GE Power Systems
Generator

Creating An Effective Maintenance Program

I. BACKGROUND

Implementing a thorough maintenance program is the most effective way to retain generator reliability and avoid major failure expenses. However, it must be cost effective in that there are demonstrated savings in improved availability & reliability to offset the cost of implementing the program. The three important elements of a thorough program are maintenance frequency, electrical testing and visual inspection. It is the intent of this instruction to provide information on each of these elements which will aid the owner/operator to establish a thorough and cost effective maintenance program.

II. MAINTENANCE FREQUENCY

There are a number of components which require routine maintenance or inspections between scheduled outages. The operator will find these recommendations in various equipment sections, and should also include additional maintenance tasks as operating experience indicates. Results of this routine maintenance should be retained in well organized files readily available for reference. These routine maintenance records coupled with the information from the monitored operating data are a good indicator of pending service or operating problems that should be addressed at the next scheduled outage. The monitored information alone is usually not sufficient for tracking or highlighting tends.

During the first several months of operation, the stator winding support system and some of the other generator components experience a break–in period with more severe duty/wear than normal. Therefore, the first major maintenance inspection is recommended for one year after it is placed in service. If the unit's operating experience has been unusual because of misoperation or very limited in–service hours, etc. you may wish to discuss your particular circumstances with your local GE Field Service Office for recommendations specific to your circumstances.

Subsequent planned outages must also be performed in a timely fashion. Experience has shown that regularly scheduled maintenance outages are one of the most important steps in retaining unit reliability and reducing major repair/failure expenses. A minor maintenance outage is recommended every 30 months. During these outages the end shields or end plates are removed to permit inspection from the end winding area, but the field remains in place. A major outage is recommended every 60 months, and includes removing the field from the stator which permits a thorough inspection of the core section of the stator and field. The maintenance must include a comprehensive series of electrical tests and a thorough visual inspection. Each has their particular advantage and neither alone is sufficient.

Older generators with asphalt insulated stator windings and core lengths greater than 150 inches are subject to girth crack failures in the stator bars, and therefore, these generators should be reinspected twice as often (Minor Outage – 18 months; Major Outage – 36 months).

These recommended outage intervals have proven themselves over many years of use. However, high equipment reliability and outage costs, have lead to increasing interest in extending the time between major inspections. Condition Based Maintenance (CBM) is one method in development to do this, and is the focus of considerable attention in the industry. CBM relies on availability of reliable on–line instrumentation and evaluation techniques. As these evaluation methods become proven and practical, they will be incorporated into recommended operation and maintenance packages such that maintenance outages can be scheduled based on the condition of the unit.

III. TESTING

Generator electrical testing is focused on the insulation systems. However, there are other tests used to monitor for degradation in other components. A list of the typical tests recommended and the test purpose is shown in Table 1. Historical records of test results should be maintained and compared to the new test results. Changes between outage test results may point to needed repairs/rework that may not be evident from the absolute test values themselves.

Many of the tests require special equipment. Test results may be misleading and useless if the right equipment is not used, or it has not been properly maintained and calibrated to assure accurate results.

TABLE 1 – RECOMMENDED STANDARD TESTS

Test	Areas Of Interest	Inspection Objectives & Assessment
(At Each Minor Outage)		
RTD Element Cu. Res.	Stator Gas & Winding	Check for calibration & poor connections
RTD Ground Insulation	Stator Winding	Insulation condition
Winding Copper Res.	Field & Stator Windings	Check for poor connections & breaks
Megohmmeter	Stator & Field Winding Bearing & Hydrogen Seal Ins.	Insulation condition Integrity against shaft voltage
Over Potential/Hipot	Stator Winding	Ground wall insulation integrity
DC Leakage Current	Stator Winding	Contamination and/or deterioration
AC Impedance	Field Inter–Turn Insulation	Turn shorts & speed sensitive turn shorts
Vacuum Decay	Water Cooled Stator Winding	Water leaks in stator winding & hydraulic circuit
Pressure Decay	Water Cooled Stator Winding	Water leaks in stator winding & hydraulic circuit
(At Each Major Outage With Field Removed)		
Tracer Gas/Helium	Water Cooled Stator Winding	Detect minute leaks
Capacitance Mapping	Water Cooled Stator Winding	Wet ground wall bar insulation
Magnetic Scalar Potential (EL CID)	Stator Core Insulation	Weak or damaged core enamel
Wedge Tightness Map	Stator Wedges	Detect wedge tightness deterioration

(Optional/ Diagnostic Tests)

Test	Areas Of Interest	Test Objectives & Assessment
Partial Discharge Analysis	Stator Winding Insulation	Localized deterioration
Over Potential/Hipot	Field Ground Insulation	Ground wall insulation integrity
Water Flow Verification	Water Cooled Stator Winding	Restrictions in hydraulic circuit
Core Ring Test	Stator Core Insulation	Weak or damaged core enamel
Dynamic Freq. Response	Stator End Winding	Potentially damaging resonance
Air Gap Flux Probe	Field Inter–Turn Insulation	Turn shorts at operating speed

IV. INSPECTION

A visual inspection performed by an experienced individual can disclose unit conditions not detected by monitoring equipment or indicated by tests. Even the stator and field insulation systems must be significantly degraded to be detected by electrical testing. Also, for example there is not a definitive test for contamination, rust or oil and water leaks, and yet the presence of any of these could significantly adversely affect reliability and operation. A typical inspection should include those items listed in Table 2.

As important as it is, visual inspection is limited to areas that can be accessed for view either directly or with mirrors, boroscopes, cameras, etc., and therefore, it must be combined with testing to give a complete picture of generator condition.

TABLE 2 – VISUAL INSPECTION AREAS

		Foreign Material/Contamination	Cleanliness	Loose or Displaced Parts	Movement	Mechanical Damage	Deterioration (General)	Corrosion	Surface Condition and Wear	Water Leaks (Water-Cooled Winding)	Cracks	Worn Parts	Burning	Blocked Ventilation	Bar Sparking	Tape Migration	Broken Ties	Shorted Core Punchings	Core Tightness
Stator	**All Components**	X	X	X	X	X	X												
	Bars									X	X	X	X		X	X			
	EW Support System										X	X		X					
	Slot Support System											X		X	X				
	Conn. Rgs & Lower Lds.									X	X	X	X				X		
	High Voltage Bushings									X	X		X	X					
Core	**All Components**	X	X	X	X	X	X	X										X	X
	Core End										X		X	X					
	Ventilation Ducts													X					
	Laminations												X					X	X
	Key Bars																		X
Field	**All Components**	X	X	X	X	X	X	X	X										
	Body & Wedges										X		X	X					
	Retaining Rings										X		X						
	Fans										X								
	Spindles										X	X							
	Winding													X					
	Collectors											X	X						

V. MAINTENANCE PLANNING

Major maintenance outages are usually scheduled well in advance of the actual outage date, and preparation for the outage should begin early. An important part of that is to review previous inspection reports for any indication of work needed, and review recommendations from GE communicated by Technical Information Letters, Engineering Change Notices, etc. to integrate those items into your plans. Materials you expect to need should be ordered to have available at the start of the outage to avoid the risk of costly delays waiting for material.

Your maintenance program should reflect the level of acceptable risk for the unit. That will probably vary from unit to unit and plant to plant, and will change over time as the importance of the unit to the power system changes. In addition, new technologies are constantly being developed to improve unit reliability, performance, monitoring & inspection equipment, and otherwise provide more cost effective means for maintaining the generator. The owner/operator should be aware of these developments and modify the maintenance program accordingly. While this should be a continuous process, the "maintenance outage planning review" is an appropriate check point.

Your local GE Field Service Office can assist you in your maintenance planning, and review of your overall maintenance program, incorporating any appropriate new maintenance and upgrade technologies available.

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