V.L. LINE AND SUBSTATION OPERATION AND MAINTENANCE

1.0 GENERAL REQUIREMENTS

1.1 Preventive maintenance shall be performed at a level that assures that the unscheduled outage performance of Customer owned equipment is at least as good as that of the TO's system to which it is connected.

1.2 Each facility owner shall have an established and documented program for the maintenance of all equipment critical to the reliable operation of the bulk power system.

1.3 Maintenance programs can vary in range from strict adherence to manufacturers recommendations to RCM (reliability centered maintenance), as appropriate, but should reflect Good Utility Practice.

1.4 Maintenance of equipment shall be performed such that the facility owner is able to support any local interconnection agreements. Loss of a piece of equipment due to lack of sufficient maintenance can lead to unnecessary higher operating costs and unnecessarily long outage time, consequently compromising transmission reliability. Additionally, the maintenance of system spare equipment must not be overlooked.

1.5 Substation equipment shall be maintained by qualified personnel in accordance with applicable industry standards and Good Utility Practice to provide maximum operating performance and reliability.

1.6 Incorrect operation of equipment or equipment failure should be thoroughly investigated and documented to determine the root cause of the problem. Misoperations or failures of equipment that adversely impact the Transmission System should be investigated in collaboration with the affected Transmission Owners.

2.0 EQUIPMENT AND FACILITIES

2.1 Equipment diagnostic tools and tests can be utilized in the evaluation of the need for required maintenance. Examples include dielectric testing and analysis, breaker timing, thermography scans, and acoustic monitoring. The facility owner's plan should be clear as to the application, as appropriate, of these diagnostic tools. Pass/fail ranges and testing intervals should be well documented.

2.2 Thermography scanning should be incorporated in inspections. Thermography in electrical inspection is a non-contacting operation, which is applied to in-service equipment while energized and carrying load. Problems are detected either as a function of excessive temperature

rise (such as a poor connection) or a subnormal temperature (such as a cool transformer radiator fin signifying a blocked passage). It is considered by many to be an easy and very productive method of finding potential problems before they become failures. Most utilities conduct such inspections at least annually.

2.3 Frequency of operation should also be factored into the determination of maintenance periodicity. Trending of equipment performance versus maintenance should be used to re-evaluate maintenance intervals.

2.4 For equipment under warranty all required maintenance to maintain warranty should be performed. It is suggested that equipment performance be reviewed prior to warranty expiration.

2.5 Maintenance of equipment should include diagnostics, overhauls and painting as required to maintain system integrity. Attention should be given to both the mechanical and the electrical aspects of the equipment being maintained. Use of incorrect lubricants can adversely affect equipment performance.

2.6 Adequate spare parts should be kept on hand to support maintenance.

2.7 Manufacturer's service bulletins must be acted upon in a timely manner.

2.A OVERHEAD TRANSMISSION LINES

2.A.1 Maintenance Intervals

Maintenance intervals shall be determined and appropriate maintenance action shall be performed at specified intervals.

2.A.2 Required Inspections

Inspection of transmission lines for defects can be accomplished via ground or aerial patrols. The purpose of these patrols is to identify transmission line defects which can include: loose / missing / worn hardware, broken/cracked insulators, broken conductor and static wire strands, guy wires, foundations, loose/missing structure bolts and other defects.

2.A.3 Repair & Maintenance

The defects identified during the transmission line inspection shall be repaired based upon the priority and significance of the defect. Routine maintenance activities such as structure painting, grounding system testing, right-of-way maintenance, etc. shall be performed on a routine basis

2.B UNDERGROUND TRANSMISSION CABLES

2.B.1 Pipe type cable systems require regular maintenance on pumping plants to confirm that the plants are operating reliably. Alarms are usually included in these plants to indicate that low pressure or frequent pump cycling has been detected. Ability to monitor the plant remotely is highly suggested.

2.B.2 Cathodic protection systems need to be periodically inspected and maintained to ensure long term pipe reliability.

2.B.3 Dissolved gas analysis of oil removed from the pipe system, usually taken from splice and termination locations should be performed periodically. Tracking levels of dissolved combustible gases in the dielectric fluid over time can be used as a sensitive method of identifying incipient failures in pipe type cable systems.

2.C TRANSFORMERS

2.C.1 Long replacement lead times, high first cost and the need for high reliability dictate that power transformers be maintained in accordance with Good Utility Practice. This includes attention to industry standards and to manufacturer's recommendations. Maintenance includes inspections, testing and corrective tasks. While there are manufacturer recommended and typical utility maintenance frequencies for these tasks, the frequency for activities, such as oil testing and visual inspections, may need to be increased in response to specific situations, such as an indication of a deteriorating condition that cannot be immediately addressed.

2.C.2 The following are typical maintenance activities. Note that some activities, such as temperature and oil level monitoring, require very frequent or even continuous attention. This is generally accomplished through SCADA system alarm monitoring.

Component/Activity	Visual	Cleaning	Testing	Filtering	Lubrication	Operational Testing	Test Electrical Circuits	Megger Testing	Inspect Contacts	Change Contacts	Operate
Control cabinet heating system	X					X					
Nitrogen Pressure	X										
Nitrogen equipment	X	X									
Load tap-changer:											
Main Contacts *		X							X	X	
Oil, including DGA			X	X							
Oil level indicator	X	X				X	X	X			
Pressure gauge	X	X				X	X	X			
Driving mechanism	X				X	X	X	X			
Automatic operation	X					X	X	X			
Record counter operations	X										
Monitor oil level	X										
Tank, cover, gaskets		X									
Conservator tank, sealed with rubber diaphragm		X									
Radiators		X									
Coolers with fans		X			X	X	X	X			
Valves		X									
Oil pumps with motors		X				X	X	X			
Fans with motors		X				X	X	X			
Oil, incl. DGA & water			X	X							
Bushings, (p. f. test)	X	X	X								
Oil level indicators	X	X					X				
Gas operated relay	X	X					X				
Temperature indicator	X	X	X				X				
Thermostats		X									
Flow indicators	X	X									
Pressure gauges	X	X									
Pressure relief devices	X	X									
Silica gel breathers	X	X									
Deenergized tap-changer		X			X	X	X	X			
Lightning arresters		X	X								
Relays and controls		X				X	X	X			
Alternate cooler/pump operation											X
AC station service changeover equipment						X					
Thermography scan			X								

Gas space sampling			X								
Calibrate sudden pressure relay			X				X				
Inspect for oil leaks	X										
Check bushing oil level	X										
Record LTC operations	X										

2.D BREAKERS

2.D.1 The following are typical preventive inspection and maintenance activities applicable to general purpose modern SF-6 Gas circuit breakers.

Monitoring overall condition of circuit breakers including but not limiting to checking gas pressure and corresponding temperature, operating mechanism air/hydraulic pressures , operation counters, visual inspection of porcelain and control cabinet.

Periodic preventive maintenance in accordance with Good Utility Practice and/or manufacturers instructions. Typical preventive maintenance should include but not be limited to performing infrared inspections, SF-6 gas moisture test as required, check monitoring systems for proper operation, timing test, ductor test, Doble test or equivalent.

Overhauls should be performed based on equipment condition, diagnostic testing and operating duties. Circuit breakers used under severe operating conditions such as capacitor bank switching or a process requiring breaker operation on a routine basis will require more stringent periodic maintenance.

2.E LOAD INTERRUPTING SWITCHES

2.E.1 Disconnect switches should be periodically maintained in accordance with Good Utility Practice, the manufacturer's instructions and with applicable industry standards. Periodic preventive maintenance should include but not be limited to infrared inspection, check and adjust for proper alignment, clean, lubricate and perform ductor tests.

2.F AIR DISCONNECT SWITCHES

2.F.1 Disconnect switches should be periodically maintained in accordance with Good Utility Practice, the manufacturer's instructions and with applicable industry standards. Periodic preventive maintenance should include but not be limited to

infrared inspection, check and adjust for proper alignment, clean, lubricate and perform ductor tests.

2.G SHUNT CAPACITORS

2.G.1 Capacitor equipment.

When Bank unbalance is detected by the protection, capacitance should be measured to locate the "offending" capacitor cans. Routine maintenance may include: Capacitance balance, infrared scans to find hot spots, loose connections; visual inspections, removal of birds nests, snakes etc.

2.G.2 Capacitor Switching Device

Due to frequent switching, the capacitor switching device may require more frequent maintenance than other devices such as line circuit breakers.

2.H INSTRUMENT TRANSFORMERS

2.H.1 Instrument transformers should be maintained in accordance with manufacturer's recommendations. This may include visual inspections (paint, porcelain, oil leaks), insulation power factor, and ratio tests.

2.I AC STATION SERVICE

2.I.1 AC station service system components, including engine-generators, must be periodically maintained by qualified personnel in accordance with applicable industry standards and practices to assure proper operating capability and reliable service.

2.I.2 To assure reliable operating performance diesel engine-generator maintenance must include routine exercise of the unit to its operating temperature, which requires placing adequate load on the unit.

2.J BATTERY AND CHARGER SYSTEMS

2.J.1 Batteries shall be maintained at a periodicity and in such a way as to ensure a duty cycle of at least 8 hours.

2.J.2 Battery monitoring systems are an alternative to conducting manual inspections. These systems can provide automatic notification of required maintenance.

2.K DC STATION SERVICE

2.K.1 DC station service system components should be periodically maintained by qualified personnel in accordance with applicable industry standards and practices.

2.L SUBSTATION/SWITCHYARD MAINTENANCE

2.L.1 Maintenance of the substation site shall include upkeep of any barriers, walls, buildings, fences, animal proofing and minimization of extraneous vegetation.

2.L.2 Special attention must be paid to maintenance of relay and control buildings. Roof leaks, breaches in security etc., can have immediate effects on system reliability.

2.M CARRIER CURRENT LINE TRAPS

2.M.1 Line traps should be maintained in accordance with the manufacturer's recommendations. This may include infrared scans, Inspection of the mechanical integrity of the main coil, and checks of carrier blocking performance.

2.N Surge Arresters

2N.1 Routine maintenance primarily consists of condition assessment checks. Moisture sealing systems are a common weak point. Periodic Power factor tests can be helpful in finding surge arresters on the road to catastrophic failure. On line leakage current measurement may be able to detect impending arrester block failure. In polluted environments, cleaning of the insulating housing may be required to maintain TOV performance.