national gas transmission

ENGINEERING JUSTIFICATION PAPER (EJP)

OFFICIAL- SENSITIVE

Valves: Valves

Click here to view our Main Business Plan

Click here to view our published document list

RIIO-GT3 NGT_EJP22

Version: 1.0

Issue: Final

December 2024

Contents

1 Summary Table

1.1.1 Please see Table 1 below for summary of this paper.

Table 1: Summary table for valves EJP

Name of Project	*Valves*		
Scheme Reference	NGT_EJP023_Valves: Valves_RIIO-GT3		
Primary Investment Driver	*Asset Health*		
Project Initiation Year	*FY2025*		
Project Close Out Year	*FY2032*		
Total Installed Cost Estimate (£m, 2023/24)	Baseline: [redacted] Uncertainty Mechanism (UM): [redacted] Total: [redacted]		
Cost Estimate Accuracy (%)	Baseline: [redacted] Uncertainty Mechanism: [redacted]		
Project Spend to date (£m, 2023/24)	*0*		
Current Project Stage Gate	*Stage 4.0*		
Reporting Table Ref	*6.4, 6.5, 11.6*		
Outputs included in RIIO-T2 Business Plan	*No*		
Spend apportionment	**RIIO-T2 (£m,2023/24)**	**RIIO-GT3 (£m,2023/24)**	**RIIO-GT4 (£m,2023/24)**
	Baseline: [redacted] UM: [redacted] Total: [redacted]	Baseline: [redacted] UM [redacted] Total: [redacted]	Baseline: [redacted]

2 Executive Summary

2.1.1 This paper proposes £113.96m of funding with a baseline value of £110.64m and an Uncertainty Mechanism (UM) with an indicative value of £3.32m. It is part of our Valves Investment Decision Pack (IDP) which requests a total of £286.3m in 2023/24 prices as shown in Table 2 below. This investment is to address defects on 474 (2.8%) of the valve population in RIIO-GT3. This will be measured through our Asset Health Network Asset Risk Metrics (NARMs) and Redundant Assets Price Control Deliverables (PCDs).

Table 2: Valves IDP investment request (£m, 2023/24)

Valves	Actuators	Pressure & Flow Control Valves	Bypass Installation & Modification	Total
Baseline: 110.64 Uncertainty Mechanism: 3.32 Total: 113.96	Baseline: 17.20	Baseline: 77.25	Baseline: 36.91 Volume Driver: 41.01 Total: 77.92	Baseline: 242.00 Uncertainty Mechanism: 3.32 Volume Driver: 41.01 Total: 286.33

2.1.2 Uncertainty Mechanism is proposed for overhauls of welded and buried Non-Return Valves (NRVs) at Aberdeen and Bishop Auckland compressor stations. This is an intervention that is new to RIIO-GT3 (as RIIO-T2 Major Overhaul intervention was only carried out on bolted / flanged NRVs) and is based on the results of overhauls being carried out on NRVs at Cambridge compressor station in RIIO-T2.

2.1.3 The primary drivers for these interventions are addressing defects across the valves and NRV population, addressing safety concerns when maintaining valves, ensuring valve availability in the future and addressing redundancy. This will ensure valves can continue to maintain their primary functions of effective isolations of pipelines and pressure vessels for planned maintenance and emergency situations and NRVs will continue to ensure efficient compressor operation. Deferring work would mean valves may not seal when required, which means they can't isolate in the event of an emergency, planned maintenance may be delayed or deferred and isolation boundaries would need to be extended, which means more environmental emissions due to venting of gas. This culminates in an increased safety risk due to longer times required for isolations in the event of emergencies and increased financial impacts for customers as we procure gas to replace unaccounted for gas (UAG) that vented-gas falls under. It also means delay or deferral of work in our capital plan, as we can't get valves to seal to facilitate outages and maintenance, eventually leading to decreased availability / reliability of our assets. These interventions will also help us be compliant with various legislations discussed in Chapter 5.

2.1.4 There are 437 valve interventions required to reduce increasing risk across RIIO-GT3 while also factoring deliverability of the interventions in terms of outage, resource and supply chain constraints. These are part of our preferred option (Option 1A post deliverability) for our Valves IDP. Valve interventions have a NARMs Long-Term Risk Benefit (LTRB) of £21.2m. This does not achieve our organisational objective to reduce risk to the start of RIIO-T2 levels. Explanations and mitigations are discussed in Chapter 10.

2.1.5 We considered several interventions across the valve portfolio to establish an optimal programme that would deliver desired regulatory outputs. In summary, we are proposing the intervention mix shown in Table 3.

Table 3: Volumes of valve intervention and their classification types

	Replacement	Overhauls	Decommissioning	Other	Total
RIIO-GT3 volumes	[redacted]	[redacted]	[redacted]	[redacted]	437

2.1.6 In RIIO-T2 we will have delivered fewer valve interventions (at a higher cost) than our original allowance of 451. This is due to issues of access for critical valves increasing project costs. The RIIO-GT3 proposed interventions are similar to RIIO-T2 plan in terms of intervention volumes but cost significantly more due to reasons discussed in **Chapter 3**.

2.1.7 Intervention volumes and investment for RIIO-GT3 plan and its comparison to RIIO-T2 is shown in Table 4 below:

Table 4: Volumes of investment in in RIIO-T2 compared to RIIO-GT3 (Baseline and UM)

	RIIO-T2 Business Plan	RIIO-T2 Forecast Delivery	RIIO-GT3 Business Plan
Intervention count	451	364	437
Investment (£m/2023/24)	48.3	101.3	113.96
% of valves population	2.7%	2.2%	2.8%

2.1.8 We must deliver the proposed valve interventions during RIIO-GT3 to ensure future network risk levels are not compromised. Table 5 below shows the intended valve investment profile in RIIO-GT3.

Table 5: Valves RIIO-GT3 funding request spend profile (£m, 2023/24)

Asset	2025	2026	2027	2028	2029	2030	2031	2032	Total	Funding Mechanism
Valves	0.02	1.67	15.33	21.72	24.00	19.66	26.41	1.82	**110.64**	Baseline
	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**3.31**	UM
	0.02	**1.91**	**16.66**	**22.05**	**25.33**	**19.74**	**26.41**	**1.82**	**113.96**	**Total**

3 Introduction

3.1.1 This EJP provides justification for the proposed RIIO-GT3 interventions in our 10-year valve investment programme. These investments have been developed to manage the health of valves across the NTS, addressing defects, and safety concerns.

3.1.2 Valves are required to ensure compliance with PSSR (Pressure System Safety Regulations), GS(M)R (Gas Safety (Management) Regulations) and PSR (Pipeline Safety Regulations) to enable safe isolation of assets for maintenance, project activities and in emergencies. Addressing defects across the valves' population ensures compliance with legislation, addresses safety concerns, addresses redundancy, and seeks to reduce environmental emissions from valve leaks. For NRVs, the main driver is to maintain asset health in line with maintenance procedures and Original Equipment Manufacturer (OEM) guidance.

3.1.3 Learning from investment development and submission experience in RIIO-T1 and RIIO-T2, we have moved from a qualitative and quantitative decision approach to a data driven asset management approach. The valves programme is a bottom-up plan built on existing defects to ensure valve assets can perform their critical functions across the NTS. Increase in investment requirements in RIIO-GT3 (from RIIO-T2) include the following:

- New interventions in the valves RIIO-GT3 plan like NRV replacements, block valve modifications to break valves out of pits, stopples & bypasses, strip and condition assessments etc. These new interventions total £32.6m.
- The addition of a larger volume of block valve replacements, which is an intervention to resolve several asset health defects on our block valves, also added to the cost increase (£26.7m in RIIO-GT3, compared to £3.3m in RIIO-T2).
- Repeated interventions from RIIO-T2 costing more in the RIIO-GT3 plan is another reason for the price increase. This is due to us having outturn costs from RIIO-T2 which reveal delivery costs have been more significant than initially forecast. This has been attributed to access issues required to remediate defects on certain valves e.g., complex isolations or maintenance facilitation devices required, excavations for buried valves, pit breakouts/modifications etc.

3.1.4 Interventions developed are from known valve defects, redundant valves, and known issues with valve safety, availability and maintainability to ensure risk levels were maintained across the network.

3.1.5 The scope of this document is aligned with our Asset Management System (AMS) and relates to three of our Business Plan Commitments (BPCs). More information on our AMS and a description of our commitments is provided in NGT_A08_Network Asset Management Strategy_RIIO_GT3 and our BPCs are detailed within our NGT_Main_Business_Plan_RIIO_GT3. These BPCs include:

- Meeting our critical obligations every hour of every da
- Ensuring world class safety levels of our workforce and the public.
- Delivering a resilient network fit for the future.

3.1.6 The decisions made upon assessing the Valve investments as part of Valves Investment Decision Pack (IDPs) have interactions with other Investment Decision Packs. These are shown below:

- **NGT_EJP19_Civils_RIIO-GT3 –** Block valve replacements will involve bringing the bridle above ground if the bridle were buried or in pits. This means that there will be an increased risk to the public if pressurised assets are easily accessible. Upgraded fencing was therefore required to contain the pressurised assets.
- **NGT_EJP18_Pressure Vessels_RIIO-GT3 –** If defects aren't remediated for PIG (Pipeline Inspection Gauge) trap isolation valves, the valve may not be operable and therefore cannot be used to isolate the PIG trap to conduct PSSR inspections.
- **NGT_EJP17_Pipeline_RIIO-GT3 –** If defects aren't remediated for critical valves for In-line inspection (ILI) runs such as PIG trap isolation valves, block valves and feeder valves, this may lead to deferral of the inspection.
- **NGT_EJP02_Site Assets - Preheating, Filters & Pipework_RIIO-GT3 –** Replacing filter isolation plug valves with double block and bleed (DBB) valves as discussed in this paper will enable effective isolations to carry out filter maintenance as part of PSSR. If these plug valves are not replaced, it could impact on maintenance. Block valve replacements will typically involve breaking out pits. Pit breakouts have been developed separately from this EJP.

- **NGT_EJP01_Site Assets - Asbestos, Stabbings and Redundant Assets_RIIO-GT3 –** Stabbings can be discovered during excavations of buried valves. As buried valves get replaced or excavated for remediation, more stabbings could be found.
- **NGT_EJP09_Sites Cathodic Protection_RIIO-GT3 –**Remediation of defects on buried valves might involve cutting the valve and the associated buried pipework which could affect the CP systems of site pipework.

4 Equipment Summary

NOTE: Further information on this section such as valve accessibility (above ground, below ground or valves in pits), valve design and valve criticality definitions can be found in Appendix 1.

4.1.1 Valves are installed throughout the NTS to enable effective isolation of sections of the network, limit gas loss in an emergency, manage flow direction, facilitate maintenance, repair, modification, testing and commissioning, and to enable safe and effective start-up and shutdown of compressor stations. There are valves operating in all areas of the NTS which control or isolate gas into, out of and around the pipeline network, plant and equipment.

4.1.2 We have 16,796 valves on the NTS, and Table 6 below shows the split of valve types.

Table 6: Equipment count of valves on the NTS.

Type of valves	Count
Valves (Ball or plug, include NRVs)	10389
Ball valve	3482
Plug valve	2162
Butterfly valve	4
Gate valve	40
Solenoid valve	719
Total	**16796**

Location of valves

4.1.3 Valves are installed on different operational locations, for example, compressor sites, block valve sites, multi-junctions, terminals, PIG trap sites and off-takes.

4.1.4 Accessibility of the valves and their operators differ across sites. Valves may be located either above ground, in a pit or below ground.

4.1.5 Figure 1 below shows the different accessibilities for valves.

Figure 1: Below ground valve and its above ground operator, above ground valve and a valve in a pit.

Pressure ratings

4.1.6 Valves typically operate at the full pressure of the NTS, which ranges from 70 bar to 94 bar. However, valves located on exit points for example, may operate between 31 bar to 70 bar.

Criticality of valves

4.1.7 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 (biennially). Maintenance management procedures Maint/6, Maint/5 and Maint/2.3 describe different categories of valves including the description of “Critical valves”.

4.1.8 Additional information on this equipment group such as the health score at the beginning and end of the price control and monetised risk are provided in the accompanying NGT_IDP10_Portfolio EJP Valves_RIIO-GT3.

5 Problem/Opportunity Statement

5.1 Why are we doing this work and what happens if we do nothing?

5.1.1 The key drivers for investment in the valve asset class are **Legislation** and **Asset**

and **deterioration**.

Legislation

5.1.2 We must comply with the following legislation that also affects valve maintenance and investment. For more information, see Appendix 2:

- PSSR – Meant to ensure the mechanical integrity of our pressurised assets i.e., valves to prevent loss of containment and gas escape.
- PSR – Ensures pipelines and isolation valves are adequately maintained.
- GS(M)R – Ensures overall safety case of our gas system with a critical part being our ability to isolate sections of our network in the event of a safety emergency.

Asset Deterioration

5.1.3 There are 7 major problem statements summarised in Table 7, with their impact on Network Asset Risk Metric (NARMs) assessed. They can all lead to CAPEX investment on valves.

Table 7: Valve issues and impacts on NARMs service risk measures.

Problem statements	Safety	Financial	Availability and Reliability	Environmental	Societal
1. **Effective isolations on valves** **Problem:** Safe isolations are becoming increasingly complex, time consuming and expensive and can impact the resilience of the NTS, potentially disrupting customers' gas supply. This also impacts our ability to deliver work across the NTS as valves are critical for isolating for planned or unplanned maintenance. This could be due to the following reasons: • Valve seats leaking where debris has built up and resulted in damage to either/or the ball/seat. Failure of individual components and an inability to lubricate valve seals and components. There are cases where injecting flush and sealant has not resolved the issue. • Sealant lines are used to inject flush and sealant into the valve to help it seal for isolations. If sealant lines are defective, this impacts on the valve's ability to isolate a section. Issues on sealant lines include corrosion and wear. These cause the lines to seize which prevents the internal valve seals from being maintained. There are a large proportion of valves that do not have sealant ports installed. Sealant ports allow flush and sealant to be injected into valves when not sealing. This enables the valve to be recovered without replacing it. • Some valves are present in pits which are too small and make it difficult for operatives to access and isolate the valves efficiently. Similarly, when pits are flooded, this causes time lag on achieving a safe isolation, potentially impacting GS(M)R obligations.	●		●		
2. **Leaking valves** **Problem:** Valves vent gas to the atmosphere for various reasons. This affects the environment negatively and has financial consumer impact. Gas-leaks to the environment could be from: • Buried inoperable valves/ cocooned valves will eventually leak due to deterioration of the seals. In the event of this happening, significant investment will be required to rectify the solution reactively compared to a proactive approach. Emergency isolations will also be required to cut out the leaking valve which could have further impacts on network operation. • Isolations requiring increasing lengths of the NTS or sections of the site to be vented resulting in an increased environmental impact. This affects Unaccounted for Gas (UAG) which has a consumer cost impact from procurement to replace lost gas. • The continual venting of gas from vent and sealant lines and stem extensions presents a safety hazard as well as environmental impact. This also affects Unaccounted for Gas (UAG) which has a consumer cost impact from procurement costs to replace lost gas. • Compression fittings installed on vent and sealant lines (e.g. [redacted]) are subject to rotational forces. These forces can cause the fitting to blow off resulting in a high-pressure gas release. Modern standards call for a fully welded construction to mitigate this risk. We are trying to remove all vent and sealant lines with compression fittings due to potential for harm to operatives.	●	●	●	●	●

Problem statements	Safety	Financial	Availability and Reliability	Environmental	Societal
3. <u>Valve availability and spares</u> **Problem: There are instances where valves fail on the network, cannot be quickly refurbished, and require replacement. Due to the long lead times of delivering new valves from suppliers, it is important to have a stock of strategic spares (for critical valves only) that can be called upon to be used to replace defective valves. Our current spares are not ring-fenced for any project. In RIIO-T2, we had 3 spares covering different pressure ranges and 1 auto/manual selection unit.** • Typical lead times have been 40 plus weeks across 2023/24 for new valves which means it can be difficult to obtain a valve when needed urgently. • OEM for [redacted] valves went into liquidation in 2023. This affects the support and availabilities of spares for [redacted] valves. • It is difficult to have an extensive valve repurposing program where old defective valves are stripped and fixed, ready to be used again instead of installing a new valve. The reasons are as follows: • A large proportion of valves have a welded body which makes repurposing them uneconomical. A welded body cannot be split, the internals removed, and refurbishment carried out as only the original vendor has the equipment to re-assemble the valve and ensure it functions correctly. In the case of a Cameron valve (welded body), this would mean shipping the valve to the USA. There is also no guarantee that the valve repair will prove economic after being shipped and dismantled. Valves with a bolted body (e.g., [redacted]t valves) will incur 60% of the cost to repurpose compared to procuring a new valve. As most of the bolted body valves on the NTS are [redacted] valves (~90%), they will be susceptible to future leaks from the body seal. We also do not bury bolted body valves as the body is a potential leak path. This means that refurbished valves are only suitable for above ground usage. • We have little knowledge and experience on efficiency of repurposing a valve. This makes spending money on repurposing valves a risk in RIIO-GT3 as this might not recover the valve and a new valve may still need to be purchased. This also affects project planning as projects can't be planned around a valve that may not be recovered through repurposing. This could be fixed by carrying out strip & condition assessments of defective valves that have been removed from the network to understand the efficiency of valve repurposing.			●		
4. <u>Valve maintainability</u> **Problem:** There are valves on the network that cannot be maintained effectively due to inadequate access: Reasons are as follows: • Some valves are present in pits which are too small and wouldn't pass modern safe design working standards. These pits are also susceptible to flooding which can lead to corrosion on the pit wall transitions. More details on pit assets and associated interventions can be seen in the **NGT_EJP02_Site Assets - Preheating, Filters & Pipework_RIIO-GT3**, however interventions on valves in these pits is included in this EJP. • These factors make it unsafe for Site Operations to conduct maintenance on these valves. **Problem:** As we deliver work that involve complex isolations, there are occasions where it Is difficult to obtain an isolation on the site to facilitate maintenance on a valve e.g. • Isolating an area of the site for maintenance without affecting flow through the site • Single feed Distribution Network (DN) offtakes contained within an isolation for PSSR remediation which need to be fed even during the isolation.	●		●		
5. <u>Redundancy</u> **Problem:** There are valves installed across the NTS which are no longer required to meet operational requirements. Despite being redundant, assets remained connected to the NTS require ongoing management including inspections and maintenance to meet regulatory and policy obligations. The expenditure associated with these activities is incurred irrespective of whether the asset is redundant or operational, with the cost ultimately being met by consumers. It is important for these redundant assets to be decommissioned as doing this later puts cost on future consumers which saw no benefit from the asset.		●			●
6. <u>Safe isolation of pressure vessels</u> **Problem:** Filters are pressurised equipment that are required to be maintained as part of PSSR regulations. A lot of these filters only have single plug valves that are used to isolate them for maintenance. Single plug valves do not provide a full double block and bleed isolation that is typically required for maintenance. Health & Safety Executive (HSE) have given a mandate that full isolation is required for filter isolation valves to protect people inspecting or remediating filters. Achieving this may require shutting down the whole site due to the need to extend the isolation boundary of the site.	●				

Problem statements	Safety	Financial	Availability and Reliability	Environmental	Societal
7. <u>Asset deterioration of non-return valves</u> **Problem:** The mechanical forces exerted on internal components of non-return valves in operation result in progressive damage to components including pins, seats, seals etc. Failure of the NRV may affect reliability of the compressor connected to it. • NRVs get maintained either from number of cycles used or the age period between overhauls, whichever comes first. Several of the NRVs have gone over both or either of the age period between overhauls and cycles between overhauls. • Welded / buried NRVs had investment deferred at [redacted] and [redacted] in RIIO-T2 and therefore we are unable to understand condition of NRVs as they have never been inspected as per OEM guidance (They are [redacted] NRVs, installed in 1998, which have a 25-year cycle between overhauls as per internal policy MAINT/6 Appendix F). [redacted] NRVs are being inspected in RIIO-T2 and this will give a better understanding of the condition of NRVs at Aberdeen and Bishop Auckland as they are thought to be in a similar condition. As NRVs help with the operation of compressors, with [redacted], uncertainty of the condition of their NRVs is a cause for concern. More information on NRV inspection as per OEM guidance and internal policy can be found in Appendix 3 of this document. • [redacted] have failure modes of detachment of auxiliary components and potential detachment of the door plates due to fatigue induced cracking of the lugs. There is a risk that detachment of a door plate, or other component from an upstream NRV could result in the door plate being ingested via the suction pipework of a downstream machine. Detachment of a door plate renders the NRV unable to prevent flow reversal and this has the potential to damage the Compressor and its components.		●	●		

5.2 What is the outcome we want to achieve?

5.2.1 We are seeking funding through this submission to ensure that the following outcomes are achieved for valves with interventions assigned as per NGT_IDP10_Portfolio EJP Valves_RIIO-GT3:

- Meet legal requirements, agreed safety standards and industry guidance.
- Valves recommended for intervention are able to perform their critical function of isolation of pipework and pressure vessels for planned maintenance or in the event of an emergency.
- All safety concerns for site operations with maintaining are eliminated.
- Improved understanding of the efficiency of valve repurposing and therefore if an extensive repurposing program is beneficial for the consumer.
- To reduce environmental emissions from valve leaks.
- Decommissioning of redundant valves to reduce potential asset health investment on assets that provide no purpose and doing this later puts the cost on future consumers which saw no benefit from the assets.

5.3 How will we understand if the spend has been successful?

5.3.1 The spend will have been successful if all issues discussed above are addressed.

- Valves compliant with legislative requirements of PSSR, PSR and GS(M)R.
- To ensure the effective maintenance of NRVs to provide their function in line with OEM guidance.
- Reduction in risks across NARMs service risk levels.

5.4 Narrative real-life example of the problem

Effective isolations on valves

Pig trap isolation valve not sealing in [redacted] to Saltwick In-Line Inspection (ILI) run

5.4.1 [redacted] did not seal (4th December, 2022) which meant the PIG trap couldn't be isolated, vented and purged for the PIG to be removed safely. This meant the ILI run couldn't go ahead as planned and had to be rescheduled incurring additional costs. Other maintenance activities had to be moved around to accommodate the re-planned inspection, and there was wastage in time, resourcing & cost due to mobilising technicians to site. This ultimately has impact on consumer costs.

Leaking valves

Stem seal leaks

5.4.2 Figure 2 below shows wear on the stem of the [redacted]. The valve has been in service since the system's commission on 1st January 1972, meaning it would be over 50 years old in 2024. The valve was removed from the network due to an integrity concern with the valve body in June 2023.

5.4.3 As part of investigation the valve was dismantled to get an overview of the general condition of the valve. One of the issues noted was that the stem is worn which likely contributed to the leak. Whilst this was not known to be leaking prior to removal from the networks it indicated the condition of valves of similar age and wear. These valves will often leak which cause negative environmental impacts to consumers.

5.4.4 As of late 2023 the vendor of replacement parts [[redacted] valve] has gone into liquidation thus if we had wanted to repair this at the time, we would have struggled with obtaining spares. This would have prevented refurbishment of valves and would have required replacing the valve with a new one.

Figure 2: Leaking stem due to wear

Valve maintainability

5.4.5 Valves at [redacted] are located in pits with insufficient space and without the provision of access ladders to undertake safe maintenance activities. Confined space of the pits also makes them susceptible to flooding. Not only does this accelerate corrosion on valves and pipework, but delays maintenance and isolation procedures whilst the pits are drained before valve operation. This may also lead to an upstream valve being used instead, extending the isolation boundary and causing negative environmental impact as more gas needs to be vented. Images are shown in Figure 3 below.

Figure 3: Insufficiently sized pit for valve maintainability

Redundancy

5.4.6 [redacted]. The site is used as an isolation point for gas flows along this feeder. Image is shown in Figure 4 below.

5.4.7 The block valve arrangement consists of three ball valves on the mainline each of which are in pits. The valves are in very small pits so safe access and egress into the pits is a problem. Pits are not designed to current safe design standards.

5.4.8 The valves also do not have vent and sealant lines installed so trying to recover the valve through injecting sealant is not possible. Within the space restrictions installing these assets within the space constraint is not possible.

5.4.9 A needs case assessment was completed, and it was confirmed there is no strategic necessity for this site, [redacted]. Therefore, it was confirmed as redundant. It is important to decommission redundant valves across the network, so consumers do not pay for inspection and maintenance for valves that serve no purpose for network operation.

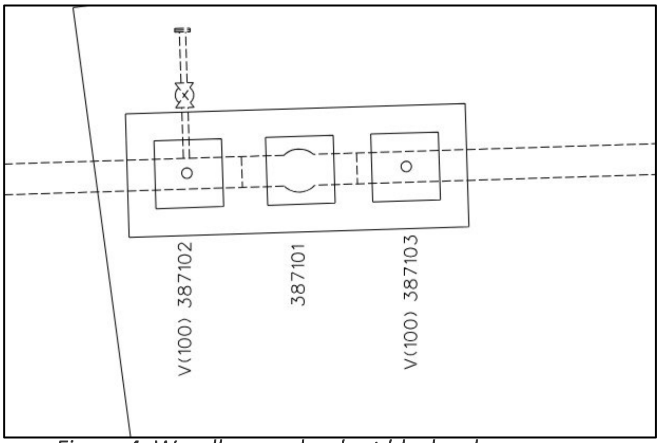


Figure 4: Woodbury redundant block valve

5.5 Project Boundaries

5.5.1 The proposed spend in this EJP are all identified interventions on valves and NRVs installed on the NTS to keep them safe and operational over RIIO-GT3.

5.5.2 Outside the scope of spend in this EJP are:

- Valve interventions specifically at the St Fergus gas terminal – these will be covered under the NGT_EJP29_St Fergus: Valves and Actuators_RIIO-GT3.
- Valve replacements at the Bacton terminal will be covered in the **Bacton reopener submission**.

6 Probability of Failure

6.1 Failure Modes

6.1.1 Probability of Failure (PoF) has been assessed both utilising historical defects but also utilising our Network Asset Risk Metric (NARMs) model built within our Copperleaf asset management decision support tool to assess the forward-looking probability of failure. This provides a different lens to consider in addition to looking at historically captured defects.

6.1.2 Not all modelled failures will result in real-world asset failure and this forecast is not a prediction of how many defects will be identified.

6.1.3 Likely failure modes for valves with an average proportion of failures of 0.5 or above are provided in Table 8, the full list of failure modes is available in the NARMs methodology.

Table 8: Valve failure modes according to NARMs

Failure mode	Average proportion of failures
Corrosion on pipework – no leak	0.53
Loss of stream regulator slam shut – trip	0.53
Loss of power – gas supply instrument trip	0.53
Corrosion no oil leak	0.59
Loss of local control	0.50
Metering fault inaccurate reading	0.87
Loss of gas quality information	0.87

6.1.4 When applied to the asset count with an assumption that no investment is made, a forecast of failures across the RIIO-GT3 period is produced, shown in Table 9. The average failure rate represents the proportion of that asset type with an unresolved failure. The forecast failures per year shows the quantity of new failures modelled to occur each year. Please see NGT_A01_Asset Management Plan (AMP)_RIIO_GT3 for more details on failures vs defects.

Table 9: Forecast valve failure rates and failures per year.

Asset Type	No. of Assets	Cumulative Average Failure Rates					Forecast Failures per Year				
		2027	2028	2029	2030	2031	2027	2028	2029	2030	2031
Valves	16796	0.48	0.49	0.50	0.51	0.53	179	192	191	200	211

Historical Defects

6.1.5 Defects are raised through inspection and maintenance activities and captured within our Maximo defect management system.

6.1.6 A sample of 1065 valves were collected from 329 sites to ensure it was a representative sample of the network and defects were reviewed for each valve. 1056 defects were identified from 2006 -2023 and this helped inform a rate for average number of defects per year. This is shown in Table 10 below. It is important to note, not all defects lead to CAPEX interventions for the valves and may be resolved with maintenance.

Table 10: Historical defect rates for different valve failure modes

Asset	Volume of Historical Defects (2006 – 2023)	Average no. of Defects per year
Valves (sample)	1056	59
Valves (extrapolating for the fleet)	**16554**	**926**

6.1.7 The phasing of these defects from the sample of valves over the last 18 years is shown in Figure 5 below. Number of defects raised has increased in recent years. This is due to increased levels of inspection towards the end of RIIO-T1 and RIIO-T2 and deterioration of the valves due to age and wear.

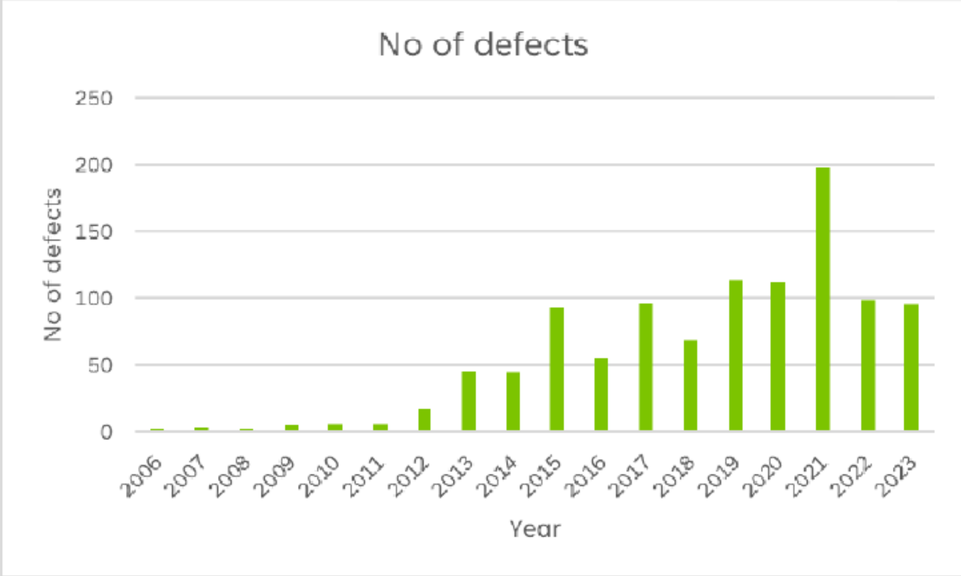


Figure 5: Historic defects raised each year for valves.

Historical Failure modes

6.1.8 A valve is considered to have failed if it cannot provide safe isolation required to facilitate routine or non-routine maintenance works. Routine inspections have identified valves that are not able to provide this function as their cavity, stem and seats have been passing gas.

6.1.9 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.
- Inability to isolate: Due to valves passing for local and remotely operated valves.
- Significant gas leak: Failure of internal components such as stem seals leading to gas leaks.
- Vent and sealant line issues: Defects such as corrosion affecting vent and sealant lines, affecting the ability to seal the valve.
- Valves not having sealant ports installed: Sealant port adaption enables valves to have sealant ports which can be used to inject flush & sealant to help the valve to seal. Without it, there is no chance of recovery of the valve after it doesn't seal.

6.1.10 For the same sample of valves discussed above, the frequencies of the discussed failure modes compared to the total number of defects raised (1056) was calculated. This is shown in Table 11.

Table 11: Failure modes and frequencies for valves sample

Failure mode	Count	Failure Mode Frequencies (%)
Valves not sealing	106	10
Valves with no sealant ports	33	3.1
Stem seal leaks	5	0.5
Vent & sealant line defects	29	2.8

6.1.11 Future strip & condition assessments of removed defective valves from the NTS will help inform efficiency of valve repurposing program going forward.

Probability of Failure Data Assurance

6.1.12 Probability of failure data presented above has been determined based on our Defect Management System. An extract from the system was undertaken in July 2023, with data analysis undertaken based on the columns of data exported from the system.

6.1.13 The NARMs Probability of Failure data was sourced from a Power BI dashboard, with data supplied from our Copperleaf asset management decision support system.

6.1.14 Defects were collected for each valve and a methodology determined to assign cost effective interventions to the valves. The interventions were verified by technicians from Site Operations to ensure they remediated defects of key valves on our operational sites.

7 Consequence of Failure

7.1.1 Without appropriate level of investment, valves will not be able to operate and will fail to conform to the legislative requirements of PSSR, PSR, GS(M)R.

7.1.2 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, and electrical failure. This deterioration will increase with duty and asset age.

7.1.3 The consequence of an NRV failing due to loss of integrity may be catastrophic to plant and people. Their presence on compressor suction and discharge pipework could impact compressor availability which would be detrimental to the wider NTS. If an NRV fails, any debris could damage the compressor and end up in the broader pipeline network. Recovery of debris from pipeline network can be difficult. Flanged components in the flow path would require removal to facilitate access for inspection and retrieval of debris. It might also be necessary to excavate and cut pipework open to facilitate retrieval or use inline inspection. These all have impacts to the network's ability to transmit gas, will lead to more environmental emissions, and ultimately have higher cost impact to consumers due to expensive operational costs.

Baseline risk changes for valves across RIIO-GT3

7.1.4 Figure 6 below presents the modelled baseline risk over RIIO-GT3 for valves assuming no investment in the period. It shows that for valves, monetised risk starts in RIIO-GT3 at £15.7m and ends at £19.7m during the period, an increase of ~25%.

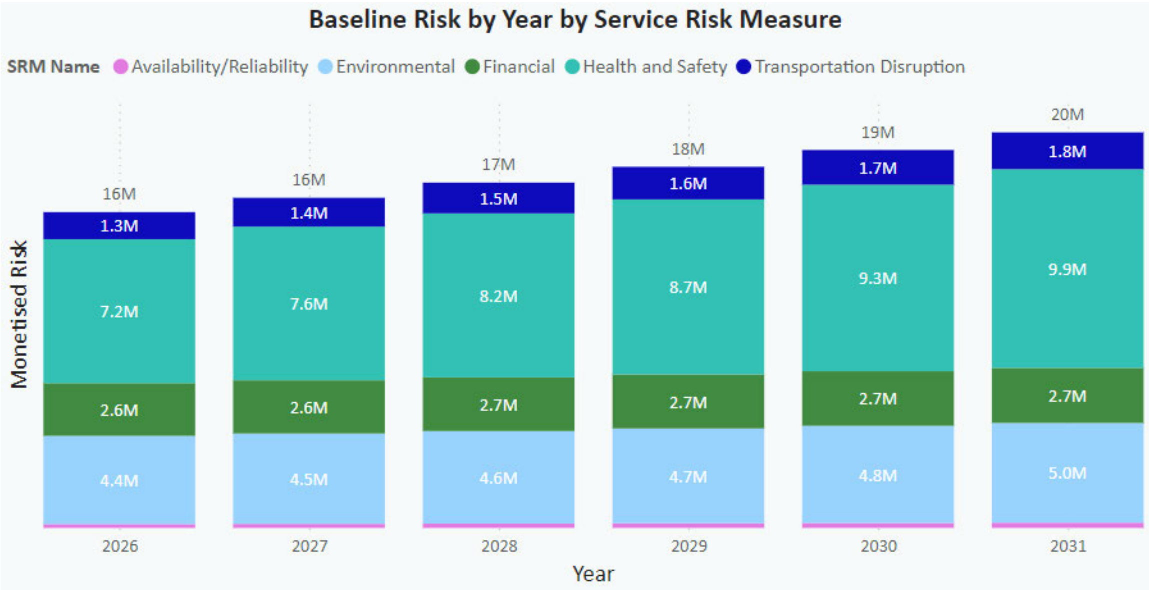


Figure 6: Baseline risk for valves across RIIO-GT3

7.1.5 The contribution of individual service risk measures towards the overall risk for valves is explained in Table 12 below.

Table 12: Consequence of Failure for all valve problems.

Impact / Consequence				
Availability	**Environment**	**Financial**	**Safety**	**Societal**
Where inability to isolate the network due to non-operational valves, outage boundary has to be extended, resulting in potential customer outages.	Loss of natural gas to the atmosphere through the inability to seal, small leaks and vents. Seals in buried inoperable valves and cocooned valves may suffer time-bound deterioration relating in leakage of gas. Where valves fail to seal, isolation boundary must be extended, and more venting is required.	Reactive costs associated with the repair of failed valves are expensive. If a valve failure occurs which is critical to repair and leads to additional isolation tools needing to be utilised, such as stopple equipment, the cost of the repairs increases dramatically. These costs could include cost of replanning work, outages, supply disruptions etc. Unplanned repairs incur long lead times. If valves are required urgently and need to be fast tracked, higher costs are associated with procurement and delivery.	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. If a failure (valve not sealing) occurs on an Emergency shutdown (ESD) system this can compromise the integrity of the system. This could result in a Unit ESD escalating to a Station ESD. Valve failures on PIG trap isolation valves, block valves, feeder isolation valves can lead to delay/rescheduling of inline inspection & remediation of pipelines. This puts the pipeline more at risk of loss of containment of gas and subsequent risk of fires/explosions. Majority of valve pits are too small and wouldn't pass safe working design standards today. Failure of a valve e.g., leaks put people at risk when they go into the pits for inspection or maintenance. Without investment on filter isolation plug valves, people inspecting or carrying out maintenance on filters are not protected by a full isolation from pressurised equipment.	Letting defects worsen by not proactively managing valves would lead to more failures and reactive maintenance which is more costly for future generations

8 Interventions Considered

8.1 Interventions

8.1.1 In considering the available Interventions, our objective has been to develop a plan that balances and optimises cost, risk, and performance and maintains an appropriate level of risk across all Interventions in the valve assets programme.

8.1.2 Deferring spend was not considered due to the need to address all problems and limit the increasing risk across valves.

8.1.3 The following Interventions have been considered to address the various problem statements articulated in **Chapter 5** [(1) – Effective isolations on valves, (2) – Leaking valves, (3) – Valve availability & Spares, (4) – Valve maintainability, (5) – Redundancy, (6) – Safe isolation of pressure vessels, (7) – Asset deterioration of NRVs]:

- Counterfactual (Do Nothing)
- Refurbish Asset / Replace Asset (Problem Statements 1, 2, 6 and 7)
- Interventions addressing redundancy (Problem Statement 5)
- Interventions addressing valve availability (Problem Statement 3)
- Interventions addressing valve maintainability (Problem Statement 4)

Counterfactual (Do Nothing)

8.1.4 For **Problem Statements 1 and 2**, this option involves carrying out enhanced maintenance to fix the valve. These are OPEX activities including flushing the valve, injecting sealant into the valve to help it seal and removing debris from the valve stops. If enhanced maintenance can resolve the issues on the valve, there will be no need for CAPEX investment. If it cannot, a defect will be raised, and CAPEX investment will be needed.

8.1.5 For **Problem Statements 3 – 7**, this involves no further actions to address the issues. This means:

- **Problem Statement 3:** Keeping no strategic spares of valves internally, and not carrying out any strip and condition assessments of defective valves when they have been removed.
- **Problem Statement 4:** Leaving valves in pits and not breaking them out. Not employing alternative maintenance facilitation techniques.
- **Problem Statement 5:** Not decommissioning any redundant valves or block valve sites.
- **Problem Statement 6:** This option involves no replacement of the valve that currently isolates filters for maintenance. Its suitable for ball valves as they can provide suitable isolations for pressurised equipment but not for plug valves as they won't be able to provide safe isolations.
- **Problem Statement 7:** This involves conducting functional checks for NRVs in accordance with maintenance policy and does not include performing more in-depth inspections such as non-destructive testing involving specialist equipment and vendors offsite.

8.1.6 The benefit for this intervention in all cases is there are no CAPEX costs. Action is taken only to conduct required maintenance or to simply monitor the condition of the assets.

8.1.7 The downside is this intervention involves the following:

- **Problem Statements 1 and 2:** If enhanced maintenance isn't successful, defective or leaking valves will be unable to safely carry out their critical functions of isolating sections of the NTS for planned maintenance or in the event of an emergency.
- **Problem Statement 3:** No strategic spares in the event of a new valve being needed in RIIO-GT3 and long lead times could make it difficult to obtain valves. Without strip and condition assessments, there will be a lack of understanding of repurposing viability for valves on the network.

- **Problem Statement 4:** Leaving valves in pits means high safety risk for personnel to perform maintenance activities in a confined space. It also means in some instances, valves cannot be inspected as the pit is too small, so isolation function cannot be tested. You are unable to carry out complex maintenance without affecting flow through a site or cutting off supply to an offtake.
- **Problem Statement 5:** For redundant assets, continued sustainment incurs ongoing costs related to inspections and maintenance. As assets degrade over time, this may lead to increased remedial works being required at cost to the consumer. Deferring the inevitable spend of decommissioning also means future consumers who have not benefitted from the assets will have to pay the costs of decommissioning. This contradicts the 'polluter pays' principle set out in the Environmental Act 2021.

Refurbish and Replace

8.1.8 Table 13 below lists different refurbishment and replacement interventions being considered for valves assets. **NOTE:** "Valve overhaul" is a specific intervention that is not meant to be confused with "valve refurbishments". It is an activity that is one of the various methods for valve refurbishments.

Table 13: Valves Refurbish and Replace Interventions

Intervention	Scope
Valve overhaul (refurb)	If enhanced maintenance cannot recover the valve and there is a defect on the valve due to a part not working on the valve, repurposing might be a better intervention than replacing. Overhaul would involve stripping valve in situ or removing and taking the valve to a workshop or third-party service provider. The valve will be stripped, repaired, rebuilt, and refitted on return. This does not re-life the valve completely, only extending its useful life
Tighten / Adjust stem seals (refurb)	During maintenance, if it is determined that the valve does not provide a satisfactory stem seal, i.e., gas passing the stem seal of the valve and leaking to atmosphere, stem can be adjusted to address a stem seal leak. This is attempted before replacing the stem seals or a valve replacement.
Stem seal replacement (refurb)	During maintenance, if it is determined that the valve does not provide a satisfactory stem seal, i.e., gas passing the stem seal of the valve and leaking to atmosphere, existing defective valve stem seal is replaced with a new one to ensure no future leak path of gas via the valve stem. As this only replaces a single element of the valve, intervention does not completely re-life the valve
Vent & sealant line replacement (refurb)	During maintenance, if it is determined that vent & sealant lines are defective, this intervention fully replaces the lines including all fittings on the valve. This allows future lubrication of valve seats and cavity venting can be conducted, preventing future gas leaks. As this only replaces a single element of the valve, intervention does not completely re-life the valve
Sealant port adaption (refurb)	If a valve doesn't have sealant ports, or has partial sealant ports, sealant port adaption helps install these ports and can potentially help recover a valve (if not sealing) without the need for replacing. This intervention is predominantly conducted on above ground valves.
NRV overhauls (refurb)	Conduct major intrusive overhauls of existing NRVs in accordance with OEM guidance. Includes replacing key components and performing non-destructive testing. For above ground bolted / flanged valves, scope will include just intrusive work but for buried and welded valves, scope will also include costs of excavating and cutting out the valve.
Valve replacement	This intervention is only considered after defects (e.g., valve not sealing or leaking considerably) have been identified and extensive enhanced maintenance has been undertaken, unsuccessfully recovering the valve. It is also only chosen when no refurb intervention will recover the valve. This intervention involves isolating the defective valve in question before cutting out and replacing the valve and its operator with a modern equivalent. The valve and its operator need to be replaced because for valves, we do not know what the top works arrangement is until its exposed, so there is no guarantee that the mating components (actuator, drive shaft etc.) will go into the new valve without modification. Modification will increase job time and potentially costs. This intervention completely relifes the valve and all its components i.e., stem, seals, and vent & sealant lines. For valves in pits, the pits will be broken out.
Replacing plug valve with Double Block and Bleed (DBB) valve	This intervention is similar to a valve replacement where valve in question is isolated and then unbolted and replaced. This ensures compliance with HSE mandate
NRV replacement	For non-compliant [redacted]. These valves are in pits. Replacement would involve accessing the pit and disconnecting the valve, taking it to be repurposed/ disposed and replacing the valve with a similar valve of the same size before bolting / flanging in place.
Block valve replacement	Replacement of a full block valve site including isolating the site, recompressing, venting, and purging. The block valve arrangement is cut out and replaced with a new setup. New block valve arrangement would involve the mainline valve, five bridle valves and two 2" valves at the end of the bridle and associated pipework and valve operators. These bridle valves will be welded together to create block valve arrangement offsite. If valves were in pits, pits will be broken out, with the bridle valves brought above ground and the mainline valve left buried.

8.1.9 Refurbishment interventions were selected over replacement interventions to resolve defects, as they are cheaper intervention options. This is unless the issue mandated a new valve i.e., non-compliant NRVs, non-compliant filter isolation plug valves or valves where refurb options could not rectify the issue and valve was unable to seal.

8.1.10 For more information on factors that led to valve replacement being chosen over various refurbishments, see **Appendix 4**

8.1.11 Block valve replacements were selected on sites where there were multiple valves on the block valve arrangement that needed replacements. Justification for the option can be found in **Appendix 5.**

Redundancy

8.1.12 Table 14 below lists different intervention options considered in addressing redundancy.

Table 14: Intervention options considered to address redundancy.

Intervention	Scope
Disconnect	To isolate the valves from the gas flow, they could be physically disconnected from the network. Intervention has been discounted as it isn't viable due to cost impact to consumers as they would have to pay for maintenance on assets that have no value
Decommission/ Pipethrough	This intervention involves removing the valve and disposing of it in a responsible way (recycling materials where possible e.g., metal). This applies to both single valves and block valve sites. For block valve sites, there is the possibility of restoring the site to greenfield after the block valve has been removed to improve the natural landscape if in rural locations; or retaining the land and using the footprint to benefit ecology.

8.1.13 Decommissioning was chosen in all cases for redundant valves as the assets are no longer required but still require intervention in the form of maintenance, so they are poor value for customers. Our System Operator has confirmed no current use for these assets and no expected use in the future based on supply and demand forecasts.

8.1.14 Single valves and block valves that are proposed to be piped-through individually were given a standard scope and unit cost approach. However, there are bespoke decommissioning projects which involve decommissioning one or more valves so individual scopes were created with project costs estimated. These are shown in Table 15 below.

Table 15: Valve bespoke decommissioning projects.

Project
[redacted]
[redacted]
[redacted]
[redacted]
[redacted]
[redacted]
[redacted]
[redacted]
[redacted]

Valve availability

8.1.15 Table 16 below lists interventions to address valve availability.

Table 16: Intervention options to address valve availability.

Intervention	Scope
Obtain spares	Purchasing valves ad keeping a strategic stock to be used when a new valve is required.
Strip & condition assessments	Defective valves that are removed from the network are stripped to see if they are recoverable

8.1.16 Having spares combats the issue of valves being long lead items (up to 40 weeks as of 2023/24). A spare could be used in the event of a shortage.

8.1.17 Strip & condition assessments will improve the understanding of the efficiency of repurposing valves going forward. This will help inform if a more robust valve repurposing program is possible in future price controls.

Valve maintainability

Individual valves in pits

8.1.18 For individual valves in pits, pit breakouts were only considered for valves that were recommended for replacement. This was done to limit the number of pit breakouts and create efficiencies when delivering valve and pit associated work. Pit breakouts are covered in NGT_EJP02_Site Assets - Preheating, Filters & Pipework_RIIO-GT3.

8.1.19 Since the valve will be replaced, the new valve will be designed to fit its new state i.e., being above ground. Therefore, no additional intervention is required to extend the valve stem or vent and sealant lines.

Block valves in pits

8.1.20 The following intervention options were considered to resolve safety issues of block valves in pits.

Table 17: Intervention options to address block valves in pits.

Intervention	Scope
Half pit	This intervention involves securing valves in a pit infrastructure that is shallower than standard pits.
Bring the entire block valve above ground	This intervention involves bringing all valves in the block valve arrangement above ground after being removed from the pits. This includes redesigning the mainline pipework and bridle pipework. Additionally, it may involve installing new fences such as a palisade and a post and rail fence to contain the now exposed assts. This is covered in NGT_EJP19_Civils_RIIO-GT3.
Bring bridle valves and pipework above ground, leave mainline valve buried while extending its valve stem and vent and sealant lines	This intervention involves bringing the bridle pipework and valves above ground, however, burying the mainline ball valve and installing vent and sealant line and extending valve stem above ground. Additionally, it may involve installing new fences such as a palisade and a post and rail fence to contain the now exposed assets. This is covered in NGT_EJP19_Civils_RIIO-GT3. It will also affect the cathodic protection that was on the previously buried pipework.

8.1.21 Half pits have been discounted as even though pit infrastructure is shallower than standard pits, for safety reasons, it is still preferred for operations technicians to not have to go into confined spaces to inspect or maintain valves.

8.1.22 Bringing the entire block valve above ground has also been discounted as it involves the highest level of technical complexity and the largest cost compared to just bringing the bridle above ground. This also exposes more assets to the public making it potentially require additional containment (fencing) and security measures. Breaking out the block valve from pits and bringing the bridle above ground, while leaving the mainline valve buried is the preferred option in this choice as it eliminates pits entirely from the block valve site and requires minimal complexity.

Valve maintenance facilitation

8.1.23 The following intervention was considered to address issues with complex maintenance facilitation.

Table 18: Intervention option to address valve maintenance facilitation.

Intervention	Scope
Stopple & Bypass	Installation of a stopple and bypass for isolation activities. This will resolve occasional complex isolation situations where we are unable to isolate a section of the site for maintenance without disrupting flow throughout the site or where we need to feed single fed customer offtakes that are in an isolated section of the network.

8.2 Intervention Summary

8.2.1 Table 19 Shows a summary of all interventions considered.

Table 19: Valves Interventions Technical Summary Table

Intervention	Equipment Design Life (Years)	Positives	Negatives	Taken Forward
Counterfactual	N/A	Lowest CAPEX intervention.	Unresolved defects	No
Valve overhaul	20	Cheaper CAPEX than replacement. Provides some useful life to the valve.	Doesn't relife valve completely so higher chance of failure in the future compared to valve replacement. Large proportion of valves have welded bodies which makes overhauling uneconomical. [redacted] valves which make up most of our bolted valves have issues with leaks from the body seal. Overhauling cannot fix this issue as it's a design flaw. Limited use case where only above ground valves will be overhauled due to our policy of not burying bolted valves with a split body.	Yes

			Long lead times for valves and lack of extensive experience overhauling valves make it difficult to plan projects around.	
Tighten / Adjust stem seals	10	Cheaper CAPEX than replacement. Relifes valve	Doesn't relife valve completely so higher chance of failure in the future compared to valve replacement.	Yes
Stem seal replacement	15	Cheaper CAPEX than replacement. Relifes valve	Doesn't relife valve completely so higher chance of failure in the future compared to valve replacement.	Yes
Vent & sealant line replacement	15	Cheaper CAPEX than replacement. Relifes valve	Doesn't relife valve completely so higher chance of failure in the future compared to valve replacement.	Yes
Sealant port adaption	10	Cheaper CAPEX than replacement. Relifes valve	Doesn't relife valve completely so higher chance of failure in the future compared to valve replacement.	Yes
NRV overhauls	15	Cheaper CAPEX than replacement. Relifes valve	Doesn't relife valve completely so higher chance of failure in the future compared to valve replacement.	Yes
Valve replacement	40	Completely relifes valves. Most cost effective for welded valves.	Higher CAPEX required than refurb	Yes
Replacing plug valve with Double Block and Bleed (DBB) valve	40	HSE compliance. Ability to safely isolate filters for maintenance. No need to extend isolation boundary during filter maintenance.	Requires CAPEX investment for plug valves	Yes
NRV replacement	30	Completely relifes valve.	High CAPEX investment	Yes
Block valve replacement	40	Completely relifes block valves. Efficiency in resolving defects on block valves without encroaching on welds and vent & sealant lines of other valves.	High CAPEX investment	Yes
Disconnect	N/A	Mitigates the risk of the redundant assets impacting operational assets.	Valves would still require removing in the future which would put cost burden on future generations	No
Decommission/ Pipethrough	N/A	Prevents future consumers for paying for the cost of decom. Reduces maintenance costs on redundant assets	High CAPEX investment in the short term	Yes
Obtain spares	40	Eliminates long lead times.	Spares need to be maintained which is OPEX	Yes
Strip & condition assessments	N/A	Gives better understanding of repurposing efficiency	None	Yes
Half pit	N/A	Pit is shallower than normal pits	Technicians are still working in a confined space	No
Bring the entire block valve above ground	N/A	Removes pits	Highest complexity and costs	No
Bring bridle valves and pipework above ground, leave mainline valve buried while extending its valve stem and vent and sealant lines	N/A	Removes pits	Moderate complexity and investment to bring bridle above ground and extend stem and sealant lines on the mainline valve	Yes
Stopple & Bypass	N/A	Allows for complex isolation activities that would not have otherwise been possible	Expensive option and will only be considered if it is the only option to carry out maintenance or the cheapest option.	Yes

8.3 Volume Derivation

8.3.1 For more information about the development of intervention volumes for valves, see **Appendix 4**

8.3.2 Table 20 below shows the development of intervention volumes for valves in RIIO-GT3.

Table 20: Development of bottom-up volumes for RIIO-GT3

Intervention	Volume	Unit of Measure	How this volume has been developed
Valve overhaul	[redacted]	Per Asset	Based on a combination of defects, valve model (i.e., whether it's a [redacted] valve, valve state (above ground, below ground or in pits) and age with defects being the primary driver. The intervention was selected through engineering assessment of the above information and verified by site operations as the right intervention for the valve.
Tighten / Adjust stem seals	[redacted]	Per Asset	
Stem seal replacement	[redacted]	Per Asset	
Vent & sealant line replacement	[redacted]	Per Asset	

Sealant port adaption	[redacted]	Per Asset	
Valve replacement	[redacted]	Per Asset	
Block valve replacement	[redacted]	Per Site	Based on block valve sites that had defects on one or more valves that required replacement.
Block valve modifications after pits have been broken out	[redacted]	Per Site	Based on known block valve sites with pits. This information has been verified by site operations.
Stopple & bypass	[redacted]	Per Installation	Derived from known stopple & bypass use in RIIO-T2. We are delivering significantly more work but also expect to realise efficiencies through feeder shut down and planned outages. His should limit the number of requirements for stopple & bypass but situations could still arise.
Replace plug valve with DBB valve	[redacted]	Per Asset	This was the number of plug valves isolating filters on AGI. It is expected to intervene on these in RIIO-GT3 and RIIO-GT4
Valve spares	[redacted]	Per Asset	Taken as a percentage of valves expected to be replaced in RIIO-GT3
Valve strip and condition assessment	[redacted]	Per Asset	Taken as a percentage of valves expected to be replaced in RIIO-GT3
Bolted / flanged NRV overhauls	[redacted]	Per Asset	Based on NRVs that either had the age limit between overhauls or cycles limit between overhauls hit in RIIO-GT3
Welded / Buried NRV Overhauls	[redacted]	Per Asset	Based on welded NRVs that were meant to be overhauled in RIIO-T2 due to age limit between overhauls (25 years) reached. These are only valid for [redacted]
NRV replacement	[redacted]	Per Asset	Based on non-complian [redacted]
Pipethrough of a single valve	[redacted]	Per Asset	Based on known list of redundant valves that are buried / inoperable / cocooned.
Pipethrough of a block valve site	[redacted]	Per Site	Based on known list of redundant block valves that are buried / inoperable / cocooned
[redacted] removal and flanging	[redacted]	Per Project	Volume of [redacted] as this intervention has been estimated as a project so cost includes all scope of works.
[redacted] redundant asset decomm	[redacted]	Per Project	
[redacted] redundant asset decomm	[redacted]	Per Project	
[redacted] redundant asset decomm	[redacted]	Per Project	
[redacted] redundant asset decomm	[redacted]	Per Project	
[redacted] redundant asset decomm	[redacted]	Per Project	
[redacted] redundant asset decomm	[redacted]	Per Project	
[redacted] redundant valves decomm	[redacted]	Per Project	
Installing a new standard Valve Bypass Arrangement at [redacted]	[redacted]	Per Project	

8.4 Unit Cost Derivation

8.4.1 Costs have been derived using known data for activities which share the scope with the interventions within this EJP. We have mapped RIIO-GT3 interventions to RIIO-T2 Unique identifiers (UIDs) and assessed the available historical outturn and/or forecasted completion costs.

8.4.2 Where historical outturn or tendered costs have not been available, we have undertaken estimating by sourcing quotations from the supply chain to calculate the Estimated Cost of Completion (ECC) or have estimated from first principles if no tendered information is available. Table 21 below summarises the cost sources and data points used to inform the unit costs in this EJP. All relevant cost breakdowns are in **Appendix 6.**

Table 21: Valves Intervention cost sources and data points (£m, 2023/24)

Intervention	Unit Cost	Unit of Measure	Cost Accuracy	Number of Data Points	Source Data
Valve overhaul	[redacted]	Per Asset	[redacted]	0	First principles – derived using known rates/activities
Tighten / Adjust stem seals	[redacted]	Per Asset	[redacted]	4	Historical outturn, Estimate at Cost of Completion
Stem seal replacement	[redacted]	Per Asset	[redacted]	2	Historical outturn, Estimate at Cost of Completion
Vent & sealant line replacement	[redacted]	Per Asset	[redacted]	69	Historical outturn, Estimate at Cost of Completion
Sealant port adaption	[redacted]	Per Asset	[redacted]	29	Historical outturn, Estimate at Cost of Completion
Valve replacement	[redacted]7	Per Asset	[redacted]	52	Historical outturn, Estimate at Cost of Completion
Block valve replacement	[redacted]	Per Site	[redacted]	0	First principles – derived using known rates/activities
Block valve modifications after pits have been broken out	[redacted]	Per Site	[redacted]	0	First principles – derived using known rates/activities

Stopple & Bypass	[redacted]	Per Installation	[redacted]	5	Historical outturn, Estimate at Cost of Completion
Replace plug valve with DBB valve	[redacted]	Per Asset	[redacted]	0	First principles – derived using known rates/activities
Valve spares	[redacted]	Per Asset	[redacted]	0	First principles – derived using known rates/activities
Valve strip and condition assessment	[redacted]	Per Asset	[redacted]	0	First principles – derived using known rates/activities
Bolted / flanged NRV overhauls	[redacted]	Per Asset	[redacted]	11	Historical outturn, Estimate at Cost of Completion
Welded / Buried NRV Overhauls	[redacted]	Per Asset	[redacted]	0	First principles – derived using known rates/activities
NRV replacement	[redacted]	Per Asset	[redacted]	0	First principles – derived using known rates/activities
Pipethrough of a single valve	[redacted]	Per Asset	[redacted]	0	First principles – derived using known rates/activities
Pipethrough of a block valve site	[redacted]	Per Site	[redacted]	0	Intervention in RIIO-T2 plan but no outturn costs yet available. First principles – derived using known rates/activities and Estimate at Cost of Completion
[redacted] removal and flanging	[redacted]	Per Project	[redacted]	0	First principles – derived using known rates/activities and Estimate at Cost of Completion
[redacted] redundant asset decomm	[redacted]	Per Project	[redacted]	0	
[redacted] redundant asset decomm	[redacted]	Per Project	[redacted]	0	
[redacted] redundant asset decomm	[redacted]	Per Project	[redacted]	0	
[redacted] redundant asset decomm	[redacted]	Per Project	[redacted]	0	
[redacted] redundant asset decomm	[redacted]	Per Project	[redacted]	0	
[redacted] redundant asset decomm	[redacted]	Per Project	[redacted]	0	
[redacted] redundant valves decomm	[redacted]	Per Project	[redacted]	0	
Installing a new standard Valve Bypass Arrangement at [redacted]	[redacted]	Per Project	[redacted]	0	

8.4.4 As an example of how we have developed these costs, the unit cost of [redacted] for a valve replacement is representative of the cost of replacing valves utilising RIIO-T2 delivery data from 11 sites and a total of 52 valves. Valve sizes replaced ranged from 200mm (8") – 1200mm (48"). This is a good representative sample of valve sizes across the network and broadly aligned to our proposed investment proposal, so this is suitable as a unit cost approach across the network. The valve states also ranged from above ground, below ground and pits. Access to the valve can greatly affect the cost of replacement e.g., if an excavation is needed.

8.4.5 Another example of cost data for Asset Health Valve works is the "Sealant Port Adaptation" intervention. The cost for this project has been produced using 29 data points for historically delivered works across 2 years and multiple sites. Following discussions with subject matter experts, only data points detailed as "Inspection and Repair" were to be included as a fair reflection of scope. Although unit costs against this scope did vary, all data points were validated as accurate and a representation of future works. In some instances, this intervention may include the replacement of sand boxes or include a full pipe exchange. One example at [redacted] showed a more complex repair with a non-routine inspection. Corrosion was also discovered which impacted the unit cost. Again, this was validated as a potential issue that may occur again in future works. The Unit Cost has been taken as a blanket average of the 29 data points with costs inflated to reflect a consistent cost base for future works.

9 Options Considered

9.1 Portfolio Approach

9.1.1 In developing our plans, we focused on value for money and deliverability, while managing the risks of aging assets. We evaluated the cost-effectiveness of our investment program through a full Cost Benefit Analysis (CBA) using the NARMs Methodology within the Copperleaf Decision support tool.

9.1.2 While this EJP emphasises interventions on actuators, we have assessed the benefit from options across the entire Valves portfolio including valves, actuators, pressure control valves and flow control valves (PCVs & FCVs), and valve bypasses, to meet investment drivers, business plan commitments, and consumer priorities. Therefore, a single CBA convers this EJP, NGT_EJP23_Valves: Actuators_RIIO-GT3, NGT_EJP24_Valves: PCVs and FCVs_RIIO-GT3 and NGT_EJP25_Valves: Bypass Installation and Modification_RIIO-GT3.

9.1.3 The options considered combining the interventions discussed previously, and those in the other valves EJPs, in varying combinations and volumes to identify the optimal investment for valves.

9.1.4 In Line with HM Treasury Green Book advice and Ofgem guidance, we assessed the value of investing in valves across the RIIO-GT3 period by analysing the cost benefit over a 20-year horizon.

9.1.5 We derived bottom-up intervention volumes using the engineering assessments described in the previous chapters. Each intervention was assessed via the Ofgem-approved NARMs Methodology embedded in Copperleaf, quantifying risk reduction and Long-Term Risk Benefit (LTRB). Analysing this performance, Copperleaf Predictive Analytics is then able to select further NARMs driven interventions to create further options to satisfy certain criteria, such as stable risk across the portfolio. Only interventions assigned to a specific asset have been assessed in the CBA, as benefits cannot be applied to interventions that are assigned to various locations (e.g., based on forecast defects).

9.2 Options

9.2.1 Using the Predictive Analytics Optimisation Module (PA) within Copperleaf, our Valve assets have been optimised against the NARMs Methodology to ensure the portfolio achieves a variety of outcome risk levels, to satisfy stakeholder needs.

9.2.2 All the options described below have been assessed against out Option 0 Counterfactual (Do Nothing) option, which considers no investment over and above maintenance and corrective repairs.

9.2.3 In all options (except the counterfactual) we include investment volumes that have been developed through our bottom-up intervention development, to address known defects and obsolescence issues. These are consistent in all options (except 1A). A table of the core bottom-up build is shown in **Appendix 7** and is included in the top row of each respective option. **NOTE:** All values provided for each option are rounded to 2 dp. Total given is correct but might be different to sum of interventions due to rounding.

9.2.4 The Options 1-6 are therefore differentiated on the volumes outside of the core bottom-up build, the volumes identified in these options have been developed from a combination of bottom-up build plus modelling using Predictive Analytics. This comprises categories as follows: Actuator Overhaul, Actuator Replacement, Pressure Regulator PSSR Inspection Remedial Works, Replace Individual Regulator, Valve Overhaul, Valve Replacement.

Option 1: Total Monetised Risk Stable to RIIO-T2 Start

9.2.5 In this option we have utilised our Copperleaf Portfolio optimisation tool to constrain the level of NARMs risk at the end of the RIIO-GT3 period to remain consistent with the levels of risk at the start of the RIIO-T2 period. Individual NARMs service risk measures are not individually constrained; however overall risk outcome is.

9.2.6 The total spend of proposed interventions in this option is £541.0m (2023/24) which addresses known and forecast defects.

Table 22: Option 1 Summary (£m, 2023/24)

Intervention	Volumes	RIIO-GT3 Value (£m, 2023/24)
Bottom-up interventions	2535	313.26
Actuator Overhaul	[redacted]	0.65
Actuator Replacement	[redacted]	27.66
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.02

Replace Individual Regulator	[redacted]	0.18
Valve Overhaul	[redacted]	28.53
Valve Replacement	[redacted]	170.74
Total	**3769**	**541.04**

Option 1A: Post Deliverability

9.2.7 In this option, our programme of investments on valves assets from Option 1 has been taken through a deliverability assessment which factors in network outage, resource and supply chain constraints. Due to the constraints, this is the only option that does not have the same bottom-up volumes as the others. The total spend in this option is £286.3m (2023/24) and the intervention breakdowns are shown in Table 23 below.

Table 23: Option 1A Intervention and spend summary.

Intervention	Total Volume in RIIO-GT3	Total spend in RIIO-GT3 (£m, 2023/24)
Bolted/Flanged NRV overhaul	[redacted]	2.86
Welded/Buried NRV Overhauls	[redacted]	3.32
NRV replacement	[redacted]	2.08
Replace Regulator Stream (Single)	[redacted]	32.09
Replace FCV Stream (Single)	[redacted]	13.84
Fuel Gas/Domestic Gas Supply Pressure Regulator Skid Replacement	[redacted]	2.51
Replacement of Multistage Pressure Reduction Skid	[redacted]	3.86
Replace Regulator Stream PCV/FCV (Single)	[redacted]	4.20
[redacted] Redundant Asset Decom	[redacted]	0.18
[redacted]t Redundant Asset Decom	[redacted]	0.21
[redacted] Redundant Asset Decom	[redacted]	0.77
Actuator Control Replacement	[redacted]	3.62
Stem seal replacement	[redacted]	1.83
Tighten/ Adjust Stem Seals	[redacted]	1.16
Sealant Port Adaption	[redacted]	0.87
Vent & sealant line replacement	[redacted]	1.71
Replace plug valve with double block and bleed valve	[redacted]	3.16
Pipethrough of block valve site	[redacted]	2.57
Pipethrough of single valve on a site (uncongested)	[redacted]	9.76
Valve strip and condition assessment	[redacted]	1.82
Valve spares	[redacted]	1.36
Block Valve Replacement	[redacted]	26.66
Block Valve modification after pits have been broken out	[redacted]	1.31
Overpressure protection study and replacement of relief valve	[redacted]	5.94
Stopple & Bypass	[redacted]	19.55
HIPPS FEED Study	[redacted]	1.78
Installation of Terminal HIPPS	[redacted]	11.60
Removal of [redacted]	[redacted]	0.14
Installing a new standard Valve Bypass Arrangement at [redacted]	[redacted]	0.31
[redacted] Redundant Asset Decom	[redacted]	0.32
[redacted] Redundant Asset Decom	[redacted]	0.46
[redacted] Redundant Asset Decom	[redacted]	0.43
[redacted] Redundant Asset Decom	[redacted]	0.75
[redacted] Redundant Asset Decom	[redacted]	0.30
[redacted] Redundant Asset Decom	[redacted]	0.66
[redacted] Redundant Asset Decom	[redacted]	0.40
Install bypass pipework	[redacted]	18.46
Modify bypass pipework	[redacted]	59.46
Bottom-up volumes total	[redacted]	**242.32**
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.26

Actuator Replacement	[redacted]	13.44
Actuator Overhaul	[redacted]	0.15
Valve Replacement	[redacted]	29.76
Valve Overhaul	[redacted]	0.41
Total	**2437**	**286.33**

Option 2: Additional 10% Risk Reduction

9.2.8 In this option we have utilised our Copperleaf Portfolio optimisation tool to achieve a 10% additional monetised risk reduction by the end of the RIIO-GT3 period. Copperleaf has selected the most cost-effective investments to meet the lower risk constraint.

9.2.9 The total spend of proposed interventions in this option is £560.0m (2023/24), addressing known and forecast defects. This option has greater spend than option 1 as the model has to work harder to achieve benefit on assets that provide less benefit than those selected in Option 1.

Table 24: Option 2 Summary (£m, 2023/24)

Intervention	Volumes	RIIO-GT3 Value (£m, 2023/24)
Bottom-up interventions	2535	313.26
Actuator Overhaul	[redacted]	0.73
Actuator Replacement	[redacted]	29.44
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.02
Replace Individual Regulator	[redacted]	0.18
Valve Overhaul	[redacted]	21.55
Valve Replacement	[redacted]	194.82
Total	**3856**	**560.01**

Option 3: Lowest Whole Life Cost (WLC)

9.2.10 In this option, we applied optimisation to select interventions with the lowest WLC. Copperleaf identifies the most beneficial interventions, and no investment is selected if the cost exceeds the asset's lifetime benefit, as per the NARMs methodology. None of our service risk measures (Availability & Reliability, Safety, Environmental, Societal and Transport) have an outcome constraint applied.

9.2.11 The total spend of proposed interventions in this option is £680.3m (2023/24). In this option PA has made a decision to intervene on any asset where the cost is outweighed by the benefit no matter how small the margin. While generally it will reduce risk more over the life of the asset, it may make decisions that are not possible i.e., trying to do too much work.

Table 25: Option 3 Summary (£m, 2023/24)

Intervention	Volumes	RIIO-GT3 Value (£m, 2023/24)
Bottom-up interventions	2535	313.26
Actuator Overhaul	[redacted]	2.70
Actuator Replacement	[redacted]	63.36
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.26
Replace Individual Regulator	[redacted]	5.24
Valve Overhaul	[redacted]	0.82
Valve Replacement	[redacted]	294.67
Total	**4844**	**680.30**

Option 4: Availability and Reliability Risk Stable to RIIO-T2 Start

9.2.12 In this option we have utilised our Copperleaf Portfolio optimisation tool to constrain our availability and reliability service risk measure to achieve a stable risk at the end of RIIO-GT3 to the start of RIIO-T2. No other service risk measures have been constrained.

9.2.13 The total spend of proposed interventions in this option is £655.6m (2023/24).

Table 26: option 4 Summary (£m, 2023/24)

Intervention	Volumes	RIIO-GT3 Value (£m, 2023/24)
Bottom-up interventions	2535	313.26
Actuator Overhaul	[redacted]	2.70
Actuator Replacement	[redacted]	58.94
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.27
Replace Individual Regulator	[redacted]	5.05

Valve Overhaul	[redacted]	45.36
Valve Replacement	[redacted]	230.00
Total	**4755**	**655.60**

Option 5: Health and Safety Risk Stable to RIIO-T2 Start

9.2.14 In this option we have utilised our Copperleaf Portfolio optimisation tool to constrain our health and safety service risk measure to achieve a stable risk at the end of RIIO-GT3 to the start of RIIO-T2. No other service risk measures have been constrained.

9.2.15 The total spend of proposed interventions in this option is £547.5m (2023/24).

Table 27: Option 5 Summary (£m, 2023/24)

Intervention	Volumes	RIIO-GT3 Value (£m, 2023/24)
Bottom-up interventions	2535	313.26
Actuator Overhaul	[redacted]	2.51
Actuator Replacement	[redacted]	44.45
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.24
Replace Individual Regulator	[redacted]	2.39
Valve Overhaul	[redacted]	19.29
Valve Replacement	[redacted]	165.33
Total	**4124**	**547.48**

Option 6: Environmental Risk Stable to RIIO-T2 Start

9.2.16 In this option we have utilised our Copperleaf Portfolio optimisation tool to constrain our environmental service risk measure to achieve a stable risk at the end of RIIO-GT3 to the start of RIIO-T2. No other service risk measures have been constrained.

9.2.17 The total spend of proposed interventions in this option is £655.5m (2023/24).

Table 28: Option 6 Summary (£m, 2023/24)

Intervention	Volumes	RIIO-GT3 Value (£m, 2023/24)
Bottom-up interventions	2535	313.26
Actuator Overhaul	[redacted]	2.70
Actuator Replacement	[redacted]	58.94
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.19
Replace Individual Regulator	[redacted]	5.05
Valve Overhaul	[redacted]	45.36
Valve Replacement	[redacted]	230.00
Total	**4745**	**655.51**

9.3 Option Summary

9.3.1 Table 29 below shows the technical summary table comparing Options 0 to 6.

Table 29: Portfolio Options Technical Summary table

Option	First Year of Spend	Final Year of Spend	Total Volume of Interventions	Investment Design Life	% of Assets intervened on	Total Spend Request (£m 2023/24)
Option 0: Counterfactual (Do Nothing)	FY25	FY32	N/A	N/A	0	0
Option 1: Total Monetised Risk Stable to RIIO-T2 start	FY25	FY32	3769	0 – 30 years	15.0	541.04
Option 1A: Post Deliverability	FY25	FY32	2437	0 – 30 years	9.8	286.33
Option 2: Additional 10% Risk Reduction	FY25	FY32	3856	0 – 30 years	15.4	560.01
Option 3: Lowest WLC	FY25	FY32	4844	0 – 30 years	19.4	680.30
Option 4: Availability and Reliability Risk Stable to RIIO-T2 start	FY25	FY32	4755	0 – 30 years	19.0	655.60
Option 5: Health and Safety Risk Stable to RIIO-T2 start	FY25	FY32	4124	0 – 30 years	16.5	547.48
Option 6: Environmental Risk Stable to RIIO-T2 start	FY25	FY32	4745	0 – 30 years	19.0	655.51

10 Business Case Outline and Discussion

10.1 Key Business Case Drivers Description

10.1.1 Valve assets (valves, NRVs, actuators, pressure control & flow control valves) deteriorate over time and with use. This in turn prevents them from performing their required functions and can also result in them no longer complying with current and future legislative requirements.

10.1.2 Therefore, in developing our desired outcomes we have considered the impact of the following drivers for investment on valve assets:

- Legislation requirements
- Asset deterioration, linked to our ageing asset base and asset type.
- Change of operational requirement (redundancy)
- Obsolescence
- Health and safety
- Decommission and remove assets that are no longer required to manage overall whole life cost and risk.
- Reducing the environmental risk of emissions

10.1.3 Managing the number of defects that are being raised on our assets is important in ensuring they continue to deliver the required network capability. Our proposed investment in the valve assets will ensure that we maintain an appropriate level of risk across all these outcomes. In developing our plans and making our decision we have been fully cognisant of the need to develop plans that are value for money, acceptable, affordable, and deliverable, whilst achieving a suitable level of risk of our aging assets.

10.2 Business Case Summary

10.2.1 In considering the most effective combination of efficient interventions, we have challenged whether our preferred programme of investments is the most cost-beneficial by carrying out a full cost benefit analysis (CBA) utilising our Copperleaf Portfolio Optimisation tool.

10.2.2 Only interventions assigned to an asset have been assessed in the CBA because no benefits can be applied to interventions that are assigned to various locations (i.e., Based on forecast defects).

10.2.3 A variety of technical interventions have been considered and combined to create a range of CBA options, the results of which are presented in Table 30 below.

Table 30: Option summary of headline business case metrics (£, 2023/24)

Option	Total Volume of Interventions	Total Spend Request (£m)	Outcome Risk End of RIIO-GT3 (£m, 2023/24)	% change in comparison to start of RIIO-T2	PV Benefit	PV Cost (£m)	NPV (£m)	Payback Period from 2031	% change in service risk measures compared to start of RIIO–T2				
									Financial	Availability /Reliability	Environmental	Health and safety	Societal
Option 0: Counterfactual (Do Nothing)	0	0	19.12	134.20	N/A	N/A	N/A	N/A	97.01	170.00	113.83	167.86	176.51
Option 1: Total Monetised Risk Stable to RIIO-T2 start	3769	541.04	13.39	94.01	160.20	521.01	360.81	Does not payback in the period	90.99	148.60	105.62	81.22	117.76
Option 1A: Post Deliverability	2437	286.33	16.66	115.96	97.57	275.73	178.16	Does not payback in the period	92.73	160.35	108.10	131.96	145.71
Option 2: Additional 10% Risk Reduction	3856	560.01	12.61	88.48	178.93	539.27	360.34	Does not payback in the period	90.84	147.69	105.27	67.95	110.82
Option 3: Lowest WLC	4844	680.30	11.33	79.55	217.80	655.11	437.32	Does not payback in the period	89.51	95.47	103.16	54.27	75.64
Option 4: Availability and Reliability Risk Stable to RIIO-T2 start	4755	655.60	11.06	77.63	218.84	631.32	412.48	Does not payback in the period	89.32	94.56	102.27	50.11	74.53
Option 5: Health and Safety Risk Stable to RIIO-T2 start	4124	547.48	13.29	93.28	159.95	528.06	368.11	Does not payback in the period	90.05	94.90	103.46	90.81	75.55
Option 6: Environmental Risk Stable to RIIO-T2 start	4745	655.51	11.05	77.55	219.05	631.24	412.19	Does not payback in the period	89.32	94.56	102.01	50.11	74.53

In Figure 7, we have plotted the cumulative Payback period for different options presented in Table 30.

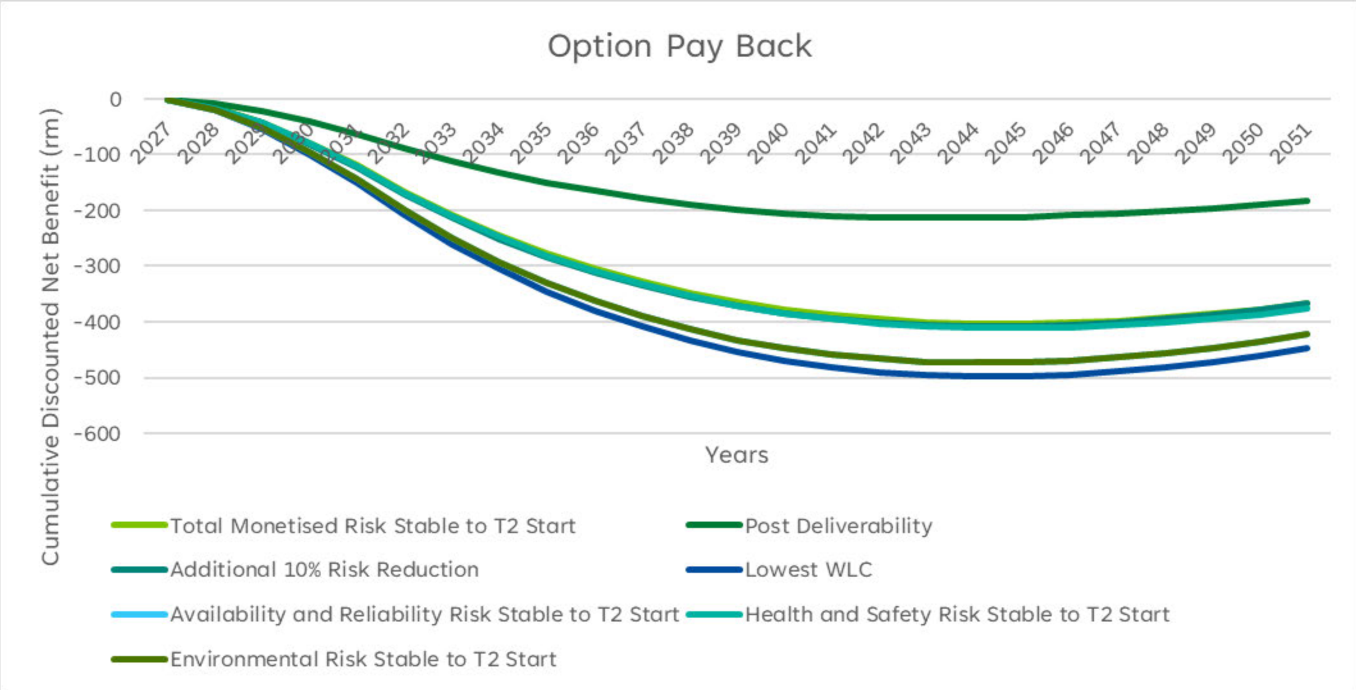


Figure 7: Cumulative payback period for all valves options

10.2.4 A variety of technical interventions have been considered and combined to create a range of CBA options, the results of which are presented in Figure 7 above. The graph illustrates the Net Present Value (NPV) of each option over a 20-year period, from 2031 (the end of RIIO-GT3), to 2051. As can be seen from the graph, Option 1A Post Deliverability shows the lowest net NPV, illustrating a greater benefit. Option 3 lowest WLC has the worst return of the options on offer. Options 4 and 6 are almost identical. The graph also shows that none of the options provide enough benefit from the investment being proposed to allow them to be paid back within the 20-year period.

10.2.5 Based on a combination of factors such as addressing known issues, maintaining network risk levels across valves assets, cost to consumer and deliverability of intervention volumes, Option 1A was selected to have the best balance of all factors even though it has the lowest risk reduction across all options. All other options will reduce overall risk compared to the start of RIIO-T2 but will come at a significantly higher cost, lower benefit and aren't deliverable due to constraints.

10.2.6 We are aware of the risk of choosing Option 1A as it doesn't meet our organisational objective of maintaining stable risk of our assets back to RIIO-T2 start but other options are not possible due to supply chain constraints identified in our deliverability assessment where only 40 valves per year and 80 actuators could be delivered. We will work with our suppliers to ensure more assets can be delivered in future price controls to prevent risk across valves assets increasing at an undesired rate. In the meantime, to mitigate this risk, internal groups will assess defects across valve assets based on severity, and short-term requirement for valves assets (i.e., if it's required for isolation to facilitate an outage) and those will be prioritised for remediation to prevent any incidents or delay to capital delivery of our plan. Interventions have been prioritised for defective valves and actuators involved in PSSR inline inspections (ILI) for pipelines to enable the valves to be able to seal during the ILI run to prevent deferring legislative work.

10.2.7 Option 1A does not pay back within the period. This is due to NARMs not capturing the full consequence of valves asset failures (valves, actuators, NRVs, PCVs / FCVs) and their intrinsic value to the network. It is also important to note that in Option 1A, majority of the interventions address known issues on a subset our assets.

11 Preferred Option and Project Plan

11.1.1 Option 1 (Total Monetised Risk Stable to RIIO-T2 start) is our preferred option in an idealistic sense where all its intervention volumes are deliverable. Our programme of investment on valves has been taken through a deliverability assessment which assesses this programme of works against outputs across our entire capital investment plan. This results in a slightly adjusted Option 1A (Post Deliverability) which becomes the preferred option and includes the mixture of interventions listed in Table 23.

11.1.2 We have developed these investments both from engineering assessment of the identified problems but also through undertaking risk-based assessments using our Copperleaf asset management decision support tool, underpinned by our NARMs framework. This combined plan forms our preferred programme of work on our Valves assets (Valves, NRVs, Actuators, Pressure and Flow Control Valves and Valve Bypasses).

11.1.3 For valves, our preferred option manages leaking valves, ensures valve availability, improves safety of technicians when maintaining valves, addresses redundancy, ensures legislative compliance, ensures OEM compliance and manages rising levels of defects on valve assets to ensure they can carry out their critical functions of effective isolations and preventing reverse flows in compressors for NRVs. Valve interventions from our preferred option are shown in Table 31 below. Please see NGT_IDP10_Portfolio EJP Valves_RIIO-GT3 for more details.

11.1.4 Intervention volumes in this EJP (437) are similar to those in RIIO-T2 (451). This will affect 474 valves (2.8% of total population). Using the RIIO-GT3 period of five years and the asset design life of a valve of 40 years, the theoretical % of assets to intervene on to maintain network risk (equals 5 / design life) was calculated as 12.5%. this calculation shows we are taking a conservative approach by intervening on a significantly smaller proportion of our valves.

11.1.5 Valve interventions proposed give a NARMs Long-Term Risk Benefit (LTRB) of £21.2m.

11.1.6 The outputs from this investment will be included in the Asset Health – NARMs and Redundant Assets PCD reporting mechanisms, and cost variance managed through the TIM mechanism.

11.1.7 Majority of the plan is funded through baseline as volumes have been built using known defects and issues and costs have been estimated using outturn data from RIIO-T2 and bottom-up estimates.

Table 31: Valves RIIO-GT3 preferred option summary (£m, 2023/24)

Intervention	Primary Driver	Volume	Unit of Measure	% Assets Intervened Upon	RIIO-GT3 Cost	Funding Mechanism	PCD Measure
Valve Overhaul	Asset health (Policy)	[redacted]	Per Asset	[redacted]	0.41	Baseline – NARMs PCD	A1
Valve Replacement	Asset health (Policy)	[redacted]	Per Asset	[redacted]	29.76	Baseline – NARMs PCD	A1
Tighten / Adjust stem seals	Asset health (Policy)	[redacted]	Per Asset	[redacted]	1.16	Baseline – NARMs PCD	A1
Stem seal replacement	Asset health (Policy)	[redacted]	Per Asset	[redacted]	1.83	Baseline – NARMs PCD	A1
Vent & sealant line replacement	Asset health (Policy)	[redacted]	Per Asset	[redacted]	1.71	Baseline – NARMs PCD	A1
Sealant port adaption	Asset health (Policy)	[redacted]	Per Asset	[redacted]	0.87	Baseline – NARMs PCD	A1
Block valve replacement	Asset health (Policy)	[redacted]	Per Site	[redacted]	26.66	Baseline – NARMs PCD	A1
Block valve modifications after pits have been broken out	Asset health (Policy)	[redacted]	Per Site	[redacted]	1.31	Baseline – NARMs PCD	A1
Stopple & Bypass	Asset health (Risk Management)	[redacted]	Per Installation	[redacted]	19.55	Baseline – Non lead Asset PCD	A3
Replace plug valve with DBB valve	Asset health (Legislation)	[redacted]	Per Asset	[redacted]	3.16	Baseline – NARMs PCD	A1
Valve spares	Asset health (Policy)	[redacted]	Per Asset	[redacted]	1.36	Baseline – NARMs PCD	A1
Valve strip and condition assessment	Asset health (Policy)	[redacted]	Per Asset	[redacted]	1.82	Baseline – NARMs PCD	A1
Bolted / flanged NRV overhauls	Asset health (Policy)	[redacted]	Per Asset	[redacted]	2.86	Baseline – NARMs PCD	A1
Welded / Buried NRV Overhauls	Asset health (Policy)	[redacted]	Per Asset	[redacted]	3.32	UM	N/A

NRV replacement	Asset health (Policy)	[redacted]	Per Asset	[redacted]	2.08	Baseline – NARMs PCD	A1
Pipethrough of a single valve	Redundant assets	[redacted]	Per Asset	[redacted]	9.76	Baseline – Redundant Assets PCD	A3
Pipethrough of a block valve site	Redundant assets	[redacted]	Per Site	[redacted]	2.57	Baseline – Redundant Assets PCD	A3
Roudham Heath Valve 1319-13 removal and flanging	Redundant assets	[redacted]	Per project	[redacted]	0.14	Baseline – Redundant Assets PCD	A3
Silk Willoughby redundant asset decomm	Redundant assets	[redacted]	Per project	[redacted]	0.32	Baseline – Redundant Assets PCD	A3
Aldfield redundant asset decomm	Redundant assets	[redacted]	Per project	[redacted]	0.46	Baseline – Redundant Assets PCD	A3
Alrewas redundant asset decomm	Redundant assets	[redacted]	Per project	[redacted]	0.43	Baseline – Redundant Assets PCD	A3
Carlisle redundant asset decomm	Redundant assets	[redacted]	Per project	[redacted]	0.75	Baseline – Redundant Assets PCD	A3
Thornton Curtis redundant asset decomm	Redundant assets	[redacted]	Per project	[redacted]	0.30	Baseline – Redundant Assets PCD	A3
Horndon redundant asset decomm	Redundant assets	[redacted]	Per project	[redacted]	0.66	Baseline – Redundant Assets PCD	A3
Bretford redundant valves decomm	Redundant assets	[redacted]	Per project	[redacted]	0.40	Baseline – Redundant Assets PCD	A3
Installing a new standard Valve Bypass Arrangement at Arbroath	Redundant assets	[redacted]	Per project	[redacted]	0.31	Baseline – Redundant Assets PCD	A3
Total		**437**	**Per asset**	**2.82%**	**110.64** **3.32**	**Baseline** **UM**	

Uncertainty Mechanism Request

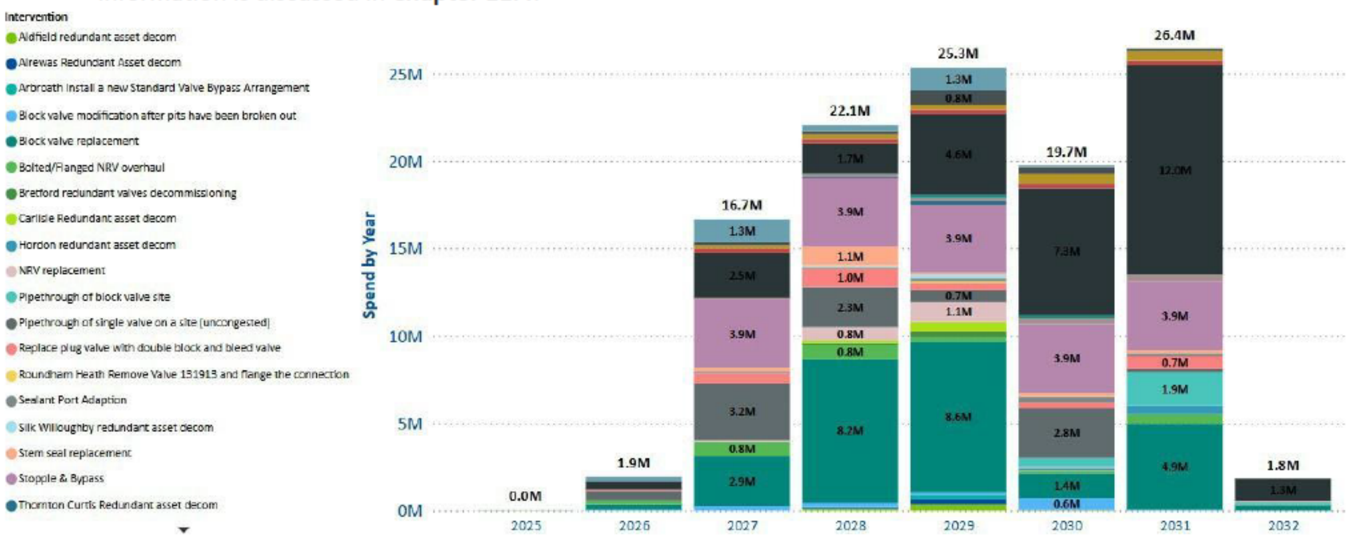
11.1.8 Through the development of our Valves investment plan, we assessed the investment required on our NRVs. For [redacted] we assessed the required interventions using engineering assessment and through our Scope, Volume and Cost (SVC) confidence standard. Due to bespoke nature of welded NRV overhauls, current scopes and estimates are preliminary and need to be refined. They, therefore, did not make it into our baseline submission.

11.1.9 Additional information from [redacted] welded buried NRVs is proposed to be utilised to inform our decision making on these assets at [redacted] and [redacted]. If results from [redacted] show NRV is in suitable condition, this UM may not be required.

11.1.10 **Request:** If required, it is proposed that development of costs and refinement of scopes are included in the first window (**January 2027**) of our annual Asset Health UM, modifying the existing mechanism from RIIO-T2. This UM has a materiality threshold for the submission so smaller asset health projects cannot be included. For more information on this, see **NGT_A01_Asset Management Plan (AMP)_RIIO_GT3**. It is proposed to be licensee triggered.

11.2 Asset Health Spend Profile

11.2.1 The below spend profile provides an indicative view on when the above interventions are to be carried out. More information is discussed in **Chapter 11.4**.



[redacted]

11.3 Investment Risk Discussion

11.3.1 The interventions scopes identified within this EJP are identified and understood. We have delivered similar scopes in RIIO-T2 for valve replacements, vent and sealant line replacements, stem seal replacements, stem seal tightening, sealant port adaption.

11.3.2 Key risks and currently identified mitigations are summarised in Table 32 below.

Table 32: Valves key risk and identified mitigations.

No.	Risk	Mitigation (based on current view)
1	There is a risk of additional site surveys, delaying the project and leading to additional costs.	Try to minimise number of surveys by getting multiple contractors to site for each aspect of works
2	There is a risk of increase to materials prices impacting project launch	Project team to work with Main Works Contractor (MWC) to make sure that materials are procured in a timely manner and multiple quotes for materials from a number of supplies to ensure value for money
3	There is a risk of diluted operational resource support due to a number of concurrent projects running on site	Assessed through our deliverability assessment and shall be monitored through our plan delivery.
4	There is a risk of additional scope requirements (including electrical, design & civil) leading to scope change / scope creep	Close engagement with contractor and site operations, development of standard scopes to capture baseline requirements early in the development process.
5	There is a risk of outage issues (prior, during or post mobilisation)	Assessed through our deliverability assessment and shall be monitored through our plan delivery.
6	There is a risk of policy changes impacting upon project requirements	Close engagement with Safety Engineering to any upcoming specification updates.
7	There is a risk of unavailability / delayed delivery of long lead items, e.g., actuators	Frequent communication with Contractor to ensure that Long Lead Items are ordered,
8	There is a risk of lack of contractor availability	Engagement with the market has been undertaken through our deliverability assessment to understand where constrains may apply and factored into our investment planning.
9	Our costs have been built through unit cost analysis and estimates from the market, however there is a risk that costs of materials may increase due to macro-economic conditions and customer and stakeholder demand	This shall partly be mitigated through the CPI-H inflation and real price effect mechanisms within our RIIO-GT3 regulatory framework

11.4 Project Plan

11.4.1 Project delivery has been split into three phases which align with our Network Development Process (ND500) as shown in Table 33 below. Commissioning dates are not relevant to all intervention types but take place at the end of the delivery phase.

Table 33: Delivery phase alignment with ND500

Delivery Phase	ND500 Stage Gate(s)
Preparation	T0, T1, F1 (Scope establishment), T2, F2 (Option selection), T3, F3 (Conceptual Design Development and Long Lead Items Purchase), T4
Delivery	F4 (Execute Project), T5, Available for Commercial Load (ACL), T6
Close Out	F5 (Reconcile and Close)

11.4.2 The below table shows the summary plan and provisional delivery phases for valves related sanctions within RIIO-GT3. Internal stakeholder engagement has identified when we can obtain network access, where required, to complete these works. It has also identified who will deliver the work between our construction team and National Gas Services (NGS).

Table 34: Valves Portfolio Programme for RIIO-GT3 period

Sanction	RIIO-T2		RIIO-GT3					RIIO-GT4
	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32
T3 Bacton Valves								
T3 Pipelines FY27								
T3 Sites AGI Construction FY27								
T3 Sites AGI Construction FY28								
T3 Sites AGI Construction FY29								
T3 Sites AGI Construction FY30								
T3 Sites AGI Construction FY31								
T3 Sites AGI NGS FY27								
T3 Sites AGI NGS FY28								
T3 Sites AGI NGS FY29								

T3 Sites AGI NGS FY30								
T3 Sites AGI NGS FY31								

11.4.3 Valves and NRVs are assets that have long lead times for delivery and therefore these assets have an extended preparation phase. The work has been profiled based on a deliverability assessment across our whole plan. Valve replacements and interventions that help defective valves seal i.e., sealant port adaptions and vent and sealant line replacements, are prioritised for defective valves involved in PSSR inline inspections (ILI) for pipelines to enable the valves to be able to seal during the ILI run to prevent deferring legislative work.

11.5 Key Business Risks and Opportunities

11.5.1 Changes to system operation or supply and demand scenarios is unlikely to impact upon the proposal in this EJP. Significant changes could mean that particular sites and assets become redundant which would remove the need for some interventions but in general, assets will still need to be maintained until the point at which decommissioning is completed.

11.5.2 Fast tracking of the transition to hydrogen within RIIO-GT3, would mean any pipelines and sites chosen to be repurposed for hydrogen transport, would require maintenance on key assets such as valves before they are repurposed. This would mean any open defects could be remediated earlier than initially phased.

11.6 Outputs included in RIIO-T2 Plans

11.6.1 We have deviated away from our baseline plan as we substitute similar interventions in the plan e.g., RIIO-T2 plan may have had a valve replacement scheduled at site A but may have not been completed at Site A and was completed at Site B. We are overall delivering our LTRB target and value of the workbook submitted is equivalent to our business plan.

- Taking additional time at the start of RIIO-T2 to land on the correct solution for specific interventions has been a key focus and although this does show a backloaded programme, it is substantially clearer in terms of the work scopes to be executed which will result in fewer delivery challenges.
- Outage challenges, access challenges that made it difficult to intervene on valves appropriately.

11.6.2 In developing the revised delivery approach, a programme of works has been devised that is deliverable within the remaining RIIO-T2 period.

12 Appendices

12.1 Appendix 1 – Additional Information on Equipment Summary

Valves and NRVs Description

12.1.1 Valves are installed throughout the NTS to enable effective isolation of sections of the network, limit gas loss in an emergency, manage flow direction, facilitate maintenance, repair, modification, testing and commissioning, and to enable safe and effective start-up and shutdown. There are valves operating in all areas of the NTS which control or isolate gas into, out of and around the pipeline network, plant and equipment.

12.1.2 Valves on the NTS are either mainly ball valves or plug valves. Other minor valve types include gate, butterfly & solenoid valves. Non-Return Valves (NRVs) are installed to ensure gas only flows in the desired direction by preventing reverse flows. The NRVs considered in scope of this EJP are those installed at compressor stations in process pipework systems to stop higher pressure discharge gas flowing to lower pressure suction pipework. They are arranged to suit either series and/or parallel unit operation when multiple machines are run together.

12.1.3 Valves may be manually operated, automatic or remotely controlled depending on the purpose they serve. Unless operated by a lever acting directly on the valve spindle, they are fitted with an operator. The operator may be a manually operated gearbox, a manually operated actuator or a powered actuator. Powered actuators utilise electricity of gas as a means of providing motive power.

12.1.4 Valves fulfil the National Gas operational and legal requirements of the Pipeline Safety Regulations (PSR) and Gas Safety (Management) Regulations (GS(M)R) to provide:

- Effective isolation of sections of the NTS to allow safe working; and
- The ability to safely shutdown and isolate sections of the NTS in the event of an incident.

Valve design

12.1.5 Valves are installed in either flanged or welded configurations:

- Flanged: Mating flanges on the pipework and valve are connected with a bolted arrangement with a gasket, or joint, sandwiched between the flanges.
- Welded: Valve is supplied with short pipe sections pre-welded to the valve body. The ends are then welded to the parent pipe upon installation.

12.1.6 Ball valves can be either welded (like a [redacted]) or bolted (like a [redacted]).

12.1.7 Bolted body valves can be dismantled but have to be removed from the line, taken to a workshop to be dismantled and condition assessed.

12.1.8 All maintenance work on valves must therefore be undertaken externally to the main valve body. Large diameter ball valves are equipped with auxiliary connections which allow the seals to be flushed to remove debris with Original Equipment Manufacturer (OEM) recommend lubricants or other specialist sealants as an enhanced maintenance option.

12.1.9 Typical configuration of a ball valve assembly is provided in Figure 9. This shows all the main elements of a valve.

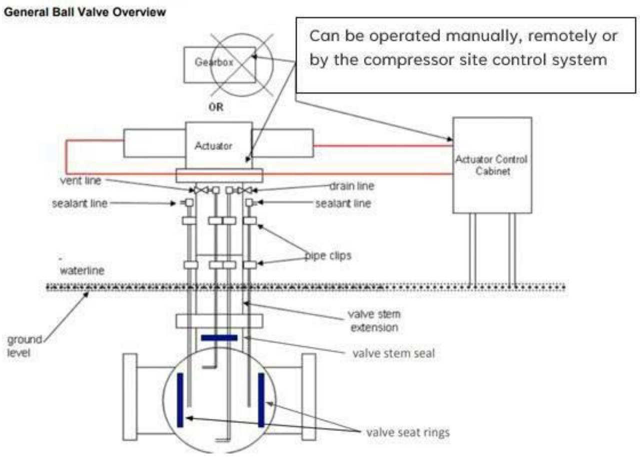


Figure 9: Configuration of a ball valve assembly

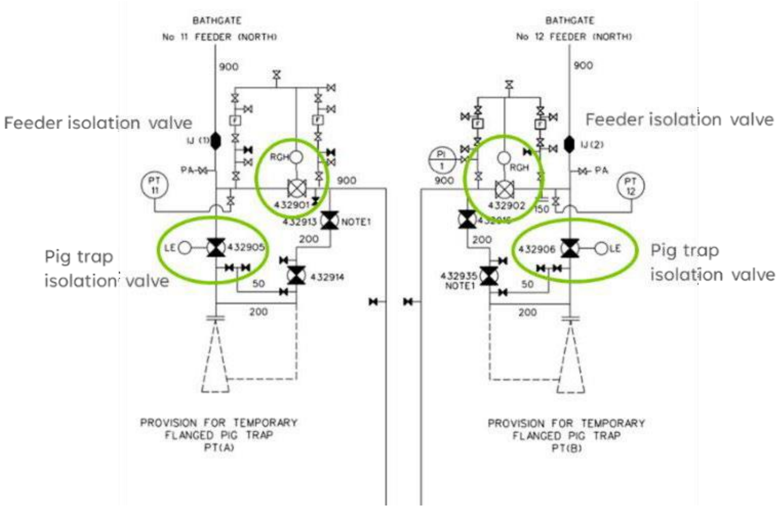
Functions of valves

12.1.10 Our valve assets have a range of functions including, not exhaustive:

- PIG trap isolation valves
- Feeder isolation valves
- Compressor unit valves
- NRVs
- Compressor station inlet and outlet valves
- Filter isolation valves
- Block valves

12.1.11 PIG (Pipeline Inspection Gauge) trap isolation valves: PIGs are used to inspect pipelines to ensure integrity and they are launched from pressurised vessels known as PIG traps either side of the pipeline. PIG trap isolation valves provide facility for safe isolation of PIG trap during in-line inspections of the pipeline. They facilitate loading of PIGs into the PIG trap at the start of the inspection and unloading of PIGs at the end of the inspection. PIG trap isolation valves are also used to isolate the PIG traps for PSSR inspections.

12.1.12 Feeder isolation valves & Block valves: Feeders are another name for pipelines. Feeder isolation & block valves enable a site or pipeline to be isolated in the event of an emergency or planned operation. They also ensure any affected section of feeder can be isolated and made safe in a timely manner in the event of an incident. Block valve sites are located throughout the NTS and typically have a configuration of six valves (1 ball and 5 plug valves). Feeder isolation valves are ball valves present on large Above Ground Installations (AGIs) such as Multijunctions. Figure 10 below shows the PIG trap isolation and feeder isolation valves present at a Multijunction.



[redacted]

Block valve site arrangement

12.1.13 A block valve site arrangement typically contains 3 ball valves (1 mainline valve and 2 bridle valves and 3 or more plug valves on the bridle pipework). Figure 11 shows the site arrangement of [redacted] Block Valve site. In this example, all valves are in pits.

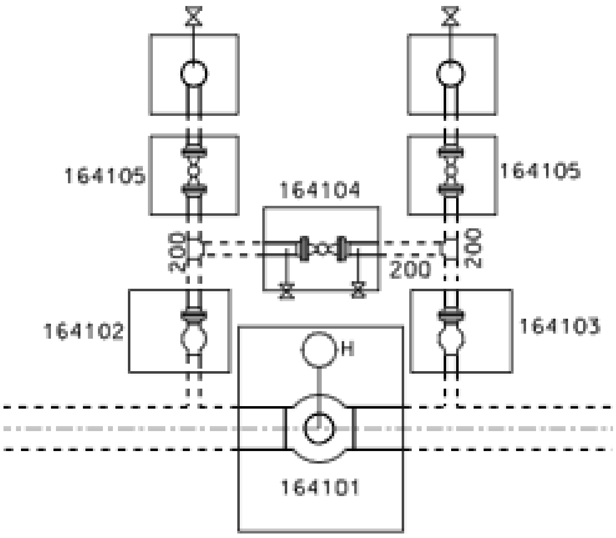
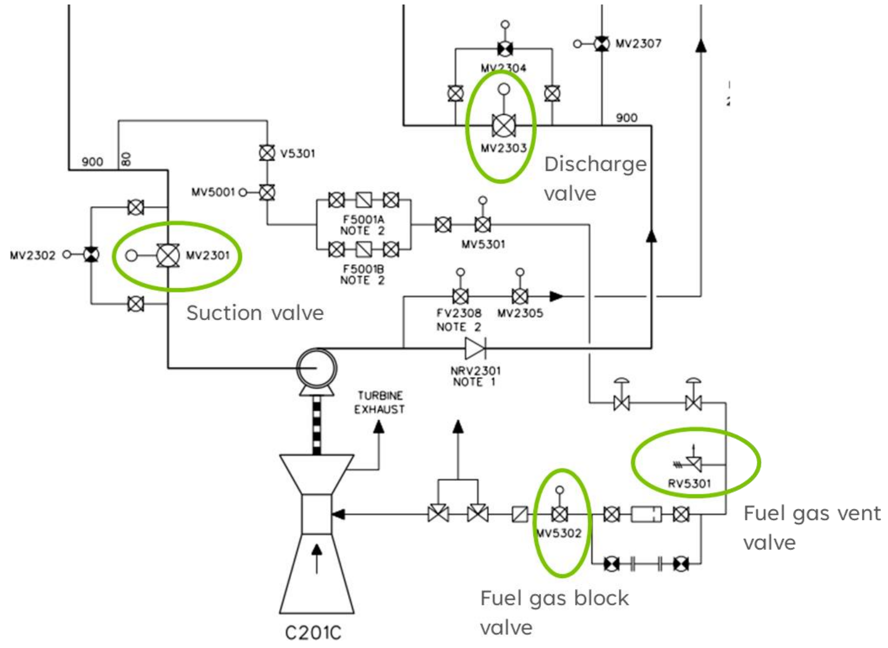


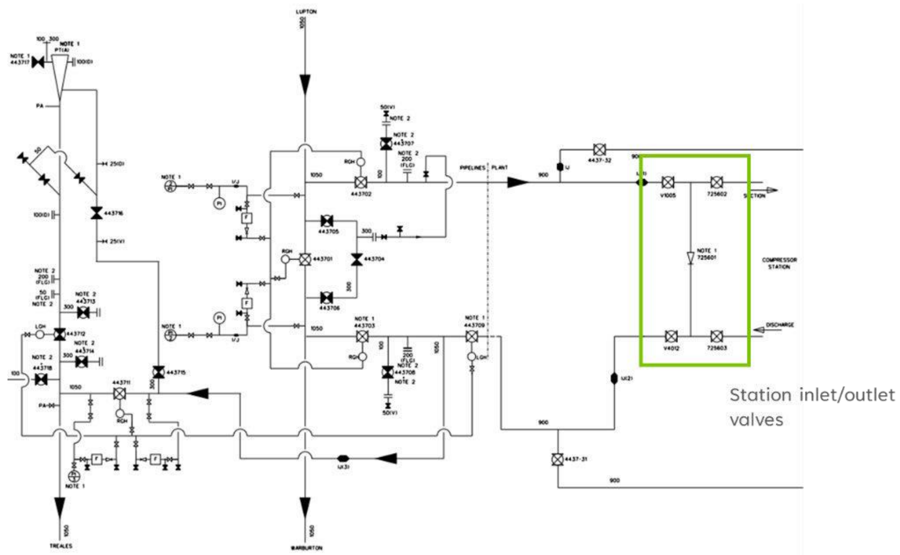
Figure 11: [redacted] block valve showing all valves in pits.

12.1.14 Compressor unit valves: These valves enable a compressor unit to be isolated when not running, or in the event of an emergency or for routine maintenance activities. They ensure any affected compressor can be isolated in a timely manner in the event of an incident. Valves included are unit suction valve (valve on the inlet of the compressor), unit discharge valve (valve on the outlet of the compressor), fuel gas block and vent valves. See Figure 12 below.



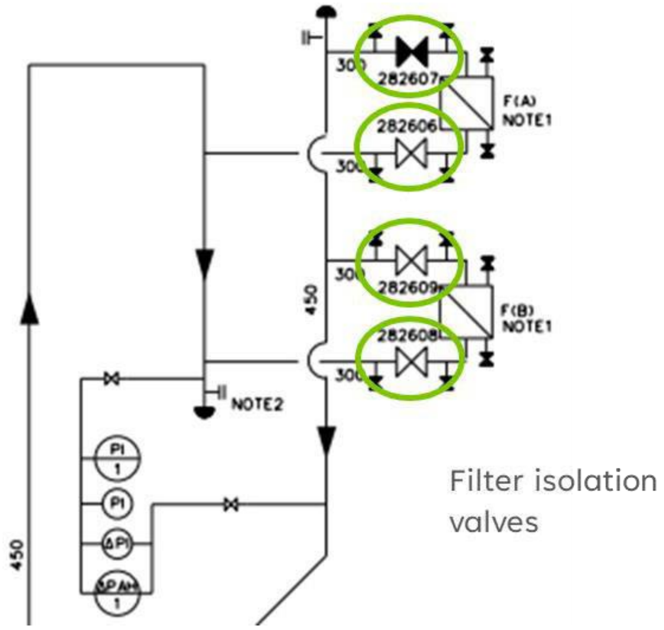
[redacted]

12.1.15 Compressor station inlet & outlet valves (including valves on above ground installation): These valves enable a compressor station/installation to be isolated when not being used, or in the event of an emergency or for routine maintenance activities. They also ensure any compressor station/installation can be isolated and made safe in a timely manner in the event of an incident. They are located at compressor stations and installations which connect the compressor station to the NTS. See Figure 13 below.



[redacted]

12.1.16 Filter isolation valves: Filters are present to remove any debris or particles present in the gas to prevent them affecting downstream equipment. They are present on compressor stations and offtakes. These filters are pressurised and are subject to statutory inspections under PSSR. Filter isolations valves are present to ensure safe isolation for maintenance as well as facilitate changing of contaminated filter elements. They are often plug valves. See Figure 14 below.



[redacted]

Ball valve/ Plug valve

12.1.17 Ball valves allow full bore access of the pipeline (i.e., there is no restriction between valve and pipeline when valve is fully open) but can only be operated with differential pressures across the valve lower than 3.5 barg, unless seals will be damaged. Ball valves when closed can have their cavities vented to provide a double block and bleed isolation. A double block and bleed is the minimum standard isolation required for maintenance.

12.1.18 Plug valves can be operated with any differential pressure across the valve but do not allow full bore flow as there is some restriction between valve and pipeline even when pipe is fully open. Closing individual plug valves will not give a full double block and bleed. To achieve that, two adjacent plug valves will need to be closed and the section between them will be vented. See Figure 15 below for images of ball and plug valves.

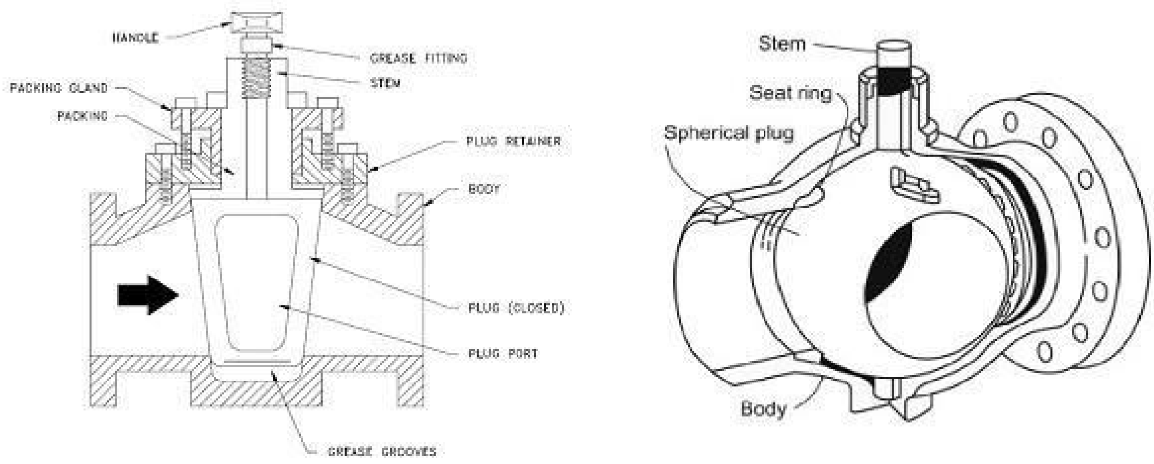


Figure 15: Plug valve (left image) and ball valve (right image) components.

State of valve

12.1.19 Wholly above ground: In this instance, the valve and operator will always be above ground.

12.1.20 In a pit: Valve is in the pit and the operator may be in the pit or extended above it.

12.1.21 Below ground: Valve is buried below ground level. The operator will always be extended above ground unless no operator is fitted. A high proportion of valves (along with the associated pipework) are buried at depths ranging typically between 0.8 and 4.5m to the crown of the pipe.

Criticality of valve

12.1.22 Critical valve

- All remote operated valves, with the following exception – remote operated valves currently not required to operate but may be needed for future applications.
- All valves which are required to isolate sections of pipe or plant to allow continued supply to customers, e.g., at a pipeline spur with a valve bridle arrangement.
- Note – Certain block valves may be re-classified as non-critical, provided an appropriate risk assessment is carried out.
- All off-take main isolation valves
- Station inlet and bypass valves for major installations (i.e., terminals, multi-junctions and compressors)
- In-line block valves for which the sole purpose is isolation of sections of pipeline that contain a specific risk area (e.g., major river crossings)

12.1.23 Non-Critical Valve

- 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.
- In-line block valves for which the sole purpose is isolation of a specific section of pipeline that contains no other equipment or specific risk area
- PIG trap isolation valves which serve no further isolation purpose
- Valves which are currently not in use but may be required for future applications.
- Valves which are only required for isolation of plant for routine maintenance.
- Any other valve defined as non-critical by the Responsible Engineering Manager.

12.1.24 Maint/5 is the 'parent' document for Critical (and non-Critical) valves and describes the maintenance scheduling requirements for these items. See Figure 16 below:

Valves & Actuators

All valves as defined in Section 3 are to be maintained in accordance with Section 8.5 and in line with the frequencies shown in the table below. Frequency optimisation can be approved locally to allow frequencies to coincide where this is deemed to create efficiencies. This applies to the increase of frequencies only and shall not apply to the reduction of frequencies. In such cases an authorised deviation shall be required.

Valve Category	Function Check (excluding seal check)	Seal Check	Major Overhaul	Maintenance Examinations
Critical (all)	1 year	2 years	As determined by functional check	6 years maximum
Non critical (with actuator)	2 years	2 years	As determined by functional check	6 years maximum
Non critical (without actuator)	3 years	3 years	As determined by functional check	6 years maximum
Redundant	2 years (atmosphere check only)		Not Required	Not Required
Ancillary (small bore valves)	2 years		As determined by functional check	6 years maximum

Figure 16: Extract from Maint/5

12.2 Appendix 2 – Legislation Affecting Valves

12.2.1 PSSR legislation: PSSR is concerned with the mechanical integrity of the pressure system. 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. As equipment ages and its condition deteriorates, it is to be expected that additional repair or replacement may be required.

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

12.2.3 GS(M)R places a duty on us to comply with safety case for the system. The safety case covers how to operate the whole system and will talk about safe isolation and shutdown system and will talk about safe isolation and shutdown systems placing o reliance on the valves to be fully functional when needed.

12.3 Appendix 3 – [redacted] NRV Maintenance as per OEM Guidance and Internal Policy

12.3.1 The intrusive overhaul requirements for NRVs are defined in Maint/6 Appendix F which, for [redacted] NRVs sets the frequency of overhaul 'every 25 years'. These are shown in Figure 17 and Figure 18 below.

Table 4 – Mechanical

Asset Description	MAINTENANCE CATEGORIES			
	Visual (Non-Intrusive Inspection)	**Functional**	**Test/Calibrate**	**Overhaul (Intrusive)**
Process Compressed Air System	3-Monthly/2000 Hours • Equipment Integrity [T/PR/MAINT/6036/B] • Vessels [T/PL/PS/4] [T/PR/MAINT/6036/B] • RF2 Restrictor [T/PR/MAINT/6036/B] 6-Monthly/4000 Hours • Coolers [T/PR/MAINT/6036/A] • Condensers [T/PR/MAINT/6036/A]	6-Monthly/4000 Hours • Safety Valve [T/PR/MAINT/6036/A] • LED/Display [T/PR/MAINT/6036/A] 1-Yearly • Small bore installations [T/PR/MAINT/2305]		3-Monthly/2000 Hours • Felt Disk [T/PR/MAINT/6036/B] 6-Monthly/4000 Hours • Air Filter [T/PR/MAINT/6036/C] • Motor Bearings [T/PR/MAINT/6036/C] 2-Yearly/8000 Hours • Oil/Air Seperator [T/PR/MAINT/6036/D] 24000 Hours • Service Head [T/PR/MAINT/6036/E]
Process Pipework System Includes the following process pipework systems - Suction - Discharge - Recycle - Bypass - Terminal	1-Yearly (Non-return Valves) • Equipment Integrity [T/PR/MAINT/6037/A] 1-Yearly (Process Pipework) • Equipment Integrity [T/PR/MAINT/6037/A 6-Yearly • Above Ground Pipe work [T/PR/MAINT/6037/D] • Non-return Valves [T/PR/MAINT/6037/D] • Unit Inline Filters [T/PR/MAINT/6037/D] • Strainer [T/PR/MAINT/6037/D] • Terminal Incomer Filters [TPR/MAINT/6037]	1-Yearly • Non-return Valves [T/PR/MAINT/6037/A] • Critical valve [T/PR/MAINT/6037/A] • Terminal Incomer Filters [T/PR/MAINT/2303] • Small bore installations [T/PR/MAINT/2305] • Flow control valves [T/PR/MAINT/2304] 2-Yearly • Non-critical valve [T/PR/MAINT/6037/B]		2-Yearly • Terminal Incomer Filters [T/PR/MAINT/2311] • Non-return Valves [T/PR/MAINT/6037C] * See Appendix F On-Condition • Above Ground Pi pework [T/PR/MAINT/6037/B] • Valve [T/PR/MAINT /6037/B] • Small bore installatons [T/PR/MAINT/2305] • Flow control valves

[redacted]

APPENDIX F, Non-Return Valve Overhaul Maintenance.

Types	1st Maintenance	Subsequent	Work Procedure
Frank Wheatley	4000 valve operations or 15 years whichever sooner.	500 valve operations or 15 years whichever sooner	T/PR/MAINT/6037/C
Petrol	200 valve operations or 8 years whichever sooner.	200 valve operations or 8 years whichever sooner.	T/PR/MAINT/6037/C
Cort Goodwin	3,400 valve operations or 15 years whichever sooner.	3,400 valve operations or 15 years whichever sooner.	T/PR/MAINT/6037/C
Mission	2000 valve operations or 10 years whichever sooner.	1000 valve operations or 10 years whichever sooner.	T/PR/MAINT/6037/C
Mokveld	25 years	25 years	T/PR/MAINT/6037/C
Stockham Noz- Check	25 years	25 years	T/PR/MAINT/6037/C

[redacted]

12.3.2 Sub-procedure Maint/6037C defines the 'what' to do. It states the overhaul requirements to be: "Overhaul in line with the Manufacturer's instructions / guidelines".

nationalgrid **T/PR/MAINT/6037/C**

May 2018

WORK PROCEDURE FOR PROCESS PIPEWORK SYSTEMS

6. METHOD OF WORKING

Reference shall be made to the maintenance manuals referenced in Section 3 of this procedure.

6.1 Overhaul (Intrusive) Maintenance

Frank Wheatley, Petrol, Cort Goodwin, Mission long & short bodied Non-Return Valves

a) Carry out NDT to the following areas:
- Hinge Pins
- Hinge pin arms including disc connections
- Disc seal faces
- Stationary seats (within valve body)

b) Replace all soft seats/seals.

c) Overhaul Non-Return Valves in line with Manufacturer's instructions/guidelines.

All other Non-Return Valves (Mokveld, Stockham Noz-Check, Other)

a) Overhaul Non-Return Valves in line with Manufacturer's instructions/guidelines.

[redacted]

12.3.3 Manufacturer's literature related to [redacted] check valves has been reviewed, extracts are shown below. No guidance was found in the current OEM literature upon which to base an overhaul scope.

[redacted]

12.4 Appendix 4 – Valves Intervention Development

12.4.1 Please see Figure 21 below that describes the development of valves interventions and options.

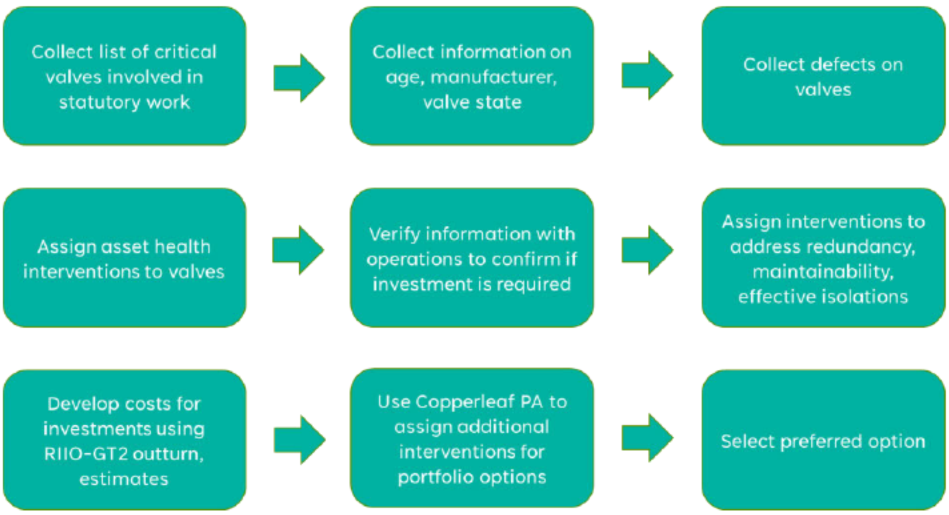


Figure 21: Methodology for development of valve investments.

12.4.2 Table 35 below shows methodology in assigning asset health interventions based on a combination of defects, valve criticality, valve accessibility, manufacturer, requirement for statutory inspections. The main evaluation criterion is defects, but all other factors contribute to assigning interventions.

Table 35: Methodology for assigning interventions to deal with defective / leaking valves.

State	Known defect	Next planned PSSR inspection	Intervention
Above ground /Pits	no sealant point or have partial sealant points	in or later than 28/29	sealant port adaption
	body cavity/ body vent passing/ gas leaking	in or later than 28/29	valve replacement
	no grease points	in or later than 28/29	sealant port adaption
	sealant line button head fittings corroded or damaged	in or later than 28/29	sealant port adaption
	doesn't seal, no sealant ports	in or later than 28/29	sealant port adaption
	valve defective but enhanced maintenance unsuccessful	in or later than 28/29	(Do nothing, ops to try further enhanced maintenance)
	Enhanced maintenance has been attempted but unsuccessful	Anytime	valve replacement
	has damaged vent and sealant lines but valve has no sealing issues	in or later than 28/29	Vent & sealant line replacement
	Any defect on stem, vent & sealant lines, valve passing	in 27/28	valve replacement
	Minor stem seal leaks	Anytime	Tighten/adjust stem seal
	Compression fittings present on vent & sealant lines.	Anytime	Vent & sealant line replacement
	leaking from stem considerably but valve sealing adequately	Anytime	Stem seal replacement
Below ground	[redacted] valve, no sealant points or grease points but seals fine	in or later than 28/29	sealant port adaption
	Valve doesn't seal	in or later than 28/29	valve replacement
	[redacted], doesn't have sealant points, grease points or vent points	in or later than 28/29	valve replacement
	cavity doesn't blow down properly	in or later than 28/29	valve replacement
	Any defect on stem, vent & sealant lines, valve passing	in 27/28	valve replacement
	if vent and sealant line has a problem but valve seals	in or later than 28/29	Vent and sealant line replacement
Filter isolation valves	If valve is a plug valve	Anytime	Replace with DBB valve
Filter isolation valves	If valve is a ball valve	Anytime	Do nothing

12.5 Appendix 5 – Block Valve Replacement Justification

12.5.1 Below is the justification for replacing the entire block valve instead of attempting to replace one or more valves on the arrangement.

12.5.2 Option 1. Cut out and remove failed block valve. Reuse existing Bridle.

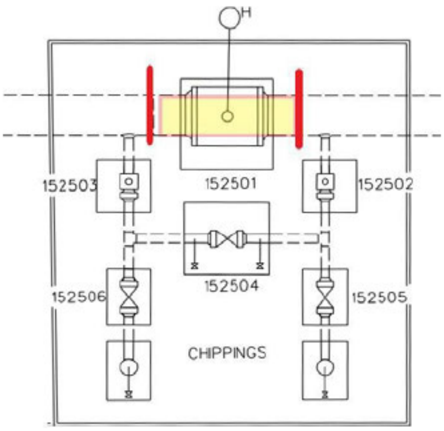


Figure 22: Block valve defect remediation Option 1

12.5.3 Option 2. Cut out and remove failed Block valve. Replace existing Bridle.

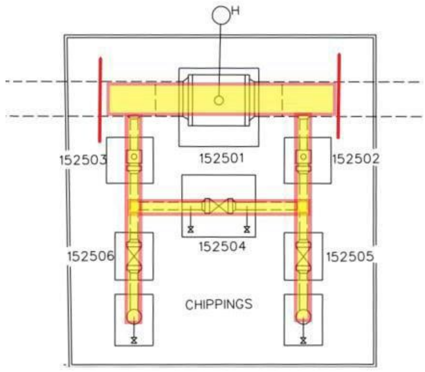


Figure 23: Block valve defect remediation Option 2

12.5.4 Option 1 introduces a number of risks:

- Risk 1. Excavation [Orange box] to expose valve encroaches on pits for bridle valves [pale green]

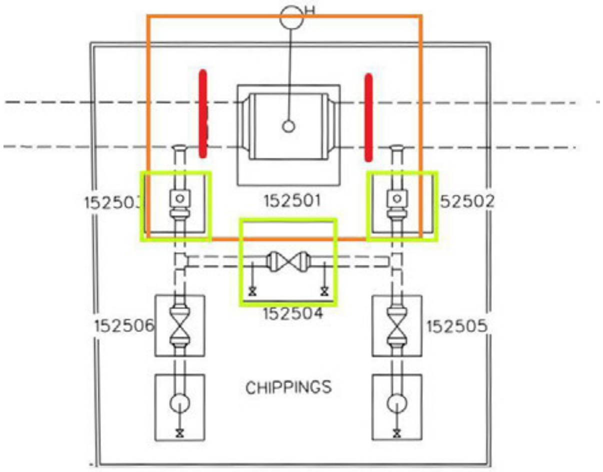


Figure 24: Excavation encroaching on pits for bridle valves.

- Subsequent excavations to remove [to make safe] encroaches onto bridle vent line valves [Dark green]. The subsequent excavations to make those pits safe encroaches onto the remaining pits.

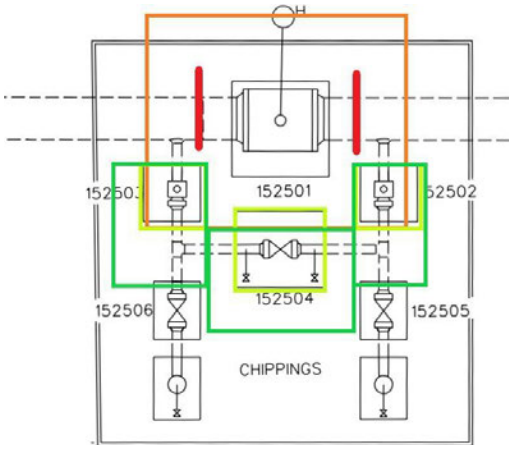


Figure 25: Excavations encroaching on bridle vent lines.

12.5.5 It will not be feasible to reinstate those pits on a like for like basis as the confined nature of the pits means that they will not pass Safe Working Design Study [SWDS].

12.5.6 As suitable solution will need to be found. The options here are;

- New pit(s) designed to pass SWDS. As not all sites are exactly the same this has to potential to be bespoke to individual sites.
- Burying of the valves with stem extensions to bring the valve operators above ground.

12.5.7 Risk 2. Cut lines [red] potentially encroach into heat affected zones related to the original construction of the bridle tees [orange stars].

- In this event the tees for the bridle will need to be cut out and be replaced [see shaded yellow areas.]

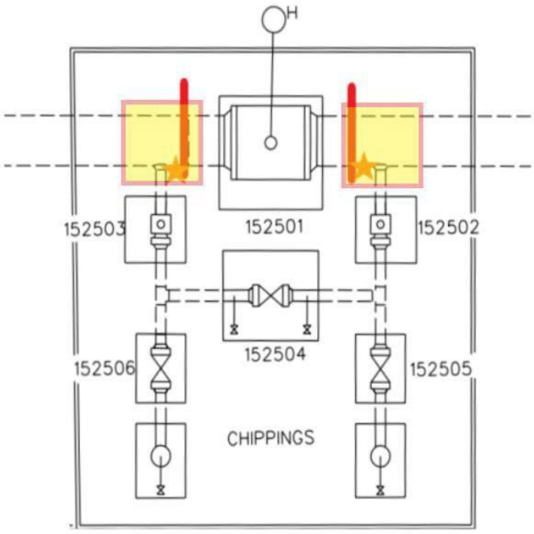


Figure 26: Excavation encroaching on heat affected zones of the block valve.

12.5.8 As the presence of heat affected zones cannot be completely ascertained until the pipework is exposed tees will need to be procured as a contingency.

12.5.9 This approach potentially increases the number of 'golden welds' [If a weld on pressure equipment cannot be subjected to a pressure test (hydrostatic or pneumatic) even though the pressure equipment design code requires it, it is called a "Golden Weld."]

12.5.10 The preferred, least complex, approach is to cut outboard of the tees removing all equipment shaded yellow, replacing with all new. The bridle valves will be fitted with stem extensions to bring the valve operators above ground. All pipework is buried on completion.

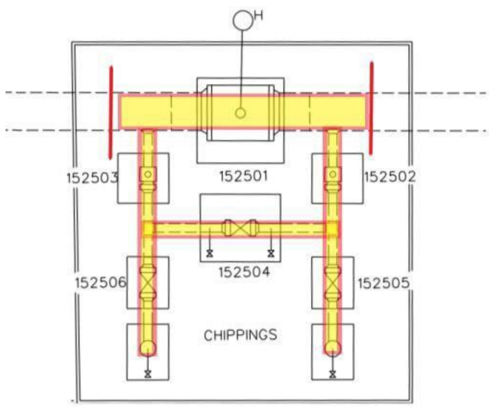


Figure 27: Preferred option for block valve remediation

12.5.11 This approach has a number of advantages.

- Designs for the replacement block valve and bridle can be made repeatable.

- Pits are removed, this removed future OPEX cost as confined space entry requirements do not need to be met. [e.g., 2 man working vs 3 man working]
- The assembly can be pressure tested off-site, meaning number of 'golden welds' is minimised.

12.6 Appendix 6 – Valve Interventions Cost Breakdown.

12.6.1 Please see table below for valve interventions cost breakdowns.

Table 36: Cost breakdown for valve interventions.

Intervention Name	External Cost	External %	NG Cost	NG %	Pre build Cost	Pre build %	Materials, Plant & Equipment cost	Materials, Plant & Equipment %	Risk & Contingency cost	Risk & Contingency (% of total cost)	RIIO-GT3 Unit cost (2023/24)
Bolted/Flanged NRV overhaul	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Welded/Buried NRV Overhauls	N/A - UM										[redacted]
NRV replacement	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted] and flange the connection	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted] Install a new Standard Valve Bypass Arrangement	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Valve Replacement	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Valve Overhaul	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Stem seal replacement	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Tighten/ Adjust Stem Seals	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Sealant Port Adaption	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Vent & sealant line replacement	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Replace plug valve with double block and bleed valve	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Pipethrough of block valve site	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted] redundantasset decom	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted] redundantasset decom	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted] Redundant Asset decom	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted] Redundantasset decom	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted] Redundantasset decom	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Pipethrough of single valve on a site (uncongested)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Stopple & Bypass	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted] redundantasset decom	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Valve strip and condition assessment	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Valve spares	N/A - Quote										[redacted]
Bretford redundant valves decommissioning	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Block valve replacement	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Block valve modification after pits have been broken out	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

12.7 Appendix 7 – Bottom-up Interventions Considered in Every Option except 1A.

12.7.1 Table 37 below shows the bottom-up interventions in every CBA option considered except Option 1A.

Table 37: Bottom-up Intervention Volumes and Value

Intervention	Total Volume in RIIO-GT3	Total Spend in RIIO-GT3 (£m, 2023/24)
Bolted/Flanged NRV overhaul	[redacted]	2.86
Welded/Buried NRV Overhauls	[redacted]	3.32
NRV replacement	[redacted]	2.08
Replace Regulator Stream (Single)	[redacted]	32.09
Replace FCV Stream (Single)	[redacted]	13.84
Fuel Gas/Domestic Gas Supply Pressure Regulator Skid Replacement	[redacted]	2.51
Replacement of Multistage Pressure Reduction Skid	[redacted]	3.86
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.26
Replace Regulator Stream PCV/FCV (Single)	[redacted]	4.20
[redacted] Redundant Asset Decom	[redacted]	0.18
[redacted] Redundant Asset Decom	[redacted]	0.21
[redacted] Redundant Asset Decom	[redacted]	0.77
Actuator Control Replacement	[redacted]	3.62
Actuator Replacement	[redacted]	19.43
Actuator Overhaul	[redacted]	0.15
Valve Replacement	[redacted]	28.95
Valve Overhaul	[redacted]	0.41
Stem seal replacement	[redacted]	1.83
Tighten/ Adjust Stem Seals	[redacted]	1.16
Sealant Port Adaption	[redacted]	0.87
Vent & sealant line replacement	[redacted]	1.71
Replace plug valve with double block and bleed valve	[redacted]	3.16
Pipethrough of block valve site	[redacted]	1.03
Pipethrough of single valve on a site (uncongested)	[redacted]	9.76
Valve strip and condition assessment	[redacted]	1.82
Valve spares	[redacted]	1.36

Block Valve Replacement	[redacted]	49.21
Block Valve modification after pits have been broken out	[redacted]	2.10
Stopple & Bypass	[redacted]	19.55
Overpressure protection study and replacement of relief valve	[redacted]	5.94
HIPPS FEED Study	[redacted]	1.78
Installation of Terminal HIPPS	[redacted]	11.60
Removal of Valve 13 and flanging at Roudham Heath	[redacted]	0.14
Installing a new standard Valve Bypass Arrangement at Arbroath	[redacted]	0.31
Silk Willoughby Redundant Asset Decom	[redacted]	0.32
Aldfield Redundant Asset Decom	[redacted]	0.46
Alrewas Redundant Asset Decom	[redacted]	0.43
Carlisle Redundant Asset Decom	[redacted]	0.75
Thornton Curtis Redundant Asset Decom	[redacted]	0.30
Horndon Redundant Asset Decom	[redacted]	0.66
Bretford Redundant Asset Decom	[redacted]	0.40
Install bypass pipework	[redacted]	18.46
Modify bypass pipework	[redacted]	59.46
Total	**2535**	**313.26**