ENGINEERING JUSTIFICATION PAPER (EJP)

OFFICIAL – FOR PUBLIC RELEASE

Cabs

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RIIO-GT3 NGT_EJP03

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1 Summary Table

Table 1: Summary Table for Cabs EJP

Name of Project	*Cabs Asset Health*		
Scheme Reference	*NGT_EJP035_Cabs_RIIO-GT3*		
Primary Investment Driver	*Asset Health*		
Project Initiation Year	*FY27*		
Project Close Out Year	*FY31*		
Total Installed Cost Estimate (£m, 2023/24)	*66.4*		
Cost Estimate Accuracy (%)	*+/-20%*		
Project Spend to date (£)	*0*		
Current Project Stage Gate	*ND500 4.0*		
Reporting Table Ref	*6.4*		
Outputs included in RIIO-T2 Business Plan	*Yes*		
Spend apportionment (£m, 2023/24)	**RIIO-T2**	**RIIO-GT3**	**RIIO-GT4**
	1.91	64.36	0.11

2 Executive Summary

2.1.1 This paper proposes £66.38m of baseline funding to maintain the health of our Compressor Acoustic Buildings (Cabs) by intervening on 44% of our Cabs in RIIO-GT3. The outputs from this request will be measured through an Asset Health – NARMS PCD.

2.1.2 The primary driver for this investment is to maintain compliance with HSE Guidance PM84 and BS ISO 21789 (Control of Safety Risk at Gas Turbine Enclosures) and legislative requirements such as Dangerous Substances and Explosive Atmosphere Regulations (DSEAR). Without investment, continued degradation of Cab assets would lead to them not being able to perform their duty with consequential impact to compressor assets resulting in constrained compression availability for NTS operations.

2.1.3 Cab assets included within the scope of this investment are ventilation systems, air intakes, exhausts, lifting equipment and fire suppression systems. We have considered a variety of different intervention options across the portfolio to establish an optimal programme and deliver desired regulatory outputs including maintaining stable risk. 55 interventions are proposed as summarised in Table 2.

Table 2: RIIO-GT3 volumes proposed in this EJP

	Refurbish	Replace	Survey	Total
RIIO-GT3 Volumes	[redacted]	[redacted]	[redacted]	55

2.1.4 This investment is a significant financial increase on allowance in RIIO-T2. Whilst there were more interventions in RIIO-T2, these were predominantly refurbishment volumes with lower costs. Most interventions in RIIO-GT3 are replacements based on lessons learnt during RIIO-T2 when refurbishment work entailed completing far more intrusive scopes than the bounds of the intended interventions provisioned for.

2.1.5 Table 3 shows a comparison between RIIO-T2 and RIIO-GT3

Table 3: RIIO-T2 BP, forecast delivery and RIIO-GT3 volumes (£m, 2023/24)

	RIIO-T2 Business Plan (Years 1-3 Only)	RIIO-T2 Forecast Delivery (Including NGT_AH2_14)	RIIO-GT3 Business Plan
Interventions	N/A (no volumes, baseline allowances only)	67	55
Investment	14.45	42.66	66.38

2.1.6 The mix of work proposed in this EJP is in line with the uncertainty mechanism funding request submitted to Ofgem during RIIO-T2 which was based on known issues following detailed surveys.

2.1.7 The deliverability has been assessed and we are confident that it can be achieved during RIIO-GT3 following the delivery of our RIIO-T2 Cab infrastructure campaign. The profile of investment for RIIO-GT3 is shown in Table 3.

Table 4: RIIO-GT3 funding request for Cabs (£m, 2023/24)

	2026	2027	2028	2029	2030	2031	2032	Total	Funding Mechanism
Cabs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**58.08**	Baseline
Fire Suppression	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**8.30**	Baseline
Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**66.38**	

3 Introduction

3.1.1 We are requesting funding to address Cabs and Fire Suppression system asset heath and legislation issues.

3.1.2 This EJP has been structured as shown in the below figure to cover two sub-themes within our Cabs asset base.

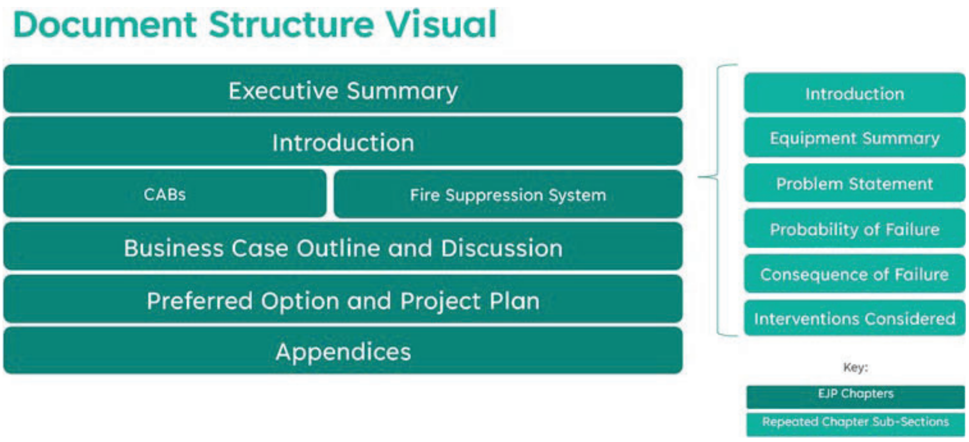

Figure 1:EJP Document structure

3.1.3 The scope of this document is aligned with our Asset Management System (AMS) and relates to our Legislative Compliance and Asset Health Business Plan Commitments (BPCs). More information on our AMS and a description of our commitments is provided in our Network Asset Management Strategy annex[1] and our BPCs are detailed within our main business plan document[2].

3.1.4 This EJP interacts with other EJPs including Rotating Machinery EJP[3], Compressor Fleet EJPs[4][5][6][7], Electrical Infrastructure EJPs[8][9][10], Civils EJP[11] and Site Assets EJPs[12][13].

[1] NGT_A01_Asset Management Plan (AMP)_RIIO_GT3
[2] NGT_Business_Plan_RIIO_GT3
[3] NGT_EJP04_Rotating Machinery_RIIO-GT3
[4] NGT_EJP13_Compressor Fleet – Network Investments and Zone 1 (Scotland)_RIIO-GT3
[5] NGT_EJP14_Compressor Fleet - Zones 2 and 3 (Central)_RIIO-GT3
[6] NGT_EJP15_Compressor Fleet - Zones 4 and 5 (South Wales and South West)_RIIO-GT3
[7] NGT_EJP16_Compressor Fleet - Zones 6 and 7 (East Midlands and South East)_RIIO-GT3
[8] NGT_EJP10_Electrical Infrastructure: Switchgear and Transformers_RIIO-GT3
[9] NGT_EJP11_Electrical Infrastructure: Standby Power Systems and LV Distribution_RIIO-GT3
[10] NGT_EJP12_Electrical Infrastructure : Site Lighting, Earthing and Lightning Protection_RIIO-GT3N
[11] NGT_EJP19_Civils_RIIO-GT3
[12] NGT_EJP02_Site Assets - Preheating, Filters & Pipework_RIIO-GT3
[13] NGT_EJP01_Site Assets - Asbestos, Stabbings and Redundant Assets_RIIO-GT3

4 Cabs - £58.08m (2023/24)

4.1 Introduction

4.1.1 This section of the EJP details the funding request to address Cab asset health issues identified during comprehensive third-party surveys and in-house inspections.

4.1.2 Cabs enable compressor machinery trains to operate safely and efficiently by ensuring optimal environmental conditions and protection. They are an essential element of our compliance with PM84 Health and Safety Executive and BS ISO21789-Gas Turbine Applications - Safety. They are also instrumental in maintaining our compliance with environmental legislation and permits regarding noise and exhaust emissions.

4.1.3 During RIIO-T2, surveys were undertaken to inform works within the regulatory period. As a lesson learnt, we have proactively conducted intrusive external surveys on 70% of the Cabs in this EJP to provide increased confidence in the scope of the works we are proposing to deliver within RIIO-GT3. The remaining 30% have undergone internal condition assessments.

4.1.4 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 Excel EJP.

4.2 Equipment Summary

4.2.1 Cabs are made up of a weather-tight and noise attenuating enclosure, an air intake (gas driven compressors only) for the combustion air into the gas turbine, a ventilation system to maintain safe and operable conditions within the enclosure, an exhaust system (gas driven compressors only) to compliantly remove combustion gases and attenuate noise, and a fire suppression system to control fires within the enclosure. A summary of Cabs assets is presented below, with additional information such as health score at the beginning and end of the price control and monetised risk provided in the accompanying Excel EJP.

Pressure Ratings

4.2.2 Cabs are designed to operate either slightly above or below atmospheric pressure depending on the ventilation system installed (forced or induced draft). The design pressures involved are of the order of a millibar gauge above or below atmospheric pressure.

Redundancy

4.2.3 Each Cab covered in this EJP houses a single compressor unit. In the event of Cab assets being unserviceable, the respective compressor unit cannot be run until the failure mode has been addressed. Therefore, the availability of any compressor unit is dependent on its Cab being in a good working condition.

4.2.4 Each individual Cab is comprised of four main elements which work together to provide a suitable environment for safe, efficient, and legally compliant operation of compressor trains and associated components. These are:

- Air Intake
- Exhaust
- Ventilation System
- Cab Enclosure

4.2.5 Also covered in this scope are investments for lifting beams and overhead cranes installed within Cabs to facilitate maintenance of compressor train assets.

Air Intakes

4.2.6 Air intakes are applicable to gas driven compressors only. They provide clean combustion air for use in gas generators and minimise the risk of damage by reducing moisture and foreign objects. Air intakes ensure air drawn into the gas generator engine for compression and combustion is of the acceptable quality and non-turbulent.

4.2.7 Air intake inlet filtration systems mitigate the risk of dust, oils, salts, liquids, and aerosols causing fouling, erosion, and corrosion of gas generators. Depending on design, air intakes also house anti-icing (heating) systems, blow in (bypass) doors and weather (snow) hoods. They also incorporate design features to reduce noise emissions from gas generators. The structural integrity must be maintained to prevent the intake from becoming a source of contamination which would damage the gas generator. Figure 2 shows a typical gas generator air intake on the NTS. The typical filtration efficiency required is ASHRAE MERV class.

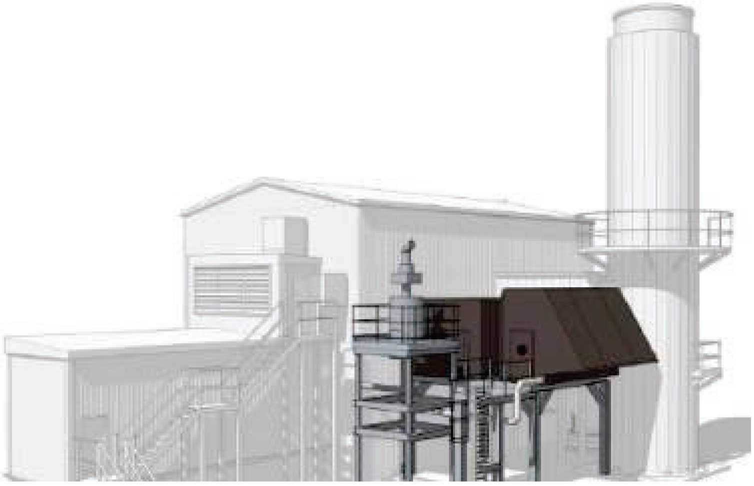

Figure 2: Air intake for gas compressor unit

Exhausts

4.2.8 Installed on gas driven compressor units, exhausts enable effective dispersal of gases and attenuate noise.

4.2.9 Exhausts are large steel structures varying in height from 5m to 15m with diameters of >4m comprising of external cladding, noise attenuation features (typically ‘bullet baffles’ to smooth airflow) and gas sampling, monitoring and inspection points.

4.2.10 Attenuation of exhaust noise is required to maintain compliance with environmental permit limits. Dispersing exhaust gases (typically 400°C – 500°C) away from ground level limits heat emitted into the Cab.

4.2.11 The nature of the operating cycle is such that corrosion of carbon steel ductwork is a significant issue, and exhaust ducts have a finite life. Figure 3 shows a typical gas generator exhaust on the NTS.

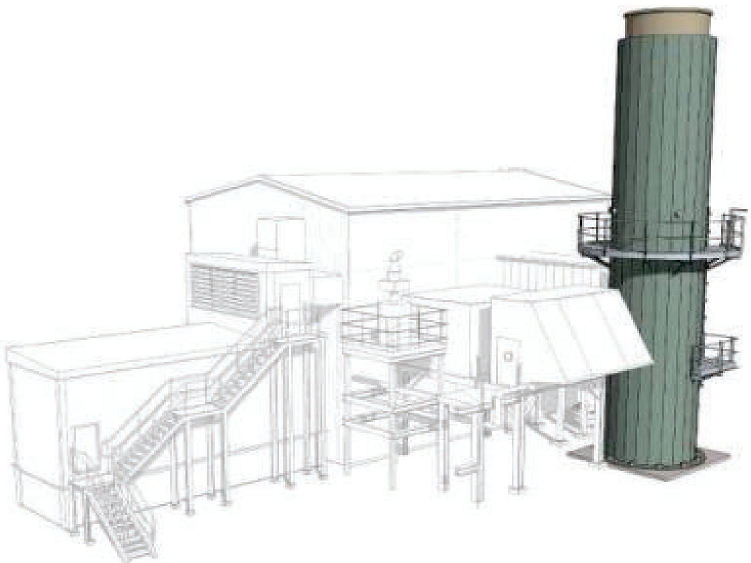

Figure 3: Typical exhaust on a gas generator

Ventilation System

4.2.12 Ventilation systems are applicable to both gas and electric driven compressors. They enable compressor Cab cooling and prevent build-up of explosive atmospheres within Cabs.

4.2.13 Suitable airflow reduces the heat created from gas generators and power turbines to prevent overheating which causes associated trips and equipment deterioration.

4.2.14 Cab ventilation includes primary and emergency back-up fans, fan motors (usually AC for primary fans and DC for emergency back-up fans), motor control and protection systems, cabling, ducting, filters, and louvres. Figure 4 shows a typical gas generator ventilation asset on the NTS. Cooling systems for VSD units are in scope of the Compressor Rotating Machinery EJP[14].

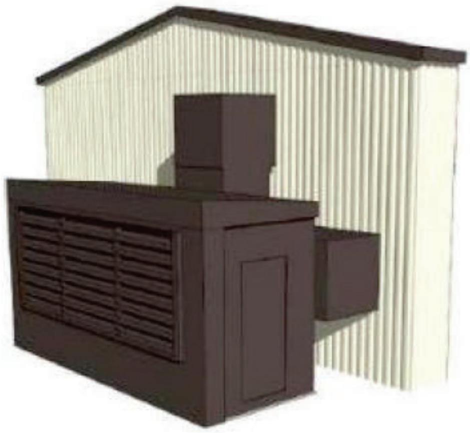

Figure 4: Compressor Cab ventilation asset

Cab Enclosure

4.2.15 Cab enclosures provide a weatherproof, sound attenuating and sealed environment to protect compressor train assets. A key function of the enclosure is to contain any gas/fire risk and enable safety systems to operate.

4.2.16 Designs of enclosures present on the NTS vary depending on age and compressor technology, either taking the form of a close- fitting enclosure around the compressor train or a much larger building providing easier access. Cab enclosures contain the following integral elements.

Permanent Lifting Beams

4.2.17 Where installed, permanent lifting beams are used to remove heavy machinery such gas generators and power turbines from within Cabs during maintenance. 75% of Cabs rely on temporary A-frames to be erected. These large heavy pieces of equipment also require additional lifting beams to be connected to Cab internal lifting beams, during which The Work at Height Regulations 2005 must be complied with.

Cab Cranes

4.2.18 90% of Cabs have permanent cranes installed to lift large items such as gas generators and power turbines. Cranes must be appropriately rated for lifting the heaviest maintainable components equipment and are subject to Lifting Operations and Lifting Equipment Regulations 1998 (LOLER) under the Health and Safety at Work etc. Act 1974.

4.3 Problem Statement

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

4.3.1 Cabs across the NTS are aging assets that suffer from weathering, mechanical wear, and corrosion. Without investment, continued deterioration would cause increased defects, resulting in non-compliance with legislation leading to them potentially being condemned on safety and environmental grounds with consequential impact to compression availability for NTS operations. Drivers for investment in Cabs include those summarised below:

Table 5: Categories of driver for cabs

Driver Category	Description
Legislation	Compliance with Dangerous Substances and Explosive Atmosphere Regulations (DSEAR) and Lifting Operations and Lifting Equipment Regulations (LOLER) legislation.

[14] NGT_EJP04_Rotating Machinery_RIIO-GT3

Driver Category	Description
	Cabs ensure compliance with Environmental Permits issued by Environment Agency, Scottish Environment Protection Agency and Natural Resources Wales.
Industry Standards and Safety	HSE Guidance PM84 and BS ISO 21789: Control of Safety Risk at Gas Turbine Enclosures. Cabs are located at the centre of hazardous areas on compressor station to provide containment as part of safety systems.
Asset Deterioration	Most Cabs are 30 to 40 years old, with some being over 50 years old. Deterioration of these assets includes corrosion, mechanical wear, and component failure. These problems reduce the efficacy of Cabs to protect other assets including compressor machinery trains.

4.3.2 Cabs house compressor trains in a weather tight, noise attenuating enclosure in line with permitted noise levels set by the Environment Agency (EA), Scottish Environment Protection Agency (SEPA) and Natural Resources Wales (NRW). The ageing structures are deteriorating due to weathering and defects reported are predominantly due to corrosion. Cab integrity is critical to ensure the ventilation system can perform its function, evacuating potentially explosive gases from the enclosure. Failures in the structural integrity of the Cab housing may also impact upon the ability of the ventilation system to maintain the optimum working temperatures for the compressor train. Should the Cab housing not maintain water tightness, water ingress may also occur, potentially damaging electrical and/or control assets.

4.3.3 As a result, Cabs require ongoing inspections and maintenance. Corrosion of corrugated sheet plates leads to weak points in the structure, resulting in a reduction in noise attenuation and ventilation capability, leading to compressor trips. Cab enclosures that comprise flat roof segments are prone to leaks. Door seal failures deteriorate ventilation performance and the ability to maintain pressure within the enclosures.

4.3.4 Air intakes have a design life of 20 to 30 years, during which time the filter media are periodically replaced. Replacement components, or the full air intake assembly if required, are refabricated at the end of their useful life. Failure and wear of internal components can create foreign bodies (such as zinc and rusting steel particles) which are drawn into the gas generator engine causing damage. Some air intakes in colder months suffer from icing on the entry point, leading to temporary bypass (where bypass doors are installed) of the filtration, and requires manual intervention to dislodge any ice.

4.3.5 Moisture accumulation in Cabs has been confirmed to be causing pitting on high value primary components such as turbine blades. This being a primary driver for incorporating dehumidifiers on air intakes.

4.3.6 Poor ventilation is causing hot spot areas where ventilation is not performing the required task and leading to non-compliance to ISO21789. High temperatures also lead to non-compliance with DSEAR regulations on electrical and electronic equipment within the Cab. Old designs built before Computational Fluid Dynamics (CFD) technology need a CFD model to demonstrate how Cabs comply with ISO 21789 which sha5ll also inform any issues enabling targeted intervention. Complying with ISO21789 demonstrates full alignment with the safety aspects within HSE PM84.

4.3.7 Being exposed to the elements and to extreme temperatures, exhausts have a finite life before requiring refurbishment or replacement with a new assembly. Annual inspections are undertaken with more intrusive inspections undertaken every five years. When performing inspections, there is no entry point to the stack other than through the top. This presents a safety risk and costly mitigation measures are required to perform the task.

4.3.8 Lifting beams facilitate removal of heavy machinery (i.e., gas generator, power turbine etc.) from compressor Cabs via the machinery doors. On the units in this scope, this currently requires the erection of a large and heavy A-frame adjacent to the Cab and the installation at height of a lifting beam on top of the A frame to connect it to the Cab internal lifting beam. The operation requires hiring a specialist lifting contractor and involves working at height to assemble the bolted connections to the internal beam and the A frame. Recommendations in the Incident Management System (IMS) investigation 8489/10/NG (Appendix A (9.1)) presented an investment requirement to install permanent lifting beams.

4.3.9 Lifting beams have already successfully been installed in two phases across the NTS including 15 [redacted] gas generator Cabs at [redacted] compressor stations. This paper is, therefore, focusing on other units where the same investment driver applies. The Cabs in this scope are of a similar design to those already modified and are part of the fleet requirements into the future.

4.3.10 Cranes are installed in Cabs. There is need for investment following a condition survey (report Appendix A (9.1)) and Appendix B (9.2) at [redacted] Compressor Station which highlighted the safe working load (SWL) of the crane is less than the gas turbine weight. The 4 tonne SWL is insufficient to remove the gas turbine which weighs 6 tonnes. When the High-Speed Pressure Turbine (HSPT) exchange was undertaken in 2017 at [redacted], a specialist forklift had to be hired to raise the HSPT 5 metres high at an extended reach. The PT is due for overhaul, meaning benefit of the crane replacement shall be realised in RIIO-GT3.

Effects of no investment

4.3.11 Not investing in Cab assets would lead to continued deterioration, limiting effective operation. If these assets are not operating effectively, they make the compressor units unsafe and inoperable increasing risk to the availability of the gas supply, with knock on impacts to consumers.

4.3.12 No investment in the air intake and its components will lead to increased corrosion, wear and failure causing inefficient running, increased wear and costly damage to the gas generators. Air intake systems are key to ensuring the gas generator operates effectively and safely as it holds the filters that clean the air.

4.3.13 Poor performance of air intakes results in damp air accumulating in Cabs causing damage to the gas turbine resulting in high turbine repair costs for new casings and turbine blade damage. This has resulted in confirmed pitting of power turbines, rectification of which requires a complete overhaul of the turbine and reconditioning or replacement of blades. Therefore, the air intakes need to be modified to incorporate dehumidifiers.

4.3.14 Figure 5 shows the effect of moisture accumulation within a Cab on an [redacted] Compressor Station.

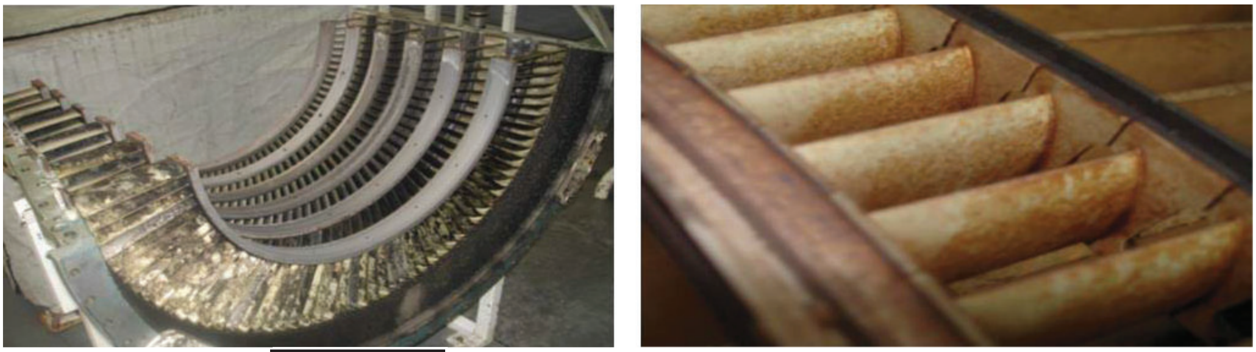

Figure 5: [redacted] IP Stator Casing Corrosion (Left) and Corroded HP Stator Vanes (Right)

4.3.15 Ineffective ventilation systems result in inadequate flow of air to cool the gas generators and their associated safety and control equipment within the Cabs leading to potential failures due to hot spots. The system will also not comply with DSEAR regulations due to temperature going above the certification of electrical and electronic components. Cooling systems on electrically driven compressor units are considered in the Rotating Machinery EJP[15]. Any gas escape may not be effectively routed through the Cab and dispersed, leading to a potential build-up of an explosive atmosphere. This increases the probability and frequency of compressor trips linked to climate change, the effects of which shall be surveyed in RIIO-GT3 aligned to the Compressor Fleet EJPs[16][17][18][19].

What is the outcome that we want to achieve?

4.3.16 The desired outcomes for RIIO-GT3 are:

- Meet legal requirements and agreed safety standards (e.g., compliance with PM84 HSE / ISO21789-Control of Risk around Gas Turbine Enclosures and DSEAR, LOLER).
- Manage deterioration of the assets such that they do not limit availability, performance or cause damage to gas turbines or safety systems.

[15] NGT_EJP04_Rotating Machinery_RIIO-GT3
[16] NGT_EJP013_Compressor Fleet – Network Investments and Zone 1 (Scotland)_RIIO-GT3
[17] NGT_EJP014_Compressor Fleet - Zones 2 and 3 (Central)_RIIO-GT3
[18] NGT_EJP015_Compressor Fleet - Zones 4 and 5 (South Wales and South West)_RIIO-GT3
[19] NGT_EJP016_Compressor Fleet - Zones 6 and 7 (East Midlands and South East)_RIIO-GT3

- Improving ventilation to meet HSE requirements and managing hot spots in Cabs due to high temperatures. With effective ventilation, overheating related compressor trips are avoided.
- Providing benefit to consumers through optimised investment to ensure the Cabs last as long as compression is needed, balancing cost, risk and performance.

How will we understand if the spend has been successful?

4.3.17 The spend will have been successful if Cab defects identified through internal and external surveys have been addressed leaving them compliant. As secondary assets, Cabs should not adversely affect availability of compressor assets.

Narrative Real-Life Example of Problem

4.3.18 Surveys conducted to assess condition of Cabs have identified numerous problems. Table 6 below summarises the findings for [redacted], the full detail of which can be found in Appendix F (9.6).

Table 6: [redacted] *survey results*

Cab Asset	Finding	Report reference
Ventilation System	The ventilation air velocity measurements of site have indicated that there are stagnant areas within the enclosure local to potential leak points. Without effective dilution a pressurised gas leak will rapidly build up a flammable gas cloud exceeding the allowable volume set out in BS EN ISO 21789: 2022 section 5.16.5.3.3 Para 3, negating the primary basis of safety, dilution of leaks to prevent or limit a flammable gas cloud. **It was recommended that the ventilation ducting be redesigned to better distribute the air flow for improved leak dilution and heat removal.**	Section 5.1.1
Air Intake filtration system	The filtration system was proved inadequate to protect the Gas Turbine Compressor from ambient conditions (the air particle sizes prevalent on site), and the shortfalls of the existing equipment in comparison with BS ISO 21789:2022 & COMP 33. **It is recommended that the system be upgraded to a modern-day air intake filtration system comprising snow hoods, inlet heating (if possible), mist eliminator vane and a multistage EPA filtration system and the material of construction be a minimum of stainless steel 304L for 25 years onward operation.**	Section 15.1
Exhaust	Shortfalls of the existing equipment in comparison with BS ISO 21789:2022 & COMP 33. **It is recommended that the system be retrofitted to a minimum stainless steel 304L for 25 years of onward operation. As the current GT exhaust system is supported by the existing GT package, which was not feasible to reverse engineer the existing structural design an independent support structure to the grid will be required.**	Section 15.4

Project Boundaries

4.3.19 Our investment considers all sub-assets including Cab enclosures, air intakes, exhausts, and ventilation systems. Other assets which are not directly part of the Cab such as lifting beams and overhead cranes are also included.

4.3.20 Excluded from this EJP:

- Asbestos related Cab investments which are contained in the Asbestos, Stabbings and Redundant Assets EJP[20].
- All Cab investments associated with St Fergus Terminal as this is submitted in a standalone justification paper, St Fergus – Civils EJP[21].
- Inspection and maintenance activities, including minor component OPEX repairs.
- Cooling systems which are included in the Compressor Rotating Machinery EJP[22].

4.4 Probability of Failure

Failure Modes

4.4.1 Probability of failure (PoF) has been assessed utilising historical defects, results from surveys and utilising our NARMs model. This model is 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.

[20] NGT_EJP01_Site Assets - Asbestos, Stabbings and Redundant Assets_RIIO-GT3
[21] NGT_EJP32_St Fergus: Civils_RIIO-GT3
[22] NGT_EJ04_Rotating Machinery_RIIO-GT3

4.4.2 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. Likely failure modes for Cabs are provided in Table 7.

Table 7: Cab Failure modes

Failure Mode	Average Proportion of Failures
Structural damage leak affecting electrical control equipment loss of control/monitoring	0.44
Loss of environmental protection/monitoring	0.17
Loss of unit – trip	0.17
Loss of gas unit – trip	0.08
Loss of vent capability	0.07
Unable to maintain equipment	0.07

4.4.3 Table 8 shows forecasted failures within RIIO-GT3 assuming nil investment. 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.

Table 8: Forecast Cab failures

Asset Type	No. of Assets	Cumulative Average Failure Rates					Forecast Failures per Year				
		2027	2028	2029	2030	2031	2027	2028	2029	2030	2031
Buildings-Compressor Cab	89	0.61	0.63	0.64	0.65	0.67	1.24	1.35	1.25	1.10	1.15
Gas Turbines-Aero Derivative-Air Intake	48	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00
Gas Turbines-Aero Derivative-Exhaust	47	0.84	0.86	0.88	0.89	0.91	0.93	0.94	0.80	0.66	0.53
Gas Turbines-Air Intake	4	0.77	0.77	0.77	0.77	0.77	0.00	0.00	0.00	0.00	0.00
Gas Turbines-Exhaust	3	0.35	0.35	0.35	0.36	0.36	0.01	0.01	0.01	0.01	0.01
Gas Turbines-Industrial-Air Intake	10	0.94	0.95	0.96	0.98	0.99	0.08	0.10	0.11	0.12	0.13
Gas Turbines-Industrial-Exhaust	10	0.61	0.63	0.66	0.69	0.72	0.19	0.23	0.27	0.32	0.37
Heating/Cooling Media-Air Conditioning	9	0.76	0.79	0.81	0.82	0.83	0.17	0.21	0.17	0.12	0.15
Heating/Cooling Media-Extractor Fan	1	0.18	0.22	0.27	0.32	0.39	0.03	0.04	0.05	0.05	0.06

Survey Results

4.4.4 Alongside modelled failures, survey results have been used to understand actual failures of Cab assets. As an example, Table 9 shows the defects on [redacted] following extensive site inspections. A detailed survey report is shown in Appendix G (9.7). These results are synonymous with survey results of [redacted]

Table 9: [redacted] Cab specific defects

Cab Asset	Defect description summary	Recommendation
Air Intake	• The current filter solution pertains to a pre-filter stage which is of outdated technology offering only a G3 (general) efficiency, and final filter stage which offers only F8 (fine) filter efficiency. No additional protection against excess moisture is offered with the existing filter media, despite generally high levels of moisture and humidity (>82% average annual relative humidity) present at this site. • Corrosion is also heavily present on the roof casings of the filter house and transition ducting to the intake. [Section 4.1 of the report]	• Replacing the combined combustion / ventilation filter house with a sufficient casing and internal material (stainless steel 304L minimum) to achieve a 25-year design life, with upgraded filtration technology offering the latest EPA efficiency (E10 or above). The use of EPA filtration significantly reduces the frequency of turbine water-washing maintenance intervals, which leads to a long-term cost benefit and lower site operating costs.
Exhaust	• Excessive corrosion and fatigue/thermal cracking was observed at various locations within the exhaust external casing or internal lining structure. • Cracking is also clearly visible at the bolting interface on the cross-brace (support channel) that spans / supports the exhaust silencer baffles, which indicates a loss of integrity of the baffle support and could lead to further degradation and eventual shearing of the support bracing from the exhaust baffle in question. • It is clear from the visible hot-spots that insulation has degraded and fallen into the lower sections of the exhaust liner between the external case and internal lining. [Section 4.2 of the report]	• Replacing the combustion exhaust with a new, internally lined combustion exhaust system in accordance with best available technology in order to offer structural integrity and achieve a 25-year design life, with stainless steel material grades and high integrity acoustic / thermal insulation. • Consideration would also be given during the concept design (FEED) stage to the use of a 'bullet' type combustion exhaust silencer and the associated acoustic and pressure loss characteristics versus the currently installed 'baffle' type exhaust silencer, with a view to offering the most optimised, best performing silencer configuration

Cab Asset	Defect description summary	Recommendation
Ventilation System	• Cab A was filled with smoke and then the ventilation fan started to identify any potential air leakages from the Cab area. Loss of Integrity / leaks to all doors and frames was observed. [Section 3.3 of the report]	• Ventilation system replacement. • CFD analysis in line with the 3D dimensional scan carried out during the survey, to offer a more 'simple' and optimised replacement ventilation system design.

4.4.5 Most Cab assets deteriorate resulting in poor performance which leads to further deterioration and eventual failure. Deterioration results in them not meeting the original design specification and requirements of current safety standards BSISO 21789.

4.4.6 All Cab infrastructure interventions are defined as consequential interventions as their prime function is to protect assets comprising the compressor train and ensure noise is within permitted levels. Consequential intervention is defined as "any intervention on a network asset or other infrastructure asset that modifies the probability of failure or consequence of failure of another network asset".

4.4.7 Corrosion is the main failure mode, and this is applicable to sub assets such as the Cab enclosure, duct work and exhausts resulting in holes on roofs, walls, and door seals. This prevents Cabs from maintaining positive pressure rendering ventilation systems ineffective. Other failure modes include fan motors failing within the ventilation system. Drivers to ventilation deterioration are largely because of fluctuating weather conditions.

4.4.8 The consequence of deterioration of ventilation systems is Cab overheating causing compressor trips resulting in unreliability and unavailability. Also exceeding the safe design temperatures of electrical equipment which makes DSEAR certification invalid.

Probability of Failure Data Assurance

4.4.9 NARMS Probability of Failure data was sourced using a Power BI dashboard, with data supplied from our Copperleaf asset management decision support system.

4.4.10 The evidence obtained from various survey results informed the need to conduct interventions proposed in this EJP.

4.5 Consequence of Failure

4.5.1 The consequence of failure for our Cabs assets, is presented below mapped against our NARMS Consequence of Failure service risk measures. The consequence of failure summary is presented in Table 10.

Table 10: Consequence of failure summary

Sub Asset	Impact / Consequence			
	Availability	Environment	Financial	Safety
Air Intake	Failure and wear of internal components can create foreign bodies (e.g., zinc particles) which are drawn into the gas generator engine causing damage resulting in loss of operation. Reduced efficiency of the turbine due to increased pressure drop across the filters. Unfiltered air will result in the turbine blades getting dirty and therefore less efficient, and potential to cause damage to the blades which could result in failure and outage affecting gas flows.	Associated with the loss of gas through trips and vents of the compressor unit.	Mostly associated with OPEX costs of operating and maintaining the network at the current level of risk.	Personnel safety due to increased intrusive maintenance and gas turbine washing. Exposure to excessive noise above acceptable levels.
Cab Enclosure	Associated with the potential unplanned outages associated with the loss of compressor trains because of failure of the Cab enclosure. This is an indirect effect and only a small proportion of enclosure failures will generate a unit trip and associated outage. Unplanned outages following noise permit incursions could occur.	Associated with the loss of gas through trips and vents of the compressor unit, caused by the failure of a fire suppression system. This is an indirect effect and only a small proportion of system failures (Enclosure, Ventilation, Exhaust, Fire Suppression) will generate a unit trip and associated vent of gas.	Mostly associated with OPEX costs of operating and maintaining the network at the current level of risk. Financial penalties for noncompliance with safety and environmental legislation.	Exposure of operatives to excessive noise above acceptable levels. Reduced effectiveness of the fire suppression system which relies on the Cab being sealed to prevent more oxygen getting in to feed the fire. Pressure differentials can result in doors

Sub Asset	Impact / Consequence			
	Availability	Environment	Financial	Safety
Cab Ventilation	When ventilation starts to fail, other enclosure assets can be damaged by heat build-up and safety controls become less effective. Trips and	Potential noise excursions result in non-compliance with environmental permits.	Potential financial penalties for being unable to supply gas as and when it is needed and associated entry constraints. Loss of value to consumers	Potential for overheating of Cab enclosure and Asphyxiation. Stagnant areas and recirculation of ventilation air can allow an explosive atmosphere to build up in the enclosure potentially resulting in an explosion.
Cab Exhaust	Ineffective dispersion of combustion gases. Potential for larger sections dropping and leading to turbine damage. Hot gases would enter the enclosure, causing overheating and a trip			Exposure to excessive noise above acceptable levels. Potential for sections of debris to be fired from the stack posing a risk to personnel.
Cranes / Lifting beams	Defective cranes and lifting beams will result in increased outage durations as alternative lifting equipment will be required.	Failure of, or inexistence of equipment will require equipment to be transported to site.	Crane or lifting beam failure whilst lifting machinery resulting in damage. Legal action could be imposed if regulations not abided by.	LOLER requires all equipment used for lifting is fit for purpose and appropriate for the task. Any failure could result in damage to people, plant & equipment.

4.6 Interventions Considered

4.6.1 The interventions in this EJP have been developed primarily based on the findings of extensive surveys which assessed condition, compliance with legislation and standards as well as internal policy. Interventions considered aim to address specific issues and defects considering best available techniques and benefits to the NTS. The scope of interventions is detailed as follows:

Counterfactual (Do Nothing)

4.6.2 This option entails retaining the current status quo and continuing in the current operation and maintenance mode. This approach applies to all Cab sub assets and is ruled out as no investment generates a compounding increase in service risk across all service risk categories.

Air Intake Refurbishment

4.6.3 Replacement or repair of parts of the air intake mainly after intrusive surveys which identify defective components. Typical refurbishment scope includes one or a combination of crack repairs, clean corrosion, replace blow in door seals and adding stages of filtration. The downside of this approach is that it provides a partial solution to the problem.

Air Intake Replacement

4.6.4 This entails the complete replacement of a defective air intake with a new filter house, dehumidifier, replace silencer and plenum walls. The main benefit is that it provides the longest whole life and best available technologies are considered in choosing the replacement air intake.

Exhaust Refurbishment

4.6.5 This intervention involves re-life of defective components. Typical exhaust refurbishment scope includes one or a combination of crack repairs, gasket replacements, bellows and expansion joint replacement and internal lining replacement. A full detailed inspection can only be carried out by removing the exhaust into its component parts, inspecting and repairing which is normally not cost effective due to amount of welding and fabrication required to repair the exhaust.

Exhaust Replacement

4.6.6 This entails complete replacement of the exhaust stack with a new one. This mitigates against realising the need for complete replacement whilst attempting to carry out a refurbishment which has been an issue during RIIO-T2.

Ventilation Refurbishment

4.6.7 This intervention involves re-life of defective ventilation system components. Typical scope includes the overhaul of dampers, vent fans and motors as well as installation of additional fans and ducting.

Ventilation Replacement

4.6.8 This entails the complete replacement of the ventilation system with a new one.

Cab Structure Roof repairs

4.6.9 This intervention involves the complete replacement of only the roof of a Cab to address leaks. This involves the removal of roof panels and roof relining, replacement including installation of guttering system.

Cab Structure Replacement

4.6.10 This involves the complete replacement of the Cab structure.

Permanent lifting beams installation

4.6.11 This involves the permanent installation of lifting beams as an alternative to erecting A-Frames to facilitate lifting operations during maintenance. This is a safety requirement.

Crane Upgrades

4.6.12 This involves replacing an undersized crane with one with a higher maximum safe working load (SWL) to meet operational and safety requirements. It also relates to replacing manually operated cranes with electric cranes to reduce manual handling and mitigate risks associated with operating cranes in line with LOLER.

4.6.13 Table 11 summarises the interventions considered for RIIO-GT3.

Table 11: Cabs interventions technical summary

Option	Investment benefit (years)	Positives	Negatives	Taken forward
Do nothing	N/A	Low-Cost option in the short term	Disregards all the current and forecasted asset health issues. Increased risk to unavailability of the plant because of outages to remediate high risk defect	No
Air Intake Refurbishment	10-15 years	Defect resolution.	Does not address lessons learned during previous refurbishment interventions. Does not provide ability to mitigate against climate change as original design cannot be retrofitted with a dehumidifier in future.	No
Air Intake Replacement	30 years	Addresses all the highlighted investment drivers and enables the installation of a new design with a dehumidifier. Clearly defined scope boundaries removing ambiguity to ensure cost and schedule adherence.	Long-lead item as manufactured to requirements	Yes
Exhaust Refurbishment	10-15 years	Defect resolution.	High risk of the need to completely replace the exhaust upon finding irreparable damage during the project. High likelihood of finding multiple deteriorations within the stacks.	No
Exhaust Replacement	30 years	Lowest whole life cost. Significant design life. Replacement provides defined scope boundary to ensure cost and schedule adherence	High initial cost but low overall whole life cost because of reduced OPEX and costly reactive repairs	Yes
Ventilation Refurbishment	10-15 years	Defect resolution.	Aged assets no longer suitable for refurbishing. Systems would require costly upgrades to meet current standards. High likelihood of programmatic challenges including scope creep leading to significant cost and schedule risks.	No
Ventilation Replacement	30 years	Mitigates identified ventilation asset health issues such as hot spots. Maximum age benefit. Clearly defined scope reduces delivery risk.	High initial cost but low overall whole life cost because of reduced OPEX and costly reactive repairs.	Yes

Option	Investment benefit (years)	Positives	Negatives	Taken forward
Cab Structure Roof repairs	30 years	Addresses identified roof leaks at an optimum cost centred on specific defect.	Additional patch repairs may be required in other areas of roof.	Yes
Cab Structure Replacement	30 years	Addresses known defects and provides maximum age benefit. Design can be optimised to align with current and future operational conditions and requirements.	Low-cost benefit as the identified defect is centred on the roof only.	No
Permanent lifting beams	40 years	Ensures safety of personnel and machinery. Self-sufficient to move equipment.	Cost to install.	Yes
Crane SWL Upgrade	25 years	Ensures cranes meet operational and safety requirements e.g., LOLER. Negates need to hire in specialised lifting equipment at cost.	Cost to install.	Yes
Upgrade to Electric Crane	25 years	Health and safety benefits including LOLER	Cost to install	Yes
Replace Cab doors	20 years	Addresses identified defects	Only addresses doors, not other aspects of Cab.	Yes
Cab surveys	N/A	Proactively assesses condition and ensures ongoing compliance with relevant legislation, standards to make informed decisions.	Does not directly address condition.	Yes

Volume Derivation

4.6.14 Volumes for the interventions have been determined from known defects and from the outputs of extensive surveys conducted by specialist third party organisations and internal assessments. Table 12 summarises how intervention volumes have been derived for Cab assets.

Table 12: Intervention volume justification

Intervention	Volume	Unit of measure	How this volume has been developed
Air Intake Replacement	[redacted]	Per Cab	Extensive third-party surveys have been undertaken for 7 of the 9 (78%) proposed units which all confirmed defects requiring air intake replacement. Results for the remaining 2 Cabs (22%) are still pending, but the probability of them being in the same condition has been assessed as being very high as they are of similar age and condition.
Exhaust Replacement	[redacted]	Per Cab	Results of external surveys highlighted need for replacement.
Ventilation Replacement	[redacted]	Per Cab	Extensive third-party surveys have been undertaken for 7 of the 12 proposed units which all confirmed defects requiring complete replacement. Results for the remaining units are still pending, but the probability of them being in the same condition has been assessed as being very high as they are of similar age and condition.
Cab Structure Roof repairs	[redacted]	Per Cab	There is a confirmed defect (leaking roof) which requires CAPEX expenditure to remediate this single volume.
Permanent lifting beams	[redacted]	Per Cab	The two volumes have beams of no known SWL. There is a need to install permanent lifting beams of a known design.
Crane Upgrade	[redacted]	Per Cab	The one volume relates to the crane which has been confirmed to be sized below the safe working load.
Upgrade to Electric Crane	[redacted]	Per Cab	Known locations with manual chain cranes.
Replace Cab doors	[redacted]	Per Cab	Extant defects.
Cab Surveys	[redacted]	Per Cab	Continuation of the rolling Cab survey programme to proactively inform future Cab investment needs.

Unit Cost Derivation

4.6.15 Unit costs for the interventions in Table 12 are based on costs incurred to deliver comparable scopes during RIIO-T2 and first principle estimating methods using known rates, contractor costs including quotes. A summary is provided in Table 13 with a further breakdown of costs provided in Appendix D (9.4).

Table 13: Cabs intervention unit cost summary (£m, 2023/24)

Option	Unit of Measure	Unit Cost	Cost Accuracy	Number of Data Points	Source Data
Air Intake Replacement	Per Cab	[redacted]	[redacted]	1	Estimate at Completion
Exhaust Replacement	Per Cab	[redacted]	[redacted]	1	Estimate at Completion
Ventilation Replacement	Per Cab	[redacted]	[redacted]	5	Estimate at Completion
Cab Structure Roof repairs	Per Asset	[redacted]	[redacted]	5	Estimate at Completion
Permanent lifting beams	Per Cab	[redacted]	[redacted]	0	First Principles
Crane SWL Upgrade	Per Cab	[redacted]	[redacted]	0	First Principles

Upgrade to Electric Crane	Per Cab	[redacted]	[redacted]	0	First Principles
Replace Cab doors	Per Cab	[redacted]	[redacted]	0	First Principles
Cab Survey	Per Cab	[redacted]	[redacted]	0	First Principles

4.6.16 Cost accuracies are determined based on types and availability of data including quantities (i.e., the number of data points) and the similarity of the scope of work performed versus the RIIO-GT3 investment programme. Interventions Table 13 with a +/-50% cost accuracy relate to interventions where suppliers were unable to provide accurate estimates due to fluctuations in markets and the protracted procurement time from initial rough order of magnitude cost to future design, fabrication, delivery, installation, and commissioning as applicable. Similarly, lessons learned show that early cost estimates for repair interventions can be inaccurate due to each repair being bespoke.

4.6.17 As an example, the estimated cost for the "Replace Cab doors" intervention has been derived from using costs provided by our [redacted] The installation of the doors used known labour rates with the project being assessed as low risk based on complexity, cost, and criticality. This resulted in a contingency allowance of 10% being applied to the net cost of the project.

4.6.18 Cost estimates for Air Intake and Exhaust Replacement interventions use at least one data point from the NGT_AH2_14 Cab Infrastructure and Fire Suppression Uncertainty Mechanism (UM) originally submitted to Ofgem in June 2023 (updated in September 2023 subsequently reissued in March 2024). These data points have been validated and are the closest reflection of the scope in this EJP.

5 Fire Suppression Systems (FSS) - £8.3m (2023/24)

5.1 Introduction

5.1.1 This section of the EJP requests funding to manage risk, remain compliant with legislation and address known asset health defects associated with Fire Suppression System (FSS) in Cabs. This request excludes Variable Speed Drive Cabs which do not have water mist systems.

5.1.2 The purpose of FSS assets is to extinguish fires within Cab enclosures to prevent fire escalation and minimise risk of damage to people, plant, equipment, and environment.

5.1.3 In the RIIO-T2 period, nitrogen-based FSS assets were sanctioned for replacement with electric pump systems on units such as [redacted]. This was after surveys revealed non-conformity to BS ISO 21789 and systems were not meeting OEM recommended capacity requirements. This EJP requests funding to continue rolling out this programme of work to Cabs elsewhere on the NTS aligned to the survey findings.

5.1.4 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 Excel EJP.

5.2 Equipment Summary

5.2.1 FSS have built-in components to detect fires as early as possible by identifying the presence of flames and smoke. The FSS then initiate alarms before activating suppression to subdue the fire before it spreads. A FSS can be considered an 'active' fire protection method because the system is triggered in response to the presence of fire. A summary of FSS equipment is presented below, with additional information such as health score at the beginning and end of the price control and monetised risk provided in the accompanying Excel EJP.

5.2.2 There are three main types of fire suppression:

- Type 1 – 200 bar nitrogen bottles are used to directly pressurise water bottles when the system is activated. This forces the water through spray heads into the enclosure to extinguish the fire. This type is typical for small older enclosures with four to fifteen spray heads.
- Type 2 – 200 bar nitrogen bottles drive a gas driven pump that takes water from a large water tank and forces it through spray heads into the enclosure. These can protect large enclosures but require approximately 30 nitrogen bottles. For each fire incident, the discharged nitrogen bottles must then be replaced.
- Type 3 – Electric motor driven pumps take water from a larger water tank. These remove issues with nitrogen but require electric supply infrastructure to be installed including necessary power generation backups.

5.2.3 A FSS typically includes:

- A temperature-controlled enclosure including thermostat and electric heater to maintain bottles at suitable temperature to avoid a pressure drop and to stop water from freezing.
- 200bar Nitrogen or a nitrogen/electric driven pump.
- Water cylinders or a bulk water storage tank.
- Discharge manifold, distribution piping and spray heads (stainless steel).
- Electrical solenoid actuator valves.
- Pneumatically actuated slave valves.
- Pressure switches (to monitor nitrogen cylinder pressure and confirm system operation).
- High pressure flexible hoses.
- System isolation valve and limit switch.
- A changeover switch from main to reserve system.
- Some utilise a pump unit and water storage tank rather than water cylinders.

5.2.4 Fire suppression systems are permanently installed on every gas generator enclosure on sites across the NTS. PSSR stipulates five and ten yearly inspections for hoses, water bottles and actuators. If fire suppression is not available, compressors cannot operate. Figure 6 shows water mist cylinders for [redacted] which was surveyed as part of investment build up for this EJP.

Figure 6 [redacted] water mist cylinders

Redundancy

5.2.5 The existing electric motor systems installed on the NTS are considered safe, reliable, and compliant, so are not being considered for replacement. The redundancy description that follows therefore only applies to nitrogen-based systems.

5.2.6 There are typically two banks of nitrogen bottles, primary and reserve for each compressor Cab with a manual changeover to allow for maintenance, repair and refurbishment and availability following a discharge of the primary bank. No automated change-over exists, so any failure of the primary systems impacts the availability of the whole compressor unit. The second bank contains additional bottles in case the fire is sustained for a long period of time and not as redundancy.

5.3 Problem Statement

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

5.3.1 Older non-pumped mist systems were designed to have a 5-minute mist duration, but current standard NFPA750 requires a minimum 30-minute duration should be available.

5.3.2 These aging assets also suffer from corrosion and wear related deterioration. Ongoing defects on the assets are reducing their effectiveness which, without intervention, may lead to further non-compliance with legislation.

5.3.3 Without reliable and fully functioning FSS, the associated gas compressor cannot operate. This limits the availability of the compressor unit with consequential impacts to NTS resilience and security of supply to customers.

5.3.4 The drivers for investment in FSS assets include those summarised in Table 14 below:

Table 14: Categories of driver for fire suppression systems

Driver Category	Description
Legislation	High-pressure elements (hoses, bottles, actuators etc.) of FSS require five and ten yearly inspections and revalidations to comply with PSSR.
Industry Standards	Many of the systems are no longer suitable for the design of the Cabs that they are installed to protect. The HSE expects all installations of this type to meet to comply with the latest standards as a condition of the ongoing licence to operate. Specific standards include ISO 21789, NFPA750, BS ISO14520, BS5306 and HSE PM84.

Driver Category	Description
Asset Deterioration	Elements of FSS assets are deteriorating due to age, corrosion, and wear. This has been known to leave deposits in pipework, bottles and hoses which cause blockages in spray heads. This in turn reduces the effectiveness of the overall system. Spare parts for the older systems have become obsolete, making it difficult to repair. This will also result in potential asset, safety, and environmental damage.
Safety	Failure to control a fire within a Cab will result in fire spreading to other equipment on site with associated risk to people, plant, equipment, and environment. Current systems utilise Nitrogen Bottles which require replacement with use. This involves multiple manual handling hazards associated with the replacement of Nitrogen bottles packed within an enclosure. All the assets considered in this scope have these issues which have resulted in safety incidents. Inadvertent Nitrogen discharge within the Fire Suppression kiosk poses a significant risk of fatality to an individual working within the premises. Nitrogen is an inert and suffocating gas that can be fatal.

5.3.5 If any FSS failed to operate correctly when required, a Cab fire could fail to be extinguished and escalate. The system primarily provides asset protection, but depending on the fire scenario there is also a risk to personnel safety and the environment.

What is the outcome that we want to achieve?

5.3.6 Maintaining the health of these assets is important in ensuring they continue to deliver the required capability. Specific outcomes associated with this investment are:

- Manage deterioration of the assets such that they are fully functional and of suitable design to not limit availability of the compressor units or cause damage to the compressor trains that they are designed to protect.
- Meet legal requirements and specified safety standards which define how quickly fires must be extinguished and what systems are suitable for gas turbine enclosures with the high temperature metal surfaces and complex machinery filled spaces.
- Ensure ongoing compliance with PM84 HSE / ISO21789 Control of Risk around Gas Turbine Enclosures and all other applicable industry standards. Section 18 of PM84 states that, ***"A fixed fire protection system should be installed to mitigate the consequences of a fire on a GT. This should be to an appropriate standard, such as NFPA750, BS ISO 14520, BS 5306 and as a minimum, designed to be capable of at least suppressing a fire on the GT or within the GT enclosure"***.
- Improve the safety of working on fire suppression systems by removing manual handling issues associated with heavy nitrogen bottles installed at height, removing risk of injury through replacement of high-pressure hoses and pipework, and limiting nitrogen asphyxiation risk.
- Providing benefit to consumers through optimised investment to ensure the fire suppression systems will be available in line with compressor fleet strategy to balance cost, risk, and performance.

5.3.7 To achieve these outcomes, continuation of the programme to replace nitrogen-based systems with electric pumps will be key.

How will we understand if the spend has been successful?

5.3.8 The spend will have been successful if the FSS defects identified through internal and external surveys have been suitably addressed to ensure compliance with legislation and industry standards.

Narrative Real-Life Example of Problem

5.3.9 Table 15 shows real life examples of FSS issues identified during third-party surveys conducted by fire specialists.

Table 15: FSS survey findings

Unit	Finding	Recommendation	Report reference
[redacted]	The manual handing and asphyxiation risk exists with operation and maintenance of the existing system. The current Nitrogen Propelled Fire Suppression system is inadequate for Fire Protection of the Site Bishop Auckland NT7240 Unit A.	Replacement of this system with an electric pump system will eliminate the manual handling and asphyxiation risk and will be designed to provide adequate fire protection for the volume of the Cab.	Section 3 (Appendix H (9.8))

Project Boundaries

5.3.10 The spend boundaries associated with this investment covers all sub assets of Cab fire suppression systems. It covers the replacement of assets such as nitrogen and water bottles, hoses, pumps, kiosks and associated instrumentation and control but no associated pipework or gas control systems.

5.3.11 The scope does not include FSS installed in Cabs at St Fergus.

5.4 Probability of Failure

Failure Modes

5.4.1 Probability of failure (PoF) has been assessed both utilising historical defects but also utilising our Network Asset Risk Metric (NARMs) model. This model is 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.

5.4.2 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.

5.4.3 Likely failure modes for fire suppression systems are provided in Table 16. All failure modes are available in the NARMS methodology.

Table 16: Fire suppression system failure modes

Failure Mode	Average Proportion of failure
Loss of gas quality information	0.87
Loss of fire protection if incident occurs	0.13
Loss of site trip	0.06
Los of unit trip	0.06
Loss of vent capability	0.05

5.4.4 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 17. 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.

Table 17: Forecast fire suppression system failures

Asset Type	No. of Assets	Cumulative Average Failure Rates					Forecast Failures per Year				
		2027	2028	2029	2030	2031	2027	2028	2029	2030	2031
Safety and Control (A.2.5)-Fire Fighting Equipment	5	0.74	0.77	0.81	0.86	0.91	0.15	0.17	0.20	0.23	0.26
Safety and Control (A.2.5)-Fire Fighting Equipment-Electric Motor	57	0.67	0.74	0.80	0.87	0.90	4.10	3.95	3.95	3.68	1.76
Safety and Control (A.2.5)-Fire Fighting Equipment-Fire Separator	5	0.54	0.55	0.56	0.57	0.58	0.12	0.05	0.05	0.05	0.05
Safety and Control (A.2.5)-Fire Fighting Equipment-Gas Equipment	16	0.52	0.53	0.56	0.58	0.59	0.23	0.29	0.36	0.38	0.20
Safety and Control (A.2.5)-Fire Fighting Equipment-Pump	3	0.75	0.80	0.84	0.87	0.92	0.13	0.14	0.12	0.11	0.12
Safety and Control (A.2.5)-Fire Fighting Equipment-Water Equipment	31	0.72	0.73	0.74	0.75	0.76	0.50	0.26	0.29	0.34	0.39

Survey Data

5.4.5 Independent water mist site surveys were undertaken to assess the existing nitrogen-based systems against required standards. Figure 7 shows common survey conclusions which highlight the inadequacies which have consequential safety, performance, and potential availability impacts.

> We have found using our [redacted] (Hydraulic Calculation software) that the current cylinder-based watermist systems protecting the Outer Compressor Building have a run time of 10.3 mins. and the systems protecting the Inner Turbine have a run time of 11.5 mins (utilising the nozzle data for a Fogtec® DK5-01). This solution is currently non-compliant and not adequate to control a fire in the Risk Area.

There is a safety concern regarding the nitrogen propellant leaking into the current cylinder kiosk/storage rooms potentially posing a high risk of asphyxiation to the engineering staff.

The 8mm tube and braided hoses monitoring the pressure in the cylinders are at a pressure of 180 – 200 bar, any failings in the tube or hoses would pose a serious threat of injury for any personnel within the kiosk.

There is a safety concern regarding the manual handling of the nitrogen and water cylinders; risk of musculoskeletal injuries. This could result in personnel fatality as identified and recorded in the NGT Hazcon minutes, a copy of which can be supplied upon request.

The existing nozzle layout would not meet the design requirements for a Fogtec® system but we cannot make any assumptions regarding the viability of the existing nozzle layout as there are no design details pertaining to the existing system manufacturers design requirements for this Risk Area.

We estimate the existing systems to be based on a design of circa 1998. These design standards have been superseded and therefore no longer comply to the latest code of British Standards BS EN 14972-1:2020 or NFPA750-2023. We are unable to provide certification for the current watermist systems including those pending modification. We cannot certify the current cylinder-based systems, neither the primary fire suppression instrumentation nor the current equipment being used.

Figure 7: Typical fire suppression system survey conclusions

Probability of Failure Data Assurance

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

5.4.7 10 surveys were conducted by [redacted] in winter 2023/24 to provide an up-to-date representative sample across the NTS of those listed in Appendix I (9.9).

5.5 Consequence of Failure

5.5.1 The consequence of failure for fire suppression systems is presented in Table 18 mapped against the NARMS Consequence of Failure service risk measures.

Table 18: Consequence of failure summary

Asset/ Sub Asset	Impact / Consequence			
	Environment	Financial	Availability	Safety
Fire Suppression System	Not being able to contain a fire within the Cab may lead to escalation of the initial incident resulting in larger fires or explosions which present environmental risks. Failure of FSS due to condition-based issues may cause inadvertent release of Nitrogen. There is also potential for FSS to cause a unit trip and associated vent of gas.	Failure of FSS when required would lead to damage requiring significant financial expenditure to remediate. Financial penalties can also be incurred for non-compliance with safety and environmental legislation. Potential financial implications for being unable to supply gas as and when it is needed and associated entry constraints.	Without a fully functioning fire suppression, system the associated gas compressor cannot be used. This limits the availability of the compressor unit and can impact the overall resilience of the NTS. Availability and reliability of the fire suppression system will be confirmed if quenching medium is released upon a fire outbreak.	The primary purpose of FSS is safety. If fire suppression systems do not operate as expected during outbreak of fire, there is a significant risk to people, plant and equipment including site personnel, emergency services. Failure to prevent escalation of the initial incident would pose greater risk to safety. There is also potential to cause fatal explosions involving the gas turbines in their acoustic enclosures if the unit fails to shut down and vent in an incident. 180 – 200 bar hoses pose a risk to personnel within the kiosks which are often confined space, hence the PSSR requirement. Inadvertent release of N2 within airtight enclosures or limited volume presents asphyxiation risk.

5.6 Interventions Considered

5.6.1 The work to phase out non-compliant systems and replace them began in RIIO-T2. There is a need to continue this work whilst considering cost, risk, and performance implications. The following interventions have been considered as summarised in Table 19.

Counterfactual

5.6.2 This do minimum option considers no specific interventions to be undertaken in RIIO-GT3. Routine operational maintenance activities will be done under OPEX. Despite being the lowest cost option in the short term, it does not address the investment drivers identified in this paper and presents multiple operational challenges. These include the need for hazardous interventions using OPEX budget and potential disruption to supplies and consumer impact.

5.6.3 This intervention is discounted as fire suppression systems should not be allowed to fail as this poses the failure consequences discussed earlier in this paper.

Refurbish existing system (Nitrogen Bottle System)

5.6.4 This intervention would aim to address survey findings which highlight deterioration that will result in failure. It includes revalidation against PSSR and changing all aged hoses, water bottles, actuators, and fittings.

5.6.5 Where possible, iterative improvements to the system may be undertaken where there is a small delta between the system versus optimal system design.

5.6.6 The current system utilises Nitrogen Bottles to propel water into the compressor housing via a distributed network of nozzles. Upon successful or spurious discharge, these Nitrogen bottles will have to be replaced with new bottles to bring the compressor back online. This involves multiple manual handling hazards associated with the replacement of Nitrogen bottles packed within an enclosure.

5.6.7 The downside of this option is that it results in residual risks being carried through due to some components being reused. Manual handling and asphyxiation risks are not removed with this option.

Replace System with new Electric Pump System

5.6.8 This intervention entails replacing the existing Nitrogen based systems with Electric Pumped Systems.

5.6.9 Inadvertent Nitrogen discharge within the Fire Suppression kiosk poses a significant risk of fatality to an individual working within the premises. Nitrogen is an inert and suffocating gas that does not support life and that can be a cause of death/ fatality. Replacing the existing Fire Suppression system with an Electric Pump system will eliminate/ remove the process (Nitrogen) from operational requirements providing a safer environment to work in.

5.6.10 Most nitrogen bottle systems only have enough volume to typically supply water mist for around 10 minutes. New electric pump systems can supply water mist for around 30 minutes which meets the requirement set out in T/SP/SFP/3 and NFPA 750. Water mist fire duration would not be addressed with the refurbishment option.

5.6.11 This scope aims to remove operational hazards given that fire suppression system is critical for the protection of Cab Enclosure that houses critical assets for Gas Compression. This is in line with the Fire Suppression Specific Asset Strategy within the Asset Management System (AMS) and continuation of the programme initiated in RIIO-T2 detailed in APPENDIX I: NTS Fire Suppression Systems I (9.9).

Increase quantity Nitrogen Bottles

5.6.12 Intervention comparable to refurbishing nitrogen bottle system, but with additional bottles. Increasing the number of nitrogen bottles (and subsequent Water Bottles) to 30 would help to fulfil the requirement of providing an increased capacity of the propellant system. However, there is currently insufficient space within existing kiosks to house any additional nitrogen and water bottles, hence a complete redesign of the kiosk and fire suppression system and rationalisation of the cylinders, instrumentation and electrical supplies would be required.

Table 19: Interventions considered

Intervention	Equipment Design Life	Positives	Negatives	Taken Forward
Counterfactual	N/A	Lowest capex option.	Does not address problems.	No
Refurbish existing system	5 years	Addresses defects in the short term	Does not mitigate N2 bottle issues. Would require substantial enhancements to attain required standard.	No
Replace System with new Electric Pump System	30 years	Meets T/SP/SFP/3 and NFPA 750 requirements. Removes operational hazards. Provides protection to people, plant, and equipment. Improved operability and reliability. Known to be a good solution already installed in Cabs on NTS.		Yes
Increase quantity Nitrogen bottles	N/A	Increases capacity of system.	Requires system redesign (new kiosk etc.) Does not mitigate N2 bottle issues. A pilot project at Peterborough and Huntingdon proved to be very unreliable with all 30 bottles needing changing per shot. It is therefore not recommended for any other units	No

5.7 Volume Derivation

5.7.1 Volumes for FSS are based on known issues which have been independently verified during comprehensive third-party surveys. Table 20 summarises how bottom-up intervention volumes have been developed. Further detail can be found in Appendix I (9.9).

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

Intervention	Volume	Unit of Measure	How this volume has been developed
Replace System with new Electric Pump System	[redacted]	Per Cab	10 FSS surveys conducted by specialist third parties with comprehensive reports. Although all compressor stations require the upgrade, deliverability of the work has been assessed to constrain the volumes to [redacted] in RIIO-GT3. Consideration to expected out of service dates has also been applied, balancing risk, cost, and performance. It has also known that Cab and FSS assets of the same age exhibit similar failure modes. As a result, the findings on RIIO-T2 assets were used to validate the forecasted investment requirement of the RIIO-GT3 assets.

5.8 Unit Cost Derivation

5.8.1 Unit costs for the selected intervention are based on comparable scopes of work which are being undertaken in RIIO-T2. A summary is provided in Table 21 with a further breakdown in Appendix D (9.4).

Table 21: Fire suppression system Intervention unit cost summary (£m, 2023/24)

Intervention	Unit of Measure	Unit Cost	Cost Accuracy	Number of Data Points	Source Data
Replace System with new Electric Pump System	Per Cab	[redacted]	[redacted]	5	Estimate at Completion

5.8.2 Cost accuracy has been determined based on types and availability of data including quantities (i.e., the number of data points) and the similarity of the scope of work performed versus the RIIO-GT3 investment programme.

5.8.3 The intervention has been delivered during RIIO-T2. Further, this intervention was included within NGT_AH2_14 Cab Infrastructure and Fire Suppression Uncertainty Mechanism (UM) originally submitted to Ofgem in June 2023 (updated in September 2023 subsequently reissued in March 2024).

5.8.4 Specifically, the cost estimate was derived from seven UM data points with a range from [redacted] which reflected seven units across five sites. The costs include provision for a variety of additional considerations including confined space, asbestos, cross site cabling and potential policy changes. There was also a unique situation at our [redacted] site where the intention is for a single fire suppression system to cover three separate Cabs which has not been undertaken before. This variation was deemed to be reflective of future scope and an additional contingency of 8% was applied to the unit cost for this intervention.

6 Options Considered

6.1 Portfolio Approach

6.1.1 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.

6.1.2 We have assessed the benefit from options across the entire Cabs portfolio to meet investment drivers, business plan commitments, and consumer priorities. Therefore, a single CBA covers Cabs and Fire Suppression Systems.

6.1.3 The options considered combine the interventions discussed previously in varying combinations and volumes to identify the optimal investment for Cab infrastructure including fire suppression systems.

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

6.1.5 We derived bottom-up intervention volumes using the engineering assessments described in the previous chapters. Each investment 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 NARM driven interventions to create further options to satisfy certain criteria, such as stable risk across the portfolio.

6.1.6 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). Interventions which have been discounted (i.e., because they do not meet legislative requirements) have also not been modelled.

6.2 Options

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

6.2.2 All options described below have been assessed against the baseline option 0, counterfactual (do nothing) option, which considers no investment over and above maintenance and corrective repairs.

6.2.3 In all options (except baseline/counterfactual), we include bottom-up intervention volumes to address known defects and obsolescence issues.

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

6.2.4 This option utilised our Copperleaf Portfolio optimisation tool to constrain the overall 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 separately constrained, however overall risk outcome is.

6.2.5 The total spend of proposed interventions in this option is £68.9m (2023/24) which addresses known and forecast defects. No additional investment is proposed through our Predictive Analytics model to keep overall NARMs risk stable. The proposed intervention volumes and the associated spend for this option are shown in Table 22.

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

Intervention	Volumes	RIIO-GT3 Value
Bottom Up Interventions	[redacted]	£68.85
Total	[redacted]	**£68.85**

Option 1A: Post Deliverability

6.2.6 This option includes bottom-up interventions with constraints applied to ensure it is deliverable. This option factors in network outage, resource and supply chain constraints. During the comprehensive deliverability evaluation process, 13 volumes of work were identified as being able to be brought forward from beyond the end of RIIO-GT3 based on bundling opportunities that were presented. These volumes are not included in the other options due to them not being assessed for deliverability. Meanwhile, three volumes were deferred out of RIIO-GT3 giving a net position of 10 additional volumes compared to other options. The total spend of the option is £66.34m (2023/24). The proposed intervention volumes and the associated spend for this option are shown in Table 23.

Table 23: Option 1A summary (£m, 2023/24)

Intervention	Volumes	RIIO-GT3 Value
Bottom Up Interventions	[redacted]	£66.38
Total	[redacted]	**£66.38**

Option 2: Maximise Risk Benefit

6.2.7 In this option, the model was allowed to maximise risk benefit from all applicable interventions and available assets. This resulted in a high-value, high-cost option for comparison purposes.

6.2.8 The total spend of proposed interventions in this option is £69.9m (2023/24) which is an additional £1m compared to Option 1: Total Monetised Risk Stable to RIIO-T2 Start which relates to the model opting to do more work to control rising in individual NARMs service risk measures, rather than keeping overall monetised risk stable. The summary is shown in Table 24.

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

Intervention	Volumes	RIIO-GT3 Value
Bottom Up Interventions	[redacted]	£68.85
Additional PA Volumes	[redacted]	£1
Total	[redacted]	**£69.85**

Option 3: Lowest WLC

6.2.9 In this option, we applied optimisation to select interventions with the lowest Whole Life Cost. 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.

6.2.10 The total spend of proposed interventions in this option is £68.9m (2023/24) which is the highest cost option. This is due to PA making an economical decision to intervene on any asset where the cost is outweighed by the benefit no matter how small the margin. Although it may reduce risk more over the life of the asset, PA may make decisions which are impossible to deliver in reality. The proposed intervention volumes and the associated spend for this option are shown in *Table 25*.

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

Intervention	Volumes	RIIO-GT3 Value
Bottom Up Interventions	[redacted]	£68.85
Additional PA Volumes	[redacted]	£0.13
Total	[redacted]	**£68.98**

Option 4: Availability and Reliability Risk Stable

6.2.11 In this option, we applied optimisation to select interventions that not only maintain overall RIIO-T2 monetised risk levels but also maintain the service risk for availability and reliability at RIIO-T2 standards, enhancing asset resilience.

6.2.12 The total spend of proposed interventions in this option is £68.98m (2023/24) which involves an increased volume of work compared to option 1 to try and control the rising risk of availability and reliability rather than overall monetised risk. To achieve this, the tool may have made reductions in other SRMs including Financial and Health and Safety due to the associated cost with maintaining supply. The proposed intervention volumes and the associated spend for this option are shown in *Table 26*.

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

Intervention	Volumes	RIIO-GT3 Value
Bottom Up Interventions	45	£68.85
Additional PA Volumes	16	£0.13
Total	**61**	**£68.98**

6.3 Option Summary

6.3.1 Table 27 presents the technical summary table.

Table 27: Options technical summary (£m, 2023/24)

Option	First Year of Spend	Final Year of Spend	Total Volume of Interventions	Investment Design Life	Total Spend Request
Option 0: Counterfactual (Do Nothing)	FY27	FY31	0	N/A	-
Option 1: Total Monetised Risk Stable to RIIO-T2 Start	FY27	FY31	45	5 to 40 years	£68.85
Option 1A: Post Deliverability	FY27	FY31	55	5 to 40 years	£66.38
Option 2: Maximise Risk Benefit	FY27	FY31	64	5 to 40 years	£69.85
Option 3: Lowest WLC	FY27	FY31	61	5 to 40 years	£68.98
Option 4: Availability and Reliability Risk Stable	FY27	FY31	61	5 to 40 years	£68.98

7 Business Case Outline and Discussion

7.1 Key Business Case Drivers Description

7.1.1 In developing the proposed programme of work, the aim was to achieve the optimal balance between the level of investment and the risk to outcomes. This has been achieved through a proactive Cabs and Fire Suppression system interventions programme dating back to previous regulatory periods. These investments proactively prevent the disruption of gas supplies due to assets failures.

7.1.2 In developing our desired outcomes, we have considered the impact of the following drivers for investment on Cabs and Fire Suppression assets:

- Legislation requirements
- Asset deterioration, linked to our ageing asset base and asset type.
- Health and safety
- Reducing the environmental risk of emissions

7.1.1 All the assets in scope have exceeded their original design life. Therefore, this approach balances ensuring the assets remain fit for purpose in the medium term whilst maintaining affordable and deliverable levels of investment in the short term.

7.1.2 Appropriate level of asset health investment has been targeted to mitigate the reliability, safety and environmental risks from ageing and non-certified and tested systems, insufficient fire time, and inferior capability to extinguish a fire compared to the required certification standard.

7.1.3 All the fire suppression systems in scope are nitrogen based and fall short of safety, legislative and strategic business requirement. Therefore, this approach balances ensuring the assets remain fit for purpose in the medium term whilst maintaining affordable and deliverable levels of investment in the short term.

7.1.4 Due to the safety critical nature of this equipment the risk of failure needs to be managed to be within a tolerable level to prevent harm to people and manage the risk of extensive damage to equipment especially on account of fire incidents. Fire suppression systems not compliant with legislative requirements and safety standards pose safety risks.

7.2 Business Case Summary

7.2.1 A variety of technical interventions have been considered and combined to create a range of CBA options. The payback period of each option is shown in Figure 8, with the key metrics presented in Table 28.

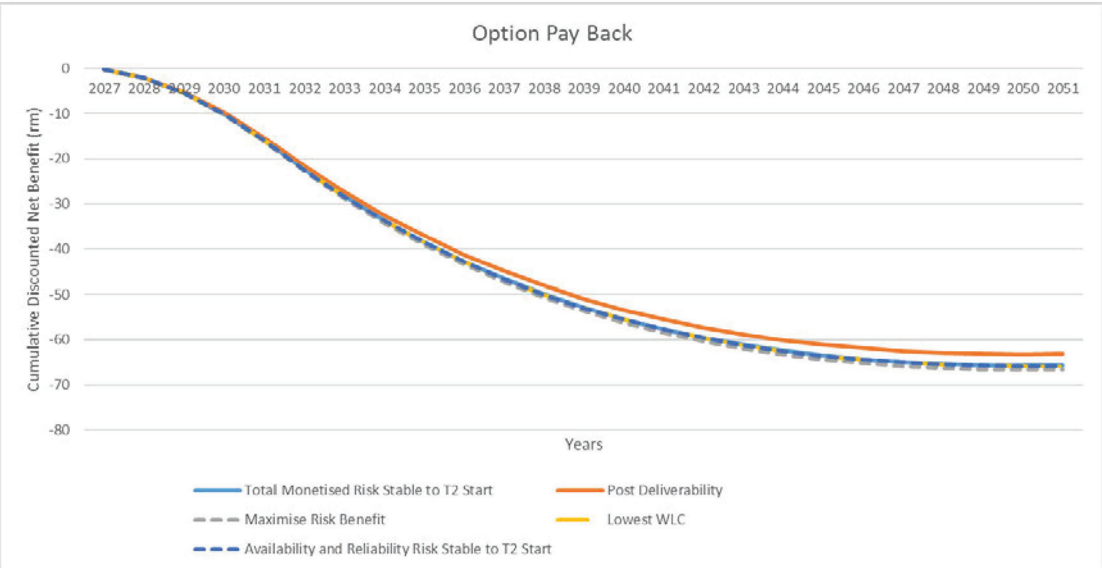

Figure 8: Option payback period

Table 28: Option summary of headline business case metrics (£m, 2023/24)

Option	Total Volume of Interventions	Total Spend Request £m	Outcome Risk End of RIIO-GT3	% change in comparison to start of RIIO-T2	PV Benefit	PV Cost	NPV	Payback Period from 2031	% change in service risk measures compared to start of RIIO–T2				
									Financial	Health and safety	Environmental	Availability Reliability	Societal
Option 0: Baseline /Counterfactual (Do Nothing)	0	0.00	0.39	99.07%	-	-	-	-	97.46%	0.00%	95.54%	188.94%	0.00%
Option 1: Total Monetised Risk Stable to RIIO-T2 Start	45	£68.85	0.32	81.33%	£1.32	£66.30	£(64.98)	Does not payback in the period	78.66%	0.00%	80.45%	121.83%	0.00%
Option 1A: Post Deliverability	55	£66.38	0.32	81.33%	£1.68	£63.92	£(62.24)	Does not payback in the period	78.66%	0.00%	80.45%	121.83%	0.00%
Option 2: Maximise Risk Benefit	64	£69.85	0.32	80.58%	£1.39	£67.26	£(65.88)	Does not payback in the period	77.54%	0.00%	80.11%	115.27%	0.00%
Option 3: Lowest WLC	61	£68.98	0.30	75.56%	£1.39	£66.43	£(65.04)	Does not payback in the period	56.89%	0.00%	80.45%	119.80%	0.00%
Option 4: Availability and Reliability Risk Stable	61	£68.98	0.32	80.80%	£1.37	£66.43	£(65.06)	Does not payback in the period	78.07%	0.00%	80.11%	117.74%	0.00%

8 Preferred Option and Project Plan

8.1.1 The preferred option to manage Cab infrastructure assets is Option 1A: Post Deliverability. This is based on the outcome of a rigorous deliverability assessment which evaluated this programme of works against outputs across our entire capital investment plan. Option 1A includes the mixture of interventions listed in Table 29.

8.1.2 The other options have been discounted due to the mix of interventions which are required to address the qualitative results of surveys, rather than the quantitative modelled failures not being assessed for deliverability. Additionally, the deliverability assessment provided opportunity to bring forward future works into RIIO-GT3 to enable efficient delivery.

8.1.3 Our proposed investment involves a mix of repair, replace, and survey interventions to address the challenges faced with managing aged infrastructure which is no longer compliant with legislative requirement and industry best practice. This will ensure we maintain safe, compliant, and available operation of compressor units.

8.1.4 The preferred option is also based on lessons learnt during previous regulatory periods. For example, Cabs which may have initially been identified as requiring refurbishing have needed major works which were only ascertained once work had commenced. Scope creep has significant impacts to achieving cost and schedule adherence as referred to in the Investment Risk Discussion.

8.1.5 The outputs from this investment will be included in the Asset Health – NARMS PCD reporting mechanism, and cost variance managed through the TIM mechanism.

8.1.6 None of the options pay back within period which is attributed to Cabs and associated assets being secondary assets which support compressor units. They have significant risks which are expensive to manage, but do not directly affect the compression of gas. Payback period would be considerably shorter if compression availability was included within the cost benefit analysis, however due to them being considered secondary assets, they were excluded. Out of the five options, Option 1A is the lowest capex cost and the highest Net Present Value, further making it the optimal choice.

Table 29: Preferred option summary (£m, 2023/24)

Intervention	Primary Driver	Volume	Unit of Measure	Total RIIO-GT3 Request	Funding Mechanism	PCD Measure
Air Intake Replacement	AH Known Defects Secondary	[redacted]	Per Cab	[redacted]	Baseline	NARMS
Exhaust Replacement	AH Known Defects Secondary	[redacted]	Per Cab	[redacted]	Baseline	NARMS
Ventilation Replacement	AH Legislation	[redacted]	Per Cab	[redacted]	Baseline	NARMS
Cab Structure Roof repairs	AH Policy	[redacted]	Per Cab	[redacted]	Baseline	NARMS
Permanent lifting beams	AH Legislation	[redacted]	Per Cab	[redacted]	Baseline	NARMS
Crane Upgrade	AH Legislation	[redacted]	Per Cab	[redacted]	Baseline	NARMS
Upgrade to Electric Crane	AH Legislation	[redacted]	Per Cab	[redacted]	Baseline	NARMS
Replace Cab doors	AH Known Defects Secondary	[redacted]	Per Cab	[redacted]	Baseline	NARMS
Cab Surveys	AH Risk Management	[redacted]	Per Cab	[redacted]	Baseline	NARMS
Replace System with new Electric Pump System	AH Legislation	[redacted]	Per Cab	[redacted]	Baseline	NARMS
	Total	55		66.38		

8.1.7 Our costs and volumes have been built using a formalised methodology including estimates at completion for similar works and first principle estimating against scopes determined from extensive surveys. Therefore, we propose the investment within this EJP is funded via baseline and will be assessed using NARMs methodology.

8.2 Asset Health Spend Profile

8.2.1 The spend profile in Figure 9 provides an indicative view on when interventions will be carried out. This is aligned to the output of rigorous deliverability assessments linked to outages, resource availability and procurement activities including long lead items and contracting mechanisms.

[redacted]

[redacted]

8.3 Investment Risk Discussion

8.3.1 A significant risk to this investment is scope creep during programme delivery. This was an issue when refurbishing the exhaust on Huntingdon Unit C during RIIO-2 which required far more work than the boundaries of a refurbishment allowed. The condition was only discovered once work had commenced, and parts of the exhaust had been removed. The result of this was a change of scope to replacement which became more costly compared to replacing it in the first instance. We have mitigated this risk by selecting exhaust replacement interventions only due to the very high likelihood of finding multiple deteriorations within the stacks.

8.3.2 Volumes have been derived based on known requirements. However, to ensure the volumes are deliverable, the preferred option, Option 1A: Post Deliverability, has been assessed for deliverability. This has constrained the plan to reflect a realistic volume including accelerating and delaying certain interventions. If these deliverability assumptions are incorrect, the volumes may change.

8.4 Project Plan

8.4.1 Project delivery has been split into three phases which align with our Network Development Process (ND500) as shown in Table 30. Commissioning dates are not relevant to all intervention types but take place at the end of the delivery phase.

Table 30: 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)

8.4.2 Table 31 shows the summary plan and provisional delivery phases for Cab infrastructure sanctions within RIIO-GT3. Internal stakeholder engagement has identified when we can obtain network access, where required, to complete these works.

Table 31: Cab infrastructure portfolio programme for RIIO-GT3 period

Sanction/Intervention	RIIO-T2		RIIO-GT3					
	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32
T3_Compressor_AH Cabs_Lot 1								
T3_Compressor_AH Cabs_Lot 2								

8.4.3 Based on experience delivering similar scopes, some preparatory work can start in RIIO-T2. The programme proposed within this EJP has been aligned to the work being profiled based on a deliverability assessment across the whole plan including compressor fleet strategy detailed in the Compressor Fleet EJPs[23][24][25][26] and other planned work requiring outages. For example, uprating the overhead crane at [redacted] is required to enable the Power Turbine to be overhauled as scheduled which is detailed in the Rotating Machinery EJP[27].

8.5 Key Business Risks and Opportunities

8.5.1 Minor changes to system operation or supply and demand scenarios are unlikely to impact upon the proposal in this EJP. Significant changes could result in certain assets or sites become redundant which would remove the need for some interventions, aligned to the Compressor Fleet EJPs[28][29][30][31].

8.5.2 Cab infrastructure would still be required as part of any transition to hydrogen within RIIO-GT3. However, redesigning the NTS would impact assets including compressors which are located within Cabs.

8.6 Outputs included in RIIO-T2 Plans

8.6.1 All investments proposed in RIIO-T2 in this theme are currently on track to be delivered within RIIO-T2 or have been completed already. Therefore, this RIIO-GT3 investment plan does not contain any re-inclusion of previously funded/proposed investments in RIIO-T2. Further information on the RIIO-T2 uncertainty mechanism is in Appendix C (9.3).

[23] NGT_EJP13_Compressor Fleet – Network Investments and Zone 1 (Scotland)_RIIO-GT3
[24] NGT_EJP14_Compressor Fleet - Zones 2 and 3 (Central)_RIIO-GT3
[25] NGT_EJP15_Compressor Fleet - Zones 4 and 5 (South Wales and South West)_RIIO-GT3
[26] NGT_EJP16_Compressor Fleet - Zones 6 and 7 (East Midlands and South East)_RIIO-GT3
[27] NGT_EJP04_Rotating Machinery_RIIO-GT3
[28] NGT_EJP13_Compressor Fleet – Network Investments and Zone 1 (Scotland)_RIIO-GT3
[29] NGT_EJP14_Compressor Fleet - Zones 2 and 3 (Central)_RIIO-GT3
[30] NGT_EJP15_Compressor Fleet - Zones 4 and 5 (South Wales and South West)_RIIO-GT3
[31] NGT_EJP16_Compressor Fleet - Zones 6 and 7 (East Midlands and South East)_RIIO-GT3

9 Appendices

9.1 APPENDIX A: Investigation Report No.8489/10/NG

9.2 APPENDIX B: [redacted] Condition Survey Report

[redacted]

9.4 APPENDIX D: Unit Cost Development

Table 34: Intervention Cost Breakdown (£m, 2023/24)

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)	Total Cost
Cab Ventilation Replacement	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Overhead Crane Upgrade to 6 tons at Aberdeen	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Air Intake Replacement	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Cab Exhaust Replacement	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Cab Surveys (To inform T4)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Lifting Beams: Installation of Permanent GG lifting beams	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Fire Suppression: Replacement of Electric Water Pump System	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Cab Roof Repairs and general condition assessment	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Upgrade to electric crane	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Replace Cab Doors	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

9.4.1 Costs have been derived using a high-level scope of work with an average unit cost calculated for each intervention which has been estimated based on the following assumptions:

9.4.2 The ventilation system and Air Intake replacements used as data points were for Avon Compressor units which are the same type of units (of similar age) being considered.

9.4.3 Average exhaust sizes which are determined by the units' thermal outputs are also the same resulting in similar costs.

9.4.4 The Cabs which require roof repairs are of similar sizes as previous data points used resulting in no major cost changes.

9.4.5 Fire suppression systems come in packaged units which are not necessarily based on the size of compressor units and will be standardised across the units. This will result in costs not changing significantly.

9.4.6 Estimates for lifting beams are based on historical surveys and designs.

9.4.7 The data points included within NGT_AH2_14 Cab Infrastructure and Fire Suppression Uncertainty Mechanism (UM) originally submitted to Ofgem in June 2023 (updated in September 2023 subsequently reissued in March 2024) have been validated against the scope of this EJP.

9.5 APPENDIX E: Cab investments (10-year horizon)

9.5.1 Figure 10 shows all investments considered for Units across a 10-year horizon. Owing to deliverability assessments, different percentages of investments have been earmarked for delivery in RIIO-GT3, with the balance to be planned for the following price control period.

Unit	Exhaust	No.	Ventilation	No.	Air intake	No.	Lifting beams	No.	Crane Uprating	No.	Cab structure	
Aberdeen A	New stack	1	Vetilation	1	Filterhouse Replacement complete with Dehumidifier	1	Nil	0	Nil	0	Nil	0
Aberdeen B	New stack	1	Vetilation	1	Filterhouse Replacement complete with Dehumidifier	1	Nil	0	Nil	0	Nil	0
Aberdeen C	New stack	1	Vetilation	1	Filterhouse Replacement complete with Dehumidifier	1	Nil	0	[illegible]	1	Nil	0
Alrewas A	New stack	1	Vetilation	1	Filterhouse Replacement complete with Dehumidifier	1	Permanent GG lifting beam	1	Nil	0	Nil	0
Alrewas B	New stack	1	Vetilation	1	Filterhouse Replacement complete with Dehumidifier	1	Permanent GG lifting beam	1	Nil	0	Nil	0
Kirrie A	Nil	0	Vetilation	1	Nil	0	Permanent GG lifting beam	1	Nil	0	Nil	0
Kirrie B	Nil	0	Vetilation	1	Nil	0	Permanent GG lifting beam	1	Nil	0	Nil	0
Felindre A	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0
Felindre B	Nil	0	Vetilation	1	Nil	0	Permanent crane already installed	0	Nil	0	Nil	0
Felindre C	Nil	0	Vetilation	1	Nil	0	Permanent crane already installed	0	Nil	0	Nil	0
Cambridge C	New stack	1	Vetilation	1	Filterhouse Replacement complete with Dehumidifier	1	Permanent crane already installed	0	Nil	0	Nil	0
Avonbridge 1A	Nil	0	Vetilation	1	Filterhouse Replacement complete with Dehumidifier	1	Permanent crane already installed	0	Nil	0	Nil	0
Avonbridge 2A	Nil	0	Vetilation	1	Filterhouse Replacement complete with Dehumidifier	1	Permanent crane already installed	0	Nil	0	Nil	0
Cambridge A	New stack	1	Vetilation	1	Filterhouse Replacement complete with Dehumidifier	1	Nil	0	Nil	0	Major Refurbishment	1
Cambridge B	New stack	1	Vetilation	1	Filterhouse Replacement complete with Dehumidifier	1	Nil	0	Nil	0	Major Refurbishment	1
Churchover E	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0
Kirriemuir E	Nil	0	Vetilation	1	Nil	0	Nil	0	Nil	0	Nil	0
Kings Lynn C	Nil	0	Vetilation	1	Filterhouse Replacement complete with Dehumidifier	1	Permanent crane already installed	0	Nil	0	Nil	0
Kings Lynn D	Nil	0	Vetilation	1	Filterhouse Replacement complete with Dehumidifier	1	Permanent crane already installed	0	Nil	0	Nil	0
Wormington C	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0
Alrewas C	Nil	0	Vetilation	1	Filterhouse Replacement complete with Dehumidifier	1	Permanent crane already installed	0	Nil	0	Nil	0
Chelmsford A	New stack	1	Vetilation	1	Filterhouse Replacement complete with Dehumidifier	1	Permanent GG and PT lifting beams	1	Nil	0	Nil	0
Chelmsford B	New stack	1	Vetilation	1	Filterhouse Replacement complete with Dehumidifier	1	Permanent GG and PT lifting beams	1	Nil	0	Nil	0
Diss A	New stack	1	Vetilation	1	Filterhouse Replacement complete with Dehumidifier	1	Permanent GG and PT lifting beams	1	Nil	0	Nil	0
Diss B	New stack	1	Vetilation	1	Filterhouse Replacement complete with Dehumidifier	1	Permanent GG and PT lifting beams	1	Nil	0	Nil	0
Diss C	New stack	1	Vetilation	1	Filterhouse Replacement complete with Dehumidifier	1	Permanent GG and PT lifting beams	1	Nil	0	Nil	0
Bishop Auckland A	Nil	0	Vetilation	1	Filterhouse Replacement complete with Dehumidifier	1	Permanent crane already installed	0	Nil	0	Nil	0
Bishop Auckland B	Nil	0	Vetilation	1	Filterhouse Replacement complete with Dehumidifier	1	Permanent crane already installed	0	Nil	0	Nil	0
Nether Kellet A	Nil	0	Vetilation	1	Filterhouse Replacement complete with Dehumidifier	1	Permanent crane already installed	0	Nil	0	Nil	0
Nether Kellet B	Nil	0	Vetilation	1	Filterhouse Replacement complete with Dehumidifier	1	Permanent crane already installed	0	Nil	0	Nil	0
Carnforth Unit C	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Major Refurbishment	1
Total Volume		13		27		22		9		1		3

Figure 10: 10-year horizon for Cab Investments

9.6 APPENDIX F: [redacted] Cab Survey report

9.7 APPENDIX G: [redacted] Cab Survey report

9.8 Appendix H: [redacted] FSS Survey Report

9.9 APPENDIX I: NTS Fire Suppression Systems

9.9.1 The programme to replace nitrogen-based FSS with electric pump systems commenced in RIIO-T2 with the UID: A22.08.2.3-Fire Suppression Replacement of Electric Water Pump System. The scope of this UID in RIIO-T2 included baseline and UM funded Units: [redacted] Table 35 shows current and required FSS on Compressor Units. Owing to deliverability assessments, only certain FSS replacements can be delivered in RIIO-GT3, with the balance to be planned for the following price control period. The units to be delivered in each year are prioritised based on deliverability (i.e., outages and other planned works), age, asset condition and future operational requirements.

Table 35: Fire Suppression System by Compressor Unit

Compressor Unit	Age	Current Fire Suppression System	Required Fire Suppression System
[redacted]	[redacted]	Nitrogen System	Electric Pump System
[redacted]	[redacted]	Nitrogen System	Electric Pump System
[redacted]	[redacted]	Nitrogen System	Electric Pump System
[redacted]	[redacted]	Nitrogen System	Electric Pump System
[redacted]	[redacted]	Nitrogen System	Electric Pump System
[redacted]	[redacted]	Nitrogen System	Electric Pump System
[redacted]	[redacted]	Nitrogen System	Electric Pump System
[redacted]	[redacted]	Nitrogen System	Electric Pump System
[redacted]	[redacted]	Nitrogen System	Electric Pump System
[redacted]	[redacted]	Nitrogen System	Electric Pump System
[redacted]	[redacted]	Nitrogen System	Electric Pump System
[redacted]	[redacted]	Nitrogen System	Electric Pump System
[redacted]	[redacted]	Nitrogen System	Electric Pump System
[redacted]	[redacted]	Nitrogen System	Electric Pump System
[redacted]	[redacted]	Nitrogen System	Electric Pump System
[redacted]	[redacted]	Nitrogen System	Electric Pump System
[redacted]	[redacted]	Nitrogen System	Electric Pump System
[redacted]	[redacted]	Nitrogen System	Electric Pump System
[redacted]	[redacted]	Nitrogen System	Electric Pump System
[redacted]	[redacted]	Nitrogen System	Electric Pump System
[redacted]	[redacted]	Nitrogen System	Electric Pump System
[redacted]	[redacted]	Nitrogen System	Electric Pump System