

Rotor Rewinds
Old Copper –vs – New Copper

22nd IRMC

Iris Rotating Machine Conference

New Orleans, LA

May 6-9, 2019

W. Howard Moudy
Director of Service Management
National Electric Coil
[*hmoudy@national-electric-coil.com*](mailto:hmoudy@national-electric-coil.com)
724-787-4967
[*www.National-Electric-Coil.com*](http://www.National-Electric-Coil.com)



Rotor Rewinds

Old Copper –vs – New Copper

- Today's Discussion
 - Rewind Background & Planning
 - Copper Conductor Facts & Issues
 - Technical & Commercial Considerations
 - Options, Risks, and Proper



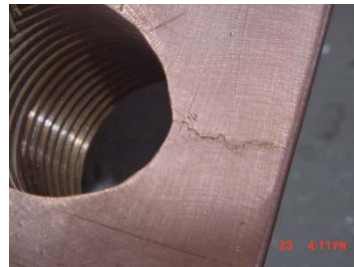
Rewind Background

- Why is the rewind being performed?
 - Historically prominent reasons have been deterioration or failure of Ground Insulation and/or Turn Insulation.
- Common Insulation Deterioration & Failure Factors
 - Mechanical Wear
 - Thermal Degradation
 - Contamination
 - Operating Events



Rewind Background

- More recent times have seen a very significant rise in cycling related fatigue failures effecting the copper conductor, connectors, and leads.



Rotor Manufacturing Design Criteria

Cycling

- IEEE C50.13
- 4.1.5 - The unit shall be designed for a minimum number of starts over the operating life of the machine. The minimum number of starts from zero speed or turning gear speed to operating speed up to rated load shall be as tabulated below:
- 3,000 starts for base load units
- 10,000 starts for peaking units or other frequently cycled units



Rewind Planning

- **Operational Expectations**

- Known deficiencies?
 - Solution option(s)
- Cyclic duty?
- Uprate in output?
- Upgrade?

- **Commercial Expectations**

- Schedule Timing?
- Schedule Duration?
- Budget?
- Advanced Task Preparation?



Turbo Generator Rotor Copper Conductor

- Copper is Copper?
 - NO
 - Rotor Conductor must:
 - Have Superior Electrical and Thermal Conductivity Characteristics
 - Withstand Rotational Forces & Thermal Stresses
 - Have Suitable Brazing Properties
- Oxygen-Free Silver-Bearing Copper
 - Tradename – Oxygen-Free with AG (often referred to as CDA 107 or 10700)
 - High conductivity copper with a min. AG content of .085%
 - Typically Medium Hard 80-85 Rockwell F scale



Oxygen-Free Silver-Bearing Copper Conductor Properties

- Superior Electrical Conductivity
- Superior Thermal Conductivity
- Very Good Corrosion Resistance
- High Resistance to Thermal Softening
- Excellent Brazing Characteristics



New -vs.- Old



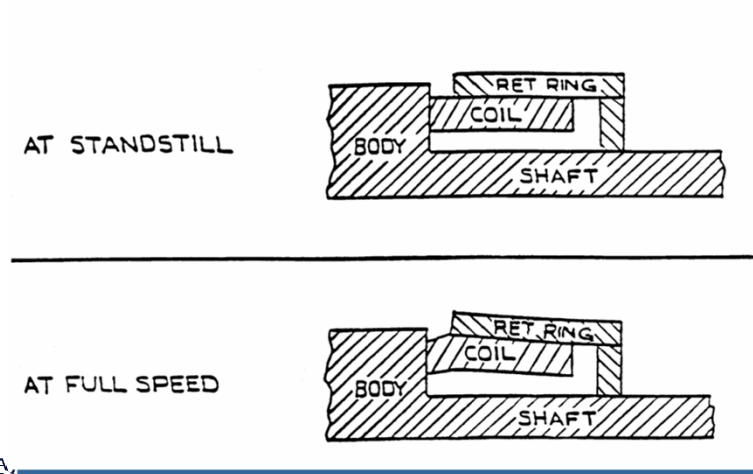
Existing Copper Considerations

- Hardness
 - Level & Consistency
- Suitability of Design
 - Past Issues
 - Future Operational Expectations & Reliability
- Conductor
 - Distortion, Compression, Dusting , Bad Joints
- Fatigue
 - Cracking Indications
 - Conductor History – Operational & Rewind



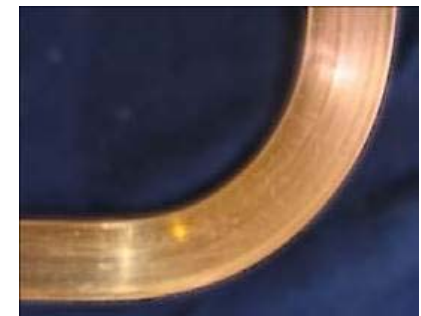
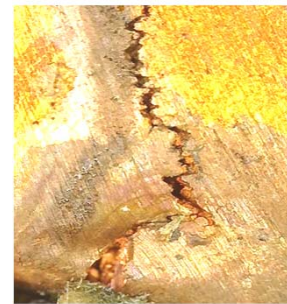
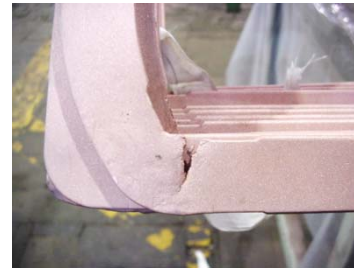
Suitability of Design Examples

Top Turn Cracking



Solution – Top Turn Isolation

Cycling Fatigue Cracking



Solution – new edge bent copper



Conductor Distortion



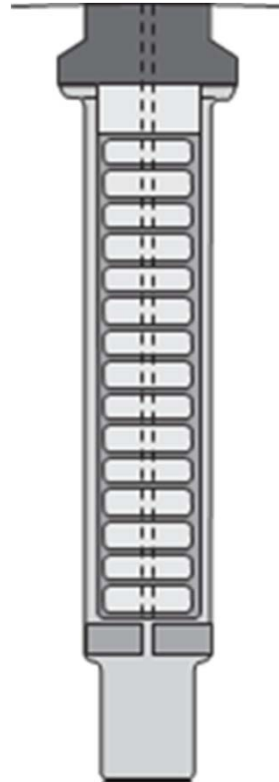
- Distortion Contributors
 - Frequent Cycling
 - Soft Copper
 - Slot and/or End Winding Friction
 - Winding Overheating
 - Poor or Damaged Blocking



Conductor

Compression, Dusting & Bad Joints

- Compression
High Temperature, softened copper – “Smashes Copper”
- Dusting
Multiple strands per turn “in Hand” & Turning Gear Friction
- Bad Joints – one or combination of
Design, Preparation, Process, Execution



Case Study

Joint Construction

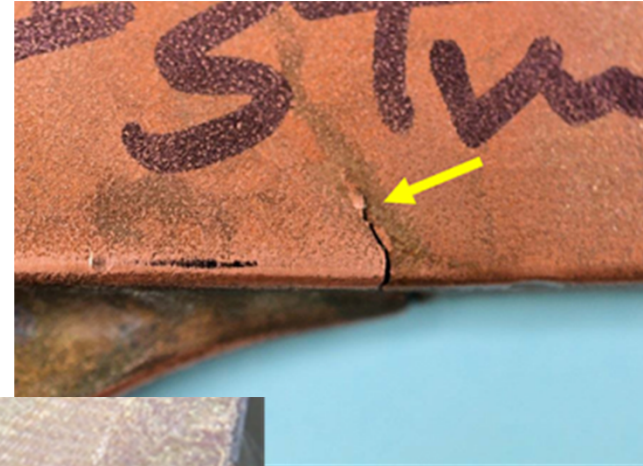
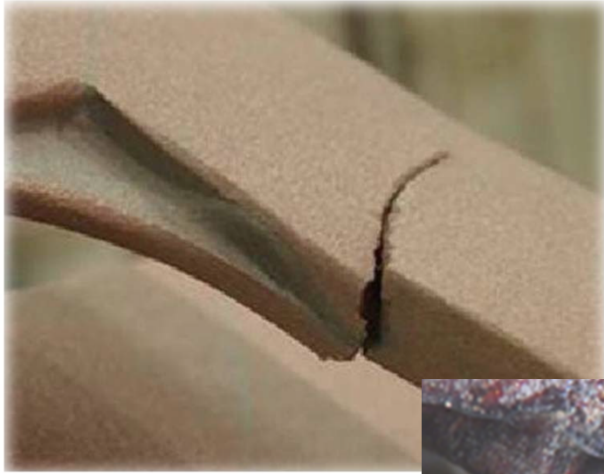


- GE 7A6 generator
- Highly Cycled
- Square Corner Conductor
 - Miter & Fillet



Case Study

Fatigue Finding Commonality



Fatigue

Winding and Un-Winding Stress



Coils close to the pole head are work hardened more as they are manipulated to wind or unwind.

Coils further away from the pole head are work hardened less as they are manipulated to wind or unwind.



Square corner or tight radius edge bent corners are work hardened more than corners with a large radius.



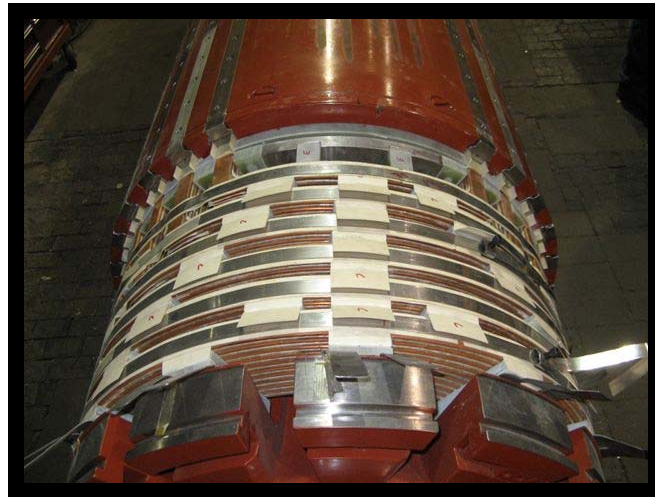
New Copper Conductor

Advantages

- Opportunity to Alter Configuration/Design
- Address Metallurgical concerns – Fatigue & Hardness
- Alleviate Conductor Distortion concerns
- With advance staging, potentially shorter rewind duration
- Improved Reliability expectation

Disadvantages

- Increased Cost
- Potentially longer schedule duration
 - Material Availability
 - Tooling development



New Copper Conductor

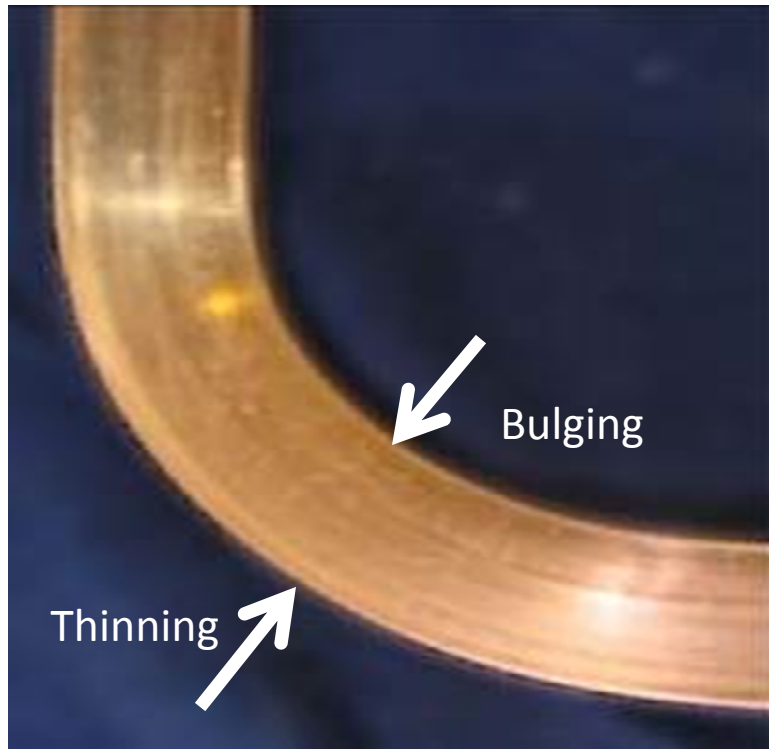
Key Success Factors

- Design Experience
- Conductor Geometry / Size Accuracy & Consistency
 - Critical - Edge bend “Keystoning”
 - Cooling Vent Accuracy & Consistency
- Joints
 - Documented process matching application
 - Qualified winders/technicians

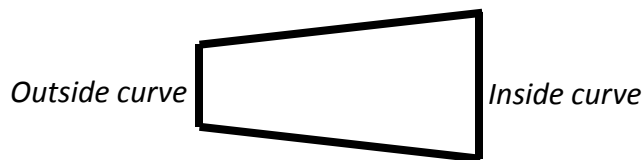


Edge Bent Corner

Bulging & Thinning – “Keystoning”



- Consistent Control is Critical:
 - to overall conductor stack height
 - to corner turn insulation long term reliability and preventing turn shorts
- Geometry must be achieved without appreciable loss of copper cross section



Keystone Cross Section



Edge Bending Copper Conductor



New Coil C-Piece Cut



New Copper Edge Bent Coils (C- Pieces)



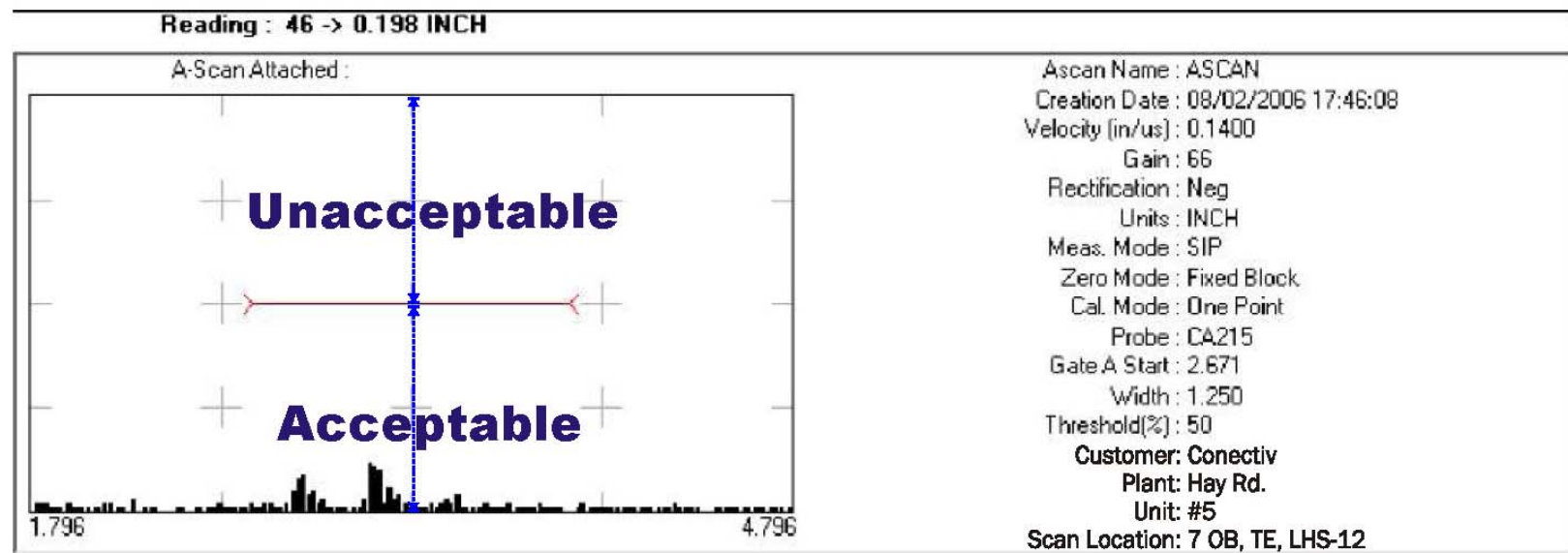
Rotor Conductor Joint Brazing Processes, Procedures & Personnel

- Proper Methods – Induction Preferred
- Execution performed to specific written process procedures, & conditions (cleanliness) under QA / QC oversight & 100% verification
- Joints made (executed) by qualified winders, certified to the specific task
- QA/QC sample and production checks to ensure strength, geometry, and minimization of porosity / voids.

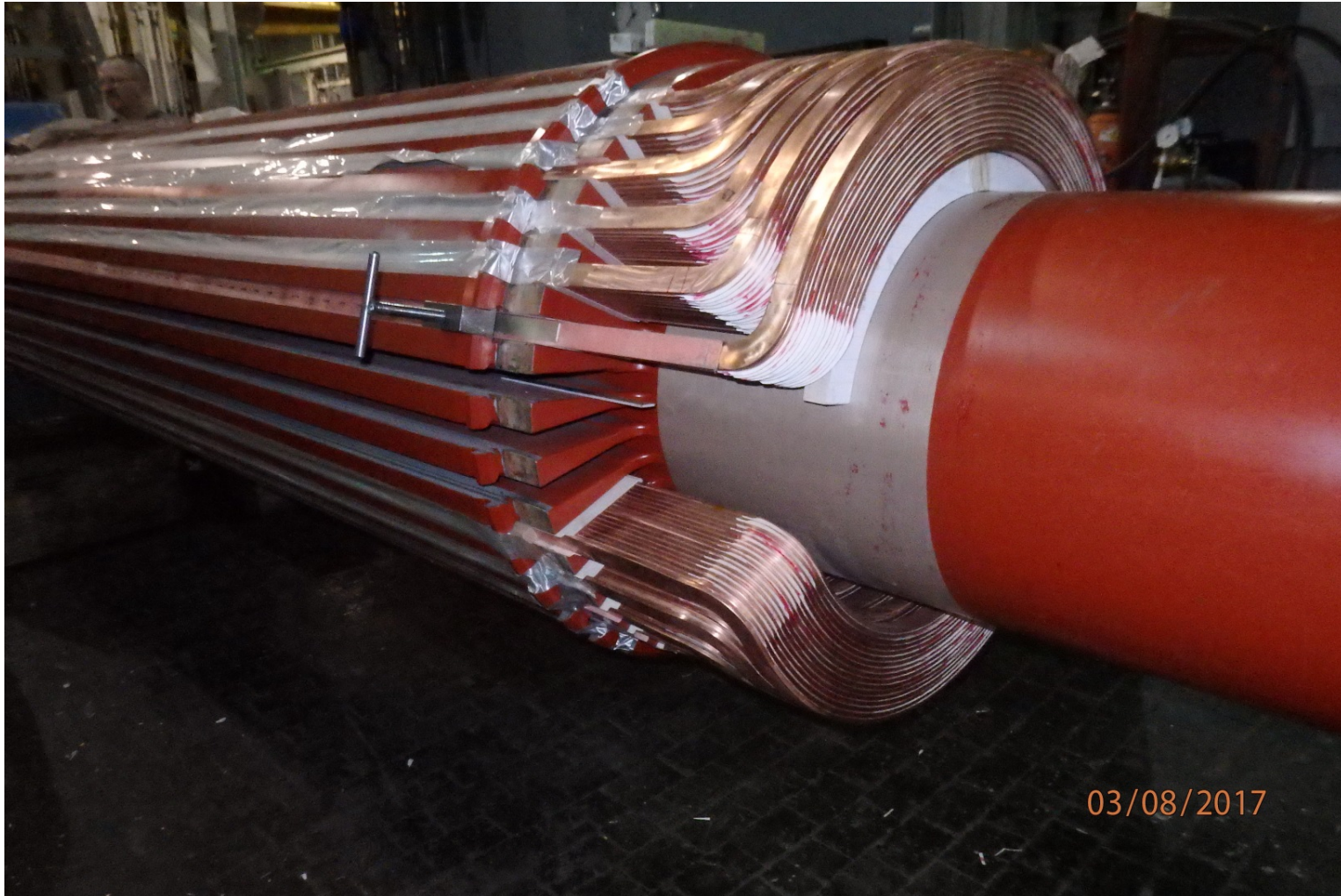


100% Braze Joint NDE

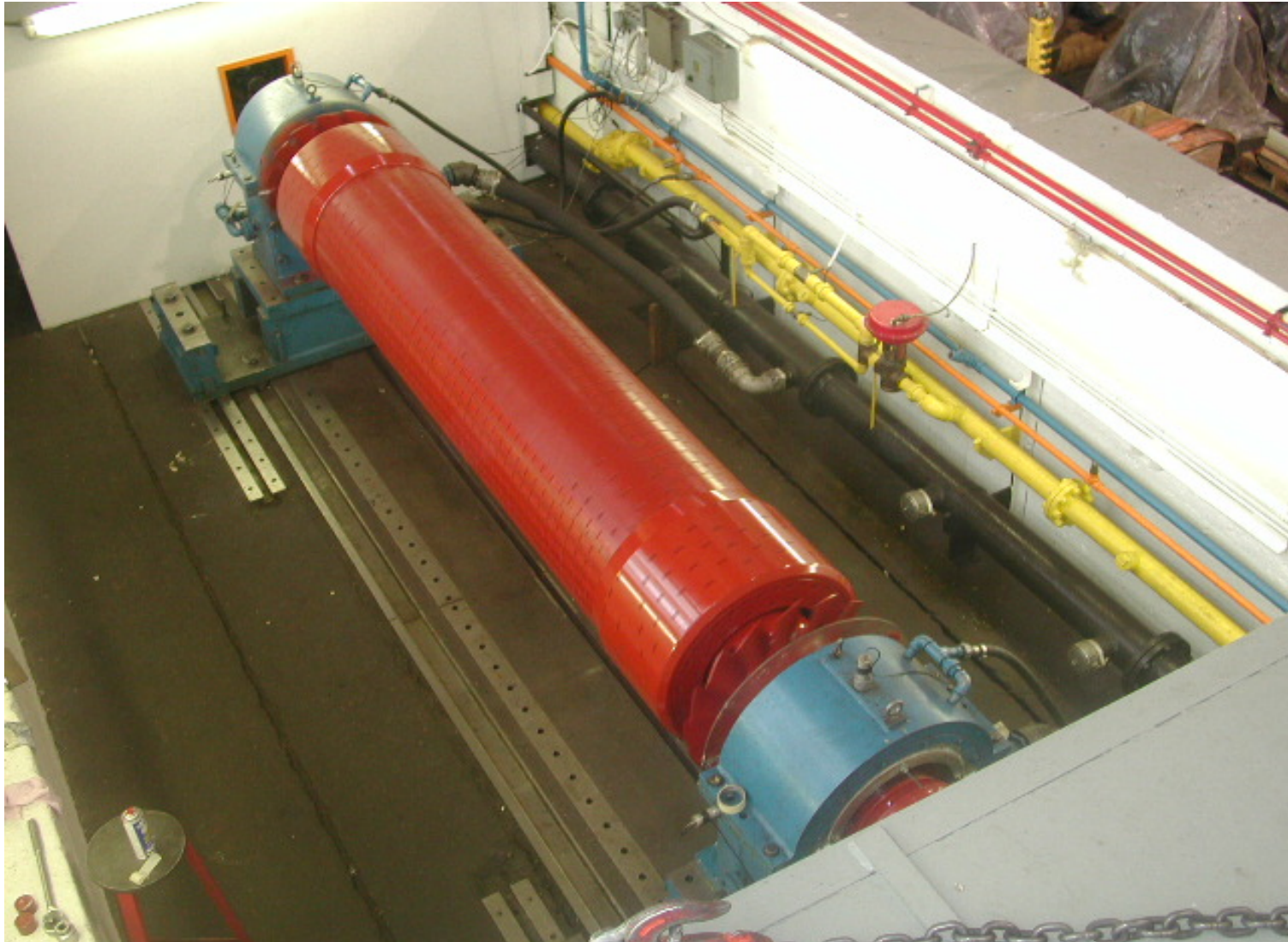
- Ultrasonic Test each brazed joint
- Document each "joint acceptance graph".



Partially Wound New Edge Bent Rotor Coils



High Speed Balance – Old or New Rewind



Old Copper –vs – New Copper

Summary

- Before making a decision on New -vs.- Old copper, understand the impetus for rewind and future expectations of the unit
- Rewinding with existing copper is perfectly acceptable if copper is qualified and other considerations are acceptable, most notably fatigue.
- New copper conductor may be the best choice but know why and have the supporting facts
- When choosing new, make certain the best design geometry and process criteria is used and installation is performed by experienced winders



Questions

W. Howard Moudy
Director of Service Management
National Electric Coil
[*hmoudy@national-electric-coil.com*](mailto:hmoudy@national-electric-coil.com)
724-787-4967
[*www.National-Electric-Coil.com*](http://www.National-Electric-Coil.com)



**INTERNATIONAL
GENERATOR TECHNICAL
COMMUNITY**

Become a member of the IGTC
Technical Forum

*Qualified members can participate in the only online
technical forum devoted solely to maintaining and repairing
power plant turbogenerators and hydrogenerators.*

www.GeneratorTechnicalForum.org

