

Hydro Generator Test and Inspection Condition Assessment Service



ABB offers a wide range of products and services to hydro customers, to help ensure overall dependability and quality operation of their equipment.

Our Hydro Generator Test and Inspection (T&I) Condition Assessment Service is one offering that is performed by highly skilled professionals to help support a customer's understanding of the actual condition of their equipment. Not knowing the condition can lead to unscheduled outages, unplanned repair costs, reduced on-line availability, and therefore lost revenue.

Realizing the benefits of ABB's Hydro Generator T&I Condition Assessment Service will:

- improve maintenance practices, outage planning, and scheduling
- identify critical spare parts in order to reduce outage durations
- establish base-line condition of units
- reduce O&M costs and annual insurance premiums
- increase annual revenue and improve on-line availability
- identify potential performance improvements

From original operation to in-kind refurbishments to equipment upgrades, the performance of hydro generators will continue to trend downward over time, even during normal operation. The goal of the

T&I plan is to provide a service that maximizes performance over the life of the equipment. ABB is well equipped to diagnose and provide equipment refurbishments (restoring equipment back to original performance levels) and/or upgrades (enhancing equipment beyond original performance levels with improved materials, designs, etc.)

As part of the service, customers will receive a final report documenting the results of the electrical tests and visual inspections performed, as well as both immediate and long term recommendations. Recommendations related to spare parts, future repair needs and additional proposed inspection schedules are also included.

Standard and Optional Tests and Inspections per Level

Table 1 below illustrates the standard and optional tests and inspections that will be performed in each T&I level. Due to various unit configurations, accessibility to all areas may not be possible. A brief description of each test, as well as visual inspections areas is provided on the following pages.

ABB can provide customers with three levels of Hydro Generator T&I Condition Assessment (see Table 1):

- **Level 1 – Rotor In / Minimum Access to Generator**
 - Electrical tests are performed at the generator main leads and visual inspections conducted if access is available
- **Level 2 – Rotor In / Some Covers Removed**
 - In addition to Level 1 inspections, removal of some panels allows more access to perform visual inspections of stator and rotor components
- **Level 3 – Rotor Out / Full Access to Entire Generator**
 - In addition to Level 2 inspections, allows for a complete inspection of the generator stator and rotor, including assessment of structural components, wedge system, stator lamination insulation, etc.

Table 1

	Offering	Description ¹	Level 1	Level 2	Level 3	
			Rotor In	Rotor In	Rotor Out	
			Duration in Days ²			
			1-2	3-4	5-7	
Stator	Standard	Insulation Resistance & Polarization Index (PI)*	X	X	X	
		Winding Resistance*	X	X	X	
		Visual Inspections (See Table 2)	X	X	X	
		Wedge Tightness Checks			X	
		RTD Resistance*			X	
		Borescope Inspection of Vent Slots (100% of selected slots)			X	
	Optional	PDA Test (Off Line)*	X	X	X	
		Power Factor (Doble) Test (Off Line)*	X	X	X	
		Core Loop Test*			X	
		EL CID Test*			X	
		Wedge Tightness Checks		X		
		AC or DC Hipot Testing*		X	X	
		DC Leakage Test*		X	X	
		Borescope Inspection of Vent Slots		X		
		Air Gap Measurements		X		
				X		
Rotor	Standard	Insulation Resistance (Includes Collector Rings if applicable)*	X	X	X	
		Winding Resistance*	X	X	X	
		AC Drop Voltage Test*	X	X	X	
		Visual Inspections (See Table 2)	X	X	X	
		Borescope Inspection of Rotor Poles			X	
	Optional	Borescope Inspection of Rotor Poles		X		
	Exciter	Standard	Type: BRUSHLESS EXCITER			
			Insulation Resistance & Polarization Index (Armature)*	X	X	X
			Insulation Resistance (Field)*	X	X	X
			Visual Inspections (Includes Rectifier Assembly) (See Table 2)	X	X	X
Type: DC EXCITER						
Insulation Resistance & Polarization Index (Armature)*			X	X	X	
Insulation Resistance (Field)*			X	X	X	
Insulation Resistance (Collector Assembly)*			X	X	X	
AC Drop Voltage Test (Rotor Poles)*			X	X	X	
Visual Inspections (See Table 2)			X	X	X	
Type: STATIC EXCITER						
Visual Inspections (See Table 2)	X	X	X			

¹ Additional tests and inspections (i.e. bearings, brakes, etc.) can also be performed and will be discussed with customers as appropriate

² Durations are approximate and may change based on generator configuration and/or number of optional tests and inspections performed.

Brief Test Descriptions

Electrical

- **Insulation Resistance & Polarization Index** - a basic characteristic of all insulating materials and has been recognized for many years as one measure of a system's reliability. Factors affecting insulation resistance are contamination, moisture, dust, dirt, oxidation and material degradation due to mechanical and/or electrical factors.
- **Winding Resistance** – recorded to provide current winding resistance, which can be compared to prior tests for trending purposes.
- **RTD Resistance** – performed to ensure the resistance temperature detectors (RTD's) are functioning properly in all slots.
- **PDA Test (Off Line)** – utilizes existing PDA couplers to record current partial discharge results of the winding. Results can be compared to prior test results for trending purposes.
- **Dissipation Factor / Power Factor (Doble) Test (Off Line)** – results can be compared to prior tests to indicate insulation condition changes. These changes can be caused by factors such as contamination or insulation degradation.
- **Stator Core Loop Test** - to determine and identify stator core iron issues when simulating rated flux density.
- **Stator Core EL CID Test** - a low power alternative to the Stator Core Loop Test. It avoids the testing problems of set-up and safety usually associated with the high excitation of the stator core loop test, yet provides an accurate indication of lamination damage.
- **AC or DC Hipot Testing** – typically performed at “suitability for service” levels (or unit voltage x 1.25 = kVAC test voltage) to ensure the integrity of the insulation system. Test levels and plan will be reviewed with customer prior to performing actual test.
- **DC Leakage / Absorption Test** - performed to ensure the integrity of the stator insulation system. A series of high voltage insulation resistance measurements taken at increasing steps of test voltage on a scheduled time basis. Test data is very useful for trending purposes to highlight potential insulation degradation.
- **Rotor AC Drop Voltage Test** - to identify shorted turns in rotor poles. Performed by applying an AC voltage across the entire field pole circuit and measuring the voltage drop on individual poles.

Non-Electrical

- **Wedge Tightness** – the purpose of the stator wedge is to retain the coil/bar into the slot with the proper tightness, while also preventing movement in the slot. Inspection will confirm if there are hollow or loose wedges, and may result in the need to perform a complete or partial rewedge of the stator.
- **Borescope Inspection of Vent Slots** - to detect contamination, blockage, as well as corona armor damage. Extra attention is focused on the high voltage portion of the winding.
- **Borescope Inspection of Rotor Poles** – to detect loose or broken connections, coil damage, ground and turn insulation movement and/or cracking.
- **Stator Roundness / Air Gap Checks** – to identify conditions that may be outside acceptance criteria for normal operating conditions.

Visual Inspections and electrical testing will be performed by qualified ABB personnel, and all ABB and/or site EHS guidelines will be strictly adhered to.

Historical records of outage test results should be maintained and compared to the new test results. Changes may point to needed repairs and/or rework that may not be evident from the absolute test values themselves.

Visual Inspections

All visual inspections will be performed by experienced ABB Hydro Field Engineers. The Field Engineers have the ability to disclose unit conditions not detected by monitoring equipment or indicated by testing. In some instances, electrical testing will only detect issues when the stator and/or rotor insulation systems have been degraded. For example, there is no definitive test for contamination, rust or

oil, etc., yet the presence of any of these items could significantly adversely affect generator reliability and operation. Typical hydro generator visual inspections will include the key components listed below in Table 2.

Visual inspections are limited to only those areas that can be accessed for view either directly or with mirrors, borescopes, cameras, etc., and therefore, must be combined with electrical testing to provide a complete picture of the generator condition.

Table 2

Key Components Inspected	Foreign Material / Contamination	Cleanliness	Loose or Displaced Parts	Vibration	Mechanical Damage	Deterioration (General)	Corrosion	Surface Condition (General)	Cracks	Worn Parts	Overheating or Burning	Corona Activity	Tape Migration / Irregularities	Broken Ties	Radial Migration	Core Tightness	Dusting and/or Greasing	Insulation Damage	Ventilation Obstructions	Oil / Water Leakage	Distortion	
	Stator																					
Frame (Keybars, Core Studs)	X	X	X	X	X	X	X	X	X													X
Core Assembly (Laminations, Finger Plates)	X	X	X	X	X	X	X			X				X	X			X				X
Slot Section (Slot Fillers, Wedges, Ripple Springs)	X	X	X	X	X	X			X	X	X							X	X			
Endwinding Support System (Bracing, Ties, Coil/Bar Insulation)	X	X	X	X	X	X			X	X	X	X		X			X	X	X			
Circuit Rings and Main & Neutral Leads	X	X	X	X	X	X				X	X	X						X	X			
Coolers	X	X	X	X	X	X			X													X
Rotor																						
Pole Amortisseur Winding	X	X	X	X	X	X	X	X	X	X								X	X			X
Pole Connections & Leads	X	X	X	X	X	X	X	X	X	X				X				X	X			X
Pole Mechanical Components (Fans, Fan Blades, Keys, Hardware)	X	X	X	X	X	X	X	X	X	X												X
Pole Coil Winding	X	X	X	X	X	X	X	X	X	X	X	X						X	X			X
Collector Rings & Brush Rigging	X	X	X	X	X	X	X	X	X	X							X		X			X
Pole Supports & Hardware	X	X	X	X	X	X	X		X	X								X	X			X
Exciter																						
Brushless, DC or Static Exciters	X	X	X	X	X	X	X		X	X								X				X



Implementing a thorough operations and maintenance program is the most effective way to retain hydro generator reliability and avoid major unplanned failure expenses. However, it must be cost effective in that there are demonstrated savings in improved availability and reliability to offset the cost of implementing the program. The most critical elements of a thorough program are performing routine electrical testing and visual inspections.

Let ABB's team of Hydro professionals (i.e. Project Management, EHS, Engineering, Field Engineers, Technical Specialists, Craft Labor, etc.) help develop your most effective long-term T&I service plan to ensure generator reliability and lower the risk of unscheduled forced outages during peak demand periods.

The purpose is simple. Regardless of age or original manufacturer, ABB's Hydro Generator Test and Inspection Condition Assessment Service is focused on supporting our customers efforts to manage equipment successfully throughout its lifetime, thereby maximizing their total investment.

ABB Inc.
305 Gregson Drive
Cary, North Carolina 27511
USA

solutions.abb/industrial-services

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Contact us:
For more information, call us toll free at +1 888 434 7378, or +1 540 387 8617 and email us at us-hydroservices@abb.com.

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