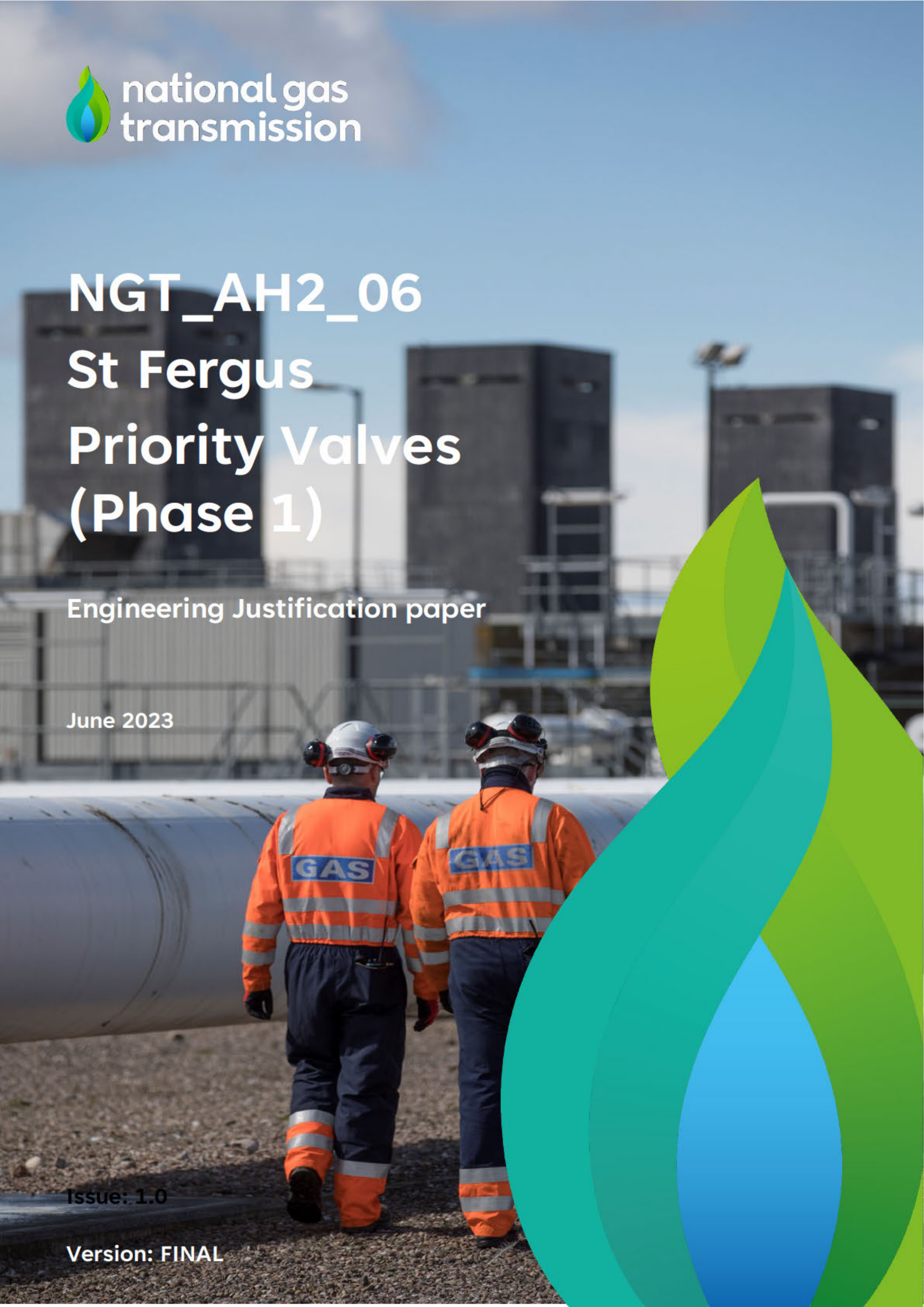

national gas transmission

NGT_AH2_06 St Fergus Priority Valves (Phase 1)

Engineering Justification paper

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Executive summary

1. National Gas Transmission, (hereafter referred to as 'NGT'), are submitting the needs case and funding request in accordance with the RIIO-T2 Engineering Justification Paper Guidance v2 document. The purpose of this stage of the process is to justify the project need, set out the different options considered along with the preferred strategic options, and request funding for the preferred option justified within this paper.

2. This EJP details the investment for the replacement of [redacted] defected valves at the St Fergus Gas Terminal over the RIIO-T2 regulatory period covering 2024 to 2026.

3. This is part of a suite of documents, shown in Figure 1, and should particularly be read in conjunction with the St Fergus Site Strategy and its appendices. The St Fergus Site Strategy describes the gas terminal's function, its criticality to the network and the proposed investments in line with the site strategy.

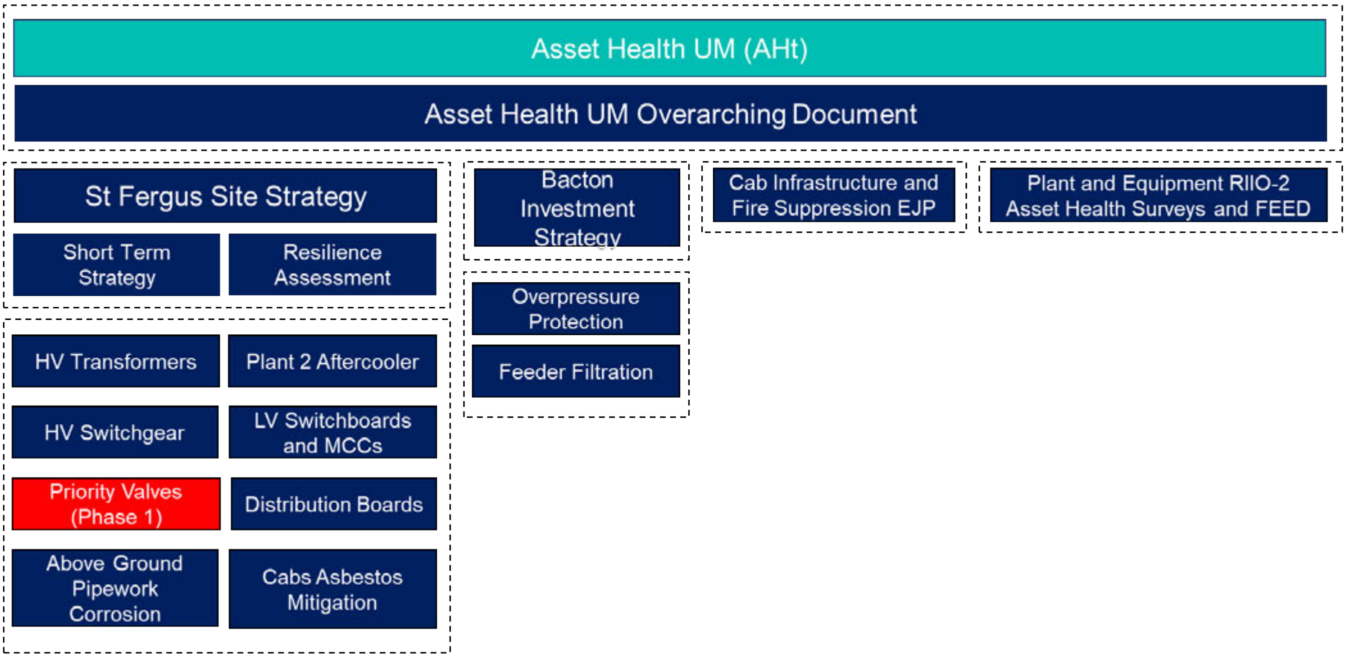


Figure 1: St Fergus Submission Documents Structure

4. The St Fergus Gas Terminal handles between 25% and 50% of the UK's gas supplies, dependent on supply and demand patterns. The site has been in continuous operation for over 45 years and is now moving beyond the design life of the critical original assets. The site is one of two upper tier COMAH sites on our network and as such is a major accident hazard site, subject to regular HSE and SEPA inspections and significant health, safety, and environmental legislation.

5. Like most assets on the terminal, most of the valves are operating beyond their design life (30 years) and are deteriorating due to age and wear. This has resulted in a growing number of condition related defects and issues that impact the functionality and operability of the valves

6. Planned maintenance works on the terminal that rely on availability of isolations are impacted by the reduced functionality of valves as many valves cannot achieve the seal required to fulfil their primary function of effective isolation.
7. Site inspections have identified a total of [redacted] valves that cannot provide effective isolation as they allow gas to pass when closed. It is noteworthy that a significant number of these valves are located underground and are welded onto pipework.
8. Furthermore, addressing the maintenance or repair of these valves has proven to be a challenging task for site operations. There is a notable risk that despite undertaking costly measures to gain access to the valves, they may still fail to function as intended (discussed in examples of the problem section).
9. Failure to provide safe isolations will not only create a safety risk but also lead to non-compliance of various regulations and standards set out by Health and Safety Executive (HSE) such as the Pipeline Safety Regulations (PSR) and Gas Safety (Management) Regulations (GS(M)R).
10. There are environmental impacts associated with the valve condition which leads to larger volumes of gas being vented to the atmosphere. Where isolation is required to carry out intrusive remediation activities on our systems, critical isolation valves are required to enable the works.
11. In circumstances where these valves are not sealing, isolation boundaries must be extended to a point where a successful valve seal can be gained. This increases the inventory of gas in the section that is then isolated to be vented.
12. The St Fergus Short-Term Strategy confirms the requirement for the replacement of defected valves for the terminal to remain operational until 2030. This is because of their impact on the functional safety and security of supply of the terminal should the valves fail to function when required.
13. The RIIO-T2 business plan included all work associated with Plant 1 and Plant 2 under the Emissions Uncertainty Mechanism as the uncertainty about the future solution affected all those assets. With a clear understanding of the required plants and units until 2050, it is now pertinent to invest in the identified priority valves.
14. NGT is submitting this investment proposal in the June 2023 asset health submission window as funding is needed immediately to ensure safe and continued operation of the site in the short-term out to 2030.
15. To address the risks and challenges brought about by operating with defected valves, the following options were assessed:
    - Do nothing
    - Repair valves on failure
    - Refurbish failed valves
    - Replace failed valves

16. The replacement of [redacted] valves was deemed to be the most feasible and deliverable solution within this regulatory period. The [redacted] valves were prioritised based on their safety impact on system processes and deliverability during planned maintenance outages within this regulatory period. This also allows for isolation in areas of site for future works making delivery of the remaining valves more efficient.

17. A separate funding request for the remaining [redacted] valves will be submitted for the next regulatory period.

18. The indicative cost of this investment is [redacted] (18/19 price base). The estimated RIIO-T2 cost profile is shown in Table 1. This project is at Stage 4.2 in the ND500 process: Option Selection. Therefore, the cost accuracy is estimated at +30% /-15% in accordance with the Infrastructure and Projects Authority (IPA) cost estimating guidance for current and planned works to replace [redacted] valves.

Table 1 Current estimated RIIO-T2 spend profile

£m 18/19	FY2023	FY2024	FY2025	FY2026	FY2027	Total	Comments
Priority valves phase 1 (£m)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	

19. NGT are making this funding application for the priority valve replacement Programme RIIO-T2 investment costs through the Asset Health Re-opener, in line with Special Condition 3.14, requesting an adjustment to the value of the NARMAHOt term for costs incurred in RIIO-T2.

20. This is summarised, along with other investments, within section 4 of the Asset Health Overarching Document provided as NGT_AH2_06 of the January 2023 Asset Health Re-opener Submission

Introduction

21. This paper provides the justification required for the replacement of valves at the St. Fergus Gas Terminal.

20. In developing our investment programmes at the St Fergus Gas Terminal since the RIIO-T2 Final Determinations, we have adopted a two-phase strategy to ensure clarity between short-term asset health and long-term site operating strategy.

21. Our St Fergus Short-Term Strategy provides certainty on the terminal operation requirements, including minimum compression across Plant 1 and 2, for operation out to 2030. The long-term strategy will deliver the enduring terminal solution, including compression, required for operation beyond 2030.

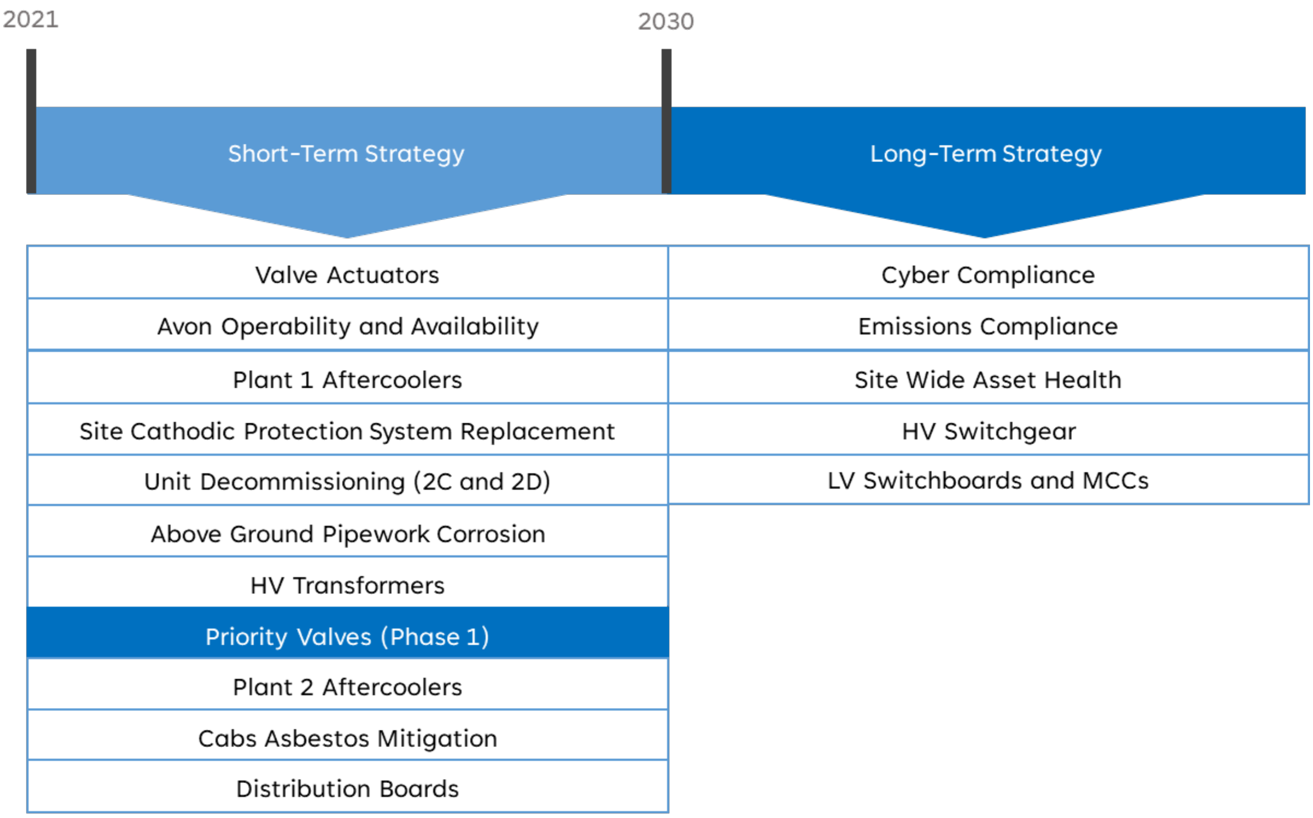


Figure 2 St Fergus Site Strategies Summary

22. The St Fergus Short-Term Strategy supports the decision to rationalise the compression units across Plant 1 and 2 to four Avon units (1A, 1B, 1D and 2B) and maintain these in operation to at least 2030. That recommendation is fundamental to the proposals in this paper; therefore, it is important that these two documents are considered in parallel.

23. The site which has been in continuous operation for over 40 years handles between 25% and 50% of the United Kingdom's gas supplies. Valves on the terminal play a critical role in ensuring the terminal continues to operate safely and reliably by:

- Providing safe isolations in an area. This is particularly important at St. Fergus given the saliferous environment which necessitates the need for continual corrosion defect remediation that requires an isolated area to facilitate the work.
- Providing additional safety of equipment either upstream or downstream from them. It is critical that equipment is protected in the event of a failure to ensure security of supply.
- Regulating flow and direction of gas to where it is required, allowing for efficient operation of the terminal.

24. Like most assets on the terminal, the majority of the valves are operating beyond their design life (around 30 years) and are deteriorating due to age and wear. This has resulted in a growing number of condition related defects and issues that impact the functionality and operability of the valves.
25. Planned maintenance works on the terminal that rely on availability of isolations are impacted by the reduced functionality of valves as many valves cannot achieve the seal required to fulfil their primary function of effective isolation. Reasons for this include leakage through the valve seats due to wear and tear caused over the lifetime of the valve, debris build up on the valve stops, failure of individual components and inability to lubricate valve seals and components.
26. Failure to provide safe isolations will not only create a safety risk but also lead to non-compliance of various regulations and standards set out by Health and Safety Executive (HSE) such as the Pipeline Safety Regulations (PSR) and Gas Safety (Management) Regulations (GS(M)R).
27. Maintenance or repair of the valves has also been a challenge for site operations as the condition of the valves are now at a point where maintenance/repairs are no longer proving to be successful. This leads to inefficiencies in project planning and delivery as works requiring outages cannot be bundled resulting in a requirement for more outages.
28. It is evident that immediate intervention on defected valves is required not only to ensure the safe and continual operation of the terminal but to meet our regulatory obligations.
29. This paper highlights the applicable challenges and risks associated with the valves and discusses potential options towards addressing them with the aim of developing an optimal solution that is in line with the terminal's short and long-term strategy.

Equipment Summary

30. There are over [redacted] valves with diameters ranging from 1" to 36" installed on the terminal, they are defined by their key purposes as follows:

- **Locally Actuated Valves (LAV) -** enable pipework section to be isolated by means of local operation in the event of an emergency or planned operation.
- **Remote Isolation Valves (RIV) -** enable pipework section to be isolated remotely by Gas National Control Centre (GNCC) in the event of an emergency or planned operation. These valves need to be reliable to ensure they will operate in the event of an emergency and enable NGT to meet legislative, regulatory, and commercial obligations.
- **Process Valves (PV) -** allow isolation of a site or section of site pipework by the site, station, or unit control system as part of normal site operations. These valve assets have a direct impact on the site reliability, availability, maintainability, and safety.
- **Non-Return Valves (NRV) -** ensure process gas flows in the desired direction whilst preventing reverse flow and segregating pressure between systems. NRVs are used for flow direction control and on the main station by-pass to control station discharge flow when on-line, allowing flow in the desired direction only. NRVs are also positioned to suit either series and/or parallel unit operation when multiple machines are designed to run together.
- **Safety Instrumented System (SIS) Valves –** Valves which are associated with a SIS need to meet specific requirements for the safety instrumented level (SIL) target, such as sealing capability and process safety time closures (PST).

31. Valves may be manually operated, automatic or remotely controlled depending on the purpose they serve. Valves fulfil the National Gas Transmission (NGT) 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 terminal to allow safe working; and
- The ability to safely shutdown and isolate sections of the terminal in the event of an incident.

Location of the valves

32. Accessibility of the valves differs across the site, for example they can be located above ground, within a pit/trench, buried below ground with just the actuator or gearbox above ground

Operating Pressure

33. Valves typically operate at the full pressure of the terminal, which ranges from 30 bar to 70 bar.

Valve design

34. Valves with bolted body closures (e.g., Cort valves) can be dismantled and, in some cases, be repaired. However, to minimise the risk of gas leakage, most large ball valves across the terminal are welded in line rather than being flanged.

35. Whilst this minimises the risk of leakage of gas from the valve body, it restricts the ability to undertake much remedial maintenance on the valve and to repair any leakage across the seal faces as the valve it must first be cut out of line. A new or overhauled contingency valve would be required to mitigate the risk of the removed valve being defected beyond repair

36. All maintenance work on valves must therefore be undertaken external 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) recommended lubricants or other specialist sealants as an enhanced maintenance option.

37. The design of the ball valves used as isolation valves across the terminal is such that they will suffer serious damage to the sealing surfaces if the valve is opened against an excessive differential pressure (typically more than 2 – 3 barg). This is one of the common causes of seal damage to ball valves.

38. To minimise this risk, small bore (2”) bypass valves are provided around the valve to equalise the pressure across the valve prior to opening. LAVs, RIVs and PVs may have a differential pressure interlock valve fitted to prevent the main line valve from being inadvertently opened against an excessive differential pressure.

39. A typical configuration of a ball valve assembly is provided in Figure 3. This shows all the main elements of a valve:

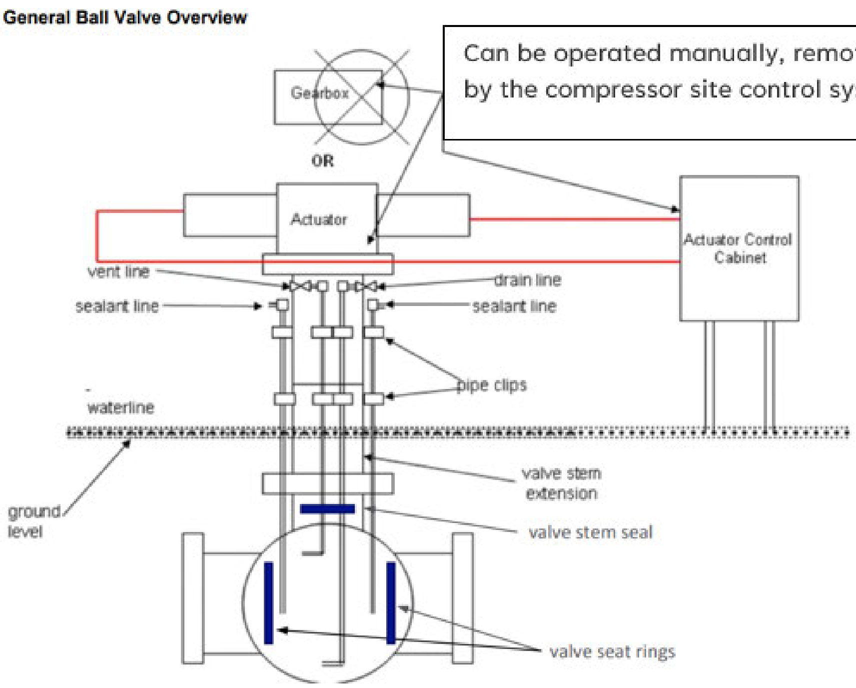


Figure 3 Valve overview

Valve operation

20. Valves may be operated manually via a gearbox or by means of a powered actuator. Actuators can be electric, electro-hydraulic, direct gas, direct hydraulic or pneumatic (using either compressed air or natural gas), gas/hydraulic or gas-over-oil powered. In most cases, actuated

valves also have a provision to allow them to be operated manually, for example via a hand operated pump.

21. Electrically powered or controlled actuators will fall under the requirements of the Dangerous Substances Explosive Atmosphere Regulations (DSEAR). These regulations require specific checks on the condition of the electrical equipment to avoid risk of fire.

22. Pneumatically (gas or air) actuated valves may fall under the Pressure Systems Safety Regulations 2000 (PSSR). These regulations impose requirements on the suppliers and operators of such equipment to ensure that it is fit for purpose throughout its lifecycle and specifically a requirement to inspect such equipment in accordance with a Written Scheme of Examination.

23. Control of actuated valves can be either from a control panel local to the valve or remotely; typically, from the control centre (via the telemetry system) used to isolate sections of pipeline in case of emergency, a local control system or via an output from a protection system (via a Compressor Station / Unit control system).

24. The terminal is currently undergoing an actuator replacement programme where actuating gas is being replaced with a mix of electric and electrohydraulic technology. Please refer St Fergus Actuator EJP submitted in January 2023.

Criticality of valves

20. 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).

21. There are around [redacted] critical valves including all RIVs and PVs and some LAVs such as those that are on the other side of Pig Traps which are required to ensure gas is contained during an ILI. All these valves are remotely operated.

22. Historically, NRVs that are only located on compressors and are non-critical have been subject to a five-yearly interval between intrusive inspections. This is an internal policy that is being changed to a more effective, duty related inspection regime based on the number of valve operations. This changes the period between inspections to between 3 and 15 years, saving process downtime, inspection and spares turnover, whilst maintaining an acceptable level of risk.

Problem Statement

23. In 2023, inspections identified [redacted] valves across the terminal that require intervention due to exhibiting issues such as significant leakage, and likely to have considerable deterioration inside the valve body. The population of valves is deteriorating due to age and wear, whereby, many valves cannot achieve the seal required to fulfil their primary function of effective isolation.
24. Various attempts have been explored to improve the valves sealing capability (discussed later in **Examples of the problem** section) but have not resolved the issue.
25. This has resulted in safe isolations becoming increasingly complex, as additional upstream valves are required to get an effective isolation (where possible). This increases turnaround time on maintenance activities which increases cost and operational risk as it impacts upon the ability to operate the terminal and provide gas paths.
26. In addition, using upstream valves to provide results in venting larger quantities of natural gas to atmosphere than would otherwise be necessary, increasing the impact on the environment.
27. Table 2 gives a summary of the valves in scope. [redacted] of the defected valves are considered critical and therefore have a significant impact on safety and security supply of the terminal should they fail when required (discussed later in the **Consequence of Failure** section).

Table 2 Summary of valves in scope

	Assembly method and Criticality						
	Bolted valves		Bolted Total	Welded valves		Welded Total	Grand Total
Valve location and accessibility	**Critical valves**	**Other**		**Critical valves**	**Other**		
Plant 1	**12.8%**	**1.2%**	**14.0%**	**11.6%**	**10.5%**	**22.1%**	**36.0%**
Above	3.5%	0.0%	3.5%	2.3%	0.0%	2.3%	5.8%
Pit	9.3%	1.2%	10.5%	8.1%	4.7%	12.8%	23.3%
Underground	0.0%	0.0%	0.0%	1.2%	5.8%	7.0%	7.0%
Plant 2	**9.3%**	**1.2%**	**10.5%**	**10.5%**	**10.5%**	**20.9%**	**31.4%**
Above	4.7%	0.0%	4.7%	1.2%	2.3%	3.5%	8.1%
Pit	4.7%	1.2%	5.8%	2.3%	0.0%	2.3%	8.1%
Underground	0.0%	0.0%	0.0%	7.0%	8.1%	15.1%	15.1%
Plant 3	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**2.3%**	**2.3%**	**2.3%**
Above	0.0%	0.0%	0.0%	0.0%	2.3%	2.3%	2.3%
Plant 4	**0.0%**	**0.0%**	**0.0%**	**8.1%**	**7.0%**	**15.1%**	**15.1%**
Underground	0.0%	0.0%	0.0%	8.1%	7.0%	15.1%	15.1%
Plant 6	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**1.2%**	**1.2%**	**1.2%**
Above	0.0%	0.0%	0.0%	0.0%	1.2%	1.2%	1.2%
South and North AGI	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**14.0%**	**14.0%**	**14.0%**
Above	0.0%	0.0%	0.0%	0.0%	11.6%	11.6%	11.6%
Underground	0.0%	0.0%	0.0%	0.0%	2.3%	2.3%	2.3%
Grand Total	**22.1%**	**2.3%**	**24.4%**	**30.2%**	**45.3%**	**75.6%**	**100.0%**

28. As the majority of the valves are underground and welded on to the pipework, they present an additional challenge to carry out maintenance/repair by site operations due to the complicated scope of works required to facilitate isolations and excavations.

Table 3 Valve accessibility summary

	Assembly method and sizes									
	Bolted			welded						Grand Total
Accessibility	**10"**	**6"**	**8"**	**18"**	**24"**	**30"**	**36"**	**6"**	**8"**	
Above	0.00%	4.65%	3.49%	1.16%	1.16%	0.00%	17.44%	0.00%	1.16%	29.07%
Pit	2.33%	12.79%	1.16%	0.00%	4.65%	8.14%	2.33%	0.00%	0.00%	31.40%
Underground	0.00%	0.00%	0.00%	1.16%	0.00%	11.63%	25.58%	1.16%	0.00%	39.53%
Grand Total	**2.3%**	**17.4%**	**4.7%**	**2.3%**	**5.8%**	**19.8%**	**45.3%**	**1.2%**	**1.2%**	**100.0%**

29. Asset health works in the terminal are aligned with planned outages which reduces the risk on security of supply when carrying out interventions. It also maximises the deliverability of works as they can be bundled together leading to cost efficiencies which delivers the most value to consumers.

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

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

31. Should the proposed interventions not be performed, the increasing defect count means that impacts of failure become more likely and drive an increasing risk profile over the period

32. The key drivers for investment are:

33. **Asset deterioration**:

- Majority of the valves on site are operating beyond their expected design life where the primary issues being detected are mechanical wear, valve passing/leakage and corrosion.
- This presents a challenge when critical isolation valves are required to provide suitable isolation boundaries to allow for sections of the plant to be decompressed to atmospheric pressure and purged to air to allow for ongoing corrosion remediation works to be undertaken as a well as facilitating routine operation requirements.

34. **Legislation**:

- **PSSR legislation:** Failure to comply with the requirements of the PSSR can result in a prohibition notice being served in cases where the condition of the asset is regarded as representing imminent danger. PSSR is concerned with the mechanical integrity of the pressure system. As equipment ages and its condition deteriorates, it is to be expected that additional repair or replacement work may be required.
- **DSEAR legislation:** Electrically powered actuators (whether directly or indirectly (e.g., using electrohydraulic actuators) or which have electrically powered components in their control systems fall under the remit of the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR). Typically, DSEAR related issues can be either inherent non-compliance in the original installation, or a failure occurring because of deterioration or wear. DSEAR is applicable to valves if they are passing as this risks the likelihood of a leak finding an ignition source. DSEAR also applies to mechanical assets or requires for the valves to have a statement of conformity that they aren't capable of creating an ignition source.
- **IEC 61508/11 Functional Safety:** Any valves, together with their associated electrical or electronic control and actuation systems, that form part of a protective system are subject to the requirements of IEC 61508 "Functional Safety of Electrical / Electronic / Programmable Electronic Safety related systems" and the related IEC61511 "Functional safety – Safety instrumented systems for the process industry sector". Although compliance with these standards is not a legal requirement, they are de facto standards across a wide range of industries and any non-compliance would be regarded negatively by the HSE, particularly if non-compliance led to a safety incident.
- **PSR and GS(M)R:** The legislation for safe shut down systems and emergency procedures for major accident hazard pipelines are included in the Pipeline Safety Regulations (PSR) and Gas Safety (Management) Regulations (GS(M)R).
- The 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 are necessary for securing that, so far as reasonably practicable, persons are protected from risk to their health and safety."
- The Gas Safety (Management) Regulation that requires pipeline operators to quickly isolate an area in the event of a leakage, where regulation 7.4 states: "Where any gas escapes from a terminal, the persons conveying the gas in the part of the terminal from which the gas escapes shall, as soon as is reasonably practicable after being so informed of the escape, attend the place where the gas is escaping and within 12 hours of being so informed of the escape, she/he shall prevent the gas escaping."

35. **Availability of spares**:

- Over 60% of the priority main line valves considered for intervention are of valve sizes between 36" and 24" as shown in Table 3

- Currently, there are no pool of spare 36” or 24” ball valves on hand at St. Fergus and various locations of NGT, National Gas Services[1] (NGS) stores, nearby licensed valve OEM or other NGT approved contractor.
- New valves of this size have long lead times, of the order of 12 to 24 months, which make it a challenge to plan critical maintenance works that require an outage.

Table 4 Valve size summary

	Assembly method									
	Bolted			welded						
Location	10"	6"	8"	18"	24"	30"	36"	6"	8"	Grand Total
Plant 1										
Above	0.0%	3.5%	0.0%	0.0%	0.0%	0.0%	2.3%	0.0%	0.0%	5.8%
Pit	1.2%	9.3%	0.0%	0.0%	3.5%	7.0%	2.3%	0.0%	0.0%	23.3%
Underground	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.0%	0.0%	0.0%	7.0%
Plant 2										
Above	0.0%	1.2%	3.5%	0.0%	0.0%	0.0%	3.5%	0.0%	0.0%	8.1%
Pit	1.2%	3.5%	1.2%	0.0%	1.2%	1.2%	0.0%	0.0%	0.0%	8.1%
Underground	0.0%	0.0%	0.0%	0.0%	0.0%	9.3%	5.8%	0.0%	0.0%	15.1%
Plant 3										
Above	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.3%	0.0%	0.0%	2.3%
Plant 4										
Underground	0.0%	0.0%	0.0%	0.0%	0.0%	2.3%	12.8%	0.0%	0.0%	15.1%
Plant 6										
Above	0.0%	0.0%	0.0%	0.0%	1.2%	0.0%	0.0%	0.0%	0.0%	1.2%
South and North AGI										
Above	0.0%	0.0%	0.0%	1.2%	0.0%	0.0%	9.3%	0.0%	1.2%	11.6%
Underground	0.0%	0.0%	0.0%	1.2%	0.0%	0.0%	0.0%	1.2%	0.0%	2.3%
Grand Total	**2.3%**	**17.4%**	**4.7%**	**2.3%**	**5.8%**	**19.8%**	**45.3%**	**1.2%**	**1.2%**	**100.0%**

[1] Previously known as the Pipeline Maintenance Centre (PMC)

Examples of the problem

36. A 30" ball valve on the terminal, V21074, was identified to be passing gas through the seals. The site maintenance team attempted to seal the valve by injecting valve flush and sealant into the valve seat which was unsuccessful.

37. Subsequent works were carried out which involved, excavation of the buried valve, removal of the actuator and actuator spool piece to provided access into the valve stem as shown in Figure 4.

Figure 4 accessing valve 21074 for repair

38. The valve stem was cleared out of any debris and sealant was injected directly into the valve seats.

Figure 5 Debris and corrosion on the valve stem

39. The valve was then re-assembled, re-tested and proved to not be sealing. There were no further works that could be carried out to remediate the defect on site.

40. Surveys by the main works contractor were able to identify that all [redacted] defected valves were in a similar or worse state and need of repair (see Appendix B: [redacted] report).

Spend Boundaries

41. The proposed investment only captures the known defective valves and associated actuators where applicable. The actuators covered in this scope are associated with mass flow control and recycle valves.

42. The mass flow control and recycle valve actuators covered in this Engineering Justification Paper were not included in the Actuator replacement programme.

Probability of Failure

43. A valve is considered to have failed if it cannot provide safe isolation required to facilitate routine or nonroutine maintenance works. Routine inspections have identified [redacted] valves that are not able to provide this function as their cavity, stem and seats have been passing gas.
44. For valves, the common failure modes that contribute most to the probability of failure are:
    - **Mechanical degradation of internal components:** This prevents inner components from providing an effective seal such as valve seats
    - **Corrosion with no leak:** Corrosion on sealant lines affecting the ability to seal the valve
    - **Mechanical or electrical fault leading to trip:** Failure of actuators leading to valve availability
    - **Significant gas leak:** Failure of internal components such as stem seals leading to gas leaks
    - **Inability to isolate:** Due to valves passing for local and remotely operated valves
45. Data on valve failure modes at St Fergus is not readily available as majority of the identified defected valves are underground. As part of this scope, an inspection of 20% of the valves requiring replacement will be undertaken to understand the common mode of failure.
46. This information will be used to inform the condition of the remaining valves on the terminal, verify the valve failure modes and plan mitigations.
47. This can only be completed once removal works have been completed and replacement works are ongoing. Majority of the valves shortlisted for intervention are ball valves. Table 5 shows the criteria that will be used (see Appendix D: Valve list).

Table 5 Minimum inspection criteria for removed valves

	Minimum inspection criteria for removal valves
1	Full surface condition assessment of the obturator (e.g.: ball), including condition of any electro-plating, signs of surface scoring and disbondment.
2	Visual assessment of top drive shaft sealing faces to include signs of mechanical interference, misalignment, and corrosion.
3	Assessment of the sealant lines condition, looking for signs of both external and internal corrosion and associated signs of any internal solid objects
4	Assessment of the condition of any sealant line NRV at entry point to valve body. Whether it passes sufficient flush and sealant quantities. Is it free in operation in forward direction. Does in seal tight in reverse direction.
5	Condition of any sealant line isolation valve at entry point to valve body. Is it free to operate. Does it pass sufficient flush and sealant quantities
6	Assessment of the general condition of all soft sealing compounds throughout valve body.
7	General condition of all sub-system mating faces and associated screw threads securing sub systems together

Consequence of Failure

48. Failure to invest in valves and their associated control systems will result in the performance of the valves continuing to deteriorate due to mechanical wear, component failure, corrosion, and electrical failure.

49. This deterioration will increase with duty and asset age. Elements of valves, such as recycle and mass flow control actuators, will be subject to increasing obsolescence, the impact of which, will be magnified as existing spares stocks are used.

50. Therefore, without the appropriate level of investment they will not be able to operate and will fail to conform to the legislative requirements of PSSR, PSR, GS(M)R, DSEAR and safety standards as agreed with Ofgem and HSE (IEC 61508).

51. 52.3% of the defected valves population are safety critical and are required during abnormal operations such as an Emergency Shut Down (ESD) scenario. Failure of these valves when required to function could have significant impacts on the terminal system processes as discussed below:

52. **Safety impact**:

- In the event of an incident, failure to isolate an area because of a valve failure might result in damage of plant and equipment and lead to serious injury/death of employees.
- If a failure (valve passing) occurs on a SIS/Emergency shutdown (ESD) system, this will compromise the integrity of the system and could lead to an escalation.
- If an overpressure event is detected through our safety systems at site and a valve fails to operate on demand, this increases the risk of catastrophic failure of our process pipework system on the terminal large loss of containment and process safety incident.

53. **Functional Safety**:

- Valves associated with a SIS which fail to operate as required, lead to SIL targets not being met due to the probability of failure calculations not being satisfied, this leads to inspection frequencies (Proof Test Procedures) being reduced to meet the required SIL target.
- By reducing the inspection frequencies there is an operational impact on suppliers at the terminal as more regular cessations of flow are required leading to multiple outages across the site above the annual ESD testing requirements for PSSR.

54. **Security of supply**:

- Potential outages associated with the inability to isolate certain areas in the event of asset failure might impact security of supply and result in high buy back costs from not meeting NSMP, Shell and Ancala flow obligations.

55. **Environmental impact**:

- Loss of natural gas to the atmosphere through the inability to seal or from small leaks and vents.
- If an ESD is initiated on a sectional plant and the valve failed to operate this could lead to a massive increase in the amount of gas vented (if a main-line isolation valve failed to close).
- This also has the potential to extend the required ESD from sectional to a full plant ESD which increases the gas vented

56. **Financial impact**:

- 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.
- Unplanned repairs incur long lead times. If critical valves are required urgently and need to be fast tracked, higher costs are associated with procurement and delivery.
- By carrying out planned intervention, isolations and outages can be programmed to enable continued flow through the site utilising existing assets to enable the work and reducing overall intervention costs, especially if the scope of work involves excavation and unplanned outages to facilitate repairs.

Options Considered

57. In total, five options are considered here for management of the condition issues and associated risks as outlined in the **Consequence of Failure** section. Of these five options, three are discounted as they are not viable for compliance reasons, described below. Options 4 and 5 are then expanded upon to outline the pros and cons to support the final option selection.

58. Key constraints:

- **Planned outages:** asset health works in the terminal are aligned with planned outages as it reduces the risk on security of supply when carrying out interventions.
- **Lead times:** new valves of the valve sizes in scope and Valve overhauls have long lead times, of the order of 6 to 24 months.

Options discounted

59. Option 1: Continue to operate without resolving valve defect risk (do nothing):

- A significant percentage of the defected valves are critical valves. Failure to intervene within this regulatory period will ultimately result in a failure of the ESD systems across the site and inability to isolate areas to facilitate maintenance and non-routine operations.
- This option is not viable due to requirements to operate safe plant in compliance with PSSR, COMAH and other safety regulations not being met. Thus this option would not meet the expectations set out by the HSE.

60. Option 2: Refurbish the defected valves

- A significant percentage of the valves (of various sizes) are underground and welded onto the pipework.
- Unless there are valves of the correct size type and rating to replace the defected valve which are being removed then repairing a mainline valve would involve a series of steps: cutting it out, removing it from the site, conducting a strip-down and repair, reassembling it, and finally welding the valves back into place.
- Refurbishing the valves would require longer outage periods as they would need to be sent away for overhaul. Long lead times of up to 6 months are expected depending on the condition of the valve, availability of spares required to return the valve to service and/or time to manufacture the required valve component.
- Consequently, this would lead to increased costs associated with excavations, since the valve sites would remain open for extended durations, and it would also impact the timely completion of the valve-related tasks.
- This option is not viable due to additional costs that would be incurred for extended outages and impact on the deliverability of the programme.

- There is also a notable risk that despite undertaking costly measures to gain access to the valves and carrying out repairs they may still fail to function as intended. Contingency valves are therefore always required to mitigate this risk.

61. **Option 3: Operate with a reactive maintenance approach to valve defects on a "fix on fail" basis (Replace on failure):**

    - All the priority valves are welded onto pipelines, reactive cut out and replacement of a single main line valve is a large, committed Scope Of Work (SOW). This is an inefficient approach that also increases the operational risk and compromises security of supply because of outages to facilitate maintenance works.
    - Therefore, when condition allows, function test and leak test will typically be carried out, followed by an attempted reseal.
    - However, for all priority valves identified as part of this scope, the information available states a wide range of issues associated with a reseal either being attempted and not resolving the issue (as discussed in the previously).
    - Challenges in achieving reseals and expensive SOW to facilitate valve replacements and/or maintenance showcase that this option is not sustainable in the long term as it will ultimately result in increased disruptions to normal operation of the terminal

Options progressed

62. The desired outcomes of the considered options are:

    - Ensure that all valves comply with legal requirements and agreed safety standards.
    - Have valves that will operate and perform their function when required to do so, particularly in an emergency, to contain an event and eliminate any further escalation.

63. **Option 4: Replace [redacted] defected valves in the RIIO-T2 regulatory period**

64. This option Involves the replacement of all [redacted] leaking valves and testing of 20% of the valves once they have been removed from service to inform the condition of valves on the site.

    Advantages:

    - Resets the asset life
    - Reduces the risk of equipment failure, safety issues and protection loss for the long term
    - Testing enables efficient planning of future maintenance works and accurate project programme costing due to the availability of valve conditional data

    Disadvantages:

    - Full volumes cannot be delivered within this regulatory period due to the increased number of outages that would result in cessation of flow across the terminal for extended periods due to time limitations to complete the full project scope required and this would greatly impact on the terminal's security of supply.
    - Long lead times of 12 to 24 months associated with ordering the valves.

65. Option 5: Replace [redacted] defected valves in RIIO-T2 and the remainder future price control periods

66. This option Involves the replacement of [redacted] leaking valves and testing of 20% of the valves once they have been removed from service to inform the condition of valves on the site.

67. These [redacted] valves have been prioritised on their impact to system processes as they are required during Emergency Shut Down (ESD) scenarios in their location and deliverability within the planned outage windows in this regulatory period. This minimises risks and costs while delivering performance.

Table 6 Summary of the [redacted] valves in scope

	Assembly method					
	Bolted Valves		Bolted Total	Welded valves	welded Total	Grand Total
Valve location and accessibility	Critical valves	other		Critical valves		
Plant 1	**55.0%**	**5.0%**	**60.0%**	**40.0%**	**40.0%**	**100.0%**
Above	15.0%	0.0%	15.0%	10.0%	10.0%	25.0%
Pit	40.0%	5.0%	45.0%	25.0%	25.0%	70.0%
Underground	0.0%	0.0%	0.0%	5.0%	5.0%	5.0%
Grand Total	**55.0%**	**5.0%**	**60.0%**	**40.0%**	**40.0%**	**100.0%**

Table 7 Summary of the [redacted] valves in scope by size

	Valve sizes					
Valves accessibility	10"	24"	30"	36"	6"	Grand Total
Above	[redacted]					
Pit						
Underground						
Grand Total						

Advantages:

- Resets asset life
- Planned outages within this regulatory period can accommodate the volumes for full delivery of the scope
- Reduces the risk of equipment failure, safety issues and protection loss for the short term

- Increases the availability of spares as the replaced defected valves can be repaired and stored
- De-risks future programmes as these are strategic to enable future works
- Simplifies subsequent outage requirements, by allowing smaller isolation requirements as these valves won't pass hence minimises operational gas-path constraints and venting requirements
- Allows phasing of works by grouping work on multiple valves which minimises the interruption to operations and introduces project efficiencies
- Testing of the valves enables efficient planning of future maintenance works and accurate project programme costing due to the availability of valve conditional data

Disadvantages:

- Although 40% of the critical valves will be replaced, the terminal will be operating for a longer period with defected valves which could result in an unplanned outage to resolve any issues that may arise.
- Long lead times of 12 to 24 months associated with ordering the valves.

Options 1 to 4 were deemed not viable and therefore not costed. This is because they present significant limitations brought about by the long lead times, the risk of the valve not functioning as required after repair and outages required to facilitate the delivery programme. These risks significantly outweigh any cost savings aimed to be achieved.

Options Cost Details

Option	Programme element	Unit cost (22/23 prices)	Cost evidence	Volume	Price base conversion	Investment value (18/19 prices)
Option 1	Do nothing					
Option 2	Refurbish [redacted] defected valves					
Option 3	Fix on fail					
Option 4	Replace [redacted] valves					
Option 5	Replace [redacted] valves					

Option analysis and selection

68. Considering the above rationale and options assessment, the following table provides a summary of the options considered.

Solution considerations	Option 1	Option 2	Option 3	Option 4	Option 5
	Do Nothing	Refurbish defected valves	Repair/Replace on failure	Replace [redacted] valves in price periods	Replace [redacted] valves in T2
Meeting HSE Requirements	Non-comp iant as the risk is not ALARP	Comp iant as a defected va ves wi be repaired	Non-comp iant as the risk is not ALARP	Comp iant as a defected va ves wi be rep aced	Partia Comp iance as a defected va ves wi be rep aced through T2 and T3
Functional safety	Not ab e to provide successfu iso ation and venting of ESD systems across a va ves in the termina	Successfu iso ation and venting of ESD systems across a va ves in the termina	Not ab e to provide successfu iso ation and venting of ESD systems across a va ves in the termina	Successfu iso ation and venting of ESD systems across a va ves in the termina	Partia Comp iance in successfu iso ation and venting of ESD systems across a va ves in the termina
Deliverability	Not app icab e	It is not feasib e to de iver a the vo umes within this regu atory period due to the increased number of outages required to faci itate works and ong ead times associated with overhau s	Not app icab e	It is not feasib e to de iver a the vo umes within this regu atory period due to the increased number of outages required to faci itate works	The specified vo umes can be de ivered within the p anned outages in this regu atory period
Cost	Medium Low initia cost but resu ts in high overa costs from expensive reactive maintenance works to keep site operationa	High- High costs associated with maintaining an excavation site for ong periods of time Refurbishment costs are unknown as the state of the inner components and work required is on y determined after va ve investigation.	High Reactive maintenance resu ts in higher project costs across the who e ife of the site.	Medium- Proactive maintenance and efficient de ivery of works through bund ing reduces costs associated with rep acement and enab es p anning of future works	Medium- Proactive maintenance and efficient de ivery of works through bund ing reduces costs associated with rep acement and enab es p anning of future works
Compli ance – PSR and GMSR	Non-comp iant	Comp iant	Comp iant	Comp iant	Comp iant
Compli ance – PSSR	Non-comp iant	Comp iant	Comp iant	Comp iant	Comp iant

Solution considerations		Option 1	Option 2	Option 3	Option 4	Option 5
		Do Nothing	Refurbish defected valves	Repair/Replace on failure	Replace [redacted] valves in price periods	Replace [redacted] valves in T2
Mainte nance	Ongoing OPEX	High operationa OPEX from increased eak, detection tests, and repair maintenance Comp ex iso ations with increased turnaround time wi be required to de iver maintenance works	Low Significant reduction in operationa costs as the va ves are in good condition.	High operationa OPEX from carrying out eak, detection, and repair maintenance Comp ex iso ations with increased turnaround time wi be required to de iver maintenance works	Low Significant reduction in operationa costs as the va ves are in good condition. Avai abi ity of spares reduces turnaround time.	Low Significant reduction in operationa costs as the va ves are in good condition. Avai abi ity of spares reduces turnaround time.
	Risk	High Va ves are passing and cannot provide safe iso ation when carrying out maintenance works	Low Va ves have been tested and shown to have capabi ity to safe y iso ate an area when needed	High Va ves are passing and cannot provide safe iso ation when carrying out maintenance works	Low Va ves have been tested and shown to have capabi ity to safe y iso ate an area when needed	Medium A percentage of va ves have been tested and shown to have capabi ity to safe y iso ate an area when needed
Operati onal Resilien ce	Security of Supply	High- Va ves in scope are priority va ves that wi have significant imp ications to security of supp y	High Increased number of outages wi be required to de iver a vo umes of va ves. This wou d create numerous interruptions in the f ow of gas	High- Va ves in scope are critica va ves that wi have significant imp ications to security of supp y	High Increased number of outages wi be required to de iver a vo umes of va ves. This wou d create numerous interruptions in the f ow of gas	Medium - Outages can be p anned to enab e maximum f ow capacity in the termina whi st de ivering the [redacted] va ves
Overall viability		Not Viable	Not Viable	Not Viable	Not viable	Viable

Preferred Option Scope, cost, and Project Plan

69. The assessments outlined in this paper and the associated discounting and costing of options demonstrates there is only one cost effective and deliverable option to take forwards: Option 5: Replace [redacted] defected valves in RIIO-T2 and the remainder ([redacted] Valves) in future price periods.

70. The focus is therefore on ensuring this is delivered at the lowest overall cost. The following factors support this:

- The St Fergus Short-Term Strategy confirms the need for a replacement of the valves to mitigate the risk on security of supply and reduce operational risk to allowable levels
- The competitive tender process undertaken for the Main Works Contractor provides assurance that best market rate is paid for the programme.
- Scopes sharing similar boundaries and durations will be bundled together for delivery

Project scope

71. Table 12 shows the selected [redacted] defective valves which have been identified for replacement within this regulatory period.

72. These valves were chosen based on the volumes that can realistically be delivered within the planned outage windows, coordination with other works occurring on site and the criticality of their function.

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

74. The following is a summary of the project scope deliverables:

- As a whole, the scope is to provide safe, fit for purpose, secure by design, reliable valves, suitable for present and future operations, allowing safe isolation of plant and equipment and continued functionality while sustaining the operational capability of the St Fergus Terminal, in line with T/PM/TR/17, T/SP/COMP/33 and T/SP/PW/11.
- The replacement valves should have a minimum 30-year design life (in accordance with T/PM/COMP/20 with sufficient availability of spares and OEM lifecycle support to maintain acceptable reliability and availability for this period.

75. The work scope includes:

- Specification and procurement of appropriate replacement valves in accordance with T/SP/V/6 or T/SP/VA/5, including as applicable (please refer to table in), actuation, gearboxes, bolting, gaskets, pup pieces, flange protection to NGT specifications
- Reassessment and potential upgrading/redesign of related civils and supports
- Reassessment of existing stress analysis models, or development of models where none exist, taking account of salient changes

- Assessment of the impact of any changes resulting from the works to previous Vibration Assessments
- Programming and coordination of works with coinciding site activities
- FPSA activities
- Temporary works including safe excavations and pit access in accordance with T/PM/SSW/22
- Removal of existing valves in [redacted] identified valve locations
- Welding and NDT activities
- Bolting activities
- Coating and painting activities
- Site Acceptance Testing including pressure testing
- Commissioning works
- Reinstatement works
- Update of site Explosion Protection Document and Hazardous area drawings to reflect any changes
- Collation and archiving of handover records

Final cost and programme

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

Table 8 Project cost breakdown

	Cost Category	Outturn Costs (£m)	Costs (£m) 2018/19 Price Base
	OEM costs	[redacted]	
Direct	EPC Estimate		
Indirect	EPC PM		
Direct	EPC Site Establishment		
Direct	NGGT Direct Company Costs		
Indirect	NGGT Indirect Company Costs		
	Contractor Risk		
Direct	NG Project Risk		
	FEED		
	Development / Optioneering		
	Land / Easements		
	TOTAL	[redacted]	[redacted]
	Direct	[redacted]	[redacted]
	Indirect		

77. **Table 4** shows the spend profile for our preferred option in 2018/19 pricing.

Table 9 Spend profile of preferred option

£m 18/19	FY2023	FY2024	FY2025	FY2026	FY2027	Total	Comments
Priority valves phase 1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	

RIIO-T2 Volume UIDs

78. Costs associated with this project have been assigned against the RIIO-T2 Unique Identifier (UID).

79. Table 10 provides a summary of the UIDs and associated funding for the scope of works proposed in this paper.

Table 10 UID details

UID	Baseline volume of Intervention (By PP) (by unit of measure)	Baseline total funding available (£ 18/19)	Current volume of intervention (by unit of measure)	ECC total funding required (£m 18/19)	Output Year	UID funding requested through UM (£m)
[redacted] ST FERGUS TERMINAL - Locally Actuated Valve Replacement	[redacted]	[redacted]	[redacted]	[redacted]	FY2027	[redacted]
[redacted] ST FERGUS TERMINAL- Process Valve Replacement (24"-30")	[redacted]	[redacted]	[redacted]	[redacted]	FY2027	[redacted]
[redacted] ST FERGUS TERMINAL- Process Valve Replacement (6"-10")	[redacted]	[redacted]	[redacted]	[redacted]	FY2027	[redacted]
[redacted] ST FERGUS TERMINAL- Process Valve Actuator Replacement (6"-10")	[redacted]	[redacted]	[redacted]	[redacted]	FY2027	[redacted]

NARMs Benefit

80. Following discussions with Ofgem in the NARM Development Monthly Meetings, it is proposed that for simplicity all the investments that arise from the UMs are collated and one NARMs update is provided after the Plant & Equipment submission. For further details and a summary of UIDs please see Section 4 and Appendix 2 of the Asset Health UM Overarching document.

Conclusion

81. This report has explained the safety concerns NGT has regarding the defected valves and the implications of these on terminal operations. As detailed in this justification paper, it is of paramount importance to secure the necessary investment to address the highlighted investment drivers.

82. Replacement of the [redacted] valves at the St Fergus gas terminal totals [redacted] (18/19 Prices). The cost accuracy at this stage of the project is estimated at +30/-15% in accordance with the Infrastructure and Projects Authority (IPA) cost estimating guidance.

Appendices

Appendix A: Project Summary

Table summarises the key information on the project.

Name of project	T2_St Fergus_2021_St Fergus RIIO-2 Asset Health Programme		
Scheme reference	[redacted]		
Primary investment driver	Asset Deterioration & Legislation		
Project initiation year	2023		
Project close out year	2026		
Total installed cost estimate (£)	[redacted]		
Cost Estimate accuracy (%)	+30/-15		
Project spend to date (£)	[redacted] (all St Fergus T2 AH UM development)		
Current project stage gate	F2		
Reporting table ref	RRP Table 6.3 (Asset Health) and Table 6.4 (Asset Health Projects)		
Outputs included in RIIO-T1 business plan	No		
Spend apportionment	T1	T2	T3
	[redacted]	[redacted]	[redacted]

Table 11: Project Summary

Appendix B: [redacted] report

1. File: 5210385-001-ME-REP-017, 17 - Valves, [redacted] Rev 03,2023

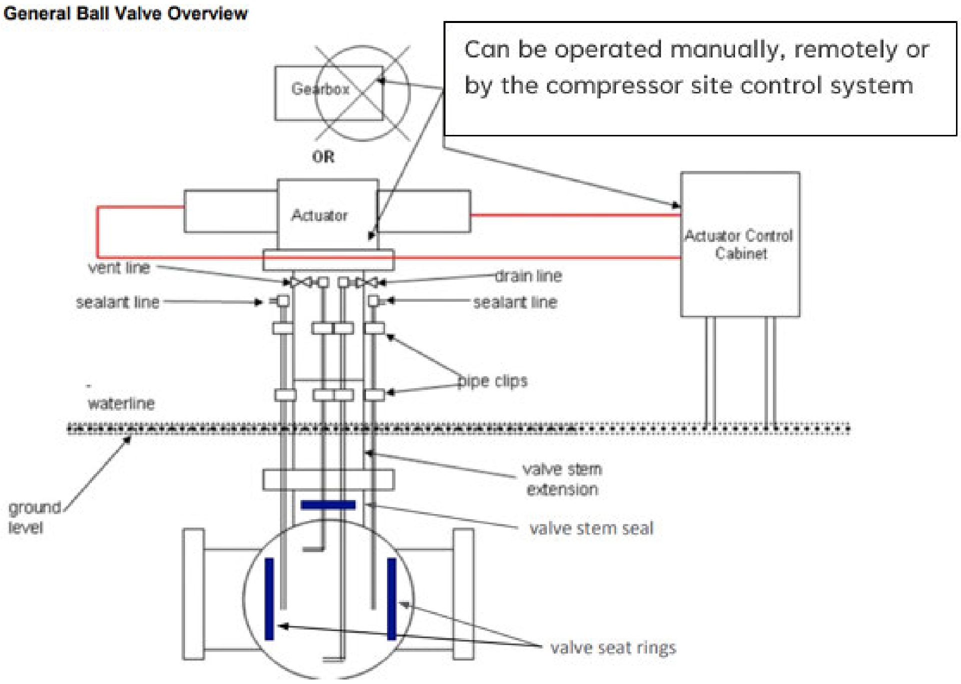
national gas transmission

Appendix C: Valves overview

A general overview of a typical valve arrangement is shown in the figure below which highlights all the typical sub-components that are associated with each of the Valve Body and associated fittings, e.g., Vent & Sealant lines, Seat rings etc.

Valve stem extension.

- Valve stem seal
- Valve operator (gearbox or actuator), associated fittings and actuating medium storage vessels
- Actuating medium up to the point of isolation or distribution point e.g., actuating gas isolation point or electrical junction point
- Instrumentation inherent to the actuator unit
- Control cabinets inclusive of all contents e.g., hand/electric pumps, regulators, and relief valves
- Applies to all valves the size 100mm to 1200mm



Appendix D: T2 Valve list

1. File: [redacted] priority valves June AH submission 2023.xlsx

[redacted]

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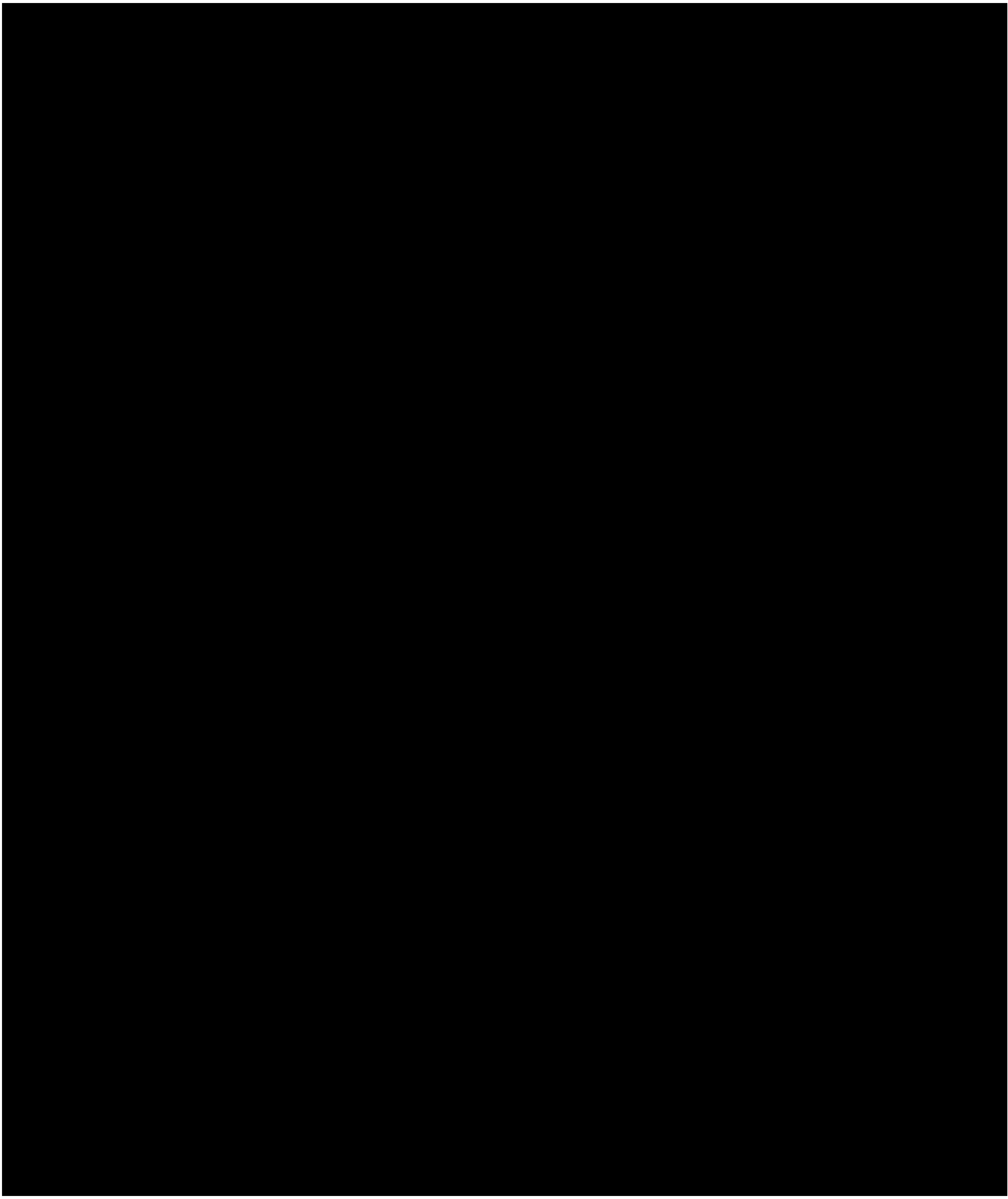

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