SEAL SANDS INCINERATOR ANNUAL OPERATION REPORT 2018

This report addresses permit requirements set out in section 4.2.2 operating permit reference ZP3438CF in accordance with environmental regulations. The report also addresses the challenges the new Best Available Technique (BAT) Reference document (BREF) for waste incineration operations in Europe published in 2017 will bring for the business.

Contents

1. Emissions

1.1 Air emissions

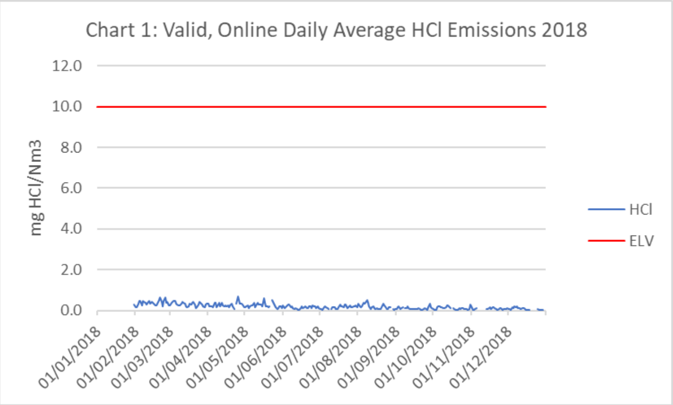
1.1.1 Continuously Monitored Air Emissions — Permit Table S3.1

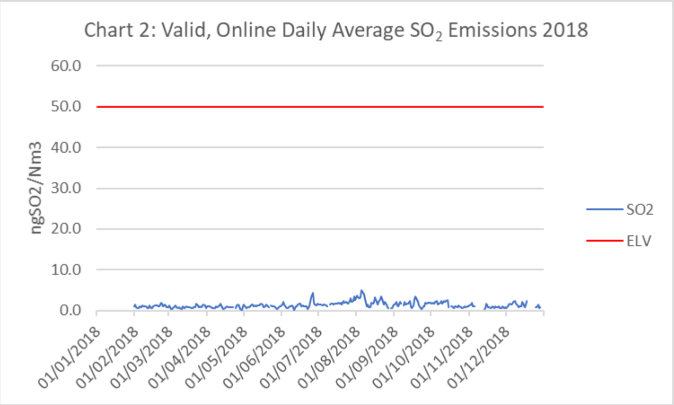
Registered emission point A1: the Lianhetech Seal Sands incinerator uses a continuous emissions monitoring system (CEMS) for its emissions to air from registered emission point A1 (flue stack). The CEMS continuously monitors all components specified in Schedule 3 table S3.1 of the Permit which are identified in the table as 'Continuous measurement' as well as hydrogen fluoride (HF) and ammonia (NH_3).

The daily averages for carbon monoxide (CO), particulates (dust), hydrogen chloride (HCl), oxides of nitrogen (NOx), sulphur dioxide (SO_2) and total organic carbon (TOC) emissions, as calculated by the data capture and reporting software are presented below. In each case, the valid 1-day average values are plotted against the 1-day ELV assigned in table S3.1 of the Permit.

Hydrogen Chloride (HCl) and Sulphur Dioxide (SO_2)

The acid gases HCl and SO_2 are both readily absorbed by the system's flue gas abatement systems in a predictable manner.

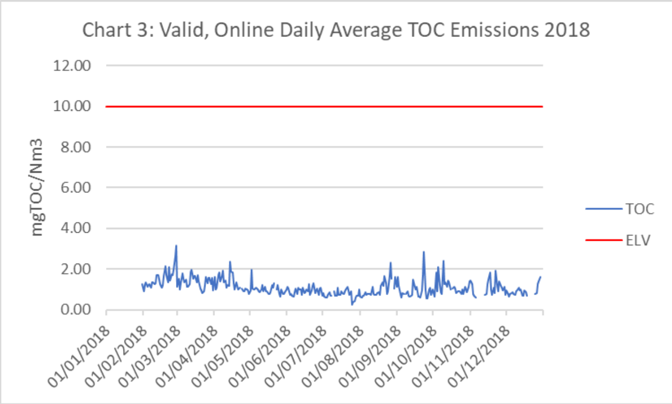


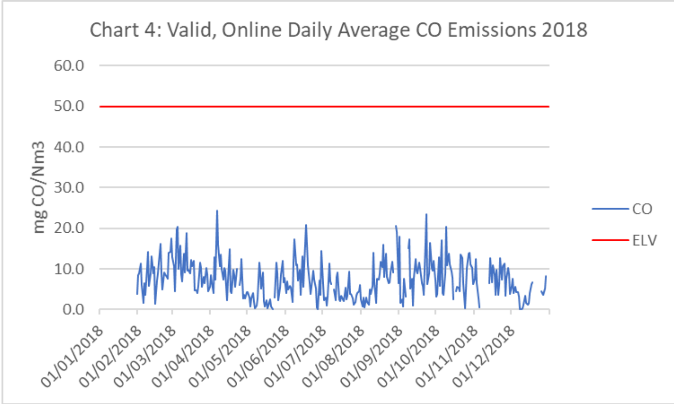


Charts 1 and 2 show HCl and SO_2 emissions are consistently low with little variation. This is helped by pH control of the scrubbing system and routine maintenance of it, which will continue in 2019.

The ELVs for HCl and SO_2 are expected to be lowered to 8mg/Nm^3 and 40mg/Nm^3, respectively. The use of wet scrubbing systems is listed in the BREF[(2)] as BAT for SO_2 and HCl abatement and indeed the system used at FES performs very well. Given the current understanding of the market FES serves and FES' waste acceptance procedure which quantifies sulphur and chlorine in waste samples, no additional investment will be required to conform to the new ELVs.

Carbon Monoxide (CO) and Total Organic Carbon (TOC)





The presence of TOC or CO in the flue gas may be indicators of inefficient combustion. Interruptions to the process, for whatever reason, present a risk of elevated emissions of both of these species. FES has no abatement technologies in operation for either species; control of emissions is a function of operation conditions only.

Charts 3 and 4 show the daily average TOC and CO emissions for 2018, respectively. Each injection lance is on a weekly rota whereby, during a weekly maintenance period of about an hour, select lances and nozzles are removed, inspected, cleaned and returned to service. This practice helps to reduce the risk of nozzle blockage and consequent pollution from CO and TOC. Maintaining balanced flow among all injection nozzles will also help to protect against premature refractory failure and maintaining optimal organic waste flow, while minimising back pressure will help FES to achieve the intended reduction in intensive gas use.

Particulates (Dust)

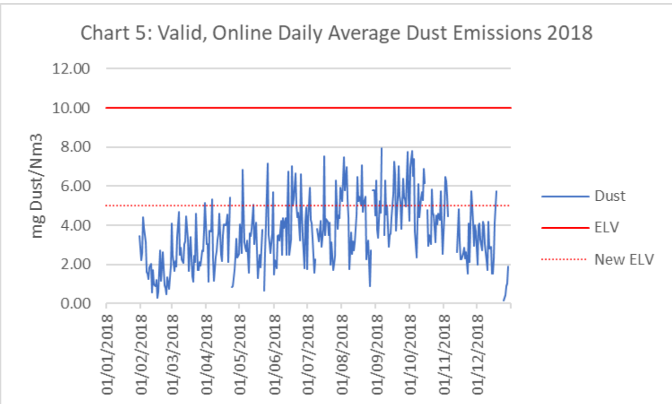
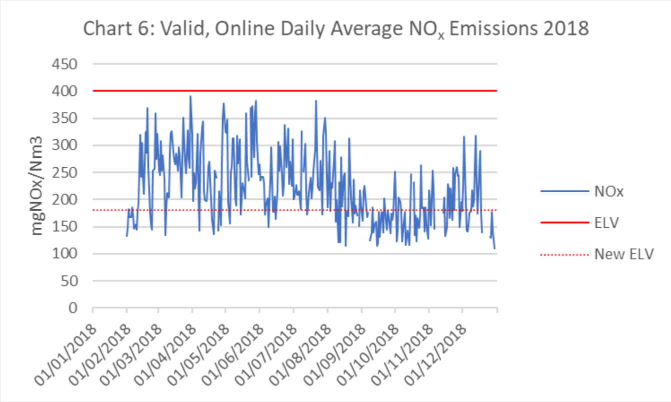


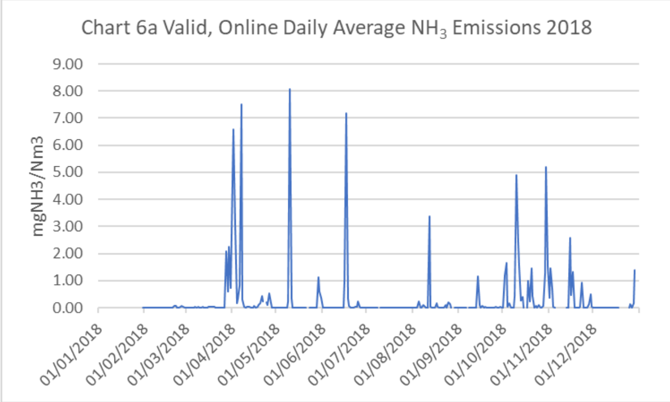
Chart 5 shows the daily averages for dust in relation to ELV for 2018. Also shown in chart 5 is the proposed new ELV within the imminent waste incineration BREF (red dashed line). Much of the BAT listed in the BREF for dust abatement is already in use at the Seal Sands facility: wet Venturi scrubber, wet counter-flow packed column scrubbing and a wet electrostatic precipitator.

Operational data has shown a link between cooling system health and dust emissions. The scattered light device cannot discriminate between water vapour droplets and other particles flowing in its path. Chart 5 shows a gradual upward trend in 'dust' emissions from February to October. In October, the cooling system heat exchangers were cleaned, and the dust emissions were much lower for the rest of the year. This provides two divergent potential paths to pursue for compliance with the proposed ELV, both of which will be considered:

1. Maintain current cooling systems at optimal performance OR
2. Invest in an extractive dust monitoring system (water vapour no longer an issue)

Nitrogen Oxides (NO_x)





All combustion systems which operate in air will produce an amount of thermal NO_x, making nitrogen mass balance as much an art based on tacit understanding and descriptive observation as it is a quantitative science. Nitrogen does not follow predictable rules in terms of mass balance; not all nitrogen in the waste input into the thermal oxidiser is converted to NO and NO_2. There is potential, even in the oxidising environment of the combustion chamber, for nitrogen oxides to be reduced to ammonia and water. Given the challenge the new ELV for NOx within the BREF will present to the waste incineration sector, this phenomenon has and will continue to receive attention.

The factors affecting the fate of nitrogen input into the process include temperature, concentration, flow rate, location of injection point and chemical nature of the nitrogen. From observation, given suitable process parameters, there seems to be a hierarchy of potential to become reduced and go on to participate in chamber de-NOx with ammonia and urea solutions at the top, followed by ammonium salts in solution. Primary amines such as mono methylamine and mono ethylamine have participated in reducing NO and NO_2 output, evidenced by low-level ammonia emissions. The more 'bound' the nitrogen, the higher the propensity to form NOx across a range of temperatures. Tertiary amines such as triethylamine and amides such as dimethylacetamide predictably contribute to elevated NOx emissions.

In 2018, new, larger-scale waste opportunities were pursed, each with an unprecedented level of tehcnical and environmental scrutiny; the materials in the market were assessed against tomorrow's environmental performance requirements. By the summer one of these vetted opportunities manifested in regular business. Chart 6 shows how this operational baseline of the same waste has contributed to lower NO_x emisions. Large quantities of techncially vetted waste is allowing for operational economies of learning, further driving the push toward lower emissions.

There are other similar opportunities being pursued with potential to provide similar benefits. If these are as successful as the mentioned campaign, it will be clear which technologies will be required to future-proof the operation to tomorrow's NO_x emissions standard.

An engineering project to design an ammonia solution delivery system for the purposes of SNCR is on the agenda for 2019. The topic has been raised with the Agency.

Techncial discssion with vendors on other options mentioned as BAT for de-NOx such as catalytic reduction and staged fuel or staged air combustion options will continue in 2019.

1.1.2 Periodic Air Emissions A1 Table S3.1

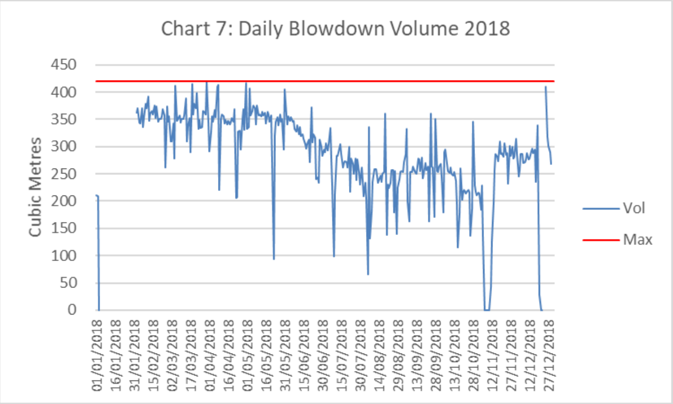
Date Report Ref.	Jun 2018 LNO14360	Nov 2018 LNO14771	Limit	Units	SRM
Dixions and Furans NATO ITEQ	0.002	0.0021	0.1	ng/Nm^3	BS EN 1948
Cd + Tl	0.002	0.002	0.05	mg/Nm^3	BS EN 14385
Heavy Metals	0.04	0.03	0.5	mg/Nm^3	BS EN 14385
Mercury	0.001	0.001	0.05	mg/Nm^3	BS EN 13211
Hydrogen Fluoride	0.1	0.15	2.0	mg/Nm^3	BS ISO 15713

Stack emissions for the parameters listed in table S3.1 of the permit are measured 6-monthly. The results for 2018 are summarised in the table above.

1.2 Emissions to private sewer or treatment facility S1 Table S3.3

1.2.1 Continuously monitored emissions

The process blowdown water flow rate and temperature are both continuously monitored by in-line measurement. The daily total for flow rate is captured by a volumetric flow meter and this data is recorded. The average blowdown temperature is consistently between 82° and 85° with little variation. The flow meter also controls the volumetric flow-proportionate composite sampler. Every day, a composite sample is analysed for solids content and pH via FES/IPC/02. A remaining aliquot of each sample is retained for periodic analysis (see 1.2.2).



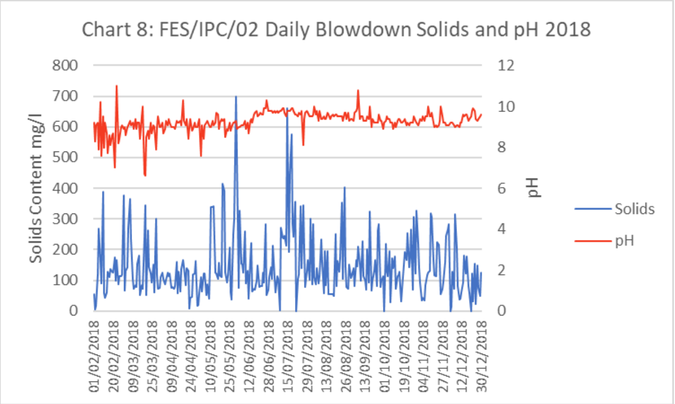
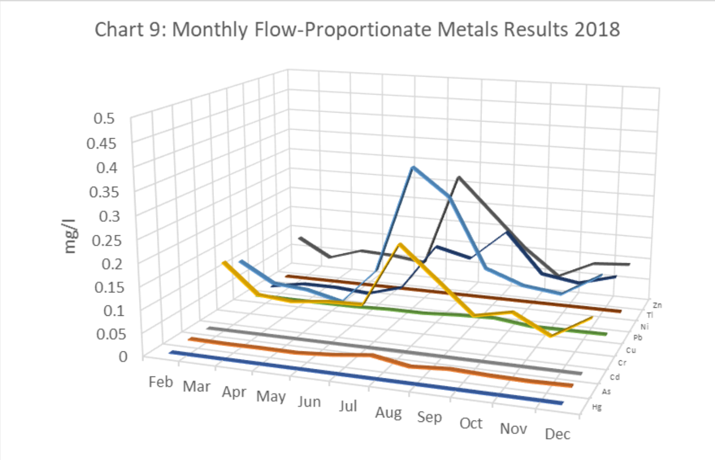


Chart 7 shows the daily differential volumetric flow against the limit set in table S3.3 of the permit. Blowdown is controlled by system level, water pH and conductivity.

Chart 8 shows the 2018 results for the daily in process check (IPC) of the flow-proportionate composite blowdown sample. IPC/02 monitors pH and suspended solids. Every 6 to 9 weeks, depending on requirement, the process is taken offline to remove refractory residues from the quench pot. Acute increases in the suspended solids content of the process blowdown water can be indicative of a need to schedule a quench-pot clean.

1.2.2 Periodic monitoring of emissions to private sewer **Permit Table S3.3**



A monthly flow-proportionate composite sample of the FES blowdown water is prepared and analysed for the metals Hg, Cd, Tl, Cr, Cu, Ni, As, Zn and Pb. Acceptance of wastes containing ppm levels of these metals is controlled under the procedure FES006: Waste Acceptance. Specifically, wastes are analysed using x-ray fluorescence spectrophotometry (XRF) and those containing levels of heavy metals are rejected.

In 2018, two historically problematic streams with propensities to contain copper were identified and disallowed for treatment. 2018 is the first year that all metals listed in table S3.3 were within specified parameters every month.

Chart 9 depicts typical heavy metals content for the portfolio of wastes accepted; mercury, cadmium, thallium and lead are very seldom present. Levels of copper, nickel, chromium and zinc fluctuate but remain below limits specified in table S3.3.

2. Productivity

The Seal Sands Incinerator exists primarily to process waste generated by organic chemical synthesis operations of Lianhetech Seal Sands. Available commercial volume therefore fluctuates complementary to site activity. In mid-2018, the diversity of the external waste portfolio peaked as commercial and technical efforts began to receive business from larger-volume continuous waste streams. From this point onward, efforts to reserve commercial capacity for a select few streams began.

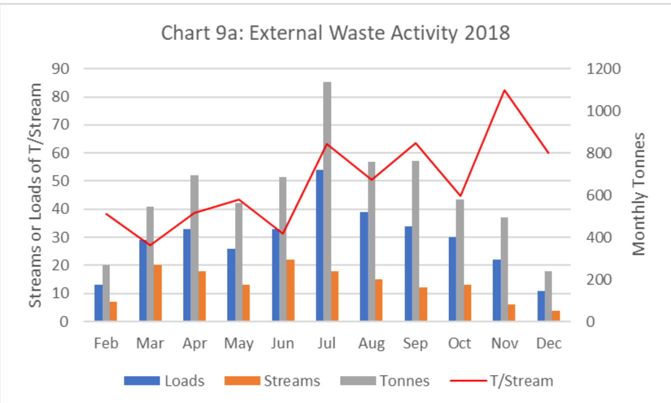
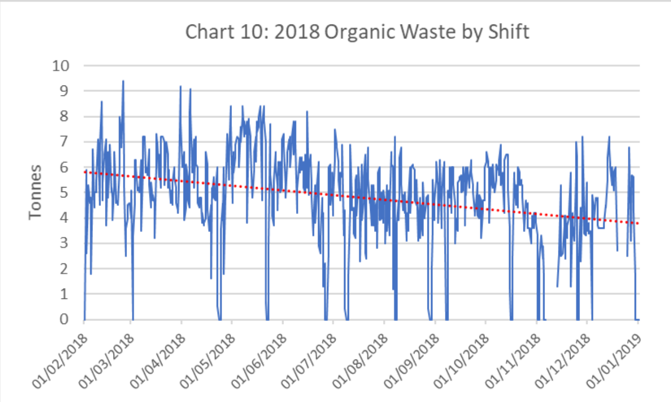


Chart 9a shows commercial, or third-party waste activity for 2018. Available capacity will be a function of site activity and plant availability. The red monthly trendline shows an increase in the amount of waste processed per unique stream or simply fewer select streams.

Fewer, larger volume streams will allow access to economies of scale and learning, both of which will contribute to the strategy for further reduction of environmental impact of the business.

2.1 Hourly Rates

There are three waste inlets for alkaline aqueous, organic and acidic wastes. Organic waste and natural gas support fuel burn in the central burner creating a high-temperature area. Aqueous waste and acidic (T1070) waste are injected from separate outer mains into this high temperature area. Mass of waste processed is recorded hourly to give the shift totals depicted in charts 10-13.



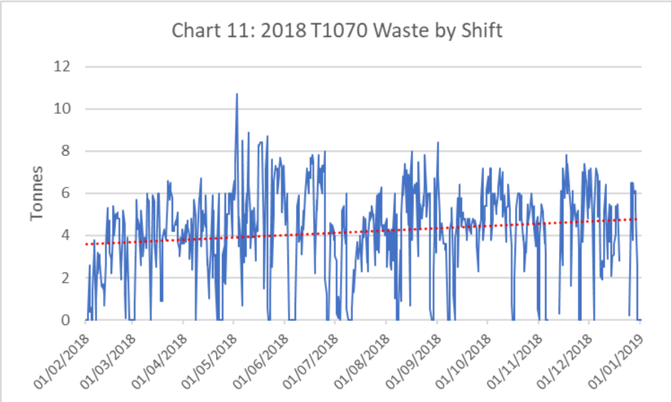
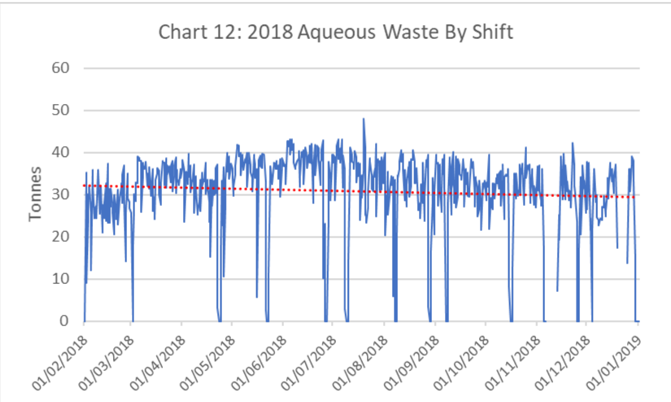
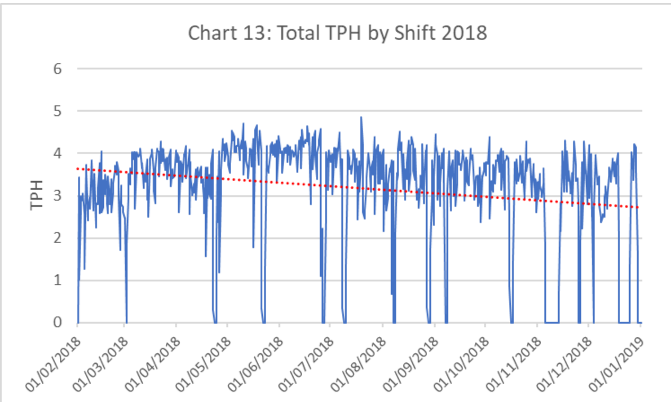


Chart 10 shows the organic waste processed per shift (12-hourly) in 2018. There is a steep decline in organic waste processed as the year progresses. This is due to processing large quantities of aqueous waste of moderate calorific value (10-12MJ/kg). Operations are currently constrained with this stream by incompatibilities with other streams and limited compatibility with materials of construction.

Conversely, Chart 11 shows an increase in the amount of acidic waste processed over the year. This is mostly due to an increase in site production. The process generating this waste will be offline for much of 2019 and moving the energetic aqueous waste into an otherwise unutilised T1070 will be looked at as efforts to optimise the process continue.





Despite the onset of more calories via the aqueous feed train, on average there was only a slight decline in rate of aqueous waste processing, indicated in Chart 12.

The multiple refractory failures are included in the global average calculation of tonnes-per-hour (TPH) in Chart 13 and overall efficacy falls by over 20% consequently.

2.2 Downtime and Slow-Running

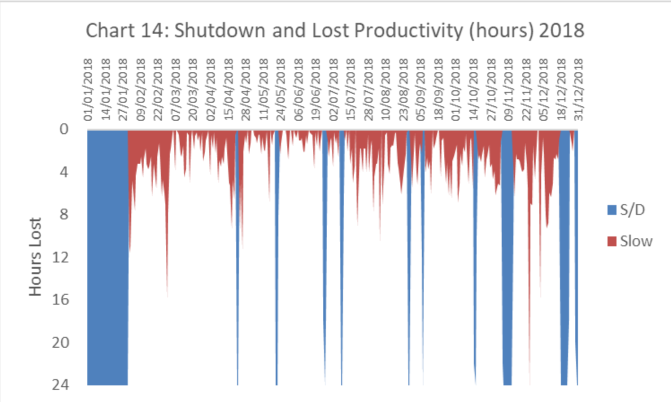


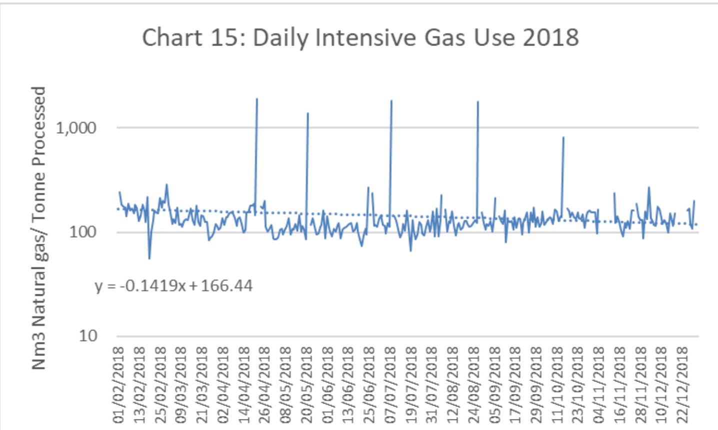
Chart 14 shows shut down periods (in blue) and lost time due to slow running (in red). An ideal chart showing 100% availability would have no blue or red encroaching into the white space. Slow running hours are calculated against KPIs for run rates set by management. Thus, while the red areas are weighted by an arbitrary standard, by these metrics the Seal Sands Incinerator was online with waste feeding on for 6,363 hours in 2018 (73% uptime). Twice as many hours were lost to shut down as to slow running or trips.

Getting more life from the refractory and preventing damage to it continue to be the vectors by which the Seal Sands Incinerator will achieve productivity targets. Having fewer streams in the portfolio

3. Utilities and Energy Consumption

3.1 Natural Gas

Intensive gas use is consumption normalised per unit of business activity, or Nm3 natural gas per tonne of waste processed. In 2018, given efforts in other areas, there was no improvement programme implemented to reduce intensive gas use. Despite this, some marginal gains were made as the year progressed, as indicated in chart 15.



3.2 Electricity Use

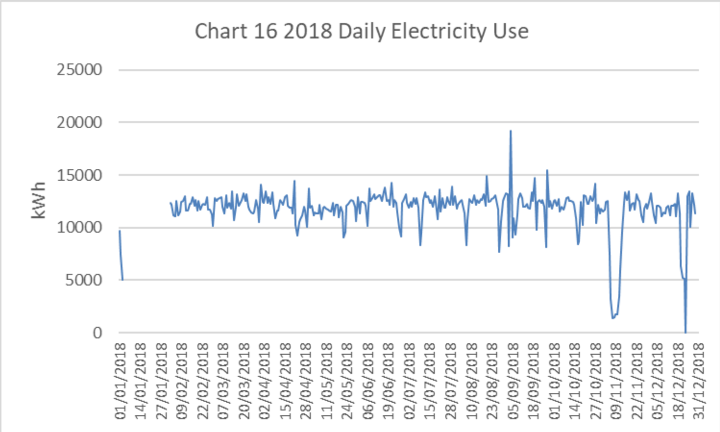


Chart 16 shows the daily electricity use for 2018. FES operates the largest motor on site for the main process induced-draught fan. The many transfer pumps in use operate close to design with little variation in terms of amps drawn. The main process fan is both large and variable is speed. The process uses a Venturi scrubber as one of the dust-abatement systems. The Venturi can be made more effective at reducing dust emissions by reducing the size of the variable-choke aperture. This increases the pressure drop across the Venturi, resulting in better performance at the cost of increased electricity use.

Many of the incinerator area transfer pumps operate inefficiently. The variance in waste density and viscosity requires operations to run pumps with margins on pressure available to maintain an acceptable level of control over flow. While less than optimal for electricity use, this is an additional measure to ensure control over the emissions from the process.

3.3 Water Use

Water use in the incinerator area can be categorised as:

1.	Metered Process Water	>50% total use
2.	Unmetered Process Water	<10% total use
3.	Raw (Unpotable) Water	35-40% total use

Items 2 and 3 are both functions of operating hours; the process consumes about 10 tonnes per operating hour of raw water to supply the quench sprays and a nominal tonne of fresh process water per operating hour for the WESP and water pump seals.

The remaining source of water use is the metered supply to the process cooling tower. The recent re-draft of HSE guidance on the management of legionella in cooling systems (3,4) abandoned the prescriptive ‘means of control’ approach for a more organic ‘desired outcomes’ approach. This considers legionella growth, microbial activity, corrosion, scale and fouling all to be related. Decisions must consider all variables and ultimately any change in an evaporative cooling system must include a legionella risk assessment.

From experience, this approach is a good fit to how the incinerator cooling system is managed in that all variables are related. Given how hard the cooling system works, there is no intention to pursue water conservation efforts here; the risks are too great. To help mitigate these risks, more water may even be used.

4. Requirements of Table S3.4

4.1 Combustion Chamber Temperature

Combustion chamber temperature is monitored by 3 thermocouples located at the base of the combustion chamber. As thermocouples have a finite lifespan, they operate on a 2 out of 3 voting system. The burner management system will trip the process if the temperature is below 850°C or above 1200°C. Feeds may not be introduced until the temperature is between these parameters.

4.2 Feed Rates (kg/day) of wastes fed by type

See section 2.1.

4.3 Exhaust Gas Temperature

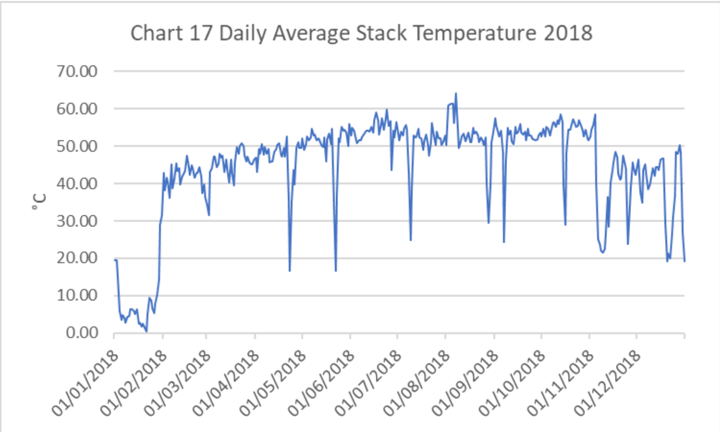


Chart 17 shows the daily average stack temperature for 2018. The process receives dilution heat from the process liquid so the dips in temperature are indicative of process downtime. A consistent stack temperature with little variation during running hours is indicative of healthy heating and cooling systems as the process gas is maintained comfortably above the saturation point. Maintaining healthy heat transfer systems will be part of the strategy to bring and keep dust emissions to below the new ELV proposed by the BREF.

4.4 Exhaust Gas pressure

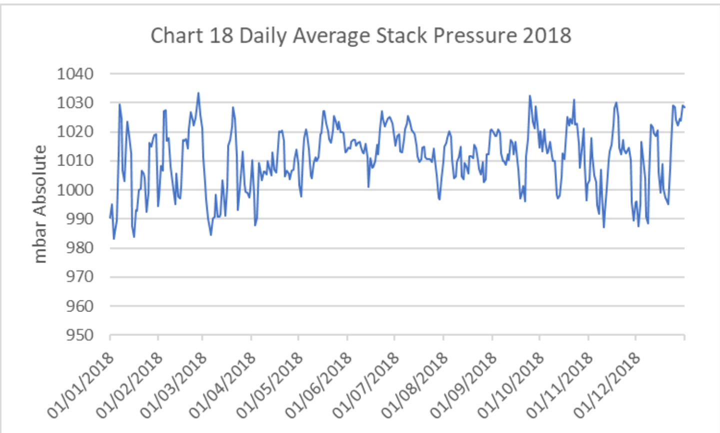


Chart 18 shows the daily average stack pressure in mbar absolute for 2018. Changes in weather patterns will account for most of the variation in this metric. The stack is 1.2m in diameter and the proportion of pressure variance attributable to changes in flow is only a few mbar.

4.5 Exhaust Gas Oxygen Content

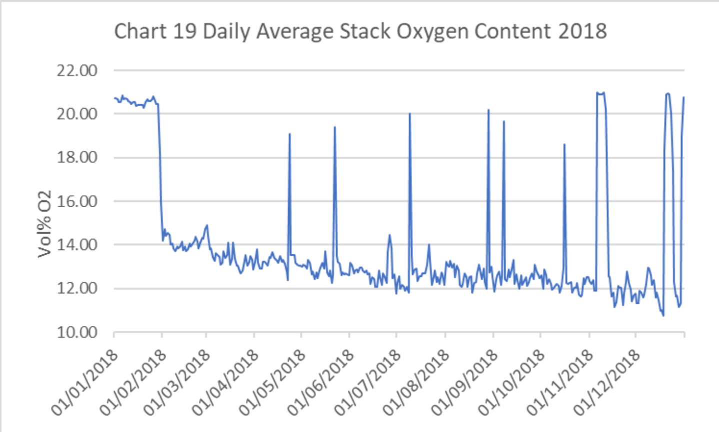


Chart 19 shows the daily average oxygen concentration in the process flue stack. During downtime, the value predictably reverts to 21%; slightly lower than this for down days in which multiple CEMS maintenance and/or calibration activities occur. Thus, this chart can be used to target periods of excessive downtime where the daily average is at or near 21vol%. A downward-sloping baseline is a feature of increasing thermal or volumetric load.

4.6 Exhaust Gas Water Concentration

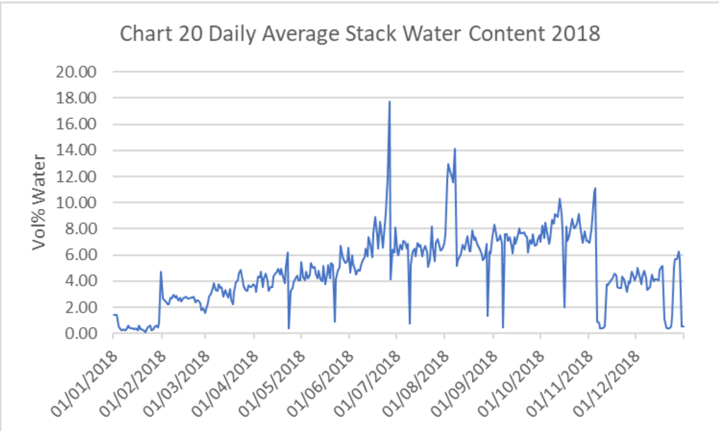


Chart 20 shows a steady incline in the amount of water in the process flue gas over the first ten months of the year. In the January shutdown, the process heat exchangers were cleaned and returned to service. Over the months, the scaling in the system gradually builds up reducing heat transfer efficacy. The process cannot operate without the heat exchangers; the water content of the stack would be far too high. Routine system flushes are being considered. This will become compliance-critical when the new ELV for dust is made live.

References

1. *Integrated Pollution Prevention and Control, Reference Document on the Best Available Techniques for Waste Incineration*, August 2006, The European Commission
2. JRC Science for Policy Report, *Best Available Techniques (BAT) Reference Document for Waste Treatment, Final Draft*, October 2017, European IPPC Bureau
3. ACOP L8: *The Control of Legionella Bacteria in Water Systems*, 2013, Health and Safety Executive
4. HSG274 Part 1, The Control of Legionella Bacteria in Evaporative Cooling Systems, 2013, The Health and Safety Executive
5. Fine Environmental Services Seal Sands Facility Permit number EPR/ZP3438CF