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Consulting Engineers Limited

Avonmouth Energy Recovery Facility

Viridor Avonmouth Waste Services Limited

Abnormal Emissions Assessment

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Document approval

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1 Introduction

Fichtner Consulting Engineers Ltd (Fichtner) has been engaged to undertake an Abnormal Emissions Assessment to support the application to vary the Environmental Permit (EP) for the Avonmouth Energy Recovery Facility (the Facility). The proposed change to the EP is to increase the processing capacity of the Facility from 376,500 tonnes per annum to 427,050 tonnes per annum of waste, based on continuous operation at the 110% MCR point on the firing diagram. This assessment considers the impact of the Facility following the EP variation ("the Proposed Facility").

The 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."

For the purpose of this assessment, the conditions detailed in Article 46(6) are considered to be "abnormal operating conditions" have been applied to the operation of 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 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 reagent dosing 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, the Facility has been designed to operate 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 is 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 EP. During the warming up period the gas cleaning plant is operational as is 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 is 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 shutdown 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)."

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

3 Plausible Abnormal Emission Levels

No data on abnormal emission levels specific to the Facility is available. Therefore, the following plausible abnormal emission levels for the Facility have been identified based on the performance of similar plants in the UK. The plausible abnormal emissions concentrations are presented in Table 1, where available, these have been based on measured data from comparable facilities. The permitted emission limits presented are those applicable for the Facility from 3 December 2023 onwards, i.e., following implementation of the BREF.

Table 1: Plausible Abnormal Emissions from an EfW

Pollutant	Permitted Emission Limit, (mg/Nm³)[(1)]		Plausible Abnormal Emission, (mg/Nm³)	% Above Max Permitted Emission
	Daily Average	½ hourly max		
Oxides of nitrogen	180	400	500[(2)]	25
Particulate matter (PM_{10})	5	30	150	400
Sulphur dioxide	40	200	450	125
Hydrogen chloride	8	60	900	1400
Hydrogen fluoride	1	4	20[(4)]	400
Dioxins and furans	0.06 ng/Nm³		6 ng/Nm³	9,900[(5)]
PCBs	0.005 mg/Nm³[(6)]		0.5 mg/Nm³	9,900[(7)]

Notes:

[(1)] All emissions expressed as Nm³ 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).

[(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 0.02 mg/Nm³.
- Emission concentration of cadmium has been taken as half the ELV for cadmium and thallium and compounds of 0.02 mg/Nm³.
- 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 where it has been assumed there is a 99% removal efficiency.

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	2,000	9,900
Nickel	220	6,600	2,900
Vanadium	6	180	2,900

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 is 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 to enable assessment of the 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, Annex VI states that the emission limits prescribed for TOC and CO 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 Dispersion Modelling Assessment. Therefore, the impact of TOC and CO have not been considered within this Abnormal Emissions Assessment.

4 Impact Resulting from Plausible Abnormal Emissions

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 as presented in Table 3. This assessment assumes that abnormal operation occurs on both lines simultaneously during the worst-case meteorological conditions for dispersion.

Table 3: Short-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	200	21.21	10.60%	26.51	13.25%
Particulate matter (PM_{10})	50	0.21	0.42%	6.35	12.69%
Sulphur dioxide (24-hour)	125	3.83	3.07%	43.12	34.50%
Sulphur dioxide (1-hour)	350	29.30	8.37%	65.91	18.83%
Sulphur dioxide (15-min)	266	35.22	13.24%	79.25	29.79%
Hydrogen chloride	750	15.78	2.10%	236.6	31.55%
Hydrogen fluoride	160	1.05	0.66%	5.26	3.29%
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	3.13	0.002%	93.99	0.06%
Chromium	150,000	25.06	0.017%	751.90	0.50%
Copper	200,000	7.90	0.004%	237.01	0.12%
Manganese	1,500,000	16.35	0.001%	490.37	0.03%
Mercury	7,500	5.26	0.070%	525.76	7.01%
Vanadium (daily mean)	1,000	0.61	0.061%	18.41	1.84%
PCBs	6,000	1.31	0.022%	131.44	2.19%

This is considered to be a highly conservative assessment as it assumes that the plausible abnormal emissions occur on both lines simultaneously and coincide with worst case meteorological conditions. 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 35% for 15-minute mean sulphur dioxide, 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 4 and Table 5.

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 4: 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	1.50	3.76%	1.52	3.80%
Particulate matter (PM_{10})	40	0.06	0.15%	0.07	0.18%
Hydrogen fluoride	16	0.01	0.07%	0.01	0.08%
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	0.13	0.003%	0.16	0.003%
Arsenic	6	0.29	4.86%	0.35	5.82%
Cadmium	5	0.12	2.39%	0.14	2.86%
Chromium	5,000	1.07	0.02%	1.29	0.03%
Chromium (VI)	0.25	0.0015	0.61%	0.0018	0.73%
Copper	10,000	0.34	0.003%	0.41	0.004%
Lead	250	0.59	0.23%	0.70	0.28%
Manganese	150	0.70	0.47%	0.84	0.56%
Mercury	250	0.24	0.10%	0.40	0.16%
Nickel	20	2.56	12.82%	3.07	15.37%
PCBs	200	0.06	0.03%	0.10	0.05%

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 16% for nickel, with all other pollutants lower.

There is no AQAL for dioxins and furans against which the impact can be assessed. Therefore, to assess the impact of dioxins, the increase in concentration at the point of maximum impact has been assessed. As can be seen from the results presented in Table 5, the impact of abnormal emissions is to increase in the maximum ground level concentration by 67.81%.

Table 5: Long Term Impacts from Predicted Dioxin Emissions

Pollutant	Predicted Impact – Normal Operation	Predicted Impact –Abnormal Emissions	
	fg/m^3	fg/m^3	% increase
Dioxins and furans	0.72	1.20	67.81%

Based on the results of the Dioxin Pathway Intake Assessment (DPIA), the highest dose of dioxins and furans is predicted to be 2.68% of the TDI. This is based on the ingestion and inhalation of dioxins and furans by a child agricultural receptor at the maximum impacted receptor location. Assuming the impact of abnormal operations, it is calculated that the process contribution at this receptor will be (2.68% x 1.6781) = 4.50% of the UK TDI for dioxins and furans. Existing sources contribute 90.65% of the TDI, and therefore the total exposure will be 95.15% of the TDI.

In addition, the DPIA considers the impact of the ingestion of dioxins and furans by an infant being breast fed by an adult agricultural receptor at the point of maximum impact. The maximum impact at a receptor location is predicted to be 16.3% of the UK TDI for dioxins and furans. There are no other significant pathways for infant receptors. Assuming the impact of abnormal operations, the impact at this receptor will be (16.3% x 1.6781) = 27.4% of the UK TDI for dioxins and furans.

Based on the conservative assumptions used within the modelling, there will be no exceedences of the TDI for dioxins and furans resulting from abnormal operation of the Facility.

5 Predicted Environmental Concentration – Abnormal Operations

The EA's Air Emissions Guidance (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 Baseline concentrations

Appendix A outlines the values for the annual average baseline concentrations that have been used to evaluate the impact of the Facility. These are the baseline concentrations presented in Table 11 of the Dispersion Modelling Assessment.

5.2 Predicted short term impacts

Table 6 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 baseline) for those pollutants for which the impact presented in Table 3 is greater than 10%. The short-term baseline concentration is assumed to be twice the annual mean baseline concentration.

Table 6: 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	47.26	26.51	73.77	36.88%
Particulate matter (PM_{10})	50	31.82	6.35	38.17	76.33%
Sulphur dioxide (24-hour)	125	31.20	43.12	74.32	59.46%
Sulphur dioxide (1-hour)	350	31.20	65.91	97.11	27.75%
Sulphur dioxide (15-min)	266	31.20	79.25	110.45	41.52%
Hydrogen chloride	750	1.42	236.63	238.05	31.74%

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 7 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 7: Long 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	40	23.63	1.52	25.15	62.88%
Pollutant	**AQAL (ng/m³)**	**Background Conc.**	**PC – Abnormal Emissions [1]**	**PEC – Abnormal Emission**	
		ng/m³	**ng/m³**	**ng/m³**	**% of AQAL**
Arsenic	6	1.00	0.35	1.35	22.49%
Cadmium	5	0.43	0.14	0.57	11.46%
Nickel	20	2.50	3.07	5.57	27.87%

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 both lines simultaneously and coincide with the worst case meteorological conditions for dispersion.

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 of the Proposed Facility. The maximum predicted short term process contribution (as % of the applied AQAL) is less than 55%; and the maximum predicted long term process contribution (as % of the applied AQAL) is less than 16%. Furthermore, when taking into considerations background concentrations, the maximum predicted PECs remain well below the relevant AQALs. In addition, there will not be any exceedences of the TDI for dioxins and furans.

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 Baseline Concentrations

Summary of Background Concentrations			
Pollutant	**Annual Mean Concentration**	**Units**	**Justification**
Nitrogen dioxide	23.63	µg/m³	Maximum mapped background concentration within modelling domain (2018 Defra dataset)
Sulphur dioxide	15.60	µg/m³	Maximum mapped background concentration within modelling domain (2001 Defra dataset)
Particulate matter (PM_{10})	15.91	µg/m³	Maximum mapped background concentration within modelling domain (2018 Defra dataset)
Hydrogen chloride	0.71	µg/m³	Maximum monitored concentration across the UK 2011 to 2015
Cadmium	0.43	ng/m³	Maximum monitored 2018 to 2022 at any UK urban background site.
Arsenic	1.00	ng/m³	
Nickel	2.50	ng/m³	

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