GE Energy

Hydro Generator Test and Inspection Condition Assessment Service

Hydro Test and Inspection Service "T&I Service"

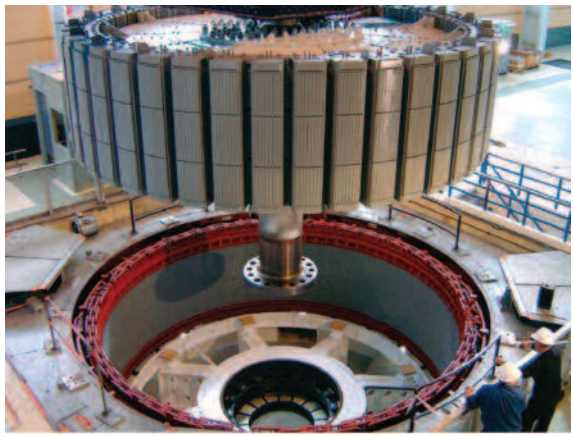
Customers with Hydro Generators in their power generation fleet can purchase Electrical Testing & Visual Inspections Services performed by highly trained hydro professionals from GE Energy, one of the leading equipment suppliers and overhaulers. Not knowing the actual condition of units in service can lead to unscheduled outages, unplanned repair cost, and reduce online availability. Realizing the benefits from T&I Service can:

- Improve maintenances practices, plan and schedule annual maintenance, and reduce risk of unscheduled outages
- Improve outage planning and scheduling, implication of recommendations, and reduce unscheduled outage risk
- Identify critical spare parts and components to stock in inventory to reduce outage durations
- Establish base-line condition, long-term trending of unit and fleet operating history comparison
- Reduce O&M cost, preventative schedule maintenance, and reduce annual insurance premiums
- Reduce budget for testing and instrumentation staff and overheads
- Increase annual revenue, and improve unit online availability

The Hydro T&I Service offers three levels of tests and inspections with options for additional electrical tests and visual inspections.

Level 1 T&I – Annual Health Check (limited access) Duration – One to Two Days

Level 1 is a standard off-line health condition assessment. Electrical tests are performed at the generator main leads and visual inspections are conducted if access is available on the stator, rotor, and exciter to assess the winding insulation condition



depending on generator configuration and access to component. Upon completion of the testing and inspection, the customer receives a T&I Service report with recommendations. Depending on unit access, test performed, and outage time, the report will indicate the condition of stator, rotor, and exciter insulation integrity. Following is the list of tests that are performed for each component at Level 1, depending on access:

Stator

- Insulation Resistance
- Polarization Index
- Winding Resistance
- Offline Partial Discharge Test and Analysis
- Offline Tan Delta Test
- Offline Power Factor (or Doble) Test

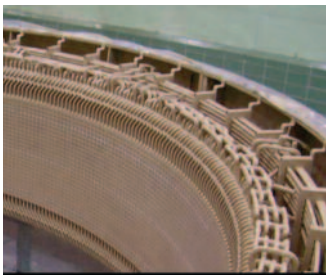
Rotor

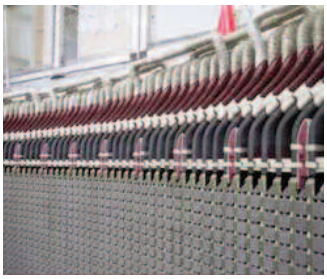
- Insulation Resistance
- Winding Resistance
- Drop Voltage Test for Rotor Poles

Exciter

Brushless Exciter

- Insulation Resistance & Polarization Index for Armature
- Insulation Resistance for Field





DC Exciter

- Insulation Resistance & Polarization Index for Armature
- Insulation Resistance for Field and Collector Assembly
- Drop Voltage Test for Rotor Poles

Static Exciter: Visual inspection only

Level 2 T&I – Minor Inspection (Covers Removed, Limited Access Rotor Remains In-Situ) Duration – Three to Four Days

Level 2 includes all tests performed during a Level 1 T&I with additional visual and borescope inspections. Removing generator access panels allows for the inspection of the end windings of the stator and rotor parts. Further disassembly allows inspections of the rotor and stator components, depending on generator design configuration and access for T&I Service. Upon completion of the testing, the customer receives a T&I Service report with findings and recommendations for maintenance and repair, if necessary.

A Level 2 T&I will indicate the condition of the stator and rotor insulation integrity, including visual assessment of the end winding areas, and accessible component condition. Following is the list of tests that are performed for each component at Level 2, depending on access:

Stator: All Level 1 Tests plus:

- Top Ripple Spring Deflection
- DC Hipot Test
- DC Leakage Test
- Borescope Inspection for Vent Slots

Rotor: All Level 1 Tests plus:

- Borescope Inspection for Rotor PolesZ

Level 3 T&I – Major Inspection (unit fully disassembled, rotor removed full access) Duration – Five to Seven Days

Level 3 is a major inspection with the rotor removed and full access gained. Along with all the electrical tests performed in a Level 1 and 2 T&I, this overhaul allows for a full inspection of the rotor and stator components, including assessment of structural components, stator wedges, and the stator lamination insulation. Upon completion of the testing, the customer receives a T&I Service Report with documentation of findings with recommendations for maintenance, parts, repairs, rewinds, and proposed inspection schedules. These electrical tests and visual inspections by GE's experienced technicians will evaluate the complete stator, rotor, and exciter windings. A compiled in-depth analysis of the generator condition is achieved enabling a thorough evaluation of the generators operation and maintenance requirements. Following is the list of tests that are performed for each component at Level 2, depending on access:

Stator: All Level 2 Tests plus:

- Core Slot Resistance
- RTD Resistance
- Core Ring (Loop) or EL CID Tests
- Stator Roundness

Rotor: All Level 1 and 2 Tests

Exciter: Same as Level 1 & 2

With millions of hours of hydro experience and a wealth of technical expertise to draw on, GE Energy's engineering teams have the knowledge to recommend preventative maintenance, spare parts requirements, and identify major component issues that could improve online availability and reduce the risk of unscheduled forced outages.

GE's Hydro T&I Service is geared to support your operating needs, goals, and reduce the risk of unscheduled forced outages that could affect revenues. The Hydro T&I Condition Assessment Report with recommendations is based on actual unit condition and operating practices. Implementation of recommendations can reduce the risk of unscheduled outage, improve online availability, and stabilize the maintenance budget. No other service can identify potential risk and provide long-term solutions for less.

Stator Windings & Rotor Field Poles Life Limitations

Stator Windings and Rotor Field Coils have a limited life expectancy and should be tested and inspected every year to assess their condition; plan and schedule maintenances outages; plan and schedule repairs as needed; replace parts or perform scheduled rewinds, restacks, and field pole refurbishments or upgrades to the generator components.

Hydro Background

Although hydro generators are designed to operate over long periods of time with minimal maintenance, unit thermo cycling, high stress on mechanical components, and electrical insulation resistance breakdown can cause:

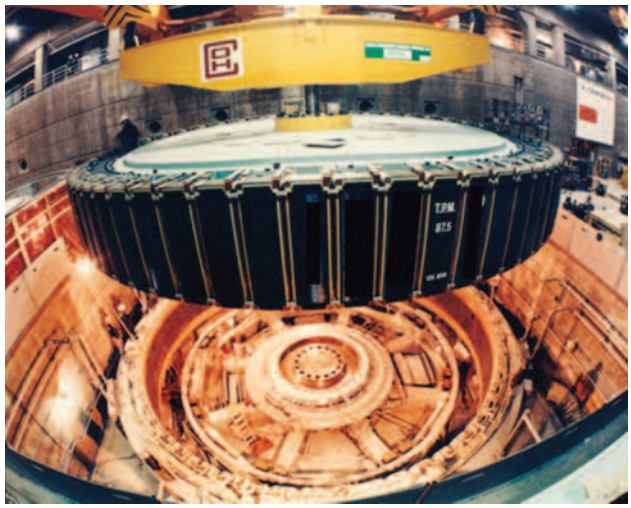
- Major component failures and increased maintenance cost beyond recommended budget.
- Long duration unscheduled outages for stator rewind or recore and rewind, or rotor field coil replacement. Repair cost can range over $5 million, depending on unit size.

Variables that can impact rotor life include:

- Maintenance practices
- Operating history
- Material properties
- Forging
- Stress/temperature

Conditions that may limit hydro generator life dependency include:

- Insulation systems are reaching life expediency and need to be replaced with modern systems
- Dirt, oil, and carbon buildup on stator windings and rotor field coils can lead to reduced air flow and cooling, electrical rating, and an increase in temperature that can cause major failure
- Loose stator winding wedges can cause mechanical damage to windings, leading to high corona levels and winding failure
- Stator core to frame key bar fretting, corrosion, and weld failure can cause core distortion and unit failure



Decisions involving extending the life of a hydro generator stator or rotor must be based on an actual testing and inspection condition assessment to determine the best course of action for each unit.

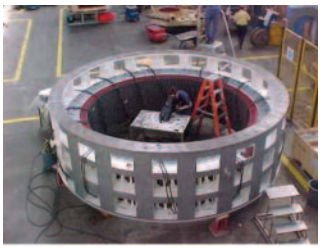
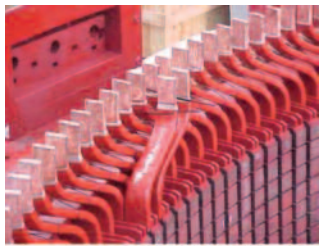
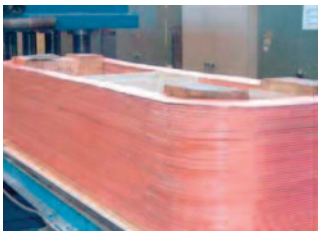
Recognizing these challenges, GE Energy provides programs designed to support you in extending the life of your hydro generator stator, rotor, exciter, and auxiliary components.

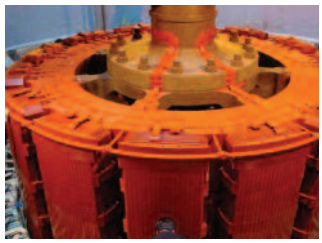
Hydro T&I Program Features

- Generator health and long-term life condition assessment test and inspection per level 1, 2, and 3 (performed at site)
  - Electrical testing of stator and rotor winding, excitation system, and pony motor
  - Visual inspections of stator, rotor, excitation and auxiliary components and equipment
  - Mechanical components and dimensional inspections (option)
- Unit-specific recommendations based on engineering analysis of the actual tests and inspections may indicate risk of unit failure. If so, the recommendations could include a repair plan.

The Hydro T&I Condition Assessment Service is applicable to:

- All OEM generators of any type, style, and vintage including smaller older units with cast iron stator frames, and today's units with fabricated large diameter stator frames with liquid cooled winding ranging up to and beyond 900 MVA



Hydro T&I Service Benefits

- The T&I Service can be tailor to customer needs, budgetary requirement, and operational contingency. Options can be performed beyond the basic level 1, 2, and 3 testing and inspections
- Advanced planning and scheduling that offers flexibility to meet power demand and scheduling requirements
- Provide long-term unit base-line data for forecasting the future
- Maintenance budgets, outage planning, and scheduling for repairs and component upgrades and risk analysis to meet contract supply comments

Develop your most effective generator O&M program, plan your future maintenance strategy with your GE representative, and develop a long-term T&I Service plan/schedule to help ensure generator reliability and lower risk of unscheduled forced outages during peak demand periods.

GE can also supply options for major equipment overhauls, rewinds, upgrades, and component replacements that can reduce planned outage durations. Beginning with the Hydro T&I Condition Assessment Service process to analyze the base-line data, then continuing with annual follow-up, T&I can produce an effective predictive maintenance program that will allow you to plan and schedule regular maintenance and major overhaul outages before major component failures occur.

Contact your local GE representative for assistance or for additional or visit www.gecom/energy

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