

## **Equipment Standards**



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Page 1 of 4

## AIR BREAK AND DISCONNECT SWITCHES

Created by: M. Rideout

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The following steps are considered as standard procedures for maintenance on air break and disconnect switches.

Report Form MSF007, "Air Break, Fuse and Disconnect Switches", is used for reporting Maintenance I, III, or V.

Also, Maintenance Standard Form MSF001, "Nameplate and Description", is completed during Maintenance I.

### Cautions

1. Only Conducto-Lube #240-200 lubricant shall be used on switch parts which are energized or may be energized through normal operation (contact surfaces).
2. Break-Free CPL, is the only aerosol lubricant which shall be used on bearings, bushings and moving parts which are part of the mounting or non-energized operating mechanisms. Other types of lubricants to be used on these parts shall be approved by Superintendent Engineering or Superintendent Electrical Maintenance.
3. When switches are maintained using Hot Line methods, the RM/JP process shall identify all hazards such as energized conductors and second points of contact and implement barriers to eliminate those hazards.
4. Items marked with an \* can only be done if a Worker Protection Code Protection Guarantee is in effect or the switch is not installed.

Type of Maint.			Procedure
I	III	V	
General			
X			1. Check that the switch is assembled and installed properly. The reliability of the switch is dependent upon the expertise with which the installation procedure is carried out.
X			2. Assign and install an ID Number.
X			3. Record the complete nameplate information on MSF001. This information should be taken from the nameplate on the switch mounting, rather than from a nameplate on the switch handle, which may not necessarily be the original switch handle.
X	X	X	4. Record the normal in-service position of the blades (open or closed).
X	X*		5. Check and, where necessary, make proper adjustments for alignment of all blades and bumpers, insulated stacks, switch hardware and drive-pipe mechanism.  The manufacturer's instructions should be followed closely during installation and should be referred to for making adjustments when doing maintenance.  The following are general guidelines for adjusting air break switches. More detailed information is provided in the manufacturer's instructions for specific switches.  1) Blades should open approximately 95 degrees for horizontal base mounting and approximately 70 degrees for vertical base mounting.  2) Stops are usually provided at the base of the rotating insulator column to limit the travel of the rotating stack lever. With the blade in the open position, adjust the stop so that a clearance of about 1.6mm (1/16 in.) is available between stop bolts. With the blade in the closed position, adjust the other stop until the blade and end jaw contacts are fully closed.

## AIR BREAK AND DISCONNECT SWITCHES

Type of Maint.			Procedure
I	III	V	
			<p>3) Adjust the fork clevis and lever linkage so that, with the switch closed, the blade rests firmly against the stop and no slack is present in this linkage.</p> <p>4) Adjust the cross-phase extension linkage, starting with the phase connected directly to the control handle.</p> <p>If this is pole No. 1, adjust the linkage length until the blade of pole No. 1 opens and closes properly when operated by the control handle. With pole No. 1 in the closed position, close pole No. 2. Adjust the cross-phase link between the two poles until both poles open and close together. With poles No. 1 and No. 2 closed, close pole No. 3. Adjust the cross-phase link between poles No. 2 and No. 3 until both poles open and close together.</p> <p>5) With the 3 poles operating in sync, check and adjust, if necessary, the control handle stops for proper setting of open and closed positions of the switch. The handle stop for the closed position of the switch should be set so that, with the switch in the closed position, no slack is present in the operating pipe.</p> <p>6) After all adjustments are complete and satisfactory switch operation is achieved, tighten clamps and setscrews on the operating pipe. Tighten all self-piercing setscrews until the operating pipe walls are pierced (i.e. the setscrews forced completed through the pipe wall). Where pipe fittings are of the U-bolt clamp type with setscrews that are not the self-piercing type, tighten the U-bolts first and setscrews last. Tighten setscrew until they are firmly embedded in the pipe.</p>
X	X*	X	<p>6. Examine the blade and jaw contacts for burn marks, arcing, or any abnormal condition. Contact surfaces can be refurbished by filing to remove high spots. Minor blemishes may be removed with emery cloth. A light coating of Conducto-Lube 240-200 on the contacts shall then be applied.</p> <p>7. For switches 25 kV and below, hot work shall only be undertaken using rubber gloves and hot sticks. The work will be restricted to (1) examining the blade and jaw contacts for burn marks, arcing, or any abnormal condition, (2) refurbishing contact surfaces using a wire brush, file or emery cloth, (3) applying a light coating of Conducto-Lube 240-200 on the contact surfaces using a paint brush and (4) applying Break-Free CPL lubricant on bearings, bushings and moving parts which are part of the mounting or non-energized operating mechanisms.</p>
		X	<p>8. For switches above 25 kV, hot work shall only be undertaken using hot sticks and shall be restricted to (1) examining the blade and jaw contacts for burn marks, arcing, or any abnormal condition, (2) refurbishing contact surfaces using a wire brush, (2) applying a light coating of Conducto-Lube 240-200 using a paint brush and (4) applying Break-Free CPL lubricant on bearings, bushings and moving parts which are part of the mounting or non-energized operating mechanisms.</p>
X	X*		<p>9. Check the physical condition of the insulators; inspect for chips, cracks, tracking, loose caps or pins, and accumulations of any foreign matter such as salt deposits, dust, etc.</p>
X	X*		<p>10. On some 138 kV air break switches, a polyethylene bearing is used in the hinge assembly at the top of the insulator stack and a "static strip" is used to connect the shaft to the live parts of the switch. Check that the static strip is in good condition and making good contact so as to avoid arcing or damage to the bearing.</p>

## AIR BREAK AND DISCONNECT SWITCHES

Type of Maint.			Procedure
I	III	V	
X	X*		<p>11. Ensure the gear reducer housing, located at the top of the control pipe on air break switches, is adequately lubricated and moves without binding.</p> <p>There should be a generous amount of good quality open gear grease applied to the gears and around the bearings inside the housing. Shafts and other moving parts of the outside of the gearbox should be well lubricated with DC-33 lubricant.</p> <p>The cross-phase linkages of an installed gang-operated switch are either in tension or compression. When disassembling the linkages or disconnecting the linkage from the gear reducer housing to ensure this stored energy does not cause the switch to partially open or close, the cross- phase linkage has to be secured.</p>
X	X*	X	<p>12. When arcing horns are employed, check that they make good contact throughout their stroke. Pits should be removed with a file, finishing with emery cloth.</p> <p>13. Arcing horn alignment may be adjusted by bending the stationery horn with hot line tools if the switch is in the open position.</p>
X	X*		14. For hook-stick operated switches, ensure that the latching mechanism is operating properly when the switch is being closed.
X	X*		15. Check that all bolts, nuts, washes, cotter pins and terminal connections are in place and tight. Cross-phase linkage, clevis pins, pipe guide bearings, rods, levers, etc., should be cleaned and lubricated as required. Seizing has proved to be a common problem. Hence it is very important that proper lubrication be carried out.
X	X*	X	<p>16. Ensure that switch bases are properly grounded. Refer to the substation grounding standards for further details.</p> <p>17. Ensure that switch handles are properly grounded. Refer to the substation grounding standards for further details.</p>
		X	18. For unplanned maintenance as a result of breakdown or diagnostic tests, make the necessary repairs and note on form MSF007.
			<b>Motor-Operated Switches Only</b>
X			19. Check that control fuses or breakers are properly sized to carry the load required.
X	X*		20. Check the operating mechanism both manually and electrically. Ensure that the limit switches operate so that motor operation will stop before any switch or control component reaches its mechanical limit. Check for proper operation, the means of decoupling the manual operating mechanism upon motorized operation.
X	X		21. Check the operation of the motor cutout switch. This switch prevents electrical operation of the unit while in the manual mode. Adjust as necessary.
X	X		<p>22. Make a general check of the control cabinet. Check for cleanliness and continuity and tightness of electrical connections and hardware.</p> <p>Check that the heater is in operation. Lubricate motor mechanism as required. Refer to manufacturer's instructions for detailed information on specific mechanisms.</p>


**Maintenance Standard Number:** MSP001

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**Page** 4 of 4

## AIR BREAK AND DISCONNECT SWITCHES

Type of Maint.			Procedure
I	III	V	
Grounding Switches Only			
X	X*		23. Ensure that the switch base is solidly grounded to the ground grid with #4/0 AWG copper conductor.
X	X*		24. Check the mechanical interlock system. This interlock is usually provided by a chain attached to both the air break switch control handle and the grounding switch control handle, or by means of a lever located on the grounding switch base. These interlock systems should be checked to ensure that they prevent the ground switch from closing when the main switch is closed.
High-speed Ground Switches Only			
			<b>Caution:</b> A high-speed ground switch must not be operated unless all power is off the associated air break switch and the transformer
X	X*		25. Check the control circuit by operating the protection scheme to energize the DC trip coil, thus closing the high-speed ground switch.
X	X*		26. When closing the switch, ensure that it stays closed without bouncing open. Inspect the jaw insulator column for signs of impact damage such as loose or broken parts.
X	X*		27. Check that the switch base is solidly grounded to the ground grid with #4/0 AWG copper conductor.
X	X		28. Check that the anti-condensation heater in the trip coil housing is operational. Since this will require that the AC power be on, it can be checked with a clip on ammeter on the supply leads at ground level.
General			
X	X	X	29. Distribute forms as required
X	X	X	30. Update the maintenance history and nameplate information in Avantis.
X	X	X	31. If there are any outstanding deficiencies, flag the maintenance record in Avantis.

## BATTERIES

Created by: G. Mayo  
Revised by: J. Barry

Reviewed by: G. Samms  
Approved by: G. Samms

The following steps are considered as standard procedures for battery maintenance.

Maintenance Standard Form MSF003, *"Battery Maintenance Report"*, is used for reporting Maintenance I, III, or V. Also, form MSF001, *"Nameplate and Description"*, is completed during Maintenance I.

Maintenance Type			Procedure
I	III	V	
X			1. Check new battery banks when received to ensure complete and undamaged shipment.
X	X	X	2. Manually engage ventilation system prior to proceeding with maintenance.
X			3. Record the nameplate information from a cell on form MSF001.
X			4. Install the battery bank as per the manufacturers instructions.
X	X		5. Install an I.D. number and individual cell numbers. See MSR005 for details.
X			6. Identify and label the pilot cell if necessary. Record pilot cell ID on MSF003.
X	X		7. Ensure that room is well ventilated and that exhaust fan is operational. Note whether the ventilation is controlled by thermostat, manually or by timer.
X	X		8. Inspect, clean and torque all terminals. Coat with a film of NYK Corrosion Preventive Compound or other non-oxide grease. Refer to MSR001-4 for torquing requirements. Remove straps only as required.
X	X		9. Adjust the float and equalize voltages and time as per the manufacturer's instructions and MSR001-2. Record float voltage/current and equalize voltage on MSF003.
X	X		10. Take specific gravity readings for all cells. Record the total number of cells on MSF003. Refer to MSR001-1 for specific gravity criteria.
X	X		11. Check pilot cell temperature and record on MSF003. For gelled electrolyte batteries, a temperature estimate is found by holding a thermometer against the terminal.
X	X		12. Add de-ionized water if level in cells is below normal. Refer to MSR001-6 regarding de-ionized water.
X	X		13. Check the output current from the charger at which the battery is being floated.
X	X	X	14. Perform an impedance test using the BITE 2P tester. Print and leave a record of the results at the site. Refer to MST003 for the impedance test procedure. Do this during maintenance V only when there is evidence of cell problems.
X	X	X	15. <b>If the battery impedance appears questionably abnormal:</b> Perform a capacity test as described in test procedure MST001.

## BATTERIES

Maintenance Type			Procedure
I	III	V	
X	X	X	16. <b>If the battery impedance appears highly abnormal or the capacity test fails:</b> Replace the battery bank as soon as possible.
X	X		17. Check cell plates for signs of deterioration. Note the amount and color of sediment at the bottom of the cell jar. Refer to the manufacturer's instructions.
X	X		18. Inspect the separators to ensure that they remain in proper position, keeping the plates properly spaced.
X	X		19. Check the accessories (i.e. hydrometer, apron, gloves, distilled water, thermometer, goggles, etc.). See that they are present and in good shape. Replace as required.
X	X		20. Clean the batteries as required.
X	X		21. Clean and paint the battery rack as required.
X	X	X	22. Turn off ventilation system before leaving site.
		X	23. For unplanned maintenance, as a result of breakdown or diagnostic tests, make the necessary repairs and note these repairs on form MSF003.
X	X	X	24. Once the impedance tests are completed download results into ProActiv database. The procedure for this can be found in the test procedure for battery impedance tests.
X			25. List the new battery bank in Avantis and retire the old bank.
X	X	X	26. Any changes made or abnormal conditions found should be reported to the Maintenance Coordinator and noted on form MSF003.
X	X	X	27. Record all maintenance performed in Avantis.

## BATTERY CHARGERS

Created by: M. Rideout  
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Reviewed by: G. Samms  
Approved by: G. Samms

The following steps are considered as standard procedures for battery charger maintenance.

Maintenance Report Form MSF004, "*Battery Charger Maintenance Report*", is used to report a Maintenance I, III, or V. Also, report form MSF001, "*Nameplate and Description*", is completed during Maintenance I.

Type of Maintenance			Procedure
I	III	V	
X			1. Assign and install an I.D. number on the battery charger.  <u>Note:</u> Battery chargers installed in cabinets which house cells are covered by the I.D. number on the cabinet unit.
X			2. Record the nameplate information from the charger on MSF001.
X			3. Ensure that there is a copy of the appropriate charger manual on-site.
X			4. With reference to charger information, determine if the supply voltage is correct.
X			5. Check tap connections to ensure that proper taps have been selected.
X			6. Ensure the charger supply leads and the leads from the charger to the battery are adequate.
X	X		7. If a manual equalize charger is used, determine the load on the battery and adjust the charger accordingly. Charger must supply load plus the necessary additional current to maintain the battery at full charge.
X	X		8. If an automatic equalize charger is used, set the float and equalize voltages at the desired levels to cover the number of cells employed.
X	X		9. Check that the charger is installed as per the manufacturer's instructions. Ensure that it is securely mounted and that ventilation is not restricted to an extent that would cause overheating.
X	X		10. Ensure the supply protection, either fuse or circuit breaker, is of the correct rating.
X	X		11. Check the operation of alarms and fault indicators, such as over-voltage alarms, under-voltage alarms, and ground detector alarms.
X	X		12. Clean dust and other deposits from selenium rectifiers and other heat radiating surfaces.
X	X		13. Check that wiring connections are tight and that fuse clips and holders are clean and have proper tension.
X	X		14. Determine if the charger is functioning as intended by checking the battery voltage levels to ensure it is being properly charged.



## BATTERY CHARGERS

Type of Maintenance			Procedure
I	III	V	
X	X		15. Check breaker, contactor, switch, and relay functions. Operation of these devices a few times will usually clean the oxides on the mechanism and contact surfaces.
X	X		16. If a load test was performed or the batteries were discharged, check and/or set the current limit on the charger (Refer to MSR001-5). If resetting is required, do so according to the manufacturer's instructions.
		X	17. For unplanned maintenance, as a result of breakdown or diagnostic tests, make the necessary repairs and note them on MSF004.
X	X	X	18. Any changes made or abnormal conditions found should be reported to the Maintenance Coordinator and noted on form MSF004.
	X		19. Ground Testing-place a positive or negative fault on charger, and confirm charger returns the correct positive or negative ground.
X	X	X	20. Record all maintenance performed in Avantis.

## CIRCUIT BREAKERS

Created by: G. Mayo  
Revised by: S. Gilharry

Reviewed by: J. Power  
Approved by: G. Samms

The following steps are considered as standard procedures for maintenance on circuit breakers. Refer to the manufacturer's literature for detailed instructions.

Form MSF005, "*Circuit Breaker Maintenance Report*", is used for reporting a 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	
General				
X	X	X		1. Review the maintenance history and thermo-scan reports for the unit.
X	X	X		2. Review the Maintenance Standard Procedures.
X	X	X		3. Review the manufacturer’s operating and maintenance instructions. A copy of the manufacturers original mechanism inspection report and a mechanism check form should be made available to the maintenance crew at this time. If no such form is offered in the manufacturer’s instructions, a list of external and internal mechanism measurements and checks should be developed prior to commencing work.
				<b>Note:</b> Pay close attention to the manufacturer’s cautionary notes, especially with respect to precautions around moving parts, harmful byproducts, and pressurized systems.
X	X	X		4. Review the test procedures to be done. Ensure the necessary test equipment is scheduled for the job and prepared prior to starting the work.
X	X	X		5. Ensure that normally consumable materials for the work and essential spare parts are on hand (i.e. at least one new moving contact finger and one interrupter for comparison with worn units).
X				6. Generate and/or install an ID number as required.
X	X	X		7. Record the nameplate information on MSF001, if not already on file.
X	X	X	X	8. Record the counter reading at the start and finish of work.
X	X	X	X	9. Make a visual inspection of the unit, noting the condition of the bushings, paint, control panel, operating mechanism, auxiliary equipment, and support structure.
X	X	X	X	10. Before taking the breaker out of service, determine if excessive or abnormal heat or noise is present.
X	X	X		11. Check that the unit is properly leveled, securely anchored, and properly grounded.
	X	X		12. Check ammeters to verify proper operation of the current transformer.
	X	X		13. Do painting as required.

## CIRCUIT BREAKERS

Type of Maintenance				Procedure
I	III	IV	V	
Oil Circuit Breakers				
X	X	X	X	14. Identify the level of PCB contamination, if any. If PCB is present, handle oil as per PCB procedures. Install a PCB label and record level in Avantis.
X	X	X		15. Check for correct oil level and for signs of oil leaks. Respond to leaks as per the emergency contingency plan.
X	X	X		16. Check the breather. If the breather is a silica gel type, check the silica gel and change as necessary. Refer to the manufacturers instructions.
X	X	X		17. Check the dielectric of the oil. Sample from the lowest port in the tank/interrupter. For minimum oil (MO) breakers it will be necessary to sample each phase individually. Due to the small quantities of oil in the interrupter, the level should be checked after sampling and topped up if required. If the dielectric is low or there is heavy contamination or carbon content, a decision will be made at this time to promote the procedure to a higher level of maintenance, as appropriate.
SF <sub>6</sub> Gas Breakers				
X	X	X		18. Check the gas pressure or gas density. The pressure or density should be compared to the table on the back of the cabinet. If there is a leak it will be noted and corrected at the first opportunity.
General				
X	X	X		19. Inspect heaters in external operating cabinets. Ensure they are working. As required, calibrate or replace heater and/or thermostats.
X	X	X		20. Clean and lubricate all external operating mechanisms. Follow the manufacturer's instructions, which usually include a lubrication chart. Note: Too much grease is as bad as not enough.
X	X	X		21. Check the external mechanism as per the manufacturer's instructions. Make necessary adjustments prior to carrying out further diagnostic checks. Record checks and measurements and attach to form MSF005. These checks will help to determine if the interrupters will need to be opened in the SF6 breakers.
X	X	X		22. Open and close the breaker by both local and remote control. Check the local and remote indications for proper operation.
X	X	X		23. With the risers disconnected and the unit: (1) closed with the three phases commoned, megger to ground; (2) closed with the two outside phases commoned, megger the center phase to the two outside phases with the ground guarded; (3) opened, megger across each open contact with the ground guarded. Refer to MST008 for meggering test procedures. Refer to MSR012 for general meggering information and result evaluation.
X	X	X		24. With the unit closed, use a ductor to measure the resistance of each phase across the bushing terminals. These values should be nearly equal and not exceed the values recommended by the manufacturer. Refer to MST006 for ductor test procedures.
X	X	X		25. Perform a motion analyzer test of the unit for a close, reclose, trip and trip-free operation. Refer to MST009 for motion analyzer procedures.

## CIRCUIT BREAKERS

Type of Maintenance				Procedure
I	III	IV	V	
X	X	X		26. If possible, perform a visual check of the bushings and bushing gaskets for signs of deterioration and corrosion. If bushing gaskets are seriously deteriorated they will be replaced. It is not intended that the bushings be removed for this check. If work is required, promote the level of maintenance to a maintenance IV.
X		X		27. For any bushing of rating 69kV or higher, or for any bushing which is in question, a power factor test will be carried out.
X				28. Perform a ratio test on the current transformers as per MST005.
X				29. Perform a polarity test on the current transformers as per MST004.
X		X		30. Check continuity and megger the secondary windings to ground at 500 volts. A reading in excess of 10 mega-ohms is adequate.  <b>Note:</b> At this time the maintenance crew will have enough information to decide if a Maintenance III should be promoted to a Maintenance IV.
<b>Bulk Oil and Minimum Oil Circuit Breakers</b>				
		X		<b>Note:</b> For small oil circuit breakers that are not adaptable to a motion analyzer test and for the 25kV FKP units that experience contact tip separation, the tanks should be opened and the moving contacts and interrupters given a visual check.  31. Filter the oil. In most cases this can be done without opening or dropping the tank.  <b>Note:</b> For minimum oil (MO) breakers, the oil will be removed and the interrupter flushed and refilled with new oil.
		X		32. Remove the oil for an internal inspection.
		X		33. Open the tank or interrupter chamber for an internal inspection.  <b>Caution:</b> When working around or entering tanks, the operating mechanisms will be blocked. The tanks of 138kV breakers will be ventilated and entered following safe entry procedures for confined spaces.
		X		34. Clean all internal components and flush the mechanism and inside of the tank with clean oil. Remove any carbon or sludge from the tank.
		X		35. Perform an internal visual inspection, looking for signs of loose connections, arcing or tracking of insulating components, etc.
		X		36. Check that energy-absorbing components are mechanically sound and secured, and that hydraulic absorbers are filled with oil.
		X		37. Inspect the tank liners and replace any that appear to have absorbed moisture. If there is any evidence of moisture the source will be found and repairs made.

## CIRCUIT BREAKERS

Type of Maintenance				Procedure
I	III	IV	V	
		X		38. Inspect the moving contacts and compare them to a new contact kept on hand for this purpose. Replace contacts if wear is greater than 80% of allowable material.  <b>Note:</b> The condition of this contact will determine whether the interrupter and stationary contact will be disassembled for rebuilding and/or replacement.
		X		39. The interrupter and grading resistor (if one exists) will be cleaned of carbon and examined for burning or deterioration.
		X		40. Use a set of indicating lights to check contact synchronization. Adjust as necessary.
		X		41. Perform internal operating mechanism checks and make the necessary adjustments, as recommended in the manufacturer's instructions. Record results on MSF005.
		X		42. Inspect internal current transformers for signs of electrical deterioration and mechanical security.
		X		43. Disassemble and clean the oil level indicators. Replace seals if necessary.
		X		44. Examine all gaskets and seals. Replace any that are questionable.
	X	X		45. Check that conduits and wiring are properly installed. Inspect wiring for damaged or deteriorated insulation, grounds or shorts.
	X	X		46. Check internal tank heaters and thermostats.
		X		47. Close the interrupting chamber.
		X		48. Refill the interrupting chamber with oil of 26kV or higher dielectric strength.
		X		49. Check and record the dielectric strength of the oil.
<b>Metal Clad Air Circuit Breakers</b>				
X	X	X		50. Remove and clean the box barriers. Inspect them for damage or burning and repair as required.
X	X	X		51. Wipe all insulating parts clean.
	X	X		52. Inspect the movable and stationary primary contacts. Roughed or galled contact surfaces can be dressed up, but badly pitted or burned contacts should be replaced.  <b>Note:</b> Burned primary contacts indicate the need for arcing contact replacement.
X		X		53. Measure the primary contact wipe as per the manufacturer's instructions. Adjust as required to come within manufacturer's specifications.
X		X		54. Measure the primary contact gap as per the manufacturer's instructions. Adjust as required to come within manufacturer's specifications.

## CIRCUIT BREAKERS

Type of Maintenance				Procedure
I	III	IV	V	
		X		55. Inspect the movable arcing contacts. Ensure that they move freely through the slot in the arc chute without touching. Check that the burning of these units has not left any area with less than the manufacturer's recommended minimum thickness, usually 25%. Such burning will require replacement of the component.
		X		56. Inspect the arcing contact wipe as per the manufacturer's instructions. If the wipe is less than specified, the arcing contacts need to be replaced.
		X		57. Remove the arc chutes for cleaning and inspection. Remove loose particles of scale collected in the chute by blowing out with compressed air. Small cracks in the fins are to be expected, but if fins are actually broken off, the chute must be changed.
	X	X		58. Inspect the blow out devices. If the insulation is shrunk, cracked or eroded by arc action to the point that there can be turn-to-turn shorts, the coil should be replaced.
X	X	X		59. Check interlocks for proper operation.
	X	X		60. Give the entire mechanism a through cleaning and lubricate where necessary, as per manufacturer's instructions.
	X	X		61. Check the various wipes, clearances and gaps pertaining to the operating mechanism as per manufacturer's instructions.
X	X	X		62. Ensure that the lifting mechanism and limit switches are operating properly.
	X	X		<b>Note:</b> It may be more beneficial to do this during the switching procedure.
	X	X		63. Check breaker in both the "test" and "operate" positions, where applicable.
<b>SF<sub>6</sub> Breakers</b>				
				<b>Note:</b> In most types of SF <sub>6</sub> breakers the interrupting chamber will only be opened if there is an indication of excessive contact wear, a malfunction or a leak.
				<b>If SF<sub>6</sub> gas needs to be drained from the unit, be sure to use the SF<sub>6</sub> gas reclaimer. Never release SF<sub>6</sub> gas directly to the atmosphere.</b>
		X		64. If the interrupters need to be opened, follow the manufacturer's instructions for disassembly, inspection, repair, and reassembly.
		X		<b>Caution:</b> Pay specific attention to the manufacturer's caution on SF <sub>6</sub> arcing byproducts.
X		X		65. Refill poles with SF <sub>6</sub> gas to correct pressure/density.
	X	X		66. Check for SF <sub>6</sub> leaks and take necessary corrective action. This shall entail checking all SF <sub>6</sub> pipes, connections, gaskets, etc. with either a SF <sub>6</sub> gas sniffer or leak check.
	X	X		67. Inspect pole unit heaters for correct operation, if applicable.
X		X		68. Check external capacitors, if they exist, using a capacitance bridge. Record the measured values of the capacitors and confirm that they match the nameplate.

## CIRCUIT BREAKERS

Type of Maintenance				Procedure
I	III	IV	V	
Breakers with Air Compressors				
X	X	X		69. Check the pneumatic mechanism for corrosion or loose hardware. Ensure that the mounting bolts are tight.
X	X	X		70. Ensure that connections on pneumatic mechanism terminal blocks, switches and relays are tight and free of corrosion.
X	X	X		71. Inspect wiring on pneumatic mechanism for deteriorated or damaged insulation. Check for possible grounds or short circuits.
	X	X		72. Drain condensation from the tank
X	X	X		73. Check the compressor oil level.
	X	X		74. Change the compressor oil. Refer to manufacturers instructions for proper oil type.
	X	X		75. Clean the air filter. Change as required.
X	X	X		76. Check the safety valves and pressure switches for proper operation. Record the operating points.
X	X	X		77. Check condition and tightness of the belts. They should deflect 6 to 12 millimeters (¼ to ½ inches) by pressing against the center of the belt with the thumb.
X	X	X		78. Check the inflation time from 0 psi to the normal cutoff pressure. Record these pressures and the time.
	X			79. Perform an operation rundown starting at the governor shutoff with the compressor knife switch open. Record the number of operations before the low-pressure cutoff opens and the number of operations after the low-pressure cutout switch opens with the switch contacts jumpered.
X	X	X		80. Record the load current of the motor near the cutout pressure.
X	X	X		81. Observe the rate of air leakage. It should not exceed 35 kPa (5 psi) per hour. If leakage is excessive the source will be located and corrected.
	X			82. Measure and record the minimum trip and close voltages for the pneumatic mechanism.
	X	X		83. Make the required pneumatic mechanism dimensional checks. Refer to the applicable manufacturers instructions for further instruction.
X	X	X		84. Check the pressure vessel permit to see if its been maintained. Note the expiry date.
	X	X		85. Repair the tank as required. Repairs to the air vessel can only be done with government approval.
ASEA Minimum Oil Circuit Breakers				
		X		86. Check the burning of the plug contact. Refer to the manufacturers instructions.

## CIRCUIT BREAKERS

Type of Maintenance				Procedure
I	III	IV	V	
X		X		87. Inspect the extinguishing chamber and the fixed contact. Refer to the manufacturers instructions for details applicable to the particular breaker model.
		X		88. Check the gas discharge valves for proper operation.
X		X		89. Dismantle the breaker and clean and inspect all parts for damage or wear.
X		X		90. Check breaker trips on both trip coils.
<b>General</b>				
		X		<b>Note:</b> Steps 92, 93 and 94 are required only if contacts were replaced, the mechanism was adjusted, etc. during Maintenance IV. If no changes are made they can be skipped.
		X		91. Repeat the megger test as in step 23. Compare the two readings. Take appropriate steps if readings are low.
		X		92. Repeat the ductor test as in step 24. Compare the two readings. Take appropriate steps if readings are high.
		X		93. Repeat the motion analyzer test as in step 25. Compare the two tests. Take appropriate action if readings are not within the manufacturers guidelines.
		X		94. Refer to the manufacturer's instructions to perform operating mechanism checks and measurements. Make adjustments as necessary. Record results in the comments section of MSF005.
X		X		95. Check that the bushing connectors are tight.
X				96. If present, remove any bushing wrap.
X*		X		97. If breaker is to be kept as spare, wrap bushings with plastic wrap.
	X	X		98. For bulk oil breakers, extract an oil sample for analysis. See MSR013 for sampling and testing procedures. Top oil up to correct level after sample has been extracted, if necessary. Record results on MSF019.
X	X	X	X	99. Update the maintenance history and nameplate information in Avantis.
X	X	X	X	100. Copies of MSF005 will be filed in the area and Electrical Maintenance Center maintenance files. If there are unresolved issues send a copy to the Substation Asset Management Group. If the equipment is being transported, attach a copy of the most recent maintenance IV report form, along with any maintenance reports completed since the last maintenance IV, to go with the unit and mail or fax a copy to the intended recipient. If the equipment is being installed, attach a copy of the MSF005 form to the SAG's installation form. After installation, send this documentation to the Superintendent of Commissioning.
X	X	X	X	99. If there are any outstanding deficiencies, record them in the "follow-up work" section on the Avantis work order.



## CIRCUIT BREAKERS

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# CURRENT TRANSFORMERS

## Free Standing Outdoor Type

Created by: M. Rideout

Revised by: B. Ropson

Reviewed by: G. Samms

Approved by: G. Samms

The following steps are considered as standard procedures for maintenance on current transformers.

Maintenance Standard Form MSF013, “*Current Transformer Maintenance Report*”, is used for reporting a Maintenance I, III, or V. Also, form MSF001, “*Nameplate and Description*”, is completed during Maintenance I.

Type of Maintenance			Procedure
I	III	V	
X			1. Assign and install an ID number.
X			2. Record the complete nameplate information on form MSF001.
X	X		3. Make a visual inspection of the transformer, noting the condition of the bushings, paint, electrical connections, etc. Refer to MSR002 and MSR014.
X	X*		4. Clean the primary bushings as required.
X	X*		5. Do touch-ups or give complete paint job at intervals as required.
X	X	X	6. Ensure an appropriate PCB label is installed on the unit. Record the PCB level on MSF013. If no lab oil test has been previously conducted on the unit, take an oil sample for lab testing.
X	X		7. Check that the transformer is properly grounded.
X	X		8. If there is an oil level gauge on the transformer, check that it reads a normal level.
X	X*		9. Megger the secondary winding to ground at 500 volts. Also, megger across the CT primary terminals and ground. Refer to MSR012 for evaluation of megger readings.
X	X*		10. Check all ratios for continuity.
X	X*		11. Check the ratio on all taps with an appropriate test set. See MST005 for procedures.
X			12. Check the polarity using the kick test method. See MST004 for procedure.
X	X		13. With the CT energized, where practical, check the current in the secondary with a clip-on ammeter to ensure there are no open or short circuits.
	X		14. With the CT in service, determine if abnormal noise is present.
X	X	X	15. Any changes made or abnormal conditions found should be reported to the Substation Asset Management Group and noted on form MSF013.
		X	16. For unplanned maintenance as a result of breakdown or diagnostic tests, make the necessary repairs and note on MSF013.
X	X	X	17. Update the maintenance history and nameplate information in Avantis.

## CURRENT TRANSFORMERS

Type of Maintenance			Procedure
I	III	V	
X	X	X	18. File copies of form MSF013 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 report with the unit 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 MSF013 to the SAG's installation form. After installation, send forms to the Superintendent of Commissioning.

**Note (\*):** These tests require de-energization of the equipment and should be omitted if the equipment cannot be taken out of service.

# **POTENTIAL TRANSFORMERS**

## **Wire Wound Outdoor Type**

Created by: G. Mayo  
Revised by: B. Ropson

Reviewed by: G. Samms  
Approved by: G. Samms

The following steps are considered as standard procedures for maintenance on wire wound potential transformers. Most procedures will be carried out with the equipment de-energized and isolated. Please refer to the manufacturer's literature for detailed instructions.

Report form MSF011, "*Potential Transformer Maintenance Report*", is used for reporting Maintenance I, III, IV or V. Also, Maintenance Standard Form MSF001, "*Nameplate and Description*", is completed during Maintenance I.

<b>Type of Maintenance</b>				<b>Procedure</b>
<b>I</b>	<b>III</b>	<b>IV</b>	<b>V</b>	
X				1. Generate and install an I.D. number.
X		X		2. Record the nameplate information on form MSF001.
X	X*	X	X	3. Make a visual inspection of the transformer, noting the condition of the bushings, paint, electrical connections, oil levels, etc.
X	X	X		4. Ensure an appropriate PCB label is installed on the unit. Record the PCB level on MSF013. If no lab oil test has been previously conducted on the unit, take an oil sample for lab testing.
X	X	X		5. Review the maintenance history, including any thermo scan information.
X	X*	X		6. Check oil level indicators are operating and showing normal oil levels. Replace indicators as required.
X	X*	X	X	7. Check for signs of oil leaks. Repair as required.
X	X*	X		8. Megger the unit as per MST008 and MSR012. When H2 is grounded it will be necessary to lift it of the ground connection. This test may detect the presence of water or deteriorated insulation in the absence of a PF tester. In a Maintenance I or III it can be used to help determine if the unit has to go to a shop for further maintenance. It will also normally be done prior to opening the unit for repairs.
X	X*	X		9. Perform a power factor test of the HV winding to ground. It will be necessary to lift off the H2 lead from ground, if it is grounded. Remember, this lead is not insulated for the rated voltage of the unit. Refer to MSR015. The power factor reading should be close to that indicated on the nameplate, however correction factors may need to be applied (see manufacturers instructions). Generally, a PF of 0.5% for 66kV units, and 0.8% for 138kV units will be acceptable. In a Maintenance I or III, this test will help to determine if the unit has to go to a shop for further maintenance. It will also normally be done prior to opening the unit for repairs.
X		X		10. Check the ratio of the windings with a ratiometer, or by applying 110 volts AC to the primary winding and ensuring that the correct voltage is obtained at the secondary terminals.

## POTENTIAL TRANSFORMERS

Type of Maintenance				Procedure
I	III	IV	V	
				<p><b>Note:</b> If there is an indication that the PT requires internal service, a decision should be made to determine whether to open the unit in the shop or ship it elsewhere for repair and/or evaluation.</p>
		X		11. <b>If unit must be opened:</b> Check the condition of the oil, noting traces of carbon or moisture. If the dielectric is below 26kV, the oil will be filtered and the dielectric strength brought up to at least 26kV. If 26kV cannot be obtained, replace with new oil. Refer to MSR010 for oil dielectric requirements.
		X		12. <b>If unit must be opened:</b> Put moisture-sensitive components in oil while outside.
		X		13. <b>If unit must be opened:</b> Clean and flush inside with new oil and do a visual inspection of insulating parts. Repair as required.
		X		14. <b>If unit must be opened:</b> Examine the busing components (i.e. insulators, tops, terminals, clamps, gaskets and static shields). Repair, replace, clean or tighten as necessary. Paint chips or cracks. Major repairs will require a Maintenance IV.
		X		15. Major repairs, including welding, will be done under a Maintenance IV.
		X		16. Follow MSR015-2 for drying procedure, as required.
		X		17. Refill the unit with oil as soon as it is dry.
X		X		18. Check all windings and taps for continuity with an ohmmeter.
		X		19. Repeat the megger test.
		X		20. Repeat the power factor test.
		X		21. Repeat the ratio test.
X	X*	X		22. Check that H1 and H2 terminals are clean and tight.
X	X	X		23. Inspect the secondary junction box. Do necessary repairs to make weather-tight.
X	X*	X		24. Clean rust and spot paint as required.
X	X*	X		25. Check the ground terminals and ensure they are clean and tight.
X	X	X		26. Ensure that the secondary wiring cable and connector are secure and intact.
X	X	X		27. Check that the secondary terminals and fuses are intact, clean and tight.
X		X		28. <b>Before the unit is released for service:</b> Back feed to nominal voltage for 15 minutes. Record the current in the low voltage winding being used. Use a test bay if one is available. <b>Use extreme caution and follow the Standard Protection Code for this procedure.</b>

## POTENTIAL TRANSFORMERS

Type of Maintenance				Procedure
I	III	IV	V	
X	X			29. Ensure that the transformer is securely mounted and properly grounded, and that the risers are not too tight or too loose.
X	X			30. Measure output voltage on all secondary windings and compare to the nameplate.
X	X			31. Visually check the primary fuses and fuse holders.
X	X		X	32. Check that no abnormal noises are present.
			X	33. For unplanned maintenance as a result of breakdown or diagnostic tests, make the necessary repairs.
X	X	X	X	34. Update the maintenance history and nameplate information in Avantis.
X	X	X	X	35. File copies of form MSF011 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 MSF011 to the SAG's installation form. After installation, send forms to the Superintendent of Commissioning.

**\* This Procedure will require that the unit be taken out of service and isolated.**

## POWER CABLES AND ACCESSORIES

Created by: M. Rideout

Reviewed by: G. Samms

Revised by: B. Ropson

Approved by: G. Samms

The following steps are considered as standard procedures for maintenance on power cables and accessories.

Form MSF014, “*Power Cables and Accessories Maintenance Report*”, is used for reporting a Maintenance I, III, or V. Also, Maintenance Standard Form MSF001, “*Nameplate and Description*”, is completed during Maintenance I.

Type of Maint.			Procedure
I	III	V	
X			1. Assign and install an ID number as required.
X			2. Record the complete nameplate information of the cable (obtained from the reel) and the termination on form MSF001.
X			3. Carry out an insulation test with a megger of the appropriate voltage.
X	X		4. Check that the cable trench or ducts are clean and free from defects.
X	X		5. Ensure cables are adequately supported. Cables for single-phase potheads should be properly spaced and supported to avoid movement during fault conditions.
X	X		6. Check the condition of the pothead, including the pothead bushings. Inspect for any sign of arcing or tracking, especially from the pothead to ground in cases where the pothead body is insulated from ground.
X	X		7. Check that the cables and potheads are properly grounded and insulated as required. Refer to MSR016 for details on the requirements for cable and pothead grounding.
X	X		8. Check for oil or compound leaks. Repair as necessary.
X			9. Ensure that all primary connections are complete and tight. Check that they are insulated where required.
X	X		10. Ensure that all grounding connections are complete and tight.
X			11. In cable installations using the low pressure oil-filled system with pre-pressurized oil reservoirs, ensure that the system is installed as per manufacturer's instructions
X	X		12. Check the oil reservoirs and piping for leaks and other defects.
X	X		13. Check the pressure on the oil reservoirs, noting the ambient temperature at the time. Refer to MSR016 for the required pressures.
	X		14. Check visible portions of cables for signs of deterioration or damage, such as arcing or melting of the lead, especially where the lead is connected to the pothead body.
X	X	X	15. Any changes made or abnormal conditions found should be noted on MSF014 and reported to the Substation Asset Management Group.

## POWER CABLES AND ACCESSORIES

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Type of Maint.			Procedure
I	III	V	
		X	16. For unplanned maintenance as a result of breakdown or diagnostic tests, make the necessary repairs and note on MSF014.
X	X	X	17. Distribute forms as required.
X	X	X	18. Update the maintenance history and nameplate information in Avantis.
X	X	X	19. If there are any outstanding deficiencies, flag the maintenance record in Avantis.



## POWER FUSES

Created by: M. Rideout

Revised by: B. Ropson

Reviewed by: G. Samms

Approved by: G. Samms

The following steps are considered as standard procedures for maintenance on power fuses.

Form MSF007, “Air Break, Fuse and Disconnect Switch Maintenance Report”, is used for reporting Maintenance I, III, or V. Also, form MSF001, “Nameplate and Description”, is completed during Maintenance I.

Type of Maint.			Procedure
I	IV	V	
X			1. Assign and install an ID number.
X			2. Record the complete nameplate information from the power fuse on MSF001.
X			3. Ensure that the fuse is in good condition and assembled as per the manufacturer’s instructions. Check the fuse for continuity.
X	X		4. Check the physical condition of the insulators, inspecting for broken or cracked porcelain.
	X		5. Carry out a visual inspection, checking for blown links, carbon buildup and signs of tracking. Ensure that fuse mounting hardware is installed properly.
X	X		6. Check blade alignment, contact surface and latching mechanism. Clean and adjust where necessary.
X	X		7. Check that line connections are tight and that insulators are not subject to unnecessary strain.
X	X		8. Check that all mounting base nuts and bolts are in place and tight.
X	X		9. Ensure that fuse mounting bases are properly grounded. Bases mounted on steel structures are grounded via the steel structure. Bases mounted on wood structures are bonded to the ground grid via a copper conductor.
X	X	X	10. Any changes made or abnormal conditions found should be noted on MSF007 and reported to the Substation Asset Management Group.
		X	11. For unplanned maintenance as a result of breakdown or diagnostic tests, make the necessary repairs and note on MSF007.
X	X	X	12. Distribute forms as required.
X	X	X	13. Update the maintenance history and nameplate information in Avantis.
X	X	X	14. If there are any outstanding deficiencies, flag the maintenance record in Avantis.

**Note:** Tests requiring equipment de-energization should be omitted if the equipment cannot be taken out of service.

## POWER TRANSFORMERS

Created by: M. Rideout

Revised by: J. Barry, M. Murphy

Reviewed by: G. Samms

Approved by: G. Samms

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.

## 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. 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.

## POWER TRANSFORMERS

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

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**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.

## OIL FILLED RECLOSERS

Created by: G. Mayo

Revised by: C. Knee

Reviewed by: G. Samms

Approved by: G. Samms

The following steps are considered as standard procedures for maintenance on oil filled reclosers. Refer to the manufacturer's literature for detailed instructions.

Maintenance Standard Form MSF006, "*Recloser Maintenance Report*", is used for reporting a Maintenance I, III, IV or V. Also, form MSF001, "*Nameplate and Description*", is completed during Maintenance I.

Type of Maintenance				Procedure
I	III	IV	V	
X	X	X		1. Review the maintenance and service history of all units due for maintenance. Review the percentage of the duty cycle remaining on the Cooper Power units that use a Form 4C or later control.
X	X	X		2. Review the Maintenance Standard Procedures.
X	X	X		3. Review the manufacturer's operating and maintenance instructions, paying particular attention to the cautionary notes.
X	X	X		4. Review the test procedures to be done. Ensure that the necessary test equipment is scheduled for the time the work will be done.
X	X	X		5. Ensure that all necessary materials are on hand (i.e. spare parts, lubricants, etc.).
X	X	X		6. Generate and/or install an ID number as required. See MSR005 for details.
X	X	X		7. Record the nameplate information on MSF001, if not already on file in Avantis.
X	X	X	X	8. Record the counter reading at the start and finish of work.
X	X	X	X	9. Make a through visual inspection of the unit, noting the condition of the bushings, paint, control panel, and electrical connections.
X	X	X	X	10. Identify and record the level of PCB contamination, if any. If a yellow label is attached to the unit and no lab information is available (other than from the chlor-n-oil test) then take an oil sample for lab analysis. If PCB is present, handle the oil as per PCB procedures.
X	X			11. Check that recloser is properly leveled, securely anchored and properly grounded.
X	X	X	X	12. Check for correct oil level and for signs of oil leaks. Respond to leaks as per the emergency contingency plan.
X	X	X		13. Check the dielectric of the oil. Sample from the drain valve at the bottom of the tank. If the dielectric is low or there is heavy contamination a decision should be made at this point to promote a Maintenance I or III to a Maintenance IV.

## OIL FILLED RECLOSERS

Type of Maintenance				Procedure
I	III	IV	V	
X	X	X		<p>14. Do a visual inspection of external current transformers, bushings and bushing gaskets. Check bushings for tightness and bushing gaskets for signs of deterioration and corrosion. If bushing gaskets appear to be seriously deteriorated, the unit should be removed to a shop for a Maintenance IV. All gaskets should be replaced during maintenance IV.</p> <p><b>Note:</b> CT's should be mounted on the source side on all reclosers except for electronic reclosers where external CT's are used for metering only.</p>
X	X	X		<p>15. Perform external operating mechanism checks. Refer to manufacturer's instructions. Make adjustments as necessary. Record measurements in the comments section.</p>
X*		X		<p>16. With the unit: (1) closed with the three phases commoned, megger to ground; (2) closed with the two outside phases commoned, megger the center phase to the two outside phases with the ground guarded; (3) opened, megger across each open contact with the ground guarded. Refer to MST008 for meggering procedures and MSR012 for evaluation.</p>
X*		X		<p>17. With the unit closed, use a ductor to measure the resistance of each phase across the bushing terminals. These values should be nearly equal and not exceed 350 micro-ohms, except for hydraulic units. For hydraulic units, the reading may be considerably higher because of the resistance of the trip coils, however they can still be used to compare phases. Refer to MST006 for ductor test procedures.</p>
X*		X		<p>18. Perform a ratio test on the current transformers. Refer to MST005. Use a voltage injection test where possible.</p>
X*		X		<p>19. Perform a polarity test on the current transformers. Refer to MST004. Select the test appropriate to the type of current transformer.</p>
X*		X		<p>20. Perform functional checks to confirm correct operation of controls. This would ideally be done using the appropriate recloser test set, but most manufacturer's provide alternate procedures in their manuals.</p> <p><b>Note:</b> At this time, the maintenance person will have enough information to determine if a Maintenance III should be promoted to a Maintenance IV.</p>
X*		X		<p>21. Lower the tank for an internal inspection.</p>
		X		<p>22. Remove the oil for filtering or replacement as required. If PCB is present, handle as per the PCB procedures. Refer to MSR010 for oil dielectric requirements.</p>
		X		<p>23. Clean all internal components and flush the mechanism and inside of the tank with clean oil. Remove any carbon or sludge from the tank.</p>
X*		X		<p>24. Perform an internal visual inspection looking for signs of loose connections, shipping damage, arcing or tracking of insulating components, corona shields, etc. For 25kV units it is our practice to install a jumper from the corona shields to the head of the recloser.</p>

## OIL FILLED RECLOSERS

Type of Maintenance				Procedure
I	III	IV	V	
X*		X		25. Inspect the tank liners and replace any that appear to have absorbed moisture. Ensure foam pads are securely in place. If there is any evidence of moisture, the source will be found and repairs made.
		X		26. Repair the tank as required. Extensive repairs will be done under a Maintenance IV. Welding work will follow Maintenance Standard Welding Procedures.
		X		27. Inspect the moving contacts. The condition of these contacts is a good indication of the condition of the stationary contacts and the interrupters. Replace as required.
		X		28. Visually inspect the interrupters. Disassemble the interrupters and contacts of all reclosers for a through inspection and rebuilding or replacement, as required. The condition of the top plates closest to the stationary contacts and nearest to the most arcing will show the most deterioration.
		X		<p><b>Note:</b> (1) In McGraw Edison type “R” units the interrupter requires replacement if a 3.5mm (9/64 in.) drill bit will fit into the exhaust port; (2) For Westinghouse type “ES” and “PR” units, perform a wipe test.</p> <p>29. Disassemble and clean all except the sealed bushings of the 25kV units. Replace gaskets, clamping rings and “O” rings. Apply a slight film of silicone grease to the aluminum side of the recloser bushing gasket.</p> <p><b>Note:</b> The sealed bushings found on some of our 25kV units should be inspected visually. If there is an indication of trouble, the bushing will be replaced and the faulty unit will be disposed of. Otherwise, clean, replace the lower gasket and clamping ring, and reinstall.</p> <p><b>Hydraulically Controlled Units</b></p>
		X		30. Remove the hydraulic pump and lockout piston for cleaning.
X*		X		31. Check the electrical condition of the closing coil. Measure its resistance. See that the nameplate information is correct.
X*		X		32. Check the condition of the closing coil contact assembly. If there is a problem, the entire assembly would normally be changed. Check that the correct fuses are installed. See that they match the nameplate information.
X*		X		33. Check the trip coils for proper ratings, electrical condition and tight connections. See that they match the nameplate information.
		X		34. Drop the mechanism from the head and examine it for loose or abnormal parts. Repair as required and reassemble.
X*		X		35. Check the fluid level in the time delay units and in the ground trip solenoid assemblies where they exist. Add the appropriate type of fluid as required. Refer to the manufacturer’s instructions.



## OIL FILLED RECLOSERS

Type of Maintenance				Procedure
I	III	IV	V	
X*		X		36. On some hydraulic reclosers, the single operation to lockout, achieved when the non-reclosing lever is pulled down, can be either fast or delayed. The internal adjustment bracket, on reclosers so equipped, should be indexed to the hole marked "F", indicating that the single trip operation will be fast.
X*		X		37. Ensure that the ratings and settings on the recloser nameplates correspond to the actual ratings and settings on internal hydraulic controls.
				<b>All Reclosers</b>
X		X		38. Visually check the control circuit components attached to the recloser head, frame and operating mechanism.
		X		39. Perform an electrical check of the control circuit components attached to the recloser head, frame, and operating mechanism. Refer to the manufacturer's instructions for specific test procedures.
X*		X		40. Check the operation of the manual control lever, the position indicator, the non-reclosing lever (hydraulically controlled units only) and the operations counter.
		X		41. Perform internal operating mechanism checks. Refer to manufacturer's instructions. Make adjustments as necessary. Record measurements in the comments section.
	X	X		42. Clean and check the head gaskets and check any gaskets used on auxiliary equipment.
X*		X		43. With the unit closed, use a ductor to measure the resistance across each contact. For hydraulic units, the measurement will be taken so that the series trip coil is not in the circuit. These values should be nearly equal and not exceed 350 micro-ohms. Refer to MST006 for ductor test procedures. Record results on MSF006.
X*		X		44. If the tank rim is of the folded or double-lip design, which can admit water via the tank bolts, use sealant on the four leading threads each time they are reinstalled. Run a bead of silicone sealant underneath the edge of the rim inside the tank. The surface should be completely clean and dry before the sealant is applied. For other types, lubricate the threads with Never-Seeze or other suitable lubricant. The tank lip should be painted at this time.
		X		45. Replace oil to proper level. Raise tank and check the level on the dipstick or sight glass.
		X		46. Re-check the dielectric of the oil. This sample will be taken from the drain valve in the bottom of the tank. Refer to MSR013 and MSR010 for oil sampling, evaluation and cautionary notes.
X	X	X		47. Re-Tank the unit.
X*		X		48. Manually operate the recloser a few times after the unit has been reassembled to expel all air from the system.

## OIL FILLED RECLOSERS

Type of Maintenance				Procedure
I	III	IV	V	
				<b>Electronically Controlled</b>
		X		49. Check the control cable for continuity and shorts.
X	X	X		50. Check the control cable and plug. Examine the cable for weathering and damage. Clean the plug and seal it with a silicone lubricant.
X	X	X		51. Check that the timing plugs, relays, and resistors are firmly in their sockets. Ensure that the circuit boards are secure in their receptacles and that all wiring connections are tight.
	X	X		52. Check control accessories. Refer to the manufacturer's instructions.
X	X			53. Perform a quick test of the battery, following the manufacturer's instructions. Generally, this will include checking the voltage to see if it is within the normal range and then applying a load for a short term and checking the voltage again to see that it hasn't dropped by more than the prescribed value. The battery will be replaced if it fails this test or if it is greater than five years old.
		X		54. If the battery is less than five years old, perform a discharge test, following the manufacturer's instructions. The battery will be replaced if it fails this test or if it is greater than or equal to five years old.
				<b>Relay Controlled (Westinghouse)</b>
X*	X	X		55. Inspect all terminations for loose connections.
X	X	X		56. Check the position indicator and the indicating lights for proper operation.
X	X	X		57. Check auxiliary switches and control relays for proper operation. Clean or replace contacts as necessary, referring to MSR004 and the manufacturer's instructions.
X	X	X		58. Check the charging motor brushes, commutator and hold-down screws.
X	X	X		59. Check the charging motor current.
X	X	X		60. Check that the capacitive trip device can still trip the recloser thirty seconds after power has been removed from the controls.
X	X	X	X	61. Ensure that the reclose block switch, operated by the manual trip lever in the upper compartment, is reset.
				<b>All Reclosers</b>
X	X	X		62. Check ammeter sockets for corrosion and loose connections. Disassemble and repair or replace as required. Measure continuity across the shorting bar. Apply a film of anti-oxidizing compound, such as Pentrox, to main contact surfaces.

## OIL FILLED RECLOSERS

Type of Maintenance				Procedure
I	III	IV	V	
X*	X	X		63. Use a current injection to check ratios and identify phases. Install numbers on CTs, protective relays and ammeters to indicate which phase each is connected to. Record and label the CT ratio. Check meter operation and label correct multiplier.
X*	X	X		64. Check cabinet heaters, if any, for proper operation.
X	X	X		65. Check the operation of, and clean and lubricate the ground trip shorting switch on hydraulic units to prevent rusting or seizing.
X	X	X		66. With the unit: (1) closed with the three commoned, megger to ground; (2) closed with the two outside phases commoned, megger the center phase to the two outside phases with the ground guarded; (3) opened, megger across each open contact with the ground guarded. Refer to MST008 for meggering procedures and MSR012 for result evaluation.
X	X	X		67. Perform functional checks to confirm correct operation of controls. This would ideally be done using the appropriate recloser test set, but most manufacturers provide alternate procedures in their manuals.
X	X	X		68. Verify control settings are as required and record these settings.  <b>Note:</b> Set the time dials of protective relays to zero if the unit is to be transported.
X		X		69. Ensure recloser is located a minimum of 9 ft from the ground to the bushing top.
X	X	X		70. Do painting as required on the tank, PT and control cabinet.
X	X	X	X	71. Install PCB label. Record the PCB level in Avantis.
X				72. If present, ensure that bushing wraps are removed.
X*		X		73. If recloser is to be kept as spare, wrap bushings with plastic wrap.
X	X			74. Check the bushing terminals for cleanliness and proper torque, the risers for tightness, the operation of the disconnect and bypass switches, and the condition of the bypass fuses as the unit is returned to service.
X	X	X	X	75. Copies of form MSF006 will be filed in the area and the Electrical Maintenance Center maintenance files. If there are unresolved issues, send a copy to the Substation Asset Management Group. If the equipment is being transported, attach the latest maintenance IV report form to go with the unit, along with any report forms completed since the last maintenance IV, and mail or fax a copy to the intended recipient. If the equipment is being installed, attach a copy of MSF006 to the SAG's installation form and, after installation, send this documentation to the Superintendent of Commissioning.
X	X	X	X	76. Update the maintenance history and nameplate information in Avantis.
X	X	X	X	77. If there are any outstanding deficiencies, flag the maintenance record in Avantis.

**\* This procedure is performed on new units only.**

**Maintenance Standard Number:** MSP010A**Effective Date:** 2011-05-24**Superseding Date:** xxxxxxxxx

Page 1 of 7

## NULEC RECLOSERS

Created by: Craig Knee  
Revised by:

Reviewed by: Allan Bartlett  
Approved by: Glenn Samms

### Nu-Lec Reclosers

Maintenance Standard Form MSF016, “*Nu-Lec Recloser Maintenance Report*”, is used for reporting a Maintenance A, B, III, or V. Also, form MSF001, “*Nameplate and Description*”, is completed during Maintenance A.

Type of Maintenance				Procedure
A	B	III	V	
X	X	X		1. Review the maintenance and service history of all units due for maintenance.
X	X	X		2. Review the Maintenance Standard Procedures.
X	X	X		3. Review the manufacturer’s operating and maintenance instructions, paying particular attention to the cautionary notes.
X	X			4. Review the test procedures to be done. Ensure that the necessary test equipment is scheduled for the time the work will be done.
X	X			5. Ensure that all necessary materials are on hand (i.e. spare parts, lubricants, etc.).
X	X			6. Generate and/or install an ID number as required. See MSR005 for details.
X	X			7. Record the nameplate information on MSF001, if not already on file in Avantis.
X	X	X	X	8. Record the counter reading at the start and finish of work.
X			X	9. Ensure the cubicle louvers are not blocked and that air vents and water drainage holes in the base are open. Check for excessive dirt on the cubicle. Clean as required.
X	X	X	X	10. Check the door sealing rubber for deterioration or undue hardening. If necessary, replace the seal.
X	X			11. AC supply cord to be installed for ramp storage. It is necessary to charge batteries and power heaters if available.
X	X			12. Ensure full supply voltage is measured between the Hot and Neutral and the Hot and Ground.
X	X			13. If available and accessible ensure the heaters and thermostats are functioning.
X	X			14. With the unit: (1) closed with the three phases commoned, megger to ground; (2) closed with the two outside phases commoned, megger the center phase to the two outside phases with the ground guarded; (3) opened, megger across each open contact with the ground guarded. Refer to MST008 for meggering procedures and MSR012 for evaluation.
X	X	X		15. With the unit closed, use a ductor to measure the resistance of each phase across the bushing terminals. These values should be nearly equal and comparable to the results obtained from the initial installation ductor test. Refer to MST006 for procedures.

## RECLOSERS

Type of Maintenance				Procedure
A	B	III	V	
X	X	X		<p>16. Sharepoint has the latest file versions used with the Nulec controller. Engineering will have to maintain Sharepoint. Such files include OCP, IOEX, DNP3, EMC Settings file for testing, the laminated procedures file, WSOS itself, etc The above files are pretty static and should not be modified very often. Webster / Departments / Electrical Engineering / Substation Projects / Sites /Substation IED Management / Recloser / Nulec. These files have to be copied to the PC.</p> <p><b>SharePoint File Location Management:</b> To ease the use of loading files copy proper file versions from SharePoint and paste in the appropriate folders on th PC hard drive.</p> <p><b>FIRMWARE:</b>C:\Program Files\WSOS\ (Create a new folder and name firmware).</p> <p><b>OCP File:</b> C:\Documents and Settings\All Users\Application Data\WSOS Switchgear Data\Configurable OCP.</p> <p><b>DNP File:</b> C:\ Program Files\WSOS\DNPADVC (Flexvue), C:\ Program Files\WSOS\DNPPTCC (CAPM 4/5).</p> <p><b>IOEX:</b>C:\ProgramFiles\WSOS\IOEXADVC(flexVue),C:\ProgramFiles\WSOS\IOEXPTCC (CAPM4/5).</p> <p><b>EMC Settings File:</b> C:\Documents and Settings\All Users\Application Data\WSOS Switchgear Data\(<i>Create a new folder and name EMC Settings file</i>) \ Paste file in new folder.</p>
X	X	X		<p>17. Open WSOS, click on Help, About WSOS and ensure the latest version according to Sharepoint is installed on your computer.</p> <p><b>Computer Cable:</b> Communication from a PC to a Nulec requires a null modem serial cable with 25 pin male at the recloser end to a 9 pin connected to the computer for a CAPM 4/5 and a null modem serial cable with 9 pin male at the recloser end to a 9 pin connected to the computer for a flexVue.</p> <p><b>Creating a New Switchgear:</b> WSOS / File / New / (<i>Ensure Automatic Ceation is Selected</i>) / Select a Name (ie:230622_Apr 07 2011) / Click Next / Click Finish. At this point the switchgear file is created and active. In Switchgear Explorer this file is in bold.</p> <p><b>Connecting to Switchgear:</b> WSOS / Options / Go On-Line</p>
X	X			<p>18. Record the firmware version the NuLec arrives with. In the past firmware version updates have slipped through without Engineering knowing. Email Operational Support with this firmware version. WSOS / File / Switchgear Properties / Software Version.</p> <p><b>Loading Firmware:</b> WSOS / Options / Go On-line / Customize / ADVC Loader Tool... \ <i>Ensure proper switchgear selected</i> / Browse (<i>Browse for proper firmware version</i>) / Select File and Open /Next / Next / Finish</p>

## RECLOSERS

Type of Maintenance				Procedure
A	B	III	V	
X	X			19. WSOS / File / Open / Browse / EMC Settings File / EMC Settings File.sos5 / Open / ( <i>File should now be set up in Switchgear Explorer</i> ) Right Click and Set Active / Options / Go-Online / Options / Write Switchgear Settings to Switchgear / <i>Choose Desired Options</i> / Next / Finish
X	X			20. WSOS / Display / IOEX / IOEX Description
X	X			21. WSOS / Display / Switchgear Communications / Protocols / DNP3 / DNP3 Point Configuration / Point Mapping.
X				22. WSOS / Display / OCP Display / OCP Description. This applies to the FlexVue controller only.
X				23. This requires special sheets of paper. The planner at the EMC should have this paper available. WSOS / Customize / OCP Configuration Tool / Open / Existing / Choose Desired OCP / Open (This places the OCP Configuration Tool on the tool bar). OCP Configuration Tool / Print Labels
				<b>OCP File Load Checks</b>
				For the flexVUE controller it will be necessary to thoroughly check the operator control panel after installing the OCP file. This file customizes the faceplate. To check the following it may be best to interface WSOS to the Nulec and operate at the controller. Indication should be the same on the OCP as within WSOS.
X				24. Scroll through all of the protection groups. Confirm the groups indeed change. WSOS / Control / Active Group. As well verify on the Operator Control Panel.
X				25. Turn Ground Protection ON / OFF. WSOS / Control /Ground Protection. As well verify on the Operator Control Panel.
X				26. Live Load Blocking. WSOS / Display / Protection / <i>Active Settings Group</i>
X				27. Local/Remote can only be changed from the controller itself. WSOS / Display / Control / Mode
X				28. WSOS / Display / Control / Auto Reclose
X				29. WSOS / Display / Control / (Hot Line Tag)
X				30. WSOS / Display / Configuration / Configuration
X	X			31. WSOS / Display / Status /. The switchgear should indicate connected and the Switchgear Data should be valid. Perform a direct end-to-end test of the control cable with an ohmmeter if there is a problem.
X				32. WSOS / Display / Status / Gas Pressure. Verify the tank pressure with a pressure gauge. If “gas low” is showing, recharge the circuit breaker SF <sub>6</sub> using a gas fill adapter. See MSR019 for a detailed procedure on SF <sub>6</sub> recharging.

## RECLOSERS

Type of Maintenance				Procedure
A	B	III	V	
X				33. WSOS / Display / Status. Check the remaining contact life. When the remaining contact life in any phase approaches zero, the recloser is worn out and should be replaced immediately. Record wear on MSF016.
X	X	X		34. Record the Manufacture Date of the battery. Label the battery with this date. 35. Record the Ah rating of the battery. This is to be entered into Avantis.
X	X	X		36. Test the battery for proper operation as per MSP002. WSOS /Display / Maintenance / Battery Health Test. Ensure the correct Rated Battery Capacity is applied before testing (7.2 Ah or 12Ah).
X	X	X	X	37. If battery is three or more years old, replace as per MSR018. If the battery is to be replaced record the Manufacture Date of the battery and label the battery with this date. Complete a Maintenance V report and forward to the Electrical Maintenance Planner.
				<b>Function Checks:</b>
X	X			38. WSOS / Display / Control / Switchgear. Check both mechanical and electrical indication.
X	X			39. Physically isolate the Close Circuit. WSOS / Status / Close Solenoid.
X	X			40. Physically isolate the Trip Circuit. WSOS / Status / Trip Solenoid.
X	X			41. Manually trip the Nulec. Check both mechanical and electrical indication.
X	X			42. Apply a Hot Line Tag while either the Nulec open or open once applied. Attempt close the Nulec. As well verify on the Operator Control Panel.
X				43. WSOS / Status / Gas Pressure. This reading should be in Psi. WSOS / Display / Maintenance / Gas Pressure Override. Turn Override State On to generate alarm.
				<b>IOEX Checks</b>
				WSOS / Customize / IOEX / Configure ADV C IOEX Mappings / Existing / <i>choose desired map</i> / Open . This screen illustrates the mapping of both the inputs and the outputs of the IOEX card. Presently WSOS software version 4.28 is required to open the PTCC (CAPM5) IOEX mappings. IOEX must be in Remote. WSOS / Display / IOEX / Configure / Mode
X	X			44. Trip the Nulec
X	X			45. Close the Nulec
X				46. No close with Hold Off ON
X				47. No Close with auto Reclose OFF
X				48. Verify Indication of the Nulec (“A” contact)
X				49. “B” Contact

## RECLOSERS

Type of Maintenance				Procedure															
A	B	III	V																
X				<p>50. WSOS / Display / Control /Protection This point can only be tested if Protection Off is enabled. WSOS / Display / Configuration / Feature Selection / Protection Off Allowed.</p> <p><b>Primary Injection Checks:</b></p>															
X	X			<p>51. Enable Group A (EMC Settings File.sos5). Block the Ground Trip. Block reclosing. After successful tripping on each phase unblock the Ground Trip to test.</p>															
X	X			<p>52. Utilize the Current Test Set to allow the Nulec to go through a series of trips and successful recloses.</p>															
X				<p>53. The Maximum values can be checked in the Event Log. WSOS / Display / History / Display.</p> <p>Phase Testing TCC104 @ 70 amps will trip at .2 sec. IEC 255 Very Inverse @ 70 amps will trip in 11 sec</p> <p>Ground Testing TCC104 @ 50 amps will trip at .1 sec. IEC 255 Very Inverse @ 50 amps will trip in 11 sec</p>															
X	X			<p>54. Inject Nulec with a single phase current test set one phase at a time. Monitor the current on the OCP. This testing can be synchronized with the minimum trip tests.</p>															
X	X			<p>55. WSOS / Display / Control / Sequence / Lockout</p>															
X				<p>56. When a load has been without power for a period of time it may be difficult to close in. The longer the power has been off the greater load may be because of home heating, fridges and demand in general.</p> <p>Cold Load Pickup times the loss of power and raises the threshold current accordingly to hold the load without tripping.</p> <p>Cold Load Pickup should be turned off if expected load is less than 2.5 amps.</p> <p>Enable Group B in the Generic settings file.</p> <p>Ensure Inrush Restraint and Ground Protection is turned off.</p> <p>WSOS / Display / Protection / Cold Load</p> <table><tr><th>Time(Min)</th><th>Operational Multiplier</th><th>Min Trip (40 amp)</th></tr><tr><td>1</td><td>1.25</td><td>50</td></tr><tr><td>2</td><td>1.5</td><td>60</td></tr><tr><td>3</td><td>1.75</td><td>70</td></tr><tr><td>4</td><td>2</td><td>80</td></tr></table>	Time(Min)	Operational Multiplier	Min Trip (40 amp)	1	1.25	50	2	1.5	60	3	1.75	70	4	2	80
Time(Min)	Operational Multiplier	Min Trip (40 amp)																	
1	1.25	50																	
2	1.5	60																	
3	1.75	70																	
4	2	80																	



## RECLOSERS

Type of Maintenance				Procedure
A	B	III	V	
X				<ol style="list-style-type: none"> <li>1. Close recloser and inject 30 amps for excess of 4 minutes.</li> <li>2. Trip recloser and remove load for 4 minutes.</li> <li>3. Close recloser and put 75 amps of current in. The recloser should not trip. Immediately reduce the current to 43 amps and the unit should trip after 4 minutes.</li> </ol> <p>57. While closing under load Inrush current occurs because of transformer magnetism, motors starting etc.</p> <p>Inrush Restraint prevents power loss due to inrush. Inrush is allowed to flow by raising the phase and ground threshold currents for a short period of time.</p> <p>Inrush Restraint is armed whenever load current is dropped below 2.5 amps.</p> <p>If load current is expected below 2.5 amps then Inrush Restraint can not be used.</p> <p>Enable Group C in the generic settings file.</p> <p>Ensure Cold Load pickup is off..</p> <p>Inrush Restraint Time is set to 10 seconds for test at 2 times the trip current. The normal phase trip current is 40 amps.</p> <p>If the Nu-Lec is closed and 75 amps applied then there should not be a trip for 10 seconds. If the Nu-Lec is closed and in excess of 80 amps is applied then there should be an immediate trip.</p> <p>WSOS / Display / Protection / Inrush Restraint</p>
X				<p>58. Activate Group A. Perform a series of trips and recloses ensuring not to lockout. Reduce current to a non trip level. Reset time can be found in the protection settings. Sequence screen will blank after reset time has elapsed. WSOS / Control / Sequence</p>
X	X			<p>59. This test can be performed during the phase and ground minimum trips. Block the ground trip, apply enough current not to trip on phase but enough to go on ground. Unblock the ground trip and the Nulec should trip. WSOS / Control / Ground Protection</p>
X	X			<p>60. Lettering available at the EMC. Holder should be attached to Nulec during acceptance testing and if unit is reserved for a specific location proper designation should be applied. Otherwise labelling should be SPARE.</p>
X				<p>61. Frequent functions to be performed with the Nulec are outlined in a separate document. These are to be printed off and placed in the Nulec cabinet. These instructions can be found on SharePoint. If not available on Sharepoint \\Nphome1\psd\COMM\Relay &amp; Recloser Info &amp; Software\Nu-Lec Recloser\Nu-Lec instructions</p>
X	X	X	X	<p>62. Copies of form MSF016 will be filed in the Area and in the Electrical Maintenance Center maintenance files. If there are unresolved issues, send a copy to the Substation Asset Management Group. If the equipment is being transported, attach the latest copy of MSF016 to go with the unit, and mail or fax a copy to the intended recipient.</p>

## RECLOSERS

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Type of Maintenance				Procedure
A	B	III	V	
X	X	X	X	63. Complete the work order information in Avantis. Update the maintenance history and nameplate information in Avantis.
X	X	X	X	64. If there are any outstanding deficiencies, flag the maintenance record in Avantis.

**Maintenance Standard Number:** MSP011**Effective Date:** 2002-04-15**Superseding Date:** 1982-06-29

Page 1 of 3

## SWITCHGEAR

Created by: M. Rideout

Reviewed by: D. Manning / G. Goodwin

Revised by: M. Royle

Approved by: G. Samms

The following steps are considered as standard procedures for maintenance on switchgear, both metal clad and open type. These procedures do not include maintenance on the breaker. Such maintenance is covered under MSP004, "Circuit Breakers".

Maintenance Standard Form MSF008, "Switchgear Maintenance Report", is used for reporting a Maintenance I, III, IV or V. A separate form should be completed for each cubicle. In addition, 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 to each cubicle.
X				2. Record the complete nameplate information on MSF001.
X		X		3. Remove the bolted covers and barriers to expose the interior of the switchgear.
X		X		4. Inspect the switchgear interior for accumulation of dust, dirt or any foreign matter. Remove dust accumulations from all insulators, bus supports, and other surfaces. A vacuum cleaner is suitable for this work. The bus and supports should be wiped clean with A55 solvent or Brodi Natural 100% Citrus Solvent Degreaser or equivalent if necessary.
X		X		5. Check all buswork, bus supports, barriers, arc chutes, insulators, cables, etc., for deterioration and signs of tracking or overheating. If bus bars are overheating, check for poor or loose connections or for overload. May have to open joint to inspect connection surfaces. Clean surfaces with approved solvent. Dress contact surfaces by buffing with "3M Scotch Brite" taking care to minimize removal of plating. Before assembly protect contact surfaces with "No-Ox-ID Special A Compound" or equivalent. Use proper torque in tightening bolted connections (15-35 ft lbs for 3/8" bolts and 30-40 ft lbs for 1/2" bolts).
X				6. Ensure that all bus connections designed to be insulated are actually insulated.
	X	X		7. Check cable terminations, potheads, etc., for any sign of arcing (e.g. between pothead body and ground points), overheating or leaking compound.
X	X	X		8. Check that bypass switches operate properly (where they exist) and lubricate where necessary. Refer to manufacturer's instructions.
X		X		9. Check for proper operation of the carriage for disconnecting potential transformers. When the carriage is rotated or pulled out, ensure that the fuses strike the grounding straps to remove static charge. Ensure fuses and holders are making good contact.
X		X		10. Megger the bus between phases and from each phase to ground. Refer to MST008 for meggering procedures and MSR012 for evaluation of readings.
X				11. Check CTs for grounds, continuity, polarity and all ratios.

## SWITCHGEAR

Type of Maintenance				Procedure
I	III	IV	V	
X	X	X		12. Ensure that ground bus connections are properly made and are tight.
X	X	X		13. Clean air filters, if applicable, by washing in any mild household detergent.
X	X	X		14. Inspect for bent or twisted doors and structure framework and for cubicle doors sticking or scraping on the floor. Make the necessary repairs.
X	X	X		15. Ensure that all heaters, thermostats and vents are properly operating.
X		X		16. Remove breakers from cubicles for inspection of the primary and secondary disconnecting contacts and their supporting insulation. Inspect for abnormal wear or overheating. Apply a light film of Vaseline or the appropriate grease (GE D50H47), according to the manufacturer's instructions, before replacing the breaker.
X		X		17. Check that breakers move freely in and out of cubicles. Ensure that racking mechanism is operating properly. Adjust limit switches as necessary. Lubricate gears and moving parts. Refer to manufacturer's instructions.
X		X		18. Check control and instrument switches and auxiliary relays for proper operation. Contacts should be inspected and dressed where necessary.
X		X		19. Check all instruments, relays and other panel-mounted devices for proper operation (e.g. trip breaker with relays, operate alarms, etc.). All relay covers should be removed and the interior of the cases inspected for dust and dirt. Refer to the manufacturer's instructions regarding maintenance on the individual devices.
X	X	X		20. Examine indicating lamps and replace as necessary.
X	X	X		21. Check control wiring. Ensure that insulation is in good condition and that wiring is properly secured at terminal blocks and other terminating points.
X		X		22. Check the primary and secondary connections of instrument transformers for tightness.
X		X		23. Check the automatic shutters for proper operation. These shutters and the associated levering or lifting mechanism should be cleaned, a few drops of oil applied to bearings and a thin film of grease to guide surfaces, racks, screws and bolt threads.
X	X	X		24. Check that all safety interlocks are operating properly. Refer to the manufacturer's instructions.
X		X		25. Check that all structure bolts are in place and properly secured.
X	X	X		26. Ensure that indoor covers are properly in place and that outdoor covers on metal clad buildings are sealed and that the cable entrances are blocked off so as to make each cubicle weatherproof.
X	X	X		27. Ensure that all openings into the switchgear are vermin proof.

## SWITCHGEAR

Type of Maintenance				Procedure
I	III	IV	V	
X	X	X		28. Check the condition of the paint inside and outside. Paint as required. Refer to MSR014 for paint condition.
X	X	X		29. Check the roof and doors of metal clad switchgear for possible leaks. Take the necessary action to eliminate any, if they exist.
X	X	X	X	30. Check the circuit breakers, where applicable, as per MSP004, using form MSF005.
X	X	X	X	31. Any changes made or abnormal conditions found should be noted on MSF008 and reported to the Substation Asset Management Group.
			X	32. For unplanned maintenance as a result of breakdown or diagnostic tests, make the necessary repairs and note on MSF008.
X	X	X	X	33. File copies of form MSF008 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 MSF011 to the SAG's installation form. After installation, send forms to the Superintendent of Commissioning.
X	X	X	X	34. Update the maintenance history and nameplate information in Avantis.
X	X	X	X	35. If there are any outstanding deficiencies, create an Avantis work request for each deficiency.

## TAPCHANGERS

Created by: M. Rideout  
Revised by: M. Robinson

Reviewed by: G. Samms  
Approved by: G. Samms

The following steps are considered as standard procedures for maintenance on on-load tapchangers on power transformers. Maintenance on tapchangers is typically performed in conjunction with transformer maintenance. Any tapchanger maintenance is recorded under the appropriate transformer record in Avantis.

Form MSF010, "*Tapchanger Maintenance Report*", is used for reporting a 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	X	X	X	1. Record the counter reading at the start and finish of work.
X	X	X		2. Check that the operations counter is operating properly.
X	X	X		3. Observe the oil level gauges, noting the oil level in the tapchanger compartment and in the diverter compartment, where this is a separate compartment. Whenever oil has to be removed, note on MSF010 the amount of oil involved.
X	X	X		4. Ensure an appropriate PCB label is installed on the unit. Record the PCB level.
X	X	X		5. Check the dielectric of the insulating oil. If it is less than 22kV during Maintenance III, the Substation Asset Management Group should be consulted concerning the need for filtering at this time. During Maintenance I and IV, the oil will be filtered anyway when being removed to provide access to the tapchanger mechanism.
X		X		6. Carry out an internal inspection of the tapchanger. Refer to the manufacturer's instruction manual, following the specific instructions closely. Clean and replace components as necessary. Check for any sign of moisture. Where the oil is found to be carboned up, flush the mechanism and tank walls with clean oil and wipe out the compartment with clean rags, removing all traces of carbon. Check the mechanism generally for signs of undue wear.
				<b>Note:</b> Before operating the mechanism, ensure the oil levels are as recommended in the manufacturers instructions to prevent mechanism damage.
X		X		7. Operate the mechanism manually and observe the operation of the components. Inspect arc chutes, insulation barriers, shafts, contacts, moving arms, gears, cams, braking features, mechanical stops, chain drives, etc. Check clearances, gaps and wipes. Verify timing using factory gear markings (which must align). Refer to manufacturer's instructions for detailed operating characteristics.
X		X		8. Check for any sign of oil leakage between the main tank and the tapchanger or diverter compartments.
X		X		9. Check all bolts, nuts, pins, springs, etc., for tightness and proper tension. Ensure that locking plates on bolts and nuts are locked. Check and adjust torque settings for lugs.
X		X		10. Carry out tapchanger motor insulation tests. Megger line-gnd with a 500V megger.

## TAPCHANGERS

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

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 <b>at least</b> 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>



## VOLTAGE REGULATORS

Created by: G. Mayo

Revised by: J. Barry

Reviewed by: G. Samms

Approved by: G. Samms

The following steps are considered as standard procedures for maintenance on voltage regulators. Refer to the manufacturer's literature for detailed instructions.

Maintenance Standard Form MSF012, "*Voltage Regulator Maintenance Report*", is used for reporting a Maintenance I, III, IV or V. Also, Maintenance Report Form MSF001, "*Nameplate and Description*", is completed during Maintenance I. Note that Maintenance III will be done with the unit in service, however the maintenance person is advised to perform only those procedures which he/she considers safe.

Type of Maintenance				Procedure
I	III	IV	V	
X				1. Generate and install an I.D. number as required. See MSR005 for details.
X		X		2. Record the nameplate information on form MSF001.
X	X	X	X	3. Review the maintenance history.
X	X	X	X	4. Record the counter reading at the start and finish of work.
X	X		X	5. Record the control panel settings (i.e. set point, bandwidth, time delay and compensation).
X	X		X	6. Make a visual inspection of the regulator, noting the condition of the bushings, paint, control panel, electrical connections, arresters, bypass switches and platform (cross arm, pole, etc.). Refer to the Maintenance Standard References.
	X			7. To check the unit before bypassing, operate it two steps up and down.
X	X	X		8. Check that the oil level indicator is operating and showing normal oil level.
		X		9. Replace oil level indicators as required.
X	X	X	X	10. Check for signs of oil leaks.
X		X		11. Check the nameplate for PCB information. Carry out further tests as required. If PCB is present, handle the oil as per PCB procedures. Refer to MSR013 for oil sampling, evaluation and cautionary notes. Record PCB information in Avantis and label unit with an appropriate sticker.
X	X	X		12. Check the condition of the oil, noting traces of carbon or moisture. If the dielectric is below 22kV, the unit will be removed to a shop for a Maintenance IV. Filter or replace the oil to obtain a dielectric strength of 26kV or higher. Refer to MSR013 for oil sampling, evaluation and cautionary notes.
X		X		13. Check for continuity between all combinations of the 3 bushings with an ohmmeter.
X		X		14. Megger between any bushing and the tank. Refer to MST008 for procedure.

## VOLTAGE REGULATORS

Type of Maintenance				Procedure
I	III	IV	V	
X	X	X	X	<p><b>Note:</b> To make some control tests the unit will have to be taken out of service. To do maintenance inside the tank, the regulator must be taken to a repair shop.</p> <p style="text-align: center;"><b><u>Ensure that the unit is in the neutral position before bypassing.</u></b></p>
X*		X		<p>15. Remove the regulator tank.</p> <p><b>Note:</b> Once the regulator tank is removed, if it requires radiator replacement it should be sent to a repair shop for blasting/painting as required. The regulator must be dried out as per MSR023 if it is exposed to the atmosphere for more than 8 hours. If the original tank is not available, store the mechanism in the holding tank in its own oil. Refer to the manufacturer's instructions for the following procedures.</p>
X*		X		16. Clean all internal components and flush the mechanism and inside of the tank with oil. Remove any carbon or sludge from the tank.
		X		17. Make a visual inspection of the internal parts. Check all insulating parts for signs of arcing, tracking, or loose hardware. Repair or replace as necessary.
		X		18. Perform a visual and continuity check on the exciting, regulating, preventive autotransformer, equalizer, current transformer, and potential transformer windings. Do visual checks on all control wiring.
		X		19. Examine the stationary and movable contacts on the main and reversing switches, and replace as required.
		X		20. Check that all nuts and connections are tight. Use a torque wrench and the manufacturer's torquing recommendations where appropriate.
		X		21. Using an external 120V AC supply to the motor, operate the tap changer and observe contact alignment and limit switch operation. Adjust as necessary.
		X		22. Examine the tap changer drive gears, bearings, springs, cams, bushings, pins, retaining rings, etc. Replace parts as necessary.
		X		23. Inspect the position indicator drive, plug, terminals, limit switches, load bonus switches, seals, viewing window and hinges.
X	X	X		24. Check that the actual neutral position of the regulator corresponds with the position indicator and the neutral light. For maintenance III only check that the position indicator and neutral light correspond.
X		X		25. Examine the surge bypass arresters.
X		X		26. Examine the bushings and associated clamps, gaskets, static shielding and terminals. Replace, clean or tighten as necessary.
		X		27. Examine and replace, as necessary, the gaskets on the hand hole, cover, control cabinet, etc.

## VOLTAGE REGULATORS

Type of Maintenance				Procedure
I	III	IV	V	
		X		28. Replace the unit in the tank and top up the oil to the correct level. Record the amount of time the tank was exposed to the atmosphere on MSF012.
		X		29. Repeat the megger test. Refer to MST008.
X*		X		30. Measure the motor load current through all tap positions.
X*		X		31. Perform a ratio test. Refer to MST014.
X*		X		32. Perform a PT ratio test. Refer to MSR013.
X*		X		33. Perform a current test. Refer to MSR012. Use a clip on ammeter to check the CT ratio, rather than opening the secondary.
X*		X		34. Do a Reverse Power Flow Test, if applicable. Refer to manufacturer's instructions.
X	X	X		35. Refer to the manufacturer's instructions to check that the various control features, such as voltage level, bandwidth, time delay, neutral indicating light, etc., are functioning properly.
X	X	X		36. Check for proper operation of the position indicator and resetting of the drag hands.
X		X		37. Clean rust and spot paint as required.
		X		38. Major repairs requiring welding and full paint jobs will be done under Maintenance IV. Weld as per standard welding procedures.
X		X		39. Ensure that the bushing identification is legible.
X	X	X		40. Clean the position indicator and control panel screws and hinges, and lubricate with a white lithium spray lubricant. Apply silicone grease to the indicator knobs. Lubricate the hinges, hasp, etc., on the control panel door. During maintenance III, do this only if the regulator can be kept in service.
X		X		41. Ensure the ground terminal is clean and tight.
X	X	X		42. Check the physical condition of the cable to the control panel. Repair or replace as required. This will require the unit to be taken out of service for maintenance III.
				<b>Note:</b> New units should be moved to a test bay to test their operation. For units that have been previously serviced and their maintenance history is known, use a test bay only if there is one available.
X		X		43. Leave the unit in neutral.
X*		X		44. Record the primary voltage rating for which the PT is tapped.
X		X		45. Install the yellow breather caps or plugs before transporting, and remove before putting into service, if the regulator is so equipped.

## VOLTAGE REGULATORS

Type of Maintenance				Procedure
I	III	IV	V	
X				46. If present, remove any bushing wrap.
X*		X		47. If regulator is to be kept as spare, wrap bushings with plastic wrap.
X	X			48. Ensure the regulator is securely mounted, properly grounded, and that the drop leads are ok.
X				49. Check that the disconnect and bypass devices are working properly.
X		X		50. Test Regulator in Regulator Test Bay. Record date of final testing.
X	X	X	X	51. Update the maintenance history and nameplate information (if required) in Avantis.
X	X	X	X	52. Copies of form MSF012 will be filed in the Area and in the Electrical Maintenance Center files. If there are unresolved issues, send a copy to the Substation Asset Management Group. 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 the equipment is being installed, attach a copy of MSF012 to the SAG's installation form, and, after installation, send this documentation to the Superintendent of Commissioning.
X	X	X	X	53. If there are any outstanding deficiencies, flag the maintenance record in Avantis.

**\* This procedure is required for new units only.**

## MISCELLANEOUS EQUIPMENT

Created by: M. Rideout

Revised by: B. Ropson

Reviewed by: G. Samms

Approved by: G. Samms

The following steps are considered as standard procedures for maintenance on substation miscellaneous equipment.

Maintenance Standard Form MSF015, “*Miscellaneous Equipment Maintenance Report*”, is used for reporting maintenance carried out on this equipment. In addition, Maintenance Standard Form MSF001, “*Nameplate and Description*”, is completed during Maintenance I.

Maint. Type		Procedure
I	III	
X	X	1. Check steel tower leg bolts on footings. Tighten any loose nuts or bolts.
X	X	2. Check backfill around tower footings. Arrange for backfilling where required.
X	X	3. Inspect structure for plumbness, alignment, visible damage and loose guys.
X	X	4. Check for rust spots and galvanizing damage. Touch up where necessary with Zinc-It or a similar cold galvanizing spray.
X	X	5. Inspect crossarms for damage.
X	X	6. Check wood structure for any holes, cracks or cuts that would weaken the structure. Arrange to have poles replaced if required.
<b>Buswork</b>		
X	X	7. Make a visual inspection, checking for proper clearances to adjacent phases, ground and equipment. Abnormal conditions should be reported to the Substation Asset Management Group.
X		8. Ensure that the bus is securely supported.
	X	9. Check for broken and contaminated insulators. If the power is off, clean or replace insulators as required.
X		10. Check for the use of dissimilar metals on bus fittings. To prevent galvanic corrosion resulting from two dissimilar metals, our general practice is to use copper wire and fittings only on substation buses. Transition from copper to aluminum on incoming lines is usually done immediately after the dead-ending of the line on the substation structure. Therefore, there should be no aluminum to copper contact inside the substation bus system.
	X	11. If the power is off, check the nuts and bolts on all connections for tightness. Clean connections where necessary.
<b>Insulators</b>		
X	X	12. Check insulators for contamination, signs of flashover, broken or cracked porcelain, and loose or missing pins.
X	X	13. Change or clean insulators as required.

## MISCELLANEOUS EQUIPMENT

Maint. Type		Procedure
I	III	
<b>Lightning Arresters</b>		
X		14. Assign and install an ID number as required.
X	X	15. Check condition of arrester mounting base and ensure that the arrester is properly fastened and mounting bolts are in place and tight.
X	X	16. Check the condition of the porcelain. Hairline cracks are cause for immediate replacement. Refer to MSR002 for bushing condition information.
X	X	17. Check the line connections (if power is off) and ground connections for tightness.
X	X	18. Inspect cement in flanges for cracks that might admit moisture. Seal or repair as required.
X	X	19. If the power is off, clean the porcelain as necessary.
<b>Metering Tanks</b>		
X	X	20. Ensure that the vent plug is removed and that the tank is in place, securely mounted and properly grounded.
X	X	21. If the power is off, check the primary and secondary connections for tightness.
X	X	22. Make a visual inspection, checking for broken bushings, signs of oil leaks and paint condition. Ensure that the power is off and repair as required.
<b>Yard Lighting</b>		
X	X	23. Ensure that lighting fixtures are secure and properly mounted to the structure.
X	X	24. Check that all lights are operating properly and that all lenses and enclosures are complete and in place.
X	X	25. Ensure controls (i.e. switches or circuit breakers) are left in the desired position. As a security measure, these should be left in the "on" position so that the lights will turn on automatically after dark.
<b>Foundations</b>		
X	X	26. Check the foundation for cracks, serious spalling and frost heaving. Inspect to ensure the foundation is level. Refer to MSR007 for reporting foundation condition.
<b>Grounding</b>		
X	X	27. Make a through check of substation grounding to ensure equipment and structures are adequately grounded. Refer to the substation grounding standards for current grounding practices. On older installations, the practice and conductor sizes may not be identical to those described in the grounding standards. This should not be necessarily interpreted as being incorrect. Any deviation from the recommended standards should be noted on MSF015 and reported to the Substation Asset Management Group.
<b>Control Cables</b>		
X		28. Make a visual inspection to ensure that cables are properly in place and protected from any potential source of damage.

## MISCELLANEOUS EQUIPMENT

Maint. Type		Procedure
I	III	
X	X	29. Check the connections at both ends for tightness if these connections are accessible. Check also for signs of corrosion and moisture at the terminal blocks.
<b>Control Building and Yard</b>		
		<b>Note:</b> In addition to the following steps, refer to MSI001, “ <i>Routine Substation Inspection</i> ”, for detailed requirements on building and yard maintenance procedures.
X	X	30. Inspect the building for security, safety and appearance. Check the paint condition both inside and outside. Check that doors and windows fit properly and that locks are in good working order. Check for leaks in the roof and elsewhere, such as water coming in through conduits. Make repairs where possible and report any deficiencies on MSF015.
X	X	31. Check that electrical and mechanical accessories are as they should be (e.g. lights receptacles and switches in good condition; thermostats and heaters operating properly; emergency lighting operating properly; lavatory in good working order; building or battery room (where one exists) properly ventilated; and danger or warning signs installed as required). Make repairs as required and report any deficiencies on MSF015.
X	X	32. Inspect yard for security, safety and appearance. Ensure that fence and gates are in good condition, so as to prevent unauthorized entry. Ensure that locks are operating properly and trenches are in good condition, with covers in place. Make sure the yard is clean and tidy, danger signs are in place, the fence is properly grounded, crushed stone is adequate, and adequate snow clearing is provided in winter.
X	X	33. Make a visual inspection, checking for oil leakage, chipped or cracked bushings and paint condition. Ensure that the tank is properly grounded.
X	X	34. Check the oil’s dielectric strength. Refer to MSR010 for dielectric requirements. During Maintenance III this should only be done if requested.
X	X	35. In cases where the transformer is mounted outdoors on the structure, ensure that the secondary leads are looped up and enter the bushing terminals from the top, rather than up into the bottom of the terminals. This is to prevent water from running down through the conductor strands and getting into the switch or distribution panel in the building. All new transformer installations or replacements should be stainless steel cased. These will have spade terminal secondary bushings and these spade terminal connections should be air sealed and taped.
<b>AC and DC Distribution</b>		
X	X	36. Check that panels are mounted securely; all circuit breakers are installed correctly; all cable connections are tight; and that cables and conduits are properly connected to the panels and adequately supported.
X	X	37. Ensure that load currents are within the rating of the distribution panel.

## MISCELLANEOUS EQUIPMENT

Maint. Type		Procedure
I	III	
X	X	38. In cases where circuit breakers are supplying more than one circuit because of insufficient breakers in the panel, check that very essential equipment, such as battery chargers, are not doubled up with anything else. Check for corrosion on circuit breaker terminals and ensure that breakers are of the proper rating for the circuit being supplied.
<b>The Following Steps Apply to all of the Equipment Mentioned Above</b>		
		39. For unplanned maintenance as a result of breakdown or diagnostic tests, make the necessary repairs and note on MSF015.
X	X	40. Any changes or abnormal conditions found should be reported to the Substation Asset Management Group and noted on MSF015.
X	X	41. Distribute forms as required.
X	X	42. Update the maintenance history and nameplate information in Avantis.
X	X	43. If there are any outstanding deficiencies, flag the maintenance record in Avantis.