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Consulting Engineers Limited

GENT FAIRHEAD AND CO LTD
RIVENHALL IWMF
ABNORMAL EMISSIONS ASSESSMENT

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1 INTRODUCTION

Fichtner Consulting Engineers Ltd ("Fichtner") has been engaged to undertake an Abnormal Emissions Assessment to support the Environmental Permit variation application for the Rivenhall Integrated Waste Management Facility (IWMF). This is a repeat of the abnormal emissions assessment submitted with the original application, but taking account of the reduced stack height and reduced emission limits, where appropriate.

The Environmental Permitting Regulations require that abnormal event scenarios are considered.

Article 46(6) of the 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 and only applies to the CHP plant.

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 CHP 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 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 CHP plant would 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 CHP plant from cold will be conducted with clean support fuel (low sulphur light fuel oil). Waste is not introduced into the CHP plant unless the temperature is above the minimum requirement (850ºC) 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 850ºC 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 is fully operational, as will be the control systems and monitoring equipment.

It should also be noted that start-up and shutdown are infrequent events; the CHP plant 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, recent research has been undertaken by AEA Technology on behalf of the Environment Agency. 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 CHP plant.

3 Plausible Abnormal Emission Levels

The following plausible abnormal emission levels for the proposed CHP plant 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 a comparable facility.

Table 1: Plausible Abnormal Emissions from an EfW

Pollutant	Permitted Emission, (mg/m^3)		Plausible Abnormal Emission, (mg/m^3)	% Above Max Permitted Emission
	Daily Average	½ hourly max		
Oxides of nitrogen	100	200	550	175
Particulate matter (PM_{10}s)	10	30	150(1)	400
Sulphur dioxide	50	90	480	405
Hydrogen chloride	10	60	900(2)	1,400
Hydrogen fluoride	1	4	90	2,150
Dioxins	0.1 ng/m^3 (3)		10 ng/m^3 (4)	9900

(1) Taken from the Industrial Emissions Directive.
(2) Based on information presented in the Devonport Decision Document
(3) *As previously requested by the Environment Agency.*

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

(1) Emission concentration of mercury has been assumed to be 100% of the WID emission concentration of 0.05mg/m³.

(2) Emission concentration of cadmium has been taken as the proposed emission concentration for cadmium and thallium and compounds of 0.02mg/m³.

(3) 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 "Environment Agency Guidance to Applicants on Metals Impact Assessment for Stack Emissions (September 2012 Version 3". This guidance summarises the existing emissions from 19 EfW facilities in the UK over a period between 2007 and 2009 and is the guidance used for the original application.

(4) Emission concentration of chromium (VI) is based on the ratio of the effective chromium (VI) emission concentration presented in the "Environment Agency Guidance to Applicants on Metals Impact Assessment for Stack Emissions (September 2012 Version 3", to total metals emission.

(5) The Predicted Abnormal Emission are calculated based on 15 times the emission concentration, as it is assumed that metals are in the particulate phase.

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

Table 2: Predicted Abnormal Metal Emissions from an EfW			
Pollutant	**Emission Concentrations (µg/m³)**	**Predicted Abnormal Emission (µg/m³)**	**% Above Max Permitted Emission**
Antimony	11.5	172.5	1400
Arsenic	3	45	1400
Cadmium	20	300	1400
Chromium	52.1	781.5	1400
Chromium (VI)	0.013546	0.20319	1400
Copper	16.3	244.5	1400
Lead	36.8	552	1400
Manganese	36.5	547.5	1400
Mercury	50	750	1400
Nickel	136.2	2043	1400
Vanadium	1	15	1400

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.

4 Impact Resulting from Plausible Abnormal Emissions

All point source emissions from the IWMF will emit to atmosphere via stacks contained within a common windshield. The effect of this is to have one visible stack. Emissions from this stack will include the two CHP lines, exhaust air from the pulp plant, the two AD gas engines, and the AD biofilter. Although there will be no combustion gases within the exhaust from the pulp plant or the biofilter, the temperature of the release is much lower than the CHP plant and will impact upon the buoyancy of the plume. The exhaust air from the pulp plant and the bioflter has been included to ensure any reduction is buoyancy is considered in the assessment. For the purpose of this Abnormal Emissions Assessment, the gas engines have been assumed to operate at their emission limits.

4.1 Predicted short term impacts

In order to assess the effect on short term ground level concentrations associated with the CHP plant operating at the identified abnormal emission concentration, the calculated ground level concentration for metals, which are not released by the gas engines, has been increased pro-rata as presented in Table 3. For other pollutants, the dispersion model has been re-run with the higher emission concentration.

Table 3: Short term Impacts Resulting from Plausible Abnormal Emissions

Pollutant	EAL / AQO (µg/m³)	Predicted Impact – permitted Half Hourly Limit		Predicted Impact – Abnormal Emission	
		Conc. µg/m³	% of EAL	Conc. µg/m³	% of EAL
Nitrogen dioxide	200	8.4	4.18%	44.5	22.23%
Particulate matter (PM_{10}s)	50	0.6	1.28%	8.6	17.13%
Sulphur dioxide (24-hour)	125	7.8	6.24%	66.8	53.47%
Sulphur dioxide (1-hour)	350	11.9	3.39%	101.5	29.01%
Sulphur dioxide (15-min)	266	13.4	5.03%	114.5	43.03%
Hydrogen chloride	750	2.9	0.38%	259.8	34.64%
Hydrogen fluoride	160	0.2	0.12%	17.3	10.82%
Pollutant	**EAL / AQO (ng/m³)**	**Predicted Impact – Daily Average Limits**		**Predicted Impact – Abnormal Emission**	
		Conc. ng/m³	**% of EAL**	**Conc. ng/m³**	**% of EAL**
Antimony	150,000	3.32	0.002%	49.79	0.033%
Chromium	150,000	26.56	0.018%	398.36	0.266%
Copper	200,000	8.37	0.004%	125.57	0.063%
Manganese	1,500,000	17.32	0.001%	259.80	0.017%
Mercury	7,500	14.43	0.192%	216.50	2.887%
Vanadium	1,000	1.73	0.173%	25.98	2.598%

This is considered to be a highly conservative assessment as it assumes that the plausible abnormal emissions coincide with worst case meteorological conditions. Even with these highly conservative factors, there are no exceedences of any of the short term air quality limits. The maximum predicted process contribution (as a % of the applied EAL) is less than 60%.

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 as presented in Table 4 and Table 5. This assessment assumes that the facility is operating at the daily average IED emission limits 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	EAL / AQO (µg/m³)	Predicted Impact –Daily Average Limits		Predicted Impact – Abnormal Emission	
		Conc. (µg/m³)	% of EAL	Conc. (µg/m³)	% of EAL
Nitrogen dioxide	40	1.31	3.27%	1.35	3.37%
Particulate matter (PM_{10}s)	40	0.19	0.48%	0.21	0.52%
Hydrogen fluoride	16	0.02	0.12%	0.03	0.19%
Pollutant	**EAL / AQO (ng/m³)**	**Predicted Impact –Daily Average Limits**		**Predicted Impact – Abnormal Emission**	
		Conc. (ng/m³)	**% of EAL**	**Conc. (ng/m³)**	**% of EAL**
Antimony	5,000	0.45	0.009%	0.49	0.010%
Arsenic	3	0.21	6.891%	0.23	7.552%
Cadmium	5	0.18	3.595%	0.20	3.940%
Chromium	5,000	1.65	0.033%	1.81	0.036%
Chromium (VI)	0.2	0.000002	0.001%	0.000003	0.001%
Copper	10,000	0.52	0.005%	0.57	0.006%
Lead	250	0.90	0.362%	0.99	0.396%
Manganese	150	1.08	0.719%	1.18	0.788%
Mercury	250	0.90	0.360%	0.99	0.394%
Nickel	20	3.95	19.774%	4.33	21.670%
Vanadium	5,000	0.108	0.002%	0.118	0.00236%

This is considered to be a highly conservative assessment as it assumes that the plausible abnormal emissions coincide with worst case meteorological conditions. Even with these highly conservative factors, there are no exceedences of any of the long term air quality limits. The maximum predicted process contribution (as a % of the applied EAL) is less than 22%.

There is no Air Quality Objective for dioxins against which the impact can be assessed. Therefore, to assess the impact of dioxins, the increase for the receptor exposed to the Tolerable Daily Intake has been used to assess whether there will be a significant increase in the impact of dioxins by assessing against the receptor exposed to the Tolerable Daily Intake. As can be seen from the results presented in Table 5 this represents an increase in the maximum ground level concentration of 67.81%.

Table 5: Long Term Impacts from Predicted Dioxin Emissions

Pollutant	Predicted Impact – Permitted Limits	Predicted Impact –Abnormal Emission	
	pg/m³	pg/m³	% increase
Dioxins	0.36	0.6	67.81%

Based on the results of the Human Health Risk Assessment, the receptor receiving the highest dose of dioxins from the facility is predicted to be exposed to 0.9 % of the Tolerable Daily Intake (TDI). Assuming the impact of abnormal operations, it is calculated that the receptor receiving the highest maximum dose will be exposed to (0.9% x 1.6781) = 1.51 % of the UK TDI for dioxins.

Assuming the conservative factors stated within the modelling, there will be no exceedences of the TDI for dioxins.

5 Predicted Environmental Concentration –Abnormal Operations

Environment Agency guidance note H1 Annex F 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 AQO/EAL 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 Environmental Permit application.

5.2 Predicted short term impacts

Table 6 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 which the impact presented in Table 3 are greater than 10%.

Table 6: Short Term PEC Resulting from Plausible Abnormal Emissions

Pollutant	EAL / AQO (µg/m³)	Background Conc.	PC – Abnormal Emissions	PEC – Abnormal Emission	
		µg/m³	µg/m³	µg/m³	% of EAL
Nitrogen dioxide	200	37.2	44.47	81.7	40.8%
Particulate matter (PM_{10}s)	50	20.2	8.56	28.8	57.5%
Sulphur dioxide (24-hour)	125	12.4	66.84	79.2	63.4%
Sulphur dioxide (1-hour)	350	12.4	101.54	113.9	32.6%
Sulphur dioxide (15-min)	266	12.4	114.46	126.9	47.7%
Hydrogen chloride	750	1.4	259.80	261.2	34.8%
Hydrogen fluoride	160	4.7	17.32	22.0	13.8%
Pollutant	**EAL / AQO (ng/m³)**	**Background Conc.**	**PC – Abnormal Emissions (1)**	**PEC – Abnormal Emission**	
		ng/m³	**ng/m³**	**ng/m³**	**% of EAL**
The PC abnormal emissions for all metals is less than 10% of the associated EALs.					

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

5.3 Predicted long term impact

The following table 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 is operating at the daily average IED emission limits 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	EAL / AQO (µg/m³)	Background Conc.	PC – Abnormal Emissions	PEC – Abnormal Emission	
		µg/m³	µg/m³	µg/m³	% of EAL
Nitrogen dioxide	40	14.9	1.35	19.9	49.9%
Pollutant	**EAL / AQO (ng/m³)**	**Background Conc.**	**PC – Abnormal Emissions (1)**	**PEC – Abnormal Emission**	
		ng/m³	**ng/m³**	**ng/m³**	**% of EAL**
Cadmium	5	0.15	0.2	0.35	6.9%
Arsenic	3	0.5	0.23	0.70	23.2%
Nickel	20	1.43	4.33	5.70	28.5%

(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 be exceed the AQO/EAL 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 CHP plant 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 ration between the normal and plausible abnormal emission values. This is considered to be a highly conservative assessment as it assumes that the plausible abnormal emissions 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 EAL) is less than 53%; and the maximum predicted long term process contribution (as % of the applied EAL) is less than 22%. Abnormal emissions from the facility will not cause any exceedences of any Air Quality Objective. 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.

Appendix A

Summary of Background Concentrations

Pollutant	Annual Mean Concentration	Units	Justification
Nitrogen dioxide	14.89	µg/m^3	2011 mapped background dataset maximum grid square within the modelling domain.
Oxides of nitrogen	22.01	µg/m^3	
Sulphur dioxide	3.65	µg/m^3	2001 mapped background dataset maximum grid square within the modelling domain.
Particulate matter (as PM_{10})	19.58	µg/m^3	2011 mapped background dataset maximum grid square within the modelling domain.
Particulate matter (as $PM_{2.5}$)	12.47	µg/m^3	
Carbon monoxide	267	µg/m^3	2001 mapped background dataset maximum grid square within the modelling domain.
Hydrogen chloride	0.72	µg/m^3	Maximum over the past 4 years from all UK monitoring sites.
Hydrogen fluoride	2.35	µg/m^3	Maximum measured baseline hydrogen fluoride concentration as presented in the EPAQS report.
Ammonia	1.48	µg/m^3	Maximum mapped background concentration within the modelling domain – 2011 dataset.
Benzene	0.35	µg/m^3	Maximum mapped background concentration within the modelling domain – 2001 dataset.
1,3-butadiene	0.14	µg/m^3	
Mercury	1.38	ng/m^3	The maximum monitored metal concentration from at a rural site between 2012 and 2013.
Cadmium	0.20	ng/m^3	
Arsenic	0.81	ng/m^3	
Antimony	-	ng/m^3	
Chromium	1.32	ng/m^3	
Cobalt	-	ng/m^3	
Copper	4.44	ng/m^3	
Manganese	3.49	2ng/m^3	
Lead	8.38	ng/m^3	
Nickel	1.43	ng/m^3	
Vanadium	1.75	ng/m^3	
Dioxins and furans	22.82	fg/m^3	The maximum monitored metal concentration from at a rural site between 2008 to 2010
Polychlorinated biphenyl (PCBs)	141.5	pg/m^3	
Benzo(a)pyrene (PaB)	2.00	ng/m^3	Maximum monitored concentration from a background site between 2009 and 2011.

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