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ABBREVIATIONS

BAT	Best Available Technique
BAT- AEL	Best Available Technique- Associated Emission Levels
BATREF	Best Available Technique Reference (document)
CEMS	Continuous Emissions Monitoring System
CHP	Combined Heat and Power
EA	Environment Agency
EMS	Environmental Management System
EPCm	Engineering, Procurement and Construction Management
EPR	Environmental Permitting Regulations
EU	European Union
FEED	Front End Engineering Design
IED	Industrial Emissions Directive
IPPC	Integrated Pollution Prevention and Control
ISBL	Inside Battery Limits
LCP	Large Combustion Plant
MCR	Maximum Continuous Rate
MoC	Management of Change
NO_x	Nitrogen Oxides
OSBL	Outside Battery Limits
OTNOC	Other Than Normal Operating Conditions
PM	Particulate Matter
SNCR	Selective Non–Catalytic Reduction
TDS	Total Dissolved Solids
TIC	Total Installed Cost
UK	United Kingdom
ULNB	Ultra-Low-NO_X Burners

CONTENTS

1. INTRODUCTION

1.1 Background

Venator Materials UK Ltd (Venator) has contracted with Wood to provide EPCm services for the replacement of their boiler plant located at the Greatham Works, Teesside, United Kingdom.

Venator has identified that its existing boiler equipment is unable to be upgraded to meet forthcoming emission regulations and therefore must be replaced. It is of utmost criticality that this replacement work is completed and the new boiler system fully commissioned and operational prior to the regulatory imposed deadline of 30 June 2020. Any slippage beyond this point would result in the plant being unable to operate and as such must be avoided at all costs.

The replacement boilers will operate on generally the same duty and within the same operations as the current boiler package, so in many respects are a 'like for like' replacement in terms of their process requirements.

Wood has been appointed for the Inside Battery Limits (ISBL) scope which broadly comprises the new boiler package together with the associated service / utility tie ins which are to be provided by Venator (who are undertaking the OSBL scope themselves) at various locations on the existing site.

Previously, Venator completed a Concept study for the project which identified a cleared brownfield area of their existing Greatham site (formerly known as the Black End) on which the boiler package will be located together with the location of the various tie ins which are typically located on the existing pipe-racks on the site.

Wood undertook a FEED study for the project from June to October 2018 (refer to FEED Study Report 17202101-8840-RP-0100) which forms the basis and starting point to this Engineering, Procurement and Construction Management (EPCm) phase.

The extent of work to be executed from Wood's operational centres is outlined in the Wood Project Execution Plan - 17202108-8820-PR-0001 and its associated attachments.

1.2 Description of Project

4 new boilers are required with a total capacity of greater than 100tph steam at 245 ^{0}C - 275 ^{0}C and 24 barg, with a minimum of 245 ^{0}C and 22.8 barg available for the end users. The new facility must be operating before mid 2020 in order to meet the Industrial Emissions Directive (IED) deadline.

1.3 Purpose

The Environmental Permitting Regulations (EPR) are understood to be applicable to the Greatham Works, so an assessment against the relevant technical guidance is required to ensure utilisation of Best Available Techniques (BAT).

This report considers the relevant Environment Agency (EA) sector guidance and the European Union (EU) Industrial Emissions Directive (IED) / Integrated Pollution

Prevention and Control (IPPC) BAT Conclusions and BAT Reference (BATREF) Documents for both sector specific and horizontal guidance.

2. BATREF DOCUMENTS

A BAT Demonstration is mandated by the current Industrial Emissions Directive (IED) and its UK regulatory implementation of the Environmental Permitting Regulations.

To assure compliance, current guidance is consulted. The Greatham Works is considered under the BATREF for Large Volume Inorganic Chemicals – Solids and Others Industry (1) but the BATREF does not make any specific mention of utilities, which is the main provision of this project. However, the project is covered by the BATREF for Large Combustion Plants (2) as the total rated thermal input of the boilers is greater than 50 MW. Each boiler has a net thermal input of 20.4 MW with a maximum of 4 boilers in operation.

3. BAT ASSESSMENT

A review of the techniques required as part of the Large Combustion Plants (LCP) BATREF documents has been conducted. Using natural gas as the fuel source for the burners, represents a key technique to reduce SO_2 emissions as it is a low sulphur fuel. Only the BATREF's relevant to Natural Gas Fired Boilers will be analysed in this report.

3.1 Environmental Management Systems

LCP BATREF BAT 1 Environmental Management Systems.

Venator Materials UK Ltd Environmental Management System (EMS) is registered with ISO14001:2015 accreditation. A review of the BAT 1 features is provided in Table 3-1 and for the new boilers, Venator's EMS is considered to be BAT.

Table 3-1 - BAT 1 Feautures

Item	BAT	Comment	BAT (Y/N)
i	Commitment of top management (commitment of the top management is regarded as a precondition for the successful application of energy efficiency management)	This is demonstrated through Venator's EMS which is compliant with ISO14001:2015.	Y
ii	Definition of an energy efficiency policy for the installation by top management	This is demonstrated through Venator's EMS which is compliant with ISO14001:2015.	Y
iii	Planning and establishing the necessary procedures, objectives and targets, in conjunction with financial planning and investment	This is demonstrated through Venator's EMS which is compliant with ISO14001:2015.	Y
iv	Implementation of procedures	This is demonstrated through Venator's EMS which is compliant with ISO14001:2015.	Y

Item	BAT	Comment	BAT (Y/N)
v	Checking performance and taking corrective action	This is demonstrated through Venator's EMS which is compliant with ISO14001:2015 and also the new boilers will have CEMS with the relevant procedures and protocols to be put in place prior to the boilers being started up.	Y
vi	Review, by senior management, of the EMS and its continuing suitability, adequacy and effectiveness	This is demonstrated through Venator's EMS which is compliant with ISO14001:2015.	Y
vii.	Following the development of cleaner technologies	The new boilers have been designed with cleaner technologies, e.g. natural gas used as the fuel source as opposed to liquid fuels. Venator's environmental department also keep up to date on technologies through various external technical and stakeholder bodies.	Y
viii.	Consideration of eventual decommissioning	Normally decommissioning of TiO_2 process equipment would be covered as a stand-alone project at the time of decommissioning via Venator's MOC and Risk management process. The construction of the new boilers takes into account the eventual decommissioning of the boilers, with design features such as modular pipe rack structures being employed.	Y
ix.	Application of sectoral benchmarking on a regular basis	Compliance with the BAT is a form of sectoral benchmarking and is further demonstrated through Venator's EMS which is compliant with ISO14001:2015.	Y
x.	QA/QC of natural gas	Natural gas is supplied by Equinor via the National Grid which supplies gas to the Gas Safety (Management) Regulations 1996 with the gas quality controlled within specified ranges.	Y
xi.	Management plan to reduce emissions to air/water under non-routine periods	This is currently not conducted for existing boilers but Venator will cover this within the New Boilers Operating procedures as appropriate. Emissions to water are negligible compared to the rest of the site and is managed using existing operational controls.	Y

Item	BAT	Comment	BAT (Y/N)
xii.	Waste management plan	Venator use specific waste management plans for events such as shutdowns. Specific plans for boilers are not in place as they generate very little waste, however site disposal is covered under Venator's general waste management procedures.	Y
xiii.	System for dealing with uncontrolled or unplanned emissions to environment	Venator do not have a system specifically for the boilers as they don't use liquid fuels or self-heating/self-igniting fuels. Venator's EMS does cover spillage of process fluids and gas oil to drains.	Y
xiv.	Dust management plan	Venator's new and existing boilers (the existing Waste Heat Boilers) only use natural gas, and there are no license requirements, so a dust management plan isn't applicable for the boilers.	Y
xv.	Noise management plan	Noise was assessed during the initial introduction of PPC in about 2005 but wasn't considered an issue. No specific monitoring requirements have been inserted in Venator's environmental permit for noise. All equipment for the new boilers, including vents to atmosphere have been designed to not exceed 75 dB.	Y
xvi.	Odour management plan	Venator's boilers will only use natural gas, so a specific odour management plan is not considered to be a requirement. There are no specific odour requirements in Venator's Environmental permit.	Y

3.2 Monitoring

3.2.1 Boiler efficiency

LCP BATREF BAT 2 Boiler efficiency. This will be demonstrated as part of the commissioning process by the boiler vendor and any future impact on net total fuel utilisation will be subject to Venator's Management of Change (MoC) process and EMS.

3.2.2 Monitoring of Process Parameters

LCP BATREF BAT 3

The flue-gas stream should be monitored for flow, Oxygen content, temperature and pressure. The BATREF states this can be periodic or continuous. Currently the boiler design has temperature transmitters and oxygen content analysers on the flue gas so continuous monitoring of these parameters is provided. The current boiler design does not provide continuous water content monitoring.

Continuous Emissions Monitoring System(s) (CEMS) will be provided for the stack.

Manual sample points will be provided which allows for periodic measurement of the flue-gas stream. Monitoring of the water vapour content in the flue gas is assumed not necessary because it is dried prior to analysis.

CEMS, will be provided and the flue-gas oxygen content and temperature will be monitored continuously, therefore emissions monitoring provision is deemed to comply with BAT.

3.2.3 Monitoring Emissions to Air

LCP BATREF BAT 4

For natural gas fired boilers, the substance parameters that should be monitored are NO_X and CO (2 p. 740). The table in BATREF 4 states that the minimum monitoring frequency for NO_X and CO is to have continuous monitoring. However, footnote 3 in the table states, *'In the case of plants with a rated thermal input of < 100 MW operated <1500 h/yr, the minimum monitoring frequency may be at least once every six months'* (2 p. 743). In Article 16(1), which states that, *"The monitoring requirements referred to in Article 14(1)(c) shall, where applicable, be based on the conclusions on monitoring as described in the BAT conclusions"* (3). So, on this basis Wood's interpretation would be that Continuous Emissions Monitoring System (CEMS) is required since the plant is <100 MW but the operating hours are >1500 hr/yr.

However, IED 2010/75/EU Annex V Part 3 (3) states that:

The concentrations of SO2, NOx and dust in waste gases from each combustion plant with a total rated thermal input of 100 MW or more shall be measured continuously.

The concentration of CO in waste gases from each combustion plant firing gaseous fuels with a total rated thermal input of 100 MW or more shall be measured continuously.

This could be interpreted to indicate that only LCP over 100 MW thermal input require continuous monitoring and that any LCP less than 100 MW thermal input design does not require continuous monitoring.

Furthermore, Article 16(2) of the IED states that *"The frequency of the periodic monitoring referred to in Article 14(1)(e) shall be determined by the competent authority in a permit for each individual installation or in general binding rules."*. This means there could be some room for discussion with the Regulator if the requirements are thought to be unreasonably stringent, based on the size of plant and operating hours. The requirement is not clear cut, and the actual requirement will quite likely come down to how this is interpreted by the Regulator.

Confirmation of the CEMS requirement was sought by Venator from the regulator and it has been confirmed that CEMS **is** required and therefore will be included as part of the design (4). Suitable manual sampling points have also been included in the stack design.

3.2.4 Abatement of Continuous Emissions to Air

For the new boiler plant, there is only one emission to air source stream, which is the Boiler vent stack. The boiler feed water is supplied from existing systems and the vent stream from the existing Deaerator has not been included in this assessment and is not included as a requirement within the BATREF to be assessed

The relevant substances to be abated for the project are:

- Nitrogen Oxides (NO_X)
- Sulphur Oxides (SO_X)
- Particulate Matter (PM)
- Carbon Dioxide (CO_2)
- Carbon Monoxide (CO)

3.2.5 Emissions Control

In Section 3 General Techniques to Prevent and/or Reduce Emissions and Consumption of the LCP BATREF, applied common techniques for emissions control are provided.

Table 3-2 - Description of primary techniques for emission control

Fuels/parameters	Combustion modifications			
	Capacity derating	Air and fuel modifications	Burner modifications	In-furnace combustion modifications
Gaseous fuel/NO_X	Reduced temperature reduces thermal NO_X	Flue-gas recycling, fuel air premixing.	Low-NO_X burners	Staged combustion. Reburning, water and steam addition

For this project fuel-air premixing, Flue gas recycling, Ultra-low NOx burners and staged combustion are being provided, therefore are deemed to be BAT.

3.2.6 Integrated Combustion Processes

The boilers are not designed as part of a Cogeneration or Combined heat and power (CHP) Integrated gasification combined cycle or a Combined-cycle combustion process. Therefore, have not been considered further in this report.

3.2.7 Fuel type

Section 3.1.1.5 of the LCP BATREF provides guidance on the fuel type. Fuel gas (circa 87% Methane) is a low-sulphur fuel so is a suitable fuel choice and therefore is considered BAT.

3.2.8 Nitrogen Oxides (NO_X)

LCP BATREF BAT 41 (2 p. 781) considers the prevention or reduction of NO_x emissions from combustion of gaseous fuels. This is reviewed in Table 3-3 with the descriptions taken directly from the LCP BATREF

Table 3-3 - Review of Emissions to Air Techniques

Technique	Description	Discussion
Air and/or fuel staging	The creation of several combustion zones in the combustion chamber with different oxygen contents for reducing NO_X emissions and ensuring optimised combustion. The technique involves a primary combustion zone with substoichiometric firing (i.e. with deficiency of air) and a second reburn combustion zone (running with excess air) to improve combustion. Some old, small boilers may require a capacity reduction to allow the space for air staging.	
Advanced control system	The use of a computer-based automatic system to control the combustion efficiency and support the prevention and/or reduction of emissions. This also includes the use of high-performance monitoring.	This technique is being implemented as part of the boiler and burner management systems.
Flue-gas recirculation	Recirculation of part of the flue-gas to the combustion chamber to replace part of the fresh combustion air, with the dual effect of cooling the temperature and limiting the O2 content for nitrogen oxidation, thus limiting the NO_X generation. It implies the supply of flue-gas from the furnace into the flame to reduce the oxygen content and therefore the temperature of the flame. The	This technique is being implemented as part of the boiler design.

Technique	Description	Discussion
	use of special burners or other provisions is based on the internal recirculation of combustion gases which cool the root of the flames and reduce the oxygen content in the hottest part of the flames.	
Low-NO_X burners (LNB)	The technique (including ultra- or advanced low-NO_X burners) is based on the principles of reducing peak flame temperatures; boiler burners are designed to delay but improve the combustion and increase the heat transfer (increased emissivity of the flame). The air/fuel mixing reduces the availability of oxygen and reduces the peak flame temperature, thus retarding the conversion of fuel-bound nitrogen to NO_X and the formation of thermal NO_X, while maintaining high combustion efficiency. It may be associated with a modified design of the furnace combustion chamber. The design of ultra-low-NO_X burners (ULNBs) includes combustion staging (air/fuel) and firebox gases' recirculation (internal flue-gas recirculation). The performance of the technique may be influenced by the boiler design when retrofitting old plants.	This technique is being implemented as part of the burner design.
Reduction of the combustion air temperature	The use of combustion air at ambient temperature. The combustion air is not preheated in a regenerative air preheater.	This technique will be implemented as part of the boiler design.

Technique	Description	Discussion
Selective catalytic reduction (SCR)	Selective reduction of nitrogen oxides with ammonia or urea in the presence of a catalyst. The technique is based on the reduction of NO_X to nitrogen in a catalytic bed by reaction with ammonia (in general aqueous solution) at an optimum operating temperature of around 300–450 °C. Several layers of catalyst may be applied. A higher NOX reduction is achieved with the use of several catalyst layers. The technique design can be modular, and special catalysts and/or preheating can be used to cope with low loads or with a wide flue-gas temperature window. 'In-duct' or 'slip' SCR is a technique that combines SNCR with downstream SCR which reduces the ammonia slip from the SNCR unit.	This has not been included in the design of the boilers, due to the other measures incorporated into the design, the additional expense and limited additional reduction in emissions this technique is likely to achieve.
Selective non–catalytic reduction (SNCR)	Selective reduction of nitrogen oxides with ammonia or urea without a catalyst. The technique is based on the reduction of NOX to nitrogen by reaction with ammonia or urea at a high temperature. The operating temperature window is maintained between 800 °C and 1 000 °C for optimal reaction.	This technique has been deemed not to be applicable as per the guidance provided in LCP BATREF BAT 41 Table 10.4.1.2, which states that 'generally it is not applicable to combustion plants of < 100 MW.

For new combustion plant the yearly average Best Available Technique - Associated Emission Levels (BAT-AEL) is provided in Figure 1 (2 p. 785). For new combustion plant the BAT-AEL is a maximum of 60 mg/Nm^3 and the boilers are to be designed to operate at levels below the maximium BAT-AEL levels. High combustion efficiency is ensured by running excess oxygen in the flue, with a control point of 3% excess. A feature is configured to trip the boiler if the excess oxygen level drops below 1%. The boiler design is considered to be compliant with BAT.

Table 10.25: BAT-associated emission levels (BAT-AELs) for NO_X emissions to air from the combustion of natural gas in boilers and engines

Type of combustion plant	BAT-AELs (mg/Nm^3)			
	Yearly average (1)		Daily average or average over the sampling period	
	New plant	Existing plant (2)	New plant	Existing plant (3)
Boiler	10–60	50–100	30–85	85–110
Engine (4)	20–75	20–100	55–85	55–110 (5)

(1) Optimising the functioning of an existing technique to reduce NO_X emissions further may lead to levels of CO emissions at the higher end of the indicative range for CO emissions given after this table.
(2) These BAT-AELs do not apply to plants operated < 1 500 h/yr.
(3) For plants operated < 500 h/yr, these levels are indicative.
(4) These BAT-AELs only apply to spark-ignited and dual-fuel engines. They do not apply to gas-diesel engines.
(5) In the case of engines for emergency use operated < 500 h/yr that could not apply the lean-burn concept or use SCR, the higher end of the indicative range is 175 mg/Nm^3.

Figure 1 - BAT-AELS For NO_X Emissions to Air

3.2.9 Sulphur Oxides (SO_x)

As stated in the LCP BATREF, the '*SO_x emissions from combustion plants burning natural gas are not an environmental concern under normal operation and controlled combustion conditions. However, whilst SO_2 emissions are not environmentally significant, a small portion of the SO_2 can oxidise to SO_3, a reaction enhanced where catalyst is present, resulting in fouling and corrosion of downstream surfaces*' (2 p. 547). Therefore, abatement techniques for SO_2 in the flue gas e.g. scrubbing processes are deemed unnecessary and not assessed further. The design is deemed to be BAT.

3.2.10 Dust and Particulate Matter (PM)

The particulate matter emissions from the flue gas are negligible due to the use of clean gas fuel and not assessed further. The design is deemed to be BAT.

3.2.11 Carbon Dioxide (CO_2)

No specific BAT but implied by generic principles.

Carbon dioxide emissions arise from the combustion of the hydrocarbon fuel and are not considered a contaminant as such. However, the amount of carbon dioxide emission is related to the efficiency of the boiler, which is given as 93.1% at 100% Maximum Continuous Rate (MCR) and 92.5% efficiency at 33% MCR.

3.2.12 Carbon Monoxide (CO)

LCP BATREF BAT 44 states, 'In order to prevent or reduce CO emissions to air from the combustion of natural gas, BAT is to ensure optimised combustion and/or to use oxidation catalysts' (2 p. 783). The optimised combustion follows the same principles identified in section 3.2.5 Emissions Control. BAT-AEL levels for CO are provided as 5 to 15 mg/Nm^3 (2 p. 785). The boiler is designed to be within these limits and is therefore deemed to comply with BAT.

3.3 General Environmental and Combustion Performance

LCP BATREF BAT 6 requires optimised combustion to reduce CO and other unburnt substances. Appropriate combination of techniques is required and Table 3-4 shows the review of techniques that will be applied, and the design is deemed to comply with BAT.

Table 3-4 - General Enviromental and Combustion Performance Review

Technique		Description	Discussion
a	Fuel blending and mixing	Ensure stable combustion conditions and/or reduce the emission of pollutants by mixing different qualities of the same fuel type	This technique is not being implemented as part of the boiler and burner management systems. Excess air will be used in the burners.
b	Maintenance of the combustion system	Regular planned maintenance according to suppliers' recommendations	This will be applied as per Venator's maintenance management system, EMS and maintenance contract with suppliers
c	Advanced control system		This technique is being implemented as part of the boiler and burner management systems
d	Good design of the combustion equipment	Good design of furnace, combustion chambers, burners and associated devices	This technique is being implemented as part of the boiler and burner management systems
e	Fuel choice	Select or switch totally or partially to another fuel(s) with a better environmental profile (e.g. with low sulphur and/or mercury content) amongst the available fuels, including in start-up situations or when back-up fuels are used	Natural gas will be used which has low sulphur content. No back-up fuels are to be used.

LCP BATREF BAT 9 requires full characterisation and ongoing testing of the fuel quality to be used by the boiler. The natural gas supply to the Greatham works is from the National Transmission System and will be subject to a product quality specification so is deemed to comply with BAT.

LCP BATREF BAT 10 requires other than normal operating conditions (OTNOC) to be included in the EMS to consider and implement in the design scenarios that could impact

emissions to air, water and soil. Additionally, the preventative maintenance and review and recording of emissions from OTNOC scenarios with corrective actions are required to be included in the EMS. It is assumed that with Venator's ISO 14001 certification and Maintenance Management System that these requirements are in place and deemed to comply with BAT

LCP BATREF BAT 11 requires appropriate monitoring of emissions to air and/or water during OTNOC which can be conducted by direct measurement or surrogate parameters. This is not included in the current design and therefore does not comply with BAT

3.4 Energy efficiency

LCP BATREF BAT12 (2 p. 748) provides general techniques that should be used in combination to increase the energy efficiency of natural-gas-fired boilers. The review is provided in Table 3-5. Only the techniques applicable to this design have been reviewed and listed in the table.

Table 3-5 - Energy Efficiency Technique Review

Technique		Description	Discussion
a	Combustion optimisation	Optimising the combustion minimises the content of unburnt substances in the flue-gases and in solid combustion residues	This technique is being implemented as part of the boiler and burner management systems.
b	Optimisation of the working medium conditions	Operate at the highest possible pressure and temperature of the working medium gas or steam, within the constraints associated with, for example, the control of NO_X emissions or the characteristics of energy demanded	Implemented as part of the design.
d	Minimisation of energy consumption	Minimising the internal energy consumption (e.g. greater efficiency of the feed-water pump)	Fuel gas economiser included in the design
g	Advanced control system	Computerised control of the main combustion parameters enables the combustion efficiency to be improved	Implemented as part of the design.
h	Feed-water preheating using recovered heat	Preheat water coming out of the steam condenser with recovered heat, before reusing it in the boiler	Boiler Feed Water is preheated in the Economiser and prior to entering the deaerator.
o	Fuel pre-drying	The reduction of fuel moisture content before combustion to improve combustion conditions	Fuel gas is supplied as a dry gas from the site main.

As part of BAT40, the BAT AEEL's (Associated Energy Efficiency Levels) for the combustion of Natural gas are required and need to comply with the values as shown in Figure 2. The stated net total fuel utilisation is 92.7%.

Table 10.23: BAT-associated energy efficiency levels (BAT-AEELs) for the combustion of natural gas

Type of combustion unit	BAT-AEELs (1) (2)				
	Net electrical efficiency (%)		Net total fuel utilisation (%) (3)(4)	Net mechanical energy efficiency (%) (4)(5)	
	New unit	Existing unit		New unit	Existing unit
Gas engine	39.5–44 (6)	35–44 (6)	56–85 (6)	No BAT-AEEL.	
Gas-fired boiler	39–42.5	38–40	78–95	No BAT-AEEL.	
Open cycle gas turbine, ≥ 50 MWth	36–41.5	33–41.5	No BAT-AEEL	36.5–41	33.5–41
Combined cycle gas turbine (CCGT)					
CCGT, 50–600 MW_{th}	53–58.5	46–54	No BAT-AEEL	No BAT-AEEL	
CCGT, ≥ 600 MW_{th}	57–60.5	50–60	No BAT-AEEL	No BAT-AEEL	
CHP CCGT, 50–600 MW_{th}	53–58.5	46–54	65–95	No BAT-AEEL	
CHP CCGT, ≥ 600 MW_{th}	57–60.5	50–60	65–95	No BAT-AEEL	

(1) These BAT-AEELs do not apply to units operated < 1 500 h/yr.
(2) In the case of CHP units, only one of the two BAT-AEELs 'Net electrical efficiency' or 'Net total fuel utilisation' applies, depending on the CHP unit design (i.e. either more oriented towards electricity generation or heat generation).
(3) Net total fuel utilisation BAT-AEELs may not be achievable if the potential heat demand is too low.
(4) These BAT-AEELs do not apply to plants generating only electricity.
(5) These BAT-AEELs apply to units used for mechanical drive applications.
(6) These levels may be difficult to achieve in the case of engines tuned in order to reach NO_X levels lower than 190 mg/Nm^3.

Figure 2 - BAT-AEELs for Combustion of Natural GAs

The combination of techniques applied for the boiler plant can be considered compliant with BAT.

3.5 Emissions to Water

There is no flue-gas treatment required for the design. However, an automatic Total Dissolved Solids (TDS) blowdown system will be installed which has an analyser with control panel, which will automatically monitor the boiler water TDS and then maintain the solids level within the operational specification of the boiler. The blowdown system uses raw water with a temperature controller to ensure the purged boiler feed water waste stream is below 50 ^{0}C, which is 10 ^{o}C below the maximum design temperature of the plant drains system.

The effluent system at Greatham is designed to discharge up to 12,000m3/day to the Tees estuary at high tide via large settling and holding lagoons. The boiler blowdown from the new boilers will directly replace the boiler blowdown from the existing boilers and is in the order of 1% of boiler output. Maximum steam demand is 94tph. Therefore, the blowdown is approx. 1m^3/hour or 24m^3/day and considered insignificant compared to the total effluent discharged.

The plant drains system is clay in construction, and while clay is resistant to elevated temperatures if heated slowly, shock heating can cause failure. As the automatic

blowdown will control the TDS, the purge of boiler feed water will be intermittent, and the amount of raw water used for cooling would be minimised. Replacement of the drains to withstand a higher temperature to handle the blowdown waste stream, was not considered feasible, as it would have required excavation and movement of subsoil, disposal of redundant clay drain and installation of a new drain.

Re-use of the waste stream from the blowdown vessel e.g. recovering the waste water for use in cooling water towers, was not deemed feasible as the water flow throughputs would be minimal and the capital costs would be disproportionate to any benefit gained.

The design is considered to be compliant with BAT.

3.6 Noise Emissions

LCP BATREF BAT17 Noise emissions is to reduce the noise levels emitted by the equipment. A review of the applied techniques is provided in Table 3-6. Only the applicable techniques have been reviewed and listed in the table.

Table 3-6 - Noise Emissions Review

Technique		Description	Discussion
a	Operational measures	These include: improved inspection and maintenance of equipment, closing of doors and windows of enclosed areas, if possible, equipment operated by experienced staff avoidance of noisy activities at night, if possible and provisions for noise control during maintenance activities	This is applied and controlled as part of Venator's safe systems of work.
b	Low-noise equipment	This potentially includes compressors, pumps and disks	The only rotating equipment is the flue-gas recirculation fans which are supplied with acoustic foam lining to limit the operating noise level to 75 dB(A) @ 1 metre at M.C.R.
c	Noise attenuation	Noise propagation can be reduced by inserting obstacles between the emitter and the receiver. Appropriate obstacles include protection walls, embankments and buildings	This is not considered to be required as the noise levels of the specified equipment will be limited to 75 dB(A) @ 1 metre at M.C.R.

Technique		Description	Discussion
d	Noise-control equipment	This includes, noise-reducers, equipment insulation, enclosure of noisy equipment and soundproofing of buildings	Snorkel air inlet silencer to be fitted to all burners as standard, and is complete with acoustic foam lining to limit the operating noise level to 75 dB(A) @ 1 metre at M.C.R. Boiler steam auto vents will be fitted with silencers to reduce noise from Steam venting
e	Appropriate location of equipment and buildings	Noise levels can be reduced by increasing the distance between the emitter and the receiver and by using buildings as noise screens	The equipment will be relocated in an area that was previously used for process plant and will be located a minimum of 10 metres away from any occupied building

The combination of techniques applied for the boiler plant can be considered to comply with BAT.

4. CONCLUSION

It can be determined from the assessment that many of the techniques applied to the boiler design and Venator's EMS comply with BAT for Natural gas fired boilers for combustion plant greater than 50 MW and greater than 1500 hr/year operation.

5. REFERENCES

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