

# **Generator Specification and Outage Considerations**

**National Electric Coil**

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Service Manager

# Discussion Topics

- Specification Purpose
- Outage Priorities & Resource Alignment
- Planning, Performing & Documenting Generator Outages for use in the spec
- Outage Execution
- Outage Wrap Up & Lessons Learned

# Specifications

- The purpose of the specification is to clearly define the expectations and requirements for the project.
- The best time to develop specifications is before you need them!
- Overall Philosophy?
  - Tell us what to do, not how to do it.
  - Clearly State Expectations and Requirements
  - Minimize Risk

# Primary Generator Specifications

- Test & Inspect
- Stator Rewind
- Stator Coil Manufacturing
- Re-insulate Field Poles
- Core Replacement

# Owner Outage Priorities

- Reliability
- Cost
- Time (schedule)
- Quality

**“This even applies to the black box”**

# Maintenance Review

- Standard Equipment Monitoring
- Visual Inspection
- Stator – Electrical Testing
- Stator – Special Testing
- Field Pole – Electrical Testing
- Core – Special Testing

# Testing Summary

## BE SURE ALL CIRCUITS ARE DE-ENERGIZED)

MAINTENANCE ACTIVITY	SHOWS	FREQUENCY
Dielectric Absorption	Winding cleanliness	Major Outage
Polarization Index (PI)	Winding cleanliness/moisture	Major and Minor Outage Cycles
Power Factor	Insulation integrity	Major Outage Cycle
Partial Discharge (PD)	Coil tightness; insulation integrity	On-line or Outage Cycle
Megger	Integrity of Insulation	Major and Minor Outage Cycles
Blackout	Corona suppression integrity	Rewind
Resistance	Integrity of joints and connections	Major and Minor Outage Cycles
Flux Probe	Rotor winding shorts	On-line, Rewind
Rotor Impedance	Rotor winding shorts	Rewind
Ground Fault	Rotor Ground	Continuous
Split Voltage	Location of rotor grounds	As Needed
Voltage Drop	Presence of shorted turns	Major Outage Cycle
El Cid	Integrity of stator core	Major Outage Cycle
Core Loop	Integrity of stator core	Major Outage Cycle
Bolt Torque	Stator core looseness	Major Outage Cycle
Ultrasonic	Cracks, defects in forgings	Major Outage Cycle
Temperature Monitoring	Normal/abnormal operation	On-line and Continuous
Dye Penetrant	Cracks, defects in forgings	Major Outage Cycle
Eddy Current	Cracks, defects in forgings	Major Outage Cycle
Magnetic Particle	Cracks, defects in forgings	Major Outage Cycle
Wedge Mapping	Stator winding tightness	Major Outage Cycle
Hi-Pot	Insulation integrity	Major Outage Cycle
Vibration	Rotor imbalance	Monthly and On-line
Visual Inspection	Normal/Abnormal Performance	As Available
Oil Chemistry and Count	Bearing oil contamination	Twice Yearly

# Four Primary Types of Outages

- **Minor – General Maintenance / Rotor In**
- **Major – Rotor Out**
- **Life Extension – Rewind / Replace**
- **Forced Outage**

# Minor Outages

(rotor in)

- Establish and follow your maintenance plan
- Review past outage reports, especially findings and recommendations
- Consider extra work contingencies
- Division of responsibilities with vendors
- Cooperatively interact with vendors

# Division of Responsibilities List

Item	Plant	Vendor
Crane	X	
Crane Inspection	X	
Crane Operator		X
Project Office		X
Phone Lines (2)	X	
Ethernet, H.S. Internet Line	X	
Scaffolding	X	
Shop Air	X	
220V; 50 Amp Electrical Distribution Panel	X	
Loop Test Power; 2300 V 200A	X	
Loop Test Cable to Breaker		X
Port-o-Johns		X
Wash Room Facilities		X

**For Example only**

# Major Outages

(Rotor Out)

- Get started early!
- Start by reviewing OEM and other previous vendor recommendations and their past outage reports.
- Before finalizing specifications, interact with vendors to be sure all scope options and solution options have been considered.

# Major Outages cont.

## (Rotor Out)

- Establish hard milestone interaction points with vendor(s) to review findings and limit wasted time in acting upon issues needing immediate attention.
- Review special tools inventory and condition. Offer inspection by vendor.
- Crane condition and certification?
- Rotor support and protection based upon scope?
- Rotor Shipping preparation – Permits? Holiday restrictions?

# Major Outages cont.

## (Rotor Out)

- Vendor site orientation
  - Safety requirements
  - Coordination & Cooperation with other vendors and work being done at the same time
  - Lay down plan
  - Site support resources
- Vendor – Plant contact points
- Mobilization plan
- Will FME be required? If so, program / process?  
Who should have access?
- Other – this is only a partial list, there many things along this line to consider; as well as unique company, plant, unit, and project specific items.

# Rewind Considerations

## Newer vs. Older

### Newer Vintage

- Rewind Cause – normally one or a combination of:
  - Design concern
  - Material concern
  - Operational concern
- What is the root cause?
  - Specific – not a symptom
  - How can it best be corrected
- How can long-term reliable life best be achieved?

### Older Vintage

- Rewind Cause – normally age deterioration of components. Possibly machine characteristic change to support system needs.
- Were there any major technical deficiencies in the machine?
- Is an Up-Rate desirable?
- Incorporation of new materials and technologies

# Rewind Considerations

## Planning

- Solution to the Root Cause?
- Safety Expectations
- FME?
  - Level
  - Process for access
  - Who can enter
- Division of Responsibilities is crucial especially:
  - Utility requirements
  - Lifting
- Vendor coordination on the generation deck
- Lay-down space allotment – Plant Overhead Drawing

# Planning, Performing & Documenting Generator Outages

- Should be a proactive effort
- Create a “Bull Pen” – Qualified Vendors
- Expand your vendor options – Data Collection
- Establish Blanket T&C’s with key vendors
- Become knowledgeable about your machine – “Go to School”
- Develop Performance based specifications
- Consider improvements in maintenance practices
- Effectively plan and execute outages
- Be prepared for emergencies
- Document and properly trend generator information

# Creating a Qualified Bull Pen

- Baseball teams (users) have Bull Pens for their Pitchers (vendors). Shouldn't you?
- How can you be sure Vendors have the “stuff” and are ready to pitch?
- What are some of the key considerations?

# Vendor Selection Criteria

- Company Experience & Relations With Past Customers
- Safety Program & Record
- Cost / Value
- Engineering Resources
- Facility Resources
  - High Speed Balance Pit
  - Machining
  - Cleanliness
  - Lifting Capacity
  - In House Technology
- Capacity Capabilities
  - Shop Loading / Capacity
  - Performance to Schedule
- Coil Supply, Repair, and Manufacturing
  - Experience
  - Demonstrated Reliability
  - Visit Facility
  - Delivery
- Personnel Resources
  - Background
  - Experience
  - Depth
- QA/QC Programs
  - Documentation and Archiving
  - Certification
  - In Process checks

# To Expand Your Options - Winding Data Is Essential !

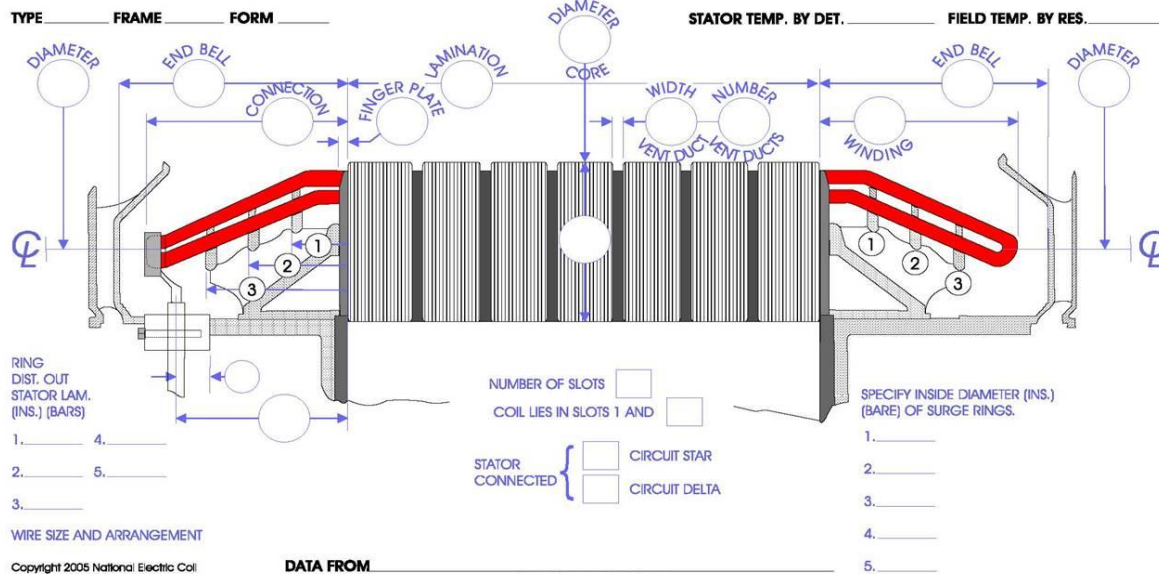


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### STATOR CORE AND WINDING DATA FOR TURBO-GENERATORS

UNIT #/s _____	#Hg <u>0.5</u>	STATOR AMPS _____	FIELD AMPS _____	DATA TAKEN BY _____	DATE _____
MAKE _____	KVA <u>15</u>	RPM _____	PHASE _____	STATOR VOLTS _____	EXC. VOLTS _____
MACHINE _____	30 _____	CYCLE _____	P.F. _____	SER _____	
TYPE _____	FRAME _____	FORM _____	STATOR TEMP. BY DET. _____	FIELD TEMP. BY RES. _____	



# “Go to School”

- Know your machine and it's specific issues
- Sources of Information
  - Past Outage Reports
  - Trended Information
  - Other Users
  - Users Groups
  - Vendors
  - Technical Papers
  - Exhibitions
  - IEEE
  - Web Sites



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### TMM 402: Stator Winding Data Banking

**Applications:** Generator owners can benefit from NEC's Stator Winding Data Banking Service. When the OEM is the only holder of detailed winding data, owners may find themselves with the qualified bidders that can supply a quality replacement winding. With NEC's Data Banking Service, owners can create a competitive bidding situation between the OEM and NEC. This service includes measurement of your stator winding to track new coils can be manufactured at any time in the future. It is available for all generator makes and models, from 1 MW to 1,000 MW and typically, is available to owners at no cost.

**NEC's Technical Maintenance Memo™ Recommendations**  
NEC's stator winding data for stator faulting, generators and hydrogenerators. We make the highest quality coils utilizing an ISO 9001:2000 certified quality management system. This includes windings for all OEM machines, including air- or hydrogen-cooled machines, inner-cooled machines with single- or double-side slots bars, or machines with water-cooled bars. Owners wishing further savings in schedule and budget for expedited replacement windings may want to take advantage of our Coil Ready Package program. This program jumps starts the manufacturing process with early completion of the engineering design and prototype manufacturing and testing stages. See our Specialized Engineering Solutions™ equipment, SES-401, for more information. Highlights of this program are detailed in the far left column.

**NEC Qualifications & Resources**  
An industry leader in generator rewinds and repairs, National Electric Coil has specialized in the manufacture of stator and rotor windings for the last 50 years. NEC is recognized in the industry by owners and insurers as a qualified alternative to the OEM, because of its expertise in designing and manufacturing windings and servicing generators.

**Call Us Today!**  
If you have additional questions about our Stator Winding Data Banking Service or our Coil Ready Package program, please call or email Bill Moore at 614.488.1101 x100, [moore@national-electric-coil.com](mailto:moore@national-electric-coil.com) or Steve Jerny at 614.488.1101 x105, [jerny@national-electric-coil.com](mailto:jerny@national-electric-coil.com).

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IEEE Std 1434-2000

## IEEE Trial-Use Guide to the Measurement of Partial Discharges in Rotating Machinery

Sponsor  
Electric Machinery Committee  
of the  
IEEE Power Engineering Society

Approved 26 April 2000  
IEEE-SA Standards Board

**Abstract:** A review of the nature of partial discharge in machine windings, how it can be measured under both off-line and on-line conditions, how it can be measured for individual form-wound coils or bars, and the significance and limitations of the measured values are covered.  
**Keywords:** electrical insulation, form-wound bars, form-wound coils, partial discharge, rotating machine windings

# IGTC Forum



## INTERNATIONAL GENERATOR TECHNICAL COMMUNITY

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**[www.GeneratorTechnicalForum.org](http://www.GeneratorTechnicalForum.org)**

# Terms and Conditions

- A necessary evil for everyone in business today
- If handled before problems arise, the focus remains on the problem, when they do arise
- Companies need Vendors & Vendors need business! Without a prior commercial understanding, they may not get together.

# Blanket Terms & Conditions

- The process usually takes an extended period to resolve
- Should emergencies arise, an absence of T&C's, with qualified vendors, can cause major delays and increased cost

# Blanket Terms & Conditions cont.

- Four most common T&C sticking points:
  - Indemnification
  - Limitation of Liability
  - Warranty
  - Termination

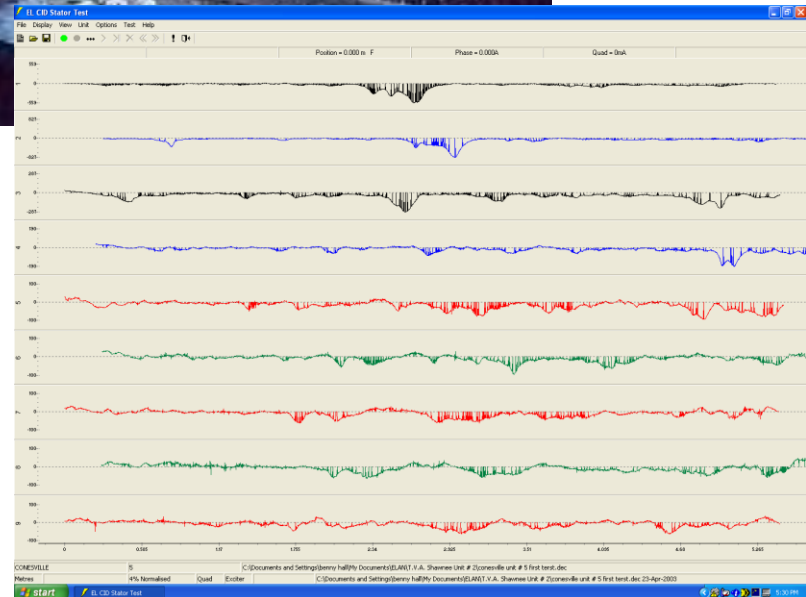
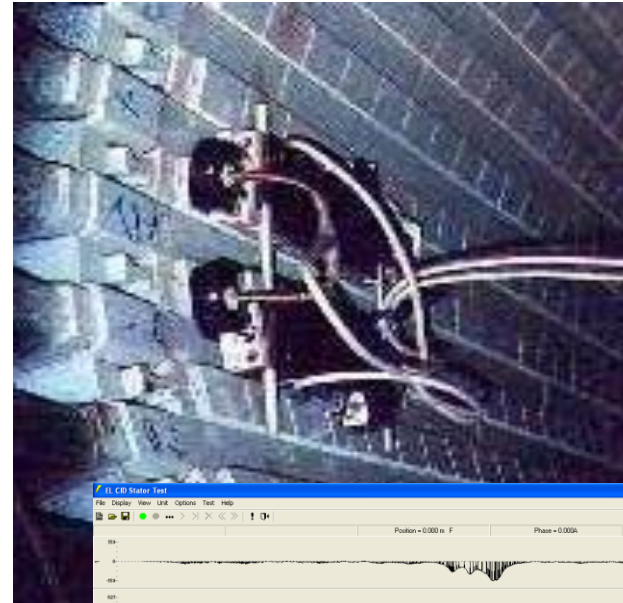
# Rewind

## Specification Elements

- Stator Core Iron Evaluation
- Field Pole Evaluation
- Key Elements for Quality Stator Coils
- Stator Coil Side Packing
- Generator issues or concerns listed
- Stator Testing Program
- Division of Responsibilities
- Vendor to Attach Project Technical Proposal

# Stator Core Iron Evaluation ELCID Test

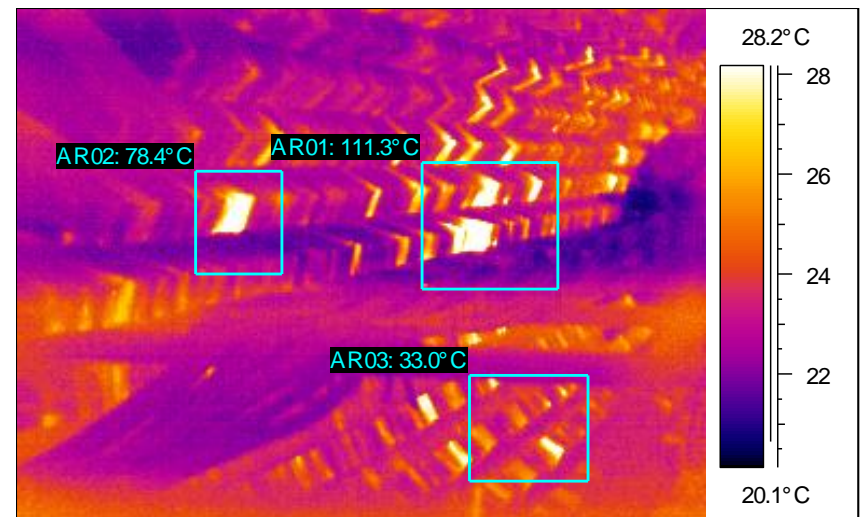
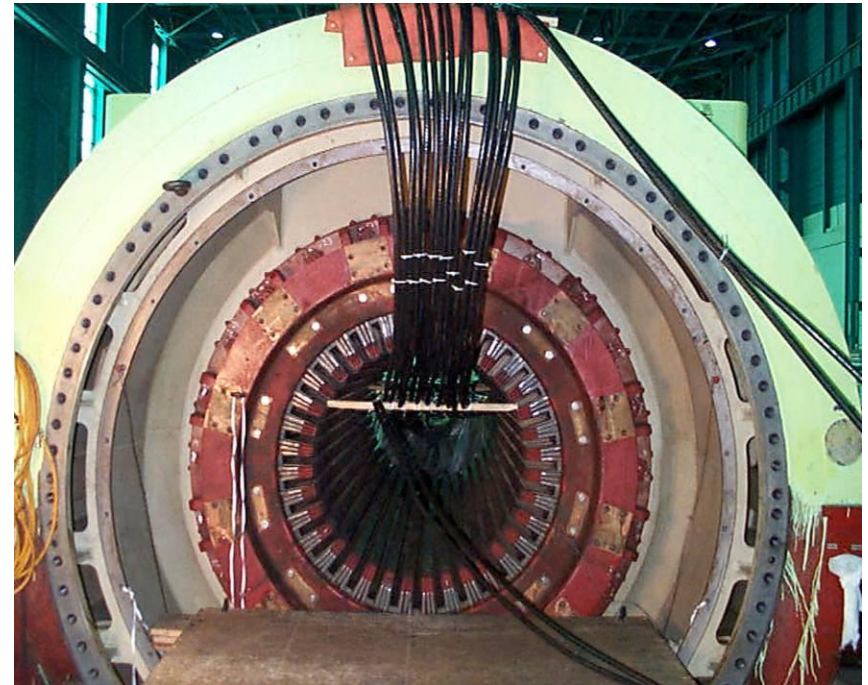
- Excite core to only 4% of rated flux density
- Search coil on trolley detects interlaminar circulating currents
- 100 milliamp action threshold
- Uses 110 vac – easy to set up and use
- 3 Tests - Before Stripping, After Stripping, and After Wedges Installed



# Stator Core Iron Evaluation cont.

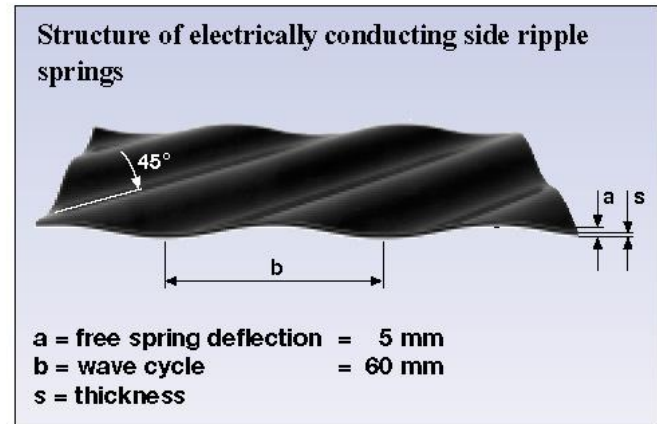
## Loop Test

- Test creates near full flux of the core and is viewed with a thermo graphic camera
- Requires high voltage power supply with adequate current
- Normally a one hour test but significant setup is required



# Stator Coil Side Packing

- Side packing is a critical component to the corona protection system and to preventing vibration and coil abrasion
- Flat side Filler does not maintain side pressure on the coil
- Even if initially installed tight, insulation shrinkage, can create gaps and increase the potential for slot discharge
- Ripple side packing keeps constant pressure on the coil to minimize vibration and the potential for abrasion.



# Stator Testing Program

- Should be a coordinated testing program from coil final test through in process testing to final machine acceptance testing
- Final testing should at least include:
  - Megger & PI (PI of 2 or greater to HiPot)
  - AC or DC HiPot ( $2E + 1,000$ ) for AC
    - DC most common, convenient, and easiest to perform
    - Most common AC level is  $2E + 1 = AC$
    - For DC level multiply by 1.7
  - Per phase Resistance Test (balanced?)

# Key Elements for Quality Stator Coils

- Mica Based, Epoxy Resin Impregnated
- Class F Insulation System (thermal rating)
- Qualified Insulation System
  - IEEE 1043 Voltage Endurance Testing
- Design Uprate?
- Design that Minimizes Losses
  - Strand Losses – optimize strand thickness
  - Circulating Current Losses – maximize transposition/roebel
  - $I^2R$  losses – maximize copper content
- Fit Monitoring
- Control OCP Surface Resistance

# Documentation and Trending

- Outage Reports
  - Should be kept together, organized by date, so they can be easily referenced
  - Electronic and paper files
  - Photos
  - Track recommendations, their completion and the details of completion (process, date)
  - Test Results – File by date
    - Normalize temperature and humidity

# Documentation and Trending cont.

- Trended Data

- Megger / Polarization Index
- Polarization Index
- Impedance
- Winding Resistance
- Hi Pot / DC Ramp Test
- Electrical Test – normalized for temperature and humidity
- Flux Probe
- Other pertinent electrical tests also perhaps mechanical readings and findings

# Documentation and Trending cont.

- Documented information provides insight about where we have been and where we are.
- Trended information provides insight about where we are going.

# Outage Contingency Planning

- Back up's to critical equipment – induction heating / brazing, test set's
- Specialty Tools on hand and in good condition
- Spares – on hand and qualified for use
  - Extra Consumables – resins, tapes
  - Emphasis on Long lead items such as Brushless Exciter Fuses & Diodes
  - Spare Coils?

# Outage Contingencies - Spare Bars



These spare bars may sit here on this shelf for 30 years and never be used. Then again, they may be needed next week.

# In Review

- Specification: Be problem specific, provide as much information as possible.
- Resource Alignment
- Planning, Performing & Documenting Generator Outages
- Coil testing
- Outage Wrap Up & Lessons Learned

# **Generator Specification and Outage Consideration**

## **Questions?**

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