Q. Schedule B, page 2, states that "MUN-T1 last underwent full maintenance in June 2018 and MUN-T2 in July 2020."

(a) Please provide details on the standard industry practice for full maintenance schedules on power transformers.

(b) Please provide the full maintenance schedule for Newfoundland Power's power transformers.

(c) When is MUN-T1 scheduled for its next full maintenance?

(d) Does the full maintenance schedule accelerate or change as the age of the power transformer increases?

(e) Please detail the monitoring that Newfoundland Power plans with respect to MUN-T1 during the 2023-2024 period prior to the replacement of MUN-T2 (e.g., increased frequency of oil samples, etc.).

A. (a) Newfoundland Power has not undertaken an industry-wide survey of standard practices covering full maintenance schedules on power transformers. Based on its participation in various industry forums, the Company understands that various factors can impact utilities' maintenance schedules, including transformer criticality, condition and available redundancy.

Newfoundland Power's substation inspection and maintenance practices were reviewed by the Board's consultant, The Liberty Consulting Group ("Liberty"), in 2014. Liberty noted that:

> "*Newfoundland Power's substation maintenance activities are an appropriate mix of time-based inspections and predictive and preventive maintenance activities, and of condition-based major preventive equipment maintenance/overhaul activities, based on inspections, oil tests and other non-intrusive tests, and operating issues, and by the Company's experience with the equipment*." [1]
>
> And
>
> "*Newfoundland Power's substation inspection, corrective maintenance, and preventive maintenance practices are consistent with good utility practices*." [2]

(b) Attachment A to this response provides Newfoundland Power's standard power transformer maintenance practices.

[1] See conclusion 3.6 on page 51 of Liberty's *Report on Island Interconnected System to Interconnection with Muskrat Falls addressing Newfoundland Power*, December 17, 2014.

[2] Ibid.

The frequency of power transformer maintenance activities are as follows:

(i) Full transformer maintenance is scheduled every 12 years.[3] This frequency is subject to change depending on transformer oil analysis, physical condition and coordination with other ongoing projects.[4]
(ii) Transformer protection checks are completed every six years (if applicable).[5]
(iii) Transformer main tank and tap changer oil is tested annually. This includes dissolved gas analysis and furan analysis. For units above 50 years of age, transformer main tank oil is tested twice per year.[6]
(iv) Tap changer vibration analysis is completed annually (if applicable).[7]
(v) Infrared scans are completed annually.[8]
(vi) Visual inspections are completed every six weeks during routine substation inspections.[9]

(c) Based on the standard 12-year cycle, MUN-T1 is scheduled for its next full maintenance in 2030. Full maintenance may be completed sooner if oil sampling or inspections show the power transformer's condition is deteriorating. See part (d) of this response for more information.

(d) The full maintenance schedule does not change based solely on the age of the power transformer. Oil sampling to gauge the condition of power transformers is accelerated from once annually to twice annually once a power transformer reaches 50 years in service. The schedule for full maintenance may change based on condition of the unit. For example, maintenance may be accelerated if oil

[3] Full transformer maintenance includes megger testing, power factor testing, capacitance testing, winding resistance testing, and transformer turns ratio testing.
[4] The 12-year full transformer maintenance cycle could be lower or higher. The cycle depends on the condition reflected in the latest oil samples and other factors, such as whether there is an opportunity to coordinate with the deployment of a portable substation for capital work. For example, power transformer SCR-T1 is not yet at its 12-year mark, but the Company is installing a portable substation in 2023 at Seal Cove Road Substation to complete work related to the *PCB Bushing Phase-Out* project. Full power transformer maintenance will be completed at this time and the 12-year maintenance cycle will be reset.
[5] Transformer protection checks are completed on gas detector relays and temperature gauges. Checks include a visual inspection of protection equipment, megger testing, voltage tests, alarm checking, cooling checks, and moisture prevention.
[6] Oil tests include standard oil tests and dissolved gas in oil analysis. Standard oil tests check for contaminants and moisture, which at unacceptable levels can lower the dielectric strength of oil and cause a fault. Dissolved gas analysis is used to monitor and diagnose internal transformer electrical problems, such as the presence of arcing or poor electrical connections.
[7] Tap changer vibration analysis includes recording the vibration of the tap changer to see if it has increased from previous tests.
[8] Infrared scans use a thermal imaging camera to check for hot spots/cold spots at equipment connections and on the equipment itself. If a problem is detected, corrective work will be completed, such as replacement of a terminal connection.
[9] Visual inspections on power transformers include checks for tank and cooler leaks, cooling fan and pump operation, operation of liquid and winding temperature equipment, oil level, tank pressure, breather operation and controls operation.

sampling indicates signs of deterioration such as high gassing levels, or if inspections show physical concerns such as oil leaks from the tank or bushings.

(e) Newfoundland Power is monitoring changes in the condition of MUN-T1 through accelerated oil sampling. Based on its age, MUN-T1 would typically undergo oil sampling twice per year to gauge changes in its condition. Effective February 2023, the Company shifted to monthly oil sampling for MUN-T1.[10] The oil sampling results will inform whether additional measures are required to mitigate risks to the delivery of reliable service to the customer, such as the deployment of a portable substation. Newfoundland Power intends to continue monthly oil sampling for MUN-T1 until MUN-T2 is replaced in 2024.

[10] See the responses to Requests for Information PUB-NP-005 and CA-NP-006.

ATTACHMENT A:

Maintenance Standard Number MSP009

NEWFOUNDLAND POWER
A FORTIS COMPANY

Maintenance Standard Number: MSP009
Effective Date: 2002-04-15
Superseding Date: 1982-09-10
Page 1 of 4

POWER TRANSFORMERS

Created by: M. Rideout
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The following steps are considered as standard procedures for maintenance on power transformers.

Form MSF009, *"Power Transformer Maintenance Report"*, is used in reporting Maintenance I, III, IV or V. Also, Maintenance Standard Form MSF001, *"Nameplate and Description"*, is completed during Maintenance I.

Type of Maintenance				Procedure
I	III	IV	V	
X				1. Assign and install an ID number.
X				2. Record the complete nameplate information on MSF001. This will include the main nameplate, the tapchanger (if it has a separate nameplate), bushings, lightning arresters, gas detector relays, fan motors, and any other accessories that would have a nameplate.
X				3. An internal inspection should be made on all new transformers and on transformers that have been in storage or have been moved from one location to another. For transformers that have been energized previously, this internal inspection may be omitted if the Substation Asset Management Group has determined that it is not practical or necessary. Refer to MSR017 for detailed guidelines to be followed in completing this internal inspection.
X				4. Perform a dew point test if moisture is suspected to have entered the tank.
X				5. Ensure continuity of all CT taps; check that the CT is not grounded; and check all ratios. Refer to MST005 for ratio checking procedures.
X				6. If not already installed, install a fall arrest bracket on the unit.
X	X	X		7. Ensure an appropriate PCB label is installed on the unit. Record the PCB level on MSF009. If no lab oil test has been previously conducted on the unit, take an oil sample for lab testing.
X	X	X		8. Make a visual inspection, noting the general condition of the transformer. Check for such things as dents, oil leaks (particularly around gasketed joints), paint condition, damaged bushings, broken glass on gauges, abnormal readings on thermometers, oil level gauges, etc.
X	X	X	X	9. Check that the tank is properly grounded. A good, permanent, low-resistance ground is essential. Our current practice is to use 4/0 AWG copper. On older installations, the conductor may be a different size but this should not necessarily be interpreted as being incorrect.
X	X	X		10. Check the oil level as indicated by the gauge on the conservator tank or on the main tank if there is no conservator tank.
X	X	X		11. Check bushings for oil leakage and oil level where possible.

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Type of Maintenance				Procedure
I	III	IV	V	
X	X	X		12. Check radiators for paint condition, oil leaks, and position of all valves. Radiators should be kept well painted to prevent corrosion and rusting.
X	X	X		13. Check the condition of the silica gel. Replace as required. Breathers should be kept clean and operating. Refer to MSR020 for silica gel breather requirements.
X		X*		14. Install or replace humidity absorbent packets in the gas detector relay as required.
X	X	X	X	15. If the unit is equipped with a spill pan, check that heat tracing and valve is operational. Ensure pan is free of oil and drained.
X		X*		16. Clean bushings as required. Also clean lightning arresters where they exist. The porcelain should be kept clean and free from atmospheric pollution. Inspect closely for chips and cracks.
X	X	X		17. Painting is done at intervals as determined by visual inspection. Refer to MSR014 for equipment painting guidelines. If the transformer is de-energized for a short period of time for some other reason, an effort should be made to paint at least the top, if it needs to be painted.
X	X	X		18. Check that the upper diaphragm on the explosion vent is intact.
X		X		19. Check the operation of the gas detector relay. Refer to MST007.
	X			20. Record the reading of the maximum indicating pointer on the temperature gauges and check that the method of resetting the pointer is operational.
X		X		21. Check the operation of the temperature gauges including the settings of switches. Refer to MST010.
X	X*	X		22. Check the operating handle of off-load tapchangers for seizing and corrosion. Under no circumstances should the off-load tapchanger be operated unless the transformer is completely de-energized, since to do so would not only result in damage to the transformer but would also endanger the life of the operator. The locking pins in these handles should be checked for seizing and lubricated with silicone grease or some similar lubricant. If the transformer is de-energized, the tapchanger should be operated throughout its entire range to ensure that the switches are aligned properly and, at the same time, remove any oxidation that may be on the contacts.
X	X	X		23. Check the cooling fans for proper operation. Ensure that drain plugs or adhesive tape is removed from fan motors. If the unit is equipped with a fan exerciser, ensure it is operational and that an appropriate time interval is established.
X	X	X		24. Check the dielectric value of the insulating oil. Refer to MSR013 for method of testing. Refer to MSR010 for oil dielectric requirements.
X	X	X	X	25. Obtain an oil sample with a syringe and bottle for gas analyses. Refer to MSR013 for sampling procedures. Record results on MSF020. Do this during Maintenance V only if requested.

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Type of Maintenance				Procedure
I	III	IV	V	
X		X*		26. Megger the windings. To do so, all bushings should be wiped clean and dry and all connections to live bus bars and lightning arresters should be disconnected. Give the measured resistance on MSF009 (do not make the temperature correction conversion). Refer to MSR012 for evaluation of megger readings and maximum meggering voltages. Refer to MST008 for transformer meggering procedure.
X		X*		27. Megger core ground with a 500V megger. If this will require removing oil, which may not be practical, this step may be omitted. This must be done as part of the acceptance procedure for a new unit.
X		X*		28. Carry out ratio tests with ratiometer. Refer to MST011 for procedure.
X		X		29. Carry out a Transformer Protection Devices Inspection as per maintenance standard MST017. Ensure to inspect all junction boxes, making special note of any wear/cracking or any point at which water could enter the box. Ensure all gaskets and seals are checked and replaced as necessary.
X		X		30. Ensure that all accessories are tested. Examine all apparatus, electrical cables and conductors, signaling and operating devices. A megger test is recommended where applicable.
X	X	X		31. Observe drop leads for signs of strain on bushings or associated equipment. If transformer is de-energized, check line connections for tightness.
X	X	X		32. Ensure that the control cabinet is clean and dry. The cabinet heater should be in operation so as to prevent condensation.
X				33. If present, ensure that any bushing wrap is removed.
X*		X		34. If transformer is to be kept as spare, wrap bushings with plastic wrap.
			X	35. For unplanned maintenance as a result of breakdown or diagnostic tests, make the necessary repairs and note on MSF009.
X	X	X	X	36. Any changes made or abnormal conditions found should be noted on MSF009 and reported to the Substation Asset Management Group.
				37. File copies of form MSF009 in the local maintenance file and the master file at the Electrical Maintenance Center. If the equipment is being transported, send a copy of the last maintenance IV report with the unit, along with any other maintenance reports that have been filed since the last maintenance IV, and mail or fax a copy to the intended recipient. If there are unresolved issues with the equipment or with the procedures, send a copy to the Substation Asset Management Group. If the equipment is being installed, attach a copy of form MSF009 to the SAG's installation form. After installation, send forms to the Superintendent of Commissioning.
				38. Update maintenance history and nameplate information in Avantis.

*** Only if the transformer is de-energized and if it is deemed necessary to make these checks.**

POWER TRANSFORMERS

Caution: For some transformer maintenance, control wiring may have to be disconnected to disable alarms and trip circuits. This normally applies to gas detector relays, temperature gauges, pressure relief devices, etc., that are connected to external trip schemes.

Note: For transformers with an on-load tapchanger, refer to MSP012 for standard maintenance procedures for such devices.