

1 **Substations**

2

3 **Q. Reference: "2025 Capital Budget Application," Newfoundland Power Inc.,**

4 **June 28, 2024, Supporting Materials, Substations: 2.1, sec. 2.2, p. 5.**

5

6 **As part of the substation asset management practices, Newfoundland Power**

7 **conducts regular inspections and oil sample analysis to gauge the internal**

8 **health of power transformers to determine when corrective maintenance is**

9 **required. All power transformers undergo annual oil sampling. Additionally,**

10 **power transformers are scheduled for a major overhaul every 12 years.**

11

12 **a) Please provide the specific parameters checked, and their purpose, during**

13 **the annual oil sampling.**

14 **b) Please provide a detailed breakdown of what is included in the 12-year**

15 **overhaul. What specific tests are performed and what parts are typically**

16 **replaced? Please provide a copy of any check sheets that are used.**

17

18 A. a) The parameters checked during annual oil sampling include the volume of hydrogen,

19 methane, ethane, ethylene, acetylene, carbon monoxide, carbon dioxide, and

20 nitrogen in oil, particle counts, moisture, dielectric breakdown strength, acid

21 number, interfacial tension, color number, power factor, oxidation inhibitor and

22 furans.

23

24 Standard oil tests check for contaminants and moisture, which at unacceptable levels

25 can lower the dielectric strength of oil and cause a fault. Dissolved gas analysis is

26 used to monitor and diagnose internal transformer electrical problems, such as the

27 presence of arcing or poor electrical connections. Certain gases naturally increase as

28 a transformer ages, but can be a sign of excessive temperatures and overloading in

29 newer transformers. Oil sampling and analysis is completed annually to gauge the

30 internal health of transformers.

31

32 b) Full transformer maintenance includes an insulation resistance test,

33 dissipation/power factor test, turns ratio test, winding resistance test, tap changer

34 operation testing and bushing condition inspection. Inspections also check for tank

35 and cooler leaks, cooling fan and pump operation, operation of liquid and winding

36 temperature equipment, oil level, tank pressure, breather operation and controls

37 operation.

38

39 Refer to Attachment A for Newfoundland Power's Maintenance Standards and

40 Maintenance Standard Report Forms for Power Transformers and Tapchangers.

41 Refer to Type of Maintenance IV for the standard procedures conducted during this

42 maintenance type which is typically conducted on a 12-year cycle.

ATTACHMENT A:

Maintenance Standards and Maintenance Standard Report Forms for
Power Transformers and Tapchangers

POWER TRANSFORMERS

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The following steps are considered as standard procedures for maintenance on power transformers. Other scope may be completed as required on a case-by-case basis.

Form MSF009, “Power Transformer Maintenance Report”, is used in reporting Maintenance I, III, IV or V through paper form or PowerDB. 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. Place a label on the inside of the control cabinet indicating PCB level. 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. Report issues to the electrical Maintenance Planner Group.
X	X	X	X	9. Ensure that the tank is properly grounded. A good, permanent, low-resistance ground is essential. All grounding and neutral connections to be upgraded to 19/#9 copper clad steel unless otherwise noted.
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. Top up as required.
X	X	X		11. Check bushings for oil leakage and oil level where possible. Report issues to the electrical Maintenance Planner Group

POWER TRANSFORMERS

Type of Maintenance				Procedure
I	III	IV	V	
X	X	X		12. Check radiators for paint condition, oil leaks, and position of all valves. Ensure Radiators are well painted to prevent corrosion and rusting unless otherwise noted.
X	X	X		13. Check the condition of the silica gel. Replace as required. Breather piping and silica gel canister shall be replaced unless otherwise noted. Refer to MSR020 for silica gel breather requirements.
X		X*		14. Install or replace humidity absorbent packets in the gas detector relay as required if relay is not replaced.
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 and lightning arresters where they exist. The porcelain should be kept clean and free from atmospheric pollution. Inspect closely for chips and cracks. All chips and cracks are to be reported to the Electrical Maintenance Planner Group and painted with glyptol to prevent moisture ingress. In cases with excessive damage bushings may require replacement
X	X	X		17. Painting is done at intervals determined by visual inspection. Refer to MSR014 for painting guidelines. The entire transformer shall be painted unless otherwise noted.
X	X	X		18. Check that the upper diaphragm on the explosion vent is intact. PRD and piping shall be installed if identified in the scope of work by the Planner.
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 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		23. 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	24. 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 if requested.
X		X*		25. 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.

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Type of Maintenance				Procedure
I	III	IV	V	
X		X*		26. 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*		27. Carry out ratio tests with ratiometer. Refer to MST011 for TTR procedure.
		X		28. Carry out power factor and winding resistance testing. See appropriate manufacture manual for the test equipment that is being used.
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. Install humidisorb packs in all junction boxes.
X		X		30. Ensure that all accessories are tested. Examine all apparatus, electrical cables, conductors, signaling and operating devices. A megger test is recommended if 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. Ensure the cabinet heater is operating to prevent condensation build up.
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.
X	X	X	X	37. Send copies of form MSF009 to the Electrical Maintenance Planners' group along with any unresolved issues with the equipment or with the procedures. Any outstanding work shall be entered into an Avantis work request and submitted.
X	X	X	X	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.**

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. An approved protection plan may be required for such cases.

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



Maintenance Standard Report Form
POWER TRANSFORMERS

MSF009
Form No. 353

Revised: 2023-03-29

Substation/Location:	Work Order Number:	ID Number:	
Manufacturer:	Serial Number:	Rated Voltage (kV):	KVA:

Complete the following:

Dew Point (if required): _____ °C

Oil Dielectric: _____ kV

PCB Level: _____ PPM

Megger Test (in oil):

Core – Ground _____ at 250V

Two-Winding Transformers

a) H – L&G _____ at _____ V

b) L – H&G _____ at _____ V

c) H&L – G _____ at _____ V

Three-Winding Transformers

a) H – LT&G _____ at _____ V

b) L – HT&G _____ at _____ V

c) T – HL&G _____ at _____ V

d) H&L – T&G _____ at _____ V

e) H&T – L&G _____ at _____ V

f) L&T – H&G _____ at _____ V

g) HL&T – G _____ at _____ V

Weather Conditions and Temperature at Time of

Oil Testing and Meggering _____

If Tank was Open to Atmosphere:

Time Duration Open _____

Weather Conditions While Open _____

Voltage Connection _____

Megger Test Control Wiring For:

Oil Level Gauge _____ at 250V

Oil Temperature Gauge _____ at 250V

Winding Temperature Gauge _____ at 250V

Gas Detector Relay _____ at 250V

Pressure Relief Device _____ at 250V

Oil Temperature _____ °C

Oil Temperature Alarm Setting _____ °C

Oil Temperature Trip Setting _____ °C

Temperature Gauge Setting to Start Fans:

1st Stage _____ °C 2nd Stage _____ °C

Winding Temperature _____ °C

Winding Temperature Alarm Setting _____ °C

Winding Temperature Trip Setting _____ °C

Oil Level Gauge Reading _____

Mark the appropriate block with an X:

	Yes	No
Tank Opened	<input type="checkbox"/>	<input type="checkbox"/>
Humidity Absorbent Packet Installed in Gas Detector Relay	<input type="checkbox"/>	<input type="checkbox"/>
Core Exposed to Atmosphere	<input type="checkbox"/>	<input type="checkbox"/>
Spill Pan Free of Oil	<input type="checkbox"/>	<input type="checkbox"/>
Vacuum Pulled	<input type="checkbox"/>	<input type="checkbox"/>
Oil Sample Obtained for Gas Analyses	<input type="checkbox"/>	<input type="checkbox"/>
Tank Ground Connections Tight	<input type="checkbox"/>	<input type="checkbox"/>
Grounding Upgraded to CCS	<input type="checkbox"/>	<input type="checkbox"/>
Varmint Proofing Installed	<input type="checkbox"/>	<input type="checkbox"/>
Evidence of Oil Leakage	<input type="checkbox"/>	<input type="checkbox"/>
Lubricant Applied to Off-Load Tapchanger Handle	<input type="checkbox"/>	<input type="checkbox"/>
All Nuts and Bolts Tight	<input type="checkbox"/>	<input type="checkbox"/>
All Gauges in Good Physical Condition	<input type="checkbox"/>	<input type="checkbox"/>
Fan Motor Drains Open	<input type="checkbox"/>	<input type="checkbox"/>
Fan and Exerciser Operating Properly	<input type="checkbox"/>	<input type="checkbox"/>
Conduits Properly Fastened	<input type="checkbox"/>	<input type="checkbox"/>
Control Wiring in Good Condition	<input type="checkbox"/>	<input type="checkbox"/>
Transformer Protection Devices Inspection Completed	<input type="checkbox"/>	<input type="checkbox"/>
All Junction Boxes Inspected	<input type="checkbox"/>	<input type="checkbox"/>
Oil Added	<input type="checkbox"/>	<input type="checkbox"/>
Pressure Relief Device on Transformer	<input type="checkbox"/>	<input type="checkbox"/>
If So, Operation Indicator and Alarm Switch Required Resetting	<input type="checkbox"/>	<input type="checkbox"/>
Internal Inspection of Transformer Made	<input type="checkbox"/>	<input type="checkbox"/>
<i>If So, Complete Remainder of This Section</i>		
Loose or Damaged Parts	<input type="checkbox"/>	<input type="checkbox"/>
Tools or Debris Found	<input type="checkbox"/>	<input type="checkbox"/>
Explosion Vent Lower Diaphragm Intact	<input type="checkbox"/>	<input type="checkbox"/>
Main Tank Oil-Level Gauge Checked	<input type="checkbox"/>	<input type="checkbox"/>
Spray Nozzles Installed	<input type="checkbox"/>	<input type="checkbox"/>
Bushing Leads in Good Condition	<input type="checkbox"/>	<input type="checkbox"/>
CT Leads and Control Wiring Good and in Place	<input type="checkbox"/>	<input type="checkbox"/>
Tapchanger Leads Good and Connections Tight	<input type="checkbox"/>	<input type="checkbox"/>
All Nuts and Bolts in Place and Tight	<input type="checkbox"/>	<input type="checkbox"/>
Core Laminations and Supports in Place	<input type="checkbox"/>	<input type="checkbox"/>
Off-Load Tapchanger in Good Condition	<input type="checkbox"/>	<input type="checkbox"/>
Terminal Board structure Good	<input type="checkbox"/>	<input type="checkbox"/>
Any Sign of Carbon or Tracking	<input type="checkbox"/>	<input type="checkbox"/>
Shipping Braces (if any) Removed	<input type="checkbox"/>	<input type="checkbox"/>
CTs, PTs and Auxiliary Transformers Properly Mounted	<input type="checkbox"/>	<input type="checkbox"/>
Coils and Insulation in Good Condition	<input type="checkbox"/>	<input type="checkbox"/>
Bottom of Tank Free from Debris or Loose Parts	<input type="checkbox"/>	<input type="checkbox"/>
Any Sign of Moisture	<input type="checkbox"/>	<input type="checkbox"/>
Cracks in Tank Wall, Especially in Welding	<input type="checkbox"/>	<input type="checkbox"/>
Damage Marks on Tank Wall	<input type="checkbox"/>	<input type="checkbox"/>
Links Checked for Proper Connections and Tightness	<input type="checkbox"/>	<input type="checkbox"/>



Maintenance Standard Report Form POWER TRANSFORMERS

Revised: 2023-03-29

Check if Okay:

Physical Condition	_____	Line Connections	_____	Cabinet Heaters	_____
Paint	_____	Alarms Operational	_____	Breather	_____
Bushings	_____	Gaskets	_____	Silica Gel	_____
Lightning Arresters	_____	Control Wiring Terminal Connections	_____	Fans	_____
Bushing Oil Level	_____	Control Cabinet	_____	Foundation	_____

Ratio Test:

Tap Position	H1 Phase		H2 Phase		H3 Phase		Tap Position	H1 Phase		H2 Phase		H3 Phase	
	H1 - _____	H1 - _____	H2 - _____	H2 - _____	H3 - _____	H3 - _____		H1 - _____	H1 - _____	H2 - _____	H2 - _____	H3 - _____	H3 - _____
1							18						
2							19						
3							20						
4							21						
5							22						
6							23						
7							24						
8							25						
9							26						
10							27						
11							28						
12							29						
13							30						
14							31						
15							32						
16							33						
17													

Remarks:

Type of Maintenance _____ Date _____ Inspected By _____

TAPCHANGERS

2024-08-22

Type of Maintenance				Procedure
I	III	IV	V	
X		X		11. Operate the tapchanger manually and electrically through all its steps. Look and listen for abnormal conditions. Pay strict attention to possible sticking or binding of the mechanism.
X	X	X		12. Record the current drawn by the tapchanger motor as it operates the tapchanger.
X		X		13. Check the contactors and relays in the control circuit. Clean or replace as required. Use Ductor Testing to determine which contacts contain residue, dirt or film. These tests should be carried out on both sides of each tap ring for the first half of the taps. This should be done with the preventative auto isolated so that only the contact resistance is read, not the PA winding. Any dirty contacts should be removed and cleaned with a scotch brite pad. (For further details, please see Reference Article: "Load Tap Changer Maintenance and Contact Materials", MSR021-2.)
X		X		14. Perform contact pressure testing using the Cooper Load Cell and a handheld indicator. (All standard contact pressures are listed in MSR021-2.)
X	X	X		15. Check the auxiliary and limit switches for proper operation. Repair or adjust as required.
X	X	X		16. Check the operation of the position indicator including the remote operation of the drag hands, where this feature exists. Repair or adjust as required. When ready to re-energize the transformer after Maintenance IV, ensure that the tapchanger is on the same position as it was when de-energized.
X	X	X		17. Lubricate gears, shafts and bearings as required. Refer to the manufacturer's instructions.
X	X	X		18. Check breather and/or relief vent if one exists. Ensure that the breather or vent is not clogged with paint or other foreign material. Refer to the manufacturer's instructions.
X	X	X		19. Check gaskets. Replace if necessary.
X	X	X		20. Check all control wiring connections for tightness on terminal blocks. Ensure that wiring is in good condition. Ensure that control cabinet heaters, tank heaters (where they exist), and light bulbs are operating properly.
X	X	X		21. Inspect cable insulation(s). Check for wear and overheating.
X	X	X	X	22. After carrying out any work or during an inspection, if the transformer is de-energized, check the operation of the limit switches as follows: operate the mechanism to each limiting position by means of the hand crank. Do not attempt to operate by hand crank beyond the end positions. Then set the mechanism on one of the intermediate positions and operate electrically to each limit by means of the manual control switch. Attempt to operate electrically beyond the end positions and note that the limit switches operate properly. Return the mechanism to the appropriate tap setting.
X	X	X		23. Obtain an oil sample with a syringe and bottle for gas analyses. (Do this during Maintenance V only if requested.) Refer to MSR013 for sampling procedures.

TAPCHANGERS

2024-08-22

Type of Maintenance				Procedure
I	III	IV	V	
X	X	X	X	<p>Record results on MSF021. If the tapchanger has separate selector and diverter compartments, two samples are required. If the oil was replaced, wait at least one week before taking sample(s). (Note that filtering the existing oil does not require a waiting period.)</p> <p>24. File copies of form MSF010 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 MSF010 to the SAG's installation form.</p>

Maintenance Standard Report Form TAPCHANGERS

Revised: 2024-08-22

Substation/Location:	Work Order Number:	ID Number:
Manufacturer:	Serial Number:	Type:

Complete the following:

Counter Reading:

Start _____ Finish _____

Oil Dielectric:

Tapchanger Compartment _____ kV

Diverter (if separate) _____ kV

PCB Level: _____ PPM

Oil Level Gauge Reading:

Tapchanger Compartment _____ kV

Diverter (if separate) _____ kV

Motor Megger Test _____ Mega-Ohms

Motor Current _____ Amps

Mark the appropriate block with an X:

	<u>Yes</u>	<u>No</u>	Check:	
Operated: Manually	<input type="checkbox"/>	<input type="checkbox"/>	Insulating Barriers	_____
Electrically	<input type="checkbox"/>	<input type="checkbox"/>	Arc Chutes	_____
Evidence of Oil Leakage Outside	<input type="checkbox"/>	<input type="checkbox"/>	Contacts	_____
Evidence of Oil Leakage Between Tanks	<input type="checkbox"/>	<input type="checkbox"/>	Gears	_____
Evidence of Moisture in Compartment(s)	<input type="checkbox"/>	<input type="checkbox"/>	Cams	_____
Oil Filtered	<input type="checkbox"/>	<input type="checkbox"/>	Chain Drive (where applicable)	_____
Oil Replaced	<input type="checkbox"/>	<input type="checkbox"/>	Mechanical Stops	_____
Compartment(s) Flushed With Clean Oil	<input type="checkbox"/>	<input type="checkbox"/>	Brake Operation	_____
Gears, Shafts, Bearings, etc., Lubricated	<input type="checkbox"/>	<input type="checkbox"/>	Operations Counter	_____
All Control Features Operational	<input type="checkbox"/>	<input type="checkbox"/>	Gaskets	_____
Tap Position Indicator Operational	<input type="checkbox"/>	<input type="checkbox"/>	Relief Vent and/or Breather	_____
Drag Hand Reset Operational	<input type="checkbox"/>	<input type="checkbox"/>	Oil Filter (if applicable)	_____
Limit Switches Operational	<input type="checkbox"/>	<input type="checkbox"/>	Contactors	_____
All Nuts and Bolts Tight	<input type="checkbox"/>	<input type="checkbox"/>	Relay Contacts	_____
All Pins Properly in Position	<input type="checkbox"/>	<input type="checkbox"/>	Auxiliary Switches	_____
Pressure Relief Device on Tapchanger	<input type="checkbox"/>	<input type="checkbox"/>	Cabinet Heaters and Thermostat	_____
If So, Operation Indicator and/or Alarm Switch Required Resetting	<input type="checkbox"/>	<input type="checkbox"/>	Cabinet Light and Receptacle	_____
Control Cabinet Clean and Dry	<input type="checkbox"/>	<input type="checkbox"/>	Wiring Connections Tight	_____
Oil Sample Obtained	<input type="checkbox"/>	<input type="checkbox"/>		

Remarks:
