national gas transmission

Critical Valves and Actuators EJP – Bacton FOSR Cost Re-Opener

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1.0	August 2024	First draft
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Contents

1 Executive Summary

1.1.1 National Gas Transmission, hereafter referred to as NGT, are requesting funding to manage Asset Health requirements related to identified Critical Valves and Actuators at Bacton Terminal. This is aimed at maintaining the ongoing safe, secure, and reliable operation of the UK Gas National Transmission System (NTS).

1.1.2 Due to the age of the site and its coastal location, Bacton is faced with a high deterioration of its numerous different sized valves. A number of these have defects i.e., internal leakage, stem seals leakage, stuck in position etc, as detailed in Section 6 of the FEED Study Report (Appendix H). A program of limited asset replacement and refurbishment has been undertaken in the RIIO-T1 and RIIO-T2 price controls. However, to safeguard the site for future energy requirements up to 2050, detailed valve studies have been done to predict the performance of the assets in Section 4 of the April 2023 RAM Study report (Appendix E).

1.1.3 This EJP proposes asset health interventions for 50 valves as confirmed in the final critical valves index. The proposed interventions will address currently identified asset health issues to support the extension of the terminal's operational life.

1.1.4 The consequence of failure has varying impacts on terminal availability and the environment such as gas leaks into the atmosphere, safety events ranging from minor isolations to carryout repairs, to lack of containment resulting in incomer stream shut down / out of service.

1.1.5 This Engineering Justification Paper (EJP) emanates from the Bacton Final Option Selection Report (FOSR) submitted to Ofgem in February 2024. The FOSR provided a summary of all the work performed to date to evaluate, cost, analyse and justify the full suite of feasible options. These considered ensuring we maintain current levels of network capability and availability for our customers.

1.1.6 This EJP focusses on one of the FOSR recommendations which is the replacement of identified Critical Valves and Actuators at Bacton Terminal in RIIO-T2, in RIIO-GT3 in RIIO-GT4.

1.1.7 An independent review was carried out with a specialist contractor [redacted] which resulted in a set of recommendations which have fed into the work scope, this includes the specification and procurement of appropriate replacement valves in accordance with T/SP/V/6 - Specification for steel valves for use with natural gas at normal operating pressure above 7 bar and sizes above DN15. Removal of defective valves for assessment of suitability for repair to store and reuse as strategic stock at an estimated cost of [redacted] per valve. Together with commissioning and return to service.

1.1.8 As an Upper Tier, Control of Major Accident and Hazard (COMAH) site, NGT has an obligation to effectively manage process safety and demonstrate compliance with COMAH regulations at Bacton. A mandatory safety case must be submitted to the Health and Safety Executive to demonstrate 'all measures necessary' have been taken in the management of the major accident hazard plant and equipment in order to ensure continued safe operation of the terminal.

1.1.9 This paper requests direct cost estimate including escalator of [redacted] (2018/19) prices of Uncertainty Mechanism (UM) funding for asset health investment on the Bacton Terminal valves and actuators. This investment will ensure continued safe and reliable operation of Bacton terminal at the lowest Whole Life Cost to consumers.

1.1.10 The investments in this EJP are required in RIIO-T2 to initiate the project and across RIIO-GT3 and RIIO-GT4 as no investment will lead to continued and increasing deterioration of the identified valves as detailed in Section 4 of the Bacton Reliability Availability Maintainability (RAM) study (Appendix E), limiting their effective operation. If these assets are not functioning correctly, there is a risk of major operational challenges which shall be discussed in detail under Section 5 Problem Statement. These challenges in turn leads to a network unable to meet customer needs.

Name of Project	Bacton Valves and Actuators Investments
Scheme Reference	
Primary Investment Driver	Asset Health
Project Initiation Year	FY2026
Project Close Out Year	FY2035
Direct Cost Estimate (£m, 2018/19)	[redacted]
Direct Cost Estimate with Escalator applied @ (1.23069)	[redacted]
Cost Estimate Accuracy (%)	+15/-10%
Project Spend to date (£)	0.00
Current Project Stage Gate	ND500 (4.3) Develop and Sanction
Outputs included in RIIO-T2	• Tendering contractor award and conceptual design (Site surveys) • ECI X22 [redacted] Contract award - design and build. • Initiate Long lead item order for year 1 delivery.
Outputs included in RIIO-GT3	• Detailed design and commence delivery
Outputs included in RIIO-GT4	• Complete delivery, commissioning • Project closure

Table 1: Summary table for Valves and Actuators

1.1.11 Table 2 below sets out the cost summary for delivering the selected final option for this project.

	RIIO-T2		RIIO-GT3					RIIO-GT4					
£m 18/19	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35	Total	Total plus Escalator
Direct Cost Phasing (£m)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 2: Bacton Critical Valves and Actuators Direct Cost Summary

2 Introduction

2.1.1 The Bacton site originally went into service in 1968. The site is now beyond its design life of 40 years. Since then, there have been several significant additions and up-grades to the site including the facilities owned and operated by Interconnector which share the same site as NGT. The Terminal is both a key system entry and exit point on the National Transmission System, which has proved pivotal to securing Europe's gas supplies particularly during the current conflict in Ukraine.

2.1.2 The original design and install of the terminal had a total gas throughput capacity of 112 million cubic metres per day (mcm/d) at standard conditions. Under the current licence Bacton terminal will need to maintain the capability of delivering 120 mcm/d until 2050. Further details in Section 7 of the FEED Study report (Appendix H). Bacton Terminal accommodates flows from Southern North Sea gas fields, as well as hosting interconnectors to the Netherlands and Belgium. This makes it one of the strategic terminals for importing and exporting natural gas.

2.1.3 Due to the age of the site and its coastal location, NGT has encountered numerous defects impacting the operation of many valves and actuators at the site. Previous major investments programmes have been undertaken in the preceding regulatory periods however these have not addressed the scale of the issues affecting Bacton currently. In 2016 circa 33 valves were replaced to address defects impacting the safe operation of the terminal. However, with the forecasted importance and requirement of the site to operate beyond 2050 additional investment is required for valves and actuators to ensure the terminal continues to deliver NGT's Obligations.

2.1.4 Our Bacton Investment Strategy seeks to optimise the management of our assets at Bacton Terminal from RIIO-T2 out to 2050 as detailed in Section 3 of the Bacton Investment Strategy (Appendix I). The condition of the assets and their expected continued deterioration over time presents a gradually increasing risk that needs managing. Several assets are failing which has implications and restrictions on the mode of operation of the terminal, reducing site flexibility. These issues coupled with the consequence of failure has the potential to significantly impact on UK and European Security of Supply.

2.1.5 Extending operations to 2035 / 2050 will require work to the existing facilities. The Base Case Asset Health option approved in the FOSR has informed the single option to replace the identified defective valves detailed in Section 4. Other essential interventions are captured in separate EJPs.

2.1.6 Like most assets on the terminal, most of the valves and actuators are operating beyond their design life and are deteriorating due to a combination of wear, defects and age. This combination has resulted in a growing number of condition related defects and issues that impact the functionality and operability of the valves as detailed in Section 4 Problem Statement.

2.1.7 Valves are critical for the safe day-to-day operation of the plant and in shutdown scenarios. It is therefore important to have a proactive maintenance or replacement approach to avoid valve failure consequences. Valve surveys and asset maintenance data analysis have been undertaken to inform the investment decisions proposed in this EJP. Funding is therefore required to make the necessary interventions as detailed in Section 8 Preferred Option and Project Scope.

2.1.8 The requirement for valve/actuator replacement was driven primarily by the function and criticality of the valve and the severity of the fault identified, this is further detailed in Section 4 of this paper Problem Statement. Valve availability and ability to function as expected will be key to securing the safety and operability of the Terminal. Included in Appendix B is a Bacton Critical Valve index that presents the defective critical valves requiring replacement.

3 Equipment Summary

3.1.1 There are over 1000 valves at the Bacton Gas Terminal ranging from 50 mm in diameter to 1220 mm at the largest size. There is a blend of valve manufacturers and OEMs some of which are still operating with others no longer in business, generally driven by historic changes and work completed at the site as opposed to a single / standard valve type manufacturer being used.

3.1.2 The criticality of valves to operation of the site is linked to the flow paths as well as the duty that the given valve is intended to fulfil. A Reliability Availability Maintainability (RAM) study and a Remnant Life study have provided the necessary data to give confidence on the condition of the below ground assets and what investment is required.

3.1.3 As highlighted in the FOSR, the accepted level of functionality of Bacton terminal requires all current incomers and export routes to meet its baseline obligated flows. Figure 1 below is a simplified Process Flow Diagram (PFD) detailing where the valves in scope are located (boxed in red) within the terminal and the flow path they sit on. These valves constitute about 17% of the total population of mainline valves (circa 300) at site. This volume was determined by considering the valve criticality and recurring of defects.

[redacted]

Figure 1: Process Flow Diagram

3.1.4 Table 3 shows a list of the exact valves covered in this EJP including their main purpose and quantities on the terminal. All these valves are classified as critical to the operation of the terminal and therefore have a significant impact on deliverability, safety, and security of supply of the terminal should they fail to operate when required.

3.1.5 The majority of these valves are linked to our Emergency Shut Down (ESD) system and need to all work to a high level of reliability to safely isolate the Terminal and / or NTS pipeline feeders from a loss of containment scenario. Failure to do such significantly undermines our Safety Case commitments and ability to mitigate the impact and effects of a major accident hazard scenario and / or pipeline incident.

Valve Reference	Duty	Quantity
A1/1; A1/2; A1/3; S4/1; S4/3	• Primary and Secondary Isolation valves for the over pressure protection systems. • They should have fast acting actuators to meet the required closure time (process safety time, to prevent overpressure). Currently the valves and actuators are not fast acting actuators, hence their inclusion in this scope.	5
A2/8A; A2/8B; A2/8C.	• Flow Control Valves • Used to reduce pressure and manage differential pressures onsite.	3
F2-6; F2-12; F2-13; F2-14; F3-6; F3/7; F3-12; F4-18; F5-7; F5-12; F5-18; F4-16; F5/13; F2/7; F4-13; A2-1; A2-2; A2-3; S4-2	• Mainline to feeder isolation valves	19
S1-9A; S1-9B; S1-9C; S4/10A; S3/11A; S3/9C; A2-7A; A2/12A; A1/9A; S3/10C; S3/8A; S3/8B; S3/8C; S3/9A;	• Stream to Feeder/s manifold isolation valves	14
F4-22A; F4-22B, F4-22C; F5-22B	• Feeder meter stream isolation valves	4
R1; R5; R6	• Ring to Feeders isolation valves	3
S3/1	• Main incomer to stream	1
FM4-3	• Link Valves between plant and Feeders.	1
TOTAL		50

Table 3: Valves in scope

3.1.6 Table 4 below gives a summary of the processes completed to determine the final volumes of this EJP.

Stage	Valve replacement Volumes	Description
RAM/FOSR Stage	56	The RAM Study completed in April 2023 informed the scope and volumes proposed in the FOSR which was approved in July 2024.
NGT Review	50	As part of the submission process of this EJP, NGT has conducted further volume reviews to lockdown the final volume position of this project. At this stage, the volume of the valves was reduced from 56 to 50.

Table 4: Valve Replacement Volume Determination Process

3.1.7 Valves are installed at Bacton to enable day-to-day operation of the plant, effective isolation of sections of the site, limit gas loss in an emergency, manage flow direction (routing), flow rate and pressure, facilitate maintenance, repair, modification, testing and commissioning.

- **Isolations** – this is necessary when gas is not required in a certain section of the pipework and should be restricted from flowing. This is to facilitate maintenance work and day to day operations.
- **Routing** – this is important when there is need to change the direction of gas flow path e.g., for maintenance or site operations.
- **Regulation** – In cases where the volume of gas supplied or received should be varied, flow control valves are used.
- **Emergency operation**– In case of emergency, for instance in case of a fire outbreak, there will be need to quickly shut down gas supply using valves.
- **Incomer pressure protection-** The system and associated valves and actuators are primary protective devices to prevent an over-pressure event occurring. They are denoted Safety Instrumented Systems and are required to achieve certain Safety integrity levels. This is in accordance with Industry best-practice standards (BS EN 61511 / 61508). There are two main types of valves used on the terminal process pipework which are:
- Plug Valves
- Ball Valves

3.1.8 **Plug valves** – consists of a tapered plug within a valve body which can be rotated through 90°closed to open to allow gas to pass through the plug within the valve body. Plug valves are only a single block type valve and are very good for high differential pressures. Figure 2 shows an example of a Plug Valve at site.

Figure 2: Plug Valve

3.1.9 **Ball valve** - consists of a hollow ball (cavity) within a body which can be rotated 90° closed to open to allow gas to pass through the ball cavity within the valve boy. One advantage ball valves have over plug valves is the ability to vent the cavity down to provide a double block and bleed on a single valve. Figure 3 shows an example of a Ball Valve at site.

Figure 3: Ball Valve

3.1.10 Figure 4 further shows the internal configurations and components of a plug valve and a ball valve.

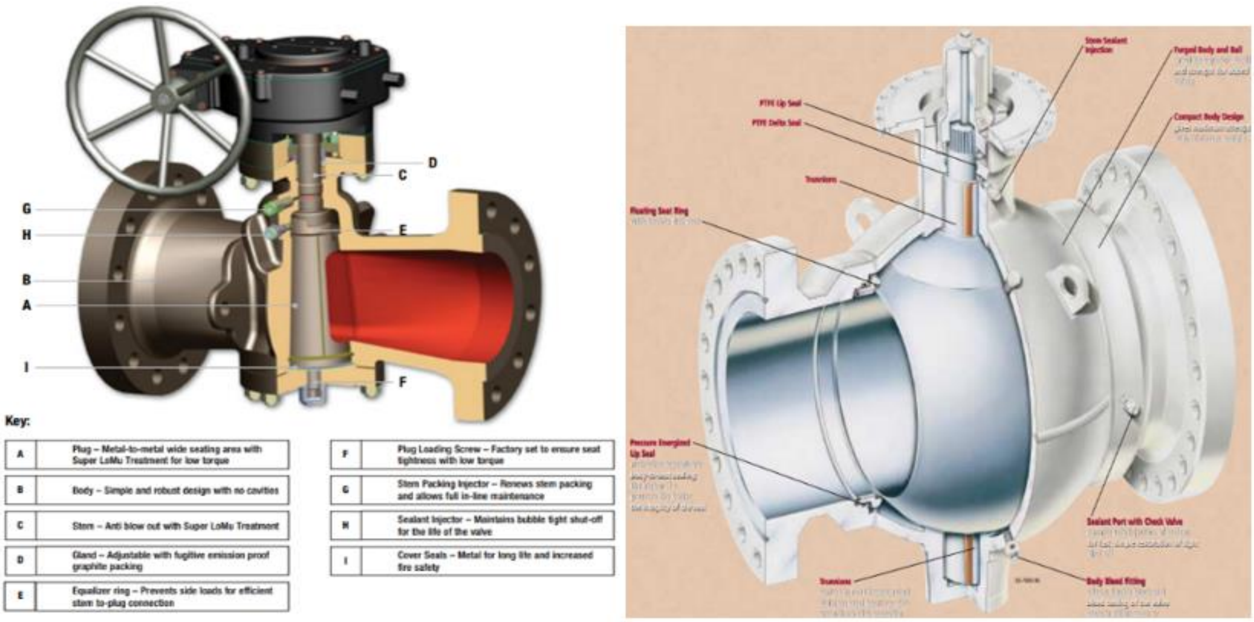


Figure 4: Plug valve (left image) and ball valve (right image) components.

3.1.11 Valves are located at different operational locations within the site depending on their purpose and pipework configuration. Valves may be located wholly above ground, in a pit or below ground which determines their accessibility and how they are operated.

3.1.12 Flow Control Valves are typically designed to operate at the full NTS line pressure, with over pressure protection set at 73 bar. Valves can either be installed in flanged or welded configuration (Figure 5), but the majority of larger valves on site are welded. The main advantage of flanged valves is their ease of maintenance as they can be easily unbolted for repairs. In contrast, welded valves require an expensive and time-consuming process to 'cut out' for repairs. The reinstallation process requires extensive mechanical works to prepare welding procedures, undertake the welding process; and perform a variety of quality assurance and non-destructive testing requirements in line with industry best-practice and wider company policy requirements.

Figure 5: Flanged valve (left image) and Welded Valve (right image)

3.1.13 To minimise the risk of gas leakage, most large ball valves across the network are of fully welded construction. Whilst this minimises the risk of leakage of gas from the valve body, it restricts the ability to undertake remedial maintenance on the valve, as fully Welded body valves cannot typically be dismantled. To do so requires them to be cut open and then re-welded closed. The technicality of this makes refurbishment of welded body valves almost always uneconomical.

3.1.14 The most common use of valves is to provide isolation, regulate flow, pressure, direction, and volume on sections of feeder or items of plant and equipment. Isolation valves can be operated in one of the following ways:

- **Locally Actuated Valves (LAV)** - enable pipework section to be isolated by means of local operation in the event of an emergency or planned operation.
- **Remotely Operated Valves (ROV)** - enable pipework section to be isolated remotely by from the site control room. These valves need to be reliable to ensure they can be operated remotely in the event of an emergency and enable NGT to meet legislative, regulatory, and commercial obligations.

3.1.15 There are also Process Valves (PV) on the terminal which allow isolation of a site or section of site pipework as part of normal site operations. These valve assets have a direct impact on the site reliability, availability, maintainability, and safety.

Valve Operation

3.1.16 Actuators are the prime mover to operate valves and more than 90% of the actuators in this scope are electric. Electrically powered or controlled actuators fall under the requirements of the Dangerous Substances Explosive Atmosphere Regulations (DSEAR). These regulations require specific checks on the condition of the electrical and mechanical equipment to avoid risk of fire or explosion.

3.1.17 The control of actuated valves can be either from a control panel local to the valve or remotely from the site control room.

Criticality of Valves

3.1.18 Valves can be categorised as critical or non-critical. Critical valves are those with a specific safety or reliability function and are subject to a more frequent inspection (Annually) and testing regime than non-critical valves (Biennial).

3.1.19 Critical valves can generally be described as:

- All remotely operated valves are considered to be critical valves, except for those which are not required for daily operations.
- All valves which are required to isolate sections of pipe to allow continued supply to customers.
- Terminal inlet and bypass valves.

3.1.20 Non-Critical Valves can generally be described as:

- Valves that can be operated at any time without affecting the overall flow of gas.
- Valves that form a bypass to the main flow of gas and serve no further isolation purpose.
- Pig trap isolation valves which serve no further isolation purpose
- Valves which are only required for isolation of plant for routine maintenance.

4 Problem Statement

4.1.1 The identified valves in this EJP will require investments in RIIO-T2 to initiate the project and across RIIO-GT3 and RIIO-GT4 to design and deliver the project as highlighted in Table 1. This will mitigate the continued asset deterioration and comply with safety legislation that allows the safe operation of the terminal up to 2050.

4.1.2 Valves are one of the few parts of a pipeline system that are subject to routine operations they are known to have a finite number of operations before the internal components of the valve begin to wear. Wearing of the valve internal components will manifest in a number of different ways, but it is typical for issues with sealing and closure time to occur as over years of operation. Because of the wearing of valves, it commonly accepted that valves have a finite life and intervention programs are often needed to replace or refurbish valves throughout the operating life of process or gas plants to ensure ongoing safe operation of the asset.

4.1.3 The table below shows a summary of current valve defects and examples of the faults, further details in Bacton Valve Defects list (Appendix K). Without the intervention, it is highly probable that the quantity of medium and high severity defects will escalate, negatively impacting daily operations of the Terminal.

4.1.4 As demonstrated in the table below, there are significant defects on the current defects list which cannot be remediated, and replacement will be the only viable option. The ultimate failure mode for such standing defects will be lack of containment resulting in gas leak.

Defect type	Quantity	Example of Defect	Risk
Safety	87	• [redacted] valve steam seal gas leak. • Takes 2 minutes to close against a target time of 6 seconds. Leak on the valve sealant line, rectification attempted without success.	• If a failure such as a valve not sealing occurs on an Emergency shutdown, this can compromise the integrity of the system. • If an overpressure event is detected through our safety systems and a valve fails to operate on demand, this increases the risk of catastrophic failure such as a loss of containment.
Availability and Reliability	109	• Corrective Maintenance attempted without success. • [redacted] valve passing gas through plug. • Valves flashed and greased many times but still unable to get a satisfactory seal to use as an isolation point.	• Loss or reduced capacity of Bacton Terminal to receive gas from its suppliers as well as distributing it to its customers. • In the case of buried valves any leak will nearly always result in an isolation being required which will adversely affect in flow restriction.
Environmental	5	• Valve when operated leaks through the stem seal. • Heavy blow once cavity vented, no seal on valve • Stem seal leak in transit.	• Loss of gas through stem leaks contributes to greenhouse gases and global warming. • Potential noise excursions resulting in noncompliance with environmental permits.

Table 5: Current Valve Defects

4.1.5 The identified valves and actuators have deteriorated through normal operational use over the years, resulting in poor performance. An example of this was the failure of Valve A1/2 to close within the SOL (Safe Operating Limit) during a study conducted in 2020, for further details see Section 4 of the A/1, A/2, S/4 Valve Closure Time Dynamic Study (Appendix F).

4.1.6 Based on the valves asset health interventions proposed in the FOSR. 56 in-line valves were identified as necessary to be replaced to ensure safe operation of the terminal, meet required demand flow rates, and sustain required levels of reliability to 2050. Following this, internal reviews conducted by NGT to further assess the valves in scope confirmed that the defects on six of the valves could be resolved by Opex intervention. This EJP therefore is focussed on the remaining 50 valves as shown in the Critical Valves Index summarised below and detailed in Appendix B.

Legislation and Best Practice Standards Requirements

4.1.7 The aim of PSSR is to prevent serious injury from the hazards of stored energy. In this case, the valves are regulated assets on gas pipework which ensures pressurised gas containment. Compliance with PSSR drives inspection and validation of the assets and associated remediation of any defects found. Failure to comply with the requirements of the PSSR can result in a prohibition notice being served in cases where the condition of the asset is regarded as representing imminent danger. PSSR is concerned with the mechanical integrity of the pressure system. As equipment ages and its condition deteriorates, it is to be expected that additional repair or replacement work may be required.

4.1.8 The legislation for safe shut down systems and emergency procedures for major accident hazard pipelines are included in the Pipeline Safety Regulations (PSR) and Gas Safety Management Regulations (GS(M)R).

4.1.9 The PSR requires all pipeline operators to maintain the pipeline and its isolation valves. Regulation 6 states that, “The operator shall ensure that no fluid is conveyed in a pipeline unless it has been provided with such safety systems as are necessary for securing that, so far as reasonably practicable, persons are protected from risk to their health and safety.”

4.1.10 Regulation 6 of the GS(M)R states that, “Where any gas escapes from a network the persons conveying the gas in the part of the network from which the gas escapes shall, as soon as is reasonably practicable after being so informed of the escape, attend the place where the gas is escaping and within 12 hours of being so informed of the escape, he shall prevent the gas escaping.”

4.1.11 In addition to the requirements of GS(M)R and PSR, the HSE document ‘HSG253’ (The safe isolation of plant and equipment) and NGT technical specification T/PM/TR/17 sets out requirements for the safe isolation of plant and equipment to allow work to be undertaken. These requirements are a function of line size, operating pressure, materials being handled, and the type and duration of the work being undertaken.

4.1.12 Electrically powered actuators fall under the remit of the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR). All sites handling flammable or explosive materials are required to be divided into zones according to the risk of a flammable atmosphere being present. All electrical and applicable mechanical equipment used within a zoned area is required to be compliant with the applicable standards for design, installation, and maintenance for that zone. This is to ensure that the installations are maintained in a satisfactory condition for continued use within a hazardous area. If on testing a failure is found, then interventions will need to take place based on defined response criteria.

4.1.13 Adherence to safety standards not specifically mandated in legislation, is covered by safety-case commitments, and needs to be adhered to. Functional Safety Requirements include BS EN 61508/11- International standard for functional safety for electrical, electronic, and programmable electronic safety related systems.

Asset Deterioration

4.1.14 Most of the valves that play a pivotal role in ensuring the safe and efficient operation of Bacton Terminal are now operating beyond the design life. Mechanical wear of soft part material, corrosion, and component failure as shown in Table 5 are contributing causes of increasing defects being identified in valves.

4.1.15 As shown in Figure 9 and 10 below, many of the valves have incurred internal damage to the sealing surfaces over the years. This damage is a result of general wear as well as by the small quantities of liquids and solids that are inevitably present in the pipework. This can cause entrained debris within the valve seats, leading to scoring on the surface of the ball and eventual leakage across the valve seats. Safe isolations are therefore becoming increasingly complex, time consuming and expensive and sometimes a total failure. If sealing performance cannot be recovered to a safe level through valve servicing, the only option is usually a complete replacement of the valve.

4.1.16 For example, gas has historically been received directly from any incomer towards Feeder 2(FD2) or Feeder 4(FD4) manifolds. But due to a defect with the F2/13 valve on FD2, gas can no longer be received direct from [redacted] onto the FD2 manifold. Due to this, getting gas to where it is required (INT/FD2) the gas must be routed via FD4 in a complex loop around the site to FD2 via F2/6 and F24/6 valves. Whilst this workaround allows operation to continue, it severely restricts other site configurations, maintenance activities and required isolations. This arrangement will also significantly impede project isolation requirements. Replacing this critical valve would return the flexibility required for efficient site operations.

4.1.17 Some valves are now passing gas to the atmosphere through leakages from deteriorating seals. A typical example is the loss of containment due to stem seal leaks at Gilwern AGI 2019.

4.1.18 In the event of this happening, significant investment will be required to mitigate the leakages. Emergency isolations will also be required to cut out the leaking valve which could have further impacts on network operation. Furthermore, environmental legislation is becoming more stringent, and by not having valves which are capable of sealing, we have to extend the extent of any required isolation. This restricts plant availability and results in far larger volumes of gas having to be safely vented (as the isolation boundary has extended).

4.1.19 As an example, to isolate Feeder 2 at Bacton Terminal to address a defect it will be required to vent 83.1m3 of gas. This equivalent to an average of 26 days of gas usage by a typical UK household. Typical daily UK household usage data 3.1m3/day

4.1.20 Some Circa 80% of the valves identified in this EJP are underground and welded in to the pipework. This presents an additional challenge to conduct maintenance/repair by site operations due to the complicated scope of works required to facilitate isolations and excavations.

4.1.21 Primary and Secondary Isolation valves for the overpressure protection systems have a common problem of failing to meet the required closing time to prevent over pressure. We have undertaken studies which show in some cases we need our incomer pressure protection systems to operate within a desired process safety time (else we over-pressurise pipe-work and associated assets beyond their safe operating limits). Currently our incomer pressure protection systems are incapable of meeting these process safety closure times, which is dangerous and prevents our safety instrumented systems / primary protection systems from functioning to their required safety requirements. This can only be resolved by replacing these assets with faster-acting ones.

4.1.22 As detailed in Section 4 of Valve Closure Time Dynamic Study (Appendix F), times taken between pressure rising to the SOL level and completion of closure of Emergency Shut Down Valve (ESDV), exceeds the safety requirement specification. In the current set-up of valves A1/1, A2/1 and S4/1, they will not protect the pipelines from overpressure and the pressure will stay above the SOL after closure of the valves until the lines are depressurised. Further details of the Safety Requirement Specification are shown in Appendix L.

Rationalisation

4.1.23 Whilst rationalisation has been a key consideration in the development of the Base Asset Health option, it has not been adopted as initially highlighted in the FOSR due to the necessity of maintaining Bacton terminal's flexibility and resilience to meet peak supply forecasts for until 2050. This is crucial due to the contractual obligations and complexity of terminal operations.

4.1.24 The [redacted] incomer provides additional resilience and operational flexibility which outweighs the cost and risk of decommissioning. The decommissioning process would involve significant cost and risk for permanent welds, isolation, de-gassing, excavation, and modifications impacting the terminal ability to flow gas to various feeders. Maintaining the current state of incomers allows for safe and continuous operations, supporting asset health, work and legal requirements for overpressure system protection testing.

4.1.25 Furthermore, F2/6 and F3/6 are proposed to be replaced as valves are not part of the ENI assets to be decommissioned, but part of the manifold required to route gas via manifolds 2-5 (boundary isolation valves). Valves F2/6 and F3/6 are intended to be retained as part of the manifold which allows routing of gas from UKCS incomers to Feeders and Interconnectors and is not part of the scope of ENI decommissioning

What the investments seek to achieve

4.1.26 This investment aims to secure funding to intervene on the defective valves within this regulatory period and in line with the terminal's outage windows. This will:

- Ensure that all valves comply with legal requirements and agreed safety standards.
- Have valves that will operate and perform their function when required to do so, particularly in an emergency or process upset condition, to contain the bulk flow of gas in a safe manner.
- Ensure that valves are fully supportable such that any unexpected defects can be remediated without significant impact on the availability of the terminal.
- Drive continued environmental improvements by reducing planned and unplanned emissions of methane to atmosphere.
- Safely remove assets that are no longer required, to manage overall whole life cost and risk.

4.1.27 Should the proposed interventions not be performed, the increasing defect count means that impacts of failure become more likely and drive an increasing risk profile as shown in Table 5.

How will we understand if the project has been successful?

4.1.28 The project will be deemed successful following testing and commissioning to confirm that the protections systems that rely on valves will operate within the required specification and that there will be no restrictions on plant operation caused by valve defects. And that all scope has been delivered and comply to the relevant technical specifications, safety, and engineering standards.

Narrative Real-Life Example of Problem

4.1.29 The assessment of buried valves is a major challenge across the National Transmission network as it involves the request for funding and long outages only to excavate and investigate a valve to determine the full extent of the scope of work. Figure 6 below show the extent of excavations required to access a buried valve.

4.1.30 In the context of this investment, it is not practically feasible to excavate all the buried valves to conduct preliminary investigation work and determine if suitable for repair. However, a sampling method used on the NTS to assess the condition of buried valves was completed in September 2024, as detailed in the Valve Conditional Assessment Project (Appendix G). The results have been used as a representation of other valves in a similar environment and of similar age.

4.1.31 In 2016, circa 33 buried valves were excavated and replaced at Bacton Terminal due to the assets failing. The replaced valves which were installed at the same time as the valves in this scope showed signs of extreme deterioration. We can therefore surmise that the buried valves in this scope are in a similar if not worse state of condition.

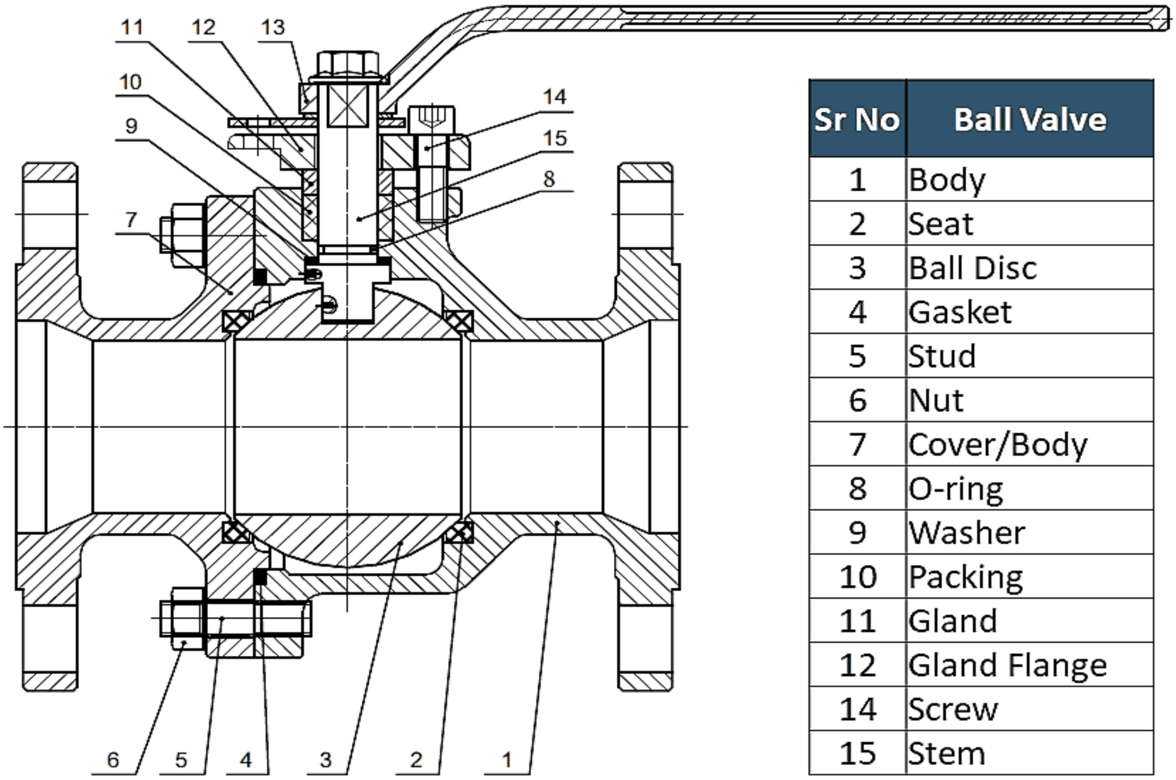
Figure 6: Bacton Terminal excavated valve.

4.1.32 In the recent investigation at Nether Kinmundy site an inspection and conditional review was conducted on a 36-inch Class 600 Robert Cort ball valve which has been underground for circa 50 years. This valve was isolated, excavated and cut out then removed and shipped to [redacted] (NGT's valve maintenance partner) for investigation as part of a wider project undertaking the disassembly and conditional review of similar large valves. The aim of the investigation was to review the condition of the valve and establish if an overhaul is a viable and cost-effective solution or if the valve should be replaced.

4.1.33 Figure 7 shows the valve as received at the workshop before stripping.

Figure 7: Assembled valve

4.1.34 Figure 8 as an engineering drawing showing the internal components of valve.



Sr No	Ball Valve
1	Body
2	Seat
3	Ball Disc
4	Gasket
5	Stud
6	Nut
7	Cover/Body
8	O-ring
9	Washer
10	Packing
11	Gland
12	Gland Flange
14	Screw
15	Stem

Figure 8: Ball Valve internal components

Valve Ball Condition

4.1.35 Upon disassembly, the ball was noted to be contaminated with corrosion product and a greasy / oily substance, likely the remnants of previous sealant injection work scopes. Once cleaned the ball was found to be heavily scored in the direction of operation, likely to have occurred from debris trapped between the ball and seat interface or from degradation of the seat interface. Some of the deep scoring was identified across the sealing faces as shown in Figure 9.

Figure 9: Ball Side A Scoring

Seat

4.1.36 On seat B deep scoring is found on the metal sealing face which also extends into the O-ring in some locations. In Figure 10, impregnation of the O-ring seat can be seen.

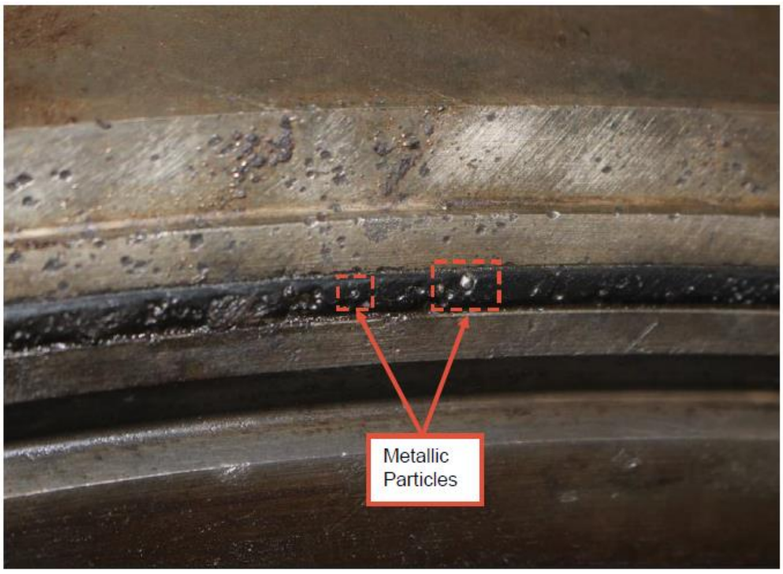


Figure 10: Seat B Damage

Valve Stem Condition Assessment

4.1.37 The stem was noted to be corroded around the contact area as shown in Figure 11 for the gland plate and transition plate, likely from excess moisture within the soil or other liquids sitting within the crevices. There are no seals between these components to prevent ingress of moisture into the stem area. Corrosion and flaking of the coating have occurred close to the upper stem seal within the bonnet and other areas of the stem's surface. This damage, if left untreated, could have degraded further disrupting the sealing capabilities of the upper O-ring.

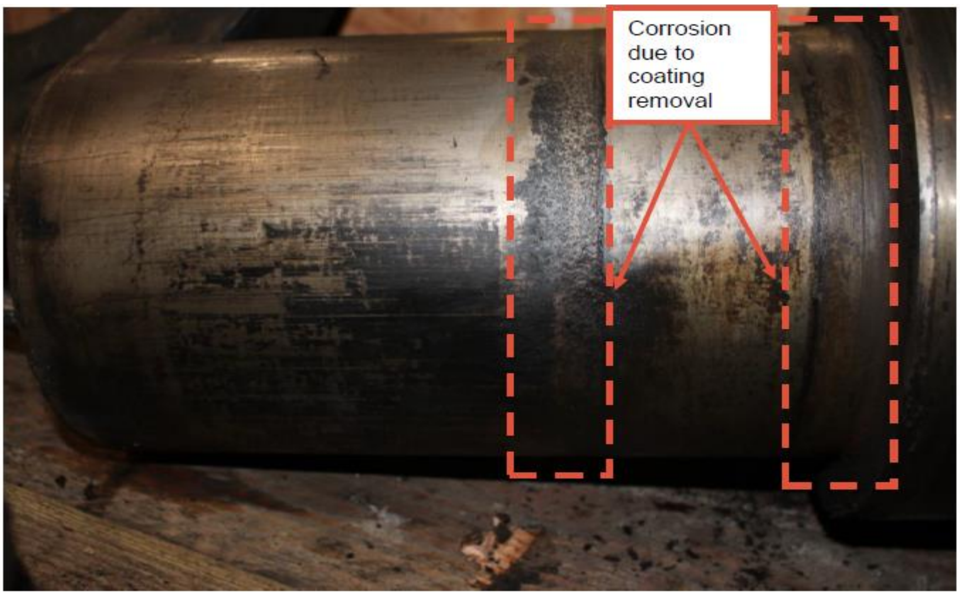


Figure 11: Stem damage

4.1.38 The results of the Nether Mundy valve investigation showed extensive deterioration and what remedial work will be required to repair the valve. For further details see Section 3 Valve Condition Assessment Report (Appendix G). Ball heavily scored, requires coating removal, grind and recoat.

- Stem corroded and scored, requires renewal.
- Seat soft inserts compressed, damaged, and impregnated with metallic debris, metal sealing face scored and pitted, require renewal.
- Seat pockets pitted, require weld repair and machine to size.
- Adaptor seal areas pitted, require weld repair and machine to size.
- Body seal areas pitted, require weld repair and machine to size.
- Transition plate corroded, requires shotblast and clean.
- All other components require Score standard refurbishment.

4.1.39 The uncertainty associated with both the scope of repair and the length of time it takes to repair a valve of this size is not viable as it would adversely impact the reliability and availability of the terminal. As shown in the Final FOSR Critical Valves Index (Appendix B), 80% of the valves covered in this EJP have been buried for circa 50years and there is high probability that they are in the same condition as the real-life example above.

Spend Boundaries

4.1.40 This paper only covers Bacton valves and is aligned to the RIIO-GT3 program. The proposed investments only cover known defective valves and associated actuators where applicable. It is also important to note that additional works such as replacing pipe fittings may be required to successfully complete the project. This detail will be confirmed following the detailed design. As such, a provision has been factored into the Quantitative Risk Assessment (QRA) to cover the associated costs.

4.1.41 This particular funding request does not cover instrumentation and power cables for the actuators. However, these will be covered in the Electrical Assets EJP and will be installed during the same outage as one project for efficiencies. This will also allow the elimination of all DSEAR defects for cable installation and support.

5 Probability of Failure

5.1.1 A valve is considered to have failed if it can no longer provide its function, for instance, safe isolation required to facilitate routine or non-routine maintenance works. As detailed in the Critical Valve Index (Appendix B) inspections have identified 50 valves that are not able to provide their intended function for various reasons. See defects summary in Table 5 above.

5.1.2 Common failure modes that contribute most to the probability of failure are:

- **Mechanical degradation of internal components** - This prevents inner components from providing an effective seal such as valve seats.
- **Corrosion with no leak** - Corrosion on sealant lines affecting the ability to seal the valve.
- **Mechanical or electrical fault leading to trip** - Failure of actuators leading to valve availability.
- **Significant gas leak** - Failure of internal components such as stem seals leading to gas leaks.
- **Inability to isolate** - Due to valves passing for local and remotely operated valves.

5.1.3 The real-life example detailed in the Problem Statement section 4 also helps to gauge the probability of failure of the valves in scope as they are almost of the same age with most of them in the same operating environment.

5.1.4 The valves in this scope were analysed to determine their probability of failure. The analysis included an insight into major defects, maintenance history, valve installation (Welded or Flanged) and location (above ground or underground).

5.1.5 Individual valve analysis results are summarised in Appendix B which shows a Critical Valves Index.

5.1.6 Fast acting valves closure reports were also done to confirm the process safety closure times. For more details see Valve Closure Time Dynamic Study (Appendix F). The results thereof justified the need to replace some valves with operational safety compliant ones.

Probability of Failure Data Assurance

5.1.7 In addition to these assets being life expired, the Valve Closure Time Dynamic Study, the increasing number of defects detailed in the Maximo downloads and Critical Valve Index; it is demonstrated that the valves in this scope have already failed with the remaining mainline having a high probability of failure.

5.1.8 The requirement for valve replacement is driven primarily by the purpose of the valve and the severity of the fault identified. Valve availability and ability to function as expected (i.e., without fault to a high degree of reliability) are key to securing the safety and operability of the Bacton Terminal. Positive valve sealing is also a requirement for maintenance operations, ensuring that sections of the Terminal piping can be isolated prior to said operations being conducted; whilst also ensuring the minimum amounts of gas inventory are released into the environment.

5.1.9 As part of developing this scope, the NGT Engineers in consultation with our specialist contractor verified the proposed interventions as suitable to mitigate the probability of failure.

6 Consequence of Failure

6.1.1 The consequence of failure has varying impacts on availability, environment, finance, and safety as detailed in Table 7. For example, in a scenario where we are unable to flow gas at Bacton Terminal due to failure we will incur penalties as shown in Table 6.

[redacted]

Table 6: Bacton Terminal Penalty Costs ***(Based on FES 2024)***

6.1.2 In the event of total asset failure, the need for Bacton to operate continuously would be severely affected as any downtime is meticulously planned to ensure the plant returns to service promptly. NGT holds emergency repair stock through NGT Services but does not hold reserve stock for specific investment programs like the scope in this EJP.

Impact/Consequence	Description
Safety impact	• **Mechanical or electrical fault leading to valve failure:** In the event of an incident, failure to isolate an area because of a valve failure might result in damage of equipment and lead to serious injury/death of employees or the public. • **Corrosion with no leak:** If a failure (valve not sealing) occurs on an Emergency shutdown (ESD) system this can compromise the integrity of the system and could lead to an escalation. • **Inability to isolate in time:** If an overpressure event is detected through our safety systems at site and a valve fails to operate on demand, this increases the risk of catastrophic failure of our process pipework system on the terminal large loss of containment and process safety incident.
Availability	**Mechanical degradation** • Of internal parts can lead to the inability to isolate the network due to non-operational valves. • Outage boundary has to be extended, resulting in potential customer outages and large environmental gas releases • Reduced Terminal operational flexibility. • Reduced ability to undertake pro-active maintenance and inspection activities. • Reduced security of supply.
Financial	**Mechanical or electrical fault leading to valve failure** • Unplanned outage (customer constraint) costs. • Increased re-active breakdown / repair costs. • Reduced intrusive maintenance / outage costs. • Regulatory costs (from a loss of containment incident) - HSE investigation, improvement notices and penalties. • Knock on impact to other planned work delays. • Cost of lost / vented gas passed to consumer through shrinkage. • Average daily penalty for unplanned shutdown is shown in Table 7 above.
Environment	**Significant gas leak:** • Gas leaks - small leaks but for a long duration • Gas leaks - big uncontrolled loss of containment incident requiring immediate isolation, but resulting high volume of gas released. • Enhanced isolation foot-print - resulting in higher planned volumes of gas being vented. • As an example, isolating Feeder 2 at Bacton Terminal to address a defect it will be required to vent 83.1m3 of gas. This is equivalent to an average of 26days of gas usage by a typical UK household.

Table 7: Consequence of Valve Failure

6.1.3 Without appropriate level of investment, valves will not be able to operate and will fail to conform to the legislative requirements of PSSR, PSR, COMAH, GS(M)R, and other relevant safety legislation and 'best-practice' technical standards.

6.1.4 Failure to invest in defective valves to remediate the defects will result in the performance of the valves continuing to deteriorate due to mechanical wear, component failure, corrosion / erosion, and electrical failure. This deterioration will increase with duty and asset age resulting in failure to facilitate safe operation and maintenance of the plant.

6.1.5 Failure to ensure all the primary and secondary fast acting actuator isolation valves for the over pressure protection systems operate within their time limits will result is safety risks to personnel. This increases the likelihood of a major accident hazard event occurring such as pipeline rapture due to over pressure.

6.1.6 This investment seeks to reduce the probability and consequences of failure. These types of failures have significant impacts on financial safety and reputational status.

7 Options Considered

7.1.1 Table 8 details the options considered to address the critical valves issues outlined in the problem statement. The investments are based on assessments undertaken as part of NGT's asset health plans including the RAM study, FEED study and Valve Closure Time Dynamic Study. The estimated costs associated with the options below are derived from scope assumptions to give a guide except for the replacement option which is from the cost book developed for this EJP.

Options Considered	Option description	Pros	Cons	Estimate investment value (2023/24)
Do Nothing	No specific intervention to be undertaken save for the typical valve maintenance required to maintain all relevant safety regulations and other legal obligations. Examples of typical valve maintenance includes valve flushing and injecting sealant to improve sealing.	There is no CAPEX investment required for the valve	Intervention does not re-life the valve hence higher chance of failure in the future. In the scenario of an unplanned shutdown daily penalties will be incurred as detailed in Table 7 above.	Average daily penalties for unplanned shutdown of Bacton incomers are shown in Table 7.
Fix on fail	All the priority valves are welded onto pipelines, reactive cut out and replacement of a single main line valve is a large, committed Scope of Work (SOW). This is an inefficient approach that also increases the operational risk and compromises security of supply because of outages to facilitate maintenance works.	N/A	Reduced plant Reliability Availability Maintainability Increased unplanned costs due to unplanned breakdowns. Safety and environmental risks. Breaches of legislation.	As per 'do nothing / counterfactual' option.
Valves Refurbishment	This entails conducting major works aimed at addressing the identified defects such as stem seal replacement. For underground welded valves, this the scope includes: • Excavation work. • Valve cutting out. • Stripping and repair • Welding back the valve after repairs.	If successful on the first attempt, there is a chance of rectifying the operational challenges at a lower cost as compared to complete replacement.	[redacted] valves which constitute 64% of the valves in scope will need to be shipped to the OEM in the USA for refurbishment with no guarantee of success. In addition, these are welded body valves which are uneconomical to refurbish as they cannot be easily disassembled and reassembled. The turnaround time for repairing a valve is circa 20 weeks which will severely impact the reliability and flexibility of terminal operations. It will also incur additional costs for storage and transportation and temporary welding of the	In the scenario where the repair scope is limited to costs to Strip / Rebuild / Test, replace seals (O-Ring Seals), Bolting, Bushes, Testing and refit on return. our internal operations team in consultation with our valve maintenance specialist has estimated a cost of [redacted] This estimate excludes the following necessary elements for a complete valve refurbishment project. •Management of change / design appraisal costs •Temporary works

			dome ends of the pipework for the duration of the repairs. Realisation that the valve cannot be refurbished and needs complete replacement after stripping will result in extended and more expensive outages. There will be need to source for replacement valves which have long lead times.	•Civils & hot works (to remove / then refit valve) •Asset isolation / removal (cranage) / transport •Breaking containment •Painting coating (above-ground) / Coatings / wraps (below-ground) •For buried pipework) excavation / re-instatement costs) Therefore, the conservative estimate to deliver the limited scope above for [redacted] In addition, our specialist valve maintenance partner has confirmed that based on their review of the excavated valve from the Nether Kinmundy site, the savings of repairing the valve over replacing is negligible Section 3.2 (Appendix G).
Valves Replacement	This option entails the complete replacement of all the defective critical valves as justified by their condition and impact to site operations. This will be determined by the Critical valve index (Appendix B).	Resets the valve asset life. Planned outages within this regulatory period can accommodate the volumes for full delivery of the scope. Reduces the risks of equipment failure / unplanned customer outage, as well as wider environmental and safety compliance issues. Increases the availability of spare valves as the replaced defected valves can be repaired and stored as engineering spares. Allows phasing of works by grouping work on multiple valves which minimises the	Longer lead-times of 12 to 24 months to procure new assets (but reduce the time without asset in-situ, compared to a valve refurbishment). More expensive 'initial' CAPEX investment (albeit reduced whole-life costs over asset life)	As per Table 11: Preferred Option Final Costs

		interruption to operations and introduces project efficiencies.		

Table 8: Options Considered & Associated Proxy Cost Estimates

Option Selection

7.1.2 The Table 9 below illustrate a process used to select the optimum option for the critical valves. All the options considered were compared using a set criterion which is based on variables such as cost and compliance to legislative requirements. The table also summarises the viability of each option and highlights the recommended option.

7.1.3 Option 3 is selected as the most optimum which meets all operational and safety requirements.

Solution considerations		**Option 1**	**Option 2**	**Option 3**	**Option 4 (Preferred)**
		Do Nothing	**Fix on Failure**	**Valves Refurbishment**	**Valves Replacement**
Cost		Low initial cost but results in high overall costs from expensive reactive maintenance works to keep site operational. Continuing to operate with defective assets will adversely impact RAM and can result in enforcement action.	Low initial cost but results in high overall costs from expensive reactive maintenance works to keep site operational	High costs associated with maintaining an excavation site for long periods of time. Refurbishment costs are unknown and have high risk as the state of the inner components and work required is only determined after valve investigation	Proactive maintenance and efficient delivery of works through bundling reduces costs associated with replacement and enables planning of future works
Meeting HSE Regulatory requirements		Non-compliant as the risk is not ALARP (All Measures Necessary have not been taken to manage risks)	Non-compliant as the risk is not ALARP (All Measures Necessary have not been taken to manage risks)	Compliant as all defected valves will be repaired	Compliant as all defected valves will be replaced
Deliverability		Will result in uncontrolled maintenance which are difficult to deliver and incur cost premium.	Will result in uncontrolled maintenance which are difficult to deliver and incur cost premium.	It is not certain that all the identified valves can be refurbished and put back into service within the planned outage. There is a risk of reverting to the replacement option in the likely event of this the project will incur additional costs and time.	The specified volumes can be delivered within the planned FOSR duration. Planned outages are more cost effective and controlled.
Compliance	**PSR and GMSR**	Non-compliant	Compliant	Compliant	Compliant
	PSSR	Non-compliant	Non-compliant	Compliant	Compliant

Solution considerations		Option 1 Do Nothing	Option 2 Fix on Failure	Option 3 Valves Refurbishment	Option 4 (Preferred) Valves Replacement
Maintenance	Ongoing OPEX	High operational OPEX from increased leak, detection tests, and repair maintenance Complex isolations with increased turnaround time will be required to deliver maintenance works	High operational OPEX from increased leak, detection tests, and repair maintenance Complex isolations with increased turnaround time will be required to deliver maintenance works	Significant reduction in operational costs as the valves are in good condition.	Significant reduction in operational costs as the valves are in good condition. Availability of spares reduces turnaround time.
	Risk	High Valves are passing and cannot provide safe isolation when conducting maintenance works	High Valves are passing and cannot provide safe isolation when conducting maintenance works	Low Valves will be tested to prove capability to safely isolate an area when needed	Low Valves will be tested to prove capability to safely isolate an area when needed
Operational Resilience	Security of Supply	High Valves in scope are priority valves that will have significant implications to security of supply upon failure	High Valves in scope are priority valves that will have significant implications to security of supply upon failure	High Increased duration of outages will be required to deliver all volumes of valves. This would create numerous interruptions in the flow of gas.	Medium - Outages can be planned to enable maximum flow capacity in the terminal whilst delivering the all the valves
Overall viability		Not Viable	Not Viable	Not Viable	Viable

Table 9: Option Selection Criteria

8 Preferred Option Scope and Project Plan

8.1.1 The assessments outlined in this paper and the associated discounting and costing of options demonstrates that the most viable, cost effective and logical options to take forward in this reopener is the complete replacement of all the 50 critical valves and their actuators.

8.1.2 This is in line with the Ofgem decision in accordance with Special Condition 3.10.7, to approve the option identified by National Gas Transmission as the Final Preferred Option which is Option 1 Base Case Asset Health. See Section 5 of the Bacton Terminal site development consultation (Appendix J).

8.1.3 The focus is therefore on ensuring this is delivered at the lowest Whole Life Cost to consumers. It has been identified that the criteria for replacing the valves lie mainly on them being defective, life expired and malfunctioning.

Project scope

8.1.4 Appendix B shows a list of all the identified valves in this scope, their criticality, and the justification for their replacement.

8.1.5 The deliverability of this scope has been assessed in line with isolation requirements and has been confirmed to be achievable. Appendix C shows Bacton FOSR Valve Replacement Program. This has also been assessed in line with RIIO-GT3 work.

8.1.6 The valves have been systematically put into common groups based on their location and isolation requirements. As shown in Appendix D Valve Groupings, there are 14 groups each containing a total number of valves ranging from two to nine. This will improve the efficiency of the project as common isolation will be used during the valve replacement process which reduces outage times. This also reduces the quantities of gas vented during outages and mitigates the associated environmental impact.

8.1.7 As an example, to isolate Feeder 2 at Bacton Terminal to address a defect it will be required to vent 83.1m3 of gas. This is equivalent to an average of 26days of gas usage by a typical UK household.1

8.1.8 This approach minimises the impact on operations and security of supply in the short term and de-risks future programmes as these are strategic to enable future works.

8.1.9 The scope is to provide safe, fit for purpose, secure, reliable valves, suitable for present and future operations, allowing safe isolation of plant and equipment and continued functionality while sustaining the operational capability of the Bacton Terminal.

8.1.10 The replacement valves should have a minimum 30-year design life (in accordance with T/PM/COMP/20 with sufficient availability of spares and OEM lifecycle support to maintain acceptable reliability and availability for this period.

8.1.11 The work scope includes:

- Design, Specification, and procurement of appropriate replacement valves in accordance with T/SP/V/6 or T/SP/VA/5, including applicable actuation.
- Programming and coordination of works with coinciding site activities.
- Temporary works including safe excavations and pit access in accordance with T/PM/SSW/22
- Removal of existing valves
- Assessment and repair of recovered valves where practicable
- Welding and NDT activities
- Site Acceptance Testing including pressure testing.
- Commissioning works
- Reinstatement works.
- Collation and archiving of handover spares and records.

8.1.12 Table 10 below, gives the outline milestones for delivering the project across RII0-T2, RIIO-GT3 and RIIO-GT4.

	Activity Name	Indicative Completion Dates
001	Anticipated Contract Award	August 25
002	Detailed Design Complete	August 26
003	Anticipated Construction Start date	September 26
004	Completion of Works including demobilisation	January 2034
005	Completion Handover Documents	March 2034
006	Project Closure	September 2034

Table 10: Bacton Valves and Actuators Replacement Indicative Milestones

[1] Typical daily UK household usage data 3.2m3 /day. https://www.ukpower.co.uk/home-energy/average-household-gas-and-electricity-usage

Final costs

8.1.13 To ensure robustness of the FOSR costs, NGT employed the use of a Designer / Main Works Contractor (MWC) to validate scope, understand some of the engineering challenges associated and to help refine details as well as building up an externally priced estimate showing how the market would cost works of this nature. NGT Utilised John Murphy and Sons to undertake this work as they were already in contract with NGT for the first stage of work undertaken to supplement the FOSR submission in February 2024. Further details are highlighted in Section 4 of the Overarching document.

8.1.14 Table 11 provides a breakdown of the final costs for the project split by several categories.

[redacted]

Table 11: Preferred Option Final Costs

Asset Health spend Profile

8.1.15 Table 12 shows the spend profile for our preferred options in 2018/19 pricing.

	RIIO-T2		RIIO-GT3					RIIO-GT4					
£m 18/19	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35	Total	Total plus Escalator
Direct Cost Phasing (£m)	[redacted]												

Table 12: Spend profile of preferred option

8.1.16 The cost accuracy at this stage of the project is estimated at +15/-10% in accordance with the Infrastructure and Projects Authority (IPA) cost estimating guidance.

8.1.17 This report has explained the safety, environmental and operational risk concerns NGT has regarding the defective valves and the implications of these on terminal operations. The interventions are necessary to ensure the safety of site personnel and ongoing 24/7/365 operation of the terminal facility.

8.1.18 Removal and the subsequent replacement of Critical Valve Assets at Bacton Terminal totals [redacted] (2018/19) Prices.

Deliverability Challenges

8.1.19 Due to the complexity of the site, there are significant challenges in delivering this work, a few of which are highlighted below. This is all captured in the estimated cost.

- All excavations require additional planning, temporary works, and a more complex dig strategy as Bacton is a 24/7/365 terminal site.
- All civils work will be conducted in accordance with all relevant safety standards.
- The dense population of buried services, plant and equipment leads to above ground complications with heavy machinery.
- Co-ordination with other projects on site to allow continued operation of a live strategically important site.
- Evolving scope leading to additional works required.
- Wider COMAH Regulation requirements related to safety report; management of change' modification implications and associated wider regulatory oversight.

8.1.20 Despite the challenges detailed above, NGT has completed a series of deliverability assessments to confirm the scope is deliverable within the planned program. See Table 10 above for outline milestones and Appendix C Bacton FOSR Valve Replacement Program for further details.

8.1.21 Deliverability has also been aligned to the RIIO-GT3 plan, and other adjacent work aligned to customer outages e.g., [redacted] shutdown.

9 Conclusion

9.1.1 This report has explained the approach that NGT has taken to manage valves and associated actuators at Bacton Terminal and the implications of not continuing to invest in them. As detailed in this paper, it is of paramount importance to secure the necessary investment to maintain compliance with legislation.

9.1.2 The need to preserve the performance of valves to facilitate the operation of the site is well understood within the industry and the option proposed in this paper meets current industry guidance and international standards.

9.1.3 Failure to obtain funding will put our valve assets at unreasonable risk, leaving Bacton terminal vulnerable to integrity incidents caused by valve failures and would ultimately result in an abdication of NGTs statutory duties.

10 Appendices

10.1 Appendix A – Bacton Process Flow Diagram

File: [redacted]

10.2 Appendix B – Final FOSR Critical Valves Index

File: [redacted]

10.3 Appendix D: Valve Groupings

File: [redacted]

10.4 Appendix E: Bacton RAM Study

File: [redacted]

10.5 Appendix F: Valve Closure Time Dynamic Study

File: [redacted]

10.6 Appendix G: Valve Conditional Assessment Project

File: [redacted]

10.7 Appendix H: FEED Study Report

File: [redacted]

10.8 Appendix I: Bacton Investments Strategy Summary

File: [redacted]

10.9 Appendix J: Bacton Terminal Site Development Consultation

File: [redacted]

10.10 Appendix K: Bacton Valves defects List

File: [redacted]

10.11 Appendix L: Valves Safety Requirement Specification

File: [redacted]

11 Glossary

Glossary	
CBA	**Cost Benefit Analysis:** A mathematical decision support tool to quantify the relative benefits of each site option.
CDS	Conceptual Design Study
COMAH	Control of Major Accident Hazards (COMAH) Regulations 2015. Bacton Terminal is one of two designated NGT COMAH establishments. The other being St Fergus Terminal
DSEAR	Dangerous Substances and Explosive Atmospheres Regulations 2002
ECI	Early Contractor Involvement
EJP	Engineering Justification Paper
Entry Capacity	Holdings give NTS users the right to bring gas onto the NTS on any day of the gas year. Capacity rights can be procured in the long term or through shorter term processes, up to the gas day itself. Each NTS Entry point has an allocated Baseline which represents a level of Capacity that NGT is obligated to make available for delivery against on every day of the year
EPC	Engineering Procurement and Construction
Exit Capacity	Holdings give NTS users the right to take gas off the NTS on any day of the gas year. Capacity rights can be procured in the long term or through shorter term processes, up to the gas day itself. Each NTS Exit point has an allocated Baseline which represents a level of Capacity that NGT is obligated to make available for offtake on every day of the year.
FEED	**Front End Engineering Design:** The FEED is basic engineering which comes before the detailed design stage. The FEED design process focusses on the technical requirements as well as an approximate budget investment cost for the project.
FES	**Future Energy Scenarios:** An annual industry-wide consultation process encompassing questionnaires, workshops, meetings, and seminars to seek feedback on latest scenarios and shape future scenario work. The Future Energy Scenarios document is produced annually by National Grid ESO and contains their latest scenarios.
FOS	Future Operating Strategy
FOSR	Final Option Selection Report
GS(M)R	**Gas Safety (Management) Regulations:** The Gas Safety (Management) Regulations 1996 (GS(M)R) apply to the conveyance of natural gas (methane) through pipes to domestic and other consumers
HSE	**Health and Safety Executive**

Glossary	
IPA	**Infrastructure and Projects Authority**
LNG	Liquified Natural Gas, Natural gas that has been cooled to a liquid state (around -162°C) and either stored and/or transported in this liquid form.
LAV	Locally Actuated Valves
MWC	Main Works Contractor
(G)NDP	**Network Development Process:** The process by which NGT identifies and implements physical investment on the NTS.
NEA	Network Entry Agreement
NEC	New Engineering Contract
NGT	National Gas Transmission
NTS	**National Transmission System:** The high-pressure system consisting of Terminals, compressor stations, pipeline systems and offtakes. Designed to operate at pressures up to 94 barg. NTS pipelines transport gas from Terminals to NTS offtakes.
OEM	**Original Equipment Manufacturer**
Ofgem	**Office of Gas and Electricity Markets:** The regulatory agency responsible for regulating Great Britain's gas and electricity markets.
PFD	**Process Flow Diagram**
PV	**Process Valves**
PSSR	Pressure Systems Safety Regulations 2000
RAM	**Reliability Availability Maintainability**
Re-opener	Re-openers are a type of RIIO uncertainty mechanism. Depending on their design, they allow Ofgem to adjust a licensee's allowances (in some cases up and in some cases down), outputs and delivery dates in response to changing circumstances during the price control period.
RIIO	**Revenue = Incentives + Innovation + Outputs**: RIIO-T2 is the second transmission price control review to reflect the framework; it sets out what the transmission network companies are expected to deliver and details of the regulatory framework that supports both effective and efficient delivery for energy consumers.
ROV	**Remotely Operated Valves**
SOL	**Safe Operating Limit**

national gas transmission

Glossary	
Uncertainty Mechanism	Uncertainty mechanisms exist to allow price control arrangements to respond to change. They protect both end consumers and licensees from unforecastable risk or changes in circumstances.
UKCS	**United Kingdom Continental Shelf:** The UK Continental Shelf (UKCS) is the region of waters surrounding the United Kingdom, in which the country has mineral rights. The UK continental shelf includes parts of the North Sea, the North Atlantic, the Irish Sea and the English Channel; the area includes large resources of oil and gas.
UID	Unique Identifier

Contact:
[redacted]

nationalgas.com