Q. **Reference: Reliability and Resource Adequacy Study 2022 Update, Volume III, page 26-27.**

Provide any study or assessment of the reliability of the Hardwoods and Stephenville gas turbines that has been completed, including the availability of spare parts for these units.

A. Since 2018, Newfoundland and Labrador Hydro ("Hydro") has tracked and reported the reliability of the Hardwoods and Stephenville Gas Turbines on a monthly basis. The annual reliability performance of the units since 2018 is summarized in Table 1.

Table 1: Annual Reliability Metrics

	Hardwoods Gas Turbine		Stephenville Gas Turbine	
Year	UFOP	DAUFOP	UFOP	DAUFOP
2018	4.80%	8.28%	1.45%	47.48%
2019	4.13%	20.52%	4.80%	5.66%
2020	4.46%	16.25	8.13%	8.13%
2021	0.12%	1.91%	0.38%	1.11%
2022	0.50%	1.16%	11.70%	11.70%

Likewise, Hydro completes annual assessments of its spare components for the Hardwoods and Stephenville Gas Turbines. The results of these assessments were reported in the December 2022 "2022–2023 Winter Readiness Report."[1]

In 2021, Hydro engaged Hatch Ltd. to complete an assessment of the Hardwoods and Stephenville Gas Turbines. The scope of their review was to assess the current condition and reliability of the facilities as well as spare parts availability from Hydro service providers to determine the potential for extending the life of both facilities. Please refer to PUB-NLH-280, Attachment 1 for the "Project Report Volume III for Hardwoods and Stephenville Viability Assessment."[2]

[1] "2022–2023 Winter Readiness Planning Report," Newfoundland and Labrador Hydro, December 12, 2022.
[2] "Project Report Volume III for Hardwoods and Stephenville Viability Assessment," Hatch Ltd., June 27, 2022.

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Newfoundland and Labrador Hydro

Project Report Volume III

For

Hardwoods and Stephenville Viability Assessment

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Project Report

June 27, 2022

Newfoundland and Labrador Hydro

Hardwoods and Stephenville Viability Assessment

Distribution
Jessica McGrath
Robert Shandera

Project Report Volume III

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List of Abbreviations

Abbreviation or Acronym	Definition
AC	Alternating Current
API	American Petroleum Institute
AVR	Automatic Voltage Regulator
BESS	Battery Electric Storage System
CBA	Capital Budget Application
CRF	Capital Recovery Factor
DAUFOP	Derated Adjusted Utilization Forced Outage Probability
DC	Direct Current
DCS	Distributed Control System
EEFL	End of Economically Feasible Life
EMV	Expected Monetary Value
HMI	Human Machine Interface
HWD	Hardwoods Gas Turbine Facility
HP	High Pressure
ID	Identification
INA	Information Not Available
K	Escalation Rate Factor
NLH	Newfoundland and Labrador Hydro
OPS	Operations
PCB	Polychlorinated Biphenyl
PFS	Pre-Feasibility Study
RAC	Risk Assessment Code
SVL	Stephenville Gas Turbine Facility
TRO	Transmission Rural Operator
UFOP	Utilization Forced Outage Probability
USPWF	Uniform Series Present Worth Factor

1. Executive Summary

1.1 Hardwoods (HWD) and Stephenville (SVL) Gas Turbine Facilities

This comprehensive report provided to Newfoundland Labrador Hydro (NLH) includes a condition assessment and a Life Cycle Cost Analysis of the HWD and SVL Gas Turbine Facilities. Hydro intends to use this information to inform its options for generation, should it be determined that additional backup generation is required to support the provision of least cost and reliable service.

The condition assessment of the HWD and SVL power plant's include equipment such as Gas Generator Engines and Subsystems, Power Turbines and Subsystems, Generators, and key common systems including the Instrumentation and Control System, Electrical Systems, Fuel Oil Systems, Glycol Cooling Systems, and Support Buildings to ensure the reliable power generation. The condition assessment was completed using a combination of site investigations, inspections, and documentation reviews. A detailed list of all critical assets graded based on their current condition is provided in this report.

The viability assessment focuses on the following extension of operational timelines:

- Operation until End of Economically Feasible Life (EEFL)
- Additional 2 years of operation (2025)
- Additional 5 years of operation (2028)
- Additional 10 years of operation (2033).

NLH wishes to understand the capital and operational requirements more fully should the following options be considered for HWD and SVL:

- Continued extension of the HWD and SVL Generating Stations as currently used in backup operations mode beyond the current March 31, 2023, retirement.
- The viability and suitability of the Generating Stations to be used as backup generating facilities to support the island system in the event of a prolonged outage of the Labrador-Island Link until the End of Economically Feasible Life (EEFL) of the plants.
- Recommendations for retirement of SVL facility and utilization of components to extend the life of HWD.
- Recommendation and cost associated with relocation of the SVL facility to another location in the province.

1.2 Sensitivity Analysis and Rank of Options

The sensitivity analysis is an essential part of the risk assessment and provides a systematic approach to bridge uncertainty gaps. In the numerical model, the sensitivity analysis is a method that measures the impact of uncertainties on multiple variables that can lead to cost related repairs and down time from power production. The Risk Assessment Code (RAC) percentage value was derived by assigning values of 1-5 for a Severity category and a Probability category, then placing them into an RAC matrix for each major piece of equipment and maintenance service. The complete description of the Sensitivity Analysis and the RAC matrix is included in section 6.1.

The Rank hierarchy recommended by Hatch for HWD and SVL operational timeline options 1-4, seen in the following tables, are based on least-cost with reliable service per year of operation.

The assigned severity, probability, risk values, and the related contingencies can be found in Appendix C HWD and SVL Capital Upgrades and Major Maintenance Items.

1.2.1 Hardwoods

The Life Cycle Cost Analysis Summary for the Hardwoods Gas Turbine Facility operational timeline options is outlined in Table 1-1. It includes costs associated with Capital Projects, upgrades and/ or modifications, operating costs, and fuel consumption as required to provide appropriate performance in a backup generating capacity.

Hatch considers there are mandatory maintenance items that include the service of the gas turbines and power turbine. These must be completed to sustain operations through the EEFL of 2033. If the gas turbines and power turbines provide appropriate performance in their continued extension major rebuilds may not be required but this is an identified risk. Should the gas turbines and power turbines not require rebuild and refurbishment the associated Average Cost per Year in Table 1-1 would be reduced.

Many other items are considered risk items for the site. They are not necessary, but they carry risk for maintaining continued performance. Risk items include an associated contingency cost.

Table 1-1: HWD Life Cycle Cost Analysis Summary of Options ($1000’s)

Rank	Option	Average Cost per Year
2	Option 1 - EEFL Capital Upgrades and Maintenance	2,567
4	Option 2 - Additional 2 years of operation (2025)	2,735
3	Option 3 - Additional 5 years of operation (2028)	2,583
1	Option 4 - Additional 10 years of operation (2033)	2,482

For the basis of this study, an operation scenario of 50 hours per year was utilized for fuel consumption and included in each option.

Table 1-2: HWD Summary of Costs by Scenario ($1000's)

Option		2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	Total
1	Capital	2,285	4,172*	150	150	150	150	150	150	150	150	
	Operating	450	450	450	450	450	450	450	450	450	450	
	Fuel	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	**25,668**
2	Capital	934	934	--	--	--	--	--	--	--	--	
	Operating	450	450	--	--	--	--	--	--	--	--	
	Fuel	1,351	1,351	--	--	--	--	--	--	--	--	**5,471**
3	Capital	405	2,292 *	405	405	405	--	--	--	--	--	
	Operating	450	450	450	450	450	--	--	--	--	--	
	Fuel	1,351	1,351	1,351	1,351	1,351	--	--	--	--	--	**12,915**
4	Capital	492	2,379*	492	492	492	492	492	492	492	492	
	Operating	450	450	450	450	450	450	450	450	450	450	
	Fuel	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	**24,817**

**There is a requirement to replace the main transformer in 2025. Option 2 does not include replacement of the transformer.*

1.2.2 Stephenville

The Life Cycle Cost Analysis Summary for the Stephenville Gas Turbine Facility operational timeline options is outlined in Table 1-3. It includes costs associated with Capital Projects, upgrades and/ or modifications as required to provide appropriate performance in a backup generating capacity.

Hatch considers there are mandatory maintenance items that include the service of the gas turbines and power turbine. These must be completed to sustain operations through the EEFL of 2033. If the gas turbines and power turbines provide appropriate performance in their continued extension major rebuilds may not be required but this is an identified risk. Should the gas turbines and power turbines not require rebuild and refurbishment the associated Average Cost per Year in Table 1-3 would be reduced.

Many other items are considered risk items for the site. They are not necessary, but they carry risk for maintaining continued performance. Risk items include an associated contingency cost.

Table 1-3: SVL Life Cycle Cost Analysis Summary of Options ($1000's)

Rank	Option	Average Cost per Year
2	Option 1 – EEFL Capital Upgrades and Maintenance	2,561
4	Option 2 - Additional 2 years of operation (2025)	2,711
3	Option 3 - Additional 5 years of operation (2028)	2,577
1	Option 4 - Additional 10 years of operation (2033)	2,477

Table 1-4: SVL Summary of Costs by Scenario ($1000's)

Option		2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	Total
1	Capital	2,254	4,158*	149	149	149	149	149	149	149	149	
	Operating	450	450	450	450	450	450	450	450	450	450	
	Fuel	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	**25,609**
2	Capital	910	910	--	--	--	--	--	--	--	--	
	Operating	450	450	--	--	--	--	--	--	--	--	
	Fuel	1,351	1,351	--	--	--	--	--	--	--	--	**5,422**
3	Capital	395	2299*	395	395	395	--	--	--	--	--	
	Operating	450	450	450	450	450	--	--	--	--	--	
	Fuel	1,351	1,351	1,351	1,351	1,351	--	--	--	--	--	**12,882**
4	Capital	486	2390*	486	486	486	486	486	486	486	486	
	Operating	450	450	450	450	450	450	450	450	450	450	
	Fuel	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	**24,773**

**There is a requirement to replace the main transformer in 2025. Option 2 does not include replacement of the transformer.*

For the basis of this study, an operation scenario of 50 hours per year was utilized for fuel consumption and included in each option.

1.3 Availability of Replacement Parts and Spares for HWD & SVL

Replacement parts and stock spares for the facilities, to sustain or improve reliability, will be required for continued economic operation of the units. Alba Power is currently the sole service provider for the Olympus turbine. There is a concern related to having a single source for replacement parts and service. Alba advised they see the end of service for the engine family in 10-15 years. They are currently stocked with parts from the secondary market, and they have the ability to manufacture many of the parts required on the turbine. Alba's manufacturing abilities includes the reverse engineering of components, modelling, and re-designing specific to customer requirements. Their part portfolio includes compressor blades, turbine blades, nozzles, shrouds, impellers, and discs.

Alba has offered a 10-year plan to maintain the Hardwoods and Stephenville turbines, indicating they are indeed committed to the technology for that duration. As the last viable supplier, economic feasible life ends when services are no longer available. Using the low end of their expectations and noting they are willing to commit to a 10-year contract, the longest remaining economic feasible life for the units is 10 years.

1.4 Staffing Plan HWD & SVL

At this time, there is no impact on staffing requirements. For all Options, a change in staffing prior to end of life is not recommended. Should the stations be allocated as emergency backup power generating sites, a designated operator would not be required but a dispatchable site flexible TRO (Transmission Rural Operations) employee would be necessary.

1.5 HWD Condition Assessment

The overall condition of HWD was found in a good condition for continued operation beyond 2023. The plant has had significant historical major upgrades completed over the past ten years. These major upgrades include a Life Extension Project, fuel piping replacement, battery replacement, filtration upgrades, instrumentation replacements and upgrades, replacement of the demister, upgrades to the air inlet and exhaust stacks, upgraded HMI and AVR, and the replacement of the fuel control valves.

HWD has had a substantial amount of major maintenance over the past ten years including several engine overhauls, Fuel Tank inspection, the Buildings and Structures underwent a coating program, a Brush generator upgrade including the rewinding of the Stator Assembly, Rotor and Exciter Armature, Exciter assembly, replaced heaters, and upgraded filtration system. This, together with continued predictive maintenance, inspections, reliability assessment programs, and ongoing life-cycle maintenance investment, supports the strategy of continued use of the asset.

Recommended maintenance, equipment replacements, and a detail of aging equipment is outlined in Section 5.3 Hardwood Gas Turbine Facility (HWD) of this report.

1.6 SVL Condition Assessment

The overall condition of SVL was found in good condition for continued operation beyond 2023. The plant has had significant historical major upgrades completed over the past ten years. These major upgrades include a Glycol System upgrade, Generator rewind and major overhaul, Fuel System upgrades, replacement of the Motor Control Center, Exhaust Stack and Air Inlet repairs, installation of a Generator Fire Suppression System, the installation of a new Main Lube Oil glycol heat exchanger, instrumentation upgrades, upgrades to the filtration system, replacement of the Generator bed Heater, and the replacement of the demister system.

SVL has had a substantial amount of major maintenance over the past ten years including several engine overhauls, brush generator inspection, and a Gas Turbine Air Intake inspection. This, together with continued predictive maintenance, inspections, reliability assessment programs, and ongoing life-cycle maintenance investment, supports the strategy of continued use of the asset.

Recommended maintenance, equipment replacements, and a detail of aging equipment is outlined in Section 5.4 Stephenville Gas Turbine Facility (SVL) of this report.

1.7 HWD and SVL Site Inspections

Hatch personnel conducted onsite external visual inspections of the Gas Generator Engines, Power Turbines, Generators, Instrumentation and Controls, Electrical Systems, Fuel Oil Systems, Glycol Cooling Systems, and the facilities Support Buildings. The findings of these inspections are summarized in this report and detailed in the Hatch Inspection Report attached as Appendix B Inspection Report.

1.8 Summary of Recommendations for HWD & SVL

The summary of recommendations for replacement of equipment, components and maintenance related items based on the assigned RAC (Risk Assessment Code) can be found in Appendix D HWD and SVL Summary of Recommendations.

The assigned severity, probability, risk values, and related contingencies can be found in Appendix C HWD and SVL Capital Upgrades and Major Maintenance Items.

1.9 Grading

A detailed list was prepared of all critical assets, graded on a scale of 1 to 5 based on their current condition, and is provided in this report. The scale used for this grading is as follows.

Table 1-5: Asset Grading Scale

Grade	Condition	Description
5	Excellent	No visible defects, new or near new condition, may still be under warranty if applicable.
4	Good	Good condition, but no longer new, may have some slightly defective or deteriorated component(s), but is overall functional.
3	Adequate	Moderately deteriorated or defective components; but has not exceeded useful life.
2	Marginal	Defective or deteriorated component(s) in need of replacement; exceeded useful life
1	Poor	Critically damaged component(s) or in need of immediate repair; well past useful life

1.9.1 Hardwoods Gas Turbine Facility

The Hardwoods Gas Turbine Facility, given its age, is generally in good running condition with a few areas needing attention. A summary of the grades for each unit's critical assets is provided in Table 1-6. Greater detail is provided in Section 5.4.

Table 1-6: HWD Summary of Asset Grades

Asset	Grade
Gas Generator Engines and Subsystems Unit A	**4**
Power Turbine, Generator and Subsystems Unit A	**4**
Gas Generator Engines and Subsystems Unit B	**4**
Power Turbine and Subsystems Unit B	**4**
Instrumentation and Control Systems	**3**[1]
Electrical Systems	**4**
Fuel Oil System	**4**
Glycol Cooling System	**2**[2]
Support Buildings	**4**

[1]The Bailey Control System, currently owned and supplied by ABB, is in working condition, but it was noted that it is old equipment.

[2]The Main Lube Oil Cooling System / Glycol Cooler is in marginal condition. The cooling fins require combing to straighten, and the cooler requires power washing. It is recommended to complete this maintenance to achieve better performance. NLH has advised that this maintenance has been added to the 2022 Spring/ Summer Maintenance Outage. If the required performance is not achieved, especially during the hot season, it is recommended that this system is further reviewed, and equipment upgraded as necessary.

1.9.2 Stephenville Gas Turbine Facility

The Stephenville Gas Turbine Facility, given its age, is generally in good running condition with a few areas needing attention. A summary of the grades for each unit's critical assets is provided in Table 1-7. Greater detail is provided in Section 5.3

Table 1-7: SVL Summary of Asset Grades

Asset	Grade
Gas Generator Engines and Subsystems Unit A	**4**
Power Turbine, Generator and Subsystems Unit A	**4**
Gas Generator Engines and Subsystems Unit B	**4**
Power Turbine and Subsystems Unit B	**4**
Instrumentation and Control Systems	**3**[1]
Electrical Systems	**4**
Fuel Oil System	**4**
Glycol Cooling System	**4**
Support Buildings	**4**

[1]The Bailey Control System, currently owned and supplied by ABB, is in working condition, but it was noted that it is old equipment.

1.9.3 Comparison of Hardwoods and Stephenville Gas Turbine Facilities Grading

Hardwoods and Stephenville are both in good running condition given their age. This can be attributed to the Maintenance and Major Upgrades that have been completed over the past ten years. In comparison with Hardwoods, Stephenville has a higher average Grade and is generally in better condition.

1.10 Recommendation for SVL Retirement and Utilization of Major Components to Extend the Life of HWD

When the timeline to retire SVL is decided by NLH the following is recommended for the utilization of SVL components to extend the life of HWD. The SVL facility shall be placed in a "mothball" state. All equipment shall be placed in a cold and dry condition and preparations made to utilize SVL as a scavenge site. Main transmission power shall be disconnected, and auxiliary power shall be required for lighting and operator safety. All hydrocarbons shall be removed from equipment and relocated to another facility for use. It is recommended that NLH contact their insurance provider to confirm that fire suppression systems would not be required after the removal of hydrocarbons.

The turbines shall remain in their berths with subsystems and piping disconnected in preparation for their future use at HWD. The main lube oil system shall be drained and thoroughly cleaned. The main transformer shall de decommissioned and removed.

All major and minor equipment shall be thoroughly catalogued, graded, and moved to an inventory system with an equipment list of items that can be utilized at HWD or other NLH facilities. All equipment that is not in an acceptable condition for utilization in operations shall be catalogued in the decommissioning plan or added to a scrap register. A full decommissioning plan for SVL shall be completed including a timeline for the complete removal of the facility.

1.11 Recommendation and Cost Associated with Relocation of SVL

NLH has requested a high-level review which targets the development of a budgetary estimate and scope for the relocation of the 50 MW SVL facility from its current location to another location, yet to be specified, within the province.

1.11.1 Project Schedule Summary

The order of magnitude project schedule summary is based on expert opinion and knowledge, assumptions, and previously completed similar projects.

- Overall Schedule: 37-43 weeks
  - Tendering Phase: 5-7 Weeks
  - Implementation Phase: 32-36 weeks
    - Power Plant Dismantling
    - Packing and Freight
    - Power Plant Reconstruction

1.11.2 Methodology

Dismantling SVL

Hatch recommends that the dismantling work be competitively tendered and primarily lump sum with preference given to the local contracting community, to the extent that the necessary skills and demonstrated competence are available.

Packing and Freight

It is proposed that the power plant would be dismantled in the largest practical sections for ease of transportation and reassembly, although special consideration needs to be taken with regards to corrosion protection and impact damage of specific items. Transporting of the plant will be a challenge due to the location of the plant and the size and weight of some of the major components.

Reconstruction

The reconstruction works at the proposed site would commence in parallel with the dismantling work at the existing SVL site to avoid prolonged storage requirements. This shall include site preparation works, foundations and other civil works, pipe services, galleries, mechanical/ electrical install, etc.

Commissioning

Planning for commissioning shall start early in the decommissioning phase and commissioning shall commence as systems become available.

1.11.3 Order of Magnitude Estimate

Development of budget estimate is based on Hatch internal networking and Hatch engineers' previous experiences conducting works of this nature.

Table 1-8:SVL Relocation Order of Magnitude Estimate ($1000's)

No.	Description	Total
10	**Project and Construction Management**	3,326
20	**Engineering**	1,107
30	**Procurement** (not required in current scope)	
40	**Contract packages**	35,461
50	**Commissioning**	752
60	**Project Spares** (not required in current scope)	
	Total	**$ 40,646**

2. Introduction

2.1 HWD & SVL

This comprehensive report provided to Newfoundland Labrador Hydro (NLH) includes a Condition Assessment and Life Cycle Cost Analysis of the Hardwoods (HWD) and Stephenville (SVL) Gas Turbine Facilities. Following the receipt of this report NLH intends to use this information to inform its options for generation, should it be determined that additional backup generation is required to support the provision of least cost and reliable service.

2.2 Background

2.2.1 HWD

The Hardwoods Gas Turbine Facility began service in 1976. HWD operates as both a generator for peaking and emergency backup and as a synchronous condenser. Operating as a synchronous condenser is the dominant mode of operation for this station.

Figure 2-1: Hardwoods Gas Turbine Station

Figure 2-2: Hardwoods Elevation View

2.2.2 SVL

The Stephenville Gas Turbine Facility began service in 1975. SVL is a sister unit to HWD. SVL operates as both a generator for peaking and emergency backup and as a synchronous condenser. Operating as a synchronous condenser is the dominant mode of operation for this station.

Figure 2-3: Stephenville Gas Turbine Station

Figure 2-4: Stephenville Elevation View

2.3 HWD General Description of the Facility

The Gas Turbine is located within a terminal station consisting of 66 kV and 230 kV bus work, transformers, circuit breakers, and transmission lines. The Gas Turbine generator output voltage of 13.8 kV is connected via an enclosed bus duct to a circuit breaker located in a switchgear assembly.

2.3.1 Gas Generator Engines and Subsystems

The facility consists of two Rolls Royce Olympus C type 2022 Gas Generator Engines (A&B). The gas generator engines are fired on #2 Fuel Oil also known as Diesel Fuel. Each of the gas generator engines (A&B) have independent air intake structures.

2.3.2 Power Turbine, Generator and Subsystems

Each of the two Rolls Royce Olympus C Gas Generator Engines (A&B) drive independent Curtis Wright Power Turbines equipped with SSS size 208T clutches. Each of the power turbines have independent exhaust stacks.

A 63,341 kVA 13.8 kV Brush Generator is common to and driven by either or both power turbines as required by operations. The generator has a rotating exciter connected to the shaft. Fan blades on the generator shaft induces filtered outside air through the stator and rotor providing cooling air to the generator.

Each of the power turbines, clutches, and the generator share a common lube oil system. The lube oil system is cooled by an external Glycol Cooling fin fan heat exchanger.

2.3.3 Instrumentation and Control Systems

The system is controlled by an ELSAG Bailey INFI 90 Distributed Control System (DCS) located within the Control Building. It provides process control, human machine interface

(HMI), and monitoring functions for the HWD facility. The gas turbine can also be remotely started, stopped, and monitored from the Energy Control Centre located in St. John's using a Supervisory Control and Data Acquisition (SCADA) system.

2.3.4 Electrical Systems

The electrical system consists of a 13.8 kV switchgear assembly housed in an outdoor enclosure. An enclosed bus duct connects the generator to its circuit breaker and a 13.8/66 kV step-up transformer.

The Control Building houses motor control centers, protection and control devises, a battery charger, and an inverter. The 125 V DC batteries are installed in a battery room within the Control Building.

2.3.5 Fuel Oil System

The Fuel Oil System consists of a fuel truck unloading pump set located in a fuel oil unloading building at the storage tank area, one fuel oil storage tank of 14,000 bbl, and a piping system between the storage tank and the fuel forwarding pump sets. Both AC and DC motors are located in a dedicated fuel forwarding building.

2.3.6 Glycol Cooling System

The Glycol Cooling System for the main lube oil system consists of a fin fan air cooled heat exchanger and a single glycol circulation pump with a three-way temperature control valve. The glycol cooler is located outdoors, and the circulating pump and three-way temperature control valve are located in the Auxiliary Module Building dedicated for the lube oil storage and pump facility.

2.3.7 Support Buildings

The facility layout includes the following support structures; A Control Building, Fuel Unloading Building, Fuel Forwarding Building, Auxiliary Module Building, Maintenance and Parts Storage Building, High Voltage Switchgear Building, and Emergency Back-up Diesel Generator Building.

2.4 SVL General Description of the Facility

The Gas Turbine is located within a terminal station consisting of 66 kV and 230 kV bus work, transformers, circuit breakers, and transmission lines. The Gas Turbine generator output voltage of 13.8 kV is connected via an enclosed bus duct to a circuit breaker located in a switchgear assembly.

2.4.1 Gas Generator Engines and Subsystems

The facility consists of two Rolls Royce Olympus C type 2022 Gas Generator Engines (A&B). The gas generator engines are fired on #2 Fuel Oil (Diesel). Each of the gas generator engines (A&B) have independent air intake structures.

2.4.2 Power Turbine, Generator and Subsystems

Each of the two Rolls Royce Olympus C Gas Generator Engines (A&B) drive independent Curtis Wright Power Turbines equipped with SSS size 208T clutches. Each of the power turbines have independent exhaust stacks.

A 63,341 kVA 13.8 kV Brush Generator is common to and driven by either or both power turbines as required by operations. The generator is cooled by a 50/50 glycol water mixture which absorbs heat from the generator casing and discharges heat to atmosphere through an external heat exchanger that is complete with fan cooling.

Each of the power turbines, clutches, and the generator share a common lube oil system. The lube oil system is cooled by an external Glycol Cooling fin fan heat exchanger.

2.4.3 Instrumentation and Control Systems

The system is controlled by an ELSAG Bailey INFI 90 Distributed Control System (DCS) located within the Control Building, and it provides human machine interface (HMI) and monitoring functions for the SVL facility. The gas turbine can also be remotely started, stopped, and monitored from the Energy Control Centre located in St. John’s using a Supervisory Control and Data Acquisition (SCADA) system.

2.4.4 Electrical Systems

The electrical system consists of a 13.8 kV switchgear assembly housed in an outdoor enclosure. An enclosed bus duct connects the generator to its circuit breaker and a 13.8/66 kV step-up transformer.

The Control Building houses motor control centers, protection and control devices, battery chargers, 250 V and 125 V batteries, and an inverter.

2.4.5 Fuel Oil System

The fuel oil system includes a fuel truck unloading facility with fuel unloading pumps, three fuel oil storage tanks each with 3000 bbl nominal capacity, and fuel forwarding pumps located within the Fuel Forwarding Building.

2.4.6 Glycol Cooling System

The Glycol Cooling System for the main lube oil system consists of a fin fan air cooled heat exchanger and a glycol circulation pump with a three-way temperature control valve. The glycol cooler is located outdoors

2.4.7 Support Buildings

The SVL facility layout includes the following support structures; A Control Building, Fuel Forwarding Building, Parts Storage Shed, Waste Oil Storage Shed, and Emergency Back-up Diesel Generator Building.

3. Project Description

3.1 HWD & SVL Project Overview

Newfoundland and Labrador Hydro (NLH) is considering the future role of the Hardwoods (HWD) and Stephenville (SVL) 50 MW Gas Turbine Stations post commissioning of the Muskrat Falls Project assets. Currently, these two facilities are planned for retirement as early as March 31, 2023. There are no proposed capital projects for either the HWD or SVL stations in the 2022 Capital Budget Application (CBA) or in the five-year capital plan.

NLH wishes to understand the capital and operational requirements more fully should the following options be considered for HWD and SVL:

- Continued extension of the HWD and SVL Generating Stations, as currently used in backup operations mode beyond the current March 31, 2023, retirement.
- The viability and suitability of the Generating Stations to be used as backup generating facilities to support the island system in the event of a prolonged outage of the Labrador-Island Link until the End of Economically Feasible Life (EEFL) of the plants be considered.
- Recommendations for retirement of SVL facility and utilization of components to extend the life of HWD.
- Recommendation and cost associated with relocation of the SVL facility to another location in the province.

4. Methodology

4.1 HWD & SVL

The objective of this work is to map out the potential futures for the Hardwoods and Stephenville stations to inform supply planning activities at NLH. The work provides an independent assessment of the condition of the HWD and SVL stations to determine capital requirements for the facility to extend its current retirement date.

The scope of work completed through the methodology outlined in this section adheres to the requirements of the RFP.

4.1.1 Part A: Document Review

Design documents and historical records including the basic plant design documents, operational history, plant performance and availability, major plant issues that caused trips over the past ten years, major maintenance, and major overhauls performed on plant equipment were reviewed.

The key documents used for this study are listed below:

- HWD and SVL Operating Hours 2010-2020 (Excel sheet)
- HWD and SVL Reliability; DAUFOP and UFOP (Excel sheets)
- HWD and SVL Major Upgrades (Word document)
- HWD and SVL Preventative Maintenance (numerous PDFs)

4.1.2 Part A: Site Inspection

Our Site Inspectors focused on visual inspections of the state of equipment and systems, reviewed critical operating parameters, and observed ongoing maintenance activities. Information gathered from the site visits was used in ascertaining viable reliability and potential feasible upgrades.

Hatch developed a Site Inspection Plan which is attached in Appendix A.

Hatch developed a Site Inspection Report with images attached in Appendix B.

4.1.3 Part B: Viability Study

The Viability Study includes cost estimates to understand the requirements more fully for the continued extension of the HWD and SVL Generating Stations beyond the current retirement period, viability, and suitability for the stations to be used as backup generating facilities to support the provision of least-cost reliable service. The viability study includes a sensitivity analysis which is an essential part of the risk assessment. The sensitivity analysis is a systematic approach to bridge uncertainty gaps. In the numerical model the sensitivity analysis is a method that measures the impact of uncertainties on multiple variables that can lead to cost related repairs and down time from power production.

For the purposes of determining viability and suitability of the HWD and SVL Generating Stations as backup generating facilities, a reference emergency power case of one outage of up to three weeks duration, occurring once per ten-year period will be considered. A sensitivity case considering one outage of up to six weeks duration occurring once per ten-year period will be considered as well.

5. HWD and SVL Condition Assessment

5.1 Boundaries

The Condition Assessment includes all major system components of the HWD and SVL Generating Stations. The study and site inspections focused on the Gas Turbine Facility and includes the following:

- Fuel unloading system
- Fuel Storage and distribution system
- Fuel forwarding module
- Control module
- Air intake structures
- Gas turbines
- Power turbines
- Exhaust stacks
- Building enclosures
- Clutches, generator, and exciter
- Control systems
- Power systems
- Auxiliary systems including compressed air, lube oil, glycol systems, etc.
- Turbine performance and reliability upgrades.

5.2 HWD & SVL Asset Grading

Grades from the asset grading scale in Table 5-1 were assigned to each critical asset.

Table 5-1: Asset Grading Scale

Grade	Condition	Description
5	Excellent	No visible defects, new or near new condition, may still be under warranty if applicable.
4	Good	Good condition, but no longer new, may have some slightly defective or deteriorated component(s), but is overall functional.
3	Adequate	Moderately deteriorated or defective components; but has not exceeded useful life.
2	Marginal	Defective or deteriorated component(s) in need of replacement; exceeded useful life.
1	Poor	Critically damaged component(s) or in need of immediate repair; well past useful life.
INA	--	Information Not Available. Information was not available or was inconclusive.

5.3 Hardwood Gas Turbine Facility (HWD)

The plant given its age is generally in good running condition with a few areas needing attention. Extension site photos are included in Appendix B Inspection Report. A summary of the grades for each unit's critical assets is provided in the Tables below.

Table 5-2: HWD Unit A Asset Grading

Description	Grade
Gas Generator Engines and Subsystems Unit A[1]	
Rolls Royce Olympus C Gas Turbine Engines	
Fuel Piping	**4**
Woodward Governor	**5**
Gas Generator Engines Lube Oil System	**5**
Gas Generator Engines Bearings	**4**
Compressed Air Starting System	**4**
Temperature monitoring system	**3**
Vibration monitoring system	**2**
Lube oil system	**3**
Lube Oil Controls	**3**
Air Inlet System	**3**
Exhaust Stacks	**INA[2]**
Fire Fighting System	**4**
Building Envelope	**3**

Description	Grade
Power Turbine, Generator and Subsystems Unit A	
Generator and Power Turbine Enclosure	**4**
Curtiss Wright Power Turbine[2]	**4**
SSS Power Turbine Clutches	**4**
Bearings	**INA[3]**
Main Lube Oil System (common to the Power Turbines, Clutches and Generator Bearings)	**4**
Generator Air Cooling System	**4**
Generator	**4**
Rotating Exciter	**4**
Automatic Voltage Regulator (AVR)	**4**
Generator Enclosure	**4**
Fire Fighting System	**4**

[1] *Borescope indicated carbon buildup on turbine and fuel nozzles.*

[2] *INA- Exhaust stacks for Unit A were not accessible during site visit. Exterior does not indicate heat escape.*

[3] *INA- Bearings were not accessible during site visit.*

Table 5-3: HWD Unit B Asset Grading

Description	Grade
Gas Generator Engines and Subsystems Unit B[1]	
Rolls Royce Olympus C Gas Generator Engines	
Fuel Piping	**4**
Woodward Governor	**5**
Gas Generator Engines Lube Oil System	**4**
Gas Generator Engines Lube Oil System	**4**
Gas Generator Engines Bearings	**4**
Compressed Air Starting System	**3**
Gas Generator Engine and Power Turbine Enclosure	**3**
Temperature monitoring system	**4**
Vibration monitoring system	**2**
Lube oil system	**4**
Lube Oil Controls	**3**
Air Inlet System	**4**
Exhaust Stacks	**4**
Fire Fighting System	**4**
Building Envelope	**3**
Power Turbine and Subsystems Unit B	
Curtiss Wright Power Turbine	**4**
SSS Power Turbine Clutches	**4**
Bearings	**4**
Fire Fighting System	**4**

[1] *Borescope indicated carbon buildup on turbine and fuel nozzles.*

Table 5-4: HWD I&C Asset Grading

Description	Grade
Instrumentation and Control	
Bailey Control System	**3**
Gas Turbine Control Building Envelope	**4**

Table 5-5: HWD Electrical Asset Grading

Description	Grade
Electrical Systems[1]	
High Voltage Switchgear Building envelope	**4**
13.8 kV Switchgear (generator breaker)	**4**
Generator Output Bus Duct	**4**
Generator protection relays	**4**
Sync-check relay	**INA[2]**
Motor Control Centres (AC & DC)	**4**
Station DC supply (batteries and chargers)	**5**
Inverter (AC supply for control systems)	**5**
Emergency Backup Diesel Generator	**3[3]**

[1]The main transformer fans and cooler on the northeast side are heavily rusted. The transformer is in working condition but will need to be replaced in 2025.

[2]INA- Operation of the relay was not completed and visual inspection is not adequate for grading purposes.

[3]Emergency Backup Diesel Generator is capable of black start with operator intervention and managing the loads.

Table 5-6: HWD Fuel Oil Asset Grading

Description	Grade
Fuel Oil System	
Fuel Unloading Building envelope	**4**
Fuel Forwarding Building envelope	**4**
Oil Unloading	**4**
Oil Storage and Secondary Containment	**4**
Fuel Forwarding Equipment	**INA[1]**
Fuel Piping	**INA[1]**
Instrumentation and Control	**INA[1]**
Fuel oil tanks	**4**
Fuel forwarding system	**4**
Fire Fighting Systems	**4**

[1]INA- Information available is not adequate for grading purposes.

Table 5-7: HWD Glycol Cooling Asset Grading

Description	Grade
Glycol Cooling System	
Main Lube Oil Cooling System / Glycol Cooler[1]	**2**

[1] The cooling fins require combing to straighten, and the cooler requires power washing. NLH has advised that this maintenance has been added to the 2022 Spring/ Summer Maintenance Outage. If the required performance is not achieved, especially during the hot season, it is recommended that this system is further reviewed, and equipment upgraded as necessary.

Table 5-8: HWD Support Buildings Asset Grading

Description	Grade
Support Buildings	
Auxiliary Module Building Envelope	**4**
Maintenance and Parts Storage Building Envelope	**4**

5.3.1 Hardwoods Historical Operating Hours

The HWD Unit has served the customer base with varied run hours of the prior ten years. High utilization is noted from 2014 to 2018 with reductions to less significant operations for 2019-2021. Based on projections from NLH the unit is expected to be dispatched approximately 50 hours per year, with the exception being emergency coverage for loss of other generation. Lower operating hours are favorable for extending the life of the asset and avoiding high-cost maintenance expenses.

The operating hours for HWD per year are shown in the chart below:

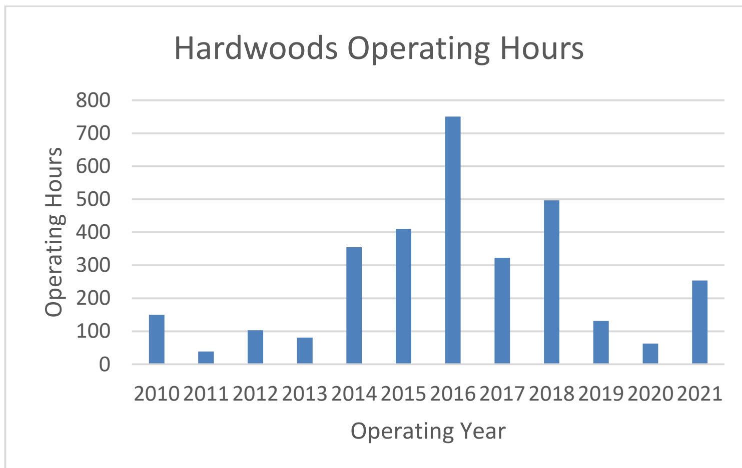

Figure 5-1: HWD Operating Hours

5.3.2 Hardwoods Historical DAUFOP and UFOP

HWD has experienced performance issues over the previous ten years and is currently exhibiting much improved operating performance. The Derated Adjusted Utilization Forced Outage Probability (DAUFOP) provides an indication of the unit's full capability and periods when it was limited from full production. The Utilization Forced Outage Probability (UFOP) provides an indication of the time the unit was not capable of any generation. The delta between the DAUFOP and UFOP provides an indication of the times a single gas generator was out of service or the site was limited for other reasons. It's noted the DAUFOP was higher than expected from 2010 through 2016. This period is also noted with high maintenance requirements for the site. 2017 through 2021 show UFOP less than 5% which is generally considered acceptable performance. DAUFOP is high in 2019 and 2020, however the unit was still able to meet the core mission of voltage support and emergency power over 95% of the time. The improving trend in reliability and the noted efforts to resolve operating issues and improve equipment condition are all signs that acceptable performance will continue with similar efforts in future years.

The Derated Adjusted Utilization Forced Outage Probability (external conditions excluded) and Utilization Forced Outage Probability (external conditions excluded) from 2010 – 2020 is shown in the chart below:

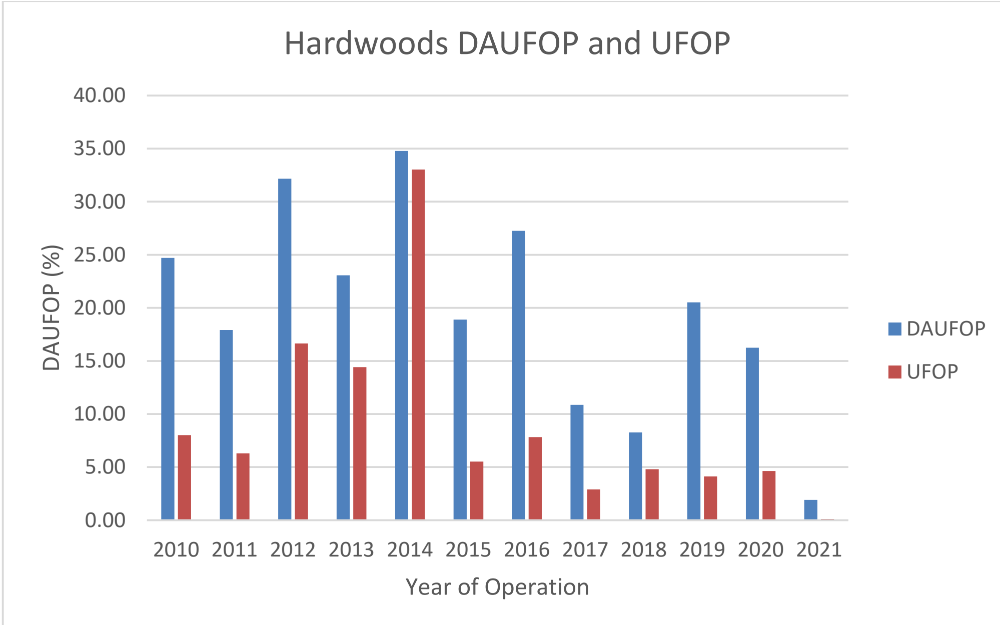

Figure 5-2: HWD DAUFOP and UFOP

5.3.3 Hardwoods Historical Major Upgrades

The table below outlines major upgrades and the associated costs from 2009-2019 completed at HWD. Over this time period a total of $22,178,800.00 was invested in major upgrades at HWD.

Table 5-9: HWD Historical Major Upgrades

Year(s)	Cost ($)	Project
2009-2012	$4,506K	Life extension project: - Refurbish inlet air system & exhaust stacks - Engine overhauls/PT Inspection - Inlet air/exhaust stack refurbishment - Main Lube Oil cooler refurbishment - Enclosure refurbishment - Fuel tank refurbishment - Other misc. refurbishments
2013	$8,420K	Generator replacement
2016	$255K	In enclosure fuel piping replacement
2016	$3,047K	Engine 202205 refurbishment
2016	$80.7	Replace 125V batteries

Year(s)	Cost ($)	Project
2017	$957K	Life Extension Project: - Filtration upgrades - Instrumentation upgrades
2018	$3,823K	Life Extension Project: - Replace demister - Upgrade air inlet & Exhaust stacks
2019	$685.9K	Upgrade HMI & AVR
2019	$404.2K	Replace fuel control valves

5.3.4 *Historical Major Maintenance*

Between HWD and SVL there have been eight engine overhauls since 2014 costing on average approximately $1,600,000.00 each, totalling approximately $12,800,000.00

Table 5-10: Engine Overhauls and Associated Cost

Year(s)	Cost ($)	Engine Serial Number	Failure
2014	~$1,600K	202223	- INA
2015	~$1,600K	202224	- Combustion cans severely damaged - Large pieces of combustion chamber formed around HP turbine stator blade
2016	~$1,600K	202204	- Mainline bearing failure - Inadequate lubrication
2016	~$1,600K	202205	- Cracked interconnector - Damaged combustion chambers - Damaged turbine blades
2017	~$1,600K	202205	- Damaged combustion chambers
2017	~$1,600K	202224	- Erosion and cracking combustion chambers - LP turbine blade damage - Soot and wet oil No 9 bearing
2018	~$1,600K	202204	- HP turbine blade detachment - Damaged turbine blades
2019	~$1,600K	202223	- Damaged combustion chamber - Damaged bearings - Damaged HP turbine blades - Cracked starter gear box

5.3.5 *Historical Maintenance Catalogued*

The table below outlines the maintenance activities at HWD from documentation shared by NLH for the purpose of conducting this assessment.

Table 5-11: HWD Maintenance

Year(s)	Project
2013	Brush generator upgrade including Wound Stator Assembly, Rotor and Exciter Armature, Exciter Assembly, fault detector system, replacement heaters, upgraded Filtration System and effective seal and door lock to the lineside cubicle.
2013	Buildings and structures coating program.
2015	Stantec Gas Turbine Air Intake Inspection Report.
2015	Out of service API 653 Inspection of Tank No: 1.
2018	Forced outage resulted in Brush inspection of generator. Bearings were replaced or inspected, cleaned and returned to service.
2019	Preventative maintenance. Doble testing of the generator, 13.8 kV bus duct. Inspect and clean bus duct.
2019	Preventative maintenance. Overspeed test.
2019	Preventative maintenance. Generator annual inspection.
2019	Brush inspection of generator. The EE end main generator bearing was changed and the third bearing for the exciter had liners replaced.
2020	Preventative maintenance. Doble testing.
2020	Borescope End A & B.

5.3.6 Rolls Royce Olympus C Gas Generator Engines and Curtis Wright Power Turbines (A & B)

Figure 5-3: Rolls Royce Olympus C Compressor End

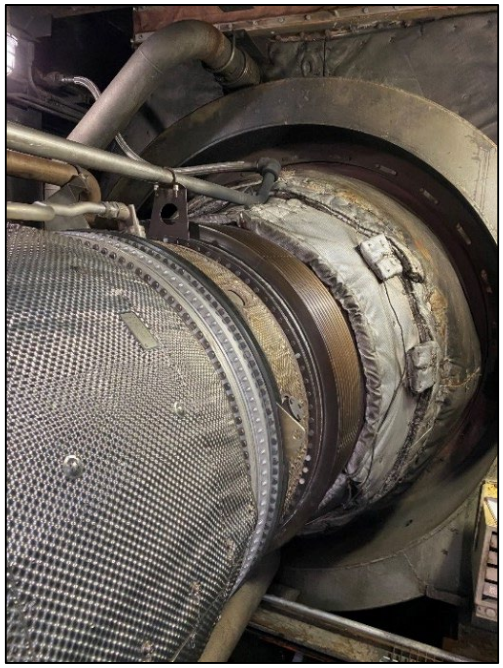

Figure 5-4: Rolls Royce Olympus C Turbine End

The Temperature Monitoring System and Vibration Monitoring System on Unit A Rolls Royce Olympus C Gas Generator Engine is nearing end of life and replacement is recommended. A borescope was conducted on Unit A that showed signs of carbon buildup on the turbine and on several nozzles. It is recommended that the nozzles are cleaned in an ultrasonic solvent bath and evaluated for replacement.

The Woodward Governors on Unit A & B have been replaced within the past 2 years and are in good condition. The fuel piping, gas generator engine bearings, and the compressed air starting system subcomponents are in good condition.

The southwest side of Gas Generator Engine and Power Turbine Enclosure of Unit A shows signs of corrosion, and it is recommended that the enclosure is repainted.

The Curtiss Wright Power Turbines on Unit A & B are clean with no visible oil leaks. The SSS Power Turbine Clutches show no signs of leaks and are clean. The Rotating Exciter is in good condition and the Automatic Voltage Regulator (AVR) was recently replaced (within the past 2 years). The Generator Enclosure is in good condition with no visible damage, and it was removed for work within the last ten years.

The Main Lube Oil System is in good working condition with many system components having been replaced in the recent past. The Lube Oil System uses a specific model of filter that is preferred by NLH, but this filter is no longer manufactured. It is recommended that an oil filter replacement meeting NLH standards is sourced from a vendor specializing in the fabrication of custom filters. The Lube Oil Pumps have been replaced within the last 10 years and the piping system is in good condition. The lube oil controls use mainly analog gauges, and it is recommended that these are replaced with an electronic system for performance and tracking purposes.

The Air Inlet Systems on Units A and B have a pre-filter to remove larger particles, and the filters closer to the road are exposed to a higher buildup of particles. These filters are degrading with age and will need general maintenance to continue their intended service through the end of life.

The Fire Fighting Systems on Units A & B have been replaced from a Halon system to an Inergen System.

5.3.7 Instrumentation and Control Systems

The Bailey Control System, currently owned and supplied by ABB, is in working condition, but it was noted that it is old equipment. The power was off during the site inspection and some of the relays moved easily.

From the ABB articles on their website, the Infi 90 has been migrated from Bailey Net 90 to Infi 90 to Harmony distributed control system and can be enhanced with the applications from the latest generation DCS System 800xA. For more than 30 years, ABB has evolved the Symphony family, ensuring that each new generation enhances its predecessors and is backwardly compatible with them - all in accordance with their long-held policy of "evolution without obsolescence”.

In understanding this backward compatibility, the current system should offer full-service life and product availability for the remaining life of the unit.

A human machine interface, HMI, that is connected to a network is always a security concern. New updates and security patches are often forgotten which leaves the system vulnerable to cyber and physical attacks. Embedded systems such as these are typically changed out every 10-15 years and upgraded to the latest operating system including security, antivirus, and firewall protection. Depending on the suggested end of service life, an HMI upgrade is suggested to meet the longest life duration.

The vibration system is din rail mounted Allen Bradley XM series. The XM modules provide a 4-20mA signal to the DCS. Alarming and tripping of the unit are done in the DCS. There are cards for eccentricity and dynamic measurement. The control node can be expanded to 8 modules and would give an alternative provision for a failed ABB I/O card or failed metering device. In not fully understanding the custom configuration, replacing the vibration system with an Infi 90 integrated solution is suggested. It is recommended that the ability to significantly add cards to the DCS is reviewed.

Woodward LQ series valves and drives provide precise electronic fuel control. In comparison with later model hydraulic valves such as Woodward’s TM55, hydraulic leaks and associated equipment failures have been eliminated. The fuel valve upgrade provides solid service for years to come with available support and replacement parts from Woodward.

The Generator AVR has been retrofitted with a redundant Basler DECS 250N. This is a robust voltage regulator with shelf availability and replacement is not predicted, unless malfunction, till the end of service life. The DECS 250N contains negative field forcing capabilities which makes it well suited to be used with a power system stabilizer. This is basically defined as dampening generator phase oscillations or harmonics. If rotor angle stability, frequency stability, or voltage stability is an area of concern, the addition of a power system stabilizer is recommended.

The 125/220V DC Cordex 4.4 kW Rectifiers are still readily available and not swappable. No replacement unless malfunction is recommended.

The Auto Pulse 442R Fire Controller and system should be periodically tested according to local fire laws. No replacement is recommended.

HMIs are being used today as the main operation interface. The door switches and raise / lower levers are not being exercised. A once-a-year PM that exercises all contactors, relays, and lights is to be checked and replaced as necessary. This is the unit's secondary starting and control interface during HMI malfunction and loss of network communications.

5.3.8 Electrical Systems

The fans and cooler on the northeast side of the Main Transformer are showing signs of corrosion. It is recommended that the fans are replaced and the Cooler repainted. The replacement of the transformer is required by 2025 due to PCB containing oil. Any repairs should be considered against the mandated replacement.

Figure 5-5 Transformer, Cooler and Fans

The 13.8 kV Switchgear and Generator Output Bus Duct is original equipment. The Generator Protection Relays original equipment has been replaced. The Motor Control Centers (AC and DC) are original, in good condition and are clean.

The Station DC supply, batteries, and chargers have been replaced within the last five years.

The Emergency Backup Diesel Generator is 40 kW and provides power to the batteries and some of the lighting. The generator is capable of starting the plant from black conditions with operator intervention and managing the loads.

5.3.9 Fuel Oil System

The Fuel Oil Transfer System including unloading pumps, transfer pumps, and piping are in good condition with no visible signs of leaking. The Fuel Forwarding System including pumps and piping have been replaced within the last ten years. The exterior of the Oil Storage Tank is in good condition.

5.3.10 Glycol Cooling System

The Main Lube Oil Cooling System / Glycol Cooler is in marginal condition. The cooling fins require combing to straighten, and the cooler requires power washing. NLH has advised that this maintenance has been added to the 2022 Spring/ Summer Maintenance Outage. If the required performance is not achieved, especially during the hot season, it is recommended that this system is further reviewed, and equipment upgraded as necessary.

Figure 5-6: Glycol Coolers – Top View

5.3.11 Support Buildings

The Power Station Buildings and Exhaust Stack envelopes show signs of rust and corrosion. Grinding to bare metal and repainting is recommended to stop the advancing corrosion.

Figure 5-7: Building Envelopes

5.4 Stephenville Gas Turbine Facility (SVL)

The plant, given its age, is generally in running condition with a few areas needing attention. Extensive site photos are included in Appendix B Inspection Report. A summary of the grades for each unit's critical assets is provided in the Tables below.

Table 5-12: SVL Unit A Asset Grading

Description	Grade
Gas Generator Engines and Subsystems Unit A	
Rolls Royce Olympus C Gas Generator Engines	
Fuel Piping	**4**
Woodward Governor	**4**
Gas Generator Engines Lube Oil System	**4**
Gas Generator Engines Bearings	**4**
Compressed Air Starting System	**4**
Gas Generator Engine and Power Turbine Enclosure	**4**
Temperature monitoring system	**4**
Vibration monitoring system	**INA**[1]
Lube oil system	**2**
Lube Oil Controls	**4**
Air Inlet System	**INA**[1]
Exhaust Stacks	**4**
Fire Fighting System	**3**
Building Envelope	**4**
Power Turbine, Generator and Subsystems Unit A	
Curtiss Wright Power Turbine	**4**
SSS Power Turbine Clutches	**4**
Bearings	**4**
Main Lube Oil System (common to the Power Turbines, Clutches and Generator Bearings)	**4**
Generator Air Cooling System	**4**
Generator	**3**
Rotating Exciter	**4**
Automatic Voltage Regulator (AVR)	**5**
Generator Enclosure	**4**
Fire Fighting System	**INA**[1]

Table 5-13: SVL Unit B Asset Grading

Description	Grade
Gas Generator Engines and Subsystems Unit B	
Rolls Royce Olympus C Gas Generator Engines	
Fuel Piping	**4**
Woodward Governor	**4**
Gas Generator Engines Lube Oil System	**4**
Gas Generator Engines Lube Oil System	**4**
Gas Generator Engines Bearings	**4**
Compressed Air Starting System	**4**
Gas Generator Engine and Power Turbine Enclosure	**4**
Temperature Monitoring System	**4**
Vibration Monitoring System	**2**
Lube Oil System	**2**
Lube Oil Controls	**3**
Air Inlet System	**4**
Exhaust Stacks	**4**
Fire Fighting System	**4**
Building Envelope	**4**
Power Turbine and Subsystems Unit B	
Curtiss Wright Power Turbine	**4**
SSS Power Turbine Clutches	**4**
Bearings	**INA**[1]
Rotating Exciter	**4**
Automatic Voltage Regulator (AVR)	**4**
Fire Fighting System	**4**

[1]*INA- Information available is not adequate for grading purposes.*

Table 5-14: SVL I&C Asset Grading

Description	Grade
Instrumentation and Control	
Bailey Control System	**3**
Gas Turbine Control Building Envelope	**4**

Table 5-15: SVL Electrical Asset Grading

Description	Grade
Electrical Systems	
High Voltage Switchgear Building envelope	**4**
13.8 kV Switchgear (generator breaker)	**4**
Generator Output Bus Duct	**4**
Generator Protection Relays	**4**
Sync-check Relay	**INA[1]**
Motor Control Centres (AC & DC)	**INA[1]**
Station DC Supply (batteries and chargers)	**2**
Inverter (AC supply for control systems)	**5**
Emergency Backup Diesel Generator	**INA[1]**

[1]INA- Information available is not adequate for grading purposes.

Table 5-16: SVL Fuel Oil Asset Grading

Description	Grade
Fuel Oil System	
Fuel Unloading Building envelope	**4**
Fuel Forwarding Building envelope	**4**
Oil Unloading	**INA[1]**
Oil Storage and Secondary Containment	**INA[1]**
Fuel Forwarding Equipment	**4**
Fuel Piping	**4**
Instrumentation and Control	**3**
Fuel Oil Tanks	**INA[1]**
Fuel Forwarding System	**INA[1]**
Fire Fighting Systems	**INA[1]**

[1]INA- Information available is not adequate for grading purposes.

Table 5-17: SVL Glycol Cooling Asset Grading

Description	Grade
Glycol Cooling System	
Main Lube Oil Cooling System / Glycol Cooler	**4**

Table 5-18: SVL Support Buildings Asset Grading

Description	Grade
Support Buildings	
Emergency Backup Diesel Generator Building	**4**
Parts Storage Shed	**4**
Waste Oil Storge Building	**4**

5.4.1 Stephenville Historical Operating Hours

The SVL Unit has served the customer base with varied run hours over the past ten years. High utilization is noted from 2014 to 2018 with reductions to less significant operations for 2019-2021. Based on projections from NLH the unit is expected to be dispatched approximately 50 hours per year, with the exception being emergency coverage for loss of other generation. Lower operating hours are favorable for extending the life of the asset and avoiding high-cost maintenance expenses.

The operating hours for SVL per year are shown in the chart below.

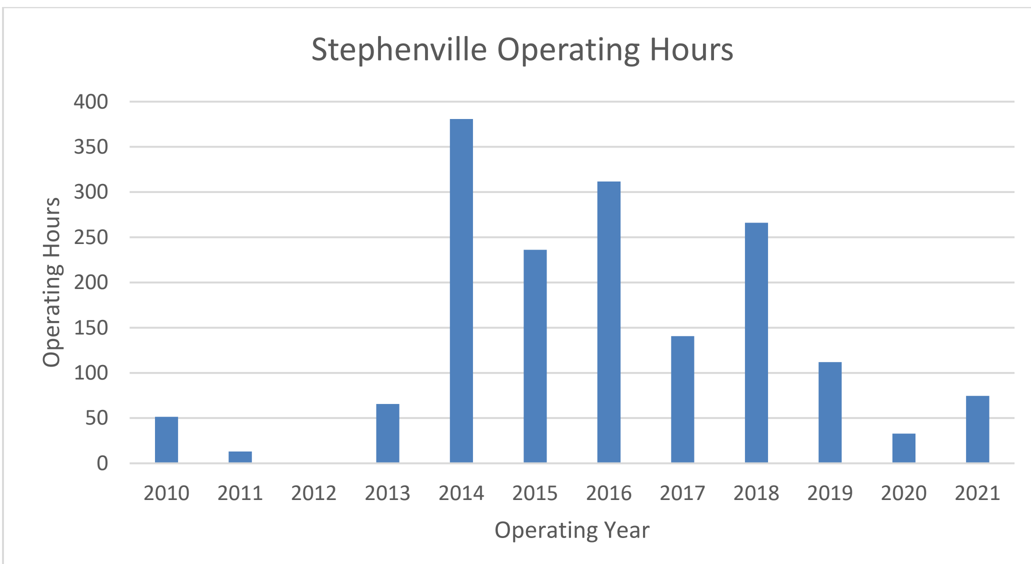

Figure 5-8: SVL Operating Hours

5.4.2 Stephenville Historical DAUFOP and UFOP

SVL has experienced performance issues over the previous ten years and is currently exhibiting much improved operating performance. The Derated Adjusted Utilization Forced Outage Probability (DAUFOP) provides an indication of the unit's full capability and periods when it was limited from full production. The Utilization Forced Outage Probability (UFOP) provides an indication of the time the unit was not capable of any generation. The delta between the DAUFOP and UFOP provides an indication of the times a single gas generator was out of service, or the site was limited for other reasons. It's noted the DAUFOP was higher than expected from 2010 through 2018 which includes a generator outage that spanned 2012 and part of 2013. This period is also noted with high maintenance requirements for the site. 2017 through 2021 show UFOP less than 5% which is generally considered acceptable performance. The improving trend in reliability and the noted efforts to resolve operating issues and improve equipment condition are all signs that acceptable performance will continue with similar efforts in future years.

The Derated Adjusted Utilization Forced Outage Probability (external conditions excluded) and Utilization Forced Outage Probability (external conditions excluded) from 2010 – 2021 is shown in the chart below:

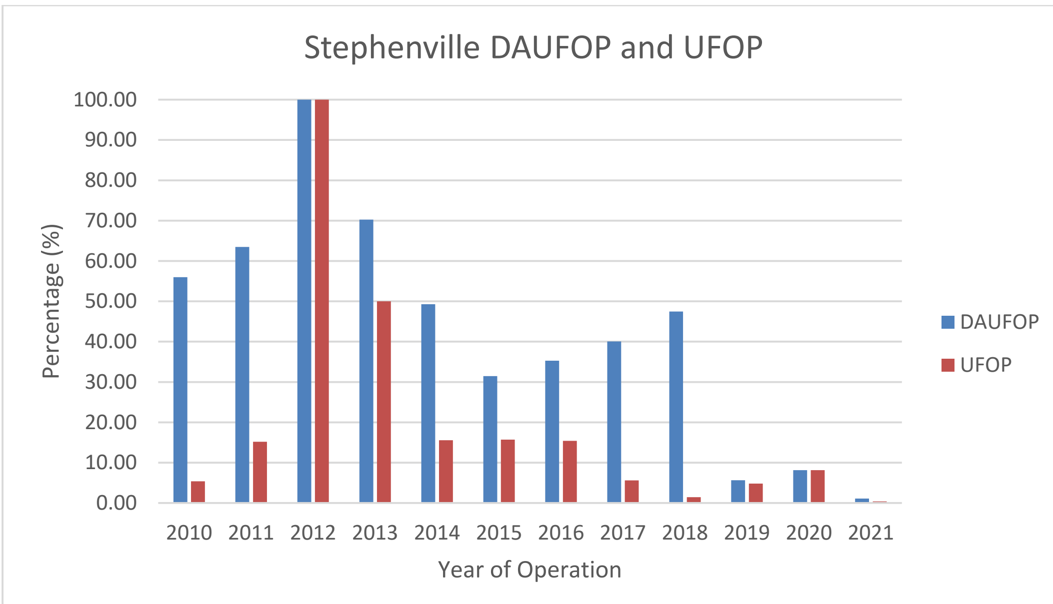

Figure 5-9: SVL DAUFOP and UFOP

5.4.3 *Stephenville Historical Major Upgrades*

The table below outlines major upgrades and the associated costs from 2010-2018 completed at SVL. Over this time period a total of $14,986,000.00 was invested in major upgrades at SVL.

Table 5-19: SVL Historical Major Upgrades

Year(s)	Cost ($)	Project
2010-2014	$1,147K	Glycol system upgrades
2012-2013	$5,700K	Generator Rewind and Major Overhaul
2014-2015	$1,353K	- Replace fuel filtration system - Upgrade instrumentation - Replace fuel valve actuators - Upgrade air start system
2015	$2,665K	- Replace motor control center - Replace station service transformer power cable - Replace vibration sensors
2016	$2,525K	- Exhaust stack & Air inlet repair - Generator fire suppression installation - Install of new Main Lube Oil glycol heat exchanger, Main Lube Oil pumps, & glycol pump
2017	$634K	Instrumentation Upgrades - Replace obsolete instrumentation - Install additional instrumentation including wiring to DCS & I/O cards - Install of emergency stops in engine enclosures
2017	$230K	Filtration upgrades - Fuel offloading, forwarding duplex filter - Duplex oil filter, fuel heater
2017	$489K	Replace generator bed heater
2018	$243K	Replace demister system

5.4.4 *Historical Major Maintenance**

Between HWD and SVL there has been eight engine overhauls since 2014 costing on average approximately $1,600,000.00 each.

*(Repeated from section 5.3.4 for consistency and inclusion).

5.4.5 *Historical Maintenance Catalogued*

The table below outlines the maintenance activities at SVL from documentation shared by NLH for the purpose of conducting this assessment.

Table 5-20: SVL Maintenance

Year(s)	Description
2015	Stantec Gas Turbine Air Intake Inspection Report.
2018	Preventative maintenance Brush generator minor inspection.
2019	Preventative maintenance. Doble testing of the generator, 13.8 kV bus duct. Inspect and clean bus duct.
2020	Borescope End A & B.

5.4.6 *Rolls Royce Olympus C Gas Generator Engines and Curtis Wright Power Turbines (A & B)*

The Rolls Royce Olympus C Gas Generator Engine Unit A & B Fuel Piping, Woodward Governor, Engine Lube Oil System, Temperature Monitoring System, and Engine Bearings are in good condition. The Gas Generator Engine and Power Turbine Enclosures are clean and in good condition with no visible signs of leaks. The Vibration Monitoring System on Unit A and Unit B are in marginal condition nearing end of life and replacement is recommended.

The Firefighting Systems on Units A & B have been replaced in the recent past with an Inergen System. The Firefighting system is in good condition.

The Air Inlet System is clean and in good condition, and the media filters are in good condition.

The Exhaust Stack on Unit A has a small heat leak and there is movement of the insulation. The insulation should be replaced as necessary and firmly reattached. All thermal damage to the stack shell and coating systems should be repaired.

The Curtiss Wright Power Turbines on Units A & B are clean with no visible oil leaks. The SSS Power Turbine Clutches show no signs of leaks and are clean. The Rotating Exciter is in good condition and the Automatic Voltage Regulator (AVR) was recently replaced (within the past two years). The Generator Enclosure is in good condition with no visible damage.

The Air Compressor System is in new condition. Two air compressors have been replaced.

The Generator glycol and water (50/50) cooling system is in good condition.

5.4.7 *Instrumentation and Control Systems*

The Bailey Control System, currently owned and supplied by ABB, is in working condition, but it was noted that it is old equipment.

From the ABB articles on their website, the Infi 90 has been migrated from Bailey Net 90 to Infi 90 to Harmony distributed control system and can be enhanced with the applications from the latest generation DCS System 800xA. For more than 30 years, ABB has evolved the Symphony family, ensuring that each new generation enhances its predecessors and is backwardly compatible with them - all in accordance with their long-held policy of "evolution without obsolescence".

In understanding this backward compatibility, the current system should offer full-service life and product availability for the remaining life of the unit.

A human machine interface, HMI, that is connected to a network is always a security concern. New updates and security patches are often forgotten which leaves the system vulnerable to attacks. Embedded systems such as these are typically changed out every 10-15 years and upgraded to the latest operating system including security, antivirus, and firewall protection. Depending on the suggested end of service life, an HMI upgrade is suggested to meet the longest life duration.

The vibration system is din rail mounted Allen Bradley XM series. The XM modules relay a 4-20mA signal to the DCS. There are cards for eccentricity and dynamic measurement. The control node can be expanded to 8 modules and would give an alternative provision for a failed ABB I/O card or failed metering device. In not fully understanding the custom configuration, replacing the vibration system with an Infi 90 integrated solution is suggested. It is recommended that the ability to significantly add cards to the DCS is reviewed.

Woodward LQ series valves and drives provide precise electronic fuel control. In comparison with later model hydraulic valves such as Woodward's TM55, hydraulic leaks and associated equipment failures have been eliminated. The fuel valve upgrade provides solid service for years to come with available support and replacement parts from Woodward.

The Generator AVR has been retrofitted with a redundant Basler DECS 250N. This is a robust voltage regulator with shelf availability and replacement is not predicted, unless malfunction, till the end of service life. The DECS 250N contains negative field forcing capabilities which makes it well suited to be used with a power system stabilizer. This is basically defined as dampening generator phase oscillations or harmonics. If rotor angle stability, frequency stability, or voltage stability is an area of concern, the addition of a power system stabilizer is recommended.

The 125/220V DC Cordex 4.4kW Rectifiers are still readily available and not swappable. No replacement unless malfunction is recommended.

The Auto Pulse 442R Fire Controller and system should be periodically tested according to local fire laws. No replacement is recommended.

HMIs are being used today as the main operation interface. The door switches and raise / lower levers are not being exercised. A once-a-year PM that exercises all contactors, relays, and lights is to be checked and replaced as necessary. This is the unit's secondary starting and control interface during HMI malfunction and loss of network communications.

5.4.8 *Electrical Systems*

The 13.8 kV Switchgear, Generator Output Bus Duct, and Generator Protection Relays are original equipment.

The station DC supply equipment includes lead acid batteries which have not been replaced in the recent past. The DC supply batteries are a critical asset and replacement with upgraded batteries is recommended.

The Inverter for AC supply to the control systems is in good condition and has been replaced within the last five years.

The replacement of the main transformer is required by 2025 due to PCB containing oil.

5.4.9 *Fuel Oil System*

The Fuel Oil Heater used during fuel unloading is in new condition.

The Fuel Forwarding Equipment including pumps have been replaced within the last twelve years, there are spare pumps in inventory and the fuel piping is in good condition.

The exteriors of the Fuel Oil Storage Tanks are visibly in good condition.

The Fuel Oil System instrumentation includes many analog gauges throughout. Upgrading to digital instrumentation should be considered to increase performance tracking.

5.4.10 *Glycol Cooling System*

The Main Lube Oil Cooling System (glycol cooler) is in good condition.

5.4.11 *Support Buildings*

The SVL Support Building Envelopes are in good condition with some areas of the plant requiring paint.

5.4.12 *General Civil Works*

The area around the fuel storage tanks is prone to flooding, requiring regular pumping. Typically, light oil storage areas have membranes to contain leaks. A design review should be conducted to ensure stormwater is properly handled.

Figure 5-10: Fuel Oil Storage Tanks

The side of the road leading to the station has significant material washout creating a ravine. If the dirt road is compromised the station would not be accessible to NLH staff and for fuel oil deliveries. It is recommended that this hazard is corrected. The estimated cost of repair is on the order of $100K.

Figure 5-11: Shoulder of Service Road

6. HWD & SVL Life Cycle Cost Analysis and Viability Assessment

Hatch reviewed information provided by NLH regarding current operating problems, significant upgrades, and maintenance work performed at the HWD and SVL facilities in the past for consideration in making assessments on operating reliability. The assessment identifies potential problems in continuing to operate the facilities as they presently exist. The viability assessment focuses on the following extension of operational timelines:

- Operation until End of Economically Feasible Life (EEFL)
- Additional 2 years of operation (2025)
- Additional 5 years of operation (2028)
- Additional 10 years of operation (2033).

This Viability Assessment recommends solutions with associated cost estimates for maintaining the Facilities as reliable generating units for the durations outlined above. This assessment includes potential problems associated with equipment service support, availability of replacement parts and equipment and the associated supply chain.

The cost estimates produced by Hatch and incorporated in this report include the following scenarios:

- Costs for Capital Upgrades and Maintenance as required to ensure reliable service in backup generation mode for the periods of 2, 5, and 10 years.
- Costs for Plant upgrades and/ or modifications as required to provide appropriate performance in a backup generating capacity for the scenarios identified.
- Cost and operating hour triggers for routine maintenance.

6.1 Sensitivity Analysis

The sensitivity analysis is an essential part of the risk assessment. The sensitivity analysis is based on expert opinion and knowledge, assumptions, and probability distributions. The sensitivity analysis is a systematic approach to bridge uncertainty gaps. In the numerical model the sensitivity analysis is a method that measures the impact of uncertainties on multiple variables that can lead to cost related repairs and down time from power production. This analysis is useful because it aids in improving the prediction of the overall model output and results in an associated cost distribution for contingency planning.

An incremental contingency has been included into the four Options overall costs. This proposed contingency is an amount of monies allocated for the sporadic operation issues that the sites regularly experience. It is recommended that these funds are spent on root cause analysis investigations and the associated solution. The contingency was derived by assigning values of 1-5 for a Severity category and a Probability category into a Risk Assessment Code (RAC) Matrix for each major piece of equipment and maintenance service.

Figure 6-1: Risk Assessment Code Matrix

Risk Assessment Code (RAC) Matrix							
Probability			Very Low	Low	Medium	High	Very High
5	50%	Very High	2.50%	7.50%	20.00%	35.00%	50.00%
4	20%	High	1.00%	3.00%	8.00%	14.00%	20.00%
3	10%	Medium	0.50%	1.50%	4.00%	7.00%	10.00%
2	5%	Low	0.25%	0.75%	2.00%	3.50%	5.00%
1	2%	Very Low	0.10%	0.30%	0.80%	1.40%	2.00%
			5%	15%	40%	70%	100%
		Severity	**1**	**2**	**3**	**4**	**5**
	Probability is the likelihood to cause an incident or failure						
	Severity is the outcome/degree if an incident or failure did occur						

A percentage value is then extracted from the RAC matrix and multiplied by the total cost of the equipment replacement or maintenance service and all items are summed to a final contingency cost. The contingency cost and the associated risk depict the potential spread of expenses that should be planned and accounted for. The assigned severity, probability, risk values, and the related contingencies can be found in Appendix C HWD and SVL Capital Upgrades and Major Maintenance Items.

6.2 Hardwoods Life Cycle Cost Analysis and Viability Assessment

The review of the Hardwoods site indicates the turbine/generator and support equipment are in good condition for the age of the equipment. Recent investments in maintenance of the structures and turbines and the rewinding of the generator have restored the plant to good service. The benefits of these efforts are reflected in the improved reliability as reported in the DAUFOP performance of the unit.

Upgrades to the facility to sustain or improve reliability will be required for continued economic operation of the unit. Those upgrades are discussed in the following sections. Hatch considers there are mandatory maintenance items that include the service of the gas turbines and power turbine. These must be completed to sustain operations through 2033. Many other items are considered risk items for the site. They are not necessary, but they carry risk for maintaining continued performance. The improvement items are noted with a risk ranking for probability and consequence. This rating is multiplied by the cost of the modification or work to attain the expected monetary value (EMV). The EMV is the risk value of the item. The total EMV for each unit provides the funding that should be considered for continued operation. The risk will increase the longer the station is kept in service resulting in greater expense at the end of life to maintain performance. The recognition of these risks will allow NLH to make business decisions regarding the investment in the site and the required run profile as plant retirement nears.

Alba Power is currently the sole service provider for the Olympus turbine. Alba advised they see the end of service for the engine family in 10-15 years. They are currently stocked with parts from the secondary market, and they have the ability to manufacture many of the parts required on the turbine. Alba has offered a 10-year plan to maintain the Hardwoods turbines, indicating they are indeed committed to the technology for that duration. As the last viable supplier, economic feasible life ends when services are no longer available. Using the low end of their expectations and noting they are willing to commit to a 10-year contract, the longest remaining economic feasible life for the units is 10 years.

Hatch has reviewed alternatives to replace the generation and voltage support provided by Hardwoods CT. The first alternative is a replacement aero-derivative CT of modern technology that could be utilized to replace the existing unit and would perform many of the same duties. The newer engine technology has longer service intervals to lower maintenance cost on a per hour basis and provides power with better efficiency than the current technology. The second alternative is battery electric storage system (BESS). A BESS could be utilized to provide voltage support for the Hardwoods terminal station and provide power during periods of system disturbance. This technology does not have the long run profile of a gas turbine but can be further evaluated to determine if it meets the system planning needs for the area.

6.2.1 Life Extension of Operation Options

The Life Cycle Cost Analysis Summary for the Hardwoods Gas Turbine Facility for the options outlined below including costs associated with upgrades and/ or modifications, operating costs, and fuel consumption as required to provide appropriate performance in a backup generating capacity is provided in Table 6-1. Details of the recommended Capital Upgrades, Major Maintenance items, Operating Costs, and Fuel Consumption including contingency costs for all Options are outlined in Appendix C.

Table 6-1 HWD Summary of Costs by Scenario ($1000's)

Option		2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	Total
1	Capital	2,285	4,172*	150	150	150	150	150	150	150	150	
	Operating	450	450	450	450	450	450	450	450	450	450	
	Fuel	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	**25,668**
2	Capital	934	934	--	--	--	--	--	--	--	--	
	Operating	450	450	--	--	--	--	--	--	--	--	
	Fuel	1,351	1,351	--	--	--	--	--	--	--	--	**5,471**
3	Capital	405	2,292 *	405	405	405	--	--	--	--	--	
	Operating	450	450	450	450	450	--	--	--	--	--	
	Fuel	1,351	1,351	1,351	1,351	1,351	--	--	--	--	--	**12,915**
4	Capital	492	2,379*	492	492	492	492	492	492	492	492	
	Operating	450	450	450	450	450	450	450	450	450	450	
	Fuel	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	**24,817**

**There is a requirement to replace the main transformer in 2025. Option 2 does not include replacement of the transformer.*

6.3 Stephenville Life Cycle Cost Analysis and Viability Assessment

The review of the Stephenville site indicates the turbine/generator and support equipment are in good condition for the age of the equipment. Recent investments in maintenance of the structures and turbines and the rewinding of the generator have restored the plant to good service. The benefits of these efforts are reflected in the improved reliability as reported in the DAUFOP performance of the unit.

Upgrades to the facility to sustain or improve reliability will be required for continued economic operation of the unit. Those upgrades are discussed in the following sections. Hatch considers there are mandatory maintenance items that include the service of the gas turbines and power turbine. These must be completed to sustain operations through 2033. Many other items are considered risk items for the site. They are not necessary, but they carry risk for maintaining continued performance. The improvement items are noted with a risk ranking for probability and consequence.

Hatch has reviewed alternatives to replace the generation and voltage support provided by Stephenville CT. The first alternative is a replacement aero-derivative CT of modern technology could be utilized to replace the existing unit and would perform many of the same duties. The newer engine technology has longer service intervals to lower maintenance cost on a per hour basis and provides power with better efficiency than the current technology. The second alternative is battery electric storage system (BESS). A BESS could be utilized to provide voltage support for the Stephenville terminal station and provide power during periods of system disturbance. This technology does not have the long run profile of a gas turbine but can be further evaluated to determine if it meets the system planning needs for the area.

6.3.1 *Life Extension of Operation Options*

The Life Cycle Cost Analysis Summary for the Stephenville Gas Turbine Facility for the options outlined below including costs associated with upgrades and/ or modifications, operating costs, and fuel consumption as required to provide appropriate performance in a backup generating capacity is provided in Table 6-2. Details of the recommended Capital Upgrades and Major Maintenance items including contingency costs for all Options are outlined in Appendix C.

Table 6-2: SVL Summary of Costs by Scenario ($1000's)

Option		2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	Total
1	Capital	2,254	4,158*	149	149	149	149	149	149	149	149	
	Operating	450	450	450	450	450	450	450	450	450	450	
	Fuel	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	**25,609**
2	Capital	910	910	--	--	--	--	--	--	--	--	
	Operating	450	450	--	--	--	--	--	--	--	--	
	Fuel	1,351	1,351	--	--	--	--	--	--	--	--	**5,422**
3	Capital	395	2299*	395	395	395	--	--	--	--	--	
	Operating	450	450	450	450	450	--	--	--	--	--	
	Fuel	1,351	1,351	1,351	1,351	1,351	--	--	--	--	--	**12,882**
4	Capital	486	2390*	486	486	486	486	486	486	486	486	
	Operating	450	450	450	450	450	450	450	450	450	450	
	Fuel	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	1,351	**24,773**

**There is a requirement to replace the main transformer in 2025. Option 2 does not include replacement of the transformer.*

6.4 Replacement Energy Sources

Hatch has reviewed the potential for replacement of the Hardwood and Stephenville gas turbines with new aeroderivative gas turbine or battery electric storage system (BESS) technologies. We have limited to these two technologies at this time based on their ability to provide real and reactive power. The gas turbine capacity has been modeled as a direct replacement for the existing units and represents the replacement of one station only. The BESS has been modeled as a 10 MW system with 20 MHh of battery capacity and represents the replacement of one station. This is based on the low utilization of the HWD and SVL units in recent years and the continuing improvements in off island generation availability.

It should be noted that utilization of an aeroderivative turbine for a 10 year book life is unusual, and this technology would continue to provide system benefits for an additional 20 years. It is shown at 10 years to provide appropriate context regarding the continued use of HWD and SVL.

The existing CTs are models based on expected expenses.

The Data runs are based on the following assumptions:

Table 6-3: Capital Costs and Operating Expenses

New Generation	Aero SC CT	Notes/Units
Cost per kW	$1,567	2019 USD/.75 Simple Cycle, EIA
Plant Capacity	50,000	kW
Installed Base	$78,333,333	CAD
Decommissioning Cost	$923,017	CAD
Fixed Charge Rate	20%	
WC Capital	11%	
Plant Life	10	years
Inflation	2%	
Fixed O&M Rate	$21.73	$/kW-year
Variable O&M Rate	$6.27	$/MWh
Hours Online	50	hours
Annual Generation	25000000	kwh
Fixed O&M	$450,000	CAD
Variable O&M	$156,667	CAD
USPWF (Uniform Series Present Worth Factor)	5.889232011	
CRF (Capital Recovery Factor)	0.169801427	
K (Escalation Rate Factor)	0.963963964	
Levelizing Factor	1.304074215	

Table 6-4: BESS 10 Year Estimate Inputs

New Generation	BESS	Notes/Units
Cost per kW	$ 1,852	2019 USD/.75 BESS, EIA
Plant Capacity	10000	kW
Installed Base	$ 18,520,000	CAD
Decommissioning Cost	$ 250,000	CAD
Fixed Charge Rate	20%	
WC Capital	11%	
Plant Life	10	years
Inflation	2%	
Fixed O&M Rate	$ 24.80	$/kW-year
Variable O&M Rate	$ 0	$/MW-hr
Hours Online	50	hours
Annual Generation	5000000	kWh
Fixed O&M	$ 248,000.00	CAD
Variable O&M	$ 0	CAD
USPWF (Uniform Series Present Worth Factor)	5.889232011	
CRF (Capital Recovery Factor)	0.169801427	
K (Escalation Rate Factor)	0.963963964	
Levelizing Factor	1.304074215	

Table 6-5: Life Extension and New Gen 10 Year Cost Review ($1000's)

Line	Capital and Operating Cost	HWD/SVL Continued Ops	New Generation	BESS
A	Capital Cost	$ 6,763	$ 78,333	$ 18,520
B	Escalation	$ 273	$ 3,164	$ 748
C	Direct Cost	$ 7,036	$ 81,498	$ 19,268
D	AFUDC (Allowance of Funds Used During Construction)	$ 1,633	$ 18,916	$ 4,472
E	Capital Cost Total	$ 8,669	$ 100,414	$ 23,740
F	Operating Cost	$ 450	$ 450	$ 248
G	Fixed Charges (20% x Line E)	$ 1,734	$ 20,083	$ 4,748
H	Operating Cost (1.88491 x Line F)	$ 587	$ 587	$ 323
I	Fixed Charges (8.36371 x Line G)	$ 10,211	$ 118,272	$ 27,962
J	Operating Cost (8.36371 x Line H)	$ 3,456	$ 3,456	$ 1,905
K	Total Present Worth	$ 13,667	$ 121,728	$ 29,867

7. HWD & SVL Conclusion and Recommendations

The typical median expected operating life of a liquid burning aeroderivative gas turbine peaking station is 25 years when a proper preventative maintenance program has been implemented and procedures conducted. HWD and SVL were installed in 1976 and 1975 respectively. With significant capital investment HWD and SVL have been able to operate 20+ years beyond the median operating life of similar stations.

7.1 Hardwoods Gas Turbine Facility

The Hardwoods Gas Turbine Facility, given its age, is generally in running condition with a few areas needing attention. A summary of the grades for each unit's critical assets is provided in Table 7-1.

Table 7-1: HWD Summary of Asset Grades

Asset	Grade
Gas Generator Engines and Subsystems Unit A	**4**
Power Turbine, Generator and Subsystems Unit A	**4**
Gas Generator Engines and Subsystems Unit B	**4**
Power Turbine and Subsystems Unit B	**4**
Instrumentation and Control Systems	**4**
Electrical Systems	**4**
Fuel Oil System	**4**
Glycol Cooling System	**2**
Support Buildings	**4**

7.2 Stephenville Gas Turbine Facility

The Stephenville Gas Turbine Facility, given its age, is generally in running condition with a few areas needing attention. A summary of the grades for each unit's critical assets is provided in Table 7-2.

Table 7-2: SVL Summary of Asset Grades

Asset	Grade
Gas Generator Engines and Subsystems Unit A	**4**
Power Turbine, Generator and Subsystems Unit A	**4**
Gas Generator Engines and Subsystems Unit B	**4**
Power Turbine and Subsystems Unit B	**4**
Instrumentation and Control Systems	**3**
Electrical Systems	**4**
Fuel Oil System	**4**
Glycol Cooling System	**4**
Support Buildings	**4**

For all Options outlined and ranked in Table 7-3 and Table 7-4, it is recommended and advantageous to have a whole spare engine assembly between HWD and SVL. The Olympus C units are not being supported by Rolls Royce and replacement parts are currently only available from Alba Power a Sulzer brand. Alba can provide replacement parts, whole assembly spares, and service the units. There is a concern related to having a single source for replacement parts and service. An additional concern with Alba is the quantity and variety of parts kept in inventory. For example, an HP blade replacement can take on the order of 9 months to manufacturer. Alba has advised they foresee a 10 to 15-year remaining life for support of the Olympus. As the last remaining service firm for the engine this sets the final duration for the useful life of the gas turbines.

Capital planning and project execution are time intensive practices for power generation organizations and site construction. Assuming that replacement capacity of generation or voltage support is needed at the sites, immediate action is needed to avoid the low end of the suppliers remaining service time of 10 years.

At this time there is no impact on staffing requirements. For all Options a change in staffing prior to end of life is not recommended. Should the stations be allocated as emergency backup power generating sites a designated operator would not be required but a dispatchable site flexible employee (Transmission Rural Operations) would be necessary.

For all Options it is recommended that the spare parts inventory is assessed. Excessive spare parts in stock should be avoided If NLH decides to retire HWD and/ or SVL.

For all Options consideration of deferring the Main Transformer replacement and decommissioning the existing transformer after plant retirement is recommended.

7.3 HWD Summary of Life Cycle Cost Analysis

To support the provision of least cost and reliable generating service a Rank has been assigned to each of the Options. The Rank is based on risk and capital investment per year. Table 7-3 details the Options with a Rank and the associated cost. The total Cost for each Option includes a contingency, fuel consumption, and operating costs.

Table 7-3: HWD Life Cycle Cost Analysis Summary of Options ($1000's)

Rank	Option	Average Cost per Year*
2	Option 1 – EEFL Capital Upgrades and Maintenance	2,567
4	Option 2 - Additional 2 years of operation (2025)	2,735
3	Option 3 - Additional 5 years of operation (2028)	2,583
1	Option 4 - Additional 10 years of operation (2033)	2,482

**Cost includes contingency.*

- Option 1 has the highest recommended contingency and requires more capital spending early in the EEFL plan. This Option includes replacement of the Vibration Monitoring System, Temperature Monitoring System, Inspection of the Power Turbines with refurbishments as necessary, and assumes that Engines A & B would require major refurbishments as recommended by Alba in the first two years of life extension.
- Option 2 is the highest cost per year with highest reliable generating service. Given the short extension of operation, this Option does not include all of the maintenance items and replacement of the main transformer required by other Options.
- Option 3 is an outlier because of the associated transformer replacement required in 2025 just three years before retirement.
- Option 4 spreads out the cost of capital upgrades over the 10 additional years of operation and has a lower contingency compared to Option 1. Upgrades include replacement of the Vibration Monitoring System, Temperature Monitoring System, Inspection of the Power Turbines with refurbishments as necessary, and assumes that Engines A & B would require refurbishments.

7.4 SVL Summary of Life Cycle Cost Analysis

To support the provision of least cost and reliable generating service a Rank has been assigned to each of the Options. The Rank is based on risk and capital investment per year. Table 7-4 details the Options with a Rank and the associated cost. The total Cost for each Option includes a contingency, fuel consumption, and operating costs.

Table 7-4: SVL Life Cycle Cost Analysis Summary of Options ($1000's)

Rank	Option	Average Cost per Year*
2	Option 1 - EEFL Capital Upgrades and Maintenance	2,561
4	Option 2 - Additional 2 years of operation (2025)	2,711
3	Option 3 - Additional 5 years of operation (2028)	2,577
1	Option 4 - Additional 10 years of operation (2033)	2,477

**Cost includes contingency.*

- Option 1 has the highest recommended contingency and requires more capital spending early in the EEFL plan. This Option includes replacement of the Vibration Monitoring System, Temperature Monitoring System, Inspection of the Power Turbines with refurbishments as necessary, and assumes that Engines A & B would require major refurbishments as recommended by Alba in the first two years of life extension.
- Option 2 is the highest cost per year with highest reliable generating service. Given the short extension of operation, this Option does not include all of the maintenance items and replacement of the main transformer required by other Options.
- Option 3 is an outlier because of the associated transformer replacement required in 2025 just three years before retirement.
- Option 4 spreads out the cost of capital upgrades over the 10 additional years of operation and has a lower contingency compared to Option 1. Upgrades include replacement of the Vibration Monitoring System, Temperature Monitoring System, Inspection of the Power Turbines with refurbishments as necessary, and assumes that Engines A & B would require refurbishments.

7.5 Recommendation for SVL Retirement and Utilization of Major Components to Extend the Life of HWD

When the timeline to retire SVL is decided by NLH the following is recommended for the utilization of SVL components to extend the life of HWD.

- SVL shall be mothballed in place and used as a scavenge site. All equipment shall be placed in a cold and dry state as recommended by the OEM maintenance guides for long term storage.
- Auxiliary power shall be required for lighting and operator safety.
- All main power shall be disconnected.
- Turbines shall remain in their berths until they are required for use at HWD.
- All hydrocarbons shall be removed from equipment and relocated to another facility for use.

- The main lube oil system shall be drained and thoroughly cleaned.
- The main transformer shall be decommissioned and removed.
- All major equipment shall be catalogued, graded, and moved to an inventory system with an equipment list of items that can be utilized at HWD.
- All equipment that is not in acceptable condition for utilization at HWD shall be catalogued in the decommissioning plan or added to a scrap register.
- A decommissioning plan for SVL shall be completed with a timeline for the complete removal of the facility.

7.6 Recommendation and Cost Associated with Relocation of SVL

NLH has requested a high-level review which targets the development of a budgetary estimate and scope for the relocation of the 50 MW SVL facility from its current location to another location, yet to be specified, within the province.

7.6.1 Proposed Pre-feasibility Study

Hatch recommends that a pre-feasibility study (PFS) be performed to verify the assumptions and methodologies used to prepare this report. The PFS will use information gained during site visits, plant construction details, documentation, and drawings as well interviews of key stakeholders to verify the proposed method for dismantling, shipping, and reconstruction of the equipment from the current location to the proposed new location.

7.6.2 Project Schedule Summary

The order of magnitude project schedule summary is based on expert opinion and knowledge, assumptions, and previously completed similar projects.

- Tendering Phase: 5-7 Weeks
- Implementation Phase: 32-36 weeks
  - Power Plant Dismantling
  - Packing and Freight
  - Power Plant Reconstruction

The reconstruction effort at the new site is expected to commence and run in parallel with the dismantling of the equipment from the existing site.

7.6.3 Methodology

7.6.3.1 Permitting and Approvals

Prior to the initiation of any work regarding the dismantlement of the SVL unit for relocation, plant siting, permitting, and other jurisdictional approvals should be completed and attained.

7.6.3.2 Dismantling SVL

Hatch recommends that the dismantling work be competitively tendered and primarily lump sum with preference given to the local contracting community, to the extent that the necessary skills and demonstrated competence are available.

The assumed methodology to be used for dismantling of the equipment would be likely based on the following:

1. Remove the equipment in the largest possible pieces keeping in mind the functional design of the equipment, packing, transport, shipping constraints/requirements, and ease of reassembly.
2. Piping on the equipment will be left intact as far as reasonably practical. All pipes shall be removed by dismantling at flange connections, unions, joints, clamps, etc., in the event that there are no flanges, pipe shall be cut after match-marking so that same can be reused. Spool pieces will be required to replace sections of piping that contain heat effected zones of the cut locations. Structural Assessments will be required during the dismantling process.
3. Grouted foundation bolts will be gas cut and will not be salvaged.
4. All heavy equipment would be lifted by jacks and freed before rigging.
5. Platforms and equipment base frames to be removed and reused.
6. Oil in gearboxes and any leftover oil in tanks will be removed and stored for disposal by the Contractor.
7. Motors, transformers, electrical cabinets, etc. will be hand cleaned by using suitable cleaning agents before it is adequately protected with plastic wrap and packed for dispatch, Commutators and the like will have to be covered by VCI papers.
8. Equipment ID and match-marking method will need to be defined for equipment identification to ensure orderly and proper reinstallation of facilities. Methods shall include:
   i) Color coding
   ii) Equipment numbering
   iii) Wire and cable cut beyond the cable number tags to enable the wire stubs with the number tags to go with the equipment.
9. Extensive photographs of the facilities to be taken before and during the disassembly and removal works for use during reassembly.
10. Retrieve drawings and documentation for disassembly, assembly, refurbishment, erection, installation, and commissioning. A set of drawings will be required to be marked up to clearly indicate equipment ID numbers and match-marking identifications.

11. Cleaning and protection of equipment, cleaning of the equipment shall be good enough for shipping, protective coating shall be applied to critical items and equipment for protection during shipment, transportation, and storage.
12. Packing and cautionary tagging appropriate for protecting machined surfaces and critical equipment.
13. Small parts such as nuts, bolts, valves, etc. shall be put in boxes with proper marking/identification
14. Electrical/mechanical items packed separately. Some electrical items may require vacuum packing.
15. All packages being shipped require marking, this shall be clear and legible, and shall be carried out with non-smudging paint / tagging / long-life stickers; boxes/crates will require provision for forklift.
16. Proper moisture absorbent will be used in all packing boxes.
17. Packing list with each box with requisite details.
18. Detailed inventory of non-salvageable components developed for procurement for reassembly.

7.6.3.3 Packing and Freight

It is proposed that the power plant would be dismantled in the largest practical sections for ease of transportation and reassembly although special consideration needs to be taken with regards to corrosion protection and impact damage of specific items. Transporting of the plant will be a challenge due to the location of the plant and the size and weight of some of the major components.

It may be a pertinent for certain equipment to be transported in a combination of enclosed and or open top shipping containers to ensure protection from damage and the elements. This option would be used for critical items only.

The remaining equipment would be transported on specialized trailers as required. It will include a number of oversized and overweight loads, and these will considerably more expensive than standard trailers or containers. Some of these will require special transportation frames or crates.

7.6.3.4 Reconstruction

The reconstruction works on at the proposed site would commence in parallel with the dismantling work at the existing SVL site so as to avoid prolonged storage requirements. This shall include site preparation works, foundations and other civil works, pipe services, galleries, mechanical/ electrical install, etc.

7.6.3.5 Commissioning

Planning for commissioning shall start early in the decommissioning phase and commissioning shall commence as systems become available.

7.7 Order of Magnitude Estimate

Development of budget estimate is based on Hatch internal networking and Hatch engineers' previous experiences conducting works of this nature.

Table 7-5: SVL Relocation Detailed Order of Magnitude Estimate ($1000's)

No.	Description	Estimate	Contingency %	Contingencies $	Total (000)
10	**Project and Construction Management**				
	Project Management & Construction Management	3,024	10	302	3,326
20	**Engineering**				
	Engineering and Design Work	1,054	5	53	1,107
30	**Procurement**				
	not required in current scope	0		0	0
40	**Contract packages**				
	Removal of Gas Generator Engines and Subsystems	1,577	30	473	2,050
	Removal of Power Turbine, Generator and Subsystems	1,026	30	308	1,334
	Removal of Fuel Support System	233	30	70	303
	Removal of Cooling System	146	30	44	190
	Removal of Control Rooms	119	30	36	155
	Misc. Items for Removal	248	30	74	322
	Transport	1,995	10	199	2,194
	Re-Installation at Proposed Site*	24,095	20	4,819	28,914
50	**Commissioning**				
	Specialist Commissioning Activities	263	10	26	290
	Commissioning Personnel	421	10	42	463
60	**Project Spares**				
	not required in current scope				
	Total (000)	**34,200**		**6,446**	**40,646**
			Total Estimate		**40,646**

**Includes replacement of main transformer.*

End of Technical Content

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Appendix A
Hatch Inspection Plan

HATCH

Notice of Meeting/Agenda

H365408

25-OCT-2021

NLH
Condition Assessment for HWD and SVL

Notice of Meeting

Date: 25-OCT-2021

Subject: Site Inspection and Assessment

Agenda

1. Introduction

Newfoundland and Labrador Hydro (NLH) is considering the future role of the Hardwoods (HWD) and Stephenville (SVL) 50 MW Gas Turbine Stations. Currently, these two facilities are planned for retirement as early as March 31, 2023. Hydro wishes to more fully understand the capital and operational requirements should the options of continued extension of the HWD and SVL Generating Stations, as currently used in backup operations mode beyond the current March 31, 2023 retirement and the viability and suitability of the Generating Stations to be used as a backup generating facilities to support the island system in the event of a prolonged outage of the Labrador-Island Link until the End of Economically Feasible Life (EEFL) of the plants be considered.

To accomplish this, Hydro has requested that a comprehensive report be provided to Hydro that includes a Condition Assessment and Life Cycle Cost Analysis of the Hardwoods and Stephenville Gas Turbine Facilities.

2. Safety Share

Review site specific and walkdown specific safety requirements with the Client and local points of contact prior to commencing work.

3. Scope of Assessment

During walkdown, please utilize Inspection Report H365408-00000-240-051-0001 in conjunction with this document.

3.1 Hardwoods (HWD) and Stephenville (SVL) – Equipment and structures at each site

3.1.1 Buildings

- Gas Turbine Control Building
- High Voltage Switchgear Building
- Fuel Unloading Building (HWD)
- Fuel Forwarding Building (HWD)
- Auxiliary Module Building(HWD)
- Maintenance and Parts Storage Building (HWD)
- Emergency Backup Diesel Generator Building (SVL)
- Parts Storage Shed (SVL)
- Fuel Unloading and Forwarding Building (SVL)
- Waste Oil Storage Building (SVL)

3.1.2 Gas Generator Engines and Subsystems Unit A & B

- Rolls Royce Olympus C Gas Generator Engines Unit A & B
  - Fuel Piping
  - Woodward Governor
  - Gas Generator Engines Lube Oil System
  - Gas Generator Engines Bearings
  - Compressed Air Starting System
- Gas Generator Engine and Power Turbine Enclosures Unit A & B
- Air Inlet Systems Unit A & B
- Exhaust Stacks Unit A & B
- Fire Fighting Systems Unit A & B

3.1.3 Power Turbine, Alternator (Generator) and Subsystems

- Curtiss Wright Power Turbines Unit A & B
- S.S.S. Power Turbine Clutches Unit A & B
- Bearings
- Main Lube Oil System (common to the Power Turbines, Clutches and Alternator Bearings)
- Main Lube Oil Cooling System / Glycol Cooler
  - **Special attention shall be paid to the glycol system at Hardwoods**

- Alternator Air Cooling System
- Alternator (Generator)
- Rotating Exciter
- Automatic Voltage Regulator (AVR)
- Alternator (Generator) Enclosure
- Fire Fighting System

3.1.4 Instrumentation and Control

- Bailey Control System
- Temperature monitoring system
- Vibration monitoring system
- Auxiliary Systems Instrumentation Devices
    - Fuel oil tanks
    - Fuel forwarding system
    - Compressed Air System
    - Glycol cooling system
    - Lube oil system

3.1.5 Electrical Systems

- 13.8 kV Switchgear (alternator breaker)
- Alternator Output Bus Duct
- Alternator protection relays
- Sync-check relay
- Motor Control Centres (AC & DC)
- Station DC supply (batteries and chargers)
- Inverter (AC supply for control systems)
- Emergency Backup Diesel Generator

3.1.6 Fuel Oil System

- Oil Unloading
  - Oil Storage and Secondary Containment
  - Fuel Forwarding Equipment
  - Fuel Piping
- Fire Fighting Systems

Michael Seidlich

MS:ms
Attachment(s)/Enclosure

HATCH

Inspection Report

Inspector:______________ Date: 25-OCT-2021 Document No.: H365408-00000-240-051-0001

Client Name: NLH

Document Number: H365408-00000-240-051-0001
Date: 25-OCT-2021

Inspection Information			
Project Name:	Condition Assessment		
Site and Unit:	HWD		
Materials Inspected:	Gas Generator Engines and Subsystems Unit A		
Date(s) of Visit:		Date of Previous Visit:	
Attention Risk (circle):	1-3 years	4-6 years	7-10 years
Image number(s):			

Inspection Summary and Conclusion:

Rolls Royce Olympus C Gas Generator Engines Unit A

- Fuel Piping
- Woodward Governor
- Gas Generator Engines Lube Oil System
- Gas Generator Engines Bearings
- Compressed Air Starting System

Gas Generator Engine and Power Turbine Enclosures Unit A

Temperature monitoring system

Vibration monitoring system

Lube oil system

- Lube oil controls

Air Inlet Systems Unit A

Exhaust Stacks Unit A

Fire Fighting Systems Unit A

Building Envelope

Inspection Report

Inspector:________________________ Date: 25-OCT-2021 Document No.: H365408-00000-240-051-0001

Recommended Action:

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Inspection Report

Inspector: Date: 25-OCT-2021 Document No.: H365408-00000-240-051-0001

Inspection Information	
Project Name:	Condition Assessment
Site and Unit:	HWD
Materials Inspected:	Power Turbine, Alternator (Generator) and Subsystems
Date(s) of Visit:	Date of Previous Visit:
Attention Risk (circle):	1-3 years · 4-6 years · 7-10 years
Image number(s):	

Inspection Summary and Conclusion:

- Curtiss Wright Power Turbines Unit A
- S.S.S. Power Turbine Clutches Unit A
- Bearings
- Main Lube Oil System (common to the Power Turbines, Clutches and Alternator Bearings)
- Alternator Air Cooling System
- Alternator (Generator)
- Rotating Exciter
- Automatic Voltage Regulator (AVR)
- Alternator (Generator) Enclosure
- Fire Fighting System

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Inspection Report

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Inspection Information

Project Name:	Condition Assessment
Site and Unit:	HWD
Materials Inspected:	Gas Generator Engines and Subsystems Unit B
Date(s) of Visit:	Date of Previous Visit:
Attention Risk (circle):	1-3 years / 4-6 years / 7-10 years
Image number(s):	

Inspection Summary and Conclusion:

Rolls Royce Olympus C Gas Generator Engines Unit B

- Fuel Piping
- Woodward Governor
- Gas Generator Engines Lube Oil System
- Gas Generator Engines Bearings
- Compressed Air Starting System

Gas Generator Engine and Power Turbine Enclosures Unit B

Temperature monitoring system

Vibration monitoring system

Lube oil system

- Lube oil controls

Air Inlet Systems Unit A

Exhaust Stacks Unit A

Fire Fighting Systems Unit A

Building Envelope

Inspection Report

Inspector:________________________ Date:25-OCT-2021 Document No.: H365408-00000-240-051-0001

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Inspection Report

Inspector:______________________ Date:25-OCT-2021 Document No.: H365408-00000-240-051-0001

Inspection Information			
Project Name:	Condition Assessment		
Site and Unit:	HWD		
Materials Inspected:	Power Turbine, Alternator (Generator) and Subsystems		
Date(s) of Visit:		Date of Previous Visit:	
Attention Risk (circle):	1-3 years	4-6 years	7-10 years
Image number(s):			

Inspection Summary and Conclusion:

- Curtiss Wright Power Turbines Unit B
- S.S.S. Power Turbine Clutches Unit B
- Bearings
- Main Lube Oil System (common to the Power Turbines, Clutches and Alternator Bearings)
- Alternator Air Cooling System
- Alternator (Generator)
- Rotating Exciter
- Automatic Voltage Regulator (AVR)
- Alternator (Generator) Enclosure
- Fire Fighting System

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Inspector: ______ Date: 25-OCT-2021 Document No.: H365408-00000-240-051-0001

Inspection Information					
Project Name:	Condition Assessment				
Site and Unit:	HWD				
Materials Inspected:	Instrumentation and Control				
Date(s) of Visit:		Date of Previous Visit:			
Attention Risk (circle):	1-3 years		4-6 years		7-10 years
Image number(s):					

Inspection Summary and Conclusion:

- Gas Turbine Control Building envelope
- Bailey Control System

Inspection Report

Inspector:________________________ Date:25-OCT-2021 Document No.: H365408-00000-240-051-0001

Recommended Action:

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Inspection Report

Inspector:__________ Date: 25-OCT-2021 Document No.: H365408-00000-240-051-0001

Inspection Information			
Project Name:	Condition Assessment		
Site and Unit:	HWD		
Materials Inspected:	Electrical Systems		
Date(s) of Visit:		Date of Previous Visit:	
Attention Risk (circle):	1-3 years	4-6 years	7-10 years
Image number(s):			

Inspection Summary and Conclusion:

- High Voltage Switchgear Building envelope
- 13.8 kV Switchgear (alternator breaker)
- Alternator Output Bus Duct
- Alternator protection relays
- Sync-check relay
- Motor Control Centres (AC & DC)
- Station DC supply (batteries and chargers)
- Inverter (AC supply for control systems)
- Emergency Backup Diesel Generator

Inspection Report

Inspector:________________________ Date:25-OCT-2021 Document No.: H365408-00000-240-051-0001

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Inspection Information			
Project Name:	Condition Assessment		
Site and Unit:	HWD		
Materials Inspected:	Fuel Oil System		
Date(s) of Visit:		Date of Previous Visit:	
Attention Risk (circle):	1-3 years	4-6 years	7-10 years
Image number(s):			

Inspection Summary and Conclusion:

Fuel Unloading Building envelope (HWD)

Fuel Forwarding Building envelope (HWD)

Oil Unloading

Oil Storage and Secondary Containment

Fuel Forwarding Equipment

Fuel Piping

Instrumentation and Control

Fuel oil tanks

Fuel forwarding system

Fire Fighting Systems

Inspection Report

Inspector:______________________ Date:25-OCT-2021 Document No.: H365408-00000-240-051-0001

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Inspection Report

Inspector:______________ Date:25-OCT-2021 Document No.: H365408-00000-240-051-0001

Inspection Information			
Project Name:	Condition Assessment		
Site and Unit:	HWD		
Materials Inspected:	Glycol Cooling System		
Date(s) of Visit:		Date of Previous Visit:	
Attention Risk (circle):	1-3 years	4-6 years	7-10 years
Image number(s):			
Inspection Summary and Conclusion:			

- Main Lube Oil Cooling System / Glycol Cooler

- Equipment- specify

Inspection Report

Inspector:______________________ Date:25-OCT-2021 Document No.: H365408-00000-240-051-0001

Recommended Action:

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Inspection Report

Inspector: ______________ Date: 25-OCT-2021 Document No.: H365408-00000-240-051-0001

Inspection Information				
Project Name:	Condition Assessment			
Site and Unit:	HWD			
Materials Inspected:	Compressed Air System			
Date(s) of Visit:		Date of Previous Visit:		
Attention Risk (circle):	1-3 years	4-6 years	7-10 years	
Image number(s):				

Inspection Summary and Conclusion:

- Equipment- specify

- Instrumentation and Controls

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Recommended Action:

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Inspection Report

Inspector:________________ Date: 25-OCT-2021 Document No.: H365408-00000-240-051-0001

Inspection Information			
Project Name:	Condition Assessment		
Site and Unit:	HWD		
Materials Inspected:	Buildings		
Date(s) of Visit:		Date of Previous Visit:	
Attention Risk (circle):	1-3 years	4-6 years	7-10 years
Image number(s):			

Inspection Summary and Conclusion:

- Auxiliary Module Building (HWD)
- Maintenance and Parts Storage Building (HWD)

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Inspection Information			
Project Name:	Condition Assessment		
Site and Unit:	HWD		
Materials Inspected:			
Date(s) of Visit:		Date of Previous Visit:	
Attention Risk (circle):	1-3 years	4-6 years	7-10 years
Image number(s):			
Inspection Summary and Conclusion:			

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Inspection Information

Project Name:	Condition Assessment
Site and Unit:	HWD
Materials Inspected:	
Date(s) of Visit:	Date of Previous Visit:
Attention Risk (circle):	1-3 years 4-6 years 7-10 years
Image number(s):	

Inspection Summary and Conclusion:

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Inspection Report

Inspector: ______________ Date: 25-OCT-2021 Document No.: H365408-00000-240-051-0001

Inspection Information			
Project Name:	Condition Assessment		
Site and Unit:	HWD		
Materials Inspected:			
Date(s) of Visit:		Date of Previous Visit:	
Attention Risk (circle):	1-3 years	4-6 years	7-10 years
Image number(s):			
Inspection Summary and Conclusion:			

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Inspector:________________________ Date: 25-OCT-2021 Document No.: H365408-00000-240-051-0001

Recommended Action:

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Inspection Report

Inspector: Date: 25-OCT-2021 Document No.: H365408-00000-240-051-0001

Client Name: NLH Document Number: H365408-00000-240-051-0001
Date: 25-OCT-2021

Inspection Information	
Project Name:	Condition Assessment
Site and Unit:	SVL
Materials Inspected:	Gas Generator Engines and Subsystems Unit A
Date(s) of Visit:	Date of Previous Visit:
Attention Risk (circle):	1-3 years 4-6 years 7-10 years
Image number(s):	

Inspection Summary and Conclusion:

Rolls Royce Olympus C Gas Generator Engines Unit A

- Fuel Piping
- Woodward Governor
- Gas Generator Engines Lube Oil System
- Gas Generator Engines Bearings
- Compressed Air Starting System

Gas Generator Engine and Power Turbine Enclosures Unit A

Temperature monitoring system

Vibration monitoring system

Lube oil system

- Lube oil controls

Air Inlet Systems Unit A

Exhaust Stacks Unit A

Fire Fighting Systems Unit A

Building Envelope

HATCH

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Inspection Report

Inspector:________________________ Date: 25-OCT-2021 Document No.: H365408-00000-240-051-0001

Inspection Information

Project Name:	Condition Assessment		
Site and Unit:	SVL		
Materials Inspected:	Power Turbine, Alternator (Generator) and Subsystems		
Date(s) of Visit:		Date of Previous Visit:	
Attention Risk (circle):	1-3 years	4-6 years	7-10 years
Image number(s):			

Inspection Summary and Conclusion:

- Curtiss Wright Power Turbines Unit A
- S.S.S. Power Turbine Clutches Unit A
- Bearings
- Main Lube Oil System (common to the Power Turbines, Clutches and Alternator Bearings)
- Alternator Air Cooling System
- Alternator (Generator)
- Rotating Exciter
- Automatic Voltage Regulator (AVR)
- Alternator (Generator) Enclosure
- Fire Fighting System

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Inspection Information			
Project Name:	Condition Assessment		
Site and Unit:	SVL		
Materials Inspected:	Gas Generator Engines and Subsystems Unit B		
Date(s) of Visit:		Date of Previous Visit:	
Attention Risk (circle):	1-3 years	4-6 years	7-10 years
Image number(s):			

Inspection Summary and Conclusion:

Rolls Royce Olympus C Gas Generator Engines Unit B

- Fuel Piping
- Woodward Governor
- Gas Generator Engines Lube Oil System
- Gas Generator Engines Bearings
- Compressed Air Starting System

Gas Generator Engine and Power Turbine Enclosures Unit B

Temperature monitoring system

Vibration monitoring system

Lube oil system

- Lube oil controls

Air Inlet Systems Unit A

Exhaust Stacks Unit A

Fire Fighting Systems Unit A

Building Envelope

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Inspector:__________ Date: 25-OCT-2021 Document No.: H365408-00000-240-051-0001

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Inspection Report

Inspector:________________________ Date:25-OCT-2021 Document No.: H365408-00000-240-051-0001

Inspection Information

Project Name:	Condition Assessment
Site and Unit:	SVL
Materials Inspected:	Power Turbine, Alternator (Generator) and Subsystems
Date(s) of Visit:	Date of Previous Visit:
Attention Risk (circle):	1-3 years · 4-6 years · 7-10 years
Image number(s):	

Inspection Summary and Conclusion:

- Curtiss Wright Power Turbines Unit B
- S.S.S. Power Turbine Clutches Unit B
- Bearings
- Main Lube Oil System (common to the Power Turbines, Clutches and Alternator Bearings)
- Alternator Air Cooling System
- Alternator (Generator)
- Rotating Exciter
- Automatic Voltage Regulator (AVR)
- Alternator (Generator) Enclosure
- Fire Fighting System

Inspection Report

Inspector:________________ Date:25-OCT-2021 Document No.: H365408-00000-240-051-0001

Recommended Action:

HATCH

Inspection Report

Inspector: Date: 25-OCT-2021 Document No.: H365408-00000-240-051-0001

Inspection Information	
Project Name:	Condition Assessment
Site and Unit:	SVL
Materials Inspected:	Instrumentation and Control
Date(s) of Visit:	Date of Previous Visit:
Attention Risk (circle):	1-3 years / 4-6 years / 7-10 years
Image number(s):	

Inspection Summary and Conclusion:

- Gas Turbine Control Building envelope
- Bailey Control System

Inspection Report

Inspector:________________________ Date:25-OCT-2021 Document No.: H365408-00000-240-051-0001

Recommended Action:

HATCH

Inspection Report

Inspector: ______________________ Date: 25-OCT-2021 Document No.: H365408-00000-240-051-0001

Inspection Information	
Project Name:	Condition Assessment
Site and Unit:	SVL
Materials Inspected:	Electrical Systems
Date(s) of Visit:	Date of Previous Visit:
Attention Risk (circle):	1-3 years 4-6 years 7-10 years
Image number(s):	

Inspection Summary and Conclusion:

- High Voltage Switchgear Building envelope
- 13.8 kV Switchgear (alternator breaker)
- Alternator Output Bus Duct
- Alternator protection relays
- Sync-check relay
- Motor Control Centres (AC & DC)
- Station DC supply (batteries and chargers)
- Inverter (AC supply for control systems)
- Emergency Backup Diesel Generator

Inspection Report

Inspector:____________________ Date:25-OCT-2021 Document No.: H365408-00000-240-051-0001

Recommended Action:

HATCH

Inspection Report

Inspector:________________________ Date:25-OCT-2021 Document No.: H365408-00000-240-051-0001

Inspection Information			
Project Name:	Condition Assessment		
Site and Unit:	SVL		
Materials Inspected:	Fuel Oil System		
Date(s) of Visit:		Date of Previous Visit:	
Attention Risk (circle):	1-3 years	4-6 years	7-10 years
Image number(s):			

Inspection Summary and Conclusion:

Fuel Unloading Building envelope (HWD)

Fuel Forwarding Building envelope (HWD)

Oil Unloading

Oil Storage and Secondary Containment

Fuel Forwarding Equipment

Fuel Piping

Instrumentation and Control

Fuel oil tanks

Fuel forwarding system

Fire Fighting Systems

Inspection Report

Inspector:________________________ Date: 25-OCT-2021 Document No.: H365408-00000-240-051-0001

Recommended Action:

HATCH

Inspection Report

Inspector:______________ Date: 25-OCT-2021 Document No.: H365408-00000-240-051-0001

Inspection Information			
Project Name:	Condition Assessment		
Site and Unit:	SVL		
Materials Inspected:	Glycol Cooling System		
Date(s) of Visit:		Date of Previous Visit:	
Attention Risk (circle):	1-3 years	4-6 years	7-10 years
Image number(s):			

Inspection Summary and Conclusion:

- Main Lube Oil Cooling System / Glycol Cooler
- Equipment- specify

Inspection Report

Inspector:________________________ Date:25-OCT-2021 Document No.: H365408-00000-240-051-0001

Recommended Action:

HATCH

Inspection Report

Inspector:________________________ Date:25-OCT-2021 Document No.: H365408-00000-240-051-0001

Inspection Information			
Project Name:	Condition Assessment		
Site and Unit:	SVL		
Materials Inspected:	Compressed Air System		
Date(s) of Visit:		Date of Previous Visit:	
Attention Risk (circle):	1-3 years	4-6 years	7-10 years
Image number(s):			

Inspection Summary and Conclusion:

- Equipment- specify

- Instrumentation and Controls

HATCH

Inspection Report

Inspector:________________________ Date:25-OCT-2021 Document No.: H365408-00000-240-051-0001

Recommended Action:

HATCH

Inspection Report

Inspector: ______________ Date: 25-OCT-2021 Document No.: H365408-00000-240-051-0001

Inspection Information			
Project Name:	Condition Assessment		
Site and Unit:	SVL		
Materials Inspected:	Buildings		
Date(s) of Visit:		Date of Previous Visit:	
Attention Risk (circle):	1-3 years	4-6 years	7-10 years
Image number(s):			

Inspection Summary and Conclusion:

- Emergency Backup Diesel Generator Building (SVL)
- Parts Storage Shed (SVL)
- Waste Oil Storage Building (SVL)

HATCH

Inspection Report

Inspector:____________________ Date: 25-OCT-2021 Document No.: H365408-00000-240-051-0001

Recommended Action:

HATCH

Inspection Report

Inspector:______________________ Date: 25-OCT-2021 Document No.: H365408-00000-240-051-0001

Inspection Information			
Project Name:	Condition Assessment		
Site and Unit:	SVL		
Materials Inspected:			
Date(s) of Visit:		Date of Previous Visit:	
Attention Risk (circle):	1-3 years	4-6 years	7-10 years
Image number(s):			
Inspection Summary and Conclusion:			

Inspection Report

Inspector:________________________ Date:25-OCT-2021 Document No.: H365408-00000-240-051-0001

Recommended Action:

HATCH

Inspection Report

Inspector:________________________ Date: 25-OCT-2021 Document No.: H365408-00000-240-051-0001

Inspection Information			
Project Name:	Condition Assessment		
Site and Unit:	SVL		
Materials Inspected:			
Date(s) of Visit:		Date of Previous Visit:	
Attention Risk (circle):	1-3 years	4-6 years	7-10 years
Image number(s):			
Inspection Summary and Conclusion:			

Inspection Report

Inspector:________________________ Date: 25-OCT-2021 Document No.: H365408-00000-240-051-0001

Recommended Action:

Inspection Report

Inspector:__________________ Date:25-OCT-2021 Document No.: H365408-00000-240-051-0001

Inspection Information

Project Name:	Condition Assessment
Site and Unit:	SVL
Materials Inspected:	
Date(s) of Visit:	Date of Previous Visit:
Attention Risk (circle):	1-3 years 4-6 years 7-10 years
Image number(s):	

Inspection Summary and Conclusion:

Inspection Report

Inspector:________________________ Date:25-OCT-2021 Document No.: H365408-00000-240-051-0001

Recommended Action:

Appendix B
Site Visual Inspection Report

Project Report

June 27, 2022

Newfoundland and Labrador Hydro

Hardwoods and Stephenville Viability Assessment

Site Visual Inspection Report

			K. Meghari	Todd R Thomas	K. Meghari
2022-Jun-27	0	Information	K. Meghari	T. Thomas	K. Meghari
2021-Nov-03	A	Preliminary	M. Seidlich	T. Thomas	K. Meghari
Date	**Rev.**	**Status**	**Prepared By**	**Checked By**	**Approved By**
HATCH					

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1. Executive Summary

This Site Visual Inspection Initial Report presents the findings of a site inspection conducted by Hatch personnel of the Hardwoods (HWD) and Stephenville (SVL) Gas Turbine Stations. This Report is presented in three sections. Section 1 outlines and summarizes the site inspection findings. Section 2 provides an introduction and background of the overall project justification. Section 3 provides the boundaries of the site investigations, and the assets have been assigned a score utilizing a grading scale.

1.1 Hardwoods Inspection Summary

Hatch personnel, accompanied by Newfoundland and Labrador Hydro (NLH) personnel, conducted a detailed site investigation of the Hardwoods Gas Turbine Station on 25-Oct-2021 thru 27-Oct-2021. The site investigation of HWD was conducted during a scheduled outage.

The plant given its age is generally in good running condition with a few critical assets needing attention. The southwest side of Unit A Gas Generator Engine and Power Turbine enclosure is showing signs of corrosion requiring grinding to bare material and repainting the surfaces. The Temperature Monitoring System and Vibration Monitoring System on Unit A Rolls Royce Olympus C Gas Generator Engine is nearing end of life and replacement is recommended. The Lube Oil System requires a filter replacement, but filters are no longer manufactured for this model. It is recommended that an oil filter replacement is sourced from a vendor specializing in the fabrication of custom filters. A borescope was conducted on Unit A that showed signs of carbon buildup on the turbine and on several nozzles. It is recommended that the nozzles are cleaned in an ultrasonic solvent bath and evaluated for replacement.

The Compressed Air System on Unit B is showing signs of aging and the Air Dryer is in poor condition. It is recommended that the Air Dryer is replaced. The Unit B Gas Generator Engine and Power Turbine Enclosure is showing signs of corrosion requiring grinding to bare material and repainting of the surfaces. The Vibration Monitoring System is nearing end of life and replacement is recommended.

The Bailey Control System is in working condition, but it was noted that it is old equipment. NH Hydro to advise if they have a modernization plan with the OEM, if not Hatch will evaluate and advise.

The Emergency Backup Diesel Generator is 40 kW and provides power to the batteries and some of the lighting. The generator is not capable of starting the plant from black conditions. Upgrading this system is recommended if NLH deems it necessary to be capable of starting the plant in a black condition.

The fans and cooler on the northeast side of the Main Transformer are showing signs of corrosion. It is recommended that the fans are replaced and the Cooler repainted. The replacement of the transformer is required by 2025 due to PCB containing oil. Any repairs should be considered against the mandated replacement.

The Main Lube Oil Cooling System / Glycol Cooler is in poor condition. The cooling fins require combing to straighten, and the cooler requires power washing.

The Power Station Buildings and Exhaust Stack envelopes show signs of rust and corrosion. Grinding to bare metal and repainting is recommended to stop the advancing corrosion.

1.2 Stephenville Inspection Summary

Hatch personnel, accompanied by Newfoundland and Labrador Hydro (NLH) personnel, conducted a detailed site investigation of the Stephenville Gas Turbine Station on 28-Oct-2021. The site investigation of SVL was conducted during operation.

The plant given its age is generally in good running condition with a few assets needing attention. The Exhaust Stack on Unit A has a small heat leak and there is movement of the insulation. The insulation should be replaced as necessary and firmly reattached. All thermal damage to the stack shell and coating systems should be repaired.

The Vibration Monitoring System on Unit A are nearing end of life and replacement is recommended.

The Vibration Monitoring System on Unit B Rolls Royce Olympus C Gas Generator Engine is nearing end of life and is currently not getting all of the temperature readings. Replacement of the Vibration Monitoring System is recommended.

The station DC supply equipment includes acid batteries which have not been replaced in the recent past. If NLH considers the DC supply batteries a critical asset, then replacement with upgraded batteries is recommended.

The Fuel Oil System instrumentation includes many analog gauges throughout. Upgrading to digital instrumentation should be considered to increase performance tracking.

The replacement of the main transformer is required by 2025 due to PCB containing oil.

The side of the road leading to the station has significant material washout creating a ravine. It is recommended that this hazard is corrected.

2. Introduction

NLH is considering the future role of the Hardwoods (HWD) and Stephenville (SVL) 50 MW Gas Turbine Stations post commissioning of the Muskrat Falls Project assets. Currently, these two facilities are planned for retirement as early as March 31, 2023.

Hydro wishes to more fully understand the capital and operational requirements should the options of continued extension of the HWD and SVL Generating Stations, as currently used in backup operations mode beyond the current March 31, 2023 retirement and the viability and suitability of the Generating Stations to be used as a backup generating facilities to support the island system in the event of a prolonged outage of the Labrador-Island Link until the End of Economically Feasible Life (EEFL) of the plants be considered.

2.1 General Investigation Plant Onsite Inspection

The objective of this overall work is to map out the potential futures for the Hardwoods and Stephenville stations to inform supply planning activities at NLH. The visual inspection will be combined with a review of historical documentation to produce a comprehensive viability assessment study Final Report.

2.2 Background

2.2.1 Hardwood Gas Turbine Facility (HWD)

The Hardwoods Gas Turbine Facility was placed in service in 1976 and operates as both a peaking / emergency generator and a synchronous condenser. The gas turbine is located within a terminal station consisting of 66 kV and 230 kV bus work, circuit breakers, transformers and transmission lines.

The facility consists of two (2) Rolls Royce Olympus C, Gas Turbines (A & B) fired on #2 diesel oil, each driving a Curtiss Wright Power Turbine equipped with a SSS size 208T clutch that couples to a common synchronous electrical generator. Each Gas Turbine Engine has an air intake structure, and each power turbine has an exhaust stack.

2.2.2 Stephenville Gas Turbine Facility (SVL)

The Stephenville Gas Turbine Facility was placed in service in 1975 and operates as both a peaking/ emergency generator and a synchronous condenser. SVL is a sister unit to HWD. The gas turbine is located within a terminal station consisting of 66 kV and 230 kV bus work, circuit breakers, transformers and transmission lines.

The facility consists of two (2) Rolls Royce Olympus C, Gas Turbines (A & B) fired on #2 diesel oil, each driving a Curtiss Wright Power Turbine equipped with a SSS size 208T clutch that couples to a common synchronous electrical generator. Each Gas Turbine Engine has an air intake structure, and each power turbine has an exhaust stack.

3. Onsite Inspection

3.1 Boundaries of the Site Investigation

The site inspection included all major system components of the HWD and SVL Generating Stations. The site inspections focused on the Gas Turbine Facility in its entirety and included the following:

- Fuel unloading system;
- Fuel Storage and distribution system;
- Fuel forwarding module;
- Control module;
- Air intake structures;
- Gas turbines;
- Power turbines;

- Exhaust stacks;
- Building enclosures;
- Clutches, alternator and exciter;
- Control systems;
- Power systems; and
- Auxiliary systems including compressed air, lube oil and glycol systems* etc.

*Special attention was paid to the glycol system at HWD.

3.2 Asset Grading

Grades from the asset grading scale in Table 3-1 were assigned to each system and / or component.

Table 3-1: Asset Grading Scale

Grade	Condition	Description
5	Excellent	No visible defects, new or near new condition, may still be under warranty if applicable.
4	Good	Good condition, but no longer new, may have some slightly defective or deteriorated component(s), but is overall functional.
3	Adequate	Moderately deteriorated or defective components; but has not exceeded useful life.
2	Marginal	Defective or deteriorated component(s) in need of replacement; exceeded useful life
1	Poor	Critically damaged component(s) or in need of immediate repair; well past useful life

3.3 Initial Site Inspection Findings

Initial asset grading in the table below is based on visual inspections, site images and onsite interviews with NLH team members. Asset grade(s) are subject to change after a review of the historical documentation is completed. A thorough asset assessment shall be included in the Final Report deliverable.

3.3.1 Hardwood Gas Turbine Facility (HWD)

The plant given its age is generally in good running condition with a few areas needing attention. A summary of the grades for each unit's critical assets is provided in the Tables below.

Table 3-2: HWD Unit A Asset Grading

Asset	Category	Description	Grade
Gas Generator Engines and Subsystems Unit A[1]			
	Rolls Royce Olympus C Gas Turbine Engines		
		Fuel Piping	**4**
		Woodward Governor	**5**
		Gas Generator Engines Lube Oil System	**5**
		Gas Generator Engines Bearings	**4**
		Compressed Air Starting System	**4**
	Temperature monitoring system		**3**
	Vibration monitoring system		**2**
	Lube oil system		**3**
		Lube Oil Controls	**3**
	Air Inlet System		**3**
	Exhaust Stacks		**INA[2]**
	Fire Fighting System		**4**
	Building Envelope		**3**
Power Turbine, Alternator (Generator) and Subsystems Unit A			
	Generator and Power Turbine Enclosure		**4**
	Curtiss Wright Power Turbine[2]		**4**
	SSS Power Turbine Clutches		**4**
	Bearings		**INA**
	Main Lube Oil System (common to the Power Turbines, Clutches and Alternator Bearings)		**4**
	Alternator Air Cooling System		**4**
	Alternator (Generator)		**4**
	Rotating Exciter		**4**
	Automatic Voltage Regulator (AVR)		**4**
	Alternator (Generator) Enclosure		**4**
	Fire Fighting System		**4**

[1] Borescope indicated carbon buildup on turbine and fuel nozzles.

[2] INA- Exhaust stacks for Unit A were not accessible during site visit. Exterior does not indicate heat escape.

Table 3-3: HWD Unit B Asset Grading

Asset	Category	Description	Grade
Gas Generator Engines and Subsystems Unit B[1]			
	Rolls Royce Olympus C Gas Generator Engines		
		Fuel Piping	**4**
		Woodward Governor	**5**
		Gas Generator Engines Lube Oil System	**4**
		Gas Generator Engines Lube Oil System	**4**
		Gas Generator Engines Bearings	**4**
		Compressed Air Starting System	**1**
	Gas Generator Engine and Power Turbine Enclosure		**3**
	Temperature monitoring system		**4**
	Vibration monitoring system		**2**
	Lube oil system		**4**
		Lube Oil Controls	**3**
	Air Inlet System		**4**
	Exhaust Stacks		**4**
	Fire Fighting System		**4**
	Building Envelope		**3**
Power Turbine and Subsystems Unit B			
	Curtiss Wright Power Turbine		**4**
	SSS Power Turbine Clutches		**4**
	Bearings		**4**
	Fire Fighting System		**4**

[1] Borescope indicated carbon buildup on turbine and fuel nozzles.

Table 3-4: HWD I&C Asset Grading

Asset	Category	Description	Grade
Instrumentation and Control			
	Bailey Control System		**3**
	Gas Turbine Control Building Envelope		**4**

Table 3-5: HWD Electrical Asset Grading

Asset	Category	Description	Grade
Electrical Systems[1]			
	High Voltage Switchgear Building envelope		**4**
	13.8 kV Switchgear (alternator breaker)		**4**
	Alternator Output Bus Duct		**4**
	Alternator protection relays		**4**
	Sync-check relay		**INA**
	Motor Control Centres (AC & DC)		**4**
	Station DC supply (batteries and chargers)		**5**
	Inverter (AC supply for control systems)		**5**
	Emergency Backup Diesel Generator		**2**

[1]The main transformer fans and cooler on the northeast side are heavily rusted. The transformer is in working condition but will need to be replaced in 2025.

Table 3-6: HWD Fuel Oil Asset Grading

Asset	Category	Description	Grade
Fuel Oil System			
	Fuel Unloading Building envelope		**4**
	Fuel Forwarding Building envelope		**4**
	Oil Unloading		**4**
	Oil Storage and Secondary Containment		**4**
	Fuel Forwarding Equipment		**INA**
	Fuel Piping		**INA**
	Instrumentation and Control		**INA**
	Fuel oil tanks		**4**
	Fuel forwarding system		**4**
	Fire Fighting Systems		**4**

Table 3-7: HWD Glycol Cooling Asset Grading

Asset	Category	Description	Grade
Glycol Cooling System			
		Main Lube Oil Cooling System / Glycol Cooler[1]	**2**
		Equipment	**--**

[1]The cooler fins need to be combed, pressure washed and cleaned.

Table 3-8: HWD Support Buildings Asset Grading

Asset	Category	Description	Grade
Support Buildings			
		Auxiliary Module Building Envelope	**4**
		Maintenance and Parts Storage Building Envelope	**4**

3.3.2 *Stephenville Gas Turbine Facility (SVL)*

The plant given its age is generally in running condition with a few areas needing attention. A summary of the grades for each unit's critical assets is provided in the Tables below.

Table 3-9: SVL Unit A Asset Grading

Asset	Category	Description	Grade
Gas Generator Engines and Subsystems Unit A			
	Rolls Royce Olympus C Gas Generator Engines		
		Fuel Piping	**4**
		Woodward Governor	**4**
		Gas Generator Engines Lube Oil System	**4**
		Gas Generator Engines Bearings	**4**
		Compressed Air Starting System	**2**
	Gas Generator Engine and Power Turbine Enclosure		**4**
	Temperature monitoring system		**4**
	Vibration monitoring system		**INA**
	Lube oil system		**2**
		Lube Oil Controls	**4**
	Air Inlet System		**INA**
	Exhaust Stacks		**4**
	Fire Fighting System		**3**
	Building Envelope		**4**
Power Turbine, Alternator (Generator) and Subsystems Unit A			
	Curtiss Wright Power Turbine		**4**
	SSS Power Turbine Clutches		**4**
	Bearings		**4**
	Main Lube Oil System (common to the Power Turbines, Clutches and Alternator Bearings)		**4**
	Alternator Air Cooling System		**4**
	Alternator (Generator)		**3**
	Rotating Exciter		**4**
	Automatic Voltage Regulator (AVR)		**5**
	Alternator (Generator) Enclosure		**4**
	Fire Fighting System		**INA**

Table 3-10: SVL Unit B Asset Grading

Asset	Category	Description	Grade
Gas Generator Engines and Subsystems Unit B			
	Rolls Royce Olympus C Gas Generator Engines		
		Fuel Piping	**4**
		Woodward Governor	**4**
		Gas Generator Engines Lube Oil System	**4**
		Gas Generator Engines Lube Oil System	**4**
		Gas Generator Engines Bearings	**4**
		Compressed Air Starting System	**4**
	Gas Generator Engine and Power Turbine Enclosure		**4**
	Temperature monitoring system		**4**
	Vibration monitoring system		**2**
	Lube oil system		**2**
		Lube Oil Controls	**3**
	Air Inlet System		**4**
	Exhaust Stacks		**4**
	Fire Fighting System		**4**
	Building Envelope		**4**
Power Turbine and Subsystems Unit B			
	Curtiss Wright Power Turbine		**4**
	SSS Power Turbine Clutches		**4**
	Bearings		**INA**
	Rotating Exciter		**4**
	Automatic Voltage Regulator (AVR)		**4**
	Fire Fighting System		**4**

Table 3-11: SVL I&C Asset Grading

Asset	Category	Description	Grade
Instrumentation and Control			
	Bailey Control System		**3**
	Gas Turbine Control Building Envelope		**4**

Table 3-12: SVL Electrical Asset Grading

Asset	Category	Description	Grade
Electrical Systems			
	High Voltage Switchgear Building envelope		**4**
	13.8 kV Switchgear (alternator breaker)		**4**
	Alternator Output Bus Duct		**4**
	Alternator protection relays		**4**
	Sync-check relay		**INA**
	Motor Control Centres (AC & DC)		**INA**
	Station DC supply (batteries and chargers)		**2**
	Inverter (AC supply for control systems)		**5**
	Emergency Backup Diesel Generator		**INA**

Table 3-13: SVL Fuel Oil Asset Grading

Asset	Category	Description	Grade
Fuel Oil System			
	Fuel Unloading Building envelope		**4**
	Fuel Forwarding Building envelope		**4**
	Oil Unloading		**INA**
	Oil Storage and Secondary Containment		**INA**
	Fuel Forwarding Equipment		**4**
	Fuel Piping		**4**
	Instrumentation and Control		**3**
	Fuel oil tanks		**INA**
	Fuel forwarding system		**INA**
	Fire Fighting Systems		**INA**

Table 3-14: SVL Glycol Cooling Asset Grading

Asset	Category	Description	Grade
Glycol Cooling System			
	Main Lube Oil Cooling System / Glycol Cooler		**4**
	Equipment		**--**

Table 3-15: SVL Support Buildings Asset Grading

Asset	Category	Description	Grade
Support Buildings			
	Emergency Backup Diesel Generator Building		**4**
	Parts Storage Shed		**4**
	Waste Oil Storge Building		**4**

4. Hardwoods Site Images

Figure 4-1: Fuel Forwarding Pumps

Figure 4-1: Fuel Forwarding Piping and Instrumentation

Figure 4-2: Fuel Forwarding Equipment

Figure 4-3: Air Intake

Figure 4-4: Turbine Enclosure

Figure 4-5: Turbine Enclosure

Figure 4-6: Turbine Enclosure

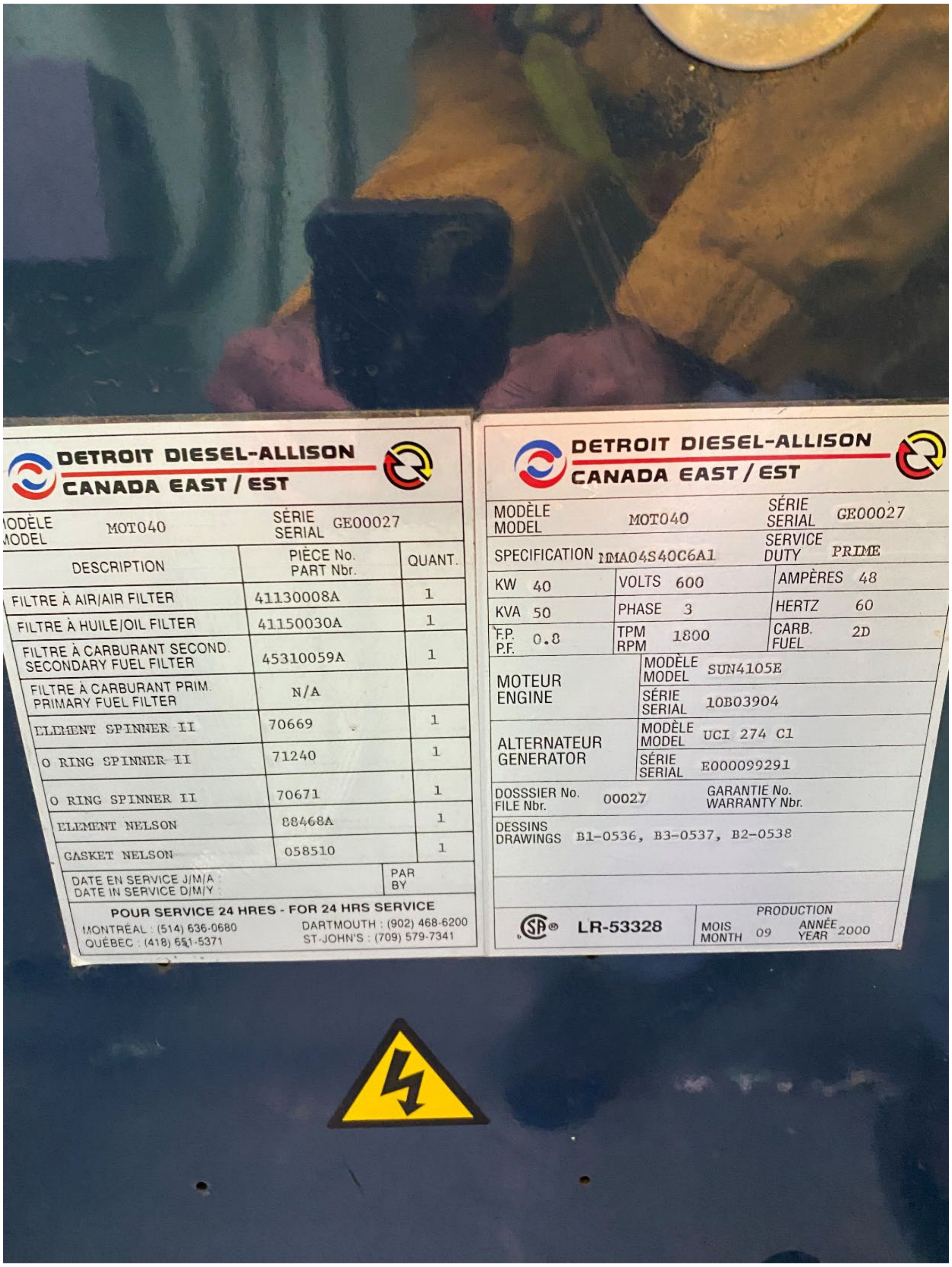

Figure 4-7: Diesel Generator Nameplate

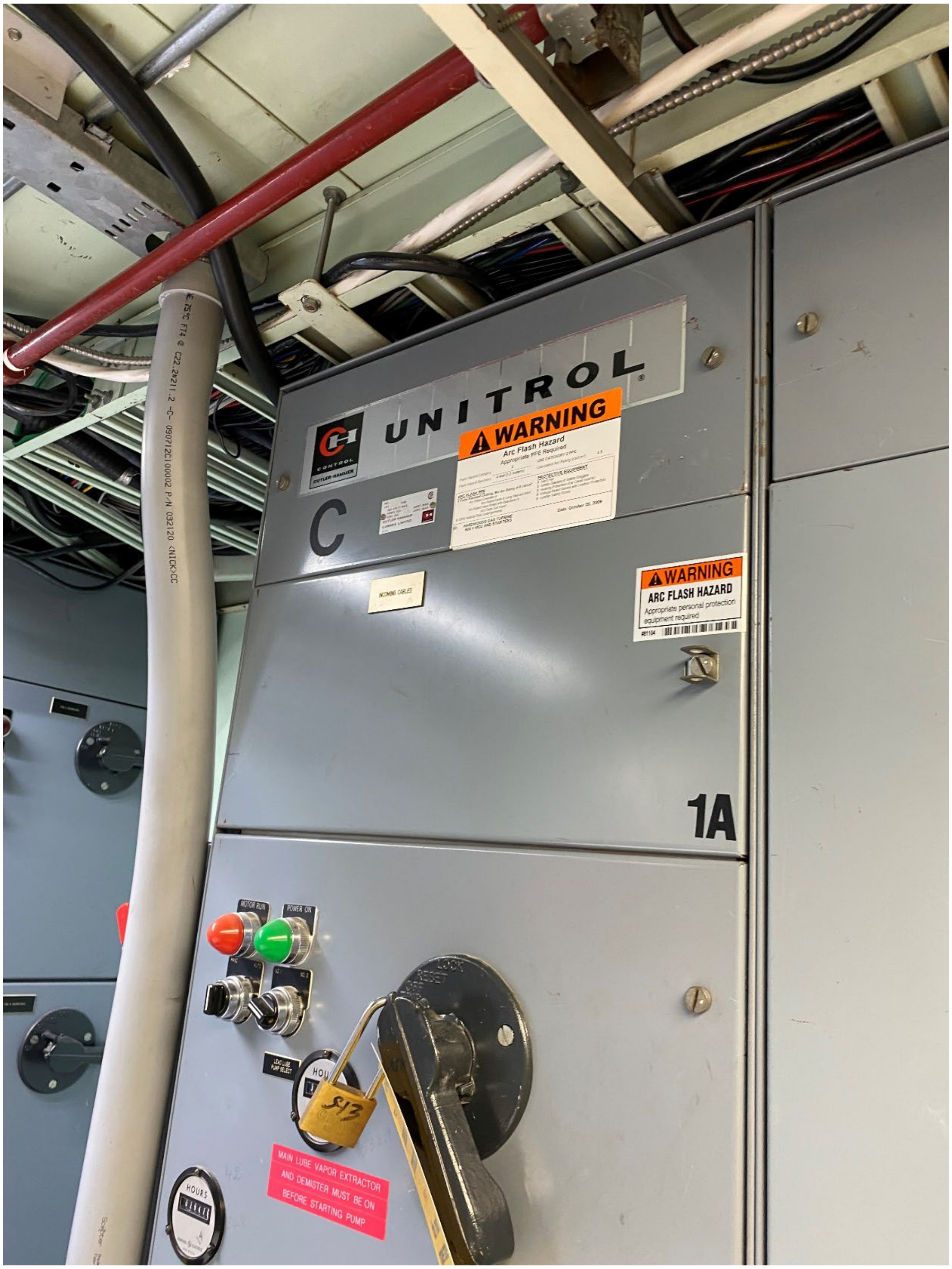

Figure 4-8: AC MCC

Figure 4-9: AC MCC

Figure 4-10: DC MCC

Figure 4-11: Fuel Valve Drivers and Power Supplies

Figure 4-12: Battery Charger

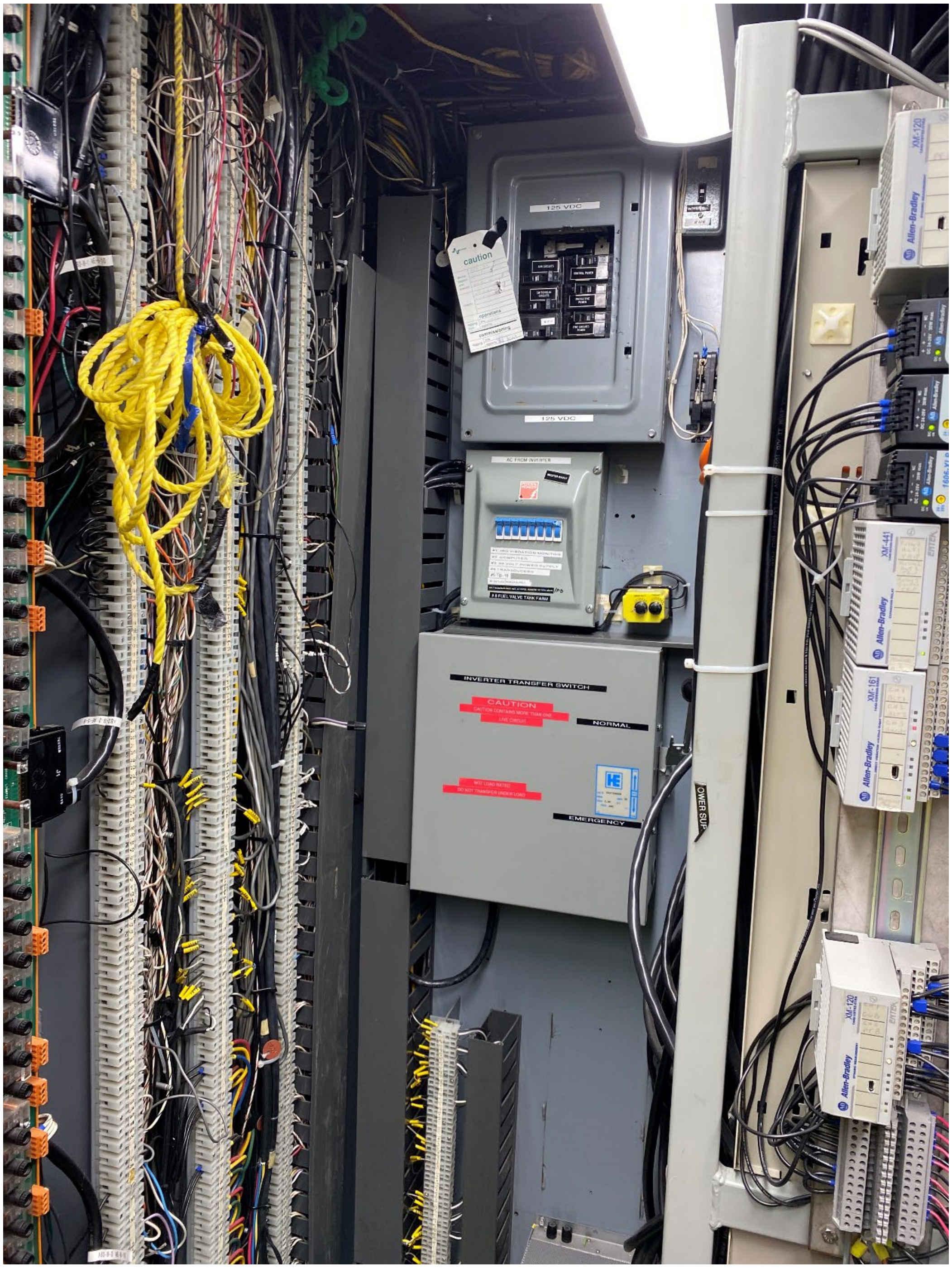

Figure 4-13: 125VDC Panel and Transfer Switch

Figure 4-14: Protection and Control Panel Interior

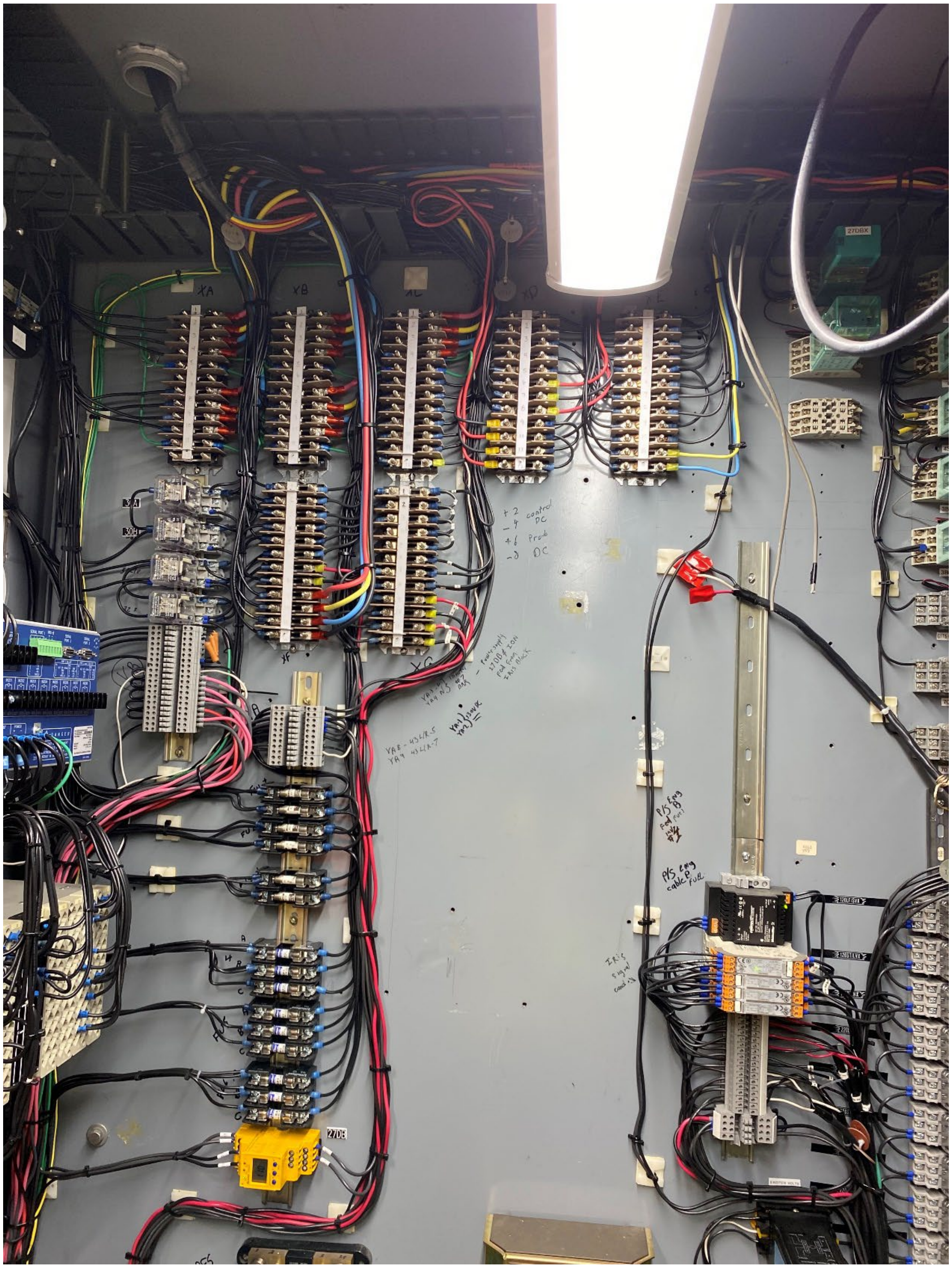

Figure 4-15: Protection and Control Panel Interior

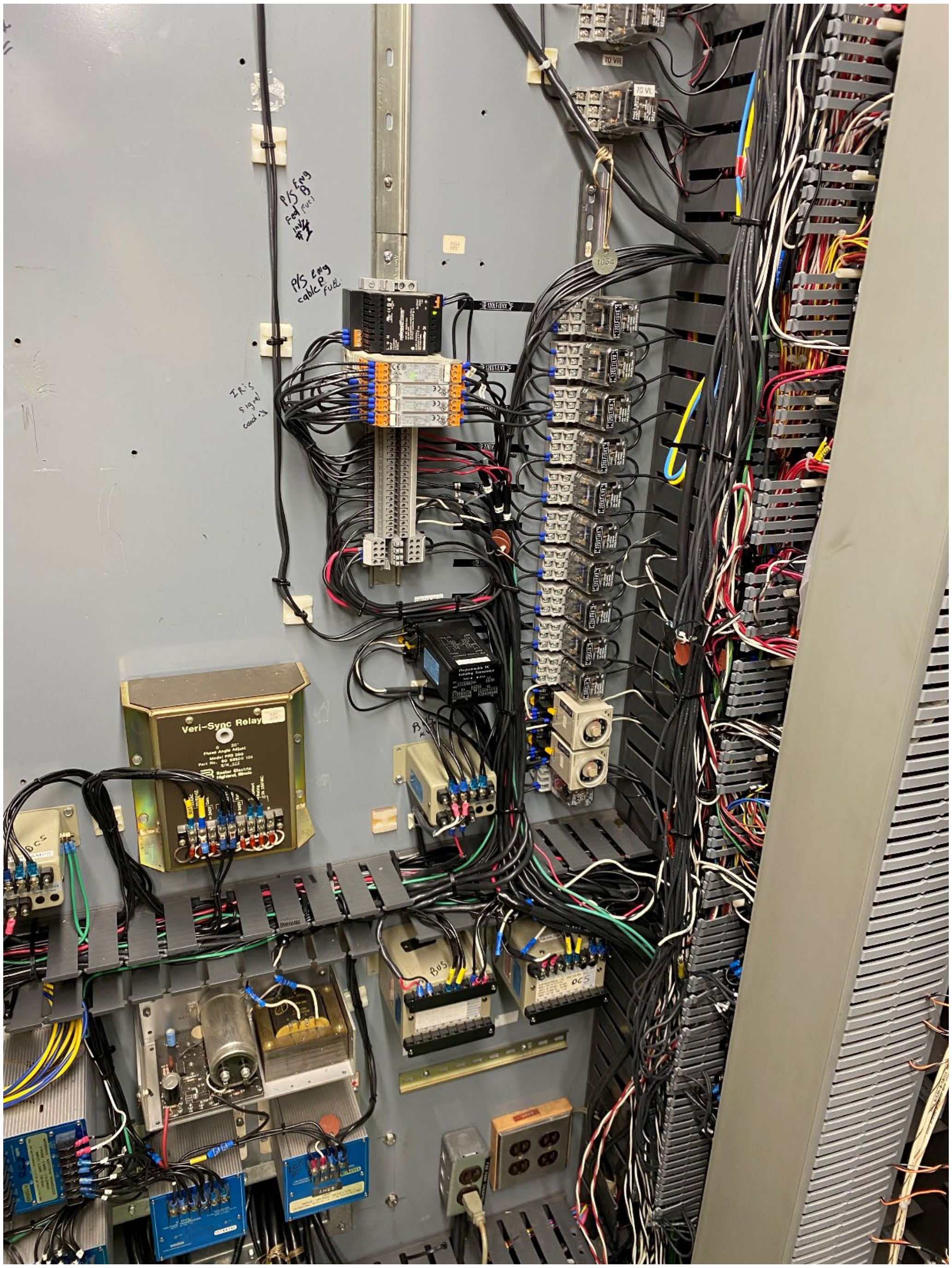

Figure 4-16: Protection and Control Panel Interior

Figure 4-17: ABB Symphony Plus Control Governor

Figure 4-18: ABB Symphony Plus Control Governor

Figure 4-19: Control Enclosure Envelope

Figure 4-20: Control Enclosure Envelope

Figure 4-21: Control Room & Battery Building

Figure 4-22: Switchgear

Figure 4-23: Switchgear Envelope

Figure 4-24: Switchgear Envelope

Figure 4-25: Potential Transformers for Protection and Control

Figure 4-26: Transformer, Cooler, & Fans

Figure 4-27: Transformer, Oil Reserve Tank, and Bus Duct

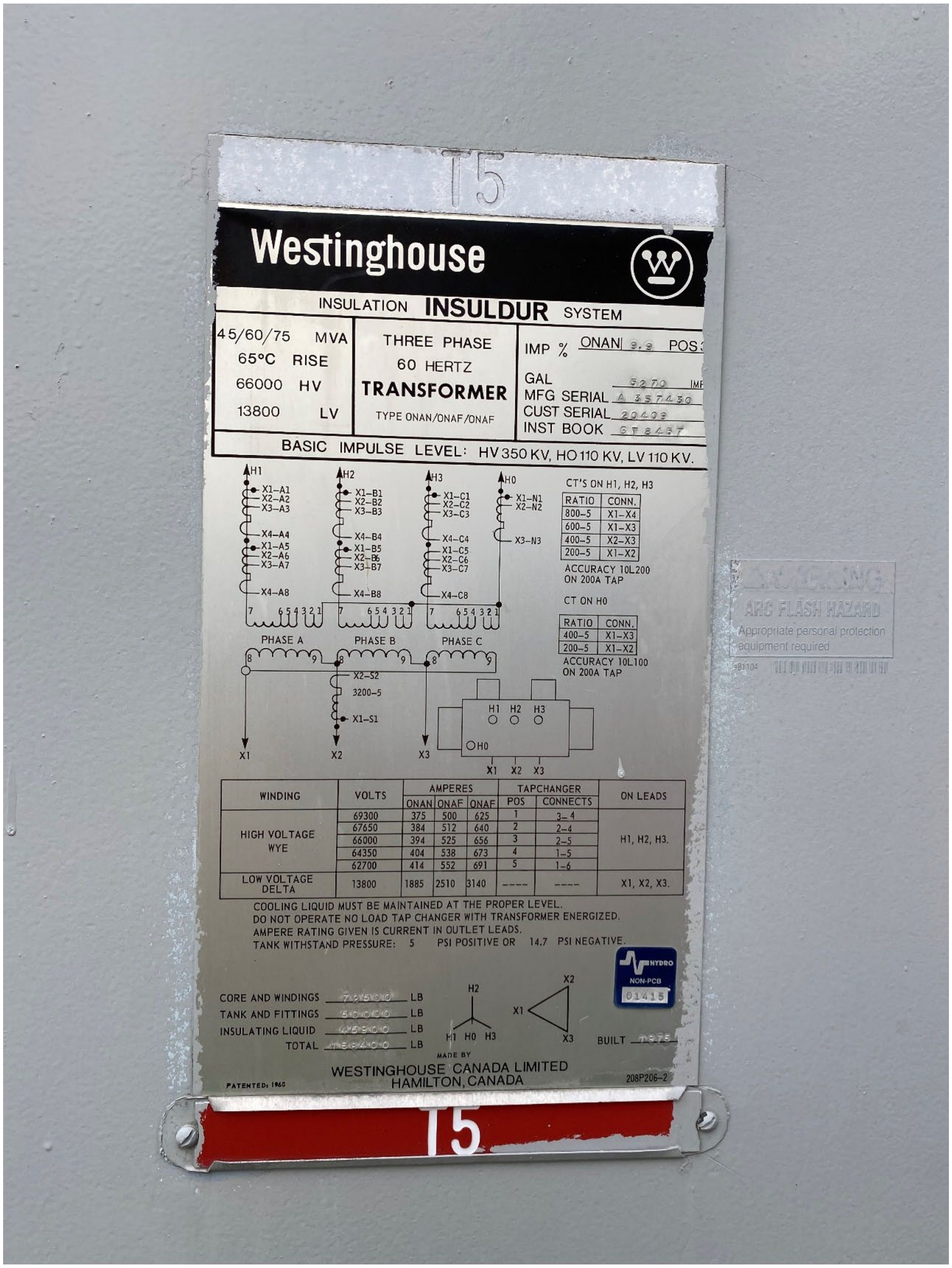

Figure 4-28: Transformer Nameplate

Figure 4-29: Fuel Valve - Woodward LQ series

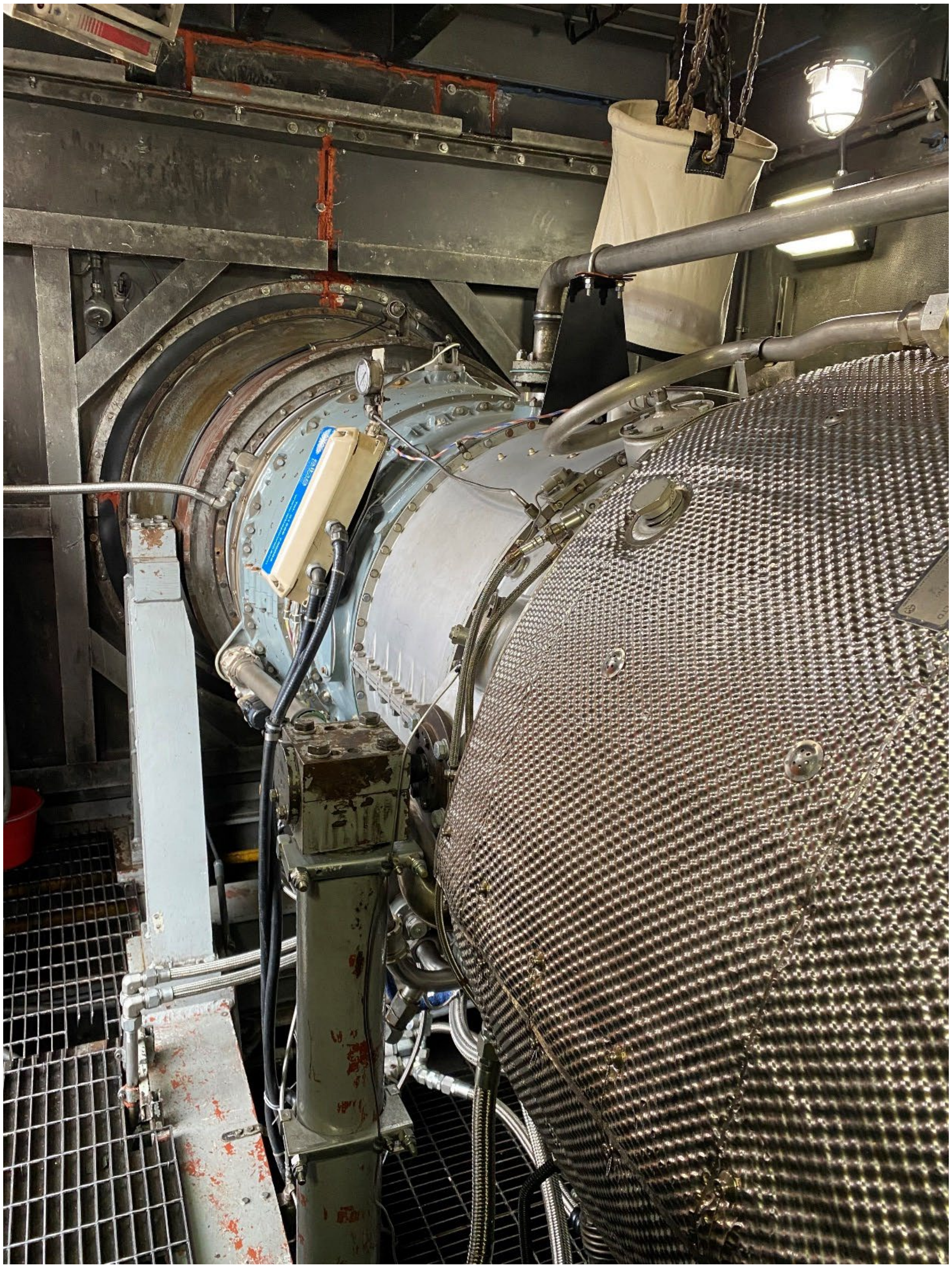

Figure 4-30: Rolls Royce Olympus C Compressor End

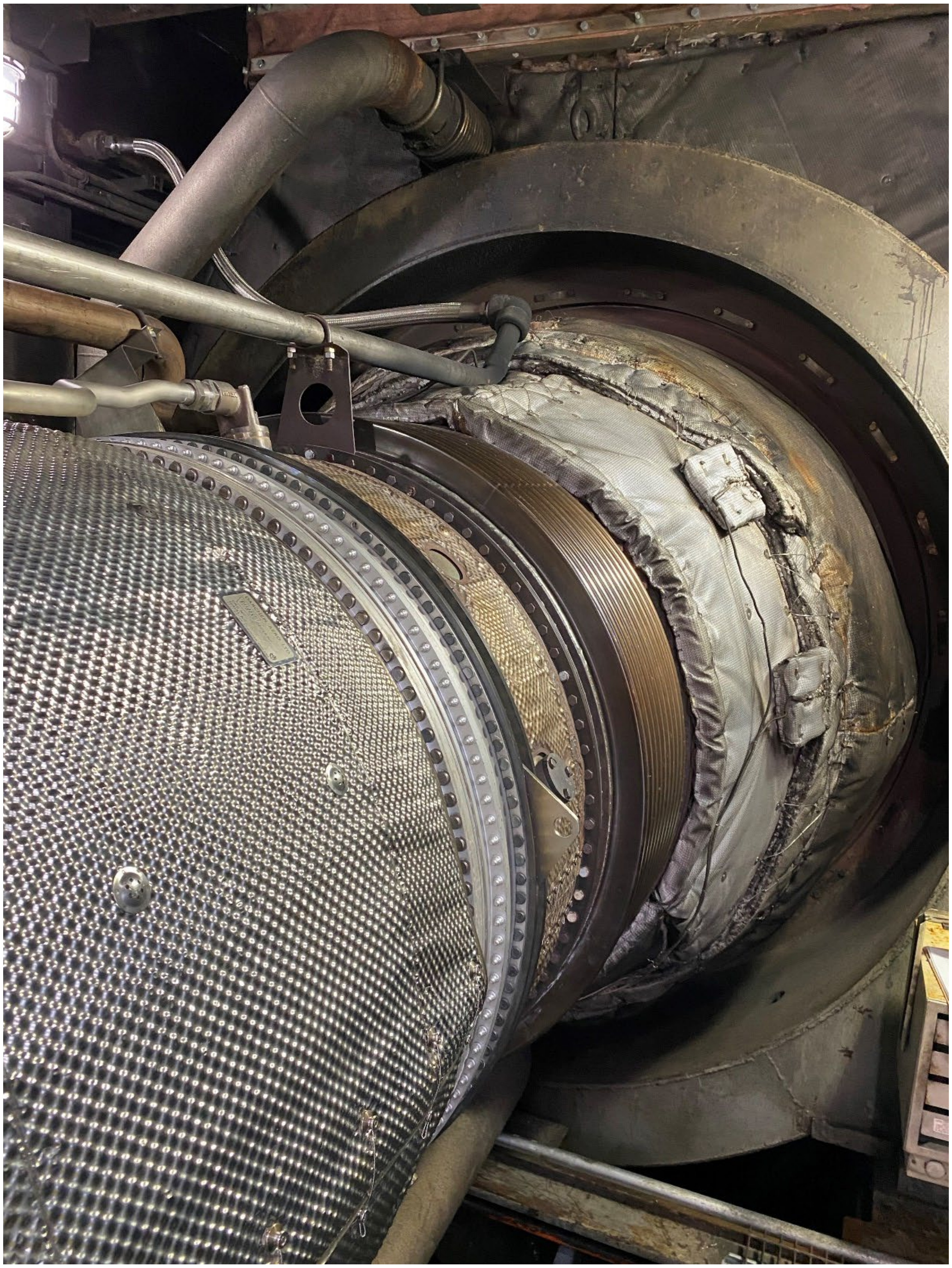

Figure 4-31: Rolls Royce Olympus C – Turbine End

Figure 4-32: Lube Oil

Figure 4-33: Transformer

Figure 4-34: Gas Insulated Breaker

Figure 4-35: Switchyard

Figure 4-36: Generator Breaker Control Cabinet

Figure 4-37: Air Intake & Fuel Inlet

Figure 4-38: Air Intake

Figure 4-39: Exhaust Stacks and Generator Envelope

Figure 4-40: Exhaust Stacks and Generator Envelope

Figure 4-41: Air Intake Silencer

Figure 4-42: Compressor Inlet

Figure 4-43: Air Intake Envelope

Figure 4-44: Air Intake Envelope

Figure 4-45: Structure Envelope

Figure 4-46: HWD-B Rolls Royce Olympus C - Starter

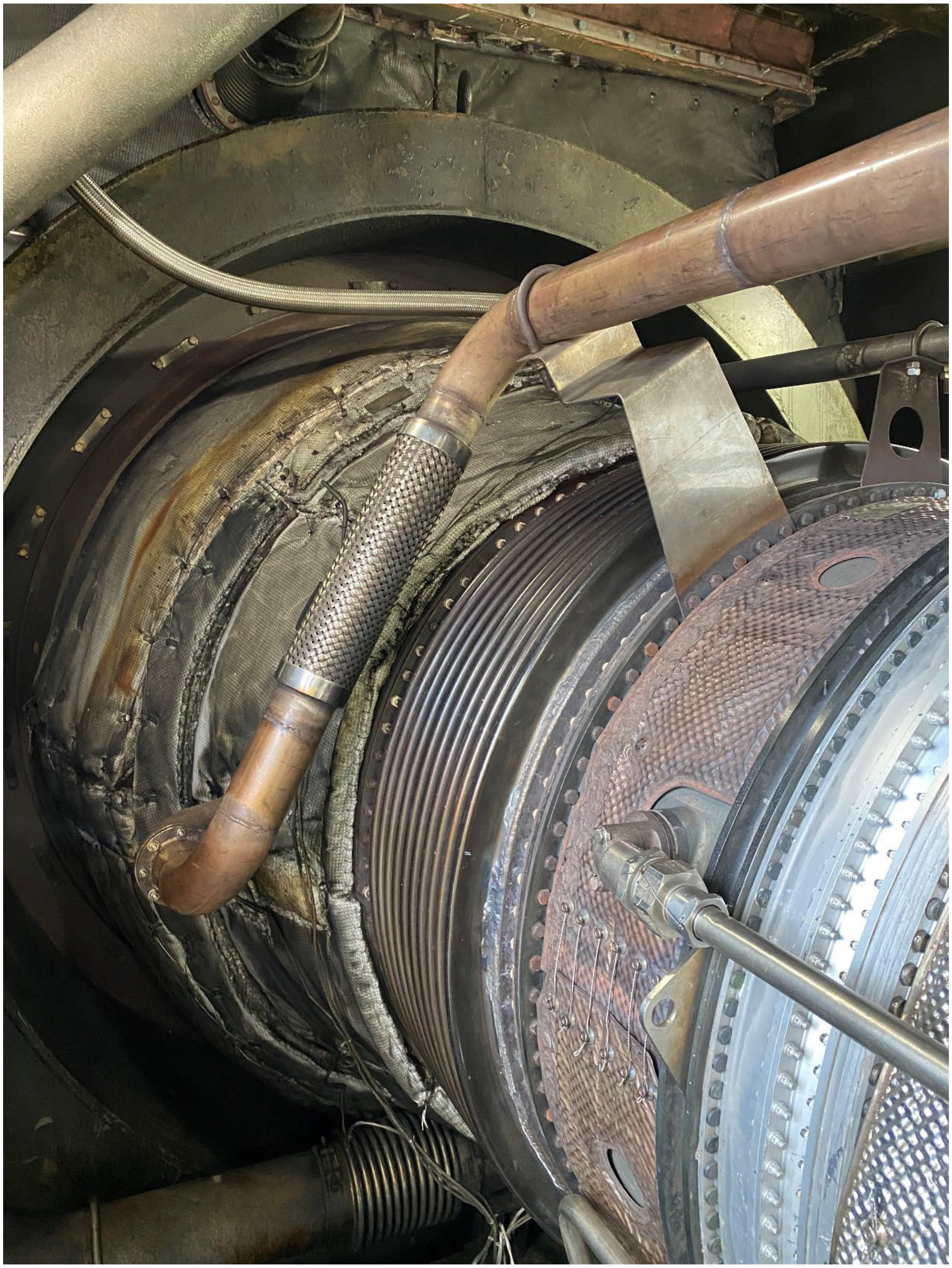

Figure 4-47: HWD-B Rolls Royce Olympus C Compressor End

Figure 4-48: Glycol Cooler

Figure 4-49: Glycol Cooler

Figure 4-50: Structure Envelope

Figure 4-51: Structure Envelope

Figure 4-52: Lube Oil Equipment

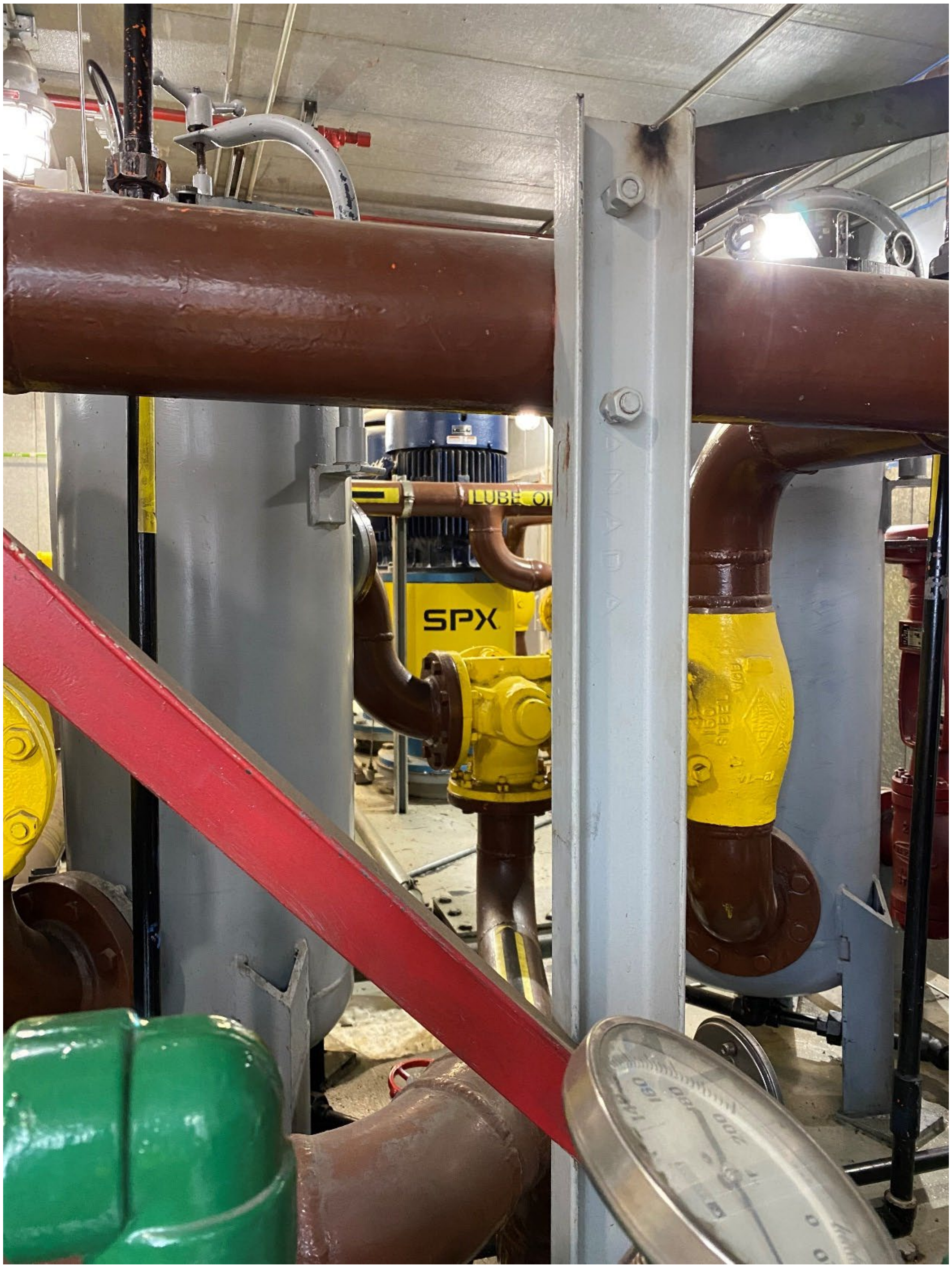

Figure 4-53: Lube Oil Equipment

Figure 4-54: Lube Oil Equipment

Figure 4-55: Generator Air Intake – Snow Hood

Figure 4-56: Generator Air Intake – Snow Hood

Figure 4-57: SSS Clutch A

Figure 4-58: SSS Clutch DE – Power Turbine Bearing

Figure 4-59: Generator Nameplate

Figure 4-60: Generator Bearing & Site Glass

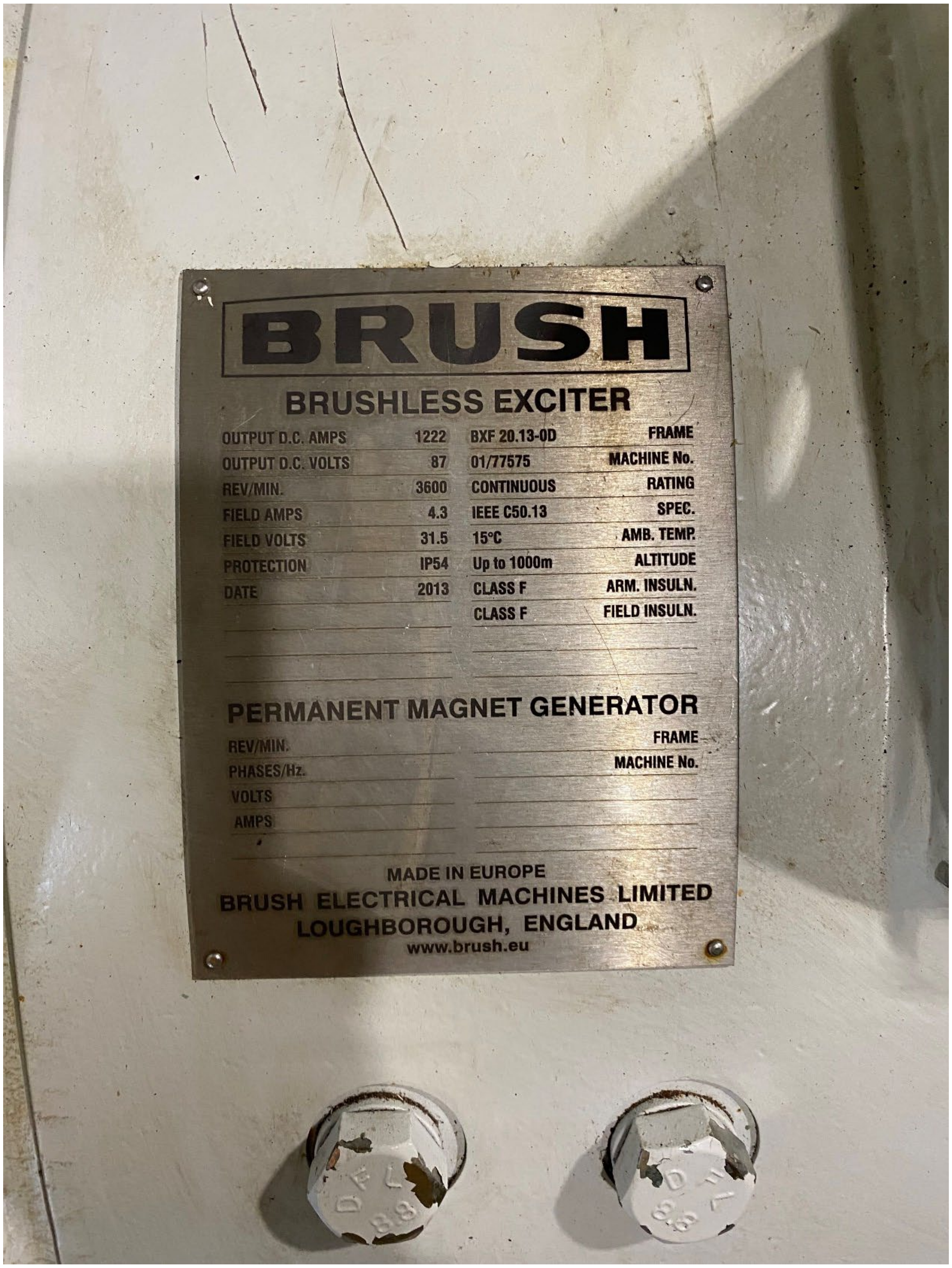

Figure 4-61: PMG - Brushless Exciter Nameplate

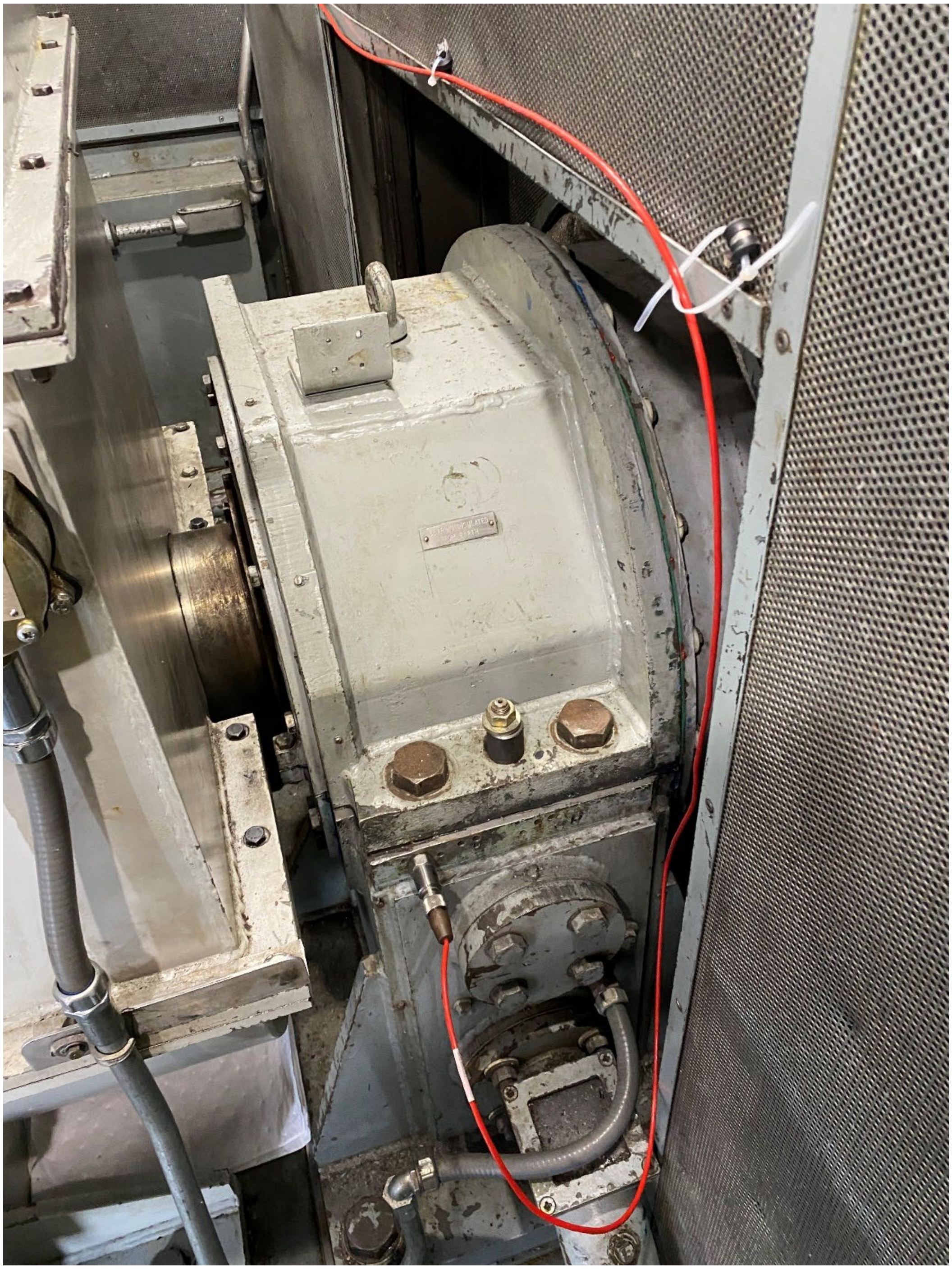

Figure 4-62: Generator Bearing & Site Glass

Figure 4-63: Jacking Oil Pump

Figure 4-64: DC Lube Oil Pumps, Piping and Equipment

Figure 4-65: AC Lube Oil Pumps, Piping and Equipment

Figure 4-66: Lube Oil Instrumentation

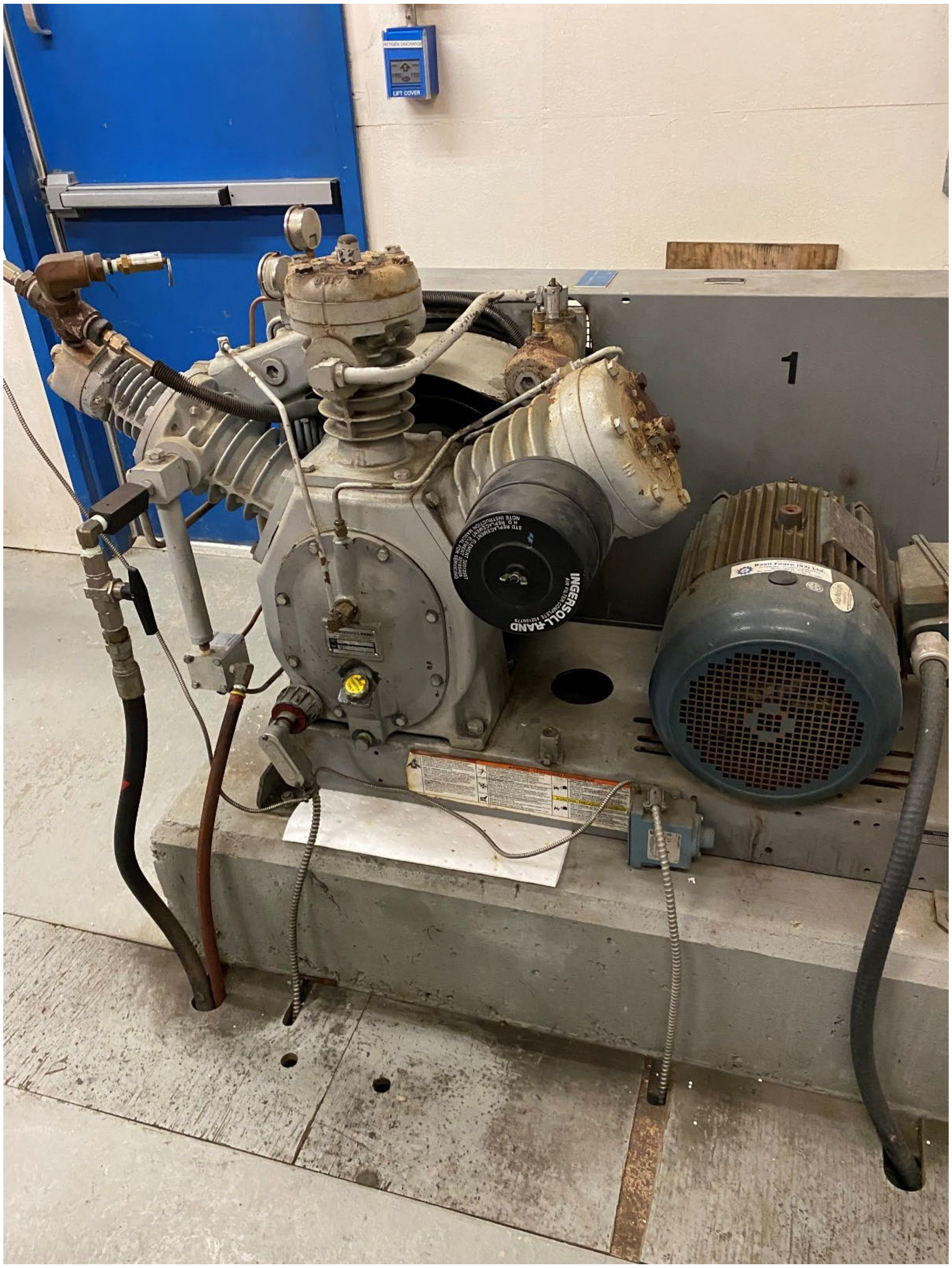

Figure 4-67: Air Compressor #1

Figure 4-68: Air Compressor #2

Figure 4-69: Air Dryer

Figure 4-70: Air Receiver 1 of 2

Figure 4-71: Air Receiver 2 of 2

Figure 4-72: Generator Bearing NDE

Figure 4-73: Jacking Oil Pump

Figure 4-74: SSS Clutch - B

Figure 4-75: Power Turbine Bearing

Figure 4-76: SSS Clutch and Bearing Drain

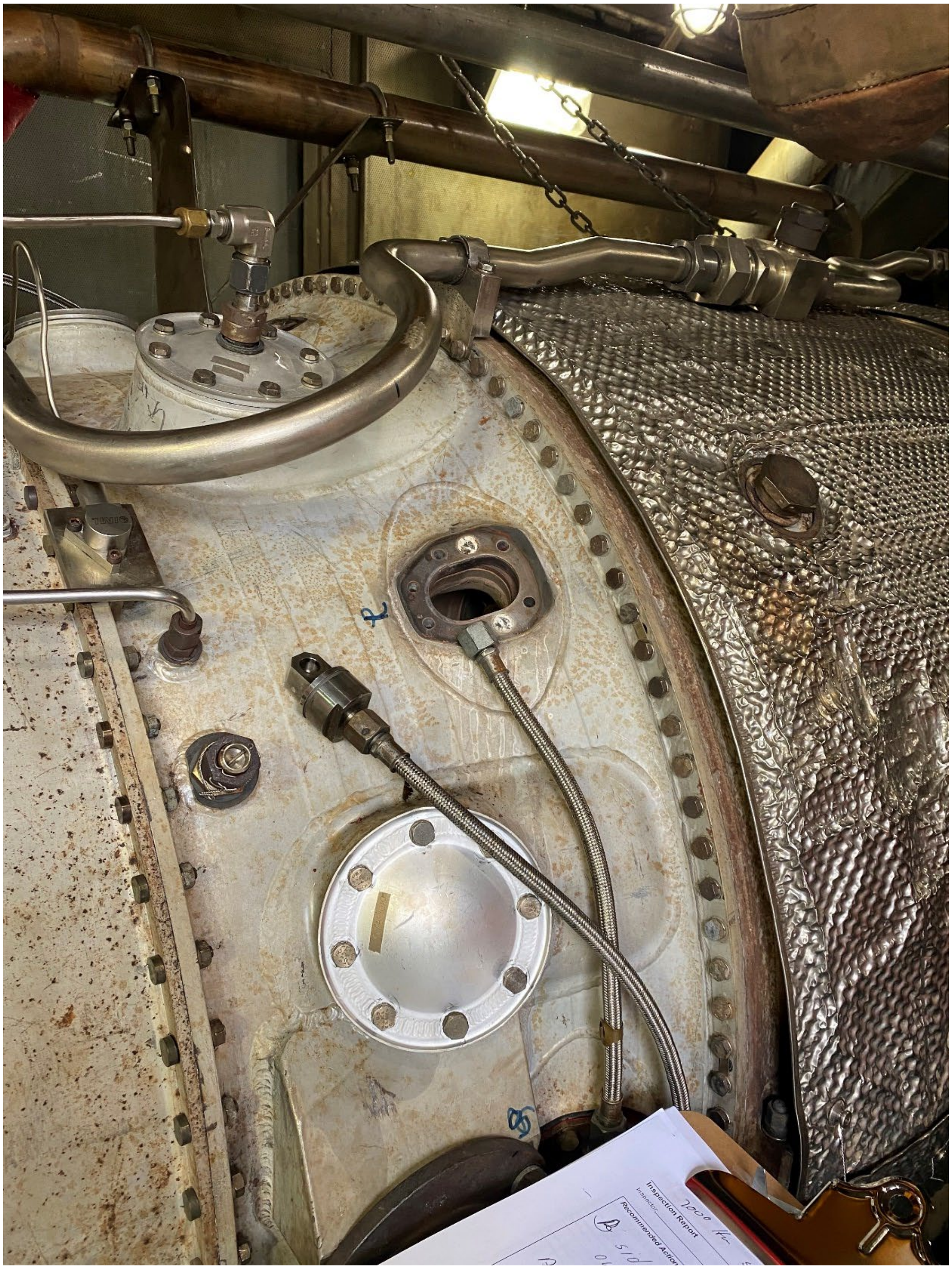

Figure 4-77 : Olympus C Can-Annular Fuel Nozzle Port

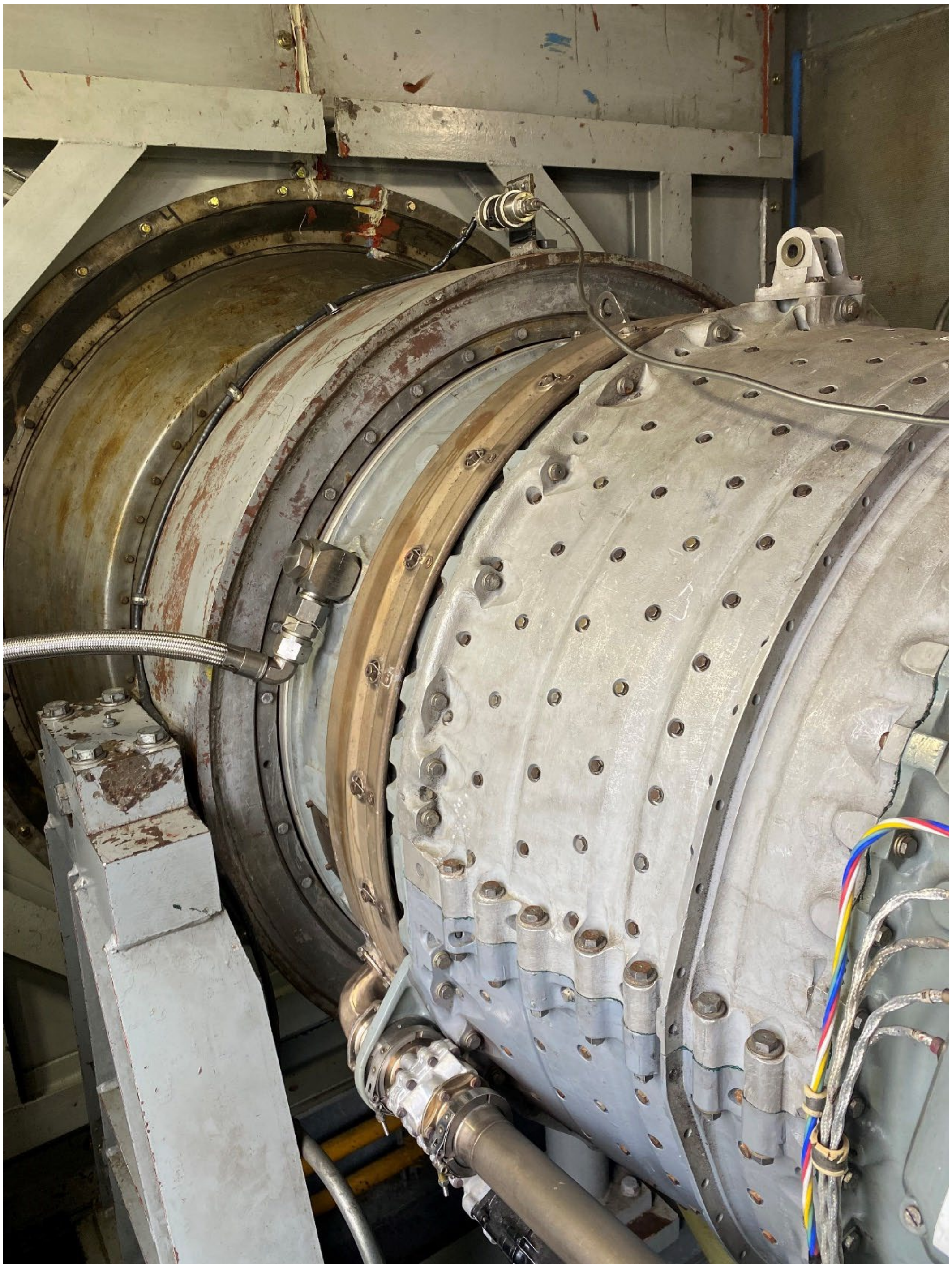

Figure 4-78: HWD-B CT Compressor Shell

Figure 4-79: Structure Envelope

Figure 4-80: Exhaust Stack Envelope

Figure 4-81: Exhaust Stack Envelopes

Figure 4-82: Structures

Figure 4-83 : Fuel Nozzles – Burner Assembly

Figure 4-84 : Fuel Nozzles – Burner Assembly

Figure 4-85: Air Intake Interior

Figure 4-86: Primary Air Filters

Figure 4-87: Air Intake Media Filters

Figure 4-88: Air Intake Media Filters

Figure 4-89: Air Intake Media Filters

Figure 4-90: Primary Air Filter

Figure 4-91: Primary Filter Blower

Figure 4-92: Interior Structure Corrosion

Figure 4-93: Air Intake Media Filters

Figure 4-94: Air Intake Interior

Figure 4-95: Air Intake Media Filters

Figure 4-96: Air Intake Media Filters

Figure 4-97: Glycol Coolers – Top View

5. Stephenville Site Images

Figure 5-1: Fuel Oil Storage Tank & Piping

Figure 5-2: Fuel Oil Storage Tanks

Figure 5-3: Station Entrance

Figure 5-4: Station Entrance

Figure 5-5: Support Building

Figure 5-6: Fuel Oil Storage Tanks

Figure 5-7: Intake and Exhaust Envelope

Figure 5-8: Unit Exterior

Figure 5-9: Unit Exterior

Figure 5-10: Control Interface and Generator Control Panel

Figure 5-11: AC MCC

Figure 5-12: DC MCC

Figure 5-13: DC MCC

Figure 5-14: AC MCC Incoming Section

Figure 5-15: Generator Protection Panel

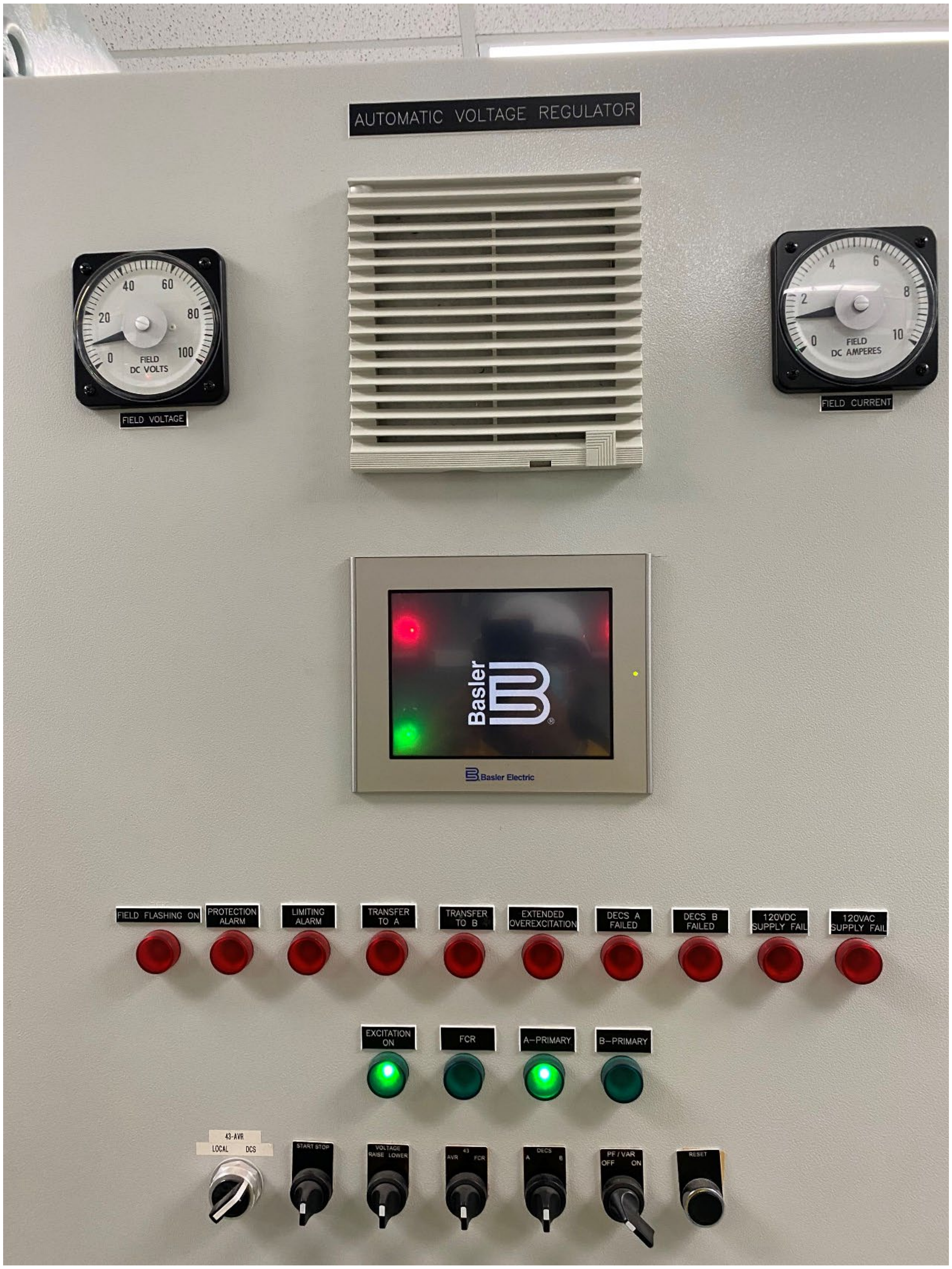

Figure 5-16: Generator Automatic Voltage Regulator

Figure 5-17: Battery Charger

Figure 5-18: Battery Charger

Figure 5-19: DC Batteries

Figure 5-20: DC Batteries

Figure 5-21: Low Voltage DC Battery

Figure 5-22: DC Batteries

Figure 5-23: Spare Combustion Turbine

Figure 5-24: Air Compressor

Figure 5-25: Air Dryer

Figure 5-26: Air Compressor

Figure 5-27: Fuel Oil Storage

Figure 5-28: Fuel Forwarding Piping and Equipment

Figure 5-29: Fuel Forwarding Piping and Equipment

Figure 5-30: Fuel Forwarding Piping and Equipment

Figure 5-31: Rolls Royce Olympus C Exhaust End

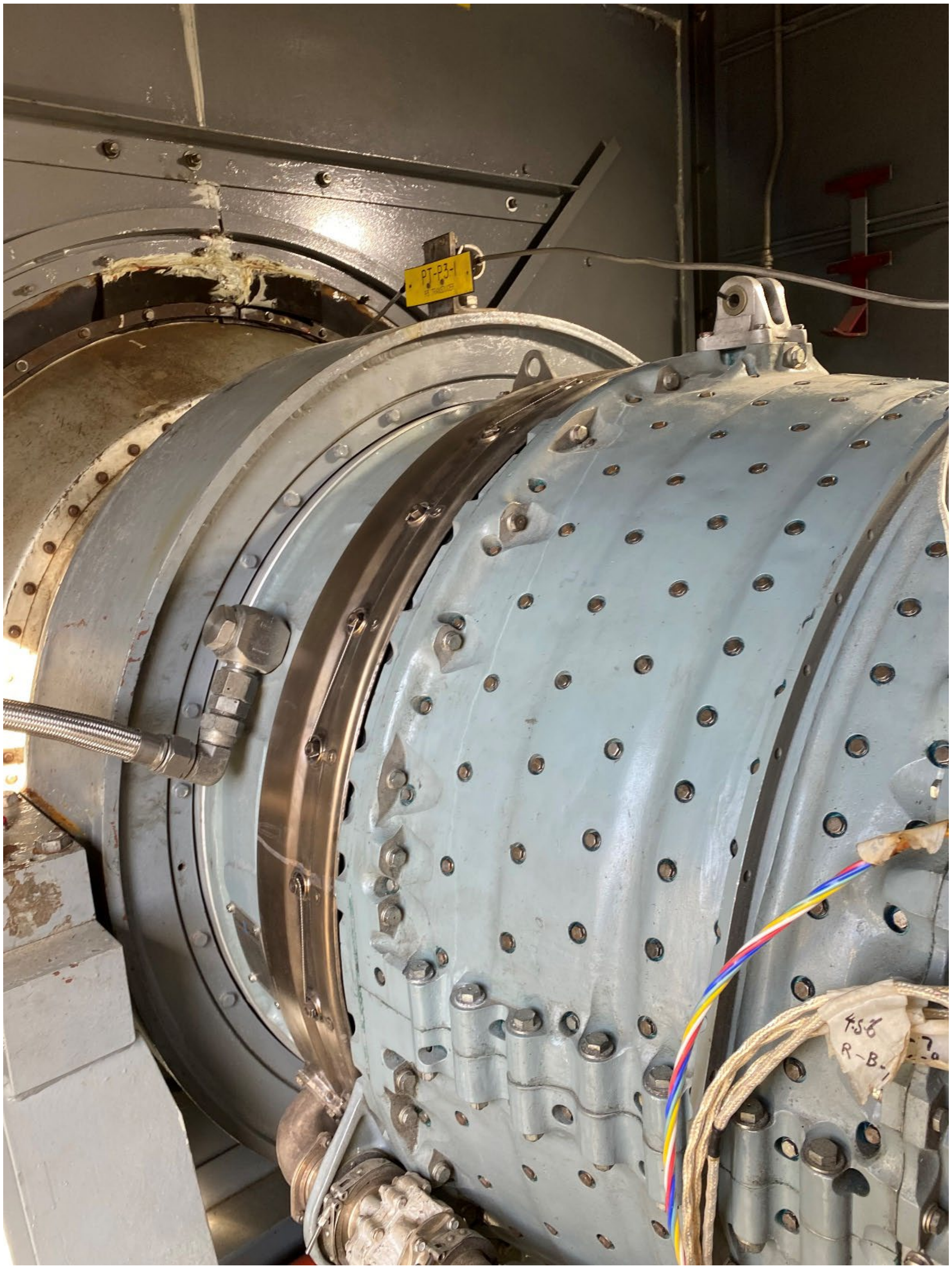

Figure 5-32: Rolls Royce Olympus C Compressor End

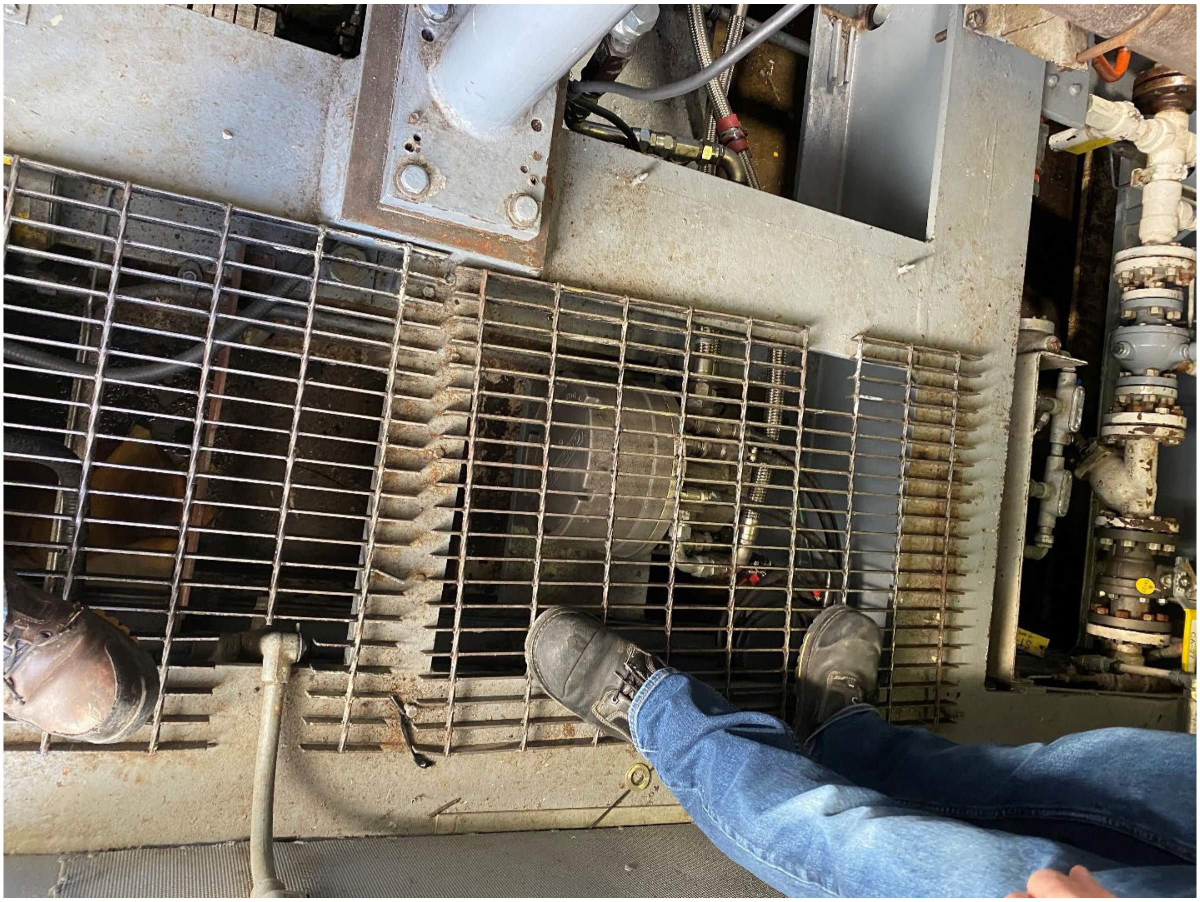

Figure 5-33: Fuel Valve – Woodward LQ series

Figure 5-34: Lube Oil Filters

Figure 5-35: Lube Oil Pumps

Figure 5-36: Intake and Exhaust Envelope

Figure 5-37: Exhaust Stack

Figure 5-38: Terminal Station

Figure 5-39: Terminal Station

Figure 5-40: Terminal Station

Figure 5-41: Support Building

Figure 5-42: Support Building Envelope

Figure 5-43: Diesel Generator

Figure 5-44: Battery Chargers Electrical Control Panel

Figure 5-45: Diesel Generator Nameplate

Figure 5-46: Air Receivers

Figure 5-47: Intake Structure

Figure 5-48: Exhaust Stack

Figure 5-49: Fuel Filter

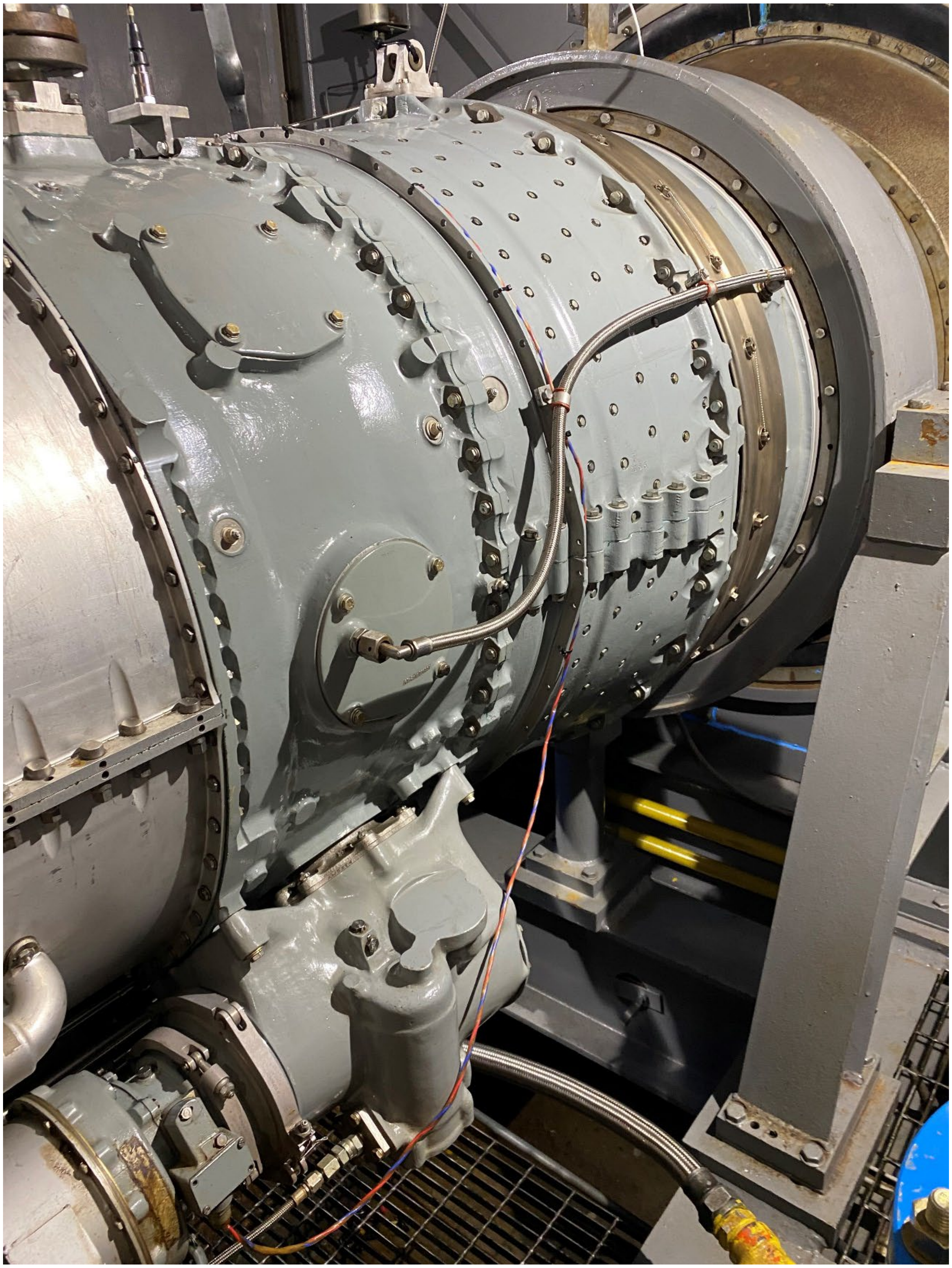

Figure 5-50: Rolls Royce Olympus C - Starter

Figure 5-51: Panel

Figure 5-52: Miscellaneous I&C Equipment

Figure 5-53: Glycol Equipment

Figure 5-54: Generator Bearing

Figure 5-55: Clutch

Figure 5-56: Lube Oil Control Panel

Figure 5-57: Glycol Cooler

Figure 5-58: Glycol Cooler

Figure 5-59: Plant Entrance Shoulder of Road Washout

Appendix C
HWD and SVL Capital Upgrades and Major Maintenance Items

Hardwood Options include the following recommended Capital Upgrades and Major Maintenance items detailed in Table C-1.

Table C-1: HWD Capital Upgrades and Major Maintenance Items

Asset	Option 1	Severity	Probability	Option 1 RAC	Option 2	Severity	Probability	Option 2 RAC	Option 3	Severity	Probability	Option 3 RAC	Option 4	Severity	Probability	Option 4 RAC	Cost (2021 Cdn$) (000)
Gas Generator and Power Turbines																	
Engine A & B removed, disassembled and major refurbishments as required	2X	5	5	50.00%	X	5	1	2.00%	X	5	3	10.00%	2X	5	4	20.00%	1500
Replace Vibration Monitoring System on A & B	X	3	5	20.00%	X	3	5	20.00%	X	3	5	20.00%	X	3	5	20.00%	210
Replace Temperature Monitoring System on A & B	X	3	5	20.00%	X	3	5	20.00%	X	3	5	20.00%	X	3	5	20.00%	60
Upgrade Lube Oil Monitoring Controls	X	2	5	7.50%					X	2	3	1.50%	X	2	4	3.00%	50
Inspect Compressed Air Starting System and replace components as necessary	X	2	5	7.50%	X	2	5	7.50%	X	2	5	7.50%	X	2	5	7.50%	8
Power Turbine A & B inspected, and major refurbishments as required	X	5	5	50.00%									X	5	4	20.00%	1000
SSS Clutches disassembled and inspected	X	5	5	50.00%					X	5	3	10.00%	X	5	4	20.00%	19
Replace Fuel Valve Assemblies	X	5	2	5.00%									X	5	1	2.00%	85
Replace Ignition Exciters	X	5	5	50.00%					X	5	3	10.00%	X	5	4	20.00%	36
Alternator																	
Alternator Testing	X	2	5	7.50%					X	2	3	1.50%	X	2	4	3.00%	10
Alternator removal, remove the rotor, inspect stator and rotor, replace bearings, etc.	X	5	5	50.00%									X	5	4	20.00%	As required by testing
Main Lube Oil Glycol Cooler																	
Glycol Cooler cleaned, serviced, sand blasted and repainted	X	5	5	50.00%	X	5	5	50.00%	X	5	5	50.00%	X	5	5	50.00%	25
Glycol System Upgrade (if cleaning and servicing is not effective)	X	4	3	7.00%					X	4	1	1.40%	X	4	2	3.50%	1307
Electrical System																	
Service 13.8 kV circuit breaker	X	3	5	20.00%					X	3	3	4.00%	X	3	4	8.00%	10
Inspect the Alternator Output Bus Duct	X	2	5	7.50%					X	2	3	1.50%	X	2	4	3.00%	10
Replace Transformer Cooling Fans					X	3	5	20.00%									8
Replace Main Transformer, Transformer Cooler, and associated power cables	X	5	5						X	5	5		X	5	5		1887
Upgrade and replace the Emergency Backup Diesel Generator and Controls (if Black start at load is required)	X	4	4	14.00%					X	4	2	3.50%	X	4	3	7.00%	100
Instrumentation																	
Bailey Control System inspect, troubleshoot, and upgrade as necessary	X	2	5	7.50%	X	2	2	0.75%	X	2	3	1.50%	X	2	4	3.00%	20
Replace existing DCS system interface computer with a new PC and upgrade software	X	2	5	7.50%					X	2	3	1.50%	X	2	4	3.00%	30
Fuel Oil System																	
Fuel Oil Storage Tanks inspection and repair of stairs and platforms	X	2	5	7.50%					X	2	3	1.50%	X	2	4	3.00%	15
Fuel Oil Storage Tanks clean and repaint exterior	X	3	5	20.00%									X	2	4	3.00%	30
Building Envelopes																	
Engine and Power Turbine Enclosures interior and exteriors sand blasted and recoated	X	3	5	20.00%					X	3	3	4.00%	X	3	4	8.00%	15

Asset	Option 1	Severity	Probability	Option 1 RAC	Option 2	Severity	Probability	Option 2 RAC	Option 3	Severity	Probability	Option 3 RAC	Option 4	Severity	Probability	Option 4 RAC	Cost (2021 Cdn$) (000)
Alternator Enclosure interior and exterior sand blasted and repainted	X	3	5	20.00%					X	3	3	4.00%	X	3	4	8.00%	12
Inlet Air A & B interiors, exteriors and silencers sand blasted and repainted	X	3	5	20.00%					X	3	3	4.00%	X	3	4	8.00%	20
Exhaust Stacks A & B inspected and repaired as required	X	3	5	20.00%	X	3	2		X	3	3	4.00%	X	3	4	8.00%	5
Exhaust Stacks A & B sand blasted and repainted	X	3	5	20.00%					X	3	3	4.00%	X	3	4	8.00%	40
Exhaust Stacks A & B Snow Doors replaced	X	3	5	20.00%									X	3	4	8.00%	8
Exhaust Stacks A & B ladder and platforms inspected and replaced as required	X	3	5	20.00%					X	3	3	4.00%	X	3	4	8.00%	5
Inspect Bus Duct Envelope and repair as necessary	X	2	5	7.50%					X	2	3	1.50%	X	2	4	3.00%	5
Control Building Envelope sand blast and repaint exterior	X	3	5	20.00%					X	3	3	4.00%	X	3	4	8.00%	8
Fuel Unloading Building repair roof as necessary, sand blast and repaint exterior	X	3	5	20.00%					X	3	3	4.00%	X	3	4	8.00%	4
Fuel Forwarding Building repair roof as necessary, exterior sand blasted and repainted	X	3	5	20.00%					X	3	3	4.00%	X	3	4	8.00%	4
Aux Building repair roof as necessary, exterior sand blasted and repainted	X	3	5	20.00%					X	3	3	4.00%	X	3	4	8.00%	4
Maintenance and Parts Storage Building repair roof as necessary, exterior sand blasted and repainted	X	3	5	20.00%					X	3	3	4.00%	X	3	4	8.00%	5
High Voltage Switchgear building repair roof as necessary, exterior sand blasted and repainted	X	3	5	20.00%					X	3	3	4.00%	X	3	4	8.00%	10
Emergency Backup Diesel Generator Building sandblast and repaint exterior	X	3	5	20.00%					X	3	3	4.00%	X	3	4	8.00%	3
Spare Parts																	
Starter Assembly	X								X				X				--
Fuel Injection Nozzles; complete set	X				X				X				X				--
Glycol Circulating Pumps	X												X				--
Fuel Forwarding Pumps	X												X				--
Spare Control Valve for Fuel Oil System	X				X				X				X				--
Spare Pressure Control Valve for Lube Oil System	X				X				X				X				--
Contingency																	
1501.44	X																1501
98.85					X												99
252.298									X								252
649.885													X				650
Operating Cost																	
																	450
Fuel Cost																	
																	1351
SUM Total (000)	$ 25,668.44				$ 5,470.85				$ 12,914.30				$ 24,816.89				

SVL Options include the following recommended Capital Upgrades and Major Maintenance items detailed in Table C-2.

Table C-2: SVL Option 1 Capital Upgrades and Major Maintenance Items

Asset	Option 1	Severity	Probability	Option 1 RAC	Option 2	Severity	Probability	Option 2 RAC	Option 3	Severity	Probability	Option 3 RAC	Option 4	Severity	Probability	Option 4 RAC	Cost (2021 Cdn$) (000)
Gas Generator and Power Turbines																	
Engine A & B removed, disassembled and major refurbishments as required	2X	5	5	50.00%	X	5	1	2.00%	X	5	3	10.00%	2X	5	4	20.00%	1500
Replace Vibration Monitoring System on A & B	X	3	5	20.00%	X	3	5	20.00%	X	3	5	20.00%	X	3	5	20.00%	210
Replace Temperature Monitoring System on A & B	X	3	5	20.00%	X	3	5	20.00%	X	3	5	20.00%	X	3	5	20.00%	
Upgrade Lube Oil Monitoring Controls	X	2	5	7.50%					X	2	3	1.50%	X	2	4	3.00%	50
Inspect Compressed Air Starting System and replace dryer as necessary	X	2	5	7.50%	X	2	5	7.50%	X	2	5	7.50%	X	2	5	7.50%	8
Power Turbine A & B inspected, and major refurbishments as required	X	5	5	50.00%									X	5	4	20.00%	1000
SSS Clutches disassembled and inspected	X	5	5	50.00%					X	5	3	10.00%	X	5	4	20.00%	19
Replace Fuel Valve Assemblies	X	5	5	50.00%					X	5	3	10.00%	X	5	4	20.00%	85
Replace Ignition Exciters	X	5	5	50.00%					X	5	3	10.00%	X	5	4	20.00%	36
Alternator																	
Alternator Testing	X	2	5	7.50%					X	2	3	1.50%	X	2	4	3.00%	10
Alternator removal, remove the rotor, inspect stator and rotor, replace bearings, etc.	X	5	5	50.00%					X	5	3	10.00%	X	5	4	20.00%	As required by testing
Main Lube Oil Glycol Cooler																	
Glycol Cooler cleaned, serviced, sand blasted and repainted	X	5	5	50.00%	X	5	5	50.00%	X	5	5	50.00%	X	5	5	50.00%	25
Electrical System																	
Service 13.8 kV circuit breaker	X	3	5	20.00%									X	3	4	8.00%	10
Inspect the Alternator Output Bus Duct	X	2	5	7.50%					X	2	3	1.50%	X	2	4	3.00%	10
Replace Main Transformer, Transformer Cooler and associated power cables	X	5	5						X	5	5		X	5	5		1904
Inspect the Emergency Backup Diesel Generator	X	2	5	7.50%	X	2	5	7.50%	X	2	3	1.50%	X	2	4	3.00%	5
Instrumentation																	
Bailey Control System inspect, troubleshoot, and upgrade as necessary	X	2	5	7.50%	X	2	2		X	2	3	1.50%	X	2	4	3.00%	20
Replace existing DCS system interface computer with a new PC and upgrade software	X	2	5	7.50%					X	2	3	1.50%	X	2	4	3.00%	30
HMI Replacement	X	4	4	14.00%	X	4	1		X	4	2	3.50%	X	4	3	7.00%	468
Fuel Oil System																	
Fuel Oil Storage Tanks inspection and repair of stairs and platforms as required	X	2	4	3.00%					X	2	2	0.75%	X	2	3	1.50%	15
Fuel Oil Storage Tanks clean and repaint exterior	X	3	4	8.00%									X	2	3	1.50%	30
Building Envelopes																	
Engine and Power Turbine Enclosures interior and exteriors sand blasted and recoated	X	3	3	4.00%					X	3	1	0.80%	X	3	2	2.00%	15
Alternator Enclosure interior and exterior sand blasted and repainted	X	3	3	4.00%					X	3	1	0.80%	X	3	2	2.00%	12

Asset	Option 1	Severity	Probability	Option 1 RAC	Option 2	Severity	Probability	Option 2 RAC	Option 3	Severity	Probability	Option 3 RAC	Option 4	Severity	Probability	Option 4 RAC	Cost (2021 Cdn$) (000)
Inlet Air A & B interiors, exteriors and silencers sand blasted and repainted	X	3	3	4.00%					X	3	1	0.80%	X	3	2	2.00%	20
Exhaust Stacks A & B inspected and repaired as necessary	X	3	3	4.00%	X	3	1	0.80%	X	3	1	0.80%	X	3	2	2.00%	5
Exhaust Stacks A & B sand blasted and repainted	X	3	3	4.00%					X	3	1	0.80%	X	3	2	2.00%	40
Exhaust Stacks A & B Snow Doors replaced	X	3	3	4.00%									X	3	2	2.00%	8
Exhaust Stacks A & B ladder and platforms inspected and replaced as required	X	2	3	1.50%					X	2	1	0.30%	X	2	2	0.75%	5
Inspect Bus Duct Envelope and repair as necessary	X	3	3	4.00%					X	3	1	0.80%	X	3	2	2.00%	5
Control Building Envelope sand blast and repaint exterior	X	3	3	4.00%					X	3	1	0.80%	X	3	2	2.00%	8
Fuel Forwarding Building repair roof as necessary, exterior sand blasted and repainted	X	3	3	4.00%					X	3	1	0.80%	X	3	2	2.00%	4
Waste Oil Storage Shed inspect roof and repair as necessary, exterior envelope repainted	X	3	3	4.00%					X	3	1	0.80%	X	3	2	2.00%	5
Parts Storage Shed repair roof as necessary, exterior repainted	X	3	3	4.00%					X	3	1	0.80%	X	3	2	2.00%	8
High Voltage Switchgear building repair roof as necessary, exterior sand blasted and repainted	X	3	3	4.00%					X	3	1	0.80%	X	3	2	2.00%	10
Emergency Backup Diesel Generator Building repaint exterior	X	3	3	4.00%					X	3	1	0.80%	X	3	2	2.00%	3
Spare Parts																	
Starter Assembly	X								X				X				--
Fuel Injection Nozzles; complete set	X				X				X				X				--
Glycol Circulating Pumps	X												X				--
Fuel Forwarding Pumps	X												X				--
Spare Control Valve for Fuel Oil System	X				X				X				X				--
Spare Pressure Control Valve for Lube Oil System	X				X				X				X				--
Civil Work																	
Shoulder of Service Road, backfill, and remediate vegetation	X	5	5	50.00%	X	5	5	50.00%	X	5	5	50.00%	X	5	5	50.00%	50
Sump system required around fuel storage tanks to increase drainage	X	3	5	20.00%	X	3	2	2.00%	X	3	3	4.00%	X	3	4	8.00%	As required
Contingency																	
1,486	X																1,486
111					X												111
264									X								264
649													X				649
Operating Cost																	
																	450
Fuel Cost																	
																	1,351
SUM Total (000)	$ 25,609.64				$ 5,422.52				$ 12,882.56				$ 24,772.98				

Appendix D
HWD and SVL Summary of Recommendations

The summary of recommendations for HWD based on the assigned RAC (Risk Assessment Code) is detailed in Table D-1.

Table D-1: HWD Life Cycle Cost Analysis Summary of Options

Asset	Option 1 RAC	Option 2 RAC	Option 3 RAC	Option 4 RAC
Gas Generator and Power Turbines				
Engine A & B removed, disassembled and major refurbishments as required	**50.00%**	**2.00%**	**10.00%**	**20.00%**
Replace Vibration Monitoring System on A & B	**20.00%**	**20.00%**	**20.00%**	**20.00%**
Replace Temperature Monitoring System on A & B	**20.00%**	**20.00%**	**20.00%**	**20.00%**
Upgrade Lube Oil Monitoring Controls	**7.50%**	**--**	**1.50%**	**3.00%**
Inspect Compressed Air Starting System and replace components as necessary	**7.50%**	**7.50%**	**7.50%**	**7.50%**
Power Turbine A & B inspected, and major refurbishments as required	**50.00%**	**--**	**--**	**20.00%**
SSS Clutches disassembled and inspected	**50.00%**	**--**	**10.00%**	**20.00%**
Replace Fuel Valve Assemblies	**5.00%**	**--**	**--**	**2.00%**
Replace Ignition Exciters	**50.00%**	**--**	**10.00%**	**20.00%**
Alternator				
Alternator Testing	**7.50%**	**--**	**1.50%**	**3.00%**
Alternator removal, remove the rotor, inspect stator and rotor, replace bearings, etc.	**50.00%**	**--**	**--**	**20.00%**
Main Lube Oil Glycol Cooler				
Glycol Cooler cleaned, serviced, sand blasted and repainted	**50.00%**	**50.00%**	**50.00%**	**50.00%**
Glycol System Upgrade (if cleaning and servicing is not effective)	**7.00%**	**--**	**1.40%**	**3.50%**
Electrical System				
Service 13.8 kV circuit breaker	**20.00%**	**--**	**4.00%**	**8.00%**
Inspect the Alternator Output Bus Duct	**7.50%**	**--**	**1.50%**	**3.00%**
Replace Transformer Cooling Fans	**--**	**20.00%**	**--**	**--**
Replace Main Transformer, Transformer Cooler and associated power cables[1]	**--**	**--**	**--**	**--**
Upgrade and replace the Emergency Backup Diesel Generator and Controls (if Black start at load is required)	**14.00%**	**--**	**3.50%**	**7.00%**
Instrumentation				
Bailey Control System inspect, troubleshoot and upgrade as necessary	**7.50%**	**0.75%**	**1.50%**	**3.00%**
Replace existing DCS system interface computer with a new PC and upgrade software	**7.50%**	**--**	**1.50%**	**3.00%**
Fuel Oil System				
Fuel Oil Storage Tanks inspection and repair of stairs and platforms	**7.50%**	**--**	**1.50%**	**3.00%**
Fuel Oil Storage Tanks clean and repaint exterior	**20.00%**	**--**	**--**	**3.00%**

Asset	Option 1 RAC	Option 2 RAC	Option 3 RAC	Option 4 RAC
Building Envelopes				
Engine and Power Turbine Enclosures interior and exteriors sand blasted and recoated	**20.00%**	**--**	**4.00%**	**8.00%**
Alternator Enclosure interior and exterior sand blasted and repainted	**20.00%**	**--**	**4.00%**	**8.00%**
Inlet Air A & B interiors, exteriors and silencers sand blasted and repainted	**20.00%**	**--**	**4.00%**	**8.00%**
Exhaust Stacks A & B inspected and repaired as required	**20.00%**	**--**	**4.00%**	**8.00%**
Exhaust Stacks A & B sand blasted and repainted	**20.00%**	**--**	**4.00%**	**8.00%**
Exhaust Stacks A & B Snow Doors replaced	**20.00%**	**--**	**--**	**8.00%**
Exhaust Stacks A & B ladder and platforms inspected and replaced as required	**20.00%**	**--**	**4.00%**	**8.00%**
Inspect Bus Duct Envelope and repair as necessary	**7.50%**	**--**	**1.50%**	**3.00%**
Control Building Envelope sand blast and repaint exterior	**20.00%**	**--**	**4.00%**	**8.00%**
Fuel Unloading Building repair roof as necessary, sand blast and repaint exterior	**20.00%**	**--**	**4.00%**	**8.00%**
Fuel Forwarding Building repair roof as necessary, exterior sand blasted and repainted	**20.00%**	**--**	**4.00%**	**8.00%**
Aux Building repair roof as necessary, exterior sand blasted and repainted	**20.00%**	**--**	**4.00%**	**8.00%**
Maintenance and Parts Storage Building repair roof as necessary, exterior sand blasted and repainted	**20.00%**	**--**	**4.00%**	**8.00%**
High Voltage Switchgear building repair roof as necessary, exterior sand blasted and repainted	**20.00%**	**--**	**4.00%**	**8.00%**
Emergency Backup Diesel Generator Building sandblast and repaint exterior	**20.00%**	**--**	**4.00%**	**8.00%**

[1] *Replacement of the main transformer is required for Options 1, 3 & 4 and is included in capital upgrades.*

The summary of recommendations for SVL based on the assigned RAC (Risk Assessment Code) is detailed in Table D-2.

Table D-2: SVL Life Cycle Cost Analysis Summary of Options

Asset	Option 1 RAC	Option 2 RAC	Option 3 RAC	Option 4 RAC
Gas Generator and Power Turbines				
Engine A & B removed, disassembled and major refurbishments as required	**50.00%**	**2.00%**	**10.00%**	**20.00%**
Replace Vibration Monitoring System on A & B	**20.00%**	**20.00%**	**20.00%**	**20.00%**
Replace Temperature Monitoring System on A & B	**20.00%**	**20.00%**	**20.00%**	**20.00%**
Upgrade Lube Oil Monitoring Controls	**7.50%**	**--**	**1.50%**	**3.00%**
Inspect Compressed Air Starting System and replace dryer as necessary	**7.50%**	**7.50%**	**7.50%**	**7.50%**
Power Turbine A & B inspected, and major refurbishments as required	**50.00%**	**--**	**--**	**20.00%**
SSS Clutches disassembled and inspected	**50.00%**	**--**	**10.00%**	**20.00%**
Replace Fuel Valve Assemblies	**50.00%**	**--**	**10.00%**	**20.00%**
Replace Ignition Exciters	**50.00%**	**--**	**10.00%**	**20.00%**
Alternator				
Alternator Testing	**7.50%**	**--**	**1.50%**	**3.00%**
Alternator removal, remove the rotor, inspect stator and rotor, replace bearings, etc.	**50.00%**	**--**	**10.00%**	**20.00%**
Main Lube Oil Glycol Cooler				
Glycol Cooler cleaned, serviced, sand blasted and repainted	**50.00%**	**50.00%**	**50.00%**	**50.00%**
Electrical System				
Service 13.8 kV circuit breaker	**20.00%**	**--**	**--**	**8.00%**
Inspect the Alternator Output Bus Duct	**7.50%**	**--**	**1.50%**	**3.00%**
Replace Main Transformer, Transformer Cooler and associated power cables[1]		**--**	**--**	**--**
Inspect the Emergency Backup Diesel Generator	**7.50%**	**7.50%**	**1.50%**	**3.00%**
Instrumentation				
Bailey Control System inspect, troubleshoot, and upgrade as necessary	**7.50%**	**--**	**1.50%**	**3.00%**
Replace existing DCS system interface computer with a new PC and upgrade software	**7.50%**	**--**	**1.50%**	**3.00%**
HMI Replacement	**14.00%**	**--**	**3.50%**	**7.00%**
Fuel Oil System				
Fuel Oil Storage Tanks inspection and repair of stairs and platforms as required	**3.00%**	**--**	**0.75%**	**1.50%**
Fuel Oil Storage Tanks clean and repaint exterior	**8.00%**	**--**	**--**	**1.50%**

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Asset	Option 1 RAC	Option 2 RAC	Option 3 RAC	Option 4 RAC
Building Envelopes				
Engine and Power Turbine Enclosures interior and exteriors sand blasted and recoated	**4.00%**	--	**0.80%**	**2.00%**
Alternator Enclosure interior and exterior sand blasted and repainted	**4.00%**	--	**0.80%**	**2.00%**
Inlet Air A & B interiors, exteriors and silencers sand blasted and repainted	**4.00%**	--	**0.80%**	**2.00%**
Exhaust Stacks A & B inspected and repaired as necessary	**4.00%**	**0.80%**	**0.80%**	**2.00%**
Exhaust Stacks A & B sand blasted and repainted	**4.00%**	--	**0.80%**	**2.00%**
Exhaust Stacks A & B Snow Doors replaced	**4.00%**	--	--	**2.00%**
Exhaust Stacks A & B ladder and platforms inspected and replaced as required	**1.50%**	--	**0.30%**	**0.75%**
Inspect Bus Duct Envelope and repair as necessary	**4.00%**	--	**0.80%**	**2.00%**
Control Building Envelope sand blast and repaint exterior	**4.00%**	--	**0.80%**	**2.00%**
Fuel Forwarding Building repair roof as necessary, exterior sand blasted and repainted	**4.00%**	--	**0.80%**	**2.00%**
Waste Oil Storage Shed inspect roof and repair as necessary, exterior envelope repainted	**4.00%**	--	**0.80%**	**2.00%**
Parts Storage Shed repair roof as necessary, exterior repainted	**4.00%**	--	**0.80%**	**2.00%**
High Voltage Switchgear building repair roof as necessary, exterior sand blasted and repainted	**4.00%**	--	**0.80%**	**2.00%**
Emergency Backup Diesel Generator Building repaint exterior	**4.00%**	--	**0.80%**	**2.00%**
Civil Work				
Shoulder of Service Road, backfill and remediate vegetation	**50.00%**	**50.00%**	**50.00%**	**50.00%**
Sump system required around fuel storage tanks to increase drainage	**20.00%**	**2.00%**	**4.00%**	**8.00%**

[1] *Replacement of the main transformer is required for Options 1, 3 & 4 and is included in capital upgrades.*

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