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Rough Gas Storage Facility

An Operational Overview



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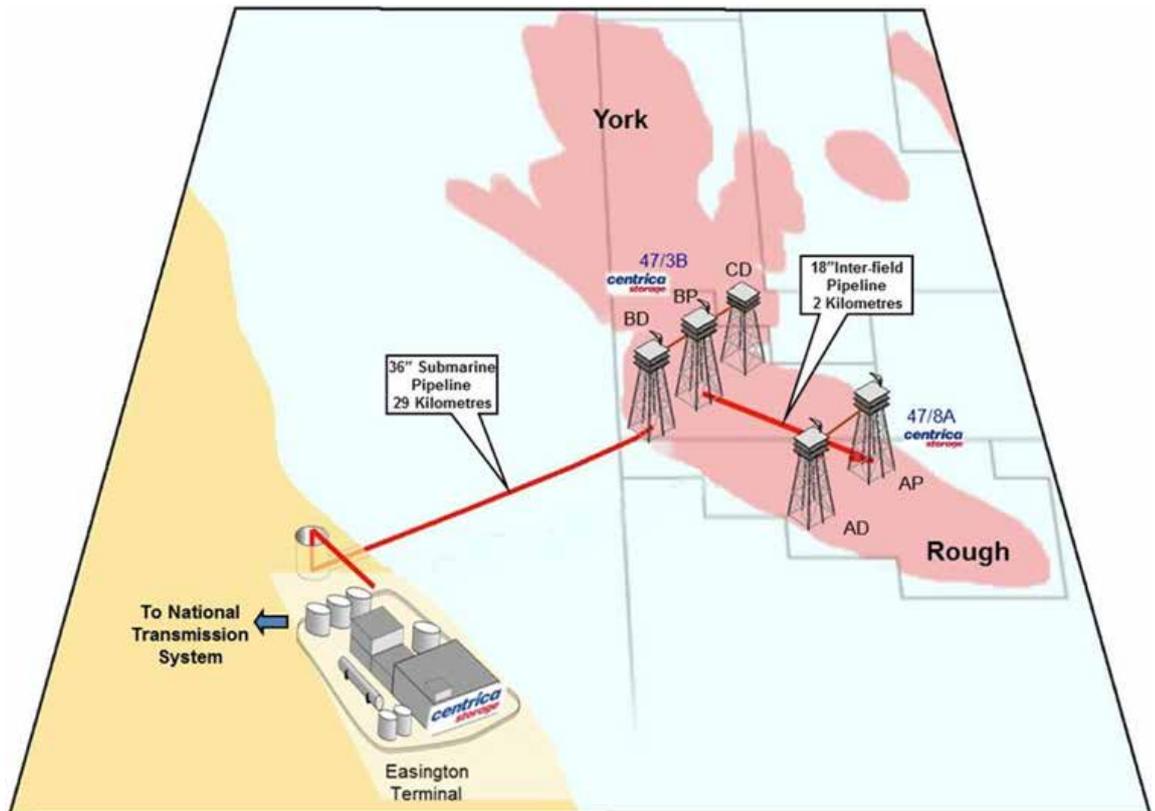
The Rough gas storage facility

This guide explains the operational parameters of Rough and provides a brief explanation of the Rough gas storage facility, the licensed and technical capability and an outline of the operational and maintenance activity.

Please note that in accordance with both the Gas Act 1986 (s.11C) and the Rough Undertakings, information about the day-to-day operations of Rough is likely to fall within the definition of ‘Commercially Sensitive Information’ (CSI). CSL is under an obligation to disclose CSI on a non-discriminatory basis. Therefore CSL will be unable to answer any specific questions which could contain CSI unless the information is published to the whole market (e.g. within this Operational Guide or other form of market announcement, such as a REMIT notice).

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The Rough gas storage facility



As shown in the schematic above, the Rough gas storage facility comprises:

- the Rough reservoir
- offshore installations (47/3B and 47/8A); and
- the onshore terminal (Easington)

2.1.

The Rough reservoir

The Rough reservoir is located approx. 29 km offshore from Easington and is approximately 2.7 km below the sea bed.

2.2.

Offshore installations

The Rough reservoir is accessed via two offshore installations.

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The Rough gas storage facility

2.2.1. 47/3B Installation

The 47/3B installation has up to 24 wells available for withdrawal or for injection. During withdrawal mode the installation utilises the gas pressure from within the reservoir to deliver gas to the onshore installation.

During gas injection the installation utilises one or two compression units to raise the gas to the pressure of the reservoir. The installation connects to the Easington terminal via a 36" diameter subsea pipeline.

2.2.2. 47/8A Installation

The 47/8A installation has up to 5 wells available for withdrawal only and one further well which is out of operation. The installation connects to the 47/3B platform via a 2km 18" diameter subsea pipeline. As 47/8A is only used for production operations, maintenance activities are concentrated in the injection season.

2.3. Easington Terminal

The Easington terminal is used for the injection and withdrawal of gas to and from the Rough reservoir. The Easington terminal is also used for the processing and delivery of other gas (currently from the Amethyst and York fields).

During gas withdrawal mode, the Easington terminal receives and processes gas and liquid from the 47/3B installation. The gas is dried, filtered, metered and delivered into the National Grid Transmission system (NTS). Liquids recovered from the process (gas condensate and water) are processed, stored and then dispatched from the site via either a dedicated pipeline (gas condensate) or road tanker (water).

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Licensed and technical capability of Rough

The licensed and technical capability of Rough is outlined below and is described in terms of the working volume (space), withdrawal capability and injection capability.

3.1. Working volume (space)

The gas within the Rough reservoir comprises working gas, recoverable gas and unrecoverable gas. Working gas is made up of gas injected by CSL customers from the NTS together with CSL’s operational stock (refer to section 4.1 for definition of operational stock). Recoverable and unrecoverable gas constitutes Rough’s cushion gas and is just under 320 bcf of gas. Under normal operations, the cushion gas remains in the reservoir and serves to maintain the operating pressure required to provide an effective storage service from the Rough facility.

The Rough Working volume, together with the recoverable and unrecoverable cushion gas, is illustrated in the chart below.

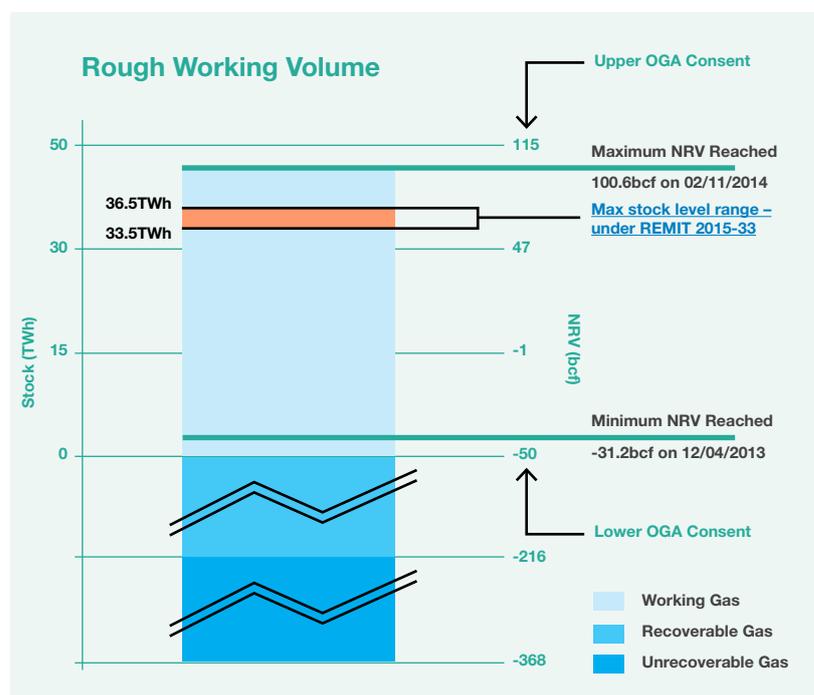


Chart 1: Rough Working Volume

Note: Oil & Gas Authority (OGA) formerly part of DECC

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Licensed and technical capability of Rough

The Rough reservoir is subject to the provisions of a production licence, granted by DECC which states the upper and lower reservoir limits to which gas can be stored.

The volume of Working gas that CSL is permitted to hold under its current consent from Oil and Gas Authority (formerly part of DECC) is between a maximum permitted Net Reservoir Volume (NRV) of 115 bcf to a minimum permitted NRV level of -50 bcf (i.e. 165bcf in total). The -50 bcf NRV level is equivalent to the “zero” stock level (in kWh) as reported on the National Grid website after adjustment for any gas held by National Grid for Operating Margins purposes.

Due to variations in calorific value (approximately 39.2 MJ/m³), there are in practice likely to be minor differences between the -50 bcf NRV and the zero stock level (in kWh).

The actual maximum NRV that Rough can achieve is dependent on a number of factors including: injection availability, customer utilisation, system pressures and carry-over of customer stock at the end of the previous storage year. The maximum NRV achieved to date is 100.6 bcf on 02/11/14.

The actual minimum NRV that Rough can achieve is also dependent on a number of factors including: customer nominations, any use by National Grid of the Operating Margins gas it holds in Rough and the use of gas held by CSL for system integrity purposes. The minimum NRV achieved to date is -31.2 bcf on 12/04/13.

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Licensed and technical capability of Rough

3.2.

Withdrawal capability

Gas compression is not used for withdrawal from the Rough gas facility. The indicative withdrawal rate is a function of total reservoir stock as shown in the Chart 2. However, actual rates achieved are also influenced by a number of factors including ambient conditions, well performance and the pressure of gas on the NTS in the vicinity of Easington. The chart is accurate to within a tolerance of 10%. The capability curve assumes constant withdrawal rates from the reservoir. Rates could be increased at a given stock level if there have been significant periods of relaxation.

The maximum technical capability of Rough to withdraw is 485 GWhs/day (Withdrawal rate of 44.7mcm/day). However, the 47/8A installation is unable to withdraw at high reservoir levels due to the high reservoir pressure.

Withdrawal rates decline as the reservoir empties due to the reducing pressure in the reservoir and the potential for sand production.

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Licensed and technical capability of Rough

In order to provide market participants with the most up-to-date information, CSL will generally inform the market where Rough capability in withdrawal mode deviates or is expected to deviate from the line shown below by 5mcm/d or more. CSL will publish an updated version of this chart here whenever the expected curve deviates by more than 5mcm/d from the previously published version. CSL will publish both the original and updated withdrawal curves, normally by issuing a revised version of this document on its website. The current version of Chart 2: Withdrawal curve (Maximum rate vs. Stock) dated 20/07/15 shows the withdrawal capability for 2015/16.

Short term reductions in the withdrawal capability will generally be announced to the market on the CSL website as outlined in section 4.

Total stock levels in the Rough reservoir are published on a daily basis on the National Grid website (under Storage and LNG Operator information) at: <http://www2.nationalgrid.com/uk/Industry-information/gas-transmission-operational-data/supplementary-reports/>. The stock levels reported on the website exclude any gas held by National Grid for Operating Margins purposes and the amount of stock held for this purpose is currently 0.444 TWh.

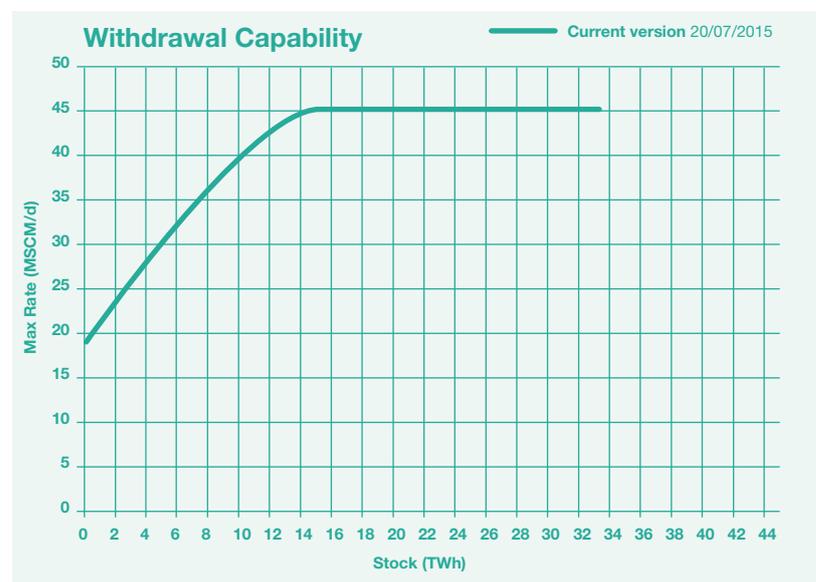


Chart 2:
Withdrawal curve (Maximum rate v Stock)

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Licensed and technical capability of Rough

3.3. Injection

The maximum injection rate is a function of reservoir pressure which can be approximated by total reservoir stock as shown in the Injection Capability graph. However, actual rates achieved are also influenced by a number of factors including, historic injection rates, atmospheric temperature and pressure conditions, the calorific value of gas, the pressure of gas on the NTS in the vicinity of Easington and well and compressor performance (typical error is around 10%). Injection rates may be higher than indicated if there is a period of reduced nominations allowing the reservoir to relax.

Injection has three possible operation modes which are driven by the pressure in the reservoir:

1. "Two train" where both compressors on the 47/3B are in operation
2. "Single train" where one compressor on the 47/3B is in operation
3. "Stop/start" where one compressor on the 47/3B is run for a period and then the reservoir is allowed to relax for a period (up to 48 hours depending on fullness).

Under two train operations, the maximum technical capability of Rough to inject is generally 305 GWhs/day (but this could be higher if additional NTS exit capacity is available at Easington). Injection rates decline as the reservoir fills due to pressure increase in the reservoir.

Once the reservoir reaches a critical pressure level, it is only possible to inject using a single train (compressor). By default, in the standard operating mode, the move to single train operations is expected to occur around a stock level of 34 TWh (assuming 100% injection utilisation) to 38 TWh (assuming 50% injection utilisation). Under REMIT 2015-33 operating mode, the move to single train operations is expected to occur around a stock level of 26 TWh to 28 TWh. Significant periods of relaxation (e.g. the annual maintenance) in the reservoir will also impact the stock level at which single train operation applies. CSL will generally make a market announcement on the expected date of the switch to single train operation.

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Licensed and technical capability of Rough

As the reservoir pressure rises further, at a certain point in time CSL may need to operate injection on a non-continuous 'stop-start' operation. By default, in the standard operating mode, the move to stop/start operations is expected to occur around stock levels above 37 TWh with the precise level dependent on reservoir pressure. Under REMIT 2015-33 operating mode, the move to stop/start operations is expected to occur around stock levels above 29 TWh. Typically, injection is run on single train operation for 24 hours and then the reservoir is allowed to relax for 24 hours with the relaxation time increasing at higher reservoir pressures. The injection rates shown in the graph below show the average rate – actual rates will be around 10mcm/d during "start" and zero during "stop". CSL will generally make a market announcement on the expected date of the switch to "start/stop" operations.

Recent investment in Rough means that injection can remain in continuous single train operation for longer duration, potentially until the end of the injection season.

Performance during the injection season will be reported via REMIT bulletins on the Centrica Storage website. The Injection Capability graph, Chart 3: Injection curve (Maximum rate vs. Stock), may be updated during the injection season based upon actual reservoir performance.

Short term reductions in the injection capability will generally be announced to the market on the CSL website as outlined in section 4 below.

Total stock levels in the Rough reservoir are published on a daily basis on the National Grid website (under Storage and LNG Operator information) at: <http://www2.nationalgrid.com/uk/Industry-information/gas-transmission-operational-data/supplementary-reports/>. The stock levels reported on the website exclude any gas held by National Grid for Operating Margins purposes and the amount of stock held for this purpose is currently 0.444 TWh.

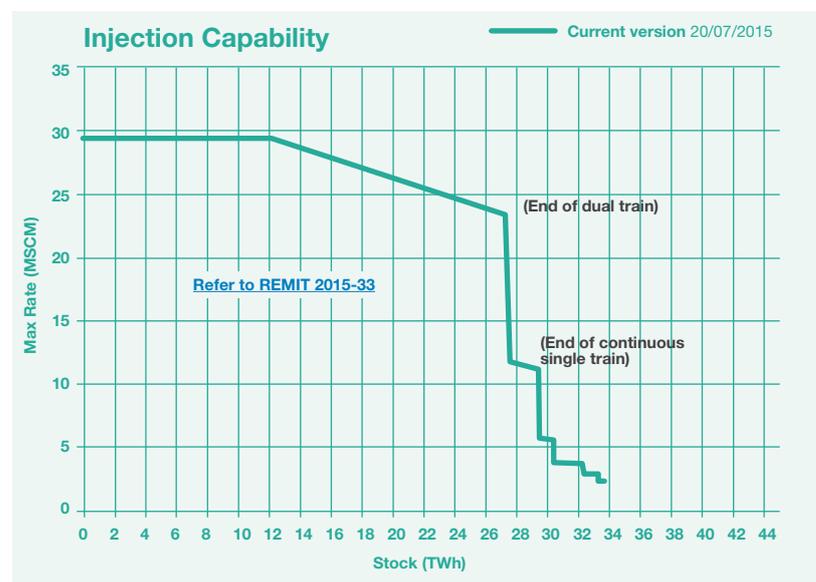


Chart 3:
Injection curve
(Maximum
rate v Stock)

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Rough operation and maintenance

Centrica Storage Ltd (CSL) aims to ensure that Rough is operated safely, efficiently and to its maximum capability with high levels of reliability. The operation of Rough is primarily driven by customer nominations, however, a range of factors including, essential maintenance of the facility, network related factors (pressure, gas quality) and market factors (economic signals to use storage capacity) will all influence the operations of Rough within and across years. At certain times, CSL may not flow in line with customer nominations as it is more efficient to not flow the gas or turnaround the site (for example a small injection or withdrawal nomination).

4.1. CSL operational stock

CSL holds stock in the reservoir in line with CSL's regulatory and contractual obligations to ensure the integrity and efficiency of the storage operation and the operation of the Storage Service Contract. Stock is used for the purposes of fuel gas, to maintain steady flows, to keep flows above sweep rates or for pigging and for customer stock management as a result of outages. At certain times it will be necessary for CSL to inject or withdraw gas to manage the stock levels held by CSL for these purposes.

4.2.

Essential maintenance requirements

This maintenance is carried out to ensure that the Rough Storage facility continues to operate in a safe and efficient manner and delivers to the contractual requirements of our customers and in line with the expectations of the market.

CSL is committed to planning the timing of these outages with regard to minimising the impact upon the gas market.

The timing of the outages, however, cannot always be predicted or pre-determined at the start of the gas year and therefore timing and subsequent announcement of an outage will be based upon a number of factors including manufacturers' maintenance recommendations, reservoir pressures, gas composition and usage of the facilities by our customers.

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Rough operation and maintenance

4.2.1. Withdrawal – keeping the sealine free of liquids

It is periodically necessary to run a 'pig' through the 36" sealine. The pig pushes out any contaminants from the sealine such as wax, liquids etc. that have settled in the line, and reduces the risk of pipeline corrosion. A pig is simply a sphere whose size is that of the diameter of the sealine and is inserted into the sealine from the offshore platform and received at the Easington terminal.

Pigging is more common at the end of the withdrawal season, when the gas is wet with liquids naturally contained within the reservoir, and when the gas flow cannot be maintained at a sufficient level in order to sweep the liquids through the sealine.

A minimum production rate of 22.7mcm/d (known as sweep rate) is required for a continuous period of 18 hours in order to remove liquids from the sealine and negate the need to run a pig. If the sweep rate cannot be maintained then the sealine must be pigged within 44 hours in order to prevent liquids building up.

The pigging operation should be carried out at a production rate of no more than 10mcm/d, in order to maintain the pig at a safe and prescribed speed throughout the run, and takes in the order of 6 hours to complete.

Compared to a maximum withdrawal rate of 44.7mcm/d, pig runs effectively reduce the maximum withdrawal capability to around 10 mcm/d or approximately 25% once ramp rates (see below) are also taken in to account.

Once the pig run is completed the plant can either be shut down, turned around to injection mode, or it can continue with gas production.

In the event that net customer withdrawal nominations are insufficient for this purpose, CSL may utilise some of the operational stock it holds in the reservoir in order to run the pig or maintain sweep rate.

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Rough operation and maintenance

4.2.2.

Withdrawal – sales gas filter changes

Before gas enters the NTS, gas is passed through two parallel sales gas filters. The filters are essential to maintain critical metering equipment just prior to the gas entering the National Gas Transmission system. The filtering elements housed within the onshore sales gas filters need to be changed out for clean filtering elements. The differential pressure across the filters is monitored and when trigger points measuring the effectiveness of the filter process are neared, outages are planned to facilitate the change. Each of the two filter housings requires a 50% outage for a 12 hour period, meaning that production rates are restricted to 50% of maximum, circa 22 mcm/d rate.

Assuming that both filters are changed within one day, and compared to a maximum withdrawal rate of 44.7mcm/d, changing both gas sales filters reduces the maximum withdrawal capability over a full day by around 22 mcm/d or 50%.

4.2.3.

Withdrawal – ramp rates

When gas production (withdrawal) commences, after shutdown or in transition from injection mode the rate of withdrawal needs to be “ramped” gradually in order to ensure safe and reliable plant operation.

The ramp rate is 10.4 million cubic metres per day rate per hour, meaning that it will take four hours to increase the rate from zero to maximum withdrawal capability (44.7mcm/d).

4.2.4.

Injection – gas compression

Gas compression is always required when gas is being injected back into the reservoir. There is one compression unit at the Easington Terminal and two compression units on the 47/3B installation. Depending upon the required injection flow, one or both of these compressors are required to provide the second stage of the gas compression, raising the gas pressure to the reservoir pressure. Compressor maintenance is planned in advance when the associated outage is expected to have minimal impact upon the customer.

4.2.5.

Gas generator (compressor) washes

For optimal operation, the gas compressors should be subject to a water wash approximately every 750 hours of operation. A compressor wash takes in the order of 4 hours to complete. Where a compressor wash is required Centrica Storage will inform the market of the date, timing and operational impact.

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Rough operation and maintenance

4.2.6.

Other Maintenance Activities

Wherever possible, any maintenance work that requires the widespread isolation of gas to make the work area safe is scheduled to take place in the Annual Maintenance Shutdown, normally planned for September. These planned shutdown windows typically last for 14 to 21 days. However, there is a limit to the amount of activity that can be fitted into these shutdown windows.

Where additional maintenance outages are required, every effort is made to ensure that any other outages are scheduled to take place at a time when the impact upon customers and the market is minimised. In many cases the equipment being taken out of service for maintenance does not affect the availability of the operation directly, but the isolation required to provide safe access to the equipment may. Centrica Storage is committed to the safety of its employees and protection of the environment and to the requirement to meet stringent isolation standards aligned to procedures which are written to provide compliance with HSE standards and guidance.

4.3.

Operational Turn Around Times

When there is a change in gas nomination resulting in the need to 'turn around' the operation from one mode (injection/withdrawal) to the other, a minimum of at least 4-6 hours is required to safely shut down one mode and to reconfigure the plant to the opposite mode. During this period no gas can be injected or withdrawn from the facility.

The sealine will require pigging when changing mode from withdrawal to injection, and taking the pig run into account, the turnaround time is extended to between 6–10 hours.

4.4.

Contacts at CSL

If you have any questions about the operation of the Rough Storage facility please email Commercial Operations at Opsdesk@centrica-sl.co.uk

If you would like to find out more about the products and services that we offer then please email Sales & Marketing at Salesandmarketing@centrica-sl.co.uk

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Alphabetical index of technical terms

Please 'control click' on the term/hyperlink of interest, below, in order to be taken direct to the relevant section of the operational guide.

[Easington Terminal](#)
[Gas Compression](#)
[Gas Generator \(Compressor\) Washes](#)
[Gas Production Ramp Rates](#)
[Injection](#)
[47/3B Installation](#)
[47/8A Installation](#)
[Operational Turn-Around Times](#)
[Other Maintenance Activities](#)
[Pigging](#)
[Sales Gas Filter Changes](#)
[“Single Train” operations](#)
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[Sweep rate](#)
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[Withdrawal](#)
[Working volume](#)

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An Operational Overview



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