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BAT reference Number	**BAT Statement**	**Applicability Assessment**	**State if in place or state schedule for implementation**
BAT 1	BAT 1.In order to improve the overall environmental performance of plants for the refining of mineral oil and gas, BAT is to implement and adhere to an environmental management system (EMS) that incorporates all of the following features: (i) commitment of the management, including senior management; (ii) definition of an environmental policy that includes the continuous improvement for the installation by the management; (iii) planning and establishing the necessary procedures, objectives and targets, in conjunction with financial planning and investment; (iv) implementation of the procedures paying particular attention to: (a) structure and responsibility (b) training, awareness and competence (c) communication (d) employee involvement (e) documentation (f) efficient process control (g) maintenance programmes (h) emergency preparedness and response (i) safeguarding compliance with environmental legislation. (v) checking performance and taking corrective action, paying particular attention to: (a) monitoring and measurement (see also the reference document on the General Principles of Monitoring) (b) corrective and preventive action (c) maintenance of records (d) independent (where practicable) internal and external auditing in order to determine whether or not the EMS conforms to planned arrangements and has been properly implemented and maintained; 28.10.2014 L 307/46 Official Journal of the European Union EN	*Applicable*	*Yes - Standardised EMS in place, this is incorporated as part of the site HSE management system*

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	(vi) review of the EMS and its continuing suitability, adequacy and effectiveness by senior management; (vii) following the development of cleaner technologies; (viii) consideration for the environmental impacts from the eventual decommissioning of the installation at the stage of designing a new plant, and throughout its operating life; (ix) application of sectoral benchmarking on a regular basis.		
BAT 2	BAT 2.In order to use energy efficiently, BAT is to use an **<u>appropriate combination</u>** of the techniques given	Applicable to main plant operation	Yes - Combination of techniques described is in place
	(i) Design Techniques	a) Pinch Analysis	Yes – this is integral to refinery operations as the efficiency of each unit is sought to be optimised
		b) Heat integration	Yes – the refinery heating system is integrated. Refinery engineering practices are followed for heat integration, for example; streams at temperatures >100 DegC are used in heat exchangers such that excess heat energy is passed to another process stream. IOW are also in the process of filling the position of Energy Engineer, identification of new opportunities will be within this person's remit
		c) Heat and power recovery	Yes – the site operates a CHP plant which reduces the need to draw electricity from the national grid. CHP uptime and electricity generated are tracked

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			monthly and reported annually as part of the IE license annual report
	(ii) Process control and maintenance techniques	a) Process Optimisation	Yes – process optimisation is integral to IOW refinery operations. All combustion units operate via computer control systems. All combustion units have CO and O2 monitors in place. There are targets on O2 and safe operating limit alarms on minimum O2. Fuel usage is monitored versus steam/heat output in order to optimise fuel usage. Off-gases from all units are fed into the refinery gas mains for use as fuel. Uptime and efficiency of each unit is reviewed monthly versus throughput
		b) Management and reduction of steam consumption	Yes Furnace/boiler efficiency and steam consumption is monitored and managed
		c) Use of energy benchmark	Will be – External benchmarking was completed on a regular basis and energy use is currently tracked by the unit engineers. IOW are in the process of filling the role of Energy engineer, part of this role will be benchmarking and production of an energy efficiency index.
	(iii) Energy Efficient Production Techniques	a) Use of combined heat and power	The site operates a CHP unit at SG5
		b) Integrated gasification combined cycle	**N/A**
BAT 3	In order to prevent or, where that is not practicable, to reduce dust emissions from the storage and handling of dusty materials, BAT is to use one or a combination of the techniques	Not Applicable, No powder handling processes on site	**N/A**

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BAT reference Number	**BAT Statement**	**Applicability Assessment**	**State if in place or state schedule for implementation**
	given		
BAT 4.	BAT is to monitor emissions to air by using the monitoring techniques with at least the minimum frequency given and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality	i) **SOx & NOx** **Applicable** for combustion units: (**50-100MW**) F401 **(<50MW):** F402/ 501/ 201/ 202AN/ 202BX/CX/ 203/ 204/ 206/207/ 801/802/ 901, CHP **Not applicable** to units that do not burn refinery fuel: A2-12/13/14; C201's & C202 (<5MW, burn nat gas only), and A1-1,2,3; SG4/ SG5/ SG6 (<50MW, burn natural gas only) **Dust** **Applicable** for combustion units: **(50-100MW)** F401 **(<50MW):** F402/ 501/ 201/ 202AN/ 202BX/CX/ 203/ 204/ 206/207/ 801/802/ 901, CHP **Not applicable** to units that do not burn refinery fuel: A2-12/13/14; C201's & C202 (<5MW), and A1-1,2,3; SG4/ SG5/ SG6 (<50MW, burn natural gas only) **Note,** for the ASA Sulphur Recovery Unit (A2-18), only SO_2 is **applicable**	**SOX, NOx, Will Be** See attached Table 4 for revised monitoring plan Dust; **Will Be** Significant modifications are required at the emission points listed to allow monitoring for dust. These changes can only be completed during a site shut down. The next site shutdown is scheduled for 2019 and therefore IOW will be able to measure emission points for dust from Q4 2019
		ii) NH_3 Applicable to ASA (A2-18)	**Will be,** The recent EU guidance document *'Commission Implementing Decision (EU) 2017/1442 of 31 July 2017 establishing best available*

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			techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for large combustion plants', covers large combustion plants (LCP) with a thermal input of a minimum of 50MW, with no upper limit to the thermal input. BAT 4 within the BATc document for LCP is similar to that for the refining of oil and gas, in that it requires the continuous monitoring of ammonia where a plant is equipped with SCR. However, the BATc for LCP includes a footnote, footnote 4, relating to the requirement for continuous monitoring. Footnote 4 states: *'In the case of use of SCR, the minimum monitoring frequency may be at least once every year, if the emission levels are proven to be sufficiently stable'*. IOW propose to utilize this footnote to undertake periodic monitoring of ammonia. Plants falling within the scope of the LCP are over 25x larger than the burner for the ASA unit at A2-18. SCR ammonia consumption is a function of unit size, and as there is an allowance for larger SCR plant to utilize periodic monitoring, it would be proportionate to allow IOW to do so as well IOW propose to carry out monitoring for ammonia at the emission point A2-18 (ASA stack) quarterly, beginning Q4 2018. Once emission levels are proven to be sufficiently stable,

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			IOW propose to reduce the monitoring frequency to annually
		iii) CO **Applicable** for combustion units. F401/ F402/ 501/ 201/ 202AN/ 202BX/CX/ 203/ 204/ 206/207/ 801/802/ 901, CHP **Not applicable** to units that do not burn refinery fuel: A2-12/13/14; C201's & C202 (<5MW), and A1-1,2,3; SG4/ SG5/ SG6 (<50MW, burn natural gas only) **Not applicable** for Sulphur Recovery unit (A2-18)	**Will be,** See attached Table 4 for revised monitoring plan The relevant emission points are currently monitored annually for CO. These will be monitored every 6 months from Oct 2018
		iv) Metal emissions **Not applicable** to units burning only gaseous fuels. All combustion units at IOW use gaseous fuels during normal operation	N/A
		v) PCDD/F; **Applicable to combustion units** burning off -gases from the Reformer: F401/ F402/ 501/ 201/ 202AN/ 202BX_CX/ 203/ 204/ 206/207/ 801/802/ 901 **Not applicable** to units that do not burn refinery fuel: A2-12/13/14; C201's & C202 (<5MW), and A1-1,2,3; SG4/ SG5/ SG6 (<50MW, burn natural gas only) **Not applicable** for Sulphur Recovery unit (A2-18), (not associated with reformer unit) **Not applicable** for CHP (not associated with reformer unit)	**Will be;** Monitoring PCDD/F is not currently required as part the existing IE license. Significant changes are required at the emission points listed to monitor for PCDD/F. These changes can only be completed during a site shut down. The next site shutdown is scheduled for 2019 and therefore IOW will be able to measure emission points for PCDD/F from Q4 2019 The relevant emission points will be monitored annually until data demonstrates stability. Once stable the requirement will be reduced or removed.

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BAT reference Number	**BAT Statement**	**Applicability Assessment**	**State if in place or state schedule for implementation**
BAT 5	BAT is to monitor the relevant process parameters linked to pollutant emissions at catalytic cracking and **combustion units** by using appropriate techniques and with at least the frequency given	**Applicable for combustion units**. CEMs for NOx & SOx not in place. Applicable to furnaces burning refinery fuel gas F401, F402, F501, F201, F202AN, F202BX/CX, F203, F204, F206/207, F801/802 & F901, CHP **Not applicable** to boilers SG4, SG5 and SG6, or compressors as these burn natural gas only.	**Yes – O2 monitors** already in place at stacks **Will be** – Capability and procedures for N & S analysis of refinery fuel gas will be in place by the end of Q3 2018. The N& S content of refinery fuel gas will be analysed at an interval to be determined, for use in indirect continuous emissions monitoring by calculation (Ref BAT4 (i))
BAT 6	BAT is to monitor diffuse VOC emissions to air from the entire site by using all of the following techniques:	**Applicable**	
	Sniffing methods associated with correlation curves for key equipment		Will be, LDAR system to be put in place by Q4 2018
	Optical gas monitoring techniques		Will be, LDAR system to be put in place by Q4 2018
	Calculations of chronic emissions based on emissions factors periodically validated by measurements		**Yes** – VOC losses from tankage are calculated monthly and are validated as part of inventory tracking. VOC losses from other sources – plant leak losses, WWTP etc, are calculated annually by mass balance and are submitted as part of the PRTR
BAT 7	In order to prevent or reduce emissions to air, BAT is to operate the ***acid gas removal units, Sulphur recovery*** units and all other waste gas treatment system with a high availability and at optimal capacity	**Applicable** to ASA plant (amine & sulphuric acid plant removes sulphur from refinery fuel gas)	**Yes** ASA (Amine & Sulphuric Acid) plant has >96% uptime and is optimised to maximise sulphuric acid production for sale. ASA Plant downtime is recorded for inclusion in quarterly reports, ref IE license conditions 5.7, 5.8 and 6.19.
BAT 8	In order to prevent and reduce	Applicable to SCR at ASA	**Yes**

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	ammonia (NH3) emissions to air when applying selective catalytic reduction (SCR) or selective non-catalytic reduction (SNCR) techniques, BAT is to maintain suitable operating conditions of the SCR or SNCR waste gas treatment systems, with the aim of limiting emissions of unreacted NH3.	plant	The ASA (Amine & Sulphuric Acid) is operated to minimise NH_3 slip. The design spec of the plant is such that the outlet of the SCR should have an ammonia concentration of 10ppm or less. The vendor specification documents, including the mass balance, indicate there should be no ammonia emission at the outlet stack, as anything not used up in the catalysis will be removed in the SO_2 converter The ammonia is prepared to give a uniform concentration and mixers are installed to ensure a homogeneous composition and temperature of the flue gas
	BAT Associated Emission Level	<5-15mg/Nm3	**Will Be** Measurement of NH3 at the ASA plant will be undertaken from Q4 2018 as per the response to BAT4.
BAT 9	In order to prevent and reduce emissions to air when using a sour water steam stripping unit, BAT is to route the acid off-gases from this unit to an SRU or any equivalent gas treatment system.	**Applicable** – Sour water stripper	**Yes** The sour water stripper routed to the Wet Sulphuric acid section of the Amine Sulphuric Acid (ASA) plant for acid gas treatment
BAT 10	BAT is to monitor emissions to water by using the monitoring techniques with at least the frequency given in Table 3) and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.	**Applicable** for SW1, WWTP emission point.	**Will be.** The current SW1 sampling regime will be modified to align with the BAT requirements by end Q3 2018 using a combination of on-site laboratory analysis and contract laboratories.
BAT 11	In order to reduce water consumption and the volume of	i) Water stream integration – **Not**	N/A

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	contaminated water, BAT is to use all of the techniques given	**applicable, existing installation**	
		(ii) Water and drainage system for segregation of contaminated water streams- **Not applicable, existing installation**	N/A – All process waste-water and surface water is treated in the site WWTP
		(iii) Segregation of non-contaminated water streams (e.g. once- through cooling, rain water) **Not applicable, existing installation**	N/A – All process waste-water and surface water is treated in the site WWTP
		(iv) Prevention of spillages and leaks	Bulk tanks are taken out of service on a rolling schedule whereby they are emptied, inspected and any repairs completed. Overhaul includes repair and replacement of seals, including phased installation of secondary seals for floating roof tanks. Internal tank coatings are inspected/repaired (tank bottom and 1m high on walls). A comprehensive pipe management and maintenance system is in operated whereby details of all the pipe circuits are stored electronically IOW operates integrity testing under the American Petroleum Institute (API) Inspection Industry Standard. The inspection group schedule integrity testing based on historical data, trends and pre-set alarms as per the API 570 Standard. All (100%) of the above ground pipes are visually inspected and non-destructive testing is completed at regular intervals at specific Thickness Monitoring Location (TML) points on

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			each circuit. Resistivity testing by Specialist Contractor is completed as required along the buried pipes sections
BAT 12	In order to reduce the emission load of pollutants in the waste water discharge to the receiving water body, BAT is to remove insoluble and soluble polluting substances by using all of the techniques given.	(i) Removal of insoluble substances by recovering oil: **Applicable**	Yes – API separator in place
		ii) Removal of insoluble substances by recovering suspended solids and dispersed oil: **Applicable**	Yes – DAF unit and sand filter in place
		iii)Removal of soluble substances including biological treatment and clarification: **Applicable**	Yes – Clarifier and biological treatment in place
BAT 13.	When further removal of organic substances or nitrogen is needed, BAT is to use an additional treatment step as described	**Applicable**	Yes – Biological treatment in place for removal of nitrogen
BAT 14	In order to prevent or, where that is not practicable, to reduce waste generation, BAT is to adopt and implement a waste management plan that, in order of priority, ensures that waste is prepared for reuse, recycling, recovery or disposal.	**Applicable**	Yes – The site operates a tiered waste management system whereby the waste hierarchy is followed. This is shown in attachments C.1, C.2 and C.3 The waste management system aims to reduce waste production, reuse and /or recycle where possible. Opportunities for improvement of the amount of the site's waste sent for recycling have been identified and these will be progressed with IOW's waste management companies in 2018
BAT 15	In order to reduce the amount of sludge to be treated or disposed of, BAT is to use one or a combination of the techniques given.	(i) Sludge pretreatment; **Applicable**	Yes – Sludge recovered from the API separator is returned to tankage for reprocessing. Sludge collected for disposal is dewatered in a centrifuge prior to disposal
		(ii) Reuse of sludge in process units; **Applicable**	
BAT 16.	In order to reduce the generation of spent solid catalyst waste, BAT is to use one or a combination of the	(i) Spent solid catalyst management; **Applicable**	Spent catalyst is collected from six units on site. Catalyst use is optimised to minimise the need for

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	techniques given.		change out (catalyst is regenerated where feasible until fully spent). Catalyst is collected and shipped as hazardous waste to specialised facilities where precious metals are recovered and recycled.
		(ii) Removal of catalyst from slurry decant oil; **Not Applicable**	N/A, IOW does not produce this type of waste (does not operate an FCC or similar unit
BAT 17.	In order to prevent or reduce noise, BAT is to use **one or a combinatio**n of the techniques given:	i) Make an environmental noise assessment and formulate a noise management plan as appropriate to the local environment; **Applicable**	Yes - Environmental noise measurements are completed annually as part of the IE license condition 6.14 and as per emission limits in schedule B.4 The site has five noise-sensitive locations identified, two of which are residential areas A site noise mapping exercise completed in 2016 highlighted the areas of highest noise generation on site
		(ii) Enclose noisy equipment/operation in a separate structure/unit; **Applicable**	Yes – equipment such as pressure relief valves are enclosed where practicable to reduce noise
		(iii) Use embankments to screen the source of noise;	N/A The site is surrounded by established trees which help reduce noise
		iv) Use noise protection walls.	N/A The site is surrounded by established trees which help reduce noise
BAT 18.	In order to prevent or reduce diffuse VOC emissions, BAT is to apply the techniques given		
	i. Techniques related to plant design	**Not applicable, existing installation** i. Limiting the number of potential emission sources ii. Maximizing inherent process containment features iii. Selecting high integrity equipment	**N/A –** However the site endeavours to minimise losses through mechanical and procedural means, see iii below. Will be applied to new units

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		iv. Facilitating monitoring and maintenance activities by ensuring access to potentially leaking components	
	ii. Techniques related to plant installation and commissioning	**Not applicable, existing installation,** i. Well defined procedures for construction and assembly ii. Robust commissioning and handover procedures to ensure that the plant is installed in line with the design requirements	**N/A –** However well-defined and robust procedure for construction, handover and commissioning are in place for new units
	iii. Techniques related to plant operation – **Generally Applicable**	**Applicable** Use of a risk based leak detection and repair LDAR programme in order to identify leaking components and to repair these leaks Table 1.20.6	IOW operates and monitors a VRU at the road loading facility as per the requirements of VOC license Bulk tanks are taken out of service on a rolling schedule whereby they are emptied, inspected and any repairs completed. Overhaul includes repair and replacement of seals, including phased installation of secondary seals for floating roof tanks. Internal tank coatings are inspected/repaired (tank bottom and 1m high on walls). A comprehensive pipe management and maintenance system is in operated whereby details of all the pipe circuits are stored electronically IOW operates integrity testing under the American Petroleum Institute (API) Inspection Industry Standard. The inspection group schedule integrity testing based on historical data, trends and pre-set alarms as per the API 570

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			Standard. All (100%) of the above ground pipes are visually inspected and non-destructive testing is completed at regular intervals at specific Thickness Monitoring Location (TML) points on each circuit. Resistivity testing by Specialist Contractor Met Lab is completed as required along the buried pipes sections LDAR programme will be formalised by Q4 2018 as per BAT 6
BAT 19	In order to prevent hydrofluoric acid (HF) emissions to air from the hydrofluoric acid alkylation process, BAT is to use wet scrubbing with alkaline solution to treat incondensable gas streams prior to venting to flare.	**Not applicable** No HF alkylation takes place on site	N/A
BAT 20.	In order to reduce emissions to water from the hydrofluoric acid alkylation process, BAT is to use a combination of the techniques given	**Not applicable** No HF alkylation takes place on site	N/A
BAT 21	In order to reduce the emissions to water from the sulphuric acid alkylation process, BAT is to reduce the use of sulphuric acid by regenerating the spent acid and to optimize the waste water generated by this process before routing to waste water treatment.	**Not applicable** No sulphuric acid alkylation takes place on site	N/A
BAT 22	In order to prevent and reduce the emissions of hazardous substances to air and water from base oil production processes, BAT is to use one or a combination of the techniques given.	**Not applicable** No base oil production takes place on site	N/A
BAT 23	In order to prevent and reduce emissions to air from the bitumen production process, BAT is to treat the gaseous	**Not applicable** No bitumen production takes place on site	N/A

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	overhead by using one of the techniques given.		
BAT 24..	In order to prevent or reduce NOX emissions to air from the catalytic cracking process (regenerator), BAT is to use one or a combination of the techniques given.	**Not applicable** No catalytic cracking takes place on site	N/A
BAT 25.	In order to reduce dust and metals emissions to air from the catalytic cracking process (regenerator), BAT is to use one or a combination of the techniques given.	**Not applicable** No catalytic cracking takes place on site	N/A
BAT 26	In order to prevent or reduce SOX emissions to air from the catalytic cracking process (regenerator), BAT is to use one or a combination of the techniques given.	**Not applicable** No catalytic cracking takes place on site	N/A
BAT 27	In order to reduce carbon monoxide (CO) emissions to air from the catalytic cracking process (regenerator), BAT is to use one or a combination of the techniques given.	**Not applicable** No catalytic cracking takes place on site	N/A
BAT 28.	In order to reduce emissions of polychlorinated dibenzodioxins/furans (PCDD/F) to air from the catalytic reforming unit, BAT is to use one or a combination of the techniques given.	**Applicable,** two catalytic units (Reformer and Isomerization) operate on site that use chlorinated additives and their off gases are used in the Refinery Fuel Gas system Choice of catalyst promoter – use of catalyst promoter in order to minimize PCDD/F formation; **Applicable**	Yes, The site operates two units that require addition of chlorinated catalyst promoter, Per-Chloro Ethylene (PERC), the reformer and the Isomerisation units. The PERC is added to the reformer only when regenerations are required. Only the amount of PERC required is added based on molecular ratio of Cl. The isomerisation unit has a continuous addition of PERC, again at the molecular ratio of Cl required
		Regeneration gas recycling loop with adsorption bed; **Not applicable, existing**	N/A

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		installation	
		Wet Scrubbing	Yes; The Isomerisation unit off gases are passed through a caustic scrubber to remove HCl prior to the gas being sent to the refinery fuel system. The Reformer unit off gases are passed through a chloride guard drum prior to the gases being sent to the refinery fuel system.
		Electrostatic precipitators **Not applicable, techniques in place are sufficient**	N/A
BAT 29	In order to reduce emissions to air from the coking production processes, BAT is to use one or a combination of the techniques	**Not applicable** No coking production processes take place on site	N/A
BAT 30.	In order to reduce NOX emissions to air from the calcining of green coke process, BAT is to use selective non-catalytic reduction (SNCR).	**Not applicable** No calcining of green coke process takes place on site	N/A
BAT 31	In order to reduce SOX emissions to air from the calcining of green coke process, BAT is to use one or a combination of the techniques given.	**Not applicable** No calcining of green coke process takes place on site	N/A
BAT 32	In order to reduce dust emissions to air from the calcining of green coke process, BAT is to use a combination of the techniques given.	**Not applicable** No calcining of green coke process takes place on site	N/A
BAT 33	In order to reduce water consumption and emissions to water from the desalting process, BAT is to use one or a combination of the techniques given.	(i) Recycling water and optimization of the desalting process. **Applicable**	Yes – Recycled water is used in the desalter, maintained at a flow just sufficient to maintain feed. The wash rate is monitored closely however fresh water top up is required. Daily monitoring of pH and electric field potential coalescence in place. Low shear mixers installed
		(ii) Multistage desalter. **Not applicable, existing installation**	N/A
		(iii) Additional separation step.	The desalter waste goes to a flare drum prior to

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		Applicable	transfer to the WWTP. This drum acts as a separator. The first stage of the waste water treatment plant is an API separator which removes and recovers oil/hydrocarbons.
BAT 34	In order to prevent or reduce **NOx** emissions to air from the combustion units, BAT is to use one or a combination of the techniques given:		
	Selection or Treatment of Fuel	Use of gas to replace liquid fuel **Applicable**	Yes – only one unit on site (SG5; A1-2) uses liquid fuel. The RFO is a finished product gasoil, processed to EN standards and hydrotreated. SG5 (A1-2), only uses liquid fuel during start up
		Use of low nitrogen refinery fuel oil e.g. by RFO selection or by hydro treatment of RFO **Applicable**	Yes – only one unit on site (SG5, A1-2) uses RFO. The RFO used is a finished product gasoil, processed to EN standards & hydrotreated. SG5 only uses liquid fuel during start up.
	Combustion Modifications	a) Staged combustion • Air Staging • Fuel Staging **Applicable**	Yes, 10 of the 11 furnaces on site use either staged air or staged combustion
		b) Optimization of Combustion; **Applicable**	Yes. All combustion units have CO and O2 monitors in place. There are targets for O2 with safe operating limit alarms on low O2. Fuel usage is monitored versus steam/heat output to optimise fuel usage. Operators are trained to monitor combustion conditions and react to inefficient burning.

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		c) Flue gas recirculation	Flue gas recirculation is in place in F801/802 (A2-10)
		d) Diluent Injection **Note Applicable**	N/A – sufficient techniques in place
		e) Use of Low NOx burners **Applicable**	Yes, Low NOx burners are in place in 10 of the 11 furnaces on site and there are plans in place to install low NOx burners as the remaining furnace and boilers are upgraded
	Secondary end of pipe techniques such as	a) Selective Catalytic Reduction (SCR) – **Not applicable, existing installation**	N/A
		b) Selective non-catalytic reduction (SNCR) – **Not applicable, existing installation**	N/A
		c) Low temperature oxidation – **Not applicable due to age and design of units**	N/A
		d) SNOx combined technique – **not applicable due to low flue gas flow**	N/A
	BAT Associated Emission Levels for NOx, expressed as NO_2 (Table 9). Emissions to air from a **gas turbine**	Gas turbine (including combined cycle gas turbine – CCGT) and integrated gasification combined cycle turbine (IGCC) (Table 9) 40-120 mg/m3 (existing turbines) – **Applicable to SG5 (A1-2) when in CHP mode** 20-50 mg/m3 (new turbine) **Not applicable, existing system**	Will be, SG5 does not always run in CHP mode and has capability to run as a standard boiler burning natural gas (in which case it does not come under this BATc). Therefore, the NOx AEL for A1-2 will be dependent on its mode of operation • CHP Mode: 120 mg/m3 It is the intention of IOW to apply the integrated approach described in BAT 57, all emission points will have been measured and compliance versus this approach demonstrated by the end of 2018
	BAT Associated Emission Levels	**Gas Firing: Applicable**	Will be, see attached table

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	NOx, expressed as NO_2 (Table 10). Emissions to air from a gas fired combustion unit, with the exception of gas turbines	(table 10) to Furnaces F401, F402, F501, F201, F202AN, F202BX/CX, F203, F204, F206/207, F801/802 & F901 **30-150mg/m3** for existing units – **Applicable**, 30-100 for new units – **Not applicable, all units existing**	Application of this BAT AEL represents a significant reduction from the current ELV of 450mg/m3, with which the site emission points are compliant. The site will be compliant with the upper end of this AEL It is the intention of IOW to apply the integrated approach described in BAT 57, all emission points will have been measured and compliance versus this approach demonstrated by the end of 2018
		Multi Fuel Firing (table 11) 30-300mg/m3 **Not Applicable**	N/A
BAT 35	In order to prevent or reduce **dust and metal** emissions to air from the combustion units, BAT is to use one or a combination of the techniques given:		
	i) Selection of treatment of Fuel	a) Use of gas to replace liquid fuel – **applicable**	Yes – only one unit on site (SG5; A1-2) uses liquid fuel. The RFO used is a finished product gasoil, processed to EN standards and hydrotreated. SG5 (A1-2), only uses liquid fuel during start up
		b) Use of low Sulphur refinery fuel oil e.g by RFO selection or by hydro treatment of RFO **– Applicable**	Yes The IOW refinery runs low sulphur crudes and therefore the RFO is generally low sulphur. Only one unit on site (SG5, A1-2) uses RFO, a finished product gasoil, processed to EN standards and hydrotreated. SG5 (A1-2), only uses liquid fuel during start up
	(ii) Combustion modifications	a) Optimization of combustion - **Applicable**	Yes. All combustion units have CO and O2 monitors in place. There are targets for O2 with safe operating limit alarms on low O2. Fuel usage is monitored versus

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			steam/heat output to optimise fuel usage. Operators are trained to monitor combustion conditions and react to inefficient burning.
		b) Atomization of liquid fuel – **applicable to SG5 (A1-2) only**	Yes – only one unit on site (SG5; A1-2) uses refinery fuel oil (finished gas oil) and the liquid fuel is atomized with air when in use
	II) Secondary end of Pipe techniques	i) Electrostatic precipitation – **Not applicable as only SG5 uses liquid fuel, and this is only used during start up**	**N/A**
		ii) Third stage blowback filter **Not applicable as only SG5 uses liquid fuel, and this is only used during start up**	**N/A**
		iii) Wet scrubber **Not applicable as only SG5 uses liquid fuel, and this is only used during start up**	**N/A**
		iv) Centrifugal Washers **Not applicable as only SG5 uses liquid fuel, and this is only used during start up**	**N/A**
	BAT Associated Emission Levels for Dust in Multi fuel Firing Units	Not Applicable No **multi-fuel firing** units on site.	N/A
BAT 36	In order to prevent or reduce **SOx** emissions to air from the combustion units, BAT is to use one or a combination of the techniques given		
	I) Primary or process related techniques based on a selection or a treatment of the fuel such as:	i) Use of gas to replace liquid fuel - **applicable**	Yes – only one unit on site (SG5; A1-2) uses liquid fuel. The RFO used is a finished product gasoil, processed to EN standards and hydrotreated. SG5 (A1-2), only uses liquid fuel during start up
		ii) Treatment of refinery fuel gas (RFG) – **Applicable**	Yes The refinery fuel gas system draws from several sources. The most heavily H_2S

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			contaminated RFG is treated in the site Amine & Sulphuric Acid plant, which removes H_2S from the gas streams. The H_2S removal is sufficient to comply with current SO_2 emission limits and with BAT AEL, however the refinery has several improvement projects planned which will further improve the H_2S removal from the RFG system
		iii) Use of low Sulphur refinery fuel oil (RFO) e.g. by RFO selection or by hydrotreatment of RFO – **Applicable**	Yes The IOW refinery runs low sulphur crudes and therefore the refinery fuel oil is generally low sulphur. Only one unit on site (SG5, A1-2) uses RFO, a finished product gasoil, processed to EN standards and hydrotreated. Additionally, SG5 (A1-2), only uses liquid fuel during start up
	II) Secondary end of pipe techniques	i) Wet scrubbing or seawater scrubbing **- Not Applicable Sufficient primary techniques in place**	N/A
		ii) Regenerative scrubbing **Not applicable. Sufficient primary techniques in place**	N/A
		iii) SNOx combined technique **– not applicable due to low flue gas flow**	N/A
	BAT Associated Emission Levels for SO2 emissions to air from a combustion unit firing **refinery fuel gas** with the exception of gas turbines	5-35 mg/m3 – **Applicable to furnaces** F401, F402, F501, F201, F202AN, F202BX/CX, F203, F204, F206/207, F801/802 & F901 **Not applicable to boilers** A1-1 SG4 A1-2 SG5 A1-3 SG6	Yes IOW emission points for furnaces are currently compliant with the upper end of this range as per the current IE license limit of 35mg/m3. The emission point at the Amine & Sulphuric Acid

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		as they fire on natural gas **Not applicable** to SG5 (A1-2) when in CHP mode (BAT excludes gas turbines) **Not applicable** to Compressors A2-12/13/14 as they **fire on natural gas only**	plant (ASA), A2-18 has a separate limit for SOx of 260mg/m3 in the current IE license. The BAT AELs for SO_2 do not mention specific limits for sulphur recovery units If the current limit for A2-18 cannot be maintained under BREF requirements, IOW will be compliant by application of the integrated approach described in BAT 58, however A2-18 should retain a separate limit for SO_2.
	BAT Associated Emission Levels for SO2 emissions to air from multi-fuel fired combustion units, with the exception of gas turbines and stationary gas engines	35-600 mg/m3 - **Not Applicable**	N/A
BAT 37	In order to reduce carbon monoxide (CO) emissions to air from the combustion units, BAT is to use a combustion operation control as per 1.20.5	**Applicable** Combustion operation control Catalyst for CO oxidation – **not applicable** CO Boiler – **not applicable** as FCC units not in use	Yes The refinery furnaces and boilers operate on a computer control system (DCS) and are monitored 24/7 by operators in the main control room. CO and O2 are monitored continuously. As CO is an indication of poor burning, and as operational targets include optimised fuel consumption, actions are taken to correct inefficient burning. Operators received training on monitoring burning efficiency and how to respond to increasing CO as both a safety and environmental concern.
	BAT associated emission levels for carbon monoxide emissions to air from a combustion unit	<100mg/m3 **Applicable to furnaces** F401, F402, F501, F201, F202AN, F202BX/CX, F203, F204, F206/207, F801/802 & F901 and SG5 in CHP mode	Yes – All emission points are currently compliant with the BAT AEL

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BAT 38	In order to reduce emissions to air from the etherification process, BAT is to ensure the appropriate treatment of off gases by routing them to the refinery fuel gas system	**Not applicable – esterification not used in IOW refinery**	N/A
BAT 39	In order to prevent upset of the bio-treatment, BAT is to use a storage tank and appropriate unit production plan management to control the toxic components dissolved content of the waste water stream prior to final treatment	**Applicable to WWTP**	Yes • IOW operate a continuous production process. This means the feed to the WWTP is largely steady with only occasional extra waste brought online (e.g. spent caustic). This is done in a controlled manner to avoid upset to the biological treatment steps • Additional storage is available where waste streams can be routed until such time as treatment is appropriate. • Internal sampling and analysis of the individual WWTP unit operations is completed as an ongoing monitoring & control method. • The waste water passes through two large equalisation basins prior to transfer to the biological section of the WWTP for the purpose of maintaining a consistent feed composition. pH adjustment is in place here to maintain a stable pH in the feed to the MBBRs
BAT 40	In order to reduce emissions to air of chlorinated compounds, BAT is to optimize the use of chlorinated organic compounds used to maintain catalyst activity when such a process is in place	**Applicable to Reformer and Isomerization unit**	Yes, Two units on site use chlorinated additives for catalyst protection; the Isomerisation unit and the Reformer.

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	or to use non-chlorinated catalytic systems		Per-Chloro-Ethylene (PERC) is added to both units as a catalyst protector. The PERC is added only in the correct amount to maintain the molar ratio of Cl needed. PERC is added continuously to the Isomerisation catalysts PERC is only added to the reformer when catalyst regeneration is taking place. There is a caustic scrubber in place at the Isomerisation unit and the caustic activity is tested daily to ensure no over/undercharging of PERC is happening.
BAT 41	In order to reduce Sulphur dioxide emissions to air from the natural gas plant BAT is to apply BAT 54	**Not applicable, no natural gas plant in place**	N/A
BAT 42	In order to reduce nitrogen oxides (NOx) emissions to air from the natural gas plant, BAT is to apply BAT 34	**Not applicable, no natural gas plant in place**	N/A
BAT 43	In order to prevent emissions of mercury when present in raw natural gas, BAT is to remove the mercury and recovery the mercury containing sludge for waste disposal	**Not applicable, no natural gas plant in place**	N/A
BAT 44	In order to prevent or reduce waste water flow generation from the distillation process, BAT is to use liquid ring vacuum pumps or surface condensers	**Not Applicable**, refinery does not operate vacuum distillation	N/A
BAT 45	In order to prevent or reduce waste water flow generation from the distillation process, BAT is to route sour water to the sour stripping unit	**Applicable**	Yes, Sour water is generated at several units on site. The majority of these are routed to the sour water stripper however some do route to the WWTP via a separator drum. IOW has identified several streams for diversion to the sour water stripper, project to progress these diversions

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			are ongoing.
BAT 46	In order to prevent or reduce emissions to air from distillation units, BAT is to ensure the appropriate treatment of process off-gases, especially incondensable off gases, by acid gas removal prior to further use	**Applicable**	Yes –All off gases from the distillation units are used as fuel in the site furnaces. An Amine & Sulphuric Acid plant (ASA) in place to remove H2S from off gases prior to their use as fuel.
BAT 47	In order to reduce emissions to air from the products treatment process, BAT is to ensure the appropriate disposal of off gases, especially odorous spent air from sweetening units, by routing them to destruction e.g. by incineration	**Applicable**	Yes – Off gases from production processes are used as refinery furnace fuel. The Amine & Sulphuric acid plant (ASA) removes H2S from gases prior to their combustion in the site furnaces. If the sulphuric acid plant portion of the ASA plant is not available, the off gases are routed to the site flare safety system for combustion prior to release to atmosphere. Odorous LPG is routed first to the Amine Sulphuric Acid plant and then onto a caustic treatment plant where sulphur components are removed. Safety flares are available at all times should it be required to route off gases away from the gas mains.
BAT 48	In order to reduce waste and waste water generation when a products treatment process using caustic is in place. BAT is to use cascading caustic solution and a global management of spent caustic, including recycling after appropriate treatment e.g. by stripping	**Applicable**	Sodium hydroxide (caustic solution) is used in two processes at the IOW refinery. • At the Crude distillation unit to remove H2S from LPG (Propane/Butane), which is sold commercially and has a specification for sulphur. • At the isomerisation unit, where off gases are passed through a caustic scrubber to remove HCl prior to the gas being sent to the refinery fuel system

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			The caustic is reused until it is spent. It is sampled regularly to confirm caustic content. The amount of times the material can be reused is dependent on the crude type being processed. Once spent, the caustic is transferred to storage for further treatment prior to disposal. The spent caustic is treated in a dedicated plant that is fully automated. The material is treated with sulphuric acid to remove sulphides by conversion to sulphate salt and release of H_2S gas. The H_2S gas is disposed of by complete combustion at the sour flare. Prior to disposal to the on-site waste water treatment plant, the treated spent caustic is further processed to remove residual sulphur mercaptans, which can create odour issues at very low levels (odour detected at parts per trillion levels). The treated spent caustic is then transferred to the site WWTP for disposal. , which is designed to handle feed of a certain pH, in line with the expected caustic content of the waste water.
BAT 49	In order to reduce VOC emissions to air from the storage of volatile liquid hydrocarbon compounds, BAT is to use floating roof storage tanks equipped with high efficiency seals or a fixed roof rank connected to a vapour recovery unit	**Applicable to** crude, intermediate and product storage tanks	See attached table 49. Applicable to 35 tanks Floating roofs are fitted to 50% of bulk storage tanks, the remainder are cone or domed. Floating roofs are used for Class 1 flammable products such as crude and volatile products. Secondary seals are in use

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			in 3o% of all tanks The site operates an ongoing tank inspection and overhaul programme which includes secondary seal installation and/or seal replacement. Tanks are taken out of service, emptied and cleaned at regular intervals for internal inspected VOC emissions estimated monthly as part of PRTR preparation and loss tracking
BAT 50	In order to reduce VOC emissions to air from the storage of volatile liquid hydrocarbon compounds, BAT is to use one or a combination of the techniques given	**i)** Manual crude oil tank cleaning - **Applicable**	Yes – crude oil tanks are taken out of service at regular intervals as per API Standard #653; are emptied and cleaned manually prior to visual internal inspection
		ii) Use of a closed loop system - **Applicable**	Yes – crude oil tanks are periodically emptied, cleaned and rendered gas free. The tank bottoms are dissolved in other hydrocarbons and transferred to crude tankage for reprocessing
BAT 51	In order to prevent or reduce VOC emissions to soil and groundwater from storage of liquid hydrocarbon compounds, BAT is to use **one or a combination** of the techniques given	i) Maintenance programme including corrosion monitoring, prevention and control - **Applicable**	Yes In addition to daily operator checks and walk downs, electronic level monitoring is in place on all bulk tanks. High, independent high-high and critical level alarms are in place and all tanks have a maximum operating level fixed below the alarm points. Tanks are monitored during filling and emptying and expected fill times are calculated as well as operator response times. Inventory is monitored and controlled carefully to maximise throughput without overfilling crude or product tanks

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BAT reference Number	**BAT Statement**	**Applicability Assessment**	**State if in place or state schedule for implementation**
			IOW operate a risk based inspection programme in line with API guidelines. Tanks are taken out of service at regular intervals, emptied, cleaned and rendered gas free prior to manual cleaning and thorough visual inspection. Internal tank coatings (base & 1m up walls) are inspected/repaired and secondary seals are being installed in floating roof tanks on a phased basis. Any structural repairs are followed by full hydrostatic integrity testing. Spill kits are available throughout the site and bunding is in place, registered and tested as per site IE license requirements. All spills in process areas will be routed to the site process drainage system and clean-up is progressed immediately upon discovery of a spill to avoid risk to groundwater. An oil spill has been identified as one of the site's major accident hazards and the site is fully set up to respond to a large spill. Oil spill contingency plan training and exercises are undertaken with external resources annually
		ii) Double bottomed tanks **Not applicable, existing installation**	Tanks are coated internally (base and 1m up walls) but do not have double bottoms
		iii) Impervious membrane liners **Not applicable, existing installation**	Tanks are coated internally (base and 1m up walls) but do not have membranes applied.

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BAT reference Number	**BAT Statement**	**Applicability Assessment**	**State if in place or state schedule for implementation**
		iv) Sufficient tank farm bund containment - **Applicable**	Will be One area of site (Corkbeg) has been identified as having bund capacity that is not in compliance with the 25% rule as per condition 3.6.2 (ii) if the site IE license. IOW are currently in the process of designing increased catchment capacity and changes will be implemented by the end of Q3 2018, however this may be extended if planning permission is required for the changes. The site will then be fully compliant for tank farm bunding capacity once this change is complete
BAT 52	In order to prevent or reduce VOC emissions to air from loading and unloading operations of volatile hydrocarbon compounds, BAT is to use one or a combination of the techniques given below to achieve a recovery rate of at least 95%	Applicable to road loading Not applicable to Sea Going vessel loading due to throughput < 1 million m3/yr	Yes – the road loading area has a vapour recover unit (absorption unit) in operation as per the requirements of the site's VOC license. This unit achieves a recovery rate of >95%
	Vapour Recovery By: i) Condensation ii) Absorption iii) Adsorption iv) Membrane Separation v) Hybrid Systems		
	BAT Associated emission levels for non-methane VOC and benzene emissions to air from loading and unloading operations of volatile liquid hydrocarbon compounds	NMVOC – 0.15 – 10g/Nm3	**Yes** - VOC measurements are undertaken at the road loading VRU quarterly and typical measured VOC is 0.0% W/V (all quarterly tests completed in 2016 and 2017 have shown 0% W/V for VOCs)
		Benzene - <1mg/Nm3 – not applicable as the NMVOC measurements are below the lower end of the range above	N/A – as the NMVOCs are below the lower end of the BAT AEL, benzene monitoring is not necessary. See footnote 3, BAT 52, Table 16
BAT 53	In order to reduce emissions to	**Not applicable** – activity not	N/A

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	water from visbreaking and other thermal processes, BAT is to ensure the appropriate treatment of waste water streams by applying techniques in BAT 11	carried out at Whitegate refinery	
BAT 54	In order to reduce sulphur emissions to air from off gases containing hydrogen sulphide (H2S), BAT is to use all of the techniques given	i) Acid gas removal e.g. by amine treating - **Applicable**	Yes – the IOW refinery operates an Amine & Sulphuric acid plant which treats off gases from several unit operations. H_2S rich off gases are first passed through the Amine unit and clean gases are routed to the gas mains. Acid gases from the amine unit are then passed through the Wet Sulphuric Acid section of the plant (WSA) which produce sulphuric acid and steam.
		ii) Sulphur recovery unit (SRU) e.g. by Claus process - **Applicable**	Yes – The WSA unit as described above recovers sulphur in the form of sulphuric acid. Claus process is not used
		iii) Tail gas treatment unit (TGTU) – **Not Applicable**	Yes, the WSA section of the plant produces liquid sulphuric acid. Clean off gases from the ASA plant are routed to the refinery fuel gas system
	BAT associated environmental performance levels for a waste gas Sulphur (H2S) recovery system	Acid Gas removal – Achieve hydrogen sulphide (H2S) removal in the treated RFG in order to meet gas firing BAT-AEL for BAT 36	Yes, as described above IOW operate an Amine & sulphuric acid (ASA) unit that removes H_2S from contaminated off gases prior to being routed to the refinery fuel gas system. All units are compliant with BAT AEL, As described in BAT 36, there is no BAT AEL for SO2 for sulphur recovery units (ADA A2-18)
		Sulphur Removal Efficiency: New Unit 99.5 – 99.9% **Not applicable, existing installation**	Yes , the ASA plant described above is designed to achieve 99.5% sulphur removal efficiency

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		Existing Unit: >=98.5%. **Applicable**	
BAT 55	In order to prevent emissions to air from flares, BAT is to use flaring only for safety reasons or for non-routine operational conditions (e.g start up / shutdowns)	Applicable to flaring operations	Yes. IOW only operate the flare system for safety reasons. Flaring is reviewed internally as part of weekly and monthly management reviews. Flaring is reported to the EPA as part of quarterly reports
BAT 56	In order to prevent emissions to air from flares, when flaring is unavoidable, BAT is to use the techniques given	i) Correct plant design – **Not applicable, existing installation**	N/A, however correct plant design will be in place for new units wrt flaring, all existing units were installed to industry best practices
		ii) Plant management	Yes IOW operate the flare system for safety reasons. Flaring is tracked continuously and is reviewed internally as part of monthly and quarterly management reviews. Flaring is reported to the EPA as part of quarterly reports
		iii) Correct flaring device design **Not applicable, existing installation**	N/A, however flare devices were installed to industry best practice at the time
		iv) Monitoring and reporting	Yes – Flaring is tracked continuously and is reviewed internally as part of monthly and quarterly management reviews. Flaring and flaring events are reported to the EPA as part of quarterly reports
BAT 57	In order to achieve an overall reduction in NOx emissions to air from combustion units and fluid catalytic cracking (FCC) units, BAT is to use an integrated emissions management	Applicable for combustion units, as per the reasons set out in BAT34 above - Site complexity (22 individual combustion units under 18 emission	Yes – see attachment for calculation of BAT AEL based on emission data from 2014, 2015, 2016 and 2017

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	technique as an alternative to applying BAT 24 and BAT 34	points) - Frequency of process adjustments increasing due to increasing variations in available crude feedstock - Process adjustments causing variations in refinery fuel gas system	
BAT 58	In order to achieve an overall reduction in SO2 emissions to air from combustion units and fluid catalytic cracking (FCC) units and waste gas Sulphur recovery units, BAT is to use an integrated emissions management technique as an alternative to applying BAT 26 and BAT 36 and BAT 54	Applicable for combustion units as per the reasons sent out in BAT36 - Site complexity (22 individual combustion units under 18 emission points) - Frequency of process adjustments increasing due to increasing variations in available crude feedstock Process adjustments causing variations in refinery fuel gas system	Yes – see attachment for calculation of BAT AEL based on emission data from 2014, 2015, 2016 and 2017