0.0029		0.0024
Mass Emission	g/hr	3.0	2.5	3.7		3.1
Uncertainty	±g/hr	0.63	0.52	0.78		0.64

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	10.9	9.7	9.3		10.0
Uncertainty	±% v/v	0.59	0.53	0.50		0.54

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 0.0036		< 0.0036

General Sampling Information

Parameter	Value	
Standard	EN 14385	
Technical Procedure	MD 006	
Name of Analytical Laboratory	EET	
Analytical Laboratory's Procedure	CAT-AP-07	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	27/07/2023	
Probe Material	Titanium	
Filter Housing Material	Titanium	
Impinger Material	Borosilicate Glass	
Absorption Solution	Nitric Peroxide	
Positioning of Filter	Out Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	2 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	20 / 20	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10 - B1, B2, B3, B4, B5, B6, B7, B8, B9, B10	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

HEAVY METALS: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	Run 2	Run 3
Absolute pressure of stack gas, P_s				
Barometric pressure, P_b	mmHg	759.8	759.8	759.8
Stack static pressure, P_{static}	mmH_2O	11.9	11.9	11.9
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	760.7	760.7	760.7
Volume of water vapour collected, V_{wstd}				
Total mass collected in impingers (liquid trap)	g	132.0	113.5	119.8
Total mass collected in impingers (silica trap)	g	10.2	8.2	7.6
Total mass of liquid collected, V_{lc}	g	142.2	121.7	127.4
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.1772	0.1516	0.1587
Volume of gas metered dry, V_{mstd}				
Volume of gas sample through gas meter, V_m	m^3	1.7000	1.6800	1.8600
Gas meter correction factor, Y_d	-	0.9610	0.9610	0.9610
Average dry gas meter temperature, T_m	°C	37.1	42.8	43.4
Average pressure drop across orifice, ΔH	mmH_2O	82.9	81.1	81.5
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	1.4496	1.4062	1.5540
Moisture content, B_{wo} & R_{wv}				
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.1089	0.0973	0.0927
B_{wo} as a percentage	% v/v	10.89	9.73	9.27
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	10.89	9.73	9.27
Volume of gas metered wet, V_{mstw}				
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	1.6268	1.5579	1.7128
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$				
IED & Incinerates Hazardous Material? (Yes = no positive O_2 correction)	-	No	No	No
% wet oxygen measured in gas stream, $ACT\%O_{2w}$	% v/v	7.47	7.40	7.49
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	9.85	9.76	9.87
% oxygen reference condition, $REF\%O_2$	% v/v	10.00	10.00	10.00
O_2 Reference Factor wet $(O_{2REFw}) = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$	-	0.81	0.81	0.81
O_2 Reference Factor dry $(O_{2REFd}) = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$	-	0.99	0.98	0.99
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	2.0004	1.9257	2.1039
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	1.4691	1.4371	1.5722
Molecular weight of dry gas stream, M_d				
CO_2	% v/v	20.00	20.00	9.00
O_2	% v/v	9.85	9.76	9.87
Total	% v/v	29.85	29.76	18.87
N_2	% v/v	70.15	70.24	81.13
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	31.59	31.59	29.83
Molecular weight of stack gas (wet), M_s				
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	30.11	30.27	28.74
Velocity of stack gas, V_s				
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97
Velocity pressure coefficient, C_p	-	0.84	0.84	0.84
Average of velocity heads, ΔP_{avg}	mmH_2O	37.70	37.00	37.05
Average square root of velocity heads, $\sqrt{\Delta P}$	$\sqrt{mmH_2O}$	6.14	6.08	6.09
Average stack gas temperature, T_s	°C	148.5	158.2	155.6
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{(M_s)(P_s)})$	m/s	24.46	24.45	25.03
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})				
Area of stack, A_s	m^2	5.31	5.31	5.31
$Q_a = (60)(A_s)(V_s)$	m^3/min	7794.3	7790.1	7975.9
Conversion factor (K/mm.Hg), C_f	-	0.3592	0.3592	0.3592
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	5053.3	4936.9	5085.4
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	4502.9	4456.4	4614.1
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	6213.9	6102.7	6246.6
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	4563.5	4554.3	4668.1
Percent isokinetic, %I				
Nozzle diameter, D_n	mm	6.02	6.02	6.02
Nozzle area, A_n	mm^2	28.47	28.47	28.47
Total sampling time, q	min	60	60	60
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	100.1	98.1	104.7

HEAVY METALS: SAMPLING DETAILS

(PAGE 1 OF 5)

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	06:00 - 07:05	07:15 - 08:20	09:50 - 10:55
Sampling Dates	-	20/07/2023	20/07/2023	20/07/2023
Sampling Device	-	ISO	ISO	ISO
Volume Sampled (REF)	m³	1.4691	1.4371	1.5722
Arsenic				
Mass on Filter / in Rinse	µg	0.57	< 0.50	< 0.50
Mass in Front Impingers	µg	< 0.10	< 0.09	< 0.10
Mass in Back Impinger	µg	< 0.03	< 0.04	< 0.03
Total Mass Collected	µg	0.70	< 0.63	< 0.63
Calculated Concentration	mg/m³	0.00048	< 0.00044	< 0.00040
Reported Concentration	mg/m³	0.00048	< 0.00044	< 0.00040
Mass Emission	g/hr	0.12	< 0.11	< 0.10
Cobalt				
Mass on Filter / in Rinse	µg	< 0.50	0.50	< 0.50
Mass in Front Impingers	µg	< 0.07	< 0.06	< 0.06
Mass in Back Impinger	µg	< 0.02	< 0.03	< 0.02
Total Mass Collected	µg	< 0.59	0.59	< 0.59
Calculated Concentration	mg/m³	< 0.00040	0.00041	< 0.00037
Reported Concentration	mg/m³	< 0.00040	0.00041	< 0.00038
Mass Emission	g/hr	< 0.10	0.10	< 0.10
Chromium				
Mass on Filter / in Rinse	µg	4.12	0.60	< 0.60
Mass in Front Impingers	µg	2.82	6.39	14.69
Mass in Back Impinger	µg	1.62	1.21	1.50
Total Mass Collected	µg	8.56	8.21	16.78
Calculated Concentration	mg/m³	0.0058	0.0057	0.011
Reported Concentration	mg/m³	0.0058	0.0057	0.011
Mass Emission	g/hr	1.47	1.44	2.70
Copper				
Mass on Filter / in Rinse	µg	0.88	0.60	< 0.60
Mass in Front Impingers	µg	< 0.13	< 0.12	0.38
Mass in Back Impinger	µg	0.23	0.20	0.24
Total Mass Collected	µg	1.24	0.92	1.22
Calculated Concentration	mg/m³	0.00085	0.00064	0.00078
Reported Concentration	mg/m³	0.00085	0.00064	0.00078
Mass Emission	g/hr	0.21	0.16	0.20
Manganese				
Mass on Filter / in Rinse	µg	1.98	0.40	< 0.40
Mass in Front Impingers	µg	0.92	0.95	0.73
Mass in Back Impinger	µg	< 0.02	0.03	0.06
Total Mass Collected	µg	2.93	1.38	1.19
Calculated Concentration	mg/m³	0.0020	0.0010	0.00076
Reported Concentration	mg/m³	0.0020	0.0010	0.00076
Mass Emission	g/hr	0.50	0.24	0.19

HEAVY METALS: SAMPLING DETAILS

(PAGE 2 OF 5)

Sample Runs (continued)

Parameter	Units	Run 1	Run 2	Run 3
Nickel				
Mass on Filter / in Rinse	µg	0.92	0.60	< 0.60
Mass in Front Impingers	µg	< 0.07	< 0.06	< 0.06
Mass in Back Impinger	µg	< 0.02	< 0.03	0.04
Total Mass Collected	µg	1.01	0.69	0.70
Calculated Concentration	mg/m³	0.00069	0.00048	0.00045
Reported Concentration	mg/m³	0.00069	0.00048	0.00045
Mass Emission	g/hr	0.17	0.12	0.11
Lead				
Mass on Filter / in Rinse	µg	1.13	0.50	< 0.50
Mass in Front Impingers	µg	< 0.07	< 0.06	0.16
Mass in Back Impinger	µg	0.03	0.03	0.11
Total Mass Collected	µg	1.23	0.59	0.77
Calculated Concentration	mg/m³	0.00084	0.00041	0.00049
Reported Concentration	mg/m³	0.00084	0.00041	0.00049
Mass Emission	g/hr	0.21	0.10	0.12
Antimony				
Mass on Filter / in Rinse	µg	0.60	0.60	< 0.60
Mass in Front Impingers	µg	< 0.07	< 0.06	< 0.06
Mass in Back Impinger	µg	< 0.02	< 0.03	< 0.02
Total Mass Collected	µg	0.69	0.69	< 0.69
Calculated Concentration	mg/m³	0.00047	0.00048	< 0.00044
Reported Concentration	mg/m³	0.00047	0.00048	< 0.00044
Mass Emission	g/hr	0.12	0.12	< 0.11
Vanadium				
Mass on Filter / in Rinse	µg	< 0.40	0.40	< 0.40
Mass in Front Impingers	µg	< 0.03	0.06	0.06
Mass in Back Impinger	µg	0.01	0.03	0.02
Total Mass Collected	µg	0.44	0.48	0.48
Calculated Concentration	mg/m³	0.00030	0.00034	0.00030
Reported Concentration	mg/m³	0.00030	0.00034	0.00030
Mass Emission	g/hr	0.077	0.085	0.077

HEAVY METALS: SAMPLING DETAILS

Sample Runs (continued)

Heavy Metals Combined					
Total Mass Collected	µg	17.4	14.2	23.1	
Calculated Concentration	mg/m³	0.012	0.010	0.015	
Reported Concentration	mg/m³	0.012	0.010	0.015	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	**Units**	**Blank 1**
Blank Dates	-	20/07/2023
Average Volume Sampled (REF)	m³	1.4928
Arsenic		
Mass on Filter / in Rinse	µg	< 0.50
Mass in Front Impingers	µg	< 0.06
Mass in Back Impinger	µg	< 0.03
Total Mass Collected	µg	< 0.60
Calculated Concentration	mg/m³	< 0.00040
Reported Concentration	mg/m³	< 0.00040
Cobalt		
Mass on Filter / in Rinse	µg	< 0.50
Mass in Front Impingers	µg	< 0.04
Mass in Back Impinger	µg	< 0.02
Total Mass Collected	µg	< 0.56
Calculated Concentration	mg/m³	< 0.00038
Reported Concentration	mg/m³	< 0.00038

HEAVY METALS: SAMPLING DETAILS

(PAGE 4 OF 5)

Blank Runs (continued)

Parameter	Units	Blank 1
Chromium		
Mass on Filter / in Rinse	µg	< 0.60
Mass in Front Impingers	µg	< 0.02
Mass in Back Impinger	µg	< 0.01
Total Mass Collected	µg	< 0.63
Calculated Concentration	mg/m³	< 0.00042
Reported Concentration	mg/m³	< 0.00042
Copper		
Mass on Filter / in Rinse	µg	< 0.60
Mass in Front Impingers	µg	< 0.08
Mass in Back Impinger	µg	< 0.04
Total Mass Collected	µg	< 0.73
Calculated Concentration	mg/m³	< 0.00049
Reported Concentration	mg/m³	< 0.00049
Manganese		
Mass on Filter / in Rinse	µg	< 0.40
Mass in Front Impingers	µg	< 0.04
Mass in Back Impinger	µg	< 0.02
Total Mass Collected	µg	< 0.46
Calculated Concentration	mg/m³	< 0.00031
Reported Concentration	mg/m³	< 0.00031
Nickel		
Mass on Filter / in Rinse	µg	< 0.60
Mass in Front Impingers	µg	< 0.04
Mass in Back Impinger	µg	< 0.02
Total Mass Collected	µg	< 0.66
Calculated Concentration	mg/m³	< 0.00044
Reported Concentration	mg/m³	< 0.00044
Lead		
Mass on Filter / in Rinse	µg	< 0.50
Mass in Front Impingers	µg	< 0.04
Mass in Back Impinger	µg	< 0.02
Total Mass Collected	µg	< 0.56
Calculated Concentration	mg/m³	< 0.00038
Reported Concentration	mg/m³	< 0.00038
Antimony		
Mass on Filter / in Rinse	µg	< 0.60
Mass in Front Impingers	µg	< 0.04
Mass in Back Impinger	µg	< 0.02
Total Mass Collected	µg	< 0.66
Calculated Concentration	mg/m³	< 0.00044
Reported Concentration	mg/m³	< 0.00044
Vanadium		
Mass on Filter / in Rinse	µg	< 0.40
Mass in Front Impingers	µg	< 0.02
Mass in Back Impinger	µg	< 0.01
Total Mass Collected	µg	< 0.43
Calculated Concentration	mg/m³	< 0.00029
Reported Concentration	mg/m³	< 0.00029

HEAVY METALS: SAMPLING DETAILS

(PAGE 5 OF 5)

Blank Runs (continued)

Heavy Metals Combined			
Total Mass Collected	µg	5.30	
Calculated Concentration	mg/m³	< 0.0036	
Reported Concentration	mg/m³	< 0.0036	

HEAVY METALS: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	27.2	26.9	29.8
Pre-Sampling Leak Rate	l/min	0.20	0.20	0.10
Post-Sampling Leak Rate	l/min	N/A	N/A	N/A
Allowable Leak Rate	l/min	0.40	0.40	0.40
Leak Test Acceptable	-	Yes	Yes	Yes

Absorption Efficiency	Units	Run 1	Run 2	Run 3
Arsenic	%	100.0	100.0	100.0
Cobalt	%	100.0	100.0	100.0
Chromium	%	81.1	85.2	91.1
Copper	%	81.4	78.7	80.1
Manganese	%	100.0	98.1	95.0
Nickel	%	100.0	100.0	94.8
Lead	%	97.3	95.1	85.6
Antimony	%	100.0	100.0	100.0
Vanadium	%	97.3	94.0	96.2
Allowable Absorption Efficiency	%	N/A	N/A	N/A
Absorption Efficiency Acceptable	-	Yes	Yes	Yes

Where the emissions are < 30% of the ELV, MID 14385 does not require the absorption efficiency requirement to be applied

Detection Limit	Units	Run 1	Run 2	Run 3
Arsenic	µg/m³	0.43	0.44	0.40
Cobalt	µg/m³	0.40	0.41	0.37
Chromium	µg/m³	0.44	0.45	0.41
Copper	µg/m³	0.53	0.54	0.49
Manganese	µg/m³	0.33	0.34	0.31
Nickel	µg/m³	0.47	0.48	0.44
Lead	µg/m³	0.40	0.41	0.37
Antimony	µg/m³	0.47	0.48	0.44
Vanadium	µg/m³	0.30	0.31	0.28
Allowable Detection Limit	µg/m³	5.0	5.0	5.0
Detection Limit Acceptable	-	Yes	Yes	Yes

Water Droplets	Units	Run 1	Run 2	Run 3
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Measurement Uncertainty (MU)	%	5.4	5.5	5.4
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

HEAVY METALS: QUALITY ASSURANCE

(PAGE 2 OF 2)

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Less than 50% Faded	%	Yes	Yes	Yes

Isokinetic Criterion Compliance	Units	Run 1	Run 2	Run 3
Isokinetic Variation	%	100.1	98.1	104.7
Allowable Isokinetic Range	%	95 - 115	95 - 115	95 - 115
Isokineticity Acceptable	-	Yes	Yes	Yes

Filter Temperatures	Units	Run 1	Run 2	Run 3
Maximum Filter Temperature	°C	180	180	180

Impingers Exit Temperature	Units	Run 1	Run 2	Run 3
Maximum Temperature Recorded	°C	10	10	11
Maximum Allowable Temperature	°C	30	30	30
Exit Temperature Acceptable	-	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	20.0
Pre-Sampling Leak Rate	l/min	0.20
Post-Sampling Leak Rate	l/min	N/A
Allowable Leak Rate	l/min	0.40
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m^3	0.0500
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	2	3
There are no deviations associated with the sampling employed.	wx	wx	wx

HEAVY METALS: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value				Standard uncertainty				
Measured Quantities	Symbol	Run 1	Run 2	Run 3	Symbol	Units	Run 1	Run 2	Run 3
Sampled Volume (Actual)	V_m	1.7000	1.6800	1.8600	uV_m	m^3	0.0340	0.0336	0.0372
Sampled Gas Temperature	T_m	310.1	315.8	316.4	uT_m	K	2.00	2.00	2.00
Sampled Gas Pressure	ρ_m	101.4	101.4	101.4	$u\rho_m$	kPa	0.50	0.50	0.50
Sampled Gas Humidity	H_m	0.00	0.00	0.00	uH_m	% v/v	1.00	1.00	1.00
Leak	L	0.73	0.74	0.34	uL	%	-	-	-
Laboratory Result	L_r	9.60	9.60	9.60	uL_r	%	-	-	-

	Uncertainty as a Percentage				
Measured Quantities	Units	Run 1	Run 2	Run 3	Requirement of Standard
Sampled Volume (Actual)	%	2.00	2.00	2.00	≤2%
Sampled Gas Temperature	%	0.65	0.63	0.63	≤1%
Sampled Gas Pressure	%	0.49	0.49	0.49	≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00	≤1%
Leak	%	0.73	0.74	0.34	≤2%
Laboratory Result	%	9.60	9.60	9.60	No Requirement

	Uncertainty in Measurement Units					Sensitivity Coefficient		
Measured Quantities	Symbol	Units	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	m^3	1.4496	1.4062	1.5540	0.01	0.01	0.01
Leak	L	mg/m^3	0.000	0.000	0.000	1.00	1.00	1.00
Laboratory Result	L_r	mg/m^3	0.001	0.001	0.001	1.00	1.00	1.00

	Uncertainty in Result			
Measured Quantities	Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	mg/m^3	0.000	0.000	0.000
Leak	mg/m^3	0.0001	0.0000	0.0000
Laboratory Result	mg/m^3	0.0011	0.0009	0.0014

	Oxygen Correction Part of MU Budget			
Measured Quantities	Units	Run 1	Run 2	Run 3
O_2 Correction Factor	-	0.99	0.98	0.99
Stack Gas O_2 Content	% v/v	9.85	9.76	9.87
MU for O_2 Correction	-	0.04	0.04	0.04
Overall MU For O_2 Measurement	%	4.49	4.45	4.49

Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	mg/m^3	0.0012	0.0010	0.0015
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.0023	0.0019	0.0029
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	0.0024	0.0020	0.0029
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.0024	0.0020	0.0029
Reported Uncertainty	mg/m^3	0.0024	0.0020	0.0029
Expanded uncertainty (95% confidence), without Oxygen Correction	%	19.6	19.6	19.6
Expanded uncertainty (95% confidence), with Oxygen Correction	%	20.1	20.1	20.1
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	20.1	20.1	20.1
Reported Uncertainty	%	20.1	20.1	20.1

APPENDIX 2

MERCURY: RESULTS SUMMARY

Irish Cement Ltd, County Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	mg/m³	0.0114	0.0149	0.0118		0.0127
Uncertainty	±mg/m³	0.0027	0.0035	0.0028		0.0030
Mass Emission	g/hr	3.1	4.0	3.2		3.4
Uncertainty	±g/hr	0.75	0.98	0.78		0.84

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	9.6	10.2	10.3		10.0
Uncertainty	±% v/v	0.51	0.55	0.56		0.54

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 0.00013		< 0.00013

General Sampling Information

Parameter	Value	
Standard	EN 13211	
Technical Procedure	MD 006	
Name of Analytical Laboratory	EET	
Analytical Laboratory's Procedure	CAT-AP-08	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	31/07/2023	
Probe Material	Titanium	
Filter Housing Material	Titanium	
Impinger Material	Borosilicate Glass	
Absorption Solution	Potassium Dichromate	
Positioning of Filter	Out Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	2 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	20 / 20	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10 - B1, B2, B3, B4, B5, B6, B7, B8, B9, B10	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

MERCURY: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	Run 2	Run 3
Absolute pressure of stack gas, P_s				
Barometric pressure, P_b	mmHg	759.8	759.8	759.8
Stack static pressure, P_{static}	mmH_2O	18.0	18.0	11.9
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	761.1	761.1	760.7
Volume of water vapour collected, V_{wstd}				
Total mass collected in impingers (liquid trap)	g	114.2	124.4	123.9
Total mass collected in impingers (silica trap)	g	6.3	8.3	7.2
Total mass of liquid collected, V_{lc}	g	120.5	132.7	131.1
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.1501	0.1653	0.1634
Volume of gas metered dry, V_{mstd}				
Volume of gas sample through gas meter, V_m	m^3	1.6600	1.7200	1.7000
Gas meter correction factor, Y_d	-	0.9610	0.9610	0.9610
Average dry gas meter temperature, T_m	°C	38.0	39.6	43.0
Average pressure drop across orifice, ΔH	mmH_2O	80.9	81.8	83.3
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	1.4112	1.4548	1.4224
Moisture content, B_{wo} & R_{wv}				
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.0962	0.1021	0.1030
B_{wo} as a percentage	% v/v	9.62	10.21	10.30
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	9.62	10.21	10.30
Volume of gas metered wet, V_{mstw}				
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	1.5613	1.6201	1.5857
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$				
IED & Incinerates Hazardous Material? (Yes = no positive O_2 correction)	-	No	No	No
% wet oxygen measured in gas stream, $ACT\%O_{2w}$	% v/v	7.54	7.42	7.48
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	9.93	9.78	9.86
% oxygen reference condition, $REF\%O_2$	% v/v	10.00	10.00	10.00
O_2 Reference Factor wet $(O_{2REFw}) = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$	-	0.82	0.81	0.81
O_2 Reference Factor dry $(O_{2REFd}) = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$	-	0.99	0.98	0.99
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	1.9111	2.0005	1.9490
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	1.4197	1.4841	1.4404
Molecular weight of dry gas stream, M_d				
CO_2	% v/v	20.00	20.00	20.00
O_2	% v/v	9.93	9.78	9.86
Total	% v/v	29.93	29.78	29.86
N_2	% v/v	70.07	70.22	70.14
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	31.60	31.59	31.59
Molecular weight of stack gas (wet), M_s				
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	30.29	30.20	30.19
Velocity of stack gas, V_s				
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97
Velocity pressure coefficient, C_p	-	0.84	0.84	0.84
Average of velocity heads, ΔP_{avg}	mmH_2O	37.55	37.20	37.70
Average square root of velocity heads, $\sqrt{\Delta P}$	$\sqrt{mmH_2O}$	6.13	6.10	6.14
Average stack gas temperature, T_s	°C	158.7	152.3	154.5
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{(M_s)(P_s)})$	m/s	24.63	24.37	24.61
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})				
Area of stack, A_s	m^2	5.31	5.31	5.31
$Q_a = (60)(A_s)(V_s)$	m^3/min	7847.6	7763.8	7839.6
Conversion factor (K/mm.Hg), C_f	-	0.3592	0.3592	0.3592
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	4970.0	4990.9	5010.7
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	4492.0	4481.6	4494.6
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	6083.6	6162.6	6158.5
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	4519.3	4571.9	4551.4
Percent isokinetic, %I				
Nozzle diameter, D_n	mm	6.02	6.02	6.02
Nozzle area, A_n	mm^2	28.47	28.47	28.47
Total sampling time, q	min	60	60	60
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	97.7	100.9	98.4

MERCURY: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	11:05 - 12:10	12:20 - 13:25	13:35 - 14:40
Sampling Dates	-	20/07/2023	20/07/2023	20/07/2023
Sampling Device	-	ISO	ISO	ISO
Volume Sampled (REF)	m^3	1.4197	1.4841	1.4404
Mass on Filter / in Rinse	µg	< 0.03	0.04	0.39
Mass in Front Impingers	µg	14.60	20.20	14.75
Mass in Back Impinger	µg	1.57	1.81	1.83
Total Mass Collected	µg	16.21	22.05	16.97
Calculated Concentration	mg/m^3	0.0114	0.0149	0.0118
Reported Concentration	mg/m^3	0.0114	0.0149	0.0118

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	20/07/2023
Average Volume Sampled (REF)	m^3	1.4481
Mass on Filter / in Rinse	µg	< 0.03
Mass in Front Impingers	µg	< 0.10
Mass in Back Impinger	µg	< 0.05
Total Mass Collected	µg	< 0.19
Calculated Concentration	mg/m^3	< 0.00013
Reported Concentration	mg/m^3	< 0.00013

MERCURY: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	26.6	27.5	27.2
Pre-Sampling Leak Rate	l/min	0.02	0.20	0.20
Post-Sampling Leak Rate	l/min	N/A	N/A	N/A
Allowable Leak Rate	l/min	0.40	0.40	0.40
Leak Test Acceptable	-	Yes	Yes	Yes

Absorption Efficiency	Units	Run 1	Run 2	Run 3
Absorption Efficiency	%	90.3	91.8	88.9
Allowable Absorption Efficiency	%	95	95	95
Final Impinger Concentration	µg/m³	1.11	1.22	1.27
Absorption Efficiency Acceptable	-	Yes	Yes	Yes

EN 13211 requirement is to have <5% of the total mercury in all absorbers or <2µg/m^3 in the final impinger

Water Droplets	Units	Run 1	Run 2	Run 3
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Measurement Uncertainty (MU)	%	5.3	5.4	5.5
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Less than 50% Faded	%	Yes	Yes	Yes

Isokinetic Criterion Compliance	Units	Run 1	Run 2	Run 3
Isokinetic Variation	%	97.7	100.9	98.4
Allowable Isokinetic Range	%	95 - 115	95 - 115	95 - 115
Isokineticity Acceptable	-	Yes	Yes	Yes

Filter Temperatures	Units	Run 1	Run 2	Run 3
Maximum Filter Temperature	°C	180	180	180

Impingers Exit Temperature	Units	Run 1	Run 2	Run 3
Maximum Temperature Recorded	°C	10	12	11
Maximum Allowable Temperature	°C	30	30	30
Exit Temperature Acceptable	-	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

MERCURY: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	20.0
Pre-Sampling Leak Rate	l/min	0.20
Post-Sampling Leak Rate	l/min	N/A
Allowable Leak Rate	l/min	0.40
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m^3	0.005
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	2	3
There are no deviations associated with the sampling employed.	wx	wx	wx

MERCURY: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Symbol	Value Run 1	Value Run 2	Value Run 3	Symbol	Units	Standard uncertainty Run 1	Standard uncertainty Run 2	Standard uncertainty Run 3
Sampled Volume (Actual)	V_m	1.6600	1.7200	1.7000	uV_m	m^3	0.0332	0.0344	0.0340
Sampled Gas Temperature	T_m	311.0	312.6	316.0	uT_m	K	2.00	2.00	2.00
Sampled Gas Pressure	ρ_m	101.5	101.5	101.4	$u\rho_m$	kPa	0.50	0.50	0.50
Sampled Gas Humidity	H_m	0.00	0.00	0.00	uH_m	% v/v	1.00	1.00	1.00
Leak	L	0.08	0.73	0.73	uL	%	-	-	-
Laboratory Result	L_r	11.50	11.50	11.50	uL_r	%	-	-	-

Measured Quantities	Units	Uncertainty as a Percentage Run 1	Run 2	Run 3	Requirement of Standard
Sampled Volume (Actual)	%	2.00	2.00	2.00	≤2%
Sampled Gas Temperature	%	0.64	0.64	0.63	≤1%
Sampled Gas Pressure	%	0.49	0.49	0.49	≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00	≤1%
Leak	%	0.08	0.73	0.73	≤2%
Laboratory Result	%	11.50	11.50	11.50	No Requirement

Measured Quantities	Symbol	Units	Uncertainty in Measurement Units Run 1	Run 2	Run 3	Sensitivity Coefficient Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	m^3	1.4112	1.4548	1.4224	0.01	0.01	0.01
Leak	L	mg/m^3	0.0000	0.0001	0.0000	1.00	1.00	1.00
Laboratory Result	L_r	mg/m^3	0.0013	0.0017	0.0014	1.00	1.00	1.00

Measured Quantities	Units	Uncertainty in Result Run 1	Run 2	Run 3
Sampled Volume (STP)	mg/m^3	0.0003	0.0004	0.0003
Leak	mg/m^3	0.0000	0.0001	0.0000
Laboratory Result	mg/m^3	0.0013	0.0017	0.0014

Measured Quantities	Units	Oxygen Correction Part of MU Budget Run 1	Run 2	Run 3
O_2 Correction Factor	-	0.99	0.98	0.99
Stack Gas O_2 Content	% v/v	9.93	9.78	9.86
MU for O_2 Correction	%	0.04	0.04	0.04
Overall MU For O_2 Measurement	%	4.52	4.46	4.49

Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	mg/m^3	0.0013	0.0018	0.0014
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.0026	0.0034	0.0027
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	0.0027	0.0035	0.0028
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.0027	0.0035	0.0028
Reported Uncertainty	mg/m^3	0.0027	0.0035	0.0028
Expanded uncertainty (95% confidence), without Oxygen Correction	%	23.1	23.2	23.2
Expanded uncertainty (95% confidence), with Oxygen Correction	%	23.6	23.6	23.6
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	23.6	23.6	23.6
Reported Uncertainty	%	23.6	23.6	23.6

DIOXINS & FURANS: RESULTS SUMMARY

(PAGE 1 OF 4)

Irish Cement Ltd, County Limerick
A2-01 Kiln 6

TEQ1 - UPPER LIMITS (worst case where <LOD = LOD)

Sample Runs (UPPER NATO I-TEQ)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.0014	0.0016	0.0014		0.0014
Uncertainty	±ng/m³	0.00029	0.00033	0.00028		0.00030
Mass Emission	µg/hr	0.38	0.42	0.37		0.39
Uncertainty	±µg/hr	0.081	0.092	0.080		0.084

Sample Runs (UPPER WHO TEQ Humans / Mammals)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.0017	0.0018	0.0017		0.0017
Uncertainty	±ng/m³	0.00035	0.00038	0.00036		0.00036
Mass Emission	µg/hr	0.46	0.49	0.47		0.47
Uncertainty	±µg/hr	0.10	0.11	0.10		0.10

Sample Runs (UPPER WHO TEQ Fish)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.0019	0.0020	0.0018		0.0019
Uncertainty	±ng/m³	0.00039	0.00041	0.00038		0.00039
Mass Emission	µg/hr	0.50	0.53	0.50		0.51
Uncertainty	±µg/hr	0.11	0.12	0.11		0.11

Sample Runs (UPPER WHO TEQ Birds)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.0030	0.0040	0.0030		0.0033
Uncertainty	±ng/m³	0.00061	0.00084	0.00063		0.00069
Mass Emission	µg/hr	0.80	1.1	0.82		0.90
Uncertainty	±µg/hr	0.17	0.24	0.18		0.20

DIOXINS & FURANS: RESULTS SUMMARY

(PAGE 2 OF 4)

Irish Cement Ltd, County Limerick
A2-01 Kiln 6

TEQ2 - LOWER LIMITS (best case where <LOD = 0)

Sample Runs (LOWER NATO I-TEQ)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.0000091	0.00020	0.0000061		0.000073
Uncertainty	±ng/m³	0.0000019	0.000042	0.0000013		0.000015
Mass Emission	µg/hr	0.0025	0.055	0.0016		0.020
Uncertainty	±µg/hr	0.00053	0.012	0.00036		0.0043

NOTE: Where the maximum Blank concentration is higher than the Sample concentration, the Blank concentration has been reported.

Sample Runs (LOWER WHO TEQ Humans / Mammals)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.0000073	0.00020	0.0000048		0.000071
Uncertainty	±ng/m³	0.0000015	0.000042	0.0000010		0.000015
Mass Emission	µg/hr	0.0020	0.054	0.0013		0.019
Uncertainty	±µg/hr	0.00043	0.012	0.00028		0.0042

NOTE: Where the maximum Blank concentration is higher than the Sample concentration, the Blank concentration has been reported.

Sample Runs (LOWER WHO TEQ Fish)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.0000067	0.00010	0.0000044		0.000037
Uncertainty	±ng/m³	0.0000014	0.000021	0.00000092		0.0000077
Mass Emission	µg/hr	0.0018	0.027	0.0012		0.010
Uncertainty	±µg/hr	0.00040	0.0059	0.00026		0.0022

NOTE: Where the maximum Blank concentration is higher than the Sample concentration, the Blank concentration has been reported.

Sample Runs (LOWER WHO TEQ Birds)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.0000067	0.0020	0.0000044		0.00067
Uncertainty	±ng/m³	0.0000014	0.00042	0.00000092		0.00014
Mass Emission	µg/hr	0.0018	0.54	0.0012		0.18
Uncertainty	±µg/hr	0.00040	0.12	0.00026		0.039

NOTE: Where the maximum Blank concentration is higher than the Sample concentration, the Blank concentration has been reported.

DIOXINS & FURANS: RESULTS SUMMARY

(PAGE 3 OF 4)

Irish Cement Ltd, County Limerick
A2-01 Kiln 6

TEQ1 - UPPER LIMITS (worst case where <LOD = LOD)

Blank Runs (UPPER NATO I-TEQ)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m^3	0.00081	0.00081

Blank Runs (UPPER WHO TEQ Humans / Mammals)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m^3	0.0011	0.0011

Blank Runs (UPPER WHO TEQ Fish)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m^3	0.0012	0.0012

Blank Runs (UPPER WHO TEQ Birds)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m^3	0.0015	0.0015

TEQ2 - LOWER LIMITS (best case where <LOD = 0)

Blank Runs (LOWER NATO I-TEQ)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m^3	0.0000061	0.0000061

Blank Runs (LOWER WHO TEQ Humans / Mammals)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m^3	0.0000048	0.0000048

Blank Runs (LOWER WHO TEQ Fish)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m^3	0.0000044	0.0000044

Blank Runs (LOWER WHO TEQ Birds)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m^3	0.0000044	0.0000044

DIOXINS & FURANS: RESULTS SUMMARY

(PAGE 4 OF 4)

Irish Cement Ltd, County Limerick
A2-01 Kiln 6

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	11.7	9.0	9.3		10.0
Uncertainty	±% v/v	0.64	0.49	0.51		0.55

General Sampling Information

Parameter	Value	
Standard	EN 1948	
Technical Procedure	MD 007	
Name of Analytical Laboratory	ELD	
Analytical Laboratory's Procedure	PM137, TM201	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	08/08/2023	
Probe Material	Titanium	
Filter Housing Material	Titanium	
Glassware Material	Borosilicate Glass	
Absorption Material	XAD-2	
Positioning of Filter	Out Stack	
Filter Size and Material	90mm Quartz Fibre	
Number of Sampling Lines Used	2 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	20 / 20	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10 - B1, B2, B3, B4, B5, B6, B7, B8, B9, B10	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

DIOXINS & FURANS: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	Run 2	Run 3
Absolute pressure of stack gas, P_s				
Barometric pressure, P_b	mmHg	755.3	759.8	759.8
Stack static pressure, P_{static}	mmH_2O	11.9	11.9	11.9
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	756.2	760.7	760.7
Volume of water vapour collected, V_{wstd}				
Total mass collected in impingers (liquid trap)	g	792.7	692.3	719.4
Total mass collected in impingers (silica trap)	g	37.0	9.6	10.1
Total mass of liquid collected, V_{lc}	g	829.7	701.9	729.5
$V_{wstd} = (0.001246)(V_{lc})$	m^3	1.0338	0.8746	0.9090
Volume of gas metered dry, V_{mstd}				
Volume of gas sample through gas meter, V_m	m^3	9.2220	10.6500	10.7190
Gas meter correction factor, Y_d	-	0.9610	0.9610	0.9610
Average dry gas meter temperature, T_m	°C	37.6	44.0	47.1
Average pressure drop across orifice, ΔH	mmH_2O	68.6	85.7	87.1
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	7.7923	8.8854	8.8569
Moisture content, B_{wo} & R_{wv}				
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.1171	0.0896	0.0931
B_{wo} as a percentage	% v/v	11.71	8.96	9.31
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	11.71	8.96	9.31
Volume of gas metered wet, V_{mstw}				
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	8.8261	9.7600	9.7658
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$				
IED & Incinerates Hazardous Material? (Yes = no positive O_2 correction)	-	No	No	No
% wet oxygen measured in gas stream, $ACT\%O_{2w}$	% v/v	10.54	8.83	8.82
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	9.56	9.79	9.78
% oxygen reference condition, $REF\%O_2$	% v/v	10.00	10.00	10.00
O_2 Reference Factor wet $(O_{2REFw}) = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$	-	1.05	0.90	0.90
O_2 Reference Factor dry $(O_{2REFd}) = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$	-	0.96	0.98	0.98
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	8.3938	10.7987	10.8175
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	8.1017	9.0539	9.0371
Molecular weight of dry gas stream, M_d				
CO_2	% v/v	20.00	20.00	20.00
O_2	% v/v	9.56	9.79	9.78
Total	% v/v	29.56	29.79	29.78
N_2	% v/v	70.44	70.21	70.22
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	31.58	31.59	31.59
Molecular weight of stack gas (wet), M_s				
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	29.99	30.37	30.33
Velocity of stack gas, V_s				
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97
Velocity pressure coefficient, C_p	-	0.84	0.84	0.84
Average of velocity heads, ΔP_{avg}	mmH_2O	30.98	38.83	39.10
Average square root of velocity heads, $\sqrt{\Delta P}$	$\sqrt{mmH_2O}$	5.57	6.23	6.25
Average stack gas temperature, T_s	°C	146.3	156.5	156.6
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{(M_s)(P_s)})$	m/s	22.23	24.96	25.07
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})				
Area of stack, A_s	m^2	5.31	5.31	5.31
$Q_a = (60)(A_s)(V_s)$	m^3/min	7082.0	7950.9	7986.0
Conversion factor (K/mm.Hg), C_f	-	0.3592	0.3592	0.3592
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	4588.0	5057.9	5079.3
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	4050.6	4604.7	4606.6
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	4363.3	5596.2	5626.3
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	4211.5	4692.0	4700.3
Percent isokinetic, %I				
Nozzle diameter, D_n	mm	6.02	6.02	6.02
Nozzle area, A_n	mm^2	28.47	28.47	28.47
Total sampling time, q	min	360	360	360
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	99.7	100.0	99.6

DIOXINS & FURANS: SAMPLING DETAILS

RUN 1

Parameter	Units	Value
Sampling Times	-	10:00 - 16:10
Sampling Dates	-	18/07/2023
Sampling Device	-	ISO
Volume Sampled (REF)	m^3	8.1017

Where: ISO stands for Manual Isokinetic Sampling Train

				NATO I-TEQ		WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
2378-TCDD	ng	ND	0.00255	0.0026	0.0000	0.0026	0.0000	0.0026	0.0000	0.0026	0.0000	115
12378-PeCDD	ng	ND	0.00708	0.0035	0.0000	0.0071	0.0000	0.0071	0.0000	0.0071	0.0000	96
123478-HxCDD	ng	ND	0.00330	0.0003	0.0000	0.0003	0.0000	0.0017	0.0000	0.0002	0.0000	75
123678-HxCDD	ng	ND	0.00331	0.0003	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	73
123789-HxCDD	ng	ND	0.00341	0.0003	0.0000	0.0003	0.0000	0.0000	0.0000	0.0003	0.0000	-
1234678-HPeCDD	ng	ND	0.00208	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	73
OCDD	ng	0.0178	0.00369	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	92
Total Dioxins	ng	0.0178	-	0.0071	0.0000	0.0107	0.0000	0.0114	0.0000	0.0102	0.0000	-
2378-TCDF	ng	ND	0.00809	0.0008	0.0000	0.0008	0.0000	0.0004	0.0000	0.0081	0.0000	80
12378-PeCDF	ng	ND	0.00423	0.0002	0.0000	0.0001	0.0000	0.0002	0.0000	0.0004	0.0000	99
23478-PeCDF	ng	ND	0.00434	0.0022	0.0000	0.0013	0.0000	0.0022	0.0000	0.0043	0.0000	82
123478-HxCDF	ng	ND	0.00187	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	76
123678-HxCDF	ng	ND	0.00178	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	73
234678-HxCDF	ng	ND	0.00234	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	65
123789-HxCDF	ng	ND	0.00260	0.0003	0.0000	0.0003	0.0000	0.0003	0.0000	0.0003	0.0000	102
1234678-HPeCDF	ng	0.0053	0.00147	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	71
1234789-HPeCDF	ng	ND	0.00168	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	96
OCDF	ng	0.0036	0.00236	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	82
Total Furans	ng	0.0088	-	0.0041	0.0001	0.0032	0.0001	0.0037	0.0001	0.0138	0.0001	-
Totals	ng	0.0266	-	0.0113	0.0001	0.0138	0.0001	0.0151	0.0001	0.0240	0.0001	-
Total Concentration	ng/m^3	-	-	0.0014	0.0000	0.0017	0.0000	0.0019	0.0000	0.0030	0.0000	-
Limit of Detection	ng/m^3	-	-	0.0014	-	0.0017	-	0.0019	-	0.0030	-	-

Where: ND stands for Non Detected

DL stands for Analytical Detection Limit

TEQ1 refers to Non Detected Congeners at the Detection Limit

TEQ2 refers to Non Detected Congeners at Zero

% Rec stands for the Recovery Percentage of the Sample

DIOXINS & FURANS: SAMPLING DETAILS

(Continued)

RUN 2

Parameter	Units	Value
Sampling Times	-	07:15 - 13:20
Sampling Dates	-	19/07/2023
Sampling Device	-	ISO
Volume Sampled (REF)	m^3	9.0539

Where: ISO stands for Manual Isokinetic Sampling Train

				NATO I-TEQ		WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
2378-TCDD	ng	ND	0.00358	0.0036	0.0000	0.0036	0.0000	0.0036	0.0000	0.0036	0.0000	103
12378-PeCDD	ng	ND	0.00693	0.0035	0.0000	0.0069	0.0000	0.0069	0.0000	0.0069	0.0000	93
123478-HxCDD	ng	ND	0.00445	0.0004	0.0000	0.0004	0.0000	0.0022	0.0000	0.0002	0.0000	75
123678-HxCDD	ng	ND	0.00397	0.0004	0.0000	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	78
123789-HxCDD	ng	ND	0.00409	0.0004	0.0000	0.0004	0.0000	0.0000	0.0000	0.0004	0.0000	-
1234678-HPeCDD	ng	ND	0.00151	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	80
OCDD	ng	0.0205	0.00344	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	95
Total Dioxins	ng	0.0205	-	0.0083	0.0000	0.0118	0.0000	0.0128	0.0000	0.0112	0.0000	-
2378-TCDF	ng	0.0181	0.01138	0.0018	0.0018	0.0018	0.0018	0.0009	0.0009	0.0181	0.0181	75
12378-PeCDF	ng	ND	0.00544	0.0003	0.0000	0.0002	0.0000	0.0003	0.0000	0.0005	0.0000	93
23478-PeCDF	ng	ND	0.00558	0.0028	0.0000	0.0017	0.0000	0.0028	0.0000	0.0056	0.0000	78
123478-HxCDF	ng	ND	0.00210	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	76
123678-HxCDF	ng	ND	0.00200	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	74
234678-HxCDF	ng	ND	0.00254	0.0003	0.0000	0.0003	0.0000	0.0003	0.0000	0.0003	0.0000	67
123789-HxCDF	ng	ND	0.00282	0.0003	0.0000	0.0003	0.0000	0.0003	0.0000	0.0003	0.0000	101
1234678-HPeCDF	ng	ND	0.00128	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	73
1234789-HPeCDF	ng	ND	0.00146	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	92
OCDF	ng	0.0058	0.00306	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	80
Total Furans	ng	0.0238	-	0.0058	0.0018	0.0046	0.0018	0.0049	0.0009	0.0252	0.0181	-
Totals	ng	0.0443	-	0.0142	0.0018	0.0164	0.0018	0.0178	0.0009	0.0364	0.0181	-
Total Concentration	ng/m^3	-	-	0.0016	0.0002	0.0018	0.0002	0.0020	0.0001	0.0040	0.0020	-
Limit of Detection	ng/m^3	-	-	0.0015	-	0.0017	-	0.0019	-	0.0033	-	-

Where: ND stands for Non Detected

DL stands for Analytical Detection Limit

TEQ1 refers to Non Detected Congeners at the Detection Limit

TEQ2 refers to Non Detected Congeners at Zero

% Rec stands for the Recovery Percentage of the Sample

DIOXINS & FURANS: SAMPLING DETAILS

(Continued)

RUN 3

Parameter	Units	Value
Sampling Times	-	13:35 - 19:40
Sampling Dates	-	19/07/2023
Sampling Device	-	ISO
Volume Sampled (REF)	m³	9.0371

Where: ISO stands for Manual Isokinetic Sampling Train

				NATO I-TEQ		WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
2378-TCDD	ng	ND	0.00269	0.0027	0.0000	0.0027	0.0000	0.0027	0.0000	0.0027	0.0000	102
12378-PeCDD	ng	ND	0.00859	0.0043	0.0000	0.0086	0.0000	0.0086	0.0000	0.0086	0.0000	87
123478-HxCDD	ng	ND	0.00300	0.0003	0.0000	0.0003	0.0000	0.0015	0.0000	0.0002	0.0000	75
123678-HxCDD	ng	ND	0.00301	0.0003	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	78
123789-HxCDD	ng	ND	0.00310	0.0003	0.0000	0.0003	0.0000	0.0000	0.0000	0.0003	0.0000	-
1234678-HPeCDD	ng	ND	0.00231	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	78
OCDD	ng	0.0127	0.00511	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	94
Total Dioxins	ng	0.0127	-	0.0079	0.0000	0.0122	0.0000	0.0128	0.0000	0.0118	0.0000	-
2378-TCDF	ng	ND	0.00978	0.0010	0.0000	0.0010	0.0000	0.0005	0.0000	0.0098	0.0000	73
12378-PeCDF	ng	ND	0.00450	0.0002	0.0000	0.0001	0.0000	0.0002	0.0000	0.0005	0.0000	102
23478-PeCDF	ng	ND	0.00463	0.0023	0.0000	0.0014	0.0000	0.0023	0.0000	0.0046	0.0000	68
123478-HxCDF	ng	ND	0.00161	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	81
123678-HxCDF	ng	ND	0.00187	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	71
234678-HxCDF	ng	ND	0.00202	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	67
123789-HxCDF	ng	ND	0.00224	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	97
1234678-HPeCDF	ng	0.0033	0.00090	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	70
1234789-HPeCDF	ng	ND	0.00103	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	101
OCDF	ng	ND	0.00349	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	84
Total Furans	ng	0.0033	-	0.0043	0.0000	0.0033	0.0000	0.0038	0.0000	0.0157	0.0000	-
Totals	ng	0.0160	-	0.0123	0.0000	0.0155	0.0000	0.0167	0.0000	0.0275	0.0000	-
Total Concentration	ng/m³	-	-	0.0014	0.0000	0.0017	0.0000	0.0018	0.0000	0.0030	0.0000	-
Limit of Detection	ng/m³	-	-	0.0014	-	0.0017	-	0.0018	-	0.0030	-	-

Where: ND stands for Non Detected

DL stands for Analytical Detection Limit

TEQ1 refers to Non Detected Congeners at the Detection Limit

TEQ2 refers to Non Detected Congeners at Zero

% Rec stands for the Recovery Percentage of the Sample

APPENDIX 2

DIOXINS & FURANS: SAMPLING DETAILS

(Continued)

BLANK 1

Parameter	Units	Value
Sampling Dates	-	18/07/2023
Sampling Device	-	ISO
Average Volume Sampled (REF)	m^3	8.7309

Where: ISO stands for Manual Isokinetic Sampling Train

				NATO I-TEQ		WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
2378-TCDD	ng	ND	0.0010	0.0010	0.0000	0.0010	0.0000	0.0010	0.0000	0.0010	0.0000	111
12378-PeCDD	ng	ND	0.0058	0.0029	0.0000	0.0058	0.0000	0.0058	0.0000	0.0058	0.0000	93
123478-HxCDD	ng	ND	0.0028	0.0003	0.0000	0.0003	0.0000	0.0014	0.0000	0.0001	0.0000	91
123678-HxCDD	ng	ND	0.0031	0.0003	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	83
123789-HxCDD	ng	ND	0.0032	0.0003	0.0000	0.0003	0.0000	0.0000	0.0000	0.0003	0.0000	-
1234678-HPeCDD	ng	ND	0.0013	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	84
OCDD	ng	0.0132	0.0024	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	102
Total Dioxins	ng	0.0132	-	0.0048	0.0000	0.0077	0.0000	0.0082	0.0000	0.0072	0.0000	-
												Paramete
2378-TCDF	ng	ND	0.0021	0.0002	0.0000	0.0002	0.0000	0.0001	0.0000	0.0021	0.0000	85
12378-PeCDF	ng	ND	0.0024	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0002	0.0000	99
23478-PeCDF	ng	ND	0.0025	0.0012	0.0000	0.0007	0.0000	0.0012	0.0000	0.0025	0.0000	85
123478-HxCDF	ng	ND	0.0016	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	90
123678-HxCDF	ng	ND	0.0017	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	83
234678-HxCDF	ng	ND	0.0017	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	83
123789-HxCDF	ng	ND	0.00189	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	99
1234678-HPeCDF	ng	0.0037	0.00088	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	79
1234789-HPeCDF	ng	ND	0.00100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	98
OCDF	ng	0.0032	0.00124	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	86
Total Furans	ng	0.0068	-	0.0023	0.0000	0.0018	0.0000	0.0022	0.0000	0.0056	0.0000	-
Totals	ng	0.0200	-	0.0071	0.0001	0.0094	0.0000	0.0104	0.0000	0.0128	0.0000	-
Total Concentration	ng/m^3	-	-	0.0008	0.0000	0.0011	0.0000	0.0012	0.0000	0.0015	0.0000	-

Where: ND stands for Non Detected

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TEQ1 refers to Non Detected Congeners at the Detection Limit

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% Rec stands for the Recovery Percentage of the Sample

DIOXINS & FURANS: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	24.6	28.4	28.6
Pre-Sampling Leak Rate	l/min	0.20	0.30	0.30
Post-Sampling Leak Rate	l/min	0.20	0.20	0.20
Allowable Leak Rate	l/min	1.23	1.42	1.43
Leak Test Acceptable	-	Yes	Yes	Yes

Water Droplets	Units	Run 1	Run 2	Run 3
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Measurement Uncertainty (MU)	%	5.5	5.5	5.5
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Less than 50% Faded	%	Yes	Yes	Yes

Isokinetic Criterion Compliance	Units	Run 1	Run 2	Run 3
Isokinetic Variation	%	99.7	100.0	99.6
Allowable Isokinetic Range	%	95 - 115	95 - 115	95 - 115
Isokineticity Acceptable	-	Yes	Yes	Yes

Filter Temperatures	Units	Run 1	Run 2	Run 3
Maximum Filter Temperature	°C	120	120	120
Maximum Allowable Temperature	°C	125	125	125
Temperature Acceptable	-	Yes	Yes	Yes

Condenser Exit Temperature	Units	Run 1	Run 2	Run 3
Maximum Temperature Recorded	°C	16	15	16
Maximum Allowable Temperature	°C	20	20	20
Exit Temperature Acceptable	-	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

DIOXINS & FURANS: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	20.0
Sampling Leak Rate	l/min	0.20
Allowable Leak Rate	l/min	1.00
Leak Test Acceptable	-	Yes

Validity of NATO I-TEQ Blank vs ELV	Units	Blank 1
Allowable Blank	ng/m^3	0.0
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	Run Number 2	Run Number 3
There are no deviations associated with the sampling employed.	wx	wx	wx

DIOXINS & FURANS (NATO I-TEQ): MEASUREMENT UNCERTAINTY CALCULATIONS

	Value				Standard uncertainty				
Measured Quantities	**Symbol**	**Run 1**	**Run 2**	**Run 3**	**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (Actual)	V_m	9.2220	10.6500	10.7190	uV_m	m^3	0.1844	0.2130	0.2144
Sampled Gas Temperature	T_m	310.6	317.0	320.1	uT_m	K	2.00	2.00	2.00
Sampled Gas Pressure	ρ_m	100.8	101.4	101.4	$u\rho_m$	kPa	0.50	0.50	0.50
Sampled Gas Humidity	H_m	0.00	0.00	0.00	uH_m	% v/v	1.00	1.00	1.00
Leak	L	0.81	0.70	0.70	uL	%	-	-	-
Laboratory Result	L_r	10.0	10.0	10.0	uL_r	%	-	-	-

	Uncertainty as a Percentage				
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**	**Requirement of Standard**
Sampled Volume (Actual)	%	2.00	2.00	2.00	≤2%
Sampled Gas Temperature	%	0.64	0.63	0.62	≤1%
Sampled Gas Pressure	%	0.50	0.49	0.49	≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00	≤1%
Leak	%	0.81	0.70	0.70	≤5%
Laboratory Result	%	10.0	10.0	10.0	No Requirement

	Uncertainty in Measurement Units					Sensitivity Coefficient		
Measured Quantities	**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (STP)	V_m	m^3	7.7923	8.8854	8.8569	0.00	0.00	0.00
Leak	L	ng/m^3	0.0000	0.0000	0.0000	1.00	1.00	1.00
Laboratory Result	L_r	ng/m^3	0.0001	0.0002	0.0001	1.00	1.00	1.00

	Uncertainty in Result			
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (STP)	ng/m^3	0.0000	0.0000	0.0000
Leak	ng/m^3	0.0000	0.0000	0.0000
Laboratory Result	ng/m^3	0.0001	0.0002	0.0001

	Oxygen Correction Part of MU Budget			
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**
O_2 Correction Factor	-	0.96	0.98	0.98
Stack Gas O_2 Content	% v/v	9.56	9.79	9.78
MU for O_2 Correction	-	0.04	0.04	0.04
Overall MU For O_2 Measurement	%	4.37	4.46	4.45

Parameter	**Units**	**Run 1**	**Run 2**	**Run 3**
Combined uncertainty	ng/m^3	0.00014	0.00016	0.00014
Expanded uncertainty (95% confidence), without Oxygen Correction	ng/m^3	0.00028	0.00032	0.00028
Expanded uncertainty (95% confidence), with Oxygen Correction	ng/m^3	0.00029	0.00033	0.00028
Expanded uncertainty (95% confidence), estimated with Method Deviations	ng/m^3	0.00029	0.00033	0.00028
Reported Uncertainty	ng/m^3	0.00029	0.00033	0.00028
Expanded uncertainty (95% confidence), without Oxygen Correction	%	20.3	20.3	20.3
Expanded uncertainty (95% confidence), with Oxygen Correction	%	20.8	20.8	20.8
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	20.8	20.8	20.8
Reported Uncertainty	%	20.8	20.8	20.8

PCBs: RESULTS SUMMARY

(PAGE 1 OF 4)

Irish Cement Ltd, County Limerick
A2-01 Kiln 6

TEQ1 - UPPER LIMITS (worst case where <LOD = LOD)

Sample Runs (UPPER WHO TEQ Humans / Mammals)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.00014	0.00019	0.000174		0.00017
Uncertainty	±ng/m³	0.000028	0.000040	0.000036		0.000035
Mass Emission	µg/hr	0.037	0.052	0.047		0.045
Uncertainty	±µg/hr	0.0080	0.011	0.0102		0.0098

Sample Runs (UPPER WHO TEQ Fish)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.0000090	0.000016	0.0000127		0.000013
Uncertainty	±ng/m³	0.0000019	0.0000033	0.00000264		0.0000026
Mass Emission	µg/hr	0.0024	0.0043	0.0034		0.0034
Uncertainty	±µg/hr	0.00053	0.00093	0.00074		0.00073

Sample Runs (UPPER WHO TEQ Birds)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.00090	0.0023	0.00169		0.0016
Uncertainty	±ng/m³	0.00019	0.00047	0.000352		0.00034
Mass Emission	µg/hr	0.25	0.61	0.458		0.44
Uncertainty	±µg/hr	0.053	0.13	0.099		0.095

PCBs: RESULTS SUMMARY

(PAGE 2 OF 4)

Irish Cement Ltd, County Limerick
A2-01 Kiln 6

TEQ2 - LOWER LIMITS (best case where <LOD = 0)

Sample Runs (LOWER WHO TEQ Humans / Mammals)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.0000077	0.00019	0.0000077		0.000068
Uncertainty	±ng/m³	0.0000016	0.000039	0.0000016		0.000014
Mass Emission	µg/hr	0.0021	0.051	0.0021		0.019
Uncertainty	±µg/hr	0.00045	0.011	0.00045		0.0040

NOTE: Where the maximum Blank concentration is higher than the Sample concentration, the Blank concentration has been reported.

Sample Runs (LOWER WHO TEQ Fish)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.0000026	0.000016	0.00000477		0.0000077
Uncertainty	±ng/m³	0.00000054	0.0000033	0.000000994		0.0000016
Mass Emission	µg/hr	0.00071	0.0043	0.001293		0.0021
Uncertainty	±µg/hr	0.00015	0.00093	0.000280		0.00045

Sample Runs (LOWER WHO TEQ Birds)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.00078	0.0023	0.001531		0.0015
Uncertainty	±ng/m³	0.00016	0.00047	0.000319		0.00032
Mass Emission	µg/hr	0.21	0.61	0.415		0.41
Uncertainty	±µg/hr	0.045	0.13	0.0898		0.089

PCBs: RESULTS SUMMARY

(PAGE 3 OF 4)

Irish Cement Ltd, County Limerick
A2-01 Kiln 6

TEQ1 - UPPER LIMITS (worst case where <LOD = LOD)

Blank Runs (UPPER WHO TEQ Humans / Mammals)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.000083		0.000083

Blank Runs (UPPER WHO TEQ Fish)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.0000040		0.0000040

Blank Runs (UPPER WHO TEQ Birds)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.00016		0.00016

TEQ2 - LOWER LIMITS (best case where <LOD = 0)

Blank Runs (LOWER WHO TEQ Humans / Mammals)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.0000077		0.0000077

Blank Runs (LOWER WHO TEQ Fish)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.00000022		0.00000022

Blank Runs (LOWER WHO TEQ Birds)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.000078		0.000078

PCBs: RESULTS SUMMARY

(PAGE 4 OF 4)

Irish Cement Ltd, County Limerick
A2-01 Kiln 6

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	11.7	9.0	9.3		10.0
Uncertainty	±% v/v	0.64	0.49	0.51		0.55

General Sampling Information

Parameter	Value	
Standard	EN 1948	
Technical Procedure	MD 007	
Name of Analytical Laboratory	ELD	
Analytical Laboratory's Procedure	PM137, TM201	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	08/08/2023	
Probe Material	Titanium	
Filter Housing Material	Titanium	
Glassware Material	Borosilicate Glass	
Absorption Material	XAD-2	
Positioning of Filter	Out Stack	
Filter Size and Material	90mm Quartz Fibre	
Number of Sampling Lines Used	2 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	20 / 20	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10 - B1, B2, B3, B4, B5, B6, B7, B8, B9, B10	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

PCBs: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	Run 2	Run 3
Absolute pressure of stack gas, P_s				
Barometric pressure, P_b	mmHg	755.3	759.8	759.8
Stack static pressure, P_{static}	mmH_2O	11.9	11.9	11.9
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	756.2	760.7	760.7
Volume of water vapour collected, V_{wstd}				
Total mass collected in impingers (liquid trap)	g	792.7	692.3	719.4
Total mass collected in impingers (silica trap)	g	37.0	9.6	10.1
Total mass of liquid collected, V_{lc}	g	829.7	701.9	729.5
$V_{wstd} = (0.001246)(V_{lc})$	m^3	1.0338	0.8746	0.9090
Volume of gas metered dry, V_{mstd}				
Volume of gas sample through gas meter, V_m	m^3	9.2220	10.6500	10.7190
Gas meter correction factor, Y_d	-	0.9610	0.9610	0.9610
Average dry gas meter temperature, T_m	°C	37.6	44.0	47.1
Average pressure drop across orifice, ΔH	mmH_2O	68.6	85.7	87.1
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	7.7923	8.8854	8.8569
Moisture content, B_{wo} & R_{wv}				
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.1171	0.0896	0.0931
B_{wo} as a percentage	% v/v	11.71	8.96	9.31
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	11.71	8.96	9.31
Volume of gas metered wet, V_{mstw}				
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	8.8261	9.7600	9.7658
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$				
IED & Incinerates Hazardous Material? (Yes = no positive O_2 correction)	-	No	No	No
% wet oxygen measured in gas stream, $ACT\%O_{2w}$	% v/v	10.54	8.83	8.82
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	9.56	9.79	9.78
% oxygen reference condition, $REF\%O_2$	% v/v	10.00	10.00	10.00
O_2 Reference Factor wet (O_{2REFw}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2w}$)	-	1.05	0.90	0.90
O_2 Reference Factor dry (O_{2REFd}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2d}$)	-	0.96	0.98	0.98
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	8.3938	10.7987	10.8175
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	8.1017	9.0539	9.0371
Molecular weight of dry gas stream, M_d				
CO_2	% v/v	20.00	20.00	20.00
O_2	% v/v	9.56	9.79	9.78
Total	% v/v	29.56	29.79	29.78
N_2	% v/v	70.44	70.21	70.22
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	31.58	31.59	31.59
Molecular weight of stack gas (wet), M_s				
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	29.99	30.37	30.33
Velocity of stack gas, V_s				
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97
Velocity pressure coefficient, C_p	-	0.84	0.84	0.84
Average of velocity heads, ΔP_{avg}	mmH_2O	30.98	38.83	39.10
Average square root of velocity heads, $\sqrt{\Delta P}$	$\sqrt{mmH_2O}$	5.57	6.23	6.25
Average stack gas temperature, T_s	°C	146.3	156.5	156.6
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{(M_s)(P_s)})$	m/s	22.23	24.96	25.07
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})				
Area of stack, A_s	m^2	5.31	5.31	5.31
$Q_a = (60)(A_s)(V_s)$	m^3/min	7082.0	7950.9	7986.0
Conversion factor (K/mm.Hg), C_f	-	0.3592	0.3592	0.3592
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	4588.0	5057.9	5079.3
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	4050.6	4604.7	4606.6
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	4363.3	5596.2	5626.3
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	4211.5	4692.0	4700.3
Percent isokinetic, %I				
Nozzle diameter, D_n	mm	6.02	6.02	6.02
Nozzle area, A_n	mm^2	28.47	28.47	28.47
Total sampling time, q	min	360	360	360
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	99.7	100.0	99.6

PCBs: SAMPLING DETAILS

RUN 1

Parameter	Units	Value
Sampling Times	-	10:00 - 16:10
Sampling Dates	-	18/07/2023
Sampling Device	-	ISO
Volume Sampled (REF)	m^3	8.1017

Where: ISO stands for Manual Isokinetic Sampling Train

				WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	Units	Result	DL	TEQ1	TEQ2	TEQ1	TEQ2	TEQ1	TEQ2	% Rec
PCB-81	ng	0.02431	0.01104	0.0000073	0.0000073	0.0000122	0.0000122	0.0024310	0.0024310	68
PCB-77	ng	0.07695	0.00504	0.0000077	0.0000077	0.0000077	0.0000077	0.0038475	0.0038475	75
PCB-123	ng	0.01432	0.00337	0.0000004	0.0000004	0.0000001	0.0000001	0.0000001	0.0000001	84
PCB-118	ng	0.15116	0.00328	0.0000045	0.0000045	0.0000008	0.0000008	0.0000015	0.0000015	83
PCB-114	ng	0.00786	0.00351	0.0000002	0.0000002	0.0000000	0.0000000	0.0000008	0.0000008	82
PCB-105	ng	0.06296	0.00355	0.0000019	0.0000019	0.0000003	0.0000003	0.0000063	0.0000063	81
PCB-126	ng	ND	0.01037	0.0010370	0.0000000	0.0000519	0.0000000	0.0010370	0.0000000	84
PCB-167	ng	0.00660	0.00189	0.0000002	0.0000002	0.0000000	0.0000000	0.0000001	0.0000001	103
PCB-156	ng	0.01023	0.00188	0.0000003	0.0000003	0.0000001	0.0000001	0.0000010	0.0000010	107
PCB-157	ng	0.00483	0.00209	0.0000001	0.0000001	0.0000000	0.0000000	0.0000005	0.0000005	103
PCB-169	ng	ND	0.00157	0.0000471	0.0000000	0.0000001	0.0000000	0.0000016	0.0000000	81
PCB-189	ng	0.0050	0.00080	0.0000001	0.0000001	0.0000000	0.0000000	0.0000000	0.0000000	87
Totals	ng	0.0050	-	0.001107	0.000023	0.000073	0.000021	0.007327	0.006289	-
Total Concentration	ng/m^3	-	-	0.000137	0.000003	0.000009	0.000003	0.000904	0.000776	-
Limit of Detection	ng/m^3	-	-	0.000134	-	0.000007	-	0.000296	-	-

Where: ND stands for Non Detected

DL stands for Analytical Detection Limit

TEQ1 refers to Non Detected Congeners at the Detection Limit

TEQ2 refers to Non Detected Congeners at Zero

% Rec stands for the Recovery Percentage of the Sample

PCBs: SAMPLING DETAILS

RUN 2

Parameter	Units	Value
Sampling Times	-	07:15 - 13:20
Sampling Dates	-	19/07/2023
Sampling Device	-	ISO
Volume Sampled (REF)	m^3	9.0539

Where: ISO stands for Manual Isokinetic Sampling Train

				WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	Units	Result	DL	TEQ1	TEQ2	TEQ1	TEQ2	TEQ1	TEQ2	% Rec
PCB-81	ng	0.06347	0.02154	0.0000190	0.0000190	0.0000317	0.0000317	0.0063470	0.0063470	57
PCB-77	ng	0.24988	0.01336	0.0000250	0.0000250	0.0000250	0.0000250	0.0124940	0.0124940	64
PCB-123	ng	0.04452	0.00879	0.0000013	0.0000013	0.0000002	0.0000002	0.0000004	0.0000004	86
PCB-118	ng	0.47042	0.00845	0.0000141	0.0000141	0.0000024	0.0000024	0.0000047	0.0000047	87
PCB-114	ng	0.01991	0.00898	0.0000006	0.0000006	0.0000001	0.0000001	0.0000020	0.0000020	86
PCB-105	ng	0.20261	0.00944	0.0000061	0.0000061	0.0000010	0.0000010	0.0000203	0.0000203	84
PCB-126	ng	0.01650	0.01394	0.0016500	0.0016500	0.0000825	0.0000825	0.0016500	0.0016500	79
PCB-167	ng	0.01640	0.00486	0.0000005	0.0000005	0.0000001	0.0000001	0.0000002	0.0000002	108
PCB-156	ng	0.02446	0.00497	0.0000007	0.0000007	0.0000001	0.0000001	0.0000024	0.0000024	109
PCB-157	ng	0.00974	0.00546	0.0000003	0.0000003	0.0000000	0.0000000	0.0000010	0.0000010	106
PCB-169	ng	ND	0.00060	0.0000180	0.0000000	0.0000000	0.0000000	0.0000006	0.0000000	90
PCB-189	ng	0.0060	0.00157	0.0000002	0.0000002	0.0000000	0.0000000	0.0000001	0.0000001	88
Totals	ng	0.0060	-	0.001736	0.001718	0.000143	0.000143	0.020523	0.020522	-
Total Concentration	ng/m^3	-	-	0.000192	0.000190	0.000016	0.000016	0.002267	0.002267	-
Limit of Detection	ng/m^3	-	-	0.000157	-	0.000009	-	0.000466	-	-

Where: ND stands for Non Detected

DL stands for Analytical Detection Limit

TEQ1 refers to Non Detected Congeners at the Detection Limit

TEQ2 refers to Non Detected Congeners at Zero

% Rec stands for the Recovery Percentage of the Sample

PCBs: SAMPLING DETAILS

RUN 3

Parameter	Units	Value
Sampling Times	-	13:35 - 19:40
Sampling Dates	-	19/07/2023
Sampling Device	-	ISO
Volume Sampled (REF)	m^3	9.0371

Where: ISO stands for Manual Isokinetic Sampling Train

				WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	Units	Result	DL	TEQ1	TEQ2	TEQ1	TEQ2	TEQ1	TEQ2	% Rec
PCB-81	ng	0.04074	0.01698	0.0000122	0.0000122	0.0000204	0.0000204	0.0040740	0.0040740	64
PCB-77	ng	0.19469	0.00909	0.0000195	0.0000195	0.0000195	0.0000195	0.0097345	0.0097345	72
PCB-123	ng	0.02754	0.00556	0.0000008	0.0000008	0.0000001	0.0000001	0.0000003	0.0000003	82
PCB-118	ng	0.40645	0.00538	0.0000122	0.0000122	0.0000020	0.0000020	0.0000041	0.0000041	82
PCB-114	ng	0.01652	0.00572	0.0000005	0.0000005	0.0000001	0.0000001	0.0000017	0.0000017	82
PCB-105	ng	0.17251	0.00589	0.0000052	0.0000052	0.0000009	0.0000009	0.0000173	0.0000173	80
PCB-126	ng	ND	0.01427	0.0014270	0.0000000	0.0000714	0.0000000	0.0014270	0.0000000	83
PCB-167	ng	0.01133	0.00293	0.0000003	0.0000003	0.0000001	0.0000001	0.0000001	0.0000001	106
PCB-156	ng	0.01784	0.00310	0.0000005	0.0000005	0.0000001	0.0000001	0.0000018	0.0000018	106
PCB-157	ng	0.00631	0.00326	0.0000002	0.0000002	0.0000000	0.0000000	0.0000006	0.0000006	105
PCB-169	ng	ND	0.00309	0.0000927	0.0000000	0.0000002	0.0000000	0.0000031	0.0000000	81
PCB-189	ng	0.0035	0.00089	0.0000001	0.0000001	0.0000000	0.0000000	0.0000000	0.0000000	86
Totals	ng	0.0035	-	0.001571	0.000052	0.000115	0.000043	0.015264	0.013834	-
Total Concentration	ng/m^3	-	-	0.000174	0.000006	0.000013	0.000005	0.001689	0.001531	-
Limit of Detection	ng/m^3	-	-	0.000169	-	0.000009	-	0.000397	-	-

Where: ND stands for Non Detected

DL stands for Analytical Detection Limit

TEQ1 refers to Non Detected Congeners at the Detection Limit

TEQ2 refers to Non Detected Congeners at Zero

% Rec stands for the Recovery Percentage of the Sample

PCBs: SAMPLING DETAILS

BLANK 1

Parameter	Units	Value
Sampling Dates	-	18/07/2023
Sampling Device	-	ISO
Volume Sampled (REF)	m^3	8.7309

Where: ISO stands for Manual Isokinetic Sampling Train

				WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
PCB-81	ng	ND	0.00094	0.0000003	0.0000000	0.0000005	0.0000000	0.0000940	0.0000000	76
PCB-77	ng	0.0135	0.00153	0.0000013	0.0000013	0.0000013	0.0000013	0.0006730	0.0006730	74
PCB-123	ng	ND	0.00234	0.0000001	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	79
PCB-118	ng	0.0538	0.00234	0.0000016	0.0000016	0.0000003	0.0000003	0.0000005	0.0000005	78
PCB-114	ng	0.0026	0.00233	0.0000001	0.0000001	0.0000000	0.0000000	0.0000003	0.0000003	80
PCB-105	ng	0.0207	0.00243	0.0000006	0.0000006	0.0000001	0.0000001	0.0000021	0.0000021	78
PCB-126	ng	ND	0.00658	0.0006580	0.0000000	0.0000329	0.0000000	0.0006580	0.0000000	89
PCB-167	ng	0.0029	0.00140	0.0000001	0.0000001	0.0000000	0.0000000	0.0000000	0.0000000	98
PCB-156	ng	0.0062	0.00137	0.0000002	0.0000002	0.0000000	0.0000000	0.0000006	0.0000006	104
PCB-157	ng	0.0027	0.00148	0.0000001	0.0000001	0.0000000	0.0000000	0.0000003	0.0000003	100
PCB-169	ng	0.0021	0.00071	0.0000630	0.0000630	0.0000001	0.0000001	0.0000021	0.0000021	81
PCB-189	ng	0.0036	0.00074	0.0000001	0.0000001	0.0000000	0.0000000	0.0000000	0.0000000	83
Totals	ng	0.1079	-	0.000725	0.000067	0.000035	0.000002	0.001431	0.000679	-
Total Concentration	ng/m^3	-	-	0.000083	0.000008	0.000004	0.000000	0.000164	0.000078	-

Where: ND stands for Non Detected

DL stands for Analytical Detection Limit

TEQ1 refers to Non Detected Congeners at the Detection Limit

TEQ2 refers to Non Detected Congeners at Zero

% Rec stands for the Recovery Percentage of the Sample

PCBs: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	24.6	28.4	28.6
Pre-Sampling Leak Rate	l/min	0.20	0.30	0.30
Post-Sampling Leak Rate	l/min	0.20	0.20	0.20
Allowable Leak Rate	l/min	1.23	1.42	1.43
Leak Test Acceptable	-	Yes	Yes	Yes

Water Droplets	Units	Run 1	Run 2	Run 3
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Measurement Uncertainty (MU)	%	5.5	5.5	5.5
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Less than 50% Faded	%	Yes	Yes	Yes

Isokinetic Criterion Compliance	Units	Run 1	Run 2	Run 3
Isokinetic Variation	%	99.7	100.0	99.6
Allowable Isokinetic Range	%	95 - 115	95 - 115	95 - 115
Isokineticity Acceptable	-	Yes	Yes	Yes

Filter Temperatures	Units	Run 1	Run 2	Run 3
Maximum Filter Temperature	°C	120	120	120
Maximum Allowable Temperature	°C	125	125	125
Temperature Acceptable	-	Yes	Yes	Yes

Condenser Exit Temperature	Units	Run 1	Run 2	Run 3
Maximum Temperature Recorded	°C	16	15	16
Maximum Allowable Temperature	°C	20	20	20
Exit Temperature Acceptable	-	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

PCBs: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	20.0
Sampling Leak Rate	l/min	0.20
Allowable Leak Rate	l/min	1.00
Leak Test Acceptable	-	Yes

Validity of WHO TEQ H/M Blank vs ELV	Units	Blank 1
Allowable Blank	ng/m^3	N/A
Blank Acceptable	-	N/A

Method Deviations

Nature of Deviation	Run Number			
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1	2	3	
There are no deviations associated with the sampling employed.	wx	wx	wx	

PCBs (WHO TEQ HUMANS / MAMMALS): MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value				Standard uncertainty				
	Symbol	Run 1	Run 2	Run 3	Symbol	Units	Run 1	Run 2	Run 3
Sampled Volume (Actual)	V_m	9.2220	10.6500	10.7190	uV_m	m^3	0.1844	0.2130	0.2144
Sampled Gas Temperature	T_m	310.6	317.0	320.1	uT_m	K	2.00	2.00	2.00
Sampled Gas Pressure	ρ_m	100.8	101.4	101.4	$u\rho_m$	kPa	0.50	0.50	0.50
Sampled Gas Humidity	H_m	0.00	0.0	0.0	uH_m	% v/v	1.00	1.00	1.00
Leak	L	0.81	0.70	0.70	uL	%	-	-	-
Laboratory Result	L_r	10.0	10.0	10.0	uL_r	%	-	-	-

Measured Quantities	Uncertainty as a Percentage				Requirement of Standard
	Units	Run 1	Run 2	Run 3	
Sampled Volume (Actual)	%	2.00	2.00	2.00	≤2%
Sampled Gas Temperature	%	0.64	0.63	0.62	≤1%
Sampled Gas Pressure	%	0.50	0.49	0.49	≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00	≤1%
Leak	%	0.81	0.70	0.70	≤5%
Laboratory Result	%	10.0	10.0	10.0	No Requirement

Measured Quantities	Uncertainty in Measurement Units					Sensitivity Coefficient		
	Symbol	Units	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	m^3	7.7923	8.8854	8.8569	0.00	0.00	0.00
Leak	L	ng/m^3	0.0000	0.0000	0.0000	1.00	1.00	1.00
Laboratory Result	L_r	ng/m^3	0.0000	0.0000	0.0000	1.00	1.00	1.00

Measured Quantities	Uncertainty in Result			
	Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	ng/m^3	0.0000	0.0000	0.0000
Leak	ng/m^3	0.0000	0.0000	0.0000
Laboratory Result	ng/m^3	0.0000	0.0000	0.0000

Measured Quantities	Oxygen Correction Part of MU Budget			
	Units	Run 1	Run 2	Run 3
O_2 Correction Factor	-	0.96	0.98	0.98
Stack Gas O_2 Content	% v/v	9.56	9.79	9.78
MU for O_2 Correction	-	0.04	0.04	0.04
Overall MU For O_2 Measurement	%	4.37	4.46	4.45

Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	ng/m^3	0.00001	0.00002	0.00002
Expanded uncertainty (95% confidence), without Oxygen Correction	ng/m^3	0.00003	0.00004	0.00004
Expanded uncertainty (95% confidence), with Oxygen Correction	ng/m^3	0.00003	0.00004	0.00004
Expanded uncertainty (95% confidence), estimated with Method Deviations	ng/m^3	0.00003	0.00004	0.00004
Reported Uncertainty	ng/m^3	0.00003	0.00004	0.00004
Expanded uncertainty (95% confidence), without Oxygen Correction	%	20.3	20.3	20.3
Expanded uncertainty (95% confidence), with Oxygen Correction	%	20.8	20.8	20.8
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	20.8	20.8	20.8
Reported Uncertainty	%	20.8	20.8	20.8

HYDROGEN FLUORIDE: RESULTS SUMMARY

Irish Cement Ltd, County Limerick

A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	mg/m³	0.090	< 0.032	< 0.031		0.051
Uncertainty	±mg/m³	0.012	0.0041	0.0040		0.0066
Mass Emission	g/hr	22.7	< 8.0	< 7.8		12.8
Uncertainty	±g/hr	3.2	1.1	1.1		1.8

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	11.5	11.6	12.5		11.8
Uncertainty	±% v/v	0.47	0.47	0.50		0.48

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 0.027		< 0.027

General Sampling Information

Parameter	Value	
Standard	CEN/TS 17340	
Technical Procedure	MD 010	
Name of Analytical Laboratory	EET	
Analytical Laboratory's Procedure	CAT-AP-01	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	27/07/2023	
Probe Material	Titanium	
Filter Housing Material	Monel	
Impinger Material	Polyethylene	
Absorption Solution	HPLC Grade Water	
Positioning of Filter	Out Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	B3	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

HYDROGEN FLUORIDE: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	11:00 - 12:00	12:15 - 13:15	13:30 - 14:30
Sampling Dates	-	18/07/2023	18/07/2023	18/07/2023
Sampling Device	-	MFC / MV	MFC / MV	MFC / MV
Duration	mins	60	60	60
Volume Sampled (STP, Dry)	m³	0.5521	0.5521	0.5521
Volume Sampled (STP, Wet)	m³	0.6237	0.6245	0.6307
Volume Sampled (REF)	m³	0.5680	0.5728	0.5748
Sample Flow Rate	l/min	8.62	8.62	8.62
Laboratory Result for Front Impingers	µg/ml	0.18	< 0.05	< 0.05
Laboratory Result for Back Impinger	µg/ml	< 0.05		
Volume in Front Impingers	ml	253.3	363.5	356.0
Volume in Back Impinger	ml	107.3		
Mass in Front Impingers	µg	45.6	< 18.2	< 17.8
Mass in Back Impinger	µg	< 5.4		
Total Mass Collected	µg	51.0	< 18.2	< 17.8
Calculated Concentration	mg/m³	0.09	< 0.03	< 0.03
Liquid Trap Start Mass	g	1685.4	1688.0	1679.2
Liquid Trap End Mass	g	1735.5	1739.4	1737.5
Silica Trap Start Mass	g	691.0	698.4	705.1
Silica Trap End Mass	g	698.4	705.1	709.9
Total Mass Of Water Vapour	g	57.5	58.1	63.1
Calculated Water Vapour	% v/v	11.5	11.6	12.5

Where: MFC stands for Mass Flow Controller, MV stands for Mass View Flowmeter

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	18/07/2023
Average Volume Sampled (REF)	m³	0.5719
Laboratory Result for Impingers	µg/ml	< 0.05
Volume in Impingers	ml	309.4
Total Mass Collected	µg	< 15.5
Calculated Concentration	mg/m³	< 0.027

HYDROGEN FLUORIDE: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	8.6	8.6	8.6
Pre-Sampling Leak Rate	l/min	0.02	0.02	0.01
Post-Sampling Leak Rate	l/min	0.02	0.02	0.01
Allowable Leak Rate	l/min	0.17	0.17	0.17
Leak Test Acceptable	-	Yes	Yes	Yes

Absorption Efficiency	Units	Run 1
Absorption Efficiency	%	100.0
Allowable Absorption Efficiency	%	N/A [2]
Absorption Efficiency Acceptable	-	Yes [2]

[2] The concentration is less than 30% of the ELV, therefore no assessment against an allowable efficiency is required.

Water Droplets	Units	Run 1	Run 2	Run 3
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Measurement Uncertainty (MU)	%	4.1	4.1	4.0
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Less than 50% Faded	%	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	9.0
Pre-Sampling Leak Rate	l/min	0.02
Post-Sampling Leak Rate	l/min	0.10
Allowable Leak Rate	l/min	0.18
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m^3	0.10
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation	Run Number		
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1	2	3
There are no deviations associated with the sampling employed.	wx	wx	wx

HYDROGEN FLUORIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Symbol	Value Run 1	Value Run 2	Value Run 3	Standard uncertainty Symbol	Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	0.5521	0.5521	0.5521	uV_m	m^3	0.0110	0.0110	0.0110
Leak	L	0.23	0.23	0.12	uL	%	-	-	-
Laboratory Result	L_r	5.85	5.85	5.85	uL_r	%	-	-	-

Measured Quantities	Units	Uncertainty as a Percentage Run 1	Run 2	Run 3	Requirement of Standard
Sampled Volume (STP)	%	2.00	2.00	2.00	≤2%
Leak	%	0.23	0.23	0.12	≤2%
Laboratory Result	%	5.85	5.85	5.85	No Requirement

Measured Quantities	Symbol	Units	Uncertainty in Measurement Units Run 1	Run 2	Run 3	Sensitivity Coefficient Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	m^3	0.5521	0.5521	0.5521	0.16	0.06	0.06
Leak	L	mg/m^3	0.000	0.000	0.000	1.00	1.00	1.00
Laboratory Result	L_r	mg/m^3	0.005	0.002	0.002	1.00	1.00	1.00

Measured Quantities	Units	Uncertainty in Result Run 1	Run 2	Run 3
Sampled Volume (STP)	mg/m^3	0.002	0.001	0.001
Leak	mg/m^3	0.0001	0.0000	0.0000
Laboratory Result	mg/m^3	0.0052	0.0019	0.0018

Measured Quantities	Units	Oxygen Correction Part of MU Budget Run 1	Run 2	Run 3
O_2 Correction Factor	-	0.97	0.96	0.96
Stack Gas O_2 Content	% v/v	9.68	9.59	9.55
MU for O_2 Correction	-	0.04	0.04	0.04
Overall MU For O_2 Measurement	%	4.42	4.38	4.37

Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	mg/m^3	0.0055	0.0020	0.0019
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.0109	0.0038	0.0038
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	0.012	0.0041	0.0040
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.012	0.0041	0.0040
Reported Uncertainty	mg/m^3	0.012	0.0041	0.0040
Expanded uncertainty (95% confidence), without Oxygen Correction	%	12.1	12.1	12.1
Expanded uncertainty (95% confidence), with Oxygen Correction	%	12.9	12.9	12.9
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	12.9	12.9	12.9
Reported Uncertainty	%	12.9	12.9	12.9

AMMONIA: RESULTS SUMMARY

Irish Cement Ltd, County Limerick

A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	mg/m^3	24.4	25.0	27.7		25.7
Uncertainty	$\pm mg/m^3$	4.5	4.6	5.1		4.7
Mass Emission	g/hr	6165	6329	6998		6497
Uncertainty	±g/hr	1195	1226	1356		1259

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	11.3	11.5	10.6		11.1
Uncertainty	±% v/v	0.46	0.46	0.43		0.45

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m^3	< 0.056		< 0.056

General Sampling Information

Parameter	Value	
Standard	ISO 21877	
Technical Procedure	MD 014	
Name of Analytical Laboratory	RPS	
Analytical Laboratory's Procedure	A6	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	08/08/2023	
Probe Material	Titanium	
Filter Housing Material	Titanium	
Impinger Material	Polyethylene	
Absorption Solution	0.05 mol/l Sulphuric Acid	
Positioning of Filter	In Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	B3	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

AMMONIA: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	11:00 - 12:00	12:15 - 13:15	13:30 - 14:30
Sampling Dates	-	19/07/2023	19/07/2023	19/07/2023
Sampling Device	-	MFC / MV	MFC / MV	MFC / MV
Duration	mins	60	60	60
Volume Sampled (STP, Dry)	m^3	0.5521	0.5521	0.5521
Volume Sampled (STP, Wet)	m^3	0.6222	0.6236	0.6174
Volume Sampled (REF)	m^3	0.5601	0.5619	0.5571
Sample Flow Rate	l/min	8.62	8.62	8.62
Laboratory Result for Front Impingers	µg/ml	51.90	38.40	40.00
Laboratory Result for Back Impinger	µg/ml	0.10		
Volume in Front Impingers	ml	263.0	366.4	385.6
Volume in Back Impinger	ml	105.1		
Mass in Front Impingers	µg	13649.7	14069.8	15424.0
Mass in Back Impinger	µg	10.5		
Total Mass Collected	µg	13660.2	14069.8	15424.0
Calculated Concentration	mg/m^3	24.39	25.04	27.69
Liquid Trap Start Mass	g	1703.0	1702.3	1725.1
Liquid Trap End Mass	g	1755.1	1754.4	1772.9
Silica Trap Start Mass	g	727.5	731.7	737.0
Silica Trap End Mass	g	731.7	737.0	741.6
Total Mass Of Water Vapour	g	56.3	57.4	52.4
Calculated Water Vapour	% v/v	11.3	11.5	10.6

Where: MFC stands for Mass Flow Controller, MV stands for Mass View Flowmeter

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	19/07/2023
Average Volume Sampled (REF)	m^3	0.5597
Laboratory Result for Impingers	µg/ml	< 0.10
Volume in Impingers	ml	313.1
Total Mass Collected	µg	< 31.3
Calculated Concentration	mg/m^3	< 0.056

AMMONIA: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	8.6	8.6	8.6
Pre-Sampling Leak Rate	l/min	0.02	0.02	0.03
Post-Sampling Leak Rate	l/min	0.02	0.02	0.02
Allowable Leak Rate	l/min	0.17	0.17	0.17
Leak Test Acceptable	-	Yes	Yes	Yes

Absorption Efficiency	Units	Run 1
Absorption Efficiency	%	99.9
Allowable Absorption Efficiency	%	N/A
Absorption Efficiency Acceptable	-	N/A

Water Droplets	Units	Run 1	Run 2	Run 3
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Measurement Uncertainty (MU)	%	4.1	4.1	4.1
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Less than 50% Faded	%	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	9.0
Pre-Sampling Leak Rate	l/min	0.01
Post-Sampling Leak Rate	l/min	0.02
Allowable Leak Rate	l/min	0.18
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m^3	5.0
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	2	3
There are no deviations associated with the sampling employed.	wx	wx	wx

AMMONIA: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Symbol	Value Run 1	Value Run 2	Value Run 3	Standard uncertainty Symbol	Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	0.5521	0.5521	0.5521	uV_m	m^3	0.0110	0.0110	0.0110
Leak	L	0.23	0.23	0.23	uL	%	-	-	-
Laboratory Result	L_r	8.90	8.90	8.90	uL_r	%	-	-	-

Measured Quantities	Units	Uncertainty as a Percentage Run 1	Run 2	Run 3	Requirement of Standard
Sampled Volume (STP)	%	2.00	2.00	2.00	≤2%
Leak	%	0.23	0.23	0.23	≤2%
Laboratory Result	%	8.90	8.90	8.90	No Requirement

Measured Quantities	Symbol	Units	Uncertainty in Measurement Units Run 1	Run 2	Run 3	Sensitivity Coefficient Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	m^3	0.5521	0.5521	0.5521	44.18	45.35	50.15
Leak	L	mg/m^3	0.033	0.034	0.037	1.00	1.00	1.00
Laboratory Result	L_r	mg/m^3	2.171	2.228	2.464	1.00	1.00	1.00

Measured Quantities	Units	Uncertainty in Result Run 1	Run 2	Run 3
Sampled Volume (STP)	mg/m^3	0.488	0.501	0.554
Leak	mg/m^3	0.0327	0.0335	0.0371
Laboratory Result	mg/m^3	2.1706	2.2285	2.4641

Measured Quantities	Units	Oxygen Correction Part of MU Budget Run 1	Run 2	Run 3
O_2 Correction Factor	-	0.99	0.98	0.99
Stack Gas O_2 Content	% v/v	9.84	9.80	9.90
MU for O_2 Correction	-	0.04	0.04	0.04
Overall MU For O_2 Measurement	%	4.48	4.47	4.50

Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	mg/m^3	2.2	2.3	2.5
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	4.4	4.5	5.0
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	4.5	4.6	5.1
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	4.5	4.6	5.1
Reported Uncertainty	mg/m^3	4.5	4.6	5.1
Expanded uncertainty (95% confidence), without Oxygen Correction	%	17.9	17.9	17.9
Expanded uncertainty (95% confidence), with Oxygen Correction	%	18.4	18.4	18.4
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	18.4	18.4	18.4
Reported Uncertainty	%	18.4	18.4	18.4

HYDROGEN CHLORIDE: RESULTS SUMMARY

Irish Cement Ltd, County Limerick

A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	mg/m³	3.1	1.3	1.2		1.9
Uncertainty	±mg/m³	0.19	0.082	0.077		0.12
Mass Emission	g/hr	785	327	314		475
Uncertainty	±g/hr	67.1	28.5	27.1		40.9

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	12.3	11.9	11.4		11.9
Uncertainty	±% v/v	0.50	0.48	0.46		0.48

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 0.027		< 0.027

General Sampling Information

Parameter	Value	
Standard	EN 1911	
Technical Procedure	MD 011	
Name of Analytical Laboratory	EET	
Analytical Laboratory's Procedure	CAT-AP-01	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	27/07/2023	
Probe Material	Titanium	
Filter Housing Material	Titanium	
Impinger Material	Quartz Glass	
Absorption Solution	HPLC Grade Water	
Positioning of Filter	In Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	B3	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

HYDROGEN CHLORIDE: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	07:00 - 08:00	08:15 - 09:15	09:30 - 10:30
Sampling Dates	-	19/07/2023	19/07/2023	19/07/2023
Sampling Device	-	MFC / MV	MFC / MV	MFC / MV
Duration	mins	60	60	60
Volume Sampled (STP, Dry)	m³	0.5468	0.5503	0.5521
Volume Sampled (STP, Wet)	m³	0.6234	0.6250	0.6232
Volume Sampled (REF)	m³	0.5886	0.5556	0.5731
Sample Flow Rate	l/min	8.62	8.62	8.62
Laboratory Result for Front Impingers	µg/ml	6.70	1.94	1.94
Laboratory Result for Back Impinger	µg/ml	< 0.050		
Volume in Front Impingers	ml	271.9	370.9	367.0
Volume in Back Impinger	ml	105.7		
Mass in Front Impingers	µg	1821.7	719.5	712.0
Mass in Back Impinger	µg	< 5.3		
Total Mass Collected	µg	1827.0	719.5	712.0
Calculated Concentration	mg/m³	3.10	1.29	1.24
Liquid Trap Start Mass	g	1713.4	1704.4	1702.4
Liquid Trap End Mass	g	1765.7	1758.9	1755.4
Silica Trap Start Mass	g	708.8	718.0	723.4
Silica Trap End Mass	g	718.0	723.4	727.5
Total Mass Of Water Vapour	g	61.5	59.9	57.1
Calculated Water Vapour	% v/v	12.29	11.94	11.42

Where: MFC stands for Mass Flow Controller, MV stands for Mass View Flowmeter

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	19/07/2023
Average Volume Sampled (REF)	m³	0.5724
Laboratory Result for Impingers	µg/ml	< 0.05
Volume in Impingers	ml	312.3
Total Mass Collected	µg	< 15.6
Calculated Concentration	mg/m³	< 0.027

HYDROGEN CHLORIDE: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	8.6	8.6	8.6
Pre-Sampling Leak Rate	l/min	0.02	0.01	0.02
Post-Sampling Leak Rate	l/min	0.02	0.02	0.02
Allowable Leak Rate	l/min	0.17	0.17	0.17
Leak Test Acceptable	-	Yes	Yes	Yes

Absorption Efficiency	Units	Run 1
Absorption Efficiency	%	100.0
Allowable Absorption Efficiency	%	N/A [1]
Absorption Efficiency Acceptable	-	Yes [1]

[1] The concentration in the last absorber was less than 5 times the analytical detection limit.

Water Droplets	Units	Run 1	Run 2	Run 3
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Measurement Uncertainty (MU)	%	4.05	4.05	4.05
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Less than 50% Faded	%	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	9.0
Pre-Sampling Leak Rate	l/min	0.03
Post-Sampling Leak Rate	l/min	0.04
Allowable Leak Rate	l/min	0.18
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m^3	1.0
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	2	3
There are no deviations associated with the sampling employed.	wx	wx	

HYDROGEN CHLORIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value: Symbol	Value: Run 1	Value: Run 2	Value: Run 3	Standard uncertainty: Symbol	Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	0.5468	0.5503	0.5521	uV_m	m^3	0.0109	0.0110	0.0110
Leak	L	0.23	0.23	0.23	uL	%	-	-	-
Laboratory Result	L_r	1.05	1.05	1.05	uL_r	%	-	-	-

Measured Quantities	Uncertainty as a Percentage: Units	Run 1	Run 2	Run 3	Requirement of Standard
Sampled Volume (STP)	%	2.00	2.00	2.00	≤2%
Leak	%	0.23	0.23	0.23	≤2%
Laboratory Result	%	1.05	1.05	1.05	No Requirement

Measured Quantities	Uncertainty in Measurement Units: Symbol	Units	Run 1	Run 2	Run 3	Sensitivity Coefficient: Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	m^3	0.5468	0.5503	0.5521	5.68	2.35	2.25
Leak	L	mg/m^3	0.004	0.002	0.002	1.00	1.00	1.00
Laboratory Result	L_r	mg/m^3	0.033	0.014	0.013	1.00	1.00	1.00

Measured Quantities	Uncertainty in Result: Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	mg/m^3	0.062	0.026	0.025
Leak	mg/m^3	0.0042	0.0017	0.0017
Laboratory Result	mg/m^3	0.0326	0.0136	0.0130

Measured Quantities	Oxygen Correction Part of MU Budget: Units	Run 1	Run 2	Run 3
O_2 Correction Factor	-	0.93	0.99	0.96
Stack Gas O_2 Content	% v/v	9.16	9.89	9.58
MU for O_2 Correction	-	0.04	0.04	0.04
Overall MU For O_2 Measurement	%	4.22	4.50	4.38

Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	mg/m^3	0.070	0.029	0.028
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.14	0.057	0.055
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	0.19	0.082	0.077
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.19	0.082	0.077
Reported Uncertainty	mg/m^3	0.19	0.082	0.077
Expanded uncertainty (95% confidence), without Oxygen Correction	%	4.4	4.4	4.4
Expanded uncertainty (95% confidence), with Oxygen Correction	%	6.1	6.3	6.2
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	6.1	6.3	6.2
Reported Uncertainty	%	6.1	6.3	6.2

TOTAL VOCs (as CARBON): RESULTS SUMMARY

Irish Cement Ltd, County Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m³	19.9		19.9
Uncertainty	±mg/m³	0.89		0.89
Mass Emission	g/hr	5040		5040
Uncertainty	±g/hr	376		376

General Sampling Information

Parameter	Value	
Standard	EN 12619:2013	
Technical Procedure	MD 020	
Probe Material	Stainless Steel	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Type	Propane in 11% O_2 in N_2 (5 Grade)	
Span Gas Reference Number	CYL 12.0518 in N_2 | CYL 1.0555 in AIR	
Span Gas Expiry Date	24/03/2025 | 28/01/2028	
Span Gas Start Pressure (bar)	50 | 20	
Gas Cylinder Concentration (ppm)	84.19 | 79.53	
Span Gas Set Point (ppm)	81.75	This is the blended concentration of both propane cylinders
Span Gas Uncertainty (%)	2 | 2	
Zero Gas Type	11% O_2 in N_2 (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	Centre Point	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

TOTAL VOCs (as CARBON): DATA TREND

Graphical Trend of Data

TOTAL VOCs (as CARBON): SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1
Sampling Times	-	14:00 - 22:00
Sampling Dates	-	18/07/2023
Instrument Range	ppm	100
Span Gas Value	ppm	81.7

Quality Assurance

	Zero Drift	Units	Run 1
CAL 1	Zero Down Sampling Line (Pre)	ppm	0.00
CAL 1	Zero Down Sampling Line (Post)	ppm	0.00
CAL 1	Zero Drift	ppm	0.00
CAL 1	Zero Drift	%	0.00
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Zero Drift	± ppm	4.09
	Zero Drift Acceptable	-	Yes

	Span Drift	Units	Run 1
CAL 1	Span Down Sampling Line (Pre)	ppm	81.00
CAL 1	Span Down Sampling Line (Post)	ppm	80.70
CAL 1	Span Drift	ppm	-0.30
CAL 1	Span Drift	%	-0.37
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Span Drift	± ppm	4.09
	Span Drift Acceptable	-	Yes

Test Conditions	Units	Run 1
Run Ambient Temperature Range	°C	30 - 40

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1
There are no deviations associated with the sampling employed.	x

TOTAL VOCs (as CARBON): MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	RUN 1		Units
Limit value	25.0		mg/m^3 (REF)
Allowable MU	15.0		%
Measured concentration	20.83		mg/m^3 (STP, dry)
Range Used	100.0		ppm
Range Used [A]	160.6		mg/m^3
Cal gas conc.	81.7		ppm
Conversion	1.61		ppm to mg/m^3
MCERTS Range [B]	15.0		mg/m^3
Lower of [A] or [B]	15.0		mg/m^3
Cal gas conc.	131.3		mg/m^3

Performance characteristics	RUN 1		Units
Response time	45		seconds
Number of readings in measurement	480		-
Repeatability at zero	2.00		% full scale
Repeatability at span level	0.00		% full scale
Deviation from linearity	0.11		% of value
Zero drift	0.00		% full scale
Span drift	-0.37		% full scale
Volume or pressure flow dependence	1.60		% of full scale
Atmospheric pressure dependence	0.30		% of value/kPa
Ambient temperature dependence	1.40		% full scale/10K
Combined interference	0.45		% range
Dependence on voltage	0.50		% full scale/10V
Losses in the line (leak)	0.00		% of value
Uncertainty of calibration gas	2.83		% of value

Performance characteristic	RUN 1		Units
Standard deviation of repeatability at zero	use rep at span		mg/m^3
Standard deviation of repeatability at span level	0.00		mg/m^3
Lack of fit	0.01		mg/m^3
Drift	0.00		mg/m^3
Volume or pressure flow dependence	0.00		mg/m^3
Atmospheric pressure dependence	0.01		mg/m^3
Ambient temperature dependence	0.20		mg/m^3
Combined interference (from MCERTS Certificate)	0.04		mg/m^3
Dependence on voltage	0.06		mg/m^3
Losses in the line (leak)	0.00		mg/m^3
Uncertainty of calibration gas	0.34		mg/m^3

			RUN 1		Units
Measurement uncertainty		**Result**	20.83		mg/m^3
Combined uncertainty			0.40		mg/m^3
Expanded uncertainty	k =	1.96	0.79		mg/m^3
Uncertainty corrected to std conds. (O_2)			0.75		mg/m^3 (REF)

	RUN 1		Units
Expanded uncertainty (no O_2) - at 95% Confidence	3.78		% of Value
Expanded uncertainty (no O_2) - at 95% Confidence	3.15		% at ELV
Overall Allowable uncertainty (no O_2) - at 95% Confidence	15.0		% at ELV
Result of Compliance with Uncertainty Requirement	**N/A**		-

	RUN 1		Units
Expanded uncertainty (with O_2) - at 95% Confidence	4.46		% of Value
Expanded uncertainty (with O_2) - at 95% Confidence	3.84		% at ELV
Overall Allowable uncertainty (with O_2) - at 95% Confidence	15.2		% at ELV
Result of Compliance with Uncertainty Requirement	**COMPLIANT**		-

Requirement for SRM is that Uncertainty should be <15% of the value at the ELV, on a dry gas basis, or if O_2 correction is applied less than 15% + the uncertainty associated with the O_2 correction (using sqrt of sum squares to add uncertainty components).

OXIDES OF NITROGEN (as NO_2): RESULTS SUMMARY

Irish Cement Ltd, County Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m³	412		412
Uncertainty	±mg/m³	15.3		15.3
Mass Emission	g/hr	104224		104224
Uncertainty	±g/hr	7322		7322

General Sampling Information

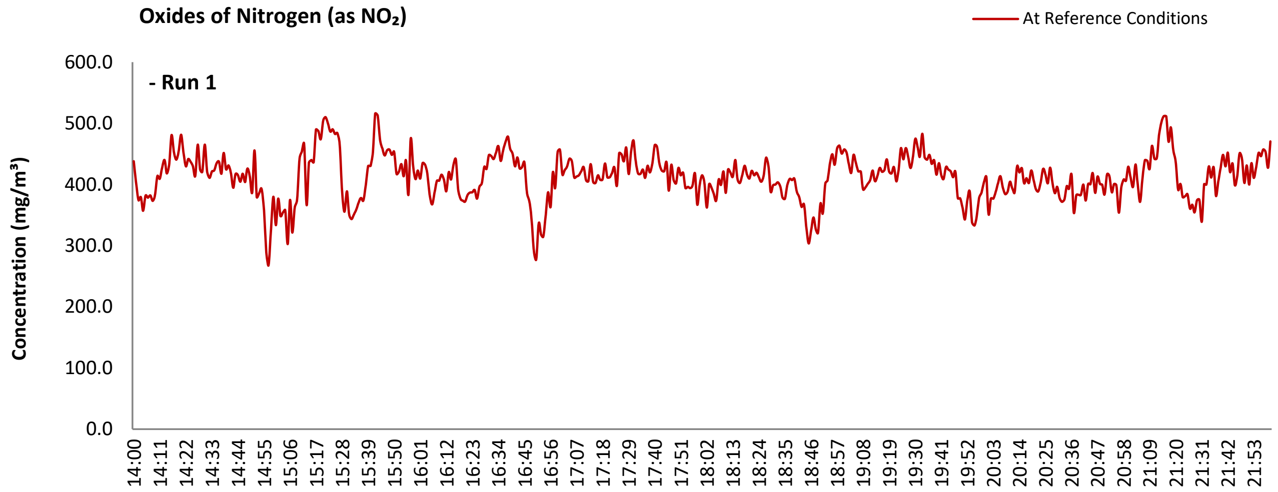
Parameter	Value	
Standard	EN 14792	
Technical Procedure	MD 039	
Probe Material	Stainless Steel	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Date & Result of Last Converter Check	08/02/2023 - 95.1%	
Span Gas Type	Nitrogen Monoxide	
Span Gas Reference Number	CYL 12.0518	
Span Gas Expiry Date	24/03/2025	
Span Gas Start Pressure (bar)	50	
Gas Cylinder Concentration (ppm)	413.4	NOTE: Dilution performed to achieve correct span value
Span Gas Uncertainty (%)	2	
Zero Gas Type	Nitrogen (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	Centre Point	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

OXIDES OF NITROGEN (as NO_2): DATA TREND

Graphical Trend of Data



OXIDES OF NITROGEN (as NO_2): SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1
Sampling Times	-	14:00 - 22:00
Sampling Dates	-	18/07/2023
Instrument Range	ppm	500
Span Gas Value	ppm	243.6

Quality Assurance

Conditioning Unit Temperature	Units	Run 1
Average Temperature	°C	N/A
Allowable Temperature	< °C	N/A
Temperature Acceptable	-	N/A

	Zero Drift	Units	Run 1
CAL 1	Zero at Analyser (Pre)	ppm	0.00
CAL 1	Zero at Analyser (Post)	ppm	0.00
CAL 1	Zero Drift	ppm	0.00
CAL 1	Zero Drift	%	0.00
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Zero Drift	± %	5.00
	Zero Drift Acceptable	-	Yes

	Span Drift	Units	Run 1
CAL 1	Span at Analyser (Pre)	ppm	243.00
CAL 1	Span at Analyser (Post)	ppm	234.00
CAL 1	Span Drift	ppm	-9.00
CAL 1	Zero Adj. Span Drift	%	3.69
CAL 1	Drift Correction Applied	2-5%	Yes
	Allowable Span Drift	± %	5.00
	Span Drift Acceptable	-	Yes

Test Conditions	Units	Run 1
Run Ambient Temperature Range	°C	30 - 40

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1
There are no deviations associated with the sampling employed.	x

OXIDES OF NITROGEN (as NO_2): MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	RUN 1		Units
Limit value	500.0		mg/m³ (REF)
Allowable MU	10.0		%
Measured concentration	430.77		mg/m³ (STP, dry)
Ratio NO / NO_2	5		%
Range Used	500.0		ppm
Range Used [A]	1026.1		mg/m³
Cal gas conc.	243.6		ppm
Conversion	2.05		ppm to mg/m³
MCERTS Range [B]	205.0		mg/m³
Lower of [A] or [B]	205.0		mg/m³
Cal gas conc.	500.0		mg/m³

Performance characteristics	RUN 1		Units
Response time	31		seconds
Number of readings in measurement	480		-
Repeatability at zero	0.00		% full scale
Repeatability at span level	0.10		% full scale
Deviation from linearity	0.35		% of value
Zero drift	0.00		% full scale
Span drift	0.00		% full scale
Volume or pressure flow dependence	0.10		% of full scale
Atmospheric pressure dependence	0.10		% of value/kPa
Ambient temperature dependence	0.04		% full scale/10K
Combined interference	0.63		% range
Dependence on voltage	-0.23		% full scale/10V
Converter efficiency	95.1		%
Losses in the line (leak)	0.41		% of value
Uncertainty of calibration gas blending	1.40		% of value
Uncertainty of calibration gas	2.00		% of value

Performance characteristic	RUN 1		Units
Standard deviation of repeatability at zero	use rep at span		mg/m³
Standard deviation of repeatability at span level	0.00		mg/m³
Lack of fit	0.41		mg/m³
Drift	0.00		mg/m³
Volume or pressure flow dependence	0.00		mg/m³
Atmospheric pressure dependence	0.06		mg/m³
Ambient temperature dependence	0.01		mg/m³
Combined interference (from MCERTS Certificate)	0.75		mg/m³
Dependence on voltage	-0.03		mg/m³
Converter efficiency	0.61		mg/m³
Losses in the line (leak)	1.02		mg/m³
Uncertainty of calibration gas blending	3.48		mg/m³
Uncertainty of calibration gas	4.97		mg/m³

			RUN 1		Units
Measurement uncertainty		Result	430.77		mg/m³
Combined uncertainty			6.25		mg/m³
Expanded uncertainty	k =	1.96	12.24		mg/m³
Uncertainty corrected to std conds. (O_2)			11.72		mg/m³ (REF)

	RUN 1		Units
Expanded uncertainty (no O_2) - at 95% Confidence	2.84		% of Value
Expanded uncertainty (no O_2) - at 95% Confidence	2.45		% at ELV
Overall Allowable uncertainty (no O_2) - at 95% Confidence	10.0		% at ELV
Result of Compliance with Uncertainty Requirement	**N/A**		-

	RUN 1		Units
Expanded uncertainty (with O_2) - at 95% Confidence	3.70		% of Value
Expanded uncertainty (with O_2) - at 95% Confidence	3.33		% at ELV
Overall Allowable uncertainty (with O_2) - at 95% Confidence	10.3		% at ELV
Result of Compliance with Uncertainty Requirement	**COMPLIANT**		-

Requirement for SRM is that Uncertainty should be <10% of the value at the ELV, on a dry gas basis, or if O_2 correction is applied less than 10% + the uncertainty associated with the O_2 correction (using sqrt of sum squares to add uncertainty components).

CARBON MONOXIDE: RESULTS SUMMARY

Irish Cement Ltd, County Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m³	348		348
Uncertainty	±mg/m³	12.8		12.8
Mass Emission	g/hr	87916		87916
Uncertainty	±g/hr	6171		6171

General Sampling Information

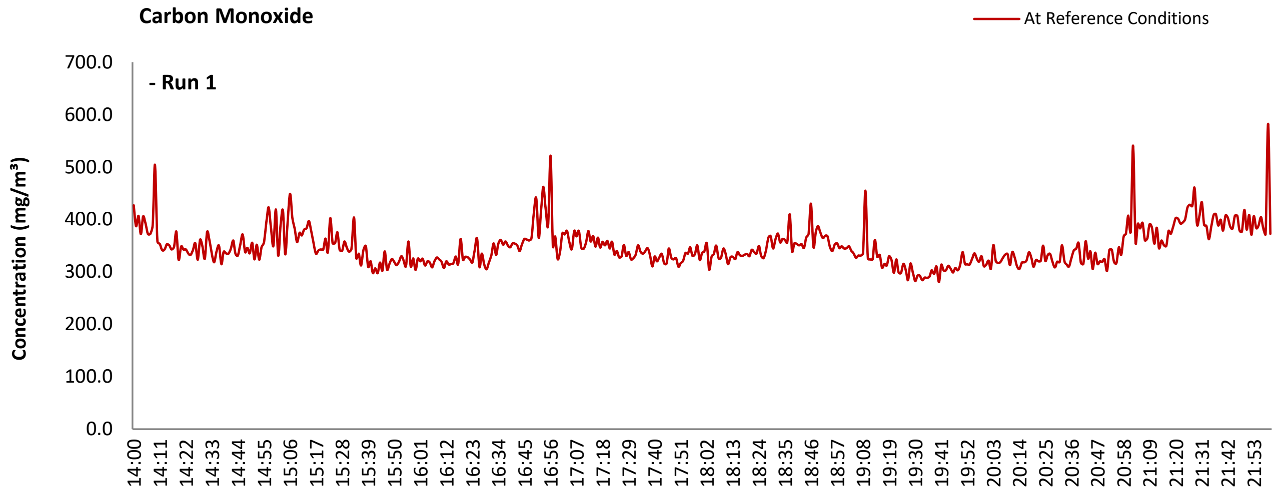
Parameter	Value	
Standard	EN 15058	
Technical Procedure	MD 039	
Probe Material	Stainless Steel	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Type	Carbon Monoxide	
Span Gas Reference Number	CYL 12.0518	
Span Gas Expiry Date	24/03/2025	
Span Gas Start Pressure (bar)	50	
Gas Cylinder Concentration (ppm)	407.3	NOTE: Dilution performed to achieve correct span value
Span Gas Uncertainty (%)	2	
Zero Gas Type	Nitrogen (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	Centre Point	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

CARBON MONOXIDE: DATA TREND

Graphical Trend of Data



CARBON MONOXIDE: SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1
Sampling Times	-	14:00 - 22:00
Sampling Dates	-	18/07/2023
Instrument Range	ppm	2000
Span Gas Value	ppm	407.3

Quality Assurance

Conditioning Unit Temperature	Units	Run 1
Average Temperature	°C	N/A
Allowable Temperature	< °C	N/A
Temperature Acceptable	-	N/A

	Zero Drift	Units	Run 1
CAL 1	Zero at Analyser (Pre)	ppm	0.00
CAL 1	Zero at Analyser (Post)	ppm	1.00
CAL 1	Zero Drift	ppm	1.00
CAL 1	Zero Drift	%	0.25
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Zero Drift	± %	5.00
	Zero Drift Acceptable	-	Yes

	Span Drift	Units	Run 1
CAL 1	Span at Analyser (Pre)	ppm	403.00
CAL 1	Span at Analyser (Post)	ppm	397.00
CAL 1	Span Drift	ppm	-6.00
CAL 1	Zero Adj. Span Drift	%	1.72
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Span Drift	± %	5.00
	Span Drift Acceptable	-	Yes

Test Conditions	Units	Run 1
Run Ambient Temperature Range	°C	30 - 40

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1
There are no deviations associated with the sampling employed.	x

CARBON MONOXIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	RUN 1		Units
Limit value	1500.0		mg/m^3 (REF)
Allowable MU	6.0		%
Measured concentration	363.37		mg/m^3 (STP, dry)
Range Used	2000.0		ppm
Range Used [A]	2498.4		mg/m^3
Cal gas conc.	407.3		ppm
Conversion	1.25		ppm to mg/m^3
MCERTS Range [B]	75.0		mg/m^3
Lower of [A] or [B]	75.0		mg/m^3
Cal gas conc.	508.8		mg/m^3

Performance characteristics	RUN 1		Units
Response time	28		seconds
Number of readings in measurement	480		-
Repeatability at zero	0.10		% full scale
Repeatability at span level	0.20		% full scale
Deviation from linearity	0.74		% of value
Zero drift	0.25		% full scale
Span drift	-1.72		% full scale
Volume or pressure flow dependence	0.10		% of full scale
Atmospheric pressure dependence	0.22		% of value/kPa
Ambient temperature dependence	-0.20		% full scale/10K
Combined interference	-0.48		% range
Dependence on voltage	-0.35		% full scale/10V
Losses in the line (leak)	0.49		% of value
Uncertainty of calibration gas blending	1.40		% of value
Uncertainty of calibration gas	2.00		% of value

Performance characteristic	RUN 1		Units
Standard deviation of repeatability at zero	use rep at span		mg/m^3
Standard deviation of repeatability at span level	0.01		mg/m^3
Lack of fit	0.32		mg/m^3
Drift	0.00		mg/m^3
Volume or pressure flow dependence	0.00		mg/m^3
Atmospheric pressure dependence	0.05		mg/m^3
Ambient temperature dependence	-0.03		mg/m^3
Combined interference (from MCERTS Certificate)	-0.21		mg/m^3
Dependence on voltage	-0.04		mg/m^3
Losses in the line (leak)	1.03		mg/m^3
Uncertainty of calibration gas blending	2.94		mg/m^3
Uncertainty of calibration gas	4.20		mg/m^3

			RUN 1		Units
Measurement uncertainty		**Result**	363.37		mg/m^3
Combined uncertainty			5.24		mg/m^3
Expanded uncertainty	k =	1.96	10.27		mg/m^3
Uncertainty corrected to std conds. (O_2)			9.83		mg/m^3 (REF)

	RUN 1		Units
Expanded uncertainty (no O_2) - at 95% Confidence	2.83		% of Value
Expanded uncertainty (no O_2) - at 95% Confidence	0.68		% at ELV
Overall Allowable uncertainty (no O_2) - at 95% Confidence	6.0		% at ELV
Result of Compliance with Uncertainty Requirement	**N/A**		-

	RUN 1		Units
Expanded uncertainty (with O_2) - at 95% Confidence	3.69		% of Value
Expanded uncertainty (with O_2) - at 95% Confidence	2.46		% at ELV
Overall Allowable uncertainty (with O_2) - at 95% Confidence	6.5		% at ELV
Result of Compliance with Uncertainty Requirement	**COMPLIANT**		-

Requirement for SRM is that Uncertainty should be <6% of the value at the ELV, on a dry gas basis, or if O_2 correction is applied less than 6% + the uncertainty associated with the O_2 correction (using sqrt of sum squares to add uncertainty components).

CARBON DIOXIDE: RESULTS SUMMARY

Irish Cement Ltd, County Limerick
A2-01 Kiln 6

Sample Runs

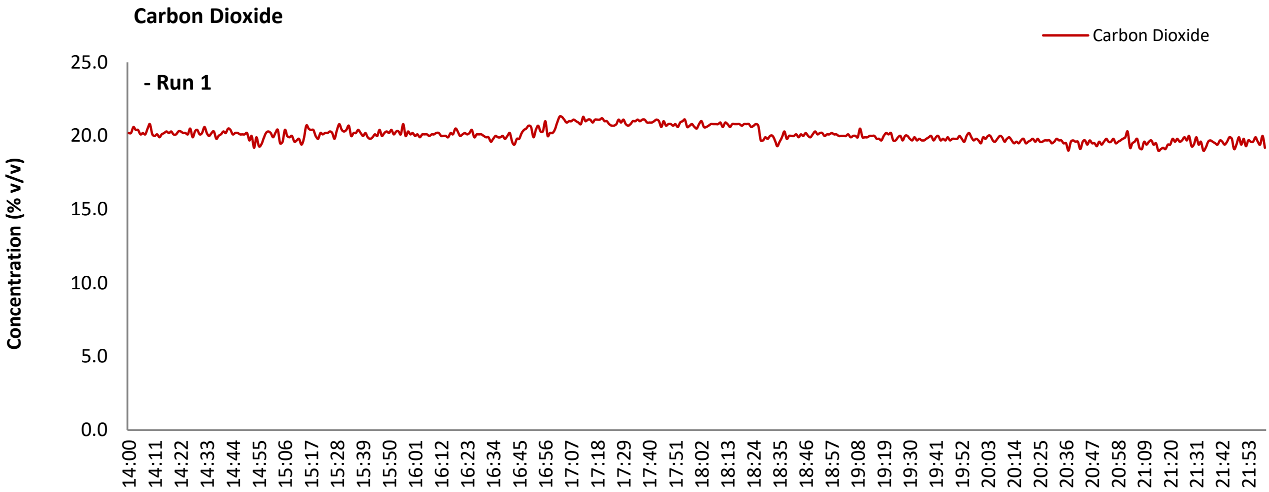
Parameter	Units	Run 1		Mean
Concentration	% v/v	20.1		20.1
Uncertainty	±% v/v	0.49		0.49

General Sampling Information

Parameter	Value	
Standard	CEN/TS 17405	
Technical Procedure	MD 039	
Probe Material	Stainless Steel	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Type	Carbon Dioxide	
Span Gas Reference Number	CYL 6.0072	
Span Gas Expiry Date	04/11/2026	
Span Gas Start Pressure (bar)	30	
Gas Cylinder Concentration (% v/v)	16.07	
Span Gas Uncertainty (%)	2.00	
Zero Gas Type	Nitrogen (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	Centre Point	

CARBON DIOXIDE: DATA TREND

Graphical Trend of Data



CARBON DIOXIDE: SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1
Sampling Times	-	14:00 - 22:00
Sampling Dates	-	18/07/2023
Instrument Range	% v/v	20
Span Gas Value	% v/v	16.1

Quality Assurance

Conditioning Unit Temperature	Units	Run 1
Average Temperature	°C	N/A
Allowable Temperature	< °C	N/A
Temperature Acceptable	-	N/A

	Zero Drift	Units	Run 1
CAL 1	Zero Down Sampling Line (Pre)	% v/v	0.00
CAL 1	Zero Down Sampling Line (Post)	% v/v	0.16
CAL 1	Zero Drift	% v/v	0.16
CAL 1	Zero Drift	%	1.06
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Zero Drift	± %	5.00
	Zero Drift Acceptable	-	Yes

	Span Drift	Units	Run 1
CAL 1	Span Down Sampling Line (Pre)	% v/v	15.99
CAL 1	Span Down Sampling Line (Post)	% v/v	15.96
CAL 1	Span Drift	% v/v	-0.03
CAL 1	Zero Adj. Span Drift	%	1.74
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Span Drift	± %	5.00
	Span Drift Acceptable	-	Yes

Test Conditions	Units	Run 1
Run Ambient Temperature Range	°C	30 - 40

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1
There are no deviations associated with the sampling employed.	x

CARBON DIOXIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	RUN 1		Units
Limit value	N/A		%vol
Allowable MU	25.0		%
Measured concentration	20.09		%vol
Range Used	20.0		%vol
Cal gas conc.	16.1		%vol

Performance characteristics	RUN 1		Units
Response time	29		seconds
Number of readings in measurement	480		-
Repeatability at zero	0.00		% full scale
Repeatability at span level	0.10		% full scale
Deviation from linearity	0.49		% of value
Zero drift	1.06		% full scale
Span drift	-1.74		% full scale
Volume or pressure flow dependence	0.10		% of full scale
Atmospheric pressure dependence	0.30		% of value/kPa
Ambient temperature dependence	-0.20		% full scale/10K
Combined interference	0.00		% range
Dependence on voltage	0.40		% full scale/10V
Losses in the line (leak)	0.50		% of value
Uncertainty of calibration gas	2.00		% of value

Performance characteristic	RUN 1		Units
Standard deviation of repeatability at zero	use rep at span		%vol
Standard deviation of repeatability at span level	0.00		%vol
Lack of fit	0.06		%vol
Drift	0.00		%vol
Volume or pressure flow dependence	0.00		%vol
Atmospheric pressure dependence	0.02		%vol
Ambient temperature dependence	-0.03		%vol
Combined interference (from MCERTS Certificate)	0.00		%vol
Dependence on voltage	0.05		%vol
Losses in the line (leak)	0.06		%vol
Uncertainty of calibration gas	0.23		%vol

			RUN 1		Units
Measurement uncertainty		Result	20.09		%vol
Combined uncertainty			0.25		%vol
Expanded uncertainty	k =	1.96	0.49		%vol

	RUN 1		Units
Expanded uncertainty (no O_2) - at 95% Confidence	2.5		% of Value

OXYGEN: RESULTS SUMMARY

Irish Cement Ltd, County Limerick
A2-01 Kiln 6

Sample Runs

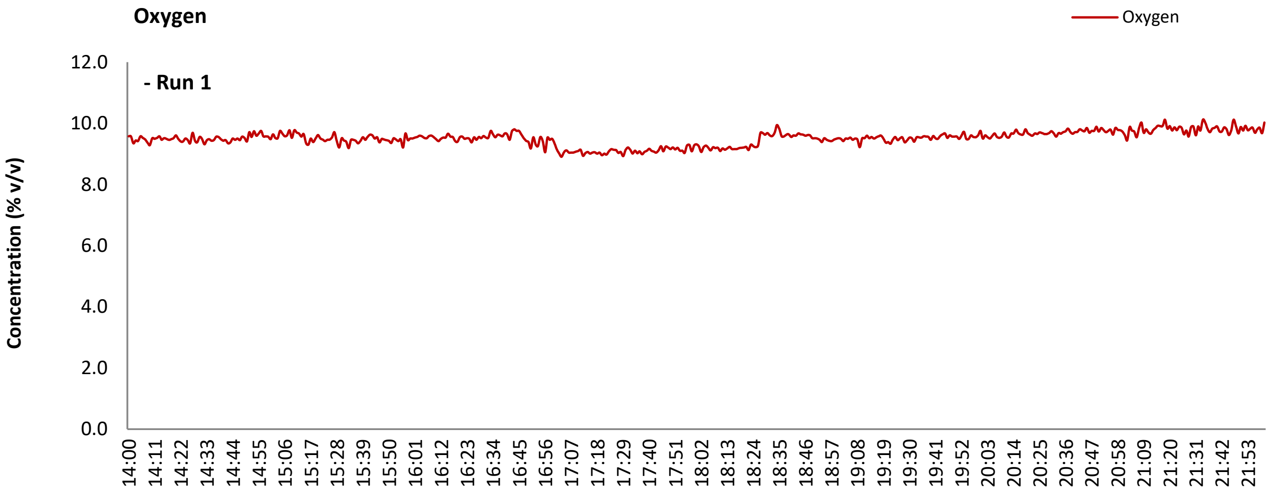
Parameter	Units	Run 1		Mean
Concentration	% v/v	9.5		9.5
Uncertainty	±% v/v	0.23		0.23

General Sampling Information

Parameter	Value	
Standard	EN 14789	
Technical Procedure	MD 039	
Probe Material	Stainless Steel	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Type	Synthetic Air (5 Grade)	
Span Gas Reference Number	CYL 11.0566	
Span Gas Expiry Date	06/09/2027	
Span Gas Start Pressure (bar)	40	
Gas Cylinder Concentration (% v/v)	21.12	NOTE: Dilution performed to achieve correct span value
Span Gas Uncertainty (%)	2	
Zero Gas Type	Nitrogen (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	Centre Point	

OXYGEN: DATA TREND

Graphical Trend of Data



APPENDIX 2

OXYGEN: SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1
Sampling Times	-	14:00 - 22:00
Sampling Dates	-	18/07/2023
Instrument Range	% v/v	25.0
Span Gas Value	% v/v	13.0

Quality Assurance

Conditioning Unit Temperature	Units	Run 1
Average Temperature	°C	N/A
Allowable Temperature	< °C	N/A
Temperature Acceptable	-	N/A

	Zero Drift	Units	Run 1
CAL 1	Zero at Analyser (Pre)	% v/v	0.00
CAL 1	Zero at Analyser (Post)	% v/v	-0.14
CAL 1	Zero Drift	% v/v	-0.14
CAL 1	Zero Drift	%	1.08
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Zero Drift	± %	5.00
	Zero Drift Acceptable	-	Yes

	Span Drift	Units	Run 1
CAL 1	Span at Analyser (Pre)	% v/v	13.01
CAL 1	Span at Analyser (Post)	% v/v	13.20
CAL 1	Span Drift	% v/v	0.19
CAL 1	Zero Adj. Span Drift	%	2.54
CAL 1	Drift Correction Applied	2-5%	Yes
	Allowable Span Drift	± %	5.00
	Span Drift Acceptable	-	Yes

Test Conditions	Units	Run 1
Run Ambient Temperature Range	°C	30 - 40

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1
There are no deviations associated with the sampling employed.	x

OXYGEN: MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	RUN 1		Units
Limit value	N/A		%vol
Allowable MU	6.0		%
Measured concentration	9.51		%vol
Range Used	25.0		%vol
Cal gas conc.	21.1		%vol

Performance characteristics	RUN 1		Units
Response time	41		seconds
Number of readings in measurement	480		-
Repeatability at zero	0.02		% full scale
Repeatability at span level	0.02		% full scale
Deviation from linearity	0.03		% of value
Zero drift	-1.08		% full scale
Span drift	0.00		% full scale
Volume or pressure flow dependence	0.10		% of full scale
Atmospheric pressure dependence	0.19		% of value/kPa
Ambient temperature dependence	-0.21		% full scale/10K
Combined interference	0.00		% range
Dependence on voltage	0.02		% full scale/10V
Losses in the line (leak)	0.08		% of value
Uncertainty of calibration gas	2.00		% of value

Performance characteristic	RUN 1		Units
Standard deviation of repeatability at zero	use rep at span		%vol
Standard deviation of repeatability at span level	0.00		%vol
Lack of fit	0.00		%vol
Drift	0.00		%vol
Volume or pressure flow dependence	0.00		%vol
Atmospheric pressure dependence	0.01		%vol
Ambient temperature dependence	-0.03		%vol
Combined interference (from MCERTS Certificate)	0.00		%vol
Dependence on voltage	0.00		%vol
Losses in the line (leak)	0.00		%vol
Uncertainty of calibration gas	0.11		%vol

			RUN 1		Units
Measurement uncertainty		Result	9.51		%vol
Combined uncertainty			0.11		%vol
Expanded uncertainty	k =	1.96	0.23		%vol

	RUN 1		Units
Expanded uncertainty (no O_2) - at 95% Confidence	2.4		% of Value
Result of Compliance with Uncertainty Requirement	**COMPLIANT**		-

Requirement for SRM is that Uncertainty should be 0.3% vol absolute or 6% relative whichever is the lower, on a dry gas basis. Source, EN 14789.

VERSION HISTORY

Version Number	Record of changes made within this version of the document
V1	The original document issued to the client

Report Title	Air Emissions Compliance Monitoring Emissions Report
Company address	Air Scientific Ltd., Unit 3 Westlink Business Park, Clondrinagh, Limerick, V94 K6XK
Contact Details	Phone: 061 324587
Stack Emissions Testing Report Commissioned by	Irish Cement Limited
Facility Name	Irish Cement Limited
EPA Licence Number	P0029-06
Licence Holder	Irish Cement Limited
Stack Reference Number	A2-01 (Kiln)
Dates of the Monitoring Campaign	30/08/2023 & 31/08/2023
Job Reference Number	IRLITL12290823
Report Written By	Mr. Jarlath Sammon
Report Approved by	Mark McGarry
Stack Testing Team	Mr. Jarlath Sammon & Mr. Ben Drysdale
Report Date	24-10-2023
Report Type	Test Report Compliance Monitoring
Version	1
Signature of Approver	**Operations Manager**

Contents

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All sampling and reporting are completed in accordance with Environmental Protection Agency Air Guidance Note 2 requirements.

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TESTING
DETAILED IN SCOPE REG NO.319T

1.0 Executive Summary

1.1 Overall aim of the monitoring campaign

The aim of the monitoring campaign was to demonstrate compliance with a set of emission limit values as specified in the site licence.

1.2 Summary of substances to be monitored at each emission point

Stack Name:	**A2-01**
Total Particulate Matter	
Total Gaseous Organic Compounds	
Carbon Monoxide	
Nitrogen Oxides (as NO_2)	
Oxygen	
Carbon Dioxide	
Sulphur Dioxide	
Chloride (as HCl)	
Fluoride (as HF)	
Ammonia	
Metals & Mercury	
Dioxins and Furans	
Volumetric Flow Rate (Ref)	

1.3 Special Requirements

There were no special requirements

1.4 Summary of Results

Emission Point Number: A2-01

Parameter	Method	Units	Result	MU +/-	Limit	O_2 Ref. (%)	Moisture Ref. (%)	Blanks	Date	Time on	Time off	Accreditation	
												Sampling	Analysis
Total Particulate Matter (TPM)	EN13284	$mg.m^{-3}$	<1.09	0.35	10	10	Dry	<0.96	30/08/2023	13:20	13:54	Yes	Yes
Nitrogen Oxides	EN 14792	$mg.m^{-3}$	457.5	28.6	500	10	Dry	N/a	30/08/2023	10:39	11:09	Yes	N/a
Sulphur Dioxide	EN/TS 17021	$mg.m^{-3}$	7.1	1.9	50	10	Dry	N/a	30/08/2023	10:39	11:09	Yes	N/a
Carbon Monoxide	EN 15058	$mg.m^{-3}$	332.8	10.4	1,500	10	Dry	N/a	30/08/2023	10:39	11:09	Yes	N/a
Carbon Dioxide	EN/TS 17045	vol%	17.91	0.4	-	N/a	Dry	N/a	30/08/2023	10:39	11:09	Yes	N/a
Oxygen	EN 14789	vol%	10.68	0.3	-	N/a	Dry	N/a	30/08/2023	10:39	11:09	Yes	N/a
Total Organic Compounds	EN 12619	$mg.m^{-3}$	18.2	0.76	25	10	Dry	N/a	30/08/2023	12:27	12:57	Yes	N/a
Hydrogen Chloride	EN 1911	$mg.m^{-3}$	0.37	0.03	10	10	Dry	<0.13	31/08/2023	09:47	10:47	Yes	Yes
Hydrogen Fluoride	ISO 15713	$mg.m^{-3}$	0.36	0.03	1	10	Dry	<0.13	31/08/2023	10:47	11:47	Yes	Yes
Ammonia	ISO 21877	$mg.m^{-3}$	22.45	1.75	50	10	Dry	0.254	31/08/2023	08:10	08:40	Yes	Yes
Total Cd / Tl	EN 14385	$mg.m^{-3}$	<0.001	0.00004	0.05	10	Dry	<0.0009	30/08/2023	12:04	13:07	Yes	Yes
Total Hg	EN 14385	$mg.m^{-3}$	<0.002	0.00007	0.05	10	Dry	<0.0007	30/08/2023	12:04	13:07	Yes	Yes
Remaining Metals	EN 14385	$mg.m^{-3}$	<0.011	0.00045	0.5	10	Dry	<0.0050	30/08/2023	12:04	13:07	Yes	Yes
Dioxins and Furans	EN 1948-1	$ng.m^{-3}$	<0.0004	0.00001	0.1	10	Dry	0.000199	31/08/2023	09:34	15:34	Yes	Yes
Volumetric Flow Rate (Ref)	EN 16911	$m^3.h^{-1}$	213,610	9,169	500,000	10	Dry	N/a	30/08/2023	12:04	13:07	Yes	N/a

Note 1: All results are normalised to standard temperature and pressure ($0^{O}C$ and 101.3kPa)
Note 2: All results are reported in the format as defined by the EPA in guidance note AG2:2021.

1.5 Operating Information

Please reference Process Details as per Appendix III attached.

1.6 Monitoring Deviations

Stack Name: A2-01	
Parameter	Deviation
Total Particulate Matter	None
Total Gaseous Organic Compounds	None
Carbon Monoxide	None
Nitrogen Oxides (as NO_2)	None
Oxygen	None
Carbon Dioxide	None
Sulphur Dioxide	None
Chloride (as HCl)	None
Fluoride (as HF)	None
Ammonia	None
Metals & Mercury	None
Dioxins and Furans	None
Volumetric Flow Rate (Ref)	EN 16911 - in accordance with MID 16911-1

1.7 Reference Documents

Risk Assessment (RA)	SOP 1011
Site Review (SR)	SOP 1015
Site Specific Protocol (SSP)	SOP 1015

1.8 Revision History

Revision Number	Changes to the report
1	Original version of the report

Part 2: Supporting Information	
Report Title	Air Emissions Compliance Monitoring Emissions Report
Company address	Air Scientific Ltd., Unit 3 Westlink Business Park, Clondrinagh, Limerick, V94 K6XK
Stack Emissions Testing Report Commissioned by	Irish Cement Limited
Facility Name	Irish Cement Limited
EPA Licence Number	P0029-06
Licence Holder	Irish Cement Limited
Stack Reference Number	A2-01 (Kiln)
Dates of the Monitoring Campaign	30/08/2023 & 31/08/2023
Job Reference Number	IRLITL12290823
Report Written By	Mr. Jarlath Sammon
Report Approved by	Mark McGarry
Stack Testing Team	Mr. Jarlath Sammon & Mr. Ben Drysdale
Report Date	24-10-2023
Report Type	Test Report Compliance Monitoring
Version	1
Signature of Approver	……………… **Operations Manager**

ISO 17025 INAB ACCREDITED TESTING
DETAILED IN SCOPE REG NO.319T

Appendix I

1.1 Monitoring Personnel

Team Leader	Name	Jarlath Sammon
	System approval	ASL Team Leader Approved
Technician	Name	Ben Drysdale
	System approval	ASL Technician Approved

1.2 Equipment Inventory

ID	Item of Equipment	Used	ID	Item of Equipment	Used	ID	Item of Equipment	Used
ASLLK12EQ500	Pump		ASLLK12EQ525	Horiba (PG-250) X		ASLLK13EQ501	Vernier Calipers	✓
ASLLK12EQ532	Pump		ASLLK16EQ508	Horiba- PG250z		ASLLK14EQ503	Vernier Calipers	
ASLLK12EQ536	Pump		ASLLK14EQ501	Horiba-PG 350		ASLLK14EQ507	Vernier Calipers	
ASLLK12EQ537	Pump		ASLLK17EQ515	Horiba 350		ASLLK17EQ533	Vernier Calipers	
ASLLK12EQ538	Pump		ASLLK20EQ506	Horiba 350	✓	ASLLK18EQ506	Vernier Calipers	
ASLLK12EQ542	Pump		ASLLK21EQ503	Horiba 350		ASLLK20EQ516	Vernier Calipers	
ASLLK12EQ543	Pump		ASLLK21EQ522	Horiba 350				
ASLLK13EQ514	Pump							
ASLLK16EQ518	Pump					ASLLK13EQ503	1kg weight	
ASLLK16EQ519	Pump		ASLLK12EQ526	Chiller		ASLLK13EQ508	500g Hafner weight	
ASLLK17EQ509	Pump		ASLLK14EQ513	Chiller		ASLLK13EQ509	500g Hafner weight	
ASLLK17EQ510	Pump		ASLLK16EQ509	Chiller		ASLLK14EQ515	500g Weight	
ASLLK17EQ522	Pump		ASLLK18EQ505	Chiller	✓	ASLLK15EQ511	1kg Weight	
ASLLK17EQ523	Pump		ASLLK21EQ504	Chiller		ASLLK15EQ512	1kg weight	
ASLLK17EQ524	Pump		ASLLK22EQ509	Chiller		ASLLK16EQ511	1kg weight	
ASLLK17EQ525	Pump					ASLLK16EQ512	500g weight	
ASLLK17EQ526	Pump					ASLLK17EQ529	500g weight	
ASLLK18EQ517	Pump		ASLLK14EQ518	Velocity Meter		ASLLK17EQ530	1kg weight	
ASLLK18EQ518	Pump		ASLLK16EQ501	Velocity Meter		ASLLK19EQ513	500g weight	
ASLLK21EQ507	Pump		ASLLK17EQ508	Velocity Meter		ASLLK19EQ514	1kg Weight	
ASLLK21EQ508	Pump		ASLLK17EQ514	Velocity Meter		ASLLK19EQ519	1kg weight	✓
ASLLK21EQ509	Pump		ASLLK18EQ504	Velocity Meter		ASLLK19EQ520	500g weight	✓
ASLLK21EQ510	Pump		ASLLK19EQ502	Velocity Meter				
ASLLK21EQ511	Pump		ASLLK20EQ504	Velocity Meter				
ASLLK22EQ500	Pump					ASLLK17EQ534	ST5	✓
ASLLK22EQ501	Pump		ASLLK20EQ513	Anemometer (Hotwire)		ASLLK18EQ503	ST5	
ASLLK22EQ502	Pump	✓	ASLLK21EQ528	TSI (Vane)		ASLLK18EQ513	ST5	
ASLLK22EQ503	Pump					ASLLK19EQ509	ST5	
ASLLK22EQ504	Pump					ASLLK20EQ500	ST5	
ASLLK22EQ505	Pump		ASLLK16EQ502	FID		ASLLK21EQ519	ST5	
			ASLLK17EQ517	FID		ASLLK22EQ508	ST5	
			ASLLK19EQ508	FID				
ASLLK21EQ500	MF Meter		ASLLK20EQ507	FID				
ASLLK21EQ501	MF Meter		ASLLK20EQ508	FID	✓	ASLLK14EQ510	Digital Protractor	
ASLLK21EQ502	MF Meter		ASLLK17EQ535	Signal Cutter		ASLLK14EQ511	Digital Protractor	✓
ASLLK21EQ526	MF Meter					ASLLK17EQ528	Digital Protractor	
ASLLK21EQ530	MF Meter					ASLLK18EQ507	Digital Protractor	
ASLLK21EQ531	MF Meter		ASLLK16EQ510	Measuring Tape		ASLLK20EQ514	Digital Protractor	
ASLLK22EQ514	MF Meter	✓	ASLLK17EQ527	Measuring Tape		ASLLK20EQ515	Digital Protractor	
			ASLLK18EQ508	Measuring Tape				
ASLLK14EQ514	Heated Line		ASLLK19EQ516	Measuring Tape				
ASLLK17EQ502	Heated Line		ASLLK20EQ509	Measuring Tape		ASLLK12EQ522	Balance	
ASLLK17EQ503	Heated Line		ASLLK21EQ521	Measuring Tape	✓	ASLLK15EQ509	Balance	
ASLLK17EQ539	Heated Line (5m)					ASLLK15EQ510	Balance	
ASLLK19EQ523	Heated Line					ASLLK17EQ537	Balance	
ASLLK20EQ520	Heated Line		ASLLK20EQ519	PCDD Thermometer		ASLLK19EQ515	Balance	
ASLLK20EQ521	Heated Line	✓				ASLLK21EQ505	Balance	
ASLLK21EQ523	Heated Line (5m)		ASLLK16EQ515	Thermocouple K type		ASLLK21EQ506	Balance	
ASLLK21EQ524	Heated Line (5m)		ASLLK16EQ516	Thermocouple K type		ASLLK21EQ525	Balance	✓
ASLLK22EQ510	Heated Line (40m)		ASLLK21EQ513	K type Thermocouple		ASLLK21EQ529	Balance	
ASLLK22EQ512	Heated Line (5m)	✓	ASLLK21EQ514	K type Thermocouple				
ASLLK22EQ513	Heated Line (5m)		ASLLK21EQ515	K type Thermocouple				
			ASLLK21EQ516	K type Thermocouple				
ASLLK12EQ518	S type Pitot Tube		ASLLK21EQ517	K type Thermocouple				
ASLLK12EQ520	L Type Pitot tube		ASLLK21EQ518	K type Thermocouple				
ASLLK13EQ506	S type Pitot Tube		ASLLK23EQ509	K type Thermocouple	✓			
ASLLK14EQ506	1m S type & K type							
ASLLK16EQ506	S type Pitot Tube							
ASLLK16EQ517	S type Pitot Tube Long		ASLLK17EQ519	Stopwatch				
ASLLK17EQ507	1m S type & K type		ASLLK17EQ520	Stopwatch	✓			
ASLLK17EQ536	S type Pitot Tube		ASLLK17EQ521	Stopwatch				
ASLLK18EQ514	S type Pitot Tube		ASLLK18EQ509	Stopwatch				
ASLLK18EQ515	S type Pitot Tube		ASLLK19EQ518	Stopwatch				
ASLLK19EQ510	S type pitot tube		ASLLK21EQ512	Stopwatch				
ASLLK19EQ511	S type pitot tube							
ASLLK19EQ521	1m S type & K type							
ASLLK19EQ522	Pitot							
ASLLK22EQ506	S type pitot tube							
ASLLK22EQ507	S type pitot tube							
ASLLK22EQ520	S type pitot tube	✓						

Appendix II

2.1 Stack Emission Point Reference: A2-01

2.1.1 Suitability of Sample Location:

General Information	Kiln
Permanent/Temporary	Permanent
Inside/ Outside	Outside

Platform Details		
Irish EPA Technical Guidance Note AG1 / BS EN 15259 Platform Requirements	Value	Comment
Sufficient Working area to manipulate probe and measuring instruments	Yes	-
Platform has 2 handrails (approx. 0.5m & 1.0 m high)	Yes	-
Platform has vertical base boards (approx. 0.25 m high)	Yes	-
Platform has chains / self-closing gates at top of ladders	N/a	-
There are no obstructions present which hamper insertion of sampling equipment	Yes	-
Safe Access Available	Yes	-
Easy Access Available	Yes	-
Sampling Location / Platform Improvement Recommendations		
None		
EN 15259 Homogeneity Test Requirements		
2.		
Select Option: 1: There is no requirement to perform a BSEN15259 Homogeneity Test on this stack 2: Test results were obtained from previous Homogeneity test carried out by ASL 3: Test results were obtained from previous Homogeneity test carried out by Alternative contractor 4: Homogeneity Test is required on this stack and the client has been informed of this requirement		

2.1.2 Stack Diagram

Figure 1: A2-01

2.1.3 Stack Raw Data

Title:	**Determination of Total Particulates**				
Method:	EN 13284-1				
Client:	Irish Cement				
Test Date:	30/08/2023		**Air Volume at Pump**	0.7908	m^3
Test Time	13:20		**Temperature at Pump**	23.47	Deg C
Laboratory Used:	RPS		**Pressure at Pump**	83.1	kPa
Stack Name	A2-01		**Humidity at Pumps**	0	%
Run I.D.	1		**Filter Weight**	0.11	mg
Filter I.D.	256210		**Front End Weight**	0.5	mg
Moisture Content	7.68	%			
Reference Oxygen	10	%	**Flow Uncertainty**	9,050	m^3/hr
Measured Oxygen	10.68	%	**Flow Uncertainty**	4.3	%
Stack Flow Rate	243539	Nm^3/hr			
Adjusted Stack Flow Rate	210808.7884	Nm^3/hr, dry @ % Oxygen			
Volume of Air Sampled	0.5974	Nm^3			
Leak Check Results	**Result**		**% Leak**		
Before Sample 1	0	l/min	0.0		
Average Flow Rate	20.02	l/min	0.0		
Standard Maximum	0.4004	l/min	2%		
Back Pressure	51.88	kPa			
Standard Criteria to be Met	**Result**	**Std. Requirement**			
Angle of Flow	Yes	<15 Degrees	**Probe material**	Stainless Steel	
Negative Flow in the Stack	Yes	None	**Filter housing**	Stainless Steel	
Pitot Pressure Difference	Yes	>5Pa	**Positioning of filter**	In Stack	
Ratio of Flow Measurement	Yes	<3:1	**Filter Size & Material**	47mm Quartz	
Stagnation Test	Yes	<10Pa			
Pitot Tube Leak Check	**Result**				
Positive Pressure	Pass	-			
Negative Pressure	Pass	-			
Number of Ports	2	2			
Straight length before sample point	Yes	> 5 Hydraulic Diameters			
Straight length after sample point	Yes	> 5 Hydraulic Diameters to Stack Outlet or 2HD to Fan/ Bend			
Sample Calculations					
Blank (Filter and Front Wash Combined)	0.54	mg			
Sample 1 (Filter and Front Combined)	0.61	mg			
Volume of Air Sampled	0.5974	Nm^3			
Blank Result	0.90	mg/Nm^3, dry	0.96	mg/Nm^3, dry @ Ref O_2	
Sample Result	1.02	mg/Nm^3, dry	1.09	mg/Nm^3, dry @ Ref O_2	
Uncertainty of Measurement	0.35	mg/Nm^3			
Emission Limit Value	10	mg/Nm^3			
Blank as Percentage of ELV	9.0	%	**Requirement <10% ELV or <0.5 mg/m^3**		
Isokinetic Criterion Compliance					
Isokinetic Variation	-0.1	%			
Allowable Isokinetic Range	-5 to + 15%	%			
Isokinetic Acceptable	Yes				

DUCT AND GAS SPECIFICATION			
Name			a2-01
Section			Circular
Diameter		[m]	2.6
Area		[m2]	5.309292
Ports		[#]	2
Points	P	[#]	10
Density	ρn	[kg/Nm3]	1.396
Carbon Dioxide	CO2	[%]	17.91
Oxygen	O2	[%]	10.68
Water Vapor Ratio	rw	[0;1]	0.077
Nozzle	nz	[mm]	6
Turbolence factor	ft	[sec]	1
Wall Adjustment Factor	waf		
PITOT DATA SPECIFICATION			
Name			
Velocity	[m/sec]	5	0.83
Velocity	[m/sec]	10	0.83
Velocity	[m/sec]	20	0.83
Velocity	[m/sec]	30	0.83
Velocity	[m/sec]	40	0.83
NORMALIZATION FACTOR			
Tnorm		[K]	273
Pnorm		[kPa]	101.3
DUCT FLOW RATE			
Dry actual	QVa	[m3/h]	359043
Moist actual	Q'Va	[m3/h]	389000
Moist norm. [Tnorm Pnorm]	Q'Vn	[Nm3/h]	243539
Dry norm. [Tnorm Pnorm]	QVn	[Nm3/h]	224786
AVERAGE VALUES			
Total Points		[#]	2
Velocity	v'a	[m/sec]	20.45
Stack temperature	tstack	[°C]	159.97
Stack Pressure	Pa	[kPa]	100.58
Isokinetic Rate	DI	[%]	-0.1
Velocity at nozzle	v'N	[m/sec]	20.444
Probe temperature	tprobe	[°C]	177.3
Filter temperature	tfilter	[°C]	143.5
Outlet temperature	toutlet	[°C]	45.5
Aux temperature	taux	[°C]	33.8
Ambient Pressure	Pamb	[kPa]	100.69
GAS METER SAMPLED VOLUMES			
Elapsed time	et		00:30:00
Norm. Volume [Tnorm Pnorm]	Vgn		0.5974
Moist Volume at stack conditions	V'ga		1.0338
Volume at dgm conditions	Vdgm		0.7908
Gas meter temperature	tdgm		23.47
Gas Meter Pressure	Pdgm		83.1

Uncertainty calculation for EN 13284					
	Symbol	**Unit**	**Values**	**UOM as %**	**Std Requirement**
Sampled Volume	V_m	m^3	0.001	0.13	<=5%
Sampled gas Temperature	T_m	k	2.00	0.67	<=2%
Sampled gas Pressure	ρ_m	kPa	1.00	1.20	<=2%
Sampled gas Humidity	H_m	% by volume	1.00	1.00	<=1%
Oxygen content	$O_{2,m}$	% by volume	0.10	-	<=5%
Mass particulate	m	mg	0.096	15.78	<5% of limit value
Leak	L		-	0.00	<=2%
Uncollected Mass	UCM		-	0.00	<10% of limit value
Corrected Volume (STP)	V	m^3	0.60	1.71	-
Mass	m	mg	0.61	15.78	-
Factor for O2 Correction	fc		1.07	0.97	-
Leak	L	$mg.m^{-3}$	0.00	0.00	-
Uncollected mass	UCM	mg	0.00	0.00	-
Combined measurement uncertainty			**0.17**	-	-
Expanded uncertainty as percentage of measured value				**31.81**	% measured of value
Expanded uncertainty in units of measurement				**0.35**	mg.m-3
Expanded uncertainty as percentage of limit value				**3.46**	% ELV

Title:	***Determination of Flue Gases***					
Method:	EN 14792 / TS 17021 / EN 15058 / TS 17045 / EN 14789					
Test Date:	30/08/2023					
Stack Name:	A2-01		**Quality Assurance**			
Test Start Time:	10:39		Probe Material		Stainless Steel	
Reference Conditions			Filtration Type/size		Stainless Steel	
Measured Oxygen	10.7	%	Heated Filter used		Yes	
Reference Oxygen	10	%	No. of sampling lines		1	
Reference Moisture	0		No. of Sampling points		1	
			Sampling point I.D.s		1	
Parameter		**NO**	**SO2**	**CO**	**CO2**	**O2**
Emission Limit Values	$mg.m^{-3}$ ref	500	50	1500	-	-
Instrument Range	ppm	500	200	1000	30.00%	25.00%
Span Gas Value	ppm	431	149	814	16.42%	20.90%
Acceptable Gas Range	-	Yes	Yes	Yes	Yes	Yes
Calibration Gas Reference No.	-	ASLLK23IG317	ASLLK23ING314	ASLLK18ING546	ASLLK19ING558	-
Calibration Gas Uncertainty	%	1.2	1.2	0.4	0.9	0.35
Calibration Gas Start Bar	Bar	35	50	60	15	-
Expiry Date	-	Jul-24	Oct-24	Oct-23	Nov-23	-
Quality Assurance	Units	**NO**	**SO2**	**CO**	**CO2**	**O2**
Conditioning Unit Temperature	C	2	2	2	2	2
Average Temperature	< C	2	2	2	2	2
Allowable Temperature	-	4	4	4	4	4
Temperature Acceptable	-	Yes	Yes	Yes	Yes	Yes
Pump flow rate	l/min.	0.5	0.5	0.5	0.5	0.5
Instrument Zero Drift	Units	**NO**	**SO2**	**CO**	**CO2**	**O2**
Instrument Zero (Ambient air or Nitrogen)		Nitrogen	Nitrogen	Nitrogen	Nitrogen	Nitrogen
Instrument Zero (Pre)	ppm	0	0	0	0.00%	0.00%
Instrument Zero (Check)	ppm	0.6	0.9	0	0.02%	-0.01%
Compliance Statement	Pass / Fail	Pass	Pass	Pass	Pass	Pass
Instrument Zero (Post)	ppm	0	-0.3	0	0.03%	-0.20%
Zero Drift	ppm	0	-0.3	0	0.03%	-0.20%
Allowable Zero Drift (Less than 2%)	ppm equiv.	8.62	2.98	16.28	-	0.42%
Adjustable Zero Drift (2 - 5%) / 5% CO_2	ppm equiv.	21.55	7.45	40.7	0.82%	1.05%
Zero Drift Failure (<5% / >5% CO_2)	ppm equiv.	21.55	7.45	40.7	0.82%	1.05%
Zero Drift Acceptable	-	Yes	Yes	Yes	Yes	Yes
Adjust for Zero Drift	-	No	No	No	No	No
Reject results	-	No	No	No	No	No
Calculated Drift	%	0.00%	-0.20%	0.00%	0.18%	-0.96%
Instrument Span Drift	Units	**NO**	**SO2**	**CO**	**CO2**	**O2**
Instrument Span Down (Pre)	ppm	431	149	814	16.42%	20.90%
Instrument Check Span (Post)	ppm	423.6	147	800	16.38%	20.66%
Span Drift	ppm	-7.4	-2	-14	-0.04%	-0.24%
Allowable Span Drift (less than 2%)	ppm equiv.	8.62	2.98	16.28	0.33%	0.42%
Adjustable Span Drift (2 - 5%)	ppm equiv.	21.55	7.45	40.7	0.00821	1.05%
Span Drift Failure (Greater than 5%)	ppm equiv.	21.55	7.45	40.7	0.82%	1.05%
Span Drift Acceptable (Y/N)	-	Yes	Yes	Yes	Yes	Yes
Adjust for Span Drift	-	No	No	No	No	No
Reject results	-	No	No	No	No	No
Calculated Drift	%	-1.72%	-1.34%	-1.72%	-0.24%	-1.15%
Heated Line Check Including Leak Check		**NO**	**SO2**	**CO**	**CO2**	**O2**
Span Gas Conc.	ppm	431	149	814	16.42%	20.90%
Zero Check Acceptable Limit (+/-)	ppm	8.62	2.98	16.28	0.33%	0.42%
Heated Line Check Zero Gas	ppm	0.4	1.5	0	0.00%	0.17%
Compliance Statement	Pass / Fail	Pass	Pass	Pass	Pass	Pass
Heated Line Check Span Gas	ppm or %	428.1	148.3	800	16.15%	20.89%
Span Gas Leak Detected	ppm or %	-2.9	-0.7	-14	-0.27%	-0.01%
Leak check acceptable (< 2%)	ppm or %	8.62	2.98	16.28	0.33%	0.42%
Compliance Statement	Pass / Fail	Pass	Pass	Pass	Pass	Pass
Response Time (<200 seconds)		Yes	Yes	Yes	Yes	Yes

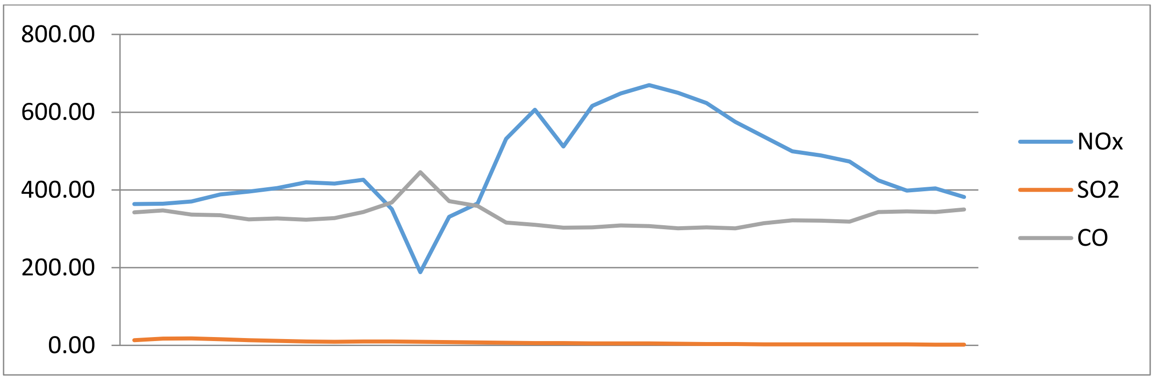
Test Conditions	Units	
Run Ambient Temperature Range	C	20

Raw Data

Date/Time	**NOx**	**SO2**	**CO**	**CO2**	**O2**
	ppm	**ppm**	**ppm**	**vol%**	**vol%**
30/08/2023 10:39	166.1	4.3	256.6	17.92	10.78
30/08/2023 10:40	166.3	5.7	260.3	17.95	10.73
30/08/2023 10:41	169.1	5.9	252.3	17.92	10.76
30/08/2023 10:42	177.2	5.0	251.0	17.85	10.79
30/08/2023 10:43	180.5	4.3	243.3	17.80	10.80
30/08/2023 10:44	184.9	3.7	244.9	17.89	10.78
30/08/2023 10:45	191.6	3.3	242.7	17.95	10.73
30/08/2023 10:46	190.1	3.1	245.8	18.02	10.70
30/08/2023 10:47	194.5	3.3	256.9	18.05	10.65
30/08/2023 10:48	160.0	3.3	276.0	17.97	10.64
30/08/2023 10:49	85.9	3.0	334.1	17.85	10.70
30/08/2023 10:50	151.1	2.7	278.3	17.89	10.69
30/08/2023 10:51	166.9	2.3	269.1	17.82	10.72
30/08/2023 10:52	242.4	2.1	236.7	17.76	10.78
30/08/2023 10:53	276.7	1.9	232.6	17.85	10.74
30/08/2023 10:54	233.5	2.0	226.8	17.71	10.79
30/08/2023 10:55	281.4	1.8	227.5	17.78	10.79
30/08/2023 10:56	295.9	1.7	231.3	17.71	10.78
30/08/2023 10:57	305.7	1.7	230.3	17.82	10.70
30/08/2023 10:58	296.8	1.5	225.8	17.82	10.73
30/08/2023 10:59	284.6	1.1	227.5	17.90	10.71
30/08/2023 11:00	262.4	1.1	225.9	17.81	10.74
30/08/2023 11:01	245.1	1.0	235.7	17.89	10.66
30/08/2023 11:02	227.7	0.9	241.2	17.97	10.63
30/08/2023 11:03	223.0	0.8	240.8	17.91	10.66
30/08/2023 11:04	215.8	0.8	238.9	17.93	10.62
30/08/2023 11:05	193.7	0.9	256.9	18.14	10.53
30/08/2023 11:06	181.9	0.7	258.3	18.16	10.46
30/08/2023 11:07	184.3	0.7	257.2	18.08	10.51
30/08/2023 11:08	174.4	0.6	261.9	18.08	10.49
30/08/2023 11:09	164.5	0.7	269.8	18.11	10.45
Average	**208.8**	**2.3**	**249.6**	**17.91**	**10.68**

Referenced Data

	NOx	SO2	CO	CO2	O2
	mg/Nm3	mg/Nm3	mg/Nm3	vol%	vol%
30/08/2023 10:39	363.92	13.20	342.22	17.92	10.78
30/08/2023 10:40	364.31	17.37	347.22	17.95	10.73
30/08/2023 10:41	370.48	17.88	336.44	17.92	10.76
30/08/2023 10:42	388.17	15.41	334.77	17.85	10.79
30/08/2023 10:43	395.47	13.07	324.44	17.80	10.80
30/08/2023 10:44	404.98	11.44	326.66	17.89	10.78
30/08/2023 10:45	419.67	10.15	323.66	17.95	10.73
30/08/2023 10:46	416.46	9.43	327.77	18.02	10.70
30/08/2023 10:47	426.12	10.02	342.66	18.05	10.65
30/08/2023 10:48	350.53	9.99	368.12	17.97	10.64
30/08/2023 10:49	188.24	9.18	445.58	17.85	10.70
30/08/2023 10:50	330.92	8.16	371.12	17.89	10.69
30/08/2023 10:51	365.60	7.15	358.89	17.82	10.72
30/08/2023 10:52	531.08	6.41	315.65	17.76	10.78
30/08/2023 10:53	606.20	5.72	310.21	17.85	10.74
30/08/2023 10:54	511.42	6.03	302.43	17.71	10.79
30/08/2023 10:55	616.39	5.34	303.43	17.78	10.79
30/08/2023 10:56	648.24	5.29	308.54	17.71	10.78
30/08/2023 10:57	669.60	5.24	307.21	17.82	10.70
30/08/2023 10:58	650.07	4.63	301.21	17.82	10.73
30/08/2023 10:59	623.36	3.38	303.43	17.90	10.71
30/08/2023 11:00	574.86	3.36	301.32	17.81	10.74
30/08/2023 11:01	537.00	2.98	314.32	17.89	10.66
30/08/2023 11:02	498.90	2.62	321.66	17.97	10.63
30/08/2023 11:03	488.46	2.31	321.10	17.91	10.66
30/08/2023 11:04	472.65	2.44	318.66	17.93	10.62
30/08/2023 11:05	424.35	2.62	342.66	18.14	10.53
30/08/2023 11:06	398.50	2.21	344.55	18.16	10.46
30/08/2023 11:07	403.72	2.01	343.00	18.08	10.51
30/08/2023 11:08	382.00	1.83	349.33	18.08	10.49
30/08/2023 11:09	360.44	1.98	359.78	18.11	10.45
Average	**457.49**	**7.06**	**332.84**	**17.91**	**10.68**
Uncertainty of Measurement	**28.60**	**1.88**	**10.36**	**0.45**	**0.35**
Uncertainty as % of ELV	**5.72**	**3.75**	**0.69**	**-**	**-**
Standard Requirement	**<10%**	**<15%**	**<6%**	**<25%**	**<6%**



QGU-010-2013 Uncertainty calculation for Gaseous Measurement EN 14792 Nox

v4

Limit value	500	**mg.m^{-3} (corrected) NO2**	**Gas**	NO	
			Full Scale	500	**ppm**
Measured concentration	208.84	**ppm**	**Cal gas conc**	431	**ppm**
Measured concentration	428.76	**mg.m^{-3} (corrected) NO2**	**Conversion**	2.053	
Ratio NO/NO2	100.00		**Full Scale**	1026.5	**mg.m^{-3} (NO2)**
			Cal gas conc	884.843	**mg.m^{-3} (NO2)**

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	10.00	0.00	101.30	**273.00**
	measured	10.68	0.00	101.30	**273.00**
Factors		1.07	1.00	1.00	1.00
Correction Factor		**1.07**			

Performance characteristics	**Value**				**specification**
Response time		30	seconds		180.000
Number of readings in measurement		30			
Repeatability at zero		0.03	% full scale		0.200
Repeatability at span level		0.06	% full scale		2.000
Deviation from linearity		0.2	% of value		2.000
Zero drift		0	% full scale		2.000
Span drift		-1.48	% full scale		2.000
volume or pressure flow dependence		0	% of full scale/kPa		0.033
atmospheric pressure dependence		0	% of value/kPa		0.750
ambient temperature dependence		0.3	% full scale/10K		0.300
NH3 (20 mg/m3)		0	mg/m3		
CO2 (15%)		0.209	% by vol		
H2O (30%)		0.0	% by vol		4.000
dependence on voltage		0.1	% full scale/10V		2%fs/10V
converter efficiency		95	%		95%
losses in the line (leak)		0.672853828	% of value		2% of value
Uncertainty of calibration gas		1.2	% of value		

Effect of drift		
-6.35	mg/m3	- 0.7171472
-1.48	% value	

	ranges		
	min	max	value at calib
flow	95	105	100
pressure	101.30	101.3	101.3
temp	289	289	283
NH3 range	0	0	0
CO2 range	0	15	0
H2O range	0	0	0
Instrument Voltage Rating			110
Voltage	93	121	110

Measurement performance related to stationary conditions

Performance characteristic	**Uncertainty**	**Value of uncertainty quantity**		
Standard deviation of repeatability at zero	u_{r0}	for mean		use rep at span
Standard deviation of repeatability at span level	u_{rs}	for mean		0.01
Lack of fit	u_{fit}			1.19
Drift	u_{0dr}			-3.66
volume or pressure flow dependence	u_{spres}			0.00
atmopsheric pressure dependence	u_{apres}			0.00
ambient temperature dependence	u_{temp}			0.18
NH3 (20 mg/m3)	u_{interf}			0.00
CO2 (15%)				0.12
H2O (30%)				0.00
Dependence on voltage	u_{volt}			0.09
Converter efficiency	u_{ceff}			12.38
losses in the line (leak)	u_{leak}			1.67
Uncertainty of calibration gas	u_{calib}			2.97

Use largest negative or positive interferent effect	
0	0.00
0	0.12
0	0.00
0	0.12
Interference uncertainty	0.12

Measurement uncertainty		Result	428.76	mg/m^3
Combined uncertainty			13.40	mg/m^3
Expanded uncertainty	k =	2	26.81	mg/m^3
Uncertainty corrected to std conds			28.60	mg.m-3 (corrected)
Expanded uncertainty	**expressed with a level of confidence of 95%**		**5.72**	**% ELV**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**28.60**	**mg.m^{-3} at ELV**

Air Scientific

QGU-008-2013 Uncertainty calculation for Gaseous Measurement SO2 EN TS 17021

V2 Jul-08

Limit value	50	**mg/m³ (corrected) SO2**	**Cal gas conc**	426.14	**mg.m⁻³**
Measured concentration	6.62	**mg/m3**	**Full Scale**	572	**mg/m³**
Measured concentration	7.06	**mg/m³ (Corrected)**			

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	10.00	0.00	101.30	**273.00**
	measured	10.68	0.00	101.30	**273.00**
	Uncert	0.35	1.00	0.00	**1.00**
Factors		1.07	1.00	1.00	1.00
Uncertainty in factor		0.04	0.01	0.00	0.00
Correction Factor		**1.07**	uf	**0.04**	

Performance characteristics	**Value**				**specification**
Response time		160	seconds		180.000
Logger sampling interval		60	seconds		
Measurement period		30	minutes		
Number of readings in measurement		30			
Repeatability at zero		0.25	% full scale		<1 % range
Repeatability at span level		0.15	% full scale		<2 % range
Deviation from linearity		0.2	% of value		<2 % range
Zero drift		-0.15	% full scale		<2% range / 24hr
Span drift		-1	% full scale		<2% range/24hr
volume or pressure flow dependence		0.02	% of full scale/3 kPa		<2 % / 3 kPa
atmospheric pressure dependence		0.8	% of full scale/2 kPa		<3% / 2 kPa
ambient temperature dependence		0.01	% full scale/10K		<3% range / 10 K
N_2O (mg/m3)	20	0.2	mg/m3		
CO_2 (% vol)	15	0.2	mg/m3		
CH_4 (mg/m3)	40	0.7	mg/m3		
H2O (% vol)	20	0.2	mg/m3		
dependence on voltage		0.1	% full scale/10V		<2% range
losses in the line (leak)		0.469798658	% of value		< 0.1%vol /10 volt
Uncertainty of calibration gas		1.2	% of value		< 2% of value

Effect of drift	
-0.17	mg/m3
-2.36	% value

	ranges			
	min	max	value at calib	
flow	0.3	0.5	0.4	l/hr
pressure	100.76	100.92	100.88	kPa
temp	287	288.5	287.5	K
N2O range	0	0	0	mg/m3
CO2 range	0	40	0	%vol
CH4 range	0	57	0	mg/m3
H2O range	0	1	0	%vol
Voltage	93	121	110	V

Performance characteristic			**Uncertainty**		**Value of uncertainty quantity**		
Standard deviation of repeatability at zero			u_{r0}		for mean		use rep at span
Standard deviation of repeatability at span level			u_{rs}		for mean		0.03
Lack of fit			u_{fit}				0.66
Drift			u_{0dr}				-0.10
volume or pressure flow dependence			u_{spres}				0.00
atmopsheric pressure dependence			u_{apres}				0.14
ambient temperature dependence			u_{temp}				0.00
N2O (mg/m3)			u_{interf}				0.00
CO2 (% vol)			u_{interf}				0.31
CH4 (mg/m3)			u_{interf}				0.58
H2O (% vol)			u_{interf}				0.01
Dependence on voltage			u_{volt}				0.49
losses in the line (leak)			u_{leak}				0.02
Uncertainty of calibration gas			u_{calib}				0.05
Uncertianty in factor			uf				0.25

Use largest of sum of all positive or all negative influences			
0.89	all +ves		Criteria
0	all -ves		sum <4% range
0.89	largest		0.132328817
Value to use for intereference uncertainty			
u_{int}	0.89		

Measurement uncertainty			7.06	mg/m³
Combined uncertainty			0.88	mg/m³
Expanded uncertainty	k =	2	1.76	mg/m³
Uncertainty corrected to std conds			1.88	mg/m³
Expanded uncertainty	**expressed with a level of confidence of 95%**		**3.75**	**% ELV**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**1.88**	**mg.m⁻³**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**26.58**	**% value**

Uncertainty calculation for Gaseous Measurement CO

Limit value	1500	**mg/m³ (corrected)**	**Cal gas conc**	1017.5	**mg.m⁻³**
Measured concentration	311.94	**mg/m3**	**Full Scale**	1250	**mg/m³**
Measured concentration	10.36	**mg/m³ (Corrected)**			

Correction for reference conditions

		O2, %	Moisture, %	Pressure, KPa	Temperature, K
	ref	10.00	0.00	101.30	**273.00**
	measured	10.68	0.00	101.30	**273.00**
	Uncert	0.35	1.00	0.00	**1.00**
Factors		1.07	1.00	1.00	1.00
Uncertainty in factor		0.04	0.01	0.00	0.00
Correction Factor		**1.07**	uf	**0.04**	

Performance characteristics	**Value**				**specification**
Response time		30	seconds		180.000
Logger sampling interval		60	seconds		
Measurement period		30	minutes		
Number of readings in measurement		30			
Repeatability at zero		0.25	% full scale		<1 % range
Repeatability at span level		0.15	% full scale		<2 % range
Deviation from linearity(lack of fit)		0.7	% of value		<2 % range
Zero drift		0	mg/m3		<2% range / 24hr
Span drift		-17.5	mg/m3		<2% range/24hr
volume or pressure flow dependence		0.02	% of full scale/3 kPa		<2 % / 3 kPa
atmospheric pressure dependence		0.8	% of full scale/2 kPa		<3% / 2 kPa
ambient temperature dependence		0.01	% full scale/10K		<3% range / 10 K
N_2O (mg/m3)	20	0.2	mg/m3		
CO_2 (% vol)	15	0.2	mg/m3		
CH_4 (mg/m3)	40	0.7	mg/m3		
H2O (% vol)	20	0.2	mg/m3		
dependence on voltage		0.1	% full scale/10V		<2% range
losses in the line (leak)		-1.72	% of value		< 0.1%vol /10 volt
Uncertainty of calibration gas		0.4	% of value		< 2% of value

Effect of drift	
-5.37	mg/m3
-0.43	% full scale

	ranges			
	min	max	value at calib	
flow	95.00	105	100	kPa
pressure	100.76	100.92	100.88	kPa
temp	287	288.5	287.5	K
N2O range	0	40	0	mg/m3
CO2 range	0	15	0	%vol
CH4 range	0	57	0	mg/m3
H2O range	0	1	0	%vol
Voltage	93	121	110	V

Performance characteristic	**Uncertainty**	**Value of uncertainty quantity**	**mg/m3**
Standard deviation of repeatability at zero	u_{r0}	for mean	use rep at span
Standard deviation of repeatability at span level	u_{rs}	for mean	0.34
Lack of fit	u_{fit}		1.26
Drift	u_{0dr}		-3.10
volume or pressure flow dependence	u_{spres}		0.24
atmopsheric pressure dependence	u_{apres}		0.31
ambient temperature dependence	u_{temp}		0.00
N2O (mg/m3)	u_{interf}		0.23
CO2 (% vol)	u_{interf}		0.12
CH4 (mg/m3)	u_{interf}		0.58
H2O (% vol)	u_{interf}		0.01
Dependence on voltage	u_{volt}		1.08
losses in the line (leak)	u_{leak}		-3.10
Uncertainty of calibration gas	u_{calib}		0.72

Use largest of sum of all positive or all negative influences

0.93	all +ves	Criteria
0	all -ves	sum <4% range
0.93	largest	6.238776882

Value to use for intereference uncertainty

u_{int} 0.93

Measurement uncertainty				
Combined uncertainty			4.86	mg/m³
Expanded uncertainty	k =	2	9.71	mg/m³
Uncertainty corrected to std conds			**10.36**	**mg/m³**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**0.69**	**% ELV**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**10.36**	**mg.m⁻³**

QGU-007-2013 Uncertainty calculation for Gaseous Measurement Carbon Dioxide

V2.2 Jul-08

Limit value	n/a	**%vol**	**Calibration gas**	**0.1642**	**%vol**
Measured concentration	17.91	**%vol**	**Full Scale**	**25**	**%vol**

Performance characteristics	**Value**				**specification**
Response time		30	seconds		< 200 s
Logger sampling interval		60	seconds		
Measurement period		30	minutes		
Number of readings in measurement		30	Assuming 1 minute collected over 1 hour		
Repeatability at zero		0.015	% by volume	stdev	<0.2 % range
Repeatability at span level		0.014	% by volume	stdev	<0.4 % range
Deviation from linearity		0.13	% vol	+/-	<0.3 % volume
Zero drift (during measurement period)		0	% vol at zero level	+/-	<2% of volume / 24hr
Span drift (during measurement period)		0	% vol at span level	+/-	<2% volume/24hr
volume or pressure flow dependence		0	% of fs / 10l/h	+- 5 l/h	<1% range
atmospheric pressure dependence		0.3	% of fs/kPa	+- 2kPa	< 1.5 % range
ambient temperature dependence		-0.07	% by volume /10K	+- 15K	<0.3% volume 10 K
CO_2 (% vol)	15	0.07	% by volume per	15	
NO (mg/m3)	300	0.02	% by volume per	300	
NO_2 (mg/m3)	30	0	% by volume per	30	
Combined interference		0.56	% range		<2% range
Dependence on voltage		0.1	% by volume /10V	+- 5%	< 0.1%vol /10 volt
Losses in the line (leak)		1.644336175	% of value		< 2% of value
Uncertainty of calibration gas		0.9	% of value		

Effect of drift	
0.00	% vol
0.00	% value

	range of variation from conditions at calibration			
	min	max	value at calib	
flow	5	15	10	l/h
pressure	99.00	101	100	kPa
temp	280	285	285	K
CO_2 range	8	15	0	% vol
NO range	100	150	0	mg/m3
NO_2 range	5	7.5	0	mg/m3
Voltage	105	115	110	V

Performance characteristic	**Uncertainty**	**Value of uncertainty quantity**	**% vol**
Standard deviation of repeatability at zero	u_{r0}	for mean	Only use rep at span
Standard deviation of repeatability at span level	u_{rs}	for mean	0.00
Lack of fit	u_{fit}		0.08
Drift	u_{0dr}		0.00
volume or pressure flow dependence	u_{spres}		0.00
atmospheric pressure dependence	u_{apres}		0.04
ambient temperature dependence	u_{temp}		-0.02
CO_2			0.05
NO			0.01
NO_2			0.00
Combined interference (from mcerts)			0.08
dependence on voltage	u_{volt}		0.03
losses in the line (leak)	u_{leak}		0.17
Uncertainty of calibration gas	u_{calib}		0.09

Use largest of sum of all positive or all negative influences		
0.06	all +ves	Criteria
0	all -ves	sum <2% value
0.06	largest	0.358256452
Value to use for intereference uncertainty		
u_{int}	0.06	

Measurement uncertainty			17.91	%vol
Combined uncertainty			0.22	%vol
% of value			1.25	%
Coverage factor k =	2			
Expanded uncertainty	**expressed with a level of confidence of 95%**		**2.50**	**% of value**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**0.45**	**% vol**

QGU-007-2013 Uncertainty calculation for Gaseous Measurement Oxygen EN14789

V2.2 Jul-08

Limit value	n/a	**%vol**	**Calibration gas**	**0.209**	**%vol**
Measured concentration	10.68	**%vol**	**Full Scale**	**0.25**	**%vol**

Performance characteristics	**Value**				**specification**
Response time		30	seconds		< 200 s
Logger sampling interval		60	seconds		
Measurement period		30	minutes		
Number of readings in measurement		30	Assuming 1 minute collected over 1 hour		
Repeatability at zero		0.015	% by volume	stdev	<0.2 % range
Repeatability at span level		0.014	% by volume	stdev	<0.4 % range
Deviation from linearity		0	% vol	+/-	<0.3 % volume
Zero drift (during measurement period)		-0.002	% vol at zero level	+/-	<2% of volume / 24hr
Span drift (during measurement period)		-0.0024	% vol at span level	+/-	<2% volume/24hr
volume or pressure flow dependence		0	% of fs / 10l/h	+- 5 l/h	<1% range
atmospheric pressure dependence		0.3	% of fs/kPa	+- 2kPa	< 1.5 % range
ambient temperature dependence		-0.07	% by volume /10K	+- 15K	<0.3% volume 10 K
CO_2 (% vol)	15	0.07	% by volume per	15	
NO (mg/m3)	300	0.02	% by volume per	300	
NO_2 (mg/m3)	30	0	% by volume per	30	
Combined interference		0.56	% range		<2% range
Dependence on voltage		0.1	% by volume /10V	+- 5%	< 0.1%vol /10 volt
Losses in the line (leak)		0.04784689	% of value		< 2% of value
Uncertainty of calibration gas		0.35	% of value		

Effect of drift	
0.00	% vol
0.00	% value

	range of variation from conditions at calibration			
	min	max	value at calib	
flow	5	15	10	l/h
pressure	99.00	101	100	kPa
temp	280	285	285	K
CO_2 range	8	15	0	% vol
NO range	100	150	0	mg/m3
NO_2 range	5	7.5	0	mg/m3
Voltage	105	115	110	V

Performance characteristic			**Uncertainty**		**Value of uncertainty quantity**		**% vol**
Standard deviation of repeatability at zero			u_{r0}		for mean		Only use rep at span
Standard deviation of repeatability at span level			u_{rs}		for mean		0.00
Lack of fit			u_{fit}				0.08
Drift			u_{0dr}				0.00
volume or pressure flow dependence			u_{spres}				0.00
atmospheric pressure dependence			u_{apres}				0.04
ambient temperature dependence			u_{temp}				-0.02
CO_2							0.05
NO							0.01
NO_2							0.00
Combined interference (from mcerts)							0.08
dependence on voltage			u_{volt}				0.03
losses in the line (leak)			u_{leak}				0.13
Uncertainty of calibration gas			u_{calib}				0.03

Use largest of sum of all positive or all negative influences		
0.06	all +ves	Criteria
0	all -ves	sum <2% value
0.06	largest	0.22
Value to use for intereference uncertainty		
u_{int}	0.06	

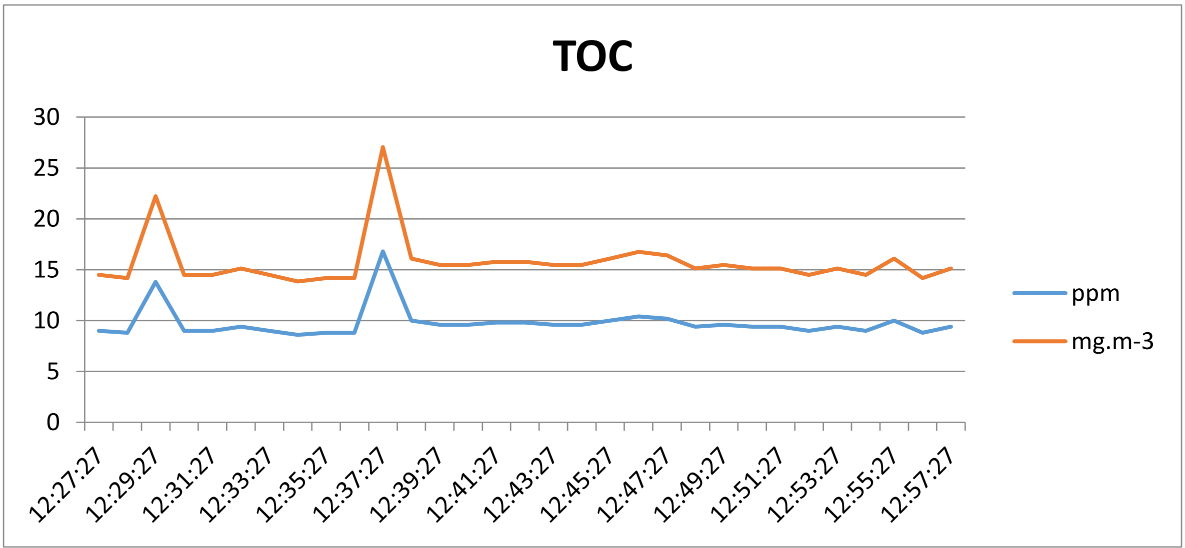
Measurement uncertainty			10.68	%vol
Combined uncertainty			0.17	%vol
% of value			1.62	%
Coverage factor k =	2			
Expanded uncertainty	**expressed with a level of confidence of 95%**		**3.23**	**% of value**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**0.35**	**% vol**

Title:	**Determination of Total Organic Compounds**	
Method:	EN 12619	
Client:	Irish Cement	
Stack Reference:	A2-01	
Licence Limits		
Emission Limit Value	25	$mg.m^{-3}$
Flow Rate Limit	500000	$m^3.Hr^{-1}$
Results		
TOC Concentration	18.2	$mg.m^{-3}$ ref O_2 dry
Flow Rate	-	$m^3.Hr^{-1}$
Uncertainty of Measurement	0.76	$mg.m^{-3}$
Reference Conditions		
Temperature (K)	273.13	^0K
Pressure (kPa)	101.3	kPa
Gas (Wet or Dry)	Wet	
Oxygen	10	%
Stack Concentrations		
Oxygen	10.68	%
Moisture	7.68	%
CO_2	17.91	%
Quality Data		**Units**
Sampling Date	30/08/2023	
Sampling Time	12:27:27	-
Instrument Range	99.9	ppm
Span Gas Value	74.9	ppm
Acceptable Gas Range	Yes	50 - 90% of Range
Oven Temperature	184	^0C
Average Temperature	184	^0C
Temperature Acceptable	Yes	Yes or No
Sample line temperature	180	C
Zero Drift		**Units**
Zero Down Sampling Line (Pre)	0	ppm
Zero Check after Span	0.1	ppm
Allowable Resolution	0.4	ppm
Zero Down Sampling Line (Post)	-0.01	ppm
Zero drift	-0.01	ppm
Allowable Zero Drift	1.498	ppm
Zero Drift Acceptable (<2%)	Yes	Yes or No
Adjust for Zero Drift Limit (2 - 5%)	No	Yes or No
Reject results if > 5%	3.745	ppm
Span Drift		**Units**
Span (Pre)	74.9	ppm
Span (Post)	73.5	ppm
Span Drift	-1.4	ppm
Allowable Span Drift	1.498	ppm
Span Drift Acceptable (<2%)	Yes	Yes or No
Adjust for Zero Drift Limit (2 - 5%)	No	Yes or No
Reject results if > 5%	3.745	ppm
Leak Check		
Span Gas Conc.	74.9	ppm
Recorded Conc. down Line	73.6	ppm
Leak Result	1.3	ppm
Leak check acceptable (< 2%)	1.5	(Y/N)
Response Time (<200 seconds)	Yes	Yes or No
Parameter		
Standard	EN 12619	
Technical Procedure	2009	
Probe material	Stainless Steel	

Filtration Type	Ceramic Filter	
Heated Head Filter Used	Yes	
Heated Line Temperature	180	Deg C
Span Gas Reference Number	ASLLK23ING306	
Span Gas Expiry Date	Mar-25	
Span Gas Start Pressure (bar)	60	bar
Gas Cylinder Concentration (ppm)	74.9	ppm
Span Gas Uncertainty (%)	0.3	%
Zero Gas Type	Air	
Number of Sampling Lines Used	1	
Number of Sampling Points Used	1	
Sample Point I.D's	1	
Measured Quantities		
Certified Range of Analyser	1000	ppm
Operational Range of Analyser	99.9	ppm
Measured Reading	4	ppm
Non linearity	0.4	ppm
Temperature Dependent Zero drift	0.15	ppm Per Degree
Temperature Dependent Span drift	0.0999	% Per Degree
Cross-sensitivity	0.1	ppm
Leak	1.3	ppm
Calibration Gas uncertainty	0.3	ppm

Title:	***Determination of Total Organic Compounds***
Method:	EN 12619
Client:	Irish Cement
Stack Reference:	A2-01

Run 1	**Time**	**ppm**	**$mg.m^{-3}$**
1	12:27:27	9	14.5
2	12:28:27	8.8	14.2
3	12:29:27	13.8	22.2
4	12:30:27	9	14.5
5	12:31:27	9	14.5
6	12:32:27	9.4	15.1
7	12:33:27	9	14.5
8	12:34:27	8.6	13.8
9	12:35:27	8.8	14.2
10	12:36:27	8.8	14.2
11	12:37:27	16.8	27.0
12	12:38:27	10	16.1
13	12:39:27	9.6	15.5
14	12:40:27	9.6	15.5
15	12:41:27	9.8	15.8
16	12:42:27	9.8	15.8
17	12:43:27	9.6	15.5
18	12:44:27	9.6	15.5
19	12:45:27	10	16.1
20	12:46:27	10.4	16.7
21	12:47:27	10.2	16.4
22	12:48:27	9.4	15.1
23	12:49:27	9.6	15.5
24	12:50:27	9.4	15.1
25	12:51:27	9.4	15.1
26	12:52:27	9	14.5
27	12:53:27	9.4	15.1
28	12:54:27	9	14.5
29	12:55:27	10	16.1
30	12:56:27	8.8	14.2
31	12:57:27	9.4	15.1
Average		**9.8**	**15.7**
Adjusted for O_2 and Moisture			**18.2**



Uncertainty calculation for Gaseous Measurement TOC							
Stack Reference:							
Limit value	25	**mg/m^3 (corrected)**	**Cal gas conc**	120.589	**$mg.m^{-3}$ (Propane)**		
Measured concentration	9.8	**ppm**					
Measured concentration	16	**mg/m3 (101.3kPa, 273K)**					
Measured concentration	16	**mg/m^3 (Corrected)**					
Performance characteristics	**Value**				**specification**		
Response time		90	seconds		180.000		
Logger sampling interval		60	seconds				
Measurement period		30	minutes				
Number of readings in measurement		30					
Repeatability at zero		0.25	% full scale		<1 % range		
Repeatability at span level		0.15	% full scale		<2 % range		
Deviation from linearity(lack of fit)		0.65	% of value		<2 % range		
Zero drift		0.2	mg/m3		<2% range / 24hr		
Span drift		1	mg/m3		<2% range/24hr		
Volume or pressure flow dependence		0	%of full scale/kPa		<2 % / kPa		
Atmospheric pressure dependence		0	%of value /kPa		<3% / kPa		
Ambient temperature dependence		0	% full scale/10K		<3% range / 10 K		
Losses in the line (leak)		0	% of value		< 0.1%vol /10 volt		
Uncertainty of calibration gas		2	% of value		< 2% of value		
Performance characteristic			**Uncertainty**		**Value of uncertainty quantity**		**mg/m3**
Standard deviation of repeatability at zero			u_{r0}		for mean		use rep at span
Standard deviation of repeatability at span level			u_{rs}		for mean		0.00
Lack of fit			u_{fit}				0.06
Drift			u_{0dr}				0.33
volume or pressure flow dependence			u_{spres}				0.00
atmopsheric pressure dependence			u_{apres}				0.00
ambient temperature dependence			u_{temp}				0.00
losses in the line (leak)			u_{leak}				0.00
Uncertainty of calibration gas			u_{calib}				0.18
Measurement uncertainty							
Combined uncertainty			0.38	mg/m^3			
Expanded uncertainty	k =	2	0.76	mg/m^3			
Expanded uncertainty	**expressed with a level of confidence of 95%**		**3.05**	**% ELV**			
Expanded uncertainty	**expressed with a level of confidence of 95%**		**0.76**	**$mg.m^{-3}$**			
Expanded uncertainty	**expressed with a level of confidence of 95%**		**4.85**	**% value**			

Title:	**Determination of Inorganic Compounds**		
Method:	EN 1911	ISO 15713	
Test Date	31/08/2023	31/08/2023	
Test Time Started:	09:47	10:47	
Test Time Finished:	09:47	10:47	
Laboratory Used:	RPS		
Stack Reference:	A2-01		
Leak Check Results	**HCL**	**HF**	
Prior to test:	0	0	l/min
Post Test:	0	0	l/min
Sample Volume Flow Rate:	2.30	2.30	l/min
Test Result: (Requirement <2%)	0.0	0.0	%
Test Status	Pass	Pass	
Reference Details			
Reference Oxygen	10	%	
Measured Oxygen	10.68	%	
Reference Moisture	0	%	
Calibration Details	**HCL**	**HF**	
Pump Number:	ASLLK22EQ503	ASLLK22EQ503	
Calibration Unit:	ASLLK22EQ514	ASLLK22EQ514	
Calibration Rate Before Test:	2.3	2.3	l/min
Calibration Rate After Test:	2.3	2.3	l/min
Average sample Volume:	2.30	2.30	l/min
Sample Test Time:	30	30	minutes
Pump Gas Temperature:	20	20	^{O}C
Pump Sample Pressure:	101.3	101.3	kPa
Normalised Gas Volume:	0.064	0.064	Nm^3
Sample Details	**HCL**	**HF**	
Impinger Solution	DI Water	DI Water	
Solution ID Number:	Run 1	Run 1	
Blank Identification Number:	Run 1	Run 1	
Impinger Material	PTFE	PTFE	
Breakthrough Occurred	No	No	
Transport Temp meets Standard	Yes	Yes	
Analysed Within Specified Timeframe	Yes	Yes	
Transport Container Airtight	Yes	Yes	
Exposed to Sunlight	No	No	
Calculations	**HCL**	**HF**	
Laboratory Result Imp 1 / 2	0.12	0.09	ug/ml
Laboratory Result Imp Final	0.07	0.14	ug/ml
Impinger Final Volume Imp 1 / 2	152	152	ml
Impinger Final Volume Imp Final	50	50	ml
Combined Concentration	0.02174	0.02068	mg
Factor	1.028	1.053	
Concentration	0.022	0.022	mg
Emissions Concentration	0.3	0.3	$mg.m^{-3}$
Referenced Results	**HCL**	**HF**	
Emissions Concentration	0.4	0.4	$mg.m^{-3}$ Ref O_2
Uncertainty	0.03	0.03	$mg.m^{-3}$
Licence Limits	10	1	$mg.m^{-3}$
Blank Calculation	**HCL**	**HF**	
Laboratory Impinger / Rinse Result	0.05	0.05	ug/ml
Blank Concentration	0.1	0.1	$mg.m^{-3}$ Ref O_2
% of Licence Limit	1.3	13.3	%
Field Blank <10% ELV	Yes	No	

$$c = \frac{m}{V} f_c$$

Uncertainty calculation for		**HCL**							
Limit value (ELV)	10	**mg.m^{-3}**	**Reference oxygen**	10	**% by volume**				
Measured concentration	0.37	**mg.m^{-3} (at reference conditions)**							
Measured Quantities	**Symbol**	**Value**	**Standard uncertainty**		**Units**		**Uncertainty as percentage**	**Uncertainty at lv**	**Requirement of std**
Sampled Volume Gas	V_m	0.064290102	uV_m	0.001	**m^3**		1.56		<=2%
Sampled gas Temperature	T_m	293	uTm	2	k		2.00		<2.5 k
Sampled gas Pressure	ρ_m	101.3	$u\rho_m$	1	**kPa**		0.99		<=1%
Sampled gas Humidity	H_m	0	uH_m	1	**% by volume**		1.00		<=1%
Oxygen content	$O_{2,m}$	10.68	$uO_{2,m}$	0.1	**% by volume**		0.94		<=5%
Concentration in impinger	C	0.19	uC	0.0057	**mg/l**		3.00		<5%
Impinger solution volume	VS	202	uVS	0.001	**l**		0.00		<1%
Mass Analyte	m	0.02174	um	0.00	**mg**		3.00	0.11	<5% of limit value
Note - Sampled gas humidity, temperature and pressure are values at the gas meter									
Leak	L	0			**%**		0.00		<=2%

$$f_s = \frac{(100 - H_m)}{100} \frac{273}{T_m} \frac{\rho_m}{101.3}$$

$$V = V_m f_s$$

$$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$$

Intermediate calculations							
Factor for std conds	fs	0.93					
uncertainty components	symbol	**sensitivity coeff**		**u (in units of fs)**			
	ρ_m	0.009		0.009			
	H_m	0.009		0.009			
	T_m	0.003		0.006			
	ufs			0.015			1.56
Corrected volume	V	0.06	uV	0.001	**m^3**		2.29
Factor for O2 correction	fc	1.07					
uncertainty components	symbol	**sensitivity coeff**		**u**			
	$O_{2,m}$	0.10		0.010			
Factor for O2 Correction	ufc	1.07		0.010			0.97

Parameter		**Value**	**Units**	**Sensitivity coeff**	**Uncertainty contribution**		**Uncertainty as %**	
Corrected Volume (standard conditions)	V	0.06	m^3	6.19	0.01	mg.m^{-3}	2.29	%
Mass	m	0.02	mg	17.05	0.01	mg.m^{-3}	3.00	%
Factor for O2 Correction	fc	1.07		0.35	0.00	mg.m^{-3}	0.97	%
Leak	L	0.00	mg.m^{-3}	1.00	0.00	mg.m^{-3}	0.00	%
Combined uncertainty					**0.01**	mg.m^{-3}		

Expanded uncertainty as percentage of measured value	**7.79**	**% measured of value**	**expressed with a level of confidence of 95%** **(Using a coverage factor k=2)**
Expanded uncertainty in units of measurement	**0.03**	**mg.m^{-3}**	
Expanded uncertainty as percentqge of limit value	**0.29**	**% ELV**	

$$c = \frac{m}{V} f_c$$

Uncertainty calculation for		**HF**							
Limit value (ELV)	1	**mg.m^{-3}**	**Reference oxygen**	10	**% by volume**				
Measured concentration	0.36	**mg.m^{-3} (at reference conditions)**							
Measured Quantities	**Symbol**	**Value**	**Standard uncertainty**		**Units**		**Uncertainty as percentage**	**Uncertainty at lv**	**Requirement of std**
Sampled Volume Gas	V_m	0.064290102	uV_m	0.001	**m^3**		1.56		<=2%
Sampled gas Temperature	T_m	293	uTm	2	k		2.00		<2.5 k
Sampled gas Pressure	ρ_m	101.3	$u\rho_m$	1	**kPa**		0.99		<=1%
Sampled gas Humidity	H_m	0	uH_m	1	**% by volume**		1.00		<=1%
Oxygen content	$O_{2,m}$	10.68	$uO_{2,m}$	0.1	**% by volume**		0.94		<=5%
Concentration in impinger	C	0.23	uC	0.0069	**mg/l**		3.00		<5%
Impinger solution volume	VS	202	uVS	0.001	**l**		0.00		<1%
Mass Analyte	m	0.02068	um	0.00	**mg**		3.00	1.08	<5% of limit value
Note - Sampled gas humidity, temperature and pressure are values at the gas meter									
Leak	L	0			**%**		0.00		<=2%

$$f_s = \frac{(100 - H_m)}{100} \frac{273}{T_m} \frac{\rho_m}{101.3}$$

$$V = V_m f_s$$

$$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$$

Intermediate calculations							
Factor for std conds	fs	0.93					
uncertainty components	symbol	**sensitivity coeff**		**u (in units of fs)**			
	ρ_m	0.009		0.009			
	H_m	0.009		0.009			
	T_m	0.003		0.006			
	ufs			0.015			1.56
Corrected volume	V	0.06	uV	0.001	**m^3**		2.29
Factor for O2 correction	fc	1.07					
uncertainty components	symbol	**sensitivity coeff**		**u**			
	$O_{2,m}$	0.10		0.010			
Factor for O2 Correction	ufc	1.07		0.010			0.97

Parameter		**Value**	**Units**	**Sensitivity coeff**	**Uncertainty contribution**		**Uncertainty as %**	
Corrected Volume (standard conditions)	V	0.06	m^3	6.03	0.01	mg.m^{-3}	2.29	%
Mass	m	0.02	mg	17.47	0.01	mg.m^{-3}	3.00	%
Factor for O2 Correction	fc	1.07		0.34	0.00	mg.m^{-3}	0.97	%
Leak	L	0.00	mg.m^{-3}	1.00	0.00	mg.m^{-3}	0.00	%
Combined uncertainty					**0.01**	mg.m^{-3}		

Expanded uncertainty as percentage of measured value	**7.79**	**% measured of value**	**expressed with a level of confidence of 95%** **(Using a coverage factor k=2)**
Expanded uncertainty in units of measurement	**0.03**	**mg.m^{-3}**	
Expanded uncertainty as percentqge of limit value	**2.81**	**% ELV**	

Title:	**Determination of Inorganic Compounds**	
Method:	ISO 21877	
Test Date	31/08/2023	
Test Time Started:	08:10	
Test Time Finished:	08:40	
Laboratory Used:	RPS	
Stack Reference:	A2-01	
Leak Check Results	**NH3**	
Prior to test:	0	l/min
Post Test:	0	l/min
Sample Volume Flow Rate:	2.30	l/min
Test Result: (Requirement <2%)	0.0	%
Test Status	Pass	
Reference Details		
Reference Oxygen	10	
Measured Oxygen	10.63	
Reference Moisture	0	
Calibration Details	**NH3**	
Pump Number:	ASLLK22EQ503	
Calibration Unit:	ASLLK22EQ514	
Calibration Rate Before Test:	2.3	l/min
Calibration Rate After Test:	2.3	l/min
Average sample Volume:	2.30	l/min
Sample Test Time:	30	minutes
Pump Gas Temperature:	20	^{O}C
Pump Sample Pressure:	101.3	kPa
Normalised Gas Volume:	0.064	Nm^3
Sample Details	**NH3**	
Impinger Solution	0.1 N H2SO4	
Solution ID Number:	Run 1	
Blank Identification Number:	Run 1	
Impinger Material	PTFE	
Breakthrough Occurred	No	
Transport Temp meets Standard	Yes	
Analysed Within Specified Timeframe	Yes	
Transport Container Airtight	Yes	
Exposed to Sunlight	No	
Calculations	**NH3**	
Laboratory Result Imp 1 / 2	8.8	ug/ml
Laboratory Result Imp Final	0.1	ug/ml
Impinger Final Volume Imp 1 / 2	154	ml
Impinger Final Volume Imp Final	44	ml
Combined Concentration	1.3596	mg
Factor	1	
Concentration	1.360	mg
Emissions Concentration	21.1	$mg.m^{-3}$
Referenced Results	**NH3**	
Emissions Concentration	22.4	$mg.m^{-3}$ Ref O_2
Uncertainty	1.75	$mg.m^{-3}$
Licence Limits	50	$mg.m^{-3}$
Blank Calculation	**NH3**	
Laboratory Impinger / Rinse Result	0.1	ug/ml
Blank Concentration	0.3	$mg.m^{-3}$ Ref O_2
% of Licence Limit	0.5	%
Field Blank <10% ELV	Yes	

$$c = \frac{m}{V} f_c$$

$$f_s = \frac{(100 - H_m)}{100} \frac{273}{T_m} \frac{\rho_m}{101.3}$$

$$V = V_m f_s$$

$$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$$

Uncertainty calculation for		NH3							
Limit value (ELV)	50	mg.m^{-3}	Reference oxygen	10	% by volume				
Measured concentration	22.45	mg.m^{-3} (at reference conditions)							
Measured Quantities	**Symbol**	**Value**	**Standard uncertainty**		**Units**		**Uncertainty as percentage**	**Uncertainty at lv**	**Requirement of std**
Sampled Volume Gas	V_m	0.064290102	uV_m	0.001	m^3		1.56		<=2%
Sampled gas Temperature	T_m	293	uTm	2	k		2.00		<2.5 k
Sampled gas Pressure	ρ_m	101.3	$u\rho_m$	1	kPa		0.99		<=1%
Sampled gas Humidity	H_m	0	uH_m	1	% by volume		1.00		<=1%
Oxygen content	$O_{2,m}$	10.63	$uO_{2,m}$	0.1	% by volume		0.94		<=5%
Concentration in impinger	C	8.9	uC	0.267	mg/l		3.00		<5%
Impinger solution volume	VS	198	uVS	0.001	l		0.00		<1%
Mass Analyte	m	1.3596	um	0.04	mg		3.00	1.35	<5% of limit value
Note - Sampled gas humidity, temperature and pressure are values at the gas meter									
Leak	L	0			%		0.00		<=2%
Intermediate calculations									
Factor for std conds	fs	0.93							
uncertainty components	symbol	**sensitivity coeff**		**u (in units of fs)**					
	ρ_m	0.009		0.009					
	H_m	0.009		0.009					
	T_m	0.003		0.006					
	ufs			0.015			1.56		
Corrected volume	V	0.06	uV	0.001	m^3		2.29		
Factor for O2 correction	fc	1.06							
uncertainty components	symbol	**sensitivity coeff**		**u**					
	$O_{2,m}$	0.10		0.010					
Factor for O2 Correction	ufc	1.06		0.010			0.96		

Parameter		Value	Units	Sensitivity coeff	Uncertainty contribution		Uncertainty as %	
Corrected Volume (standard conditions)	V	0.06	m^3	374.70	0.51	mg.m^{-3}	2.29	%
Mass	m	1.36	mg	16.51	0.67	mg.m^{-3}	3.00	%
Factor for O2 Correction	fc	1.06		21.16	0.22	mg.m^{-3}	0.96	%
Leak	L	0.00	mg.m^{-3}	1.00	0.00	mg.m^{-3}	0.00	%
Combined uncertainty					**0.87**	mg.m^{-3}		

Expanded uncertainty as percentage of measured value	**7.79**	**% measured of value**	**expressed with a level of confidence of 95%**
			(Using a coverage factor k=2)
Expanded uncertainty in units of measurement	**1.75**	**mg.m^{-3}**	
Expanded uncertainty as percentqge of limit value	**3.50**	**% ELV**	

Title:	**Determination of Total Metals and Mercury**				
Method:	EN 14385 & EN 13211				
Client:	Irish Cement				
Test Date:	30/08/2023		Air Volume at Pump	1.8365	m^3
Test Time	12:04		Temperature at Pump	22.25	Deg C
Laboratory Used:	RPS		Pressure at Pump	72.26	kPa
Stack Name	A2-01		Humidity at Pumps	0	%
Run I.D.	1				
Filter I.D.	256311		Flow Uncertainty	9,169	m^3/hr
Dry Volume of Air Sampled Metals	1.2114	Nm^3	Flow Uncertainty	4.3	%
Dry Volume of Air Sampled Mercury	1.2114	Nm^3			
Moisture Content	7.7	%	Emission Limit Value Cd/Tl:	0.05	$mg.m^{-3}$
Stack Flow Rate	246,775	Nm^3/hr	Emission Limit Value Hg:	0.05	$mg.m^{-3}$
Adjusted Stack Flow Rate	213,610	$m^3 \cdot hr^{-1}$ Ref O_2, Dry	Emission Limit Value Metals:	0.5	$mg.m^{-3}$
Volume of Air Sampled	1.2114	Nm^3			
Reference Conditions					
Measured Oxygen	10.68	%			
Reference Oxygen	10	%			
Reference Moisture	0	%			

Leak Check Results	Result		% Leak
Before Sample 1	0	l/min	0.0
Average Flow Rate	19.77	l/min	0.0
Standard Maximum	0.395	l/min	2%
Back Pressure	69	kPa	

Standard Criteria to be Met	Result	Std. Requirement		
Angle of Flow	Yes	<15 Degrees	Probe material	Titanium
Negative Flow in the Stack	Yes	None	Filter housing	Titanium
Pitot Pressure Difference	Yes	>5Pa	Positioning of filter	Out Stack
Ratio of Flow Measurement	Yes	<3:1	Filter Size & Material	47mm Quartz
Stagnation Test	Yes	<10Pa		
Pitot Tube Leak Check	Result			
Positive Pressure	Pass	-		
Negative Pressure	Pass	-		
Number of Ports	2	2		
Straight length before sample point	Yes	> 5 Hydraulic Diameters		
Straight length after sample point	Yes	> 5 Hydraulic Diameters to Stack Outlet or 2HD to Fan/ Bend		

Sample Calculations

	Filter	Imp 1 & 2	Imp 3	Total Metal
	ug / filter	**ug/L**	**ug/L**	**ug**
Antimony	0.6	0.2	0.2	0.7
Arsenic	0.5	0.3	0.3	0.6
Cadmium	0.5	0.2	0.2	0.6
Chromium	1.5	4.7	8	4.1
Cobalt	0.5	0.2	0.2	0.6
Copper	2.1	3.6	0.4	3.3
Lead	0.5	0.5	0.2	0.7
Manganese	0.7	0.4	0.3	0.9
Nickel	0.8	0.3	0.3	0.9
Thallium	0.4	0.2	0.2	0.5
Vanadium	0.4	0.3	0.2	0.5
Mercury (Metal Train)	0.53	0.5	0.5	0.8
		Impinger 5	**Impinger 6**	
Mercury (Mercury Train)	-	3.8	0.5	1.2
	Metals		**Mercury**	
Impinger 1 & 2 Total Volume (Incl Rinse)	330	Impinger 5	300	mls
Impinger 3 Total Volume (Incl Rinse)	128	Impinger 6	132	mls

Concentration Calculation

	$mg.m^{-3}$	mg/m^3 Ref O_2	Uncertainty
Antimony	0.0006	0.0006	0.000025
Arsenic	0.0005	0.0006	0.000023
Cadmium	0.0005	0.0005	0.000022
Chromium	0.0034	0.0036	0.000149
Cobalt	0.0005	0.0005	0.000022
Copper	0.0028	0.0029	0.000122
Lead	0.0006	0.0006	0.000025
Manganese	0.0007	0.0008	0.000032
Nickel	0.0008	0.0008	0.000034
Thallium	0.0004	0.0004	0.000018
Vanadium	0.0004	0.0005	0.000019
Mercury	0.0016	0.0017	0.000072
Total Metals	**0.0127**	**0.0136**	**0.000564**
Total Cd / Tl	0.0009	0.0010	0.000040
Total Hg	0.0016	0.0017	0.000072
Remaining Metals	0.0102	0.0109	0.000452

Blank Calculations

	Filter	Impingers	Total Metals	Concentration
	ug / filter	**ug/L**	**ug**	**mg/m^3 Ref O_2**
Antimony	0.6	0.2	0.666	0.00059
Arsenic	0.5	0.3	0.599	0.00053
Cadmium	0.5	0.2	0.566	0.00050
Chromium	0.6	0.3	0.699	0.00062
Cobalt	0.5	0.2	0.566	0.00050
Copper	0.6	0.4	0.732	0.00064
Lead	0.5	0.2	0.566	0.00050
Manganese	0.6	0.2	0.666	0.00059
Nickel	0.6	0.3	0.699	0.00062
Thallium	0.4	0.2	0.466	0.00041
Vanadium	0.4	0.2	0.466	0.00041
Mercury Total	0.53	1	0.830	0.00073
				% of ELV
Total Metals			**0.0066**	1.3243
Blank < 10% of the Emission Limit Values			Yes	**Yes / No**

DUCT AND GAS SPECIFICATION

Name			a2-01
Section			Circular
Diameter		[m]	2.6
Area		[m^2]	5.309292
Ports	B	[#]	2
Points	P	[#]	10
Density	ρn	[$^{kg}/_{nm^3}$]	1.396
Carbon Dioxide	CO_2	[%]	17.91
Oxygen	O_2	[%]	10.68
Water Vapor Ratio	rw	[0;1]	0.077
Nozzle	nz	[mm]	6
Turbolence factor	ft	[sec]	1
Wall Adjustment Factor	waf		0.995

PITOT DATA SPECIFICATION

Name			p0.84
Velocity	[$^m/_{sec}$]	5	0.83
Velocity	[$^m/_{sec}$]	10	0.83
Velocity	[$^m/_{sec}$]	20	0.83
Velocity	[$^m/_{sec}$]	30	0.83
Velocity	[$^m/_{sec}$]	40	0.83

NORMALIZATION FACTOR

T_{norm}		[K]	273
P_{norm}		[kPa]	101.3

DUCT FLOW RATE

Dry actual	QV_a	[$^{m3}/_h$]	363130
Moist actual	$Q'V_a$	[$^{m3}/_h$]	393432
Moist norm. [T_{norm} P_{norm}]	$Q'V_n$	[$^{nm3}/_h$]	246775
Dry norm. [T_{norm} P_{norm}]	QV_n	[$^{nm3}/_h$]	227773

AVERAGE VALUES

Total Points		[#]	2
Velocity	v'_a	[$^m/_{sec}$]	20.69
Pitot Differential Pressure	dP_{avg}	[Pa]	263.11
Stack temperature	t_{stack}	[°C]	159.01
Stack Pressure	P_a	[kPa]	100.55
Isokinetic Ratio	IR	[%]	-0.3
Velocity at nozzle	v'_N	[$^m/_{sec}$]	20.645
Probe temperature	t_{probe}	[°C]	177.6
Filter temperature	t_{filter}	[°C]	183
Outlet temperature	t_{outlet}	[°C]	42.8
Aux temperature	t_{aux}	[°C]	31.5
Ambient Pressure	P_{amb}	[kPa]	100.69

GAS METER SAMPLED VOLUMES

Elapsed time	et	[hh:mm:ss]	01:00:00
Norm. Volume [T_{norm} P_{norm}]	V_{gn}	[nm^3]	1.2114
Moist Volume at stack conditions	V'_{ga}	[m^3]	2.0922
Volume at dgm conditions	V_{dgm}	[m^3]	1.8365
Gas meter temperature	t_{dgm}	[°C]	22.25
Gas Meter Pressure	P_{dgm}	[kPa]	72.26

start ts [timestamp]	port [###]	point [###]	Probe pos [cm]	Elapsed Time [hh:mm:ss]	t_{stack} avg [°C]	P_a avg [kPa]	dP Pitot avg [Pa]	velocity avg [$^m/_{sec}$]
30/08/2023 11:08:58	1	1	6.7	00:00:30 00:00:30	147.24 147.26	100.56 100.56	266.92 266.6	20.55 20.54
30/08/2023 11:09:51	1	2	21.3	00:00:30 00:00:30	147.15 147.15	100.56 100.56	277.7 277.52	20.96 20.95
30/08/2023 11:10:26	1	3	38.1	00:00:30 00:00:30	147.08 147.08	100.56 100.56	267.96 267.85	20.59 20.58
30/08/2023 11:11:02	1	4	58.8	00:00:30 00:00:30	146.95 146.95	100.56 100.56	267.1 268	20.55 20.59
30/08/2023 11:11:58	1	5	88.9	00:00:30 00:00:30	146.84 146.84	100.56 100.56	270.98 270.32	20.7 20.67
30/08/2023 11:12:31	1	6	171.2	00:00:30 00:00:30	146.32 146.33	100.56 100.56	269.9 269.06	20.64 20.61
30/08/2023 11:13:03	1	7	201.3	00:00:30 00:00:30	146.19 146.19	100.55 100.55	270.37 268.59	20.66 20.59
30/08/2023 11:13:37	1	8	222	00:00:30 00:00:30	146.06 146.07	100.56 100.56	269.2 268.46	20.61 20.58
30/08/2023 11:14:13	1	9	238.8	00:00:30 00:00:30	147.13 147.03	100.56 100.56	260.73 260.97	20.31 20.32
30/08/2023 11:14:44	1	10	253.4	00:00:30 00:00:30	150.01 149.95	100.55 100.55	261 260.36	20.39 20.36
30/08/2023 11:15:32	2	1	6.7	00:00:30 00:00:30	151.31 151.29	100.56 100.56	258.06 258.59	20.3 20.32
30/08/2023 11:16:08	2	2	21.3	00:00:30 00:00:30	152.35 152.32	100.56 100.56	261.51 261.42	20.46 20.46
30/08/2023 11:16:41	2	3	38.1	00:00:30 00:00:30	153.32 153.3	100.56 100.56	264.35 264.21	20.6 20.59
30/08/2023 11:17:14	2	4	58.8	00:00:30 00:00:30	153.81 153.8	100.55 100.56	261.24 260.84	20.49 20.47
30/08/2023 11:17:47	2	5	88.9	00:00:30 00:00:30	154.2 154.19	100.56 100.56	264.49 264.39	20.63 20.62
30/08/2023 11:18:20	2	6	171.2	00:00:30 00:00:30	154.35 154.35	100.56 100.56	260.57 259.57	20.48 20.44
30/08/2023 11:18:53	2	7	201.3	00:00:30 00:00:30	154.28 154.28	100.55 100.55	274.94 276.19	21.03 21.08
30/08/2023 11:19:27	2	8	222	00:00:30 00:00:30	154.15 154.16	100.56 100.57	253.06 241.96	20.17 19.73
30/08/2023 11:20:01	2	9	238.8	00:00:30 00:00:30	153.76 153.77	100.55 100.55	272.69 272.6	20.93 20.93
30/08/2023 11:20:36	2	10	253.4	00:00:30 00:00:30	153.26 153.27	100.55 100.55	270.89 270.99	20.85 20.86

Uncertainty calculation for Velocity and Volume Flow Rate Measurement by Pitot tube EN ISO 16911-1

V1.4 Oct-16

Enter data in orange cells only <---- Complete (Don't Touch)

Constants		
Gas constant	8.314	J/(K.mol)

Enter Data in yellow cells only (They should pull correctly)

Pitot coefficient, K	0.83	
Expanded uncertainty (95%, k=2)	0.03	

Characteristics of pressure sensor used for Delta P		
Enter uncertainties as (95%,k=2) where relevant		
Range of Delta P transducer	2500	Pa
Resolution of Delta P transducer	10	Pa
Repeatability of Delta P transducer	0.01	% of value
Drift of Delta P transducer	0.32	% of range between calibrations
Lack of fit of measurement system	0.25	% of range
Uncertainty in Delta P transducer	2.5	Pa
Enter uncertainties as (95%,k=2) where relevant		
Uncertainty in temperature readout system	1	°C
Uncertainty in atmospheric pressure transducer	160.5	Pa
Uncertainty in duct area measurement	1.0	%

Uncertainty in stack gas composition		
Enter uncertainties as (95%,k=2) where relevant		
Water vapour measurement	2	% relative
CO content measurement	2	% relative
CO_2 content measurement	2	% relative
O_2 content measurement	2	% relative

Duct dimensions	Circular			Rectangular		
	Diameter	2.60	m	a		m
	Area	5.3	m2	b		m
				Area	0.0	m2

All Pressures should be entered in Pascals, Pa

Measurement Point	Atmospheric Pressure, Pa	Stack Pressure, Pa	Static Pressure, Pa	meas1, Pa	Delta P, Pa	Stack Temp	Water Vapo	CO, ppm (Dry gas basis)	CO_2, %	N_2, %	O_2, %	dry molecular wt, g/	stack molecular wt, g/
1	100690	201240	100550	360	359.9965	263.11	7.7	0	0.1	79.0	20.9	28.85	28.02
Mean	**100690**	**201240**	**100550.0**	**360.0**	**360.0**	**263.1**	**7.7**	**0.0**	**0.1**	**79.0**	**20.9**	**28.85**	**28.02**

$$\rho = \frac{molar\ mass\ .\ absolute\ pressure}{R.gas\ temperature}$$

Mean density	**1.265**	**kg/m3**

$$Velocity = K.\sqrt{\frac{2.\Delta_p}{\rho}}$$

Mean velocity	**20.69**	**m/sec**		
Standard uncertainty of velocity	**0.37**	**m/sec**	**1.8**	**% of value**
Expanded uncertainty in velocity	**0.75**	**m/sec**	**3.6**	**% of value**

	Circular duct		Rectangular duct	
Flow rate	**213610**	**m^3/hour**	**213610**	**m3/hour**
Volume flow rate expanded uncertainty	**9169**	**m^3/hour**	**#DIV/0!**	**m3/hour**
Volume flow rate expanded uncertainty	**4.3**	**% of value**	**#DIV/0!**	**% of value**

Uncertainty calculation for EN 13284 Determination of low range mass concentration of dust, Manual Gravimetric Method — **Version 14**

Stack Name: A2-01

Limit value (ELV)	0.5	**$mg.m^{-3}$**	**Reference oxygen**	10	**% by volume**
Measured concentration	0.01	**$mg.m^{-3}$ (at reference conditions)**			

Measurement Equation

$$c = \frac{m}{V} f_c$$

Measured Quantities	Symbol	Value	Standard uncertainty		Units	Uncertainty as percentage	Uncertainty at lv	Requirement
Sampled Volume	V_m	1.8365	uV_m	0.001	m^3	0.05		<=5%
Sampled gas Temperature	T_m	295.25	uTm	2	k	0.68		<=2%
Sampled gas Pressure	ρ_m	72.26	$u\rho_m$	1	kPa	1.38		<=2%
Sampled gas Humidity	H_m	0	uH_m	1	% by volume	1.00		<=1%
Oxygen content	$O_{2,m}$	10.68	$uO_{2,m}$	0.1	% by volume	0.94		<=5%
Mass particulate	m	15.406	um	0.16	mg	1.03	0.03	<5% of limit va
Note - Sampled gas humidity, temperature and pressure are values at the gas meter								
Leak	L	0.00			%	0.00		<=2%
Uncollected Mass (Instack filter - no rinse)	UCM	0			mg	0		<=10%
Intermediate calculations								
Factor for std conds	fs	0.66						
uncertainty components	symbol	**sensitivity coeff**	**u (in units of fs)**					
	ρ_m	0.009		0.009				
	H_m	0.007		0.007				
	T_m	0.002		0.004				
	ufs			0.012		1.84		
Corrected volume	V	1.21	uV	0.022	m^3	1.84		
Factor for O2 correction	fc	1.07						
uncertainty components	symbol	**sensitivity coeff**	**u**					
	$O_{2,m}$	0.10		0.010				
Factor for O2 Correction	ufc	1.07		0.010		0.97		

$$f_s = \frac{(100 - H_m)}{100} \frac{273}{T_m} \frac{\rho_m}{101.3}$$

$$V = V_m f_s$$

$$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$$

Parameter		Value	Units	Sensitivity coeff	Uncertainty contribution		Uncertainty as %	
Corrected Volume (standard conditions)	V	1.21	m^3	0.01	0.00	$mg.m^{-3}$	1.84	%
Factor for O2 Correction	fc	1.07		0.01	0.00	$mg.m^{-3}$	0.97	%
Leak	L	0.00	$mg.m^{-3}$	1.00	0.00	$mg.m^{-3}$	0.00	%
Combined measurement uncertainty					**0.00**	$mg.m^{-3}$		

Expanded uncertainty as percentage of measured value	**4.16**	**% measured of value**	**expressed with a level of confidence of 95% (Using a coverage factor k=2)**
Expanded uncertainty in units of measurement	**0.00**	**$mg.m^{-3}$**	
Expanded uncertainty as percentage of limit value	**0.11**	**% ELV**	

Title:	**Determination of Dioxins and Furans**				
Method:	EN 1948-1				
Client:	Irish Cement				
Test Date:	31/08/2023		**Air Volume at Pump**	7.1966	m^3
Test Time:	09:34		**Temperature at Pump**	24.33	Deg C
Laboratory Used:	Marchwood		**Pressure at Pump**	80.94	kPa
Stack Name	A2-01		**Humidity at Pumps**	0	%
Filter I.D.	A2-01				
Moisture Content	9.62		**Reference Moisture**	0	%
Measured Oxygen	10.63	%	**Flow Uncertainty**	9,584	m^3/hr
Reference Oxygen	10	%	**Flow Uncertainty**	4.3	%
Stack Flow Rate	262,224	Nm^3/hr			
Adjusted Stack Flow Rate	223,300	Nm^3/hr, dry @ % Oxygen			
Dry Volume of Air Sampled	5.2792	m^3			
Emission Limit Value	0.1	$ng.m^{-3}$			
Leak Check Results	**Result**		**% Leak**		
Before Blank	0	cc/min	0.0		
Before Sample 1	0	cc/min	0.0		
Changing Ports	0	cc/min	0.0		
After Sample 1	0	cc/min	0.0		
Average Flow Rate	14.68	cc/min	0.0		
Standard Maximum	0.734	cc/min	5%		
Back Pressure	54.75	kPa			
Standard Criteria to be Met	**Result**	**Standard Requirement**			
Angle of Flow	Pass	<15 Degree	**Probe material**	Titanium	
Negative Flow in the Stack	Pass	None	**Filter housing**	Titanium	
Pitot Pressure Difference	Pass	>5Pa	**Positioning of filter**	Out Stack	
Ratio of Flow Measurement	Pass	<3:1	**Filter Size & Material**	47mm Quartz	
Stagnation Check	Pass	<10 Pa			
Pitot Tube Leak Check	**Result**				
Positive Pressure	Pass	-			
Negative Pressure	Pass	-			
Number of Ports	2	2			
Straight length before sample point	Yes	> 5 Hydraulic Diameters			
Straight length after sample point	Yes	> 5 HD from fan or bend / >2 from stack exit			

Sample Calculations	2010/75/EU I-TEF	Amount ng	2010/75/EU I-TEQ ng	Concentration 2010/75/EU $ng.m^{-3}$	Uncertainty $ng.m^{-3}$
2,3,7,8-TCDF	0.1	0.00434	0.00043	0.000087	0.000003
1,2,3,7,8-PeCDF	0.05	0.00063	0.00003	0.000006	0.000000
2,3,4,7,8-PeCDF	0.5	0.00182	0.00091	0.000183	0.000007
1,2,3,4,7,8-HxCDF	0.1	0.00065	0.00007	0.000013	0.000000
1,2,3,6,7,8-HxCDF	0.1	0.00045	0.00005	0.000009	0.000000
2,3,4,6,7,8-HxCDF	0.1	0.00043	0.00004	0.000009	0.000000
1,2,3,7,8,9-HxCDF	0.1	0.00011	0.00001	0.000002	0.000000
1,2,3,4,6,7,8-HpCDF	0.01	0.00174	0.00002	0.000003	0.000000
1,2,3,4,7,8,9-HpCDF	0.01	0.00064	0.00001	0.000001	0.000000
OCDF	0.001	0.00141	0.00000	0.000000	0.000000
2,3,7,8-TCDD	1	0.00014	0.00014	0.000028	0.000001
1,2,3,7,8-PeCDD	0.5	0.00021	0.00011	0.000021	0.000001
1,2,3,4,7,8-HxCDD	0.1	0.00023	0.00002	0.000005	0.000000
1,2,3,6,7,8-HxCDD	0.1	0.00022	0.00002	0.000004	0.000000
1,2,3,7,8,9-HxCDD	0.1	0.00023	0.00002	0.000005	0.000000
1,2,3,4,6,7,8-HpCDD	0.01	0.00148	0.00001	0.000003	0.000000
OCDD	0.001	0.00486	0.00000	0.000001	0.000000
Total Amount		**0.0196**	**0.0019**	**0.00038**	**0.000014**

Blank Calculations	2000/76/EC I-TEF	Amount ng	2010/75/EU I-TEQ ng	Concentration 2010/75/EU I-TEQ ng/m^3
2,3,7,8-TCDF	0.1	0.00432	0.00043	0.000087
1,2,3,7,8-PeCDF	0.05	0.00011	0.00001	0.000001
2,3,4,7,8-PeCDF	0.5	0.00011	0.00006	0.000011
1,2,3,4,7,8-HxCDF	0.1	0.00010	0.00001	0.000002
1,2,3,6,7,8-HxCDF	0.1	0.00009	0.00001	0.000002
2,3,4,6,7,8-HxCDF	0.1	0.00018	0.00002	0.000004
1,2,3,7,8,9-HxCDF	0.1	0.00009	0.00001	0.000002
1,2,3,4,6,7,8-HpCDF	0.01	0.00009	0.00000	0.000000
1,2,3,4,7,8,9-HpCDF	0.01	0.00022	0.00000	0.000000
OCDF	0.001	0.00060	0.00000	0.000000
2,3,7,8-TCDD	1	0.00028	0.00028	0.000056
1,2,3,7,8-PeCDD	0.5	0.00022	0.00011	0.000022
1,2,3,4,7,8-HxCDD	0.1	0.00016	0.00002	0.000003
1,2,3,6,7,8-HxCDD	0.1	0.00022	0.00002	0.000004
1,2,3,7,8,9-HxCDD	0.1	0.00018	0.00002	0.000004
1,2,3,4,6,7,8-HpCDD	0.01	0.00012	0.00000	0.000000
OCDD	0.001	0.00045	0.00000	0.000000
Total Blank		**0.0075**	**0.0010**	**0.00020**
Field Blank Status	0.20	**<10% of ELV**		
Method Blank Status	Pass	**Pass / Fail**		
Blank < 10% of the Emission Limit Values		Yes		

DUCT AND GAS SPECIFICATION

Name			a2-01
Section			Circular
Diameter		[m]	2.6
Area		[m^2]	5.309292
Ports	B	[#]	2
Points	P	[#]	10
Density	ρn	[$^{kg}/_{nm^3}$]	1.408
Carbon Dioxide	CO_2	[%]	19.71
Oxygen	O_2	[%]	10.63
Water Vapor Ratio	rw	[0;1]	0.096
Nozzle	nz	[mm]	5
Turbolence factor	ft	[sec]	1
Wall Adjustment Factor	waf		0.995

PITOT DATA SPECIFICATION

Name			p0.84
Velocity	[$^m/_{sec}$]	5	0.83
Velocity	[$^m/_{sec}$]	10	0.83
Velocity	[$^m/_{sec}$]	20	0.83
Velocity	[$^m/_{sec}$]	30	0.83
Velocity	[$^m/_{sec}$]	40	0.83

NORMALIZATION FACTOR

T_{norm}		[K]	273
P_{norm}		[kPa]	101.3

DUCT FLOW RATE

Dry actual	QV_a	[$^{m3}/_h$]	369885
Moist actual	$Q'V_a$	[$^{m3}/_h$]	409169
Moist norm. [T_{norm} P_{norm}]	$Q'V_n$	[$^{nm3}/_h$]	262224
Dry norm. [T_{norm} P_{norm}]	QV_n	[$^{nm3}/_h$]	237050

AVERAGE VALUES

Total Points		[#]	2
Velocity	v'_a	[$^m/_{sec}$]	21.52
Pitot Differential Pressure	dP_{avg}	[Pa]	290.67
Stack temperature	t_{stack}	[°C]	147.05
Stack Pressure	P_a	[kPa]	99.89
Isokinetic Ratio	IR	[%]	99.9
Velocity at nozzle	v'_N	[$^m/_{sec}$]	21.511
Probe temperature	t_{probe}	[°C]	115.5
Filter temperature	t_{filter}	[°C]	121.3
Outlet temperature	t_{outlet}	[°C]	12.1
Aux temperature	t_{aux}	[°C]	31.6
Ambient Pressure	P_{amb}	[kPa]	100.02

GAS METER SAMPLED VOLUMES

Elapsed time	et	[hh:mm:ss]	06:00:00
Norm. Volume [T_{norm} P_{norm}]	V_{gn}	[nm^3]	5.2792
Moist Volume at stack conditions	V'_{ga}	[m^3]	9.1127
Volume at dgm conditions	V_{dgm}	[m^3]	7.1966
Gas meter temperature	t_{dgm}	[°C]	24.33
Gas Meter Pressure	P_{dgm}	[kPa]	80.94

Title:	***Determination of Flue Gases***			
Method:	EN 14792 / TS 17021 / EN 15058 / TS 17045 / EN 14789			
Test Date:	31/08/2023			
Stack Name:	A2-01		**Quality Assurance**	
Test Start Time:	08:29		Probe Material	Stainless Steel
Reference Conditions			Filtration Type/size	Stainless Steel
Measured Oxygen	10.5	%	Heated Filter used	Yes
Reference Oxygen	10	%	No. of sampling lines	1
Reference Moisture	0		No. of Sampling points	1
			Sampling point I.D.s	1

Parameter		CO2	O2
Emission Limit Values	mg.m^{-3} ref	-	-
Instrument Range	ppm	30.00%	25.00%
Span Gas Value	ppm	16.42%	20.90%
Acceptable Gas Range	-	Yes	Yes
Calibration Gas Reference No.	-	ASLLK19ING558	-
Calibration Gas Uncertainty	%	0.9	0.35
Calibration Gas Start Bar	Bar	15	-
Expiry Date	-	Nov-23	-
Quality Assurance	Units	**CO2**	**O2**
Conditioning Unit Temperature	C	2	2
Average Temperature	< C	2	2
Allowable Temperature	-	4	4
Temperature Acceptable	-	Yes	Yes
Pump flow rate	l/min.	0.5	0.5
Instrument Zero Drift	Units	**CO2**	**O2**
Instrument Zero (Ambient air or Nitrogen)		Nitrogen	Nitrogen
Instrument Zero (Pre)	ppm	0.00%	0.00%
Instrument Zero (Check)	ppm	-0.11%	0.04%
Compliance Statement	Pass / Fail	Pass	Pass
Instrument Zero (Post)	ppm	-0.03%	0.02%
Zero Drift	ppm	-0.03%	0.02%
Allowable Zero Drift (Less than 2%)	ppm equiv.	-	0.42%
Adjustable Zero Drift (2 - 5%) / 5% CO_2	ppm equiv.	0.82%	1.05%
Zero Drift Failure (<5% / >5% CO_2)	ppm equiv.	0.82%	1.05%
Zero Drift Acceptable	-	Yes	Yes
Adjust for Zero Drift	-	No	No
Reject results	-	No	No
Calculated Drift	%	-0.18%	0.10%
Instrument Span Drift	Units	**CO2**	**O2**
Instrument Span Down (Pre)	ppm	16.42%	20.90%
Instrument Check Span (Post)	ppm	16.30%	20.79%
Span Drift	ppm	-0.12%	-0.11%
Allowable Span Drift (less than 2%)	ppm equiv.	0.33%	0.42%
Adjustable Span Drift (2 - 5%)	ppm equiv.	0.00821	1.05%
Span Drift Failure (Greater than 5%)	ppm equiv.	0.82%	1.05%
Span Drift Acceptable (Y/N)	-	Yes	Yes
Adjust for Span Drift	-	No	No
Reject results	-	No	No
Calculated Drift	%	-0.73%	-0.53%
Heated Line Check Including Leak Check		**CO2**	**O2**
Span Gas Conc.	ppm	16.42%	20.90%
Zero Check Acceptable Limit (+/-)	ppm	0.33%	0.42%
Heated Line Check Zero Gas	ppm	-0.28%	0.25%
Compliance Statement	Pass / Fail	Pass	Pass
Heated Line Check Span Gas	ppm or %	16.33%	20.86%
Span Gas Leak Detected	ppm or %	-0.09%	-0.04%
Leak check acceptable (< 2%)	ppm or %	0.33%	0.42%
Compliance Statement	Pass / Fail	Pass	Pass
Response Time (<200 seconds)		Yes	Yes

Test Conditions	Units	
Run Ambient Temperature Range	C	20

Raw Data

Date/Time	**CO2 vol%**	**O2 vol%**
31/08/2023 08:29	17.71	10.62
31/08/2023 08:30	17.69	10.62
31/08/2023 08:31	17.58	10.65
31/08/2023 08:32	17.68	10.65
31/08/2023 08:33	17.68	10.71
31/08/2023 08:34	17.87	10.65
31/08/2023 08:35	18.00	10.59
31/08/2023 08:36	17.90	10.66
31/08/2023 08:37	18.16	10.59
31/08/2023 08:38	18.23	10.58
31/08/2023 08:39	18.19	10.60
31/08/2023 08:40	18.13	10.64
31/08/2023 08:41	18.22	10.53
31/08/2023 08:42	18.14	10.58
31/08/2023 08:43	18.13	10.61
31/08/2023 08:44	17.55	10.93
31/08/2023 08:45	18.13	10.50
31/08/2023 08:46	17.93	10.53
31/08/2023 08:47	17.86	10.53
31/08/2023 08:48	17.92	10.50
31/08/2023 08:49	18.09	10.43
31/08/2023 08:50	17.96	10.47
31/08/2023 08:51	18.12	10.37
31/08/2023 08:52	18.05	10.41
31/08/2023 08:53	17.93	10.46
31/08/2023 08:54	18.03	10.40
31/08/2023 08:55	18.11	10.39
31/08/2023 08:56	18.22	10.36
31/08/2023 08:57	18.19	10.35
31/08/2023 08:58	18.10	10.44
31/08/2023 08:59	18.07	10.46
Average	**17.99**	**10.54**

Referenced Data

	CO2	O2
	vol%	**vol%**
31/08/2023 08:29	17.71	10.62
31/08/2023 08:30	17.69	10.62
31/08/2023 08:31	17.58	10.65
31/08/2023 08:32	17.68	10.65
31/08/2023 08:33	17.68	10.71
31/08/2023 08:34	17.87	10.65
31/08/2023 08:35	18.00	10.59
31/08/2023 08:36	17.90	10.66
31/08/2023 08:37	18.16	10.59
31/08/2023 08:38	18.23	10.58
31/08/2023 08:39	18.19	10.60
31/08/2023 08:40	18.13	10.64
31/08/2023 08:41	18.22	10.53
31/08/2023 08:42	18.14	10.58
31/08/2023 08:43	18.13	10.61
31/08/2023 08:44	17.55	10.93
31/08/2023 08:45	18.13	10.50
31/08/2023 08:46	17.93	10.53
31/08/2023 08:47	17.86	10.53
31/08/2023 08:48	17.92	10.50
31/08/2023 08:49	18.09	10.43
31/08/2023 08:50	17.96	10.47
31/08/2023 08:51	18.12	10.37
31/08/2023 08:52	18.05	10.41
31/08/2023 08:53	17.93	10.46
31/08/2023 08:54	18.03	10.40
31/08/2023 08:55	18.11	10.39
31/08/2023 08:56	18.22	10.36
31/08/2023 08:57	18.19	10.35
31/08/2023 08:58	18.10	10.44
31/08/2023 08:59	18.07	10.46
Average	**17.99**	**10.54**
Uncertainty of Measurement	**0.31**	**0.35**
Uncertainty as % of ELV	**-**	**-**
Standard Requirement	**<25%**	**<6%**

QGU-007-2013 Uncertainty calculation for Gaseous Measurement Carbon Dioxide

V2.2 Jul-08

Limit value	n/a	**%vol**	**Calibration gas**	**0.1642**	**%vol**
Measured concentration	17.99	**%vol**	**Full Scale**	**25**	**%vol**

Performance characteristics	**Value**				**specification**
Response time		30	seconds		< 200 s
Logger sampling interval		60	seconds		
Measurement period		30	minutes		
Number of readings in measurement		30	Assuming 1 minute collected over 1 hour		
Repeatability at zero		0.015	% by volume	stdev	<0.2 % range
Repeatability at span level		0.014	% by volume	stdev	<0.4 % range
Deviation from linearity		0.13	% vol	+/-	<0.3 % volume
Zero drift (during measurement period)		0	% vol at zero level	+/-	<2% of volume / 24hr
Span drift (during measurement period)		0	% vol at span level	+/-	<2% volume/24hr
volume or pressure flow dependence		0	% of fs / 10l/h	+- 5 l/h	<1% range
atmospheric pressure dependence		0.3	% of fs/kPa	+- 2kPa	< 1.5 % range
ambient temperature dependence		-0.07	% by volume /10K	+- 15K	<0.3% volume 10 K
CO_2 (% vol)	15	0.07	% by volume per	15	
NO (mg/m3)	300	0.02	% by volume per	300	
NO_2 (mg/m3)	30	0	% by volume per	30	
Combined interference		0.56	% range		<2% range
Dependence on voltage		0.1	% by volume /10V	+- 5%	< 0.1%vol /10 volt
Losses in the line (leak)		0.548112058	% of value		< 2% of value
Uncertainty of calibration gas		0.9	% of value		

Effect of drift	
0.00	% vol
0.00	% value

	range of variation from conditions at calibration			
	min	max	value at calib	
flow	5	15	10	l/h
pressure	99.00	101	100	kPa
temp	280	285	285	K
CO_2 range	8	15	0	% vol
NO range	100	150	0	mg/m3
NO_2 range	5	7.5	0	mg/m3
Voltage	105	115	110	V

Performance characteristic	**Uncertainty**	**Value of uncertainty quantity**	**% vol**
Standard deviation of repeatability at zero	u_{r0}	for mean	Only use rep at span
Standard deviation of repeatability at span level	u_{rs}	for mean	0.00
Lack of fit	u_{fit}		0.08
Drift	u_{0dr}		0.00
volume or pressure flow dependence	u_{spres}		0.00
atmospheric pressure dependence	u_{apres}		0.04
ambient temperature dependence	u_{temp}		-0.02
CO_2			0.05
NO			0.01
NO_2			0.00
Combined interference (from mcerts)			0.08
dependence on voltage	u_{volt}		0.03
losses in the line (leak)	u_{leak}		0.06
Uncertainty of calibration gas	u_{calib}		0.09

Use largest of sum of all positive or all negative influences			
0.06	all +ves		Criteria
0	all -ves		sum <2% value
0.06	largest		0.359731183
Value to use for intereference uncertainty			
u_{int}	0.06		

Measurement uncertainty		17.99	%vol
Combined uncertainty		0.16	%vol
% of value		0.87	%
Coverage factor k =	2		
Expanded uncertainty	**expressed with a level of confidence of 95%**	**1.75**	**% of value**
Expanded uncertainty	**expressed with a level of confidence of 95%**	**0.31**	**% vol**

QGU-007-2013 Uncertainty calculation for Gaseous Measurement Oxygen EN14789

V2.2 Jul-08

Limit value	n/a	**%vol**	**Calibration gas**	**0.209**	**%vol**
Measured concentration	10.54	**%vol**	**Full Scale**	**0.25**	**%vol**

Performance characteristics	**Value**				**specification**
Response time		30	seconds		< 200 s
Logger sampling interval		60	seconds		
Measurement period		30	minutes		
Number of readings in measurement		30	Assuming 1 minute collected over 1 hour		
Repeatability at zero		0.015	% by volume	stdev	<0.2 % range
Repeatability at span level		0.014	% by volume	stdev	<0.4 % range
Deviation from linearity		0	% vol	+/-	<0.3 % volume
Zero drift (during measurement period)		0.0002	% vol at zero level	+/-	<2% of volume / 24hr
Span drift (during measurement period)		-0.0011	% vol at span level	+/-	<2% volume/24hr
volume or pressure flow dependence		0	% of fs / 10l/h	+- 5 l/h	<1% range
atmospheric pressure dependence		0.3	% of fs/kPa	+- 2kPa	< 1.5 % range
ambient temperature dependence		-0.07	% by volume /10K	+- 15K	<0.3% volume 10 K
CO_2 (% vol)	15	0.07	% by volume per	15	
NO (mg/m3)	300	0.02	% by volume per	300	
NO_2 (mg/m3)	30	0	% by volume per	30	
Combined interference		0.56	% range		<2% range
Dependence on voltage		0.1	% by volume /10V	+- 5%	< 0.1%vol /10 volt
Losses in the line (leak)		0.19138756	% of value		< 2% of value
Uncertainty of calibration gas		0.35	% of value		

Effect of drift	
0.00	% vol
0.00	% value

	range of variation from conditions at calibration			
	min	max	value at calib	
flow	5	15	10	l/h
pressure	99.00	101	100	kPa
temp	280	285	285	K
CO_2 range	8	15	0	% vol
NO range	100	150	0	mg/m3
NO_2 range	5	7.5	0	mg/m3
Voltage	105	115	110	V

Performance characteristic	**Uncertainty**	**Value of uncertainty quantity**	**% vol**
Standard deviation of repeatability at zero	u_{r0}	for mean	Only use rep at span
Standard deviation of repeatability at span level	u_{rs}	for mean	0.00
Lack of fit	u_{fit}		0.08
Drift	u_{0dr}		0.00
volume or pressure flow dependence	u_{spres}		0.00
atmospheric pressure dependence	u_{apres}		0.04
ambient temperature dependence	u_{temp}		-0.02
CO_2			0.05
NO			0.01
NO_2			0.00
Combined interference (from mcerts)			0.08
dependence on voltage	u_{volt}		0.03
losses in the line (leak)	u_{leak}		0.13
Uncertainty of calibration gas	u_{calib}		0.03

Use largest of sum of all positive or all negative influences			
0.06	all +ves		Criteria
0	all -ves		sum <2% value
0.06	largest		0.22
Value to use for intereference uncertainty			
u_{int}	0.06		

Measurement uncertainty		10.54	%vol
Combined uncertainty		0.17	%vol
% of value		1.64	%
Coverage factor k =	2		
Expanded uncertainty	**expressed with a level of confidence of 95%**	**3.28**	**% of value**
Expanded uncertainty	**expressed with a level of confidence of 95%**	**0.35**	**% vol**

AirScientific

Title:	**Determination of Moisture Content**			
Method	EN 14790			
Stack Name	A2-01			
Test Time	09:47:00			
Leak Check Results				
Prior to test:	0			
Post Test:	0			
Sample Volume Flow Rate:	2.3			
Standard Requirement:	<2%			
Test Result:	0			
Test Status	Pass			
Calibration Details				
Pump Number	ASLLK22EQ503			
Calibrator Number	ASLLK22EQ514			
Calibration Rate Before	2.3	N Litres per Minute		
Calibration Rate After	2.3	N Litres per Minute		
Air Volume at Pump	2.3	N Litres per Minute		
Sample Time	30	Minutes		
Temperature at Pump	20	Deg C		
Pressure at Pump	101.3	kPa		
Volume from Mass Flow Meter	0.064	Nm^3		
Balance Calibration	**Weight**			
0.0	0.0	g	Eccentric load indication carried out - Balance Ok	Yes
500.0	500.0	g		
1000.0	1000.0	g		
Impinger Weights	**Initial**	**Final**	**Difference**	
Total Impinger Weight	598.6	602.9	4.3	
Volume of Air Sampled	0.064	Nm^3	4.3	
Moisture Content (EN 14790)	7.68	%		
Uncertainty	0.39	%		

QGU-009-2013 Uncertainty calculation for EN 14791										
v2										
							Measurement Equation			
Limit value (ELV)		**$mg.m^{-3}$**								
Measured concentration	7.68	**$mg.m^{-3}$ (at reference conditions)**								
Measured Quantities	**Symbol**	**Value**	**Standard uncertainty**		**Units**		**Uncertainty as percentage**	**Uncertainty at lv**	**Requirement of std**	
Sampled Volume Gas	V_m	0.064290102	uV_m	0.001	**m^3**		1.56		<=2%	
Sampled gas Temperature	T_m	293	uTm	2	k		2.00		<2.5 k	
Sampled gas Pressure	ρ_m	101.3	$u\rho_m$	1	**kPa**		0.99		<=1%	
Sampled gas Humidity	H_m	0	uH_m	1	**% by volume**		1.00		<=1%	
Note - Sampled gas humidity, temperature and pressure are values at the gas meter										
Leak	L	2			**%**		2.00		<=2%	
Intermediate calculations										
Factor for std conds	fs	0.93								
uncertainty components	symbol	**sensitivity coeff**		**u (in units of fs)**						
	ρ_m	0.009		0.009						
	H_m	0.009		0.009						
	T_m	0.003		0.006						
	ufs			0.015			1.56			
Corrected volume	V	0.06	uV	0.001	**m^3**		2.29			
Factor for O2 correction	fc	#REF!								
uncertainty components	symbol	**sensitivity coeff**		**u**						
	$O_{2,m}$	#REF!		#REF!						
Factor for O2 Correction	ufc	#REF!		#REF!			#REF!			
Parameter		**Value**	**Units**	**Sensitivity coeff**	**Uncertainty contribution**		**Uncertainty as %**			
Corrected Volume (standard conditions)	V	0.06	m^3	128.27	0.18	$mg.m^{-3}$	2.29	%		
Leak	L	0.09	$mg.m^{-3}$	1.00	0.09	$mg.m^{-3}$	1.15	%		
Combined uncertainty					**0.20**	$mg.m^{-3}$				
Expanded uncertainty as percentage of measured value			**5.12**	**% measured of value**		**expressed with a level of confidence of 95%**				
						(Using a coverage factor k=2)				
Expanded uncertainty in units of measurement			**0.39**	**%**						

Title:	**Determination of Moisture Content**			
Method	EN 14790			
Stack Name	A2-01			
Test Time	08:10:00			
Leak Check Results				
Prior to test:	0			
Post Test:	0			
Sample Volume Flow Rate:	2.3			
Standard Requirement:	<2%			
Test Result:	0			
Test Status	Pass			
Calibration Details				
Pump Number	ASLLK22EQ503			
Calibrator Number	ASLLK22EQ514			
Calibration Rate Before	2.3	N Litres per Minute		
Calibration Rate After	2.3	N Litres per Minute		
Air Volume at Pump	2.3	N Litres per Minute		
Sample Time	30	Minutes		
Temperature at Pump	20	Deg C		
Pressure at Pump	101.3	kPa		
Volume from Mass Flow Meter	0.064	Nm^3		
Balance Calibration	**Weight**			
0.0	0.0	g	Eccentric load indication carried out - Balance Ok	Yes
500.0	500.0	g		
1000.0	1000.0	g		
Impinger Weights	**Initial**	**Final**	**Difference**	
Total Impinger Weight	594.6	600.1	5.5	
Volume of Air Sampled	0.064	Nm^3	5.5	
Moisture Content (EN 14790)	9.62	%		
Uncertainty	0.49	%		

QGU-009-2013 Uncertainty calculation for EN 14791									
v2									
							Measurement Equation		
Limit value (ELV)		**$mg.m^{-3}$**							
Measured concentration	9.62	**$mg.m^{-3}$ (at reference conditions)**							
Measured Quantities	**Symbol**	**Value**	**Standard uncertainty**		**Units**		**Uncertainty as percentage**	**Uncertainty at lv**	**Requirement of std**
Sampled Volume Gas	V_m	0.064290102	uV_m	0.001	**m^3**		1.56		<=2%
Sampled gas Temperature	T_m	293	uTm	2	k		2.00		<2.5 k
Sampled gas Pressure	ρ_m	101.3	$u\rho_m$	1	**kPa**		0.99		<=1%
Sampled gas Humidity	H_m	0	uH_m	1	**% by volume**		1.00		<=1%
Note - Sampled gas humidity, temperature and pressure are values at the gas meter									
Leak	L	2			**%**		2.00		<=2%
Intermediate calculations									
Factor for std conds	fs	0.93							
uncertainty components	symbol	**sensitivity coeff**		**u (in units of fs)**					
	ρ_m	0.009		0.009					
	H_m	0.009		0.009					
	T_m	0.003		0.006					
	ufs			0.015			1.56		
Corrected volume	V	0.06	uV	0.001	**m^3**		2.29		
Factor for O2 correction	fc	#REF!							
uncertainty components	symbol	**sensitivity coeff**		**u**					
	$O_{2,m}$	#REF!		#REF!					
Factor for O2 Correction	ufc	#REF!		#REF!			#REF!		
Parameter		**Value**	**Units**	**Sensitivity coeff**	**Uncertainty contribution**		**Uncertainty as %**		
Corrected Volume (standard conditions)	V	0.06	m^3	160.63	0.22	$mg.m^{-3}$	2.29	%	
Leak	L	0.11	$mg.m^{-3}$	1.00	0.11	$mg.m^{-3}$	1.15	%	
Combined uncertainty					**0.25**	$mg.m^{-3}$			
Expanded uncertainty as percentage of measured value			**5.12**	**% measured of value**		**expressed with a level of confidence of 95%**			
						(Using a coverage factor k=2)			
Expanded uncertainty in units of measurement			**0.49**	**%**					

Appendix III: Certificates and Process Detail Form

Attach Process Details.

Process Details Form

The process information below has been requested by the EPA and supplied by the client and as such ASL assume no responsibility or liability for any errors or omissions in the content of this Process Detail Form. The information provided in this form is provided on an 'as is' basis with no guarantees of completeness, accuracy or reliability.

Licensee	Irish Cement Ltd	**Contractor**	Air Scientific Limited
Reg. Number	P0029-06		
Site Contact	Neasa de Barra	**Contractor's Contact**	Jarlath Sammon
Role	Env Engineer	**Role**	
Signature	Neasa de Barra	**Signature**	

Emission Point as per License			
Type of process	O Rotogravure printing	O Rotogravure printing	O Rotogravure printing
	● Cement plant	O Cement plant	O Cement plant
	O Electrical generation	O Electrical generation	O Electrical generation
	O Steam boiler	O Steam boiler	O Steam boiler
	O Other:	O Other:	O Other:
Load of Process (**Rotogravure printing**: the solvent type and content of the ink, the ink delivery rate, the press temperature, the status of abatement plant, printing rate (m/s), etc.; **Cement plant**: Clinker source and loading rate, fuel source and load rate; **Power plant**: Electrical generation (MW) and fuel; **Cement, chemical or pharmaceutical plants**: Rate of material processed (tons/ hour); **General manufacturing processes**: Rate of items processed per hour; **Steam boilers**: Percentage with regards maximum capacity where appropriate)	Loading: ~210tph Clinker Source: Kiln 6 (onsite) Fuel: Pet coke, SRF		
Abatement system	● Bag filter	O Bag filter	O Bag filter
	O Electrostatic precipitator	O Electrostatic precipitator	O Electrostatic precipitator
	O Cyclone	O Cyclone	O Cyclone
	O Thermal oxidiser	O Thermal oxidiser	O Thermal oxidiser
	O Active carbon bed	O Active carbon bed	O Active carbon bed
	O NSCR	O NSCR	O NSCR
	O SCR	O SCR	O SCR
	O Dry scrubber	O Dry scrubber	O Dry scrubber
	O Wet scrubber	O Wet scrubber	O Wet scrubber
	O Lime injection	O Lime injection	O Lime injection
	O Biofilter	O Biofilter	O Biofilter
	O None	O None	O None
	O Other:	O Other:	O Other:

Process Details Form

List of solvents used per process (to be added to the solvent suite)

Emission point as per Licence		
A2-01		

CERTIFICATE OF ANALYSIS

MSSL reference: 23-39570

Report date: 02-10-2023

Customer: Air Scientific Ltd
Unit 3,
Westlink Business Park,
Clondrinagh,
Limerick,
V94 K6XK

Customer contact(s): Jarlath Sammon

Customer reference: IRLITL12300823
Customer PO: -
Customer sampling date: 31-08-2023
Date received: 08-09-2023

Analysis started: 26-09-2023
Analysis complete: 01-10-2023
Conforming: YES

Results only relate to the items tested. Results apply to the samples as received.

Conformance is contingent upon accurate information being provided by the customer and customer compliance with relevant sample handling and storage conditions prior to receipt at the laboratory.

All opinions and interpretations expressed within this report are outside Marchwood's scope of accreditation.

Accreditation Key:
Y : ISO/IEC 17025 M : MCERTS
N : Non Accredited (S) : Subcontracted

Notes:

Reported by: Lesley Jeffery
Position: Scientist

Approved by: Thomas Walmsley
Position: Team Leader
For/on behalf of Marchwood Scientific Services Ltd

UKAS TESTING 1668

t: 02380 786979 w: www.cawood.co.uk/marchwood
Marchwood, 371 Millbrook Road West, Southampton SO15 0HW

Supporting a safer, healthier planet
www.cawood.co.uk

337472 Dioxin Results Summary

Sample Type : Stack
MSS Sample Ref : 337472
Customer Sample Ref : A2-01 Kiln Dioxins Filter,Trap & Condensate
Sample Condition : Conforming
Test Method : 2002b

Dioxins/ Furans

Analysis	Accreditation	Lower Bound	Upper Bound
I-TEQ	M	0.00157	0.00190

337472 Dioxin Results

Sample Type : Stack
MSS Sample Ref : 337472
Customer Sample Ref : A2-01 Kiln Dioxins Filter,Trap & Condensate
Sample Condition : Conforming
Test Method : 2002b

Congener	LOD	Detected	Lower Bound	Upper Bound	Recovery	Sampling Recovery	UKAS
Dioxins/Furans	ng/Sample	ng/Sample	ng/Sample	ng/Sample	%	%	
2378-TCDD	0.00014	< 0.00014	0.0000	0.00014	111		M
12378-PeCDD	0.00021	< 0.00021	0.0000	0.00011	113		M
123478-HxCDD	0.00023	< 0.00023	0.0000	0.00002	79		M
123678-HxCDD	0.00022	< 0.00022	0.0000	0.00002	81		M
123789-HxCDD	0.00023	< 0.00023	0.0000	0.00002			M
1234678-HpCDD	0.00023	0.00148	0.00001	0.00001	77		M
OCDD	0.0003	0.00486	0.00000	0.00000	97		M
Dioxins Total			0.00002	0.00033			M
2378-TCDF	0.00069	0.00434	0.00043	0.00043	85		M
12378-PeCDF	0.00015	0.00063	0.00003	0.00003		118	M
23478-PeCDF	0.00015	0.00182	0.00091	0.00091	92		M
123478-HxCDF	0.00010	0.00065	0.00006	0.00006	74		M
123678-HxCDF	0.00010	0.00045	0.00005	0.00005	73		M
234678-HxCDF	0.00011	0.00043	0.00004	0.00004	63		M
123789-HxCDF	0.00011	< 0.00011	0.0000	0.00001		117	M
1234678-HpCDF	0.00009	0.00174	0.00002	0.00002	62		M
1234789-HpCDF	0.00012	0.00064	0.00001	0.00001		108	M
OCDF	0.00012	0.00141	0.00000	0.00000	77		M
Furans Total			0.00155	0.00156			M
Dioxin/Furan Total			0.00157	0.00190			M

Additional Information

Measurement Information

	Institution	Air Scientific Ltd Limerick
	Person	n/a
	Site sampling location	IRLITL12300823
	Date : Time	31/08/2023

		PCDD/F
Precision		5.7%
Expanded Uncertainty (of total TEQ)		14.8%
Sample storage	Location	Millbrook
	Temperature (^{O}C)	<25
	Date into storage	08/09/23
Extraction	Date	26/09/23
	Standard Concentration	1 ng
	Date Added	26/09/23
Concentration		
	Final Volume	30µl
Recovery Standards		
	Date Added	28/09/23
	Extract volume at injection	30µl
	Date of Analysis	29/09/23

Expanded Uncertainty - (95% coverage established over 12 month period). Further information on individual congener uncertainties are available on request.

The analysis was performed in accordance with EN1948-2:2006 and this European Standard, i.e. EN1948-4:2010

337473 Dioxin Results Summary

Sample Type : Stack
MSS Sample Ref : 337473
Customer Sample Ref : Blank Dioxins Filter, Trap &Condensate
Sample Condition : Conforming
Test Method : 2002b

Dioxins/ Furans

Analysis	Accreditation	Lower Bound	Upper Bound
I-TEQ	M	0.00076	0.00099

337473 Dioxin Results

Sample Type : Stack
MSS Sample Ref : 337473
Customer Sample Ref : Blank Dioxins Filter, Trap &Condensate
Sample Condition : Conforming
Test Method : 2002b

Congener	LOD	Detected	Lower Bound	Upper Bound	Recovery	Sampling Recovery	UKAS
Dioxins/Furans	ng/Sample	ng/Sample	ng/Sample	ng/Sample	%	%	
2378-TCDD	0.00011	0.00028	0.00028	0.00028	108		M
12378-PeCDD	0.00022	< 0.00022	0.0000	0.00011	129		M
123478-HxCDD	0.00016	< 0.00016	0.0000	0.00002	84		M
123678-HxCDD	0.00018	0.00022	0.00002	0.00002	94		M
123789-HxCDD	0.00018	< 0.00018	0.0000	0.00002			M
1234678-HpCDD	0.00012	< 0.00012	0.0000	0.00000	84		M
OCDD	0.0005	< 0.00045	0.0000	0.00000	101		M
Dioxins Total			0.00030	0.00045			M
2378-TCDF	0.00032	0.00432	0.00043	0.00043	89		M
12378-PeCDF	0.00011	< 0.00011	0.0000	0.00001		103	M
23478-PeCDF	0.00011	< 0.00011	0.0000	0.00005	101		M
123478-HxCDF	0.00010	< 0.00010	0.0000	0.00001	77		M
123678-HxCDF	0.00009	< 0.00009	0.0000	0.00001	84		M
234678-HxCDF	0.00009	0.00018	0.00002	0.00002	83		M
123789-HxCDF	0.00009	< 0.00009	0.0000	0.00001		91	M
1234678-HpCDF	0.00009	< 0.00009	0.0000	0.00000	73		M
1234789-HpCDF	0.00012	0.00022	0.00000	0.00000		96	M
OCDF	0.00016	0.00060	0.00000	0.00000	77		M
Furans Total			0.00045	0.00054			M
Dioxin/Furan Total			0.00076	0.00099			M

Additional Information

Measurement Information

	Institution	Air Scientific Ltd Limerick
	Person	n/a
	Site sampling location	IRLITL12300823
	Date : Time	31/08/2023
		PCDD/F
Precision		5.7%
Expanded Uncertainty (of total TEQ)		14.8%
Sample storage	Location	Millbrook
	Temperature (^{O}C)	<25
	Date into storage	08/09/23
Extraction	Date	26/09/23
	Standard Concentration	1 ng
	Date Added	26/09/23
Concentration		
	Final Volume	30µl
Recovery Standards		
	Date Added	28/09/23
	Extract volume at injection	30µl
	Date of Analysis	29/09/23

Expanded Uncertainty - (95% coverage established over 12 month period). Further information on individual congener uncertainties are available on request.

The analysis was performed in accordance with EN1948-2:2006 and this European Standard, i.e. EN1948-4:2010

Element Ireland, Unit D8 North City Business Park, North Road, Finglas, Dublin 11
Your Element Ireland Contact: Dónal Ó Faogáin (+353 861 746 367)
E: donal.ofaogain@element.com

Stack Emissions Testing Report Commissioned by
Irish Cement Ltd

Installation Name & Address
Irish Cement Ltd
Limerick Works
Castlemungret
County Limerick

Industrial Emissions Licence: P0029-06

Stack Reference
A2-01 Kiln 6

Dates of the Monitoring Campaign
13th - 21st September 2023

Job Reference Number
EMT06515

Report Written by
Mateusz Terlecki Team Leader MCERTS Level 2 MM17 1448 TE1 TE2 TE3 TE4

Report Approved by
Darragh Long Team Leader MCERTS Level 2 MM 18 1494 TE1 TE2 TE3 TE4

Report Date
17th October 2023

Version
Version 1

Signature of Report Approver
DLong

CONTENTS

Opinions and interpretations expressed herein are outside the scope of Element Ireland's ISO 17025 accreditation.

The testing performed fully meets the technical requirements in Irish EPA Guidance Note, AG2.

MONITORING OBJECTIVES

Irish Cement Ltd, Limerick
A2-01 Kiln 6
13th - 21st September 2023

Overall Aim of the Monitoring Campaign

Element Ireland were commissioned by Irish Cement Ltd to carry out stack emissions testing on the A2-01 Kiln 6 at Limerick.

The aim of the monitoring campaign was to demonstrate compliance with a set of emission limit values (ELVs) as specified in the Site's Licence.

Special Requirements

There were no special requirements.

Target Parameters

Total Particulate Matter, Sulphur Dioxide, Cadmium & Thallium, Heavy Metals, Mercury, Dioxins & Furans, PCBs, Hydrogen Chloride, Hydrogen Fluoride, Ammonia, Total VOCs (as Carbon), Oxides of Nitrogen (as NO_2), Carbon Monoxide, Ammonia, Hydrogen Chloride, Sulphur Dioxide, Oxides of Nitrogen (as NO_2), Carbon Monoxide

Executive Summary

(Page 2 of 7)

MONITORING RESULTS

Irish Cement Ltd, Limerick
A2-01 Kiln 6
13th - 21st September 2023

where MU = Measurement Uncertainty associated with the Result

	Concentration				Mass Emission			
Parameter	**Units**	**Result**	**MU +/-**	**Limit**	**Units**	**Result**	**MU +/-**	**Limit**
Cadmium & Thallium [1]	mg/m³	0.001	0.0002	0.05	g/hr	0.29	0.05	-
Heavy Metals [1]	mg/m³	0.011	0.002	0.5	g/hr	2.9	0.60	-
Mercury	mg/m³	0.008	0.002	0.05	g/hr	2.0	0.48	-
Dioxins & Furans Upper Limit (worst case where <LOD = LOD)								
Dioxins & Furans (NATO I-TEQ) [1]	ng/m³	0.0038	0.0008	0.1	µg/hr	0.99	0.21	-
Dioxins & Furans (WHO TEQ Humans / Mammals) [1]	ng/m³	0.0046	0.0010	-	µg/hr	1.20	0.26	-
Dioxins & Furans (WHO TEQ Fish) [1]	ng/m³	0.0049	0.0010	-	µg/hr	1.26	0.27	-
Dioxins & Furans (WHO TEQ Birds) [1]	ng/m³	0.0065	0.0013	-	µg/hr	1.68	0.36	-
Dioxins & Furans Lower Limit (best case where <LOD = 0)								
Dioxins & Furans (NATO I-TEQ) [1]	ng/m³	0.0022	0.0005	-	µg/hr	0.58	0.12	-
Dioxins & Furans (WHO TEQ Humans / Mammals) [1]	ng/m³	0.0028	0.0006	-	µg/hr	0.73	0.16	-
Dioxins & Furans (WHO TEQ Fish) [1]	ng/m³	0.0028	0.0006	-	µg/hr	0.72	0.15	-
Dioxins & Furans (WHO TEQ Birds) [1]	ng/m³	0.0040	0.0008	-	µg/hr	1.03	0.22	-
PCBs Upper Limit (worst case where <LOD = LOD)								
PCBs (WHO TEQ Humans / Mammals) [1]	ng/m³	0.000227	0.000047	-	µg/hr	0.06	0.013	-
PCBs (WHO TEQ Fish) [1]	ng/m³	0.000013	0.000003	-	µg/hr	0.003	0.001	-
PCBs (WHO TEQ Birds) [1]	ng/m³	0.001021	0.000213	-	µg/hr	0.26	0.056	-
PCBs Lower Limit (best case where <LOD = 0)								
PCBs (WHO TEQ Humans / Mammals) [1]	ng/m³	0.000127	0.000026	-	µg/hr	0.03	0.007	-
PCBs (WHO TEQ Fish) [1]	ng/m³	0.000009	0.000002	-	µg/hr	0.002	0.0005	-
PCBs (WHO TEQ Birds) [1]	ng/m³	0.000941	0.000196	-	µg/hr	0.24	0.05	-
Ammonia [1]	mg/m³	5.6	1.0	50	g/hr	1463	280	-
Total VOCs (as Carbon) [1]	mg/m³	11.3	0.64	25	g/hr	2939	214	-
Oxides of Nitrogen (as NO_2) [1]	mg/m³	479	17.5	500	g/hr	124274	7299	-
Carbon Monoxide [1]	mg/m³	280	10.3	1500	g/hr	72603	4273	-
Oxygen	% v/v	**Dry** 10.4	0.25					
Stack Gas Temperature	°C	146.6						
Stack Gas Velocity	m/s	24.2	0.19					
Volumetric Flow Rate (ACTUAL)	m³/hr	462645	21265					
Volumetric Flow Rate (REF) [1]	m³/hr	259215	11914					

NOTE: VOLUMETRIC FLOW RATE & VELOCITY DATA TAKEN FROM THE PRELIMINARY VELOCITY TRAVERSE.

[1] Reference Conditions (REF) are: 273K, 101.3kPa, dry gas, 10% oxygen.

MONITORING DATE(S) & TIMES

Irish Cement Ltd, Limerick
A2-01 Kiln 6
13th - 21st September 2023

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
Cadmium & Thallium	R1	mg/m³	0.001	g/hr	0.29	13/09/2023	18:05 - 19:05	60
Cadmium & Thallium	R2	mg/m³	< 0.001	g/hr	< 0.28	14/09/2023	08:15 - 09:15	60
Cadmium & Thallium	R3	mg/m³	< 0.001	g/hr	< 0.29	14/09/2023	17:07 - 18:07	60
Heavy Metals	R1	mg/m³	0.016	g/hr	4.1	13/09/2023	18:05 - 19:05	60
Oxygen (Metals Run 1)	R1	% v/v	10.2			13/09/2023	18:05 - 19:05	60
Water Vapour (Metals Run 2)	R1	% v/v	11.3			13/09/2023	18:05 - 19:05	60
Heavy Metals	R2	mg/m³	0.006	g/hr	1.5	14/09/2023	08:15 - 09:15	60
Oxygen (Metals Run 2)	R2	% v/v	10.1			14/09/2023	08:15 - 09:15	60
Water Vapour (Metals Run 2)	R2	% v/v	10.7			14/09/2023	08:15 - 09:15	60
Heavy Metals	R3	mg/m³	0.012	g/hr	3.1	14/09/2023	17:07 - 18:07	60
Oxygen (Metals Run 3)	R2	% v/v	10.6			14/09/2023	17:07 - 18:07	60
Water Vapour (Metals Run 3)	R2	% v/v	10.2			14/09/2023	17:07 - 18:07	60
Mercury	R1	mg/m³	0.006	g/hr	1.5	13/09/2023	18:05 - 19:05	60
Oxygen (Mercury Run 1)	R1	% v/v	10.2			13/09/2023	18:05 - 19:05	60
Water Vapour (Mercury Run 1)	R1	% v/v	11.8			13/09/2023	18:05 - 19:05	60
Mercury	R2	mg/m³	0.007	g/hr	1.7	14/09/2023	08:15 - 09:15	60
Oxygen (Mercury Run 2)	R2	% v/v	10.1			14/09/2023	08:15 - 09:15	60
Water Vapour (Mercury Run 2)	R2	% v/v	11.0			14/09/2023	08:15 - 09:15	60
Mercury	R3	mg/m³	0.011	g/hr	2.8	14/09/2023	17:07 - 18:07	60
Oxygen (Mercury Run 3)	R3	% v/v	10.6			14/09/2023	17:07 - 18:07	60
Water Vapour (Mercury Run 3)	R3	% v/v	10.1			14/09/2023	17:07 - 18:07	60
Dioxins & Furans (NATO)	R1	ng/m³	0.0020	µg/hr	0.53	13/09/2023	12:00 - 18:00	360
Oxygen (Dioxins Run 1)	R1	% v/v	10.5			13/09/2023	12:00 - 18:00	360
Water Vapour (Dioxins Run 1)	R1	% v/v	12.1			13/09/2023	12:00 - 18:00	360
Dioxins & Furans (NATO)	R2	ng/m³	0.0066	µg/hr	1.7	14/09/2023	09:30 - 13:36, 14:50 - 16:44	360
Oxygen (Dioxins Run 2)	R2	% v/v	10.5			14/09/2023	09:30 - 13:36, 14:50 - 16:44	360
Water Vapour (Dioxins Run 2)	R2	% v/v	9.0			14/09/2023	09:30 - 13:36, 14:50 - 16:44	360
Dioxins & Furans (NATO)	R3	ng/m³	0.0029	µg/hr	0.745	15/09/2023	09:20 - 15:20	360
Oxygen (Dioxins Run 3)	R3	% v/v	10.8			15/09/2023	09:20 - 15:20	360
Water Vapour (Dioxins Run 3)	R3	% v/v	13.6			15/09/2023	09:20 - 15:20	360
PCBs	R1	ng/m³	0.0001	µg/hr	0.032	13/09/2023	12:00 - 18:00	360
PCBs	R2	ng/m³	0.0004	µg/hr	0.105	14/09/2023	09:30 - 13:36, 14:50 - 16:44	360
PCBs	R3	ng/m³	0.0002	µg/hr	0.039	15/09/2023	09:20 - 15:20	360
Ammonia	R1	mg/m³	0.36	g/hr	93.9	15/09/2023	10:15 - 10:45	30
Oxygen (NH3 Run 1)	R1	% v/v	10.7			15/09/2023	10:15 - 10:45	30
Water Vapour (NH3 Run 1)	R1	% v/v	9.6			15/09/2023	10:15 - 10:45	30
Ammonia	R2	mg/m³	6.0	g/hr	1567	15/09/2023	10:55 - 11:25	30
Oxygen (NH3 Run 2)	R2	% v/v	10.7			15/09/2023	10:55 - 11:25	30
Water Vapour (NH3 Run 2)	R2	% v/v	8.4			15/09/2023	10:55 - 11:25	30
Ammonia	R3	mg/m³	10.5	g/hr	2728	15/09/2023	11:35 - 12:05	30
Oxygen (NH3 Run 3)	R3	% v/v	10.7			15/09/2023	11:35 - 12:05	30
Water Vapour (NH3 Run 3)	R3	% v/v	7.6			15/09/2023	11:35 - 12:05	30
Total VOCs (as Carbon)	R1	mg/m³	11.3	g/hr	2939	14/09/2023	18:30 - 02:30	480
Oxides of Nitrogen (as NO_2)	R1	mg/m³	479	g/hr	124274	14/09/2023	18:30 - 02:30	480
Carbon Monoxide	R1	mg/m³	280	g/hr	72603	14/09/2023	18:30 - 02:30	480
Carbon Dioxide	R1	% v/v	18.9			14/09/2023	18:30 - 02:30	480
Oxygen	R1	% v/v	10.1			14/09/2023	18:30 - 02:30	480
Velocity Traverse	R1					13/09/2023	11:00 - 11:25	

All results are expressed at the respective reference conditions.

PROCESS DETAILS

Irish Cement Ltd, Limerick
A2-01 Kiln 6
13th - 21st September 2023

Standard Operating Conditions

Parameter	Value
Process Status	Cement Kiln
Capacity (of 100%) and Tonnes / Hour	180 Tonnes / Hour
Continuous or Batch Process	Continuous
Feedstock (if applicable)	Raw Meal
Abatement System	Bag Filter & SNCR
Abatement System Running Status	Normal Operating Conditions
Fuel	Petcoke and SRF
Plume Appearance	Visible

MONITORING & ANALYTICAL METHODS

Irish Cement Ltd, Limerick
A2-01 Kiln 6
13th - 21st September 2023

Parameter	Monitoring: Standard	Monitoring: Technical Procedure	Monitoring: Sampling Status	Monitoring: Testing Lab	Analysis: Analytical Procedure	Analysis: Analytical Technique	Analysis: Analysis Status	Analysis: Analysis Lab	Overall Status	LOD (Average)
Cadmium & Thallium	EN 14385	MD 006	MCERTS	EET	CAT-AP-07	ICP-MS	MCERTS	EET	MCERTS	0.001 mg/m³
Heavy Metals	EN 14385	MD 006	MCERTS	EET	CAT-AP-07	ICP-MS	MCERTS	EET	MCERTS	0.006 mg/m³
Mercury	EN 13211	MD 006	MCERTS	EET	CAT-AP-08	CV-AFS	MCERTS	EET	MCERTS	0.00027 mg/m³
Dioxins & Furans	EN 1948	MD 007	MCERTS	EET	PM137, TM201	GC-HRMS	MCERTS	EET	MCERTS	0.0026 ng/m³
PCBs	EN 1948	MD 007	MCERTS	EET	PM137, TM201	GC-HRMS	MCERTS	ELD	MCERTS	0.00015 ng/m³
Ammonia	ISO 21877	MD 014	MCERTS	EET	A6	IC	MCERTS	RPS	MCERTS	0.143 mg/m³
Total VOCs (as Carbon)	EN 12619:2013	MD 020	MCERTS	EET	Flame Ionisation Detection by Sick 3006				MCERTS	0.32 mg/m³
Oxides of Nitrogen (as NO_2)	EN 14792	MD 039	MCERTS	EET	Chemiluminescence by Horiba PG-350E				MCERTS	0.41 mg/m³
Carbon Monoxide	EN 15058	MD 039	MCERTS	EET	NDIR by Horiba PG-350E				MCERTS	0.25 mg/m³
Carbon Dioxide	CEN/TS 17405	MD 039	MCERTS	EET	NDIR by Horiba PG-350E				MCERTS	0.1 %
Oxygen	EN 14789	MD 039	MCERTS	EET	Dry Paramagnetic Cell by Horiba PG-350E				MCERTS	0.1 %
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	MD 041	MCERTS	EET	Pitot Tube and Thermocouple				MCERTS	1.2 m/s

ANALYSIS LABORATORIES

(with short name reference as appears in the table above)

Element (Deeside Lab - ELD)	ISO 17025 Accreditation Number: 4225
Element (Stockport Lab - EET)	ISO 17025 Accreditation Number: 4279

SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
All	All	There are no deviations associated with the sampling employed.

SUITABILITY OF SAMPLING LOCATION

Duct Characteristics

Parameter	Units	Value
Type	-	Circular
Depth	m	2.60
Width	m	-
Area	m²	5.31
Port Depth	cm	21
Orientation of Duct	-	Vertical
Number of Ports	-	2
Sample Port Size	-	5" Flange

Location of Sampling Platform

General Platform Information	Value
Permanent / Temporary Platform	Permanent
Inside / Outside	Outside

Platform Details

Irish EPA Technical Guidance Note AG1 / EN 15259 Platform Requirements	Value
Sufficient working area to manipulate probe and operate the measuring instruments	Yes
Platform has 2 levels of handrails (approx. 0.5m & 1.0m high)	Yes
Platform has vertical base boards (approx. 0.25m high)	Yes
Platform has chains / self closing gates at top of ladders	Yes
There are no obstructions present which hamper insertion of sampling equipment	Yes
Safe Access Available	Yes
Easy Access Available	Yes

Sampling Location / Platform Improvement Recommendations

The sampling location meets all the requirements specified in Irish EPA Guidance Note AG1 and EN 15259, and therefore there are no improvement recommendations.

EN 15259 Homogeneity Test Requirements

A valid EN 15259 Homogeneity test was performed by Element on this Stack on 19th June 2021, Report ID: EMT01136, and the stack gas profile was found to be homogenous.

Sampling Plane Validation Criteria (from EN 15259)

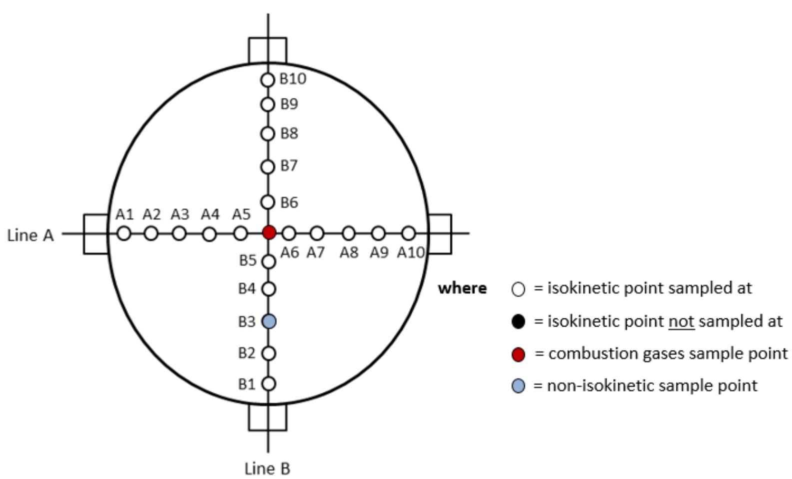
Criteria in EN 15259	Units	Traverse 1	Required	Compliant
Lowest Differential Pressure	Pa	302.0	> 5 Pa	Yes
Mean Velocity	m/s	24.20	-	-
Lowest Gas Velocity	m/s	22.01	-	-
Highest Gas Velocity	m/s	26.53	-	-
Ratio of Above	: 1	1.21	< 3 : 1	Yes
Maximum Angle of Swirl	°	8.00	< 15°	Yes
No Local Negative Flow	-	Yes	-	Yes

PLANT PHOTOS

Photo 1

Photo 2

SAMPLE POINTS



APPENDIX CONTENTS

STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	Mateusz Terlecki	MCERTS Level 2	MM17 1448	TE1 TE2 TE3 TE4
Team Leader	Simon FitzHugh	MCERTS Level 2	MM20 1595	TE1

LIST OF EQUIPMENT

Extractive Sampling	
Equipment Type	**Equipment I.D.**
Control Box DGM (1)	CAT 7.100
Control Box DGM (2)	CAT 7.42
Box Thermocouples (1)	CAT 3.204
Box Thermocouples (2)	CAT 3.103
Umbilical (1)	CAT 3.204
Umbilical (2)	CAT 3.103
Oven Box (1)	CAT 12.125
Oven Box (2)	-
Heated Probe (1)	CAT 5.13
Heated Probe (2)	CAT 5.119
Heated Probe (3)	-
S-Pitot (1)	CAT 21P.92/21P.93
S-Pitot (2)	CAT 21P.189
L-Pitot	-
Site Balance	CAT 17.68
500g / 1Kg Check Weights	CAT 17.68
Last Impinger Arm	CAT 4.0060
Callipers	CAT 23.58
Tubes Kit Thermocouple	-

Instrumental Analysers	
Equipment Type	**Equipment I.D.**
Horiba PG-350E	CAT 39.36
SELECT Horiba Model (2)	-
SELECT Servomex Model	-
SELECT NOX Analyser/Convertor	-
ABB AO2020-URAS26	-
Testo 350 XL	-
M&C PSS5	CAT 4.00158
Gasmet DX4000	CAT 19.7
Gasmet Sampling System	CAT 10.4
Sick 3006	CAT 8.15
M&C PSS	CAT 12.84
Mass Flow Controller (1)	CAT 6.45
Mass Flow Controller (2)	CAT 6.85
Mass View (1)	CAT 25.58
Mass View (2)	-
Hioki 5043 (V)	CAT 12.121
SELECT Logger 2	-
Bioaerosols Temperature Logger	-
Electronic Refrigerator	-

Miscellaneous Items	
Equipment Type	**Equipment I.D.**
Digital Manometer (1)	CAT 3.112
Digital Manometer (2)	-
Digital Temperature Meter	CAT 3.112
Stopwatch	CAT 14.53
Barometer	CAT 13.59
Stack Thermocouple (1)	CAT 4.1075
Stack Thermocouple (2)	CAT 4.1571
Stack Thermocouple (3)	-
1m Heated Line (1)	-
1m Heated Line (2)	-
1m Heated Line (3)	-
5m Heated Line (1)	-
10m Heated Line (1)	CAT 20.107
20m Heated Line (1)	-
20m Heated Line (2)	-
Dual Channel Heater Controller	CAT 3.135
Single Channel Heater Controller	-
Laboratory Balance	
Tape Measure	CAT 16.102

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
Cadmium & Thallium	EN 14385	MD 006
Heavy Metals	EN 14385	MD 006
Mercury	EN 13211	MD 006
Dioxins & Furans	EN 1948	MD 007
PCBs	EN 1948	MD 007
Ammonia	ISO 21877	MD 014
Total VOCs (as Carbon)	EN 12619:2013	MD 020
Oxides of Nitrogen (as NO_2)	EN 14792	MD 039
Carbon Monoxide	EN 15058	MD 039
Carbon Dioxide	CEN/TS 17405	MD 039
Oxygen	EN 14789	MD 039
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	MD 041

PRELIMINARY STACK SURVEY: CALCULATIONS

General Stack Details

Stack Details (from Traverse)	Units	Value
Stack Diameter / Depth, D	m	2.60
Stack Width, W	m	-
Stack Area, A	m²	5.31
Average Stack Gas Temperature, T_a	°C	146.6
Average Stack Gas Pressure	Pa	366.6
Average Stack Static Pressure, P_{static}	kPa	-0.414
Average Barometric Pressure, P_b	kPa	101.7
Average Pitot Tube Calibration Coefficient, C_p	-	0.84

Stack Gas Composition & Molecular Weights

Component	Conc ppm	Conc Dry % v/v	Conc Wet % v/v	Volume Fraction r	Molar Mass M	Density kg/m³ p	Conc kg/m³ p_i
CO_2	-	18.88	16.90	0.1888	44.01	1.9635	0.37068
O_2	-	10.42	9.33	0.1042	32.00	1.4277	0.14876
N_2	-	70.70	63.31	0.7070	28.01	1.2498	0.88367
Moisture (H_2O)	-	-	10.46	0.1046	18.02	0.8037	0.08404

Where: $p = M / 22.41$

$p_i = r \times p$

Calculation of Stack Gas Densities

Determinand	Units	Result
Dry Density (STP), P_{STD}	kg/m³	1.403
Wet Density (STP), P_{STW}	kg/m³	1.340
Dry Density (Actual), P_{Actual}	kg/m³	0.913
Average Wet Density (Actual), $P_{ActualW}$	kg/m³	0.872

Where: P_{STD} = sum of component concentrations, kg/m³ (not including water vapour)

P_{STW} = sum of all wet concentrations / 100 x density, kg/m³ (including water vapour)

$P_{Actual} = P_{STD} \times (T_{STP} / (P_{STP})) \times ((P_{static} + P_b) / T_a)$

$P_{ActualW}$ (at each sampling point) $= P_{STW} \times (T_s / P_s) \times (P_a / T_a)$

Calculation of Stack Gas Volumetric Flowrate, Q

Duct gas flow conditions	Units	Actual	REF [1]
Temperature	°C	146.6	0.0
Total Pressure	kPa	101.3	101.3
Moisture	%	10.46	0.00
Oxygen (Dry)	%	10.4	10.0

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m³/hr	462645
Gas Volumetric Flowrate (STP, Wet)	m³/hr	300957
Gas Volumetric Flowrate (STP, Dry)	m³/hr	269489
Gas Volumetric Flowrate REF [1]	m³/hr	259215

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID)

(1 of 1)

Parameter	Units	Value
Date of Survey	-	13/09/2023
Time of Survey	-	11:00 - 11:25
Atmospheric Pressure	kPa	101.7
Average Stack Static Pressure	Pa	-414
Result of Pitot Stagnation Test	-	Pass
Are Water Droplets Present?	-	No
Device Used	S-Type Pitot with KIMO MP 210 (500Pa)	

Parameter	Units	Value
Initial Pitot Leak Check	-	Pass
Final Pitot Leak Check	-	Pass
Orientation of Duct	-	Vertical
Pitot Tube, C_p	-	0.84
Number of Lines Available	-	2
Number of Lines Used	-	2

		Sampling Line A					Sampling Line B				
Traverse Point	**Depth m**	**ΔP Pa**	**Temp °C**	**Wet Density kg/m³**	**Velocity m/s**	**Swirl °**	**ΔP Pa**	**Temp °C**	**Wet Density kg/m³**	**Velocity m/s**	**Swirl °**
STATIC (Units: Pa)		*-418.0*					*-410.0*				
Mean		**356.6**	**146.6**	**0.872**	**23.86**		**376.5**	**146.6**	**0.872**	**24.55**	
1	0.07	302.0	146.5	0.872	22.01	6.0	305.0	146.6	0.872	22.12	6.0
2	0.21	439.0	146.5	0.872	26.53	7.0	320.0	146.6	0.872	22.66	6.0
3	0.38	431.0	146.6	0.872	26.29	5.0	346.0	146.6	0.872	23.56	4.0
4	0.59	426.0	146.6	0.872	26.14	6.0	389.0	146.6	0.872	24.98	5.0
5	0.89	358.0	146.7	0.872	23.97	7.0	388.0	146.7	0.872	24.95	6.0
6	1.71	334.0	146.7	0.872	23.15	6.0	395.0	146.7	0.872	25.18	7.0
7	2.01	325.0	146.6	0.872	22.83	8.0	414.0	146.7	0.872	25.77	5.0
8	2.22	316.0	146.6	0.872	22.52	4.0	406.0	146.7	0.872	25.52	5.0
9	2.39	321.0	146.5	0.872	22.69	4.0	388.0	146.6	0.872	24.95	6.0
10	2.53	314.0	146.5	0.872	22.44	5.0	414.0	146.6	0.872	25.77	5.0

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID) - MEASUREMENT UNCERTAINTY

(1 of 1)

Performance characteristics (Uncertainty Components)	Uncertainty	Value	Units
Standard Uncertainty on the coefficient of the Pitot Tube	u(k)	0.005	-
Standard Uncertainty associated with the mean local dynamic pressures	u(Δpi)	7.605	Pa
- Resolution	u(res)	0.00087	
- Calibration	u(cal)	13.990	
- Drift	u(drift)	0.083	
- Lack of Fit	u(fit)	42.758	
- Overall corrections to dynamic measurements	u(Cf)	56.832	
Standard uncertainty associated with the molar mass of the gas	u(M)	0.00010	-
- φO_2,w	-	9.330	
- φCO_2,w	-	16.904	
- Oxygen, dry	u(ϕO_2,d)	0.319	
- Carbon Dioxide, dry	u(ϕCO_2,d)	0.578	
- Water Vapour	u(ϕH_2O)	0.533	
- Oxygen, wet	u(ϕO_2,w)	0.291	
- Carbon Dioxide, wet	u(ϕCO_2,w)	0.527	
Standard uncertainty associated with the stack temperature	u(Tc)	2.141	K
Standard uncertainty associated with the absolute pressure in the duct	u(pc)	175.774	Pa
- Atmospheric Pressure	u(patm)	175.692	
- Static Pressure	u(pstat)	5.377	
Standard uncertainty associated with the density in the duct	u(ρ)	0.00470	-
Standard uncertainty associated with the local velocities	u(vi)	0.266	Pa
Standard uncertainty associated with the mean velocity	u(v)	0.099	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	Uc(v)	0.193	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	Uc,rel(v)	0.80	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	Uc(qV,w)	21264.7	m^3/hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00055	
- $u^2(qV,w)$	-	117707912	
- u(qV,w)	-	10849.3	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	Uc,rel(qV,w)	4.60	%

CADMIUM & THALLIUM: RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	mg/m³	0.0011	< 0.0011	< 0.0011		0.0011
Uncertainty	±mg/m³	0.0002	0.0002	0.0002		0.0002
Mass Emission	g/hr	0.29	< 0.28	< 0.29		0.29
Uncertainty	±g/hr	0.05	0.05	0.05		0.05

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	11.3	10.7	10.2		10.7
Uncertainty	±% v/v	0.58	0.56	0.54		0.56

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 0.001		< 0.001

General Sampling Information

Parameter	Value	
Standard	EN 14385	
Technical Procedure	MD 006	
Name of Analytical Laboratory	EET	
Analytical Laboratory's Procedure	CAT-AP-07	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	29/09/2023	
Probe Material	Titanium	
Filter Housing Material	Borosilicate Glass	
Impinger Material	Borosilicate Glass	
Absorption Solution	Nitric Peroxide	
Positioning of Filter	Out Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	2 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	20 / 20	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1 - A10, B1 - B10	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

CADMIUM & THALLIUM: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	Run 2	Run 3
Absolute pressure of stack gas, P_s				
Barometric pressure, P_b	mmHg	762.8	762.8	762.8
Stack static pressure, P_{static}	mmH_2O	-42.6	-42.6	-42.6
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	759.7	759.7	759.7
Volume of water vapour collected, V_{wstd}				
Total mass collected in impingers (liquid trap)	g	95.2	91.9	89.6
Total mass collected in impingers (silica trap)	g	6.2	4.6	3.3
Total mass of liquid collected, V_{lc}	g	101.4	96.5	92.9
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.1263	0.1202	0.1158
Volume of gas metered dry, V_{mstd}				
Volume of gas sample through gas meter, V_m	m^3	1.1100	1.1220	1.1400
Gas meter correction factor, Y_d	-	0.9980	0.9980	0.9980
Average dry gas meter temperature, T_m	°C	32.7	33.9	34.7
Average pressure drop across orifice, ΔH	mmH_2O	33.5	33.4	34.4
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	0.9963	1.0029	1.0165
Moisture content, B_{wo} & R_{wv}				
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.1125	0.1071	0.1022
B_{wo} as a percentage	% v/v	11.25	10.71	10.22
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	11.25	10.71	10.22
Volume of gas metered wet, V_{mstw}				
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	1.1226	1.1232	1.1322
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$				
IED & Incinerates Hazardous Material? (Yes = no positive O_2 correction)	-	No	No	No
% wet oxygen measured in gas stream, $ACT\%O_{2w}$	% v/v	9.12	9.02	9.41
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	10.22	10.11	10.55
% oxygen reference condition, $REF\%O_2$	% v/v	10.00	10.00	10.00
O_2 Reference Factor wet (O_{2REFw}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2w}$)	-	0.93	0.92	0.95
O_2 Reference Factor dry (O_{2REFd}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2d}$)	-	1.02	1.01	1.05
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	1.2128	1.2235	1.1931
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	0.9761	0.9927	0.9656
Molecular weight of dry gas stream, M_d				
CO_2	% v/v	21.00	21.00	21.00
O_2	% v/v	10.22	10.11	10.55
Total	% v/v	31.22	31.11	31.55
N_2	% v/v	68.78	68.89	68.45
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	31.77	31.76	31.78
Molecular weight of stack gas (wet), M_s				
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	30.22	30.29	30.37
Velocity of stack gas, V_s				
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97
Velocity pressure coefficient, C_p	-	0.88	0.88	0.88
Average of velocity heads, ΔP_{avg}	mmH_2O	35.71	35.63	36.25
Average square root of velocity heads, √ΔP	$\sqrt{mmH_2O}$	5.98	5.97	6.02
Average stack gas temperature, T_s	°C	151.8	153.9	150.2
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{(M_s)(P_s)})$	m/s	24.87	24.87	24.95
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})				
Area of stack, A_s	m^2	5.31	5.31	5.31
$Q_a = (60)(A_s)(V_s)$	m^3/min	7924.1	7924.8	7948.6
Conversion factor (K/mm.Hg), C_f	-	0.3592	0.3592	0.3592
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	5090.8	5066.2	5125.8
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	4517.9	4523.9	4601.8
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	5499.7	5518.8	5401.5
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	4426.1	4477.7	4371.4
Percent isokinetic, %I				
Nozzle diameter, D_n	mm	4.79	4.79	4.79
Nozzle area, A_n	mm^2	18.02	18.02	18.02
Total sampling time, q	min	60	60	60
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	108.3	108.9	108.5

CADMIUM & THALLIUM: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	18:05 - 19:05	08:15 - 09:15	17:07 - 18:07
Sampling Dates	-	13/09/2023	14/09/2023	14/09/2023
Sampling Device	-	ISO	ISO	ISO
Volume Sampled (REF)	m³	0.9761	0.9927	0.9656
Cadmium				
Mass on Filter / in Rinse	µg	< 0.50	< 0.50	< 0.50
Mass in Front Impingers	µg	< 0.07	< 0.07	< 0.06
Mass in Back Impinger	µg	< 0.02	< 0.02	< 0.02
Total Mass Collected	µg	< 0.60	< 0.59	< 0.58
Calculated Concentration	mg/m³	< 0.0006	< 0.0006	< 0.0006
Reported Concentration	mg/m³	< 0.0006	< 0.0006	< 0.0006
Mass Emission	g/hr	< 0.16	< 0.15	< 0.16
Thallium				
Mass on Filter / in Rinse	µg	0.40	< 0.40	< 0.40
Mass in Front Impingers	µg	< 0.07	< 0.07	< 0.06
Mass in Back Impinger	µg	< 0.02	< 0.02	< 0.02
Total Mass Collected	µg	0.50	< 0.49	< 0.48
Calculated Concentration	mg/m³	0.0005	< 0.0005	< 0.0005
Reported Concentration	mg/m³	0.0005	< 0.0005	< 0.0005
Mass Emission	g/hr	0.13	< 0.13	< 0.13
Cadmium & Thallium Combined				
Total Mass Collected	µg	1.10	< 1.08	< 1.07
Calculated Concentration	mg/m³	0.0011	< 0.0011	< 0.0011
Reported Concentration	mg/m³	0.0011	< 0.0011	< 0.0011

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	13/09/2023
Average Volume Sampled (REF)	m³	0.9781
Cadmium		
Mass on Filter / in Rinse	µg	< 0.50
Mass in Front Impingers	µg	< 0.04
Mass in Back Impinger	µg	< 0.02
Total Mass Collected	µg	< 0.56
Calculated Concentration	mg/m³	< 0.0006
Reported Concentration	mg/m³	< 0.0006
Thallium		
Mass on Filter / in Rinse	µg	< 0.40
Mass in Front Impingers	µg	< 0.04
Mass in Back Impinger	µg	< 0.02
Total Mass Collected	µg	< 0.46
Calculated Concentration	mg/m³	< 0.0005
Reported Concentration	mg/m³	< 0.0005
Cadmium & Thallium Combined		
Total Mass Collected	µg	< 1.02
Calculated Concentration	mg/m³	< 0.0010
Reported Concentration	mg/m³	< 0.0010

CADMIUM & THALLIUM: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	18.5	18.7	19.0
Pre-Sampling Leak Rate	l/min	0.11	0.14	0.14
Post-Sampling Leak Rate	l/min	N/A	N/A	N/A
Allowable Leak Rate	l/min	0.30	0.30	0.30
Leak Test Acceptable	-	Yes	Yes	Yes

Absorption Efficiency	Units	Run 1	Run 2	Run 3
Cadmium	%	100.0	100.0	100.0
Thallium	%	100.0	100.0	100.0
Allowable Absorption Efficiency	%	N/A	N/A	N/A
Absorption Efficiency Acceptable	-	Yes	Yes	Yes

Where the emissions are < 30% of the ELV, MID 14385 does not require the absorption efficiency requirement to be applied

Detection Limit	Units	Run 1	Run 2	Run 3
Cadmium	µg/m³	0.6	0.6	0.6
Thallium	µg/m³	0.5	0.5	0.5
Allowable Detection Limit	µg/m³	5	5	5
Detection Limit Acceptable	-	Yes	Yes	Yes

Water Droplets	Units	Run 1	Run 2	Run 3
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Measurement Uncertainty (MU)	%	5.2	5.2	5.2
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Less than 50% Faded	%	Yes	Yes	Yes

Isokinetic Criterion Compliance	Units	Run 1	Run 2	Run 3
Isokinetic Variation	%	108.3	108.9	108.5
Allowable Isokinetic Range	%	95 - 115	95 - 115	95 - 115
Isokineticity Acceptable	-	Yes	Yes	Yes

Filter Temperatures	Units	Run 1	Run 2	Run 3
Maximum Filter Temperature	°C	160	160	160

Impingers Exit Temperature	Units	Run 1	Run 2	Run 3
Maximum Temperature Recorded	°C	13	16	15
Maximum Allowable Temperature	°C	30	30	30
Exit Temperature Acceptable	-	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

CADMIUM & THALLIUM: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	15.0
Pre-Sampling Leak Rate	l/min	0.11
Post-Sampling Leak Rate	l/min	N/A
Allowable Leak Rate	l/min	0.30
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m³	0.005
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	2	3
There are no deviations associated with the sampling employed.	wx	wx	wx

CADMIUM & THALLIUM: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value					Standard uncertainty				
Measured Quantities	**Symbol**	**Run 1**	**Run 2**	**Run 3**		**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (Actual)	V_m	1.1100	1.1220	1.1400		uV_m	m^3	0.0222	0.0224	0.0228
Sampled Gas Temperature	T_m	305.7	306.9	307.7		uT_m	K	2.00	2.00	2.00
Sampled Gas Pressure	ρ_m	101.3	101.3	101.3		$u\rho_m$	kPa	0.50	0.50	0.50
Sampled Gas Humidity	H_m	0.00	0.00	0.00		uH_m	% v/v	1.00	1.00	1.00
Leak	L	0.60	0.75	0.74		uL	%	-	-	-
Laboratory Result	L_r	7.60	7.60	7.60		uL_r	%	-	-	-

	Uncertainty as a Percentage				
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**	**Requirement of Standard**
Sampled Volume (Actual)	%	2.00	2.00	2.00	≤2%
Sampled Gas Temperature	%	0.65	0.65	0.65	≤1%
Sampled Gas Pressure	%	0.49	0.49	0.49	≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00	≤1%
Leak	%	0.60	0.75	0.74	≤2%
Laboratory Result	%	7.60	7.60	7.60	No Requirement

	Uncertainty in Measurement Units						Sensitivity Coefficient		
Measured Quantities	**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**		**Run 1**	**Run 2**	**Run 3**
Sampled Volume (STP)	V_m	m^3	0.9963	1.0029	1.0165		0.001	0.001	0.001
Leak	L	mg/m^3	0.000	0.000	0.000		1.00	1.00	1.00
Laboratory Result	L_r	mg/m^3	0.000	0.000	0.000		1.00	1.00	1.00

	Uncertainty in Result			
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (STP)	mg/m^3	0.00003	0.00003	0.00003
Leak	mg/m^3	0.0000	0.0000	0.0000
Laboratory Result	mg/m^3	0.0001	0.0001	0.0001

	Oxygen Correction Part of MU Budget			
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**
O_2 Correction Factor	-	1.02	1.01	1.05
Stack Gas O_2 Content	% v/v	10.22	10.11	10.55
MU for O_2 Correction	-	0.05	0.05	0.05
Overall MU For O_2 Measurement	%	4.64	4.59	4.79

Parameter	**Units**	**Run 1**	**Run 2**	**Run 3**
Combined uncertainty	mg/m^3	0.0001	0.0001	0.0001
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.0002	0.0002	0.0002
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	0.0002	0.0002	0.0002
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.0002	0.0002	0.0002
Reported Uncertainty	mg/m^3	0.0002	0.0002	0.0002
Expanded uncertainty (95% confidence), without Oxygen Correction	%	15.7	15.8	15.8
Expanded uncertainty (95% confidence), with Oxygen Correction	%	16.4	16.4	16.5
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	16.4	16.4	16.5
Reported Uncertainty	%	16.4	16.4	16.5

HEAVY METALS: RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3	Mean
Concentration	mg/m³	0.02	0.01	0.01	0.01
Uncertainty	±mg/m³	0.003	0.001	0.002	0.002
Mass Emission	g/hr	4.1	1.5	3.1	2.9
Uncertainty	±g/hr	0.85	0.30	0.65	0.60

Parameter	Units	Run 1	Run 2	Run 3	Mean
Water Vapour	% v/v	11.3	10.7	10.2	10.7
Uncertainty	±% v/v	0.58	0.56	0.54	0.56

Blank Runs

Parameter	Units	Blank 1	Maximum
Concentration	mg/m³	< 0.01	< 0.01

General Sampling Information

Parameter	Value	
Standard	EN 14385	
Technical Procedure	MD 006	
Name of Analytical Laboratory	EET	
Analytical Laboratory's Procedure	CAT-AP-07	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	29/09/2023	
Probe Material	Titanium	
Filter Housing Material	Borosilicate Glass	
Impinger Material	Borosilicate Glass	
Absorption Solution	Nitric Peroxide	
Positioning of Filter	Out Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	2 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	20 / 20	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1 - A10, B1 - B10	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

HEAVY METALS: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	Run 2	Run 3	
Absolute pressure of stack gas, P_s					
Barometric pressure, P_b	mmHg	762.8	762.8	762.8	
Stack static pressure, P_{static}	mmH_2O	-42.6	-42.6	-42.6	
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	759.7	759.7	759.7	
Volume of water vapour collected, V_{wstd}					
Total mass collected in impingers (liquid trap)	g	95.2	91.9	89.6	
Total mass collected in impingers (silica trap)	g	6.2	4.6	3.3	
Total mass of liquid collected, V_{lc}	g	101.4	96.5	92.9	
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.1263	0.1202	0.1158	
Volume of gas metered dry, V_{mstd}					
Volume of gas sample through gas meter, V_m	m^3	1.1100	1.1220	1.1400	
Gas meter correction factor, Y_d	-	0.9980	0.9980	0.9980	
Average dry gas meter temperature, T_m	°C	32.7	33.9	34.7	
Average pressure drop across orifice, ΔH	mmH_2O	33.5	33.4	34.4	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	0.9963	1.0029	1.0165	
Moisture content, B_{wo} & R_{wv}					
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.1125	0.1071	0.1022	
B_{wo} as a percentage	% v/v	11.25	10.71	10.22	
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	11.25	10.71	10.22	
Volume of gas metered wet, V_{mstw}					
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	1.1226	1.1232	1.1322	
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$					
IED & Incinerates Hazardous Material? (Yes = no positive O_2 correction)	-	No	No	No	
% wet oxygen measured in gas stream, $ACT\%O_{2w}$	% v/v	9.12	9.02	9.41	
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	10.22	10.11	10.55	
% oxygen reference condition, $REF\%O_2$	% v/v	10.00	10.00	10.00	
O_2 Reference Factor wet (O_{2REFw}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2w}$)	-	0.93	0.92	0.95	
O_2 Reference Factor dry (O_{2REFd}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2d}$)	-	1.02	1.01	1.05	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	1.2128	1.2235	1.1931	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	0.9761	0.9927	0.9656	
Molecular weight of dry gas stream, M_d					
CO_2	% v/v	21.00	21.00	21.00	
O_2	% v/v	10.22	10.11	10.55	
Total	% v/v	31.22	31.11	31.55	
N_2	% v/v	68.78	68.89	68.45	
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	31.77	31.76	31.78	
Molecular weight of stack gas (wet), M_s					
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	30.22	30.29	30.37	
Velocity of stack gas, V_s					
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97	
Velocity pressure coefficient, C_p	-	0.88	0.88	0.88	
Average of velocity heads, ΔP_{avg}	mmH_2O	35.71	35.63	36.25	
Average square root of velocity heads, √ΔP	$\sqrt{mmH_2O}$	5.98	5.97	6.02	
Average stack gas temperature, T_s	°C	151.8	153.9	150.2	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{(M_s)(P_s)})$	m/s	24.87	24.87	24.95	
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})					
Area of stack, A_s	m^2	5.31	5.31	5.31	
$Q_a = (60)(A_s)(V_s)$	m^3/min	7924.1	7924.8	7948.6	
Conversion factor (K/mm.Hg), C_f	-	0.3592	0.3592	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	5090.8	5066.2	5125.8	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	4517.9	4523.9	4601.8	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	5499.7	5518.8	5401.5	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	4426.1	4477.7	4371.4	
Percent isokinetic, %I					
Nozzle diameter, D_n	mm	4.79	4.79	4.79	
Nozzle area, A_n	mm^2	18.02	18.02	18.02	
Total sampling time, q	min	60	60	60	
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	108.3	108.9	108.5	

HEAVY METALS: SAMPLING DETAILS

(PAGE 1 OF 5)

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	18:05 - 19:05	08:15 - 09:15	17:07 - 18:07
Sampling Dates	-	13/09/2023	14/09/2023	14/09/2023
Sampling Device	-	ISO	ISO	ISO
Volume Sampled (REF)	m³	0.9761	0.9927	0.9656
Arsenic				
Mass on Filter / in Rinse	µg	< 0.50	< 0.50	< 0.50
Mass in Front Impingers	µg	< 0.11	< 0.10	< 0.09
Mass in Back Impinger	µg	< 0.04	< 0.04	< 0.03
Total Mass Collected	µg	< 0.65	< 0.64	< 0.62
Calculated Concentration	mg/m³	< 0.0007	< 0.0006	< 0.0006
Reported Concentration	mg/m³	< 0.0007	< 0.0006	< 0.0006
Mass Emission	g/hr	< 0.17	< 0.17	< 0.17
Cobalt				
Mass on Filter / in Rinse	µg	< 0.50	< 0.50	< 0.50
Mass in Front Impingers	µg	< 0.07	< 0.07	< 0.06
Mass in Back Impinger	µg	< 0.02	< 0.02	< 0.02
Total Mass Collected	µg	< 0.60	< 0.59	< 0.58
Calculated Concentration	mg/m³	< 0.0006	< 0.0006	< 0.0006
Reported Concentration	mg/m³	< 0.0006	< 0.0006	< 0.0006
Mass Emission	g/hr	< 0.16	< 0.15	< 0.16
Chromium				
Mass on Filter / in Rinse	µg	< 0.60	< 0.60	< 0.60
Mass in Front Impingers	µg	0.63	< 0.03	0.34
Mass in Back Impinger	µg	0.77	< 0.01	0.41
Total Mass Collected	µg	1.99	< 0.65	1.35
Calculated Concentration	mg/m³	0.0020	< 0.0007	0.0014
Reported Concentration	mg/m³	0.0020	< 0.0007	0.0014
Mass Emission	g/hr	0.53	< 0.17	0.36
Copper				
Mass on Filter / in Rinse	µg	4.89	< 0.60	4.04
Mass in Front Impingers	µg	1.22	< 0.13	0.31
Mass in Back Impinger	µg	0.21	< 0.05	0.08
Total Mass Collected	µg	6.31	< 0.78	4.43
Calculated Concentration	mg/m³	0.0065	< 0.0008	0.0046
Reported Concentration	mg/m³	0.0065	< 0.0008	0.0046
Mass Emission	g/hr	1.68	< 0.20	1.19
Manganese				
Mass on Filter / in Rinse	µg	< 0.40	< 0.40	< 0.40
Mass in Front Impingers	µg	0.47	< 0.07	0.23
Mass in Back Impinger	µg	0.07	< 0.02	< 0.02
Total Mass Collected	µg	0.93	< 0.49	0.65
Calculated Concentration	mg/m³	0.0010	< 0.0005	0.0007
Reported Concentration	mg/m³	0.0010	< 0.0005	0.0007
Mass Emission	g/hr	0.25	< 0.13	0.17

HEAVY METALS: SAMPLING DETAILS

(PAGE 2 OF 5)

Sample Runs (continued)

Parameter	Units	Run 1	Run 2	Run 3
Nickel				
Mass on Filter / in Rinse	µg	2.59	< 0.60	2.05
Mass in Front Impingers	µg	0.42	< 0.07	0.25
Mass in Back Impinger	µg	0.04	< 0.02	< 0.02
Total Mass Collected	µg	3.05	< 0.69	2.31
Calculated Concentration	mg/m³	0.0031	< 0.0007	0.0024
Reported Concentration	mg/m³	0.0031	< 0.0007	0.0024
Mass Emission	g/hr	0.81	< 0.18	0.62
Lead				
Mass on Filter / in Rinse	µg	< 0.50	< 0.50	< 0.50
Mass in Front Impingers	µg	0.27	< 0.07	0.10
Mass in Back Impinger	µg	0.05	< 0.02	< 0.02
Total Mass Collected	µg	0.81	< 0.59	0.63
Calculated Concentration	mg/m³	0.0008	< 0.0006	0.0006
Reported Concentration	mg/m³	0.0008	< 0.0006	0.0006
Mass Emission	g/hr	0.22	< 0.15	0.17
Antimony				
Mass on Filter / in Rinse	µg	< 0.60	< 0.60	< 0.60
Mass in Front Impingers	µg	< 0.07	< 0.07	< 0.06
Mass in Back Impinger	µg	< 0.02	< 0.02	< 0.02
Total Mass Collected	µg	< 0.70	< 0.69	< 0.68
Calculated Concentration	mg/m³	< 0.0007	< 0.0007	< 0.0007
Reported Concentration	mg/m³	< 0.0007	< 0.0007	< 0.0007
Mass Emission	g/hr	< 0.19	< 0.18	< 0.18
Vanadium				
Mass on Filter / in Rinse	µg	< 0.40	< 0.40	< 0.40
Mass in Front Impingers	µg	0.06	< 0.03	0.04
Mass in Back Impinger	µg	< 0.01	< 0.01	< 0.01
Total Mass Collected	µg	0.47	< 0.45	0.45
Calculated Concentration	mg/m³	0.0005	< 0.0004	0.0005
Reported Concentration	mg/m³	0.0005	< 0.0004	0.0005
Mass Emission	g/hr	0.12	< 0.12	0.12

HEAVY METALS: SAMPLING DETAILS

Sample Runs (continued)

Parameter	Units	Run 1	Run 2	Run 3	
Heavy Metals Combined					
Total Mass Collected	µg	15.52	5.56	11.71	
Calculated Concentration	mg/m³	0.0159	0.0056	0.0121	
Reported Concentration	mg/m³	0.0159	0.0056	0.0121	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	13/09/2023	
Average Volume Sampled (REF)	m³	0.9781	
Arsenic			
Mass on Filter / in Rinse	µg	< 0.50	
Mass in Front Impingers	µg	< 0.06	
Mass in Back Impinger	µg	< 0.03	
Total Mass Collected	µg	< 0.59	
Calculated Concentration	mg/m³	< 0.0006	
Reported Concentration	mg/m³	< 0.0006	
Cobalt			
Mass on Filter / in Rinse	µg	< 0.50	
Mass in Front Impingers	µg	< 0.04	
Mass in Back Impinger	µg	< 0.02	
Total Mass Collected	µg	< 0.56	
Calculated Concentration	mg/m³	< 0.0006	
Reported Concentration	mg/m³	< 0.0006	

HEAVY METALS: SAMPLING DETAILS

Blank Runs (continued)

Parameter	Units	Blank 1
Chromium		
Mass on Filter / in Rinse	µg	< 0.60
Mass in Front Impingers	µg	< 0.02
Mass in Back Impinger	µg	< 0.01
Total Mass Collected	µg	< 0.63
Calculated Concentration	mg/m³	< 0.0006
Reported Concentration	mg/m³	< 0.0006
Copper		
Mass on Filter / in Rinse	µg	< 0.60
Mass in Front Impingers	µg	< 0.08
Mass in Back Impinger	µg	< 0.04
Total Mass Collected	µg	< 0.72
Calculated Concentration	mg/m³	< 0.0007
Reported Concentration	mg/m³	< 0.0007
Manganese		
Mass on Filter / in Rinse	µg	< 0.40
Mass in Front Impingers	µg	< 0.04
Mass in Back Impinger	µg	< 0.02
Total Mass Collected	µg	< 0.46
Calculated Concentration	mg/m³	< 0.0005
Reported Concentration	mg/m³	< 0.0005
Nickel		
Mass on Filter / in Rinse	µg	< 0.60
Mass in Front Impingers	µg	< 0.04
Mass in Back Impinger	µg	< 0.02
Total Mass Collected	µg	< 0.66
Calculated Concentration	mg/m³	< 0.0007
Reported Concentration	mg/m³	< 0.0007
Lead		
Mass on Filter / in Rinse	µg	< 0.50
Mass in Front Impingers	µg	< 0.04
Mass in Back Impinger	µg	< 0.02
Total Mass Collected	µg	< 0.56
Calculated Concentration	mg/m³	< 0.0006
Reported Concentration	mg/m³	< 0.0006
Antimony		
Mass on Filter / in Rinse	µg	< 0.60
Mass in Front Impingers	µg	< 0.04
Mass in Back Impinger	µg	< 0.02
Total Mass Collected	µg	< 0.66
Calculated Concentration	mg/m³	< 0.0007
Reported Concentration	mg/m³	< 0.0007
Vanadium		
Mass on Filter / in Rinse	µg	< 0.40
Mass in Front Impingers	µg	< 0.02
Mass in Back Impinger	µg	< 0.01
Total Mass Collected	µg	< 0.43
Calculated Concentration	mg/m³	< 0.0004
Reported Concentration	mg/m³	< 0.0004

HEAVY METALS: SAMPLING DETAILS

(PAGE 5 OF 5)

Blank Runs (continued)

Parameter	Units	Blank 1	
Heavy Metals Combined			
Total Mass Collected	µg	5.29	
Calculated Concentration	mg/m^3	< 0.0054	
Reported Concentration	mg/m^3	< 0.0054	

HEAVY METALS: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	18.5	18.7	19.0
Pre-Sampling Leak Rate	l/min	0.11	0.14	0.14
Post-Sampling Leak Rate	l/min	N/A	N/A	N/A
Allowable Leak Rate	l/min	0.30	0.30	0.30
Leak Test Acceptable	-	Yes	Yes	Yes

Absorption Efficiency	Units	Run 1	Run 2	Run 3
Arsenic	%	100.0	100.0	100.0
Cobalt	%	100.0	100.0	100.0
Chromium	%	61.6	100.0	69.8
Copper	%	96.7	100.0	98.2
Manganese	%	92.9	100.0	100.0
Nickel	%	98.6	100.0	100.0
Lead	%	94.4	100.0	100.0
Antimony	%	100.0	100.0	100.0
Vanadium	%	100.0	100.0	100.0
Allowable Absorption Efficiency	%	N/A	N/A	N/A
Absorption Efficiency Acceptable	-	Yes	Yes	Yes

Where the emissions are < 30% of the ELV, MID 14385 does not require the absorption efficiency requirement to be applied

Detection Limit	Units	Run 1	Run 2	Run 3
Arsenic	µg/m³	0.7	0.6	0.6
Cobalt	µg/m³	0.6	0.6	0.6
Chromium	µg/m³	0.7	0.7	0.7
Copper	µg/m³	0.8	0.8	0.8
Manganese	µg/m³	0.5	0.5	0.5
Nickel	µg/m³	0.7	0.7	0.7
Lead	µg/m³	0.6	0.6	0.6
Antimony	µg/m³	0.7	0.7	0.7
Vanadium	µg/m³	0.5	0.4	0.5
Allowable Detection Limit	µg/m³	5	5	5
Detection Limit Acceptable	-	Yes	Yes	Yes

Water Droplets	Units	Run 1	Run 2	Run 3
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Measurement Uncertainty (MU)	%	5.2	5.2	5.2
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

HEAVY METALS: QUALITY ASSURANCE

(PAGE 2 OF 2)

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Less than 50% Faded	%	Yes	Yes	Yes

Isokinetic Criterion Compliance	Units	Run 1	Run 2	Run 3
Isokinetic Variation	%	108.3	108.9	108.5
Allowable Isokinetic Range	%	95 - 115	95 - 115	95 - 115
Isokineticity Acceptable	-	Yes	Yes	Yes

Filter Temperatures	Units	Run 1	Run 2	Run 3
Maximum Filter Temperature	°C	160	160	160

Impingers Exit Temperature	Units	Run 1	Run 2	Run 3
Maximum Temperature Recorded	°C	13	16	15
Maximum Allowable Temperature	°C	30	30	30
Exit Temperature Acceptable	-	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	15.0
Pre-Sampling Leak Rate	l/min	0.11
Post-Sampling Leak Rate	l/min	N/A
Allowable Leak Rate	l/min	0.30
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m^3	0.05
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation	Run Number		
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1	2	3
There are no deviations associated with the sampling employed.	wx	wx	wx

HEAVY METALS: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value: Symbol	Run 1	Run 2	Run 3	Standard uncertainty: Symbol	Units	Run 1	Run 2	Run 3
Sampled Volume (Actual)	V_m	1.1100	1.1220	1.1400	uV_m	m³	0.0222	0.0224	0.0228
Sampled Gas Temperature	T_m	305.7	306.9	307.7	uT_m	K	2.00	2.00	2.00
Sampled Gas Pressure	ρ_m	101.3	101.3	101.3	$u\rho_m$	kPa	0.50	0.50	0.50
Sampled Gas Humidity	H_m	0.00	0.00	0.00	uH_m	% v/v	1.00	1.00	1.00
Leak	L	0.60	0.75	0.74	uL	%	-	-	-
Laboratory Result	L_r	9.60	9.60	9.60	uL_r	%	-	-	-

Measured Quantities	Uncertainty as a Percentage: Units	Run 1	Run 2	Run 3	Requirement of Standard
Sampled Volume (Actual)	%	2.00	2.00	2.00	≤2%
Sampled Gas Temperature	%	0.65	0.65	0.65	≤1%
Sampled Gas Pressure	%	0.49	0.49	0.49	≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00	≤1%
Leak	%	0.60	0.75	0.74	≤2%
Laboratory Result	%	9.60	9.60	9.60	No Requirement

Measured Quantities	Uncertainty in Measurement Units: Symbol	Units	Run 1	Run 2	Run 3	Sensitivity Coefficient: Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	m³	0.9963	1.0029	1.0165	0.02	0.01	0.01
Leak	L	mg/m³	0.000	0.000	0.000	1.00	1.00	1.00
Laboratory Result	L_r	mg/m³	0.002	0.001	0.001	1.00	1.00	1.00

Measured Quantities	Uncertainty in Result: Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	mg/m³	0.0004	0.0001	0.0003
Leak	mg/m³	0.0001	0.0000	0.0001
Laboratory Result	mg/m³	0.0015	0.0005	0.0012

Measured Quantities	Oxygen Correction Part of MU Budget: Units	Run 1	Run 2	Run 3
O_2 Correction Factor	-	1.02	1.01	1.05
Stack Gas O_2 Content	% v/v	10.22	10.11	10.55
MU for O_2 Correction	-	0.05	0.05	0.05
Overall MU For O_2 Measurement	%	4.64	4.59	4.79

Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	mg/m³	0.002	0.001	0.001
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m³	0.003	0.001	0.002
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m³	0.003	0.001	0.002
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m³	0.003	0.001	0.002
Reported Uncertainty	mg/m³	0.003	0.001	0.002
Expanded uncertainty (95% confidence), without Oxygen Correction	%	19.5	19.5	19.5
Expanded uncertainty (95% confidence), with Oxygen Correction	%	20.0	20.0	20.1
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	20.0	20.0	20.1
Reported Uncertainty	%	20.0	20.0	20.1

MERCURY: RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	mg/m^3	0.0056	0.0067	0.0106		0.0077
Uncertainty	$\pm mg/m^3$	0.0013	0.0016	0.0025		0.0018
Mass Emission	g/hr	1.5	1.7	2.8		2.0
Uncertainty	±g/hr	0.35	0.42	0.66		0.48

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	11.8	11.0	10.1		11.0
Uncertainty	±% v/v	0.62	0.57	0.53		0.57

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m^3	< 0.0002		< 0.0002

General Sampling Information

Parameter	Value	
Standard	EN 13211	
Technical Procedure	MD 006	
Name of Analytical Laboratory	EET	
Analytical Laboratory's Procedure	CAT-AP-08	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	28/09/2023	
Probe Material	Titanium	
Filter Housing Material	Titanium	
Impinger Material	Borosilicate Glass	
Absorption Solution	Potassium Dichromate	
Positioning of Filter	Out Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	2 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	20 / 20	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1 - A10, B1 - B10	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

MERCURY: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	Run 2	Run 3
Absolute pressure of stack gas, P_s				
Barometric pressure, P_b	mmHg	762.8	762.8	762.8
Stack static pressure, P_{static}	mmH_2O	-42.6	-42.6	-42.6
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	759.7	759.7	759.7
Volume of water vapour collected, V_{wstd}				
Total mass collected in impingers (liquid trap)	g	93.7	91.1	80.1
Total mass collected in impingers (silica trap)	g	5.3	4.7	5.7
Total mass of liquid collected, V_{lc}	g	99.0	95.8	85.8
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.1234	0.1194	0.1069
Volume of gas metered dry, V_{mstd}				
Volume of gas sample through gas meter, V_m	m^3	1.0330	1.0720	1.0600
Gas meter correction factor, Y_d	-	0.9940	0.9940	0.9940
Average dry gas meter temperature, T_m	°C	33.3	31.0	32.6
Average pressure drop across orifice, ΔH	mmH_2O	31.3	31.1	31.2
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	0.9214	0.9633	0.9476
Moisture content, B_{wo} & R_{wv}				
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.1181	0.1103	0.1014
B_{wo} as a percentage	% v/v	11.81	11.03	10.14
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	11.81	11.03	10.14
Volume of gas metered wet, V_{mstw}				
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	1.0447	1.0827	1.0545
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$				
IED & Incinerates Hazardous Material? (Yes = no positive O_2 correction)	-	No	No	No
% wet oxygen measured in gas stream, $ACT\%O_{2w}$	% v/v	9.12	9.02	9.41
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	10.22	10.11	10.55
% oxygen reference condition, $REF\%O_2$	% v/v	10.00	10.00	10.00
O_2 Reference Factor wet (O_{2REFw}) = $(21 - REF\%O_2) / (21 - ACT\%O_{2w})$	-	0.93	0.92	0.95
O_2 Reference Factor dry (O_{2REFd}) = $(21 - REF\%O_2) / (21 - ACT\%O_{2d})$	-	1.02	1.01	1.05
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	1.1286	1.1794	1.1112
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	0.9027	0.9535	0.9002
Molecular weight of dry gas stream, M_d				
CO_2	% v/v	21.00	21.00	21.00
O_2	% v/v	10.22	10.11	10.55
Total	% v/v	31.22	31.11	31.55
N_2	% v/v	68.78	68.89	68.45
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	31.77	31.76	31.78
Molecular weight of stack gas (wet), M_s				
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	30.14	30.25	30.38
Velocity of stack gas, V_s				
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97
Velocity pressure coefficient, C_p	-	0.88	0.88	0.88
Average of velocity heads, ΔP_{avg}	mmH_2O	36.00	36.00	36.00
Average square root of velocity heads, $\sqrt{\Delta P}$	$\sqrt{mmH_2O}$	6.00	6.00	6.00
Average stack gas temperature, T_s	°C	151.8	151.9	151.8
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{(M_s)(P_s)})$	m/s	25.15	25.11	25.05
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})				
Area of stack, A_s	m^2	5.31	5.31	5.31
$Q_a = (60)(A_s)(V_s)$	m^3/min	8011.8	7999.5	7979.9
Conversion factor (K/mm.Hg), C_f	-	0.3592	0.3592	0.3592
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	5147.1	5137.4	5126.6
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	4539.4	4571.0	4606.9
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	5560.5	5596.3	5402.3
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	4447.2	4524.4	4376.2
Percent isokinetic, %I				
Nozzle diameter, D_n	mm	4.81	4.81	4.81
Nozzle area, A_n	mm^2	18.17	18.17	18.17
Total sampling time, q	min	60	60	60
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	98.8	102.6	100.2

MERCURY: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	18:05 - 19:05	08:15 - 09:15	17:07 - 18:07
Sampling Dates	-	13/09/2023	14/09/2023	14/09/2023
Sampling Device	-	ISO	ISO	ISO
Volume Sampled (REF)	m^3	0.9027	0.9535	0.9002
Mass on Filter / in Rinse	µg	< 0.03	< 0.03	< 0.03
Mass in Front Impingers	µg	4.01	5.26	8.45
Mass in Back Impinger	µg	1.01	1.13	1.11
Total Mass Collected	µg	5.05	6.42	9.58
Calculated Concentration	mg/m^3	0.0056	0.0067	0.0106
Reported Concentration	mg/m^3	0.0056	0.0067	0.0106

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	13/09/2023
Average Volume Sampled (REF)	m^3	0.9188
Mass on Filter / in Rinse	µg	< 0.03
Mass in Front Impingers	µg	< 0.09
Mass in Back Impinger	µg	< 0.04
Total Mass Collected	µg	< 0.17
Calculated Concentration	mg/m^3	< 0.0002
Reported Concentration	mg/m^3	< 0.0002

MERCURY: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	17.1	17.8	17.6
Pre-Sampling Leak Rate	l/min	0.12	0.11	0.12
Post-Sampling Leak Rate	l/min	N/A	N/A	N/A
Allowable Leak Rate	l/min	0.30	0.30	0.30
Leak Test Acceptable	-	Yes	Yes	Yes

Absorption Efficiency	Units	Run 1	Run 2	Run 3
Absorption Efficiency	%	79.8	82.3	88.4
Allowable Absorption Efficiency	%	95	95	95
Final Impinger Concentration	µg/m³	1.12	1.19	1.23
Absorption Efficiency Acceptable	-	Yes	Yes	Yes

EN 13211 requirement is to have <5% of the total mercury in all absorbers or <2µg/m³ in the final impinger

Water Droplets	Units	Run 1	Run 2	Run 3
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Measurement Uncertainty (MU)	%	5.2	5.2	5.2
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Less than 50% Faded	%	Yes	Yes	Yes

Isokinetic Criterion Compliance	Units	Run 1	Run 2	Run 3
Isokinetic Variation	%	98.8	102.6	100.2
Allowable Isokinetic Range	%	95 - 115	95 - 115	95 - 115
Isokineticity Acceptable	-	Yes	Yes	Yes

Filter Temperatures	Units	Run 1	Run 2	Run 3
Maximum Filter Temperature	°C	180	180	180

Impingers Exit Temperature	Units	Run 1	Run 2	Run 3
Maximum Temperature Recorded	°C	13	13	14
Maximum Allowable Temperature	°C	30	30	30
Exit Temperature Acceptable	-	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

MERCURY: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	15.0
Pre-Sampling Leak Rate	l/min	0.13
Post-Sampling Leak Rate	l/min	N/A
Allowable Leak Rate	l/min	0.30
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m^3	0.005
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	2	3
There are no deviations associated with the sampling employed.	wx	wx	wx

MERCURY: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Symbol	Value Run 1	Value Run 2	Value Run 3	Symbol	Units	Standard uncertainty Run 1	Standard uncertainty Run 2	Standard uncertainty Run 3
Sampled Volume (Actual)	V_m	1.0330	1.0720	1.0600	uV_m	m^3	0.0207	0.0214	0.0212
Sampled Gas Temperature	T_m	306.3	304.0	305.6	uT_m	K	2.00	2.00	2.00
Sampled Gas Pressure	ρ_m	101.3	101.3	101.3	$u\rho_m$	kPa	0.50	0.50	0.50
Sampled Gas Humidity	H_m	0.00	0.00	0.00	uH_m	% v/v	1.00	1.00	1.00
Leak	L	0.70	0.62	0.68	uL	%	-	-	-
Laboratory Result	L_r	11.50	11.50	11.50	uL_r	%	-	-	-

Measured Quantities	Units	Uncertainty as a Percentage Run 1	Run 2	Run 3	Requirement of Standard
Sampled Volume (Actual)	%	2.00	2.00	2.00	≤2%
Sampled Gas Temperature	%	0.65	0.66	0.65	≤1%
Sampled Gas Pressure	%	0.49	0.49	0.49	≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00	≤1%
Leak	%	0.70	0.62	0.68	≤2%
Laboratory Result	%	11.50	11.50	11.50	No Requirement

Measured Quantities	Symbol	Units	Uncertainty in Measurement Units Run 1	Run 2	Run 3	Sensitivity Coefficient Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	m^3	0.9214	0.9633	0.9476	0.01	0.01	0.01
Leak	L	mg/m^3	0.0000	0.0000	0.0000	1.00	1.00	1.00
Laboratory Result	L_r	mg/m^3	0.0006	0.0008	0.0012	1.00	1.00	1.00

Measured Quantities	Units	Uncertainty in Result Run 1	Run 2	Run 3
Sampled Volume (STP)	mg/m^3	0.0001	0.0002	0.0003
Leak	mg/m^3	0.0000	0.0000	0.0000
Laboratory Result	mg/m^3	0.0006	0.0008	0.0012

Measured Quantities	Units	Oxygen Correction Part of MU Budget Run 1	Run 2	Run 3
O_2 Correction Factor	-	1.02	1.01	1.05
Stack Gas O_2 Content	% v/v	10.22	10.11	10.55
MU for O_2 Correction	%	0.05	0.05	0.05
Overall MU For O_2 Measurement	%	4.64	4.59	4.79

Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	mg/m^3	0.0007	0.0008	0.0013
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.0013	0.0016	0.0025
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	0.0013	0.0016	0.0025
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.0013	0.0016	0.0025
Reported Uncertainty	mg/m^3	0.0013	0.0016	0.0025
Expanded uncertainty (95% confidence), without Oxygen Correction	%	23.1	23.1	23.1
Expanded uncertainty (95% confidence), with Oxygen Correction	%	23.6	23.6	23.6
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	23.6	23.6	23.6
Reported Uncertainty	%	23.6	23.6	23.6

DIOXINS & FURANS: RESULTS SUMMARY

(PAGE 1 OF 4)

Irish Cement Ltd, Limerick
A2-01 Kiln 6

TEQ1 - UPPER LIMITS (worst case where <LOD = LOD)

Sample Runs (UPPER NATO I-TEQ)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.002	0.007	0.003		0.004
Uncertainty	±ng/m³	0.000	0.001	0.001		0.001
Mass Emission	µg/hr	0.53	1.7	0.74		0.99
Uncertainty	±µg/hr	0.11	0.36	0.16		0.21

Sample Runs (UPPER WHO TEQ Humans / Mammals)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.002	0.008	0.003		0.005
Uncertainty	±ng/m³	0.000	0.002	0.001		0.001
Mass Emission	µg/hr	0.61	2.2	0.83		1.2
Uncertainty	±µg/hr	0.13	0.46	0.18		0.26

Sample Runs (UPPER WHO TEQ Fish)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.003	0.009	0.003		0.005
Uncertainty	±ng/m³	0.001	0.002	0.001		0.001
Mass Emission	µg/hr	0.66	2.24	0.88		1.26
Uncertainty	±µg/hr	0.14	0.48	0.19		0.27

Sample Runs (UPPER WHO TEQ Birds)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.004	0.010	0.005		0.006
Uncertainty	±ng/m³	0.001	0.002	0.001		0.001
Mass Emission	µg/hr	0.93	2.7	1.4		1.7
Uncertainty	±µg/hr	0.20	0.58	0.30		0.36

DIOXINS & FURANS: RESULTS SUMMARY

(PAGE 2 OF 4)

Irish Cement Ltd, Limerick
A2-01 Kiln 6

TEQ2 - LOWER LIMITS (best case where <LOD = 0)

Sample Runs (LOWER NATO I-TEQ)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.000	0.006	0.001		0.002
Uncertainty	±ng/m³	0.000	0.001	0.000		0.000
Mass Emission	µg/hr	0.07	1.5	0.18		0.58
Uncertainty	±µg/hr	0.02	0.32	0.04		0.12

Sample Runs (LOWER WHO TEQ Humans / Mammals)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.000	0.007	0.001		0.003
Uncertainty	±ng/m³	0.000	0.002	0.000		0.001
Mass Emission	µg/hr	0.07	1.9	0.18		0.73
Uncertainty	±µg/hr	0.01	0.41	0.04		0.16

Sample Runs (LOWER WHO TEQ Fish)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.000	0.008	0.000		0.003
Uncertainty	±ng/m³	0.000	0.002	0.000		0.001
Mass Emission	µg/hr	0.06	2.0	0.07		0.72
Uncertainty	±µg/hr	0.01	0.43	0.02		0.15

Sample Runs (LOWER WHO TEQ Birds)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.000	0.010	0.002		0.004
Uncertainty	±ng/m³	0.000	0.002	0.000		0.001
Mass Emission	µg/hr	0.06	2.5	0.53		1.0
Uncertainty	±µg/hr	0.01	0.53	0.11		0.22

DIOXINS & FURANS: RESULTS SUMMARY

(PAGE 3 OF 4)

Irish Cement Ltd, Limerick
A2-01 Kiln 6

TEQ1 - UPPER LIMITS (worst case where <LOD = LOD)

Blank Runs (UPPER NATO I-TEQ)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m³	0.0007	0.0007

Blank Runs (UPPER WHO TEQ Humans / Mammals)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m³	0.0010	0.0010

Blank Runs (UPPER WHO TEQ Fish)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m³	0.0010	0.0010

Blank Runs (UPPER WHO TEQ Birds)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m³	0.0014	0.0014

TEQ2 - LOWER LIMITS (best case where <LOD = 0)

Blank Runs (LOWER NATO I-TEQ)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m³	0.00001	0.00001

Blank Runs (LOWER WHO TEQ Humans / Mammals)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m³	0.00001	0.00001

Blank Runs (LOWER WHO TEQ Fish)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m³	0.00001	0.00001

Blank Runs (LOWER WHO TEQ Birds)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m³	0.00001	0.00001

DIOXINS & FURANS: RESULTS SUMMARY

(PAGE 4 OF 4)

Irish Cement Ltd, Limerick

A2-01 Kiln 6

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	12.1	9.0	13.6		11.6
Uncertainty	±% v/v	0.64	0.47	0.73		0.61

General Sampling Information

Parameter	Value	
Standard	EN 1948	
Technical Procedure	MD 007	
Name of Analytical Laboratory	EET	
Analytical Laboratory's Procedure	PM137, TM201	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	10/10/2023	
Probe Material	Titanium	
Filter Housing Material	Borosilicate Glass	
Glassware Material	Borosilicate Glass	
Absorption Material	XAD-2	
Positioning of Filter	Out Stack	
Filter Size and Material	90mm Quartz Fibre	
Number of Sampling Lines Used	2 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	20 / 20	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1 - A10, B1 - B10	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

DIOXINS & FURANS: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	Run 2	Run 3	
Absolute pressure of stack gas, P_s					
Barometric pressure, P_b	mmHg	762.8	762.8	762.8	
Stack static pressure, P_{static}	mmH_2O	-42.6	-42.6	-42.6	
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	759.7	759.7	759.7	
Volume of water vapour collected, V_{wstd}					
Total mass collected in impingers (liquid trap)	g	606.8	459.7	714.1	
Total mass collected in impingers (silica trap)	g	27.7	8.9	38.3	
Total mass of liquid collected, V_{lc}	g	634.5	468.6	752.4	
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.7906	0.5839	0.9375	
Volume of gas metered dry, V_{mstd}					
Volume of gas sample through gas meter, V_m	m^3	6.4790	6.5990	6.6680	
Gas meter correction factor, Y_d	-	0.9940	0.9940	0.9940	
Average dry gas meter temperature, T_m	°C	34.5	33.2	33.7	
Average pressure drop across orifice, ΔH	mmH_2O	32.5	31.9	31.3	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	5.7568	5.8882	5.9397	
Moisture content, B_{wo} & R_{wv}					
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.1207	0.0902	0.1363	
B_{wo} as a percentage	% v/v	12.07	9.02	13.63	
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	12.07	9.02	13.63	
Volume of gas metered wet, V_{mstw}					
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	6.5474	6.4721	6.8772	
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$					
IED & Incinerates Hazardous Material? (Yes = no positive O_2 correction)	-	No	No	No	
% wet oxygen measured in gas stream, $ACT\%O_{2w}$	% v/v	9.32	9.38	9.65	
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	10.46	10.51	10.82	
% oxygen reference condition, $REF\%O_2$	% v/v	10.00	10.00	10.00	
O_2 Reference Factor wet (O_{2REFw}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2w}$)	-	0.94	0.95	0.97	
O_2 Reference Factor dry (O_{2REFd}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2d}$)	-	1.04	1.05	1.08	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	6.9496	6.8396	7.0952	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	5.5180	5.6133	5.4953	
Molecular weight of dry gas stream, M_d					
CO_2	% v/v	21.00	21.00	21.00	
O_2	% v/v	10.46	10.51	10.82	
Total	% v/v	31.46	31.51	31.82	
N_2	% v/v	68.54	68.49	68.18	
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	31.78	31.78	31.79	
Molecular weight of stack gas (wet), M_s					
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	30.11	30.54	29.91	
Velocity of stack gas, V_s					
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97	
Velocity pressure coefficient, C_p	-	0.88	0.88	0.88	
Average of velocity heads, ΔP_{avg}	mmH_2O	36.88	36.34	35.83	
Average square root of velocity heads, $\sqrt{\Delta P}$	$\sqrt{mmH_2O}$	6.07	6.03	5.99	
Average stack gas temperature, T_s	°C	148.1	148.1	149.8	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{(M_s)(P_s)})$	m/s	25.35	24.99	25.13	
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})					
Area of stack, A_s	m^2	5.31	5.31	5.31	
$Q_a = (60)(A_s)(V_s)$	m^3/min	8077.7	7962.2	8005.3	
Conversion factor (K/mm.Hg), C_f	-	0.3592	0.3592	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	5234.2	5160.2	5167.0	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	4602.1	4694.7	4462.6	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	5555.7	5453.3	5330.7	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	4411.3	4475.5	4128.7	
Percent isokinetic, %I					
Nozzle diameter, D_n	mm	4.81	4.81	4.81	
Nozzle area, A_n	mm^2	18.17	18.17	18.17	
Total sampling time, q	min	360	360	360	
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	101.5	101.8	108.0	

DIOXINS & FURANS: SAMPLING DETAILS

RUN 1

Parameter	Units	Value
Sampling Times	-	12:00 - 18:00
Sampling Dates	-	13/09/2023
Sampling Device	-	ISO
Volume Sampled (REF)	m³	5.5180

Where: ISO stands for Manual Isokinetic Sampling Train

				NATO I-TEQ		WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
2378-TCDD	ng	ND	0.00161	0.0016	0.0000	0.0016	0.0000	0.0016	0.0000	0.0016	0.0000	84
12378-PeCDD	ng	ND	0.00551	0.0028	0.0000	0.0055	0.0000	0.0055	0.0000	0.0055	0.0000	75
123478-HxCDD	ng	ND	0.00385	0.0004	0.0000	0.0004	0.0000	0.0019	0.0000	0.0002	0.0000	70
123678-HxCDD	ng	ND	0.00436	0.0004	0.0000	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	59
123789-HxCDD	ng	ND	0.00464	0.0005	0.0000	0.0005	0.0000	0.0000	0.0000	0.0005	0.0000	-
1234678-HPeCDD	ng	0.02639	0.00265	0.0003	0.0003	0.0003	0.0003	0.0000	0.0000	0.0000	0.0000	74
OCDD	ng	0.06268	0.00612	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	77
Total Dioxins	ng	0.0000	-	0.0060	0.0003	0.0087	0.0003	0.0092	0.0000	0.0079	0.0000	-
2378-TCDF	ng	ND	0.00503	0.0005	0.0000	0.0005	0.0000	0.0003	0.0000	0.0050	0.0000	66
12378-PeCDF	ng	ND	0.00431	0.0002	0.0000	0.0001	0.0000	0.0002	0.0000	0.0004	0.0000	93
23478-PeCDF	ng	ND	0.00408	0.0020	0.0000	0.0012	0.0000	0.0020	0.0000	0.0041	0.0000	67
123478-HxCDF	ng	ND	0.00347	0.0003	0.0000	0.0003	0.0000	0.0003	0.0000	0.0003	0.0000	70
123678-HxCDF	ng	ND	0.00402	0.0004	0.0000	0.0004	0.0000	0.0004	0.0000	0.0004	0.0000	67
234678-HxCDF	ng	0.00900	0.00441	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	60
123789-HxCDF	ng	ND	0.00501	0.0005	0.0000	0.0005	0.0000	0.0005	0.0000	0.0005	0.0000	96
1234678-HPeCDF	ng	0.02437	0.00406	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	64
1234789-HPeCDF	ng	0.00603	0.00492	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	101
OCDF	ng	0.02398	0.00585	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	68
Total Furans	ng	0.0000	-	0.0052	0.0012	0.0043	0.0012	0.0050	0.0012	0.0120	0.0012	-
Totals	ng	0.0000	-	0.0112	0.0016	0.0130	0.0015	0.0141	0.0012	0.0199	0.0012	-
Total Concentration	ng/m³	-	-	0.0020	0.0003	0.0024	0.0003	0.0026	0.0002	0.0036	0.0002	-
Limit of Detection	ng/m³	-	-	0.0019	-	0.0022	-	0.0024	-	0.0035	-	-

Where: ND stands for Non Detected

DL stands for Analytical Detection Limit

TEQ1 refers to Non Detected Congeners at the Detection Limit

TEQ2 refers to Non Detected Congeners at Zero

% Rec stands for the Recovery Percentage of the Sample

DIOXINS & FURANS: SAMPLING DETAILS

(Continued)

RUN 2

Parameter	Units	Value
Sampling Times	-	09:30 - 13:36, 14:50 - 16:44
Sampling Dates	-	14/09/2023
Sampling Device	-	ISO
Volume Sampled (REF)	m³	5.6133

Where: ISO stands for Manual Isokinetic Sampling Train

				NATO I-TEQ		WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
2378-TCDD	ng	ND	0.00397	0.0040	0.0000	0.0040	0.0000	0.0040	0.0000	0.0040	0.0000	90
12378-PeCDD	ng	0.02482	0.01004	0.0124	0.0124	0.0248	0.0248	0.0248	0.0248	0.0248	0.0248	76
123478-HxCDD	ng	0.01161	0.00692	0.0012	0.0012	0.0012	0.0012	0.0058	0.0058	0.0006	0.0006	72
123678-HxCDD	ng	0.02154	0.00763	0.0022	0.0022	0.0022	0.0022	0.0002	0.0002	0.0002	0.0002	63
123789-HxCDD	ng	0.02300	0.00812	0.0023	0.0023	0.0023	0.0023	0.0002	0.0002	0.0023	0.0023	-
1234678-HPeCDD	ng	0.11620	0.00201	0.0012	0.0012	0.0012	0.0012	0.0001	0.0001	0.0001	0.0001	75
OCDD	ng	0.13402	0.00347	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	84
Total Dioxins	ng	0.0000	-	0.0233	0.0193	0.0356	0.0316	0.0352	0.0312	0.0320	0.0280	-
2378-TCDF	ng	0.00728	0.00576	0.0007	0.0007	0.0007	0.0007	0.0004	0.0004	0.0073	0.0073	69
12378-PeCDF	ng	0.00966	0.00817	0.0005	0.0005	0.0003	0.0003	0.0005	0.0005	0.0010	0.0010	113
23478-PeCDF	ng	0.01243	0.00773	0.0062	0.0062	0.0037	0.0037	0.0062	0.0062	0.0124	0.0124	69
123478-HxCDF	ng	0.01129	0.00506	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	72
123678-HxCDF	ng	0.01379	0.00495	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	68
234678-HxCDF	ng	0.02325	0.00686	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	57
123789-HxCDF	ng	ND	0.00779	0.0008	0.0000	0.0008	0.0000	0.0008	0.0000	0.0008	0.0000	112
1234678-HPeCDF	ng	0.05637	0.00368	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	69
1234789-HPeCDF	ng	0.00522	0.00446	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	103
OCDF	ng	0.01969	0.00419	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	71
Total Furans	ng	0.0000	-	0.0137	0.0129	0.0110	0.0102	0.0133	0.0125	0.0269	0.0261	-
Totals	ng	0.0000	-	0.0370	0.0322	0.0466	0.0418	0.0485	0.0437	0.0589	0.0542	-
Total Concentration	ng/m³	-	-	0.0066	0.0057	0.0083	0.0075	0.0086	0.0078	0.0105	0.0097	-
Limit of Detection	ng/m³	-	-	0.0033	-	0.0039	-	0.0044	-	0.0057	-	-

Where: ND stands for Non Detected

DL stands for Analytical Detection Limit

TEQ1 refers to Non Detected Congeners at the Detection Limit

TEQ2 refers to Non Detected Congeners at Zero

% Rec stands for the Recovery Percentage of the Sample

DIOXINS & FURANS: SAMPLING DETAILS

(Continued)

RUN 3

Parameter	Units	Value
Sampling Times	-	09:20 - 15:20
Sampling Dates	-	15/09/2023
Sampling Device	-	ISO
Volume Sampled (REF)	m^3	5.4953

Where: ISO stands for Manual Isokinetic Sampling Train

				NATO I-TEQ		WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
2378-TCDD	ng	ND	0.00325	0.0033	0.0000	0.0033	0.0000	0.0033	0.0000	0.0033	0.0000	91
12378-PeCDD	ng	ND	0.00628	0.0031	0.0000	0.0063	0.0000	0.0063	0.0000	0.0063	0.0000	73
123478-HxCDD	ng	ND	0.00513	0.0005	0.0000	0.0005	0.0000	0.0026	0.0000	0.0003	0.0000	70
123678-HxCDD	ng	0.00619	0.00592	0.0006	0.0006	0.0006	0.0006	0.0001	0.0001	0.0001	0.0001	59
123789-HxCDD	ng	0.00811	0.00630	0.0008	0.0008	0.0008	0.0008	0.0001	0.0001	0.0008	0.0008	-
1234678-HPeCDD	ng	0.05608	0.00276	0.0006	0.0006	0.0006	0.0006	0.0001	0.0001	0.0001	0.0001	70
OCDD	ng	0.07408	0.00486	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	76
Total Dioxins	ng	0.0000	-	0.0090	0.0021	0.0121	0.0020	0.0123	0.0002	0.0107	0.0009	-
2378-TCDF	ng	0.00951	0.00628	0.0010	0.0010	0.0010	0.0010	0.0005	0.0005	0.0095	0.0095	68
12378-PeCDF	ng	ND	0.00513	0.0003	0.0000	0.0002	0.0000	0.0003	0.0000	0.0005	0.0000	107
23478-PeCDF	ng	ND	0.00592	0.0030	0.0000	0.0018	0.0000	0.0030	0.0000	0.0059	0.0000	69
123478-HxCDF	ng	ND	0.00630	0.0006	0.0000	0.0006	0.0000	0.0006	0.0000	0.0006	0.0000	65
123678-HxCDF	ng	0.00622	0.00276	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	64
234678-HxCDF	ng	ND	0.00486	0.0005	0.0000	0.0005	0.0000	0.0005	0.0000	0.0005	0.0000	63
123789-HxCDF	ng	ND	0.00595	0.0006	0.0000	0.0006	0.0000	0.0006	0.0000	0.0006	0.0000	100
1234678-HPeCDF	ng	0.02505	0.00545	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	66
1234789-HPeCDF	ng	ND	0.00516	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	107
OCDF	ng	0.01340	0.00417	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	65
Total Furans	ng	0.0000	-	0.0068	0.0018	0.0055	0.0018	0.0063	0.0013	0.0186	0.0104	-
Totals	ng	0.0000	-	0.0158	0.0039	0.0176	0.0038	0.0186	0.0016	0.0293	0.0113	-
Total Concentration	ng/m^3	-	-	0.0029	0.0007	0.0032	0.0007	0.0034	0.0003	0.0053	0.0021	-
Limit of Detection	ng/m^3	-	-	0.0026	-	0.0029	-	0.0032	-	0.0046	-	-

Where: ND stands for Non Detected

DL stands for Analytical Detection Limit

TEQ1 refers to Non Detected Congeners at the Detection Limit

TEQ2 refers to Non Detected Congeners at Zero

% Rec stands for the Recovery Percentage of the Sample

APPENDIX 2

DIOXINS & FURANS: SAMPLING DETAILS

(Continued)

BLANK 1

Parameter	Units	Value
Sampling Dates	-	13/09/2023
Sampling Device	-	ISO
Average Volume Sampled (REF)	m^3	5.5422

Where: ISO stands for Manual Isokinetic Sampling Train

				NATO I-TEQ		WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
2378-TCDD	ng	ND	0.00050	0.0005	0.0000	0.0005	0.0000	0.0005	0.0000	0.0005	0.0000	87
12378-PeCDD	ng	ND	0.00330	0.0017	0.0000	0.0033	0.0000	0.0033	0.0000	0.0033	0.0000	75
123478-HxCDD	ng	ND	0.00088	0.0001	0.0000	0.0001	0.0000	0.0004	0.0000	0.0000	0.0000	73
123678-HxCDD	ng	ND	0.00101	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	62
123789-HxCDD	ng	ND	0.00108	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	-
1234678-HPeCDD	ng	ND	0.00114	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	64
OCDD	ng	0.01133	0.00132	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	72
Total Dioxins	ng	0.0000	-	0.0025	0.0000	0.0041	0.0000	0.0043	0.0000	0.0040	0.0000	-
												Paramete
2378-TCDF	ng	ND	0.00146	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0015	0.0000	68
12378-PeCDF	ng	ND	0.00162	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.0002	0.0000	104
23478-PeCDF	ng	ND	0.00153	0.0008	0.0000	0.0005	0.0000	0.0008	0.0000	0.0015	0.0000	67
123478-HxCDF	ng	ND	0.00123	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	72
123678-HxCDF	ng	ND	0.00125	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	69
234678-HxCDF	ng	ND	0.00149	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	60
123789-HxCDF	ng	ND	0.00170	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	104
1234678-HPeCDF	ng	0.00268	0.00065	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	68
1234789-HPeCDF	ng	ND	0.00079	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	96
OCDF	ng	0.00174	0.00144	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	65
Total Furans	ng	0.0000	-	0.0016	0.0000	0.0013	0.0000	0.0015	0.0000	0.0038	0.0000	-
Totals	ng	0.0000	-	0.0041	0.0000	0.0054	0.0000	0.0058	0.0000	0.0077	0.0000	-
Total Concentration	ng/m^3	-	-	0.0007	0.0000	0.0010	0.0000	0.0010	0.0000	0.0014	0.0000	-

Where: ND stands for Non Detected

DL stands for Analytical Detection Limit

TEQ1 refers to Non Detected Congeners at the Detection Limit

TEQ2 refers to Non Detected Congeners at Zero

% Rec stands for the Recovery Percentage of the Sample

DIOXINS & FURANS: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	**Units**	**Run 1**	**Run 2**	**Run 3**
Mean Sampling Rate	l/min	17.9	18.2	18.4
Pre-Sampling Leak Rate	l/min	0.14	0.11	0.11
Post-Sampling Leak Rate	l/min	0.16	0.13	0.21
Allowable Leak Rate	l/min	0.89	0.91	0.92
Leak Test Acceptable	-	Yes	Yes	Yes

Water Droplets	**Units**	**Run 1**	**Run 2**	**Run 3**
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	**Units**	**Run 1**	**Run 2**	**Run 3**
Measurement Uncertainty (MU)	%	5.3	5.2	5.3
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

Silica Gel (Concurrent Water Vapour)	**Units**	**Run 1**	**Run 2**	**Run 3**
Less than 50% Faded	%	Yes	Yes	Yes

Isokinetic Criterion Compliance	**Units**	**Run 1**	**Run 2**	**Run 3**
Isokinetic Variation	%	101.5	101.8	108.0
Allowable Isokinetic Range	%	95 - 115	95 - 115	95 - 115
Isokineticity Acceptable	-	Yes	Yes	Yes

Filter Temperatures	**Units**	**Run 1**	**Run 2**	**Run 3**
Maximum Filter Temperature	°C	120	120	120
Maximum Allowable Temperature	°C	125	125	125
Temperature Acceptable	-	Yes	Yes	Yes

Condenser Exit Temperature	**Units**	**Run 1**	**Run 2**	**Run 3**
Maximum Temperature Recorded	°C	19	19	19
Maximum Allowable Temperature	°C	20	20	20
Exit Temperature Acceptable	-	Yes	Yes	Yes

Test Conditions	**Units**	**Run 1**	**Run 2**	**Run 3**
Ambient Temperature Recorded?	-	Yes	Yes	Yes

DIOXINS & FURANS: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	15.0
Sampling Leak Rate	l/min	0.19
Allowable Leak Rate	l/min	0.75
Leak Test Acceptable	-	Yes

Validity of NATO I-TEQ Blank vs ELV	Units	Blank 1
Allowable Blank	ng/m^3	0.01
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation	Run Number			
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1	2	3	
There are no deviations associated with the sampling employed.	wx	wx	wx	

DIOXINS & FURANS (NATO I-TEQ): MEASUREMENT UNCERTAINTY CALCULATIONS

	Value				Standard uncertainty				
Measured Quantities	**Symbol**	**Run 1**	**Run 2**	**Run 3**	**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (Actual)	V_m	6.4790	6.5990	6.6680	uV_m	m^3	0.1296	0.1320	0.1334
Sampled Gas Temperature	T_m	307.5	306.2	306.7	uT_m	K	2.00	2.00	2.00
Sampled Gas Pressure	ρ_m	101.3	101.3	101.3	$u\rho_m$	kPa	0.50	0.50	0.50
Sampled Gas Humidity	H_m	0.00	0.00	0.00	uH_m	% v/v	1.00	1.00	1.00
Leak	L	0.89	0.71	1.14	uL	%	-	-	-
Laboratory Result	L_r	10.0	10.0	10.0	uL_r	%	-	-	-

	Uncertainty as a Percentage				
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**	**Requirement of Standard**
Sampled Volume (Actual)	%	2.00	2.00	2.00	≤2%
Sampled Gas Temperature	%	0.65	0.65	0.65	≤1%
Sampled Gas Pressure	%	0.49	0.49	0.49	≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00	≤1%
Leak	%	0.89	0.71	1.14	≤5%
Laboratory Result	%	10.0	10.0	10.0	No Requirement

	Uncertainty in Measurement Units					Sensitivity Coefficient		
Measured Quantities	**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (STP)	V_m	m^3	5.7568	5.8882	5.9397	0.0004	0.0011	0.0005
Leak	L	ng/m^3	0.0000	0.0000	0.0000	1.00	1.00	1.00
Laboratory Result	L_r	ng/m^3	0.0002	0.0007	0.0003	1.00	1.00	1.00

	Uncertainty in Result			
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (STP)	ng/m^3	0.0001	0.0002	0.0001
Leak	ng/m^3	0.0000	0.0000	0.0000
Laboratory Result	ng/m^3	0.0002	0.0007	0.0003

	Oxygen Correction Part of MU Budget			
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**
O_2 Correction Factor	-	1.04	1.05	1.08
Stack Gas O_2 Content	% v/v	10.46	10.51	10.82
MU for O_2 Correction	-	0.05	0.05	0.05
Overall MU For O_2 Measurement	%	4.74	4.77	4.91

Parameter	**Units**	**Run 1**	**Run 2**	**Run 3**
Combined uncertainty	ng/m^3	0.0002	0.0007	0.0003
Expanded uncertainty (95% confidence), without Oxygen Correction	ng/m^3	0.0004	0.0013	0.0006
Expanded uncertainty (95% confidence), with Oxygen Correction	ng/m^3	0.0004	0.0014	0.0006
Expanded uncertainty (95% confidence), estimated with Method Deviations	ng/m^3	0.0004	0.0014	0.0006
Reported Uncertainty	ng/m^3	0.0004	0.0014	0.0006
Expanded uncertainty (95% confidence), without Oxygen Correction	%	20.3	20.3	20.3
Expanded uncertainty (95% confidence), with Oxygen Correction	%	20.8	20.8	20.9
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	20.8	20.8	20.9
Reported Uncertainty	%	20.8	20.8	20.9

PCBs: RESULTS SUMMARY

(PAGE 1 OF 4)

Irish Cement Ltd, Limerick
A2-01 Kiln 6

TEQ1 - UPPER LIMITS (worst case where <LOD = LOD)

Sample Runs (UPPER WHO TEQ Humans / Mammals)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.0001	0.0004	0.0002		0.0002
Uncertainty	±ng/m³	0.00003	0.0001	0.00003		0.00005
Mass Emission	µg/hr	0.03	0.11	0.04		0.06
Uncertainty	±µg/hr	0.01	0.02	0.01		0.01

Sample Runs (UPPER WHO TEQ Fish)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.000007	0.000021	0.000011		0.000013
Uncertainty	±ng/m³	0.000001	0.000004	0.000002		0.000003
Mass Emission	µg/hr	0.0018	0.0054	0.0027		0.0033
Uncertainty	±µg/hr	0.0004	0.0012	0.0006		0.0007

Sample Runs (UPPER WHO TEQ Birds)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.0006	0.0011	0.0014		0.0010
Uncertainty	±ng/m³	0.0001	0.0002	0.0003		0.0002
Mass Emission	µg/hr	0.15	0.28	0.36		0.26
Uncertainty	±µg/hr	0.03	0.06	0.08		0.06

PCBs: RESULTS SUMMARY

(PAGE 2 OF 4)

Irish Cement Ltd, Limerick
A2-01 Kiln 6

TEQ2 - LOWER LIMITS (best case where <LOD = 0)

Sample Runs (LOWER WHO TEQ Humans / Mammals)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.000001	0.0004	0.000005		0.0001
Uncertainty	±ng/m³	0.0000003	0.0001	0.000001		0.000026
Mass Emission	µg/hr	0.0004	0.0969	0.0013		0.0329
Uncertainty	±µg/hr	0.0001	0.0207	0.0003		0.0070

Sample Runs (LOWER WHO TEQ Fish)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.0000015	0.0000209	0.0000039		0.0000088
Uncertainty	±ng/m³	0.0000003	0.0000044	0.0000008		0.0000018
Mass Emission	µg/hr	0.0004	0.0054	0.0010		0.0023
Uncertainty	±µg/hr	0.0001	0.0012	0.0002		0.0005

Sample Runs (LOWER WHO TEQ Birds)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.0005	0.0011	0.0013		0.0009
Uncertainty	±ng/m³	0.0001	0.0002	0.0003		0.0002
Mass Emission	µg/hr	0.12	0.28	0.33		0.24
Uncertainty	±µg/hr	0.03	0.06	0.07		0.05

PCBs: RESULTS SUMMARY

(PAGE 3 OF 4)

Irish Cement Ltd, Limerick
A2-01 Kiln 6

TEQ1 - UPPER LIMITS (worst case where <LOD = LOD)

Blank Runs (UPPER WHO TEQ Humans / Mammals)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.0001		0.0001

Blank Runs (UPPER WHO TEQ Fish)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.000005		0.000005

Blank Runs (UPPER WHO TEQ Birds)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.0003		0.0003

TEQ2 - LOWER LIMITS (best case where <LOD = 0)

Blank Runs (LOWER WHO TEQ Humans / Mammals)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.000001		0.000001

Blank Runs (LOWER WHO TEQ Fish)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.000001		0.000001

Blank Runs (LOWER WHO TEQ Birds)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.0002		0.0002

PCBs: RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	12.1	9.0	13.6		11.6
Uncertainty	±% v/v	0.64	0.47	0.73		0.61

General Sampling Information

Parameter	Value	
Standard	EN 1948	
Technical Procedure	MD 007	
Name of Analytical Laboratory	ELD	
Analytical Laboratory's Procedure	PM137, TM201	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	10/10/2023	
Probe Material	Titanium	
Filter Housing Material	Borosilicate Glass	
Glassware Material	Borosilicate Glass	
Absorption Material	XAD-2	
Positioning of Filter	Out Stack	
Filter Size and Material	90mm Quartz Fibre	
Number of Sampling Lines Used	2 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	20 / 20	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1 - A10, B1 - B10	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

PCBs: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	Run 2	Run 3	
Absolute pressure of stack gas, P_s					
Barometric pressure, P_b	mmHg	762.8	762.8	762.8	
Stack static pressure, P_{static}	mmH_2O	-42.6	-42.6	-42.6	
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	759.7	759.7	759.7	
Volume of water vapour collected, V_{wstd}					
Total mass collected in impingers (liquid trap)	g	606.8	459.7	714.1	
Total mass collected in impingers (silica trap)	g	27.7	8.9	38.3	
Total mass of liquid collected, V_{lc}	g	634.5	468.6	752.4	
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.7906	0.5839	0.9375	
Volume of gas metered dry, V_{mstd}					
Volume of gas sample through gas meter, V_m	m^3	6.4790	6.5990	6.6680	
Gas meter correction factor, Y_d	-	0.9940	0.9940	0.9940	
Average dry gas meter temperature, T_m	°C	34.5	33.2	33.7	
Average pressure drop across orifice, ΔH	mmH_2O	32.5	31.9	31.3	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	5.7568	5.8882	5.9397	
Moisture content, B_{wo} & R_{wv}					
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.1207	0.0902	0.1363	
B_{wo} as a percentage	% v/v	12.07	9.02	13.63	
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	12.07	9.02	13.63	
Volume of gas metered wet, V_{mstw}					
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	6.5474	6.4721	6.8772	
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$					
IED & Incinerates Hazardous Material? (Yes = no positive O_2 correction)	-	No	No	No	
% wet oxygen measured in gas stream, $ACT\%O_{2w}$	% v/v	9.32	9.38	9.65	
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	10.46	10.51	10.82	
% oxygen reference condition, $REF\%O_2$	% v/v	10.00	10.00	10.00	
O_2 Reference Factor wet (O_{2REFw}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2w}$)	-	0.94	0.95	0.97	
O_2 Reference Factor dry (O_{2REFd}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2d}$)	-	1.04	1.05	1.08	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	6.9496	6.8396	7.0952	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	5.5180	5.6133	5.4953	
Molecular weight of dry gas stream, M_d					
CO_2	% v/v	21.00	21.00	21.00	
O_2	% v/v	10.46	10.51	10.82	
Total	% v/v	31.46	31.51	31.82	
N_2	% v/v	68.54	68.49	68.18	
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	31.78	31.78	31.79	
Molecular weight of stack gas (wet), M_s					
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	30.11	30.54	29.91	
Velocity of stack gas, V_s					
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97	
Velocity pressure coefficient, C_p	-	0.88	0.88	0.88	
Average of velocity heads, ΔP_{avg}	mmH_2O	36.88	36.34	35.83	
Average square root of velocity heads, √ΔP	$\sqrt{mmH_2O}$	6.07	6.03	5.99	
Average stack gas temperature, T_s	°C	148.1	148.1	149.8	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{(M_s)(P_s)})$	m/s	25.35	24.99	25.13	
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})					
Area of stack, A_s	m^2	5.31	5.31	5.31	
$Q_a = (60)(A_s)(V_s)$	m^3/min	8077.7	7962.2	8005.3	
Conversion factor (K/mm.Hg), C_f	-	0.3592	0.3592	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	5234.2	5160.2	5167.0	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	4602.1	4694.7	4462.6	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	5555.7	5453.3	5330.7	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	4411.3	4475.5	4128.7	
Percent isokinetic, %I					
Nozzle diameter, D_n	mm	4.81	4.81	4.81	
Nozzle area, A_n	mm^2	18.17	18.17	18.17	
Total sampling time, q	min	360	360	360	
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	101.5	101.8	108.0	

PCBs: SAMPLING DETAILS

RUN 1

Parameter	Units	Value
Sampling Times	-	12:00 - 18:00
Sampling Dates	-	13/09/2023
Sampling Device	-	ISO
Volume Sampled (REF)	m³	5.5180

Where: ISO stands for Manual Isokinetic Sampling Train

				WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
PCB-81	ng	0.00930	0.00786	0.0000028	0.0000028	0.0000047	0.0000047	0.0009300	0.0009300	73
PCB-77	ng	0.03375	0.00742	0.0000034	0.0000034	0.0000034	0.0000034	0.0016875	0.0016875	70
PCB-123	ng	ND	0.00751	0.0000002	0.0000000	0.0000000	0.0000000	0.0000001	0.0000000	80
PCB-118	ng	ND	0.0075	0.0000002	0.0000000	0.0000000	0.0000000	0.0000001	0.0000000	79
PCB-114	ng	ND	0.00737	0.0000002	0.0000000	0.0000000	0.0000000	0.0000007	0.0000000	81
PCB-105	ng	0.03185	0.00807	0.0000010	0.0000010	0.0000002	0.0000002	0.0000032	0.0000032	77
PCB-126	ng	ND	0.00588	0.0005880	0.0000000	0.0000294	0.0000000	0.0005880	0.0000000	79
PCB-167	ng	0.0064	0.0027	0.0000002	0.0000002	0.0000000	0.0000000	0.0000001	0.0000001	84
PCB-156	ng	0.01321	0.00275	0.0000004	0.0000004	0.0000001	0.0000001	0.0000013	0.0000013	83
PCB-157	ng	0.00363	0.00287	0.0000001	0.0000001	0.0000000	0.0000000	0.0000004	0.0000004	82
PCB-169	ng	ND	0.00315	0.0000945	0.0000000	0.0000002	0.0000000	0.0000032	0.0000000	79
PCB-189	ng	0.00327	0.00145	0.0000001	0.0000001	0.0000000	0.0000000	0.0000000	0.0000000	91
Totals	ng	0.0000	-	0.000691	0.000008	0.000038	0.000008	0.003215	0.002622	-
Total Concentration	ng/m³	-	-	0.000125	0.000001	0.000007	0.000002	0.000583	0.000475	-
Limit of Detection	ng/m³	-	-	0.000124	-	0.000006	-	0.000317	-	-

Where: ND stands for Non Detected

DL stands for Analytical Detection Limit

TEQ1 refers to Non Detected Congeners at the Detection Limit

TEQ2 refers to Non Detected Congeners at Zero

% Rec stands for the Recovery Percentage of the Sample

PCBs: SAMPLING DETAILS

RUN 2

Parameter	Units	Value
Sampling Times	-	09:30 - 13:36, 14:50 - 16:44
Sampling Dates	-	14/09/2023
Sampling Device	-	ISO
Volume Sampled (REF)	m^3	5.6133

Where: ISO stands for Manual Isokinetic Sampling Train

				WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
PCB-81	ng	0.01421	0.00992	0.0000043	0.0000043	0.0000071	0.0000071	0.0014210	0.0014210	63
PCB-77	ng	0.05218	0.00718	0.0000052	0.0000052	0.0000052	0.0000052	0.0026090	0.0026090	77
PCB-123	ng	ND	0.00795	0.0000002	0.0000000	0.0000000	0.0000000	0.0000001	0.0000000	84
PCB-118	ng	0.12969	0.00802	0.0000039	0.0000039	0.0000006	0.0000006	0.0000013	0.0000013	84
PCB-114	ng	ND	0.0078	0.0000002	0.0000000	0.0000000	0.0000000	0.0000008	0.0000000	84
PCB-105	ng	0.04978	0.00907	0.0000015	0.0000015	0.0000002	0.0000002	0.0000050	0.0000050	81
PCB-126	ng	0.02083	0.00802	0.0020830	0.0020830	0.0001042	0.0001042	0.0020830	0.0020830	96
PCB-167	ng	0.00988	0.00333	0.0000003	0.0000003	0.0000000	0.0000000	0.0000001	0.0000001	86
PCB-156	ng	0.01875	0.00327	0.0000006	0.0000006	0.0000001	0.0000001	0.0000019	0.0000019	87
PCB-157	ng	0.00678	0.00366	0.0000002	0.0000002	0.0000000	0.0000000	0.0000007	0.0000007	84
PCB-169	ng	ND	0.00584	0.0001752	0.0000000	0.0000003	0.0000000	0.0000058	0.0000000	99
PCB-189	ng	0.00562	0.00172	0.0000002	0.0000002	0.0000000	0.0000000	0.0000001	0.0000001	97
Totals	ng	0.0000	-	0.002275	0.002099	0.000118	0.000118	0.006129	0.006122	-
Total Concentration	ng/m^3	-	-	0.000405	0.000374	0.000021	0.000021	0.001092	0.001091	-
Limit of Detection	ng/m^3	-	-	0.000175	-	0.000008	-	0.000385	-	-

Where: ND stands for Non Detected

DL stands for Analytical Detection Limit

TEQ1 refers to Non Detected Congeners at the Detection Limit

TEQ2 refers to Non Detected Congeners at Zero

% Rec stands for the Recovery Percentage of the Sample

PCBs: SAMPLING DETAILS

RUN 3

Parameter	Units	Value
Sampling Times	-	09:20 - 15:20
Sampling Dates	-	15/09/2023
Sampling Device	-	ISO
Volume Sampled (REF)	m^3	5.4953

Where: ISO stands for Manual Isokinetic Sampling Train

				WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
PCB-81	ng	0.01988	0.01606	0.0000060	0.0000060	0.0000099	0.0000099	0.0019880	0.0019880	62
PCB-77	ng	0.09811	0.00956	0.0000098	0.0000098	0.0000098	0.0000098	0.0049055	0.0049055	77
PCB-123	ng	0.01506	0.00971	0.0000005	0.0000005	0.0000001	0.0000001	0.0000002	0.0000002	81
PCB-118	ng	0.22674	0.00966	0.0000068	0.0000068	0.0000011	0.0000011	0.0000023	0.0000023	80
PCB-114	ng	ND	0.00991	0.0000003	0.0000000	0.0000000	0.0000000	0.0000010	0.0000000	80
PCB-105	ng	0.09413	0.01035	0.0000028	0.0000028	0.0000005	0.0000005	0.0000094	0.0000094	80
PCB-126	ng	ND	0.00722	0.0007220	0.0000000	0.0000361	0.0000000	0.0007220	0.0000000	89
PCB-167	ng	0.01229	0.00365	0.0000004	0.0000004	0.0000001	0.0000001	0.0000001	0.0000001	80
PCB-156	ng	0.02268	0.00349	0.0000007	0.0000007	0.0000001	0.0000001	0.0000023	0.0000023	83
PCB-157	ng	0.00633	0.00376	0.0000002	0.0000002	0.0000000	0.0000000	0.0000006	0.0000006	81
PCB-169	ng	ND	0.00270	0.0000810	0.0000000	0.0000001	0.0000000	0.0000027	0.0000000	91
PCB-189	ng	0.00548	0.00183	0.0000002	0.0000002	0.0000000	0.0000000	0.0000001	0.0000001	90
Totals	ng	0.0000	-	0.000831	0.000027	0.000058	0.000022	0.007634	0.006908	-
Total Concentration	ng/m^3	-	-	0.000151	0.000005	0.000011	0.000004	0.001389	0.001257	-
Limit of Detection	ng/m^3	-	-	0.000147	-	0.000008	-	0.000512	-	-

Where: ND stands for Non Detected

DL stands for Analytical Detection Limit

TEQ1 refers to Non Detected Congeners at the Detection Limit

TEQ2 refers to Non Detected Congeners at Zero

% Rec stands for the Recovery Percentage of the Sample

PCBs: SAMPLING DETAILS

BLANK 1

Parameter	Units	Value
Sampling Dates	-	13/09/2023
Sampling Device	-	ISO
Volume Sampled (REF)	m^3	5.5422

Where: ISO stands for Manual Isokinetic Sampling Train

				WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
PCB-81	ng	0.00324	0.00157	0.0000010	0.0000010	0.0000016	0.0000016	0.0003240	0.0003240	68
PCB-77	ng	0.01945	0.00213	0.0000019	0.0000019	0.0000019	0.0000019	0.0009725	0.0009725	65
PCB-123	ng	ND	0.00566	0.0000002	0.0000000	0.0000000	0.0000000	0.0000001	0.0000000	76
PCB-118	ng	0.08298	0.00575	0.0000025	0.0000025	0.0000004	0.0000004	0.0000008	0.0000008	75
PCB-114	ng	ND	0.00553	0.0000002	0.0000000	0.0000000	0.0000000	0.0000006	0.0000000	78
PCB-105	ng	0.02505	0.00622	0.0000008	0.0000008	0.0000001	0.0000001	0.0000025	0.0000025	73
PCB-126	ng	ND	0.00425	0.0004250	0.0000000	0.0000213	0.0000000	0.0004250	0.0000000	74
PCB-167	ng	0.00420	0.00196	0.0000001	0.0000001	0.0000000	0.0000000	0.0000000	0.0000000	79
PCB-156	ng	0.00747	0.00203	0.0000002	0.0000002	0.0000000	0.0000000	0.0000007	0.0000007	80
PCB-157	ng	0.00221	0.00215	0.0000001	0.0000001	0.0000000	0.0000000	0.0000002	0.0000002	78
PCB-169	ng	ND	0.00089	0.0000267	0.0000000	0.0000000	0.0000000	0.0000009	0.0000000	75
PCB-189	ng	0.00170	0.00121	0.0000001	0.0000001	0.0000000	0.0000000	0.0000000	0.0000000	89
Totals	ng	0.0000	-	0.000459	0.000007	0.000026	0.000004	0.001727	0.001301	-
Total Concentration	ng/m^3	-	-	0.000083	0.000001	0.000005	0.000001	0.000312	0.000235	-

Where: ND stands for Non Detected

DL stands for Analytical Detection Limit

TEQ1 refers to Non Detected Congeners at the Detection Limit

TEQ2 refers to Non Detected Congeners at Zero

% Rec stands for the Recovery Percentage of the Sample

PCBs: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	**Units**	**Run 1**	**Run 2**	**Run 3**
Mean Sampling Rate	l/min	17.9	18.2	18.4
Pre-Sampling Leak Rate	l/min	0.14	0.11	0.11
Post-Sampling Leak Rate	l/min	0.16	0.13	0.21
Allowable Leak Rate	l/min	0.89	0.91	0.92
Leak Test Acceptable	-	Yes	Yes	Yes

Water Droplets	**Units**	**Run 1**	**Run 2**	**Run 3**
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	**Units**	**Run 1**	**Run 2**	**Run 3**
Measurement Uncertainty (MU)	%	5.3	5.2	5.3
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

Silica Gel (Concurrent Water Vapour)	**Units**	**Run 1**	**Run 2**	**Run 3**
Less than 50% Faded	%	Yes	Yes	Yes

Isokinetic Criterion Compliance	**Units**	**Run 1**	**Run 2**	**Run 3**
Isokinetic Variation	%	101.5	101.8	108.0
Allowable Isokinetic Range	%	95 - 115	95 - 115	95 - 115
Isokineticity Acceptable	-	Yes	Yes	Yes

Filter Temperatures	**Units**	**Run 1**	**Run 2**	**Run 3**
Maximum Filter Temperature	°C	120	120	120
Maximum Allowable Temperature	°C	125	125	125
Temperature Acceptable	-	Yes	Yes	Yes

Condenser Exit Temperature	**Units**	**Run 1**	**Run 2**	**Run 3**
Maximum Temperature Recorded	°C	19	19	19
Maximum Allowable Temperature	°C	20	20	20
Exit Temperature Acceptable	-	Yes	Yes	Yes

Test Conditions	**Units**	**Run 1**	**Run 2**	**Run 3**
Ambient Temperature Recorded?	-	Yes	Yes	Yes

PCBs: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	15.0
Sampling Leak Rate	l/min	0.19
Allowable Leak Rate	l/min	0.75
Leak Test Acceptable	-	Yes

Validity of WHO TEQ H/M Blank vs ELV	Units	Blank 1
Allowable Blank	ng/m³	N/A
Blank Acceptable	-	N/A

Method Deviations

Nature of Deviation	Run Number		
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1	2	3
There are no deviations associated with the sampling employed.	wx	wx	wx

PCBs (WHO TEQ HUMANS / MAMMALS): MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value: Symbol	Run 1	Run 2	Run 3	Standard uncertainty: Symbol	Units	Run 1	Run 2	Run 3
Sampled Volume (Actual)	V_m	6.4790	6.5990	6.6680	uV_m	m^3	0.1296	0.1320	0.1334
Sampled Gas Temperature	T_m	307.5	306.2	306.7	uT_m	K	2.00	2.00	2.00
Sampled Gas Pressure	ρ_m	101.3	101.3	101.3	$u\rho_m$	kPa	0.50	0.50	0.50
Sampled Gas Humidity	H_m	0.00	0.0	0.0	uH_m	% v/v	1.00	1.00	1.00
Leak	L	0.89	0.71	1.14	uL	%	-	-	-
Laboratory Result	L_r	10.0	10.0	10.0	uL_r	%	-	-	-

Measured Quantities	Uncertainty as a Percentage: Units	Run 1	Run 2	Run 3	Requirement of Standard
Sampled Volume (Actual)	%	2.00	2.00	2.00	≤2%
Sampled Gas Temperature	%	0.65	0.65	0.65	≤1%
Sampled Gas Pressure	%	0.49	0.49	0.49	≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00	≤1%
Leak	%	0.89	0.71	1.14	≤5%
Laboratory Result	%	10.0	10.0	10.0	No Requirement

Measured Quantities	Uncertainty in Measurement Units: Symbol	Units	Run 1	Run 2	Run 3	Sensitivity Coefficient: Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	m^3	5.7568	5.8882	5.9397	0.00002	0.00007	0.00003
Leak	L	ng/m^3	0.0000	0.0000	0.0000	1.00	1.00	1.00
Laboratory Result	L_r	ng/m^3	0.0000	0.0000	0.0000	1.00	1.00	1.00

Measured Quantities	Uncertainty in Result: Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	ng/m^3	0.0000	0.0000	0.0000
Leak	ng/m^3	0.0000	0.0000	0.0000
Laboratory Result	ng/m^3	0.0000	0.0000	0.0000

Measured Quantities	Oxygen Correction Part of MU Budget: Units	Run 1	Run 2	Run 3
O_2 Correction Factor	-	1.04	1.05	1.08
Stack Gas O_2 Content	% v/v	10.46	10.51	10.82
MU for O_2 Correction	-	0.05	0.05	0.05
Overall MU For O_2 Measurement	%	4.74	4.77	4.91

Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	ng/m^3	0.00001	0.00004	0.00002
Expanded uncertainty (95% confidence), without Oxygen Correction	ng/m^3	0.00003	0.00008	0.00003
Expanded uncertainty (95% confidence), with Oxygen Correction	ng/m^3	0.00003	0.00008	0.00003
Expanded uncertainty (95% confidence), estimated with Method Deviations	ng/m^3	0.00003	0.00008	0.00003
Reported Uncertainty	ng/m^3	0.00003	0.00008	0.00003
Expanded uncertainty (95% confidence), without Oxygen Correction	%	20.3	20.3	20.3
Expanded uncertainty (95% confidence), with Oxygen Correction	%	20.8	20.8	20.9
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	20.8	20.8	20.9
Reported Uncertainty	%	20.8	20.8	20.9

AMMONIA: RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	mg/m³	0.36	6.0	10.5		5.6
Uncertainty	±mg/m³	0.07	1.1	2.0		1.0
Mass Emission	g/hr	93.9	1567	2728		1463
Uncertainty	±g/hr	18.0	300	522		280

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	9.6	8.4	7.6		8.5
Uncertainty	±% v/v	0.42	0.37	0.33		0.37

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 0.10		< 0.10

General Sampling Information

Parameter	Value	
Standard	ISO 21877	
Technical Procedure	MD 014	
Name of Analytical Laboratory	RPS	
Analytical Laboratory's Procedure	A6	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	09/10/2023	
Probe Material	Titanium	
Filter Housing Material	Titanium	
Impinger Material	Polyethylene	
Absorption Solution	0.05 mol/l Sulphuric Acid	
Positioning of Filter	In Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	B2	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

AMMONIA: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	10:15 - 10:45	10:55 - 11:25	11:35 - 12:05
Sampling Dates	-	15/09/2023	15/09/2023	15/09/2023
Sampling Device	-	MFC / MV	MFC / MV	MFC / MV
Duration	mins	30	30	30
Volume Sampled (STP, Dry)	m³	0.2918	0.3091	0.3351
Volume Sampled (STP, Wet)	m³	0.3229	0.3372	0.3626
Volume Sampled (REF)	m³	0.2723	0.2889	0.3151
Sample Flow Rate	l/min	9.11	9.65	10.46
Laboratory Result for Front Impingers	µg/ml	0.30	4.20	8.10
Laboratory Result for Back Impinger	µg/ml	< 0.10		
Volume in Front Impingers	ml	283.1	415.8	409.4
Volume in Back Impinger	ml	137.2		
Mass in Front Impingers	µg	84.9	1746.4	3316.1
Mass in Back Impinger	µg	< 13.7		
Total Mass Collected	µg	98.7	1746.4	3316.1
Calculated Concentration	mg/m³	0.36	6.05	10.52
Liquid Trap Start Mass	g	1218.5	1206.9	1206.3
Liquid Trap End Mass	g	1236.9	1224.3	1222.2
Silica Trap Start Mass	g	1454.8	1461.4	1466.6
Silica Trap End Mass	g	1461.4	1466.6	1472.8
Total Mass Of Water Vapour	g	25.0	22.6	22.1
Calculated Water Vapour	% v/v	9.65	8.35	7.59

Where: MFC stands for Mass Flow Controller, MV stands for Mass View Flowmeter

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	15/09/2023
Average Volume Sampled (REF)	m³	0.2921
Laboratory Result for Impingers	µg/ml	< 0.10
Volume in Impingers	ml	305.3
Total Mass Collected	µg	< 30.5
Calculated Concentration	mg/m³	< 0.10

AMMONIA: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	9.1	9.6	10.5
Pre-Sampling Leak Rate	l/min	0.11	0.15	0.14
Post-Sampling Leak Rate	l/min	0.12	0.14	0.15
Allowable Leak Rate	l/min	0.18	0.19	0.21
Leak Test Acceptable	-	Yes	Yes	Yes

Absorption Efficiency	Units	Run 1
Absorption Efficiency	%	100.0
Allowable Absorption Efficiency	%	N/A
Absorption Efficiency Acceptable	-	N/A

Water Droplets	Units	Run 1	Run 2	Run 3
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Measurement Uncertainty (MU)	%	4.33	4.39	4.39
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Less than 50% Faded	%	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	9.5
Pre-Sampling Leak Rate	l/min	0.11
Post-Sampling Leak Rate	l/min	0.11
Allowable Leak Rate	l/min	0.19
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m^3	5.0
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation	Run Number		
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1	2	3
There are no deviations associated with the sampling employed.	wx	wx	wx

AMMONIA: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value				Standard uncertainty				
	Symbol	Run 1	Run 2	Run 3	Symbol	Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	0.2918	0.3091	0.3351	uV_m	m^3	0.0058	0.0062	0.0067
Leak	L	1.32	1.45	1.43	uL	%	-	-	-
Laboratory Result	L_r	8.90	8.90	8.90	uL_r	%	-	-	-

Measured Quantities	Uncertainty as a Percentage				Requirement of Standard
	Units	Run 1	Run 2	Run 3	
Sampled Volume (STP)	%	2.00	2.00	2.00	≤2%
Leak	%	1.32	1.45	1.43	≤2%
Laboratory Result	%	8.90	8.90	8.90	No Requirement

Measured Quantities	Uncertainty in Measurement Units					Sensitivity Coefficient		
	Symbol	Units	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	m^3	0.2918	0.3091	0.3351	1.24	19.56	31.40
Leak	L	mg/m^3	0.003	0.051	0.087	1.00	1.00	1.00
Laboratory Result	L_r	mg/m^3	0.032	0.538	0.937	1.00	1.00	1.00

Measured Quantities	Uncertainty in Result			
	Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	mg/m^3	0.007	0.121	0.210
Leak	mg/m^3	0.0028	0.0506	0.0871
Laboratory Result	mg/m^3	0.0322	0.5380	0.9366

Measured Quantities	Oxygen Correction Part of MU Budget			
	Units	Run 1	Run 2	Run 3
O_2 Correction Factor	-	1.07	1.07	1.06
Stack Gas O_2 Content	% v/v	10.73	10.72	10.66
MU for O_2 Correction	-	0.05	0.05	0.05
Overall MU For O_2 Measurement	%	4.87	4.86	4.83

Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	mg/m^3	0.03	0.55	0.96
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.06	1.09	1.89
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	0.07	1.12	1.96
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.07	1.12	1.96
Reported Uncertainty	mg/m^3	0.07	1.12	1.96
Expanded uncertainty (95% confidence), without Oxygen Correction	%	17.9	18.0	18.0
Expanded uncertainty (95% confidence), with Oxygen Correction	%	18.6	18.6	18.6
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	18.6	18.6	18.6
Reported Uncertainty	%	18.6	18.6	18.6

TOTAL VOCs (as CARBON): RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1		Mean
Raw Concentration	ppm	6.1		6.1
Concentration	mg/m³	11.3		11.3
Uncertainty	±mg/m³	0.64		0.64
Mass Emission	g/hr	2939		2939
Uncertainty	±g/hr	214		214

General Sampling Information

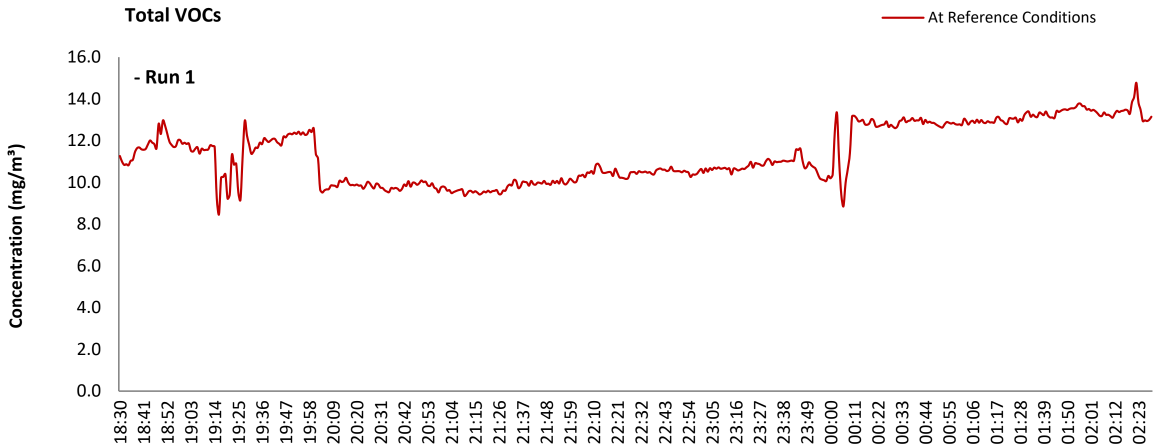
Parameter	Value	
Standard	EN 12619:2013	
Technical Procedure	MD 020	
Probe Material	Titanium	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Type	Propane in 9% O_2 in N_2 (5 Grade)	
Span Gas Reference Number	12.0519 in N_2 | 1.0554 in AIR	
Span Gas Expiry Date	24/03/2025 | 1/01/2028	
Span Gas Start Pressure (bar)	100 | 100	
Gas Cylinder Concentration (ppm)	84.11 | 79.52	
Span Gas Set Point (ppm)	82.14	This is the blended concentration of both propane cylinders
Span Gas Uncertainty (%)	2 | 2	
Zero Gas Type	9% O_2 in N_2 (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	B3	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

TOTAL VOCs (as CARBON): DATA TREND

Graphical Trend of Data



TOTAL VOCs (as CARBON): SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1
Sampling Times	-	18:30 - 02:30
Sampling Dates	-	14/09/2023
Instrument Range	ppm	100
Span Gas Value	ppm	82.1

Quality Assurance

	Zero Drift	Units	Run 1
CAL 1	Zero Down Sampling Line (Pre)	ppm	0.00
CAL 1	Zero Down Sampling Line (Post)	ppm	0.00
CAL 1	Zero Drift	ppm	0.00
CAL 1	Zero Drift	%	0.00
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Zero Drift	± ppm	4.11
	Zero Drift Acceptable	-	Yes

	Span Drift	Units	Run 1
CAL 1	Span Down Sampling Line (Pre)	ppm	81.00
CAL 1	Span Down Sampling Line (Post)	ppm	81.00
CAL 1	Span Drift	ppm	0.00
CAL 1	Span Drift	%	0.00
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Span Drift	± ppm	4.11
	Span Drift Acceptable	-	Yes

Test Conditions	Units	Run 1
Run Ambient Temperature Range	°C	12 - 15

Method Deviations

Nature of Deviation	Run Number	
(x = deviation applies to the associated run)	1	
There are no deviations associated with the sampling employed.	x	

TOTAL VOCs (as CARBON): MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	RUN 1		Units
Limit value	25.0		mg/m^3 (REF)
Allowable MU	15.0		%
Measured concentration	11.23		mg/m^3 (STP, dry)
Range Used	100.0		ppm
Range Used [A]	160.6		mg/m^3
Cal gas conc.	82.1		ppm
Conversion	1.61		ppm to mg/m^3
MCERTS Range [B]	15.0		mg/m^3
Lower of [A] or [B]	15.0		mg/m^3
Cal gas conc.	131.9		mg/m^3

Performance characteristics	RUN 1		Units
Response time	45		seconds
Number of readings in measurement	480		-
Repeatability at zero	2.00		% full scale
Repeatability at span level	0.00		% full scale
Deviation from linearity	0.50		% of value
Zero drift	0.00		% full scale
Span drift	0.00		% full scale
Volume or pressure flow dependence	1.60		% of full scale
Atmospheric pressure dependence	0.30		% of value/kPa
Ambient temperature dependence	1.40		% full scale/10K
Combined interference	0.45		% range
Dependence on voltage	0.50		% full scale/10V
Losses in the line (leak)	1.10		% of value
Uncertainty of calibration gas	2.83		% of value

Performance characteristic	RUN 1		Units
Standard deviation of repeatability at zero	use rep at span		mg/m^3
Standard deviation of repeatability at span level	0.00		mg/m^3
Lack of fit	0.04		mg/m^3
Drift	0.00		mg/m^3
Volume or pressure flow dependence	0.00		mg/m^3
Atmospheric pressure dependence	0.01		mg/m^3
Ambient temperature dependence	0.20		mg/m^3
Combined interference (from MCERTS Certificate)	0.04		mg/m^3
Dependence on voltage	0.06		mg/m^3
Losses in the line (leak)	0.07		mg/m^3
Uncertainty of calibration gas	0.18		mg/m^3

			RUN 1		Units
Measurement uncertainty		**Result**	11.23		mg/m^3
Combined uncertainty			0.29		mg/m^3
Expanded uncertainty	k =	1.96	0.58		mg/m^3
Uncertainty corrected to std conds. (O_2)			0.58		mg/m^3 (REF)

	RUN 1		Units
Expanded uncertainty (no O_2) - at 95% Confidence	5.13		% of Value
Expanded uncertainty (no O_2) - at 95% Confidence	2.30		% at ELV
Overall Allowable uncertainty (no O_2) - at 95% Confidence	15.0		% at ELV
Result of Compliance with Uncertainty Requirement	**N/A**		-

	RUN 1		Units
Expanded uncertainty (with O_2) - at 95% Confidence	5.64		% of Value
Expanded uncertainty (with O_2) - at 95% Confidence	3.31		% at ELV
Overall Allowable uncertainty (with O_2) - at 95% Confidence	15.2		% at ELV
Result of Compliance with Uncertainty Requirement	**COMPLIANT**		-

Requirement for SRM is that Uncertainty should be <15% of the value at the ELV, on a dry gas basis, or if O_2 correction is applied less than 15% + the uncertainty associated with the O_2 correction (using sqrt of sum squares to add uncertainty components).

OXIDES OF NITROGEN (as NO_2): RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1		Mean
Raw Concentration	ppm	234		234
Concentration	mg/m³	479		479
Uncertainty	±mg/m³	17.5		17.5
Mass Emission	g/hr	124274		124274
Uncertainty	±g/hr	7299		7299

General Sampling Information

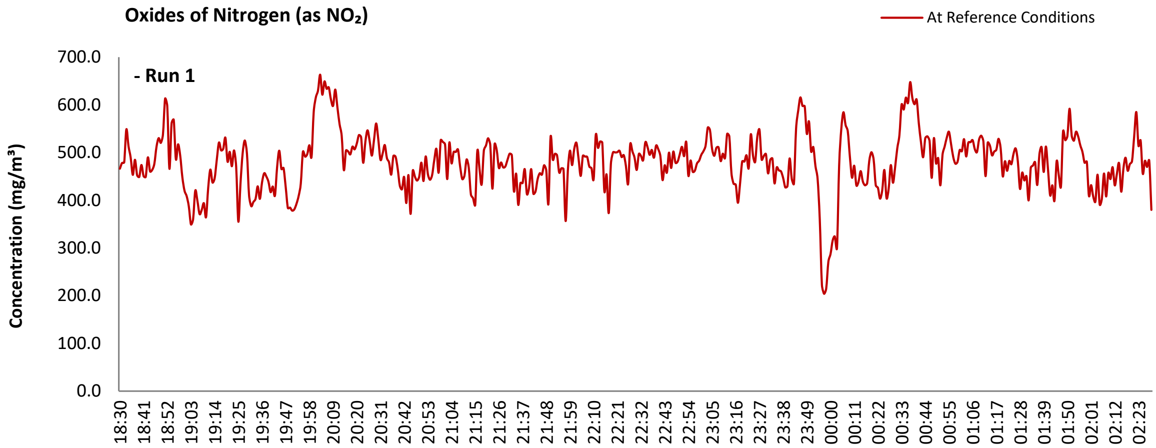
Parameter	Value	
Standard	EN 14792	
Technical Procedure	MD 039	
Probe Material	Titanium	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Date & Result of Last Converter Check	17/11/2023 - 100.2%	
Span Gas Type	Nitrogen Monoxide	
Span Gas Reference Number	12.0519	
Span Gas Expiry Date	24/03/2025	
Span Gas Start Pressure (bar)	120	
Gas Cylinder Concentration (ppm)	412.8	NOTE: Dilution performed to achieve correct span value
Span Gas Uncertainty (%)	2	
Zero Gas Type	Nitrogen (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	B2	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

OXIDES OF NITROGEN (as NO_2): DATA TREND

Graphical Trend of Data



OXIDES OF NITROGEN (as NO_2): SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1
Sampling Times	-	18:30 - 02:30
Sampling Dates	-	14/09/2023
Instrument Range	ppm	500
Span Gas Value	ppm	412.8

Quality Assurance

Conditioning Unit Temperature	Units	Run 1
Average Temperature	°C	3.0
Allowable Temperature	< °C	4.0
Temperature Acceptable	-	Yes

	Zero Drift	Units	Run 1
CAL 1	Zero at Analyser (Pre)	ppm	0.00
CAL 1	Zero at Analyser (Post)	ppm	-0.20
CAL 1	Zero Drift	ppm	-0.20
CAL 1	Zero Drift	%	0.05
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Zero Drift	± %	5.00
	Zero Drift Acceptable	-	Yes

	Span Drift	Units	Run 1
CAL 1	Span at Analyser (Pre)	ppm	412.80
CAL 1	Span at Analyser (Post)	ppm	432.00
CAL 1	Span Drift	ppm	19.20
CAL 1	Zero Adj. Span Drift	%	4.70
CAL 1	Drift Correction Applied	2-5%	Yes
	Allowable Span Drift	± %	5.00
	Span Drift Acceptable	-	Yes

Test Conditions	Units	Run 1
Run Ambient Temperature Range	°C	12 - 15

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1
There are no deviations associated with the sampling employed.	x

OXIDES OF NITROGEN (as NO_2): MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	RUN 1		Units
Limit value	500.0		mg/m³ (REF)
Allowable MU	10.0		%
Measured concentration	475.07		mg/m³ (STP, dry)
Ratio NO / NO_2	5		%
Range Used	500.0		ppm
Range Used [A]	1026.1		mg/m³
Cal gas conc.	412.8		ppm
Conversion	2.05		ppm to mg/m³
MCERTS Range [B]	205.0		mg/m³
Lower of [A] or [B]	205.0		mg/m³
Cal gas conc.	847.2		mg/m³

Performance characteristics	RUN 1		Units
Response time	31		seconds
Number of readings in measurement	480		-
Repeatability at zero	0.00		% full scale
Repeatability at span level	0.10		% full scale
Deviation from linearity	0.39		% of value
Zero drift	-0.05		% full scale
Span drift	0.00		% full scale
Volume or pressure flow dependence	0.10		% of full scale
Atmospheric pressure dependence	0.10		% of value/kPa
Ambient temperature dependence	0.04		% full scale/10K
Combined interference	0.63		% range
Dependence on voltage	-0.23		% full scale/10V
Converter efficiency	100.2		%
Losses in the line (leak)	0.19		% of value
Uncertainty of calibration gas blending	1.40		% of value
Uncertainty of calibration gas	2.00		% of value

Performance characteristic	RUN 1		Units
Standard deviation of repeatability at zero	use rep at span		mg/m³
Standard deviation of repeatability at span level	0.00		mg/m³
Lack of fit	0.46		mg/m³
Drift	0.00		mg/m³
Volume or pressure flow dependence	0.00		mg/m³
Atmospheric pressure dependence	0.06		mg/m³
Ambient temperature dependence	0.01		mg/m³
Combined interference (from MCERTS Certificate)	0.75		mg/m³
Dependence on voltage	-0.03		mg/m³
Converter efficiency	-0.03		mg/m³
Losses in the line (leak)	0.53		mg/m³
Uncertainty of calibration gas blending	3.84		mg/m³
Uncertainty of calibration gas	5.49		mg/m³

			RUN 1		Units
Measurement uncertainty		**Result**	475.07		mg/m³
Combined uncertainty			6.77		mg/m³
Expanded uncertainty	k =	1.96	13.28		mg/m³
Uncertainty corrected to std conds. (O_2)			13.40		mg/m³ (REF)

	RUN 1		Units
Expanded uncertainty (no O_2) - at 95% Confidence	2.79		% of Value
Expanded uncertainty (no O_2) - at 95% Confidence	2.66		% at ELV
Overall Allowable uncertainty (no O_2) - at 95% Confidence	10.0		% at ELV
Result of Compliance with Uncertainty Requirement	**N/A**		-

	RUN 1		Units
Expanded uncertainty (with O_2) - at 95% Confidence	3.66		% of Value
Expanded uncertainty (with O_2) - at 95% Confidence	3.57		% at ELV
Overall Allowable uncertainty (with O_2) - at 95% Confidence	10.3		% at ELV
Result of Compliance with Uncertainty Requirement	**COMPLIANT**		-

Requirement for SRM is that Uncertainty should be <10% of the value at the ELV, on a dry gas basis, or if O_2 correction is applied less than 10% + the uncertainty associated with the O_2 correction (using sqrt of sum squares to add uncertainty components).

CARBON MONOXIDE: RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1		Mean
Raw Concentration	ppm	222		222
Concentration	mg/m³	280		280
Uncertainty	±mg/m³	10.3		10.3
Mass Emission	g/hr	72603		72603
Uncertainty	±g/hr	4273		4273

General Sampling Information

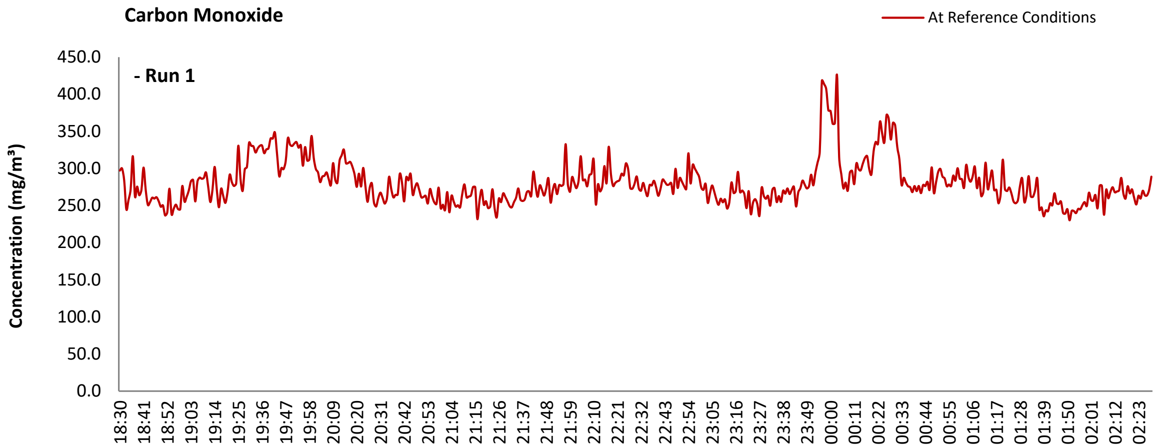
Parameter	Value	
Standard	EN 15058	
Technical Procedure	MD 039	
Probe Material	Titanium	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Type	Carbon Monoxide	
Span Gas Reference Number	12.0519	
Span Gas Expiry Date	24/03/2025	
Span Gas Start Pressure (bar)	120	
Gas Cylinder Concentration (ppm)	404.9	NOTE: Dilution performed to achieve correct span value
Span Gas Uncertainty (%)	2	
Zero Gas Type	Nitrogen (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	B2	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

CARBON MONOXIDE: DATA TREND

Graphical Trend of Data



CARBON MONOXIDE: SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1
Sampling Times	-	18:30 - 02:30
Sampling Dates	-	14/09/2023
Instrument Range	ppm	1000
Span Gas Value	ppm	404.9

Quality Assurance

Conditioning Unit Temperature	Units	Run 1
Average Temperature	°C	3.0
Allowable Temperature	< °C	4.0
Temperature Acceptable	-	Yes

	Zero Drift	Units	Run 1
CAL 1	Zero at Analyser (Pre)	ppm	0.00
CAL 1	Zero at Analyser (Post)	ppm	-1.00
CAL 1	Zero Drift	ppm	-1.00
CAL 1	Zero Drift	%	0.25
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Zero Drift	± %	5.00
	Zero Drift Acceptable	-	Yes

	Span Drift	Units	Run 1
CAL 1	Span at Analyser (Pre)	ppm	404.90
CAL 1	Span at Analyser (Post)	ppm	407.00
CAL 1	Span Drift	ppm	2.10
CAL 1	Zero Adj. Span Drift	%	0.77
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Span Drift	± %	5.00
	Span Drift Acceptable	-	Yes

Test Conditions	Units	Run 1
Run Ambient Temperature Range	°C	12 - 15

Method Deviations

Nature of Deviation	Run Number	
(x = deviation applies to the associated run)	1	
There are no deviations associated with the sampling employed.	x	

CARBON MONOXIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	RUN 1		Units
Limit value	1500.0		mg/m³ (REF)
Allowable MU	6.0		%
Measured concentration	277.54		mg/m³ (STP, dry)
Range Used	1000.0		ppm
Range Used [A]	1249.2		mg/m³
Cal gas conc.	404.9		ppm
Conversion	1.25		ppm to mg/m³
MCERTS Range [B]	75.0		mg/m³
Lower of [A] or [B]	75.0		mg/m³
Cal gas conc.	505.8		mg/m³

Performance characteristics	RUN 1		Units
Response time	28		seconds
Number of readings in measurement	480		-
Repeatability at zero	0.10		% full scale
Repeatability at span level	0.20		% full scale
Deviation from linearity	0.41		% of value
Zero drift	-0.25		% full scale
Span drift	0.77		% full scale
Volume or pressure flow dependence	0.10		% of full scale
Atmospheric pressure dependence	0.22		% of value/kPa
Ambient temperature dependence	-0.20		% full scale/10K
Combined interference	-0.48		% range
Dependence on voltage	-0.35		% full scale/10V
Losses in the line (leak)	0.47		% of value
Uncertainty of calibration gas blending	1.40		% of value
Uncertainty of calibration gas	2.00		% of value

Performance characteristic	RUN 1		Units
Standard deviation of repeatability at zero	use rep at span		mg/m³
Standard deviation of repeatability at span level	0.01		mg/m³
Lack of fit	0.18		mg/m³
Drift	0.00		mg/m³
Volume or pressure flow dependence	0.00		mg/m³
Atmospheric pressure dependence	0.05		mg/m³
Ambient temperature dependence	-0.03		mg/m³
Combined interference (from MCERTS Certificate)	-0.21		mg/m³
Dependence on voltage	-0.04		mg/m³
Losses in the line (leak)	0.75		mg/m³
Uncertainty of calibration gas blending	2.24		mg/m³
Uncertainty of calibration gas	3.20		mg/m³

			RUN 1		Units
Measurement uncertainty		Result	277.54		mg/m³
Combined uncertainty			3.99		mg/m³
Expanded uncertainty	k =	1.96	7.83		mg/m³
Uncertainty corrected to std conds. (O_2)			7.90		mg/m³ (REF)

	RUN 1		Units
Expanded uncertainty (no O_2) - at 95% Confidence	2.82		% of Value
Expanded uncertainty (no O_2) - at 95% Confidence	0.52		% at ELV
Overall Allowable uncertainty (no O_2) - at 95% Confidence	6.0		% at ELV
Result of Compliance with Uncertainty Requirement	**N/A**		-

	RUN 1		Units
Expanded uncertainty (with O_2) - at 95% Confidence	3.68		% of Value
Expanded uncertainty (with O_2) - at 95% Confidence	2.41		% at ELV
Overall Allowable uncertainty (with O_2) - at 95% Confidence	6.4		% at ELV
Result of Compliance with Uncertainty Requirement	**COMPLIANT**		-

Requirement for SRM is that Uncertainty should be <6% of the value at the ELV, on a dry gas basis, or if O_2 correction is applied less than 6% + the uncertainty associated with the O_2 correction (using sqrt of sum squares to add uncertainty components).

CARBON DIOXIDE: RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Sample Runs

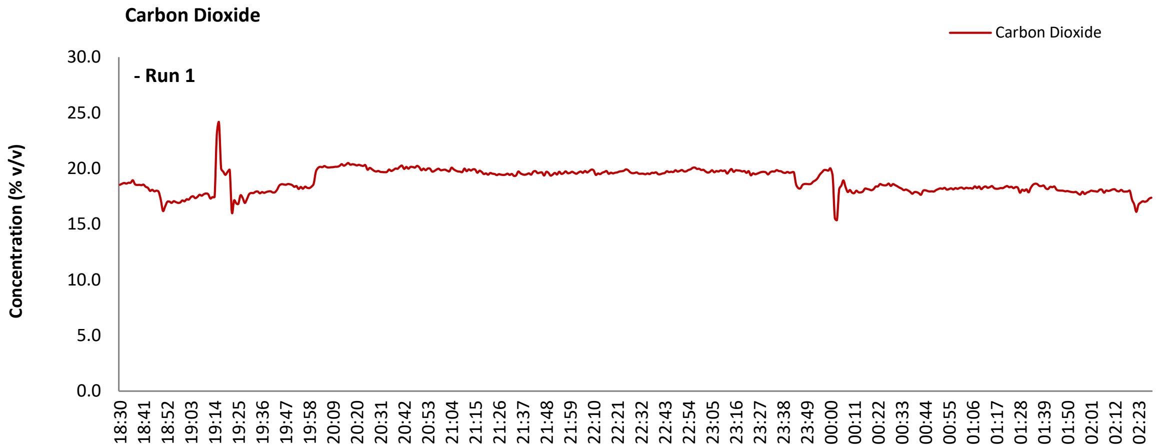
Parameter	Units	Run 1		Mean
Concentration	% v/v	18.9		18.9
Uncertainty	±% v/v	0.48		0.48

General Sampling Information

Parameter	Value	
Standard	CEN/TS 17405	
Technical Procedure	MD 039	
Probe Material	Titanium	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Type	Carbon Dioxide	
Span Gas Reference Number	6.0086	
Span Gas Expiry Date	07/06/2028	
Span Gas Start Pressure (bar)	120	
Gas Cylinder Concentration (% v/v)	16.01	
Span Gas Uncertainty (%)	2.00	
Zero Gas Type	Nitrogen (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	B2	

CARBON DIOXIDE: DATA TREND

Graphical Trend of Data



CARBON DIOXIDE: SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1
Sampling Times	-	18:30 - 02:30
Sampling Dates	-	14/09/2023
Instrument Range	% v/v	20
Span Gas Value	% v/v	16.0

Quality Assurance

Conditioning Unit Temperature	Units	Run 1
Average Temperature	°C	3.0
Allowable Temperature	< °C	4.0
Temperature Acceptable	-	Yes

	Zero Drift	Units	Run 1
CAL 1	Zero Down Sampling Line (Pre)	% v/v	0.00
CAL 1	Zero Down Sampling Line (Post)	% v/v	-0.07
CAL 1	Zero Drift	% v/v	-0.07
CAL 1	Zero Drift	%	0.44
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Zero Drift	± %	5.00
	Zero Drift Acceptable	-	Yes

	Span Drift	Units	Run 1
CAL 1	Span Down Sampling Line (Pre)	% v/v	15.98
CAL 1	Span Down Sampling Line (Post)	% v/v	15.97
CAL 1	Span Drift	% v/v	-0.01
CAL 1	Zero Adj. Span Drift	%	0.19
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Span Drift	± %	5.00
	Span Drift Acceptable	-	Yes

Test Conditions	Units	Run 1
Run Ambient Temperature Range	°C	12 - 15

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1
There are no deviations associated with the sampling employed.	x

CARBON DIOXIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	RUN 1		Units
Limit value	N/A		%vol
Allowable MU	25.0		%
Measured concentration	18.88		%vol
Range Used	20.0		%vol
Cal gas conc.	16.0		%vol

Performance characteristics	RUN 1		Units
Response time	29		seconds
Number of readings in measurement	480		-
Repeatability at zero	0.00		% full scale
Repeatability at span level	0.10		% full scale
Deviation from linearity	0.85		% of value
Zero drift	-0.44		% full scale
Span drift	0.19		% full scale
Volume or pressure flow dependence	0.10		% of full scale
Atmospheric pressure dependence	0.30		% of value/kPa
Ambient temperature dependence	-0.20		% full scale/10K
Combined interference	0.00		% range
Dependence on voltage	0.40		% full scale/10V
Losses in the line (leak)	0.19		% of value
Uncertainty of calibration gas	2.00		% of value

Performance characteristic	RUN 1		Units
Standard deviation of repeatability at zero	use rep at span		%vol
Standard deviation of repeatability at span level	0.00		%vol
Lack of fit	0.10		%vol
Drift	0.00		%vol
Volume or pressure flow dependence	0.00		%vol
Atmospheric pressure dependence	0.02		%vol
Ambient temperature dependence	-0.03		%vol
Combined interference (from MCERTS Certificate)	0.00		%vol
Dependence on voltage	0.05		%vol
Losses in the line (leak)	0.02		%vol
Uncertainty of calibration gas	0.22		%vol

			RUN 1		Units
Measurement uncertainty		**Result**	18.88		%vol
Combined uncertainty			0.25		%vol
Expanded uncertainty	k =	1.96	0.48		%vol

	RUN 1		Units
Expanded uncertainty (no O_2) - at 95% Confidence	2.56		% of Value

OXYGEN: RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Sample Runs

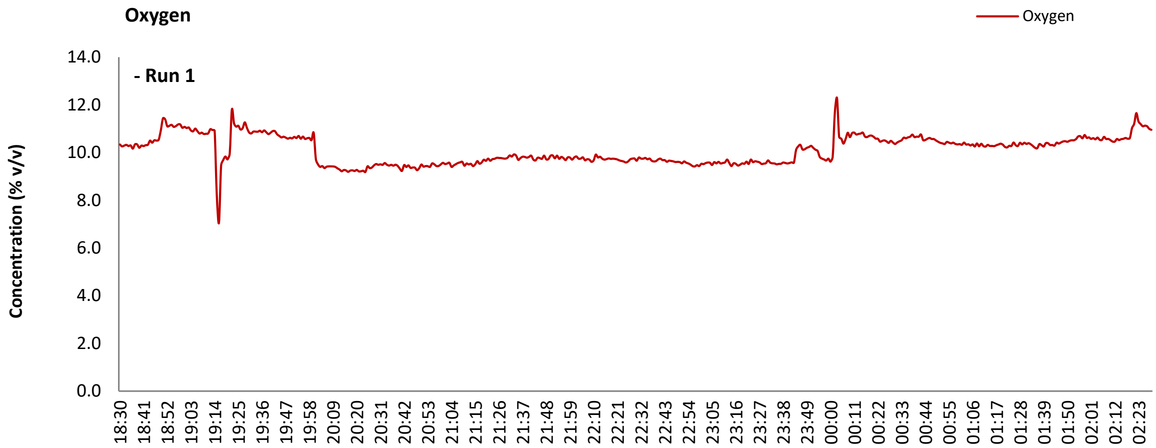
Parameter	Units	Run 1		Mean
Concentration	% v/v	10.1		10.1
Uncertainty	±% v/v	0.24		0.24

General Sampling Information

Parameter	Value	
Standard	EN 14789	
Technical Procedure	MD 039	
Probe Material	Titanium	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Type	Synthetic Air (5 Grade)	
Span Gas Reference Number	11.0553	
Span Gas Expiry Date	17/08/2027	
Span Gas Start Pressure (bar)	80	
Gas Cylinder Concentration (% v/v)	21.17	NOTE: Dilution performed to achieve correct span value
Span Gas Uncertainty (%)	2	
Zero Gas Type	Nitrogen (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	B2	

OXYGEN: DATA TREND

Graphical Trend of Data



OXYGEN: SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1
Sampling Times	-	18:30 - 02:30
Sampling Dates	-	14/09/2023
Instrument Range	% v/v	25.0
Span Gas Value	% v/v	10.0

Quality Assurance

Conditioning Unit Temperature	Units	Run 1
Average Temperature	°C	3.0
Allowable Temperature	< °C	4.0
Temperature Acceptable	-	Yes

	Zero Drift	Units	Run 1
CAL 1	Zero at Analyser (Pre)	% v/v	0.00
CAL 1	Zero at Analyser (Post)	% v/v	-0.04
CAL 1	Zero Drift	% v/v	-0.04
CAL 1	Zero Drift	%	0.40
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Zero Drift	± %	5.00
	Zero Drift Acceptable	-	Yes

	Span Drift	Units	Run 1
CAL 1	Span at Analyser (Pre)	% v/v	10.10
CAL 1	Span at Analyser (Post)	% v/v	10.05
CAL 1	Span Drift	% v/v	-0.05
CAL 1	Zero Adj. Span Drift	%	0.10
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Span Drift	± %	5.00
	Span Drift Acceptable	-	Yes

Test Conditions	Units	Run 1
Run Ambient Temperature Range	°C	12 - 15

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1
There are no deviations associated with the sampling employed.	x

OXYGEN: MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	RUN 1		Units
Limit value	N/A		%vol
Allowable MU	6.0		%
Measured concentration	10.10		%vol
Range Used	25.0		%vol
Cal gas conc.	21.2		%vol

Performance characteristics	RUN 1		Units
Response time	41		seconds
Number of readings in measurement	480		-
Repeatability at zero	0.02		% full scale
Repeatability at span level	0.02		% full scale
Deviation from linearity	0.04		% of value
Zero drift	-0.40		% full scale
Span drift	-0.10		% full scale
Volume or pressure flow dependence	0.10		% of full scale
Atmospheric pressure dependence	0.19		% of value/kPa
Ambient temperature dependence	-0.21		% full scale/10K
Combined interference	0.00		% range
Dependence on voltage	0.02		% full scale/10V
Losses in the line (leak)	0.00		% of value
Uncertainty of calibration gas	2.00		% of value

Performance characteristic	RUN 1		Units
Standard deviation of repeatability at zero	use rep at span		%vol
Standard deviation of repeatability at span level	0.00		%vol
Lack of fit	0.01		%vol
Drift	0.00		%vol
Volume or pressure flow dependence	0.00		%vol
Atmospheric pressure dependence	0.01		%vol
Ambient temperature dependence	-0.03		%vol
Combined interference (from MCERTS Certificate)	0.00		%vol
Dependence on voltage	0.00		%vol
Losses in the line (leak)	0.00		%vol
Uncertainty of calibration gas	0.12		%vol

			RUN 1		Units
Measurement uncertainty		**Result**	10.10		%vol
Combined uncertainty			0.12		%vol
Expanded uncertainty	k =	1.96	0.24		%vol

	RUN 1		Units
Expanded uncertainty (no O_2) - at 95% Confidence	2.36		% of Value
Result of Compliance with Uncertainty Requirement	**COMPLIANT**		-

Requirement for SRM is that Uncertainty should be 0.3% vol absolute or 6% relative whichever is the lower, on a dry gas basis. Source, EN 14789.

VERSION HISTORY

Version Number	Record of changes made within this version of the document
V1	The original document issued to the client

Certificate of Analysis

Report No.:	**23-10323-1**
Issue No.:	**1**
Date of Issue	**10/10/2023**
Customer Details:	Element Materials Technology Environmental UK Ltd (Ireland), Unit D8, North City Business Park, North Road, Finglas, Dublin 11, , Ireland
Customer Contact:	Mateusz Terlecki
Customer Order No.:	E130N21000011 EMT07135
Customer Reference:	E130N21000011
Quotation Reference:	Q23-05562
Description:	5 liquid samples
Date Received:	27/09/2023
Date Started:	27/09/2023
Date Completed:	09/10/2023
Test Methods:	Details available on request (refer to SOP code against relevant result/s)
Notes:	None

Approved By: **Joanne Dewhurst, Operational Manager**

This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service.
This certificate shall not be reproduced except in full without the prior written approval of the laboratory.
Observations and interpretations are outside of the scope of UKAS accreditation.
Results reported herein relate only to the items supplied to the laboratory for testing.
Results on an Interim Report are not dry-weight corrected.
Where the laboratory is not responsible for the sampling, results apply to the sample(s) as they were received.
The laboratory shall not be responsible for any information that is supplied by the customer that may affect the validity of results.

UKAS TESTING 0605

MCERTS THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME

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RPS Environmental Management Limited trading as RPS Laboratories. Registered in England No. 01756175.
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A member of the RPS Group plc. Terms and conditions apply - copy on request

Results Summary

Report No.: 23-10323-1

Customer Reference: E130N21000011

Customer Order No: E130N21000011 EMT07135

					Customer Sample No	**3.1 EMT07135-B/IMP ABC/NH3/A2-01**	**3.2 EMT07135-R1/IMP AB/NH3/A2-01**	**3.3 EMT07135-R1/IMP C/NH3/A2-01**	**3.4 EMT07135-R2/IMP ABC/NH3/A2-01**	**3.5 EMT07135-R3/IMP ABC/NH3/A2-01**
					RPS Sample No	204988	204989	204990	204991	204992
					Sample Matrix	SOLUTION	SOLUTION	SOLUTION	SOLUTION	SOLUTION
					Sampling Date	15/09/2023	15/09/2023	15/09/2023	15/09/2023	15/09/2023
Determinand	**CAS No**	**Codes**	**SOP**	**RL**	**Units**					
volume of sample supplied		U	N/A	n/a	ml	310	287	137	420	412
ammonia	7664-41-7	UM	A6	0.1	ug/mL	< 0.1	0.3	< 0.1	4.2	8.1

Deviating Samples

Report No.: 23-10323-1

Customer Reference: E130N21000011

Customer Order No: E130N21000011 EMT07135

Our policy on Deviating Samples has been implemented in accordance with UKAS Policy on Deviating Samples (TPS63).
RPS is not responsible for the integrity of samples as received, unless RPS personnel performed the sampling. Samples submitted may be declared to be deviating.
Where applicable the analysis method remains UKAS accredited, however results reported for a deviating sample may be compromised.
Where no sampling date was supplied, samples have been declared to be deviating. If the date can be supplied, results may be reissued if assessed not deviating.
Where the sample container used was unsuitable or broken, the sample is flagged as deviating and re-sampling/re-submisson may be required.

RPS No.	Customer No.	Customer ID	Date Sampled	Containers Received	Deviating	Reason for Deviation
204988	3.1 EMT07135-B/IMP ABC/NH3/A2-01		15/09/2023	Container	No	
204989	3.2 EMT07135-R1/IMP AB/NH3/A2-01		15/09/2023	Container	No	
204990	3.3 EMT07135-R1/IMP C/NH3/A2-01		15/09/2023	Container	No	
204991	3.4 EMT07135-R2/IMP ABC/NH3/A2-01		15/09/2023	Container	No	
204992	3.5 EMT07135-R3/IMP ABC/NH3/A2-01		15/09/2023	Container	No	

Report No.: 23-10323-1

Key Code	Description
N	Not Accredited Test
U	UKAS Accredited Test - UKAS accreditation is only implied if the report carries the UKAS logo
UF	UKAS Flexible Scope Test
M	MCERTS Accredited Test - MCERTS accreditation is only implied if the report carries the MCERTS logo
O	Marine Management Organisation (MMO) Validated
SN	Subcontracted to approved laboratory not accredited for the test
SU	Subcontracted to approved laboratory UKAS Accredited for the test
SM	Subcontracted to approved laboratory MCERTS/UKAS Accredited for the test
SIN	Subcontracted to internal RPS Group laboratory not accredited for the test
SIU	Subcontracted to internal RPS Group laboratory UKAS Accredited for the test
SIM	Subcontracted to internal RPS Group laboratory MCERTS/UKAS Accredited for the test
I/S (in results)	Insufficient Sample
U/S (in results)	Unsuitable Sample
S/C (in results)	See Comments
ND (in results)	Not Detected
L (in results)	Result is outside normal limits

Please note that all samples will be destroyed 4 WEEKS after the report has been issued, with the exception of asbestos samples.

Note: Sample retention may be subject to agreement with the customer for particular projects

Certificate Notes	Description
Note 1	This test report shall not be reproduced except in full, without written approval of the Laboratory.
Note 2	Unless otherwise stated, results are not corrected for analytical recoveries.
Note 3	Samples were taken by the customer and, unless otherwise stated, sampling locations were not supplied.
Note 4	Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.
Note 5	Unless otherwise stated, method D9 conditioning temperatures are 180°C for pre-weigh and 160°C for re-weigh.
Note 6	The PDF version of the certificate is the definitive copy and the Excel version is uncontrolled and provided for information only.
Note 7	For asbestos analysis, all records, communications and reports pertaining to the analysis are retained for five years from the date of issue of the report. The sample analysed is retained for six months.
Note 8	For asbestos analysis, method of analysis used is stereo microscopy, polarised light microscopy and dispersion staining.

Note: Where the following information is included in this certificate, it has usually been supplied by the customer: Customer Sample ID, Sample Location, Sampling Date and Sample Air Volumes. The laboratory shall not be responsible for any information that is supplied by the customer that may affect the validity of results.

Report No.: 23-10323-1

Determinand	CAS No	Media	SOP	% Recovery	% Uncertainty
acetaldehyde	75-07-0	tube	A40	98	16.2
benzaldehyde	100-52-7	tube	A40	100	19.4
butyraldehyde	123-72-8	tube	A40	92	11.5
formaldehyde	50-00-0	tube	A40	97	12.8
hexanal	66-25-1	tube	A40	89	11
propionaldehyde	123-38-6	tube	A40	96	12.6
valeraldehyde	110-62-3	tube	A40	93	12.3
ammonia	7664-41-7	sulphuric scid solution	A6	n/a	8.9
chlorine	7782-50-5	sodium hydroxide solution	C27	n/a	15.2
hydrogen bromide	10035-10-6	sulphuric acid solution	C27	n/a	10.9
hydrogen chloride	7647-01-0	deionised water	C27	n/a	7.9
hydrogen chloride	7647-01-0	sulphuric acid solution	C27	n/a	13.3
hydrogen fluoride	7664-3-3	sodium hydroxide solution	C27	n/a	7.9
sulphur dioxide	7446-09-5	hydrogen peroxide solution	C27	n/a	7.7
nitrogen oxide	10102-43-9	potassium permanganate solution	C27	n/a	11.7
particulates	n/a	filter	D9	n/a	12.2
particulates	n/a	wash solution	D9	n/a	14.8
formaldehyde	50-00-0	deionised water	M103	n/a	23.7
2,4- & 2,6-toluene diisocyanate (TDI)	n/a	filter	M119	n/a	8.6
hexamethylene diisocyanate (HDI)	822-06-0	filter	M119	n/a	5.6
methylene diphenyl diisocyanate (MDI)	101-68-8	filter	M119	n/a	11.8
hydrogen sulphide	7783-06-4	zinc acetate solution	M120	n/a	4.2
antimony	7440-36-0	filter	M31	n/a	10.3
arsenic	7440-38-2	filter	M31	n/a	17.1
cadmium	7440-43.9	filter	M31	n/a	12.1
chromium	7440-47-3	filter	M31	n/a	17.1
cobalt	7440-48-4	filter	M31	n/a	13.1
copper	7440-50-8	filter	M31	n/a	14
lead	7439-92-1	filter	M31	n/a	9.8
manganese	7439-96-5	filter	M31	n/a	17.5
nickel	7440-02-0	filter	M31	n/a	14.4
thallium	7440-28-0	filter	M31	n/a	15.3
tin	7440-31-5	filter	M31	n/a	18.5
vanadium	7440-62-2	filter	M31	n/a	12.1
zinc	7440-66-6	filter	M31	n/a	15.2
antimony	7440-36-0	nitric acid wash	M31	n/a	10.3
arsenic	7440-38-2	nitric acid wash	M31	n/a	17.1
cadmium	7440-43-9	nitric acid wash	M31	n/a	12.1
chromium	7440-47-3	nitric acid wash	M31	n/a	17.1
cobalt	7440-48-4	nitric acid wash	M31	n/a	13.1
copper	7440-50-8	nitric acid wash	M31	n/a	14
lead	7439-92-1	nitric acid wash	M31	n/a	9.8
manganese	7439-96-5	nitric acid wash	M31	n/a	17.5
nickel	7440-02-0	nitric acid wash	M31	n/a	14.4
selenium	7782-49-2	nitric acid wash	M31	n/a	15.1
thallium	7440-28-0	nitric acid wash	M31	n/a	15.3
tin	7440-31-5	nitric acid wash	M31	n/a	18.5
vanadium	7440-62-2	nitric acid wash	M31	n/a	12.1
zinc	7440-66-6	nitric acid wash	M31	n/a	15.2
antimony	7440-36-0	nitric/peroxide solution	M31	n/a	5.9
arsenic	7440-38-2	nitric/peroxide solution	M31	n/a	6.8
cadmium	7440-43-9	nitric/peroxide solution	M31	n/a	6.3
chromium	7440-47-3	nitric/peroxide solution	M31	n/a	7.2
cobalt	7440-48-4	nitric/peroxide solution	M31	n/a	5.2
copper	7440-50-8	nitric/peroxide solution	M31	n/a	6.8
lead	7439-92-1	nitric/peroxide solution	M31	n/a	8.6
manganese	7439-96-5	nitric/peroxide solution	M31	n/a	9.6
nickel	7440-02-0	nitric/peroxide solution	M31	n/a	5.5
selenium	7782-49-2	nitric/peroxide solution	M31	n/a	8.7
thallium	7440-28-0	nitric/peroxide solution	M31	n/a	7.7
tin	7440-31-5	nitric/peroxide solution	M31	n/a	5.8
vanadium	7440-62-2	nitric/peroxide solution	M31	n/a	6.7
zinc	7440-66-6	nitric/peroxide solution	M31	n/a	11.9
1,2,4-trimethylbenzene	95-63-6	tube	O8	88	8.1
1,3,5-trimethylbenzene	108-67-8	tube	O8	92	7.7
2-ethyltoluene	611-14-3	tube	O8	91	8.4
3- & 4-ethyltoluene	n/a	tube	O8	91	8.4
benzene	71-43-2	tube	O8	90	13.9
butyl acetate	123-86-4	tube	O8	90	10.3
decane	124-18-5	tube	O8	97	6.7
dichloromethane	75-09-2	tube	O8	88	24
ethyl acetate	141-78-6	tube	O8	n/a	n/a
ethyl benzene	100-41-4	tube	O8	92	9.8
heptane	142-82-5	tube	O8	94	10.5
hexane	110-54-3	tube	O8	n/a	n/a
limonene	138-86-3	tube	O8	93	13
m- & p-xylene	n/a	tube	O8	90	9.3
methyl isobutyl ketone (MIBK)	108-10-1	tube	O8	86	10
methyl tert-butyl ether (MTBE)	1634-04-4	tube	O8	92	15
o-xylene	95-47-6	tube	O8	86	9.9
propylbenzene	103-65-1	tube	O8	92	7.5
tetrachloroethylene	127-18-4	tube	O8	91	9.3
tetrahydrofuran (THF)	109-99-9	tube	O8	87	14.7
toluene	108-88-3	tube	O8	89	10.7
trichloroethylene	79-01-6	tube	O8	91	10.6
m- & p-cresol	n/a	tube	P1	n/a	11
m- & p-xylenol	n/a	tube	P1	n/a	11.9
o-cresol	95-48-7	tube	P1	n/a	10.8
o-xylenol	526-75-0	tube	P1	n/a	12
phenol	108-95-2	tube	P1	n/a	10.4

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Stack Emissions Testing Report Commissioned by
Irish Cement Ltd

Installation Name & Address
Irish Cement Ltd
Limerick Works
Castlemungret
County Limerick

Industrial Emissions Licence: P0029-06

Stack Reference
A2-01 Kiln 6

Dates of the Monitoring Campaign
14th - 23rd November 2023

Job Reference Number
EMT06515

Report Written by
Donal O Faogain Senior Team Leader MCERTS Level 2 MM13 1259 TE1 TE2 TE3 TE4

Report Approved by
James Magann Operations Manager MCERTS Level 2 MM15 1330 TE1 TE2 TE3 TE4

Report Date
16th January 2024

Version
Version 2

Signature of Report Approver

CONTENTS

Opinions and interpretations expressed herein are outside the scope of Element Ireland's ISO 17025 accreditation.

This test report shall not be reproduced, except in full, without the written approval of Element Ireland.

The testing performed fully meets the technical requirements in Irish EPA Guidance Note, AG2.

This version of the test report supersedes the previous version of the test report. Please destroy all previous versions to ensure no confusion arises from having multiple test reports in existence.

MONITORING OBJECTIVES

Irish Cement Ltd, Limerick
A2-01 Kiln 6
14th - 23rd November 2023

Overall Aim of the Monitoring Campaign

Element Ireland were commissioned by Irish Cement Ltd to carry out stack emissions testing on the A2-01 Kiln 6 at Limerick.

The aim of the monitoring campaign was to demonstrate compliance with a set of emission limit values (ELVs) as specified in the Site's Licence.

Special Requirements

There were no special requirements.

Target Parameters

Total Particulate Matter, Sulphur Dioxide, Cadmium & Thallium, Heavy Metals, Mercury, Dioxins & Furans, PCBs, Hydrogen Chloride, Hydrogen Fluoride, Ammonia, Total VOCs (as Carbon), Oxides of Nitrogen (as NO_2), Carbon Monoxide

Executive Summary

MONITORING RESULTS

Irish Cement Ltd, Limerick
A2-01 Kiln 6
14th - 23rd November 2023

where MU = Measurement Uncertainty associated with the Result

Parameter	Concentration				Mass Emission			
	Units	Result	MU +/-	Limit	Units	Result	MU +/-	Limit
Total Particulate Matter [1]	mg/m^3	0.24	0.56	10	g/hr	75.93	179.21	-
Sulphur Dioxide [1]	mg/m^3	3.42	0.26	50	g/hr	1085.43	96.35	-
Cadmium & Thallium [1]	mg/m^3	0.002	0.0003	0.05	g/hr	0.50	0.09	-
Heavy Metals [1]	mg/m^3	0.092	0.022	0.5	g/hr	29.14	7.05	-
Mercury	mg/m^3	0.010	0.002	0.05	g/hr	3.07	0.74	-
Dioxins & Furans Upper Limit (worst case where <LOD = LOD)								
Dioxins & Furans (NATO I-TEQ) [1]	ng/m^3	0.0113	0.0024	0.1	µg/hr	3.58	0.76	-
Dioxins & Furans (WHO TEQ Humans / Mammals) [1]	ng/m^3	0.0117	0.0024	-	µg/hr	3.73	0.80	-
Dioxins & Furans (WHO TEQ Fish) [1]	ng/m^3	0.0104	0.0022	-	µg/hr	3.29	0.70	-
Dioxins & Furans (WHO TEQ Birds) [1]	ng/m^3	0.0514	0.0107	-	µg/hr	16.32	3.49	-
Dioxins & Furans Lower Limit (best case where <LOD = 0)								
Dioxins & Furans (NATO I-TEQ) [1]	ng/m^3	0.0060	0.0012	-	µg/hr	1.89	0.40	-
Dioxins & Furans (WHO TEQ Humans / Mammals) [1]	ng/m^3	0.0055	0.0011	-	µg/hr	1.75	0.37	-
Dioxins & Furans (WHO TEQ Fish) [1]	ng/m^3	0.0039	0.0008	-	µg/hr	1.23	0.26	-
Dioxins & Furans (WHO TEQ Birds) [1]	ng/m^3	0.0450	0.0094	-	µg/hr	14.29	3.05	-
PCBs Upper Limit (worst case where <LOD = LOD)								
PCBs (WHO TEQ Humans / Mammals) [1]	ng/m^3	0.006338	0.001321	-	µg/hr	2.01	0.429	-
PCBs (WHO TEQ Fish) [1]	ng/m^3	0.000388	0.000081	-	µg/hr	0.12	0.026	-
PCBs (WHO TEQ Birds) [1]	ng/m^3	0.029995	0.006252	-	µg/hr	9.52	2.032	-
PCBs Lower Limit (best case where <LOD = 0)								
PCBs (WHO TEQ Humans / Mammals) [1]	ng/m^3	0.002451	0.000511	-	µg/hr	0.78	0.166	-
PCBs (WHO TEQ Fish) [1]	ng/m^3	0.000184	0.000038	-	µg/hr	0.06	0.012	-
PCBs (WHO TEQ Birds) [1]	ng/m^3	0.022838	0.004761	-	µg/hr	7.25	1.547	-
Hydrogen Chloride [1]	mg/m^3	0.42	0.03	10	g/hr	133.66	11.22	-
Hydrogen Fluoride [1]	mg/m^3	0.11	0.01	1	g/hr	34.49	4.84	-
Ammonia [1]	mg/m^3	20.82	3.87	50	g/hr	6607.23	1266.77	-
Total VOCs (as Carbon) [1]	mg/m^3	21.82	1.03	25	g/hr	6927.2	456.4	-
Oxides of Nitrogen (as NO_2) [1]	mg/m^3	480.69	17.87	500	g/hr	152575.64	9020.21	-
Carbon Monoxide [1]	mg/m^3	174.45	6.62	1500	g/hr	55372.92	3301.48	-
Carbon Dioxide	% v/v	**Dry** 16.72	0.53					
Oxygen	% v/v	**Dry** 11.35	0.27					
Water Vapour	% v/v	10.7	0.5					
Stack Gas Temperature	°C	152.0						
Stack Gas Velocity	m/s	34.1	0.27					
Volumetric Flow Rate (ACTUAL)	m^3/hr	651487	29953					
Volumetric Flow Rate (REF) [1]	m^3/hr	317408	14593	500000				

NOTE: VOLUMETRIC FLOW RATE & VELOCITY DATA TAKEN FROM THE PRELIMINARY VELOCITY TRAVERSE.

[1] Reference Conditions (REF) are: 273K, 101.3kPa, dry gas, 10% oxygen.

MONITORING DATE(S) & TIMES

Irish Cement Ltd, Limerick
A2-01 Kiln 6
14th - 23rd November 2023

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
Total Particulate Matter	R1	mg/m³	0.24	g/hr	75.93	20/11/2023	13:19 - 14:19	60
Oxygen (TPM/SO2)	R2	% v/v	11.1			20/11/2023	13:19 - 14:19	60
Water Vapour (TPM/SO2)	R2	% v/v	10.7			20/11/2023	13:19 - 14:19	60
Total Particulate Matter	R2	mg/m³	0.24	g/hr	75.93	21/11/2023	11:00 - 12:04	60
Oxygen (TPM/SO2)	R2	% v/v	11.6			21/11/2023	11:00 - 12:04	60
Water Vapour (TPM/SO2)	R2	% v/v	12.8			21/11/2023	11:00 - 12:04	60
Total Particulate Matter	R3	mg/m³	0.24	g/hr	75.93	22/11/2023	11:00 - 12:02	60
Oxygen (TPM/SO2)	R2	% v/v	11.2			22/11/2023	11:00 - 12:02	60
Water Vapour (TPM/SO2)	R2	% v/v	10.3			22/11/2023	11:00 - 12:02	60
Sulphur Dioxide	R1	mg/m³	1.71	g/hr	543.18	20/11/2023	13:19 - 14:19	60
Sulphur Dioxide	R2	mg/m³	5.12	g/hr	1624.68	21/11/2023	11:00 - 12:04	60
Sulphur Dioxide	R3	mg/m³	3.43	g/hr	1088.44	22/11/2023	11:00 - 12:02	60
Cadmium & Thallium	R1	mg/m³	0.002	g/hr	0.75	20/11/2023	11:53 - 12:58	60
Cadmium & Thallium	R2	mg/m³	0.001	g/hr	0.41	21/11/2023	12:21 - 13:25	60
Cadmium & Thallium	R3	mg/m³	0.001	g/hr	0.34	22/11/2023	09:50 - 10:52	60
Heavy Metals	R1	mg/m³	0.244	g/hr	77.57	20/11/2023	11:53 - 12:58	60
Oxygen (Metals)	R2	% v/v	11.3			20/11/2023	11:53 - 12:58	60
Water Vapour (Metals)	R2	% v/v	9.6			20/11/2023	11:53 - 12:58	60
Heavy Metals	R2	mg/m³	0.014	g/hr	4.55	21/11/2023	12:21 - 13:25	60
Oxygen (Metals)	R2	% v/v	11.2			21/11/2023	12:21 - 13:25	60
Water Vapour (Metals)	R2	% v/v	11.2			21/11/2023	12:21 - 13:25	60
Heavy Metals	R3	mg/m³	0.017	g/hr	5.29	22/11/2023	09:50 - 10:52	60
Oxygen (Metals)	R2	% v/v	11.0			22/11/2023	09:50 - 10:52	60
Water Vapour (Metals)	R2	% v/v	10.8			22/11/2023	09:50 - 10:52	60
Mercury	R1	mg/m³	0.007	g/hr	2.33	20/11/2023	14:35 - 15:38	60
Oxygen (Hg)	R2	% v/v	11.5			20/11/2023	14:35 - 15:38	60
Water Vapour (Hg)	R2	% v/v	10.2			20/11/2023	14:35 - 15:38	60
Mercury	R2	mg/m³	0.012	g/hr	3.72	21/11/2023	09:30 - 10:35	60
Oxygen (Hg)	R2	% v/v	11.5			21/11/2023	09:30 - 10:35	60
Water Vapour (Hg)	R2	% v/v	9.4			21/11/2023	09:30 - 10:35	60
Mercury	R3	mg/m³	0.010	g/hr	3.16	22/11/2023	12:13 - 13:15	60
Oxygen (Hg)	R2	% v/v	11.3			22/11/2023	12:13 - 13:15	60
Water Vapour (Hg)	R2	% v/v	10.1			22/11/2023	12:13 - 13:15	60
Dioxins & Furans (NATO)	R1	ng/m³	0.0014	µg/hr	0.4	20/11/2023	10:25 - 16:30	360
Oxygen (Dioxins/PCBs)	R2	% v/v	11.2			20/11/2023	10:25 - 16:30	60
Water Vapour (Dioxins/PCBs)	R2	% v/v	11.3			20/11/2023	10:25 - 16:30	60
Dioxins & Furans (NATO)	R2	ng/m³	0.0147	µg/hr	4.7	21/11/2023	09:10 - 11:50, 12:10 - 15:30	360
Oxygen (Dioxins/PCBs)	R2	% v/v	11.5			21/11/2023	09:10 - 11:50, 12:10 - 15:30	360
Water Vapour (Dioxins/PCBs)	R2	% v/v	10.9			21/11/2023	09:10 - 11:50, 12:10 - 15:30	360
Dioxins & Furans (NATO)	R3	ng/m³	0.0177	µg/hr	5.6	22/11/2023	09:45 - 14:22, 15:35 - 17:07	360
Oxygen (Dioxins/PCBs)	R2	% v/v	11.2			22/11/2023	09:45 - 14:22, 15:35 - 17:07	360
Water Vapour (Dioxins/PCBs)	R2	% v/v	10.1			22/11/2023	09:45 - 14:22, 15:35 - 17:07	360
PCBs	R1	ng/m³	0.0036	µg/hr	1.2	20/11/2023	10:25 - 16:30	360
PCBs	R2	ng/m³	0.0037	µg/hr	1.2	21/11/2023	09:10 - 11:50, 12:10 - 15:30	360

Executive Summary

MONITORING DATE(S) & TIMES

Irish Cement Ltd, Limerick
A2-01 Kiln 6
14th - 23rd November 2023

Parameter		Units	Concentration	Units	Mass Emission	Sampling	Sampling	Duration
Hydrogen Chloride	R1	mg/m³	1.06	g/hr	336.43	20/11/2023	15:40 - 16:10	30
Oxygen (HCl/HF)	R2	% v/v	11.52			20/11/2023	15:40 - 16:10	30
Water Vapour (HCl/HF)	R2	% v/v	9.86			20/11/2023	15:40 - 16:10	30
Hydrogen Chloride	R2	mg/m³	< 0.08	g/hr	< 24.12	21/11/2023	13:30 - 14:00	3
Oxygen (HCl/HF)	R2	% v/v	11.62			21/11/2023	13:30 - 14:00	30
Water Vapour (HCl/HF)	R2	% v/v	11.68			21/11/2023	13:30 - 14:00	30
Hydrogen Chloride	R3	mg/m³	< 0.13	g/hr	< 40.45	22/11/2023	13:19 - 13:49	30
Oxygen (HCl/HF)	R2	% v/v	11.32			22/11/2023	13:19 - 13:49	30
Water Vapour (HCl/HF)	R2	% v/v	11.10			22/11/2023	13:19 - 13:49	30
Hydrogen Fluoride	R1	mg/m³	< 0.12	g/hr	< 38.79	20/11/2023	15:40 - 16:10	30
Hydrogen Fluoride	R2	mg/m³	0.08	g/hr	24.14	21/11/2023	13:30 - 14:00	30
Hydrogen Fluoride	R3	mg/m³	< 0.13	g/hr	< 40.55	22/11/2023	13:19 - 13:49	30
Ammonia	R1	mg/m³	21.81	g/hr	6923.19	20/11/2023	16:40 - 17-10	30
Oxygen (NH3)	R2	% v/v	11.14			20/11/2023	16:40 - 17-10	30
Water Vapour (NH3)	R2	% v/v	11.13			20/11/2023	16:40 - 17-10	30
Ammonia	R2	mg/m³	10.80	g/hr	3426.42	21/11/2023	14:10 - 14:40	30
Oxygen (NH3)	R2	% v/v	11.55			21/11/2023	14:10 - 14:40	30
Water Vapour (NH3)	R2	% v/v	10.84			21/11/2023	14:10 - 14:40	30
Ammonia	R3	mg/m³	29.84	g/hr	9472.07	22/11/2023	14:05 - 14:22, 15:35 - 15:48	30
Oxygen (NH3)	R2	% v/v	11.21			22/11/2023	14:05 - 14:22, 15:35 - 15:48	30
Water Vapour (NH3)	R2	% v/v	10.07			22/11/2023	14:05 - 14:22, 15:35 - 15:48	30
Total VOCs (as Carbon)	R1	mg/m³	21.82	g/hr	6927.17	22/11/2023	17:30 - 01:30	480
Oxides of Nitrogen (as NO_2)	R1	mg/m³	480.69	g/hr	152575.64	22/11/2023	17:30 - 01:30	480
Carbon Monoxide	R1	mg/m³	174.45	g/hr	55372.92	22/11/2023	17:30 - 01:30	480
Carbon Dioxide	R1	% v/v	16.72			22/11/2023	17:30 - 01:30	480
Oxygen	R1	% v/v	11.37			22/11/2023	17:30 - 01:30	480
Velocity Traverse	R1					14/11/2023	11:10 - 11:45	

All results are expressed at the respective reference conditions.

Executive Summary

(Page 4 of 7)

PROCESS DETAILS

Irish Cement Ltd, Limerick
A2-01 Kiln 6
14th - 23rd November 2023

Standard Operating Conditions

Parameter	Value
Process Status	Cement Kiln
Capacity (of 100%) and Tonnes / Hour	210 Tonnes / Hour
Continuous or Batch Process	Continuous
Feedstock (if applicable)	Raw Meal
Abatement System	Bag Filter & SNCR
Abatement System Running Status	Normal Operating Conditions
Fuel	Petcoke and SRF
Plume Appearance	Visible

Site Specific Operating Conditions

Parameter	Status
Clinker Source and Loading Rate	Kiln 6 (Onsite)
Fuel Source and Load Rate	Pet Coke and SRF

MONITORING & ANALYTICAL METHODS

Irish Cement Ltd, Limerick
A2-01 Kiln 6
14th - 23rd November 2023

	Monitoring				Analysis					
Parameter	**Standard**	**Technical Procedure**	**Sampling Status**	**Testing Lab**	**Analytical Procedure**	**Analytical Technique**	**Analysis Status**	**Analysis Lab**	**Overall Status**	**LOD (Average)**
Total Particulate Matter	EN 13284-1	MD 001	MCERTS	EET	MD 103	Gravimetric	MCERTS	EET	MCERTS	0.24 mg/m³
Sulphur Dioxide	EN 14791	MD 009	MCERTS	EET	CAT-AP-01	IC	MCERTS	EET	MCERTS	0.024 mg/m³
Cadmium & Thallium	EN 14385	MD 006	MCERTS	EET	CAT-AP-07	ICP-MS	MCERTS	EET	MCERTS	0.001 mg/m³
Heavy Metals	EN 14385	MD 006	MCERTS	EET	CAT-AP-07	ICP-MS	MCERTS	EET	MCERTS	0.006 mg/m³
Mercury	EN 13211	MD 006	MCERTS	EET	CAT-AP-08	CV-AFS	MCERTS	EET	MCERTS	0.00026 mg/m³
Dioxins & Furans	EN 1948	MD 007	MCERTS	EET	PM137, TM201	GC-HRMS	MCERTS	ELD	MCERTS	0.0064 ng/m³
PCBs	EN 1948	MD 007	MCERTS	EET	PM137, TM201	GC-HRMS	MCERTS	EET	MCERTS	0.00408 ng/m³
Hydrogen Chloride	EN 1911	MD 011	MCERTS	EET	CAT-AP-01	IC	MCERTS	ELD	MCERTS	0.103 mg/m³
Hydrogen Fluoride	CEN/TS 17340	MD 010	MCERTS	EET	CAT-AP-01	IC	MCERTS	ELD	MCERTS	0.103 mg/m³
Ammonia	ISO 21877	MD 014	MCERTS	EET	A6	IC	MCERTS	RPS	MCERTS	0.181 mg/m³
Total VOCs (as Carbon)	EN 12619:2013	MD 020	MCERTS	EET	Flame Ionisation Detection by Sick 3006				MCERTS	0.32 mg/m³
Oxides of Nitrogen (as NO_2)	EN 14792	MD 039	MCERTS	EET	Chemiluminescence by Horiba PG-350E				MCERTS	0.41 mg/m³
Carbon Monoxide	EN 15058	MD 039	MCERTS	EET	NDIR by Horiba PG-350E				MCERTS	0.49 mg/m³
Carbon Dioxide	CEN/TS 17405	MD 039	MCERTS	EET	NDIR by Horiba PG-350E				MCERTS	0.1 %
Oxygen	EN 14789	MD 039	MCERTS	EET	Dry Paramagnetic Cell by Horiba PG-350E				MCERTS	0.1 %
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	MD 041	MCERTS	EET	Pitot Tube and Thermocouple				MCERTS	1.2 m/s

ANALYSIS LABORATORIES

(with short name reference as appears in the table above)

RPS Laboratories Ltd (RPS)	ISO 17025 Accreditation Number: 0605
Element (Deeside Lab - ELD)	ISO 17025 Accreditation Number: 4225
Element (Stockport Lab - EET)	ISO 17025 Accreditation Number: 4279

SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
Heavy Metals	1	The absorption efficiency for all of the individual metals was not met, however it should be noted the results were of an extremely low order.

SUITABILITY OF SAMPLING LOCATION

Duct Characteristics

Parameter	Units	Value
Type	-	Circular
Depth	m	2.60
Width	m	-
Area	m²	5.31
Port Depth	cm	21
Orientation of Duct	-	Vertical
Number of Ports	-	2
Sample Port Size	-	5" Flange

Location of Sampling Platform

General Platform Information	Value
Permanent / Temporary Platform	Permanent
Inside / Outside	Outside

Platform Details

Irish EPA Technical Guidance Note AG1 / EN 15259 Platform Requirements	Value
Sufficient working area to manipulate probe and operate the measuring instruments	Yes
Platform has 2 levels of handrails (approx. 0.5m & 1.0m high)	Yes
Platform has vertical base boards (approx. 0.25m high)	Yes
Platform has chains / self closing gates at top of ladders	Yes
There are no obstructions present which hamper insertion of sampling equipment	Yes
Safe Access Available	Yes
Easy Access Available	Yes

Sampling Location / Platform Improvement Recommendations

The sampling location meets all the requirements specified in Irish EPA Guidance Note AG1 and EN 15259, and therefore there are no improvement recommendations.

EN 15259 Homogeneity Test Requirements

A valid EN 15259 Homogeneity test was performed by Element on this Stack on 19th June 2021, Report ID: EMT01136, and the stack gas profile was found to be homogenous.

Sampling Plane Validation Criteria (from EN 15259)

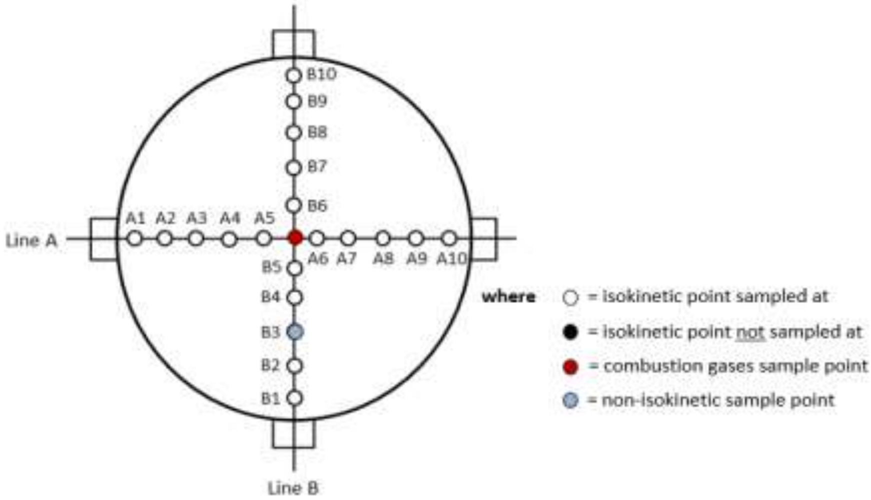
Criteria in EN 15259	Units	Traverse 1		Required	Compliant
Lowest Differential Pressure	Pa	603.0		> 5 Pa	Yes
Mean Velocity	m/s	34.08		-	-
Lowest Gas Velocity	m/s	32.30		-	-
Highest Gas Velocity	m/s	36.25		-	-
Ratio of Above	: 1	1.12		< 3 : 1	Yes
Maximum Angle of Swirl	°	8.00		< 15°	Yes
No Local Negative Flow	-	Yes		-	Yes

PLANT PHOTOS

Photo 1

Photo 2

SAMPLE POINTS



APPENDIX CONTENTS

STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	Donal O Faogain	MCERTS Level 2	MM13 1259	TE1 TE2 TE3 TE4
Team Leader	James O'Connor	MCERTS Level 2	MM22 1720	TE1 & TE4
Technician	David Grimes	MCERTS Trainee	MM23 1788	None

LIST OF EQUIPMENT

Extractive Sampling

Equipment Type	Equipment I.D.
Control Box DGM (1)	CAT 7.991
Control Box DGM (2)	CAT 7.1000
Box Thermocouples (1)	CAT 3.103
Box Thermocouples (2)	-
Umbilical (1)	CAT 3.103
Umbilical (2)	CAT 3.10004
Oven Box (1)	CAT 12.29
Oven Box (2)	CAT 12.115
Heated Probe (1)	CAT 5.51
Heated Probe (2)	CAT 5.57
Heated Probe (3)	-
S-Pitot (1)	CAT 21p.177
S-Pitot (2)	CAT 21p.165
L-Pitot	-
Site Balance	CAT 17.1
500g / 1Kg Check Weights	CAT 17.1
Last Impinger Arm	CAT 4.0001
Callipers	CAT 23.11
Tubes Kit Thermocouple	-

Instrumental Analysers

Equipment Type	Equipment I.D.
Horiba PG-350E	CAT 39.6
SELECT Horiba Model (2)	-
SELECT Servomex Model	-
SELECT NOX Analyser/Convertor	-
ABB AO2020-URAS26	-
Testo 350 XL	-
JCT JCC P1 Cooler	CAT 4.1122
Gasmet DX4000	CAT 19.7
Gasmet Sampling System	CAT 10.4
Sick 3006	CAT 8.15
Ankersmid APP100	CAT 12.134
Mass Flow Controller (1)	CAT 6.59
Mass Flow Controller (2)	CAT 6.70
Mass View (1)	CAT 25.87
Mass View (2)	-
Hioki 5031 (mA)	CAT 11.53
SELECT Logger 2	-
Bioaerosols Temperature Logger	-
Electronic Refrigerator	-

Miscellaneous Items

Equipment Type	Equipment I.D.
Digital Manometer (1)	CAT 3.250
Digital Manometer (2)	-
Digital Temperature Meter	CAT 3.250
Stopwatch	CAT 14.53
Barometer	CAT 13.39
Stack Thermocouple (1)	CAT 4.1581
Stack Thermocouple (2)	-
Stack Thermocouple (3)	-
1m Heated Line (1)	-
1m Heated Line (2)	-
1m Heated Line (3)	-
5m Heated Line (1)	-
10m Heated Line (1)	CAT 20.998
20m Heated Line (1)	-
20m Heated Line (2)	-
Dual Channel Heater Controller	-
Single Channel Heater Controller	CAT 20.998
Laboratory Balance	CAT 1.18, 1.18a, 1.18b
Tape Measure	CAT 16.94

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
Total Particulate Matter	EN 13284-1	MD 001
Sulphur Dioxide	EN 14791	MD 009
Cadmium & Thallium	EN 14385	MD 006
Heavy Metals	EN 14385	MD 006
Mercury	EN 13211	MD 006
Dioxins & Furans	EN 1948	MD 007
PCBs	EN 1948	MD 007
Hydrogen Chloride	EN 1911	MD 011
Hydrogen Fluoride	CEN/TS 17340	MD 010
Ammonia	ISO 21877	MD 014
Total VOCs (as Carbon)	EN 12619:2013	MD 020
Oxides of Nitrogen (as NO_2)	EN 14792	MD 039
Carbon Monoxide	EN 15058	MD 039
Carbon Dioxide	CEN/TS 17405	MD 039
Oxygen	EN 14789	MD 039
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	MD 041

PRELIMINARY STACK SURVEY: CALCULATIONS

General Stack Details

Stack Details (from Traverse)	Units	Value
Stack Diameter / Depth, D	m	2.60
Stack Width, W	m	-
Stack Area, A	m^2	5.31
Average Stack Gas Temperature, T_a	°C	152.0
Average Stack Gas Pressure	Pa	672.7
Average Stack Static Pressure, P_{static}	kPa	-0.262
Average Barometric Pressure, P_b	kPa	98.3
Average Pitot Tube Calibration Coefficient, C_p	-	0.85

Stack Gas Composition & Molecular Weights

Component	Conc ppm	Conc Dry % v/v	Conc Wet % v/v	Volume Fraction r	Molar Mass M	Density kg/m^3 p	Conc kg/m^3 p_i
CO_2	-	16.72	14.93	0.1672	44.01	1.9635	0.32831
O_2	-	11.35	10.13	0.1135	32.00	1.4277	0.16199
N_2	-	71.93	64.24	0.7193	28.01	1.2498	0.89905
Moisture (H_2O)	-	-	10.70	0.1070	18.02	0.8037	0.08597

Where: p = M / 22.41

p_i = r x p

Calculation of Stack Gas Densities

Determinand	Units	Result
Dry Density (STP), P_{STD}	kg/m^3	1.389
Wet Density (STP), P_{STW}	kg/m^3	1.327
Dry Density (Actual), P_{Actual}	kg/m^3	0.864
Average Wet Density (Actual), $P_{ActualW}$	kg/m^3	0.825

Where: P_{STD} = sum of component concentrations, kg/m^3 (not including water vapour)

P_{STW} = sum of all wet concentrations / 100 x density, kg/m^3 (including water vapour)

$P_{Actual} = P_{STD} \times (T_{STP} / (P_{STP})) \times ((P_{static} + P_b) / T_a)$

$P_{ActualW}$ (at each sampling point) = $P_{STW} \times (T_s / P_s) \times (P_a / T_a)$

Calculation of Stack Gas Volumetric Flowrate, Q

Duct gas flow conditions	Units	Actual	REF [1]
Temperature	°C	152.0	0.0
Total Pressure	kPa	98.0	101.3
Moisture	%	10.70	0.00
Oxygen (Dry)	%	11.3	10.0

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m^3/hr	651487
Gas Volumetric Flowrate (STP, Wet)	m^3/hr	405004
Gas Volumetric Flowrate (STP, Dry)	m^3/hr	361685
Gas Volumetric Flowrate REF [1]	m^3/hr	317408

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID)

(1 of 1)

Parameter	Units	Value
Date of Survey	-	14/11/2023
Time of Survey	-	11:10 - 11:45
Atmospheric Pressure	kPa	98.3
Average Stack Static Pressure	Pa	-262
Result of Pitot Stagnation Test	-	Pass
Are Water Droplets Present?	-	No
Device Used	S-Type Pitot with KIMO MP 210 (500Pa)	

Parameter	Units	Value
Initial Pitot Leak Check	-	Pass
Final Pitot Leak Check	-	Pass
Orientation of Duct	-	Vertical
Pitot Tube, C_p	-	0.85
Number of Lines Available	-	2
Number of Lines Used	-	2

		Sampling Line A					Sampling Line B				
Traverse Point	**Depth m**	**ΔP Pa**	**Temp °C**	**Wet Density kg/m³**	**Velocity m/s**	**Swirl °**	**ΔP Pa**	**Temp °C**	**Wet Density kg/m³**	**Velocity m/s**	**Swirl °**
STATIC (Units: Pa)		*-266.0*					*-258.0*				
Mean		**666.5**	**151.9**	**0.825**	**33.93**		**678.8**	**152.1**	**0.825**	**34.24**	
1	0.07	635.0	152.2	0.824	33.14	5.0	671.0	152.1	0.825	34.06	7.0
2	0.21	635.0	152.2	0.824	33.14	8.0	694.0	152.1	0.825	34.64	3.0
3	0.38	665.0	152.2	0.824	33.91	6.0	659.0	152.1	0.825	33.76	5.8
4	0.59	718.0	152.1	0.825	35.23	1.0	746.0	152.2	0.824	35.92	4.0
5	0.89	733.0	152.2	0.824	35.60	8.0	760.0	152.1	0.825	36.25	4.0
6	1.71	700.0	152.1	0.825	34.79	1.0	738.0	152.1	0.825	35.72	5.0
7	2.01	661.0	152.1	0.825	33.81	8.0	650.0	152.1	0.825	33.52	4.0
8	2.22	646.0	151.2	0.826	33.39	5.0	603.0	152.3	0.824	32.30	5.0
9	2.39	624.0	151.2	0.826	32.81	6.0	619.0	152.2	0.824	32.72	8.0
10	2.53	648.0	151.2	0.826	33.44	1.0	648.0	152.1	0.825	33.47	5.0

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID) - MEASUREMENT UNCERTAINTY

Performance characteristics (Uncertainty Components)	**Uncertainty**	**Value**	**Units**
Standard Uncertainty on the coefficient of the Pitot Tube	u(k)	0.005	-
Standard Uncertainty associated with the mean local dynamic pressures	u(Δpi)	14.401	Pa
- Resolution	u(res)	0.00087	
- Calibration	u(cal)	47.111	
- Drift	u(drift)	0.083	
- Lack of Fit	u(fit)	159.186	
- Overall corrections to dynamic measurements	u(Cf)	206.382	
Standard uncertainty associated with the molar mass of the gas	u(M)	0.00009	-
- φO_2,w	-	10.133	
- φCO_2,w	-	14.932	
- Oxygen, dry	u(ϕO_2,d)	0.347	
- Carbon Dioxide, dry	u(ϕCO_2,d)	0.512	
- Water Vapour	u(ϕH_2O)	0.546	
- Oxygen, wet	u(ϕO_2,w)	0.316	
- Carbon Dioxide, wet	u(ϕCO_2,w)	0.466	
Standard uncertainty associated with the stack temperature	u(Tc)	2.168	K
Standard uncertainty associated with the absolute pressure in the duct	u(pc)	175.987	Pa
- Atmospheric Pressure	u(patm)	175.692	
- Static Pressure	u(pstat)	10.183	
Standard uncertainty associated with the density in the duct	u(ρ)	0.00446	-
Standard uncertainty associated with the local velocities	u(vi)	0.383	Pa
Standard uncertainty associated with the mean velocity	u(v)	0.140	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	Uc(v)	0.275	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	Uc,rel(v)	0.81	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	Uc(qV,w)	29953.3	m^3/hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00055	
- $u^2(qV,w)$	-	233548537	
- u(qV,w)	-	15282.3	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	Uc,rel(qV,w)	4.60	%

TOTAL PARTICULATE MATTER: RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	mg/m³	0.24	0.24	0.24		0.24
Uncertainty	±mg/m³	0.56	0.56	0.56		0.56
Mass Emission	g/hr	75.9	75.9	75.9		75.9
Uncertainty	±g/hr	179.2	179.2	179.2		179.2

NOTE: Where the maximum Blank concentration is higher than the Sample concentration, the maximum Blank concentration has been reported.

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	10.69	12.77	10.29		11.25
Uncertainty	±% v/v	0.57	0.68	0.55		0.60

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	0.24		0.24

NOTE: Where the Balance Uncertainty / Limit of Detection is higher than the Blank concentration, the Balance Uncertainty / Limit of Detection concentration has been reported.

General Sampling Information

Parameter	Value	
Standard	EN 13284-1	
Technical Procedure	MD 001	
Probe Material	Titanium	
Filter Housing Material	Titanium	
Positioning of Filter	In Stack	
Filter Size and Material	47mm Glass Fibre	
Number of Sampling Lines Used	2 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	20 / 20	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1 - A10, B1 - B10	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

TOTAL PARTICULATE MATTER: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	Run 2	Run 3	
Absolute pressure of stack gas, P_s					
Barometric pressure, P_b	mmHg	744.8	751.6	744.8	
Stack static pressure, P_{static}	mmH_2O	-25.7	-25.7	-25.7	
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	742.9	749.7	742.9	
Volume of water vapour collected, V_{wstd}					
Total mass collected in impingers (liquid trap)	g	97.8	113.7	89.6	
Total mass collected in impingers (silica trap)	g	9.0	10.3	11.1	
Total mass of liquid collected, V_{lc}	g	106.8	124.0	100.7	
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.1331	0.1545	0.1255	
Volume of gas metered dry, V_{mstd}					
Volume of gas sample through gas meter, V_m	m^3	1.2600	1.1860	1.2400	
Gas meter correction factor, Y_d	-	0.9800	0.9800	0.9800	
Average dry gas meter temperature, T_m	°C	25.6	25.6	25.6	
Average pressure drop across orifice, ΔH	mmH_2O	49.5	47.6	46.5	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	1.1117	1.0556	1.0937	
Moisture content, B_{wo} & R_{wv}					
$B_{wo} = V_{wstd\,/}\,(V_{mstd} + V_{wstd})$	m^3	0.1069	0.1277	0.1029	
B_{wo} as a percentage	% v/v	10.69	12.77	10.29	
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	10.69	12.77	10.29	
Volume of gas metered wet, V_{mstw}					
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	1.2447	1.2101	1.2192	
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$					
IED & Incinerates Hazardous Material? (Yes = no positive O_2 correction)	-	No	No	No	
% wet oxygen measured in gas stream, $ACT\%O_{2w}$	% v/v	9.87	10.37	9.97	
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	11.05	11.61	11.16	
% oxygen reference condition, $REF\%O_2$	% v/v	10.00	10.00	10.00	
O_2 Reference Factor wet (O_{2REFw}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2w}$)	-	0.99	1.03	1.00	
O_2 Reference Factor dry (O_{2REFd}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2d}$)	-	1.11	1.17	1.12	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	1.2597	1.1696	1.2228	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	1.0054	0.9009	0.9781	
Molecular weight of dry gas stream, M_d					
CO_2	% v/v	21.00	21.00	17.00	
O_2	% v/v	11.05	11.61	11.16	
Total	% v/v	32.05	32.61	28.16	
N_2	% v/v	67.95	67.39	71.84	
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	31.80	31.82	31.17	
Molecular weight of stack gas (wet), M_s					
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	30.33	30.06	29.81	
Velocity of stack gas, V_s					
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97	
Velocity pressure coefficient, C_p	-	0.85	0.85	0.85	
Average of velocity heads, ΔP_{avg}	mmH_2O	39.00	37.35	37.15	
Average square root of velocity heads, √ΔP	$\sqrt{mmH_2O}$	6.24	6.11	6.10	
Average stack gas temperature, T_s	°C	147.1	145.0	152.1	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{(M_s)(P_s)})$	m/s	25.26	24.65	25.01	
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})					
Area of stack, A_s	m^2	5.31	5.31	5.31	
$Q_a = (60)(A_s)(V_s)$	m^3/min	8047.7	7854.7	7969.0	
Conversion factor (K/mm.Hg), C_f	-	0.3592	0.3592	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	5111.6	5060.1	5002.1	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	4565.1	4414.1	4487.3	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	5173.1	4890.7	5017.0	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	4128.8	3767.1	4012.9	
Percent isokinetic, %I					
Nozzle diameter, D_n	mm	5.17	5.17	5.17	
Nozzle area, A_n	mm^2	21.00	21.00	21.00	
Total sampling time, q	min	60	60	60	
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	102.6	100.8	102.7	

TOTAL PARTICULATE MATTER: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	13:19 - 14:19	11:00 - 12:04	11:00 - 12:02
Sampling Dates	-	20/11/2023	21/11/2023	22/11/2023
Sampling Device	-	ISO	ISO	ISO
Volume Sampled (REF)	m^3	1.0054	0.9009	0.9781
Filter I.D. Number	-	47-105213	47-106121	47-106120
Start Filter Mass	g	0.15067	0.15194	0.14904
End Filter Mass	g	0.15049	0.15061	0.14756
Total Mass on Filter	g	-0.00018	-0.00133	-0.00148
Probe Rinse I.D. Number	-	PR-47-105213	PR-47-106121	PR-47-106120
Start Probe Rinse Mass	g	3.06134	3.12865	2.71318
End Probe Rinse Mass	g	3.06168	3.12866	2.71340
Total Mass in Probe Rinse	g	0.00034	0.00001	0.00021
Total Mass Collected	mg	0.16	-1.32	-1.27
Calculated Concentration	mg/m^3	0.16	-1.47	-1.30
Balance Uncertainty / LOD	mg/m^3	0.23	0.26	0.24

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	20/11/2023
Average Volume Sampled (REF)	m^3	0.9615
Filter I.D. Number	-	47-104509
Start Filter Mass	g	0.14305
End Filter Mass	g	0.14283
Total Mass on Filter	g	-0.00022
Probe Rinse I.D. Number	-	PR-47-104509
Start Probe Rinse Mass	g	2.45621
End Probe Rinse Mass	g	2.45616
Total Mass in Probe Rinse	g	-0.00005
Total Mass Collected	mg	-0.27
Calculated Concentration	mg/m^3	-0.28
Balance Uncertainty / LOD	mg/m^3	0.24

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	20.6	19.4	20.3
Pre-Sampling Leak Rate	l/min	0.21	0.21	0.21
Post-Sampling Leak Rate	l/min			
Allowable Leak Rate	l/min	0.40	0.40	0.40
Leak Test Acceptable	-	Yes	Yes	Yes

Water Droplets	Units	Run 1	Run 2	Run 3
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Measurement Uncertainty (MU)	%	5.4	5.3	5.4
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Less than 50% Faded	%	Yes	Yes	Yes

Isokinetic Criterion Compliance	Units	Run 1	Run 2	Run 3
Isokinetic Variation	%	102.6	100.8	102.7
Allowable Isokinetic Range	%	95 - 115	95 - 115	95 - 115
Isokineticity Acceptable	-	Yes	Yes	Yes

Weighing Uncertainty Criteria	Units	Run 1	Run 2	Run 3
Overall Weighing Uncertainty	± mg	0.33	0.33	0.33
Overall Weighing Uncertainty	± mg/m^3	0.32	0.36	0.33
ELV [Daily ELV for IED]	mg/m^3	10.00	10.00	10.00
Allowable Weighing Uncertainty	mg/m^3	0.50	0.50	0.50
Weighing Uncertainty Acceptable	-	Yes	Yes	Yes

Filter Temperatures	Units	Run 1	Run 2	Run 3
Pre-Conditioning Temperature	°C	180	180	180
Post-Conditioning Temperature	°C	160	160	160
Maximum Filter Temperature	°C	152	146	153

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	20.0
Pre-Sampling Leak Rate	l/min	0.05
Post-Sampling Leak Rate	l/min	
Allowable Leak Rate	l/min	N/A
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m³	1.0
Blank Acceptable	-	Yes

Acetone / Water Rinse Blank	Units	Blank
Acetone / Water Rinse Value	mg/l	2.7
Allowable Blank	mg/l	10
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	2	3
There are no deviations associated with the sampling employed.	wx	wx	

TOTAL PARTICULATE MATTER: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value				Standard uncertainty				
Measured Quantities	**Symbol**	**Run 1**	**Run 2**	**Run 3**	**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (Actual)	V_m	1.2600	1.1860	1.2400	uV_m	m^3	0.0252	0.0237	0.0248
Sampled Gas Temperature	T_m	298.6	298.6	298.6	uT_m	K	2.00	2.00	2.00
Sampled Gas Pressure	ρ_m	99.1	100.0	99.1	$u\rho_m$	kPa	0.50	0.50	0.50
Sampled Gas Humidity	H_m	0.00	0.00	0.00	uH_m	% v/v	1.00	1.00	1.00
Leak	L	1.02	1.08	1.04	uL	%	-	-	-
Mass of Particulate	m	0.23	0.23	0.23	um	mg	0.23	0.23	0.23
Uncollected Mass	UCM	-0.27	-0.27	-0.27	uUCM	mg	-	-	-

	Uncertainty as a Percentage				
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**	**Requirement of Standard**
Sampled Volume (Actual)	%	2.00	2.00	2.00	≤2%
Sampled Gas Temperature	%	0.67	0.67	0.67	≤1%
Sampled Gas Pressure	%	0.50	0.50	0.50	≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00	≤1%
Leak	%	1.02	1.08	1.04	≤2%
Mass of Particulate	%	2.39	2.39	2.39	-
Uncollected Mass	%	-	-	-	-

	Uncertainty in Measurement Units					Sensitivity Coefficient		
Measured Quantities	**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (STP)	V_m	m^3	1.1117	1.0556	1.0937	0.22	0.23	0.22
Leak	L	mg/m^3	0.001	0.001	0.001	1.00	1.00	1.00
Mass of Particulate	L_r	mg	0.230	0.230	0.230	1.04	1.04	1.04
Uncollected Mass	UCM	mg	-0.15	-0.15	-0.15	1.04	1.04	1.04

	Uncertainty in Result			
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (STP)	mg/m^3	0.006	0.006	0.006
Leak	mg/m^3	0.0014	0.0015	0.0014
Mass of Particulate	mg/m^3	0.2392	0.2392	0.2392
Uncollected Mass	mg/m^3	-0.1601	-0.1601	-0.1601

	Oxygen Correction Part of MU Budget			
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**
O_2 Correction Factor	-	1.11	1.17	1.12
Stack Gas O_2 Content	% v/v	11.05	11.61	11.16
MU for O_2 Correction	-	0.06	0.06	0.06
Overall MU For O_2 Measurement	%	5.03	5.33	5.08

Parameter	**Units**	**Run 1**	**Run 2**	**Run 3**
Combined uncertainty	mg/m^3	0.29	0.29	0.29
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.56	0.56	0.56
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	0.56	0.56	0.56
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.56	0.56	0.56
Reported Uncertainty	mg/m^3	0.56	0.56	0.56
Expanded uncertainty (95% confidence), without Oxygen Correction	%	235.9	235.9	235.9
Expanded uncertainty (95% confidence), with Oxygen Correction	%	236.0	236.0	236.0
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	236.0	236.0	236.0
Reported Uncertainty	%	236.0	236.0	236.0

SULPHUR DIOXIDE: RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	mg/m³	1.71	5.12	3.43		3.42
Uncertainty	±mg/m³	0.13	0.39	0.26		0.26
Mass Emission	g/hr	543.2	1624.7	1088.4		1085.4
Uncertainty	±g/hr	47.7	145.4	96.0		96.3

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	10.69	12.77	10.29		11.25
Uncertainty	±% v/v	0.57	0.68	0.55		0.60

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	0.02		0.02

General Sampling Information

Parameter	Value	
Standard	EN 14791	
Technical Procedure	MD 009	
Name of Analytical Laboratory	EET	
Analytical Laboratory's Procedure	CAT-AP-01	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	24/11/2023	
Probe Material	Titanium	
Filter Housing Material	Titanium	
Impinger Material	Borosilicate Glass	
Absorption Solution	0.3% Hydrogen Peroxide	
Positioning of Filter	In Stack	
Filter Size and Material	47mm Glass Fibre	
Number of Sampling Lines Used	2 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	20 / 20	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1 - A10, B1 - B10	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

SULPHUR DIOXIDE: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	Run 2	Run 3	
Absolute pressure of stack gas, P_s					
Barometric pressure, P_b	mmHg	744.8	751.6	744.8	
Stack static pressure, P_{static}	mmH_2O	-25.7	-25.7	-25.7	
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	742.9	749.7	742.9	
Volume of water vapour collected, V_{wstd}					
Total mass collected in impingers (liquid trap)	g	97.8	113.7	89.6	
Total mass collected in impingers (silica trap)	g	9.0	10.3	11.1	
Total mass of liquid collected, V_{lc}	g	106.8	124.0	100.7	
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.1331	0.1545	0.1255	
Volume of gas metered dry, V_{mstd}					
Volume of gas sample through gas meter, V_m	m^3	1.2600	1.1860	1.2400	
Gas meter correction factor, Y_d	-	0.9800	0.9800	0.9800	
Average dry gas meter temperature, T_m	°C	25.6	25.6	25.6	
Average pressure drop across orifice, ΔH	mmH_2O	49.5	47.6	46.5	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	1.1117	1.0556	1.0937	
Moisture content, B_{wo} & R_{wv}					
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.1069	0.1277	0.1029	
B_{wo} as a percentage	% v/v	10.69	12.77	10.29	
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	10.69	12.77	10.29	
Volume of gas metered wet, V_{mstw}					
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	1.2447	1.2101	1.2192	
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$					
IED & Incinerates Hazardous Material? (Yes = no positive O_2 correction)	-	No	No	No	
% wet oxygen measured in gas stream, $ACT\%O_{2w}$	% v/v	9.87	10.37	9.97	
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	11.05	11.61	11.16	
% oxygen reference condition, $REF\%O_2$	% v/v	10.00	10.00	10.00	
O_2 Reference Factor wet (O_{2REFw}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2w}$)	-	0.99	1.03	1.00	
O_2 Reference Factor dry (O_{2REFd}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2d}$)	-	1.11	1.17	1.12	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	1.2597	1.1696	1.2228	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	1.0054	0.9009	0.9781	
Molecular weight of dry gas stream, M_d					
CO_2	% v/v	21.00	21.00	17.00	
O_2	% v/v	11.05	11.61	11.16	
Total	% v/v	32.05	32.61	28.16	
N_2	% v/v	67.95	67.39	71.84	
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	31.80	31.82	31.17	
Molecular weight of stack gas (wet), M_s					
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	30.33	30.06	29.81	
Velocity of stack gas, V_s					
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97	
Velocity pressure coefficient, C_p	-	0.85	0.85	0.85	
Average of velocity heads, ΔP_{avg}	mmH_2O	39.00	37.35	37.15	
Average square root of velocity heads, √ΔP	$\sqrt{mmH_2O}$	6.24	6.11	6.10	
Average stack gas temperature, T_s	°C	147.1	145.0	152.1	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{(M_s)(P_s)})$	m/s	25.26	24.65	25.01	
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})					
Area of stack, A_s	m^2	5.31	5.31	5.31	
$Q_a = (60)(A_s)(V_s)$	m^3/min	8047.7	7854.7	7969.0	
Conversion factor (K/mm.Hg), C_f	-	0.3592	0.3592	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	5111.6	5060.1	5002.1	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	4565.1	4414.1	4487.3	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	5173.1	4890.7	5017.0	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	4128.8	3767.1	4012.9	
Percent isokinetic, %I					
Nozzle diameter, D_n	mm	5.17	5.17	5.17	
Nozzle area, A_n	mm^2	21.00	21.00	21.00	
Total sampling time, q	min	60	60	60	
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	102.6	100.8	102.7	

SULPHUR DIOXIDE: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	13:19 - 14:19	11:00 - 12:04	11:00 - 12:02
Sampling Dates	-	20/11/2023	21/11/2023	22/11/2023
Sampling Device	-	ISO	ISO	ISO
Volume Sampled (REF)	m³	1.0054	0.9009	0.9781
Laboratory Result for Front Impingers	µg/ml	4.51	10.30	7.13
Laboratory Result for Back Impinger	µg/ml	0.41		
Volume in Front Impingers	ml	370.6	447.7	470.4
Volume in Back Impinger	ml	119.9		
Mass in Front Impingers	µg	1671.4	4611.3	3354.0
Mass in Back Impinger	µg	49.2		
Total Mass Collected	µg	1720.6	4611.3	3354.0
Calculated Concentration	mg/m³	1.71	5.12	3.43

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	20/11/2023
Average Volume Sampled (REF)	m³	0.9615
Laboratory Result for Impingers	µg/ml	0.05
Volume in Impingers	ml	303.4
Total Mass Collected	µg	15.2
Calculated Concentration	mg/m³	0.02

SULPHUR DIOXIDE: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	20.6	19.4	20.3
Pre-Sampling Leak Rate	l/min	0.21	0.21	0.21
Post-Sampling Leak Rate	l/min	N/A	N/A	N/A
Allowable Leak Rate	l/min	N/A	N/A	N/A
Leak Test Acceptable	-	N/A	N/A	N/A

Absorption Efficiency	Units	Run 1
Absorption Efficiency	%	97.1
Allowable Absorption Efficiency	%	N/A [2]
Absorption Efficiency Acceptable	-	Yes [2]

[2] The concentration is less than 30% of the ELV, therefore no assessment against an allowable efficiency is required.

Water Droplets	Units	Run 1	Run 2	Run 3
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Measurement Uncertainty (MU)	%	5.4	5.3	5.4
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Less than 50% Faded	%	Yes	Yes	Yes

Isokinetic Criterion Compliance	Units	Run 1	Run 2	Run 3
Isokinetic Variation	%	102.6	100.8	102.7
Allowable Isokinetic Range	%	95 - 115	95 - 115	95 - 115
Isokineticity Acceptable	-	Yes	Yes	Yes

Filter Temperatures	Units	Run 1	Run 2	Run 3
Maximum Filter Temperature	°C	152	146	153

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

SULPHUR DIOXIDE: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	20.0
Pre-Sampling Leak Rate	l/min	0.05
Post-Sampling Leak Rate	l/min	
Allowable Leak Rate	l/min	N/A
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m^3	5.0
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation	Run Number		
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1	2	3
There are no deviations associated with the sampling employed.	wx	wx	wx

SULPHUR DIOXIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Symbol	Value Run 1	Value Run 2	Value Run 3	Symbol	Units	Standard uncertainty Run 1	Standard uncertainty Run 2	Standard uncertainty Run 3
Sampled Volume (Actual)	V_m	1.2600	1.1860	1.2400	uV_m	m³	0.0252	0.0237	0.0248
Sampled Gas Temperature	T_m	298.6	298.6	298.6	uT_m	K	2.00	2.00	2.00
Sampled Gas Pressure	ρ_m	99.1	100.0	99.1	$u\rho_m$	kPa	0.50	0.50	0.50
Sampled Gas Humidity	H_m	0.00	0.00	0.00	uH_m	% v/v	1.00	1.00	1.00
Leak	L	1.02	1.08	1.04	uL	%	-	-	-
Laboratory Result	L_r	0.90	0.90	0.90	uL_r	%	-	-	-

Measured Quantities	Units	Uncertainty as a Percentage Run 1	Run 2	Run 3	Requirement of Standard
Sampled Volume (Actual)	%	2.00	2.00	2.00	≤2%
Sampled Gas Temperature	%	0.67	0.67	0.67	≤1%
Sampled Gas Pressure	%	0.50	0.50	0.50	≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00	≤1%
Leak	%	1.02	1.08	1.04	≤2%
Laboratory Result	%	0.90	0.90	0.90	No Requirement

Measured Quantities	Symbol	Units	Uncertainty in Measurement Units Run 1	Run 2	Run 3	Sensitivity Coefficient Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	m³	1.1117	1.0556	1.0937	1.54	4.85	3.14
Leak	L	mg/m³	0.010	0.032	0.021	1.00	1.00	1.00
Laboratory Result	L_r	mg/m³	0.015	0.046	0.031	1.00	1.00	1.00

Measured Quantities	Units	Uncertainty in Result Run 1	Run 2	Run 3
Sampled Volume (STP)	mg/m³	0.045	0.133	0.090
Leak	mg/m³	0.0101	0.0320	0.0205
Laboratory Result	mg/m³	0.0154	0.0461	0.0309

Measured Quantities	Units	Oxygen Correction Part of MU Budget Run 1	Run 2	Run 3
O_2 Correction Factor	-	1.11	1.17	1.12
Stack Gas O_2 Content	% v/v	11.05	11.61	11.16
MU for O_2 Correction	-	0.06	0.06	0.06
Overall MU For O_2 Measurement	%	5.03	5.33	5.08

Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	mg/m³	0.05	0.14	0.10
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m³	0.09	0.28	0.19
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m³	0.13	0.39	0.26
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m³	0.13	0.39	0.26
Reported Uncertainty	mg/m³	0.13	0.39	0.26
Expanded uncertainty (95% confidence), without Oxygen Correction	%	5.5	5.5	5.5
Expanded uncertainty (95% confidence), with Oxygen Correction	%	7.5	7.7	7.5
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	7.5	7.7	7.5
Reported Uncertainty	%	7.5	7.7	7.5

APPENDIX 2

CADMIUM & THALLIUM: RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	mg/m³	0.0024	0.0013	0.0011		0.0016
Uncertainty	±mg/m³	0.0004	0.0002	0.0002		0.0003
Mass Emission	g/hr	0.8	0.4	0.3		0.5
Uncertainty	±g/hr	0.1	0.1	0.1		0.1

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	9.63	11.23	10.80		10.55
Uncertainty	±% v/v	0.50	0.59	0.56		0.55

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 0.0010		< 0.0010

General Sampling Information

Parameter	Value	
Standard	EN 14385	
Technical Procedure	MD 006	
Name of Analytical Laboratory	EET	
Analytical Laboratory's Procedure	CAT-AP-07	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	28/11/2023	
Probe Material	Titanium	
Filter Housing Material	Borosilicate Glass	
Impinger Material	Borosilicate Glass	
Absorption Solution	Nitric Peroxide	
Positioning of Filter	Out Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	2 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	20 / 20	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1 - A10, B1 - B10	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

CADMIUM & THALLIUM: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	Run 2	Run 3
Absolute pressure of stack gas, P_s				
Barometric pressure, P_b	mmHg	751.6	751.6	751.6
Stack static pressure, P_{static}	mmH_2O	-25.7	-25.7	-25.5
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	749.7	749.7	749.7
Volume of water vapour collected, V_{wstd}				
Total mass collected in impingers (liquid trap)	g	88.4	103.1	97.1
Total mass collected in impingers (silica trap)	g	7.7	8.3	7.5
Total mass of liquid collected, V_{lc}	g	96.1	111.4	104.6
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.1197	0.1388	0.1303
Volume of gas metered dry, V_{mstd}				
Volume of gas sample through gas meter, V_m	m^3	1.2620	1.2320	1.2100
Gas meter correction factor, Y_d	-	0.9800	0.9800	0.9800
Average dry gas meter temperature, T_m	°C	25.6	25.6	25.6
Average pressure drop across orifice, ΔH	mmH_2O	49.8	51.2	47.3
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	1.1235	1.0969	1.0769
Moisture content, B_{wo} & R_{wv}				
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.0963	0.1123	0.1080
B_{wo} as a percentage	% v/v	9.63	11.23	10.80
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	9.63	11.23	10.80
Volume of gas metered wet, V_{mstw}				
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	1.2432	1.2357	1.2073
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$				
IED & Incinerates Hazardous Material? (Yes = no positive O_2 correction)	-	No	No	No
% wet oxygen measured in gas stream, $ACT\%O_{2w}$	% v/v	10.05	9.99	9.79
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	11.26	11.19	10.96
% oxygen reference condition, $REF\%O_2$	% v/v	10.00	10.00	10.00
O_2 Reference Factor wet (O_{2REFw}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2w}$)	-	1.00	1.00	0.98
O_2 Reference Factor dry (O_{2REFd}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2d}$)	-	1.13	1.12	1.10
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	1.2372	1.2371	1.2305
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	0.9951	0.9787	0.9827
Molecular weight of dry gas stream, M_d				
CO_2	% v/v	21.00	17.00	17.00
O_2	% v/v	11.26	11.19	10.96
Total	% v/v	32.26	28.19	27.96
N_2	% v/v	67.74	71.81	72.04
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	31.81	31.17	31.16
Molecular weight of stack gas (wet), M_s				
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	30.48	29.69	29.74
Velocity of stack gas, V_s				
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97
Velocity pressure coefficient, C_p	-	0.85	0.85	0.85
Average of velocity heads, ΔP_{avg}	mmH_2O	39.10	39.10	37.10
Average square root of velocity heads, √ΔP	$\sqrt{mmH_2O}$	6.25	6.25	6.09
Average stack gas temperature, T_s	°C	153.4	140.9	151.9
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{(M_s)(P_s)})$	m/s	25.30	25.26	24.91
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})				
Area of stack, A_s	m^2	5.31	5.31	5.31
$Q_a = (60)(A_s)(V_s)$	m^3/min	8061.0	8046.5	7934.8
Conversion factor (K/mm.Hg), C_f	-	0.3592	0.3592	0.3592
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	5090.4	5235.6	5029.3
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	4600.1	4647.5	4486.4
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	5065.7	5241.4	5126.3
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	4074.3	4146.4	4094.0
Percent isokinetic, %I				
Nozzle diameter, D_n	mm	5.17	5.17	5.17
Nozzle area, A_n	mm^2	21.00	21.00	21.00
Total sampling time, q	min	60	60	60
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	102.9	99.5	101.2

CADMIUM & THALLIUM: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	11:53 - 12:58	12:21 - 13:25	09:50 - 10:52
Sampling Dates	-	20/11/2023	21/11/2023	22/11/2023
Sampling Device	-	ISO	ISO	ISO
Volume Sampled (REF)	m^3	0.9951	0.9787	0.9827
Cadmium				
Mass on Filter / in Rinse	µg	1.49	< 0.50	< 0.50
Mass in Front Impingers	µg	< 0.06	0.10	0.06
Mass in Back Impinger	µg	< 0.02	0.05	< 0.02
Total Mass Collected	µg	1.58	0.65	0.58
Calculated Concentration	mg/m^3	0.0016	0.0007	0.0006
Reported Concentration	mg/m^3	0.0016	0.0007	0.0006
Mass Emission	g/hr	0.50	0.21	0.19
Thallium				
Mass on Filter / in Rinse	µg	0.70	< 0.40	< 0.40
Mass in Front Impingers	µg	< 0.06	0.14	< 0.06
Mass in Back Impinger	µg	< 0.02	0.07	0.02
Total Mass Collected	µg	0.78	0.62	0.48
Calculated Concentration	mg/m^3	0.0008	0.0006	0.0005
Reported Concentration	mg/m^3	0.0008	0.0006	0.0005
Mass Emission	g/hr	0.25	0.20	0.16
Cadmium & Thallium Combined				
Total Mass Collected	µg	2.36	1.26	1.07
Calculated Concentration	mg/m^3	0.0024	0.0013	0.0011
Reported Concentration	mg/m^3	0.0024	0.0013	0.0011

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	20/11/2023
Average Volume Sampled (REF)	m^3	0.9855
Cadmium		
Mass on Filter / in Rinse	µg	< 0.50
Mass in Front Impingers	µg	< 0.04
Mass in Back Impinger	µg	< 0.02
Total Mass Collected	µg	< 0.56
Calculated Concentration	mg/m^3	< 0.0006
Reported Concentration	mg/m^3	< 0.0006
Thallium		
Mass on Filter / in Rinse	µg	< 0.40
Mass in Front Impingers	µg	< 0.04
Mass in Back Impinger	µg	< 0.02
Total Mass Collected	µg	< 0.46
Calculated Concentration	mg/m^3	< 0.0005
Reported Concentration	mg/m^3	< 0.0005
Cadmium & Thallium Combined		
Total Mass Collected	µg	< 1.02
Calculated Concentration	mg/m^3	< 0.0010
Reported Concentration	mg/m^3	< 0.0010

CADMIUM & THALLIUM: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	**Units**	**Run 1**	**Run 2**	**Run 3**
Mean Sampling Rate	l/min	20.6	20.1	19.8
Pre-Sampling Leak Rate	l/min	0.11	0.15	0.11
Post-Sampling Leak Rate	l/min	N/A	N/A	N/A
Allowable Leak Rate	l/min	0.30	0.30	0.30
Leak Test Acceptable	-	Yes	Yes	Yes

Absorption Efficiency	**Units**	**Run 1**	**Run 2**	**Run 3**
Cadmium	%	100.0	92.7	100.0
Thallium	%	100.0	88.2	95.6
Allowable Absorption Efficiency	%	N/A	N/A	N/A
Absorption Efficiency Acceptable	-	Yes	Yes	Yes

Where the emissions are < 30% of the ELV, MID 14385 does not require the absorption efficiency requirement to be applied

Detection Limit	**Units**	**Run 1**	**Run 2**	**Run 3**
Cadmium	µg/m³	0.6	0.6	0.6
Thallium	µg/m³	0.5	0.5	0.5
Allowable Detection Limit	µg/m³	5	5	5
Detection Limit Acceptable	-	Yes	Yes	Yes

Water Droplets	**Units**	**Run 1**	**Run 2**	**Run 3**
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	**Units**	**Run 1**	**Run 2**	**Run 3**
Measurement Uncertainty (MU)	%	5.2	5.3	5.2
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

Silica Gel (Concurrent Water Vapour)	**Units**	**Run 1**	**Run 2**	**Run 3**
Less than 50% Faded	%	Yes	Yes	Yes

Isokinetic Criterion Compliance	**Units**	**Run 1**	**Run 2**	**Run 3**
Isokinetic Variation	%	102.9	99.5	101.2
Allowable Isokinetic Range	%	95 - 115	95 - 115	95 - 115
Isokineticity Acceptable	-	Yes	Yes	Yes

Filter Temperatures	**Units**	**Run 1**	**Run 2**	**Run 3**
Maximum Filter Temperature	°C	160	160	160

Impingers Exit Temperature	**Units**	**Run 1**	**Run 2**	**Run 3**
Maximum Temperature Recorded	°C	18	18	18
Maximum Allowable Temperature	°C	30	30	30
Exit Temperature Acceptable	-	Yes	Yes	Yes

Test Conditions	**Units**	**Run 1**	**Run 2**	**Run 3**
Ambient Temperature Recorded?	-	Yes	Yes	Yes

CADMIUM & THALLIUM: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	15.0
Pre-Sampling Leak Rate	l/min	0.11
Post-Sampling Leak Rate	l/min	0.05
Allowable Leak Rate	l/min	0.30
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m^3	0.005
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	2	3	
There are no deviations associated with the sampling employed.	wx	wx	wx	

CADMIUM & THALLIUM: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value				Standard uncertainty				
Measured Quantities	Symbol	Run 1	Run 2	Run 3	Symbol	Units	Run 1	Run 2	Run 3
Sampled Volume (Actual)	V_m	1.2620	1.2320	1.2100	uV_m	m^3	0.0252	0.0246	0.0242
Sampled Gas Temperature	T_m	298.6	298.6	298.6	uT_m	K	2.00	2.00	2.00
Sampled Gas Pressure	ρ_m	100.0	100.0	100.0	$u\rho_m$	kPa	0.50	0.50	0.50
Sampled Gas Humidity	H_m	0.00	0.00	0.00	uH_m	% v/v	1.00	1.00	1.00
Leak	L	0.53	0.75	0.56	uL	%	-	-	-
Laboratory Result	L_r	7.60	7.60	7.60	uL_r	%	-	-	-

	Uncertainty as a Percentage				
Measured Quantities	Units	Run 1	Run 2	Run 3	Requirement of Standard
Sampled Volume (Actual)	%	2.00	2.00	2.00	≤2%
Sampled Gas Temperature	%	0.67	0.67	0.67	≤1%
Sampled Gas Pressure	%	0.50	0.50	0.50	≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00	≤1%
Leak	%	0.53	0.75	0.56	≤2%
Laboratory Result	%	7.60	7.60	7.60	No Requirement

	Uncertainty in Measurement Units					Sensitivity Coefficient		
Measured Quantities	Symbol	Units	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	m^3	1.1235	1.0969	1.0769	0.0021	0.0012	0.0010
Leak	L	mg/m^3	0.000	0.000	0.000	1.00	1.00	1.00
Laboratory Result	L_r	mg/m^3	0.000	0.000	0.000	1.00	1.00	1.00

	Uncertainty in Result			
Measured Quantities	Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	mg/m^3	0.00006	0.00003	0.00003
Leak	mg/m^3	0.00001	0.00001	0.00000
Laboratory Result	mg/m^3	0.0002	0.0001	0.0001

	Oxygen Correction Part of MU Budget			
Measured Quantities	Units	Run 1	Run 2	Run 3
O_2 Correction Factor	-	1.13	1.12	1.10
Stack Gas O_2 Content	% v/v	11.26	11.19	10.96
MU for O_2 Correction	-	0.06	0.06	0.05
Overall MU For O_2 Measurement	%	5.13	5.09	4.98

Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	mg/m^3	0.00019	0.00010	0.00009
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.00037	0.00020	0.00017
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	0.00039	0.00021	0.00018
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.00039	0.00021	0.00018
Reported Uncertainty	mg/m^3	0.00039	0.00021	0.00018
Expanded uncertainty (95% confidence), without Oxygen Correction	%	15.8	15.8	15.8
Expanded uncertainty (95% confidence), with Oxygen Correction	%	16.6	16.6	16.5
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	16.6	16.6	16.5
Reported Uncertainty	%	16.6	16.6	16.5

APPENDIX 2

HEAVY METALS: RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	mg/m³	0.24	0.01	0.02		0.09
Uncertainty	±mg/m³	0.06	0.003	0.003		0.02
Mass Emission	g/hr	77.6	4.6	5.3		29.1
Uncertainty	±g/hr	19.1	0.9	1.1		7.0

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	9.63	11.23	10.80		10.55
Uncertainty	±% v/v	0.50	0.59	0.56		0.55

NOTE: Where water droplets are present (See the Quality Assurance page), the Water Vapour concentration as found in Annex A of EN 14790 has been reported instead of the calculated value.

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	0.01		0.01

General Sampling Information

Parameter	Value	
Standard	EN 14385	
Technical Procedure	MD 006	
Name of Analytical Laboratory	EET	
Analytical Laboratory's Procedure	CAT-AP-07	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	28/11/2023	
Probe Material	Titanium	
Filter Housing Material	Borosilicate Glass	
Impinger Material	Borosilicate Glass	
Absorption Solution	Nitric Peroxide	
Positioning of Filter	Out Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	2 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	20 / 20	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1 - A10, B1 - B10	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

HEAVY METALS: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	Run 2	Run 3
Absolute pressure of stack gas, P_s				
Barometric pressure, P_b	mmHg	751.6	751.6	751.6
Stack static pressure, P_{static}	mmH_2O	-25.7	-25.7	-25.5
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	749.7	749.7	749.7
Volume of water vapour collected, V_{wstd}				
Total mass collected in impingers (liquid trap)	g	88.4	103.1	97.1
Total mass collected in impingers (silica trap)	g	7.7	8.3	7.5
Total mass of liquid collected, V_{lc}	g	96.1	111.4	104.6
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.1197	0.1388	0.1303
Volume of gas metered dry, V_{mstd}				
Volume of gas sample through gas meter, V_m	m^3	1.2620	1.2320	1.2100
Gas meter correction factor, Y_d	-	0.9800	0.9800	0.9800
Average dry gas meter temperature, T_m	°C	25.6	25.6	25.6
Average pressure drop across orifice, ΔH	mmH_2O	49.8	51.2	47.3
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	1.1235	1.0969	1.0769
Moisture content, B_{wo} & R_{wv}				
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.0963	0.1123	0.1080
B_{wo} as a percentage	% v/v	9.63	11.23	10.80
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	9.63	11.23	10.80
Volume of gas metered wet, V_{mstw}				
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	1.2432	1.2357	1.2073
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$				
IED & Incinerates Hazardous Material? (Yes = no positive O_2 correction)	-	No	No	No
% wet oxygen measured in gas stream, $ACT\%O_{2w}$	% v/v	10.05	9.99	9.79
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	11.26	11.19	10.96
% oxygen reference condition, $REF\%O_2$	% v/v	10.00	10.00	10.00
O_2 Reference Factor wet (O_{2REFw}) = $(21 - REF\%O_2) / (21 - ACT\%O_{2w})$	-	1.00	1.00	0.98
O_2 Reference Factor dry (O_{2REFd}) = $(21 - REF\%O_2) / (21 - ACT\%O_{2d})$	-	1.13	1.12	1.10
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	1.2372	1.2371	1.2305
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	0.9951	0.9787	0.9827
Molecular weight of dry gas stream, M_d				
CO_2	% v/v	21.00	17.00	17.00
O_2	% v/v	11.26	11.19	10.96
Total	% v/v	32.26	28.19	27.96
N_2	% v/v	67.74	71.81	72.04
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	31.81	31.17	31.16
Molecular weight of stack gas (wet), M_s				
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	30.48	29.69	29.74
Velocity of stack gas, V_s				
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97
Velocity pressure coefficient, C_p	-	0.85	0.85	0.85
Average of velocity heads, ΔP_{avg}	mmH_2O	39.10	39.10	37.10
Average square root of velocity heads, $\sqrt{\Delta P}$	$\sqrt{mmH_2O}$	6.25	6.25	6.09
Average stack gas temperature, T_s	°C	153.4	140.9	151.9
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{(M_s)(P_s)})$	m/s	25.30	25.26	24.91
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})				
Area of stack, A_s	m^2	5.31	5.31	5.31
$Q_a = (60)(A_s)(V_s)$	m^3/min	8061.0	8046.5	7934.8
Conversion factor (K/mm.Hg), C_f	-	0.3592	0.3592	0.3592
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	5090.4	5235.6	5029.3
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	4600.1	4647.5	4486.4
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	5065.7	5241.4	5126.3
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	4074.3	4146.4	4094.0
Percent isokinetic, %I				
Nozzle diameter, D_n	mm	5.17	5.17	5.17
Nozzle area, A_n	mm^2	21.00	21.00	21.00
Total sampling time, q	min	60	60	60
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	102.9	99.5	101.2

HEAVY METALS: SAMPLING DETAILS

(PAGE 1 OF 5)

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	11:53 - 12:58	12:21 - 13:25	09:50 - 10:52
Sampling Dates	-	20/11/2023	21/11/2023	22/11/2023
Sampling Device	-	ISO	ISO	ISO
Volume Sampled (REF)	m^3	0.9951	0.9787	0.9827
Arsenic				
Mass on Filter / in Rinse	µg	< 0.50	< 0.50	< 0.50
Mass in Front Impingers	µg	< 0.10	< 0.10	< 0.09
Mass in Back Impinger	µg	< 0.04	< 0.04	< 0.03
Total Mass Collected	µg	< 0.63	< 0.63	< 0.62
Calculated Concentration	mg/m^3	< 0.0006	< 0.0006	< 0.0006
Reported Concentration	mg/m^3	< 0.0006	< 0.0006	< 0.0006
Mass Emission	g/hr	< 0.20	< 0.21	< 0.20
Cobalt				
Mass on Filter / in Rinse	µg	< 0.50	< 0.50	< 0.50
Mass in Front Impingers	µg	< 0.06	< 0.07	< 0.06
Mass in Back Impinger	µg	< 0.02	< 0.02	< 0.02
Total Mass Collected	µg	< 0.59	< 0.59	< 0.58
Calculated Concentration	mg/m^3	< 0.0006	< 0.0006	< 0.0006
Reported Concentration	mg/m^3	< 0.0006	< 0.0006	< 0.0006
Mass Emission	g/hr	< 0.19	< 0.19	< 0.19
Chromium				
Mass on Filter / in Rinse	µg	3.27	< 0.60	< 0.60
Mass in Front Impingers	µg	2.42	3.26	2.06
Mass in Back Impinger	µg	0.89	0.27	0.45
Total Mass Collected	µg	6.58	4.13	3.11
Calculated Concentration	mg/m^3	0.0066	0.0042	0.0032
Reported Concentration	mg/m^3	0.0066	0.0042	0.0032
Mass Emission	g/hr	2.10	1.34	1.00
Copper				
Mass on Filter / in Rinse	µg	151.53	2.44	7.56
Mass in Front Impingers	µg	3.47	0.80	0.34
Mass in Back Impinger	µg	1.82	0.56	0.11
Total Mass Collected	µg	156.82	3.79	8.01
Calculated Concentration	mg/m^3	0.1576	0.0039	0.0081
Reported Concentration	mg/m^3	0.1576	0.0039	0.0081
Mass Emission	g/hr	50.02	1.23	2.59
Manganese				
Mass on Filter / in Rinse	µg	0.59	< 0.40	< 0.40
Mass in Front Impingers	µg	0.18	0.20	0.11
Mass in Back Impinger	µg	0.06	0.14	0.04
Total Mass Collected	µg	0.83	0.74	0.55
Calculated Concentration	mg/m^3	0.0008	0.0008	0.0006
Reported Concentration	mg/m^3	0.0008	0.0008	0.0006
Mass Emission	g/hr	0.27	0.24	0.18

HEAVY METALS: SAMPLING DETAILS

Sample Runs (continued)

Parameter	Units	Run 1	Run 2	Run 3
Nickel				
Mass on Filter / in Rinse	µg	69.45	< 0.60	< 0.60
Mass in Front Impingers	µg	2.07	0.96	0.82
Mass in Back Impinger	µg	0.38	0.31	0.24
Total Mass Collected	µg	71.90	1.86	1.66
Calculated Concentration	mg/m^3	0.0723	0.0019	0.0017
Reported Concentration	mg/m^3	0.0723	0.0019	0.0017
Mass Emission	g/hr	22.94	0.60	0.54
Lead				
Mass on Filter / in Rinse	µg	4.20	< 0.50	< 0.50
Mass in Front Impingers	µg	0.29	0.26	0.10
Mass in Back Impinger	µg	0.15	0.16	0.05
Total Mass Collected	µg	4.64	0.92	0.65
Calculated Concentration	mg/m^3	0.0047	0.0009	0.0007
Reported Concentration	mg/m^3	0.0047	0.0009	0.0007
Mass Emission	g/hr	1.48	0.30	0.21
Antimony				
Mass on Filter / in Rinse	µg	0.60	< 0.60	< 0.60
Mass in Front Impingers	µg	< 0.06	< 0.07	< 0.06
Mass in Back Impinger	µg	< 0.02	< 0.02	< 0.02
Total Mass Collected	µg	0.69	< 0.69	< 0.68
Calculated Concentration	mg/m^3	0.0007	< 0.0007	< 0.0007
Reported Concentration	mg/m^3	0.0007	< 0.0007	< 0.0007
Mass Emission	g/hr	0.22	< 0.22	< 0.22
Vanadium				
Mass on Filter / in Rinse	µg	< 0.40	< 0.40	< 0.40
Mass in Front Impingers	µg	0.07	0.18	0.07
Mass in Back Impinger	µg	0.01	0.10	0.03
Total Mass Collected	µg	0.48	0.68	0.51
Calculated Concentration	mg/m^3	0.0005	0.0007	0.0005
Reported Concentration	mg/m^3	0.0005	0.0007	0.0005
Mass Emission	g/hr	0.15	0.22	0.16

HEAVY METALS: SAMPLING DETAILS

Sample Runs (continued)

Parameter	Units	Run 1	Run 2	Run 3
Heavy Metals Combined				
Total Mass Collected	µg	243.16	14.03	16.37
Calculated Concentration	mg/m³	0.2444	0.0143	0.0167
Reported Concentration	mg/m³	0.2444	0.0143	0.0167

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	20/11/2023
Average Volume Sampled (REF)	m³	0.9855
Arsenic		
Mass on Filter / in Rinse	µg	< 0.50
Mass in Front Impingers	µg	< 0.06
Mass in Back Impinger	µg	< 0.03
Total Mass Collected	µg	< 0.59
Calculated Concentration	mg/m³	< 0.0006
Reported Concentration	mg/m³	< 0.0006
Cobalt		
Mass on Filter / in Rinse	µg	< 0.50
Mass in Front Impingers	µg	< 0.04
Mass in Back Impinger	µg	< 0.02
Total Mass Collected	µg	< 0.56
Calculated Concentration	mg/m³	< 0.0006
Reported Concentration	mg/m³	< 0.0006

HEAVY METALS: SAMPLING DETAILS

(PAGE 4 OF 5)

Blank Runs (continued)

Parameter	Units	Blank 1
Chromium		
Mass on Filter / in Rinse	µg	< 0.60
Mass in Front Impingers	µg	< 0.02
Mass in Back Impinger	µg	< 0.01
Total Mass Collected	µg	< 0.63
Calculated Concentration	mg/m^3	< 0.0006
Reported Concentration	mg/m^3	< 0.0006
Copper		
Mass on Filter / in Rinse	µg	< 0.60
Mass in Front Impingers	µg	< 0.08
Mass in Back Impinger	µg	< 0.04
Total Mass Collected	µg	< 0.72
Calculated Concentration	mg/m^3	< 0.0007
Reported Concentration	mg/m^3	< 0.0007
Manganese		
Mass on Filter / in Rinse	µg	< 0.40
Mass in Front Impingers	µg	< 0.04
Mass in Back Impinger	µg	< 0.02
Total Mass Collected	µg	< 0.46
Calculated Concentration	mg/m^3	< 0.0005
Reported Concentration	mg/m^3	< 0.0005
Nickel		
Mass on Filter / in Rinse	µg	< 0.60
Mass in Front Impingers	µg	0.55
Mass in Back Impinger	µg	0.28
Total Mass Collected	µg	1.43
Calculated Concentration	mg/m^3	0.0015
Reported Concentration	mg/m^3	0.0015
Lead		
Mass on Filter / in Rinse	µg	< 0.50
Mass in Front Impingers	µg	< 0.04
Mass in Back Impinger	µg	< 0.02
Total Mass Collected	µg	< 0.56
Calculated Concentration	mg/m^3	< 0.0006
Reported Concentration	mg/m^3	< 0.0006
Antimony		
Mass on Filter / in Rinse	µg	< 0.60
Mass in Front Impingers	µg	< 0.04
Mass in Back Impinger	µg	< 0.02
Total Mass Collected	µg	< 0.66
Calculated Concentration	mg/m^3	< 0.0007
Reported Concentration	mg/m^3	< 0.0007
Vanadium		
Mass on Filter / in Rinse	µg	< 0.40
Mass in Front Impingers	µg	< 0.02
Mass in Back Impinger	µg	< 0.01
Total Mass Collected	µg	< 0.43
Calculated Concentration	mg/m^3	< 0.0004
Reported Concentration	mg/m^3	< 0.0004

HEAVY METALS: SAMPLING DETAILS

Blank Runs (continued)

Parameter	Units	Blank 1	
Heavy Metals Combined			
Total Mass Collected	µg	6.05	
Calculated Concentration	mg/m^3	0.0061	
Reported Concentration	mg/m^3	0.0061	

HEAVY METALS: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	20.6	20.1	19.8
Pre-Sampling Leak Rate	l/min	0.11	0.15	0.11
Post-Sampling Leak Rate	l/min	N/A	N/A	N/A
Allowable Leak Rate	l/min	0.30	0.30	0.30
Leak Test Acceptable	-	Yes	Yes	Yes

Absorption Efficiency	Units	Run 1	Run 2	Run 3
Arsenic	%	N/A <1% Total	100.0	100.0
Cobalt	%	N/A <1% Total	100.0	100.0
Chromium	%	86.4	93.5	85.7
Copper	%	98.8	85.4	98.6
Manganese	%	N/A <1% Total	81.6	92.0
Nickel	%	99.5	83.6	85.4
Lead	%	96.8	83.0	92.4
Antimony	%	N/A <1% Total	100.0	100.0
Vanadium	%	N/A <1% Total	85.6	93.3
Allowable Absorption Efficiency	%	90	N/A	N/A
Absorption Efficiency Acceptable	-	No	Yes	Yes

Where the emissions are < 30% of the ELV, MID 14385 does not require the absorption efficiency requirement to be applied

Detection Limit	Units	Run 1	Run 2	Run 3
Arsenic	µg/m³	0.6	0.6	0.6
Cobalt	µg/m³	0.6	0.6	0.6
Chromium	µg/m³	0.6	0.7	0.7
Copper	µg/m³	0.8	0.8	0.8
Manganese	µg/m³	0.5	0.5	0.5
Nickel	µg/m³	0.7	0.7	0.7
Lead	µg/m³	0.6	0.6	0.6
Antimony	µg/m³	0.7	0.7	0.7
Vanadium	µg/m³	0.4	0.5	0.4
Allowable Detection Limit	µg/m³	5	5	5
Detection Limit Acceptable	-	No	No	No

Water Droplets	Units	Run 1	Run 2	Run 3
Are Water Droplets Present	-	Yes	Yes	Yes

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Measurement Uncertainty (MU)	%	5.2	5.3	5.2
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

HEAVY METALS: QUALITY ASSURANCE

(PAGE 2 OF 2)

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Less than 50% Faded	%	Yes	Yes	Yes

Isokinetic Criterion Compliance	Units	Run 1	Run 2	Run 3
Isokinetic Variation	%	102.9	99.5	101.2
Allowable Isokinetic Range	%	95 - 115	95 - 115	95 - 115
Isokineticity Acceptable	-	Yes	Yes	Yes

Filter Temperatures	Units	Run 1	Run 2	Run 3
Maximum Filter Temperature	°C	160	160	160

Impingers Exit Temperature	Units	Run 1	Run 2	Run 3
Maximum Temperature Recorded	°C	18	18	18
Maximum Allowable Temperature	°C	30	30	30
Exit Temperature Acceptable	-	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	15.0
Pre-Sampling Leak Rate	l/min	0.11
Post-Sampling Leak Rate	l/min	0.05
Allowable Leak Rate	l/min	0.30
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m^3	0.1
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	2	3
The absorption efficiency for all of the individual metals was not met, however it should be noted the results were of an extremely low order.	x		

HEAVY METALS: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value				Standard uncertainty				
	Symbol	Run 1	Run 2	Run 3	Symbol	Units	Run 1	Run 2	Run 3
Sampled Volume (Actual)	V_m	1.2620	1.2320	1.2100	uV_m	m^3	0.0252	0.0246	0.0242
Sampled Gas Temperature	T_m	298.6	298.6	298.6	uT_m	K	2.00	2.00	2.00
Sampled Gas Pressure	ρ_m	100.0	100.0	100.0	$u\rho_m$	kPa	0.50	0.50	0.50
Sampled Gas Humidity	H_m	0.00	0.00	0.00	uH_m	% v/v	1.00	1.00	1.00
Leak	L	0.53	0.75	0.56	uL	%	-	-	-
Laboratory Result	L_r	9.60	9.60	9.60	uL_r	%	-	-	-

Measured Quantities	Uncertainty as a Percentage				Requirement of Standard
	Units	Run 1	Run 2	Run 3	
Sampled Volume (Actual)	%	2.00	2.00	2.00	≤2%
Sampled Gas Temperature	%	0.67	0.67	0.67	≤1%
Sampled Gas Pressure	%	0.50	0.50	0.50	≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00	≤1%
Leak	%	0.53	0.75	0.56	≤2%
Laboratory Result	%	9.60	9.60	9.60	No Requirement

Measured Quantities	Uncertainty in Measurement Units					Sensitivity Coefficient		
	Symbol	Units	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	m^3	1.1235	1.0969	1.0769	0.22	0.01	0.02
Leak	L	mg/m^3	0.001	0.000	0.000	1.00	1.00	1.00
Laboratory Result	L_r	mg/m^3	0.023	0.001	0.002	1.00	1.00	1.00

Measured Quantities	Uncertainty in Result			
	Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	mg/m^3	0.006	0.000	0.000
Leak	mg/m^3	0.0008	0.0001	0.0001
Laboratory Result	mg/m^3	0.0235	0.0014	0.0016

Measured Quantities	Oxygen Correction Part of MU Budget			
	Units	Run 1	Run 2	Run 3
O_2 Correction Factor	-	1.13	1.12	1.10
Stack Gas O_2 Content	% v/v	11.26	11.19	10.96
MU for O_2 Correction	-	0.06	0.06	0.05
Overall MU For O_2 Measurement	%	5.13	5.09	4.98

Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	mg/m^3	0.02	0.0014	0.0017
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.05	0.0028	0.0032
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	0.05	0.0029	0.0034
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.06	0.0029	0.0034
Reported Uncertainty	mg/m^3	0.06	0.0029	0.0034
Expanded uncertainty (95% confidence), without Oxygen Correction	%	19.5	19.5	19.5
Expanded uncertainty (95% confidence), with Oxygen Correction	%	20.2	20.2	20.1
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	24.2	20.2	20.1
Reported Uncertainty	%	24.2	20.2	20.1

APPENDIX 2

MERCURY: RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	mg/m³	0.0073	0.0117	0.0100		0.0097
Uncertainty	±mg/m³	0.0017	0.0028	0.0024		0.0023
Mass Emission	g/hr	2.33	3.72	3.16		3.07
Uncertainty	±g/hr	0.56	0.90	0.76		0.74

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	10.21	9.36	10.05		9.88
Uncertainty	±% v/v	0.54	0.50	0.53		0.52

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 0.0002		< 0.0002

General Sampling Information

Parameter	Value	
Standard	EN 13211	
Technical Procedure	MD 006	
Name of Analytical Laboratory	EET	
Analytical Laboratory's Procedure	CAT-AP-08	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	28/11/2023	
Probe Material	Titanium	
Filter Housing Material	Titanium	
Impinger Material	Borosilicate Glass	
Absorption Solution	Potassium Dichromate	
Positioning of Filter	Out Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	2 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	20 / 20	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1 - A10, B1 - B10	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

MERCURY: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	Run 2	Run 3
Absolute pressure of stack gas, P_s				
Barometric pressure, P_b	mmHg	748.6	751.6	751.6
Stack static pressure, P_{static}	mmH_2O	-25.8	-25.8	-25.8
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	746.7	749.7	749.7
Volume of water vapour collected, V_{wstd}				
Total mass collected in impingers (liquid trap)	g	100.1	76.0	91.6
Total mass collected in impingers (silica trap)	g	3.0	16.3	2.7
Total mass of liquid collected, V_{lc}	g	103.1	92.3	94.3
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.1285	0.1150	0.1175
Volume of gas metered dry, V_{mstd}				
Volume of gas sample through gas meter, V_m	m^3	1.2740	1.2509	1.1820
Gas meter correction factor, Y_d	-	0.9800	0.9800	0.9800
Average dry gas meter temperature, T_m	°C	25.8	25.8	25.8
Average pressure drop across orifice, ΔH	mmH_2O	51.5	51.4	48.0
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	1.1293	1.1132	1.0516
Moisture content, B_{wo} & R_{wv}				
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.1021	0.0936	0.1005
B_{wo} as a percentage	% v/v	10.21	9.36	10.05
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	10.21	9.36	10.05
Volume of gas metered wet, V_{mstw}				
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	1.2578	1.2282	1.1691
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$				
IED & Incinerates Hazardous Material? (Yes = no positive O_2 correction)	-	No	No	No
% wet oxygen measured in gas stream, $ACT\%O_{2w}$	% v/v	10.23	10.26	10.09
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	11.46	11.49	11.30
% oxygen reference condition, $REF\%O_2$	% v/v	10.00	10.00	10.00
O_2 Reference Factor wet (O_{2REFw}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2w}$)	-	1.02	1.02	1.01
O_2 Reference Factor dry (O_{2REFd}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2d}$)	-	1.15	1.16	1.13
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	1.2313	1.1993	1.1595
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	0.9795	0.9624	0.9272
Molecular weight of dry gas stream, M_d				
CO_2	% v/v	21.00	15.00	15.00
O_2	% v/v	11.46	11.49	11.30
Total	% v/v	32.46	26.49	26.30
N_2	% v/v	67.54	73.51	73.70
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	31.82	30.86	30.85
Molecular weight of stack gas (wet), M_s				
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	30.41	29.66	29.56
Velocity of stack gas, V_s				
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97
Velocity pressure coefficient, C_p	-	0.85	0.85	0.85
Average of velocity heads, ΔP_{avg}	mmH_2O	39.80	39.80	37.50
Average square root of velocity heads, √ΔP	$\sqrt{mmH_2O}$	6.31	6.31	6.12
Average stack gas temperature, T_s	°C	146.3	147.7	150.3
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{(M_s)(P_s)})$	m/s	25.39	25.70	25.07
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})				
Area of stack, A_s	m^2	5.31	5.31	5.31
$Q_a = (60)(A_s)(V_s)$	m^3/min	8090.0	8189.1	7986.8
Conversion factor (K/mm.Hg), C_f	-	0.3592	0.3592	0.3592
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	5175.4	5242.3	5080.8
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	4646.8	4751.4	4570.1
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	5066.5	5118.6	5039.1
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	4030.6	4107.7	4029.7
Percent isokinetic, %I				
Nozzle diameter, D_n	mm	5.17	5.17	5.17
Nozzle area, A_n	mm^2	21.00	21.00	21.00
Total sampling time, q	min	60	60	60
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	102.4	98.8	97.0

MERCURY: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	14:35 - 15:38	09:30 - 10:35	12:13 - 13:15
Sampling Dates	-	20/11/2023	21/11/2023	22/11/2023
Sampling Device	-	ISO	ISO	ISO
Volume Sampled (REF)	m^3	0.9795	0.9624	0.9272
Mass on Filter / in Rinse	µg	< 0.03	< 0.03	< 0.03
Mass in Front Impingers	µg	5.96	9.32	7.39
Mass in Back Impinger	µg	1.21	1.92	1.82
Total Mass Collected	µg	7.19	11.27	9.24
Calculated Concentration	mg/m^3	0.0073	0.0117	0.0100
Reported Concentration	mg/m^3	0.0073	0.0117	0.0100

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	20/11/2023
Average Volume Sampled (REF)	m^3	0.9564
Mass on Filter / in Rinse	µg	< 0.03
Mass in Front Impingers	µg	< 0.11
Mass in Back Impinger	µg	< 0.05
Total Mass Collected	µg	< 0.19
Calculated Concentration	mg/m^3	< 0.0002
Reported Concentration	mg/m^3	< 0.0002

MERCURY: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	20.8	20.4	19.3
Pre-Sampling Leak Rate	l/min	0.12	0.18	0.18
Post-Sampling Leak Rate	l/min	N/A	N/A	N/A
Allowable Leak Rate	l/min	0.30	0.30	0.40
Leak Test Acceptable	-	Yes	Yes	Yes

Absorption Efficiency	Units	Run 1	Run 2	Run 3
Absorption Efficiency	%	83.1	83.0	80.2
Allowable Absorption Efficiency	%	95	95	95
Final Impinger Concentration	µg/m³	1.23	1.99	1.97
Absorption Efficiency Acceptable	-	Yes	Yes	Yes

EN 13211 requirement is to have <5% of the total mercury in all absorbers or <2µg/m³ in the final impinger

Water Droplets	Units	Run 1	Run 2	Run 3
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Measurement Uncertainty (MU)	%	5.2	5.3	5.3
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Less than 50% Faded	%	Yes	Yes	Yes

Isokinetic Criterion Compliance	Units	Run 1	Run 2	Run 3
Isokinetic Variation	%	102.4	98.8	97.0
Allowable Isokinetic Range	%	95 - 115	95 - 115	95 - 115
Isokineticity Acceptable	-	Yes	Yes	Yes

Filter Temperatures	Units	Run 1	Run 2	Run 3
Maximum Filter Temperature	°C	180	180	180

Impingers Exit Temperature	Units	Run 1	Run 2	Run 3
Maximum Temperature Recorded	°C	19	19	19
Maximum Allowable Temperature	°C	30	30	30
Exit Temperature Acceptable	-	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

MERCURY: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	15.0
Pre-Sampling Leak Rate	l/min	0.13
Post-Sampling Leak Rate	l/min	0.12
Allowable Leak Rate	l/min	0.30
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m^3	0.005
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	2	3
There are no deviations associated with the sampling employed.	wx	wx	wx

MERCURY: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value				Standard uncertainty				
	Symbol	Run 1	Run 2	Run 3	Symbol	Units	Run 1	Run 2	Run 3
Sampled Volume (Actual)	V_m	1.2740	1.2509	1.1820	uV_m	m^3	0.0255	0.0250	0.0236
Sampled Gas Temperature	T_m	298.8	298.8	298.8	uT_m	K	2.00	2.00	2.00
Sampled Gas Pressure	ρ_m	99.6	100.0	100.0	$u\rho_m$	kPa	0.50	0.50	0.50
Sampled Gas Humidity	H_m	0.00	0.00	0.00	uH_m	% v/v	1.00	1.00	1.00
Leak	L	0.58	0.88	0.93	uL	%	-	-	-
Laboratory Result	L_r	11.50	11.50	11.50	uL_r	%	-	-	-

Measured Quantities	Uncertainty as a Percentage				Requirement of Standard
	Units	Run 1	Run 2	Run 3	
Sampled Volume (Actual)	%	2.00	2.00	2.00	≤2%
Sampled Gas Temperature	%	0.67	0.67	0.67	≤1%
Sampled Gas Pressure	%	0.50	0.50	0.50	≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00	≤1%
Leak	%	0.58	0.88	0.93	≤2%
Laboratory Result	%	11.50	11.50	11.50	No Requirement

Measured Quantities	Uncertainty in Measurement Units					Sensitivity Coefficient		
	Symbol	Units	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	m^3	1.1293	1.1132	1.0516	0.01	0.01	0.01
Leak	L	mg/m^3	0.0000	0.0001	0.0001	1.00	1.00	1.00
Laboratory Result	L_r	mg/m^3	0.0008	0.0013	0.0011	1.00	1.00	1.00

Measured Quantities	Uncertainty in Result			
	Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	mg/m^3	0.0002	0.0003	0.0003
Leak	mg/m^3	0.0000	0.0001	0.0001
Laboratory Result	mg/m^3	0.0008	0.0013	0.0011

Measured Quantities	Oxygen Correction Part of MU Budget			
	Units	Run 1	Run 2	Run 3
O_2 Correction Factor	-	1.15	1.16	1.13
Stack Gas O_2 Content	% v/v	11.46	11.49	11.30
MU for O_2 Correction	%	0.06	0.06	0.06
Overall MU For O_2 Measurement	%	5.24	5.26	5.16

Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	mg/m^3	0.0009	0.0014	0.0012
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.0017	0.0027	0.0023
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	0.0017	0.0028	0.0024
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.0017	0.0028	0.0024
Reported Uncertainty	mg/m^3	0.0017	0.0028	0.0024
Expanded uncertainty (95% confidence), without Oxygen Correction	%	23.1	23.1	23.1
Expanded uncertainty (95% confidence), with Oxygen Correction	%	23.7	23.7	23.7
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	23.7	23.7	23.7
Reported Uncertainty	%	23.7	23.7	23.7

DIOXINS & FURANS: RESULTS SUMMARY

(PAGE 1 OF 4)

Irish Cement Ltd, Limerick
A2-01 Kiln 6

TEQ1 - UPPER LIMITS (worst case where <LOD = LOD)

Sample Runs (UPPER NATO I-TEQ)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.001	0.015	0.018		0.011
Uncertainty	±ng/m³	0.0003	0.003	0.004		0.002
Mass Emission	µg/hr	0.43	4.67	5.63		3.58
Uncertainty	±µg/hr	0.09	1.00	1.20		0.76

Sample Runs (UPPER WHO TEQ Humans / Mammals)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.002	0.014	0.020		0.012
Uncertainty	±ng/m³	0.0004	0.003	0.004		0.002
Mass Emission	µg/hr	0.56	4.38	6.25		3.73
Uncertainty	±µg/hr	0.12	0.94	1.33		0.80

Sample Runs (UPPER WHO TEQ Fish)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.002	0.012	0.017		0.010
Uncertainty	±ng/m³	0.0003	0.003	0.004		0.002
Mass Emission	µg/hr	0.51	3.92	5.43		3.29
Uncertainty	±µg/hr	0.11	0.84	1.16		0.70

Sample Runs (UPPER WHO TEQ Birds)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.002	0.080	0.073		0.051
Uncertainty	±ng/m³	0.0004	0.017	0.015		0.011
Mass Emission	µg/hr	0.56	25.32	23.10		16.32
Uncertainty	±µg/hr	0.12	5.41	4.93		3.49

DIOXINS & FURANS: RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

TEQ2 - LOWER LIMITS (best case where <LOD = 0)

Sample Runs (LOWER NATO I-TEQ)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.001	0.011	0.006		0.006
Uncertainty	±ng/m³	0.0002	0.002	0.001		0.001
Mass Emission	µg/hr	0.29	3.52	1.86		1.89
Uncertainty	±µg/hr	0.06	0.75	0.40		0.40

Sample Runs (LOWER WHO TEQ Humans / Mammals)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.001	0.009	0.006		0.006
Uncertainty	±ng/m³	0.0003	0.002	0.001		0.001
Mass Emission	µg/hr	0.43	2.95	1.86		1.75
Uncertainty	±µg/hr	0.09	0.63	0.40		0.37

Sample Runs (LOWER WHO TEQ Fish)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.001	0.008	0.003		0.004
Uncertainty	±ng/m³	0.0002	0.002	0.001		0.001
Mass Emission	µg/hr	0.31	2.46	0.93		1.23
Uncertainty	±µg/hr	0.07	0.53	0.20		0.26

Sample Runs (LOWER WHO TEQ Birds)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.001	0.075	0.058		0.045
Uncertainty	±ng/m³	0.0003	0.016	0.012		0.009
Mass Emission	µg/hr	0.40	23.93	18.55		14.29
Uncertainty	±µg/hr	0.09	5.11	3.96		3.05

DIOXINS & FURANS: RESULTS SUMMARY

(PAGE 3 OF 4)

Irish Cement Ltd, Limerick
A2-01 Kiln 6

TEQ1 - UPPER LIMITS (worst case where <LOD = LOD)

Blank Runs (UPPER NATO I-TEQ)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m³	0.0008	0.0008

Blank Runs (UPPER WHO TEQ Humans / Mammals)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m³	0.0010	0.0010

Blank Runs (UPPER WHO TEQ Fish)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m³	0.0011	0.0011

Blank Runs (UPPER WHO TEQ Birds)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m³	0.0016	0.0016

TEQ2 - LOWER LIMITS (best case where <LOD = 0)

Blank Runs (LOWER NATO I-TEQ)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m³	0.0000018	0.0000018

Blank Runs (LOWER WHO TEQ Humans / Mammals)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m³	0.0000005	0.0000005

Blank Runs (LOWER WHO TEQ Fish)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m³	0.0000002	0.0000002

Blank Runs (LOWER WHO TEQ Birds)

Parameter	Units	Blank 1	Maximum
Concentration	ng/m³	0.0000002	0.0000002

DIOXINS & FURANS: RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	11.28	10.86	10.13		10.76
Uncertainty	±% v/v	0.55	0.54	0.51		0.53

General Sampling Information

Parameter	Value	
Standard	EN 1948	
Technical Procedure	MD 007	
Name of Analytical Laboratory	ELD	
Analytical Laboratory's Procedure	PM137, TM201	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	15/01/2024	
Probe Material	Titanium	
Filter Housing Material	Borosilicate Glass	
Glassware Material	Borosilicate Glass	
Absorption Material	XAD-2	
Positioning of Filter	Out Stack	
Filter Size and Material	90mm Quartz Fibre	
Number of Sampling Lines Used	2 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	20 / 20	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1 - A10, B1 - B10	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

DIOXINS & FURANS: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	Run 2	Run 3
Absolute pressure of stack gas, P_s				
Barometric pressure, P_b	mmHg	744.8	765.1	758.3
Stack static pressure, P_{static}	mmH_2O	-25.5	-25.5	-25.5
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	742.9	763.2	756.4
Volume of water vapour collected, V_{wstd}				
Total mass collected in impingers (liquid trap)	g	596.8	551.7	512.3
Total mass collected in impingers (silica trap)	g	26.9	37.4	12.1
Total mass of liquid collected, V_{lc}	g	623.7	589.1	524.4
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.7771	0.7340	0.6534
Volume of gas metered dry, V_{mstd}				
Volume of gas sample through gas meter, V_m	m^3	6.2612	6.0080	5.8342
Gas meter correction factor, Y_d	-	1.0630	1.0630	1.0630
Average dry gas meter temperature, T_m	°C	19.5	19.5	19.5
Average pressure drop across orifice, ΔH	mmH_2O	39.7	39.8	38.5
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	6.1107	6.0225	5.7961
Moisture content, B_{wo} & R_{wv}				
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.1128	0.1086	0.1013
B_{wo} as a percentage	% v/v	11.28	10.86	10.13
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	11.28	10.86	10.13
Volume of gas metered wet, V_{mstw}				
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	6.8879	6.7565	6.4495
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$				
IED & Incinerates Hazardous Material? (Yes = no positive O_2 correction)	-	No	No	No
% wet oxygen measured in gas stream, $ACT\%O_{2w}$	% v/v	10.02	10.25	10.03
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	11.22	11.48	11.23
% oxygen reference condition, $REF\%O_2$	% v/v	10.00	10.00	10.00
O_2 Reference Factor wet (O_{2REFw}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2w}$)	-	1.00	1.02	1.00
O_2 Reference Factor dry (O_{2REFd}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2d}$)	-	1.12	1.16	1.13
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	6.8779	6.6038	6.4331
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	5.4344	5.2132	5.1475
Molecular weight of dry gas stream, M_d				
CO_2	% v/v	21.00	21.00	21.00
O_2	% v/v	11.22	11.48	11.23
Total	% v/v	32.22	32.48	32.23
N_2	% v/v	67.78	67.52	67.77
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	31.81	31.82	31.81
Molecular weight of stack gas (wet), M_s				
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	30.25	30.32	30.41
Velocity of stack gas, V_s				
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97
Velocity pressure coefficient, C_p	-	0.85	0.85	0.85
Average of velocity heads, ΔP_{avg}	mmH_2O	39.75	39.75	38.23
Average square root of velocity heads, $\sqrt{\Delta P}$	$\sqrt{mmH_2O}$	6.30	6.30	6.18
Average stack gas temperature, T_s	°C	148.0	147.3	146.6
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{(M_s)(P_s)})$	m/s	25.53	25.14	24.70
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})				
Area of stack, A_s	m^2	5.31	5.31	5.31
$Q_a = (60)(A_s)(V_s)$	m^3/min	8133.0	8009.3	7870.3
Conversion factor (K/mm.Hg), C_f	-	0.3592	0.3592	0.3592
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	5155.9	5224.0	5096.7
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	4574.2	4656.5	4580.4
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	5148.5	5105.9	5083.7
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	4067.9	4030.8	4067.8
Percent isokinetic, %I				
Nozzle diameter, D_n	mm	4.90	4.90	4.90
Nozzle area, A_n	mm^2	18.83	18.83	18.83
Total sampling time, q	min	360	360	360
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	104.6	101.3	99.1

DIOXINS & FURANS: SAMPLING DETAILS

RUN 1

Parameter	Units	Value
Sampling Times	-	10:25 - 16:30
Sampling Dates	-	20/11/2023
Sampling Device	-	ISO
Volume Sampled (REF)	m^3	5.4344

Where: ISO stands for Manual Isokinetic Sampling Train

				NATO I-TEQ		WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
2378-TCDD	ng	ND	0.00098	0.0010	0.0000	0.0010	0.0000	0.0010	0.0000	0.0010	0.0000	77
12378-PeCDD	ng	0.00493	0.00278	0.0025	0.0025	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	74
123478-HxCDD	ng	ND	0.00334	0.0003	0.0000	0.0003	0.0000	0.0017	0.0000	0.0002	0.0000	90
123678-HxCDD	ng	0.02216	0.00330	0.0022	0.0022	0.0022	0.0022	0.0002	0.0002	0.0002	0.0002	87
123789-HxCDD	ng	ND	0.00329	0.0003	0.0000	0.0003	0.0000	0.0000	0.0000	0.0003	0.0000	93
1234678-HPeCDD	ng	0.00834	0.00344	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	85
OCDD	ng	ND	0.00430	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	71
Total Dioxins	ng	0.0000	-	0.0064	0.0048	0.0089	0.0072	0.0078	0.0052	0.0066	0.0052	-
2378-TCDF	ng	0.00147	0.00092	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0015	0.0015	122
12378-PeCDF	ng	0.00235	0.00092	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	123
23478-PeCDF	ng	ND	0.00098	0.0005	0.0000	0.0003	0.0000	0.0005	0.0000	0.0010	0.0000	119
123478-HxCDF	ng	ND	0.00145	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	76
123678-HxCDF	ng	ND	0.00048	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	92
234678-HxCDF	ng	ND	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-
123789-HxCDF	ng	ND	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	130
1234678-HPeCDF	ng	ND	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	102
1234789-HPeCDF	ng	ND	0.00064	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	96
OCDF	ng	ND	0.00071	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	78
Total Furans	ng	0.0000	-	0.0010	0.0003	0.0007	0.0002	0.0009	0.0002	0.0029	0.0017	-
Totals	ng	0.0000	-	0.0074	0.0050	0.0096	0.0074	0.0087	0.0054	0.0095	0.0069	-
Total Concentration	ng/m^3	-	-	0.0014	0.0009	0.0018	0.0014	0.0016	0.0010	0.0018	0.0013	-
Limit of Detection	ng/m^3	-	-	0.0008	-	0.0010	-	0.0012	-	0.0012	-	-

Where: ND stands for Non Detected

DL stands for Analytical Detection Limit

TEQ1 refers to Non Detected Congeners at the Detection Limit

TEQ2 refers to Non Detected Congeners at Zero

% Rec stands for the Recovery Percentage of the Sample

DIOXINS & FURANS: SAMPLING DETAILS

(Continued)

RUN 2

Parameter	Units	Value
Sampling Times	-	09:10 - 11:50, 12:10 - 15:30
Sampling Dates	-	21/11/2023
Sampling Device	-	ISO
Volume Sampled (REF)	m^3	5.2132

Where: ISO stands for Manual Isokinetic Sampling Train

				NATO I-TEQ		WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
2378-TCDD	ng	ND	0.01101	0.0110	0.0000	0.0110	0.0000	0.0110	0.0000	0.0110	0.0000	78
12378-PeCDD	ng	ND	0.00882	0.0044	0.0000	0.0088	0.0000	0.0088	0.0000	0.0088	0.0000	60
123478-HxCDD	ng	ND	0.00366	0.0004	0.0000	0.0004	0.0000	0.0018	0.0000	0.0002	0.0000	65
123678-HxCDD	ng	ND	0.00445	0.0004	0.0000	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	60
123789-HxCDD	ng	ND	0.00413	0.0004	0.0000	0.0004	0.0000	0.0000	0.0000	0.0004	0.0000	-
1234678-HPeCDD	ng	ND	0.00294	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	62
OCDD	ng	0.01867	0.00327	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	73
Total Dioxins	ng	0.0000	-	0.0167	0.0000	0.0211	0.0000	0.0218	0.0000	0.0205	0.0000	-
2378-TCDF	ng	0.34691	0.02468	0.0347	0.0347	0.0347	0.0347	0.0173	0.0173	0.3469	0.3469	60
12378-PeCDF	ng	0.04897	0.01925	0.0024	0.0024	0.0015	0.0015	0.0024	0.0024	0.0049	0.0049	102
23478-PeCDF	ng	0.04119	0.01981	0.0206	0.0206	0.0124	0.0124	0.0206	0.0206	0.0412	0.0412	57
123478-HxCDF	ng	ND	0.00497	0.0005	0.0000	0.0005	0.0000	0.0005	0.0000	0.0005	0.0000	61
123678-HxCDF	ng	ND	0.00549	0.0005	0.0000	0.0005	0.0000	0.0005	0.0000	0.0005	0.0000	60
234678-HxCDF	ng	ND	0.00603	0.0006	0.0000	0.0006	0.0000	0.0006	0.0000	0.0006	0.0000	52
123789-HxCDF	ng	ND	0.00632	0.0006	0.0000	0.0006	0.0000	0.0006	0.0000	0.0006	0.0000	122
1234678-HPeCDF	ng	ND	0.00182	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	61
1234789-HPeCDF	ng	ND	0.00198	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	95
OCDF	ng	0.00231	0.00203	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	68
Total Furans	ng	0.0000	-	0.0601	0.0577	0.0508	0.0485	0.0427	0.0404	0.3953	0.3930	-
Totals	ng	0.0000	-	0.0767	0.0578	0.0719	0.0485	0.0645	0.0404	0.4158	0.3930	-
Total Concentration	ng/m^3	-	-	0.0147	0.0111	0.0138	0.0093	0.0124	0.0077	0.0798	0.0754	-
Limit of Detection	ng/m^3	-	-	0.0062	-	0.0062	-	0.0069	-	0.0133	-	-

Where: ND stands for Non Detected

DL stands for Analytical Detection Limit

TEQ1 refers to Non Detected Congeners at the Detection Limit

TEQ2 refers to Non Detected Congeners at Zero

% Rec stands for the Recovery Percentage of the Sample

DIOXINS & FURANS: SAMPLING DETAILS

(Continued)

RUN 3

Parameter	Units	Value
Sampling Times	-	09:45 - 14:22, 15:35 - 17:07
Sampling Dates	-	22/11/2023
Sampling Device	-	ISO
Volume Sampled (REF)	m^3	5.1475

Where: ISO stands for Manual Isokinetic Sampling Train

				NATO I-TEQ		WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
2378-TCDD	ng	ND	0.03680	0.0368	0.0000	0.0368	0.0000	0.0368	0.0000	0.0368	0.0000	17
12378-PeCDD	ng	ND	0.02174	0.0109	0.0000	0.0217	0.0000	0.0217	0.0000	0.0217	0.0000	28
123478-HxCDD	ng	ND	0.00421	0.0004	0.0000	0.0004	0.0000	0.0021	0.0000	0.0002	0.0000	33
123678-HxCDD	ng	ND	0.00417	0.0004	0.0000	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	38
123789-HxCDD	ng	ND	0.00387	0.0004	0.0000	0.0004	0.0000	0.0000	0.0000	0.0004	0.0000	-
1234678-HPeCDD	ng	ND	0.00196	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	60
OCDD	ng	0.01176	0.00312	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	60
Total Dioxins	ng	0.0000	-	0.0489	0.0000	0.0598	0.0000	0.0607	0.0000	0.0592	0.0000	-
2378-TCDF	ng	0.30085	0.02174	0.0301	0.0301	0.0301	0.0301	0.0150	0.0150	0.3009	0.3009	14
12378-PeCDF	ng	ND	0.00421	0.0002	0.0000	0.0001	0.0000	0.0002	0.0000	0.0004	0.0000	135
23478-PeCDF	ng	ND	0.00417	0.0021	0.0000	0.0013	0.0000	0.0021	0.0000	0.0042	0.0000	22
123478-HxCDF	ng	ND	0.00387	0.0004	0.0000	0.0004	0.0000	0.0004	0.0000	0.0004	0.0000	38
123678-HxCDF	ng	ND	0.00196	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	48
234678-HxCDF	ng	ND	0.00312	0.0003	0.0000	0.0003	0.0000	0.0003	0.0000	0.0003	0.0000	58
123789-HxCDF	ng	ND	0.08337	0.0083	0.0000	0.0083	0.0000	0.0083	0.0000	0.0083	0.0000	94
1234678-HPeCDF	ng	ND	0.03972	0.0004	0.0000	0.0004	0.0000	0.0004	0.0000	0.0004	0.0000	62
1234789-HPeCDF	ng	ND	0.04089	0.0004	0.0000	0.0004	0.0000	0.0004	0.0000	0.0004	0.0000	81
OCDF	ng	ND	0.00448	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	62
Total Furans	ng	0.0000	-	0.0424	0.0301	0.0415	0.0301	0.0274	0.0150	0.3155	0.3009	-
Totals	ng	0.0000	-	0.0913	0.0301	0.1013	0.0301	0.0881	0.0150	0.3747	0.3009	-
Total Concentration	ng/m^3	-	-	0.0177	0.0058	0.0197	0.0058	0.0171	0.0029	0.0728	0.0584	-
Limit of Detection	ng/m^3	-	-	0.0123	-	0.0143	-	0.0144	-	0.0186	-	-

Where: ND stands for Non Detected

DL stands for Analytical Detection Limit

TEQ1 refers to Non Detected Congeners at the Detection Limit

TEQ2 refers to Non Detected Congeners at Zero

% Rec stands for the Recovery Percentage of the Sample

DIOXINS & FURANS: SAMPLING DETAILS

(Continued)

BLANK 1

Parameter	Units	Value
Sampling Dates	-	20/11/2023
Sampling Device	-	ISO
Average Volume Sampled (REF)	m³	5.2650

Where: ISO stands for Manual Isokinetic Sampling Train

				NATO I-TEQ		WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
2378-TCDD	ng	ND	0.00126	0.0013	0.0000	0.0013	0.0000	0.0013	0.0000	0.0013	0.0000	93
12378-PeCDD	ng	ND	0.00223	0.0011	0.0000	0.0022	0.0000	0.0022	0.0000	0.0022	0.0000	77
123478-HxCDD	ng	ND	0.00168	0.0002	0.0000	0.0002	0.0000	0.0008	0.0000	0.0001	0.0000	86
123678-HxCDD	ng	ND	0.00218	0.0002	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	67
123789-HxCDD	ng	ND	0.00226	0.0002	0.0000	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000	-
1234678-HPeCDD	ng	ND	0.00151	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	78
OCDD	ng	0.00948	0.00181	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	84
Total Dioxins	ng	0.0000	-	0.0030	0.0000	0.0041	0.0000	0.0044	0.0000	0.0038	0.0000	-
												Paramete
2378-TCDF	ng	ND	0.00310	0.0003	0.0000	0.0003	0.0000	0.0002	0.0000	0.0031	0.0000	58
12378-PeCDF	ng	ND	0.00124	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	117
23478-PeCDF	ng	ND	0.00119	0.0006	0.0000	0.0004	0.0000	0.0006	0.0000	0.0012	0.0000	67
123478-HxCDF	ng	ND	0.00092	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	72
123678-HxCDF	ng	ND	0.00091	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	74
234678-HxCDF	ng	ND	0.00112	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	62
123789-HxCDF	ng	ND	0.00126	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	107
1234678-HPeCDF	ng	ND	0.00088	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	71
1234789-HPeCDF	ng	ND	0.00105	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	100
OCDF	ng	ND	0.00100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	75
Total Furans	ng	0.0000	-	0.0014	0.0000	0.0011	0.0000	0.0013	0.0000	0.0049	0.0000	-
Totals	ng	0.0000	-	0.0044	0.0000	0.0053	0.0000	0.0056	0.0000	0.0087	0.0000	-
Total Concentration	ng/m³	-	-	0.0008	0.0000	0.0010	0.0000	0.0011	0.0000	0.0016	0.0000	-

Where: ND stands for Non Detected

DL stands for Analytical Detection Limit

TEQ1 refers to Non Detected Congeners at the Detection Limit

TEQ2 refers to Non Detected Congeners at Zero

% Rec stands for the Recovery Percentage of the Sample

DIOXINS & FURANS: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	**Units**	**Run 1**	**Run 2**	**Run 3**
Mean Sampling Rate	l/min	18.5	17.7	17.2
Pre-Sampling Leak Rate	l/min	0.14	0.12	0.11
Post-Sampling Leak Rate	l/min	0.11	0.22	0.21
Allowable Leak Rate	l/min	0.92	0.89	0.86
Leak Test Acceptable	-	Yes	Yes	Yes

Water Droplets	**Units**	**Run 1**	**Run 2**	**Run 3**
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	**Units**	**Run 1**	**Run 2**	**Run 3**
Measurement Uncertainty (MU)	%	4.9	5.0	5.0
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

Silica Gel (Concurrent Water Vapour)	**Units**	**Run 1**	**Run 2**	**Run 3**
Less than 50% Faded	%	Yes	Yes	Yes

Isokinetic Criterion Compliance	**Units**	**Run 1**	**Run 2**	**Run 3**
Isokinetic Variation	%	104.6	101.3	99.1
Allowable Isokinetic Range	%	95 - 115	95 - 115	95 - 115
Isokineticity Acceptable	-	Yes	Yes	Yes

Filter Temperatures	**Units**	**Run 1**	**Run 2**	**Run 3**
Maximum Filter Temperature	°C	120	120	120
Maximum Allowable Temperature	°C	125	125	125
Temperature Acceptable	-	Yes	Yes	Yes

Condenser Exit Temperature	**Units**	**Run 1**	**Run 2**	**Run 3**
Maximum Temperature Recorded	°C	18	18	18
Maximum Allowable Temperature	°C	20	20	20
Exit Temperature Acceptable	-	Yes	Yes	Yes

Test Conditions	**Units**	**Run 1**	**Run 2**	**Run 3**
Ambient Temperature Recorded?	-	Yes	Yes	Yes

DIOXINS & FURANS: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	15.0
Sampling Leak Rate	l/min	0.05
Allowable Leak Rate	l/min	0.75
Leak Test Acceptable	-	Yes

Validity of NATO I-TEQ Blank vs ELV	Units	Blank 1
Allowable Blank	ng/m³	0.010
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation	Run Number		
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1	2	3
There are no deviations associated with the sampling employed.	wx	wx	wx

DIOXINS & FURANS (NATO I-TEQ): MEASUREMENT UNCERTAINTY CALCULATIONS

	Value				Standard uncertainty				
Measured Quantities	Symbol	Run 1	Run 2	Run 3	Symbol	Units	Run 1	Run 2	Run 3
Sampled Volume (Actual)	V_m	6.2612	6.0080	5.8342	uV_m	m^3	0.1252	0.1202	0.1167
Sampled Gas Temperature	T_m	292.5	292.5	292.5	uT_m	K	2.00	2.00	2.00
Sampled Gas Pressure	ρ_m	99.1	101.8	100.9	$u\rho_m$	kPa	0.50	0.50	0.50
Sampled Gas Humidity	H_m	0.00	0.00	0.00	uH_m	% v/v	1.00	1.00	1.00
Leak	L	0.59	1.24	1.22	uL	%	-	-	-
Laboratory Result	L_r	10.0	10.0	10.0	uL_r	%	-	-	-

	Uncertainty as a Percentage				
Measured Quantities	Units	Run 1	Run 2	Run 3	Requirement of Standard
Sampled Volume (Actual)	%	2.00	2.00	2.00	≤2%
Sampled Gas Temperature	%	0.68	0.68	0.68	≤1%
Sampled Gas Pressure	%	0.50	0.49	0.50	≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00	≤1%
Leak	%	0.59	1.24	1.22	≤5%
Laboratory Result	%	10.0	10.0	10.0	No Requirement

	Uncertainty in Measurement Units					Sensitivity Coefficient		
Measured Quantities	Symbol	Units	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	m^3	6.1107	6.0225	5.7961	0.00	0.00	0.00
Leak	L	ng/m^3	0.0000	0.0001	0.0001	1.00	1.00	1.00
Laboratory Result	L_r	ng/m^3	0.0001	0.0015	0.0018	1.00	1.00	1.00

	Uncertainty in Result			
Measured Quantities	Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	ng/m^3	0.0000	0.0004	0.0004
Leak	ng/m^3	0.0000	0.0001	0.0001
Laboratory Result	ng/m^3	0.0001	0.0015	0.0018

	Oxygen Correction Part of MU Budget			
Measured Quantities	Units	Run 1	Run 2	Run 3
O_2 Correction Factor	-	1.12	1.16	1.13
Stack Gas O_2 Content	% v/v	11.22	11.48	11.23
MU for O_2 Correction	-	0.06	0.06	0.06
Overall MU For O_2 Measurement	%	5.11	5.25	5.12

Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	ng/m^3	0.0001	0.0015	0.0018
Expanded uncertainty (95% confidence), without Oxygen Correction	ng/m^3	0.0003	0.0030	0.0036
Expanded uncertainty (95% confidence), with Oxygen Correction	ng/m^3	0.00	0.00	0.00
Expanded uncertainty (95% confidence), estimated with Method Deviations	ng/m^3	0.0003	0.0031	0.0037
Reported Uncertainty	ng/m^3	0.0003	0.0031	0.0037
Expanded uncertainty (95% confidence), without Oxygen Correction	%	20.2	20.2	20.2
Expanded uncertainty (95% confidence), with Oxygen Correction	%	20.8	20.9	20.8
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	20.8	20.9	20.8
Reported Uncertainty	%	20.8	20.9	20.8

APPENDIX 2

PCBs: RESULTS SUMMARY

(PAGE 1 OF 4)

Irish Cement Ltd, Limerick
A2-01 Kiln 6

TEQ1 - UPPER LIMITS (worst case where <LOD = LOD)

Sample Runs (UPPER WHO TEQ Humans / Mammals)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.0036	0.0037	0.0116		0.0063
Uncertainty	±ng/m³	0.0008	0.0008	0.0024		0.0013
Mass Emission	µg/hr	1.16	1.18	3.70		2.01
Uncertainty	±µg/hr	0.25	0.25	0.79		0.43

Sample Runs (UPPER WHO TEQ Fish)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.0003	0.0003	0.0006		0.0004
Uncertainty	±ng/m³	0.0001	0.0001	0.0001		0.0001
Mass Emission	µg/hr	0.09	0.09	0.19		0.12
Uncertainty	±µg/hr	0.02	0.02	0.04		0.03

Sample Runs (UPPER WHO TEQ Birds)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.0340	0.0344	0.0215		0.0300
Uncertainty	±ng/m³	0.0071	0.0072	0.0045		0.0063
Mass Emission	µg/hr	10.80	10.93	6.83		9.52
Uncertainty	±µg/hr	2.30	2.34	1.46		2.03

PCBs: RESULTS SUMMARY

(PAGE 2 OF 4)

Irish Cement Ltd, Limerick
A2-01 Kiln 6

TEQ2 - LOWER LIMITS (best case where <LOD = 0)

Sample Runs (LOWER WHO TEQ Humans / Mammals)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.0036	0.0037	0.0000		0.0025
Uncertainty	±ng/m³	0.0008	0.0008	0.0000		0.0005
Mass Emission	µg/hr	1.15	1.18	0.00		0.78
Uncertainty	±µg/hr	0.25	0.25	0.00		0.17

NOTE: Where the maximum Blank concentration is higher than the Sample concentration, the Blank concentration has been reported.

Sample Runs (LOWER WHO TEQ Fish)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.0003	0.0003	0.0000		0.0002
Uncertainty	±ng/m³	0.0001	0.0001	0.0000		0.0000
Mass Emission	µg/hr	0.09	0.09	0.00		0.06
Uncertainty	±µg/hr	0.02	0.02	0.00		0.01

NOTE: Where the maximum Blank concentration is higher than the Sample concentration, the Blank concentration has been reported.

Sample Runs (LOWER WHO TEQ Birds)

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	ng/m³	0.0340	0.0344	0.0000		0.0228
Uncertainty	±ng/m³	0.0071	0.0072	0.0000		0.0048
Mass Emission	µg/hr	10.80	10.93	0.01		7.25
Uncertainty	±µg/hr	2.30	2.34	0.00		1.55

NOTE: Where the maximum Blank concentration is higher than the Sample concentration, the Blank concentration has been reported.

PCBs: RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

TEQ1 - UPPER LIMITS (worst case where <LOD = LOD)

Blank Runs (UPPER WHO TEQ Humans / Mammals)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.0001		0.0001

Blank Runs (UPPER WHO TEQ Fish)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.0000043		0.0000

Blank Runs (UPPER WHO TEQ Birds)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.0001		0.0001

TEQ2 - LOWER LIMITS (best case where <LOD = 0)

Blank Runs (LOWER WHO TEQ Humans / Mammals)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.0000003		0.0000003

Blank Runs (LOWER WHO TEQ Fish)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.0000001		0.0000001

Blank Runs (LOWER WHO TEQ Birds)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.0000471		0.0000471

PCBs: RESULTS SUMMARY

(PAGE 4 OF 4)

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	11.28	10.86	10.13		10.76
Uncertainty	±% v/v	0.55	0.54	0.51		0.53

General Sampling Information

Parameter	Value	
Standard	EN 1948	
Technical Procedure	MD 007	
Name of Analytical Laboratory	EET	
Analytical Laboratory's Procedure	PM137, TM201	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	15/01/2024	
Probe Material	Titanium	
Filter Housing Material	Borosilicate Glass	
Glassware Material	Borosilicate Glass	
Absorption Material	XAD-2	
Positioning of Filter	Out Stack	
Filter Size and Material	90mm Quartz Fibre	
Number of Sampling Lines Used	2 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	20 / 20	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1 - A10, B1 - B10	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

PCBs: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	Run 2	Run 3
Absolute pressure of stack gas, P_s				
Barometric pressure, P_b	mmHg	744.8	765.1	758.3
Stack static pressure, P_{static}	mmH_2O	-25.5	-25.5	-25.5
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	742.9	763.2	756.4
Volume of water vapour collected, V_{wstd}				
Total mass collected in impingers (liquid trap)	g	596.8	551.7	512.3
Total mass collected in impingers (silica trap)	g	26.9	37.4	12.1
Total mass of liquid collected, V_{lc}	g	623.7	589.1	524.4
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.7771	0.7340	0.6534
Volume of gas metered dry, V_{mstd}				
Volume of gas sample through gas meter, V_m	m^3	6.2612	6.0080	5.8342
Gas meter correction factor, Y_d	-	1.0630	1.0630	1.0630
Average dry gas meter temperature, T_m	°C	19.5	19.5	19.5
Average pressure drop across orifice, ΔH	mmH_2O	39.7	39.8	38.5
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	6.1107	6.0225	5.7961
Moisture content, B_{wo} & R_{wv}				
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.1128	0.1086	0.1013
B_{wo} as a percentage	% v/v	11.28	10.86	10.13
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	11.28	10.86	10.13
Volume of gas metered wet, V_{mstw}				
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	6.8879	6.7565	6.4495
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$				
IED & Incinerates Hazardous Material? (Yes = no positive O_2 correction)	-	No	No	No
% wet oxygen measured in gas stream, $ACT\%O_{2w}$	% v/v	10.02	10.25	10.03
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	11.22	11.48	11.23
% oxygen reference condition, $REF\%O_2$	% v/v	10.00	10.00	10.00
O_2 Reference Factor wet (O_{2REFw}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2w}$)	-	1.00	1.02	1.00
O_2 Reference Factor dry (O_{2REFd}) = (21 - $REF\%O_2$) / (21 - $ACT\%O_{2d}$)	-	1.12	1.16	1.13
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	6.8779	6.6038	6.4331
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	5.4344	5.2132	5.1475
Molecular weight of dry gas stream, M_d				
CO_2	% v/v	21.00	21.00	21.00
O_2	% v/v	11.22	11.48	11.23
Total	% v/v	32.22	32.48	32.23
N_2	% v/v	67.78	67.52	67.77
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	31.81	31.82	31.81
Molecular weight of stack gas (wet), M_s				
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	30.25	30.32	30.41
Velocity of stack gas, V_s				
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97
Velocity pressure coefficient, C_p	-	0.85	0.85	0.85
Average of velocity heads, ΔP_{avg}	mmH_2O	39.75	39.75	38.23
Average square root of velocity heads, $\sqrt{\Delta P}$	$\sqrt{mmH_2O}$	6.30	6.30	6.18
Average stack gas temperature, T_s	°C	148.0	147.3	146.6
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{(M_s)(P_s)})$	m/s	25.53	25.14	24.70
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})				
Area of stack, A_s	m^2	5.31	5.31	5.31
$Q_a = (60)(A_s)(V_s)$	m^3/min	8133.0	8009.3	7870.3
Conversion factor (K/mm.Hg), C_f	-	0.3592	0.3592	0.3592
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	5155.9	5224.0	5096.7
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	4574.2	4656.5	4580.4
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	5148.5	5105.9	5083.7
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	4067.9	4030.8	4067.8
Percent isokinetic, %I				
Nozzle diameter, D_n	mm	4.90	4.90	4.90
Nozzle area, A_n	mm^2	18.83	18.83	18.83
Total sampling time, q	min	360	360	360
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	104.6	101.3	99.1

PCBs: SAMPLING DETAILS

RUN 1

Parameter	Units	Value
Sampling Times	-	10:25 - 16:30
Sampling Dates	-	20/11/2023
Sampling Device	-	ISO
Volume Sampled (REF)	m^3	5.4344

Where: ISO stands for Manual Isokinetic Sampling Train

				WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
PCB-81	ng	0.5740	0.03391	0.0001722	0.0001722	0.0002870	0.0002870	0.0573960	0.0573960	60
PCB-77	ng	2.1638	0.01374	0.0002164	0.0002164	0.0002164	0.0002164	0.1081890	0.1081890	66
PCB-123	ng	0.3222	0.01164	0.0000097	0.0000097	0.0000016	0.0000016	0.0000032	0.0000032	76
PCB-118	ng	1.2283	0.01176	0.0000368	0.0000368	0.0000061	0.0000061	0.0000123	0.0000123	76
PCB-114	ng	0.1045	0.01197	0.0000031	0.0000031	0.0000005	0.0000005	0.0000104	0.0000104	76
PCB-105	ng	0.7290	0.01264	0.0000219	0.0000219	0.0000036	0.0000036	0.0000729	0.0000729	72
PCB-126	ng	0.1926	0.01302	0.0192610	0.0192610	0.0009631	0.0009631	0.0192610	0.0192610	83
PCB-167	ng	0.0864	0.00513	0.0000026	0.0000026	0.0000004	0.0000004	0.0000009	0.0000009	107
PCB-156	ng	0.0858	0.00500	0.0000026	0.0000026	0.0000004	0.0000004	0.0000086	0.0000086	106
PCB-157	ng	0.0449	0.00536	0.0000013	0.0000013	0.0000002	0.0000002	0.0000045	0.0000045	103
PCB-169	ng	ND	0.00350	0.0001050	0.0000000	0.0000002	0.0000000	0.0000035	0.0000000	87
PCB-189	ng	0.0085	0.00137	0.0000003	0.0000003	0.0000000	0.0000000	0.0000001	0.0000001	76
Totals	ng	5.5397	-	0.019833	0.019728	0.001480	0.001479	0.184962	0.184959	-
Total Concentration	ng/m^3	-	-	0.003650	0.003630	0.000272	0.000272	0.034036	0.034035	-
Limit of Detection	ng/m^3	-	-	0.000261	-	0.000015	-	0.000991	-	-

Where: ND stands for Non Detected

DL stands for Analytical Detection Limit

TEQ1 refers to Non Detected Congeners at the Detection Limit

TEQ2 refers to Non Detected Congeners at Zero

% Rec stands for the Recovery Percentage of the Sample

PCBs: SAMPLING DETAILS

RUN 2

Parameter	Units	Value
Sampling Times	-	09:10 - 11:50, 12:10 - 15:30
Sampling Dates	-	21/11/2023
Sampling Device	-	ISO
Volume Sampled (REF)	m^3	5.2132

Where: ISO stands for Manual Isokinetic Sampling Train

				WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
PCB-81	ng	0.61475	0.02616	0.0001844	0.0001844	0.0003074	0.0003074	0.0614750	0.0614750	65
PCB-77	ng	1.98416	0.01390	0.0001984	0.0001984	0.0001984	0.0001984	0.0992080	0.0992080	73
PCB-123	ng	0.28765	0.01510	0.0000086	0.0000086	0.0000014	0.0000014	0.0000029	0.0000029	77
PCB-118	ng	1.26822	0.01508	0.0000380	0.0000380	0.0000063	0.0000063	0.0000127	0.0000127	77
PCB-114	ng	0.09522	0.01595	0.0000029	0.0000029	0.0000005	0.0000005	0.0000095	0.0000095	77
PCB-105	ng	0.67258	0.01561	0.0000202	0.0000202	0.0000034	0.0000034	0.0000673	0.0000673	76
PCB-126	ng	0.18702	0.01532	0.0187020	0.0187020	0.0009351	0.0009351	0.0187020	0.0187020	90
PCB-167	ng	0.08729	0.00581	0.0000026	0.0000026	0.0000004	0.0000004	0.0000009	0.0000009	108
PCB-156	ng	0.08844	0.00589	0.0000027	0.0000027	0.0000004	0.0000004	0.0000088	0.0000088	104
PCB-157	ng	0.04157	0.00639	0.0000012	0.0000012	0.0000002	0.0000002	0.0000042	0.0000042	100
PCB-169	ng	0.00830	0.00787	0.0002490	0.0002490	0.0000004	0.0000004	0.0000083	0.0000083	96
PCB-189	ng	0.00825	0.00158	0.0000002	0.0000002	0.0000000	0.0000000	0.0000001	0.0000001	76
Totals	ng	0.0000	-	0.019410	0.019410	0.001454	0.001454	0.179500	0.179500	-
Total Concentration	ng/m^3	-	-	0.003723	0.003723	0.000279	0.000279	0.034432	0.034432	-
Limit of Detection	ng/m^3	-	-	0.000341	-	0.000018	-	0.000931	-	-

Where: ND stands for Non Detected

DL stands for Analytical Detection Limit

TEQ1 refers to Non Detected Congeners at the Detection Limit

TEQ2 refers to Non Detected Congeners at Zero

% Rec stands for the Recovery Percentage of the Sample

PCBs: SAMPLING DETAILS

RUN 3

Parameter	Units	Value
Sampling Times	-	09:45 - 14:22, 15:35 - 17:07
Sampling Dates	-	22/11/2023
Sampling Device	-	ISO
Volume Sampled (REF)	m^3	5.1475

Where: ISO stands for Manual Isokinetic Sampling Train

				WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
PCB-81	ng	ND	0.40080	0.0001202	0.0000000	0.0002004	0.0000000	0.0400800	0.0000000	77
PCB-77	ng	ND	0.24329	0.0000243	0.0000000	0.0000243	0.0000000	0.0121645	0.0000000	74
PCB-123	ng	ND	0.49823	0.0000149	0.0000000	0.0000025	0.0000000	0.0000050	0.0000000	90
PCB-118	ng	ND	0.54824	0.0000164	0.0000000	0.0000027	0.0000000	0.0000055	0.0000000	87
PCB-114	ng	ND	0.49949	0.0000150	0.0000000	0.0000025	0.0000000	0.0000499	0.0000000	93
PCB-105	ng	ND	0.19659	0.0000059	0.0000000	0.0000010	0.0000000	0.0000197	0.0000000	85
PCB-126	ng	ND	0.58373	0.0583730	0.0000000	0.0029187	0.0000000	0.0583730	0.0000000	71
PCB-167	ng	ND	0.16578	0.0000050	0.0000000	0.0000008	0.0000000	0.0000017	0.0000000	122
PCB-156	ng	ND	0.11123	0.0000033	0.0000000	0.0000006	0.0000000	0.0000111	0.0000000	123
PCB-157	ng	ND	0.08420	0.0000025	0.0000000	0.0000004	0.0000000	0.0000084	0.0000000	119
PCB-169	ng	ND	0.04460	0.0013380	0.0000000	0.0000022	0.0000000	0.0000446	0.0000000	76
PCB-189	ng	ND	0.14548	0.0000044	0.0000000	0.0000007	0.0000000	0.0000015	0.0000000	92
Totals	ng	0.0000	-	0.059923	0.000000	0.003157	0.000000	0.110765	0.000000	-
Total Concentration	ng/m^3	-	-	0.011641	0.000000	0.000613	0.000000	0.021518	0.000000	-
Limit of Detection	ng/m^3	-	-	0.011641	-	0.000613	-	0.021518	-	-

Where: ND stands for Non Detected

DL stands for Analytical Detection Limit

TEQ1 refers to Non Detected Congeners at the Detection Limit

TEQ2 refers to Non Detected Congeners at Zero

% Rec stands for the Recovery Percentage of the Sample

PCBs: SAMPLING DETAILS

BLANK 1

Parameter	Units	Value
Sampling Dates	-	20/11/2023
Sampling Device	-	ISO
Volume Sampled (REF)	m³	5.2650

Where: ISO stands for Manual Isokinetic Sampling Train

				WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
PCB-81	ng	ND	0.00098	0.0000003	0.0000000	0.0000005	0.0000000	0.0000980	0.0000000	77
PCB-77	ng	0.0049	0.00278	0.0000005	0.0000005	0.0000005	0.0000005	0.0002465	0.0002465	74
PCB-123	ng	ND	0.00334	0.0000001	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	90
PCB-118	ng	0.0222	0.00330	0.0000007	0.0000007	0.0000001	0.0000001	0.0000002	0.0000002	87
PCB-114	ng	ND	0.00329	0.0000001	0.0000000	0.0000000	0.0000000	0.0000003	0.0000000	93
PCB-105	ng	0.0083	0.00344	0.0000003	0.0000003	0.0000000	0.0000000	0.0000008	0.0000008	85
PCB-126	ng	ND	0.00430	0.0004300	0.0000000	0.0000215	0.0000000	0.0004300	0.0000000	71
PCB-167	ng	0.0015	0.00092	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	122
PCB-156	ng	0.0024	0.00092	0.0000001	0.0000001	0.0000000	0.0000000	0.0000002	0.0000002	123
PCB-157	ng	ND	0.00098	0.0000000	0.0000000	0.0000000	0.0000000	0.0000001	0.0000000	119
PCB-169	ng	ND	0.00145	0.0000435	0.0000000	0.0000001	0.0000000	0.0000015	0.0000000	76
PCB-189	ng	ND	0.00048	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	92
Totals	ng	0.0393	-	0.000476	0.000002	0.000023	0.000001	0.000778	0.000248	-
Total Concentration	ng/m³	-	-	0.000090	0.000000	0.000004	0.000000	0.000148	0.000047	-

Where:
ND stands for Non Detected
DL stands for Analytical Detection Limit
TEQ1 refers to Non Detected Congeners at the Detection Limit
TEQ2 refers to Non Detected Congeners at Zero
% Rec stands for the Recovery Percentage of the Sample

PCBs: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	18.5	17.7	17.2
Pre-Sampling Leak Rate	l/min	0.14	0.12	0.11
Post-Sampling Leak Rate	l/min	0.11	0.22	0.21
Allowable Leak Rate	l/min	0.92	0.89	0.86
Leak Test Acceptable	-	Yes	Yes	Yes

Water Droplets	Units	Run 1	Run 2	Run 3
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Measurement Uncertainty (MU)	%	4.9	5.0	5.0
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Less than 50% Faded	%	Yes	Yes	Yes

Isokinetic Criterion Compliance	Units	Run 1	Run 2	Run 3
Isokinetic Variation	%	104.6	101.3	99.1
Allowable Isokinetic Range	%	95 - 115	95 - 115	95 - 115
Isokineticity Acceptable	-	Yes	Yes	Yes

Filter Temperatures	Units	Run 1	Run 2	Run 3
Maximum Filter Temperature	°C	120	120	120
Maximum Allowable Temperature	°C	125	125	125
Temperature Acceptable	-	Yes	Yes	Yes

Condenser Exit Temperature	Units	Run 1	Run 2	Run 3
Maximum Temperature Recorded	°C	18	18	18
Maximum Allowable Temperature	°C	20	20	20
Exit Temperature Acceptable	-	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

PCBs: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	15.0
Sampling Leak Rate	l/min	0.05
Allowable Leak Rate	l/min	0.75
Leak Test Acceptable	-	Yes

Validity of WHO TEQ H/M Blank vs ELV	Units	Blank 1
Allowable Blank	ng/m^3	N/A
Blank Acceptable	-	N/A

Method Deviations

Nature of Deviation (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	2	3
There are no deviations associated with the sampling employed.	wx	wx	wx
PCB run 3 could not be quantified, as there was an issue with the sample matrix.			x

PCBs (WHO TEQ HUMANS / MAMMALS): MEASUREMENT UNCERTAINTY CALCULATIONS

	Value				Standard uncertainty				
Measured Quantities	**Symbol**	**Run 1**	**Run 2**	**Run 3**	**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (Actual)	V_m	6.2612	6.0080	5.8342	uV_m	m^3	0.1252	0.1202	0.1167
Sampled Gas Temperature	T_m	292.5	292.5	292.5	uT_m	K	2.00	2.00	2.00
Sampled Gas Pressure	ρ_m	99.1	101.8	100.9	$u\rho_m$	kPa	0.50	0.50	0.50
Sampled Gas Humidity	H_m	0.00	0.0	0.0	uH_m	% v/v	1.00	1.00	1.00
Leak	L	0.59	1.24	1.22	uL	%	-	-	-
Laboratory Result	L_r	10.0	10.0	10.0	uL_r	%	-	-	-

	Uncertainty as a Percentage				
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**	**Requirement of Standard**
Sampled Volume (Actual)	%	2.00	2.00	2.00	≤2%
Sampled Gas Temperature	%	0.68	0.68	0.68	≤1%
Sampled Gas Pressure	%	0.50	0.49	0.50	≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00	≤1%
Leak	%	0.59	1.24	1.22	≤5%
Laboratory Result	%	10.0	10.0	10.0	No Requirement

	Uncertainty in Measurement Units					Sensitivity Coefficient		
Measured Quantities	**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (STP)	V_m	m^3	6.1107	6.0225	5.7961	0.00	0.00	0.0020
Leak	L	ng/m^3	0.0000	0.0000	0.0001	1.00	1.00	1.00
Laboratory Result	L_r	ng/m^3	0.0004	0.0004	0.0012	1.00	1.00	1.00

	Uncertainty in Result			
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (STP)	ng/m^3	0.0001	0.0001	0.0003
Leak	ng/m^3	0.0000	0.0000	0.0001
Laboratory Result	ng/m^3	0.0004	0.0004	0.0012

	Oxygen Correction Part of MU Budget			
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**
O_2 Correction Factor	-	1.12	1.16	1.13
Stack Gas O_2 Content	% v/v	11.22	11.48	11.23
MU for O_2 Correction	-	0.06	0.06	0.06
Overall MU For O_2 Measurement	%	5.11	5.25	5.12

Parameter	**Units**	**Run 1**	**Run 2**	**Run 3**
Combined uncertainty	ng/m^3	0.0004	0.0004	0.0012
Expanded uncertainty (95% confidence), without Oxygen Correction	ng/m^3	0.0007	0.0008	0.0024
Expanded uncertainty (95% confidence), with Oxygen Correction	ng/m^3	0.0008	0.0008	0.0024
Expanded uncertainty (95% confidence), estimated with Method Deviations	ng/m^3	0.0008	0.0008	0.0024
Reported Uncertainty	ng/m^3	0.0008	0.0008	0.0024
Expanded uncertainty (95% confidence), without Oxygen Correction	%	20.2	20.2	20.2
Expanded uncertainty (95% confidence), with Oxygen Correction	%	20.8	20.9	20.8
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	20.8	20.9	20.8
Reported Uncertainty	%	20.8	20.9	20.8

HYDROGEN CHLORIDE: RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	mg/m³	1.06	< 0.08	< 0.13		0.42
Uncertainty	±mg/m³	0.07	0.01	0.01		0.03
Mass Emission	g/hr	336.4	< 24.1	< 40.4		133.7
Uncertainty	±g/hr	28.3	2.0	3.3		11.2

NOTE: Where the maximum Blank concentration is higher than the Sample concentration, the Blank concentration has been reported.

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	9.86	11.68	11.07		10.87
Uncertainty	±% v/v	0.46	0.49	0.49		0.48

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 0.08		< 0.08

General Sampling Information

Parameter	Value	
Standard	EN 1911	
Technical Procedure	MD 011	
Name of Analytical Laboratory	ELD	
Analytical Laboratory's Procedure	CAT-AP-01	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	17/11/2023	
Probe Material	Monel	
Filter Housing Material	Monel	
Impinger Material	Polyethylene	
Absorption Solution	HPLC Grade Water	
Positioning of Filter	In Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	B2	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

HYDROGEN CHLORIDE: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	15:40 - 16:10	13:30 - 14:00	13:19 - 13:49
Sampling Dates	-	20/11/2023	21/11/2023	22/11/2023
Sampling Device	-	MFC / MV	MFC / MV	MFC / MV
Duration	mins	30	30	30
Volume Sampled (STP, Dry)	m³	0.1947	0.3082	0.1991
Volume Sampled (STP, Wet)	m³	0.2160	0.3489	0.2239
Volume Sampled (REF)	m³	0.1678	0.2627	0.1752
Sample Flow Rate	l/min	6.16	9.75	6.28
Laboratory Result for Front Impingers	µg/ml	0.57	< 0.05	< 0.05
Laboratory Result for Back Impinger	µg/ml	0.12		
Volume in Front Impingers	ml	285.8	305.5	446.6
Volume in Back Impinger	ml	124.2		
Mass in Front Impingers	µg	162.9	< 15.3	< 22.3
Mass in Back Impinger	µg	14.9		
Total Mass Collected	µg	177.8	< 15.3	< 22.3
Calculated Concentration	mg/m³	1.06	< 0.06	< 0.13
Liquid Trap Start Mass	g	2046.4	2031.3	2052.3
Liquid Trap End Mass	g	2055.5	2058.1	2070.3
Silica Trap Start Mass	g	1427.2	1442.4	1425.0
Silica Trap End Mass	g	1435.2	1448.3	1426.9
Total Mass Of Water Vapour	g	17.1	32.7	19.9
Calculated Water Vapour	% v/v	9.86	11.68	11.07

Where: MFC stands for Mass Flow Controller, MV stands for Mass View Flowmeter

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	20/11/2023
Average Volume Sampled (REF)	m³	0.2019
Laboratory Result for Impingers	µg/ml	< 0.05
Volume in Impingers	ml	306.9
Total Mass Collected	µg	< 15.3
Calculated Concentration	mg/m³	< 0.08

HYDROGEN CHLORIDE: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	6.2	9.7	6.3
Pre-Sampling Leak Rate	l/min	0.13	0.02	0.00
Post-Sampling Leak Rate	l/min	0.08	0.05	0.05
Allowable Leak Rate	l/min	0.12	0.19	0.13
Leak Test Acceptable	-	Yes	Yes	Yes

Absorption Efficiency	Units	Run 1
Absorption Efficiency	%	91.6
Allowable Absorption Efficiency	%	N/A [1]
Absorption Efficiency Acceptable	-	Yes [1]

[1] The concentration in the last absorber was less than 5 times the analytical detection limit.

Water Droplets	Units	Run 1	Run 2	Run 3
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Measurement Uncertainty (MU)	%	4.6	4.2	4.4
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Less than 50% Faded	%	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	9.5
Pre-Sampling Leak Rate	l/min	0.08
Post-Sampling Leak Rate	l/min	0.09
Allowable Leak Rate	l/min	0.19
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m^3	1.0
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	2	3
There are no deviations associated with the sampling employed.	wx	wx	wx

HYDROGEN CHLORIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value				Standard uncertainty				
Measured Quantities	**Symbol**	**Run 1**	**Run 2**	**Run 3**	**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (STP)	V_m	0.1947	0.3082	0.1991	uV_m	m^3	0.0039	0.0062	0.0040
Leak	L	1.30	0.51	0.80	uL	%	-	-	-
Laboratory Result	L_r	1.05	1.05	1.05	uL_r	%	-	-	-

	Uncertainty as a Percentage				
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**	**Requirement of Standard**
Sampled Volume (STP)	%	2.00	2.00	2.00	≤2%
Leak	%	1.30	0.51	0.80	≤2%
Laboratory Result	%	1.05	1.05	1.05	No Requirement

	Uncertainty in Measurement Units					Sensitivity Coefficient		
Measured Quantities	**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (STP)	V_m	m^3	0.1947	0.3082	0.1991	5.44	0.25	0.64
Leak	L	mg/m^3	0.008	0.000	0.001	1.00	1.00	1.00
Laboratory Result	L_r	mg/m^3	0.011	0.001	0.001	1.00	1.00	1.00

	Uncertainty in Result			
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (STP)	mg/m^3	0.021	0.002	0.003
Leak	mg/m^3	0.0080	0.0002	0.0006
Laboratory Result	mg/m^3	0.0111	0.0008	0.0013

	Oxygen Correction Part of MU Budget			
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**
O_2 Correction Factor	-	1.16	1.17	1.14
Stack Gas O_2 Content	% v/v	11.52	11.62	11.32
MU for O_2 Correction	-	0.06	0.06	0.06
Overall MU For O_2 Measurement	%	5.28	5.33	5.16

Parameter	**Units**	**Run 1**	**Run 2**	**Run 3**
Combined uncertainty	mg/m^3	0.03	0.0017	0.0029
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.05	0.00	0.01
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	0.07	0.01	0.01
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.07	0.01	0.01
Reported Uncertainty	mg/m^3	0.07	0.01	0.01
Expanded uncertainty (95% confidence), without Oxygen Correction	%	4.7	4.5	4.5
Expanded uncertainty (95% confidence), with Oxygen Correction	%	7.0	7.0	6.9
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	7.0	7.0	6.9
Reported Uncertainty	%	7.0	7.0	6.9

HYDROGEN FLUORIDE: RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	mg/m³	< 0.12	0.08	< 0.13		0.11
Uncertainty	±mg/m³	0.02	0.01	0.02		0.01
Mass Emission	g/hr	< 38.8	24.1	< 40.6		34.5
Uncertainty	±g/hr	5.5	3.4	5.7		4.8

NOTE: Where the maximum Blank concentration is higher than the Sample concentration, the Blank concentration has been reported.

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	9.86	11.68	11.10		10.88
Uncertainty	±% v/v	0.46	0.50	0.49		0.48

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	0.08		0.08

General Sampling Information

Parameter	Value	
Standard	CEN/TS 17340	
Technical Procedure	MD 010	
Name of Analytical Laboratory	ELD	
Analytical Laboratory's Procedure	CAT-AP-01	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	27/11/2023	
Probe Material	Monel	
Filter Housing Material	Monel	
Impinger Material	Polyethylene	
Absorption Solution	HPLC Grade Water	
Positioning of Filter	In Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	B2	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

HYDROGEN FLUORIDE: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	15:40 - 16:10	13:30 - 14:00	13:19 - 13:49
Sampling Dates	-	20/11/2023	21/11/2023	22/11/2023
Sampling Device	-	MFC / MV	MFC / MV	MFC / MV
Duration	mins	30	30	30
Volume Sampled (STP, Dry)	m³	0.1947	0.3082	0.1986
Volume Sampled (STP, Wet)	m³	0.2160	0.3489	0.2234
Volume Sampled (REF)	m³	0.1678	0.2627	0.1748
Sample Flow Rate	l/min	6.16	9.75	6.28
Laboratory Result for Front Impingers	µg/ml	< 0.05	< 0.05	< 0.05
Laboratory Result for Back Impinger	µg/ml	< 0.05		
Volume in Front Impingers	ml	285.8	305.5	446.6
Volume in Back Impinger	ml	124.2		
Mass in Front Impingers	µg	< 14.3	< 15.3	< 22.3
Mass in Back Impinger	µg	< 6.2		
Total Mass Collected	µg	< 20.5	< 15.3	< 22.3
Calculated Concentration	mg/m³	< 0.12	< 0.06	< 0.13
Liquid Trap Start Mass	g	2046.4	2031.3	2052.3
Liquid Trap End Mass	g	2055.5	2058.1	2070.3
Silica Trap Start Mass	g	1427.2	1442.4	1425.0
Silica Trap End Mass	g	1435.2	1448.3	1426.9
Total Mass Of Water Vapour	g	17.1	32.7	19.9
Calculated Water Vapour	% v/v	9.86	11.68	11.10

Where: MFC stands for Mass Flow Controller, MV stands for Mass View Flowmeter

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	20/11/2023
Average Volume Sampled (REF)	m³	0.2018
Laboratory Result for Impingers	µg/ml	0.05
Volume in Impingers	ml	306.9
Total Mass Collected	µg	15.3
Calculated Concentration	mg/m³	0.08

HYDROGEN FLUORIDE: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	6.2	9.7	6.3
Pre-Sampling Leak Rate	l/min	0.13	0.13	0.02
Post-Sampling Leak Rate	l/min	0.08	0.08	0.05
Allowable Leak Rate	l/min	0.12	0.19	0.13
Leak Test Acceptable	-	Yes	Yes	Yes

Absorption Efficiency	Units	Run 1
Absorption Efficiency	%	100.0
Allowable Absorption Efficiency	%	N/A [2]
Absorption Efficiency Acceptable	-	Yes [2]

[2] The concentration is less than 30% of the ELV, therefore no assessment against an allowable efficiency is required.

Water Droplets	Units	Run 1	Run 2	Run 3
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Measurement Uncertainty (MU)	%	4.6	4.2	4.4
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Less than 50% Faded	%	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	9.5
Pre-Sampling Leak Rate	l/min	0.08
Post-Sampling Leak Rate	l/min	0.09
Allowable Leak Rate	l/min	0.19
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m^3	0.1
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	2	3
There are no deviations associated with the sampling employed.	wx	wx	wx

HYDROGEN FLUORIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value				Standard uncertainty				
	Symbol	Run 1	Run 2	Run 3	Symbol	Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	0.1947	0.3082	0.1986	uV_m	m^3	0.0039	0.0062	0.0040
Leak	L	1.30	0.82	0.80	uL	%	-	-	-
Laboratory Result	L_r	5.85	5.85	5.85	uL_r	%	-	-	-

Measured Quantities	Uncertainty as a Percentage				Requirement of Standard
	Units	Run 1	Run 2	Run 3	
Sampled Volume (STP)	%	2.00	2.00	2.00	≤2%
Leak	%	1.30	0.82	0.80	≤2%
Laboratory Result	%	5.85	5.85	5.85	No Requirement

Measured Quantities	Uncertainty in Measurement Units					Sensitivity Coefficient		
	Symbol	Units	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	m^3	0.1947	0.3082	0.1986	0.63	0.25	0.64
Leak	L	mg/m^3	0.001	0.000	0.001	1.00	1.00	1.00
Laboratory Result	L_r	mg/m^3	0.007	0.004	0.007	1.00	1.00	1.00

Measured Quantities	Uncertainty in Result			
	Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	mg/m^3	0.002	0.002	0.003
Leak	mg/m^3	0.0009	0.0004	0.0006
Laboratory Result	mg/m^3	0.0071	0.0044	0.0075

Measured Quantities	Oxygen Correction Part of MU Budget			
	Units	Run 1	Run 2	Run 3
O_2 Correction Factor	-	1.16	1.17	1.14
Stack Gas O_2 Content	% v/v	11.52	11.62	11.32
MU for O_2 Correction	-	0.06	0.06	0.06
Overall MU For O_2 Measurement	%	5.28	5.33	5.16

Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	mg/m^3	0.01	0.005	0.01
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.01	0.01	0.02
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	0.02	0.01	0.02
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.02	0.01	0.02
Reported Uncertainty	mg/m^3	0.02	0.01	0.02
Expanded uncertainty (95% confidence), without Oxygen Correction	%	12.2	12.2	12.2
Expanded uncertainty (95% confidence), with Oxygen Correction	%	13.3	13.3	13.2
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	13.3	13.3	13.2
Reported Uncertainty	%	13.3	13.3	13.2

AMMONIA: RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	mg/m³	21.81	10.80	29.84		20.82
Uncertainty	±mg/m³	4.06	2.01	5.55		3.87
Mass Emission	g/hr	6923.2	3426.4	9472.1		6607.2
Uncertainty	±g/hr	1327.1	658.1	1815.1		1266.8

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	11.13	10.84	10.07		10.68
Uncertainty	±% v/v	0.47	0.45	0.43		0.45

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 0.12		< 0.12

General Sampling Information

Parameter	Value	
Standard	ISO 21877	
Technical Procedure	MD 014	
Name of Analytical Laboratory	RPS	
Analytical Laboratory's Procedure	A6	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	06/12/2023	
Probe Material	Titanium	
Filter Housing Material	Titanium	
Impinger Material	Polyethylene	
Absorption Solution	0.05 mol/l Sulphuric Acid	
Positioning of Filter	In Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	B2	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

AMMONIA: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	16:40 - 17-10	14:10 - 14:40	14:05 - 14:22, 15:35 - 15:48
Sampling Dates	-	20/11/2023	21/11/2023	22/11/2023
Sampling Device	-	MFC / MV	MFC / MV	MFC / MV
Duration	mins	30	30	30
Volume Sampled (STP, Dry)	m³	0.2985	0.3022	0.3049
Volume Sampled (STP, Wet)	m³	0.3359	0.3390	0.3390
Volume Sampled (REF)	m³	0.2674	0.2596	0.2714
Sample Flow Rate	l/min	9.44	9.56	9.61
Laboratory Result for Front Impingers	µg/ml	19.80	5.50	16.30
Laboratory Result for Back Impinger	µg/ml	0.10		
Volume in Front Impingers	ml	293.9	509.6	496.9
Volume in Back Impinger	ml	143.0		
Mass in Front Impingers	µg	5819.2	2802.8	8099.5
Mass in Back Impinger	µg	14.3		
Total Mass Collected	µg	5833.5	2802.8	8099.5
Calculated Concentration	mg/m³	21.81	10.80	29.84
Liquid Trap Start Mass	g	2031.8	2141.4	2037.3
Liquid Trap End Mass	g	2053.7	2168.2	2063.4
Silica Trap Start Mass	g	1434.1	1445.4	1426.9
Silica Trap End Mass	g	1442.2	1448.1	1428.2
Total Mass Of Water Vapour	g	30.0	29.5	27.4
Calculated Water Vapour	% v/v	11.13	10.84	10.07

Where: MFC stands for Mass Flow Controller, MV stands for Mass View Flowmeter

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	20/11/2023
Average Volume Sampled (REF)	m³	0.2662
Laboratory Result for Impingers	µg/ml	< 0.10
Volume in Impingers	ml	313.0
Total Mass Collected	µg	< 31.3
Calculated Concentration	mg/m³	< 0.12

AMMONIA: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	9.4	9.6	9.6
Pre-Sampling Leak Rate	l/min	0.08	0.05	0.04
Post-Sampling Leak Rate	l/min	0.08	0.02	0.05
Allowable Leak Rate	l/min	0.19	0.19	0.19
Leak Test Acceptable	-	Yes	Yes	Yes

Absorption Efficiency	Units	Run 1
Absorption Efficiency	%	99.8
Allowable Absorption Efficiency	%	N/A
Absorption Efficiency Acceptable	-	N/A

Water Droplets	Units	Run 1	Run 2	Run 3
Are Water Droplets Present	-	No	No	No

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Measurement Uncertainty (MU)	%	4.27	4.17	4.22
Allowable MU	%	20.0	20.0	20.0
MU Acceptable	%	Yes	Yes	Yes

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3
Less than 50% Faded	%	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	9.5
Pre-Sampling Leak Rate	l/min	0.11
Post-Sampling Leak Rate	l/min	0.11
Allowable Leak Rate	l/min	0.19
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m^3	5.0
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	2	3
There are no deviations associated with the sampling employed.	wx	wx	wx

AMMONIA: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value				Standard uncertainty				
	Symbol	Run 1	Run 2	Run 3	Symbol	Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	0.2985	0.3022	0.3049	uV_m	m³	0.0060	0.0060	0.0061
Leak	L	0.85	0.21	0.52	uL	%	-	-	-
Laboratory Result	L_r	8.90	8.90	8.90	uL_r	%	-	-	-

Measured Quantities	Uncertainty as a Percentage				Requirement of Standard
	Units	Run 1	Run 2	Run 3	
Sampled Volume (STP)	%	2.00	2.00	2.00	≤2%
Leak	%	0.85	0.21	0.52	≤2%
Laboratory Result	%	8.90	8.90	8.90	No Requirement

Measured Quantities	Uncertainty in Measurement Units					Sensitivity Coefficient		
	Symbol	Units	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	m³	0.2985	0.3022	0.3049	73.07	35.72	97.88
Leak	L	mg/m³	0.107	0.013	0.090	1.00	1.00	1.00
Laboratory Result	L_r	mg/m³	1.941	0.961	2.656	1.00	1.00	1.00

Measured Quantities	Uncertainty in Result			
	Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	mg/m³	0.436	0.216	0.597
Leak	mg/m³	0.1067	0.0130	0.0896
Laboratory Result	mg/m³	1.9412	0.9608	2.6559

Measured Quantities	Oxygen Correction Part of MU Budget			
	Units	Run 1	Run 2	Run 3
O_2 Correction Factor	-	1.12	1.16	1.12
Stack Gas O_2 Content	% v/v	11.14	11.55	11.21
MU for O_2 Correction	-	0.06	0.06	0.06
Overall MU For O_2 Measurement	%	5.07	5.29	5.11

Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	mg/m³	1.99	0.98	2.72
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m³	3.91	1.93	5.34
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m³	4.06	2.01	5.55
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m³	4.06	2.01	5.55
Reported Uncertainty	mg/m³	4.06	2.01	5.55
Expanded uncertainty (95% confidence), without Oxygen Correction	%	17.9	17.9	17.9
Expanded uncertainty (95% confidence), with Oxygen Correction	%	18.6	18.6	18.6
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	18.6	18.6	18.6
Reported Uncertainty	%	18.6	18.6	18.6

APPENDIX 2

TOTAL VOCs (as CARBON): RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	ppm	10.55		10.55
Concentration	mg/m³	21.82		21.82
Uncertainty	±mg/m³	1.03		1.03
Mass Emission	g/hr	6927.2		6927.2
Uncertainty	±g/hr	456.4		456.4

General Sampling Information

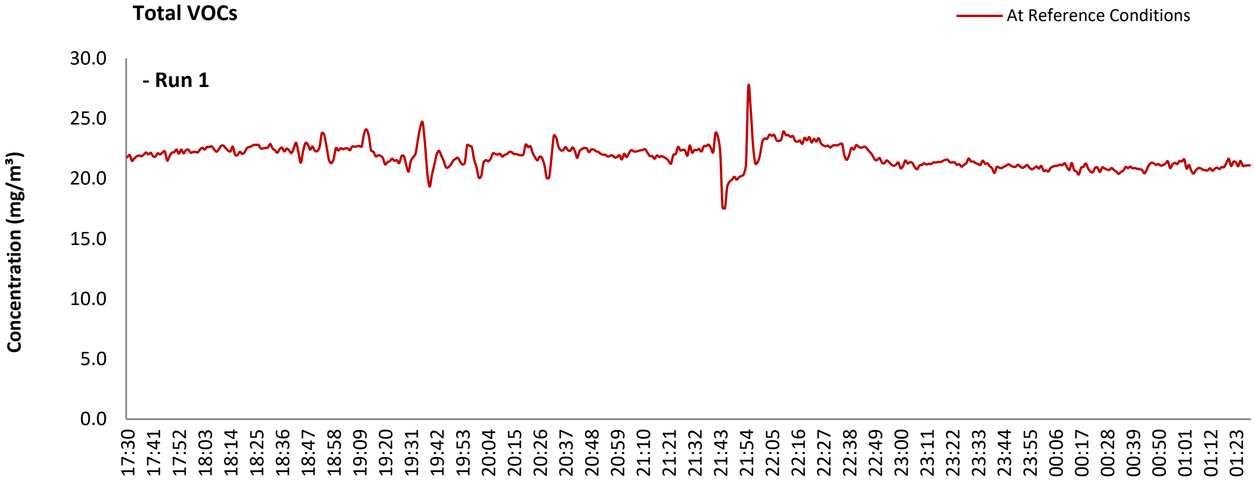
Parameter	Value	
Standard	EN 12619:2013	
Technical Procedure	MD 020	
Probe Material	Titanium	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Type	Propane in 10% O_2 in N_2 (5 Grade)	
Span Gas Reference Number	12.0517 in N_2 | 1.0554 in AIR	
Span Gas Expiry Date	24/03/2025 | 20/01/2028	
Span Gas Start Pressure (bar)	40 | 100	
Gas Cylinder Concentration (ppm)	84.17 | 79.52	
Span Gas Set Point (ppm)	81.96	This is the blended concentration of both propane cylinders
Span Gas Uncertainty (%)	2 | 2	
Zero Gas Type	10% O_2 in N_2 (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	B3	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

TOTAL VOCs (as CARBON): DATA TREND

Graphical Trend of Data



TOTAL VOCs (as CARBON): SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1
Sampling Times	-	17:30 - 01:30
Sampling Dates	-	22/11/2023
Instrument Range	ppm	100
Span Gas Value	ppm	82.0

Quality Assurance

	Zero Drift	Units	Run 1
CAL 1	Zero Down Sampling Line (Pre)	ppm	0.00
CAL 1	Zero Down Sampling Line (Post)	ppm	0.10
CAL 1	Zero Drift	ppm	0.10
CAL 1	Zero Drift	%	0.12
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Zero Drift	± ppm	4.10
	Zero Drift Acceptable	-	Yes

	Span Drift	Units	Run 1
CAL 1	Span Down Sampling Line (Pre)	ppm	81.10
CAL 1	Span Down Sampling Line (Post)	ppm	81.00
CAL 1	Span Drift	ppm	-0.10
CAL 1	Span Drift	%	-0.12
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Span Drift	± ppm	4.10
	Span Drift Acceptable	-	Yes

Test Conditions	Units	Run 1
Run Ambient Temperature Range	°C	5 - 7

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1

TOTAL VOCs (as CARBON): MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	**RUN 1**		**Units**
Limit value	25.0		mg/m³ (REF)
Allowable MU	15.0		%
Measured concentration	19.11		mg/m³ (STP, dry)
Range Used	100.0		ppm
Range Used [A]	160.6		mg/m³
Cal gas conc.	82.0		ppm
Conversion	1.61		ppm to mg/m³
MCERTS Range [B]	15.0		mg/m³
Lower of [A] or [B]	15.0		mg/m³
Cal gas conc.	131.6		mg/m³

Performance characteristics	**RUN 1**		**Units**
Response time	45		seconds
Number of readings in measurement	480		-
Repeatability at zero	2.00		% full scale
Repeatability at span level	0.00		% full scale
Deviation from linearity	0.50		% of value
Zero drift	0.12		% full scale
Span drift	-0.12		% full scale
Volume or pressure flow dependence	1.60		% of full scale
Atmospheric pressure dependence	0.30		% of value/kPa
Ambient temperature dependence	1.40		% full scale/10K
Combined interference	0.45		% range
Dependence on voltage	0.50		% full scale/10V
Losses in the line (leak)	1.10		% of value
Uncertainty of calibration gas	2.83		% of value

Performance characteristic	**RUN 1**		**Units**
Standard deviation of repeatability at zero	use rep at span		mg/m³
Standard deviation of repeatability at span level	0.00		mg/m³
Lack of fit	0.04		mg/m³
Drift	0.00		mg/m³
Volume or pressure flow dependence	0.00		mg/m³
Atmospheric pressure dependence	0.01		mg/m³
Ambient temperature dependence	0.20		mg/m³
Combined interference (from MCERTS Certificate)	0.04		mg/m³
Dependence on voltage	0.06		mg/m³
Losses in the line (leak)	0.12		mg/m³
Uncertainty of calibration gas	0.31		mg/m³

			RUN 1		**Units**
Measurement uncertainty		**Result**	19.11		mg/m³
Combined uncertainty			0.40		mg/m³
Expanded uncertainty	k =	1.96	0.78		mg/m³
Uncertainty corrected to std conds. (O_2)			0.89		mg/m³ (REF)

	RUN 1		**Units**
Expanded uncertainty (no O_2) - at 95% Confidence	4.10		% of Value
Expanded uncertainty (no O_2) - at 95% Confidence	3.13		% at ELV
Overall Allowable uncertainty (no O_2) - at 95% Confidence	15.0		% at ELV
Result of Compliance with Uncertainty Requirement	**N/A**		-

	RUN 1		**Units**
Expanded uncertainty (with O_2) - at 95% Confidence	4.72		% of Value
Expanded uncertainty (with O_2) - at 95% Confidence	4.28		% at ELV
Overall Allowable uncertainty (with O_2) - at 95% Confidence	15.2		% at ELV
Result of Compliance with Uncertainty Requirement	**COMPLIANT**		-

Requirement for SRM is that Uncertainty should be <15% of the value at the ELV, on a dry gas basis, or if O_2 correction is applied less than 15% + the uncertainty associated with the O_2 correction (using sqrt of sum squares to add uncertainty components).

OXIDES OF NITROGEN (as NO_2): RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	ppm	204.94		204.94
Concentration	mg/m³	480.69		480.69
Uncertainty	±mg/m³	17.87		17.87
Mass Emission	g/hr	152575.6		152575.6
Uncertainty	±g/hr	9020.2		9020.2

General Sampling Information

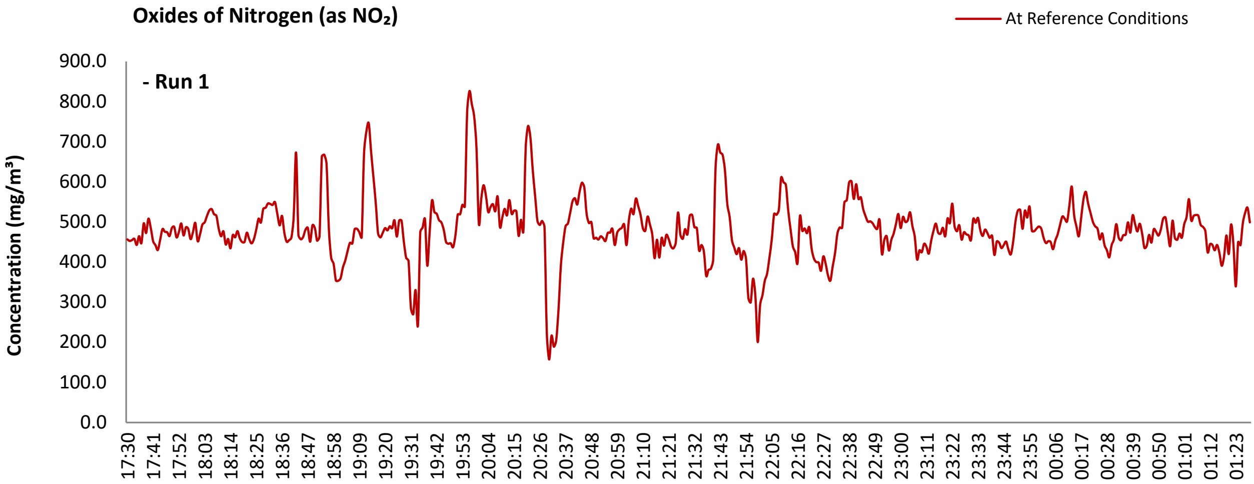
Parameter	Value	
Standard	EN 14792	
Technical Procedure	MD 039	
Probe Material	Titanium	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Date & Result of Last Converter Check	03/05/2023 - 96.6%	
Span Gas Type	Nitrogen Monoxide	
Span Gas Reference Number	12.0517	
Span Gas Expiry Date	24/03/2025	
Span Gas Start Pressure (bar)	40	
Gas Cylinder Concentration (ppm)	405.5	NOTE: Dilution performed to achieve correct span value
Span Gas Uncertainty (%)	2	
Zero Gas Type	Nitrogen (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	B2	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

OXIDES OF NITROGEN (as NO_2): DATA TREND

Graphical Trend of Data



OXIDES OF NITROGEN (as NO_2): SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1
Sampling Times	-	17:30 - 01:30
Sampling Dates	-	22/11/2023
Instrument Range	ppm	500
Span Gas Value	ppm	243.6

Quality Assurance

Conditioning Unit Temperature	Units	Run 1
Average Temperature	°C	2.1
Allowable Temperature	< °C	4.0
Temperature Acceptable	-	Yes

	Zero Drift	Units	Run 1
CAL 1	Zero at Analyser (Pre)	ppm	0.00
CAL 1	Zero at Analyser (Post)	ppm	0.05
CAL 1	Zero Drift	ppm	0.05
CAL 1	Zero Drift	%	0.02
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Zero Drift	± %	5.00
	Zero Drift Acceptable	-	Yes

	Span Drift	Units	Run 1
CAL 1	Span at Analyser (Pre)	ppm	243.63
CAL 1	Span at Analyser (Post)	ppm	241.00
CAL 1	Span Drift	ppm	-2.63
CAL 1	Zero Adj. Span Drift	%	1.10
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Span Drift	± %	5.00
	Span Drift Acceptable	-	Yes

Test Conditions	Units	Run 1
Run Ambient Temperature Range	°C	5 - 7

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1	
There are no deviations associated with the sampling employed.	x	

OXIDES OF NITROGEN (as NO_2): MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	**RUN 1**		**Units**
Limit value	500.0		mg/m^3 (REF)
Allowable MU	10.0		%
Measured concentration	420.97		mg/m^3 (STP, dry)
Ratio NO / NO_2	5		%
Range Used	500.0		ppm
Range Used [A]	1026.1		mg/m^3
Cal gas conc.	243.6		ppm
Conversion	2.05		ppm to mg/m^3
MCERTS Range [B]	205.0		mg/m^3
Lower of [A] or [B]	205.0		mg/m^3
Cal gas conc.	500.0		mg/m^3

Performance characteristics	**RUN 1**		**Units**
Response time	31		seconds
Number of readings in measurement	480		-
Repeatability at zero	0.00		% full scale
Repeatability at span level	0.10		% full scale
Deviation from linearity	0.40		% of value
Zero drift	0.02		% full scale
Span drift	-1.10		% full scale
Volume or pressure flow dependence	0.10		% of full scale
Atmospheric pressure dependence	0.10		% of value/kPa
Ambient temperature dependence	0.04		% full scale/10K
Combined interference	0.63		% range
Dependence on voltage	-0.23		% full scale/10V
Converter efficiency	96.6		%
Losses in the line (leak)	0.63		% of value
Uncertainty of calibration gas blending	1.40		% of value
Uncertainty of calibration gas	2.00		% of value

Performance characteristic	**RUN 1**		**Units**
Standard deviation of repeatability at zero	use rep at span		mg/m^3
Standard deviation of repeatability at span level	0.00		mg/m^3
Lack of fit	0.47		mg/m^3
Drift	0.00		mg/m^3
Volume or pressure flow dependence	0.00		mg/m^3
Atmospheric pressure dependence	0.06		mg/m^3
Ambient temperature dependence	0.01		mg/m^3
Combined interference (from MCERTS Certificate)	0.75		mg/m^3
Dependence on voltage	-0.03		mg/m^3
Converter efficiency	0.41		mg/m^3
Losses in the line (leak)	1.53		mg/m^3
Uncertainty of calibration gas blending	3.40		mg/m^3
Uncertainty of calibration gas	4.86		mg/m^3

			RUN 1		**Units**
Measurement uncertainty		**Result**	420.97		mg/m^3
Combined uncertainty			6.20		mg/m^3
Expanded uncertainty	k =	1.96	12.16		mg/m^3
Uncertainty corrected to std conds. (O_2)			13.89		mg/m^3 (REF)

	RUN 1		**Units**
Expanded uncertainty (no O_2) - at 95% Confidence	2.89		% of Value
Expanded uncertainty (no O_2) - at 95% Confidence	2.43		% at ELV
Overall Allowable uncertainty (no O_2) - at 95% Confidence	10.0		% at ELV
Result of Compliance with Uncertainty Requirement	**N/A**		-

	RUN 1		**Units**
Expanded uncertainty (with O_2) - at 95% Confidence	3.72		% of Value
Expanded uncertainty (with O_2) - at 95% Confidence	3.63		% at ELV
Overall Allowable uncertainty (with O_2) - at 95% Confidence	10.3		% at ELV
Result of Compliance with Uncertainty Requirement	**COMPLIANT**		-

Requirement for SRM is that Uncertainty should be <10% of the value at the ELV, on a dry gas basis, or if O_2 correction is applied less than 10% + the uncertainty associated with the O_2 correction (using sqrt of sum squares to add uncertainty components).

CARBON MONOXIDE: RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	ppm	122.43		122.43
Concentration	mg/m³	174.45		174.45
Uncertainty	±mg/m³	6.62		6.62
Mass Emission	g/hr	55372.9		55372.9
Uncertainty	±g/hr	3301.5		3301.5

General Sampling Information

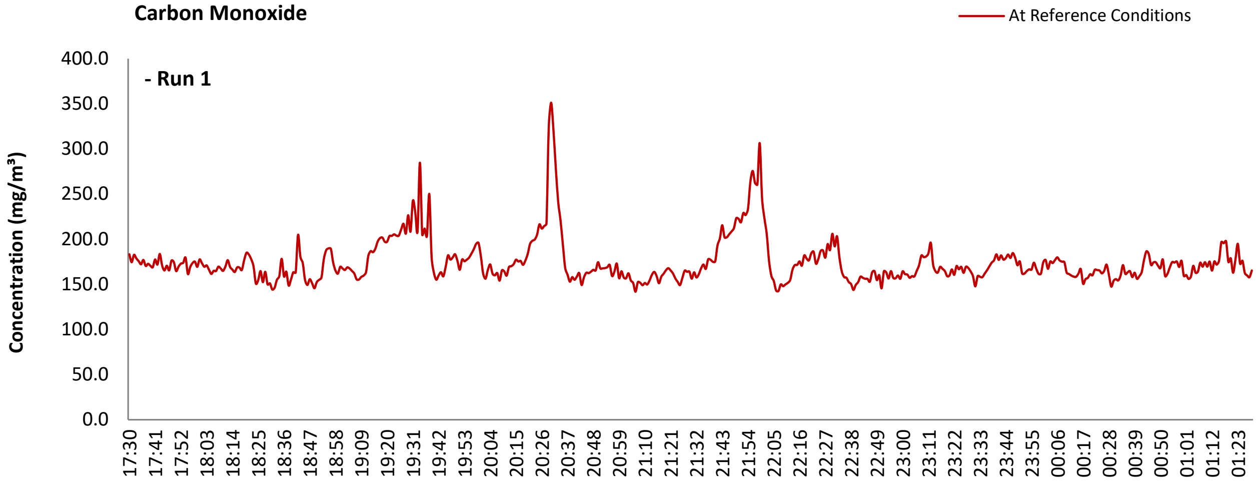
Parameter	Value	
Standard	EN 15058	
Technical Procedure	MD 039	
Probe Material	Titanium	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Type	Carbon Monoxide	
Span Gas Reference Number	12.0517	
Span Gas Expiry Date	24/03/2025	
Span Gas Start Pressure (bar)	40	
Gas Cylinder Concentration (ppm)	411.8	NOTE: Dilution performed to achieve correct span value
Span Gas Uncertainty (%)	2	
Zero Gas Type	Nitrogen (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	B2	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 10% oxygen.

CARBON MONOXIDE: DATA TREND

Graphical Trend of Data



CARBON MONOXIDE: SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1
Sampling Times	-	17:30 - 01:30
Sampling Dates	-	22/11/2023
Instrument Range	ppm	500
Span Gas Value	ppm	300.0

Quality Assurance

Conditioning Unit Temperature	Units	Run 1
Average Temperature	°C	2.1
Allowable Temperature	< °C	4.0
Temperature Acceptable	-	Yes

	Zero Drift	Units	Run 1
CAL 1	Zero at Analyser (Pre)	ppm	0.00
CAL 1	Zero at Analyser (Post)	ppm	0.00
CAL 1	Zero Drift	ppm	0.00
CAL 1	Zero Drift	%	0.00
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Zero Drift	± %	5.00
	Zero Drift Acceptable	-	Yes

	Span Drift	Units	Run 1
CAL 1	Span at Analyser (Pre)	ppm	300.00
CAL 1	Span at Analyser (Post)	ppm	296.50
CAL 1	Span Drift	ppm	-3.50
CAL 1	Zero Adj. Span Drift	%	1.17
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Span Drift	± %	5.00
	Span Drift Acceptable	-	Yes

Test Conditions	Units	Run 1
Run Ambient Temperature Range	°C	5 - 7

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1	
There are no deviations associated with the sampling employed.	x	

APPENDIX 2

CARBON MONOXIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	RUN 1		Units
Limit value	1500.0		mg/m^3 (REF)
Allowable MU	6.0		%
Measured concentration	152.78		mg/m^3 (STP, dry)
Range Used	500.0		ppm
Range Used [A]	624.6		mg/m^3
Cal gas conc.	300.0		ppm
Conversion	1.25		ppm to mg/m^3
MCERTS Range [B]	75.0		mg/m^3
Lower of [A] or [B]	75.0		mg/m^3
Cal gas conc.	374.8		mg/m^3

Performance characteristics	RUN 1		Units
Response time	28		seconds
Number of readings in measurement	480		-
Repeatability at zero	0.10		% full scale
Repeatability at span level	0.20		% full scale
Deviation from linearity	0.61		% of value
Zero drift	0.00		% full scale
Span drift	-1.17		% full scale
Volume or pressure flow dependence	0.10		% of full scale
Atmospheric pressure dependence	0.22		% of value/kPa
Ambient temperature dependence	-0.20		% full scale/10K
Combined interference	-0.48		% range
Dependence on voltage	-0.35		% full scale/10V
Losses in the line (leak)	0.93		% of value
Uncertainty of calibration gas blending	1.40		% of value
Uncertainty of calibration gas	2.00		% of value

Performance characteristic	RUN 1		Units
Standard deviation of repeatability at zero	use rep at span		mg/m^3
Standard deviation of repeatability at span level	0.01		mg/m^3
Lack of fit	0.26		mg/m^3
Drift	0.00		mg/m^3
Volume or pressure flow dependence	0.00		mg/m^3
Atmospheric pressure dependence	0.05		mg/m^3
Ambient temperature dependence	-0.03		mg/m^3
Combined interference (from MCERTS Certificate)	-0.21		mg/m^3
Dependence on voltage	-0.04		mg/m^3
Losses in the line (leak)	0.82		mg/m^3
Uncertainty of calibration gas blending	1.23		mg/m^3
Uncertainty of calibration gas	1.76		mg/m^3

			RUN 1		Units
Measurement uncertainty		**Result**	152.78		mg/m^3
Combined uncertainty			2.33		mg/m^3
Expanded uncertainty	k =	1.96	4.57		mg/m^3
Uncertainty corrected to std conds. (O_2)			5.22		mg/m^3 (REF)

	RUN 1		Units
Expanded uncertainty (no O_2) - at 95% Confidence	2.99		% of Value
Expanded uncertainty (no O_2) - at 95% Confidence	0.30		% at ELV
Overall Allowable uncertainty (no O_2) - at 95% Confidence	6.0		% at ELV
Result of Compliance with Uncertainty Requirement	**N/A**		-

	RUN 1		Units
Expanded uncertainty (with O_2) - at 95% Confidence	3.80		% of Value
Expanded uncertainty (with O_2) - at 95% Confidence	2.36		% at ELV
Overall Allowable uncertainty (with O_2) - at 95% Confidence	6.4		% at ELV
Result of Compliance with Uncertainty Requirement	**COMPLIANT**		-

Requirement for SRM is that Uncertainty should be <6% of the value at the ELV, on a dry gas basis, or if O_2 correction is applied less than 6% + the uncertainty associated with the O_2 correction (using sqrt of sum squares to add uncertainty components).

CARBON DIOXIDE: RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Sample Runs

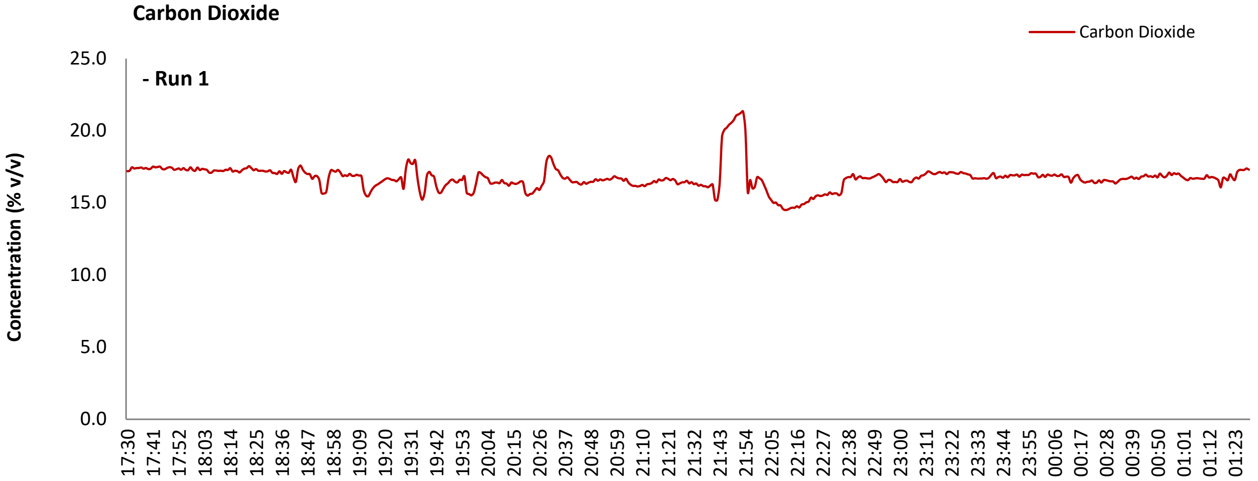
Parameter	Units	Run 1		Mean
Concentration	% v/v	16.72		16.72
Uncertainty	±% v/v	0.53		0.53

General Sampling Information

Parameter	Value	
Standard	CEN/TS 17405	
Technical Procedure	MD 039	
Probe Material	Titanium	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Type	Carbon Dioxide	
Span Gas Reference Number	6.0086	
Span Gas Expiry Date	07/06/2028	
Span Gas Start Pressure (bar)	80	
Gas Cylinder Concentration (% v/v)	16.01	
Span Gas Uncertainty (%)	2.00	
Zero Gas Type	Nitrogen (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	B2	

CARBON DIOXIDE: DATA TREND

Graphical Trend of Data



CARBON DIOXIDE: SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1
Sampling Times	-	17:30 - 01:30
Sampling Dates	-	22/11/2023
Instrument Range	% v/v	20
Span Gas Value	% v/v	16.0

Quality Assurance

Conditioning Unit Temperature	Units	Run 1
Average Temperature	°C	2.1
Allowable Temperature	< °C	4.0
Temperature Acceptable	-	Yes

	Zero Drift	Units	Run 1
CAL 1	Zero Down Sampling Line (Pre)	% v/v	0.00
CAL 1	Zero Down Sampling Line (Post)	% v/v	0.00
CAL 1	Zero Drift	% v/v	0.00
CAL 1	Zero Drift	%	0.00
CAL 1	Drift Correction Applied	2-5%	No
	Zero Drift Acceptable	-	Yes

	Span Drift	Units	Run 1
CAL 1	Span Down Sampling Line (Pre)	% v/v	15.72
CAL 1	Span Down Sampling Line (Post)	% v/v	15.75
CAL 1	Span Drift	% v/v	0.03
CAL 1	Zero Adj. Span Drift	%	1.62
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Span Drift	± %	5.00
	Span Drift Acceptable	-	Yes

Test Conditions	Units	Run 1
Run Ambient Temperature Range	°C	5 - 7

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1	
There are no deviations associated with the sampling employed.	x	

CARBON DIOXIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	RUN 1		Units
Limit value	N/A		%vol
Allowable MU	25.0		%
Measured concentration	16.72		%vol
Range Used	20.0		%vol
Cal gas conc.	16.0		%vol

Performance characteristics	RUN 1		Units
Response time	29		seconds
Number of readings in measurement	480		-
Repeatability at zero	0.00		% full scale
Repeatability at span level	0.10		% full scale
Deviation from linearity	0.42		% of value
Zero drift	0.00		% full scale
Span drift	-1.62		% full scale
Volume or pressure flow dependence	0.10		% of full scale
Atmospheric pressure dependence	0.30		% of value/kPa
Ambient temperature dependence	-0.20		% full scale/10K
Combined interference	0.00		% range
Dependence on voltage	0.40		% full scale/10V
Losses in the line (leak)	1.81		% of value
Uncertainty of calibration gas	2.00		% of value

Performance characteristic	RUN 1		Units
Standard deviation of repeatability at zero	use rep at span		%vol
Standard deviation of repeatability at span level	0.00		%vol
Lack of fit	0.05		%vol
Drift	0.00		%vol
Volume or pressure flow dependence	0.00		%vol
Atmospheric pressure dependence	0.02		%vol
Ambient temperature dependence	-0.03		%vol
Combined interference (from MCERTS Certificate)	0.00		%vol
Dependence on voltage	0.05		%vol
Losses in the line (leak)	0.17		%vol
Uncertainty of calibration gas	0.19		%vol

			RUN 1		Units
Measurement uncertainty		**Result**	16.72		%vol
Combined uncertainty			0.27		%vol
Expanded uncertainty	k =	1.96	0.53		%vol

	RUN 1		Units
Expanded uncertainty (no O_2) - at 95% Confidence	3.18		% of Value

APPENDIX 2

OXYGEN: RESULTS SUMMARY

Irish Cement Ltd, Limerick
A2-01 Kiln 6

Sample Runs

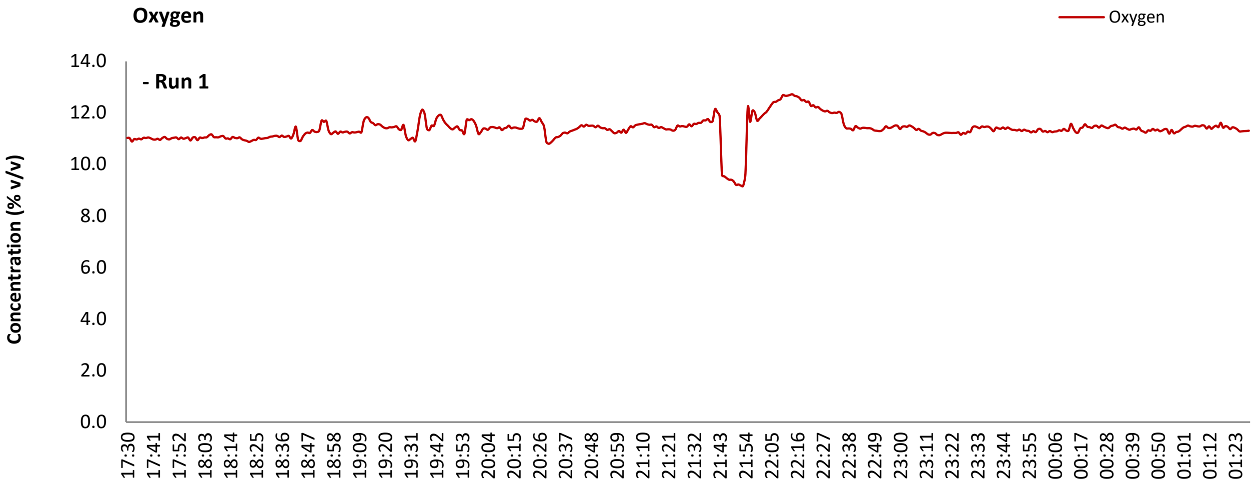
Parameter	Units	Run 1		Mean
Concentration	% v/v	11.37		11.37
Uncertainty	±% v/v	0.27		0.27

General Sampling Information

Parameter	Value	
Standard	EN 14789	
Technical Procedure	MD 039	
Probe Material	Titanium	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Type	Synthetic Air (5 Grade)	
Span Gas Reference Number	11.0555	
Span Gas Expiry Date	17/08/2027	
Span Gas Start Pressure (bar)	100	
Gas Cylinder Concentration (% v/v)	21.21	NOTE: Dilution performed to achieve correct span value
Span Gas Uncertainty (%)	2	
Zero Gas Type	Nitrogen (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	B2	

OXYGEN: DATA TREND

Graphical Trend of Data



APPENDIX 2

OXYGEN: SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1
Sampling Times	-	17:30 - 01:30
Sampling Dates	-	22/11/2023
Instrument Range	% v/v	25.0
Span Gas Value	% v/v	10.0

Quality Assurance

Conditioning Unit Temperature	Units	Run 1
Average Temperature	°C	2.1
Allowable Temperature	< °C	4.0
Temperature Acceptable	-	Yes

	Zero Drift	Units	Run 1
CAL 1	Zero at Analyser (Pre)	% v/v	0.00
CAL 1	Zero at Analyser (Post)	% v/v	0.00
CAL 1	Zero Drift	% v/v	0.00
CAL 1	Zero Drift	%	0.00
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Zero Drift	± %	5.00
	Zero Drift Acceptable	-	Yes

	Span Drift	Units	Run 1
CAL 1	Span at Analyser (Pre)	% v/v	10.01
CAL 1	Span at Analyser (Post)	% v/v	10.00
CAL 1	Span Drift	% v/v	-0.01
CAL 1	Zero Adj. Span Drift	%	0.10
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Span Drift	± %	5.00
	Span Drift Acceptable	-	Yes

Test Conditions	Units	Run 1
Run Ambient Temperature Range	°C	5 - 7

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1
There are no deviations associated with the sampling employed.	x

OXYGEN: MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	RUN 1		Units
Limit value	N/A		%vol
Allowable MU	6.0		%
Measured concentration	11.37		%vol
Range Used	25.0		%vol
Cal gas conc.	21.2		%vol

Performance characteristics	RUN 1		Units
Response time	41		seconds
Number of readings in measurement	480		-
Repeatability at zero	0.02		% full scale
Repeatability at span level	0.02		% full scale
Deviation from linearity	0.05		% of value
Zero drift	0.00		% full scale
Span drift	-0.10		% full scale
Volume or pressure flow dependence	0.10		% of full scale
Atmospheric pressure dependence	0.19		% of value/kPa
Ambient temperature dependence	-0.21		% full scale/10K
Combined interference	0.00		% range
Dependence on voltage	0.02		% full scale/10V
Losses in the line (leak)	0.00		% of value
Uncertainty of calibration gas	2.00		% of value

Performance characteristic	RUN 1		Units
Standard deviation of repeatability at zero	use rep at span		%vol
Standard deviation of repeatability at span level	0.00		%vol
Lack of fit	0.01		%vol
Drift	0.00		%vol
Volume or pressure flow dependence	0.00		%vol
Atmospheric pressure dependence	0.01		%vol
Ambient temperature dependence	-0.03		%vol
Combined interference (from MCERTS Certificate)	0.00		%vol
Dependence on voltage	0.00		%vol
Losses in the line (leak)	0.00		%vol
Uncertainty of calibration gas	0.13		%vol

			RUN 1		Units
Measurement uncertainty		**Result**	11.37		%vol
Combined uncertainty			0.14		%vol
Expanded uncertainty	k =	1.96	0.27		%vol

	RUN 1		Units
Expanded uncertainty (no O_2) - at 95% Confidence	2.34		% of Value
Result of Compliance with Uncertainty Requirement	**COMPLIANT**		-

Requirement for SRM is that Uncertainty should be 0.3% vol absolute or 6% relative whichever is the lower, on a dry gas basis. Source, EN 14789.

VERSION HISTORY

Version Number	Record of changes made within this version of the document
V1	The original document issued to the client
V2	Decimal place expanded to show result for run 3 Dioxins.

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North Road
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D02 EK8

Attention :	Dónal Ó Faogáin
Date :	15th January, 2024
Your reference :	EMT07766
Our reference :	Test Report 23/20223 Batch 1
Location :	Dublin
Date samples received :	1st December, 2023
Status :	Final Report
Issue :	202401151542

Four samples were received for analysis on 1st December, 2023 of which four were scheduled for analysis. Please find attached our Test Report which should be read with notes at the end of the report and should include all sections if reproduced. Interpretations and opinions are outside the scope of any accreditation, and all results relate only to samples supplied.
All analysis is carried out on as received samples and reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected.

The greenhouse gas emissions generated (in Carbon – Co2e) to obtain the results in this report are estimated as:

Scope 1&2 emissions - 2.027 kg of CO2

Scope 1&2&3 emissions - 4.791 kg of CO2

Authorised By:

Bruce Leslie
Project Manager

Element Materials Technology

Client Name:	**Element**		
Reference:	**EMT07766**	**Sample Date:**	**20 Nov 2023**
Location:	**Dublin**	**Date of Receipt:**	**1 Dec 2023**
Contact:	**Dónal Ó Faogáin**	**Date Analysed:**	**10 Jan 2024**

Sample ID: **1.1 EMT07766-B**
Depth:
EMT Job No: **23/20223**
EMT Sample No: **1**
Matrix: **Stack**
Method: **TM201/PM137 Dioxins, Furans and PCBs in Stationary Source Emissions**

ANALYSIS OF PCDDs and PCDFs

Q : Qualifiers

SV Indicates surrogate recovery outside performance criteria
>> Indicates value exceeds calibration range

Key

LOD Limit of Detection
ISO 17025 (UKAS)
M MCERTS accredited

CAS No		Compound	Q	Result ng/sample	LOD	I-TEFs	TEQ Lower Bound	TEQ Upper Bound	% Recovery
1746-01-6	#M	2378-TCDD		<0.00126	0.00126	1	0.00000	0.00126	93
40321-76-4	#M	12378-PCDD		<0.00223	0.00223	1	0.00000	0.00223	77
39227-28-6	#M	123478-HxCDD		<0.00168	0.00168	0.1	0.00000	0.00017	86
57653-85-7	#M	123678-HxCDD		<0.00218	0.00218	0.1	0.00000	0.00022	67
19408-74-3	#M	123789-HxCDD		<0.00226	0.00226	0.1	0.00000	0.00023	
35822-46-9	#M	1234678-HpCDD		<0.00151	0.00151	0.01	0.00000	0.00002	78
3268-87-9	#M	OCDD		0.00948	0.00181	0.0003	0.00000	0.00000	84
51207-31-9	#M	2378-TCDF		<0.00310	0.00310	0.1	0.00000	0.00031	58
57117-41-6	#M	12378-PCDF		<0.00124	0.00124	0.03	0.00000	0.00004	117
57117-31-4	#M	23478-PCDF		<0.00119	0.00119	0.3	0.00000	0.00036	67
70648-26-9	#M	123478-HxCDF		<0.00092	0.00092	0.1	0.00000	0.00009	72
57117-44-9	#M	123678-HxCDF		<0.00091	0.00091	0.1	0.00000	0.00009	74
60851-34-5	#M	234678-HxCDF		<0.00112	0.00112	0.1	0.00000	0.00011	62
72918-21-9	#M	123789-HxCDF		<0.00126	0.00126	0.1	0.00000	0.00013	107
67562-39-4	#M	1234678-HpCDF		<0.00088	0.00088	0.01	0.00000	0.00001	71
55673-89-7	#M	1234789-HpCDF		<0.00105	0.00105	0.01	0.00000	0.00001	100
39001-02-0	#M	OCDF		<0.00100	0.00100	0.0003	0.00000	0.00000	75
		Sum - TEQ					0.00000	0.00528	

Upper-Bound: 'Upper-bound' means the concept which requires using the limit of quantification for the contribution of each non-quantified congener
Lower-Bound: 'Lower-bound' means the concept which requires using zero for the contribution of each non-quantified congener
TEQ: Toxic Equivalent Value
TEF: Toxic Equivalent Factor

Element Materials Technology

Client Name:	**Element**			
Reference:	**EMT07766**		**Sample Date:**	**20 Nov 2023**
Location:	**Dublin**		**Date of Receipt:**	**1 Dec 2023**
Contact:	**Dónal Ó Faogáin**		**Date Analysed:**	**10 Jan 2024**

Sample ID: 1.1 EMT07766-B
Depth:
EMT Job No: 23/20223
EMT Sample No: 1
Matrix: Stack
Method: TM201/PM137 Dioxins, Furans and PCBs in Stationary Source Emissions

ANALYSIS OF PCBs

Q : Qualifiers

SV Indicates surrogate recovery outside performance criteria
>> Indicates value exceeds calibration range

Key

LOD Limit of Detection
ISO 17025 (UKAS)
M MCERTS accredited

CAS No		Compound	Q	Result ng/sample	LOD	I-TEFs	TEQ Lower Bound	TEQ Upper Bound	% Recovery
70362-50-4	#M	PCB-81		<0.00098	0.00098	0.0003	0.00000	0.00000	77
32598-13-3	#M	PCB-77		0.00493	0.00278	0.0001	0.00000	0.00000	74
65510-44-3	#M	PCB-123		<0.00334	0.00334	0.00003	0.00000	0.00000	90
31508-00-6	#M	PCB-118		0.02216	0.00330	0.00003	0.00000	0.00000	87
74472-37-0	#M	PCB-114		<0.00329	0.00329	0.00003	0.00000	0.00000	93
32598-14-4	#M	PCB-105		0.00834	0.00344	0.00003	0.00000	0.00000	85
57465-28-8	#M	PCB-126		<0.00430	0.00430	0.1	0.00000	0.00043	71
52663-72-6	#M	PCB-167		0.00147	0.00092	0.00003	0.00000	0.00000	122
38380-08-4	#M	PCB-156		0.00235	0.00092	0.00003	0.00000	0.00000	123
69782-90-7	#M	PCB-157		<0.00098	0.00098	0.00003	0.00000	0.00000	119
32774-16-6	#M	PCB-169		<0.00145	0.00145	0.03	0.00000	0.00004	76
39635-31-9	#M	PCB-189		<0.00048	0.00048	0.00003	0.00000	0.00000	92
		Sum - TEQ					0.00000	0.00047	
33025-41-1		PCB-60 (Standard)	SV						130
39635-35-3		PCB-159 (Standard)							102

Upper-Bound: 'Upper-bound' means the concept which requires using the limit of quantification for the contribution of each non-quantified congener
Lower-Bound: 'Lower-bound' means the concept which requires using zero for the contribution of each non-quantified congener
TEQ: Toxic Equivalent Value
TEF: Toxic Equivalent Factor

Element Materials Technology

Client Name:	**Element**			
Reference:	**EMT07766**		**Sample Date:**	**20 Nov 2023**
Location:	**Dublin**		**Date of Receipt:**	**1 Dec 2023**
Contact:	**Dónal Ó Faogáin**		**Date Analysed:**	**15 Jan 2024**

Sample ID: 1.2 EMT07766-R1
Depth:
EMT Job No: 23/20223
EMT Sample No: 2
Matrix: Stack
Method: TM201/PM137 Dioxins, Furans and PCBs in Stationary Source Emissions

ANALYSIS OF PCDDs and PCDFs

Q : Qualifiers

SV Indicates surrogate recovery outside performance criteria
>> Indicates value exceeds calibration range

Key

LOD Limit of Detection
ISO 17025 (UKAS)
M MCERTS accredited

CAS No		Compound	Q	Result ng/sample	LOD	I-TEFs	TEQ Lower Bound	TEQ Upper Bound	% Recovery
1746-01-6	#M	2378-TCDD		<0.01173	0.01173	1	0.00000	0.01173	71
40321-76-4	#M	12378-PCDD		<0.00749	0.00749	1	0.00000	0.00749	55
39227-28-6	#M	123478-HxCDD		<0.00360	0.00360	0.1	0.00000	0.00036	62
57653-85-7	#M	123678-HxCDD		<0.00452	0.00452	0.1	0.00000	0.00045	59
19408-74-3	#M	123789-HxCDD		<0.00420	0.00420	0.1	0.00000	0.00042	
35822-46-9	#M	1234678-HpCDD		<0.00299	0.00299	0.01	0.00000	0.00003	58
3268-87-9	#M	OCDD		0.01995	0.00256	0.0003	0.00001	0.00001	65
51207-31-9	#M	2378-TCDF		0.31817	0.02246	0.1	0.03182	0.03182	50
57117-41-6	#M	12378-PCDF		0.03162	0.02035	0.03	0.00095	0.00095	104
57117-31-4	#M	23478-PCDF		0.03696	0.02095	0.3	0.01109	0.01109	52
70648-26-9	#M	123478-HxCDF		<0.00433	0.00433	0.1	0.00000	0.00043	57
57117-44-9	#M	123678-HxCDF		0.00673	0.00476	0.1	0.00067	0.00067	54
60851-34-5	#M	234678-HxCDF		<0.00557	0.00557	0.1	0.00000	0.00056	47
72918-21-9	#M	123789-HxCDF		<0.00584	0.00584	0.1	0.00000	0.00058	116
67562-39-4	#M	1234678-HpCDF		0.00960	0.00165	0.01	0.00010	0.00010	57
55673-89-7	#M	1234789-HpCDF		<0.00179	0.00179	0.01	0.00000	0.00002	97
39001-02-0	#M	OCDF		0.00623	0.00286	0.0003	0.00000	0.00000	63
		Sum - TEQ					0.04464	0.06671	

Upper-Bound: 'Upper-bound' means the concept which requires using the limit of quantification for the contribution of each non-quantified congener
Lower-Bound: 'Lower-bound' means the concept which requires using zero for the contribution of each non-quantified congener
TEQ: Toxic Equivalent Value
TEF: Toxic Equivalent Factor

Element Materials Technology

Client Name:	**Element**		
Reference:	**EMT07766**	**Sample Date:**	**20 Nov 2023**
Location:	**Dublin**	**Date of Receipt:**	**1 Dec 2023**
Contact:	**Dónal Ó Faogáin**	**Date Analysed:**	**10 Jan 2024**

Sample ID: **1.2 EMT07766-R1**
Depth:
EMT Job No: **23/20223**
EMT Sample No: **2**
Matrix: **Stack**
Method: **TM201/PM137 Dioxins, Furans and PCBs in Stationary Source Emissions**

ANALYSIS OF PCBs

Q : Qualifiers

SV Indicates surrogate recovery outside performance criteria
>> Indicates value exceeds calibration range

Key

LOD Limit of Detection
ISO 17025 (UKAS)
M MCERTS accredited

CAS No		Compound	Q	Result ng/sample	LOD	I-TEFs	TEQ Lower Bound	TEQ Upper Bound	% Recovery
70362-50-4	#M	PCB-81		0.57396	0.03391	0.0003	0.00017	0.00017	60
32598-13-3	#M	PCB-77		2.16378	0.01374	0.0001	0.00022	0.00022	66
65510-44-3	#M	PCB-123		0.32220	0.01164	0.00003	0.00001	0.00001	76
31508-00-6	#M	PCB-118		1.22825	0.01176	0.00003	0.00004	0.00004	76
74472-37-0	#M	PCB-114		0.10447	0.01197	0.00003	0.00000	0.00000	76
32598-14-4	#M	PCB-105		0.72898	0.01264	0.00003	0.00002	0.00002	72
57465-28-8	#M	PCB-126		0.19261	0.01302	0.1	0.01926	0.01926	83
52663-72-6	#M	PCB-167		0.08637	0.00513	0.00003	0.00000	0.00000	107
38380-08-4	#M	PCB-156		0.08575	0.00500	0.00003	0.00000	0.00000	106
69782-90-7	#M	PCB-157		0.04486	0.00536	0.00003	0.00000	0.00000	103
32774-16-6	#M	PCB-169		<0.00350	0.00350	0.03	0.00000	0.00011	87
39635-31-9	#M	PCB-189		0.00849	0.00137	0.00003	0.00000	0.00000	76
		Sum - TEQ					0.01972	0.01983	
33025-41-1		PCB-60 (Standard)	SV						130
39635-35-3		PCB-159 (Standard)							99

Upper-Bound: 'Upper-bound' means the concept which requires using the limit of quantification for the contribution of each non-quantified congener
Lower-Bound: 'Lower-bound' means the concept which requires using zero for the contribution of each non-quantified congener
TEQ: Toxic Equivalent Value
TEF: Toxic Equivalent Factor

Element Materials Technology

Client Name:	**Element**		
Reference:	**EMT07766**	**Sample Date:**	**20 Nov 2023**
Location:	**Dublin**	**Date of Receipt:**	**1 Dec 2023**
Contact:	**Dónal Ó Faogáin**	**Date Analysed:**	**15 Jan 2024**

Sample ID: **1.3 EMT07766-R2**
Depth:
EMT Job No: **23/20223**
EMT Sample No: **3**
Matrix: **Stack**
Method: **TM201/PM137 Dioxins, Furans and PCBs in Stationary Source Emissions**

ANALYSIS OF PCDDs and PCDFs

Q : Qualifiers

SV Indicates surrogate recovery outside performance criteria
>> Indicates value exceeds calibration range

Key

LOD Limit of Detection
ISO 17025 (UKAS)
M MCERTS accredited

CAS No		Compound	Q	Result ng/sample	LOD	I-TEFs	TEQ Lower Bound	TEQ Upper Bound	% Recovery
1746-01-6	#M	2378-TCDD		<0.01101	0.01101	1	0.00000	0.01101	78
40321-76-4	#M	12378-PCDD		<0.00882	0.00882	1	0.00000	0.00882	60
39227-28-6	#M	123478-HxCDD		<0.00366	0.00366	0.1	0.00000	0.00037	65
57653-85-7	#M	123678-HxCDD		<0.00445	0.00445	0.1	0.00000	0.00044	60
19408-74-3	#M	123789-HxCDD		<0.00413	0.00413	0.1	0.00000	0.00041	
35822-46-9	#M	1234678-HpCDD		<0.00294	0.00294	0.01	0.00000	0.00003	62
3268-87-9	#M	OCDD		0.01867	0.00327	0.0003	0.00001	0.00001	73
51207-31-9	#M	2378-TCDF		0.34691	0.02468	0.1	0.03469	0.03469	60
57117-41-6	#M	12378-PCDF		0.04897	0.01925	0.03	0.00147	0.00147	102
57117-31-4	#M	23478-PCDF		0.04119	0.01981	0.3	0.01236	0.01236	57
70648-26-9	#M	123478-HxCDF		<0.00497	0.00497	0.1	0.00000	0.00050	61
57117-44-9	#M	123678-HxCDF		<0.00549	0.00549	0.1	0.00000	0.00055	60
60851-34-5	#M	234678-HxCDF		<0.00603	0.00603	0.1	0.00000	0.00060	52
72918-21-9	#M	123789-HxCDF		<0.00632	0.00632	0.1	0.00000	0.00063	122
67562-39-4	#M	1234678-HpCDF		<0.00182	0.00182	0.01	0.00000	0.00002	61
55673-89-7	#M	1234789-HpCDF		<0.00198	0.00198	0.01	0.00000	0.00002	95
39001-02-0	#M	OCDF		0.00231	0.00203	0.0003	0.00000	0.00000	68
		Sum - TEQ					0.04853	0.07193	

Upper-Bound: 'Upper-bound' means the concept which requires using the limit of quantification for the contribution of each non-quantified congener
Lower-Bound: 'Lower-bound' means the concept which requires using zero for the contribution of each non-quantified congener
TEQ: Toxic Equivalent Value
TEF: Toxic Equivalent Factor

Element Materials Technology

Client Name:	**Element**			
Reference:	**EMT07766**		**Sample Date:**	**20 Nov 2023**
Location:	**Dublin**		**Date of Receipt:**	**1 Dec 2023**
Contact:	**Dónal Ó Faogáin**		**Date Analysed:**	**10 Jan 2024**

Sample ID: **1.3 EMT07766-R2**
Depth:
EMT Job No: **23/20223**
EMT Sample No: **3**
Matrix: **Stack**
Method: **TM201/PM137 Dioxins, Furans and PCBs in Stationary Source Emissions**

ANALYSIS OF PCBs

Q : Qualifiers

SV	Indicates surrogate recovery outside performance criteria
>>	Indicates value exceeds calibration range

Key

LOD	Limit of Detection
#	ISO 17025 (UKAS)
M	MCERTS accredited

CAS No		Compound	Q	Result ng/sample	LOD	I-TEFs	TEQ Lower Bound	TEQ Upper Bound	% Recovery
70362-50-4	#M	PCB-81		0.61475	0.02616	0.0003	0.00018	0.00018	65
32598-13-3	#M	PCB-77		1.98416	0.01390	0.0001	0.00020	0.00020	73
65510-44-3	#M	PCB-123		0.28765	0.01510	0.00003	0.00001	0.00001	77
31508-00-6	#M	PCB-118		1.26822	0.01508	0.00003	0.00004	0.00004	77
74472-37-0	#M	PCB-114		0.09522	0.01595	0.00003	0.00000	0.00000	77
32598-14-4	#M	PCB-105		0.67258	0.01561	0.00003	0.00002	0.00002	76
57465-28-8	#M	PCB-126		0.18702	0.01532	0.1	0.01870	0.01870	90
52663-72-6	#M	PCB-167		0.08729	0.00581	0.00003	0.00000	0.00000	108
38380-08-4	#M	PCB-156		0.08844	0.00589	0.00003	0.00000	0.00000	104
69782-90-7	#M	PCB-157		0.04157	0.00639	0.00003	0.00000	0.00000	100
32774-16-6	#M	PCB-169		0.00830	0.00787	0.03	0.00025	0.00025	96
39635-31-9	#M	PCB-189		0.00825	0.00158	0.00003	0.00000	0.00000	76
		Sum - TEQ					0.01940	0.01940	
33025-41-1		PCB-60 (Standard)	SV						123
39635-35-3		PCB-159 (Standard)							98

Upper-Bound: 'Upper-bound' means the concept which requires using the limit of quantification for the contribution of each non-quantified congener
Lower-Bound: 'Lower-bound' means the concept which requires using zero for the contribution of each non-quantified congener
TEQ: Toxic Equivalent Value
TEF: Toxic Equivalent Factor

Element Materials Technology

Client Name:	**Element**			
Reference:	**EMT07766**		**Sample Date:**	**20 Nov 2023**
Location:	**Dublin**		**Date of Receipt:**	**1 Dec 2023**
Contact:	**Dónal Ó Faogáin**		**Date Analysed:**	**15 Jan 2024**

Sample ID: **1.4 EMT07766-R3**
Depth:
EMT Job No: **23/20223**
EMT Sample No: **4**
Matrix: **Stack**
Method: **TM201/PM137 Dioxins, Furans and PCBs in Stationary Source Emissions**

ANALYSIS OF PCDDs and PCDFs

Q : Qualifiers

SV	Indicates surrogate recovery outside performance criteria
>>	Indicates value exceeds calibration range

Key

LOD	Limit of Detection
#	ISO 17025 (UKAS)
M	MCERTS accredited

CAS No		Compound	Q	Result ng/sample	LOD	I-TEFs	TEQ Lower Bound	TEQ Upper Bound	% Recovery
1746-01-6	#M	2378-TCDD	SV	<0.03680	0.03680	1	0.00000	0.03680	17
40321-76-4	#M	12378-PCDD	SV	<0.02174	0.02174	1	0.00000	0.02174	28
39227-28-6	#M	123478-HxCDD	SV	<0.00421	0.00421	0.1	0.00000	0.00042	33
57653-85-7	#M	123678-HxCDD	SV	<0.00417	0.00417	0.1	0.00000	0.00042	38
19408-74-3	#M	123789-HxCDD		<0.00387	0.00387	0.1	0.00000	0.00039	
35822-46-9	#M	1234678-HpCDD		<0.00196	0.00196	0.01	0.00000	0.00002	60
3268-87-9	#M	OCDD		0.01176	0.00312	0.0003	0.00000	0.00000	60
51207-31-9	#M	2378-TCDF	SV	0.30085	0.08337	0.1	0.03009	0.03009	14
57117-41-6	#M	12378-PCDF	SV	<0.03972	0.03972	0.03	0.00000	0.00119	135
57117-31-4	#M	23478-PCDF	SV	<0.04089	0.04089	0.3	0.00000	0.01227	22
70648-26-9	#M	123478-HxCDF	SV	<0.00448	0.00448	0.1	0.00000	0.00045	38
57117-44-9	#M	123678-HxCDF	SV	<0.00384	0.00384	0.1	0.00000	0.00038	48
60851-34-5	#M	234678-HxCDF		<0.00298	0.00298	0.1	0.00000	0.00030	58
72918-21-9	#M	123789-HxCDF		<0.00313	0.00313	0.1	0.00000	0.00031	94
67562-39-4	#M	1234678-HpCDF		<0.00192	0.00192	0.01	0.00000	0.00002	62
55673-89-7	#M	1234789-HpCDF		<0.00208	0.00208	0.01	0.00000	0.00002	81
39001-02-0	#M	OCDF		<0.00220	0.00220	0.0003	0.00000	0.00000	62
		Sum - TEQ					0.03009	0.10482	

Upper-Bound: 'Upper-bound' means the concept which requires using the limit of quantification for the contribution of each non-quantified congener
Lower-Bound: 'Lower-bound' means the concept which requires using zero for the contribution of each non-quantified congener
TEQ: Toxic Equivalent Value
TEF: Toxic Equivalent Factor

Element Materials Technology

Client Name:	**Element**		
Reference:	**EMT07766**	**Sample Date:**	**20 Nov 2023**
Location:	**Dublin**	**Date of Receipt:**	**1 Dec 2023**
Contact:	**Dónal Ó Faogáin**	**Date Analysed:**	**15 Jan 2024**

Sample ID: **1.4 EMT07766-R3**
Depth:
EMT Job No: **23/20223**
EMT Sample No: **4**
Matrix: **Stack**
Method: **TM201/PM137 Dioxins, Furans and PCBs in Stationary Source Emissions**

ANALYSIS OF PCBs

Q : Qualifiers

SV	Indicates surrogate recovery outside performance criteria
>>	Indicates value exceeds calibration range

Key

LOD	Limit of Detection
#	ISO 17025 (UKAS)
M	MCERTS accredited

CAS No		Compound	Q	Result ng/sample	LOD	I-TEFs	TEQ Lower Bound	TEQ Upper Bound	% Recovery
70362-50-4	#M	PCB-81		NDP	0.40080	NDP	NDP	NDP	NDP
32598-13-3	#M	PCB-77		NDP	0.24329	NDP	NDP	NDP	NDP
65510-44-3	#M	PCB-123		NDP	0.49823	NDP	NDP	NDP	0
31508-00-6	#M	PCB-118		NDP	0.54824	NDP	NDP	NDP	NDP
74472-37-0	#M	PCB-114		NDP	0.49949	NDP	NDP	NDP	NDP
32598-14-4	#M	PCB-105		NDP	0.19659	NDP	NDP	NDP	NDP
57465-28-8	#M	PCB-126		NDP	0.58373	NDP	NDP	NDP	NDP
52663-72-6	#M	PCB-167		NDP	0.16578	NDP	NDP	NDP	NDP
38380-08-4	#M	PCB-156		NDP	0.11123	NDP	NDP	NDP	NDP
69782-90-7	#M	PCB-157		NDP	0.08420	NDP	NDP	NDP	NDP
32774-16-6	#M	PCB-169		NDP	0.04460	NDP	NDP	NDP	NDP
39635-31-9	#M	PCB-189		NDP	0.14548	NDP	NDP	NDP	NDP
		Sum - TEQ					NDP	NDP	
33025-41-1		PCB-60 (Standard)							NDP
39635-35-3		PCB-159 (Standard)							NDP

Upper-Bound: 'Upper-bound' means the concept which requires using the limit of quantification for the contribution of each non-quantified congener
Lower-Bound: 'Lower-bound' means the concept which requires using zero for the contribution of each non-quantified congener
TEQ: Toxic Equivalent Value
TEF: Toxic Equivalent Factor

Client Name: Element

Reference: EMT07766

Location: Dublin

Contact: Dónal Ó Faogáin

Matrix : Stack

EMT Job No.	Batch	Sample ID	Depth	EMT Sample No.	Method No.	NDP Reason
23/20223	1	1.4 EMT07766-R3		4	TM201/PM137	Sample unsuitable for this test

Element Materials Technology

Notification of Deviating Samples

Client Name: Element
Reference: EMT07766
Location: Dublin
Contact: Dónal Ó Faogáin

Matrix : Stack

EMT Job No.	Batch	Sample ID	Depth	EMT Sample No.	Analysis	Reason
23/20223	1	1.1 EMT07766-B		1	DIOXIN_FURAN, PCB	Sample holding time exceeded
23/20223	1	1.2 EMT07766-R1		2	DIOXIN_FURAN, PCB	Sample holding time exceeded
23/20223	1	1.3 EMT07766-R2		3	DIOXIN_FURAN, PCB	Sample holding time exceeded
23/20223	1	1.4 EMT07766-R3		4	DIOXIN_FURAN, PCB	Sample holding time exceeded

Please note that only samples that are deviating are mentioned in this report. If no samples are listed it is because none were deviating. Only analyses which are accredited are recorded as deviating if set criteria are not met.

It is a requirement under ISO 17025 that we inform clients if samples are deviating i.e. outside what is expected. A deviating sample indicates that the sample 'may' be compromised but not necessarily will be compromised. The result is still accredited and our analytical reports will still show accreditation on the relevant analytes.

EMT Job No.: 23/20223

SOILS and ASH

Please note we are only MCERTS accredited (UK soils only) for sand, loam and clay and any other matrix is outside our scope of accreditation.

Where an MCERTS report has been requested, you will be notified within 48 hours of any samples that have been identified as being outside our MCERTS scope. As validation has been performed on clay, sand and loam, only samples that are predominantly these matrices, or combinations of them will be within our MCERTS scope. If samples are not one of a combination of the above matrices they will not be marked as MCERTS accredited.

It is assumed that you have taken representative samples on site and require analysis on a representative subsample. Stones will generally be included unless we are requested to remove them.

All samples will be discarded one month after the date of reporting, unless we are instructed to the contrary. Asbestos samples are retained for 6 months.

If you have not already done so, please send us a purchase order if this is required by your company.

Where appropriate please make sure that our detection limits are suitable for your needs, if they are not, please notify us immediately.

All analysis is reported on a dry weight basis unless stated otherwise. Limits of detection for analyses carried out on as received samples are not moisture content corrected. Results are not surrogate corrected. Samples are dried at 35°C ±5°C unless otherwise stated. Moisture content for CEN Leachate tests are dried at 105°C ±5°C. Ash samples are dried at 37°C ±5°C.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

Where a CEN 10:1 ZERO Headspace VOC test has been carried out, a 10:1 ratio of water to wet (as received) soil has been used.

% Asbestos in Asbestos Containing Materials (ACMs) is determined by reference to HSG 264 The Survey Guide - Appendix 2 : ACMs in buildings listed in order of ease of fibre release.

Sufficient amount of sample must be received to carry out the testing specified. Where an insufficient amount of sample has been received the testing may not meet the requirements of our accredited methods, as such accreditation may be removed.

Negative Neutralization Potential (NP) values are obtained when the volume of NaOH (0.1N) titrated (pH 8.3) is greater than the volume of HCl (1N) to reduce the pH of the sample to 2.0 - 2.5. Any negative NP values are corrected to 0.

The calculation of Pyrite content assumes that all oxidisable sulphides present in the sample are pyrite. This may not be the case. The calculation may be an overesitimate when other sulphides such as Barite (Barium Sulphate) are present.

WATERS

Please note we are not a UK Drinking Water Inspectorate (DWI) Approved Laboratory .

ISO17025 accreditation applies to surface water and groundwater and usually one other matrix which is analysis specific, any other liquids are outside our scope of accreditation.

As surface waters require different sample preparation to groundwaters the laboratory must be informed of the water type when submitting samples.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

STACK EMISSIONS

Where an MCERTS report has been requested, you will be notified within 48 hours of any samples that have been identified as being outside our MCERTS scope. As validation for Dioxins and Furans and Dioxin like PCBs has been performed on XAD-2 Resin, only samples which use this resin will be within our MCERTS scope.

Where appropriate please make sure that our detection limits are suitable for your needs, if they are not, please notify us immediately.

DEVIATING SAMPLES

All samples should be submitted to the laboratory in suitable containers with sufficient ice packs to sustain an appropriate temperature for the requested analysis. The temperature of sample receipt is recorded on the confirmation schedules in order that the client can make an informed decision as to whether testing should still be undertaken.

SURROGATES

Surrogate compounds are added during the preparation process to monitor recovery of analytes. However low recovery in soils is often due to peat, clay or other organic rich matrices. For waters this can be due to oxidants, surfactants, organic rich sediments or remediation fluids. Acceptable limits for most organic methods are 70 - 130% and for VOCs are 50 - 150%. When surrogate recoveries are outside the performance criteria but the associated AQC passes this is assumed to be due to matrix effect. Results are not surrogate corrected.

DILUTIONS

A dilution suffix indicates a dilution has been performed and the reported result takes this into account. No further calculation is required.

BLANKS

Where analytes have been found in the blank, the sample will be treated in accordance with our laboratory procedure for dealing with contaminated blanks.

NOTE

Data is only reported if the laboratory is confident that the data is a true reflection of the samples analysed. Data is only reported as accredited when all the requirements of our Quality System have been met. In certain circumstances where all the requirements of the Quality System have not been met, for instance if the associated AQC has failed, the reason is fully investigated and documented. The sample data is then evaluated alongside the other quality control checks performed during analysis to determine its suitability. Following this evaluation, provided the sample results have not been effected, the data is reported but accreditation is removed. It is a requirement of our Accreditation Body for data not reported as accredited to be considered indicative only, but this does not mean the data is not valid.
Where possible, and if requested, samples will be re-extracted and a revised report issued with accredited results. Please do not hesitate to contact the laboratory if further details are required of the circumstances which have led to the removal of accreditation.
Laboratory records are kept for a period of no less than 6 years.

REPORTS FROM THE SOUTH AFRICA LABORATORY

Any method number not prefixed with SA has been undertaken in our UK laboratory unless reported as subcontracted.

Measurement Uncertainty

Measurement uncertainty defines the range of values that could reasonably be attributed to the measured quantity. This range of values has not been included within the reported results. Uncertainty expressed as a percentage can be provided upon request.

Customer Provided Information

Sample ID and depth is information provided by the customer.

Age of Diesel

The age of release estimation is based on the nC17/pristane ratio only as prescribed by Christensen and Larsen (1993) and Kaplan, Galperin, Alimi et al., (1996).
Age estimation should be treated with caution as it can be influenced by site specific factors of which the laboratory are not aware.

ABBREVIATIONS and ACRONYMS USED

#	ISO17025 (UKAS Ref No. 4225) accredited - UK.
SA	ISO17025 (SANAS Ref No.T0729) accredited - South Africa
B	Indicates analyte found in associated method blank.
DR	Dilution required.
M	MCERTS accredited.
NA	Not applicable
NAD	No Asbestos Detected.
ND	None Detected (usually refers to VOC and/SVOC TICs).
NDP	No Determination Possible
SS	Calibrated against a single substance
SV	Surrogate recovery outside performance criteria. This may be due to a matrix effect.
W	Results expressed on as received basis.
+	AQC failure, accreditation has been removed from this result, if appropriate, see 'Note' on previous page.
>>	Results above quantitative calibration range. The result should be considered the minimum value and is indicative only. The actual result could be significantly higher.
*	Analysis subcontracted to an Element Materials Technology approved laboratory.
AD	Samples are dried at 35°C ±5°C
CO	Suspected carry over
LOD/LOR	Limit of Detection (Limit of Reporting) in line with ISO 17025 and MCERTS
ME	Matrix Effect
NFD	No Fibres Detected
BS	AQC Sample
LB	Blank Sample
N	Client Sample
TB	Trip Blank Sample
OC	Outside Calibration Range

EMT Job No: 23/20223

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/SANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM201	Dioxins, Furans and PCBs in Stationary Source Emissions	PM137	Extraction and clean-up of Dioxins (PCDDs), Furans (PCDFs) and dioxin-like PCBs using accelerator solvent extractor and clean up system			AR	
TM201	Dioxins, Furans and PCBs in Stationary Source Emissions	PM137	Extraction and clean-up of Dioxins (PCDDs), Furans (PCDFs) and dioxin-like PCBs using accelerator solvent extractor and clean up system	Yes	Yes	AR	

Process Details Form

Licensee	Irish Cement Ltd	Contractor	Element Materials Technology
Reg. Number	P0029-06		
Site Contact	Eve Howard	Contractor's Contact	James Magann
Role	Environmental Manager	Role	
Signature	Eve Howard	Signature	

Emission Point as per License	A2-01		
Type of process	O Rotogravure printing	O Rotogravure printing	O Rotogravure printing
	O Cement plant	O Cement plant	O Cement plant
	O Electrical generation	O Electrical generation	O Electrical generation
	O Steam boiler	O Steam boiler	O Steam boiler
	O Other:	O Other:	O Other:
Load of Process (Rotogravure printing: the solvent type and content of the ink, the ink delivery rate, the press temperature, the status of abatement plant, printing rate (m/s), etc.; Cement plant: Clinker source and loading rate, fuel source and load rate; Power plant: Electrical generation (MW) and fuel; Cement, chemical or pharmaceutical plants: Rate of material processed (tons/ hour); General manufacturing processes: Rate of items processed per hour; Steam boilers: Percentage with regards maximum capacity where appropriate)	Loading: ~210tph Clinker Source: Kiln 6 (onsite) Fuel: Pet coke		
Abatement system	O Bag filter	O Bag filter	O Bag filter
	O Electrostatic precipitator	O Electrostatic precipitator	O Electrostatic precipitator
	O Cyclone	O Cyclone	O Cyclone
	O Thermal oxidiser	O Thermal oxidiser	O Thermal oxidiser
	O Active carbon bed	O Active carbon bed	O Active carbon bed
	O NSCR	O NSCR	O NSCR
	O SCR	O SCR	O SCR
	O Dry scrubber	O Dry scrubber	O Dry scrubber
	O Wet scrubber	O Wet scrubber	O Wet scrubber
	O Lime injection	O Lime injection	O Lime injection
	O Biofilter	O Biofilter	O Biofilter
	O None	O None	O None
	O Other: SNCR	O Other:	O Other:

Process Details Form

List of solvents used per process (to be added to the solvent suite)

Emission point as per Licence		

Certificate of Analysis

Report No.: **23-12581-1**

Issue No.: **1**
Date of Issue **06/12/2023**

Customer Details:	Element Materials Technology Environmental UK Ltd (Ireland), Unit D8, North City Business Park, North Road, Finglas, Dublin 11, , Ireland
Customer Contact:	Donal O'faogain
Customer Order No.:	E130N21000011 EMT07766
Customer Reference:	E130N21000011
Quotation Reference:	Q23-05562
Description:	5 liquid samples
Date Received:	27/11/2023
Date Started:	27/11/2023
Date Completed:	06/12/2023
Test Methods:	Details available on request (refer to SOP code against relevant result/s)
Notes:	None

Approved By: **Joanne Dewhurst, Operational Manager**

This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service.
This certificate shall not be reproduced except in full without the prior written approval of the laboratory.
Observations and interpretations are outside of the scope of UKAS accreditation.
Results reported herein relate only to the items supplied to the laboratory for testing.
Results on an Interim Report are not dry-weight corrected.
Where the laboratory is not responsible for the sampling, results apply to the sample(s) as they were received.
The laboratory shall not be responsible for any information that is supplied by the customer that may affect the validity of results.

UKAS TESTING 0605

MCERTS THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME

Results Summary

Report No.: 23-12581-1

Customer Reference: E130N21000011

Customer Order No: E130N21000011 EMT07766

					Customer Sample No	**3.1 EMT07766-B/IMP ABC/NH3/A2-1**	**3.2 EMT07766-R1/IMP AB/NH3/A2-1**	**3.3 EMT07766-R1/IMP C/NH3/A2-1**	**3.4 EMT07766-R2/IMP ABC/NH3/A2-1**	**3.5 EMT07766-R3/IMP ABC/NH3/A2-1**
					RPS Sample No	216174	216175	216176	216177	216178
					Sample Matrix	SOLUTION	SOLUTION	SOLUTION	SOLUTION	SOLUTION
					Sampling Date	20/11/2023	20/11/2023	20/11/2023	21/11/2023	22/11/2023
Determinand	**CAS No**	**Codes**	**SOP**	**RL**	**Units**					
volume of sample supplied		U	N/A	n/a	ml	317	297	147	522	437
ammonia	7664-41-7	UM	A6	0.1	ug/mL	< 0.1	19.8	< 0.1	5.5	16.3

Deviating Samples

Report No.: 23-12581-1

Customer Reference: E130N21000011

Customer Order No: E130N21000011 EMT07766

Our policy on Deviating Samples has been implemented in accordance with UKAS Policy on Deviating Samples (TPS63).
RPS is not responsible for the integrity of samples as received, unless RPS personnel performed the sampling. Samples submitted may be declared to be deviating.
Where applicable the analysis method remains UKAS accredited, however results reported for a deviating sample may be compromised.
Where no sampling date was supplied, samples have been declared to be deviating. If the date can be supplied, results may be reissued if assessed not deviating.
Where the sample container used was unsuitable or broken, the sample is flagged as deviating and re-sampling/re-submisson may be required.

RPS No.	Customer No.	Customer ID	Date Sampled	Containers Received	Deviating	Reason for Deviation
216174	3.1 EMT07766-B/IMP ABC/NH3/A2-1		20/11/2023	Container	No	
216175	3.2 EMT07766-R1/IMP AB/NH3/A2-1		20/11/2023	Container	No	
216176	3.3 EMT07766-R1/IMP C/NH3/A2-1		20/11/2023	Container	No	
216177	3.4 EMT07766-R2/IMP ABC/NH3/A2-1		21/11/2023	Container	No	
216178	3.5 EMT07766-R3/IMP ABC/NH3/A2-1		22/11/2023	Container	No	

Report No.: 23-12581-1

Key Code	Description
N	Not Accredited Test
U	UKAS Accredited Test - UKAS accreditation is only implied if the report carries the UKAS logo
UF	UKAS Flexible Scope Test
M	MCERTS Accredited Test - MCERTS accreditation is only implied if the report carries the MCERTS logo
O	Marine Management Organisation (MMO) Validated
SN	Subcontracted to approved laboratory not accredited for the test
SU	Subcontracted to approved laboratory UKAS Accredited for the test
SM	Subcontracted to approved laboratory MCERTS/UKAS Accredited for the test
SIN	Subcontracted to internal RPS Group laboratory not accredited for the test
SIU	Subcontracted to internal RPS Group laboratory UKAS Accredited for the test
SIM	Subcontracted to internal RPS Group laboratory MCERTS/UKAS Accredited for the test
I/S (in results)	Insufficient Sample
U/S (in results)	Unsuitable Sample
S/C (in results)	See Comments
ND (in results)	Not Detected
L (in results)	Result is outside normal limits

Please note that all samples will be destroyed 4 WEEKS after the report has been issued, with the exception of asbestos samples.

Note: Sample retention may be subject to agreement with the customer for particular projects

Certificate Notes	Description
Note 1	This test report shall not be reproduced except in full, without written approval of the Laboratory.
Note 2	Unless otherwise stated, results are not corrected for analytical recoveries.
Note 3	Samples were taken by the customer and, unless otherwise stated, sampling locations were not supplied.
Note 4	Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.
Note 5	Unless otherwise stated, method D9 conditioning temperatures are 180°C for pre-weigh and 160°C for re-weigh.
Note 6	The PDF version of the certificate is the definitive copy and the Excel version is uncontrolled and provided for information only.
Note 7	For asbestos analysis, all records, communications and reports pertaining to the analysis are retained for five years from the date of issue of the report. The sample analysed is retained for six months.
Note 8	For asbestos analysis, method of analysis used is stereo microscopy, polarised light microscopy and dispersion staining.

Note: Where the following information is included in this certificate, it has usually been supplied by the customer: Customer Sample ID, Sample Location, Sampling Date and Sample Air Volumes. The laboratory shall not be responsible for any information that is supplied by the customer that may affect the validity of results.

Report No.: 23-12581-1

Determinand	CAS No	Media	SOP	% Recovery	% Uncertainty
acetaldehyde	75-07-0	tube	A40	98	16.2
benzaldehyde	100-52-7	tube	A40	100	19.4
butyraldehyde	123-72-8	tube	A40	92	11.5
formaldehyde	50-00-0	tube	A40	97	12.8
hexanal	66-25-1	tube	A40	89	11
propionaldehyde	123-38-6	tube	A40	96	12.6
valeraldehyde	110-62-3	tube	A40	93	12.3
ammonia	7664-41-7	sulphuric scid solution	A6	n/a	8.9
chlorine	7782-50-5	sodium hydroxide solution	C27	n/a	15.2
hydrogen bromide	10035-10-6	sulphuric acid solution	C27	n/a	10.9
hydrogen chloride	7647-01-0	deionised water	C27	n/a	7.9
hydrogen chloride	7647-01-0	sulphuric acid solution	C27	n/a	13.3
hydrogen fluoride	7664-3-3	sodium hydroxide solution	C27	n/a	7.9
sulphur dioxide	7446-09-5	hydrogen peroxide solution	C27	n/a	7.7
nitrogen oxide	10102-43-9	potassium permanganate solution	C27	n/a	11.7
particulates	n/a	filter	D9	n/a	12.2
particulates	n/a	wash solution	D9	n/a	14.8
formaldehyde	50-00-0	deionised water	M103	n/a	23.7
2,4- & 2,6-toluene diisocyanate (TDI)	n/a	filter	M119	n/a	8.6
hexamethylene diisocyanate (HDI)	822-06-0	filter	M119	n/a	5.6
methylene diphenyl diisocyanate (MDI)	101-68-8	filter	M119	n/a	11.8
hydrogen sulphide	7783-06-4	zinc acetate solution	M120	n/a	4.2
antimony	7440-36-0	filter	M31	n/a	10.3
arsenic	7440-38-2	filter	M31	n/a	17.1
cadmium	7440-43.9	filter	M31	n/a	12.1
chromium	7440-47-3	filter	M31	n/a	17.1
cobalt	7440-48-4	filter	M31	n/a	13.1
copper	7440-50-8	filter	M31	n/a	14
lead	7439-92-1	filter	M31	n/a	9.8
manganese	7439-96-5	filter	M31	n/a	17.5
nickel	7440-02-0	filter	M31	n/a	14.4
thallium	7440-28-0	filter	M31	n/a	15.3
tin	7440-31-5	filter	M31	n/a	18.5
vanadium	7440-62-2	filter	M31	n/a	12.1
zinc	7440-66-6	filter	M31	n/a	15.2
antimony	7440-36-0	nitric acid wash	M31	n/a	10.3
arsenic	7440-38-2	nitric acid wash	M31	n/a	17.1
cadmium	7440-43-9	nitric acid wash	M31	n/a	12.1
chromium	7440-47-3	nitric acid wash	M31	n/a	17.1
cobalt	7440-48-4	nitric acid wash	M31	n/a	13.1
copper	7440-50-8	nitric acid wash	M31	n/a	14
lead	7439-92-1	nitric acid wash	M31	n/a	9.8
manganese	7439-96-5	nitric acid wash	M31	n/a	17.5
nickel	7440-02-0	nitric acid wash	M31	n/a	14.4
selenium	7782-49-2	nitric acid wash	M31	n/a	15.1
thallium	7440-28-0	nitric acid wash	M31	n/a	15.3
tin	7440-31-5	nitric acid wash	M31	n/a	18.5
vanadium	7440-62-2	nitric acid wash	M31	n/a	12.1
zinc	7440-66-6	nitric acid wash	M31	n/a	15.2
antimony	7440-36-0	nitric/peroxide solution	M31	n/a	5.9
arsenic	7440-38-2	nitric/peroxide solution	M31	n/a	6.8
cadmium	7440-43-9	nitric/peroxide solution	M31	n/a	6.3
chromium	7440-47-3	nitric/peroxide solution	M31	n/a	7.2
cobalt	7440-48-4	nitric/peroxide solution	M31	n/a	5.2
copper	7440-50-8	nitric/peroxide solution	M31	n/a	6.8
lead	7439-92-1	nitric/peroxide solution	M31	n/a	8.6
manganese	7439-96-5	nitric/peroxide solution	M31	n/a	9.6
nickel	7440-02-0	nitric/peroxide solution	M31	n/a	5.5
selenium	7782-49-2	nitric/peroxide solution	M31	n/a	8.7
thallium	7440-28-0	nitric/peroxide solution	M31	n/a	7.7
tin	7440-31-5	nitric/peroxide solution	M31	n/a	5.8
vanadium	7440-62-2	nitric/peroxide solution	M31	n/a	6.7
zinc	7440-66-6	nitric/peroxide solution	M31	n/a	11.9
1,2,4-trimethylbenzene	95-63-6	tube	O8	88	8.1
1,3,5-trimethylbenzene	108-67-8	tube	O8	92	7.7
2-ethyltoluene	611-14-3	tube	O8	91	8.4
3- & 4-ethyltoluene	n/a	tube	O8	91	8.4
benzene	71-43-2	tube	O8	90	13.9
butyl acetate	123-86-4	tube	O8	90	10.3
decane	124-18-5	tube	O8	97	6.7
dichloromethane	75-09-2	tube	O8	88	24
ethyl acetate	141-78-6	tube	O8	n/a	n/a
ethyl benzene	100-41-4	tube	O8	92	9.8
heptane	142-82-5	tube	O8	94	10.5
hexane	110-54-3	tube	O8	n/a	n/a
limonene	138-86-3	tube	O8	93	13
m- & p-xylene	n/a	tube	O8	90	9.3
methyl isobutyl ketone (MIBK)	108-10-1	tube	O8	86	10
methyl tert-butyl ether (MTBE)	1634-04-4	tube	O8	92	15
o-xylene	95-47-6	tube	O8	86	9.9
propylbenzene	103-65-1	tube	O8	92	7.5
tetrachloroethylene	127-18-4	tube	O8	91	9.3
tetrahydrofuran (THF)	109-99-9	tube	O8	87	14.7
toluene	108-88-3	tube	O8	89	10.7
trichloroethylene	79-01-6	tube	O8	91	10.6
m- & p-cresol	n/a	tube	P1	n/a	11
m- & p-xylenol	n/a	tube	P1	n/a	11.9
o-cresol	95-48-7	tube	P1	n/a	10.8
o-xylenol	526-75-0	tube	P1	n/a	12
phenol	108-95-2	tube	P1	n/a	10.4

2023

Air Emissions
REPORT

PREPARED FOR
Irish Cement
Limerick
Kiln Monitoring

Report Title	Air Emissions Compliance Monitoring Report
Company address	Axis Environmental Services Ltd., Unit 3 Westlink Business Park, Clondrinagh, Limerick, V94 K6XK
Contact Details	Phone: 061 324587, info@axisenv.ie
Stack Emissions Testing Report Commissioned by	Irish Cement Limited
Facility Name	Irish Cement Limited
EPA Licence Number	P0029-06
Licence Holder	Irish Cement Limited
Stack Reference Number	A2-01
Dates of the Monitoring Campaign	07th, 09th & 11th December 2023
Job Reference Number	IRLIMMG071223
Report Written By	Mark McGarry
Report Approved by	Joanne Murray
Stack Testing Team	Mark McGarry / Conor Healy / Jarlath Sammon
Report Date	17/01/2024
Report Type	Test Report Compliance Monitoring
Version	1
Signature of Approver	Joanne Murray Environmental Technician

Contents

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The monitoring campaign and results are confidential between Axis Environmental Services Ltd. and its client and shall not be disclosed to any other third party without the written permission from the client.
All sampling and reporting are completed in accordance with Environmental Protection Agency Air Guidance Note 2 requirements.

ISO 17025
INAB
ACCREDITED
TESTING
DETAILED IN SCOPE REG NO.408T

1.0 Executive Summary

1.1 Overall aim of the monitoring campaign

The aim of the monitoring campaign was to demonstrate compliance with a set of emission limit values as specified in the site licence.

1.2 Summary of substances to be monitored at each emission point

Stack Name:	A2-01
Total Particulate Matter	
Total Gaseous Organic Compounds	
Carbon Monoxide	
Nitrogen Oxides (as NO_2)	
Oxygen	
Carbon Dioxide	
Sulphur Dioxide	
Chloride (as HCl)	
Fluoride (as HF)	
Bromide (as HBr)	
Ammonia	
Metals & Mercury	
Dioxins and Furans	
Volumetric Flow Rate (Ref)	

1.3 Special Requirements

There were no special requirements

1.4 Summary of Results

Emission Point Number: A2-01 (Kiln) 07/12/2023

Parameter	Method	Units	Result	MU +/-	Limit	O_2 Ref. (%)	Moisture Ref. (%)	Blanks	Date	Time on	Time off	Accreditation	
												Sampling	Analysis
Nitrogen Oxides	EN 14792	$mg.m^{-3}$	459.1	28.1	500	10	Dry	N/a	07/12/2023	11:40	12:10	Yes	N/a
Sulphur Dioxide	EN/TS 17021	$mg.m^{-3}$	8.4	1.8	50	10	Dry	N/a	07/12/2023	11:40	12:10	Yes	N/a
Carbon Monoxide	EN 15058	$mg.m^{-3}$	384.7	10.2	1,500	10	Dry	N/a	07/12/2023	11:40	12:10	Yes	N/a
Oxygen	EN 14789	vol%	10.27	0.3	N/a	N/a	Dry	N/a	07/12/2023	11:40	12:10	Yes	N/a
Total Organic Compounds	EN 12619	$mg.m^{-3}$	22.0	0.85	25	10	Dry	N/a	07/12/2023	11:55	12:25	Yes	N/a
Total Cd / Tl	EN 14385	$mg.m^{-3}$	<0.002	0.00008	0.05	10	Dry	<0.002	07/12/2023	16:21	17:24	Yes	Yes
Total Hg	EN 14385	$mg.m^{-3}$	<0.008	0.00031	0.05	10	Dry	<0.001	07/12/2023	16:21	17:24	Yes	Yes
Remaining Metals	EN 14385	$mg.m^{-3}$	<0.046	0.00177	0.5	10	Dry	<0.022	07/12/2023	16:21	17:24	Yes	Yes
Total Particulate Matter (TPM)	EN13284	$mg.m^{-3}$	6.26	0.40	10	10	Dry	<0.80	07/12/2023	14:24	15:24	Yes	Yes
Volumetric Flow Rate (Ref)	EN 16911	$m^3.hr^{-1}$	291,603	12,515	500,000	10	Dry	N/a	07/12/2023	14:24	14:58	Yes	N/a
Chloride as HCl	EN 1911	$mg.m^{-3}$	<0.04	0.003	10	10	Dry	<0.02	07/12/2023	14:24	15:30	Yes	Yes
Fluoride as HF	TS 13740	$mg.m^{-3}$	0.81	0.06	1	10	Dry	<0.02	07/12/2023	14:24	15:30	Yes	Yes

Note 1: All results are normalised to standard temperature and pressure ($0^{O}C$ and 101.3kPa)
Note 2: All results are reported in the format as defined by the EPA in guidance note AG2:2021.

Emission Point Number: A2-01 (Kiln) 09 & 11/12/2023

Parameter	Method	Units	Result	MU +/-	Limit	O_2 Ref. (%)	Moisture Ref. (%)	Blanks	Date	Time on	Time off	Accreditation	
												Sampling	Analysis
Nitrogen Oxides	EN 14792	$mg.m^{-3}$	491.2	28.6	500	10	Dry	N/a	09/12/2023	10:40	11:10	Yes	N/a
Sulphur Dioxide	EN/TS 17021	$mg.m^{-3}$	7.9	1.9	50	10	Dry	N/a	09/12/2023	10:40	11:10	Yes	N/a
Carbon Monoxide	EN 15058	$mg.m^{-3}$	298.8	5.9	1,500	10	Dry	N/a	09/12/2023	10:40	11:10	Yes	N/a
Oxygen	EN 14789	vol%	10.65	0.3	N/a	N/a	Dry	N/a	09/12/2023	10:40	11:10	Yes	N/a
Total Organic Compounds	EN 12619	$mg.m^{-3}$	19.4	0.78	25	10	Dry	N/a	09/12/2023	12:40	13:10	Yes	N/a
Total Cd / Tl	EN 14385	$mg.m^{-3}$	<0.0012	0.00005	0.05	10	Dry	<0.0011	09/12/2023	14:38	15:41	Yes	Yes
Total Hg	EN 14385	$mg.m^{-3}$	<0.0054	0.00022	0.05	10	Dry	<0.0001	09/12/2023	14:38	15:41	Yes	Yes
Remaining Metals	EN 14385	$mg.m^{-3}$	<0.3308	0.01376	0.5	10	Dry	<0.0059	09/12/2023	14:38	15:41	Yes	Yes
Total Particulate Matter (TPM)	EN13284	$mg.m^{-3}$	<1.76	0.25	10	10	Dry	<0.66	09/12/2023	13:14	13:59	Yes	Yes
Volumetric Flow Rate (Ref)	EN 16911	$m^3.hr^{-1}$	294,591	12,644	500,000	10	Dry	N/a	09/12/2023	13:14	13:48	Yes	N/a
Chloride as HCl	EN1911	$mg.m^{-3}$	0.28	0.02	10	10	Dry	<0.028	09/12/2023	13:14	14:00	Yes	Yes
Fluoride as HF	CN/TS 17340	$mg.m^{-3}$	0.24	0.02	1	10	Dry	0.045	09/12/2023	13:14	14:00	Yes	Yes
Ammonia	ISO 21877	$mg.m^{-3}$	<14.07	1.10	50	10	Dry	<0.264	09/12/2023	15:30	16:00	Yes	Yes
Dioxins and Furans	EN 1948-1	$ng.m^{-3}$	<0.0019	0.00007	0.1	10	Dry	<0.00024	11/12/2023	10:28	16:43	Yes	Yes

Note 1: All results are normalised to standard temperature and pressure ($0^{O}C$ and 101.3kPa)
Note 2: All results are reported in the format as defined by the EPA in guidance note AG2:2021.

1.5 Operating Information

Please reference Process Details as per Appendix III attached.

1.6 Monitoring Deviations

Stack Name: A2-01 (07-12-2023)	
Parameter	Deviation
Total Particulate Matter	None
Total Gaseous Organic Compounds	None
Carbon Monoxide	None
Nitrogen Oxides (as NO_2)	None
Oxygen	None
Carbon Dioxide	None
Sulphur Dioxide	None
Water Vapour	None
Chloride (as HCl)	None
Fluoride (as HF)	None
Bromide (as HBr)	None
Metals & Mercury	None
Volumetric Flow Rate (Ref)	EN 16911 - in accordance with AG2 Index of Preferred Methods

Stack Name: A2-01 (09&11-12-2023)	
Parameter	Deviation
Total Particulate Matter	None
Total Gaseous Organic Compounds	None
Carbon Monoxide	None
Nitrogen Oxides (as NO_2)	None
Oxygen	None
Carbon Dioxide	None
Sulphur Dioxide	None
Water Vapour	None
Chloride (as HCl)	None
Fluoride (as HF)	None
Bromide (as HBr)	None
Ammonia	None
Metals & Mercury	None
Dioxins and Furans	None
Volumetric Flow Rate (Ref)	EN 16911 - in accordance with AG2 Index of Preferred Methods

1.7 Reference Documents

Risk Assessment (RA)	SOP 1011
Site Review (SR)	SOP 1019
Site Specific Protocol (SSP)	SOP 1019

1.8 Version History

Version Number	Changes to the report
1	Original version of the report

Appendix I

1.1 Monitoring Personnel

Team Leader	Name	Mark McGarry
	System approval	Team Leader Approved
Technician	Name	Conor Healy
	System approval	Technician Approved
	Name	Jarlath Sammon
	System approval	Team Leader Approved

1.2 Equipment Inventory

ID	Item of Equipment	Used	ID	Item of Equipment	Used	ID	Item of Equipment	Used
12EQ500	Pump		12EQ525	Horiba (PG-250) X		13EQ501	Vernier Callipers	
12EQ532	Pump		16EQ508	Horiba- PG250z		14EQ503	Vernier Callipers	
12EQ536	Pump	X	14EQ501	Horiba-PG 350		14EQ507	Vernier Callipers	
12EQ537	Pump		17EQ515	Horiba 350		17EQ533	Vernier Callipers	
12EQ538	Pump		20EQ506	Horiba 350		18EQ506	Vernier Callipers	
12EQ542	Pump		21EQ503	Horiba 350		20EQ516	Vernier Callipers	
12EQ543	Pump		21EQ522	Horiba 350	X			
13EQ514	Pump							
16EQ518	Pump					13EQ503	1kg weight	
16EQ519	Pump		12EQ526	Chiller		13EQ508	500g Hafner weight	
17EQ509	Pump		14EQ513	Chiller	X	13EQ509	500g Hafner weight	
17EQ510	Pump		16EQ509	Chiller		14EQ515	500g Weight	
17EQ522	Pump		18EQ505	Chiller		15EQ511	1kg Weight	
17EQ523	Pump		21EQ504	Chiller		15EQ512	1kg weight	
17EQ524	Pump		22EQ509	Chiller		16EQ511	1kg weight	
17EQ525	Pump					16EQ512	500g weight	
17EQ526	Pump					17EQ529	500g weight	
18EQ517	Pump		14EQ518	Velocity Meter		17EQ530	1kg weight	
18EQ518	Pump		16EQ501	Velocity Meter		19EQ513	500g weight	
21EQ507	Pump		17EQ508	Velocity Meter		19EQ514	1kg Weight	
21EQ508	Pump		17EQ514	Velocity Meter		19EQ519	1kg weight	X
21EQ509	Pump		18EQ504	Velocity Meter		19EQ520	500g weight	X
21EQ510	Pump		19EQ502	Velocity Meter				
21EQ511	Pump		20EQ504	Velocity Meter				
22EQ500	Pump					17EQ534	ST5	
22EQ501	Pump					18EQ503	ST5	
22EQ502	Pump		21EQ528	TSI (Vane)		18EQ513	ST5	
22EQ503	Pump		23EQ500	TSI (Vane)		19EQ509	ST5	X
22EQ504	Pump					20EQ500	ST5	
22EQ505	Pump		16EQ502	FID		21EQ519	ST5	
			17EQ517	FID		22EQ508	ST5	
17EQ532	MF Meter	X	19EQ508	FID	X			
21EQ500	MF Meter		20EQ507	FID				
21EQ501	MF Meter		20EQ508	FID		14EQ510	Digital Protractor	
21EQ502	MF Meter		17EQ535	Signal Cutter		14EQ511	Digital Protractor	
21EQ526	MF Meter					17EQ528	Digital Protractor	
21EQ530	MF Meter					18EQ507	Digital Protractor	
21EQ531	MF Meter		16EQ510	Measuring Tape		20EQ514	Digital Protractor	
21EQ532	MF Meter		17EQ527	Measuring Tape		20EQ515	Digital Protractor	
			18EQ508	Measuring Tape				
14EQ514	Heated Line		19EQ516	Measuring Tape				
17EQ502	Heated Line		20EQ509	Measuring Tape		12EQ522	Balance	
17EQ503	Heated Line		21EQ521	Measuring Tape		15EQ509	Balance	
17EQ539	Heated Line (5m)	X				15EQ510	Balance	
19EQ523	Heated Line					17EQ537	Balance	
20EQ520	Heated Line		20EQ519	PCDD Thermometer		19EQ515	Balance	
20EQ521	Heated Line					21EQ505	Balance	X
21EQ523	Heated Line (5m)		16EQ515	Thermocouple K type		21EQ506	Balance	
21EQ524	Heated Line (5m)		16EQ516	Thermocouple K type		21EQ525	Balance	
22EQ510	Heated Line (40m)		21EQ513	K type Thermocouple		21EQ529	Balance	
22EQ512	Heated Line (5m)		21EQ514	K type Thermocouple				
22EQ513	Heated Line (5m)		21EQ515	K type Thermocouple				
23EQ519	Heated Line (5m)	X	21EQ516	K type Thermocouple	X			
12EQ518	S type Pitot Tube		21EQ517	K type Thermocouple				
12EQ520	L Type Pitot tube		21EQ518	K type Thermocouple				
13EQ506	S type Pitot Tube		21EQ520	K type Thermocouple				
14EQ506	1m S type & K type							
16EQ506	S type Pitot Tube							
16EQ517	S type Pitot Tube Long		17EQ519	Stopwatch				
17EQ507	1m S type & K type		17EQ520	Stopwatch				
17EQ536	S type Pitot Tube		17EQ521	Stopwatch				
18EQ514	S type Pitot Tube		18EQ509	Stopwatch				
18EQ515	S type Pitot Tube		19EQ518	Stopwatch				
19EQ510	S type pitot tube		21EQ512	Stopwatch				
19EQ511	S type pitot tube							
19EQ521	1m S type & K type							
19EQ522	Pitot							
22EQ506	S type pitot tube							
22EQ507	S type pitot tube							
22EQ511	S type pitot tube	X						

Appendix II

2.1 Stack Emission Point Reference: A2-01

2.1.1 Suitability of Sample Location:

General Information	A2-01
Permanent/Temporary	Permanent
Inside/ Outside	Outside

Platform Details		
Irish EPA Technical Guidance Note AG1 / EN 15259 Platform Requirements	Value	Comment
Sufficient Working area to manipulate probe and measuring instruments	Yes	
Platform has 2 handrails (approx. 0.5m & 1.0 m high)	Yes	
Platform has vertical base boards (approx. 0.25 m high)	Yes	
Platform has chains / self-closing gates at top of ladders	N/a	
There are no obstructions present which hamper insertion of sampling equipment	Yes	
Safe Access Available	Yes	
Easy Access Available	Yes	
Sampling Location / Platform Improvement Recommendations		
None		
EN 15259 Homogeneity Test Requirements		
1		
Select Option: 1: There is no requirement to perform a EN15259 Homogeneity Test on this stack 2: Test results were obtained from previous Homogeneity test carried out by AXIS 3: Test results were obtained from previous Homogeneity test carried out by Alternative contractor 4: Homogeneity Test is required on this stack and the client has been informed of this requirement		

2.1.2 Stack Diagram

2.1.3 Stack Raw Data – Full Suite Run 1 (07/12/2023)

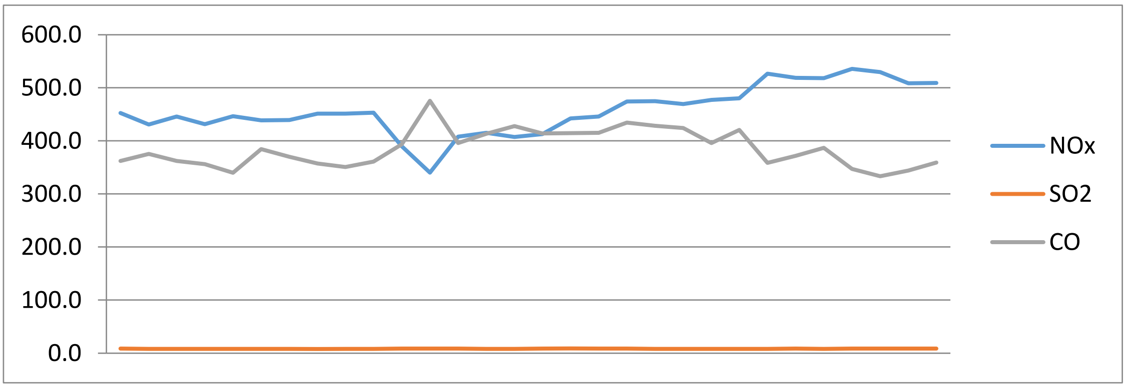
Title:	***Determination of Flue Gases***					
Method:	EN 14792 / TS 17021 / EN 15058 / TS 17045 / EN 14789					
Test Date:	07/12/2023					
Stack Name:	A2-01		**Quality Assurance**			
Test Start Time:	11:40		Probe Material		Stainless Steel	
Reference Conditions			Filtration Type/size		Stainless Steel	
Measured Oxygen	10.27	%	Heated Filter used		Yes	
Reference Oxygen	10	%	No. of sampling lines		1	
Reference Moisture	0		No. of Sampling points		1	
			Sampling point I.D.s		1	
Parameter		**NO**	**SO2**	**CO**	**CO_2**	**O_2**
Emission Limit Values	$mg.m^{-3}$ ref	500	50	1500	20	25
Instrument Range	ppm	500	200	200	30%	25.00%
Span Gas Value	ppm	427	154	151.8	19.18%	20.90%
Acceptable Gas Range	-	Yes	Yes	Yes	Yes	Yes
Calibration Gas Reference No.	-	23ING523	22ing220	21ing605	-	-
Calibration Gas Uncertainty	%	0.5	1.2	1.3	1.4	0.35
Calibration Gas Start Bar	Bar	70	60	40	30	-
Expiry Date	-	Nov-24	Jun-24	Jul-24	Jul-24	-
Quality Assurance	Units	**NO**	**SO2**	**CO**	**CO2**	**O2**
Conditioning Unit Temperature	C	2	2	2	2	2
Average Temperature	< C	2	2	2	2	2
Allowable Temperature	-	4	4	4	4	4
Temperature Acceptable	-	Yes	Yes	Yes	Yes	Yes
Pump flow rate	l/min.	0.5	0.5	0.5	0.5	0.5
Instrument Zero Drift	Units	**NO**	**SO2**	**CO**	**CO2**	**O2**
Instrument Zero (Ambient air or Nitrogen)		Nitrogen	Nitrogen	Nitrogen	Nitrogen	Nitrogen
Instrument Zero (Pre)	ppm	0	0	0	0.00%	0.00%
Instrument Zero (Check)	ppm	0	0.4	0.6	-0.16%	-0.08%
Compliance Statement	Pass / Fail	Pass	Pass	Pass	Pass	Pass
Instrument Zero (Post)	ppm	0.3	0.2	0.9	0.04%	0.08%
Zero Drift	ppm	0.3	0.2	0.9	0.04%	0.08%
Allowable Zero Drift (Less than 2%)	ppm equiv.	8.5	3.1	3.0	-	0.42%
Adjustable Zero Drift (2 - 5%) / 4% CO_2	ppm equiv.	21.4	7.7	7.6	0.77%	1.05%
Zero Drift Failure (<5% / >4% CO_2)	ppm equiv.	21.4	7.7	7.6	0.77%	1.05%
Zero Drift Acceptable	-	Yes	Yes	Yes	Yes	Yes
Adjust for Zero Drift	-	No	No	No	No	No
Reject results	-	No	No	No	No	No
Calculated Drift	%	0.1%	0.1%	0.6%	0.2%	0.4%
Instrument Span Drift	Units	**NO**	**SO2**	**CO**	**CO2**	**O2**
Instrument Span Down (Pre)	ppm	427	154	151.8	19.18%	20.90%
Instrument Check Span (Post)	ppm	419.7	152	150.8	19.14%	20.83%
Span Drift	ppm	-7.3	-2	-1	-0.04%	-0.07%
Allowable Span Drift (less than 2%)	ppm equiv.	8.54	3.08	3.036	0.38%	0.42%
Adjustable Span Drift (2 - 5%)	ppm equiv.	21.35	7.7	7.59	0.96%	1.05%
Span Drift Failure (Greater than 5%)	ppm equiv.	21.35	7.7	7.59	0.77%	1.05%
Span Drift Acceptable (Y/N)	-	Yes	Yes	Yes	Yes	Yes
Adjust for Span Drift	-	No	No	No	No	No
Reject results	-	No	No	No	No	No
Calculated Drift	%	-1.7%	-1.3%	-0.7%	-0.2%	-0.3%
Heated Line Check Including Leak Check		**NO**	**SO2**	**CO**	**CO2**	**O2**
Span Gas Conc.	ppm	427	154	151.8	19.18%	20.90%
Zero Check Acceptable Limit (+/-)	ppm	8.54	3.08	3.04	0.38%	0.42%
Heated Line Check Zero Gas	ppm	0	0.5	0.1	0.04%	0.07%
Compliance Statement	Pass / Fail	Pass	Pass	Pass	Pass	Pass
Heated Line Check Span Gas	ppm or %	422.9	152	149.2	19.14%	20.80%
Span Gas Leak Detected	ppm or %	-4.1	-2	-2.6	-0.04%	-0.10%
Leak check acceptable (< 2%)	ppm or %	8.54	3.08	3.04	0.38%	0.42%
Compliance Statement	Pass / Fail	Pass	Pass	Pass	Pass	Pass
Response Time (<200 seconds)		Yes	Yes	Yes	Yes	Yes
Test Conditions	Units					
Run Ambient Temperature Range	C	6				

Raw Data

Date/Time	*NOx ppm*	*SO_2 ppm*	*CO ppm*	*CO_2 vol%*	*O_2 vol%*
07/12/2023 11:40	215.00	2.90	282.41	17.66	10.40
07/12/2023 11:41	204.81	2.86	293.11	17.82	10.36
07/12/2023 11:42	211.72	2.82	282.41	17.72	10.36
07/12/2023 11:43	205.10	2.71	277.91	17.74	10.38
07/12/2023 11:44	212.07	2.83	265.33	17.62	10.47
07/12/2023 11:45	208.37	2.78	299.97	17.85	10.34
07/12/2023 11:46	208.67	2.82	288.77	17.80	10.36
07/12/2023 11:47	214.37	2.71	278.85	17.82	10.35
07/12/2023 11:48	214.46	2.79	273.58	17.77	10.40
07/12/2023 11:49	215.26	2.87	281.60	17.81	10.35
07/12/2023 11:50	185.39	2.88	306.84	17.87	10.33
07/12/2023 11:51	161.62	2.97	371.04	17.84	10.31
07/12/2023 11:52	193.73	2.89	309.11	17.85	10.31
07/12/2023 11:53	197.12	2.76	322.58	17.92	10.25
07/12/2023 11:54	193.49	2.78	333.65	18.11	10.16
07/12/2023 11:55	196.18	2.94	323.25	18.06	10.20
07/12/2023 11:56	210.10	3.06	323.66	18.08	10.17
07/12/2023 11:57	211.94	2.93	323.99	17.95	10.22
07/12/2023 11:58	225.28	2.92	339.12	18.11	10.12
07/12/2023 11:59	225.62	2.83	334.10	18.15	10.12
07/12/2023 12:00	223.09	2.78	331.04	18.05	10.14
07/12/2023 12:01	226.67	2.75	308.96	18.01	10.17
07/12/2023 12:02	228.15	2.76	327.99	18.09	10.10
07/12/2023 12:03	250.07	2.78	279.97	17.82	10.26
07/12/2023 12:04	246.61	2.89	289.97	17.91	10.24
07/12/2023 12:05	246.06	2.81	301.86	17.93	10.17
07/12/2023 12:06	254.51	2.90	270.73	17.86	10.29
07/12/2023 12:07	251.49	2.89	260.15	17.83	10.28
07/12/2023 12:08	241.65	3.01	268.35	17.88	10.20
07/12/2023 12:09	241.90	3.03	280.25	17.78	10.31
07/12/2023 12:10	240.23	2.91	272.90	17.74	10.26
Average	**218.1**	**2.9**	**300.1**	**17.89**	**10.27**

Referenced Data

	NOx mg/Nm³	SO_2 mg/Nm³	CO mg/Nm³	CO_2 vol%	O_2 vol%
07/12/2023 11:40	452.6	8.5	362.0	17.66	10.40
07/12/2023 11:41	431.1	8.4	375.7	17.82	10.36
07/12/2023 11:42	445.7	8.3	362.0	17.72	10.36
07/12/2023 11:43	431.7	7.9	356.2	17.74	10.38
07/12/2023 11:44	446.4	8.3	340.1	17.62	10.47
07/12/2023 11:45	438.6	8.2	384.5	17.85	10.34
07/12/2023 11:46	439.3	8.3	370.1	17.80	10.36
07/12/2023 11:47	451.3	7.9	357.4	17.82	10.35
07/12/2023 11:48	451.5	8.2	350.7	17.77	10.40
07/12/2023 11:49	453.1	8.4	360.9	17.81	10.35
07/12/2023 11:50	390.3	8.5	393.3	17.87	10.33
07/12/2023 11:51	340.2	8.7	475.6	17.84	10.31
07/12/2023 11:52	407.8	8.5	396.2	17.85	10.31
07/12/2023 11:53	415.0	8.1	413.5	17.92	10.25
07/12/2023 11:54	407.3	8.2	427.6	18.11	10.16
07/12/2023 11:55	413.0	8.6	414.3	18.06	10.20
07/12/2023 11:56	442.3	9.0	414.8	18.08	10.17
07/12/2023 11:57	446.2	8.6	415.3	17.95	10.22
07/12/2023 11:58	474.2	8.6	434.7	18.11	10.12
07/12/2023 11:59	475.0	8.3	428.2	18.15	10.12
07/12/2023 12:00	469.6	8.1	424.3	18.05	10.14
07/12/2023 12:01	477.2	8.1	396.0	18.01	10.17
07/12/2023 12:02	480.3	8.1	420.4	18.09	10.10
07/12/2023 12:03	526.4	8.1	358.8	17.82	10.26
07/12/2023 12:04	519.1	8.5	371.7	17.91	10.24
07/12/2023 12:05	518.0	8.2	386.9	17.93	10.17
07/12/2023 12:06	535.8	8.5	347.0	17.86	10.29
07/12/2023 12:07	529.4	8.5	333.4	17.83	10.28
07/12/2023 12:08	508.7	8.8	343.9	17.88	10.20
07/12/2023 12:09	509.2	8.9	359.2	17.78	10.31
07/12/2023 12:10	505.7	8.5	349.8	17.74	10.26
Average	**459.1**	**8.4**	**384.7**	**17.89**	**10.27**
Uncertainty of Measurement	**28.1**	**1.8**	**10.2**	**0.37**	**0.35**
Uncertainty as % of ELV	**5.62**	**0.91**	**0.68**	-	-
Standard Requirement	**<10%**	**<15%**	**<6%**	**<25%**	**<6%**



QGU-010-2013 Uncertainty calculation for Gaseous Measurement EN 14792 Nox

v4

Limit value	500	**mg.m^{-3} (corrected) NO2**	**Gas**	NO	
			Full Scale	500	**ppm**
Measured concentration	218.09	**ppm**	**Cal gas conc**	427	**ppm**
Measured concentration	447.73	**mg.m^{-3} (corrected) NO2**	**Conversion**	2.053	
Ratio NO/NO2	100.00		**Full Scale**	1026.5	**mg.m^{-3} (NO2)**
			Cal gas conc	876.631	**mg.m^{-3} (NO2)**

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	10.00	0.00	101.30	**273.00**
	measured	10.27	0.00	101.30	**273.00**
Factors		1.03	1.00	1.00	1.00
Correction Factor		**1.03**			

Performance characteristics	**Value**				**specification**
Response time		30	seconds		180.000
Number of readings in measurement		30			
Repeatability at zero		0.03	% full scale		0.200
Repeatability at span level		0.06	% full scale		2.000
Deviation from linearity		0.2	% of value		2.000
Zero drift		0.06	% full scale		2.000
Span drift		-1.46	% full scale		2.000
volume or pressure flow dependence		0	% of full scale/kPa		0.033
atmospheric pressure dependence		0	% of value/kPa		0.750
ambient temperature dependence		0.3	% full scale/10K		0.300
NH3 (20 mg/m3)		0	mg/m3		
CO2 (15%)		0.209	% by vol		
H2O (30%)		0.0	% by vol		4.000
dependence on voltage		0.1	% full scale/10V		2%fs/10V
converter efficiency		95	%		95%
losses in the line (leak)		0.960187354	% of value		2% of value
Uncertainty of calibration gas		0.5	% of value		

Effect of drift		
-5.92	mg/m3	-0.6857
-1.32	% value	

	ranges		
	min	max	value at calib
flow	95	105	100
pressure	101.30	101.3	101.3
temp	289	289	283
NH3 range	0	0	0
CO2 range	0	15	0
H2O range	0	0	0
Instrument Voltage Rating			110
Voltage	93	121	110

Measurement performance related to stationary conditions

Performance characteristic			**Uncertainty**		**Value of uncertainty quantity**		
Standard deviation of repeatability at zero			u_{r0}		for mean		use rep at span
Standard deviation of repeatability at span level			u_{rs}		for mean		0.01
Lack of fit			u_{fit}				1.19
Drift			u_{0dr}				-3.42
volume or pressure flow dependence			u_{spres}				0.00
atmopsheric pressure dependence			u_{apres}				0.00
ambient temperature dependence			u_{temp}				0.18
NH3 (20 mg/m3)			u_{interf}				0.00
CO2 (15%)							0.12
H2O (30%)							0.00
Dependence on voltage			u_{volt}				0.09
Converter efficiency			u_{ceff}				12.92
losses in the line (leak)			u_{leak}				2.48
Uncertainty of calibration gas			u_{calib}				1.29

Use largest negative or positive interferent effect	
0	0.00
0	0.12
0	0.00
0	0.12
Interference uncertainty	0.12

Measurement uncertainty		Result	447.73	mg/m^3
Combined uncertainty			13.71	mg/m^3
Expanded uncertainty	k =	2	27.42	mg/m^3
Uncertainty corrected to std conds			28.12	mg.m-3 (corrected)
Expanded uncertainty	**expressed with a level of confidence of 95%**		**5.62**	**% ELV**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**28.12**	**mg.m^{-3} at ELV**

QGU-008-2013 Uncertainty calculation for Gaseous Measurement SO2 EN TS 17021

V2 Jul-08

Limit value	200	**mg/m³ (corrected) SO2**	**Cal gas conc**	440.44	**mg.m⁻³**
Measured concentration	8.17	**mg/m3**	**Full Scale**	572	**mg/m³**
Measured concentration	8.38	**mg/m³ (Corrected)**			

Correction for reference conditions

		O2, %	Moisture, %	Pressure, KPa	Temperature, K
	ref	10.00	0.00	101.30	**273.00**
	measured	10.27	0.00	101.30	**273.00**
	Uncert	0.35	1.00	0.00	**1.00**
Factors		1.03	1.00	1.00	1.00
Uncertainty in factor		0.03	0.01	0.00	0.00
Correction Factor		**1.03**	uf	**0.04**	

Performance characteristics	**Value**				**specification**
Response time		160	seconds		180.000
Logger sampling interval		60	seconds		
Measurement period		30	minutes		
Number of readings in measurement		30			
Repeatability at zero		0.25	% full scale		<1 % range
Repeatability at span level		0.15	% full scale		<2 % range
Deviation from linearity		0.2	% of value		<2 % range
Zero drift		0.1	% full scale		<2% range / 24hr
Span drift		-1	% full scale		<2% range/24hr
volume or pressure flow dependence		0.02	% of full scale/3 kPa		<2 % / 3 kPa
atmospheric pressure dependence		0.8	% of full scale/2 kPa		<3% / 2 kPa
ambient temperature dependence		0.01	% full scale/10K		<3% range / 10 K
N_2O (mg/m3)	20	0.2	mg/m3		
CO_2 (% vol)	15	0.2	mg/m3		
CH_4 (mg/m3)	40	0.7	mg/m3		
H2O (% vol)	20	0.2	mg/m3		
dependence on voltage		0.1	% full scale/10V		<2% range
losses in the line (leak)		1.298701299	% of value		< 0.1%vol /10 volt
Uncertainty of calibration gas		1.2	% of value		< 2% of value

Effect of drift	
0.08	mg/m3
0.97	% value

	ranges			
	min	max	value at calib	
flow	0.3	0.5	0.4	l/hr
pressure	100.76	100.92	100.88	kPa
temp	287	288.5	287.5	K
N2O range	0	0	0	mg/m3
CO2 range	0	40	0	%vol
CH4 range	0	57	0	mg/m3
H2O range	0	1	0	%vol
Voltage	93	121	110	V

Performance characteristic	**Uncertainty**	**Value of uncertainty quantity**	
Standard deviation of repeatability at zero	u_{r0}	for mean	use rep at span
Standard deviation of repeatability at span level	u_{rs}	for mean	0.03
Lack of fit	u_{fit}		0.66
Drift	u_{0dr}		0.05
volume or pressure flow dependence	u_{spres}		0.00
atmopsheric pressure dependence	u_{apres}		0.14
ambient temperature dependence	u_{temp}		0.00
N2O (mg/m3)	u_{interf}		0.00
CO2 (% vol)	u_{interf}		0.31
CH4 (mg/m3)	u_{interf}		0.58
H2O (% vol)	u_{interf}		0.01
Dependence on voltage	u_{volt}		0.49
losses in the line (leak)	u_{leak}		0.06
Uncertainty of calibration gas	u_{calib}		0.06
Uncertianty in factor	uf		0.29

Use largest of sum of all positive or all negative influences

0.89	all +ves	Criteria
0	all -ves	sum <4% range
0.89	largest	0.163412255

Value to use for intereference uncertainty

u_{int} 0.89

Measurement uncertainty			8.38	mg/m³
Combined uncertainty			0.89	mg/m³
Expanded uncertainty	k =	2	1.78	mg/m³
Uncertainty corrected to std conds			1.82	mg/m³
Expanded uncertainty	**expressed with a level of confidence of 95%**		**0.91**	**% ELV**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**1.82**	**mg.m⁻³**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**21.77**	**% value**

Uncertainty calculation for Gaseous Measurement CO

Limit value	1500	**mg/m³ (corrected)**	**Cal gas conc**	189.75	**mg.m⁻³**
Measured concentration	375.14	**mg/m3**	**Full Scale**	250	**mg/m³**
Measured concentration	384.66	**mg/m³ (Corrected)**			

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	10.00	0.00	101.30	**273.00**
	measured	10.27	0.00	101.30	**273.00**
	Uncert	0.35	1.00	0.00	**1.00**
Factors		1.03	1.00	1.00	1.00
Uncertainty in factor		0.03	0.01	0.00	0.00
Correction Factor		**1.03**	uf	**0.04**	

Performance characteristics	**Value**				**specification**
Response time		30	seconds		180.000
Logger sampling interval		60	seconds		
Measurement period		30	minutes		
Number of readings in measurement		30			
Repeatability at zero		0.25	% full scale		<1 % range
Repeatability at span level		0.15	% full scale		<2 % range
Deviation from linearity(lack of fit)		0.7	% of value		<2 % range
Zero drift		1.125	mg/m3		<2% range / 24hr
Span drift		-1.25	mg/m3		<2% range/24hr
volume or pressure flow dependence		0.02	% of full scale/3 kPa		<2 % / 3 kPa
atmospheric pressure dependence		0.8	% of full scale/2 kPa		<3% / 2 kPa
ambient temperature dependence		0.01	% full scale/10K		<3% range / 10 K
N_2O (mg/m3)	20	0.2	mg/m3		
CO_2 (% vol)	15	0.2	mg/m3		
CH_4 (mg/m3)	40	0.7	mg/m3		
H2O (% vol)	20	0.2	mg/m3		
dependence on voltage		0.1	% full scale/10V		<2% range
losses in the line (leak)		-1.71	% of value		< 0.1%vol /10 volt
Uncertainty of calibration gas		1.3	% of value		< 2% of value

Effect of drift	
-0.25	mg/m3
-0.10	% full scale

	ranges			
	min	max	value at calib	
flow	95.00	105	100	kPa
pressure	100.76	100.92	100.88	kPa
temp	287	288.5	287.5	K
N2O range	0	40	0	mg/m3
CO2 range	0	15	0	%vol
CH4 range	0	57	0	mg/m3
H2O range	0	1	0	%vol
Voltage	93	121	110	V

Performance characteristic			**Uncertainty**		**Value of uncertainty quantity**		**mg/m3**
Standard deviation of repeatability at zero			u_{r0}		for mean		use rep at span
Standard deviation of repeatability at span level			u_{rs}		for mean		0.07
Lack of fit			u_{fit}				1.52
Drift			u_{0dr}				-0.14
volume or pressure flow dependence			u_{spres}				0.05
atmopsheric pressure dependence			u_{apres}				0.06
ambient temperature dependence			u_{temp}				0.00
N2O (mg/m3)			u_{interf}				0.23
CO2 (% vol)			u_{interf}				0.12
CH4 (mg/m3)			u_{interf}				0.58
H2O (% vol)			u_{interf}				0.01
Dependence on voltage			u_{volt}				0.22
losses in the line (leak)			u_{leak}				-3.71
Uncertainty of calibration gas			u_{calib}				2.82

Use largest of sum of all positive or all negative influences		
0.93	all +ves	Criteria
0	all -ves	sum <4% range
0.93	largest	7.502787903
Value to use for intereference uncertainty		
u_{int}	0.93	

Measurement uncertainty				
Combined uncertainty			4.99	mg/m³
Expanded uncertainty	k =	2	9.99	mg/m³
Uncertainty corrected to std conds			**10.24**	**mg/m³**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**0.68**	**% ELV**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**10.24**	**mg.m⁻³**

QGU-007-2013 Uncertainty calculation for Gaseous Measurement Carbon Dioxide

V2.2 Jul-08

Limit value	n/a	**%vol**	**Calibration gas**	**0.192**	**%vol**
Measured concentration	17.89	**%vol**	**Full Scale**	**25**	**%vol**

Performance characteristics	**Value**				**specification**
Response time		30	seconds		< 200 s
Logger sampling interval		60	seconds		
Measurement period		30	minutes		
Number of readings in measurement		30	Assuming 1 minute collected over 1 hour		
Repeatability at zero		0.015	% by volume	stdev	<0.2 % range
Repeatability at span level		0.014	% by volume	stdev	<0.4 % range
Deviation from linearity		0.13	% vol	+/-	<0.3 % volume
Zero drift (during measurement period)		0	% vol at zero level	+/-	<2% of volume / 24hr
Span drift (during measurement period)		0	% vol at span level	+/-	<2% volume/24hr
volume or pressure flow dependence		0	% of fs / 10l/h	+- 5 l/h	<1% range
atmospheric pressure dependence		0.3	% of fs/kPa	+- 2kPa	< 1.5 % range
ambient temperature dependence		-0.07	% by volume /10K	+- 15K	<0.3% volume 10 K
CO_2 (% vol)	15	0.07	% by volume per	15	
NO (mg/m3)	300	0.02	% by volume per	300	
NO_2 (mg/m3)	30	0	% by volume per	30	
Combined interference		0.56	% range		<2% range
Dependence on voltage		0.1	% by volume /10V	+- 5%	< 0.1%vol /10 volt
Losses in the line (leak)		0.208550574	% of value		< 2% of value
Uncertainty of calibration gas		1.4	% of value		

Effect of drift	
0.00	% vol
0.00	% value

	range of variation from conditions at calibration			
	min	max	value at calib	
flow	5	15	10	l/h
pressure	99.00	101	100	kPa
temp	280	285	285	K
CO_2 range	8	15	0	% vol
NO range	100	150	0	mg/m3
NO_2 range	5	7.5	0	mg/m3
Voltage	105	115	110	V

Performance characteristic	**Uncertainty**	**Value of uncertainty quantity**	**% vol**
Standard deviation of repeatability at zero	u_{r0}	for mean	Only use rep at span
Standard deviation of repeatability at span level	u_{rs}	for mean	0.00
Lack of fit	u_{fit}		0.08
Drift	u_{0dr}		0.00
volume or pressure flow dependence	u_{spres}		0.00
atmospheric pressure dependence	u_{apres}		0.04
ambient temperature dependence	u_{temp}		-0.02
CO_2			0.05
NO			0.01
NO_2			0.00
Combined interference (from mcerts)			0.08
dependence on voltage	u_{volt}		0.03
losses in the line (leak)	u_{leak}		0.02
Uncertainty of calibration gas	u_{calib}		0.14

Use largest of sum of all positive or all negative influences		
0.06	all +ves	Criteria
0	all -ves	sum <2% value
0.06	largest	0.357707858

Value to use for intereference uncertainty	
u_{int}	0.06

Measurement uncertainty		17.89	%vol
Combined uncertainty		0.18	%vol
% of value		1.03	%
Coverage factor k =	2		
Expanded uncertainty	**expressed with a level of confidence of 95%**	**2.06**	**% of value**
Expanded uncertainty	**expressed with a level of confidence of 95%**	**0.37**	**% vol**

Title:	**Determination of Moisture Content**			
Method	EN 14790			
Stack Name	A2-01			
Test Time	09:00:00			
Leak Check Results				
Prior to test:	0			
Post Test:	0			
Sample Volume Flow Rate:	2.3			
Standard Requirement:	<2%			
Test Result:	0			
Test Status	Pass			
Calibration Details				
Pump Number	22EQ505			
Calibrator Number	22EE522			
Calibration Rate Before	2.3	N Litres per Minute		
Calibration Rate After	2.3	N Litres per Minute		
Air Volume at Pump	2.3	N Litres per Minute		
Sample Time	30	Minutes		
Temperature at Pump	8	Deg C		
Pressure at Pump	100.6	kPa		
Volume from Mass Flow Meter	0.064	Nm^3		
Balance Calibration	**Weight**			
0.0	0.0	g	Eccentric load indication carried out - Balance Ok	Yes
500.0	500.0	g		
1000.0	1000.0	g		
Impinger Weights	**Initial**	**Final**	**Difference**	
Total Impinger Weight	594.1	599.8	5.7	
Volume of Air Sampled	0.064	Nm^3	5.7	
Moisture Content (EN 14790)	9.94	%		
Uncertainty	0.50	%		

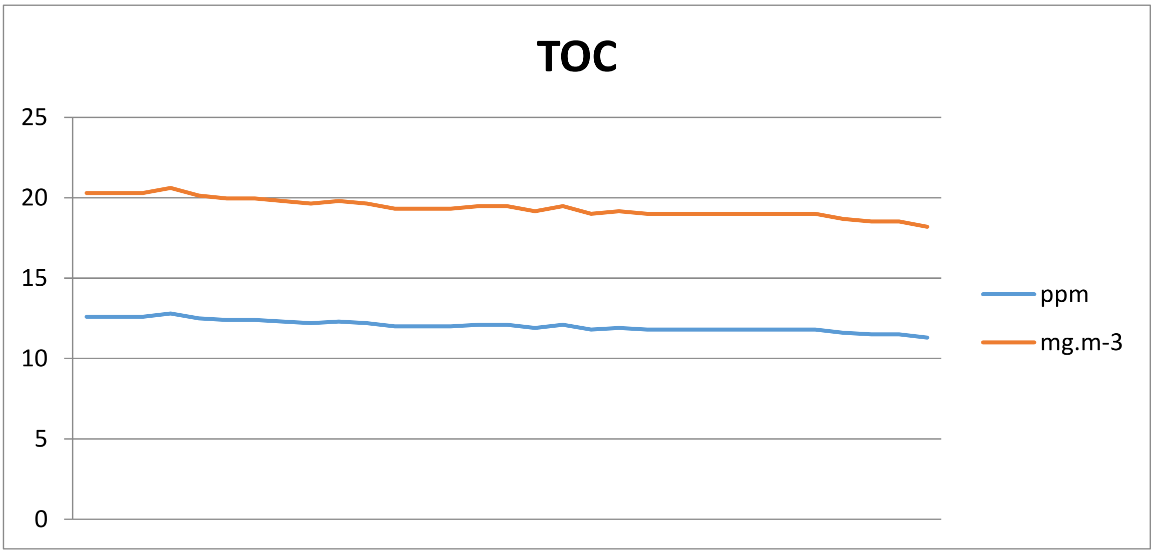
QGU-009-2013 Uncertainty calculation for EN 14791									
v2									
							Measurement Equation		
Limit value (ELV)		**$mg.m^{-3}$**							
Measured concentration	9.94	**$mg.m^{-3}$ (at reference conditions)**							
Measured Quantities	**Symbol**	**Value**	**Standard uncertainty**		**Units**		**Uncertainty as percentage**	**Uncertainty at lv**	**Requirement of std**
Sampled Volume Gas	V_m	0.064290102	uV_m	0.001	**m^3**		1.56		<=2%
Sampled gas Temperature	T_m	281	uTm	2	k		2.00		<2.5 k
Sampled gas Pressure	ρ_m	100.6	$u\rho_m$	1	**kPa**		0.99		<=1%
Sampled gas Humidity	H_m	0	uH_m	1	**% by volume**		1.00		<=1%
Note - Sampled gas humidity, temperature and pressure are values at the gas meter									
Leak	L	2			**%**		2.00		<=2%
Intermediate calculations									
Factor for std conds	fs	0.96							
uncertainty components	symbol	**sensitivity coeff**		**u (in units of fs)**					
	ρ_m	0.010		0.010					
	H_m	0.010		0.010					
	T_m	0.003		0.007					
	ufs			0.015			1.58		
Corrected volume	V	0.06	uV	0.001	**m^3**		2.26		
Factor for O2 correction	fc	#REF!							
uncertainty components	symbol	**sensitivity coeff**		**u**					
	$O_{2,m}$	#REF!		#REF!					
Factor for O2 Correction	ufc	#REF!		#REF!			#REF!		
Parameter		**Value**	**Units**	**Sensitivity coeff**	**Uncertainty contribution**		**Uncertainty as %**		
Corrected Volume (standard conditio	V	0.06	m^3	160.20	0.22	$mg.m^{-3}$	2.26	%	
Leak	L	0.11	$mg.m^{-3}$	1.00	0.11	$mg.m^{-3}$	1.15	%	
Combined uncertainty					**0.25**	$mg.m^{-3}$			
Expanded uncertainty as percentage of measured value			**5.07**	**% measured of value**		**expressed with a level of confidence of 95%**			
						(Using a coverage factor k=2)			
Expanded uncertainty in units of measurement			**0.50**	**%**					

Title:	**Determination of Total Organic Compounds**	
Method:	EN 12619	
Client:	Irish Cement	
Stack Reference:	A2-1	
Licence Limits		
Emission Limit Value	25	$mg.m^{-3}$
Flow Rate Limit	500000	$m^3.Hr^{-1}$
Results		
TOC Concentration	22.0	$mg.m^{-3}$ ref O_2 dry
Flow Rate	-	$m^3.Hr^{-1}$
Uncertainty of Measurement	0.53	$mg.m^{-3}$
Reference Conditions		
Temperature (K)	273.13	^0K
Pressure (kPa)	101.3	kPa
Gas (Wet or Dry)	Dry	
Oxygen	10	%
Stack Concentrations		
Oxygen	10.27	%
Moisture	9.75	%
CO_2	17.89	%
Quality Data		**Units**
Sampling Date	07/12/2023	
Sampling Time	11:55:00	-
Instrument Range	100	ppm
Span Gas Value	77.7	ppm
Acceptable Gas Range	Yes	50 - 90% of Range
Oven Temperature	185.5	^0C
Average Temperature	185	^0C
Temperature Acceptable	Yes	Yes or No
Sample line temperature	180.5	C
Zero Drift		**Units**
Zero Down Sampling Line (Pre)	0.2	ppm
Zero Check after Span	0.2	ppm
Allowable Resolution	0.4	ppm
Zero Down Sampling Line (Post)	0.4	ppm
Zero drift	0.2	ppm
Allowable Zero Drift	1.554	ppm
Zero Drift Acceptable (<2%)	Yes	Yes or No
Adjust for Zero Drift Limit (2 - 5%)	No	Yes or No
Reject results if > 5%	3.885	ppm
Span Drift		**Units**
Span (Pre)	77.7	ppm
Span (Post)	75.8	ppm
Span Drift	-1.9	ppm
Allowable Span Drift	1.554	ppm
Span Drift Acceptable (<2%)	No	Yes or No
Adjust for Zero Drift Limit (2 - 5%)	Yes	Yes or No
Reject results if > 5%	3.885	ppm
Leak Check		
Span Gas Conc.	77.7	ppm
Recorded Conc. down Line	77.2	ppm
Leak Result	0.5	ppm
Leak check acceptable (< 2%)	1.6	(Y/N)
Response Time (<200 seconds)	Yes	Yes or No
Parameter		
Standard	EN 12619	
Technical Procedure	2009	
Probe material	Stainless Steel	
Filtration Type	Ceramic Filter	
Heated Head Filter Used	Yes	

Heated Line Temperature	180.5	Deg C
Span Gas Reference Number	23ING504	
Span Gas Expiry Date	Oct-26	
Span Gas Start Pressure (bar)	30	bar
Gas Cylinder Concentration (ppm)	77.7	ppm
Span Gas Uncertainty (%)	1.6	%
Zero Gas Type	Air	
Number of Sampling Lines Used	1	
Number of Sampling Points Used	1	
Sample Point I.D's	1	
Measured Quantities		
Certified Range of Analyser	1000	ppm
Operational Range of Analyser	100	ppm
Measured Reading	14	ppm
Non linearity	0.4	ppm
Temperature Dependent Zero drift	0.15	ppm Per Degree
Temperature Dependent Span drift	0.1	% Per Degree
Cross-sensitivity	0.1	ppm
Leak	0.5	ppm
Calibration Gas uncertainty	1.6	ppm

Title:	***Determination of Total Organic Compounds***
Method:	EN 12619
Client:	Irish Cement
Stack Reference:	A2-1

Run 1	**Time**	**ppm**	**mg.m^{-3}**
1	07/12/2023 11:55	12.6	20.3
2	07/12/2023 11:56	12.6	20.3
3	07/12/2023 11:57	12.6	20.3
4	07/12/2023 11:58	12.8	20.6
5	07/12/2023 11:59	12.5	20.1
6	07/12/2023 12:00	12.4	20.0
7	07/12/2023 12:01	12.4	20.0
8	07/12/2023 12:02	12.3	19.8
9	07/12/2023 12:03	12.2	19.6
10	07/12/2023 12:04	12.3	19.8
11	07/12/2023 12:05	12.2	19.6
12	07/12/2023 12:06	12	19.3
13	07/12/2023 12:07	12	19.3
14	07/12/2023 12:08	12	19.3
15	07/12/2023 12:09	12.1	19.5
16	07/12/2023 12:10	12.1	19.5
17	07/12/2023 12:11	11.9	19.2
18	07/12/2023 12:12	12.1	19.5
19	07/12/2023 12:13	11.8	19.0
20	07/12/2023 12:14	11.9	19.2
21	07/12/2023 12:15	11.8	19.0
22	07/12/2023 12:16	11.8	19.0
23	07/12/2023 12:17	11.8	19.0
24	07/12/2023 12:18	11.8	19.0
25	07/12/2023 12:19	11.8	19.0
26	07/12/2023 12:20	11.8	19.0
27	07/12/2023 12:21	11.8	19.0
28	07/12/2023 12:22	11.6	18.7
29	07/12/2023 12:23	11.5	18.5
30	07/12/2023 12:24	11.5	18.5
31	07/12/2023 12:25	11.3	18.2
Average		**12.0**	**19.4**
Adjusted for O_2 and Moisture			**22.0**



Uncertainty calculation for Gaseous Measurement TOC							
Stack Reference:							
Limit value	25	**mg/m³ (corrected)**	**Cal gas conc**	125.097	**mg.m⁻³ (Propane)**		
Measured concentration	12.0	**ppm**					
Measured concentration	19	**mg/m3 (101.3kPa, 273K)**					
Measured concentration	19	**mg/m³ (Corrected)**					
Performance characteristics		**Value**			**specification**		
Response time		90	seconds		180.000		
Logger sampling interval		60	seconds				
Measurement period		30	minutes				
Number of readings in measurement		30					
Repeatability at zero		0.25	% full scale		<1 % range		
Repeatability at span level		0.15	% full scale		<2 % range		
Deviation from linearity(lack of fit)		0.65	% of value		<2 % range		
Zero drift		0.2	mg/m3		<2% range / 24hr		
Span drift		1	mg/m3		<2% range/24hr		
Volume or pressure flow dependence		0	%of full scale/kPa		<2 % / kPa		
Atmospheric pressure dependence		0	%of value /kPa		<3% / kPa		
Ambient temperature dependence		0	% full scale/10K		<3% range / 10 K		
Losses in the line (leak)		0	% of value		< 0.1%vol /10 volt		
Uncertainty of calibration gas		2	% of value		< 2% of value		
Performance characteristic			**Uncertainty**		**Value of uncertainty quantity**		**mg/m3**
Standard deviation of repeatability at zero			u_{r0}		for mean		use rep at span
Standard deviation of repeatability at span level			u_{rs}		for mean		0.00
Lack of fit			u_{fit}				0.07
Drift			u_{0dr}				0.35
volume or pressure flow dependence			u_{spres}				0.00
atmopsheric pressure dependence			u_{apres}				0.00
ambient temperature dependence			u_{temp}				0.00
losses in the line (leak)			u_{leak}				0.00
Uncertainty of calibration gas			u_{calib}				0.22
Measurement uncertainty							
Combined uncertainty			0.43	mg/m³			
Expanded uncertainty	k =	2	0.85	mg/m³			
Expanded uncertainty	**expressed with a level of confidence of 95**		**3.41**	**% ELV**			
Expanded uncertainty	**expressed with a level of confidence of 95**		**0.85**	**mg.m⁻³**			
Expanded uncertainty	**expressed with a level of confidence of 95**		**4.39**	**% value**			

Title:	Determination of Total Metals and Mercury				
Method:	EN 14385 & EN 13211				
Client:	Irish Cement				
Test Date:	07/12/2023		Air Volume at Pump	0.8292	m^3
Test Time	16:21		Temperature at Pump	14.38	Deg C
Laboratory Used:	RPS		Pressure at Pump	86.61	kPa
Stack Name	A2-01		Humidity at Pumps	0	%
Run I.D.	Run 1				
Filter I.D.	Metal Run 1		Flow Uncertainty	12,252	m^3/hr
Dry Volume of Air Sampled Metals	0.6735	Nm^3	Flow Uncertainty	4.3	%
Dry Volume of Air Sampled Mercury	0.6735	Nm^3			
Moisture Content	9.8	%	Emission Limit Value Cd/Tl:	0.05	$mg.m^{-3}$
Stack Flow Rate	325,341	Nm^3/hr	Emission Limit Value Hg:	0.05	$mg.m^{-3}$
Adjusted Stack Flow Rate	285,539	$m^3 hr^{-1}$ Ref O_2, Dry	Emission Limit Value Metals:	0.5	$mg.m^{-3}$
Volume of Air Sampled	0.6735	Nm^3			
Reference Conditions					
Measured Oxygen	10.3	%			
Reference Oxygen	10	%			
Reference Moisture	0	%			
Leak Check Results	Result		% Leak		
Before Sample 1	0.1	l/min	0.8		
Average Flow Rate	12	l/min	0.8		
Standard Maximum	0.240	l/min	2%		
Back Pressure	69	kPa			
Standard Criteria to be Met	Result	Std. Requirement			
Angle of Flow	Yes	<15 Degrees	Probe material	Titanium	
Negative Flow in the Stack	Yes	None	Filter housing	Titanium	
Pitot Pressure Difference	Yes	>5Pa	Positioning of filter	Out Stack	
Ratio of Flow Measurement	Yes	<3:1	Filter Size & Material	47mm Quartz	
Stagnation Test	Yes	<10Pa			
Pitot Tube Leak Check	Result				
Positive Pressure	Pass	-			
Negative Pressure	Pass	-			
Number of Ports	2	2			
Straight length before sample point	ok	> 5 Hydraulic Diameters			
Straight length after sample point	ok	> 5 Hydraulic Diameters to Stack Outlet or 2HD to Fan/ Bend			

Sample Calculations

	Filter	Imp 1 & 2	Imp 3	Total Metal
	ug / filter	ug/L	ug/L	ug
Antimony	0.6	0.2	0.2	0.7
Arsenic	0.9	0.3	0.3	1.1
Cadmium	0.5	0.2	0.2	0.6
Chromium	8.2	1.9	1.3	9.4
Cobalt	0.5	0.2	0.2	0.6
Copper	3.3	1	0.8	3.9
Lead	2.2	0.9	0.7	2.8
Manganese	5.4	0.7	0.6	5.9
Nickel	4.2	0.3	0.3	4.4
Thallium	0.6	0.2	0.2	0.7
Vanadium	1	0.4	0.4	1.3
Mercury (Metal Train)	4.83	0.5	0.5	5.2
		Impinger 5	**Impinger 6**	
Mercury (Mercury Train)	-	0.5	0.5	0.2
	Metals		**Mercury**	
Impinger 1 & 2 Total Volume (Incl Rinse)	476	Impinger 5	179	mls
Impinger 3 Total Volume (Incl Rinse)	200	Impinger 6	184	mls

Concentration Calculation

	$mg.m^{-3}$	mg/m^3 Ref O_2		Uncertainty
Antimony	0.0011	0.0011		0.000043
Arsenic	0.0016	0.0017		0.000065
Cadmium	0.0009	0.0010		0.000037
Chromium	0.0139	0.0143		0.000551
Cobalt	0.0009	0.0010		0.000037
Copper	0.0058	0.0060		0.000232
Lead	0.0041	0.0042		0.000163
Manganese	0.0087	0.0089		0.000345
Nickel	0.0065	0.0067		0.000259
Thallium	0.0011	0.0011		0.000043
Vanadium	0.0019	0.0019		0.000075
Mercury	0.0079	0.0082		0.000315
Total Metals	**0.0546**	**0.0562**		**0.002166**
Total Cd / Tl	0.0020	0.0021		0.000081
Total Hg	0.0079	0.0082		0.000315
Remaining Metals	0.0446	0.0459		0.001770

Blank Calculations

	Filter	Impingers	Total Metals	Concentration
	ug / filter	ug/L	ug	mg/m^3 Ref O_2
Antimony	0.6	0.2	0.695	0.00106
Arsenic	1	0.3	1.143	0.00174
Cadmium	0.5	0.2	0.595	0.00091
Chromium	5.5	0.4	5.690	0.00869
Cobalt	0.5	0.2	0.595	0.00091
Copper	0.6	0.4	0.790	0.00121
Lead	0.9	0.2	0.995	0.00152
Manganese	2.7	0.2	2.795	0.00427
Nickel	0.6	0.3	0.743	0.00113
Thallium	0.4	0.2	0.495	0.00076
Vanadium	1	0.1	1.048	0.00160
Mercury Total	0.8	0.5	0.890	0.00136
				% of ELV
Total Metals			**0.0252**	5.0307
Blank < 10% of the Emission Limit Values			Yes	**Yes**

DUCT AND GAS SPECIFICATION

Name			ICL A2-01
Section			Circular
Diameter		[m]	2.6
Area		[m^2]	5.309292
Ports	B	[#]	2
Points	P	[#]	6
Density	ρn	[$^{kg}/_{nm^3}$]	1.395
Carbon Dioxide	CO_2	[%]	17.9
Oxygen	O_2	[%]	10.3
Water Vapor Ratio	rw	[0;1]	0.09
Nozzle	nz	[mm]	4
Turbolence factor	ft	[sec]	1
Wall Adjustment Factor	waf		0.995

PITOT DATA SPECIFICATION

Name			p0.84
Velocity	[$^m/_{sec}$]	5	0.83
Velocity	[$^m/_{sec}$]	10	0.83
Velocity	[$^m/_{sec}$]	20	0.83
Velocity	[$^m/_{sec}$]	30	0.83
Velocity	[$^m/_{sec}$]	40	0.83

NORMALIZATION FACTOR

T_{norm}		[K]	273
P_{norm}		[kPa]	101.3

DUCT FLOW RATE

Dry actual	QV_a	[$^{m3}/_h$]	460236
Moist actual	$Q'V_a$	[$^{m3}/_h$]	511372
Moist norm. [T_{norm} P_{norm}]	$Q'V_n$	[$^{nm3}/_h$]	325341
Dry norm. [T_{norm} P_{norm}]	QV_n	[$^{nm3}/_h$]	292807

AVERAGE VALUES

Total Points		[#]	12
Velocity	v'_a	[$^m/_{sec}$]	29.1
Pitot Differential Pressure	dP_{avg}	[Pa]	470.66
Stack temperature	t_{stack}	[°C]	146
Stack Pressure	P_a	[kPa]	98.27
Isokinetic Ratio	IR	[%]	99.8
Velocity at nozzle	v'_N	[$^m/_{sec}$]	29.04
Probe temperature	t_{probe}	[°C]	183.7
Filter temperature	t_{filter}	[°C]	183.6
Outlet temperature	t_{outlet}	[°C]	17.7
Aux temperature	t_{aux}	[°C]	20
Ambient Pressure	P_{amb}	[kPa]	98.41

GAS METER SAMPLED VOLUMES

Elapsed time	et	[hh:mm:ss]	01:00:00
Norm. Volume [T_{norm} P_{norm}]	V_{gn}	[nm^3]	0.6735
Moist Volume at stack conditions	V'_{ga}	[m^3]	1.3093
Volume at dgm conditions	V_{dgm}	[m^3]	0.8292
Gas meter temperature	t_{dgm}	[°C]	14.38
Gas Meter Pressure	P_{dgm}	[kPa]	86.61

Uncertainty calculation for EN 13284 Determination of low range mass concentration of dust, Manual Gravimetric Method					**Version 14**				
Stack Name:	A2-01								
							Measurement Equation		
Limit value (ELV)	0.5	**mg.m^{-3}**	**Reference oxygen**	10	**% by volume**		$c = \frac{m}{V} f_c$		
Measured concentration	0.06	**mg.m^{-3} (at reference conditions)**							
Measured Quantities	**Symbol**	**Value**	**Standard uncertainty**		**Units**		**Uncertainty as percentage**	**Uncertainty at lv**	**Requireme**
Sampled Volume	V_m	0.8292	uV_m	0.001	**m^3**		0.12		<=5%
Sampled gas Temperature	T_m	287.38	uT_m	2	k		0.70		<=2%
Sampled gas Pressure	ρ_m	86.61	$u\rho_m$	1	**kPa**		1.15		<=2%
Sampled gas Humidity	H_m	0	uH_m	1	**% by volume**		1.00		<=1%
Oxygen content	$O_{2,m}$	10.3	$uO_{2,m}$	0.1	**% by volume**		0.97		<=5%
Mass particulate	m	36.7883	um	0.16	**mg**		0.43	0.05	<5% of limit v
Note - Sampled gas humidity, temperature and pressure are values at the gas meter									
Leak	L	0.10			**%**		0.10		<=2%
Uncollected Mass	UCM	0			**mg**		0		<=10%
(Instack filter - no rinse)									
Intermediate calculations									
Factor for std conds	fs	0.81							
uncertainty components	symbol	**sensitivity coeff**	**u (in units of fs)**						
	ρ_m	0.009		0.009					
	H_m	0.008		0.008		$f_s = \frac{(100 - H_m)}{100} \frac{273}{T_m} \frac{\rho_m}{101.3}$			
	T_m	0.003		0.006					
	ufs			0.014			1.68		
Corrected volume	V	0.67	uV	0.011	**m^3**	$V = V_m f_s$	1.69		
Factor for O2 correction	fc	1.03							
uncertainty components	symbol	**sensitivity coeff**	**u**			$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$			
	$O_{2,m}$	0.10		0.010					
Factor for O2 Correction	ufc	1.03		0.010			0.93		

Parameter		**Value**	**Units**	**Sensitivity coeff**	**Uncertainty contribution**		**Uncertainty as %**
Corrected Volume (standard conditio	V	0.67	m^3	0.08	0.00	mg.m^{-3}	1.69 %
Factor for O2 Correction	fc	1.03		0.05	0.00	mg.m^{-3}	0.93 %
Leak	L	0.00	mg.m^{-3}	1.00	0.00	mg.m^{-3}	0.06 %
Combined measurement uncertainty					**0.00**	mg.m^{-3}	

Expanded uncertainty as percentage of measured value	**3.86**	**% measured of value**	**expressed with a level of confidence of 95%**
			(Using a coverage factor k=2)
Expanded uncertainty in units of measurement	**0.00**	**mg.m^{-3}**	
Expanded uncertainty as percentage of limit value	**0.43**	**% ELV**	

Title:	**Determination of Total Particulates**				
Method:	EN 13284-1				
Client:	ICL				
Test Date:	07/12/2023		**Air Volume at Pump**	0.9247	m^3
Test Time	14:24		**Temperature at Pump**	15.52	Deg C
Laboratory Used:	RPS		**Pressure at Pump**	79.83	kPa
Stack Name	A2-01		**Humidity at Pumps**	0	%
Run I.D.	1		**Filter Weight**	1.51	mg
Filter I.D.	255600		**Front End Weight**	2.7	mg
Moisture Content	8.9	%			
Reference Oxygen	10	%	**Flow Uncertainty**	12,515	m^3/hr
Measured Oxygen	10.27	%	**Flow Uncertainty**	4.3	%
Stack Flow Rate	328221	Nm^3/hr			
Adjusted Stack Flow Rate	291602.6778	Nm^3/hr, dry @ % Oxygen			
Volume of Air Sampled	0.6894	Nm^3			
Leak Check Results	**Result**		**% Leak**		
Before Sample 1	0.1	l/min	0.9		
Average Flow Rate	11.00	l/min	0.9		
Standard Maximum	0.22	l/min	2%		
Back Pressure	60	kPa			
Standard Criteria to be Met	**Result**	**Std. Requirement**			
Angle of Flow	Yes	<15 Degrees	**Probe material**	Stainless Steel	
Negative Flow in the Stack	Yes	None	**Filter housing**	Stainless Steel	
Pitot Pressure Difference	Yes	>5Pa	**Positioning of filter**	In Stack	
Ratio of Flow Measurement	Yes	<3:1	**Filter Size & Material**	47mm Quartz	
Stagnation Test	Yes	<10Pa			
Pitot Tube Leak Check	**Result**				
Positive Pressure	Pass	-			
Negative Pressure	Pass	-			
Number of Ports	2	2			
Straight length before sample point	Pass	> 5 Hydraulic Diameters			
Straight length after sample point	Pass	> 5 Hydraulic Diameters to Stack Outlet or 2HD to Fan/ Bend			
Sample Calculations					
Blank (Filter and Front Wash Combined)	0.54	mg			
Sample 1 (Filter and Front Combined)	4.21	mg			
Volume of Air Sampled	0.6894	Nm^3			
Blank Result	0.78	mg/Nm^3, dry	0.80	mg/Nm^3, dry @ Ref O_2	
Sample Result	6.11	mg/Nm^3, dry	6.26	mg/Nm^3, dry @ Ref O_2	
Uncertainty of Measurement	0.40	mg/Nm^3			
Emission Limit Value	10	mg/Nm^3			
Blank as Percentage of ELV	7.8	%	**Requirement <10% ELV or <0.5 mg/m³**		
Isokinetic Criterion Compliance					
Isokinetic Variation	-0.9	%			
Allowable Isokinetic Range	-5 to + 15%	%			
Isokinetic Acceptable	Yes				

DUCT AND GAS SPECIFICATION			
Name			8
Section			Circular
Diameter		[m]	2.6
Area		[m2]	5.309292
Ports		[#]	2
Points	P	[#]	6
Density	ρn	[kg/Nm3]	1.395
Carbon Dioxide	CO2	[%]	17.9
Oxygen	O2	[%]	10.3
Water Vapor Ratio	rw	[0;1]	0.1
Nozzle	nz	[mm]	4
Turbolence factor	ft	[sec]	1
Wall Adjustment Factor	waf		
PITOT DATA SPECIFICATION			
Name			
Velocity	[m/sec]	5	0.83
Velocity	[m/sec]	10	0.83
Velocity	[m/sec]	20	0.83
Velocity	[m/sec]	30	0.83
Velocity	[m/sec]	40	0.83
NORMALIZATION FACTOR			
Tnorm		[K]	273
Pnorm		[kPa]	101.3
DUCT FLOW RATE			
Dry actual	QVa	[m3/h]	491331
Moist actual	Q'Va	[m3/h]	545917
Moist norm. [Tnorm Pnorm]	Q'Vn	[Nm3/h]	328221
Dry norm. [Tnorm Pnorm]	QVn	[Nm3/h]	295399
AVERAGE VALUES			
Total Points		[#]	2
Velocity	v'a	[m/sec]	28.71
Stack temperature	tstack	[°C]	167.27
Stack Pressure	Pa	[kPa]	98.26
Isokinetic Rate	DI	[%]	-0.9
Velocity at nozzle	v'N	[m/sec]	28.453
Probe temperature	tprobe	[°C]	117.9
Filter temperature	tfilter	[°C]	69.6
Outlet temperature	toutlet	[°C]	36
Aux temperature	taux	[°C]	20.3
Ambient Pressure	Pamb	[kPa]	98.41
GAS METER SAMPLED VOLUMES			
Elapsed time	et		01:00:00
Norm. Volume [Tnorm Pnorm]	Vgn		0.6894
Moist Volume at stack conditions	V'ga		1.2737
Volume at dgm conditions	Vdgm		0.9247
Gas meter temperature	tdgm		15.52
Gas Meter Pressure	Pdgm		79.83

start ts [timestamp]	port [###]	point [###]	Probe pos [cm]	tstack avg [°C]	Pa avg [kPa]	dP Pitot avg [Pa]	velocity avg [m/sec]
07/12/2023	1	1	11.4	131.16	98.22	607.1	30.92
14:05:50	-	-	-	-	-	-	-
	1	2	38.1	134.4	98.23	620.31	31.38
	-	-	-	-	-	-	-
	1	3	77	137.58	98.23	497.33	28.21
	-	-	-	-	-	-	-
	1	4	183.1	139.78	98.23	498.43	28.31
	-	-	-	-	-	-	-
	1	5	222	142.25	98.24	430.81	26.4
	-	-	-	-	-	-	-
				142.23	98.24	429.21	26.35
	1	6	248.7	143.9	98.25	413.44	25.91
				143.86	98.25	412.56	25.88
	2	1	11.4	145.6	98.24	396.55	25.43
				145.54	98.24	397.51	25.46
	2	2	38.1	147.12	98.24	392.42	25.34
				147.08	98.24	392.74	25.35
	2	3	77	148.71	98.24	404.49	25.78
				148.66	98.24	404.16	25.77
	2	4	183.1	150.48	98.24	386.73	25.26
				150.44	98.24	385.36	25.21
	2	5	222	151.64	98.24	387.2	25.31
				151.61	98.24	388.03	25.33
	2	6	248.7	152.34	98.25	360.21	24.43
				152.31	98.26	366.05	24.63
				152.35	98.25	359.58	24.41
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-

Uncertainty calculation for EN 13284					
	Symbol	**Unit**	**Values**	**UOM as %**	**Std Requirement**
Sampled Volume	V_m	m^3	0.001	0.11	<=5%
Sampled gas Temperature	T_m	k	2.00	0.69	<=2%
Sampled gas Pressure	ρ_m	kPa	1.00	1.25	<=2%
Sampled gas Humidity	H_m	% by volume	1.00	1.00	<=1%
Oxygen content	$O_{2,m}$	% by volume	0.10	-	<=5%
Mass particulate	m	mg	0.101	2.40	<5% of limit value
Leak	L		-	0.91	<=2%
Uncollected Mass	UCM		-	0.00	<10% of limit value
Corrected Volume (STP)	V	m^3	0.69	1.75	-
Mass	m	mg	4.21	2.40	-
Factor for O2 Correction	fc		1.03	0.93	-
Leak	L	$mg.m^{-3}$	0.03	0.52	-
Uncollected mass	UCM	mg	0.00	0.00	-
Combined measurement uncertainty			**0.20**	-	-
Expanded uncertainty as percentage of measured value				**6.32**	% measured of value
Expanded uncertainty in units of measurement				**0.40**	mg.m-3
Expanded uncertainty as percentage of limit value				**3.95**	% ELV

Uncertainty calculation for Velocity and Volume Flow Rate Measurement by Pitot tube EN ISO 16911-1					
	Unit	**Values**	**as %**	**Std Requirement**	
Range of Delta P transducer	Pa	2500	-		-
Resolution of Delta P transducer	Pa	10	-		-
Repeatability of Delta P transducer	% of value	0.01	-		-
Drift of Delta P transducer	% of range	0.32	-		-
Lack of fit of measurement system	% of range	0.25	-		-
Uncertainty in Delta P transducer	Pa	2.5	-		-
Uncertainty of pitor coefficient		0.03	-		-
Enter uncertainties as (95%,k=2) where relevant					
Uncertainty in temperature readout system	°C	1	-		-
Uncertainty in atmospheric pressure transducer	Pa	160.5	-		-
Uncertainty in duct area measurement	%	1.0	-		-
Uncertainty of Molar Mass	kg/mol	0.00001	0.05		-
Uncertainty of Temperature	K	0.5	0.11		-
Uncertainty of Stack Static Pressure	Pa	9.83	0.01		-
Uncertainty of Stack Pressure	Pa	160.8	0.08		-
Uncertainty of Gas Density	kg/m3	0.0022	0.15		-
Uncertainty in velocity	m/sec	0.52	1.8		-
Expanded Uncertainty in velocity	m/sec	1.04	3.6		-
Uncertainty of Volumetric Flow Rate	m^3/hour	6258	-		-
Expanded Uncertainty of Volumetric Flow Rate	m^3/hour	**12515**	**4.3**	<10% of ELV	

Title:	**Determination of Inorganic Compounds**		
Method:	EN 1911 .	TS 13740	
Test Date	07/12/2023	07/12/2023	
Test Time Started:	14:24:59		
Test Time Finished:	15:30:00		
Laboratory Used:	RPS		
Stack Reference:	A2-01		
Leak Check Results	**Chloride as HCL**	**Fluoride as HF**	
Prior to test:	0.1	0.1	l/min
Post Test:	0.1	0.1	l/min
Sample Volume Flow Rate:	12.00	12.00	l/min
Test Result: (Requirement <2%)	0.8	0.8	%
Test Status	Pass	Pass	
Reference Details			
Reference Oxygen	10	%	
Measured Oxygen	10.38	%	
Reference Moisture	0	%	
Calibration Details	**Chloride as HCL**	**Fluoride as HF**	
Pump Number:	19EQ509	19EQ509	
Calibration Unit:	N/a	N/a	
Calibration Rate Before Test:	N/a	N/a	l/min
Calibration Rate After Test:	N/a	N/a	l/min
Average sample Volume:	#DIV/0!	#DIV/0!	l/min
Sample Test Time:	30	30	minutes
Pump Gas Temperature:	15	15	^{O}C
Pump Sample Pressure:	82	82	kPa
Normalised Gas Volume:	0.689	0.689	Nm^3
Sample Details	**Chloride as HCL**	**Fluoride as HF**	
Impinger Solution	DI Water	DI Water	
Solution ID Number:	Run 1	Run 1	
Blank Identification Number:	Run 1	Run 1	
Impinger Material	PTFE	PTFE	
Breakthrough Occurred	No	No	
Transport Temp meets Standard	Yes	Yes	
Analysed Within Specified Timeframe	Yes	Yes	
Transport Container Airtight	Yes	Yes	
Exposed to Sunlight	No	No	
Calculations	**Chloride as HCL**	**Fluoride as HF**	
Laboratory Result Imp 1 / 2	0.05	1.95	ug/ml
Laboratory Result Imp Final	0.07	0.17	ug/ml
Impinger Final Volume Imp 1 / 2	260	260	ml
Impinger Final Volume Imp Final	176	176	ml
Combined Concentration	0.02532	0.53692	mg
Factor	1	1	
Concentration	0.025	0.537	mg
Emissions Concentration	0.0	0.8	$mg.m^{-3}$
Referenced Results	**Chloride as HCL**	**Fluoride as HF**	
Emissions Concentration	0.0	0.8	$mg.m^{-3}$ Ref O_2
Uncertainty	0.00	0.06	$mg.m^{-3}$
Licence Limits	10	1	$mg.m^{-3}$
Blank Calculation	**Chloride as HCL**	**Fluoride as HF**	
Laboratory Impinger / Rinse Result	0.05	0.05	ug/ml
Blank Concentration	0.02	0.02	$mg.m^{-3}$ Ref O_2
% of Licence Limit	0.2	2.0	%
Field Blank <10% ELV	Yes	Yes	

Uncertainty calculation for		Chloride as HCL			
Limit value (ELV)	10	$mg.m^{-3}$	Reference oxygen	10	% by volume
Measured concentration	0.04	$mg.m^{-3}$ (at reference conditions)			

$$c = \frac{m}{V} f_c$$

Measured Quantities	Symbol	Value	Standard uncertainty		Units	Uncertainty as percentage	Uncertainty at lv	Requirement of std
Sampled Volume Gas	V_m	0.6894	uV_m	0.001	m^3	0.15		<=2%
Sampled gas Temperature	T_m	288	uTm	2	k	2.00		<2.5 k
Sampled gas Pressure	ρ_m	82	$u\rho_m$	1	kPa	1.22		<=1%
Sampled gas Humidity	H_m	0	uH_m	1	% by volume	1.00		<=1%
Oxygen content	$O_{2,m}$	10.38	$uO_{2,m}$	0.1	% by volume	0.96		<=5%
Concentration in impinger	C	0.12	uC	0.0036	mg/l	3.00		<5%
Impinger solution volume	VS	436	uVS	0.001	l	0.00		<1%
Mass Analyte	m	0.02532	um	0.00	mg	3.00	0.01	<5% of limit value
Note - Sampled gas humidity, temperature and pressure are values at the gas meter								
Leak	L	0.833333333			%	0.83		<=2%

$$f_s = \frac{(100 - H_m)}{100}\frac{273}{T_m}\frac{\rho_m}{101.3}$$

$$V = V_m f_s$$

$$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$$

Intermediate calculations						
Factor for std conds	fs	0.77				
uncertainty components	symbol	sensitivity coeff		u (in units of fs)		
	ρ_m	0.009		0.009		
	H_m	0.008		0.008		
	T_m	0.003		0.005		
	ufs			0.013		1.72
Corrected volume	V	0.53	uV	0.009	m^3	1.73
Factor for O2 correction	fc	1.04				
uncertainty components	symbol	sensitivity coeff		u		
	$O_{2,m}$	0.10		0.010		
Factor for O2 Correction	ufc	1.04		0.010		0.94

Parameter		Value	Units	Sensitivity coeff	Uncertainty contribution		Uncertainty as %	
Corrected Volume (standard conditio	V	0.53	m^3	0.07	0.00	$mg.m^3$	1.73	%
Mass	m	0.03	mg	1.50	0.00	$mg.m^3$	3.00	%
Factor for O2 Correction	fc	1.04		0.04	0.00	$mg.m^3$	0.94	%
Leak	L	0.00	$mg.m^3$	1.00	0.00	$mg.m^3$	0.48	%
Combined uncertainty					0.00	$mg.m^3$		

Expanded uncertainty as percentage of measured value	7.25	% measured of value	expressed with a level of confidence of 95% (Using a coverage factor k=2)
Expanded uncertainty in units of measurement	0.00	$mg.m^{-3}$	
Expanded uncertainty as percentqge of limit value	0.03	% ELV	

Uncertainty calculation for		Fluoride as HF			
Limit value (ELV)	1	$mg.m^{-3}$	Reference oxygen	10	% by volume
Measured concentration	0.81	$mg.m^{-3}$ (at reference conditions)			

$$c = \frac{m}{V} f_c$$

Measured Quantities	Symbol	Value	Standard uncertainty		Units	Uncertainty as percentage	Uncertainty at lv	Requirement of std
Sampled Volume Gas	V_m	0.6894	uV_m	0.001	m^3	0.15		<=2%
Sampled gas Temperature	T_m	288	uTm	2	k	2.00		<2.5 k
Sampled gas Pressure	ρ_m	82	$u\rho_m$	1	kPa	1.22		<=1%
Sampled gas Humidity	H_m	0	uH_m	1	% by volume	1.00		<=1%
Oxygen content	$O_{2,m}$	10.38	$uO_{2,m}$	0.1	% by volume	0.96		<=5%
Concentration in impinger	C	2.12	uC	0.0636	mg/l	3.00		<5%
Impinger solution volume	VS	436	uVS	0.001	l	0.00		<1%
Mass Analyte	m	0.53692	um	0.02	mg	3.00	2.42	<5% of limit value
Note - Sampled gas humidity, temperature and pressure are values at the gas meter								
Leak	L	0.833333333			%	0.83		<=2%

$$f_s = \frac{(100 - H_m)}{100}\frac{273}{T_m}\frac{\rho_m}{101.3}$$

$$V = V_m f_s$$

$$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$$

Intermediate calculations						
Factor for std conds	fs	0.77				
uncertainty components	symbol	sensitivity coeff		u (in units of fs)		
	ρ_m	0.009		0.009		
	H_m	0.008		0.008		
	T_m	0.003		0.005		
	ufs			0.013		1.72
Corrected volume	V	0.53	uV	0.009	m^3	1.73
Factor for O2 correction	fc	1.04				
uncertainty components	symbol	sensitivity coeff		u		
	$O_{2,m}$	0.10		0.010		
Factor for O2 Correction	ufc	1.04		0.010		0.94

Parameter		Value	Units	Sensitivity coeff	Uncertainty contribution		Uncertainty as %	
Corrected Volume (standard conditio	V	0.53	m^3	1.53	0.01	$mg.m^3$	1.73	%
Mass	m	0.54	mg	1.50	0.02	$mg.m^3$	3.00	%
Factor for O2 Correction	fc	1.04		0.78	0.01	$mg.m^3$	0.94	%
Leak	L	0.00	$mg.m^3$	1.00	0.00	$mg.m^3$	0.48	%
Combined uncertainty					0.03	$mg.m^3$		

Expanded uncertainty as percentage of measured value	7.25	% measured of value	expressed with a level of confidence of 95% (Using a coverage factor k=2)
Expanded uncertainty in units of measurement	0.06	$mg.m^{-3}$	
Expanded uncertainty as percentqge of limit value	5.85	% ELV	

2.1.4 Stack Raw Data – Full Suite Run 2 (09&11/12/2023)

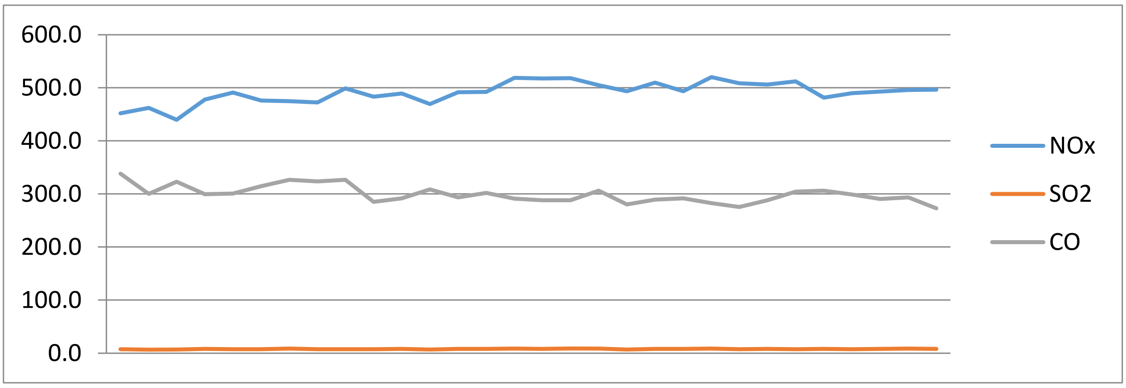
Title:	***Determination of Flue Gases***					
Method:	EN 14792 / TS 17021 / EN 15058 / TS 17045 / EN 14789					
Test Date:	09/12/2023					
Stack Name:	A2-01		**Quality Assurance**			
Test Start Time:	10:40		Probe Material		Stainless Steel	
Reference Conditions			Filtration Type/size		Stainless Steel	
Measured Oxygen	10.65	%	Heated Filter used		Yes	
Reference Oxygen	10	%	No. of sampling lines		1	
Reference Moisture	0		No. of Sampling points		1	
			Sampling point I.D.s		1	
Parameter		**NO**	**SO2**	**CO**	**CO_2**	**O_2**
Emission Limit Values	$mg.m^{-3}$ ref	500	50	1500	20	25
Instrument Range	ppm	500	200	200	30%	25.00%
Span Gas Value	ppm	427	154	151.8	19.18%	20.90%
Acceptable Gas Range	-	Yes	Yes	Yes	Yes	Yes
Calibration Gas Reference No.	-	23ING523	22ing220	21ing605	18ing567	-
Calibration Gas Uncertainty	%	0.5	1.2	1.3	1.4	0.35
Calibration Gas Start Bar	Bar	70	60	40	30	-
Expiry Date	-	Nov-24	Jun-24	Jul-24	Jul-24	-
Quality Assurance	Units	**NO**	**SO2**	**CO**	**CO2**	**O2**
Conditioning Unit Temperature	C	2	2	2	2	2
Average Temperature	< C	2	2	2	2	2
Allowable Temperature	-	4	4	4	4	4
Temperature Acceptable	-	Yes	Yes	Yes	Yes	Yes
Pump flow rate	l/min.	0.5	0.5	0.5	0.5	0.5
Instrument Zero Drift	Units	**NO**	**SO2**	**CO**	**CO2**	**O2**
Instrument Zero (Ambient air or Nitrogen)		Nitrogen	Nitrogen	Nitrogen	Nitrogen	Nitrogen
Instrument Zero (Pre)	ppm	0	0	0	0.00%	0.00%
Instrument Zero (Check)	ppm	0.4	0.6	0.1	0.03%	-0.06%
Compliance Statement	Pass / Fail	Pass	Pass	Pass	Pass	Pass
Instrument Zero (Post)	ppm	0.1	0.4	0.4	0.06%	0.01%
Zero Drift	ppm	0.1	0.4	0.4	0.06%	0.01%
Allowable Zero Drift (Less than 2%)	ppm equiv.	8.5	3.1	3.0	-	0.42%
Adjustable Zero Drift (2 - 5%) / 4% CO_2	ppm equiv.	21.4	7.7	7.6	0.77%	1.05%
Zero Drift Failure (<5% / >4% CO_2)	ppm equiv.	21.4	7.7	7.6	0.77%	1.05%
Zero Drift Acceptable	-	Yes	Yes	Yes	Yes	Yes
Adjust for Zero Drift	-	No	No	No	No	No
Reject results	-	No	No	No	No	No
Calculated Drift	%	0.0%	0.3%	0.3%	0.3%	0.0%
Instrument Span Drift	Units	**NO**	**SO2**	**CO**	**CO2**	**O2**
Instrument Span Down (Pre)	ppm	427	154	151.8	19.18%	20.90%
Instrument Check Span (Post)	ppm	425.9	152.4	151.1	19.17%	20.79%
Span Drift	ppm	-1.1	-1.6	-0.7	-0.01%	-0.11%
Allowable Span Drift (less than 2%)	ppm equiv.	8.54	3.08	3.036	0.38%	0.42%
Adjustable Span Drift (2 - 5%)	ppm equiv.	21.35	7.7	7.59	0.96%	1.05%
Span Drift Failure (Greater than 5%)	ppm equiv.	21.35	7.7	7.59	0.77%	1.05%
Span Drift Acceptable (Y/N)	-	Yes	Yes	Yes	Yes	Yes
Adjust for Span Drift	-	No	No	No	No	No
Reject results	-	No	No	No	No	No
Calculated Drift	%	-0.3%	-1.0%	-0.5%	-0.1%	-0.5%
Heated Line Check Including Leak Check		**NO**	**SO2**	**CO**	**CO2**	**O2**
Span Gas Conc.	ppm	427	154	151.8	19.18%	20.90%
Zero Check Acceptable Limit (+/-)	ppm	8.54	3.08	3.04	0.38%	0.42%
Heated Line Check Zero Gas	ppm	0.3	0.1	-0.1	0.04%	0.05%
Compliance Statement	Pass / Fail	Pass	Pass	Pass	Pass	Pass
Heated Line Check Span Gas	ppm or %	426.1	152.9	150.9	19.16%	20.79%
Span Gas Leak Detected	ppm or %	-0.9	-1.1	-0.9	-0.02%	-0.11%
Leak check acceptable (< 2%)	ppm or %	8.54	3.08	3.04	0.38%	0.42%
Compliance Statement	Pass / Fail	Pass	Pass	Pass	Pass	Pass
Response Time (<200 seconds)		yes	yes	yes	yes	yes
Test Conditions	Units					
Run Ambient Temperature Range	C	8				

Raw Data

Date/Time	***NOx*** ***ppm***	***SO_2*** ***ppm***	***CO*** ***ppm***	***CO_2*** ***vol%***	***O_2*** ***vol%***
09/12/2023 10:40	212.21	2.52	260.81	17.59	10.39
09/12/2023 10:41	217.29	2.25	232.03	17.50	10.38
09/12/2023 10:42	206.93	2.33	249.88	17.58	10.37
09/12/2023 10:43	224.63	2.80	231.46	17.48	10.38
09/12/2023 10:44	230.64	2.47	232.31	17.47	10.39
09/12/2023 10:45	224.47	2.52	243.72	17.62	10.34
09/12/2023 10:46	225.33	2.90	254.79	17.66	10.28
09/12/2023 10:47	223.98	2.47	251.98	17.64	10.29
09/12/2023 10:48	238.08	2.62	256.18	17.73	10.22
09/12/2023 10:49	226.16	2.59	219.33	17.36	10.43
09/12/2023 10:50	222.81	2.58	218.43	16.88	10.71
09/12/2023 10:51	214.47	2.22	231.51	16.98	10.67
09/12/2023 10:52	222.70	2.60	218.63	16.81	10.76
09/12/2023 10:53	216.24	2.58	218.05	16.40	11.07
09/12/2023 10:54	230.47	2.84	212.62	16.57	10.96
09/12/2023 10:55	232.84	2.65	212.77	16.77	10.83
09/12/2023 10:56	232.39	2.87	212.18	16.69	10.87
09/12/2023 10:57	231.84	2.78	230.88	17.05	10.63
09/12/2023 10:58	224.53	2.28	209.42	16.98	10.72
09/12/2023 10:59	229.24	2.56	213.67	16.82	10.83
09/12/2023 11:00	223.04	2.59	216.69	16.86	10.79
09/12/2023 11:01	233.42	2.72	208.50	16.78	10.86
09/12/2023 11:02	229.12	2.37	203.84	16.80	10.82
09/12/2023 11:03	228.61	2.59	213.53	16.88	10.80
09/12/2023 11:04	231.18	2.50	225.69	16.95	10.80
09/12/2023 11:05	219.09	2.60	229.09	17.02	10.71
09/12/2023 11:06	222.01	2.49	222.80	17.02	10.75
09/12/2023 11:07	224.92	2.71	217.97	17.04	10.68
09/12/2023 11:08	224.63	2.75	218.21	16.86	10.77
09/12/2023 11:09	224.12	2.61	202.28	16.85	10.80
09/12/2023 11:10	224.46	2.59	204.92	16.78	10.80
Average	**224.9**	**2.6**	**225.0**	**17.08**	**10.65**

Referenced Data

	NOx mg/Nm³	SO_2 mg/Nm³	CO mg/Nm³	CO_2 vol%	O_2 vol%
09/12/2023 10:40	452.0	7.5	338.2	17.59	10.39
09/12/2023 10:41	462.2	6.7	300.5	17.50	10.38
09/12/2023 10:42	439.8	6.9	323.3	17.58	10.37
09/12/2023 10:43	477.8	8.3	299.8	17.48	10.38
09/12/2023 10:44	490.9	7.3	301.1	17.47	10.39
09/12/2023 10:45	475.9	7.4	314.6	17.62	10.34
09/12/2023 10:46	474.8	8.5	326.9	17.66	10.28
09/12/2023 10:47	472.6	7.3	323.7	17.64	10.29
09/12/2023 10:48	499.0	7.7	327.0	17.73	10.22
09/12/2023 10:49	483.4	7.7	285.4	17.36	10.43
09/12/2023 10:50	489.3	7.9	292.1	16.88	10.71
09/12/2023 10:51	469.3	6.8	308.4	16.98	10.67
09/12/2023 10:52	491.6	8.0	293.9	16.81	10.76
09/12/2023 10:53	492.1	8.2	302.1	16.40	11.07
09/12/2023 10:54	518.8	8.9	291.4	16.57	10.96
09/12/2023 10:55	517.5	8.2	287.9	16.77	10.83
09/12/2023 10:56	518.4	8.9	288.2	16.69	10.87
09/12/2023 10:57	505.2	8.5	306.3	17.05	10.63
09/12/2023 10:58	493.7	7.0	280.4	16.98	10.72
09/12/2023 10:59	509.6	7.9	289.2	16.82	10.83
09/12/2023 11:00	493.7	8.0	292.0	16.86	10.79
09/12/2023 11:01	520.2	8.4	282.9	16.78	10.86
09/12/2023 11:02	508.4	7.3	275.4	16.80	10.82
09/12/2023 11:03	506.4	8.0	288.0	16.88	10.80
09/12/2023 11:04	512.0	7.7	304.3	16.95	10.80
09/12/2023 11:05	481.4	8.0	306.5	17.02	10.71
09/12/2023 11:06	489.7	7.6	299.2	17.02	10.75
09/12/2023 11:07	492.7	8.3	290.7	17.04	10.68
09/12/2023 11:08	496.1	8.5	293.4	16.86	10.77
09/12/2023 11:09	496.7	8.0	273.0	16.85	10.80
09/12/2023 11:10	497.5	8.0	276.5	16.78	10.80
Average	**491.2**	**7.9**	**298.8**	**17.08**	**10.65**
Uncertainty of Measurement	**28.6**	**1.9**	**5.9**	**0.36**	**0.35**
Uncertainty as % of ELV	**5.73**	**0.95**	**0.39**	-	-
Standard Requirement	**<10%**	**<15%**	**<6%**	**<25%**	**<6%**



QGU-010-2013 Uncertainty calculation for Gaseous Measurement EN 14792 Nox

v4

Limit value	500	**mg.m^{-3} (corrected) NO2**	**Gas**	NO	
			Full Scale	500	**ppm**
Measured concentration	224.90	**ppm**	**Cal gas conc**	427	**ppm**
Measured concentration	461.72	**mg.m^{-3} (corrected) NO2**	**Conversion**	2.053	
Ratio NO/NO2	100.00		**Full Scale**	1026.5	**mg.m^{-3} (NO2)**
			Cal gas conc	876.631	**mg.m^{-3} (NO2)**

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	10.00	0.00	101.30	**273.00**
	measured	10.65	0.00	101.30	**273.00**
Factors		1.06	1.00	1.00	1.00
Correction Factor		**1.06**			

Performance characteristics	**Value**				**specification**
Response time		30	seconds		180.000
Number of readings in measurement		30			
Repeatability at zero		0.03	% full scale		0.200
Repeatability at span level		0.06	% full scale		2.000
Deviation from linearity		0.2	% of value		2.000
Zero drift		0.02	% full scale		2.000
Span drift		-0.22	% full scale		2.000
volume or pressure flow dependence		0	% of full scale/kPa		0.033
atmospheric pressure dependence		0	% of value/kPa		0.750
ambient temperature dependence		0.3	% full scale/10K		0.300
NH3 (20 mg/m3)		0	mg/m3		
CO2 (15%)		0.209	% by vol		
H2O (30%)		0.0	% by vol		4.000
dependence on voltage		0.1	% full scale/10V		2%fs/10V
converter efficiency		95	%		95%
losses in the line (leak)		0.210772834	% of value		2% of value
Uncertainty of calibration gas		0.5	% of value		

Effect of drift		
-0.81	mg/m3	-0.0959
-0.18	% value	

	ranges		
	min	max	value at calib
flow	95	105	100
pressure	101.30	101.3	101.3
temp	289	289	283
NH3 range	0	0	0
CO2 range	0	15	0
H2O range	0	0	0
Instrument Voltage Rating			110
Voltage	93	121	110

Measurement performance related to stationary conditions

Performance characteristic			**Uncertainty**		**Value of uncertainty quantity**		
Standard deviation of repeatability at zero			u_{r0}		for mean		use rep at span
Standard deviation of repeatability at span level			u_{rs}		for mean		0.01
Lack of fit			u_{fit}				1.19
Drift			u_{0dr}				-0.47
volume or pressure flow dependence			u_{spres}				0.00
atmopsheric pressure dependence			u_{apres}				0.00
ambient temperature dependence			u_{temp}				0.18
NH3 (20 mg/m3)			u_{interf}				0.00
CO2 (15%)							0.12
H2O (30%)							0.00
Dependence on voltage			u_{volt}				0.09
Converter efficiency			u_{ceff}				13.33
losses in the line (leak)			u_{leak}				0.56
Uncertainty of calibration gas			u_{calib}				1.33

Use largest negative or positive interferent effect	
0	0.00
0	0.12
0	0.00
0	0.12
Interference uncertainty	0.12

Measurement uncertainty		Result	461.72	mg/m^3
Combined uncertainty			13.47	mg/m^3
Expanded uncertainty	k =	2	26.94	mg/m^3
Uncertainty corrected to std conds			28.65	mg.m-3 (corrected)
Expanded uncertainty	**expressed with a level of confidence of 95%**		**5.73**	**% ELV**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**28.65**	**mg.m^{-3} at ELV**

QGU-008-2013 Uncertainty calculation for Gaseous Measurement SO2 EN TS 17021

V2 Jul-08

Limit value	200	**mg/m³ (corrected) SO2**	**Cal gas conc**	440.44	**mg.m⁻³**
Measured concentration	7.38	**mg/m3**	**Full Scale**	572	**mg/m³**
Measured concentration	7.85	**mg/m³ (Corrected)**			

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	10.00	0.00	101.30	**273.00**
	measured	10.65	0.00	101.30	**273.00**
	Uncert	0.35	1.00	0.00	**1.00**
Factors		1.06	1.00	1.00	1.00
Uncertainty in factor		0.04	0.01	0.00	0.00
Correction Factor		**1.06**	uf	**0.04**	

Effect of drift	
0.19	mg/m3
2.37	% value
CORRECT FOR DRIFT	

Performance characteristics	**Value**				**specification**
Response time		160	seconds		180.000
Logger sampling interval		60	seconds		
Measurement period		30	minutes		
Number of readings in measurement		30			
Repeatability at zero		0.25	% full scale		<1 % range
Repeatability at span level		0.15	% full scale		<2 % range
Deviation from linearity		0.2	% of value		<2 % range
Zero drift		0.2	% full scale		<2% range / 24hr
Span drift		-0.8	% full scale		<2% range/24hr
volume or pressure flow dependence		0.02	% of full scale/3 kPa		<2 % / 3 kPa
atmospheric pressure dependence		0.8	% of full scale/2 kPa		<3% / 2 kPa
ambient temperature dependence		0.01	% full scale/10K		<3% range / 10 K
N_2O (mg/m3)	20	0.2	mg/m3		
CO_2 (% vol)	15	0.2	mg/m3		
CH_4 (mg/m3)	40	0.7	mg/m3		
H2O (% vol)	20	0.2	mg/m3		
dependence on voltage		0.1	% full scale/10V		<2% range
losses in the line (leak)		0.714285714	% of value		< 0.1%vol /10 volt
Uncertainty of calibration gas		1.2	% of value		< 2% of value

	ranges			
	min	max	value at calib	
flow	0.3	0.5	0.4	l/hr
pressure	100.76	100.92	100.88	kPa
temp	287	288.5	287.5	K
N2O range	0	0	0	mg/m3
CO2 range	0	40	0	%vol
CH4 range	0	57	0	mg/m3
H2O range	0	1	0	%vol
Voltage	93	121	110	V

Performance characteristic	**Uncertainty**	**Value of uncertainty quantity**	
Standard deviation of repeatability at zero	u_{r0}	for mean	use rep at span
Standard deviation of repeatability at span level	u_{rs}	for mean	0.03
Lack of fit	u_{fit}		0.66
Drift	u_{0dr}		0.11
volume or pressure flow dependence	u_{spres}		0.00
atmopsheric pressure dependence	u_{apres}		0.14
ambient temperature dependence	u_{temp}		0.00
N2O (mg/m3)	u_{interf}		0.00
CO2 (% vol)	u_{interf}		0.31
CH4 (mg/m3)	u_{interf}		0.58
H2O (% vol)	u_{interf}		0.01
Dependence on voltage	u_{volt}		0.49
losses in the line (leak)	u_{leak}		0.03
Uncertainty of calibration gas	u_{calib}		0.05
Uncertianty in factor	uf		0.28

Use largest of sum of all positive or all negative influences		
0.89	all +ves	Criteria
0	all -ves	sum <4% range
0.89	largest	0.14755312
Value to use for intereference uncertainty		
u_{int}	0.89	

Measurement uncertainty			7.85	mg/m³
Combined uncertainty			0.89	mg/m³
Expanded uncertainty	k =	2	1.78	mg/m³
Uncertainty corrected to std conds			1.89	mg/m³
Expanded uncertainty	**expressed with a level of confidence of 95%**		**0.95**	**% ELV**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**1.89**	**mg.m⁻³**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**24.09**	**% value**

Uncertainty calculation for Gaseous Measurement CO

Limit value	1500	**mg/m^3 (corrected)**	**Cal gas conc**	189.75	**$mg.m^{-3}$**
Measured concentration	281.22	**mg/m3**	**Full Scale**	250	**mg/m^3**
Measured concentration	298.79	**mg/m^3 (Corrected)**			

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	10.00	0.00	101.30	**273.00**
	measured	10.65	0.00	101.30	**273.00**
	Uncert	0.35	1.00	0.00	**1.00**
Factors		1.06	1.00	1.00	1.00
Uncertainty in factor		0.04	0.01	0.00	0.00
Correction Factor		**1.06**	uf	**0.04**	

Performance characteristics	**Value**				**specification**
Response time		30	seconds		180.000
Logger sampling interval		60	seconds		
Measurement period		30	minutes		
Number of readings in measurement		30			
Repeatability at zero		0.25	% full scale		<1 % range
Repeatability at span level		0.15	% full scale		<2 % range
Deviation from linearity(lack of fit)		0.7	% of value		<2 % range
Zero drift		0.5	mg/m3		<2% range / 24hr
Span drift		-0.875	mg/m3		<2% range/24hr
volume or pressure flow dependence		0.02	% of full scale/3 kPa		<2 % / 3 kPa
atmospheric pressure dependence		0.8	% of full scale/2 kPa		<3% / 2 kPa
ambient temperature dependence		0.01	% full scale/10K		<3% range / 10 K
N_2O (mg/m3)	20	0.2	mg/m3		
CO_2 (% vol)	15	0.2	mg/m3		
CH_4 (mg/m3)	40	0.7	mg/m3		
H2O (% vol)	20	0.2	mg/m3		
dependence on voltage		0.1	% full scale/10V		<2% range
losses in the line (leak)		-0.59	% of value		< 0.1%vol /10 volt
Uncertainty of calibration gas		1.3	% of value		< 2% of value

Effect of drift	
-0.56	mg/m3
-0.22	% full scale

	ranges		value at calib	
	min	max		
flow	95.00	105	100	kPa
pressure	100.76	100.92	100.88	kPa
temp	287	288.5	287.5	K
N2O range	0	40	0	mg/m3
CO2 range	0	15	0	%vol
CH4 range	0	57	0	mg/m3
H2O range	0	1	0	%vol
Voltage	93	121	110	V

Performance characteristic	**Uncertainty**	**Value of uncertainty quantity**	**mg/m3**
Standard deviation of repeatability at zero	u_{r0}	for mean	use rep at span
Standard deviation of repeatability at span level	u_{rs}	for mean	0.07
Lack of fit	u_{fit}		1.14
Drift	u_{0dr}		-0.32
volume or pressure flow dependence	u_{spres}		0.05
atmospheric pressure dependence	u_{apres}		0.06
ambient temperature dependence	u_{temp}		0.00
N2O (mg/m3)	u_{interf}		0.23
CO2 (% vol)	u_{interf}		0.12
CH4 (mg/m3)	u_{interf}		0.58
H2O (% vol)	u_{interf}		0.01
Dependence on voltage	u_{volt}		0.22
losses in the line (leak)	u_{leak}		-0.96
Uncertainty of calibration gas	u_{calib}		2.11

Use largest of sum of all positive or all negative influences		
0.93	all +ves	Criteria
0	all -ves	sum <4% range
0.93	largest	5.624339355
Value to use for intereference uncertainty		
u_{int}	0.93	

Measurement uncertainty				
Combined uncertainty			2.77	mg/m^3
Expanded uncertainty	k =	2	5.55	mg/m^3
Uncertainty corrected to std conds			**5.90**	**mg/m^3**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**0.39**	**% ELV**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**5.90**	**$mg.m^{-3}$**

QGU-007-2013 Uncertainty calculation for Gaseous Measurement Carbon Dioxide

V2.2 Jul-08

Limit value	n/a	**%vol**	**Calibration gas**	**0.192**	**%vol**
Measured concentration	17.08	**%vol**	**Full Scale**	**25**	**%vol**

Performance characteristics	**Value**				**specification**
Response time		30	seconds		< 200 s
Logger sampling interval		60	seconds		
Measurement period		30	minutes		
Number of readings in measurement		30	Assuming 1 minute collected over 1 hour		
Repeatability at zero		0.015	% by volume	stdev	<0.2 % range
Repeatability at span level		0.014	% by volume	stdev	<0.4 % range
Deviation from linearity		0.13	% vol	+/-	<0.3 % volume
Zero drift (during measurement period)		0	% vol at zero level	+/-	<2% of volume / 24hr
Span drift (during measurement period)		0	% vol at span level	+/-	<2% volume/24hr
volume or pressure flow dependence		0	% of fs / 10l/h	+- 5 l/h	<1% range
atmospheric pressure dependence		0.3	% of fs/kPa	+- 2kPa	< 1.5 % range
ambient temperature dependence		-0.07	% by volume /10K	+- 15K	<0.3% volume 10 K
CO_2 (% vol)	15	0.07	% by volume per	15	
NO (mg/m3)	300	0.02	% by volume per	300	
NO_2 (mg/m3)	30	0	% by volume per	30	
Combined interference		0.56	% range		<2% range
Dependence on voltage		0.1	% by volume /10V	+- 5%	< 0.1%vol /10 volt
Losses in the line (leak)		0.104275287	% of value		< 2% of value
Uncertainty of calibration gas		1.4	% of value		

Effect of drift	
0.00	% vol
0.00	% value

	range of variation from conditions at calibration min	max	value at calib	
flow	5	15	10	l/h
pressure	99.00	101	100	kPa
temp	280	285	285	K
CO_2 range	8	15	0	% vol
NO range	100	150	0	mg/m3
NO_2 range	5	7.5	0	mg/m3
Voltage	105	115	110	V

Performance characteristic	**Uncertainty**	**Value of uncertainty quantity**	**% vol**
Standard deviation of repeatability at zero	u_{r0}	for mean	Only use rep at span
Standard deviation of repeatability at span level	u_{rs}	for mean	0.00
Lack of fit	u_{fit}		0.08
Drift	u_{0dr}		0.00
volume or pressure flow dependence	u_{spres}		0.00
atmospheric pressure dependence	u_{apres}		0.04
ambient temperature dependence	u_{temp}		-0.02
CO_2			0.05
NO			0.01
NO_2			0.00
Combined interference (from mcerts)			0.08
dependence on voltage	u_{volt}		0.03
losses in the line (leak)	u_{leak}		0.01
Uncertainty of calibration gas	u_{calib}		0.14

Use largest of sum of all positive or all negative influences

0.06	all +ves	Criteria
0	all -ves	sum <2% value
0.06	largest	0.341554226

Value to use for intereference uncertainty

u_{int} 0.06

Measurement uncertainty		17.08	%vol
Combined uncertainty		0.18	%vol
% of value		1.05	%
Coverage factor k =	2		
Expanded uncertainty	**expressed with a level of confidence of 95%**	**2.09**	**% of value**
Expanded uncertainty	**expressed with a level of confidence of 95%**	**0.36**	**% vol**

QGU-007-2013 Uncertainty calculation for Gaseous Measurement Oxygen EN14789

V2.2 Jul-08

Limit value	n/a	**%vol**	**Calibration gas**	**20.9**	**%vol**
Measured concentration	10.65	**%vol**	**Full Scale**	**25**	**%vol**

Performance characteristics	**Value**				**specification**
Response time		30	seconds		< 200 s
Logger sampling interval		60	seconds		
Measurement period		30	minutes		
Number of readings in measurement		30	Assuming 1 minute collected over 1 hour		
Repeatability at zero		0.015	% by volume	stdev	<0.2 % range
Repeatability at span level		0.014	% by volume	stdev	<0.4 % range
Deviation from linearity		0	% vol	+/-	<0.3 % volume
Zero drift (during measurement period)		0.0001	% vol at zero level	+/-	<2% of volume / 24hr
Span drift (during measurement period)		-0.0011	% vol at span level	+/-	<2% volume/24hr
volume or pressure flow dependence		0	% of fs / 10l/h	+- 5 l/h	<1% range
atmospheric pressure dependence		0.3	% of fs/kPa	+- 2kPa	< 1.5 % range
ambient temperature dependence		-0.07	% by volume /10K	+- 15K	<0.3% volume 10 K
CO_2 (% vol)	15	0.07	% by volume per	15	
NO (mg/m3)	300	0.02	% by volume per	300	
NO_2 (mg/m3)	30	0	% by volume per	30	
Combined interference		0.56	% range		<2% range
Dependence on voltage		0.1	% by volume /10V	+- 5%	< 0.1%vol /10 volt
Losses in the line (leak)		0.526315789	% of value		< 2% of value
Uncertainty of calibration gas		0.35	% of value		

Effect of drift	
0.00	% vol
0.00	% value

	range of variation from conditions at calibration			
	min	max	value at calib	
flow	5	15	10	l/h
pressure	99.00	101	100	kPa
temp	280	285	285	K
CO_2 range	8	15	0	% vol
NO range	100	150	0	mg/m3
NO_2 range	5	7.5	0	mg/m3
Voltage	105	115	110	V

Performance characteristic	**Uncertainty**	**Value of uncertainty quantity**	**% vol**
Standard deviation of repeatability at zero	u_{r0}	for mean	Only use rep at span
Standard deviation of repeatability at span level	u_{rs}	for mean	0.00
Lack of fit	u_{fit}		0.08
Drift	u_{0dr}		0.00
volume or pressure flow dependence	u_{spres}		0.00
atmospheric pressure dependence	u_{apres}		0.04
ambient temperature dependence	u_{temp}		-0.02
CO_2			0.05
NO			0.01
NO_2			0.00
Combined interference (from mcerts)			0.08
dependence on voltage	u_{volt}		0.03
losses in the line (leak)	u_{leak}		0.13
Uncertainty of calibration gas	u_{calib}		0.03

Use largest of sum of all positive or all negative influences		
0.06	all +ves	Criteria
0	all -ves	sum <2% value
0.06	largest	0.22
Value to use for intereference uncertainty		
u_{int}	0.06	

Measurement uncertainty		10.65	%vol
Combined uncertainty		0.17	%vol
% of value		1.62	%
Coverage factor k =	2		
Expanded uncertainty	**expressed with a level of confidence of 95%**	**3.24**	**% of value**
Expanded uncertainty	**expressed with a level of confidence of 95%**	**0.35**	**% vol**

Title:	**Determination of Moisture Content**		
Method	EN 14790		
Stack Name	A2-01		
Test Time	10:20:00		
Leak Check Results			
Prior to test:	0		
Post Test:	0		
Sample Volume Flow Rate:	2.3		
Standard Requirement:	<2%		
Test Result:	0		
Test Status	Pass		
Calibration Details			
Pump Number	22EQ505		
Calibrator Number	22EE522		
Calibration Rate Before	2.3	N Litres per Minute	
Calibration Rate After	2.3	N Litres per Minute	
Air Volume at Pump	2.3	N Litres per Minute	
Sample Time	30	Minutes	
Temperature at Pump	10	Deg C	
Pressure at Pump	101.3	kPa	
Volume from Mass Flow Meter	0.064	Nm^3	
Balance Calibration	**Weight**		
0.0	0.0	g	Eccentric load indication carried out - Balance Ok: Yes
500.0	500.0	g	
1000.0	1000.0	g	
Impinger Weights	**Initial**	**Final**	**Difference**
Total Impinger Weight	594	599	5
Volume of Air Sampled	0.064	Nm^3	5
Moisture Content (EN 14790)	8.82	%	
Uncertainty	0.45	%	

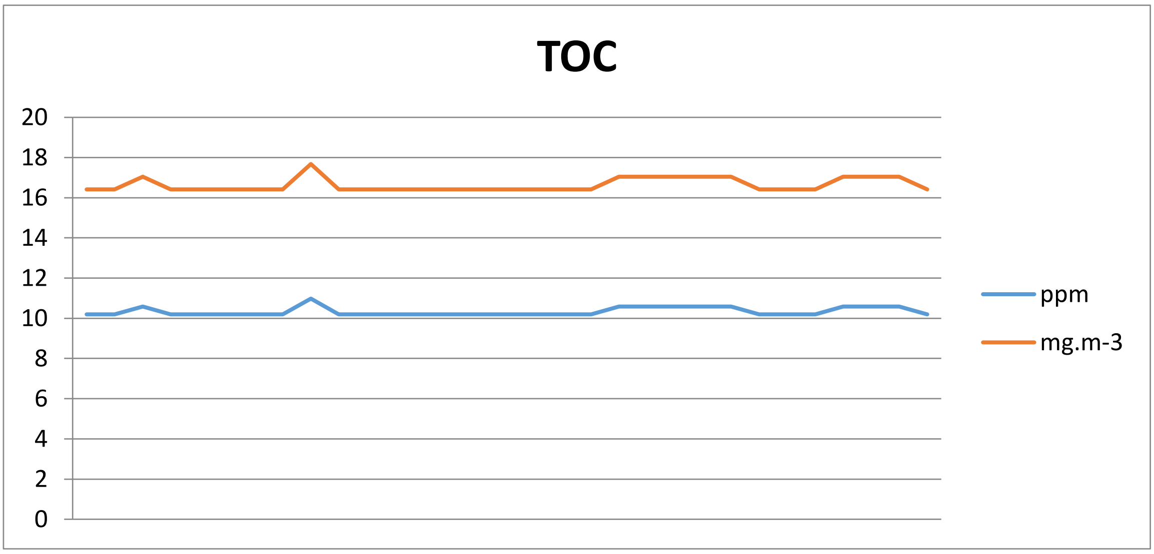
QGU-009-2013 Uncertainty calculation for EN 14791									
v2									
							Measurement Equation		
Limit value (ELV)		**$mg.m^{-3}$**							
Measured concentration	8.82	**$mg.m^{-3}$ (at reference conditions)**							
Measured Quantities	**Symbol**	**Value**	**Standard uncertainty**		**Units**		**Uncertainty as percentage**	**Uncertainty at lv**	**Requirement of std**
Sampled Volume Gas	V_m	0.064290102	uV_m	0.001	**m^3**		1.56		<=2%
Sampled gas Temperature	T_m	283	uTm	2	k		2.00		<2.5 k
Sampled gas Pressure	ρ_m	101.3	$u\rho_m$	1	**kPa**		0.99		<=1%
Sampled gas Humidity	H_m	0	uH_m	1	**% by volume**		1.00		<=1%
Note - Sampled gas humidity, temperature and pressure are values at the gas meter									
Leak	L	2			**%**		2.00		<=2%
Intermediate calculations									
Factor for std conds	fs	0.96							
uncertainty components	symbol	**sensitivity coeff**		**u (in units of fs)**					
	ρ_m	0.010		0.010					
	H_m	0.010		0.010					
	T_m	0.003		0.007					
	ufs			0.015			1.57		
Corrected volume	V	0.06	uV	0.001	**m^3**		2.25		
Factor for O2 correction	fc	#REF!							
uncertainty components	symbol	**sensitivity coeff**		**u**					
	$O_{2,m}$	#REF!		#REF!					
Factor for O2 Correction	ufc	#REF!		#REF!			#REF!		
Parameter		**Value**	**Units**	**Sensitivity coeff**	**Uncertainty contribution**		**Uncertainty as %**		
Corrected Volume (standard conditio	V	0.06	m^3	142.29	0.20	$mg.m^3$	2.25	%	
Leak	L	0.10	$mg.m^3$	1.00	0.10	$mg.m^3$	1.15	%	
Combined uncertainty					**0.22**	$mg.m^3$			
Expanded uncertainty as percentage of measured value			5.06	**% measured of value**		**expressed with a level of confidence of 95%**			
						(Using a coverage factor k=2)			
Expanded uncertainty in units of measurement			0.45	**%**					

Title:	**Determination of Total Organic Compounds**	
Method:	EN 12619	
Client:	Irish Cement Limited	
Stack Reference:	A2-01	
Licence Limits		
Emission Limit Value	25	$mg.m^{-3}$
Flow Rate Limit	-	$m^3.Hr^{-1}$
Results		
TOC Concentration	19.4	$mg.m^{-3}$ ref O_2 dry
Flow Rate	-	$m^3.Hr^{-1}$
Uncertainty of Measurement	0.51	$mg.m^{-3}$
Reference Conditions		
Temperature (K)	273.13	^0K
Pressure (kPa)	101.3	kPa
Gas (Wet or Dry)	Dry	
Oxygen	10	%
Stack Concentrations		
Oxygen	10.63	%
Moisture	8.82	%
CO_2	-	%
Quality Data		**Units**
Sampling Date	09/12/2023	
Sampling Time	12:40:01	-
Instrument Range	100	ppm
Span Gas Value	77.7	ppm
Acceptable Gas Range	Yes	50 - 90% of Range
Oven Temperature	185	^0C
Average Temperature	185	^0C
Temperature Acceptable	Yes	Yes or No
Sample line temperature	182	C
Zero Drift		**Units**
Zero Down Sampling Line (Pre)	0.1	ppm
Zero Check after Span	0.1	ppm
Allowable Resolution	0.4	ppm
Zero Down Sampling Line (Post)	0.4	ppm
Zero drift	0.3	ppm
Allowable Zero Drift	1.554	ppm
Zero Drift Acceptable (<2%)	Yes	Yes or No
Adjust for Zero Drift Limit (2 - 5%)	No	Yes or No
Reject results if > 5%	3.885	ppm
Span Drift		**Units**
Span (Pre)	77.7	ppm
Span (Post)	76.9	ppm
Span Drift	-0.8	ppm
Allowable Span Drift	1.554	ppm
Span Drift Acceptable (<2%)	Yes	Yes or No
Adjust for Zero Drift Limit (2 - 5%)	No	Yes or No
Reject results if > 5%	3.885	ppm
Leak Check		
Span Gas Conc.	77.7	ppm
Recorded Conc. down Line	77.1	ppm
Leak Result	0.6	ppm
Leak check acceptable (< 2%)	1.6	(Y/N)
Response Time (<200 seconds)	Yes	Yes or No
Parameter		
Standard	EN 12619	
Technical Procedure	2009	
Probe material	Stainless Steel	
Filtration Type	Ceramic Filter	
Heated Head Filter Used	Yes	

Heated Line Temperature	182	Deg C
Span Gas Reference Number	23ING504	
Span Gas Expiry Date	Oct-26	
Span Gas Start Pressure (bar)	50	bar
Gas Cylinder Concentration (ppm)	77.7	ppm
Span Gas Uncertainty (%)	1.6	%
Zero Gas Type	Air	
Number of Sampling Lines Used	1	
Number of Sampling Points Used	1	
Sample Point I.D's	1	
Measured Quantities		
Certified Range of Analyser	1000	ppm
Operational Range of Analyser	100	ppm
Measured Reading	12	ppm
Non linearity	0.4	ppm
Temperature Dependent Zero drift	0.15	ppm Per Degree
Temperature Dependent Span drift	0.1	% Per Degree
Cross-sensitivity	0.1	ppm
Leak	0.6	ppm
Calibration Gas uncertainty	1.6	ppm

Title:	***Determination of Total Organic Compounds***
Method:	EN 12619
Client:	Irish Cement Limited
Stack Reference:	A2-01

Run 1	**Time**	**ppm**	**mg.m^{-3}**
1	09/12/2023 12:40	10.196	16.4
2	09/12/2023 12:41	10.196	16.4
3	09/12/2023 12:42	10.588	17.0
4	09/12/2023 12:43	10.196	16.4
5	09/12/2023 12:44	10.196	16.4
6	09/12/2023 12:45	10.196	16.4
7	09/12/2023 12:46	10.196	16.4
8	09/12/2023 12:47	10.196	16.4
9	09/12/2023 12:48	10.98	17.7
10	09/12/2023 12:49	10.196	16.4
11	09/12/2023 12:50	10.196	16.4
12	09/12/2023 12:51	10.196	16.4
13	09/12/2023 12:52	10.196	16.4
14	09/12/2023 12:53	10.196	16.4
15	09/12/2023 12:54	10.196	16.4
16	09/12/2023 12:55	10.196	16.4
17	09/12/2023 12:56	10.196	16.4
18	09/12/2023 12:57	10.196	16.4
19	09/12/2023 12:58	10.196	16.4
20	09/12/2023 12:59	10.588	17.0
21	09/12/2023 13:00	10.588	17.0
22	09/12/2023 13:01	10.588	17.0
23	09/12/2023 13:02	10.588	17.0
24	09/12/2023 13:03	10.588	17.0
25	09/12/2023 13:04	10.196	16.4
26	09/12/2023 13:05	10.196	16.4
27	09/12/2023 13:06	10.196	16.4
28	09/12/2023 13:07	10.588	17.0
29	09/12/2023 13:08	10.588	17.0
30	09/12/2023 13:09	10.588	17.0
31	09/12/2023 13:10	10.196	16.4
Average		**10.3**	**16.6**
Adjusted for O_2 and Moisture			**19.4**



Uncertainty calculation for Gaseous Measurement TOC						
Stack Reference:						
Limit value	25	**mg/m^3 (corrected)**	**Cal gas conc**	125.097	**$mg.m^{-3}$ (Propane)**	
Measured concentration	10.3	**ppm**				
Measured concentration	17	**mg/m3 (101.3kPa, 273K)**				
Measured concentration	17	**mg/m^3 (Corrected)**				

Performance characteristics		**Value**			**specification**
Response time		90	seconds		180.000
Logger sampling interval		60	seconds		
Measurement period		30	minutes		
Number of readings in measurement		30			
Repeatability at zero		0.25	% full scale		<1 % range
Repeatability at span level		0.15	% full scale		<2 % range
Deviation from linearity(lack of fit)		0.65	% of value		<2 % range
Zero drift		0.2	mg/m3		<2% range / 24hr
Span drift		1	mg/m3		<2% range/24hr
Volume or pressure flow dependence		0	%of full scale/kPa		<2 % / kPa
Atmospheric pressure dependence		0	%of value /kPa		<3% / kPa
Ambient temperature dependence		0	% full scale/10K		<3% range / 10 K
Losses in the line (leak)		0	% of value		< 0.1%vol /10 volt
Uncertainty of calibration gas		2	% of value		< 2% of value

Performance characteristic			**Uncertainty**		**Value of uncertainty quantity**		**mg/m3**
Standard deviation of repeatability at zero			u_{r0}		for mean		use rep at span
Standard deviation of repeatability at span level			u_{rs}		for mean		0.00
Lack of fit			u_{fit}				0.06
Drift			u_{0dr}				0.33
volume or pressure flow dependence			u_{spres}				0.00
atmopsheric pressure dependence			u_{apres}				0.00
ambient temperature dependence			u_{temp}				0.00
losses in the line (leak)			u_{leak}				0.00
Uncertainty of calibration gas			u_{calib}				0.19

Measurement uncertainty				
Combined uncertainty			0.39	mg/m^3
Expanded uncertainty	k =	2	0.78	mg/m^3
Expanded uncertainty	**expressed with a level of confidence of 95**		**3.12**	**% ELV**
Expanded uncertainty	**expressed with a level of confidence of 95**		**0.78**	**$mg.m^{-3}$**
Expanded uncertainty	**expressed with a level of confidence of 95**		**4.68**	**% value**

Title:	**Determination of Inorganic Compounds**	
Method:	ISO 21877	
Test Date	09/12/2023	
Test Time Started:	15:30	
Test Time Finished:	16:00	
Laboratory Used:	RPS	
Stack Reference:	A2-01	
Leak Check Results	**Ammonia**	
Prior to test:	0	l/min
Post Test:	0	l/min
Sample Volume Flow Rate:	2.30	l/min
Test Result: (Requirement <2%)	0.0	%
Test Status	Pass	
Reference Details		
Reference Oxygen	10	
Measured Oxygen	10.63	
Reference Moisture	0	
Calibration Details	**Ammonia**	
Pump Number:	22EQ505	
Calibration Unit:	22EQ522	
Calibration Rate Before Test:	2.3	l/min
Calibration Rate After Test:	2.3	l/min
Average sample Volume:	2.30	l/min
Sample Test Time:	30	minutes
Pump Gas Temperature:	14	^{O}C
Pump Sample Pressure:	98	kPa
Normalised Gas Volume:	0.064	Nm^3
Sample Details	**Ammonia**	
Impinger Solution	0.1 NaOH	
Solution ID Number:	Run 1	
Blank Identification Number:	Run 1	
Impinger Material	PTFE	
Breakthrough Occurred	No	
Transport Temp meets Standard	Yes	
Analysed Within Specified Timeframe	Yes	
Transport Container Airtight	Yes	
Exposed to Sunlight	No	
Calculations	**Ammonia**	
Laboratory Result Imp 1 / 2	5.3	ug/ml
Laboratory Result Imp Final	0.1	ug/ml
Impinger Final Volume Imp 1 / 2	160	ml
Impinger Final Volume Imp Final	40	ml
Combined Concentration	0.852	mg
Factor	1	
Concentration	0.852	mg
Emissions Concentration	13.3	$mg.m^{-3}$
Referenced Results	**Ammonia**	
Emissions Concentration	14.1	$mg.m^{-3}$ Ref O_2
Uncertainty	1.10	$mg.m^{-3}$
Licence Limits	50	$mg.m^{-3}$
Blank Calculation	**Ammonia**	
Laboratory Impinger / Rinse Result	0.1	ug/ml
Blank Concentration	0.3	$mg.m^{-3}$ Ref O_2
% of Licence Limit	0.5	%
Field Blank <10% ELV	Yes	

Uncertainty calculation for		**Ammonia**			
Limit value (ELV)	50	**$mg.m^{-3}$**	**Reference oxygen**	10	**% by volume**
Measured concentration	14.07	**$mg.m^{-3}$ (at reference conditions)**			

$$c = \frac{m}{V} f_c$$

Measured Quantities	**Symbol**	**Value**	**Standard uncertainty**		**Units**		**Uncertainty as percentage**	**Uncertainty at lv**	**Requirement of std**
Sampled Volume Gas	V_m	0.064290102	uV_m	0.001	m^3		1.56		<=2%
Sampled gas Temperature	T_m	287	uTm	2	k		2.00		<2.5 k
Sampled gas Pressure	ρ_m	98	$u\rho_m$	1	kPa		1.02		<=1%
Sampled gas Humidity	H_m	0	uH_m	1	% by volume		1.00		<=1%
Oxygen content	$O_{2,m}$	10.63	$uO_{2,m}$	0.1	% by volume		0.94		<=5%
Concentration in impinger	C	5.4	uC	0.162	mg/l		3.00		<5%
Impinger solution volume	VS	200	uVS	0.001	l		0.00		<1%
Mass Analyte	m	0.852	um	0.03	mg		3.00	0.84	<5% of limit value
Note - Sampled gas humidity, temperature and pressure are values at the gas meter									
Leak	L	0			%		0.00		<=2%

Intermediate calculations							
Factor for std conds	fs	0.92					
uncertainty components	symbol	**sensitivity coeff**		**u (in units of fs)**			
	ρ_m	0.009		0.009			
	H_m	0.009		0.009			
	T_m	0.003		0.006			
	ufs			0.015			1.59
Corrected volume	V	0.06	uV	0.001	m^3		2.32
Factor for O2 correction	fc	1.06					
uncertainty components	symbol	**sensitivity coeff**		**u**			
	$O_{2,m}$	0.10		0.010			
Factor for O2 Correction	ufc	1.06		0.010			0.96

$$f_s = \frac{(100 - H_m)}{100} \frac{273}{T_m} \frac{\rho_m}{101.3}$$

$$V = V_m f_s$$

$$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$$

Parameter		**Value**	**Units**	**Sensitivity coeff**	**Uncertainty contribution**		**Uncertainty as %**	
Corrected Volume (standard conditio	V	0.06	m^3	237.74	0.33	$mg.m^3$	2.32	%
Mass	m	0.85	mg	16.51	0.42	$mg.m^3$	3.00	%
Factor for O2 Correction	fc	1.06		13.26	0.14	$mg.m^3$	0.96	%
Leak	L	0.00	$mg.m^3$	1.00	0.00	$mg.m^3$	0.00	%
Combined uncertainty					**0.55**	$mg.m^3$		

Expanded uncertainty as percentage of measured value	**7.83**	**% measured of value**	**expressed with a level of confidence of 95% (Using a coverage factor k=2)**
Expanded uncertainty in units of measurement	**1.10**	**$mg.m^{-3}$**	
Expanded uncertainty as percentqge of limit value	**2.20**	**% ELV**	

Title:	**Determination of Inorganic Compounds**		
Method:	EN1911 /	CN/TS 17340	
Test Date	09/12/2023	09/12/2023	
Test Time Started:	13:14:53	13:14:53	
Test Time Finished:	14:00	14:00	
Laboratory Used:	RPS		
Stack Reference:	Kiln A2-01		
Leak Check Results	**Chloride as HCl**	**Fluoride as HF**	
Prior to test:	0.1	0.1	l/min
Post Test:	0.1	0.1	l/min
Sample Volume Flow Rate:	12.00	12.00	l/min
Test Result: (Requirement <2%)	0.8	0.8	%
Test Status	Pass	Pass	
Reference Details			
Reference Oxygen	10	%	
Measured Oxygen	10.65	%	
Reference Moisture	0	%	
Calibration Details	**Chloride as HCl**	**Fluoride as HF**	
Pump Number:	19EQ509	19EQ509	
Calibration Unit:	N/a	N/a	
Calibration Rate Before Test:	N/a	N/a	l/min
Calibration Rate After Test:	N/a	N/a	l/min
Average sample Volume:			
Sample Test Time:	45	45	minutes
Pump Gas Temperature:	18.23	18.23	^{O}C
Pump Sample Pressure:	79.81	79.81	kPa
Normalised Gas Volume:	0.866	0.866	Nm^3
Sample Details	**Chloride as HCl**	**Fluoride as HF**	
Impinger Solution	DI Water	DI Water	
Solution ID Number:	Run 1	Run 1	
Blank Identification Number:	Run 1	Run 1	
Impinger Material	B. Glass	B. Glass	
Breakthrough Occurred	No	No	
Transport Temp meets Standard	Yes	Yes	
Analysed Within Specified Timeframe	Yes	Yes	
Transport Container Airtight	Yes	Yes	
Exposed to Sunlight	No	No	
Calculations	**Chloride as HCl**	**Fluoride as HF**	
Laboratory Result Imp 1 / 2	0.48	0.38	ug/ml
Laboratory Result Imp Final	0.09	0.15	ug/ml
Impinger Final Volume Imp 1 / 2	455	455	ml
Impinger Final Volume Imp Final	130	130	ml
Combined Concentration	0.2301	0.1924	mg
Factor	1	1	
Concentration	0.230	0.192	mg
Emissions Concentration	0.3	0.2	$mg.m^{-3}$
Referenced Results	**Chloride as HCl**	**Fluoride as HF**	
Emissions Concentration	0.3	0.2	$mg.m^{-3}$ Ref O_2
Uncertainty	0.02	0.02	$mg.m^{-3}$
Licence Limits	10	1	$mg.m^{-3}$
Blank Calculation	**Chloride as HCl**	**Fluoride as HF**	
Laboratory Impinger / Rinse Result	0.05	0.08	ug/ml
Blank Concentration	0.03	0.04	$mg.m^{-3}$ Ref O_2
% of Licence Limit	0.3	4.5	%
Field Blank <10% ELV	Yes	Yes	

Uncertainty calculation for		Chloride as HCl				
Limit value (ELV)	10	$mg.m^{-3}$	Reference oxygen	10	% by volume	
Measured concentration	0.28	$mg.m^{-3}$ (at reference conditions)				

$$c = \frac{m}{V} f_c$$

Measured Quantities	Symbol	Value	Standard uncertainty		Units	Uncertainty as percentage	Uncertainty at lv	Requirement of std
Sampled Volume Gas	V_m	0.8662	uV_m	0.001	m^3	0.12		<=2%
Sampled gas Temperature	T_m	291.23	uTm	2	k	2.00		<2.5 k
Sampled gas Pressure	p_m	79.81	up_m	1	kPa	1.25		<=1%
Sampled gas Humidity	H_m	0	uH_m	1	% by volume	1.00		<=1%
Oxygen content	$O_{2,m}$	10.65	$uO_{2,m}$	0.1	% by volume	0.94		<=5%
Concentration in impinger	C	0.57	uC	0.0171	mg/l	3.00		<5%
Impinger solution volume	VS	585	uVS	0.001	l	0.00		<1%
Mass Analyte	m	0.2301	um	0.01	mg	3.00	0.08	<5% of limit value
Note - Sampled gas humidity, temperature and pressure are values at the gas meter								
Leak	L	0.833333333			%	0.83		<=2%

Intermediate calculations					
Factor for std conds	fs	0.74			
uncertainty components	symbol	sensitivity coeff		u (in units of fs)	
	p_m	0.009		0.009	
	H_m	0.007		0.007	
	T_m	0.003		0.005	
	ufs			0.013	
Corrected volume	V	0.64	uV	0.011	m^3
Factor for O2 correction	fc	1.06			
uncertainty components	symbol	sensitivity coeff		u	
	$O_{2,m}$	0.10		0.010	
Factor for O2 Correction	ufc	1.06		0.010	0.97

$$f_s = \frac{(100 - H_m)}{100} \frac{273}{T_m} \frac{p_m}{101.3}$$

$$V = V_m f_s$$

$$f_c = \frac{21 - O_{ref}}{21 - O_{2,m}}$$

Parameter		Value	Units	Sensitivity coeff	Uncertainty contribution		Uncertainty as %	
Corrected Volume (standard conditio	V	0.64	m^3	0.44	0.00	$mg.m^3$	1.75	%
Mass	m	0.23	mg	1.23	0.01	$mg.m^3$	3.00	%
Factor for O2 Correction	fc	1.06		0.27	0.00	$mg.m^3$	0.97	%
Leak	L	0.00	$mg.m^3$	1.00	0.00	$mg.m^3$	0.48	%
Combined uncertainty					0.01	$mg.m^3$		

Expanded uncertainty as percentage of measured value	7.27	% measured of value	expressed with a level of confidence of 95% (Using a coverage factor k=2)
Expanded uncertainty in units of measurement	0.02	$mg.m^{-3}$	
Expanded uncertainty as percentqge of limit value	0.21	% ELV	

Uncertainty calculation for		Fluoride as HF				
Limit value (ELV)	1	$mg.m^{-3}$	Reference oxygen	10	% by volume	
Measured concentration	0.24	$mg.m^{-3}$ (at reference conditions)				

$$c = \frac{m}{V} f_c$$

Measured Quantities	Symbol	Value	Standard uncertainty		Units	Uncertainty as percentage	Uncertainty at lv	Requirement of std
Sampled Volume Gas	V_m	0.8662	uV_m	0.001	m^3	0.12		<=2%
Sampled gas Temperature	T_m	291.23	uTm	2	k	2.00		<2.5 k
Sampled gas Pressure	p_m	79.81	up_m	1	kPa	1.25		<=1%
Sampled gas Humidity	H_m	0	uH_m	1	% by volume	1.00		<=1%
Oxygen content	$O_{2,m}$	10.65	$uO_{2,m}$	0.1	% by volume	0.94		<=5%
Concentration in impinger	C	0.53	uC	0.0159	mg/l	3.00		<5%
Impinger solution volume	VS	585	uVS	0.001	l	0.00		<1%
Mass Analyte	m	0.1924	um	0.01	mg	3.00	0.71	<5% of limit value
Note - Sampled gas humidity, temperature and pressure are values at the gas meter								
Leak	L	0.833333333			%	0.83		<=2%

Intermediate calculations					
Factor for std conds	fs	0.74			
uncertainty components	symbol	sensitivity coeff		u (in units of fs)	
	p_m	0.009		0.009	
	H_m	0.007		0.007	
	T_m	0.003		0.005	
	ufs			0.013	
Corrected volume	V	0.64	uV	0.011	m^3
Factor for O2 correction	fc	1.06			
uncertainty components	symbol	sensitivity coeff		u	
	$O_{2,m}$	0.10		0.010	
Factor for O2 Correction	ufc	1.06		0.010	0.97

$$f_s = \frac{(100 - H_m)}{100} \frac{273}{T_m} \frac{p_m}{101.3}$$

$$V = V_m f_s$$

$$f_c = \frac{21 - O_{ref}}{21 - O_{2,m}}$$

Parameter		Value	Units	Sensitivity coeff	Uncertainty contribution		Uncertainty as %	
Corrected Volume (standard conditio	V	0.64	m^3	0.37	0.00	$mg.m^3$	1.75	%
Mass	m	0.19	mg	1.23	0.01	$mg.m^3$	3.00	%
Factor for O2 Correction	fc	1.06		0.22	0.00	$mg.m^3$	0.97	%
Leak	L	0.00	$mg.m^3$	1.00	0.00	$mg.m^3$	0.48	%
Combined uncertainty					0.01	$mg.m^3$		

Expanded uncertainty as percentage of measured value	7.27	% measured of value	expressed with a level of confidence of 95% (Using a coverage factor k=2)
Expanded uncertainty in units of measurement	0.02	$mg.m^{-3}$	
Expanded uncertainty as percentqge of limit value	1.72	% ELV	

Title:	Determination of Total Metals and Mercury				
Method:	EN 14385 & EN 13211				
Client:	Irish Cement Limited				
Test Date:	09/12/2023		Air Volume at Pump	1.6023	m^3
Test Time	14:38		Temperature at Pump	17.77	Deg C
Laboratory Used:	RPS		Pressure at Pump	73.35	kPa
Stack Name	A2-01		Humidity at Pumps	0	%
Run I.D.	Run 2				
Filter I.D.	Run 2		Flow Uncertainty	12,189	m^3/hr
Dry Volume of Air Sampled Metals	1.0892	Nm^3	Flow Uncertainty	4.3	%
Dry Volume of Air Sampled Mercury	1.0892	Nm^3			
Moisture Content	8.8	%	Emission Limit Value Cd/Tl:	0.05	$mg.m^{-3}$
Stack Flow Rate	330,636	Nm^3/hr	Emission Limit Value Hg:	0.05	$mg.m^{-3}$
Adjusted Stack Flow Rate	284,049	$m^3 \cdot hr^{-1}$ Ref O_2, Dry	Emission Limit Value Metals:	0.5	$mg.m^{-3}$
Volume of Air Sampled	1.0892	Nm^3			
Reference Conditions					
Measured Oxygen	10.63	%			
Reference Oxygen	10	%			
Reference Moisture	0	%			

Leak Check Results	Result		% Leak
Before Sample 1	0.41	l/min	1.7
Average Flow Rate	24	l/min	1.7
Standard Maximum	0.480	l/min	2%
Back Pressure	69	kPa	

Standard Criteria to be Met	Result	Std. Requirement		
Angle of Flow	Yes	<15 Degrees	Probe material	Titanium
Negative Flow in the Stack	Yes	None	Filter housing	Titanium
Pitot Pressure Difference	Yes	>5Pa	Positioning of filter	Out Stack
Ratio of Flow Measurement	Yes	<3:1	Filter Size & Material	47mm Quartz
Stagnation Test	Yes	<10Pa		
Pitot Tube Leak Check	Result			
Positive Pressure	Pass	-		
Negative Pressure	Pass	-		
Number of Ports	2	2		
Straight length before sample point	Pass	> 5 Hydraulic Diameters		
Straight length after sample point	Pass	> 5 Hydraulic Diameters to Stack Outlet or 2HD to Fan/ Bend		

Sample Calculations

	Filter	Imp 1 & 2	Imp 3	Total Metal
	ug / filter	**ug/L**	**ug/L**	**ug**
Antimony	0.6	0.2	0.2	0.7
Arsenic	0.5	0.3	0.3	0.7
Cadmium	0.5	0.2	0.2	0.6
Chromium	1.4	569	61.4	330.6
Cobalt	0.5	0.2	0.2	0.6
Copper	0.7	2.1	1.8	2.1
Lead	0.5	0.9	1.4	1.2
Manganese	0.8	0.6	1.1	1.3
Nickel	1.1	0.3	0.3	1.3
Thallium	0.4	0.3	0.4	0.6
Vanadium	0.4	0.6	1.1	0.9
Mercury (Metal Train)	2.65	0.5	0.5	3.0
		Impinger 5	**Impinger 6**	
Mercury (Mercury Train)	-	10.6	0.5	2.5
	Metals		**Mercury**	
Impinger 1 & 2 Total Volume (Incl Rinse)	565	Impinger 5	230	mls
Impinger 3 Total Volume (Incl Rinse)	126	Impinger 6	180	mls

Concentration Calculation

	$mg.m^{-3}$	mg/m^3 Ref O_2		Uncertainty
Antimony	0.0007	0.0007		0.000030
Arsenic	0.0006	0.0007		0.000029
Cadmium	0.0006	0.0006		0.000026
Chromium	0.3035	0.3222		0.013402
Cobalt	0.0006	0.0006		0.000026
Copper	0.0019	0.0021		0.000086
Lead	0.0011	0.0012		0.000048
Manganese	0.0012	0.0012		0.000052
Nickel	0.0012	0.0013		0.000053
Thallium	0.0006	0.0006		0.000025
Vanadium	0.0008	0.0009		0.000036
Mercury	0.0098	0.0104		0.000434
Total Metals	**0.3226**	**0.3424**		**0.014245**
Total Cd / Tl	0.0012	0.0012		0.000051
Total Hg	0.0098	0.0104		0.000434
Remaining Metals	0.3117	0.3308		0.013760

Blank Calculations

	Filter	Impingers	Total Metals	Concentration
	ug / filter	**ug/L**	**ug**	**mg/m^3 Ref O_2**
Antimony	0.6	0.2	0.713	0.00069
Arsenic	0.5	0.2	0.613	0.00060
Cadmium	0.5	0.2	0.613	0.00060
Chromium	0.7	0.2	0.813	0.00079
Cobalt	0.5	0.2	0.613	0.00060
Copper	0.4	0.4	0.626	0.00061
Lead	0.5	0.2	0.613	0.00060
Manganese	0.6	0.2	0.713	0.00069
Nickel	0.7	0.3	0.870	0.00085
Thallium	0.4	0.2	0.513	0.00050
Vanadium	0.4	0.1	0.457	0.00044
Mercury Total	0.03	0.5	0.145	0.00014
				% of ELV
Total Metals			**0.0071**	1.4229
Blank < 10% of the Emission Limit Values			Yes	**Yes / No**

DUCT AND GAS SPECIFICATION

Name			icla2-1
Section			Circular
Diameter		[m]	2.6
Area		[m^2]	5.309292
Ports	B	[#]	2
Points	P	[#]	6
Density	ρn	[$^{kg}/_{nm^3}$]	1.395
Carbon Dioxide	CO_2	[%]	17.9
Oxygen	O_2	[%]	10.3
Water Vapor Ratio	rw	[0;1]	0.1
Nozzle	nz	[mm]	5
Turbolence factor	ft	[sec]	1
Wall Adjustment Factor	waf		0.995

PITOT DATA SPECIFICATION

Name			p0.84
Velocity	[$^m/_{sec}$]	5	0.83
Velocity	[$^m/_{sec}$]	10	0.83
Velocity	[$^m/_{sec}$]	20	0.83
Velocity	[$^m/_{sec}$]	30	0.83
Velocity	[$^m/_{sec}$]	40	0.83

NORMALIZATION FACTOR

T_{norm}		[K]	273
P_{norm}		[kPa]	101.3

DUCT FLOW RATE

Dry actual	QV_a	[$^{m3}/_h$]	471258
Moist actual	$Q'V_a$	[$^{m3}/_h$]	523619
Moist norm. [T_{norm} P_{norm}]	$Q'V_n$	[$^{nm3}/_h$]	330636
Dry norm. [T_{norm} P_{norm}]	QV_n	[$^{nm3}/_h$]	297573

AVERAGE VALUES

Total Points		[#]	1
Velocity	v'_a	[$^m/_{sec}$]	27.53
Pitot Differential Pressure	dP_{avg}	[Pa]	464.12
Stack temperature	t_{stack}	[°C]	149.09
Stack Pressure	P_a	[kPa]	98.9
Isokinetic Ratio	IR	[%]	99.9
Velocity at nozzle	v'_N	[$^m/_{sec}$]	27.514
Probe temperature	t_{probe}	[°C]	183.9
Filter temperature	t_{filter}	[°C]	183.1
Outlet temperature	t_{outlet}	[°C]	33.6
Aux temperature	t_{aux}	[°C]	22.4
Ambient Pressure	P_{amb}	[kPa]	98.87

GAS METER SAMPLED VOLUMES

Elapsed time	et	[hh:mm:ss]	01:00:00
Norm. Volume [T_{norm} P_{norm}]	V_{gn}	[nm^3]	1.0892
Moist Volume at stack conditions	V'_{ga}	[m^3]	1.9168
Volume at dgm conditions	V_{dgm}	[m^3]	1.6023
Gas meter temperature	t_{dgm}	[°C]	17.77
Gas Meter Pressure	P_{dgm}	[kPa]	73.35

Uncertainty calculation for EN 13284 Determination of low range mass concentration of dust, Manual Gravimetric Method — **Version 14**

Stack Name: A2-01

Limit value (ELV)	0.5	**$mg.m^{-3}$**	**Reference oxygen**	10	**% by volume**
Measured concentration	0.34	**$mg.m^{-3}$ (at reference conditions)**			

Measurement Equation

$$c = \frac{m}{V} f_c$$

Measured Quantities	Symbol	Value	Standard uncertainty		Units		Uncertainty as percentage	Uncertainty at lv	Requireme
Sampled Volume	V_m	1.6023	uV_m	0.001	m^3		0.06		<=5%
Sampled gas Temperature	T_m	290.77	uTm	2	k		0.69		<=2%
Sampled gas Pressure	ρ_m	73.35	$u\rho_m$	1	kPa		1.36		<=2%
Sampled gas Humidity	H_m	0	uH_m	1	% by volume		1.00		<=1%
Oxygen content	$O_{2,m}$	10.63	$uO_{2,m}$	0.1	% by volume		0.94		<=5%
Mass particulate	m	345.7154	um	0.16	mg		0.05	0.03	<5% of limit v
Note - Sampled gas humidity, temperature and pressure are values at the gas meter									
Leak	L	0.41			%		0.41		<=2%
Uncollected Mass	UCM	0			mg		0		<=10%
(Instack filter - no rinse)									
Intermediate calculations									
Factor for std conds	fs	0.68							
uncertainty components	symbol	**sensitivity coeff**		**u (in units of fs)**					
	ρ_m	0.009		0.009					
	H_m	0.007		0.007		$f_s = \frac{(100 - H_m)}{100} \frac{273}{T_m} \frac{\rho_m}{101.3}$			
	T_m	0.002		0.005					
	ufs			0.012			1.83		
Corrected volume	V	1.09	uV	0.020	m^3	$V = V_m f_s$	1.83		
Factor for O2 correction	fc	1.06							
uncertainty components	symbol	**sensitivity coeff**		**u**		$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$			
	$O_{2,m}$	0.10		0.010					
Factor for O2 Correction	ufc	1.06		0.010			0.96		

Parameter		Value	Units	Sensitivity coeff	Uncertainty contribution		Uncertainty as %	
Corrected Volume (standard conditio	V	1.09	m^3	0.31	0.01	$mg.m^{-3}$	1.83	%
Factor for O2 Correction	fc	1.06		0.32	0.00	$mg.m^{-3}$	0.96	%
Leak	L	0.00	$mg.m^{-3}$	1.00	0.00	$mg.m^{-3}$	0.24	%
Combined measurement uncertainty					**0.01**	$mg.m^{-3}$		

Expanded uncertainty as percentage of measured value	**4.16**	**% measured of value**	**expressed with a level of confidence of 95%**
			(Using a coverage factor k=2)
Expanded uncertainty in units of measurement	**0.01**	**$mg.m^{-3}$**	
Expanded uncertainty as percentage of limit value	**2.80**	**% ELV**	

Title:	**Determination of Total Particulates**				
Method:	EN 13284-1				
Client:	Irish Cement Limited				
Test Date:	09/12/2023		**Air Volume at Pump**	1.173	m^3
Test Time	13:14		**Temperature at Pump**	18.23	Deg C
Laboratory Used:	RPS		**Pressure at Pump**	79.81	kPa
Stack Name	A2-01		**Humidity at Pumps**	0	%
Run I.D.	2		**Filter Weight**	0.04	mg
Filter I.D.	255601		**Front End Weight**	1.4	mg
Moisture Content	8.8	%			
Reference Oxygen	10	%	**Flow Uncertainty**	12,644	m^3/hr
Measured Oxygen	10.63	%	**Flow Uncertainty**	4.3	%
Stack Flow Rate	342831	Nm^3/hr			
Adjusted Stack Flow Rate	294590.5895	Nm^3/hr, dry @ % Oxygen			
Volume of Air Sampled	0.8662	Nm^3			

Leak Check Results	**Result**		**% Leak**		
Before Sample 1	0.21	l/min	0.9		
Average Flow Rate	23.00	l/min	0.9		
Standard Maximum	0.46	l/min	2%		
Back Pressure	59	kPa			
Standard Criteria to be Met	**Result**	**Std. Requirement**			
Angle of Flow	Yes	<15 Degrees	**Probe material**	Stainless Steel	
Negative Flow in the Stack	Yes	None	**Filter housing**	Stainless Steel	
Pitot Pressure Difference	Yes	>5Pa	**Positioning of filter**	In Stack	
Ratio of Flow Measurement	Yes	<3:1	**Filter Size & Material**	47mm Quartz	
Stagnation Test	Yes	<10Pa			
Pitot Tube Leak Check	**Result**				
Positive Pressure	Pass	-			
Negative Pressure	Pass	-			
Number of Ports	2	2			
Straight length before sample point	Pass	> 5 Hydraulic Diameters			
Straight length after sample point	Pass	> 5 Hydraulic Diameters to Stack Outlet or 2HD to Fan/ Bend			
Sample Calculations					
Blank (Filter and Front Wash Combined)	0.54	mg			
Sample 1 (Filter and Front Combined)	1.44	mg			
Volume of Air Sampled	0.8662	Nm^3			
Blank Result	0.62	mg/Nm^3, dry	0.66	mg/Nm^3, dry @ Ref O_2	
Sample Result	1.66	mg/Nm^3, dry	1.76	mg/Nm^3, dry @ Ref O_2	
Uncertainty of Measurement	0.25	mg/Nm^3			
Emission Limit Value	10	mg/Nm^3			
Blank as Percentage of ELV	6.2	%	**Requirement <10% ELV or <0.5 mg/m³**		

Isokinetic Criterion Compliance		
Isokinetic Variation	-0.2	%
Allowable Isokinetic Range	-5 to + 15%	%
Isokinetic Acceptable	Yes	

DUCT AND GAS SPECIFICATION			
Name			icla2-1
Section			Circular
Diameter		[m]	2.6
Area		[m2]	5.309292
Ports		[#]	2
Points	P	[#]	6
Density	ρn	[kg/Nm3]	1.395
Carbon Dioxide	CO2	[%]	17.9
Oxygen	O2	[%]	10.3
Water Vapor Ratio	rw	[0;1]	0.1
Nozzle	nz	[mm]	5
Turbolence factor	ft	[sec]	1
Wall Adjustment Factor	waf		
PITOT DATA SPECIFICATION			
Name			
Velocity	[m/sec]	5	0.83
Velocity	[m/sec]	10	0.83
Velocity	[m/sec]	20	0.83
Velocity	[m/sec]	30	0.83
Velocity	[m/sec]	40	0.83
NORMALIZATION FACTOR			
Tnorm		[K]	273
Pnorm		[kPa]	101.3
DUCT FLOW RATE			
Dry actual	QVa	[m3/h]	490255
Moist actual	Q'Va	[m3/h]	544729
Moist norm. [Tnorm Pnorm]	Q'Vn	[Nm3/h]	342831
Dry norm. [Tnorm Pnorm]	QVn	[Nm3/h]	308548
AVERAGE VALUES			
Total Points		[#]	2
Velocity	v'a	[m/sec]	28.64
Stack temperature	tstack	[°C]	149.69
Stack Pressure	Pa	[kPa]	98.75
Isokinetic Rate	DI	[%]	-0.2
Velocity at nozzle	v'N	[m/sec]	28.607
Probe temperature	tprobe	[°C]	144.9
Filter temperature	tfilter	[°C]	64.6
Outlet temperature	toutlet	[°C]	34.4
Aux temperature	taux	[°C]	25.3
Ambient Pressure	Pamb	[kPa]	98.87
GAS METER SAMPLED VOLUMES			
Elapsed time	et		00:46:00
Norm. Volume [Tnorm Pnorm]	Vgn		0.8662
Moist Volume at stack conditions	V'ga		1.5288
Volume at dgm conditions	Vdgm		1.173
Gas meter temperature	tdgm		18.23
Gas Meter Pressure	Pdgm		79.81

start ts	port	point	Probe pos	tstack avg	Pa avg	dP Pitot avg	velocity avg
[timestamp]	[###]	[###]	[cm]	[°C]	[kPa]	[Pa]	[m/sec]
09/12/2023	1	1	11.4	152.55	98.63	680.31	33.52
12:58:01	-	-	-	-	-	-	-
09/12/2023	1	2	38.1	153.11	98.63	677.62	33.47
12:58:35	-	-	-	-	-	-	-
09/12/2023	1	3	77	152.99	98.64	570.67	30.71
12:59:14	-	-	-	-	-	-	-
09/12/2023	1	4	183.1	153.06	98.63	562.28	30.49
12:59:51	-	-	-	-	-	-	-
09/12/2023	1	5	222	153.07	98.64	547.73	30.09
13:00:34	-	-	-	-	-	-	-
09/12/2023	1	6	248.7	153.15	98.64	555.06	30.29
13:01:10	-	-	-	-	-	-	-
09/12/2023	2	1	11.4	151.91	98.65	402.9	25.77
13:02:16	-	-	-	-	-	-	-
09/12/2023	2	2	38.1	151.21	98.66	389.87	25.33
13:02:53	-	-	-	-	-	-	-
09/12/2023	2	3	77	150.82	98.66	402.02	25.71
13:03:33	-	-	-	-	-	-	-
09/12/2023	2	4	183.1	150.81	98.67	401.47	25.69
13:04:22	-	-	-	-	-	-	-
09/12/2023	2	5	222	150.88	98.69	397.36	25.56
13:04:55	-	-	-	-	-	-	-
09/12/2023	2	6	248.7	150.87	98.69	401.61	25.69
13:05:29	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-

Uncertainty calculation for EN 13284					
	Symbol	Unit	Values	UOM as %	Std Requirement
Sampled Volume	V_m	m^3	0.001	0.09	<=5%
Sampled gas Temperature	T_m	k	2.00	0.69	<=2%
Sampled gas Pressure	ρ_m	kPa	1.00	1.25	<=2%
Sampled gas Humidity	H_m	% by volume	1.00	1.00	<=1%
Oxygen content	$O_{2,m}$	% by volume	0.10	-	<=5%
Mass particulate	m	mg	0.097	6.75	<5% of limit value
Leak	L		-	0.91	<=2%
Uncollected Mass	UCM		-	0.00	<10% of limit value
Corrected Volume (STP)	V	m^3	0.87	1.75	-
Mass	m	mg	1.44	6.75	-
Factor for O2 Correction	fc		1.06	0.96	-
Leak	L	$mg.m^{-3}$	0.01	0.53	-
Uncollected mass	UCM	mg	0.00	0.00	-
Combined measurement uncertainty			**0.12**	-	-
Expanded uncertainty as percentage of measured value				**14.11**	% measured of value
Expanded uncertainty in units of measurement				**0.25**	mg.m-3
Expanded uncertainty as percentage of limit value				**2.49**	% ELV

Uncertainty calculation for Velocity and Volume Flow Rate Measurement by Pitot tube EN ISO 16911-1					
	Unit	**Values**	**as %**	**Std Requirement**	
Range of Delta P transducer	Pa	2500	-		-
Resolution of Delta P transducer	Pa	10	-		-
Repeatability of Delta P transducer	% of value	0.01	-		-
Drift of Delta P transducer	% of range	0.32	-		-
Lack of fit of measurement system	% of range	0.25	-		-
Uncertainty in Delta P transducer	Pa	2.5	-		-
Uncertainty of pitor coefficient		0.03	-		-
Enter uncertainties as (95%,k=2) where relevant					
Uncertainty in temperature readout system	°C	1	-		-
Uncertainty in atmospheric pressure transducer	Pa	160.5	-		-
Uncertainty in duct area measurement	%	1.0	-		-
Uncertainty of Molar Mass	kg/mol	0.00001	0.05		-
Uncertainty of Temperature	K	0.5	0.12		-
Uncertainty of Stack Static Pressure	Pa	9.88	0.01		-
Uncertainty of Stack Pressure	Pa	160.8	0.08		-
Uncertainty of Gas Density	kg/m3	0.0024	0.15		-
Uncertainty in velocity	m/sec	0.52	1.8		-
Expanded Uncertainty in velocity	m/sec	1.04	3.6		-
Uncertainty of Volumetric Flow Rate	m^3/hour	6322	-		-
Expanded Uncertainty of Volumetric Flow Rate	m^3/hour	**12644**	**4.3**	<10% of ELV	

Title:	**Determination of Dioxins and Furans**				
Method:	EN 1948-1				
Client:	Irish Cement				
Test Date:	11/12/2023		**Air Volume at Pump**	5.4332	m^3
Test Time:	10:28		**Temperature at Pump**	19.9	Deg C
Laboratory Used:	Marchwood		**Pressure at Pump**	83.36	kPa
Stack Name	Kiln A2-01		**Humidity at Pumps**	0	%
Filter I.D.	Dioxin Run 2				
Moisture Content	9.78		**Reference Moisture**	0	%
Measured Oxygen	10.74	%	**Flow Uncertainty**	11,694	m^3/hr
Reference Oxygen	10	%	**Flow Uncertainty**	4.3	%
Stack Flow Rate	324,063	Nm^3/hr			
Adjusted Stack Flow Rate	272,521	Nm^3/hr, dry @ % Oxygen			
Dry Volume of Air Sampled	4.1667	m^3			
Emission Limit Value	0.1	$ng.m^{-3}$			

Leak Check Results	**Result**		**% Leak**		
Before Blank	0	cc/min	0.0		
Before Sample 1	0	cc/min	0.0		
Changing Ports	0	cc/min	0.0		
After Sample 1	0	cc/min	0.0		
Average Flow Rate	12	cc/min	0.0		
Standard Maximum	0.6	cc/min	5%		
Back Pressure	64	kPa			
Standard Criteria to be Met	**Result**	**Standard Requirement**			
Angle of Flow	Pass	<15 Degree	**Probe material**	Titanium	
Negative Flow in the Stack	Pass	None	**Filter housing**	Titanium	
Pitot Pressure Difference	Pass	>5Pa	**Positioning of filter**	Out Stack	
Ratio of Flow Measurement	Pass	<3:1	**Filter Size & Material**	47mm Quartz	
Stagnation Check	Pass	<10 Pa			
Pitot Tube Leak Check	**Result**				
Positive Pressure	Pass	-			
Negative Pressure	Pass	-			
Number of Ports	2	2			
Straight length before sample point	Pass	> 5 Hydraulic Diameters			
Straight length after sample point	Pass	> 5 HD from fan or bend / >2 from stack exit			

Sample Calculations

	2010/75/EU I-TEF	Amount ng	2010/75/EU I-TEQ ng	Concentration 2010/75/EU ng.m^{-3}	Uncertainty ng.m^{-3}
2,3,7,8-TCDF	0.1	0.0273	0.00273	0.000703	0.000025
1,2,3,7,8-PeCDF	0.05	0.0034	0.00017	0.000043	0.000002
2,3,4,7,8-PeCDF	0.5	0.0058	0.00291	0.000748	0.000026
1,2,3,4,7,8-HxCDF	0.1	0.0009	0.00009	0.000022	0.000001
1,2,3,6,7,8-HxCDF	0.1	0.0007	0.00007	0.000017	0.000001
2,3,4,6,7,8-HxCDF	0.1	0.0012	0.00012	0.000030	0.000001
1,2,3,7,8,9-HxCDF	0.1	0.0002	0.00002	0.000006	0.000000
1,2,3,4,6,7,8-HpCDF	0.01	0.0013	0.00001	0.000003	0.000000
1,2,3,4,7,8,9-HpCDF	0.01	0.0001	0.00000	0.000000	0.000000
OCDF	0.001	0.0017	0.00000	0.000000	0.000000
2,3,7,8-TCDD	1	0.0008	0.00078	0.000201	0.000007
1,2,3,7,8-PeCDD	0.5	0.0005	0.00027	0.000068	0.000002
1,2,3,4,7,8-HxCDD	0.1	0.0004	0.00004	0.000009	0.000000
1,2,3,6,7,8-HxCDD	0.1	0.0004	0.00004	0.000010	0.000000
1,2,3,7,8,9-HxCDD	0.1	0.0004	0.00004	0.000010	0.000000
1,2,3,4,6,7,8-HpCDD	0.01	0.0029	0.00003	0.000008	0.000000
OCDD	0.001	0.0053	0.00001	0.000001	0.000000
Total Amount		**0.0531**	**0.0073**	**0.00188**	**0.000067**

Blank Calculations	**2000/76/EC I-TEF**	**Amount ng**	**2010/75/EU I-TEQ ng**	**Concentration 2010/75/EU I-TEQ ng/m^3**
2,3,7,8-TCDF	0.1	0.0047	0.00047	0.000121
1,2,3,7,8-PeCDF	0.05	0.0001	0.00001	0.000001
2,3,4,7,8-PeCDF	0.5	0.0001	0.00005	0.000013
1,2,3,4,7,8-HxCDF	0.1	0.0001	0.00001	0.000002
1,2,3,6,7,8-HxCDF	0.1	0.0000	0.00000	0.000000
2,3,4,6,7,8-HxCDF	0.1	0.0001	0.00001	0.000002
1,2,3,7,8,9-HxCDF	0.1	0.0001	0.00001	0.000002
1,2,3,4,6,7,8-HpCDF	0.01	0.0000	0.00000	0.000000
1,2,3,4,7,8,9-HpCDF	0.01	0.0001	0.00000	0.000000
OCDF	0.001	0.0001	0.00000	0.000000
2,3,7,8-TCDD	1	0.0002	0.00021	0.000054
1,2,3,7,8-PeCDD	0.5	0.0003	0.00013	0.000033
1,2,3,4,7,8-HxCDD	0.1	0.0002	0.00002	0.000004
1,2,3,6,7,8-HxCDD	0.1	0.0002	0.00002	0.000004
1,2,3,7,8,9-HxCDD	0.1	0.0002	0.00002	0.000004
1,2,3,4,6,7,8-HpCDD	0.01	0.0002	0.00000	0.000000
OCDD	0.001	0.0004	0.00000	0.000000
Total Blank		**0.0068**	**0.0009**	**0.00024**
Field Blank Status	0.24	**<10% of ELV**		
Method Blank Status	Pass	**Pass / Fail**		
Blank < 10% of the Emission Limit Values		Yes		

MACHINE INFORMATION

Serial Number	ST54B320190380
Last calibration date	11/01/2023

GAS METER CALIBRATION

Serial Number			5287543
Point	**Flowrate**	**Gamma**	
1	0	1	

DUCT AND GAS SPECIFICATION

Name			icla2-1
Section			Circular
Diameter		[m]	2.6
Area		[m^2]	5.309292
Ports	B	[#]	2
Points	P	[#]	8
Density	ρn	[$^{kg}/_{nm^3}$]	1.385
Carbon Dioxide	CO_2	[%]	16.3
Oxygen	O_2	[%]	11.1
Water Vapor Ratio	rw	[0;1]	0.09
Nozzle	nz	[mm]	4
Turbolence factor	ft	[sec]	1
Wall Adjustment Factor	waf		0.995

PITOT DATA SPECIFICATION

Name			p0.84
Velocity	[$^m/_{sec}$]	5	0.83
Velocity	[$^m/_{sec}$]	10	0.83
Velocity	[$^m/_{sec}$]	20	0.83
Velocity	[$^m/_{sec}$]	30	0.83
Velocity	[$^m/_{sec}$]	40	0.83

NORMALIZATION FACTOR

T_{norm}	[K]	273
P_{norm}	[kPa]	101.3

DUCT FLOW RATE

Dry actual	QV_a	[$^{m3}/_h$]	465321
Moist actual	$Q'V_a$	[$^{m3}/_h$]	511343
Moist norm. [T_{norm} P_{norm}]	$Q'V_n$	[$^{nm3}/_h$]	324063
Dry norm. [T_{norm} P_{norm}]	QV_n	[$^{nm3}/_h$]	294898

AVERAGE VALUES

Total Points		[#]	2
Velocity	v'_a	[$^m/_{sec}$]	26.89
Pitot Differential Pressure	dP_{avg}	[Pa]	443.73
Stack temperature	t_{stack}	[°C]	149.17
Stack Pressure	P_a	[kPa]	99.35
Isokinetic Ratio	IR	[%]	99.9
Velocity at nozzle	v'_N	[$^m/_{sec}$]	26.869
Probe temperature	t_{probe}	[°C]	113.1
Filter temperature	t_{filter}	[°C]	107
Outlet temperature	t_{outlet}	[°C]	198.3
Aux temperature	t_{aux}	[°C]	-
Ambient Pressure	P_{amb}	[kPa]	99.77

GAS METER SAMPLED VOLUMES

Elapsed time	et	[hh:mm:ss]	06:00:00
Norm. Volume [T_{norm} P_{norm}]	V_{gn}	[nm^3]	4.1667
Moist Volume at stack conditions	V'_{ga}	[m^3]	7.2202
Volume at dgm conditions	V_{dgm}	[m^3]	5.4332
Gas meter temperature	t_{dgm}	[°C]	19.9
Gas Meter Pressure	P_{dgm}	[kPa]	83.36

Uncertainty calculation

Stack Name: Kiln A2-01

Measurement Equation

$$c = \frac{m}{V} f_c$$

Limit value (ELV)	0.1	**ng.m^{-3}**	**Reference oxygen**		**% by volume**
Measured concentration	0.000703	**ng.m^{-3} (at reference conditions)**			

Measured Quantities	Symbol	Value	Standard uncertainty		Units	Uncertainty as percentage	Uncertainty at lv	Requirement of std
Sampled Volume	V_m	5.4332	uV_m	0.001	m^3	0.02		<=2%
Sampled gas Temperature	T_m	292.9	uTm	2	k	0.68		<=1%
Sampled gas Pressure	ρ_m	83.36	$u\rho_m$	1	kPa	1.20		<=1%
Sampled gas Humidity	H_m	0	uH_m	1	% by volume	1.00		<=1%
Oxygen content	$O_{2,m}$		$uO_{2,m}$	0.1	% by volume	#DIV/0!		<=5%
Note - Sampled gas humidity, temperature and pressure are values at the gas meter								
Leak	L	0.00			%	0.00		<=2%

Intermediate calculations						
Factor for std conds	fs	0.77				
uncertainty components	symbol	**sensitivity coeff**	**u (in units of fs)**			
	ρ_m	0.009	0.009			
	H_m	0.008	0.008		$f_s = \frac{(100 - H_m)}{100} \frac{273}{T_m} \frac{\rho_m}{101.3}$	
	T_m	0.003	0.005			
	ufs		0.013			1.70
Corrected volume	V	4.17	uV 0.071	m^3	$V = V_m f_s$	1.70
Factor for O2 correction	fc	1.00				
uncertainty components	symbol	**sensitivity coeff**	**u**		$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$	
	$O_{2,m}$	0.05	0.005			
Factor for O2 Correction	ufc	1.00	0.005			0.48

Parameter		Value	Units	Sensitivity coeff	Uncertainty contribution		Uncertainty as %	
Corrected Volume (standard conditio	V	4.17	m^3	0.00	0.00	ng.m^{-3}	1.70	%
Factor for O2 Correction	fc	1.00		0.00	0.00	ng.m^{-3}	0.48	%
Leak	L	0.00	ng.m^{-3}	1.00	0.00	ng.m^{-3}	0.00	%
Combined measurement uncertainty					**0.00**	ng.m^{-3}		

Expanded uncertainty as percentage of measured value	**3.54**	**% measured of value**	**expressed with a level of confidence of 95% (Using a coverage factor k=2)**
Expanded uncertainty in units of measurement	**0.0000249**	**ng.m^{-3}**	
Expanded uncertainty as percentage of limit value	**0.02488**	**% ELV**	

Appendix III: Certificates and Process Detail Form

Process details form information not made available from Licensee at time of reporting. Details can be obtained direct from the client.

Certificate of Analysis

Report No.:	**23-13195-2**
Issue No.:	**2**
Date of Issue	**09/01/2024**
Customer Details:	Axis Environmental Services Ltd, Unit 3, Westlink Business Park, Clondrinagh, Limerick, V94 K6XK, Ireland
Customer Contact:	Mark McGarry
Customer Order No.:	IRLIMMG071223
Customer Reference:	Not Supplied
Quotation Reference:	Q23-05723
Description:	29 liquid samples, 8 solid samples
Date Received:	13/12/2023
Date Started:	13/12/2023
Date Completed:	22/12/2023
Test Methods:	Details available on request (refer to SOP code against relevant result/s)
Notes:	This report replaces issue 1 in its entirety

Approved By: **Joanne Dewhurst, Operational Manager**

This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service.

This certificate shall not be reproduced except in full without the prior written approval of the laboratory.

Observations and interpretations are outside of the scope of UKAS accreditation.

Results reported herein relate only to the items supplied to the laboratory for testing.

Results on an Interim Report are not dry-weight corrected.

Where the laboratory is not responsible for the sampling, results apply to the sample(s) as they were received.

The laboratory shall not be responsible for any information that is supplied by the customer that may affect the validity of results.

UKAS TESTING 0605

mCERTS THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME

RPS Environmental Management Limited trading as RPS Laboratories. Registered in England No. 01756175.
Unit 12, Waters Edge Business Park, Modwen Road, Salford, M5 3EZ. T +44 161 872 2443
A member of the RPS Group plc. Terms and conditions apply - copy on request

Results Summary

Report No.: 23-13195-2

Customer Reference: Not Supplied

Customer Order No: IRLIMMG071223

					Customer Sample No	Particulates Run 1 - 255600	Particulates Blank - 255578	Particulate FW Run 1	Particulate FW Blank	Kiln Metals Run 1 FW	Kiln Metals Run 1 Filter	Kiln Metals Blank FW	Kiln Metals Blank Filter	Kiln Metals Blank Impingers	Kiln Metals Run 1 Impinger 1 & 2	Kiln Metals Run 1 Impinger 3
					RPS Sample No	219520	219521	219522	219523	219524	219525	219526	219527	219528	219529	219530
					Sample Matrix	FILTER	FILTER	SOLUTION	SOLUTION	SOLUTION	FILTER	SOLUTION	FILTER	SOLUTION	SOLUTION	SOLUTION
					Sampling Date	08/12/2023	08/12/2023	08/12/2023	08/12/2023	08/12/2023	08/12/2023	08/12/2023	08/12/2023	08/12/2023	08/12/2023	08/12/2023
Determinand	**CAS No**	**Codes**	**SOP**	**RL**	**Units**											
volume of sample supplied		U	N/A	n/a	ml					60		64		143	241	192
ammonia	7664-41-7	UM	A6	0.1	ug/mL											
hydrogen chloride	7647-01-0	UM	C27	0.05	ug/mL											
arsenic	7440-38-2	UM	M31	0.2	ug						0.6		0.7			
cadmium	7440-43-9	UM	M31	0.2	ug						< 0.2		< 0.2			
cobalt	7440-48-4	UM	M31	0.2	ug						< 0.2		< 0.2			
chromium	7440-47-3	UM	M31	0.3	ug						5.2		5.8			
copper	7440-50-8	UM	M31	0.2	ug						1.9		0.2			
manganese	7439-96-5	UM	M31	0.2	ug						4.2		2.5			
nickel	7440-02-0	UM	M31	0.5	ug						2.0		< 0.5			
lead	7439-92-1	UM	M31	0.3	ug						1.7		0.7			
antimony	7440-36-0	UM	M31	0.4	ug						< 0.4		< 0.4			
thallium	7440-28-0	UM	M31	0.2	ug						< 0.2		< 0.2			
vanadium	7440-62-2	UM	M31	0.2	ug						0.8		0.8			
arsenic	7440-38-2	UM	M31	0.3	ug					< 0.3		< 0.3				
cadmium	7440-43-9	UM	M31	0.3	ug					< 0.3		< 0.3				
cobalt	7440-48-4	UM	M31	0.3	ug					< 0.3		< 0.3				
chromium	7440-47-3	UM	M31	0.3	ug					3.0		< 0.3				
copper	7440-50-8	UM	M31	0.4	ug					1.4		< 0.4				
manganese	7439-96-5	UM	M31	0.2	ug					1.2		< 0.2				
nickel	7440-02-0	UM	M31	0.1	ug					2.2		< 0.1				
lead	7439-92-1	UM	M31	0.2	ug					0.5		< 0.2				
antimony	7440-36-0	UM	M31	0.2	ug					< 0.2		< 0.2				
thallium	7440-28-0	UM	M31	0.2	ug					0.4		< 0.2				
vanadium	7440-62-2	UM	M31	0.2	ug					< 0.2		< 0.2				
arsenic	7440-38-2	UM	M31	0.3	ug/L									< 0.3	< 0.3	< 0.3
cadmium	7440-43-9	UM	M31	0.2	ug/L									< 0.2	< 0.2	< 0.2
cobalt	7440-48-4	UM	M31	0.2	ug/L									< 0.2	< 0.2	< 0.2
chromium	7440-47-3	UM	M31	0.2	ug/L									0.4	1.9	1.3
copper	7440-50-8	UM	M31	0.4	ug/L									< 0.4	1.0	0.8
manganese	7439-96-5	UM	M31	0.2	ug/L									< 0.2	0.7	0.6
nickel	7440-02-0	UM	M31	0.3	ug/L									< 0.3	< 0.3	< 0.3
lead	7439-92-1	UM	M31	0.2	ug/L									< 0.2	0.9	0.7
antimony	7440-36-0	UM	M31	0.2	ug/L									< 0.2	< 0.2	< 0.2
thallium	7440-28-0	UM	M31	0.2	ug/L									< 0.2	< 0.2	< 0.2
vanadium	7440-62-2	UM	M31	0.1	ug/L									< 0.1	0.4	0.4

Results Summary

Report No.: 23-13195-2

Customer Reference: Not Supplied

Customer Order No: IRLIMMG071223

					Customer Sample No	Particulates Run 1 - 255600	Particulates Blank - 255578	Particulate FW Run 1	Particulate FW Blank	Kiln Metals Run 1 FW	Kiln Metals Run 1 Filter	Kiln Metals Blank FW	Kiln Metals Blank Filter	Kiln Metals Blank Impingers	Kiln Metals Run 1 Impinger 1 & 2	Kiln Metals Run 1 Impinger 3
					RPS Sample No	219520	219521	219522	219523	219524	219525	219526	219527	219528	219529	219530
					Sample Matrix	FILTER	FILTER	SOLUTION	SOLUTION	SOLUTION	FILTER	SOLUTION	FILTER	SOLUTION	SOLUTION	SOLUTION
					Sampling Date	08/12/2023	08/12/2023	08/12/2023	08/12/2023	08/12/2023	08/12/2023	08/12/2023	08/12/2023	08/12/2023	08/12/2023	08/12/2023
Determinand	**CAS No**	**Codes**	**SOP**	**RL**	**Units**											
particulates		UM	D9	0.04	mg	1.51	< 0.04									
particulates		UM	D9	0.5	mg			2.7	< 0.5							
mercury	7439-97-6	UM	M112	0.03	ug						< 0.03		< 0.03			
mercury	7439-97-6	UM	M112	0.5	ug/l											
mercury	7439-97-6	UM	M112	0.5	ug/l									< 0.5	< 0.5	< 0.5
mercury	7439-97-6	UM	M112	0.5	ug/l					4.80		< 0.50				
hydrogen fluoride	7664-39-3	UM	C27	0.05	ug/mL											

Results Summary

Report No.: 23-13195-2

Customer Reference: Not Supplied

Customer Order No: IRLIMMG071223

					Customer Sample No	Kiln Mercury Run 1 Impinger 5	Kiln Mercury Run 1 Impinger 6	Kiln Mercury Blank Wash	Kiln HCL/HF Blank	Kiln HCL/HF Impinger 1 & 2	Kiln HCL/HF Impinger 3	Particulates Run 2 - 255601	Particulates Blank - 255055	Particulate FW Run 2	Particulate FW Blank	Kiln Metals Run 2 FW
					RPS Sample No	219531	219532	219533	219534	219535	219536	219537	219538	219539	219540	219541
					Sample Matrix	SOLUTION	SOLUTION	SOLUTION	SOLUTION	SOLUTION	SOLUTION	FILTER	FILTER	SOLUTION	SOLUTION	SOLUTION
					Sampling Date	08/12/2023	08/12/2023	08/12/2023	08/12/2023	08/12/2023	08/12/2023	09/12/2023	09/12/2023	09/12/2023	09/12/2023	09/12/2023
Determinand	**CAS No**	**Codes**	**SOP**	**RL**	**Units**											
volume of sample supplied		U	N/A	n/a	ml	201	166	133	172	252	182					27
ammonia	7664-41-7	UM	A6	0.1	ug/mL											
hydrogen chloride	7647-01-0	UM	C27	0.05	ug/mL				< 0.05	< 0.05	0.07					
arsenic	7440-38-2	UM	M31	0.2	ug											
cadmium	7440-43-9	UM	M31	0.2	ug											
cobalt	7440-48-4	UM	M31	0.2	ug											
chromium	7440-47-3	UM	M31	0.3	ug											
copper	7440-50-8	UM	M31	0.2	ug											
manganese	7439-96-5	UM	M31	0.2	ug											
nickel	7440-02-0	UM	M31	0.5	ug											
lead	7439-92-1	UM	M31	0.3	ug											
antimony	7440-36-0	UM	M31	0.4	ug											
thallium	7440-28-0	UM	M31	0.2	ug											
vanadium	7440-62-2	UM	M31	0.2	ug											
arsenic	7440-38-2	UM	M31	0.3	ug											< 0.3
cadmium	7440-43-9	UM	M31	0.3	ug											< 0.3
cobalt	7440-48-4	UM	M31	0.3	ug											< 0.3
chromium	7440-47-3	UM	M31	0.3	ug											0.8
copper	7440-50-8	UM	M31	0.4	ug											< 0.4
manganese	7439-96-5	UM	M31	0.2	ug											0.3
nickel	7440-02-0	UM	M31	0.1	ug											0.5
lead	7439-92-1	UM	M31	0.2	ug											< 0.2
antimony	7440-36-0	UM	M31	0.2	ug											< 0.2
thallium	7440-28-0	UM	M31	0.2	ug											0.2
vanadium	7440-62-2	UM	M31	0.2	ug											< 0.2
arsenic	7440-38-2	UM	M31	0.3	ug/L											
cadmium	7440-43-9	UM	M31	0.2	ug/L											
cobalt	7440-48-4	UM	M31	0.2	ug/L											
chromium	7440-47-3	UM	M31	0.2	ug/L											
copper	7440-50-8	UM	M31	0.4	ug/L											
manganese	7439-96-5	UM	M31	0.2	ug/L											
nickel	7440-02-0	UM	M31	0.3	ug/L											
lead	7439-92-1	UM	M31	0.2	ug/L											
antimony	7440-36-0	UM	M31	0.2	ug/L											
thallium	7440-28-0	UM	M31	0.2	ug/L											
vanadium	7440-62-2	UM	M31	0.1	ug/L											

Results Summary

Report No.: 23-13195-2

Customer Reference: Not Supplied

Customer Order No: IRLIMMG071223

					Customer Sample No	Kiln Mercury Run 1 Impinger 5	Kiln Mercury Run 1 Impinger 6	Kiln Mercury Blank Wash	Kiln HCL/HF Blank	Kiln HCL/HF Impinger 1 & 2	Kiln HCL/HF Impinger 3	Particulates Run 2 - 255601	Particulates Blank - 255055	Particulate FW Run 2	Particulate FW Blank	Kiln Metals Run 2 FW
					RPS Sample No	219531	219532	219533	219534	219535	219536	219537	219538	219539	219540	219541
					Sample Matrix	SOLUTION	SOLUTION	SOLUTION	SOLUTION	SOLUTION	SOLUTION	FILTER	FILTER	SOLUTION	SOLUTION	SOLUTION
					Sampling Date	08/12/2023	08/12/2023	08/12/2023	08/12/2023	08/12/2023	08/12/2023	09/12/2023	09/12/2023	09/12/2023	09/12/2023	09/12/2023
Determinand	**CAS No**	**Codes**	**SOP**	**RL**	**Units**											
particulates		UM	D9	0.04	mg							< 0.04	< 0.04			
particulates		UM	D9	0.5	mg									1.4	< 0.5	
mercury	7439-97-6	UM	M112	0.03	ug											
mercury	7439-97-6	UM	M112	0.5	ug/l	< 0.5	< 0.5	< 0.5								
mercury	7439-97-6	UM	M112	0.5	ug/l											
mercury	7439-97-6	UM	M112	0.5	ug/l											2.62
hydrogen fluoride	7664-39-3	UM	C27	0.05	ug/mL				< 0.05	1.95	0.17					

Results Summary

Report No.: 23-13195-2

Customer Reference: Not Supplied

Customer Order No: IRLIMMG071223

					Customer Sample No	Kiln Metals Run 2 Filter	Kiln Metals Blank FW	Kiln Metals Blank Filter	Kiln Metals Blank Impingers	Kiln Metals Run 2 Impingers 1 & 2	Kiln Metals Run 2 Impingers 3	Kiln Mercury Run 2 Impinger 5	Kiln Mercury Run 2 Impinger 6	Kiln Mercury Blank Wash	Kiln HCL/HF Blank	Kiln HCL/HF Impinger 1 & 2
					RPS Sample No	219542	219543	219544	219545	219546	219547	219548	219549	219550	219551	219552
					Sample Matrix	FILTER	SOLUTION	FILTER	SOLUTION	SOLUTION	SOLUTION	SOLUTION	SOLUTION	SOLUTION	SOLUTION	SOLUTION
					Sampling Date	09/12/2023	09/12/2023	09/12/2023	09/12/2023	09/12/2023	09/12/2023	09/12/2023	09/12/2023	09/12/2023	09/12/2023	09/12/2023
Determinand	**CAS No**	**Codes**	**SOP**	**RL**	**Units**											
volume of sample supplied		U	N/A	n/a	ml		17		128	237	117	227	180	51	107	252
ammonia	7664-41-7	UM	A6	0.1	ug/mL											
hydrogen chloride	7647-01-0	UM	C27	0.05	ug/mL										< 0.05	0.48
arsenic	7440-38-2	UM	M31	0.2	ug	< 0.2		< 0.2								
cadmium	7440-43-9	UM	M31	0.2	ug	< 0.2		< 0.2								
cobalt	7440-48-4	UM	M31	0.2	ug	< 0.2		< 0.2								
chromium	7440-47-3	UM	M31	0.3	ug	0.6		< 0.3								
copper	7440-50-8	UM	M31	0.2	ug	0.3		< 0.2								
manganese	7439-96-5	UM	M31	0.2	ug	0.5		0.3								
nickel	7440-02-0	UM	M31	0.5	ug	0.6		< 0.5								
lead	7439-92-1	UM	M31	0.3	ug	< 0.3		< 0.3								
antimony	7440-36-0	UM	M31	0.4	ug	< 0.4		< 0.4								
thallium	7440-28-0	UM	M31	0.2	ug	< 0.2		< 0.2								
vanadium	7440-62-2	UM	M31	0.2	ug	< 0.2		< 0.2								
arsenic	7440-38-2	UM	M31	0.3	ug		< 0.3									
cadmium	7440-43-9	UM	M31	0.3	ug		< 0.3									
cobalt	7440-48-4	UM	M31	0.3	ug		< 0.3									
chromium	7440-47-3	UM	M31	0.3	ug		0.4									
copper	7440-50-8	UM	M31	0.4	ug		< 0.4									
manganese	7439-96-5	UM	M31	0.2	ug		< 0.2									
nickel	7440-02-0	UM	M31	0.1	ug		0.2									
lead	7439-92-1	UM	M31	0.2	ug		< 0.2									
antimony	7440-36-0	UM	M31	0.2	ug		< 0.2									
thallium	7440-28-0	UM	M31	0.2	ug		< 0.2									
vanadium	7440-62-2	UM	M31	0.2	ug		< 0.2									
arsenic	7440-38-2	UM	M31	0.3	ug/L				< 0.3	< 0.3	< 0.3					
cadmium	7440-43-9	UM	M31	0.2	ug/L				< 0.2	< 0.2	< 0.2					
cobalt	7440-48-4	UM	M31	0.2	ug/L				< 0.2	< 0.2	< 0.2					
chromium	7440-47-3	UM	M31	0.2	ug/L				< 0.2	569	61.4					
copper	7440-50-8	UM	M31	0.4	ug/L				< 0.4	2.1	1.8					
manganese	7439-96-5	UM	M31	0.2	ug/L				< 0.2	0.6	1.1					
nickel	7440-02-0	UM	M31	0.3	ug/L				< 0.3	< 0.3	< 0.3					
lead	7439-92-1	UM	M31	0.2	ug/L				< 0.2	0.9	1.4					
antimony	7440-36-0	UM	M31	0.2	ug/L				< 0.2	< 0.2	< 0.2					
thallium	7440-28-0	UM	M31	0.2	ug/L				< 0.2	0.3	0.4					
vanadium	7440-62-2	UM	M31	0.1	ug/L				< 0.1	0.6	1.1					

Results Summary

Report No.: 23-13195-2

Customer Reference: Not Supplied

Customer Order No: IRLIMMG071223

					Customer Sample No	Kiln Metals Run 2 Filter	Kiln Metals Blank FW	Kiln Metals Blank Filter	Kiln Metals Blank Impingers	Kiln Metals Run 2 Impingers 1 & 2	Kiln Metals Run 2 Impingers 3	Kiln Mercury Run 2 Impinger 5	Kiln Mercury Run 2 Impinger 6	Kiln Mercury Blank Wash	Kiln HCL/HF Blank	Kiln HCL/HF Impinger 1 & 2
					RPS Sample No	219542	219543	219544	219545	219546	219547	219548	219549	219550	219551	219552
					Sample Matrix	FILTER	SOLUTION	FILTER	SOLUTION	SOLUTION	SOLUTION	SOLUTION	SOLUTION	SOLUTION	SOLUTION	SOLUTION
					Sampling Date	09/12/2023	09/12/2023	09/12/2023	09/12/2023	09/12/2023	09/12/2023	09/12/2023	09/12/2023	09/12/2023	09/12/2023	09/12/2023
Determinand	**CAS No**	**Codes**	**SOP**	**RL**	**Units**											
particulates		UM	D9	0.04	mg											
particulates		UM	D9	0.5	mg											
mercury	7439-97-6	UM	M112	0.03	ug	< 0.03		< 0.03								
mercury	7439-97-6	UM	M112	0.5	ug/l							10.6	< 0.5	< 0.5		
mercury	7439-97-6	UM	M112	0.5	ug/l				< 0.5	< 0.5	< 0.5					
mercury	7439-97-6	UM	M112	0.5	ug/l		< 0.50									
hydrogen fluoride	7664-39-3	UM	C27	0.05	ug/mL										0.08	0.38

Results Summary

Report No.: 23-13195-2

Customer Reference: Not Supplied

Customer Order No: IRLIMMG071223

					Customer Sample No	Kiln HCL/HF Impinger 3	Ammonia Blank	Ammonia Impinger 1 & 2	Ammonia Impinger 3
					RPS Sample No	219553	219554	219555	219556
					Sample Matrix	SOLUTION	SOLUTION	SOLUTION	SOLUTION
					Sampling Date	09/12/2023	09/12/2023	09/12/2023	09/12/2023
Determinand	**CAS No**	**Codes**	**SOP**	**RL**	**Units**				
volume of sample supplied		U	N/A	n/a	ml	127	152	107	39
ammonia	7664-41-7	UM	A6	0.1	ug/mL		< 0.1	5.3	< 0.1
hydrogen chloride	7647-01-0	UM	C27	0.05	ug/mL	0.09			
arsenic	7440-38-2	UM	M31	0.2	ug				
cadmium	7440-43-9	UM	M31	0.2	ug				
cobalt	7440-48-4	UM	M31	0.2	ug				
chromium	7440-47-3	UM	M31	0.3	ug				
copper	7440-50-8	UM	M31	0.2	ug				
manganese	7439-96-5	UM	M31	0.2	ug				
nickel	7440-02-0	UM	M31	0.5	ug				
lead	7439-92-1	UM	M31	0.3	ug				
antimony	7440-36-0	UM	M31	0.4	ug				
thallium	7440-28-0	UM	M31	0.2	ug				
vanadium	7440-62-2	UM	M31	0.2	ug				
arsenic	7440-38-2	UM	M31	0.3	ug				
cadmium	7440-43-9	UM	M31	0.3	ug				
cobalt	7440-48-4	UM	M31	0.3	ug				
chromium	7440-47-3	UM	M31	0.3	ug				
copper	7440-50-8	UM	M31	0.4	ug				
manganese	7439-96-5	UM	M31	0.2	ug				
nickel	7440-02-0	UM	M31	0.1	ug				
lead	7439-92-1	UM	M31	0.2	ug				
antimony	7440-36-0	UM	M31	0.2	ug				
thallium	7440-28-0	UM	M31	0.2	ug				
vanadium	7440-62-2	UM	M31	0.2	ug				
arsenic	7440-38-2	UM	M31	0.3	ug/L				
cadmium	7440-43-9	UM	M31	0.2	ug/L				
cobalt	7440-48-4	UM	M31	0.2	ug/L				
chromium	7440-47-3	UM	M31	0.2	ug/L				
copper	7440-50-8	UM	M31	0.4	ug/L				
manganese	7439-96-5	UM	M31	0.2	ug/L				
nickel	7440-02-0	UM	M31	0.3	ug/L				
lead	7439-92-1	UM	M31	0.2	ug/L				
antimony	7440-36-0	UM	M31	0.2	ug/L				
thallium	7440-28-0	UM	M31	0.2	ug/L				
vanadium	7440-62-2	UM	M31	0.1	ug/L				

Results Summary

Report No.: 23-13195-2

Customer Reference: Not Supplied

Customer Order No: IRLIMMG071223

						Kiln HCL/HF Impinger 3	Ammonia Blank	Ammonia Impinger 1 & 2	Ammonia Impinger 3
					Customer Sample No				
					RPS Sample No	219553	219554	219555	219556
					Sample Matrix	SOLUTION	SOLUTION	SOLUTION	SOLUTION
					Sampling Date	09/12/2023	09/12/2023	09/12/2023	09/12/2023
Determinand	**CAS No**	**Codes**	**SOP**	**RL**	**Units**				
particulates		UM	D9	0.04	mg				
particulates		UM	D9	0.5	mg				
mercury	7439-97-6	UM	M112	0.03	ug				
mercury	7439-97-6	UM	M112	0.5	ug/l				
mercury	7439-97-6	UM	M112	0.5	ug/l				
mercury	7439-97-6	UM	M112	0.5	ug/l				
hydrogen fluoride	7664-39-3	UM	C27	0.05	ug/mL	0.15			

Comments

Report No.: 23-13195-2

Customer Reference: Not Supplied

Customer Order No: IRLIMMG071223

Job	Description	Document History
23-13195	n/a	Sampling dates updated

Deviating Samples

Report No.: 23-13195-2

Customer Reference: Not Supplied

Customer Order No: IRLIMMG071223

Our policy on Deviating Samples has been implemented in accordance with UKAS Policy on Deviating Samples (TPS63).
RPS is not responsible for the integrity of samples as received, unless RPS personnel performed the sampling. Samples submitted may be declared to be deviating.
Where applicable the analysis method remains UKAS accredited, however results reported for a deviating sample may be compromised.
Where no sampling date was supplied, samples have been declared to be deviating. If the date can be supplied, results may be reissued if assessed not deviating.
Where the sample container used was unsuitable or broken, the sample is flagged as deviating and re-sampling/re-submisson may be required.

RPS No.	Customer No.	Customer ID	Date Sampled	Containers Received	Deviating	Reason for Deviation
219520	Particulates Run 1 - 255600		08/12/2023	Container	No	
219521	Particulates Blank - 255578		08/12/2023	Container	No	
219522	Particulate FW Run 1		08/12/2023	Container	No	
219523	Particulate FW Blank		08/12/2023	Container	No	
219524	Kiln Metals Run 1 FW		08/12/2023	Container	No	
219525	Kiln Metals Run 1 Filter		08/12/2023	Container	No	
219526	Kiln Metals Blank FW		08/12/2023	Container	No	
219527	Kiln Metals Blank Filter		08/12/2023	Container	No	
219528	Kiln Metals Blank Impingers		08/12/2023	Container	No	
219529	Kiln Metals Run 1 Impinger 1 & 2		08/12/2023	Container	No	
219530	Kiln Metals Run 1 Impinger 3		08/12/2023	Container	No	
219531	Kiln Mercury Run 1 Impinger 5		08/12/2023	Container	No	
219532	Kiln Mercury Run 1 Impinger 6		08/12/2023	Container	No	
219533	Kiln Mercury Blank Wash		08/12/2023	Container	No	
219534	Kiln HCL/HF Blank		08/12/2023	Container	No	
219535	Kiln HCL/HF Impinger 1 & 2		08/12/2023	Container	No	
219536	Kiln HCL/HF Impinger 3		08/12/2023	Container	No	
219537	Particulates Run 2 - 255601		09/12/2023	Container	No	
219538	Particulates Blank - 255055		09/12/2023	Container	No	
219539	Particulate FW Run 2		09/12/2023	Container	No	
219540	Particulate FW Blank		09/12/2023	Container	No	
219541	Kiln Metals Run 2 FW		09/12/2023	Container	No	
219542	Kiln Metals Run 2 Filter		09/12/2023	Container	No	
219543	Kiln Metals Blank FW		09/12/2023	Container	No	
219544	Kiln Metals Blank Filter		09/12/2023	Container	No	
219545	Kiln Metals Blank Impingers		09/12/2023	Container	No	
219546	Kiln Metals Run 2 Impingers 1 & 2		09/12/2023	Container	No	
219547	Kiln Metals Run 2 Impingers 3		09/12/2023	Container	No	
219548	Kiln Mercury Run 2 Impinger 5		09/12/2023	Container	No	
219549	Kiln Mercury Run 2 Impinger 6		09/12/2023	Container	No	
219550	Kiln Mercury Blank Wash		09/12/2023	Container	No	
219551	Kiln HCL/HF Blank		09/12/2023	Container	No	
219552	Kiln HCL/HF Impinger 1 & 2		09/12/2023	Container	No	
219553	Kiln HCL/HF Impinger 3		09/12/2023	Container	No	
219554	Ammonia Blank		09/12/2023	Container	No	
219555	Ammonia Impinger 1 & 2		09/12/2023	Container	No	
219556	Ammonia Impinger 3		09/12/2023	Container	No	