



Hawkins
Leaders in forensic investigation

40 YEARS
1980 • 2020



Introduction to Turbo-Generators and their failures

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Hawkins



The background of the 'Power Team'

Disciplines

- Metallurgists and Materials Engineers
- Mechanical Engineers
- Electrical Engineers
- Chemists
- Civil Engineers

Previous Experience

- Gas Turbine OEM
- Steam Turbine OEM
- Boiler OEM
- ESI/Utility operators
- Power Plant Development
- Chemical/Process/
Petrochemical



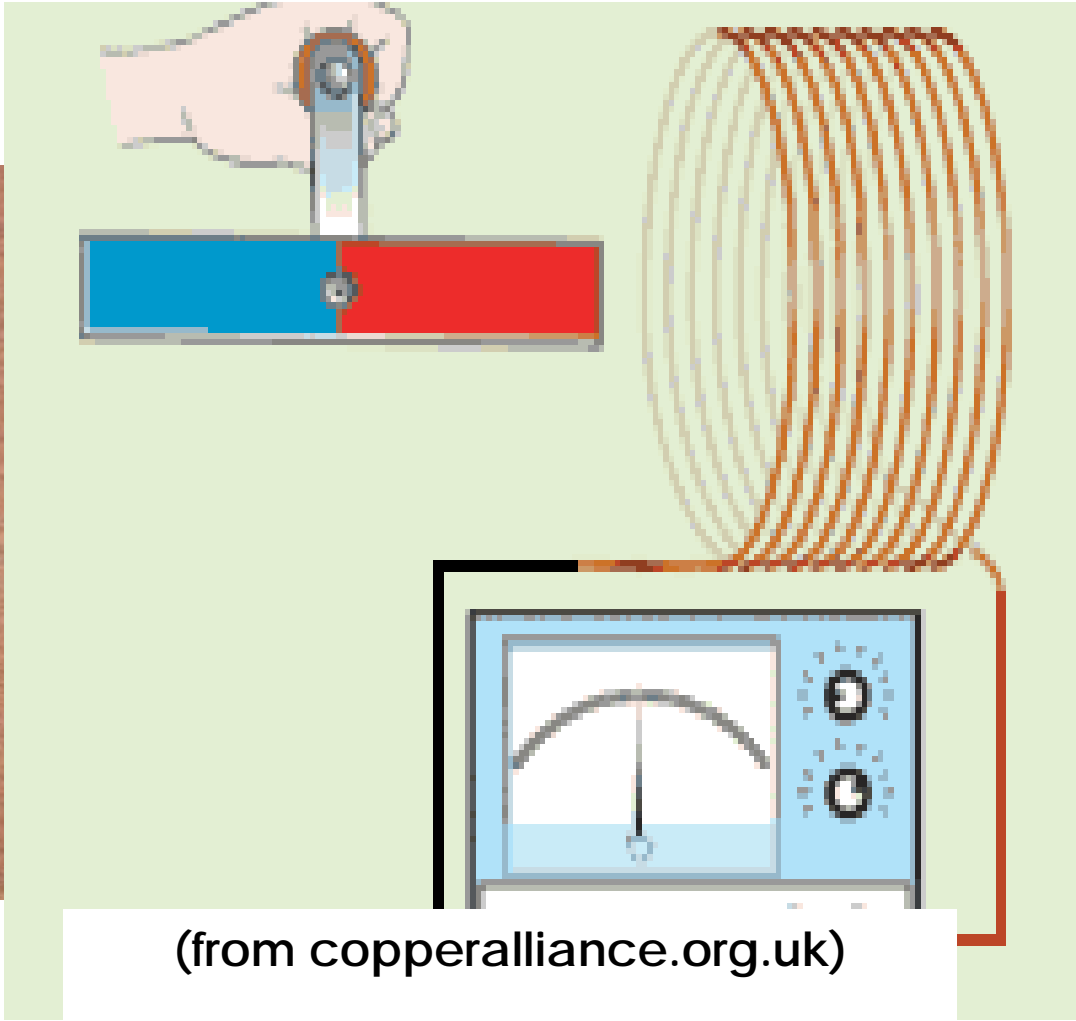
Introduction



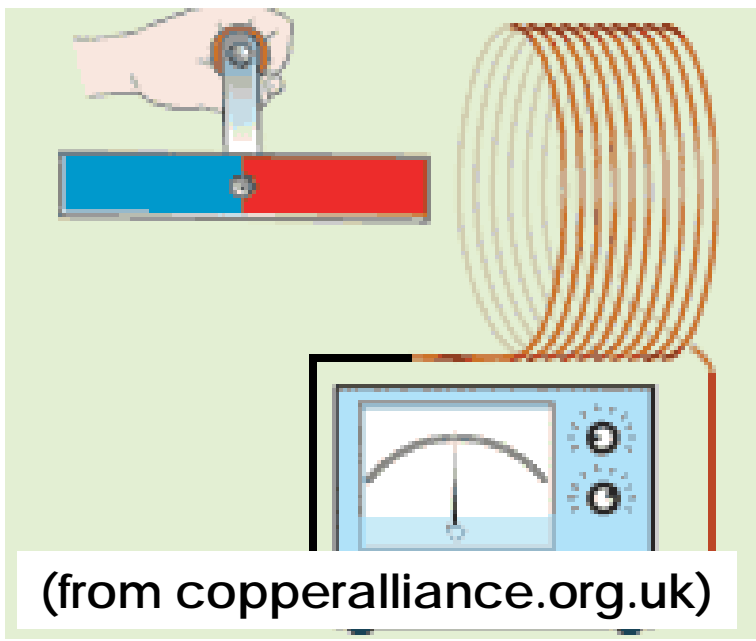
Generator Basics



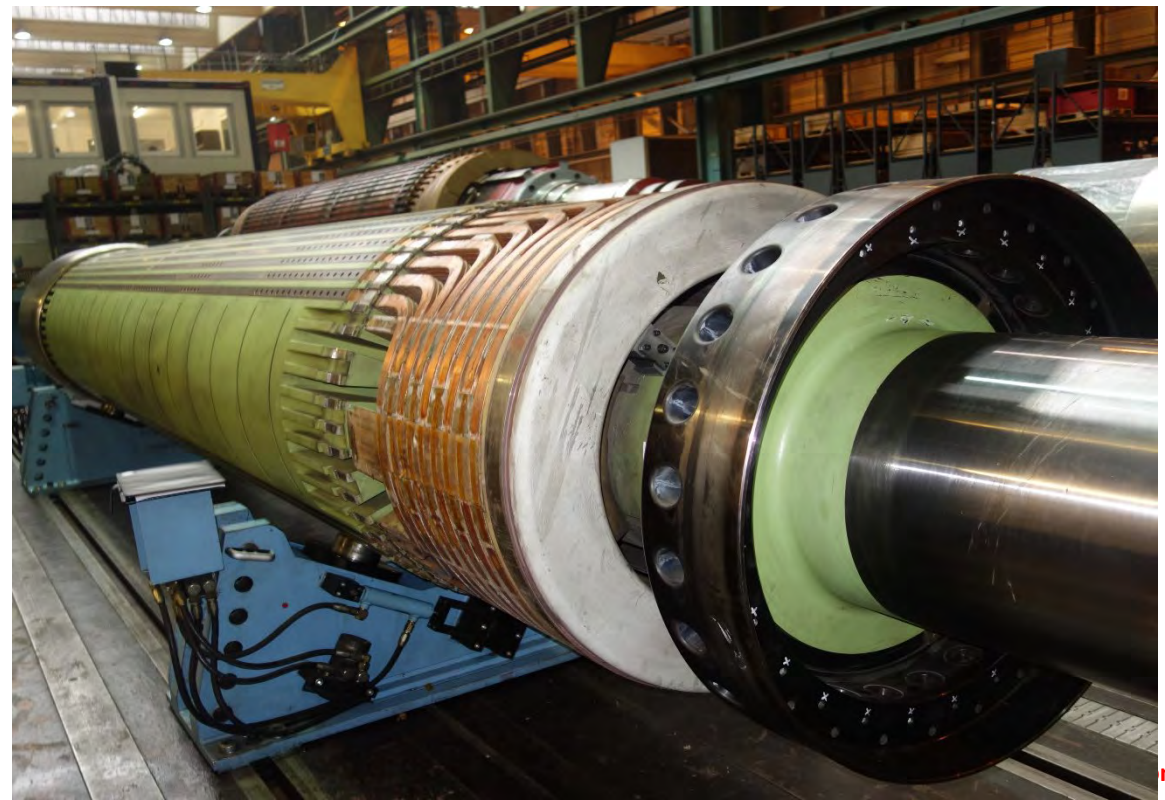
www.sciencelearn.org.nz

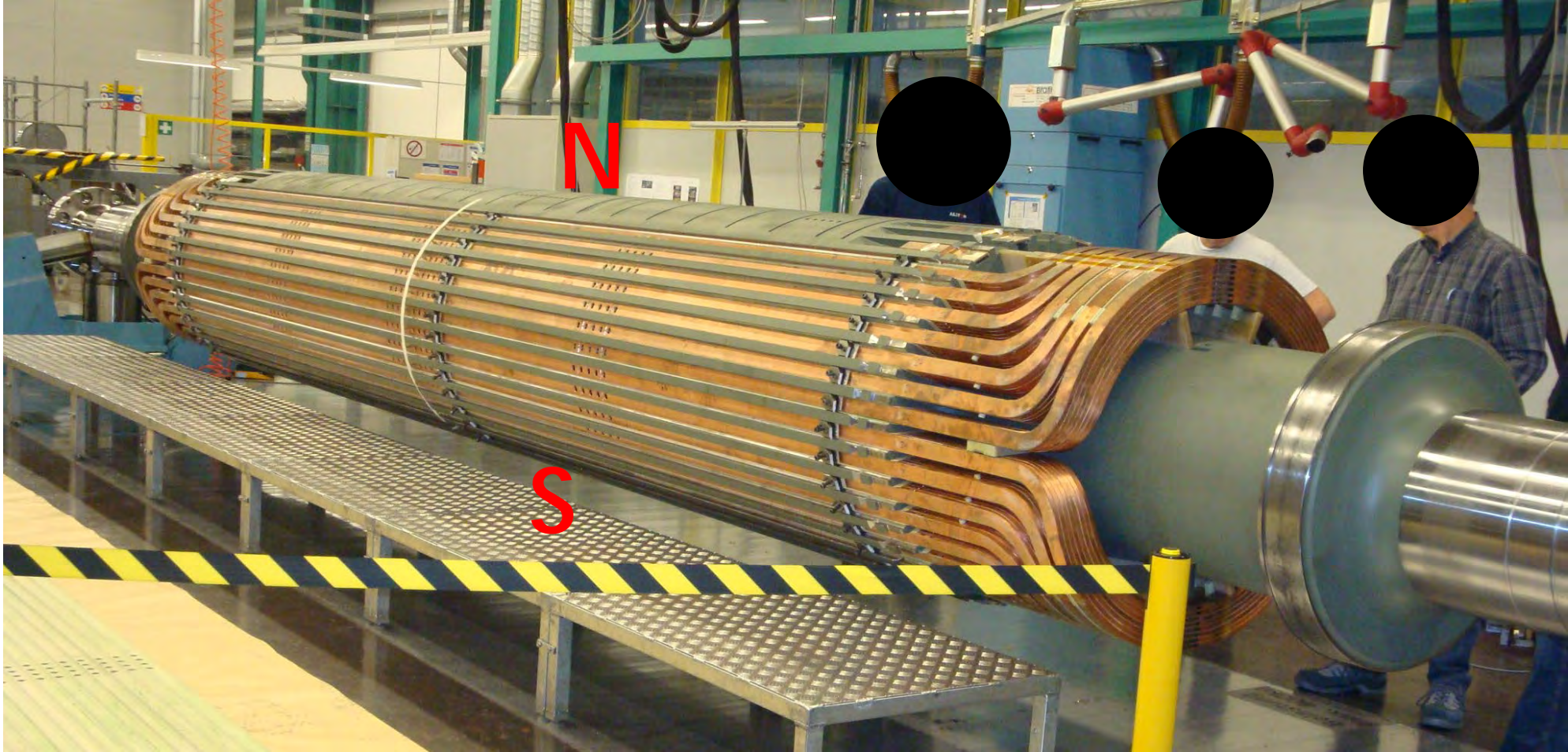


(from copperalliance.org.uk)

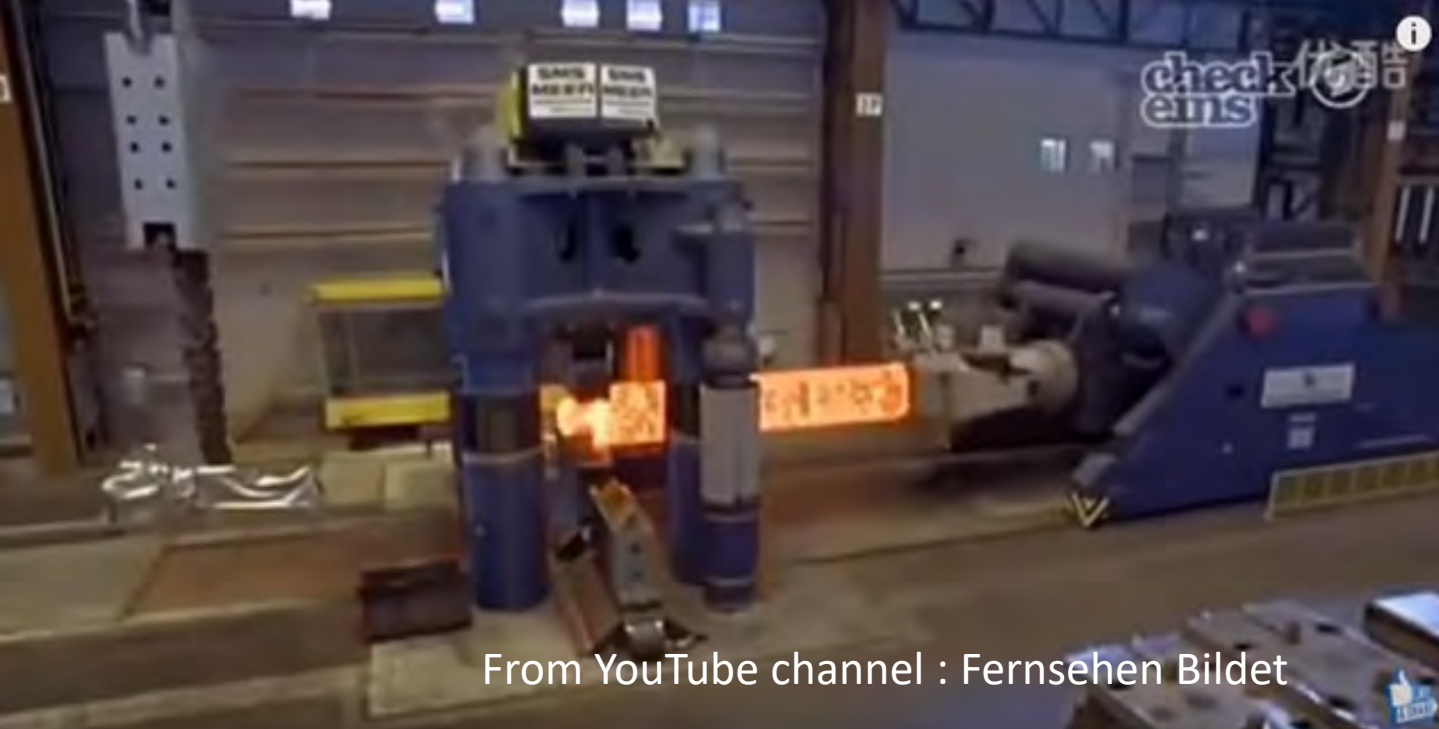


(from copperalliance.org.uk)

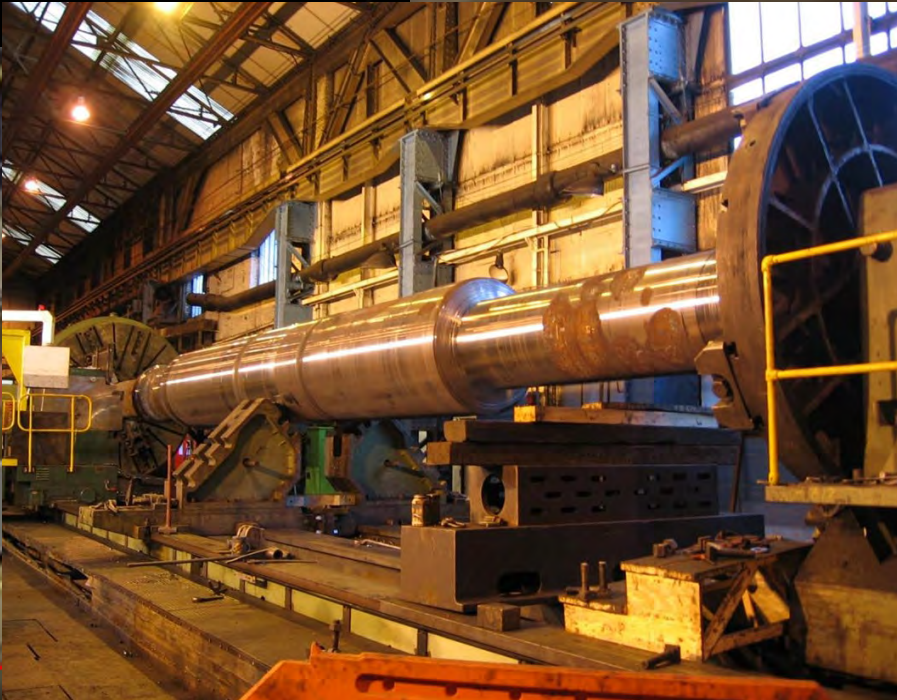


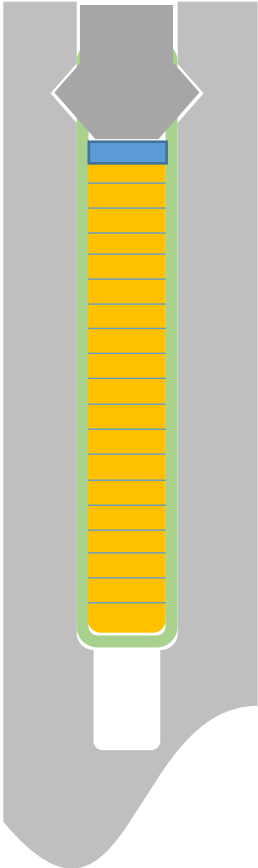


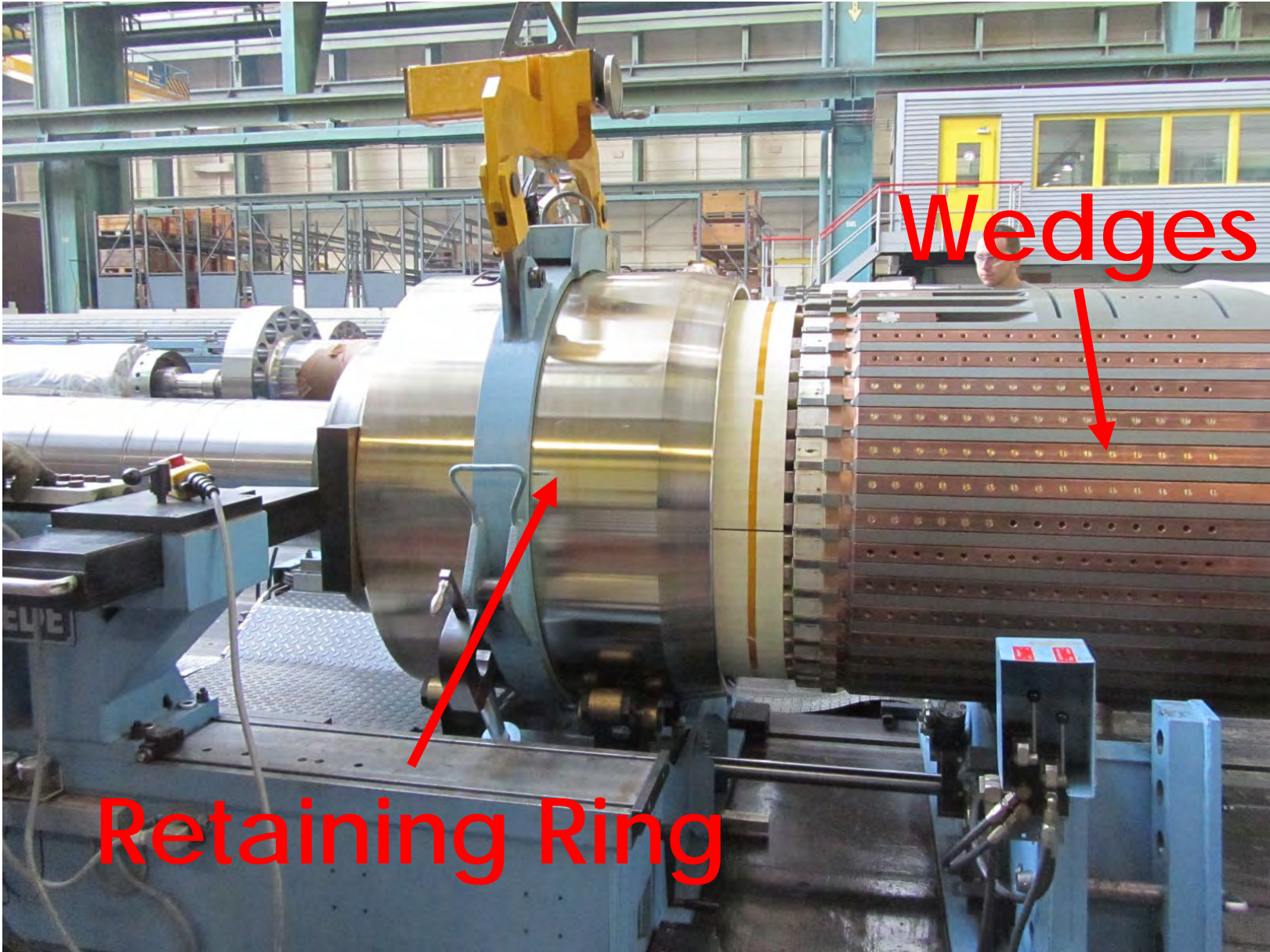
Rotor



From YouTube channel : Fernsehen Bildet

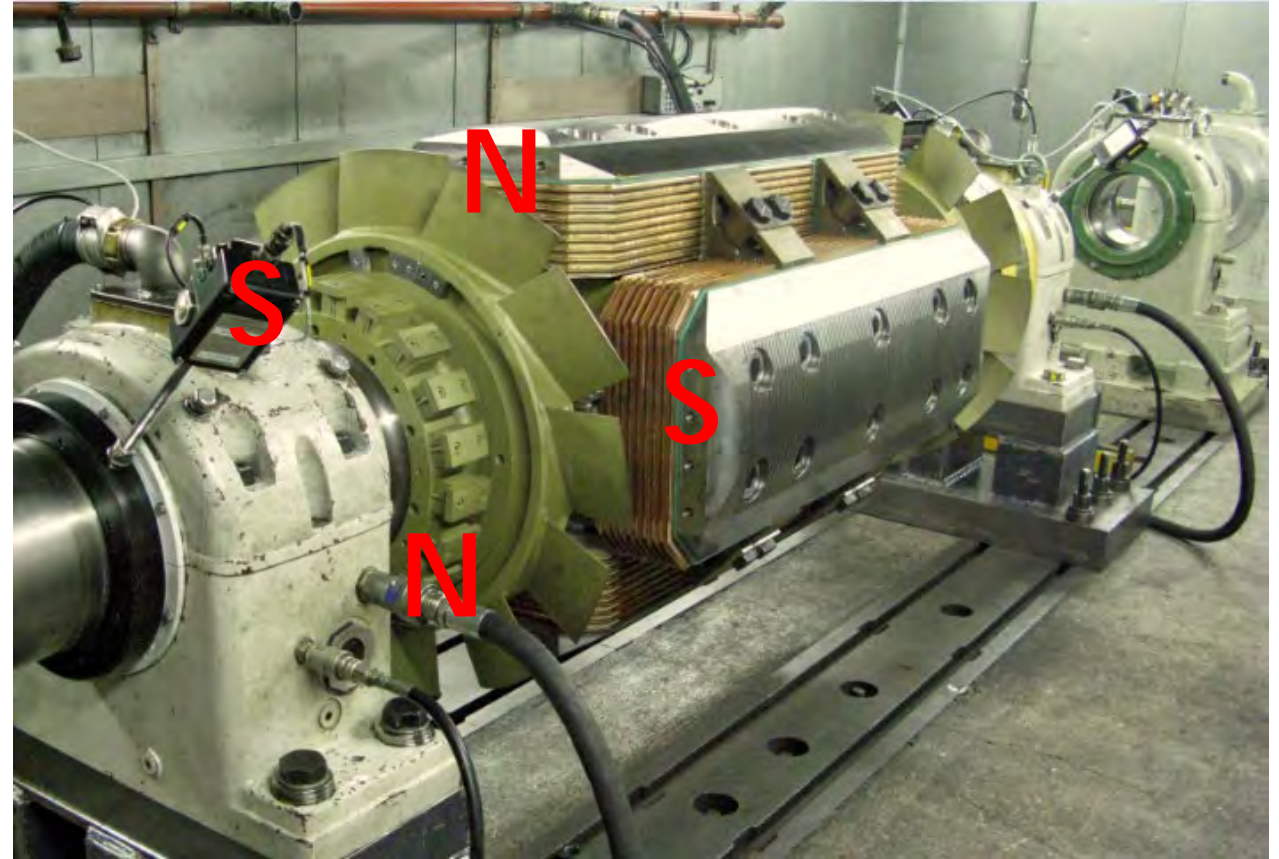
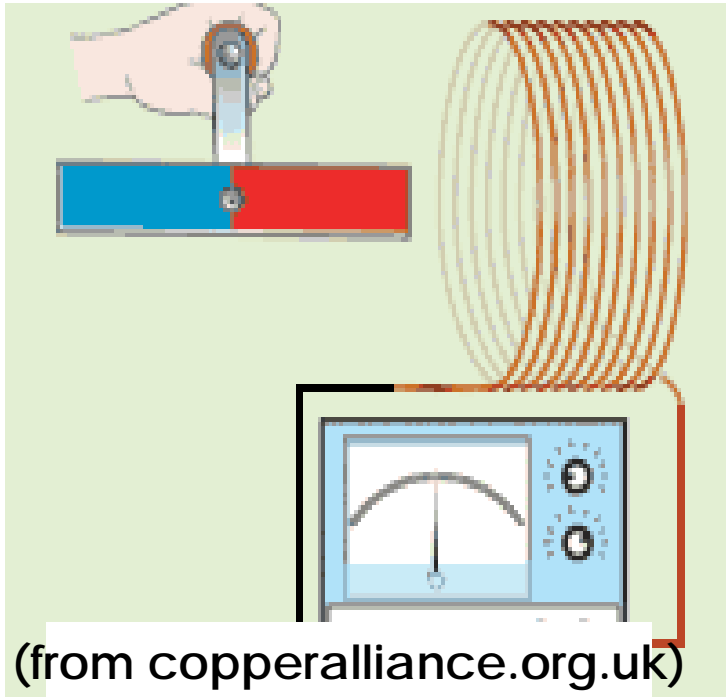






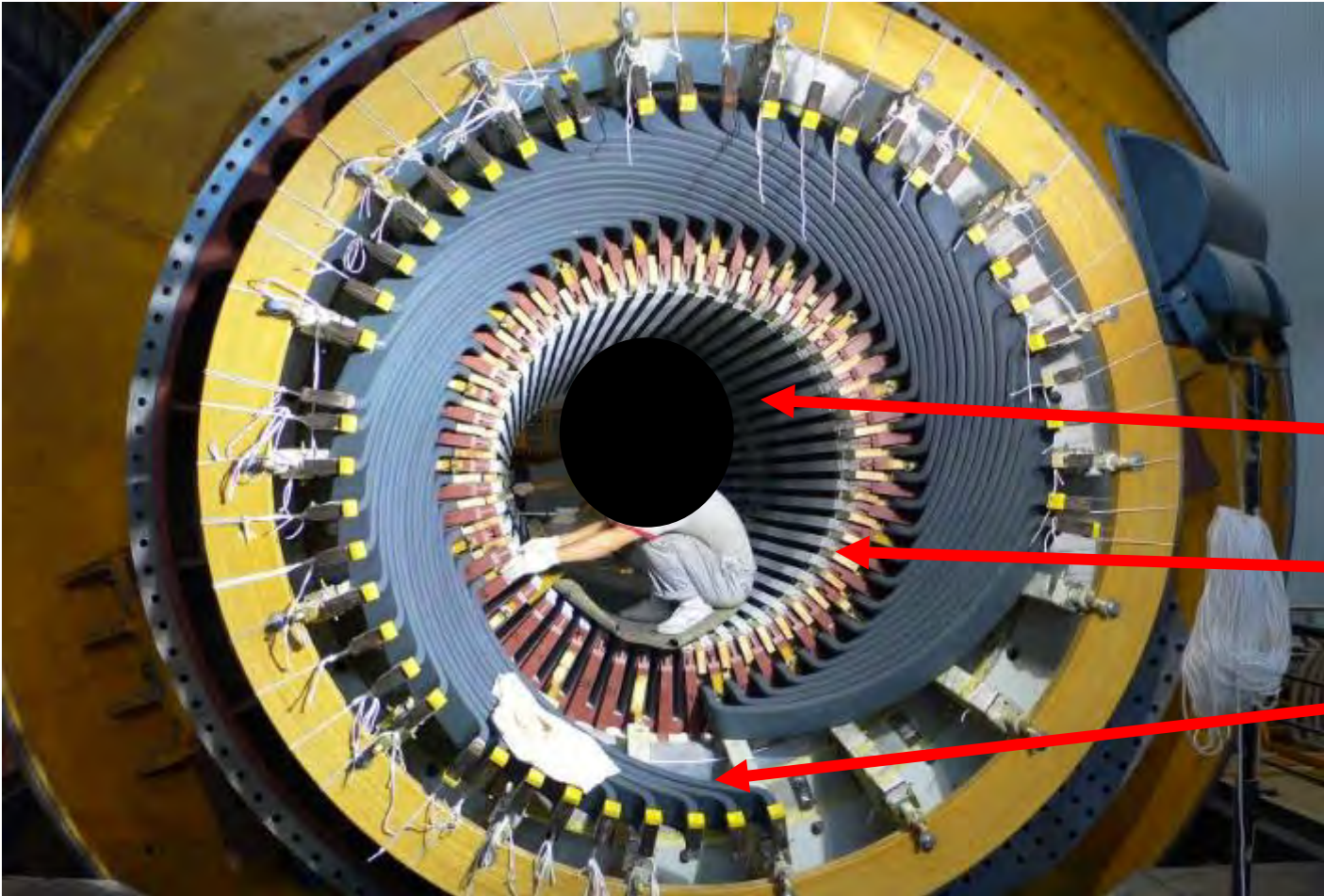
Retaining Ring

Wedges



For a 50Hz grid
2 Pole – 3000 RPM
4 Pole – 1500 RPM
40 Pole – 150 RPM
100 Pole – 60 RPM

Rotor



Bore

Slots

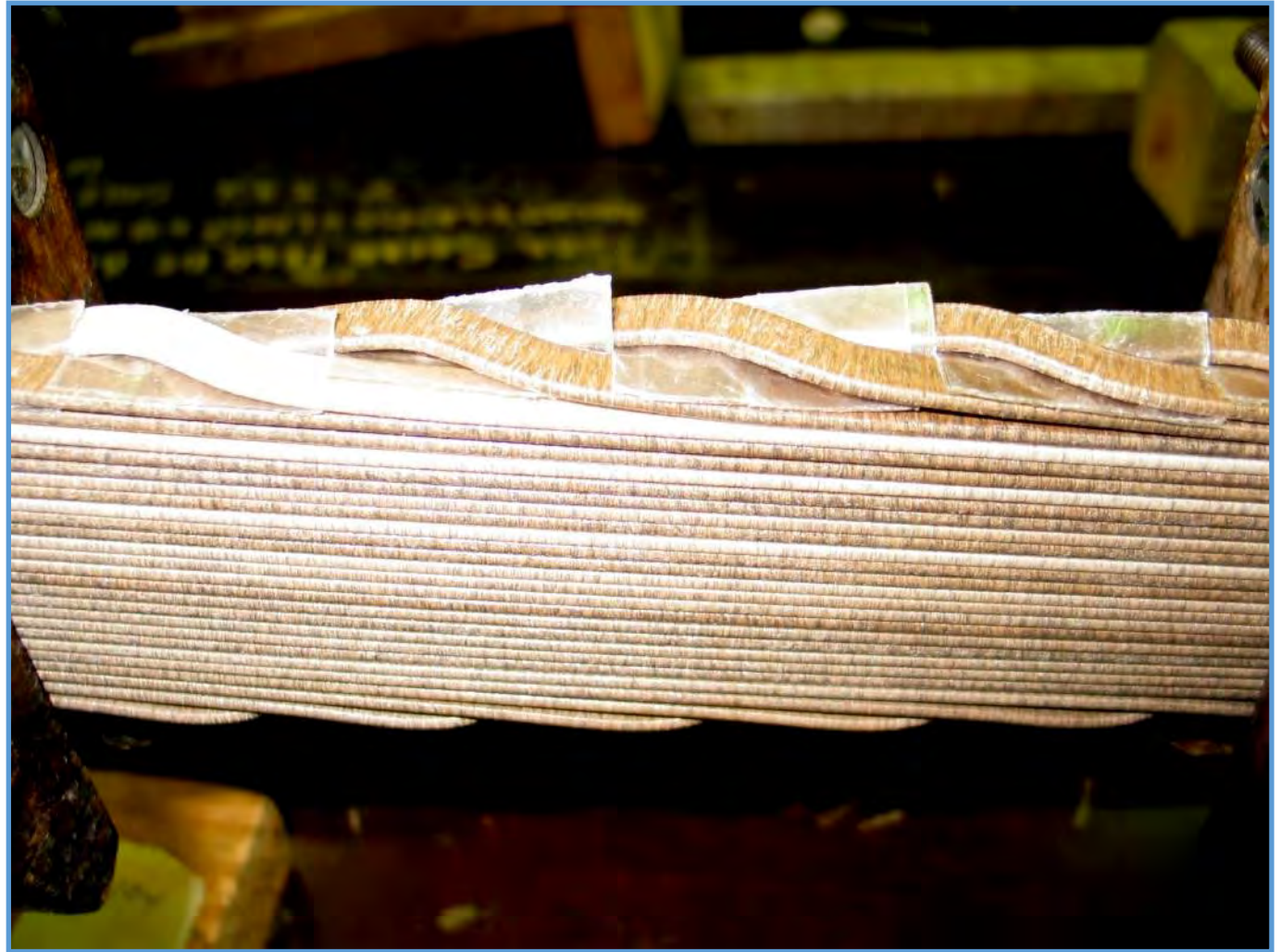
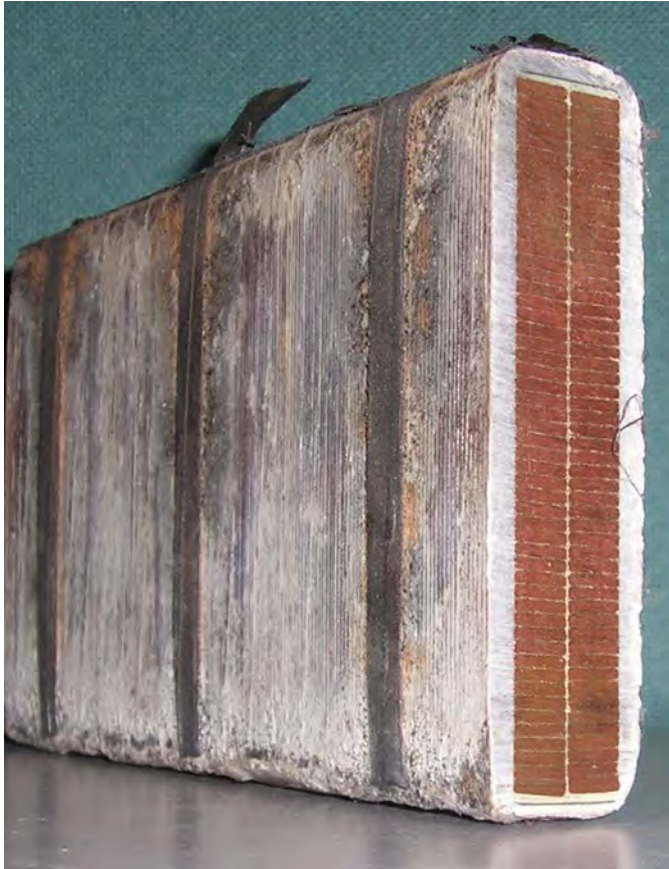
Endwinding

Stator

Generator stator core construction



“NORDIC NUCLEAR POWER GENERATOR STATOR
VIBRATIONS” from <https://energiforsk.se/>



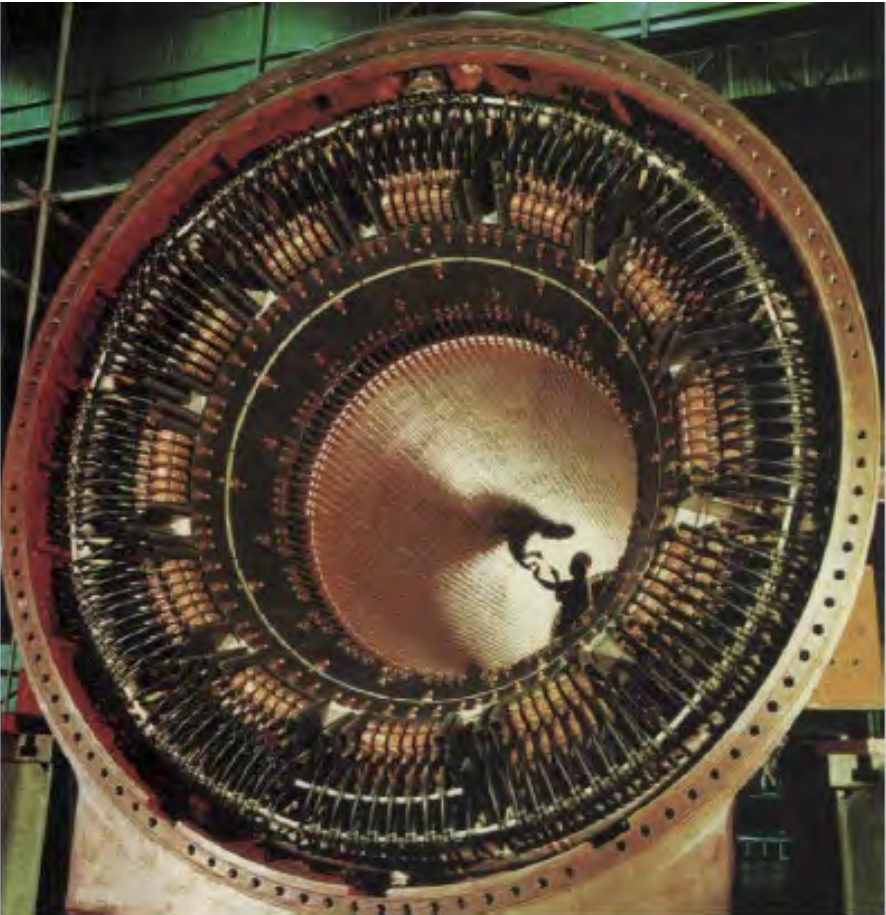
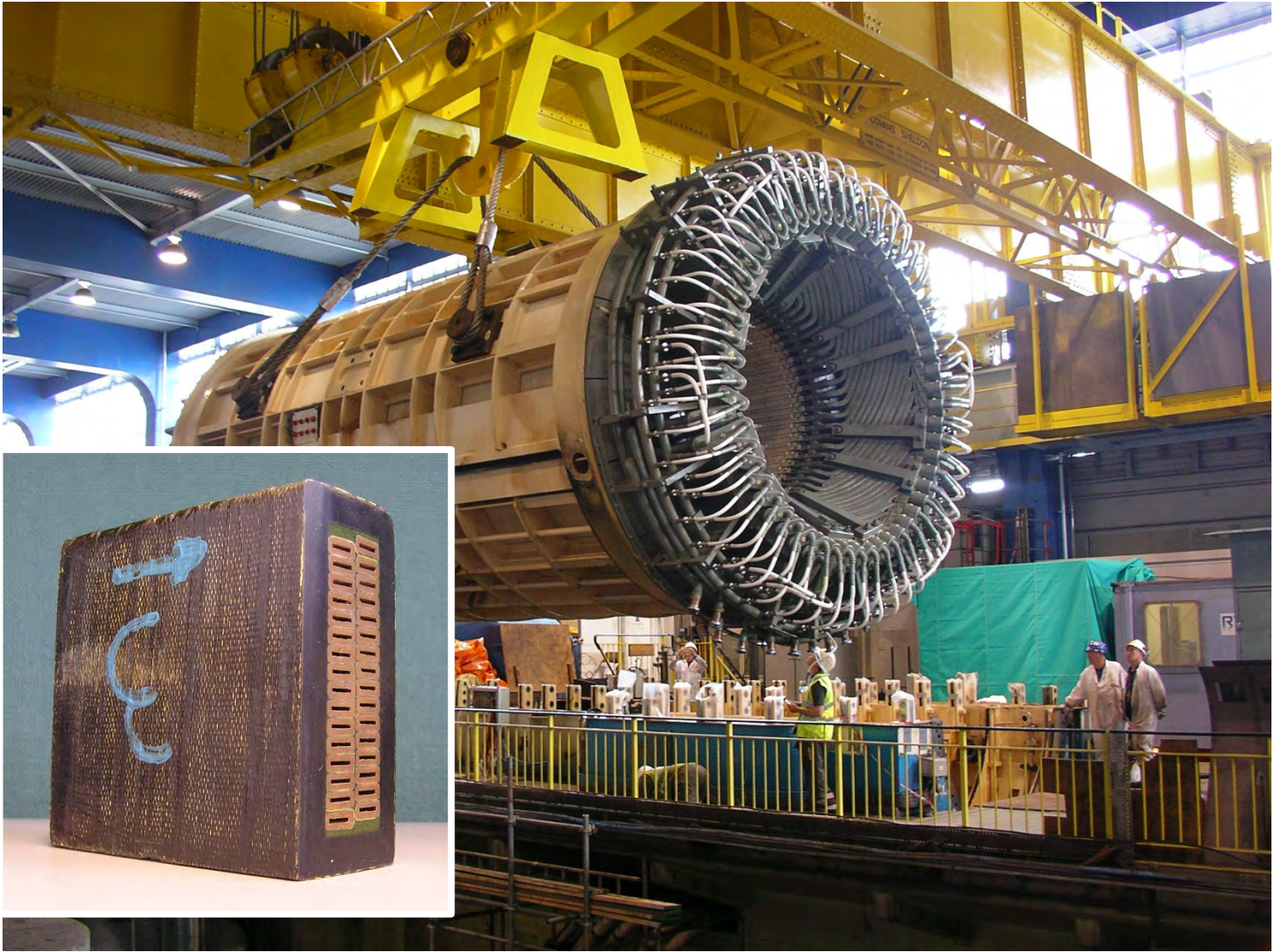
< ~300MW Air cooled



~300MW~600MW H2 Cooled



< ~600-1600MW H2/H2O Cooled

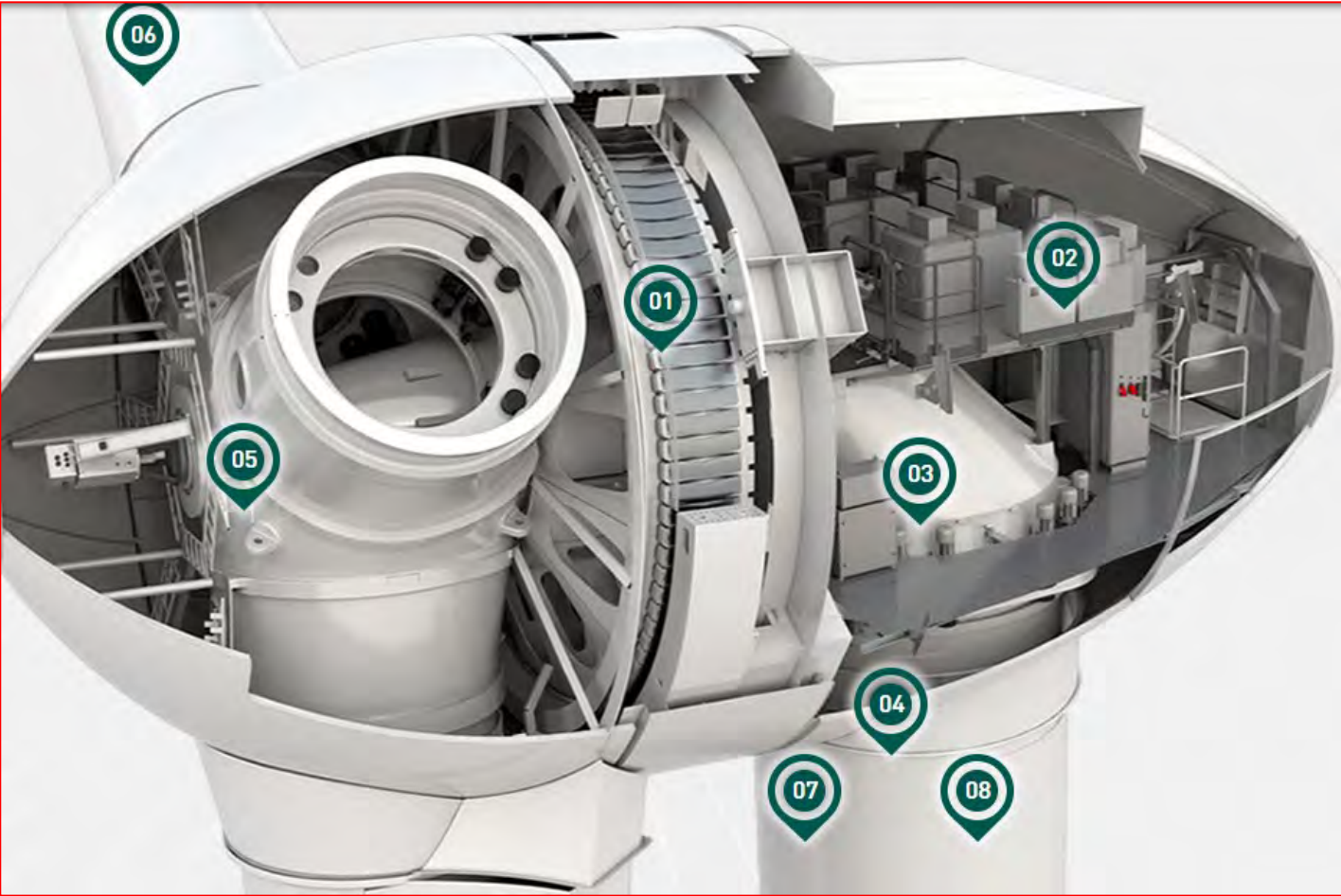


From Siemens (Cigre A1 Panel 2008)

Renewable Generators - Wind



Renewable Generators - Wind



(from Enercon)

Confidential - External

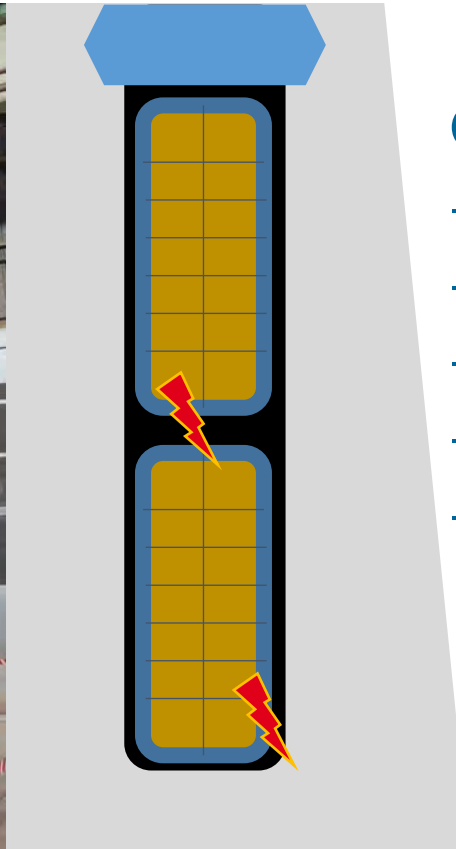
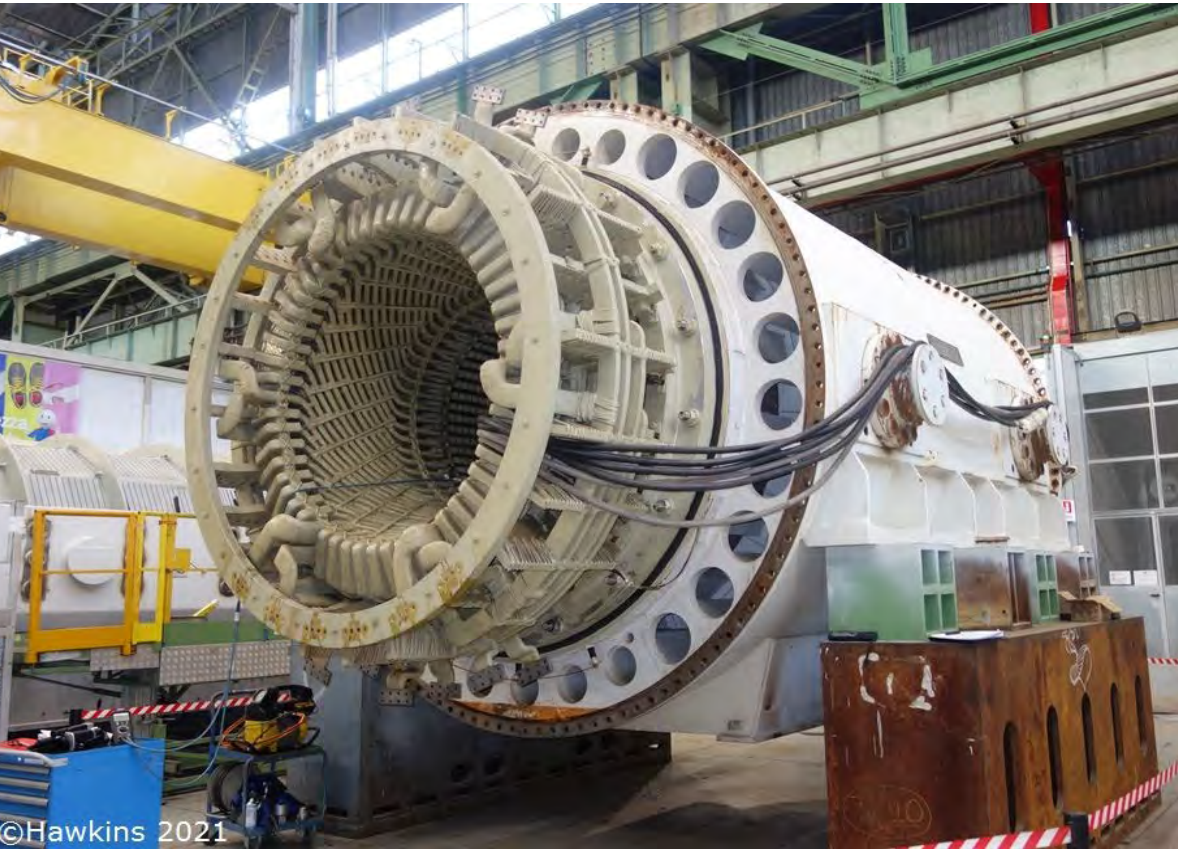
Renewable Generators - Hydro



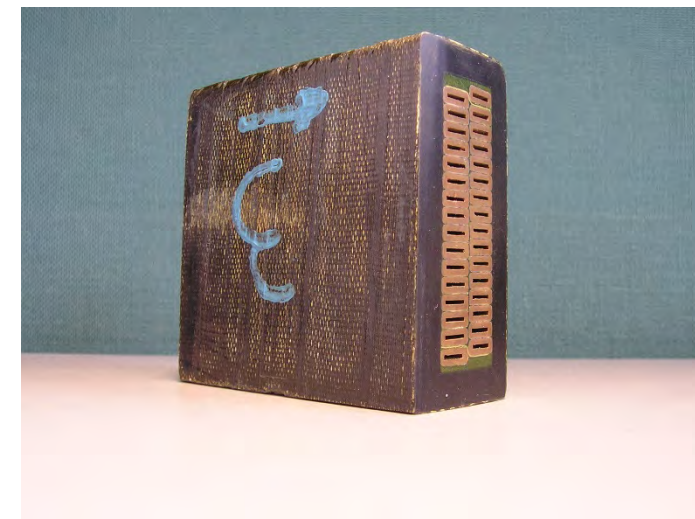
(from Voith)

What Can Go Wrong?

Stator Faults



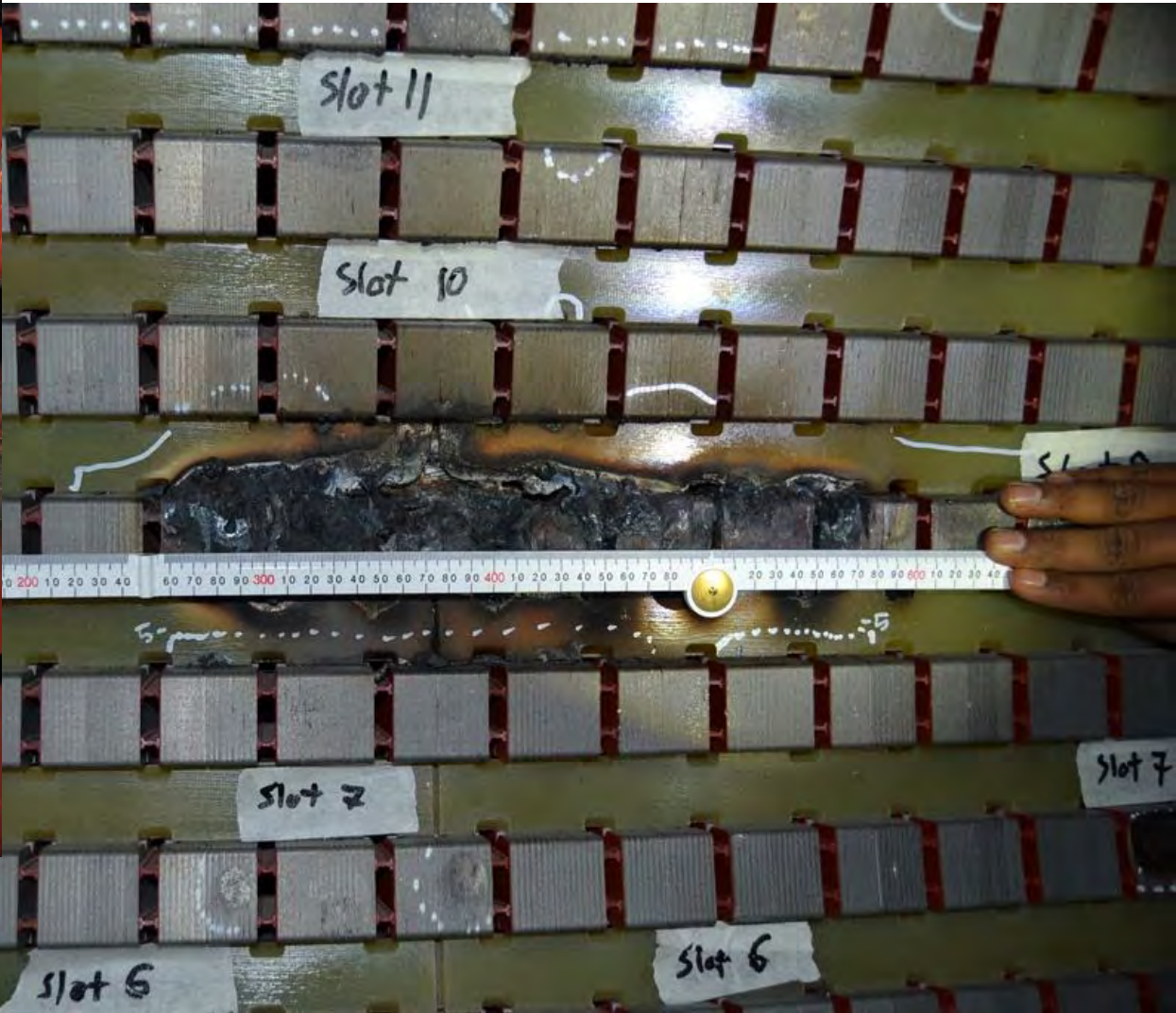
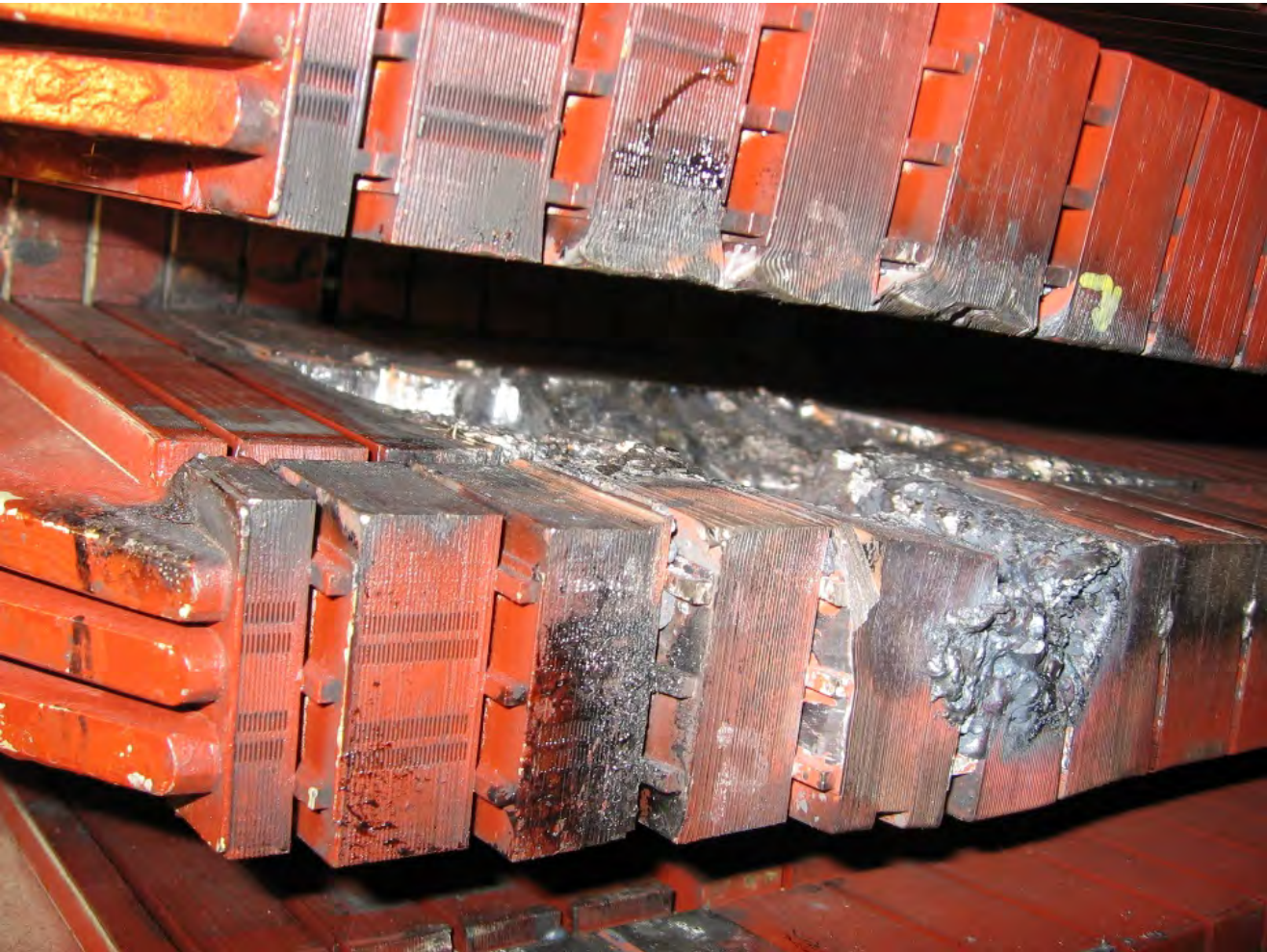
- Can be the result of:
- Insulation Ageing
 - Overheating
 - Worming Particles
 - Bar movement / Abrasion
 - Core Fault



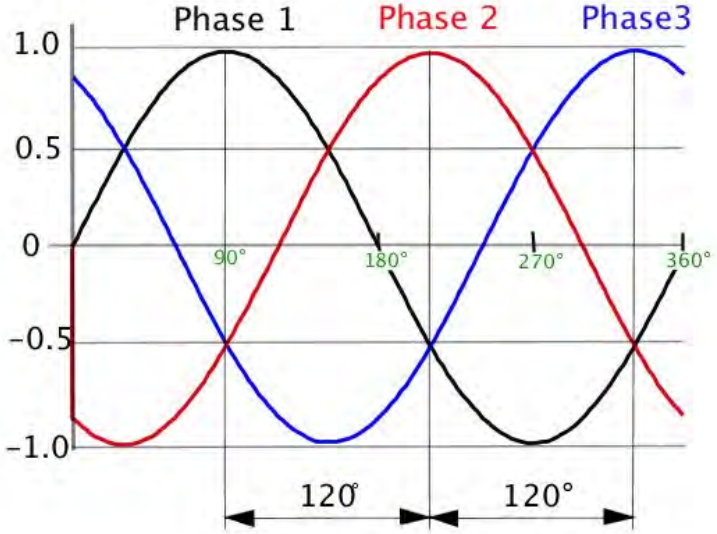
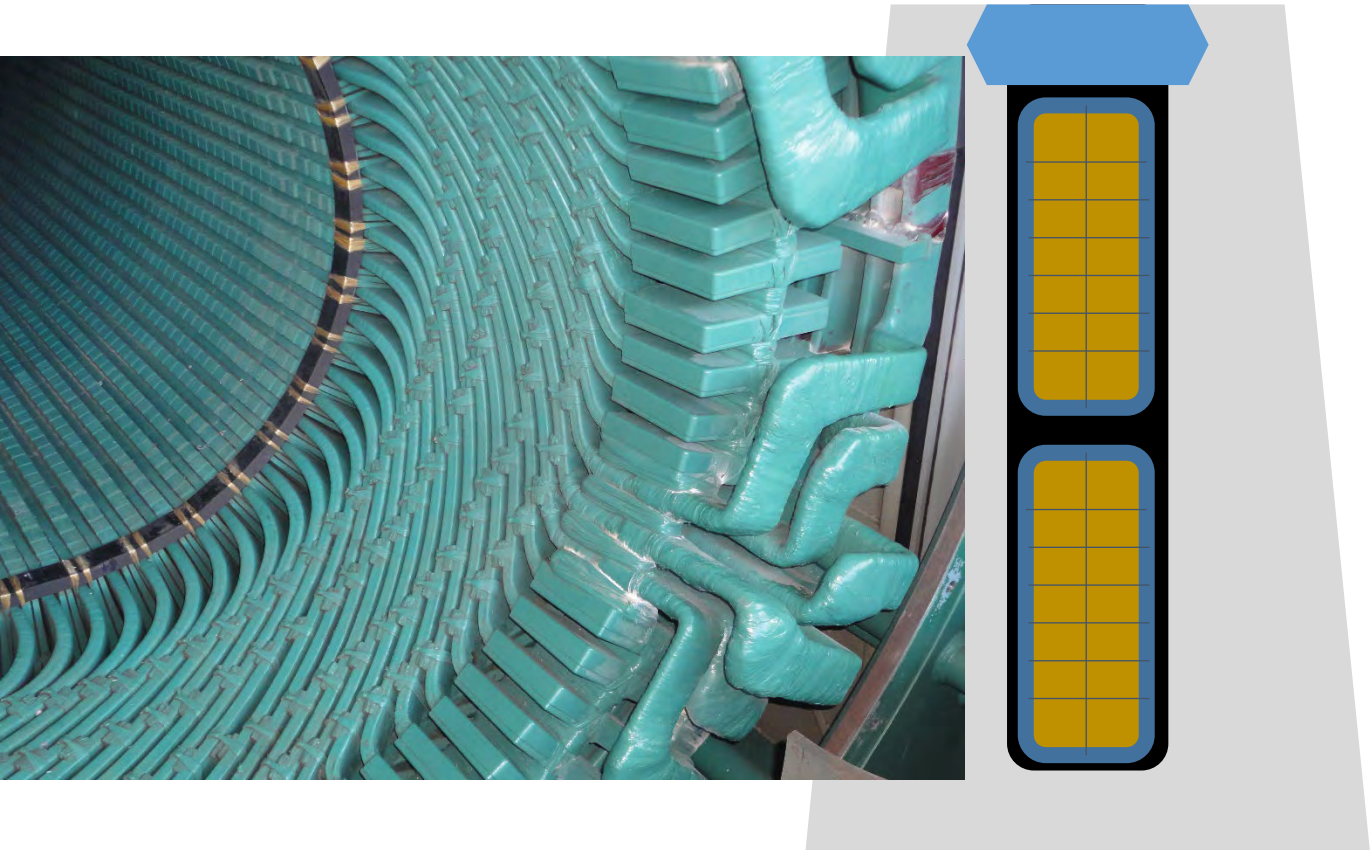
Worming Particles



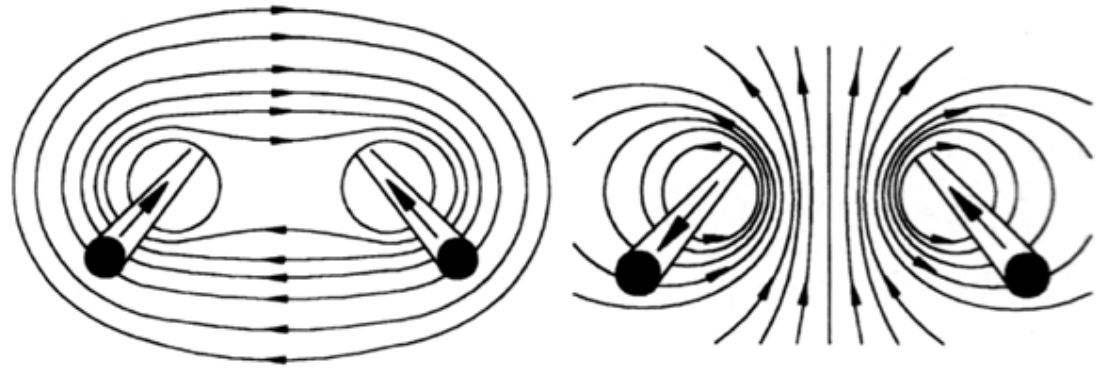
Core Fault



Bar movement / Abrasion

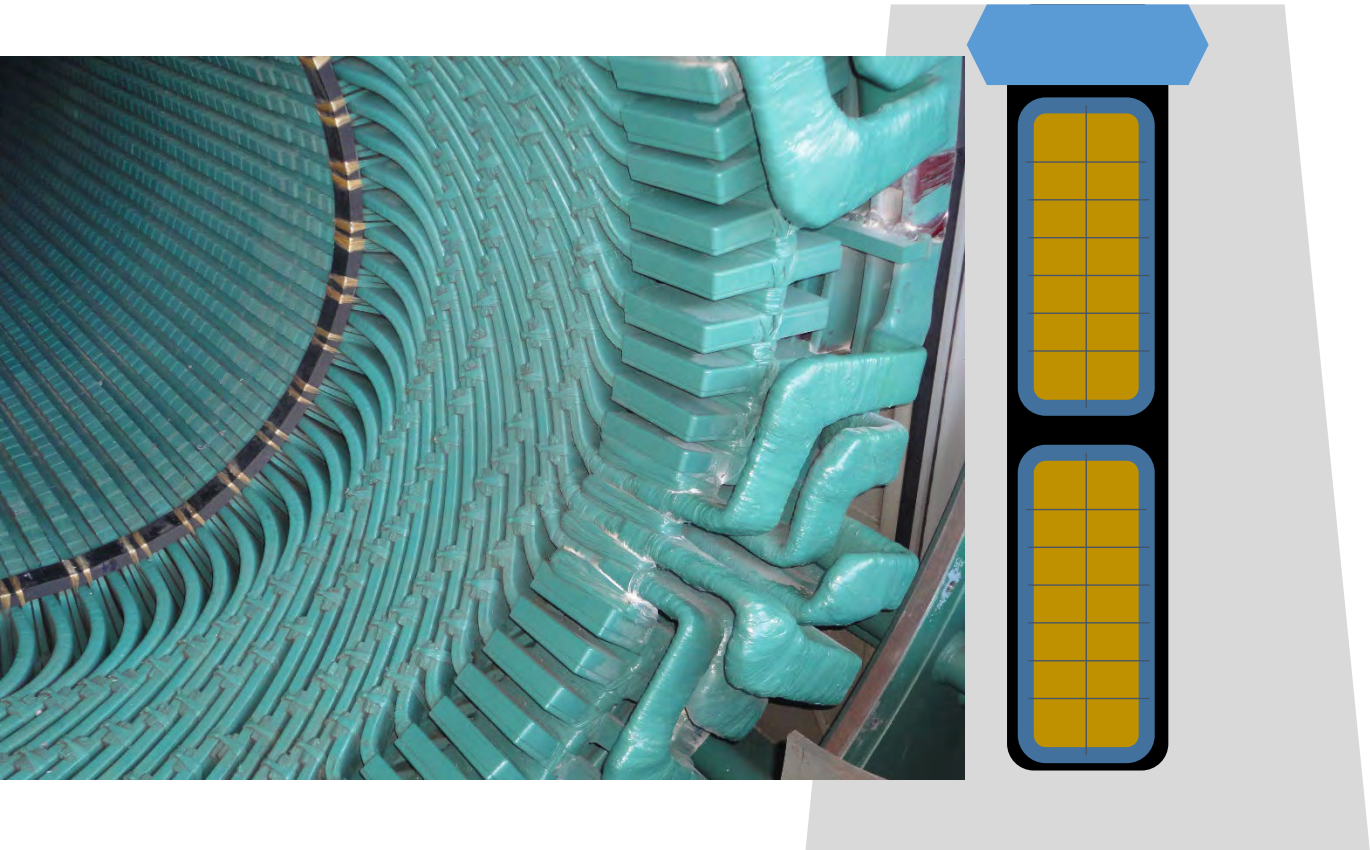


(from Wikipedia)

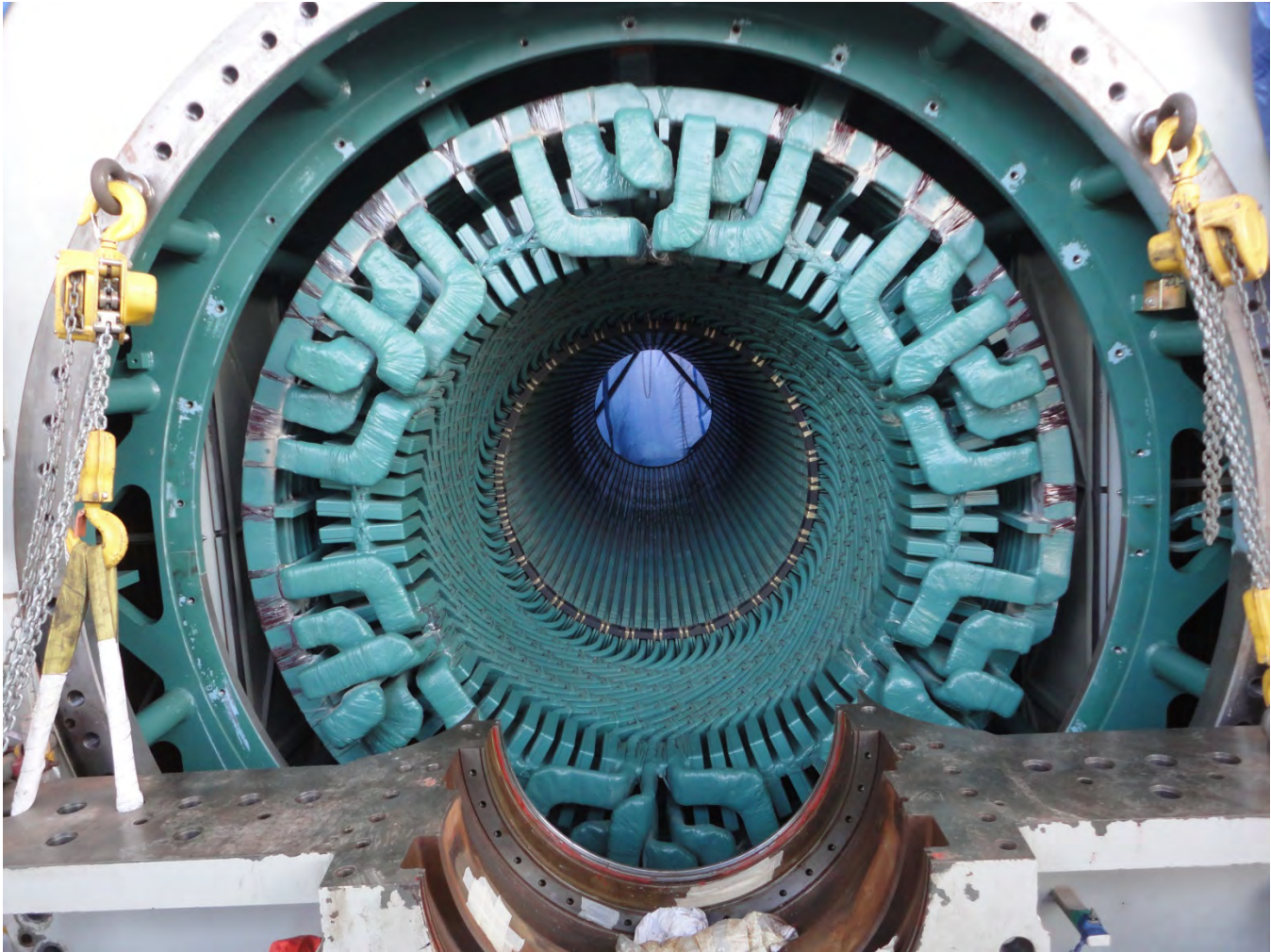


(from gaussbusters.com)

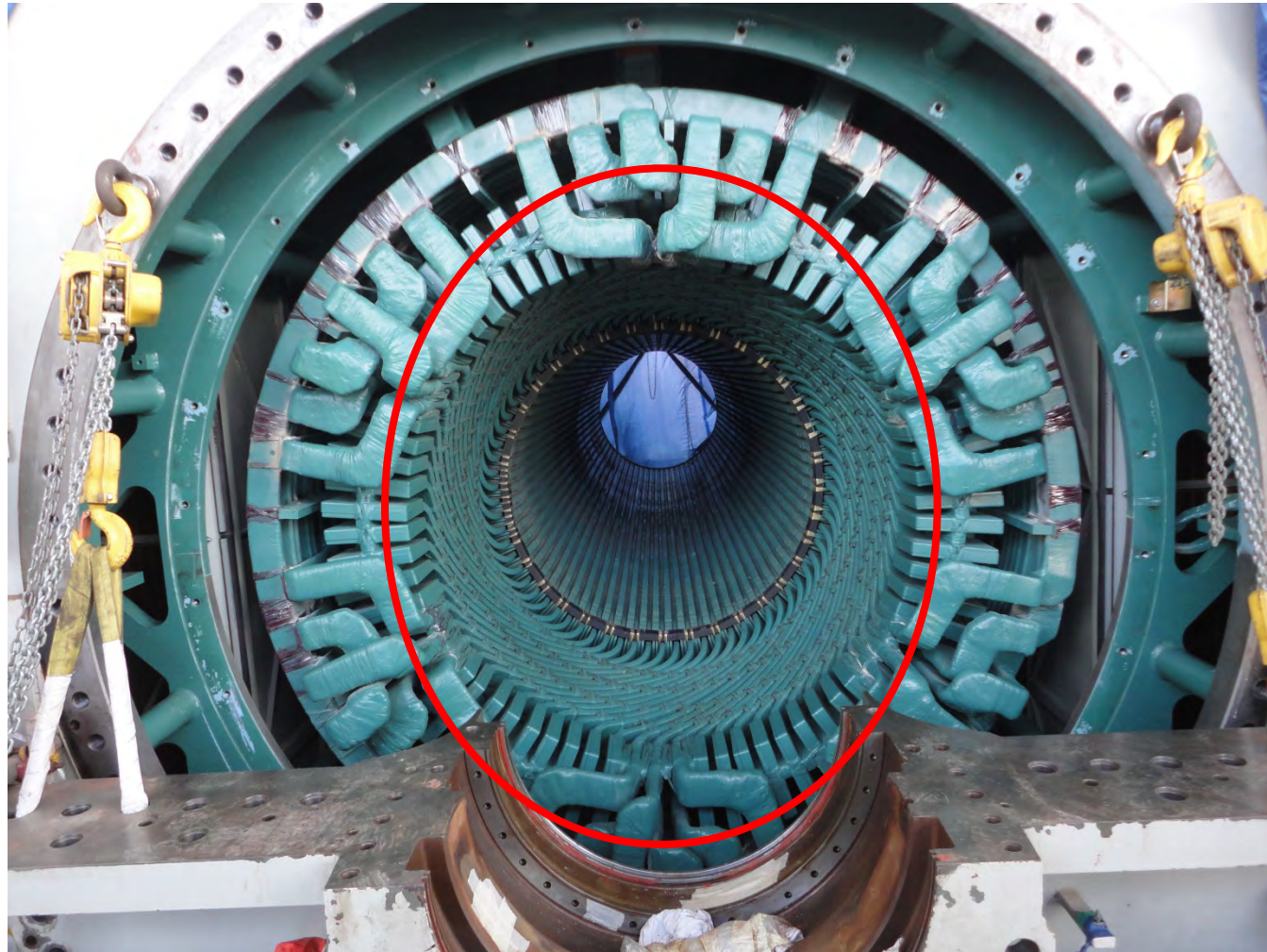
Bar movement / Abrasion



Endwinding Vibration - Local



Endwinding Vibration - Global





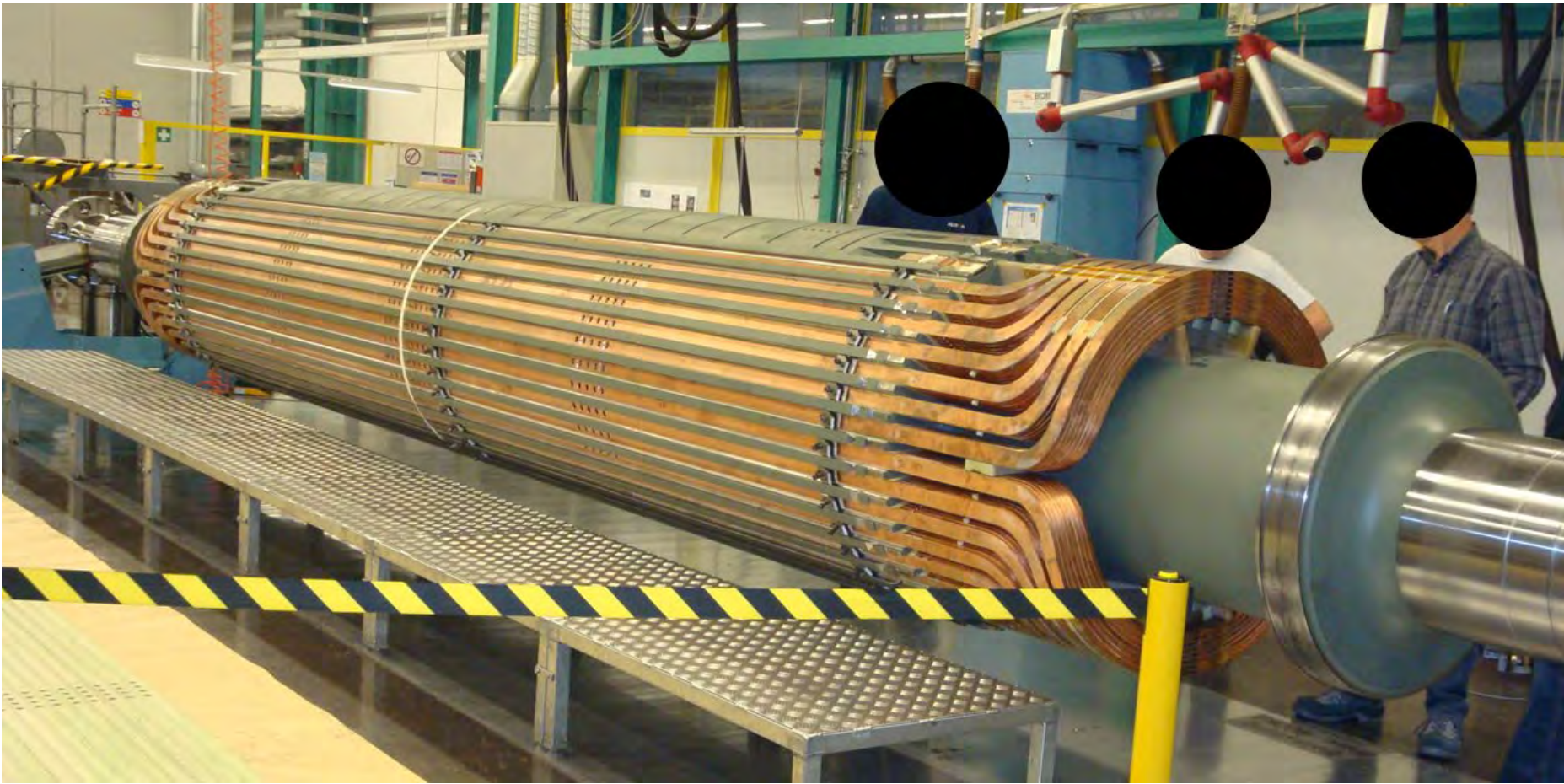
Stator Winding Faults



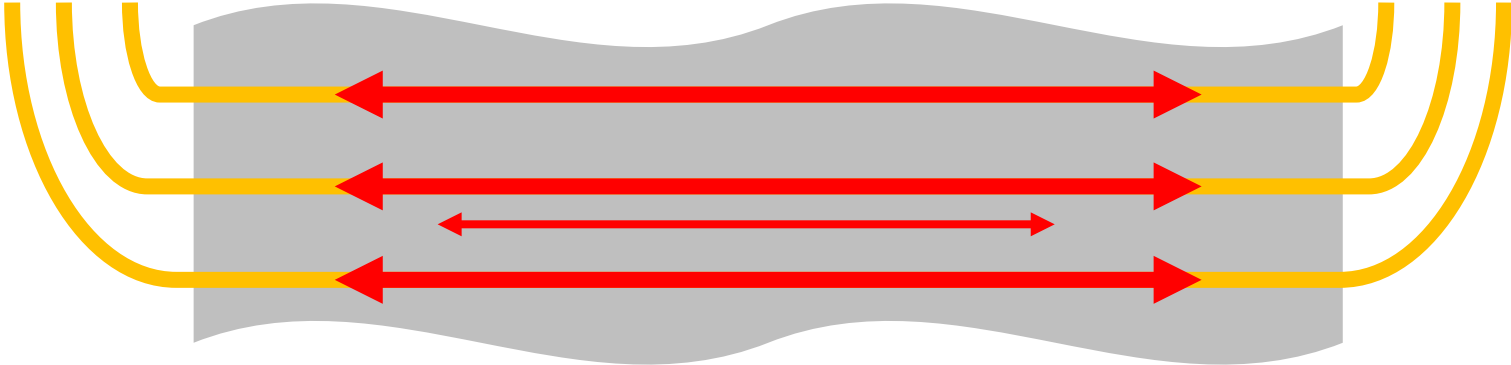
Stator Winding Faults



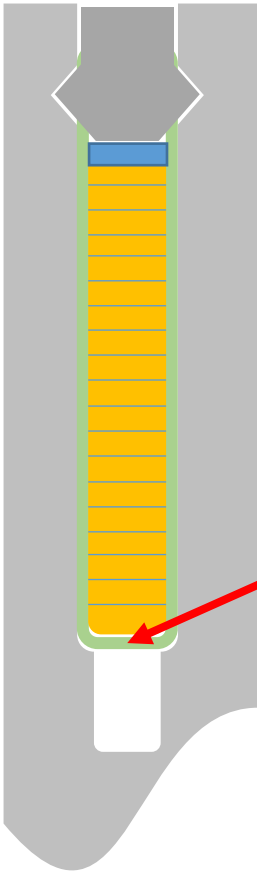
Rotor Faults



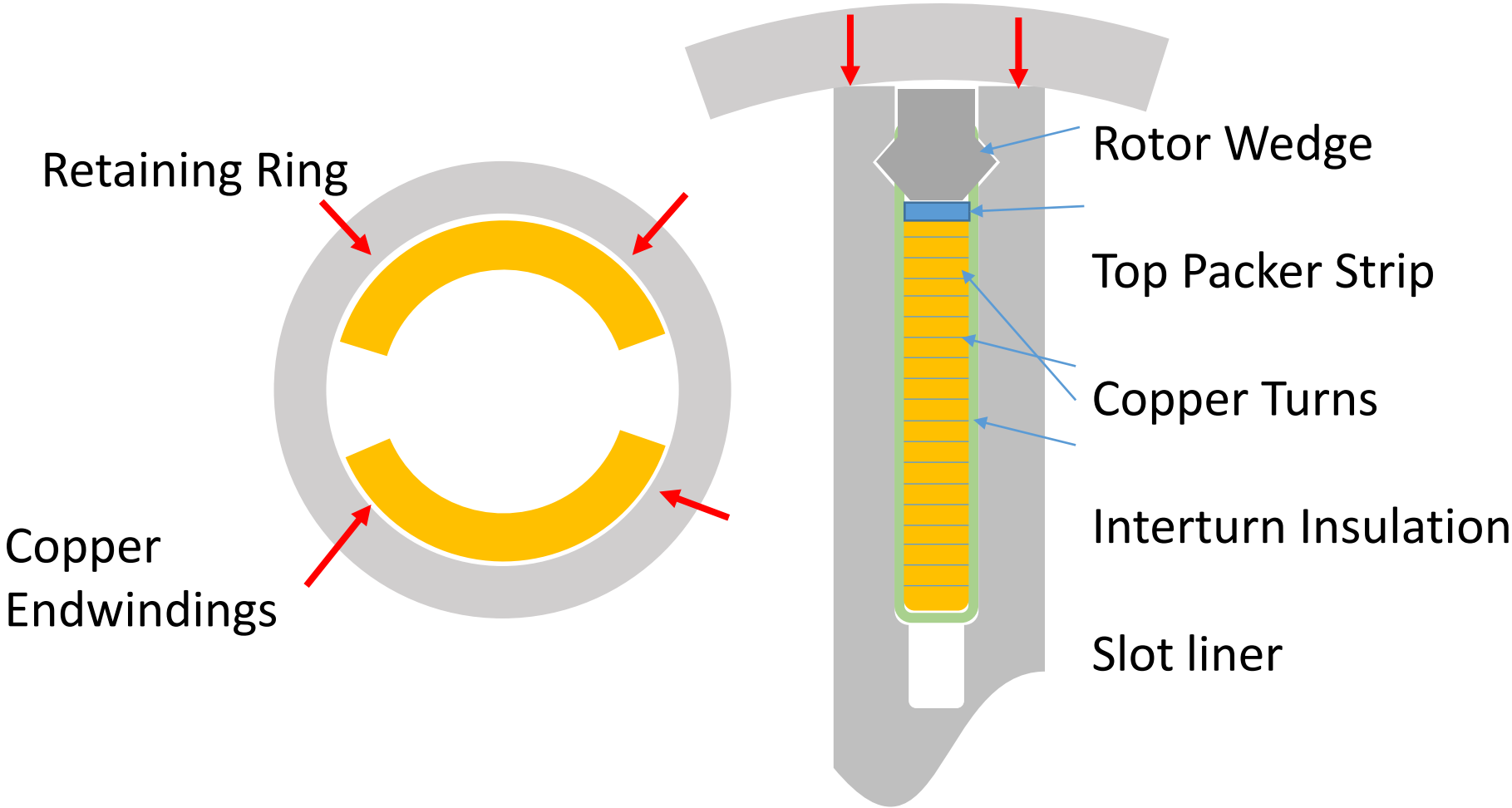
Thermal Expansion Steel/Copper

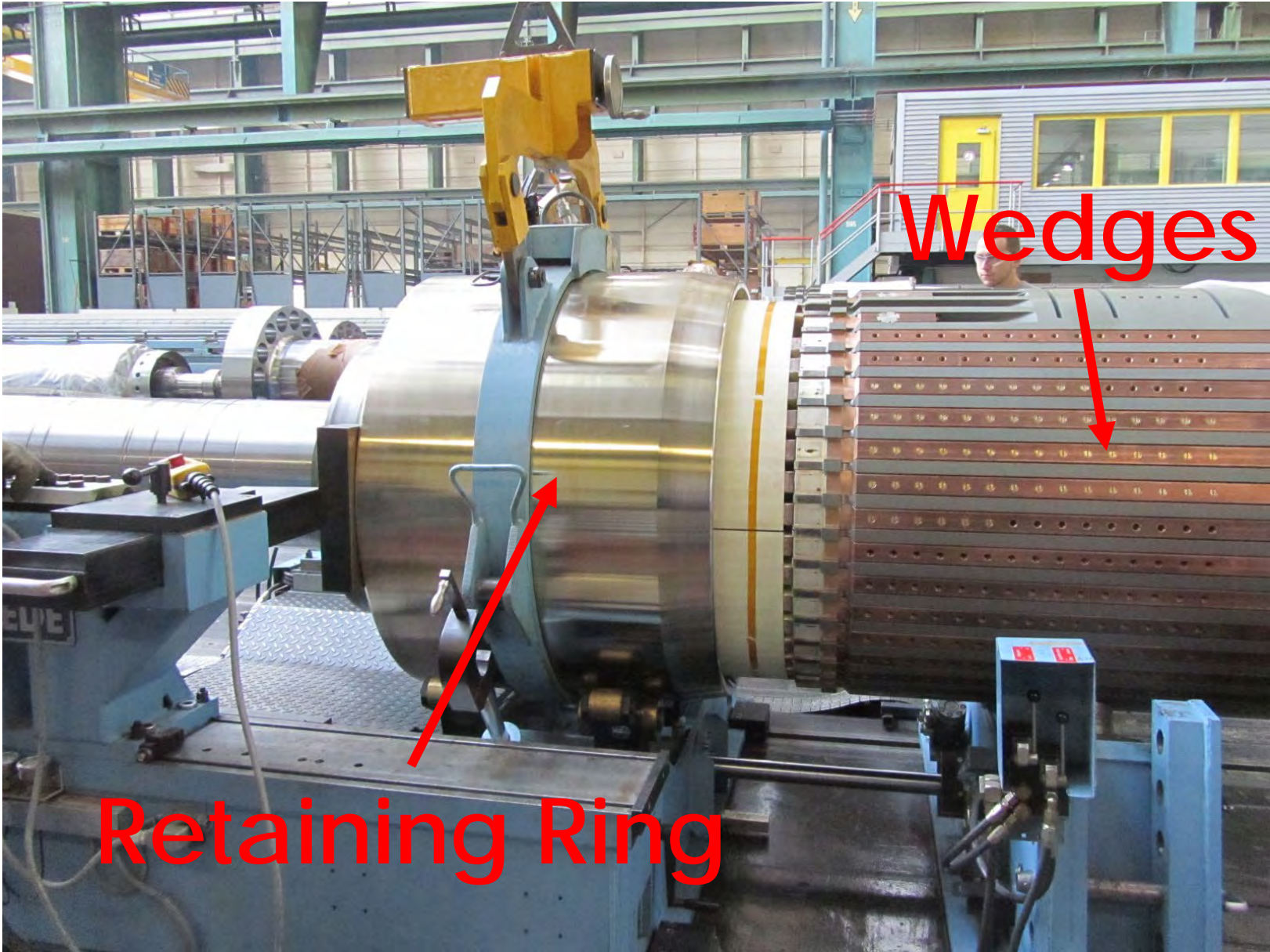


Ratcheting of insulation



Cyclic centrifugal forces

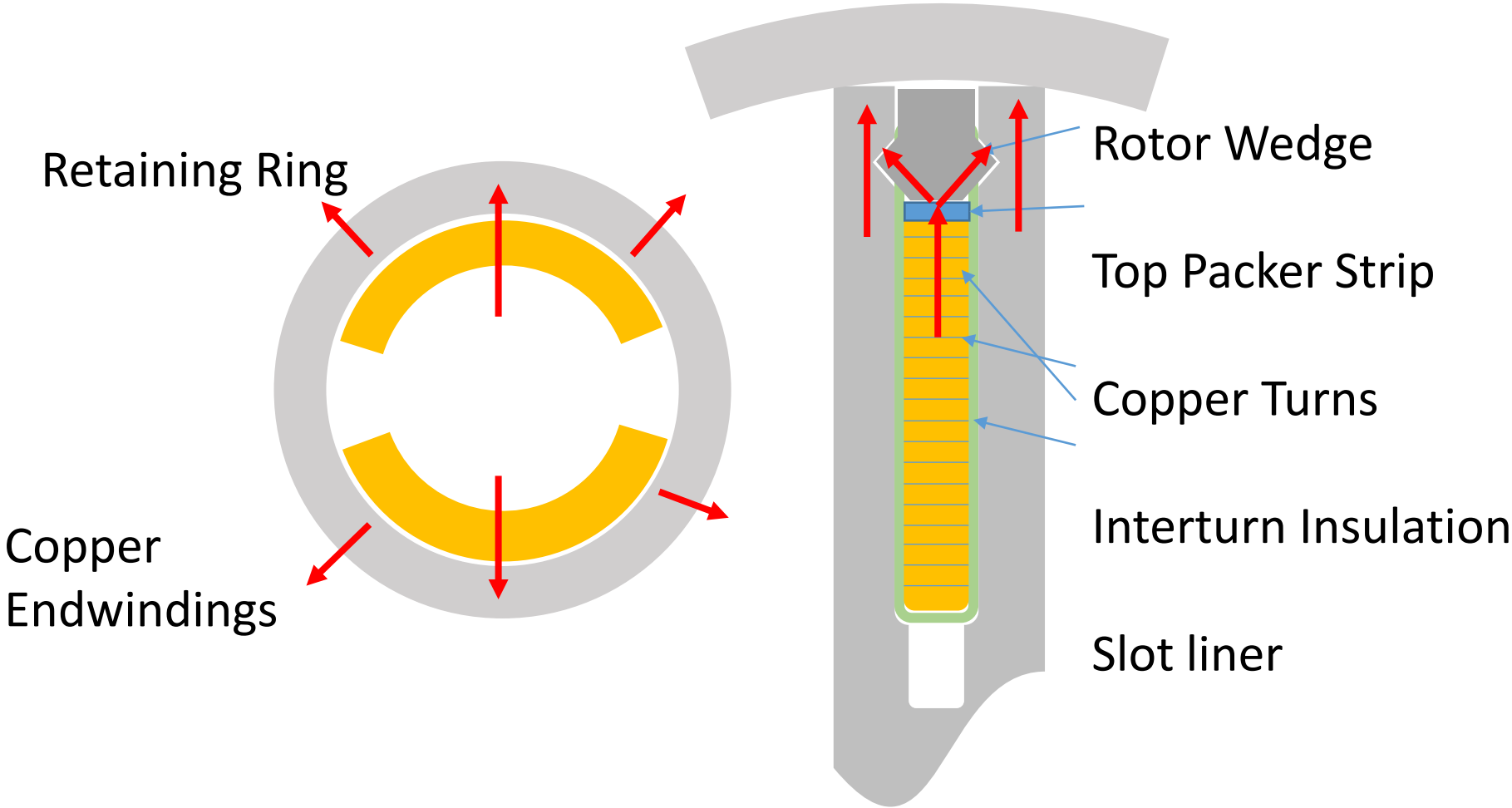




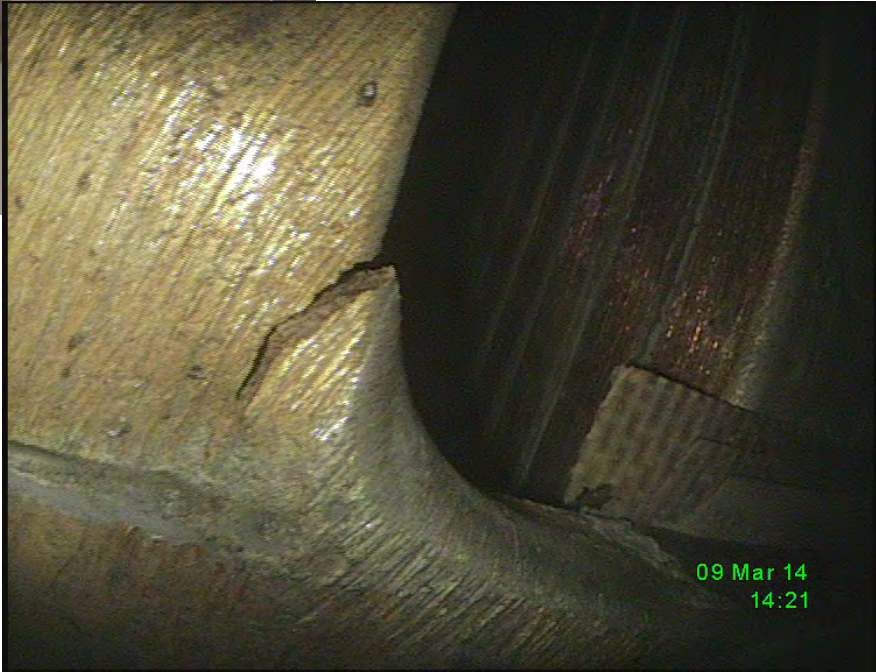
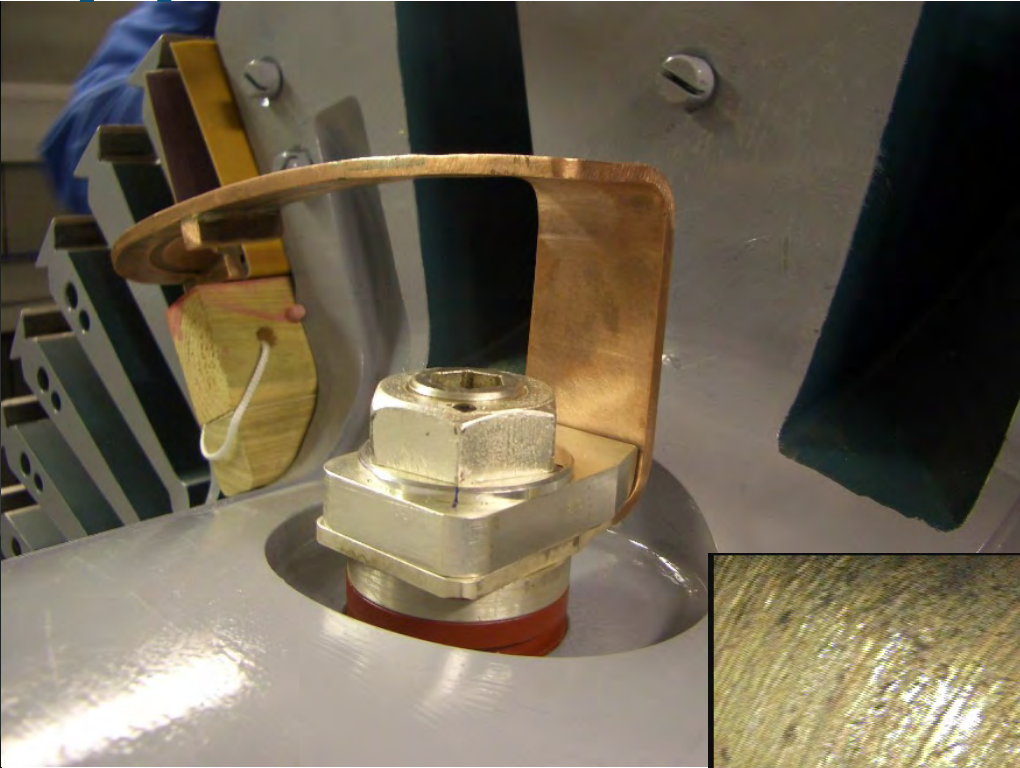
Wedges

Retaining Ring

Cyclic centrifugal forces

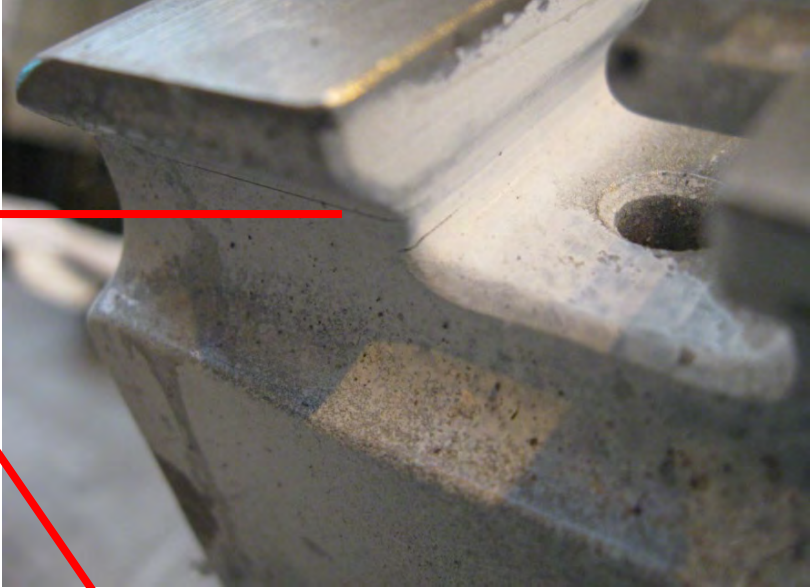
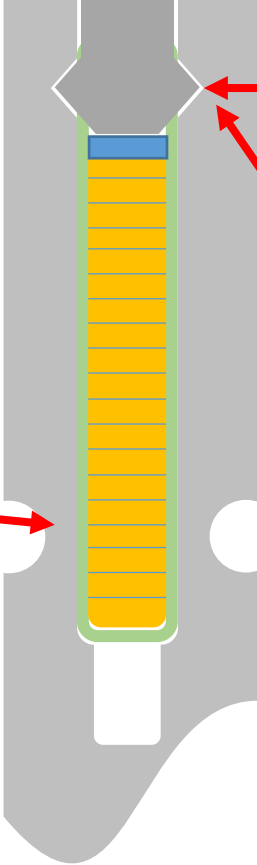


Cracking of copper



04/11/2021

Cracking of forging

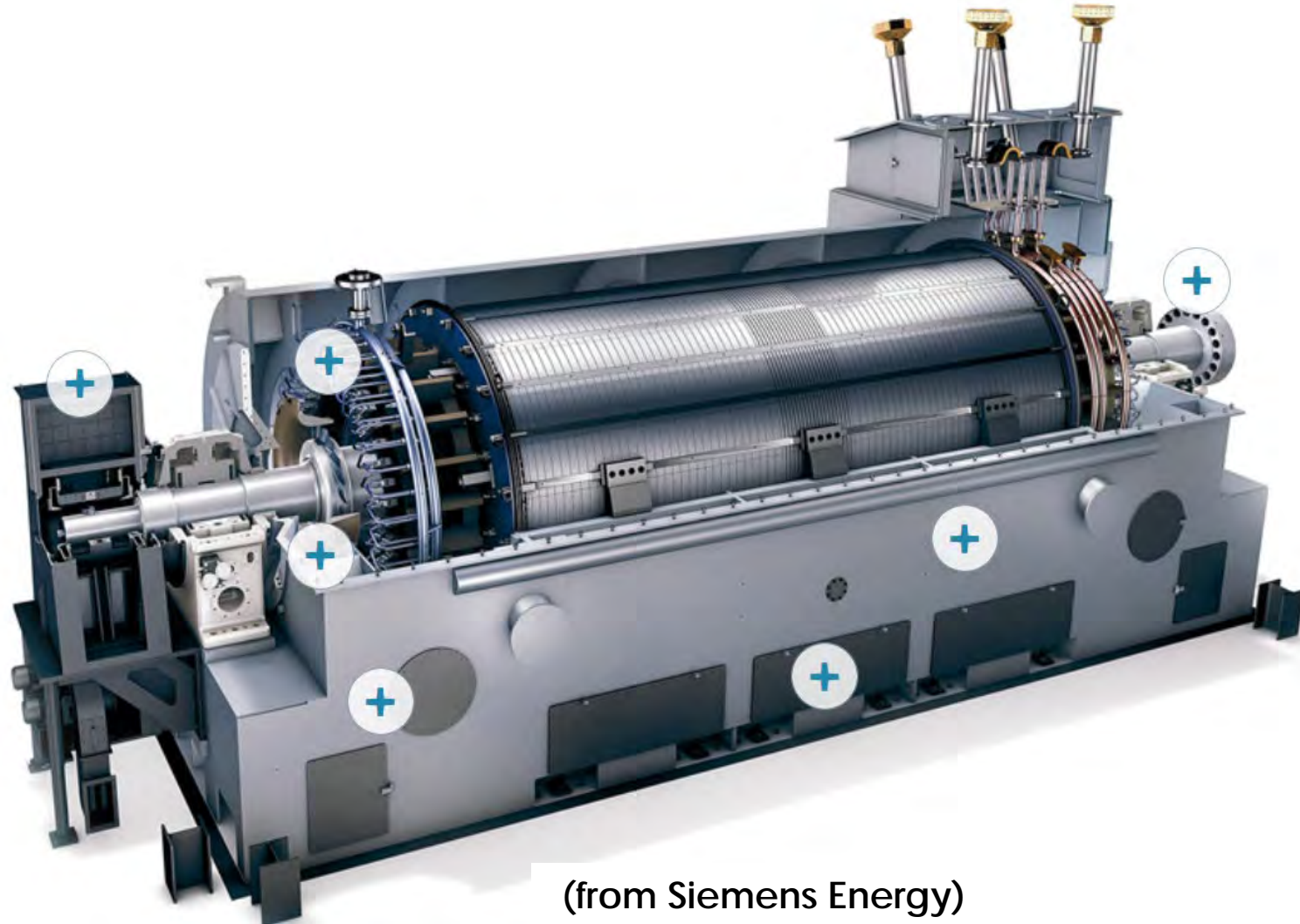


Contamination



How Does The Energy Transition Effect Generators?

Pressurised Air / Water Cooled



(from Siemens Energy)

Catastrophic Failures

Hydrogen Explosion



BUSINESS NEWS

Explosion put Medupi's unit 4 out of service for at least a year, says Eskom

Medupi Power Station was rocked by an explosion in August, which destroyed the plant's unit 4 generator.



A general view of Medupi Power Station completed on 5 August 2021 in Lephalale, South Africa. Picture: Gallo Images/Rapport/Deon Raath


<https://www.citizen.co.za/business/business-news/2877322/medupi-power-station-explosion-eskom-25-october-2021/>

Hydrogen Explosion

Politics & Government

Human Error Caused Plant Bowen Blast, Says Georgia Power

The April explosion at the coal-fired power plant outside Cartersville in Bartow County that injured three resulted from a failure to comply with procedures and communicate.

Brande Poulnot, Patch Staff 
Posted Fri, May 3, 2013 at 4:48 am ET | Updated Wed, May 8, 2013 at 3:40 pm ET

 Like 1

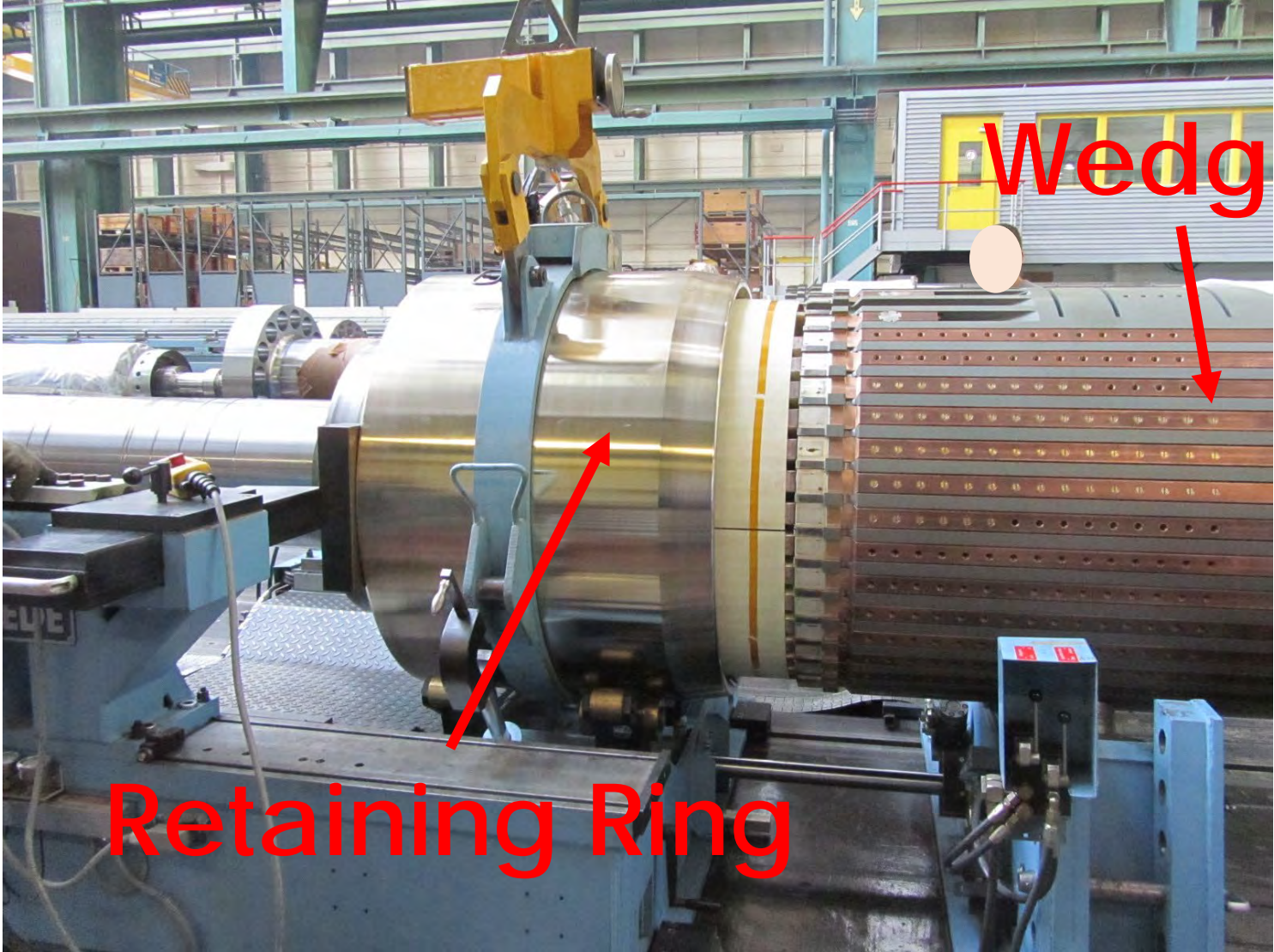
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 Reply



<https://patch.com/georgia/cartersville/human-error-caused-plant-bowen-blast-says-georgia-power>

Retaining Ring Failure

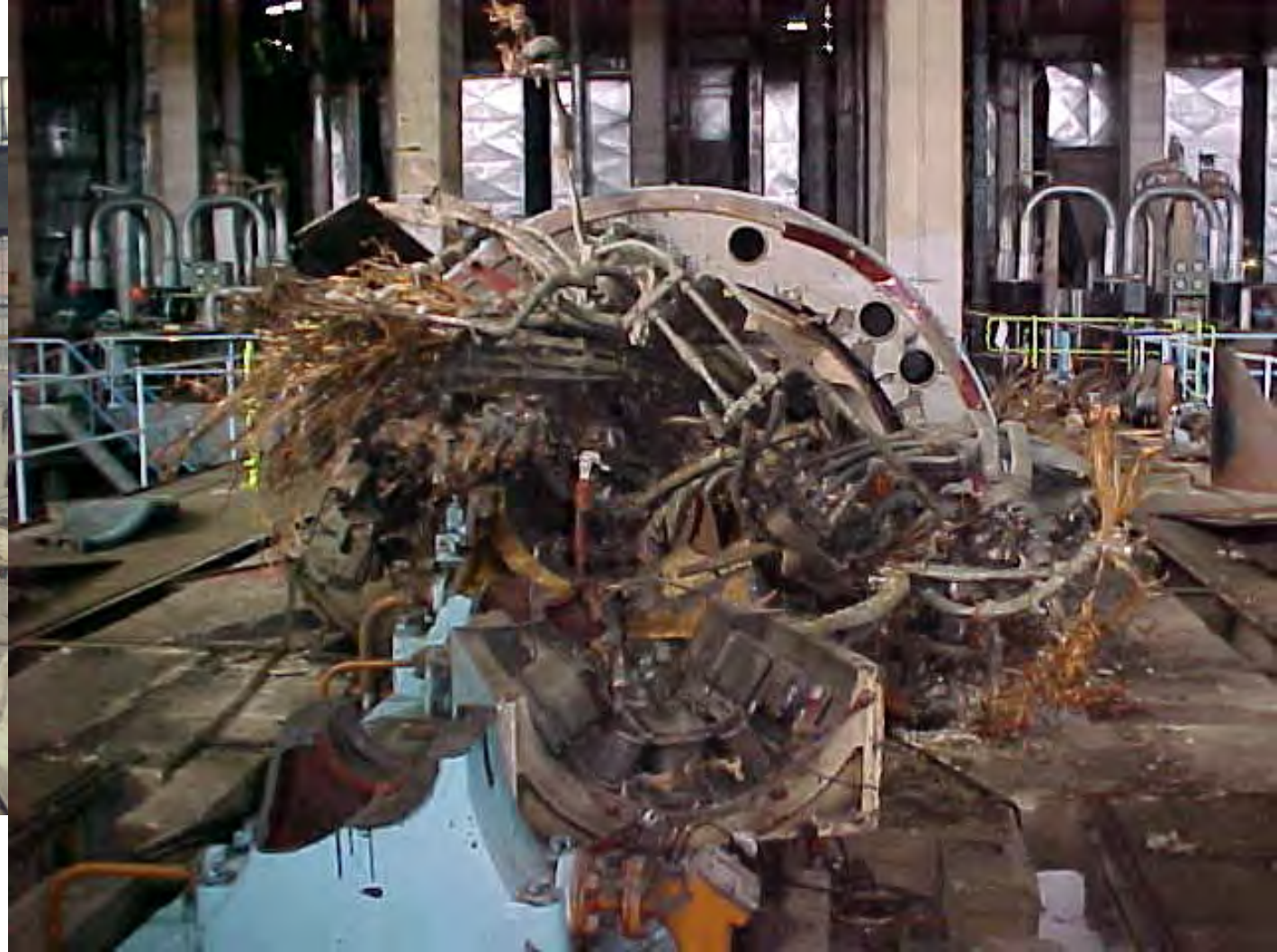
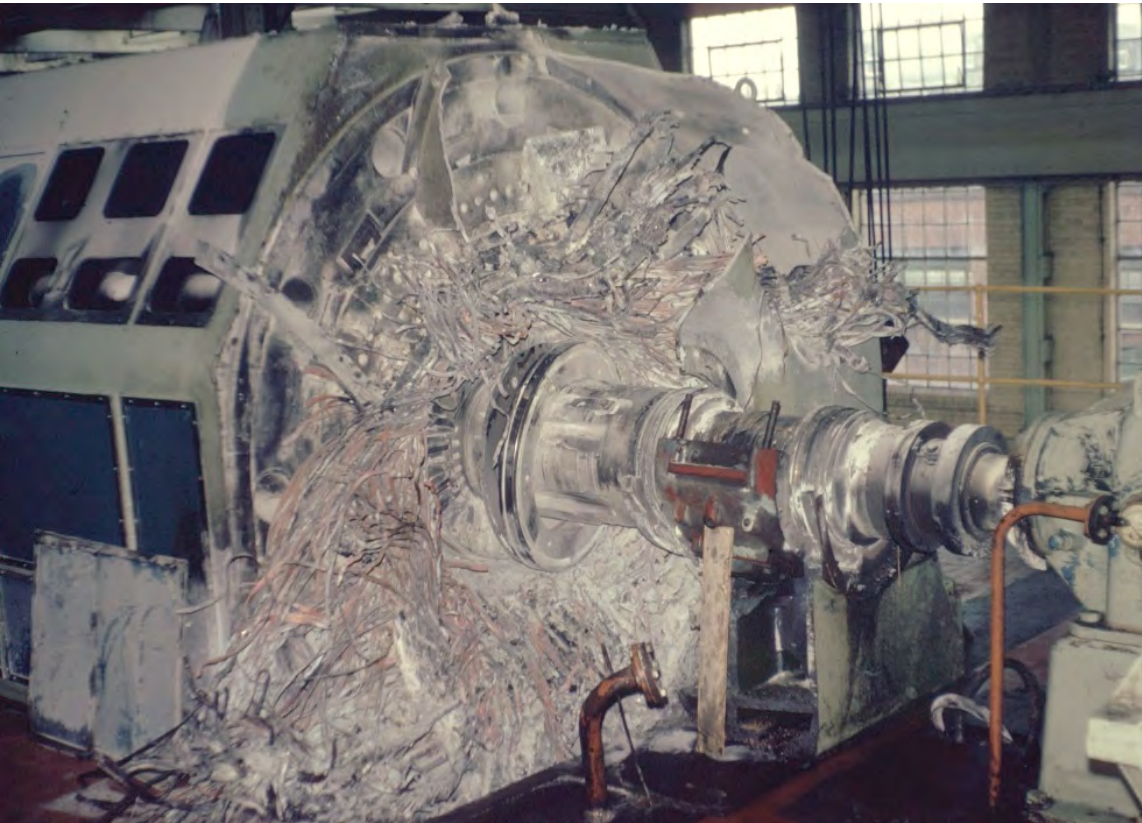


Wedges

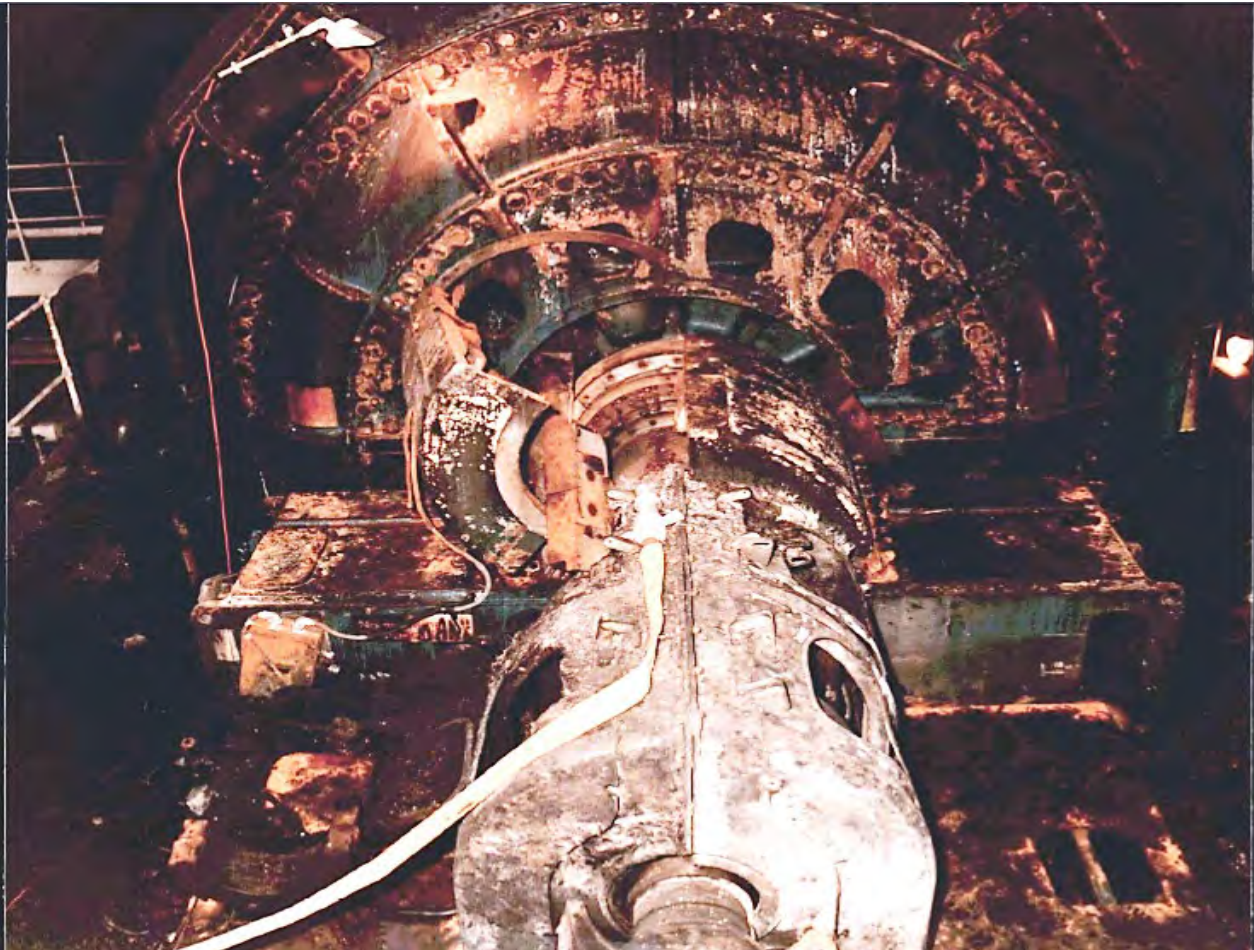


Retaining Ring

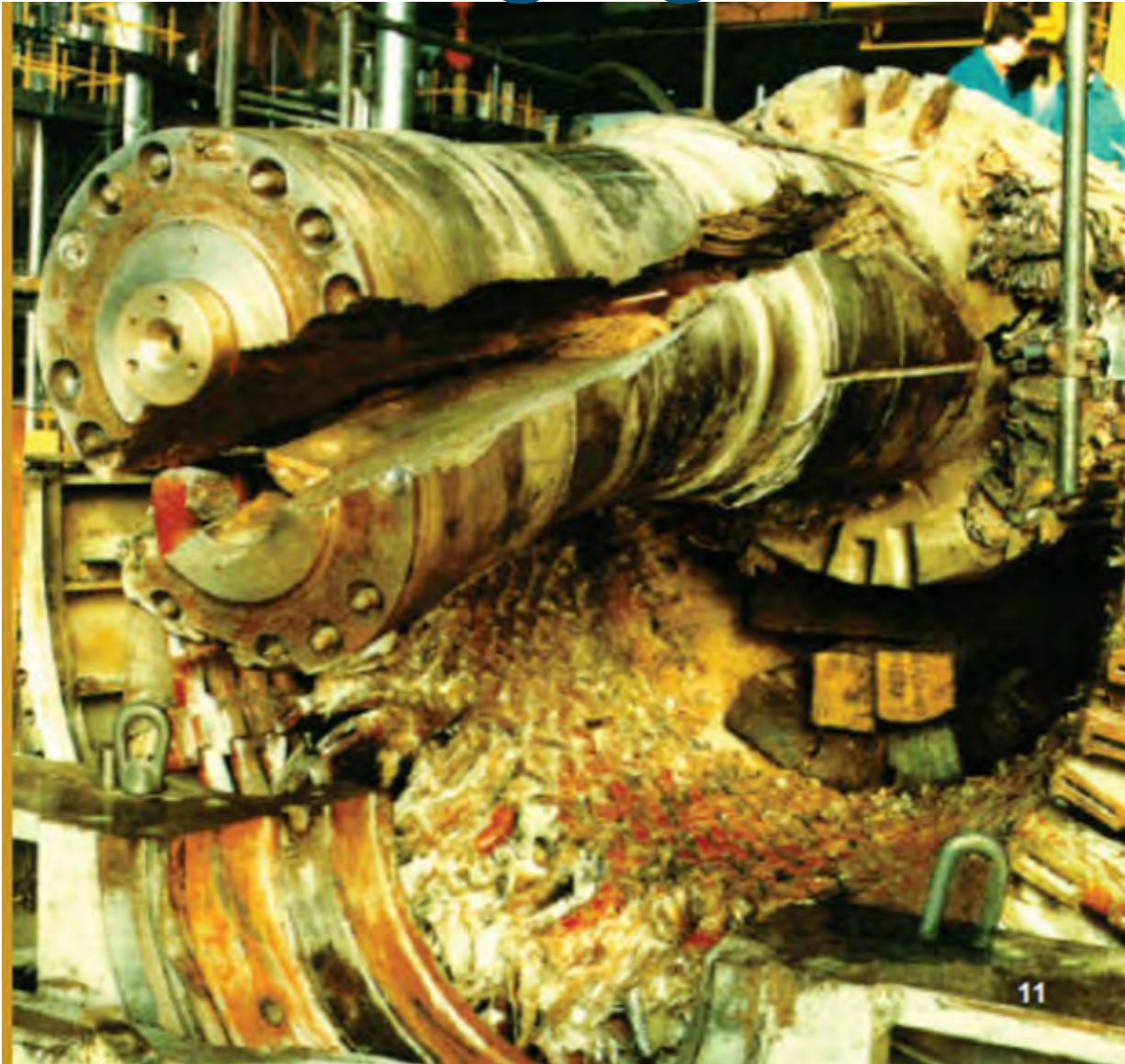
Retaining Ring Failure



Wedge Failure



Rotor Forging Failure



11

“NORDIC NUCLEAR POWER GENERATOR STATOR VIBRATIONS” by Energiforsk

Turbine Overspeed



<http://www.tathasta.com/2018/03/duvha-south-africa-turbine-overspeed.html>

Other Examples

Photo reveals 'catastrophic' damage to Callide Power Station that blacked out Queensland

By Jess Rendall

Posted Wed 2 Jun 2021 at 10:29am, updated Wed 2 Jun 2021 at 10:31am



Recent Experience



4 Phase Separations



3 Rotor Faults



2 Core Faults

1 Brushgear Failure





4 Fatigue / Vibration

3 Deficient Protection

2 Clean Conditions

1 Poor construction

1 Grid Induced

1 Poor maintenance

1 High Levels of Start / Stops



Any Questions'



- Feel free to email – ben.adams@hawkins.biz