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Consulting Engineers Limited

Ferrybridge 1 Line 3

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Abnormal Emissions Assessment

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Document approval

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Document revision record

Revision no	Date	Details of revisions	Prepared by	Checked by
0	20/08/2025	First issue	SMN	RSF
1	16/12/2025	Updated for revised capacity	RCB	SMN

Contents

1 Introduction

Fichtner Consulting Engineers Ltd (Fichtner) has been engaged to undertake an Abnormal Emissions Assessment to support the application for a variation to the Environmental Permit (EP) for the Ferrybridge 1 Energy from Waste Facility to increase the design point of the two existing waste incineration lines (L1 and L2) from 106% of maximum continuous rating (MCR) to 108% of MCR, and to add a third line (L3) with a rated thermal input of 95.4 MWth.

Environmental Permitting Regulations require that abnormal event scenarios are considered.

Article 46(6) of the Industrial Emissions Directive (IED) states that:

"… the waste incineration plant … shall under no circumstances continue to incinerate waste for a period of more than 4 hours uninterrupted where emission limit values are exceeded.

The cumulative duration or operation in such conditions over 1 year shall not exceed 60 hours."

Article 47 continues with:

"In the case of a breakdown, the operator shall reduce or close down operations as soon as practicable until normal operations can be restored."

The conditions detailed in Article 46(6) are considered to be "abnormal operating conditions" for the purpose of this assessment applies to the Facility.

2 Identification of Abnormal Operating Conditions

The following are considered to be examples of abnormal operating conditions which may lead to 'abnormal emission levels' of pollutants:

1. Reduced efficiency of the lime injection system such as through blockages or failure of fans leading to elevated acid gas emissions (with the exception of hydrogen chloride);
2. Complete failure of the lime injection system leading to unabated emissions of hydrogen chloride. (Note: this would require the plant to have complete failure of the bag filter system. As a plant of modern design the plant would have shut down before reaching these operating conditions);
3. Reduced efficiency of particulate filtration system due to bag failure and inadequate isolation, leading to elevated particulate emissions and metals in the particulate phase;
4. Reduced efficiency of the Selective Non-Catalytic Reduction (SNCR) system as a result of blockages or failure of the ammonia injection system, leading to elevated oxides of nitrogen emissions; and
5. Complete failure of the activated carbon injection system and loss of temperature control leading to high levels of dioxin reformation and their unabated release.

As a modern design, it is anticipated that the Facility will be operated to a high degree of compliance. Therefore, the identification of plausible abnormal emission levels has been based primarily on the data obtained from modern plants. Where actual data is not available, worst case conservative assumptions have been made.

2.1 Plant start-up and shutdown

Start-up of the Facility from cold will be conducted with clean support fuel (low sulphur light fuel oil). Waste is not introduced onto the grate unless the temperature is above the minimum requirement (850^{o}C) and other operating parameters (for example, air flow and oxygen levels) are within the range stipulated in the permit. During the warming up period the gas cleaning plant will be operational as will be the control systems and monitoring equipment.

The same is true during plant shutdown. The waste remaining on the grate is allowed to burn out, the temperature not being permitted to drop below 850^{o}C by the simultaneous introduction of clean support auxiliary fuel. After complete burnout of the waste, the burners are turned off and the plant is allowed to cool. During this period, the gas cleaning equipment, control systems and monitoring equipment will be fully operational.

It should also be noted that start-up and shutdown are infrequent events; the Facility is designed to operate continuously, and ideally only close down for its annual maintenance programme.

In relation to the magnitude of dioxin emissions during plant start-up and shutdown, research has been undertaken by AEA Technology on behalf of the Environment Agency (EA). Whilst elevated emissions of dioxins (within one order of magnitude) were found during shutdown and start-up phases where the waste was not fully established on the grate, the report concluded that:

"The mass of dioxin emitted during start-up and shutdown for a 4-5 day planned outage was similar to the emission which would have occurred during normal operation in the same period. The emission during the shutdown and restart is equivalent to less than 1 % of the estimated annual emission (if operating normally all year)."

There is therefore no reason why such start-up and shutdown operations will affect the long term impact of the Facility.

3 Plausible Abnormal Emission Levels

The following plausible abnormal emission levels for the Facility have been identified based on the performance of similar plants in the UK.

The existing EP (Ref: EPR/SP3239FU) includes emission limits for emissions to air based on the Industrial Emissions Directive (IED) (Directive 2010/75/EU) and the Waste Incineration BREF[1] for 'existing plants'. The varied EP will include emission limits based on those prescribed in the Waste Incineration BREF for 'new plants' for the proposed L3.

The existing emission limits and plausible abnormal emissions concentrations are presented in Table 1. Where available, the plausible abnormal emission levels have been based on measured data from a comparable Facility.

Table 1: Plausible Abnormal Emissions from an EfW

Pollutant	Permitted Emission Limit, (mg/Nm^3)$^{(1)}$		Plausible Abnormal Emission, (mg/Nm^3)	% Above Max Permitted Emission
	Daily Average	½ hourly max		
L1 & L2				
Oxides of nitrogen	180	400	500$^{(2)}$	25
Particulate matter (PM_{10})	5	30	150$^{(3)}$	400
Sulphur dioxide	40	200	450$^{(4)}$	125
Hydrogen chloride	8	60	900$^{(4)}$	1,400
Hydrogen fluoride	1		20$^{(4)}$	1,900
Dioxins and dioxin-like PCBs	0.06 ng/Nm^3		6 ng/Nm^3	9,900$^{(5)}$
PCBs	0.005 $mg/Nm^{3(6)}$		0.5 mg/Nm^3	9,900$^{(7)}$
L3				
Oxides of nitrogen	100	400	500$^{(2)}$	25
Particulate matter (PM_{10})	5	30	150$^{(3)}$	400
Sulphur dioxide	30	200	450$^{(4)}$	125
Hydrogen chloride	6	60	900$^{(4)}$	1,400
Hydrogen fluoride	1		20$^{(4)}$	1,400
Dioxins and dioxin-like PCBs	0.04 ng/Nm^3		4 ng/Nm^3	9,900$^{(5)}$
PCBs	0.005 $mg/Nm^{3(6)}$		0.5 mg/Nm^3	9,900$^{(7)}$

NOTES:

(1) All emissions expressed as Nm^3 based (dry, 0°C, 11% reference oxygen content).

(2) Taken as the upper end of the range of monitored raw flue gas after the boiler from the Waste Incineration BREF (Table 3.6)

(3) Taken from the IED maximum permitted level.

(4) Based on information presented in the Devonport Decision Document (Reference: EPR/WP3833FT).

[1] Best Available Techniques (BAT) Reference Document for Waste Incineration - 2019

(5) Assumes a 99% removal efficiency in lieu of any other information as set out in the Devonport Decision Document.

(6) The Waste Incineration BREF provides a range of values for PCB emissions to air from European municipal waste incineration plants. This states that the annual average total PCBs is less than 0.005 mg/Nm³ (dry, 11% oxygen, 273K). In lieu of other available data, this has been assumed to be the emission concentration for the Facility.

(7) In lieu of any publicly available information, the plausible emissions multiplier for PCBs is assumed to be the same as for dioxins.

A number of assumptions have been made with regard to the emissions of individual metals.

- Emission concentration of mercury has been assumed to be 100% of the Emission Limit Value (ELV) of 0.02mg/m³.
- Emission concentration of cadmium has been taken as half the ELV for cadmium and thallium and compounds of 0.02mg/m³.
- Emission concentration of heavy metals that have a short or long term EAL have been considered (antimony, arsenic, chromium, copper, lead, manganese, nickel, vanadium) and have been taken from the EA guidance document “Guidance on assessing group 3 metal stack emissions from incinerators” (version 4). This guidance summarises the existing emissions from 18 Municipal Waste Incinerators (MWIs) and Waste Wood Co-incinerators in the UK over a period between 2007 and 2015.
- The Predicted Abnormal Emission are calculated based on 30 times the emission concentration, as it is assumed that metals are in the particulate phase with the exception of mercury which would be in the vapour phase.
- The Waste Incineration BREF (WI BREF) states that for activated carbon injections systems mercury is absorbed usually to about a 95% efficiency to result in emission to air of below 30 µg/m³ (section 4.5.6.2). Therefore, based on the WI BREF the unabated mercury emission concentration due to a failure of the carbon injection system would be 600 µg/m³. This equates to 2,900% above the modelled emission limit of 20 µg/Nm³ which was used in the dispersion modelling.

The plausible abnormal emissions concentrations for metals are presented in Table 2.

Table 2: Predicted Abnormal Metal Emissions from an EfW

Pollutant	Emission Concentrations (µg/Nm³)	Predicted Abnormal Emission (µg/Nm³)	% Above Max Permitted Emission
Antimony	11.5	345	2,900
Arsenic	25	750	2,900
Cadmium	10	300	2,900
Chromium	92	2,760	2,900
Chromium (VI)	0.13	3.9	2,900
Copper	29	870	2,900
Lead	50.3	1,509	2,900
Manganese	60	1,800	2,900
Mercury	20	600	2,900

Pollutant	Emission Concentrations (µg/Nm³)	Predicted Abnormal Emission (µg/Nm³)	% Above Max Permitted Emission
Nickel (highest)	220	6,600	2,900
Nickel (third highest)[(1)]	53	1,590	2,900
Vanadium	6	180	2,900

Note:

(1) The EA metals guidance states that the two highest recorded nickel concentrations were outliers, with the next highest being 0.053 mg/Nm³[2]. This assessment has assumed an emission concentration during normal operation of 0.053 mg/Nm³.

The definition of 'abnormal operating conditions' also encompasses periods where the continuous emission monitoring equipment is not operating correctly and data relating to the actual emission concentrations are not available. This assessment has only used data where the concentration of continuously monitored pollutants has been quantified. Furthermore, no data on flow characteristics (flow rate, temperature etc.) during these abnormal operating conditions is available, so for the purposes of this assessment the design flow characteristics have been applied to the plausible emission levels to derive an emission rate and assess impact.

In defining abnormal operating conditions Annex VI, Part 3 (2) notes that under no circumstances shall the total dust concentration exceed 150 mg/Nm³ expressed as a half hourly average. As such total dust has been included in this analysis. In addition, this section continues to state that the emission limits prescribed for TOC and CO in the IED must not be exceeded. As such there is no potential for the impact of emissions of TOC and CO to be greater than those presented in the AQA. Therefore, TOC and CO have not been considered within this abnormal emissions assessment.

[2] The EA metals guidance states "0.53 mg/Nm³ or 11% of the ELV". As the ELV at the time the document was produced was 0.5 mg/Nm³ this is a clear typographical error and a concentration of 0.053 mg/Nm³ has been used.

4 Impact Resulting from Plausible Abnormal Emissions

The Facility will consist of three lines which operate individually. For the purpose of this analysis it has been assumed that all three lines operate under abnormal operating conditions concurrently. This is a very worst case assumption. As detailed in the Dispersion Modelling Assessment, all three sources have been combined in the model using the 'combine multiple flues' function. L1 and L2 combined contribute 72.7% of the flue gas and L3 contributes 27.3% of the flue gas; this has been accounted for when factoring between operation at the emission limits and the maximum plausible abnormal emission concentrations.

4.1 Predicted short term impacts

In order to assess the effect on short term ground level concentrations associated with the Facility operating at the identified abnormal emission concentration, the calculated ground level concentration has been increased pro-rata. For daily mean impacts it had been assumed that abnormal emission concentrations occur for 4 hours and emissions are at the emission limits for the remaining 20 hours. The impacts for an averaging period of one hour or less are presented in Table 3 and daily mean impacts are presented in Table 4.

Table 3: Hourly and 15 Minute Mean Impacts Resulting from Plausible Abnormal Emissions

Pollutant	AQAL (µg/m³)	Predicted Impact – Normal Operation		Predicted Impact – Abnormal Emissions	
		Conc. µg/m³	% of AQAL	Conc. µg/m³	% of AQAL
Nitrogen dioxide	200	25.24	12.62%	31.55	15.78%
Sulphur dioxide (1-hour)	350	35.58	10.17%	80.06	22.87%
Sulphur dioxide (15-min)	266	40.43	15.20%	90.96	34.20%
Hydrogen chloride	750	15.99	2.13%	239.79	31.97%
Hydrogen fluoride	160	0.27	0.17%	5.33	3.33%
Pollutant	**AQAL (ng/m³)**	**Predicted Impact – Normal Operation**		**Predicted Impact – Abnormal Emissions**	
		Conc. ng/m³	**% of AQAL**	**Conc. ng/m³**	**% of AQAL**
Antimony	150,000	3.06	0.002%	91.91	0.06%
Manganese	1,500,000	15.98	0.001%	479.54	0.03%
Mercury	600	5.33	0.89%	159.85	26.64%
Nickel	700	14.12	2.02%	423.59	60.51%
PCBs	6,000	1.33	0.022%	133.21	2.22%

Table 4: Daily Mean Impacts Resulting from Plausible Abnormal Emissions

Pollutant	AQAL (μg/m³)	Predicted Impact – Normal Operation		Predicted Impact – Abnormal Emissions	
		Conc. μg/m³	% of AQAL	Conc. μg/m³	% of AQAL
Sulphur dioxide	125	3.05	2.44%	8.68	6.94%
Particulate matter (PM_{10})	50	0.11	0.22%	0.63	1.27%
Pollutant	**AQAL (ng/m³)**	**Predicted Impact – Normal Operation**		**Predicted Impact – Abnormal Emissions**	
		Conc. ng/m³	**% of AQAL**	**Conc. ng/m³**	**% of AQAL**
Cadmium	30	1.08	3.61%	6.31	21.04%
Chromium	2,000	9.96	0.50%	58.08	2.90%
Copper	50	3.14	6.28%	18.31	36.62%
Mercury	60	2.16	3.61%	12.63	21.04%
Vanadium	1,000	0.65	0.06%	3.79	0.38%

This is considered to be a highly conservative assessment as it assumes that the plausible abnormal emissions occur on all three lines and coincide with worst case meteorological conditions for dispersion. Even with these highly conservative factors, the process contribution is not predicted to exceed any of the short term AQALs. The maximum predicted process contribution (as a % of the applied AQAL) is less than 60.5% for nickel, with all other pollutants lower.

4.2 Predicted long term impacts

In order to assess the effect on long term ground level concentrations associated with the Facility operating at the identified abnormal emission levels, the calculated long term ground level concentrations have been increased pro-rata as presented in Table 5 and Table 6.

This assessment assumes that the Facility operates at the daily average ELVs for 8,700 hours per year and at the plausible abnormal emission levels for 60 hours per year.

Table 5: Long-term Impacts Resulting from Plausible Abnormal Emissions

Pollutant	AQAL (μg/m³)	Predicted Impact – Normal Operation		Predicted Impact – Abnormal Emissions	
		Conc. (μg/m³)	% of AQAL	Conc. (μg/m³)	% of AQAL
Nitrogen dioxide	40	0.61	1.53%	0.62	1.56%
Particulate matter (PM_{10})	40	0.03	0.07%	0.03	0.08%
Hydrogen fluoride	16	0.01	0.03%	0.01	0.04%

Pollutant	AQAL (ng/m³)	Predicted Impact – Normal Operation		Predicted Impact – Abnormal Emissions	
		Conc. (ng/m³)	% of AQAL	Conc. (ng/m³)	% of AQAL
Antimony	5,000	0.06	0.00%	0.08	0.00%
Arsenic	6	0.14	2.29%	0.16	2.75%
Cadmium	5	0.06	1.10%	0.07	1.32%
Chromium (VI)	0.25	0.0007	0.29%	0.0009	0.34%
Lead	250	0.28	0.11%	0.33	0.13%
Manganese	150	0.33	0.22%	0.40	0.26%
Nickel	20	0.29	1.46%	0.35	1.75%
PCBs	200	0.03	0.01%	0.05	0.02%

The process contribution is not predicted to exceed any of the long term AQALs. The maximum predicted process contribution (as a % of the applied AQAL) is less than 3% for arsenic, with all other pollutants lower.

There is no AQAL for dioxins and dioxin-like PCBs against which the impact can be assessed. Therefore, to assess the impact of dioxins and dioxin-like PCBs, the increase in concentration at the point of maximum impact has been assessed. As can be seen from the results presented in Table 6, the impact of abnormal emissions is to increase in the maximum ground level concentration by 67.81%.

Table 6: Long Term Impacts from Predicted Dioxin Emissions

Pollutant	Predicted Impact – Normal Operation	Predicted Impact –Abnormal Emissions	
	fg/m³	fg/m³	% increase
Dioxins and dioxin like PCBs	0.31	0.51	67.81%

Based on the results of the Dioxin Pathway Intake Assessment (DPIA), the highest dose of dioxins and dioxin-like PCBs is predicted to be 2.75% of the TDI. This is based on the ingestion and inhalation of dioxins and dioxin-like PCBs by a child agricultural receptor at the point of maximum impact. Assuming the impact of abnormal operations, it is calculated that the process contribution at this receptor will be (2.75% x 1.6781) = 4.61% of the UK TDI for dioxins and dioxin-like PCBs. Existing sources contribute 90.65% of the TDI, and therefore the total exposure will be 95.26% of the TDI.

In addition, the DPIA considers the impact of the ingestion of dioxins and dioxin-like PCBs by an infant being breast fed by an adult agricultural receptor at the point of maximum impact. The impact is predicted to be 42% of the UK TDI for dioxins and dioxin-like PCBs. There are no other significant pathways for infant receptors. Assuming the impact of abnormal operations, the impact at this receptor will be (42% x 1.6781) = 70.46% of the UK TDI for dioxins and dioxin-like PCBs.

Based on the conservative assumptions used within the modelling, there will be no exceedences of the TDI for dioxins and dioxin-like PCBs.

5 Predicted Environmental Concentration – Abnormal Operations

The EA's Air Emissions Guidance includes the following method for identifying which emissions require further assessment by applying the following criteria:

- the long term process contribution is <1% of the long term environmental standard; and
- the short term process contribution is <10% of the short term environmental standard.

Where the impact of abnormal emissions is greater than the above criteria consideration of the background concentration has been made to ensure that the AQAL is not exceeded as a result of abnormal operations.

5.1 Background concentrations

Appendix A outlines the values for the annual average background concentrations that have been used to evaluate the impact of the Facility. These are as presented in the Air Quality Assessment submitted with the EP application.

5.2 Predicted short term impacts

Table 7 below presents the predicted impacts of plausible abnormal operations in the short term at the point of maximum impact and the Predicted Environmental Concentration (PEC) (process contribution plus background) for those pollutants for which the impact presented in Table 3 is greater than 10%.

Table 7: Short Term PEC Resulting from Plausible Abnormal Emissions

Pollutant	AQAL (µg/m³)	Background Conc.	PC – Abnormal Emissions	PEC – Abnormal Emissions	
		µg/m³	µg/m³	µg/m³	% of AQAL
Nitrogen dioxide	200	30.02	31.55	61.57	30.79%
Sulphur dioxide (1-hour)	350	5.87	80.06	85.93	24.55%
Sulphur dioxide (15-min)	266	5.87	90.96	96.83	36.40%
Hydrogen chloride	750	1.57	239.79	241.36	32.18%
Pollutant	**AQAL (ng/m³)**	**Background Conc.**	**PC – Abnormal Emissions**	**PEC – Abnormal Emissions**	
		ng/m³	**ng/m³**	**ng/m³**	**% of AQAL**
Mercury (1-hour)	600	5.71	159.85	165.56	27.59%
Nickel (1-hour)	700	6.26	423.59	429.8	61.41%
Cadmium (24-hour)	30	0.95	6.31	7.27	24.22%
Copper (24-hour)	50	20.16	18.31	38.47	76.94%

As shown, the PEC is not predicted to exceed the AQAL at the point of maximum impact for any pollutant during abnormal operations.

5.3 Predicted long term impacts

Table 8 below presents the predicted impacts of plausible abnormal operations in the long term at the point of maximum impact, and the PEC. This assessment assumes that the Facility operates at the ELVs for 8,700 hours per year and at the plausible abnormal emission levels for 60 hours per year.

Table 8: Long Term PEC Resulting from Plausible Abnormal Emissions

Pollutant	AQAL (µg/m³)	Background Conc.	PC – Abnormal Emissions	PEC – Abnormal Emission	
		µg/m³	µg/m³	µg/m³	% of AQAL
Nitrogen dioxide	40	15.01	0.62	15.63	39.08%
Pollutant	**AQAL (ng/m³)**	**Background Conc.**	**PC – Abnormal Emissions (1)**	**PEC – Abnormal Emission**	
		ng/m³	**ng/m³**	**ng/m³**	**% of AQAL**
Arsenic	6	1.07	0.17	1.24	20.62%
Cadmium	5	0.48	0.07	0.54	10.87%
Nickel	20	3.13	0.35	3.48	17.40%

NOTE:

(1) The ground level impact has been calculated by apportioning the maximum monitored emission concentration for each metal to the total group 3 metal Process Contribution.

As shown, the PEC is not predicted to exceed the AQAL at the point of maximum impact for any pollutant during abnormal operations.

6 Summary

An assessment of the impact on air quality associated with abnormal operating conditions from the Facility has identified plausible abnormal emissions based on a review of monitoring data from operational facilities of a similar type in the UK. Notwithstanding the low frequency of occurrence of such abnormal operating conditions identified by the review, the potential impact on air quality has been assessed.

The predicted impact on air quality associated with the identified plausible abnormal emissions has been calculated by pro-rating the impact associated with normal operations by the ratio between the normal and plausible abnormal emission values. With regard to short-term impacts this is considered to be a highly conservative assessment as it assumes that the plausible abnormal emissions occur on all three lines concurrently and they coincide with the worst case meteorological conditions.

Even with these highly conservative factors, there are no predicted exceedences of any of the short term or long term air quality limits associated with abnormal operations. The maximum predicted short term process contribution (as % of the applied AQAL) is less than 61%; and the maximum predicted long term process contribution (as % of the applied AQAL) is less than 3%. In addition, there will not be any exceedences of the TDI for dioxins.

It is concluded that during periods of abnormal operation as permissible under the IED (Article 46) is not predicted to give rise to an unacceptable impact on air quality or the environment.

Appendices

A Background Concentrations

Summary of Background Concentrations			
Pollutant	**Annual Mean Concentration**	**Units**	**Justification[(1)]**
Nitrogen dioxide	15.01	µg/m³	Maximum mapped background concentration within 5 km (2023 Defra dataset)
Particulate matter (PM_{10})	17.12	µg/m³	
Sulphur dioxide	2.93	µg/m³	
Hydrogen chloride	0.78	µg/m³	Maximum monitored concentration across the UK 2011 to 2015
Arsenic	1.07	ng/m³	Maximum monitored at a background site 2020 – 2024. For copper and nickel this excludes data from Sheffield Tinsley and Swansea Coedgwilym.
Cadmium	0.48	ng/m³	
Copper	10.08	ng/m³	
Nickel	3.13	ng/m³	
Mercury	2.86	ng/m³	Maximum monitored annual mean concentration from London Westminster 2018

Note:

All concentrations also include the contribution from the existing Ferrybridge 2 facility. Refer to the Dispersion Modelling Assessment for details.

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