Saltfleetby Wellsites

Environmental Permit Variation EPR/JB3167XB
BAT Assessment

Angus Energy Weald Basin No3 Limited

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		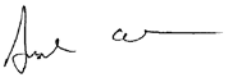	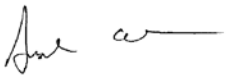
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Revision History

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Table of Contents

Figures

No table of figures entries found.

Tables

1. Report Context

1.1 Introduction

AECOM have been commissioned by Angus Energy Weald Basin No3 Limited ("the Operator" or Angus Energy) to prepare an application to vary the existing environmental permit (EPR/JB3107XB/T001) for the mining, extraction and transportation of natural gas and gas condensate from proven underground reservoirs at Saltfleetby Wellsites.

The application is being submitted to cover changes at the existing Gasfield which will facilitate the processing of natural gas to ensure it meets the quality requirements necessary to export the gas into the National Grid. This report details the assessment of Best Available Techniques (BAT) for the wellsite. The report should be read in conjunction with other supporting application information.

1.2 Background

1.2.1 Existing Operations

Saltfleetby 'A' and 'B' ("SFA", "SFB") onshore production sites were established in 1999. Both wellsites produce natural gas, water and condensate with two 6" pipelines connecting the SFA and SFB wellsites. A 10" pipeline transported hydrocarbons to the nearby Theddlethorpe Gas Terminal (TGT) for processing. Gas production at the wellsites was suspended by then Operator Wingas Storage UK Ltd in 2017 due to the closure of TGT.

In November 2019, Angus Energy farmed into the licence and became the Operator of the field with the intention to restart production from the field following the installation of a new pipeline connection to National Grid transmission system (NTS). To facilitate the resumption of operations, the intention is to:

- Keep suspended three of the remaining wells (SF 5, 6 and 7) with the potential for side-tracking any one or all of them.
- Evaluate the commercial case for continued production from Saltfleetby 8 either with or without side-tracking.
- Examine the possibility of the utilising any two of the remaining wells for geothermal heat recovery; and
- Return the existing two producing wells to natural gas and associated condensate production.

1.2.2 Proposed New Operations

Since 2017, the processing operations at the nearby Theddlethorpe Gas Terminal (TGT) has ceased. Therefore, to ensure the produced natural gas can be exported into NTS, Angus Energy also intend to:

a) install natural gas and condensate processing facilities at SFB Site. This will indicatively include the modification to the existing first stage separator, a set of compressors, a passive dehydration system to remove water, a solid state Joule-Thomson valve allowing for a drop in pressure and temperature to remove heavy hydrocarbons, a condensate stabilisation tower, a new condensate storage unit, produced water storage, a metering and analysis skid, a fuel gas skid, an enclosed ground flare, and some associated pipework manifolding, comms and electrical ancillaries; and

b) install up to 750m of pipeline from the existing TGT entry point to the new NTS connection point which is beyond the scope of this permit variation and

c) Install power generation equipment to support the above facilities.

2. Applicable Legislation and Guidance

Activities associated with the UK onshore oil and gas sector are considered within the scope of a number of pieces of legislation and sector guidance.

Activities proposed for the management and processing of natural gas at the Saltfleetby Wellsites are detailed in the Technical Plan (Application Part 4) while those in respect of managing extractive wastes associated with the operations, activities are detailed in the Waste Management Plan (Application Part 5).

A review of the proposed operations has identified the following legislation and guidance which is applicable and must be considered when evaluating BAT.

2.1 Environmental Permitting Regulations (EPR) 2016

2.1.1 Industrial Emissions Activities

The Industrial Emissions Directive (IED) 2010/75/EU sets out the requirement on integrated prevention of pollution arising from industrial activities, whilst also setting out rules designed to prevent, or where that is not practicable to reduce the emissions into air, land and water and to prevent the generation of waste, in order to achieve high levels of protection of the environment taken as a whole.

Schedule 1, Part 2 of Environmental Permitting Regulations (EPR) 2016 details a number of activities which are classed as an industrial emissions activity and taking into consideration the activities proposed at Saltfleetby, the following will apply:

- S1.2 A (1) (a): “Refining of Gas Where This is Likely to Involve the Use of 1,000 or More Tonnes of Gas in a 12 Month Period”. This is a new activity which relates to the processing of natural gas;
- Section 1.2, Part A (1) (e) (i) – the loading, unloading, handling or storage of, or the physical chemical or thermal treatment of crude oil. This is a new activity which relates to the handling, storage and loading of condensate generated during the extraction and processing of the natural gas; and
- Section 5.1, Part A (1)(a)(c): “The Burning of a Hazardous Waste Gas”. This is an existing permitted activity which will cover up combustion of up to 2,2 MMscf of gas per day during well testing activities when they are required.

2.1.2 Medium Combustion Plant Directive (MCPD) Activities

Operators of medium combustion plant (MCW) and specified generators (SG) that are within the scope of the Directive will require an environmental permit under schedule 25A and 25B of EPR 2016. A permit to operate both is determined by the capacity, emissions and operating hours of the plant.

The MCPD applies to combustion plants with a rated thermal input (th) equal to or greater than 1MW (Megawatt) and less than 50MW regardless of the fuel type.

SG are combustion plants which are used to generate electricity and are on a site aggregated to less than 50MWth (Megawatt Thermal). SG are also divided into Tranche A and B depending on the electricity supply contract they may have.

The proposed operations at Saltfleetby will involve the operation of SG with an aggregated capacity of less than 20MWth and as such an application as a standard rules permit SR2018 No 7 is being made as part of this application.

2.1.3 Mining Waste Activity

Schedule 20 of EPR 2016 transposes the requirements of the Mining Waste Directive (2006/21/EC) into UK law and requires that extractive wastes are managed in such a way that it minimises harm to human health and impact on the environment. It will apply to the management of waste (solid, liquid or gas) associated with the prospecting, extraction,

treatment and storage of the mineral resources referred to as extractive waste as detailed in the Waste Management Plan (Application Part 5)..

2.2 Onshore Oil and Gas Sector Guidance (January 2020)

The Environment Agency has published its online sector guidance providing guidance on permitting requirements specific to onshore oil and gas activities, including the management of extractive wastes and the operating of an installation.
Relevant to this application, the sector guidance makes specific reference to:

- Managing of extractive waste,
- Use of flares;
- Storing and handling crude oil (condensate);
- Treating effluents;
- Monitoring emissions; and
- Decommissioning of boreholes.

2.3 Industry Recommended Practices

Relevant to the determination of BAT is having regard to other industry guidance and practices, such as health and safety. A determining factor of BAT is whether the technique is available and, in the context of other industry guidance and practices, available can also refer to whether or not it is 'allowable for use'.

The following section sets out the industry guidance and/or recommended practices that are relevant to the sector and what constraints they pose in the context of BAT assessment in accordance with Best Available Techniques (BAT) Reference Document for the Management of Waste from Extractive Industries

2.3.1 API RP 521 Pressure-Relieving and Depressuring Systems

This standard is applicable to pressure-relieving and vapour depressuring systems. Although intended for use primarily in oil refineries, it is also applicable to petrochemical facilities, gas plants, liquefied natural gas (LNG) facilities, and oil and gas production facilities. The information provided is designed to aid in the selection of the system that is most appropriate for the risks and circumstances involved in various installations.

2.3.2 API 537 Flare Details for General Refinery and Petrochemical Service

This standard specifies the requirements and provides guidance for the selection, design, specification, operation and maintenance of flares and related combustion and mechanical components used in pressure-relieving and vapour-depressurising systems for petroleum, petrochemical and natural gas industries.

Although this international standard is intended for new flares and related equipment, it is also possible to use it and evaluate existing flare facilities.

2.3.3 BS 5908-1:2012

This British Standard provides recommendations and guidance for the control of fire and explosion risks on sites at which chemicals are stored or processed in significant quantities.

2.3.4 BS 5908-2:2012

BS 5908-2:2012 offers guidance on the legislation and standards applicable to onshore industrial premises that handle significant quantities of flammable gases, liquids or dusts.

3. Definition of BAT

3.1 Legislative Background

The Environmental Permitting (England and Wales) Regulations 2016, as amended require that activities identified under Schedule 1 be subjected to an assessment to demonstrate that the technology/technique proposed can be considered to be the 'Best Available' at the time the application is being made.

This report provides the BAT assessment for the proposed operations at Saltfleetby Wellsite.

3.2 Definition of Best Available

The EPR 2016 Regulations define BAT as " the most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and where that is not practicable, generally reduce emission and the impact on the environment as a whole".

Where the component parts of BAT are:

a) "available techniques" are those developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the cost and advantages, whether or not the techniques are used or produced inside the United Kingdom, as long as they are reasonably accessible to the Operator.

b) "best techniques" are the most effective in achieving a high general level of protection of the environment as a whole.

c) "techniques" are both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned.

BAT may be demonstrated by either:

- Compliance with the sector-level, indicative BAT performance described by the Environment Agency's Onshore oil and gas sector guidance; or
- By conducting an installation-specific, options appraisal of candidate techniques.

Previously the indicative BAT provided in the European BREF documents is based on an analysis of the costs and benefits for typical, or representative, plants within that sector. But when assessing the applicability of the sectoral, indicative, BAT standards at the installation level, departures may be justified on the grounds of the technical characteristics of the installation concerned, its geographical location and the local environment.

3.3 Outline of BAT Appraisal

In undertaking the assessment of Best Available Technique (BAT) for the Saltfleetby Wellsite, the operations and techniques proposed for the site have been compared against the following guidance:

- EA Waste Guidance for Oil and Gas Sector: Section 7 of "Onshore oil and gas sector guidance" (Jan 2020); and
- BAT for Onshore Oil and Gas (Mott MacDonald, 2015).
- Best Available Techniques (BAT) Reference Document for the Management of Waste from Extractive Industries, (BREF Note) 2018

4. BAT for Management of Extractive Waste

BAT for the management of extractive wastes is detailed in section 7.8 of the EA Guidance for the Onshore Oil and Gas Sector. The detailed information relating to the management of extractive wastes at the Saltfleetby Wellsites is detailed in the Waste Management Plan (Application Part 5) and evaluation against the BAT criteria is summarised in Table 4.1 on the following page.

Table 4-1: BAT Assessment for Management of Extractive Waste

BAT Section	BAT Criteria	BAT Justification
Planning and design	• assess the wastes you will generate on site before operations have started • apply the waste hierarchy to all wastes • design and build the well in a way that reduces the volume of drilling mud used and drill cuttings produced, but still provides well control and integrity • evaluate whether you will generate any solid wastes with elevated levels of naturally occurring radioactive substances and if so, develop plans for how you will identify and manage it in accordance with RSR guidance • for waste gases, use the methodology in the report Waste gas management at onshore oil and gas sites: framework for technique selection (or an equivalent approach) to demonstrate that BAT have been chosen to prevent (or where not practicable, to reduce) emissions and impact on the environment	• Wastes anticipated to be generated are detailed in Section 3 and Section 4 of the WMP (Application Part 5). • Where practicable waste production will be minimised and where this is not achievable was will be sent for reuse and recycling in preference to disposal. Details of the planned routes and application of the Waste Hierarchy are provided in WMP Section 5 (Application Part 5). • The WMP (Application Part 5) acknowledges there is potential to generate NORM waste and will have procedures in place to manage such waste streams. The site has an RSR permit for dealing with such wastes and is supported by an independent Radioactive Substances Advisor. • For details of BAT in relation to management of the gas at the site please refer to section 5 below.
Fluid Selection and Management	• design drilling muds in a way that minimises the amount of mud lost or fluid gained - taking into account the filter cake design, inclusion of non-hazardous lost-circulation materials, and appropriate mud weights • displace oil-based mud from the well and return all recovered mud to the supplier after you have completed each well – mud you return is not classed as waste • use a closed loop system for oil-based drilling mud, with mud passing through the solids control equipment and recirculated in the well • use a partially closed loop system for water-based mud which allows continuous fluid level management - spent water-based mud which cannot be used again is classed as extractive waste • monitor the mud management system to assess for any losses or gains • use mud pit volume totaliser to identify drilling mud lost to the formation or any gain in fluid	• No new wells will be drilled at Saltfleetby although it is acknowledged that some sidetrack work may be required to return existing wells to production. • WMP section 3 (Application Part 5) describes the general approach to such drilling activity and in the event that such sidetrack activity is required, A WR11 notification and method statement will be submitted which will confirm: a) Nature of the drilling muds to be used and how mud loss or fluid gain will be minimised; b) Drilling muds will be used in a closed loop arrangement and recirculated in the well as much as practicable; c) Anticipated volumes of drilling mud that will be used. • A record will be retained of the volume of mud used, the volume of mud lost to the formation and the volume of any fluid gained.
Well cellar construction	• construct watertight well cellars that can control any wellhead spills • test, install and operate a blow-out preventer on the well • check well cellar integrity before you start drilling	• All wells on site have been previously installed in accordance with the current permit and have been constructed in a manner that ensures:

BAT Section	BAT Criteria	BAT Justification
	• make sure all casings and tubing are appropriate for the pressures and conditions under which you will use them • make watertight anything that penetrates the well pad or lining systems (such as a rat hole) to prevent site surface water being lost, or wellhead spills entering the underlying land and groundwater	a) The well cellars are watertight; and b) That all casings and tubings were appropriate for the pressure conditions. • Prior to wells being brought back into production the well integrity will be rechecked and if necessary repairs will be made to ensure that they remain watertight and fit for purpose.
Containment measures	• install an impermeable liner across all areas of the site before you start drilling – the modelled lifespan of the membrane should exceed the anticipated life of the well • use appropriate construction quality assurance standards for the materials being installed as part of the impermeable liner • check the integrity of seals in all areas of the impermeable liner - particularly areas used by traffic, or to temporarily store extractive wastes, or with built structures • build areas for the temporary storage of extractive wastes following the standards in Containment systems for the prevention of pollution (C736) • bund all storage tanks on site following the standards in Containment systems for the prevention of pollution (C736)	• Saltfleetby Wellsites have been constructed with an impermeable liner installed across each area (please refer to information previously submitted under IC2 relating to this membrane). • The integrity of the seals particularly in areas used by traffic, to temporarily store extractive waste or where there are built structures will be checked prior to the site being brought back into production. • Site surfacing in areas of higher risk of spillage have been constructed from concrete to the appropriate BS standards Site storage tanks are provided with containment equivalent to at least 110% of the tank volume taking into consideration the standards detailed in CIRIA C736.
Drill cuttings management	• separate drill cuttings from the drilling mud as far as reasonably practicable - you must do this at the surface using suitable solids control equipment • the solids control equipment should use a mechanical separator (for example a shaker) that can separate drill cuttings from drilling fluid • the solids control system should use mud cleaners (such as de-sanders and de-silters) and centrifuges, to remove finer fraction cuttings from the drilling fluid • keep drill cuttings that are hazardous waste separate from any non-hazardous waste - you must supervise cuttings skips at all times when active mud management is taking place • separate cuttings from water-based mud, and cuttings from oil-based mud, and transfer into different temporary containers or skips (according to type) for collection • cover drill cutting skips or temporary containers to prevent water getting into them • make sure waste cuttings are characterised according to waste type • remove waste cuttings from site as soon as reasonably practicable using an authorised waste contractor who will take them to a waste management facility that has the correct permit	• The WMP (Application Part 5) details the arrangements for the management of drill cuttings in the event they are generated as a part of the sidetrack activities including: a) Separation of cuttings from drilling mud as soon far as practicable using a suitable solids control equipment; b) Sampling and characterising cuttings in accordance with WM3; c) Ensuring hazardous and non-hazardous streams are kept separate; d) Using an appropriate storage vessels for cuttings which can be covered to prevent ingress of water; and e) Ensuring that such waste is removed from site for treatment or disposal at as suitably permitted facility as soon as practicable.

BAT Section	BAT Criteria	BAT Justification
Spacer and other fluids management	• you must have a material safety data sheet for all substances used available on site • clearly mark and bund chemical storage areas using the standards in Containment systems for the prevention of pollution (C736) • do not store chemicals on site longer than is needed for your operations	• For Saltfleeby it is anticipated that this is likely to include kill fluids, workover fluids and completion fluids in the longer term. • Example MSDS sheets for typical fluids are provided in Appendix A of the WMP (Application Part 5) and full details of the specific materials will be provided to the EA in the WR11 Method Statement if workover or sidetrack activities are required. • Such fluids will be stored in IBC containers which are clearly labelled and located in a designated containment area.
Waste cement management	• pump enough cement to seal off the formations when you install casing and during well abandonment • calculate how much cement you will need and measure volumes to avoid ordering or mixing too much and generating waste cement • temporarily store excess, returned cement you cannot use on site as concrete in lined skips - as soon as reasonably practicable, use an authorised waste carrier to take them to a waste management facility with the correct permit	• Volumes of cement that will be required as part of well workover, sidetrack or abandonment activities will be determined and detailed in the WR11 method statement. • Waste cement will be stored as concrete in skips and will be removed from site as soon as practicable.
Waste Hydrocarbon Management	• separate waste oil from other wastes and put in a tank in a bunded area • carry out regular maintenance inspections on tanks and bunds • have emergency spill response equipment, expertise and procedures available on site • take waste oil off-site for recycling at a centre with the correct permit • comply with Environment Agency guidance on incinerating or flaring waste gases, see section 8 • comply with the guidance for managing vent emissions from storing and handling crude oil, see section 9.6 • manage waste gases from flowback fluid and produced water appropriately using the methodology in Waste gas management at onshore oil and gas sites: framework for technique selection or an equivalent approach	• Condensate is separated from the extracted gas stream using the 3-pahse separator and is collected as a product in a dedicated steel storage tank with its own containment (see section 6 below). • Waste gas will be managed via the flare (see section 5 below). • Waste oil is only anticipated as a result of spillage or during plant maintenance and such material will be collected in sealed drums, IVCs or similar materials. • Containers for such waste oil will be stored in a designated area with its own containment provision. • The site maintains an emergency response procedure including spills management as part of its integrated management system. This is implemented by trained operators using spills response equipment which is maintained onsite.

BAT Section	BAT Criteria	BAT Justification
Waste proppants management	• separate on-site returned proppant into an enclosed container – this must be located on the site well pad membrane • consider opportunities for reuse or recycling - where reasonably practicable • remove spent proppant off site for recycling or disposal at a permitted facility	Not applicable as no hydraulic fracturing planned at the site.
Waste flowback fluid management	• store in sealed tanks in a bunded area pending removal off-site • treat off-site at a permitted wastewater treatment facility	Not applicable as no hydraulic fracturing planned at the site.
Waste produced water management	• store on site in sealed tanks in a bunded area • re-inject for disposal • treat off-site at a permitted wastewater treatment facility	• Produced water will be stored in dedicated steel tanks which are situated within containment designed to hold at least 110% of the tank volume. • There is no reinjection of produced water at the site, any produced water will be removed by road tanker to an appropriately permitted facility for treatment or disposal.
Spill management	You must have a spill management plan which ensures that any material spilt on site will be contained and removed. Your plan must include: • training all staff supervising, loading or transferring wastes on site to use spill kits • having spill kits available on site at all times, and in all areas where you're transferring or temporarily storing extractive wastes • carrying out daily inspections for leaks and any damage to the pipework and the associated storage tanks of the drilling mud system • repairing or removing any leaking or damaged equipment immediately • recording and cleaning up all spills	• The site maintains an emergency response procedure including spills management as part of its integrated management system (ref to Section 5, Management Plan, Application Part 3). • This will be implemented by trained operators using spills response equipment which is maintained onsite. • The site undertakes routine inspections of containment and waste storage areas to ensure there are no spillages and also implements a LDAR Inspection programme to detect signs of leaks.
Waste removal	• use a risk-based approach, sample consignments of waste and characterise before removing from site - keep a reference sample • record the quantities and characterisation of drill cuttings and keep these records for at least 2 years • record all waste transfers from your site and keep these records for at least 2 years – you must make these records available for inspection by the Environment Agency when requested	• Waste will be segregated, characterised and classified as described in the WMP; • Quantities of waste will be logged and all transfer records retained for a minimum of 2 years.

5. BAT for Gas Management

5.1 Introduction

BAT for the management of gas is detailed in section 7.8 of the EA Guidance for the Onshore Oil and Gas Sector. The detailed information relating to the management of gas at the Saltfleetby site is detailed in the Technical Plan (Application Part 4) and evaluation against the BAT criteria is summarised below.

There are many variables that can affect technology choice at individual onshore oil and gas sites, including operational conditions and the phase of operation. However, the following technologies can generally be considered as the Best Available Techniques for the effective management of waste gas:

- flaring of the waste gas with an enclosed ground flare system;
- using the gas as fuel gas for power generation either for onsite use or for export to the grid;
- using the gas for heat recovery from power generation (for example via combined heat and power systems);and
- export of gas to the National Transmission System (NTS).

In order to determine BAT for the disposal of natural gas as a waste, Angus has considered alternate techniques, having due regard to the hierarchy of waste management, namely:

- Harnessing natural gas for an alternative use;
- Incineration of natural gas by flare; and
- Cold venting directly to atmosphere.

5.2 Gas Sources

With respect to the source of waste gas, this is dependent on the stage of operation and includes:

Table 5-1: Gas Sources

Operational Phase	Process	Equipment	Estimated Quantity
Preparing for Production (e.g. sidetrack, well workover or well testing)	Flaring	Flare	2.2 MMscf / day
	Oil Storage	Condensate Storage Tank	De Minimis
Production	Flaring	Emergency/Safety Flare	15-30mins blowdown ~1250m³
	Oil Storage	Condensate Storage Tank	De Minimis
Decommissioning	Export Line	10" Export line to Theddlethorpe	354 m^3
	Processing Equipment	Processing equipment on A and B wellsites	5.7 m^3
	Gas Transfer	Wellsite Pipelines (A-B, and B-B)	23.3 m^3
	Separation	Test separator	1.4 m^3

5.3 BAT for Production Preparatory Stage

During this period when the wells are being brought into operation, there is a potential for waste gas to be produced during well workover, sidetrack and well testing activities. The purpose of these activities is to bring the wells back into production allowing gas flow to surface to allow the well to reach steady state production. During this phase the new production plant will be being installed and commissioned.

5.3.1 Harnessing Gas for Export

During the initial phase flowrates and quality of the extracted gas may fluctuate and without a steady state of production being achieved, export to the NTS is not viable and is therefore not considered BAT for this stage.

5.3.2 Harnessing Gas for Alternative Use

During the initial phase flowrates may fluctuate and, therefore, although harnessing of natural gas for alternative use, such as electricity generation, during these activities is technically feasible, the flow fluctuation means that processing and electricity generating equipment can only be operated safely and efficiently when the steady state gas flow is achieved. Therefore the production of electricity cannot be considered BAT during this period.

5.3.3 Incineration of Gas by Flare

During this phase of the operation, gas may be generated during well testing activities up to 2.2 MMscf per day. Due to the inherent uncertainty of natural gas properties, and the requirement to clean up the well after a side-track from a new section of the formation, entry into the pipeline will be prohibited until reliable data is ascertained (gas quality, flow rates and pressure). This will be a short-term duration of up to 3 days. The disposal of gas by means of incineration in a flare unit would be considered as BAT. A further BAT Assessment for the 'Type of Flare' system has been provided in Section 5.6 below.

5.3.4 Cold Venting

Hydrocarbon gases, such as methane (CH4), have a Global Warming Potential (GWP) twenty-eight (28) times greater than carbon dioxide (CO2e), based on a 100-year time horizon, therefore, venting of unburnt hydrocarbons represents an increased environmental impact over incineration of natural gas. In addition, the venting of large volumes of hydrocarbons presents an increased risk of fire and/or explosion. At present there are no plans to cold vent gas during this phase of the operations.

5.3.5 BAT Conclusion for the Production Preparatory Stage

The incineration of natural gas is considered to be the preferred management technique for waste gas during this stage of the operations. A further BAT Assessment for the 'Type of Flare' system has been provided in Section 5.6 below.

5.4 BAT Assessment for Gas During Production

During production operations, for the majority of the time natural gas is extracted from the reservoir, processed and exported as a product to the national grid with a small proportion used as fuel for the site generators. During periods when the gas quality is insufficient or out of specification for export or for use as fuel or in an emergency situation, gas will be directed to the flare which will act as a safety device for short periods of approximately 10 – 15 minutes.

5.4.1 Harnessing Gas for Export

During production operations, for the majority of the time natural gas is extracted from the reservoir, processed and exported as a product to the NTS. This use of gas is considered BAT.

5.4.2 Harnessing Gas for Alternative Use

During normal production operations, a portion of the natural gas produced at the site is directed as a fuel to the onsite generators to provide power for site operations and to operate the compressors. Gas in this instance is being used as a fuel and not a waste and this is considered BAT.

5.4.3 Incineration of Gas By Flare

A flare unit will be used as a safety device should an emergency situation arise, for example, incinerating all associated gas within the production facility following a well shut in. The duration of such flaring activities during any production phase would be limited to short time intervals. The disposal of gas by means of incineration in a flare unit would be considered as

BAT for such circumstances. A further BAT Assessment for the 'Type of Flare' system has been provided in Section 5.6 below.

5.4.4 Cold Venting

Cold venting would not be considered appropriate for production operations and will not be used during this phase of operations.

5.4.5 BAT Conclusion for Production Stage

As outlined in Section 5.4.1 and 5.4.2, the export of natural gas to NTS and the harnessing of associated natural gas, during the production operations for use as a fuel to generate power and operate compressor generators (gas engines) can be considered BAT.

A flare unit being used as a safety device for short, infrequent periods of time can be considered BAT and a further BAT Assessment for the 'Type of Flare' system has been provided in Section 5.6 below.

5.5 BAT for Gas Management During Decommissioning

During this phase, production will cease, processing plant and pipelines will be removed from the site.

5.5.1 Harnessing Natural Gas for Export

Natural gas contained within the 10" gas export line to Theddlethorpe Gas Terminal will be harnessed for export to the Theddlethorpe Gas Terminal.

During the decommissioning phase, the 10" gas export line will be flushed by means of 'pigging', a technique used within the oil and gas industry where a maintenance tool, a 'pig', is inserted at the source and either pushed or pulled through the system to the endpoint. The 'pig' is designed to push the natural gas contained within the 10" gas export line to the end point, Theddlethorpe Gas Terminal, where it will be harnessed for export and use within the Natural Transmission System (NTS).

'Pigging' the 10" gas export line will ensure that all the natural gas contained within the system will be harnessed for export and cold venting or the incineration of natural gas will not be required. For clarity, the total volume of natural gas to be harnessed for export is approximately 354.0m^3 (12,501 scf), approximately 92% of the total volume of natural gas to be disposed of during the decommissioning phase of operations.

The harnessing of natural gas for export is considered BAT in this instance but can only be considered BAT for approximately 92% of the natural gas.

The remaining natural gas contained within the production equipment cannot be harnessed and approximately 30.4m^3 (12,501 scf), will have to be disposed of via an alternative method.

5.5.2 Incineration of Natural Gas by Flare

When determining BAT for the Saltfleetby Wellsites during decommissioning, the following points were considered with respect to incineration of natural gas by flare:

- The cost to install, operate and de-mobilise a flare system is not commercially viable for the low volume of natural gas to be incinerated;
- Low volumes and flow rates of natural gas may require large volumes of support fuel to maintain efficient combustion;
- Use of Nitrogen (NO_2) to purge the system may impact on flare combustion efficiency.

Angus has therefore determined that the incineration of natural gas during decommissioning is not considered BAT due to it not being commercially feasible and approximately 30.4m^3 (12,501 scf) of natural gas, will have to be disposed of via an alternative method.

5.5.3 Cold Venting of Natural Gas Directly to Atmosphere

When determining BAT for the Saltfleetby Wellsites during decommissioning, the following points were considered with respect to cold venting:

- Although cold venting of natural gas has an environmental impact, the volume of natural gas to be cold vented is not expected to have a significant impact on the environment.
- Mitigation measures will be implemented to ensure that safety risks associated with cold venting of natural gas are minimised to As Low as Reasonably Practicable (ALARP).
- Incineration of natural gas has been determined as not being technically or commercially feasible.

Angus has therefore determined that the cold venting of natural gas is considered BAT and approximately 30.4m^3 (12,501 scf) of natural gas, will be cold vented directly to atmosphere. For clarity, natural gas will be cold vented via the cold vent stack located in the southeast corner of the Saltfleetby B wellsite.

5.5.4 BAT Conclusion for Decommissioning

As outlined in Section 6.2.1, the harnessing of natural gas for export during decommissioning can only partially be achieved and the disposal of natural gas via cold venting is considered BAT.

It is, therefore, considered that, for the purpose of this Gas Management Plan, that BAT for the management of waste gases not utilised for export during decommissioning is the cold venting of natural gas directly to atmosphere.

5.6 BAT for Flaring

The specification of the flare proposed for the Saltfleetby wellsites is attached in Appendix D of the Technical Plan (Application Part 4). This flare is a high temperature 'enclosed' flare which is designed to meet the EA's requirements in terms of emissions as well and meeting the requirements of ATEX/DSEAR certification.

The EA considers an enclosed ground flare to be BAT as it provides the best environmental performance for treatment of waste gases from onshore oil and gas operations. This is due to the technical design of the flare including:

- Burners that are housed in a thermally insulated enclosure (not shrouded);
- Burners that are designed to operate within an enclosure; and
- A mechanism to control the combustion of air feed rate to optimise combustion.

The Environment Agency have stated, however, they will give consideration for alternate methods of treatment for waste gases if an enclosed flare is not applicable, or equivalent environmental performance can be achieved, on the basis that evidence of this can be provided.

Having established BAT for the method of disposal of associated gas recovered from a reservoir as flaring, Cuadrilla have considered a number of types of flares for the incineration of associated gas during the well test operations, including:

- Enclosed ground flare;
- Shrouded ground flare; and
- Elevated pipe flare.

Each flare has been assessed against the following criteria:

- Its ability to safely incinerate associated gas with high methane content across a significantly variable range of flowrates and inlet pressures, such as those likely to be experienced during the initial phase of hydrocarbon exploration, DST or well clean-up; and
- Environmental performance.

For the purpose of this BAT assessment, cost has not been included. Whilst economic viability is a consideration of BAT, technical viability and environmental performance are the most critical consideration. The findings of the assessment, together with a conclusion of BAT are detailed in the following subsections.

5.6.1 Enclosed Flare

Enclosed flares, such as those used in landfill, are designed with either a single or multiple burner, to incinerate associated gas with low methane content, typically around 56% methane and 31% carbon dioxide. These flares are limited insofar as inlet pressure and flowrate capabilities, therefore, can only be used for oilfield purposes when there is significant confidence that any associated gas pressures and/or flow rate is low. Examples where enclosed landfill type ground flares can be used for oilfield purposes are EWT and production of oil with low gas to oil ratio (GOR) or coal bed methane, where it is known that the methane content is high but the pressures and flows are low.

Enclosed flares have been designed and do exist specifically for oilfield purposes, however, from experience, their environmental performance is based on consistent pressures and flow rates. Enclosed ground flares are more sophisticated than open pipe flares or shrouded ground flares and are not easily modified to accommodate increase in support gas to sustain combustion efficiency.

Recent experience of a sophisticated enclosed ground flare being used onshore UK for hydrocarbon exploration resulted in poor environmental performance due to an inability to combust associated gas during periods of low inlet pressure, circa 1.2 bar(g). Below 1.2 bar(g) associated gas was effectively being cold vented with no feasible way of increasing support gas to sustain combustion efficiency. Likewise, the enclosed ground flare had a modest maximum flow rate, which in turn, restricted the ability to 'rock the well' in an attempt to sustain a consistent flow rate.

Sophisticated enclosed ground flares that achieve high environmental performance are designed and constructed to operate in a narrow operating envelope, based on known gas compositions, flow rates and pressures. Evidence to support this being the case is contained within the Mott MacDonald report. In response to a questionnaire, flare manufacturer Zeeco states *'We would not decide on the flare design based on what the customer is doing on their site. We would take their process data and select the best flare to achieve their specified goals. Often we don't know what the application is. We simply look at the gas composition and condition of supply to our battery limit along with the customers desired result and availability of utilities.'*

The limitations of low pressure and maximum flow rate, when used during the initial phase of hydrocarbon exploration, DST or well clean-up, where the gas composition, pressure and flow rates are unknown will inevitably result in a poor environmental performance and a protracted well operation.

Once the initial phase of hydrocarbon exploration, DST or well clean-up, has established gas composition, consistent pressures and flow rate, the industry generally accepts that an enclosed ground flare can then be specified and subsequently used for EWT and production.

5.6.2 Shrouded Flare

A shrouded flare is essentially an open pipe flare, which is designed to incinerate natural gas with high methane content across a significantly variable range of flowrates and inlet pressures, such as those likely to be experienced during the initial phase of hydrocarbon exploration, where the gas composition, pressure and flow rates are unknown. Whilst having lower combustion efficiency due to not having multiple burners, a shrouded flare provides confidence of natural gas combustion across the significantly variable range of flowrates and inlet pressures. Historically, pre August 2013, open pipe flares have been used extensively onshore UK without significant impact or concern.

Due to their simplicity of design, shrouded ground flares can be easily modified to aid combustion efficiency at low inlet pressures. This can be achieved by increasing the flow of support gas (propane).

The shroud placed around the flare tip aids in the reduction of the environmental impact, with respect to noise and visual impact. The size of the shroud is largely dictated by transportation restrictions onshore UK. As stated in National Planning Policy Framework, minerals, which

includes oil and gas, 'can only be worked where they are found', often resulting in well sites being located in areas with minimal and restrictive highway infrastructure.

5.6.3 Elevated Pipe Flare

Elevated pipe flares generally have a single burner flare tip, elevated some metres above ground to provide greater dispersion performance. The flare tip is not enclosed nor is it shrouded, resulting in a visible flame and no noise attenuation. Elevated flares are capable of incinerating natural gas with high methane content across a significantly variable range of flowrates and inlet pressures, such as those likely to be experienced during the initial phase of hydrocarbon exploration, where the gas composition, pressure and flow rates are unknown. Unlike an enclosed ground flare, which uses a multi-burner design to increase residence time to improve combustion efficiency, elevated pipe flares have the ability to introduce air or steam, which is injected into the gas to generate turbulence. This is referred to as air or steam assist. Generating turbulence improves combustion efficiency by allowing the methane to mix with the air, resulting in greater methane destruction.

Elevated pipe flares are suitable for use as a safety flare during drilling or H_2S service, where the concentration of H_2S is expected to be high. The risk of unburnt H_2S being present or high concentrations of SO_2, as a result of incineration, is a significant health and safety consideration, mitigated by elevating the release point to increase dispersion.

5.6.4 BAT Conclusion

A number of types of flares have been assessed with respect to BAT for safety use during hydrocarbon production. Sophisticated enclosed ground flares that achieve high environmental performance are designed and constructed to operate in a narrow operating envelope, based on known gas compositions, flow rates and pressures. A smaller Enclosed flare that has the ability to incinerate 'residual gas' following a well shut in is feasible, provided the operating envelope is considered suitable.

Whilst it is accepted that the elevated pipe flares are an appropriate type of flaring system for incineration of natural gas with a high concentration of H_2S, they are generally not suitable for operating in a non-industrial environment, due to increased visibility and noise (environmental considerations). Where health and safety becomes the overarching factor, as is the case with high concentrations of H_2S, then a compromise is struck with respect to environmental considerations.

Shrouded ground flares, having been designed around an open pipe flare, provide for the incineration of natural gas with high methane content across a significantly variable range of flowrates and inlet pressures, such as those likely to be experienced during the initial phase of hydrocarbon exploration, DST or well clean-up, where the gas composition, pressure and flow rates are unknown. They provide the Operator with confidence that natural gas can be destroyed, albeit at a slightly reduced combustion efficiency. Nevertheless, the ability to function across variable flowrates and pressures is a significant safety consideration and one, which outweighs a slight reduction in environmental performance.

For the reasons set out above, BAT for the incineration of waste gases during the well test and emergency scenarios during production operations is either an enclosed ground flare or shrouded flare as the flow rate of gas will be low.

6. BAT for Storing and Handling of Condensate

Condensate is produced as part of the gas production process and has a high content of hydrocarbons and therefore in accordance with the guidance it is treated as 'crude oil' for the purposes of a BAT assessment. The intention after treatment is to sell the condensate as a product to a third party. It is therefore not considered a waste.

BAT for the management of gas is detailed in section 9 of the EA Onshore Oil and Gas Sector Guidance. The detailed information relating to the management of condensate at the Saltfleetby site is detailed in the Technical Plan (Application Part 4) and evaluation against the BAT criteria is summarised below in table 6,1.

Table 6-1: BAT Assessment for Storage and Handling of Condensate

BAT Section	BAT Criteria	BAT Justification
Storage vessel design	• constructed from material that is impermeable to crude oil and water and resistant to corrosion • fitted with level detection and an overfill protection system • protected against over or under pressurisation • made with welded or flanged connections • fitted with a system that can detect water building up and can drain off water without a significant release of crude oil	• The condensate will be stored in a steel tank with welded or flanged connection. It will be impermeable to the condensate and resistant to corrosion. • As detailed in the specification in section 5.1of the Technical Plan (Application Part 4), the tank will be equipped with appropriate overfill and pressurization protection. It will be also be equipped with the system that facilitates to removal of water without a significant release of crude oil
Containment system design	• have a capacity of either 110% of the largest vessel, or 25% of the total capacity of all the vessels it contains – whichever is greater • be able to withstand the hydrostatic head of liquid when full • be made of fire resistant material which is also impermeable to crude oil and water • be fitted with metal water stops to prevent leakage from any joints in the bund construction • have joint sealants that are resistant to crude oil and water and can maintain a seal during thermal expansion or contraction of the bund • have walls or floor that are not penetrated by pipework, cables and instruments • be fitted with a high-level alarm • be fitted with a sump to allow removal of accumulated liquid	• The condensate tank will be sited inside a new local concrete containment bund with sealed joints which will be impermeable to the condensate and is fire resistant. • The design of the bund will be in accordance with CIRIA C736 Guidance and will be installed to last beyond 10 years. Including meeting the requirements for withstanding the hydrostatic head of liquid when full, having a sump arrangement to allow removal of accumulated liquid and is not penetrated by pipework, cables and instruments.
Handling system design	• install ancillary equipment associated with the storage vessel, such as pumps, oil bath heaters and filters in the containment bund • protect ancillary equipment such as heat exchangers and filters against over pressurisation • locate crude oil pipework joints inside the containment bund, where possible • protect the ground beneath any crude oil pipework joints with an impermeable liner, if it is not protected by a bund • use an oil and water separation system that can handle oil-contaminated rainwater extracted from the bund and accumulated water extracted from the oil storage vessel	• Ancillary equipment associated with condensate and joints in pipework will be situated within the containment area. • Saltfleetby Wellsites have been constructed with an impermeable liner installed across each area (please refer to information previously submitted under IC2 relating to this membrane). • The integrity of the seals particularly in areas used by traffic, to temporarily store extractive waste or where there are built structures will be checked prior to the site being brought back into production. • The site surface water management system is equipped with Class 1 interceptors which are kept isolated during normal operations. Only water which is confirmed by sampling as being

BAT Section	BAT Criteria	BAT Justification
		uncontaminated will be discharged via the interceptor. Contaminated water from bunds or in the drainage system will be removed by tanker for offsite disposal at a permitted treatment facility.
Operation of storage and handling system.	Implement a planned preventative maintenance programme which includes: • routinely check and record the level in the crude oil storage vessels • regularly check the quantity of crude oil stored against the expected inventory - based on filling and export records • visually inspect the crude oil storage and handling system every day to identify any faults	• Storage tanks are equipped with level detection and overfill protection which will be subject to planned preventative maintenance. • The tanks and associated pipework are also included with the Leak Detection and Repair (LDAR) inspection programmes.
Managing vent emissions	• predict the quantity and nature of the emissions from your crude oil storage vessel vent - based on the expected composition of the crude oil and the predicted oil storage vessel feed rate • carry out sampling to verify the composition and the quantity of your emissions • carry out an odour impact assessment and produce an odour management plan if the crude oil you are storing or handling contains hydrogen sulphide • back vent road or rail tankers to the storage vessel during loading • describe any measures needed to reduce the concentration of hydrogen sulphide or other harmful substances emitted	• Whilst it is feasible to have a feed line from the tank vent to a flare unit there is a high risk of “flare-blowback” and this could ignite the gas inside the atmospheric stock tanks which in turn could explode causing serious injury and possible fatality. As such the condensate storage tank will be fitted with a dry break coupling connection and arrangements for back venting during loading of road tankers back to the bulk storage tank for containment. • The gas composition as detailed in section 4.1 of the Technical Plan (Application Part 4) shows that gas contains negligible levels of H_2S and as such no odour management plan is proposed at this time.

7. Other BAT Considerations

7.1 Managing Effluents

The main effluents from the site will comprise produced water, well cellar fluids, contaminated rainwater from containment areas and effluent from the site welfare facilities. Consideration has been given to the nature of such effluents as detailed in Section 10 of the EA Onshore Oil and Gas Sector Guidance. None of these effluents are proposed to be discharged to surface or ground water and arrangements are in place for their removal from site to an appropriately licenced offsite facility for treatment. Such wastes will be managed in accordance with the WMP (Application Part 5), see BAT justification for extractive wastes in Section 4 above.

7.2 Managing Produced Water

Produced water will be stored in steel tanks which are resistant to corrosion and will be located within a bund capable of containing 110% capacity of the vol of a single tank or 25% of the total volume of multiple tanks if they are sited in the same bund, whichever is the larger. The produced water tanks will be equipped with the necessary overfill and pressurisation protection.

Produced water will be managed in accordance with the WMP (Application Part 5) and will be removed by tanker for offsite treatment and disposal at an appropriately permitted facility. See BAT justification for extractive wastes in section 4 above.

There will be no reinjection of produced water to the reservoir at the site and no hydraulic fracturing in proposed.

7.3 Emissions Monitoring

Emissions monitoring for the site is detailed in Section 8 of the Technical Plan (Application Part 5) and is in accordance with the requirements detailed in section 13 of the EA Onshore Oil and Gas Sector Guidance.

7.4 Decommissioning

Decommissioning activities will be managed as detailed in Section 9 of the Technical Plan (Application Part 4) and will be completed in accordance with the regulations specified in Section 14 of the EA Onshore Oil and Gas Sector Guidance.