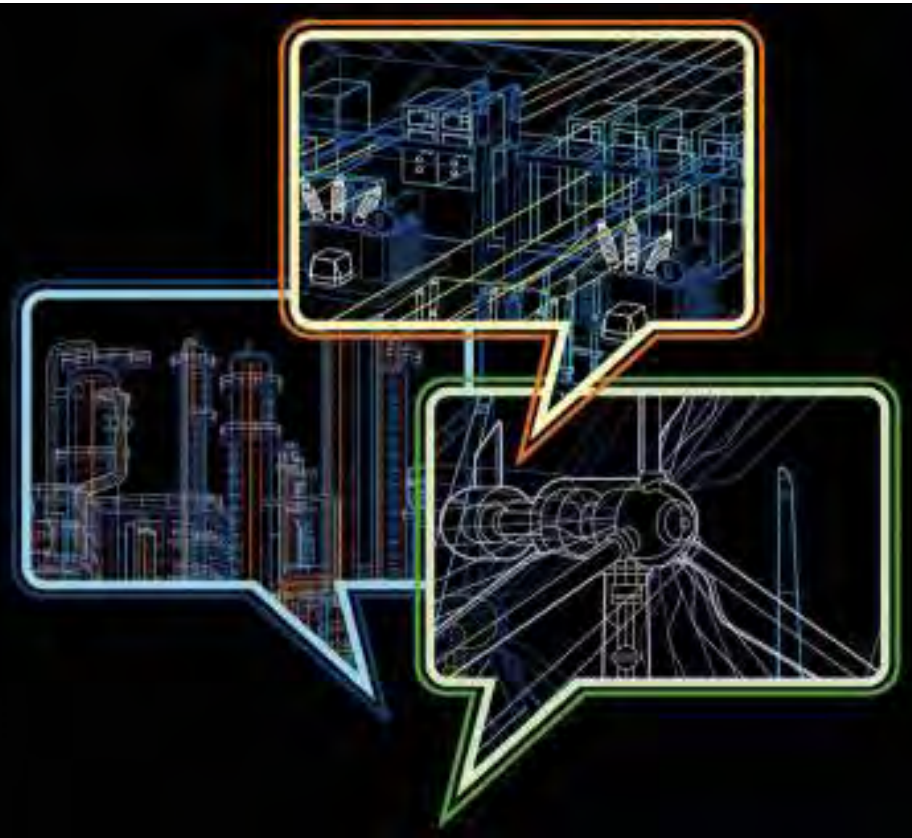
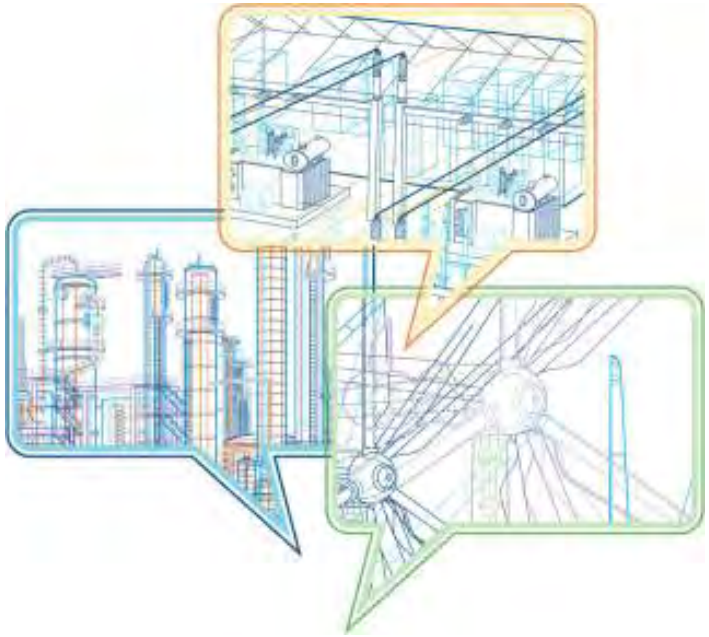


Craig L Stiegemeier

Environmentally friendly design, retrofit and remanufacturing of power transformers

Automation & Power World 2011
April 18-21, 2011 in Orlando, Florida

Automation & Power World 2011
April 18-21, 2011 in Orlando, Florida



- Save the date for this must attend" event!
- April 18-21, 2011
- Orlando World Center Marriott, Florida
- Over 400 hours of educational training
  - Business forum
  - Customer case studies
  - Hands-on training
  - Panel discussions
  - Technical workshops
- Earn PDHs and CEUs
- Technology & Solution Center
  - Over 70,000 sq. ft. of exhibits
- Network with your peers
- www.abb.com/a&pworld

ABB Automation & Power World
At-a-glance

400+

Educational Workshops
Automation & Power World offers over 400 hours of Educational Workshops specifically designed to make engineers, maintenance and management more valuable to their companies.

70K

Technology & Solution Center
Over 1 ½ acres (70,000 ft²) of with nearly100 tons of electrical gear and 100's of experts ready to answer any of your questions and share the future of Automation & Power Solutions.

4,000

Connect with Peers
With over 4,000 of your peers in attendance, this is a powerful opportunity to network and learn from the industry. In addition, over 45 customers will be sharing their own case studies.

Educational workshops developed for all audiences
Just a few examples

Roles

- **Engineering**
- **Management**
- **Maintenance**

Company types

- **Industrials**
- **EPCs**
- **Utilities**
- **OEMs**

- The coming wave of process safety system migration
- Implementing an alarm management strategy for a 100,000 I/O system - Case study
- Replacement and retrofit of large motors: Challenges and solutions
- Dynamic studies for large scale renewable energy integration at a Texas CREZ - Case study
- Secure commissioning of your process plant - Case study
- New arc flash mitigation technologies and techniques for a safer working environment
- Robotics 101
- A better approach to non-revenue water loss
- Electric vehicles: Are they real this time?
- Why is SIL more important than architecture?

Past attendees input

“I am impressed with the different parts of the program, the workshops and also the exhibit set-up... there is a lot of information to pick up.”
Duane Souers, Georgia Pacific

“It’s a great opportunity to get a lot of exposure to people and products in one week.”
Pardeep Gill, Alcoa

“It is well worth the time given the opportunities to: learn from industry experts, network with peers in the same industry, learn about emerging technologies, and build excellent supplier relationships.”
Sanjin Osmancevic, National Grid

Craig L Stiegemeier

Business Development & Technology Director; ABB Transformer Remanufacturing & Engineering Services, North America

Environmentally friendly design, retrofit and remanufacturing of power transformers

Remanufacturing vs. Repair of Power Transformers

- Transformer Lifecycle Support
- Factory repair and remanufacturing - what's the difference?
- Simulation Tools
- Materials advancements – recycle or new?
- Identification of design weaknesses
- Upgrade and design improvement opportunities
- Power transformer remanufacturing process overview
- Remanufacturing Case Study
- Specialized Processes and Equipment to support field repair

Remanufacturing vs. Repair of Power Transformers
ABB Remanufacturing Centers

- Saint Louis, Missouri
  - Up to 345kV, 1050 BIL
  - Repair of Core Form, Specialty, and Traction Transformers

- Varennes, Quebec
  - Up to 765kV, up to 2050 BIL
  - HVDC Converter Transformers
- Edmonton, Alberta

  - Up to 230kV, 100 MVA
- South Boston, Virginia
  - Up to 69kV, 20 MVA

Remanufacturing vs. Repair of Power Transformers
Similarities and Differences

- Remanufacturing and Repair both:
  - Typically require transportation to a production facility
  - “Recycle” the core steel and tank, and replace worn out organic materials
- “Reverse engineering” can be used to repair any manufacturer’s product
  - Performance is limited by the technology of the original design
  - Problems lived with in the past will continue to be experienced in the future
  - Time must be spent recreating the design and materials ordering information
- If the facility has advanced Engineering Capabilities, they can:
  - Analyze the existing design to identify weaknesses
  - Redesign the coils and insulation system, while reusing the tank and core
  - Utilize technological and application advances in winding and insulation materials
  - Create a new design that will perform better than the original design for the specific application
- Remanufacturing Can Take Advantage of Design Enhancement & Capacity Upgrade Opportunities
- As-new Transformer Life would be expected from both approaches
- Limitations & Drawbacks:
  - By reusing the core, the no-load loss performance of the core is limited to the technology advancements from the time of original design and manufacture
  - Design time must be considered in the remanufacturing process

Remanufacturing vs. Repair of Power Transformers
Similarities and Differences

If the repair operation has access to the OEM's design information, the repair can begin even before the transformer is received

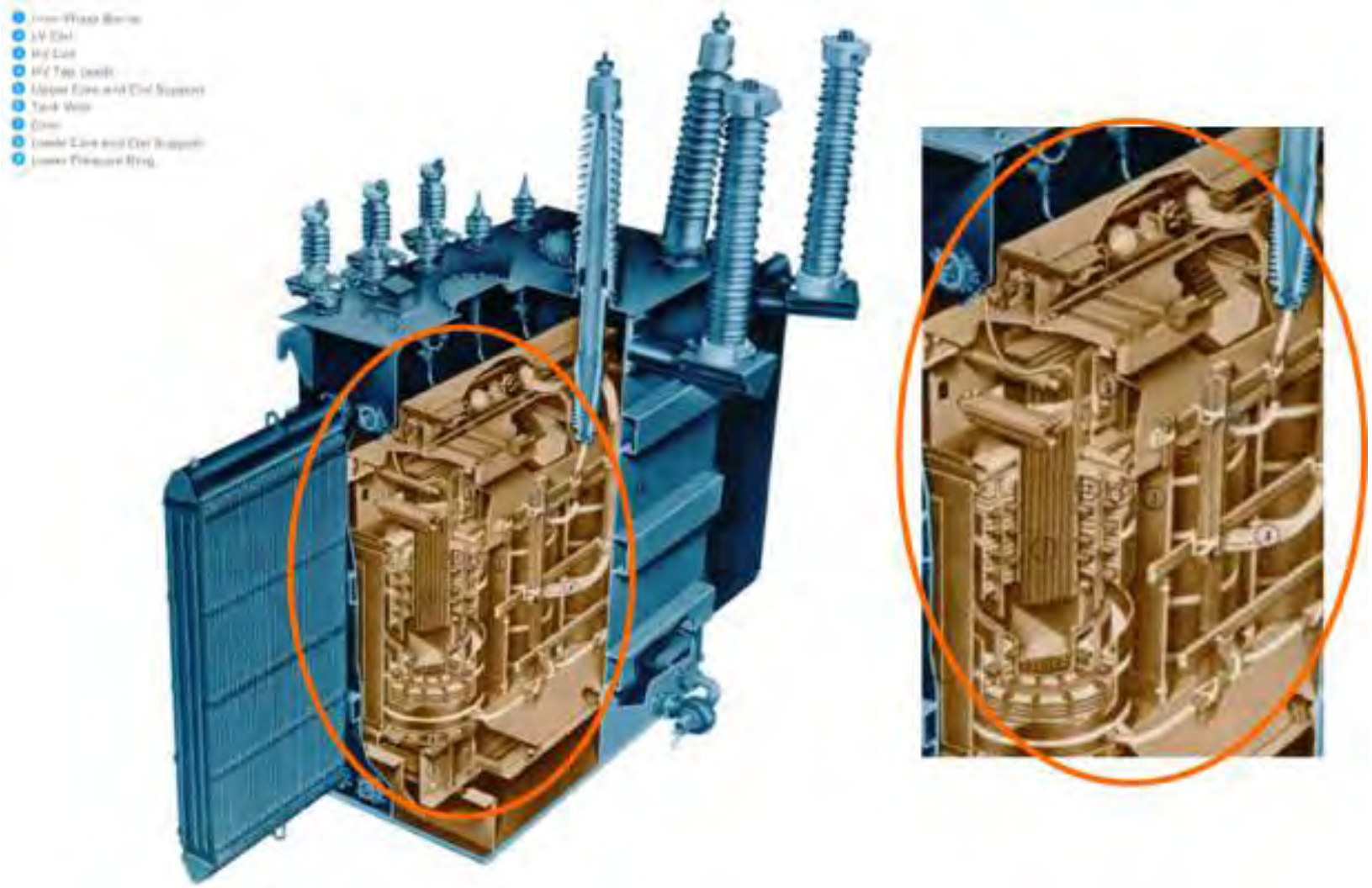
Repair/Remanufacturing Focused Factories

- Dedicated "State of the Art" Remanufacturing Facilities
- Dedicated Engineering, Drafting, and Manufacturing Resources
- "Cutting Edge" Technology That Meets Present Day New Transformer Standards
- Remanufacturing Takes Advantage of Design Enhancement & Capacity Upgrade Possibilities
- Reverse Engineering Capabilities
- Transformer Life Renewal/Extension by replacing organic materials and reusing materials that do not age
- Advance Design, Material Ordering, and Manufacturing Capabilities
- ABB Engineers can assist in providing data for the repair versus replace decision
- Understanding of All OEM Designs through hands-on experience
- ISO 9001 and 14000 Certified
- Established Quality Plans

Remanufacturing vs. Repair of Power Transformers
Broad Product Life Cycle Support

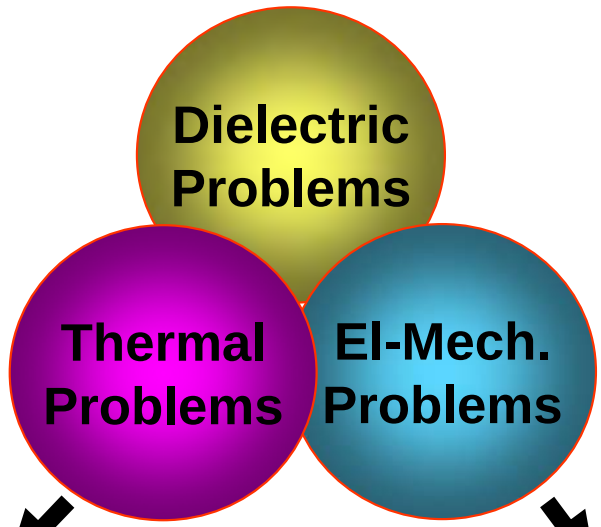
- ABB has access to the technology of the majority of installed utility power transformer assets in North America
- Typically we can access design information for 70% - 80% of transformers within days
  - ABB
  - Ansaldo
  - ASEA
  - Brown Boveri
  - GE (> 40 MVA in USA)
  - Kuhlman
  - Moloney Electric
  - National Industri
  - Strömberg
  - TTI (GE Canada)
  - Westinghouse
- We also provides services for other OEM's transformers

Remanufacturing vs. Repair of Power Transformers
Remanufacturing addresses the heart of the problem



Repair or Remanufacturing is required when

Electrical breakdown caused by overvoltages or insulation ageing



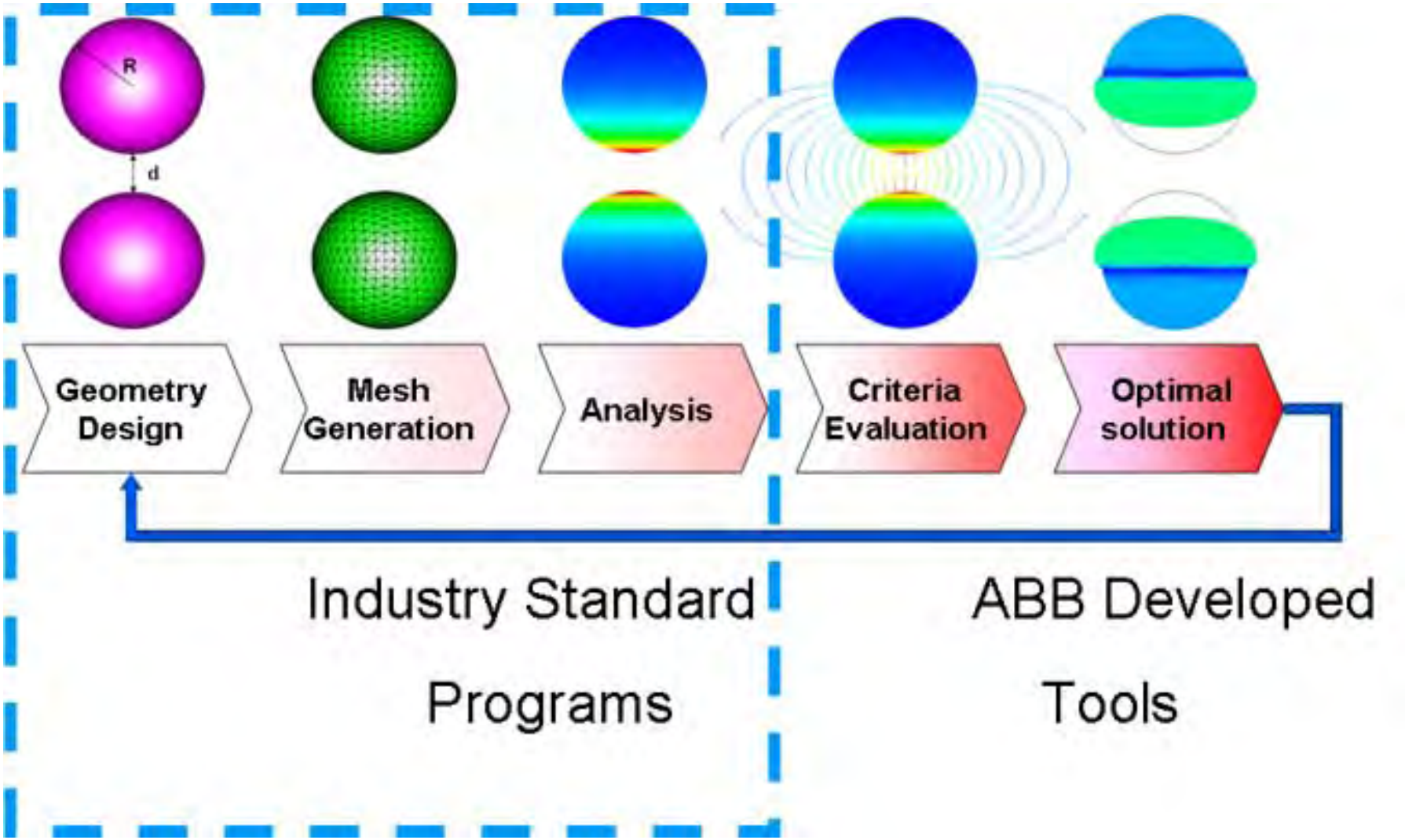
Material degradation caused by thermal overheating

Mechanical deformations caused by short-circuit faults

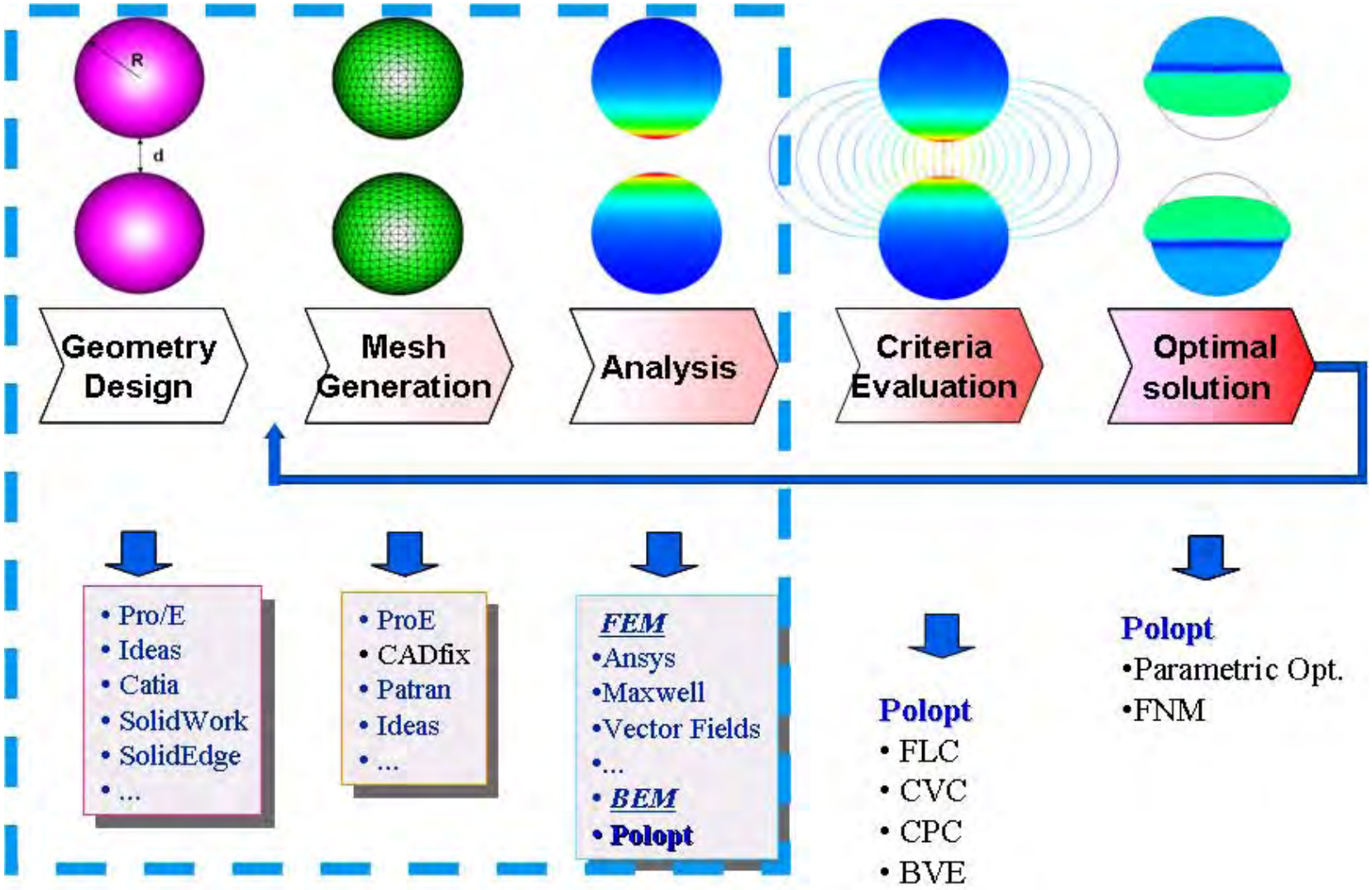
Remanufacturing vs. Repair of Power Transformers
Why Use Simulation Tools during a repair?

- Industry Situation
  - Aging fleet of power transformers is 39 + years with unknown life expectancy
  - Size of installed base (in US >130,000 power transformers)
  - GSU has 1.3 units/design - “Fleet of prototypes”
- Vast majority of the installed transformers were not designed with finite element method (FEM) tools
  - Experience has shown that key technical issues can be analyzed and solved only by 3D FEM modeling
- 3D Simulation Based Transformer Services (SBTS) is the tool for analysis of:
  - Field failures, problems or upgrades
  - New designs for replacement transformers
  - Life and condition assessment for units in operation

Remanufacturing vs. Repair of Power Transformers
CAD-Based Simulations



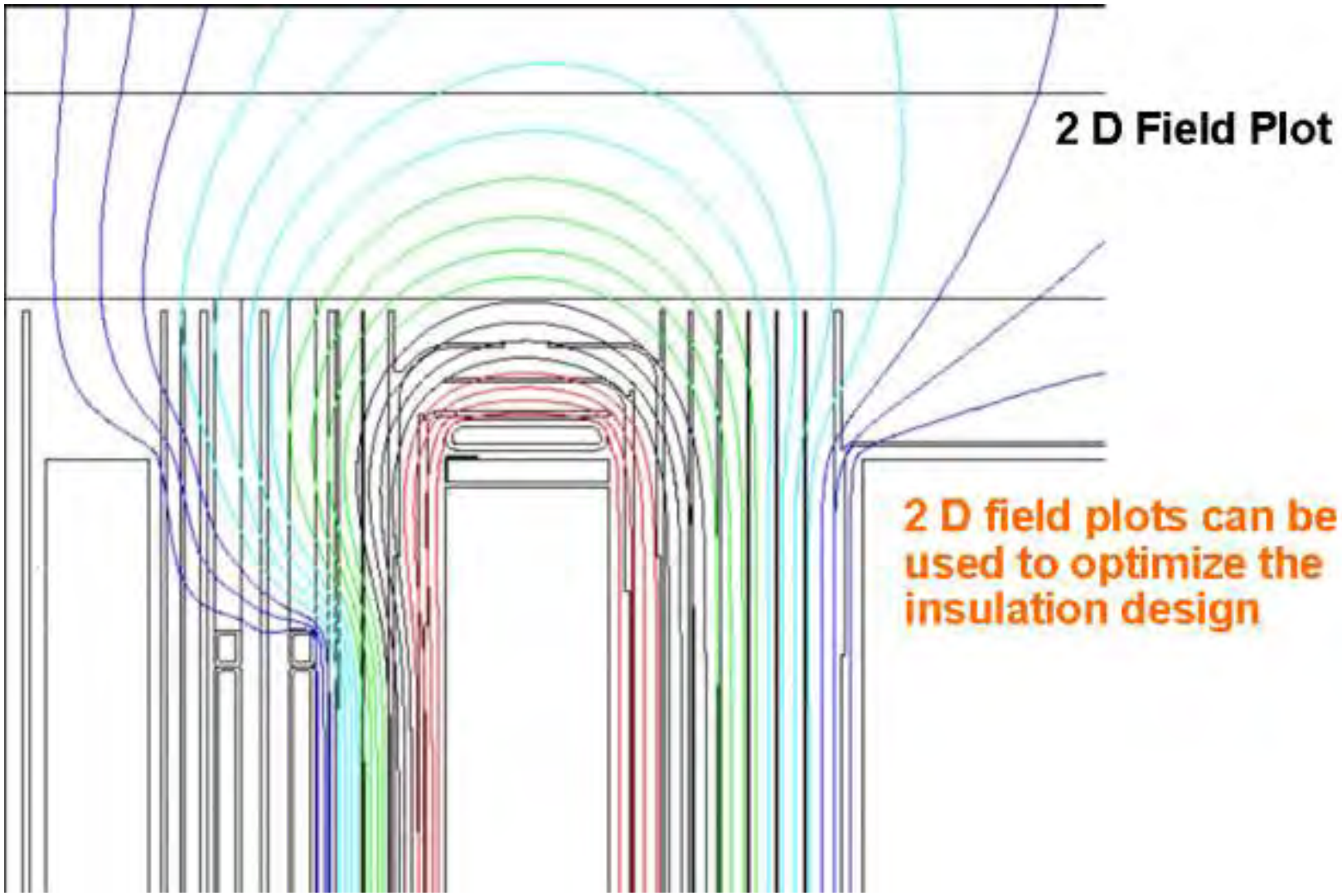
Remanufacturing vs. Repair of Power Transformers
CAD-Based Simulations



Remanufacturing vs. Repair of Power Transformers
Power Transformer Analysis Design Tools

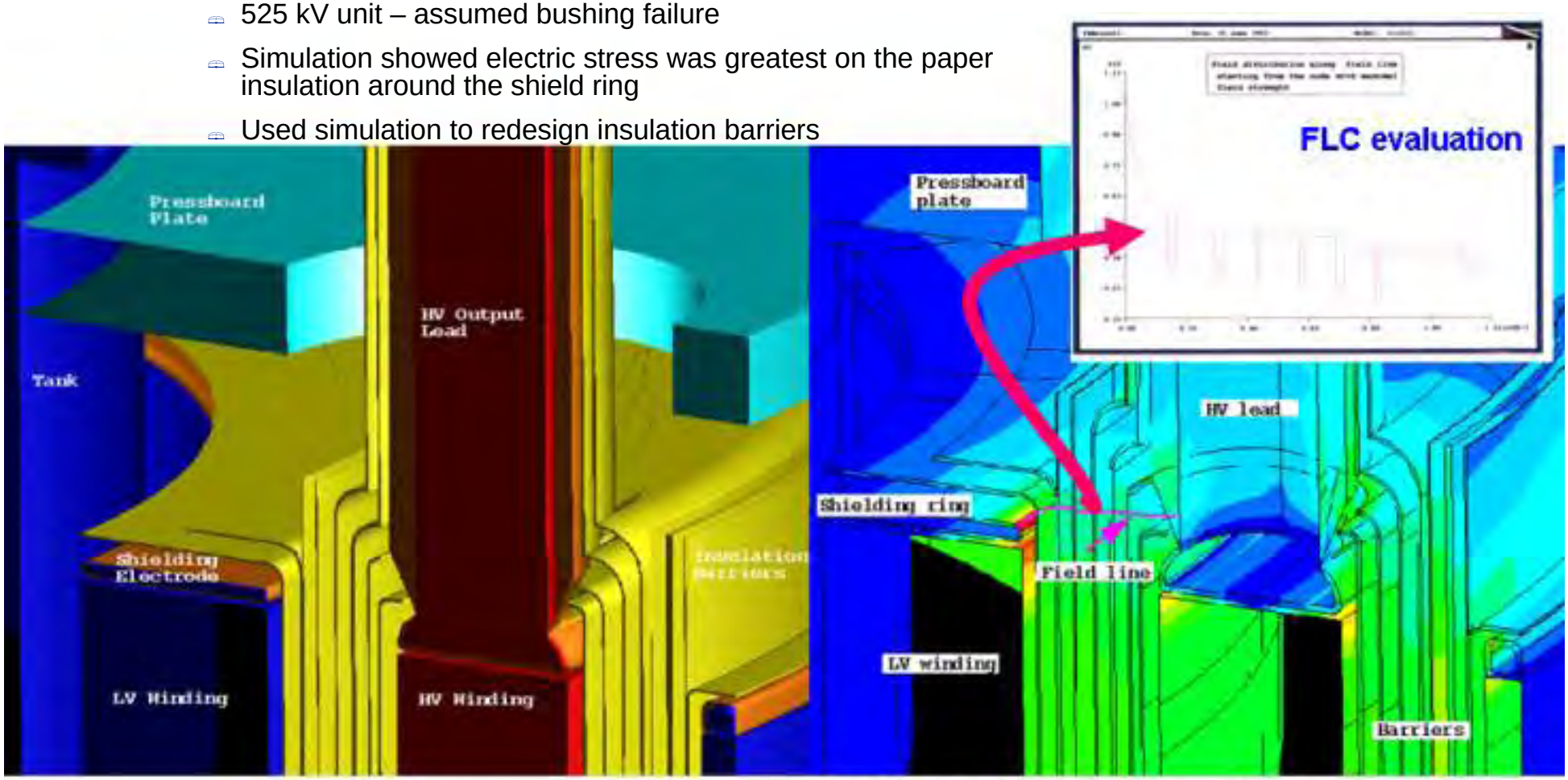
- Tools to used to identify problems during transformer repair/remanufacturing:
  - Complexity charts
  - Checklists & design rules
  - Design and analysis programs
  - Internal and external design reviews
  - Involvements of all available expertise
  - Factory inspections
- To maintain the key competences, ABB has established seven permanent Basic R&D Projects:
  - Basic dielectrics
  - Transients and Field Analysis
  - Core performance
  - Load losses and thermal performance
  - Acoustics
  - Short-circuit strength
  - Dielectric diagnostics
  - Each project has a full time project leader guided by a steering committee that are constantly improving the tools

Remanufacturing vs. Repair of Power Transformers
Main Insulation Design



Remanufacturing vs. Repair of Power Transformers
Analysis of Bushing Failure

- 525 kV unit – assumed bushing failure
- Simulation showed electric stress was greatest on the paper insulation around the shield ring
- Used simulation to redesign insulation barriers



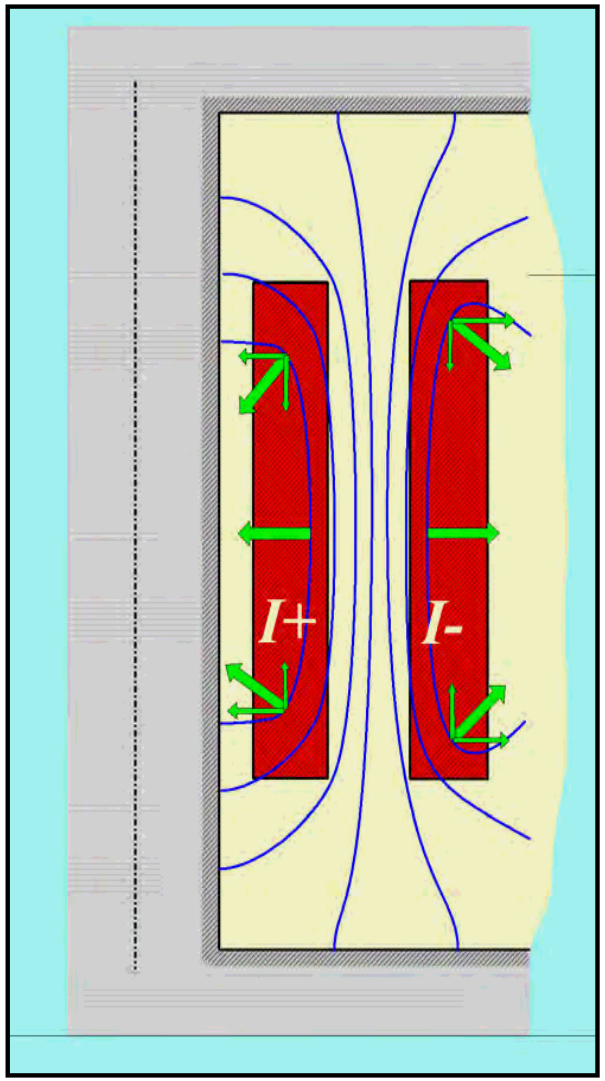
CAD-model

Field distribution over the barriers and HV-LV windings

Remanufacturing vs. Repair of Power Transformers
Design for Short-Circuit Strength

- Verifying the short-circuit strength of a transformer starts with the calculation of the short circuit currents
- Design rules require systematic calculation of the fault currents in all failure cases:
  - Three phase short-circuits
  - Single phase to ground fault
  - Phase to phase faults
  - Tap changer(s) in main and extreme position(s)
- All failure modes are considered during the remanufacturing analysis
  - Radial buckling
  - Radial stretching
  - Axial tilting
  - Axial bending
  - Axial collapsing

Remanufacturing vs. Repair of Power Transformers
Mechanical Stresses in Power Transformers

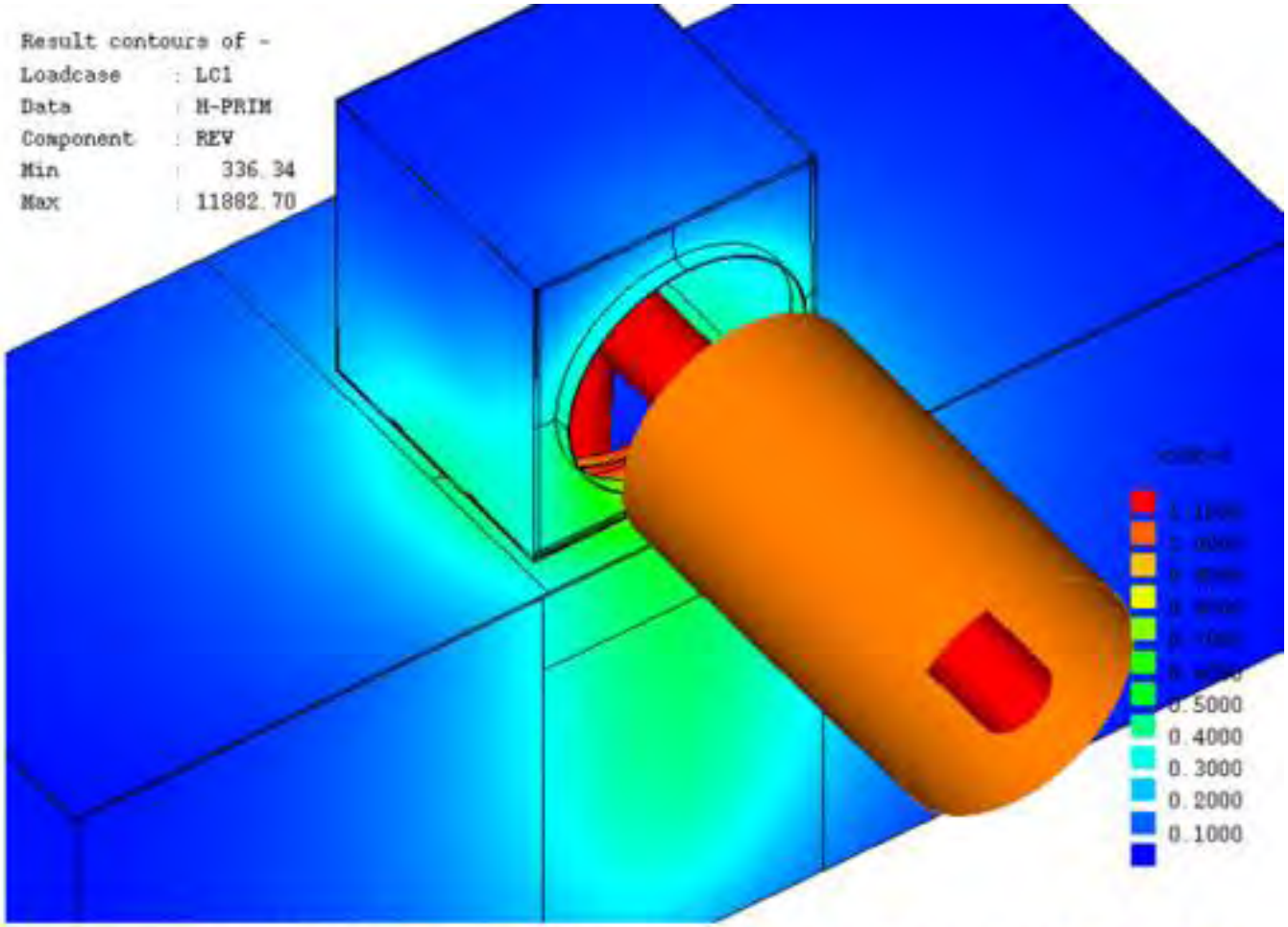


- Electromagnetic field analysis permits accurate mapping of forces
- Forces can be split into:
  - Radial components
  - Axial components

Remanufacturing vs. Repair of Power Transformers
Improved Design for Short-Circuit Strength

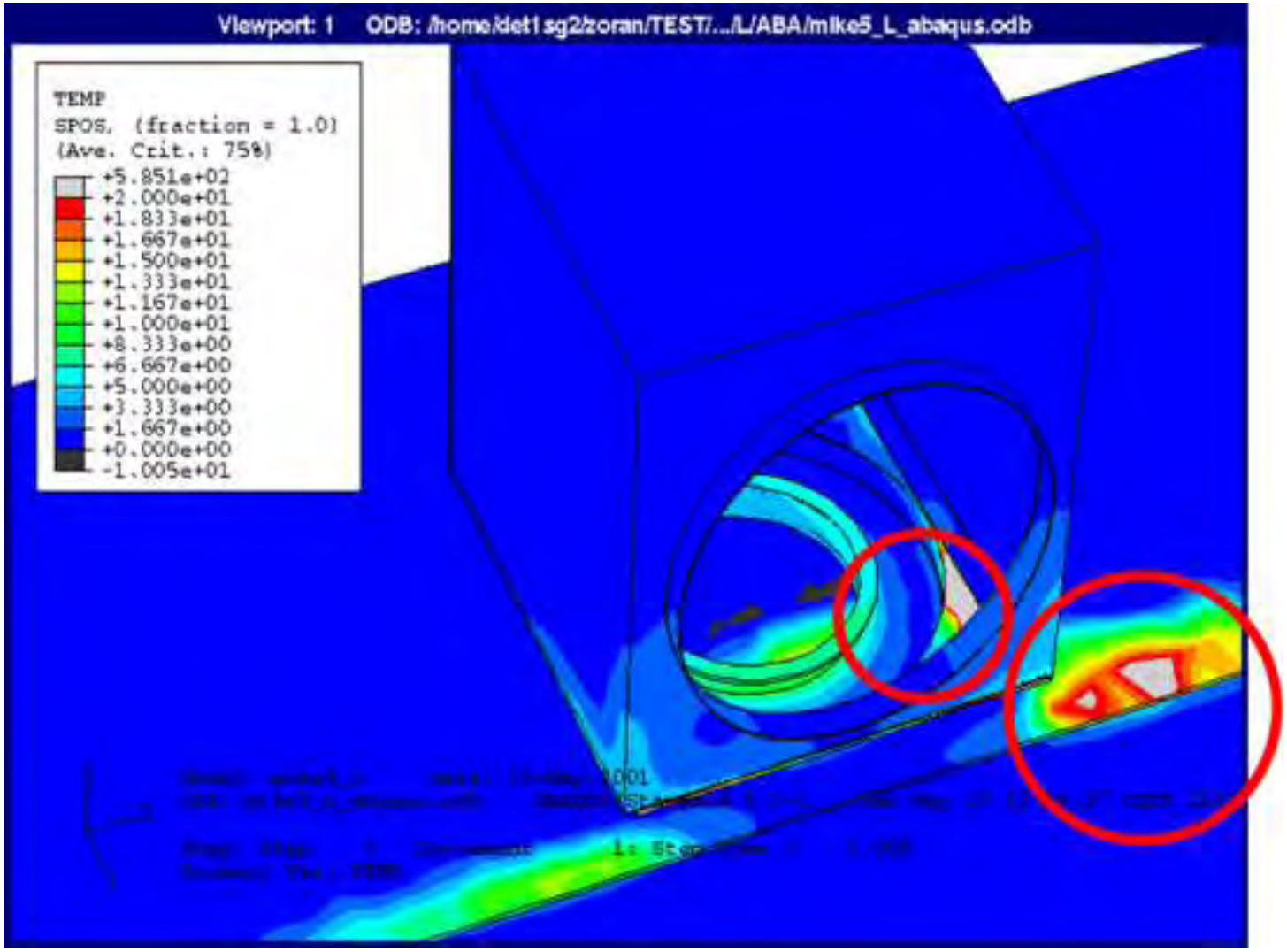
- Short-Circuit Withstand Capability can be improved by:
  - Ampere-turn balancing
  - Close tolerances – better winding support
  - Work hardening and epoxy coating of conductors
  - Rigid clamping of windings

Advanced Transformer Engineering Study



TRANSFORMER AND ISO-PHASE BUS DUCT INTERFACE
Excitation field H[A/m] distribution

Advanced Transformer Engineering Study



Remanufacturing vs. Repair of Power Transformers
Transformer Remanufacturing

The Insulation System

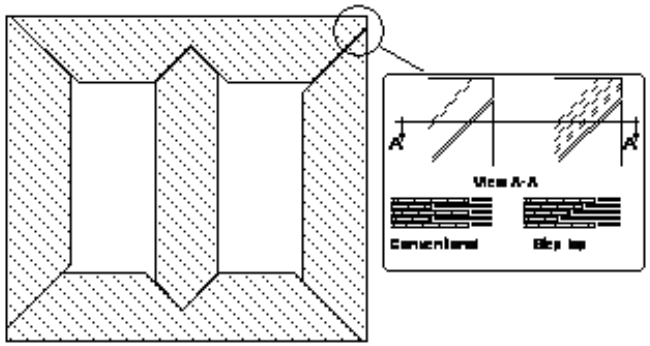
- Made from organic material that degrades over time
- Typically an aggregate of:
  - Cellulose (wood fibers)
  - Mineral oil
- Insulation system separates:
  - HV winding
  - LV winding (s)
  - Regulating winding (if present)
  - Ground
- Directs cooling oil to dissipate heat from I2R and eddy losses
- Provides support in radial and axial dimensions to withstand short circuit forces

Remanufacturing vs. Repair of Power Transformers
New Insulation System

- Winding & Active Part Kits
  - Specialized kit centers with advanced tooling and processes produce fully assembled winding kits
  - Winding cylinders are oil stabilized to limit growth
- Components are manufactured to required tolerances
- New insulation system restores transformer to original performance and full life expectation

Remanufacturing vs. Repair of Power Transformers
Transformer Remanufacturing

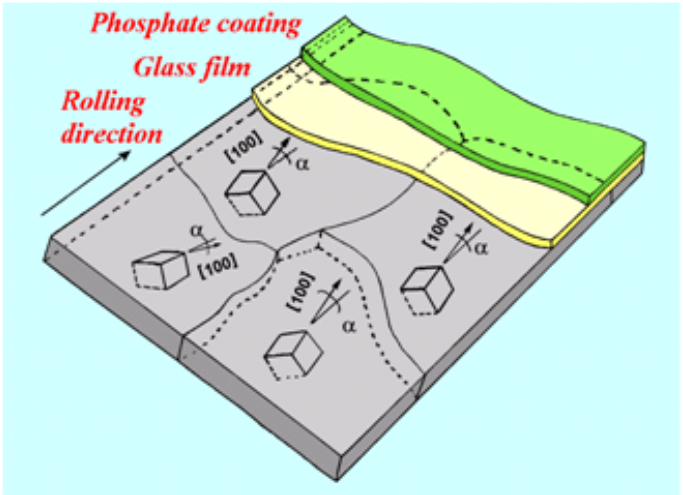
The core is an unbroken path for magnetic flux



Normally reused for a repair / remanufacture

Core is cleaned and damaged material is replaced

The core laminations are a high tech material

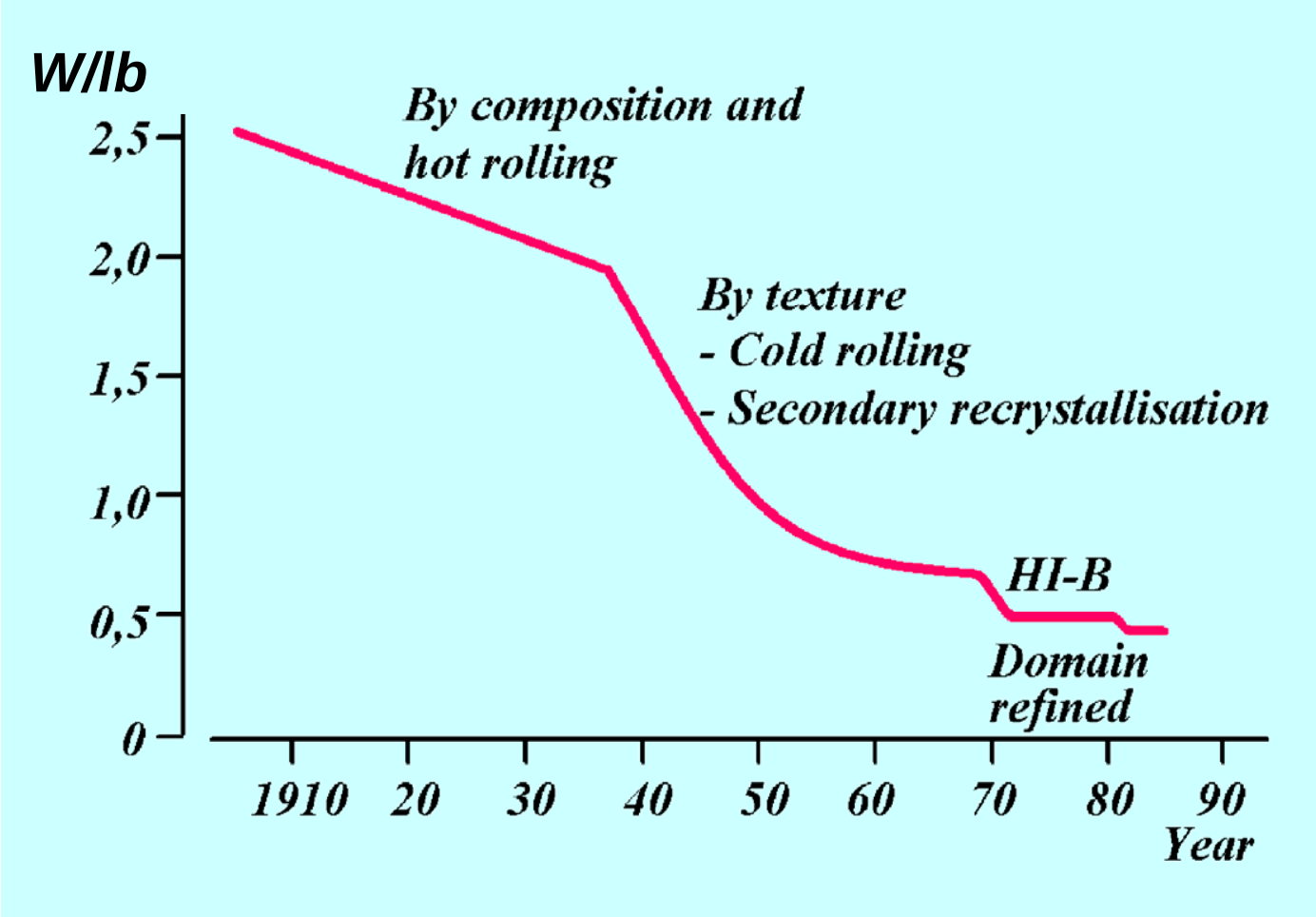


Iron crystals oriented to align with flux

Insulation coating to reduce losses from eddy currents

Remanufacturing vs. Repair of Power Transformers
Transformer Remanufacturing

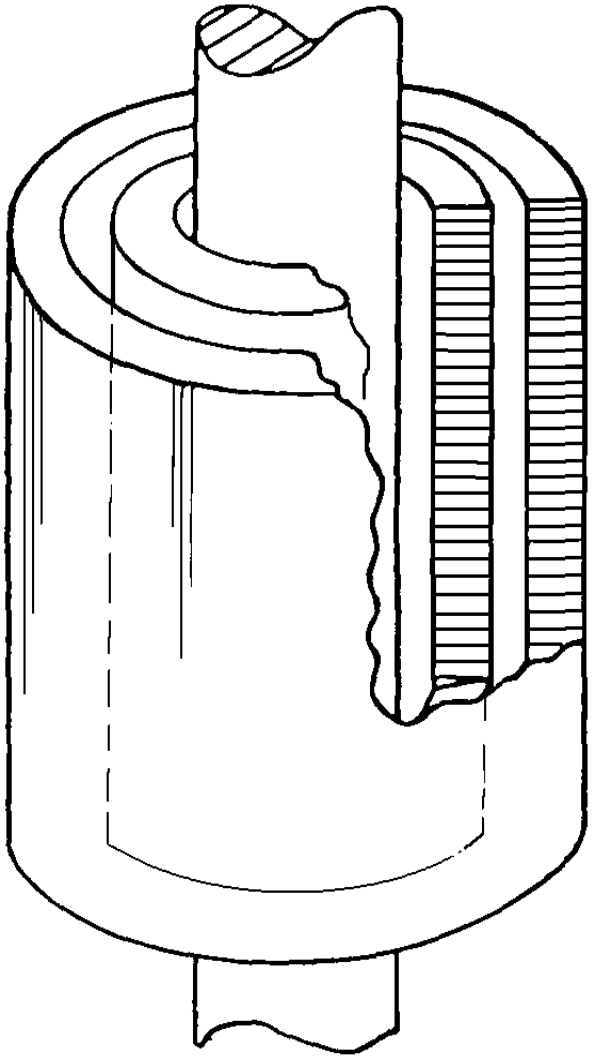
Core performance is set by the original material



Continuous improvement in core steel quality

Reduction in specific losses by a factor of five

Remanufacturing vs. Repair of Power Transformers
Transformer Remanufacturing

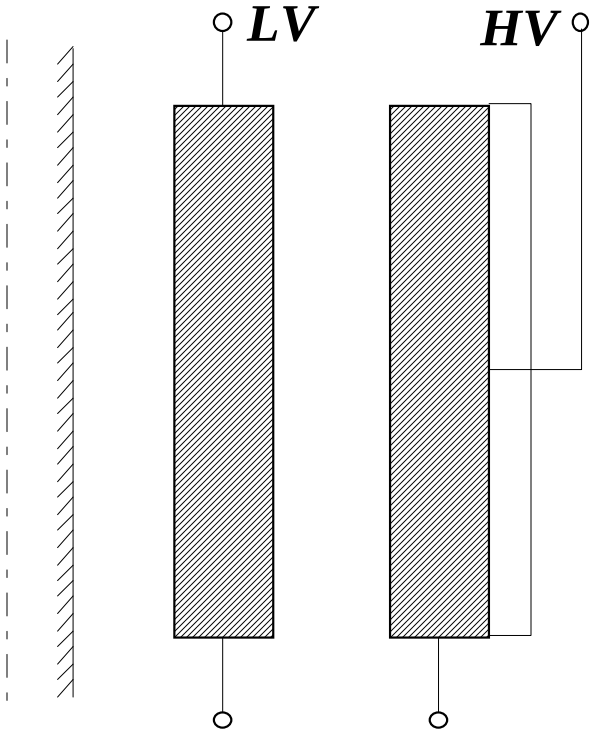


Winding arrangement can be optimized

- Winding shells:
  - Concentric arrangement
  - Effectively equal heights
  - LV often nearest core
  - HV often the outer winding
  - Equal current distribution
  - Ensure balanced flux distribution
- LTC or DeTC's can be added to transformers that did not have tap changers in the original design

Remanufacturing vs. Repair of Power Transformers
Transformer Remanufacturing

Winding rearrangement is possible

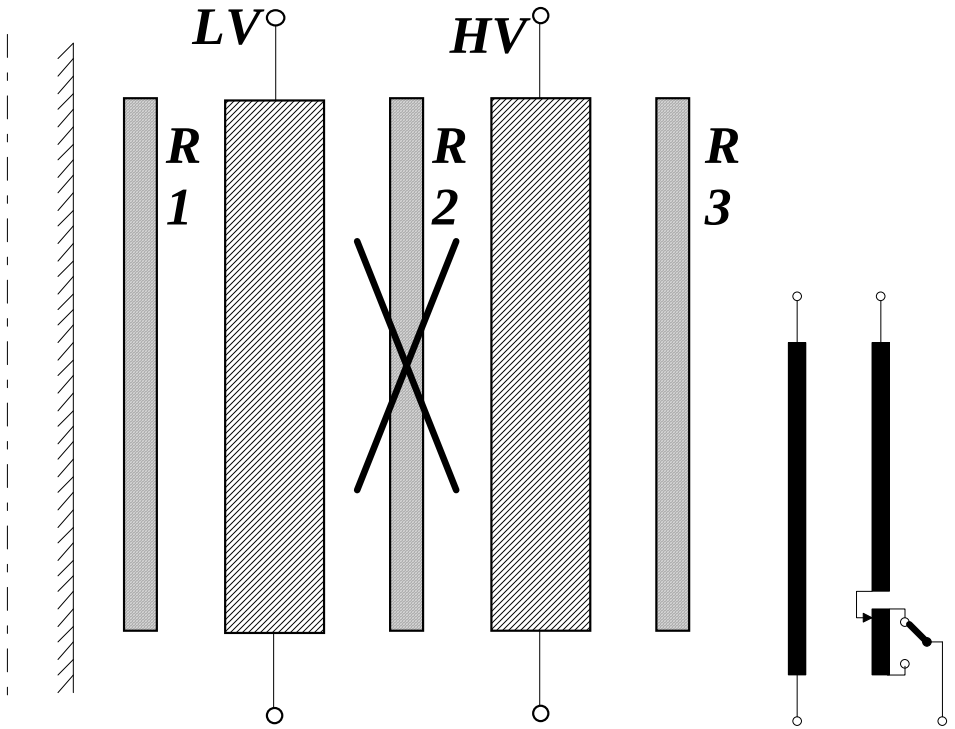


On high voltage and non-uniform insulation center entry may be advantageous:

- **Stress patterns, yoke versus center**
- **Same yoke distance at upper and lower yokes**
- **Better space utilization**

Remanufacturing vs. Repair of Power Transformers
Transformer Remanufacturing

Regulating windings can be added or rearranged

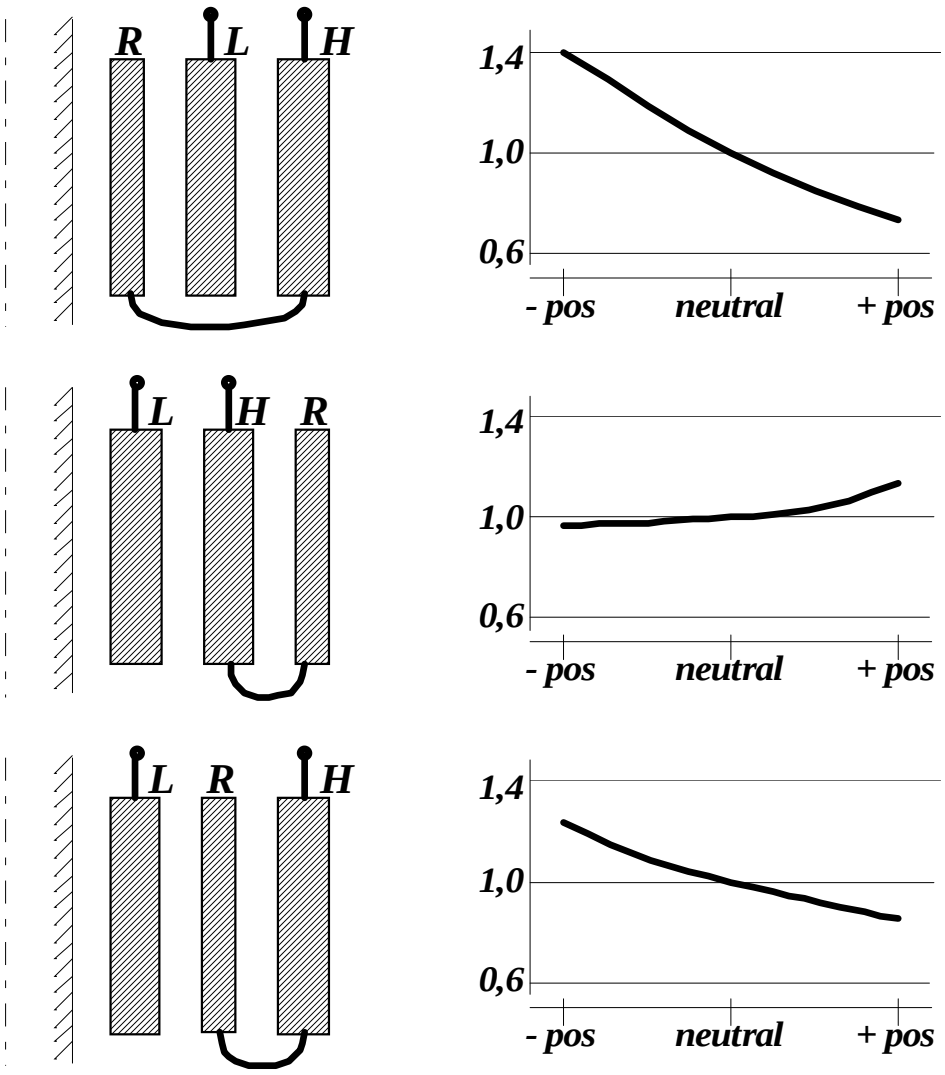


In general:

- **Inside or outside the two main windings**
- **Only in some specific and as an exception in between the main windings**

The reactance variation as a function of tap-position will depend on the position of the regulating winding

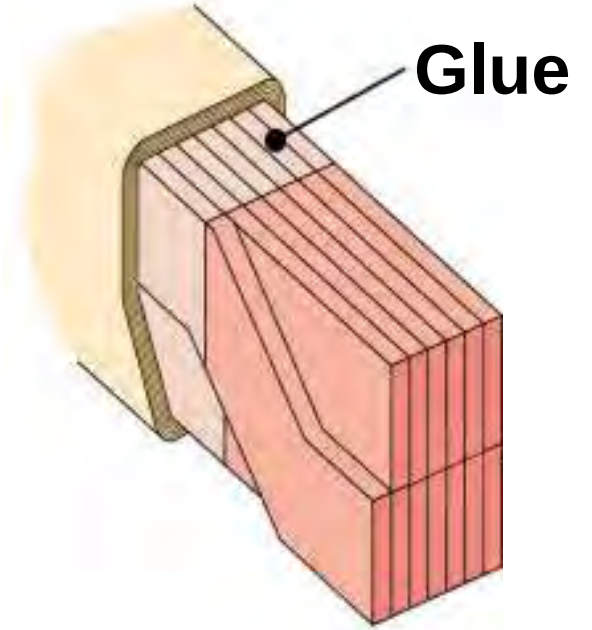
Remanufacturing vs. Repair of Power Transformers
Transformer Remanufacturing



Reactance variation can be modified to affect performance

Remanufacturing vs. Repair of Power Transformers
Transformer Remanufacturing

Load losses can be reduced and short circuit performance enhanced through the use of modern CTCs



The CTC (continuously transposed cable) is an important tool for the control of eddy current losses.

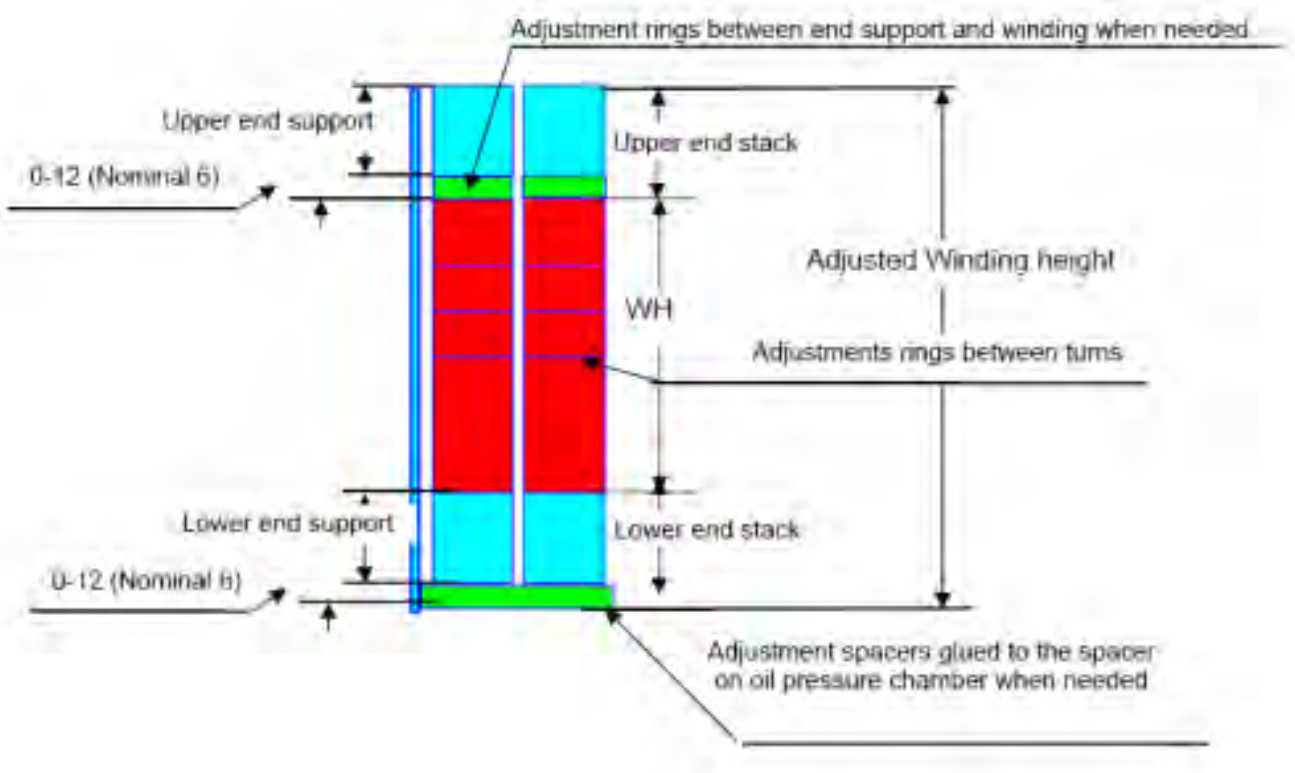
Vertical Winding Lathes (gravity compacts the winding)

Remanufacturing vs. Repair of Power Transformers
Winding Dryout & Pressing

- Very important to size the windings properly for short circuit forces
  - Remanufacturing can improve tightness
  - Winding height control
  - Centre of each winding over all other windings
- Hard Method
  - Compacting force is applied to the winding at room temperature before the drying process
  - No force applied to the winding during winding drying
  - Adjustment force is applied on the winding while still dry (or oil impregnated) after drying process

Remanufacturing vs. Repair of Power Transformers
Winding Sizing – effective axial compression

- Windings are designed for removal of pressboard
- Disc Windings – can remove “minus” keyspacers
- Layer windings – adjustment done at end of windings



Remanufacturing vs. Repair of Power Transformers
Transformer Remanufacturing - Landing of Windings

Remanufacturing vs. Repair of Power Transformers
Nesting of Windings – can improve (tighten) radial tolerances

Transformer Condition Improvements
BIOTEMP® - ABB Sensible Solution

With BIOTEMP®, ABB aims at offering a complete and reliable solution for distribution and power transformers associating environmental friendliness with enhanced fire safety, longer lifetime, and higher overload capacity.

Transformer Condition Improvements
Reasons to Consider ABB BIOTEMP®

- BIOTEMP® is a natural ester-based dielectric insulating fluid made out of sunflower seeds combining…
  - Higher biodegradability (99%)
    - Spills can be disposed through normal means and not treated as toxic waste
    - Potential for Government regulatory penalties and spills cleanup relief
    - Minimized air pollution during combustion
  - Higher fire point (360°C vs. 180°C for mineral oil)
    - Great risk mitigation on collateral damage from transformer explosion and fire potentially lowering insurance premiums
    - Elimination of active fire suppression and barrier walls when minimal spacing maintained (according to FM Global)
    - Indoors and tighter spaces applications

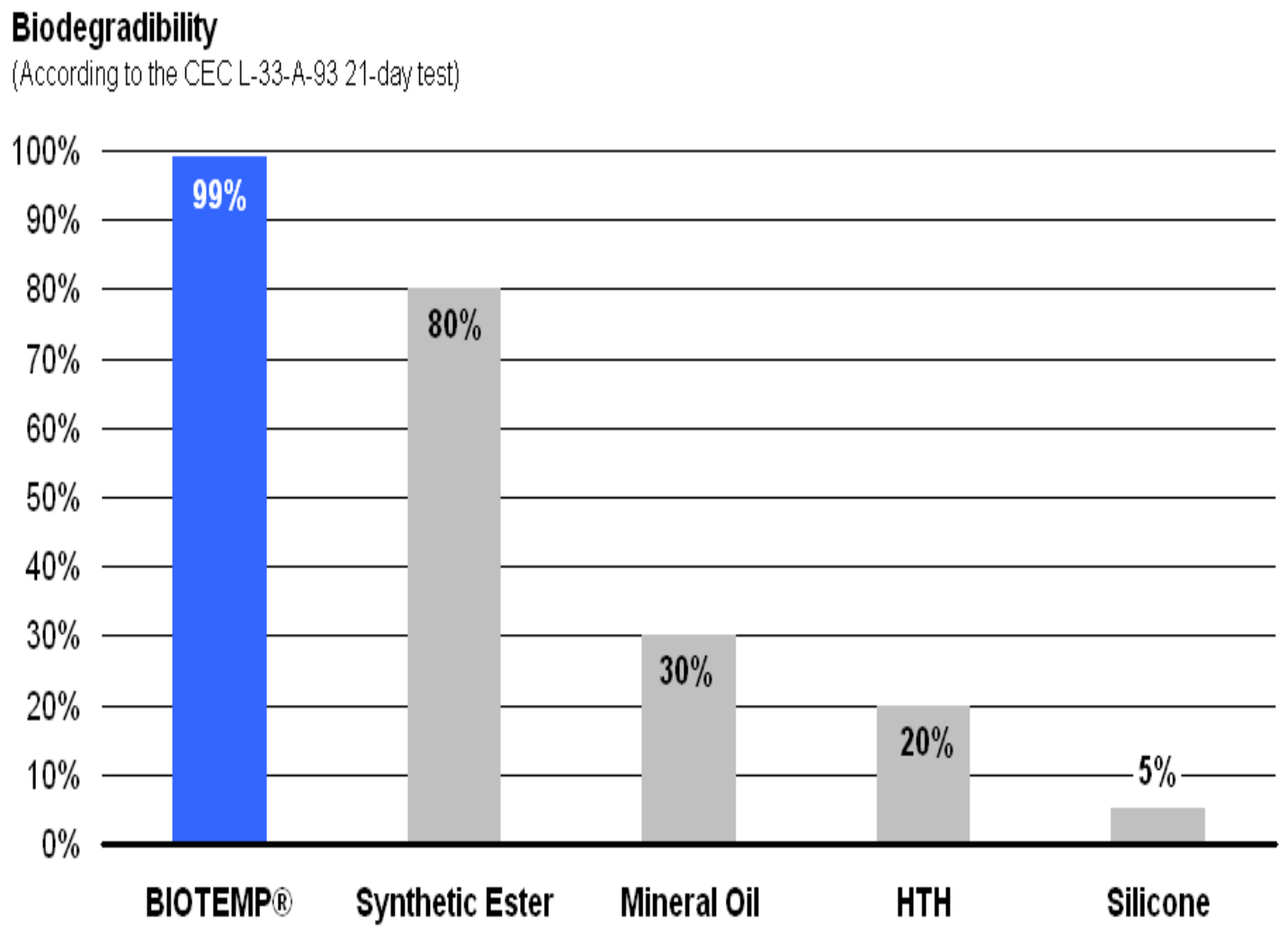
Transformer Condition Improvements
Reasons to Consider ABB BIOTEMP®

- BIOTEMP® is a natural ester-based dielectric insulating fluid made out of sunflower seeds combining…
  - Greater ability to hold moisture (10 times more than mineral oil)
    - Lower aging rate of impregnated paper, hence increasing the insulation system lifetime
    - Higher hotspot temperatures without reducing the insulation system lifetime, hence increasing the transformer peak load or overload capacity
  - Highest oxidation stability for a vegetable-based oil (main differentiator)
    - Selection of the most stable base oil (high oleic) associated to a purification process and the addition of oxidation inhibitors
  - Good dielectric performance (comparable to mineral oil)

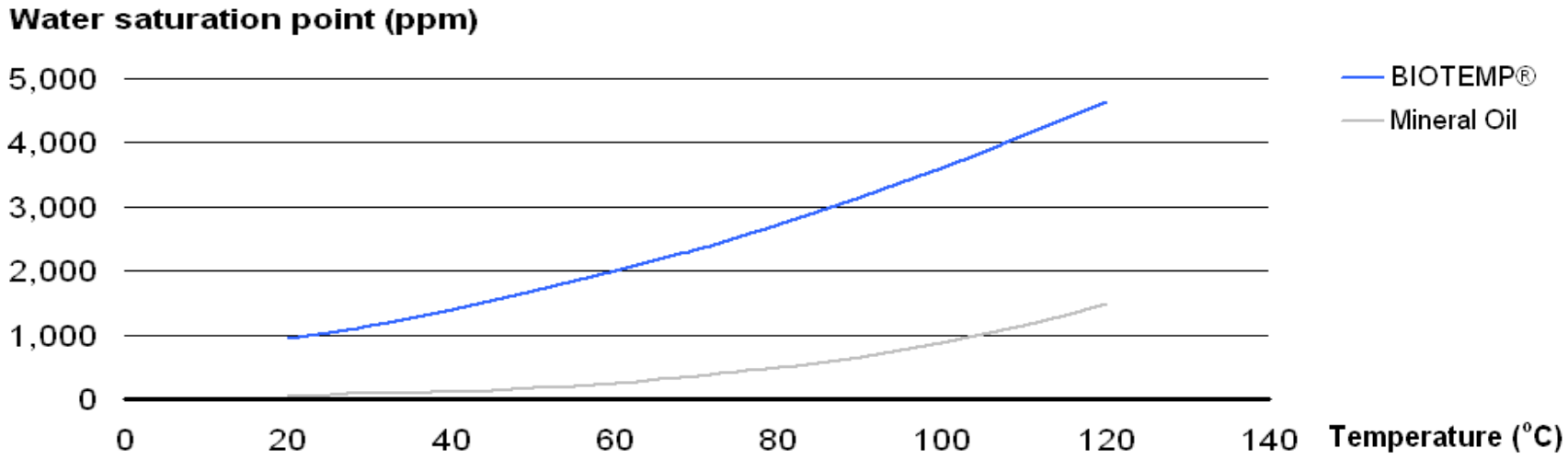
Transformer Condition Improvements
BIOTEMP® – A proven solution

- Over 3,000 distribution transformers (up to 5 MVA and 36 kV) and over 50 small power transformers (up to 56 MVA and 69 kV) sold or retrofilled with BIOTEMP® in the US since 2005
- 5 small power transformers (up to 25 MVA and 145 kV) successfully refurbished with BIOTEMP® in Brazil
  - One of which was a 15 MVA unit upgraded to 25 MVA with an extremely high and reliable overload capacity of up to 37.5 MVA for 6 hours (i.e., 150%) or up to 42 MVA for 4 hours (i.e., 170%)
- This unit has been operating safely with heavy loads and frequent overloads for close to 3 years now in Brazil

Transformer Condition Improvements
Reasons to Consider BIOTEMP®: Biodegradability

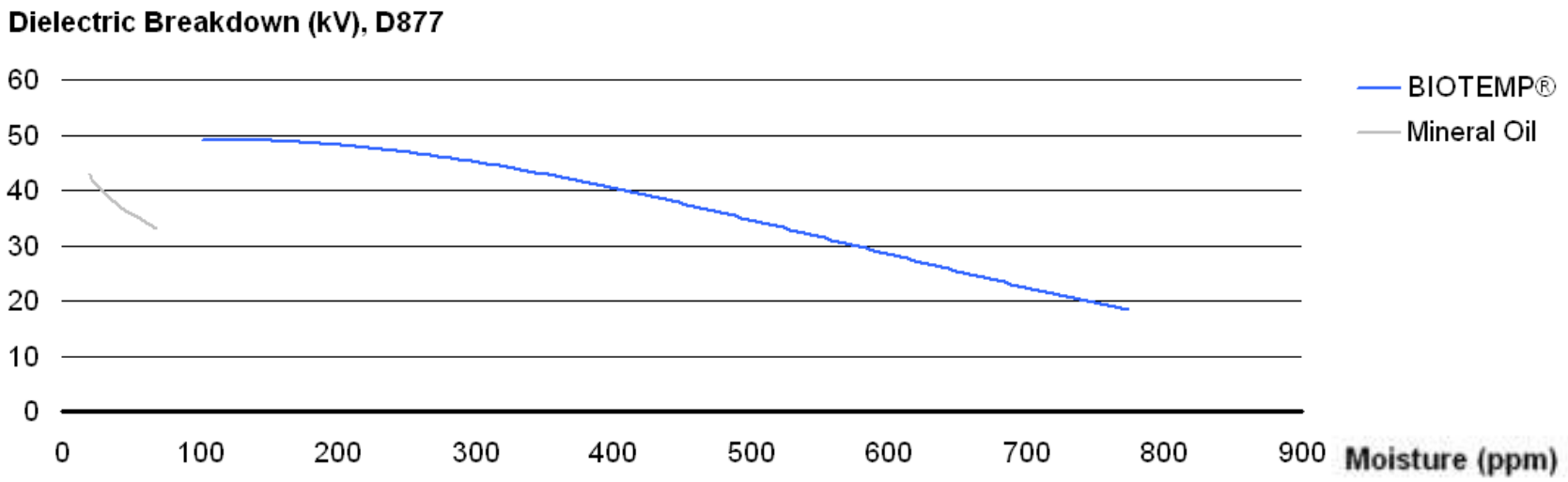


Transformer Condition Improvements
Moisture Saturation



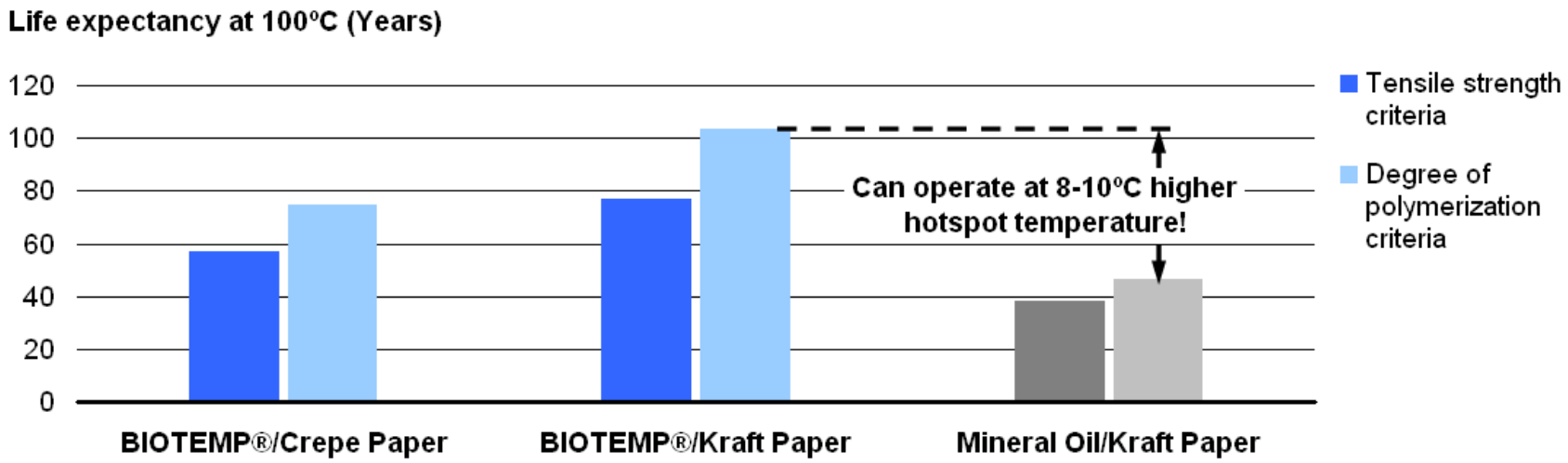
- BIOTEMP® has a much higher water saturation limit than mineral oil at all temperatures
  - 5 to 8 times that of mineral oil under normal operating conditions
- BIOTEMP® has a much greater affinity for water than mineral oil
  - In BIOTEMP®/paper insulating systems, the paper holds less water than in mineral oil/paper insulating systems

Transformer Condition Improvements
Effect of Water on Dielectric Strength



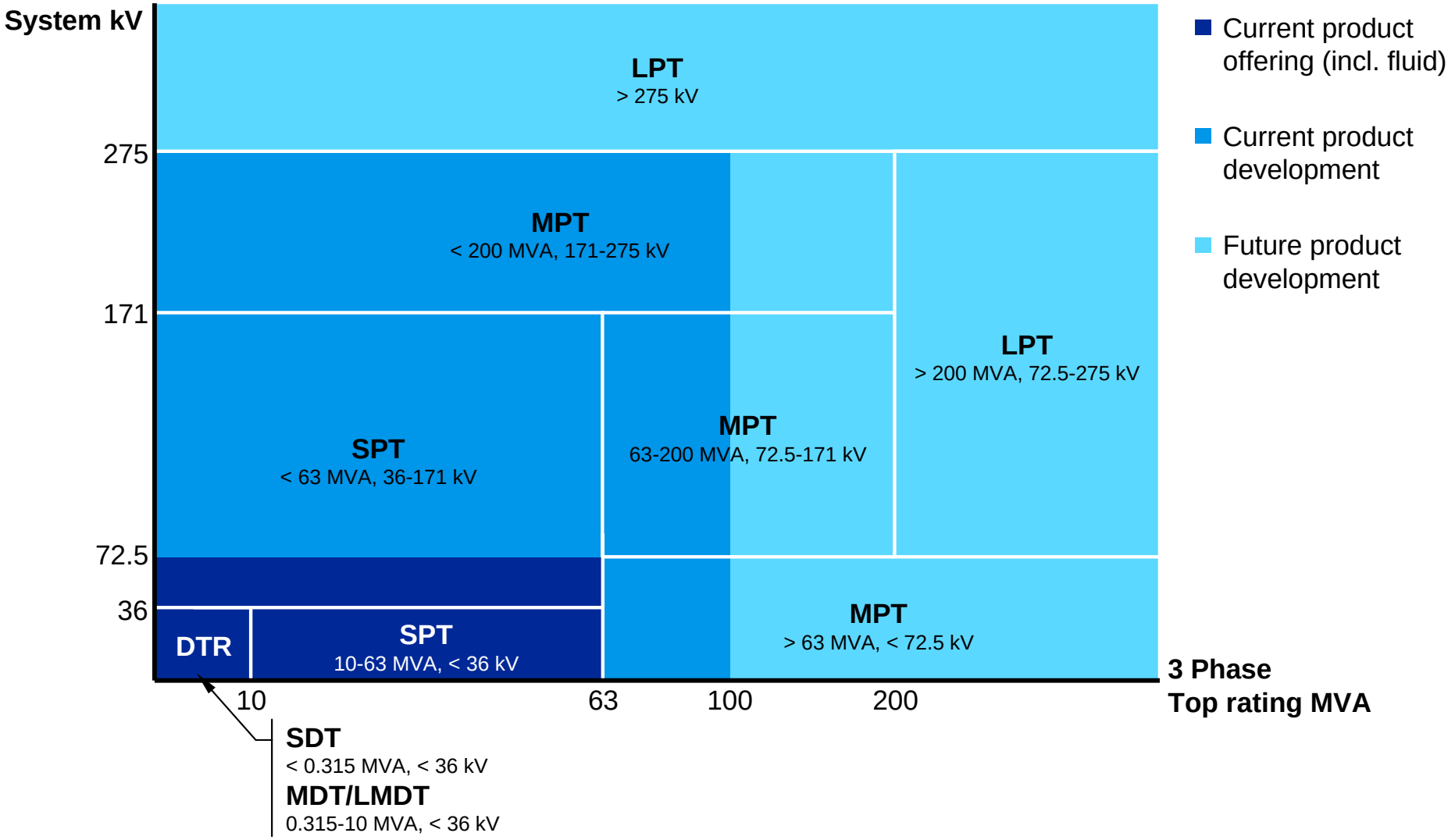
- The effect of moisture on the dielectric breakdown strength of BIOTEMP® is much less pronounced than for mineral oil
  - The allowable limit of moisture in BIOTEMP® can be much higher than that allowed for mineral oil

Greater ability to hold moisture
Lower aging rate and higher hotspot temperatures



- BIOTEMP®-impregnated paper experiences much **lower aging rate** compared to mineral oil-impregnated paper increasing **by a factor 2** the insulation system life
- BIOTEMP®-impregnated paper can alternatively operate at **8-10°C higher hotspot temperatures** and attain the same life expectancy as mineral oil-impregnated paper

Natural Esters – Next technology step
Current product offering and development overview



Transformer Condition Improvements
Life Extension with: BIOTEMP® Retro-fill Option


Kailua-Kona, Hawaii


Hilo, Hawaii

- Total turnkey retrofill service utilizing the latest biodegradable dielectric coolant **BIOTEMP®**.
- Retro-fill candidates
  - Mineral oil
  - Wecosol (Perchloroethylene)
  - Askarel (PCB)
- Benefits
  - **Longer equipment life**
  - Improved Safety – virtually eliminates the possibility of costly oil fires
  - Lower insurance and liability costs due to greatly reduced risk of fires
  - Environmentally friendly

Case Study - Saving Time
TRES Remanufacturing Project

- 1972 Asea transformer fails at a Major Utility Generating Station in February, 2006
  - Rating: 250 MVA, 345kV Auxiliary transformer
- This transformer had little or no history of operating problems
- The failure was of a catastrophic type requiring return to a factory
- The Station was now operating with “sister-unit” to the failed transformer
- Major concerns throughout the utility’s management team

Case Study - Saving Time
TRES Remanufacturing Project

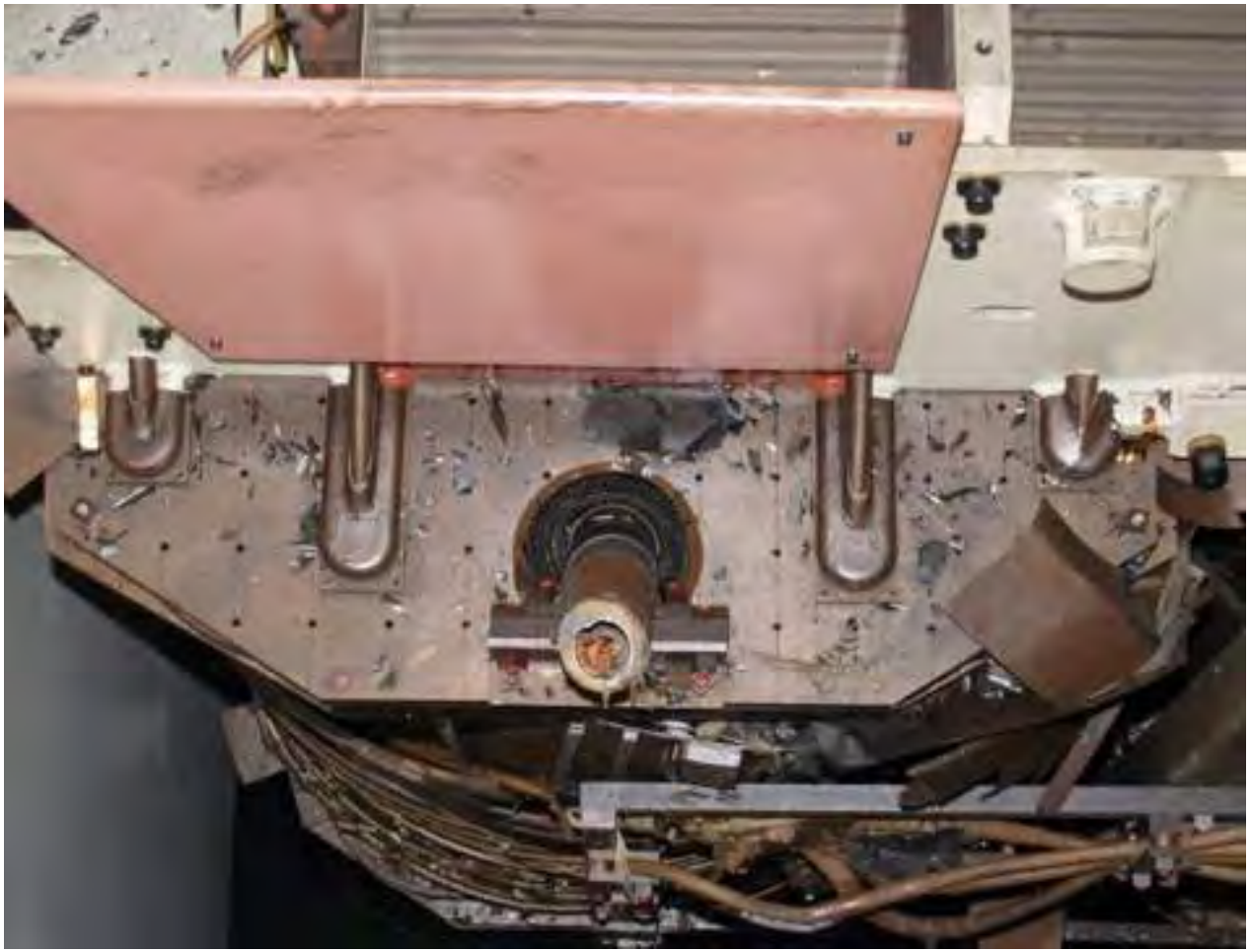
- Damaged tank as received

Case Study - Saving Time
TRES Remanufacturing Project

- Overhead view of Active Part in tank

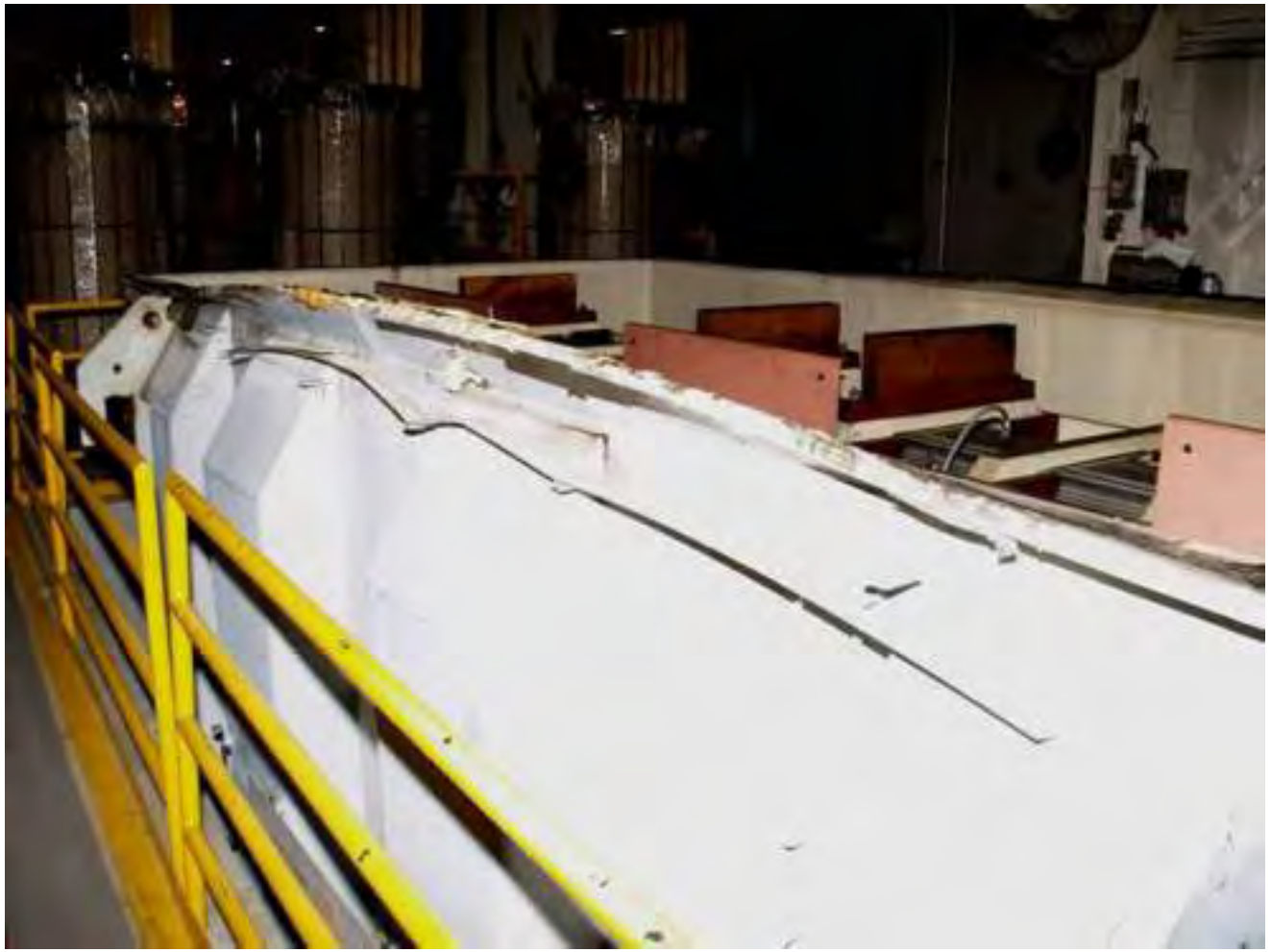
Case Study - Saving Time
TRES Remanufacturing Project

- Overhead view of contamination



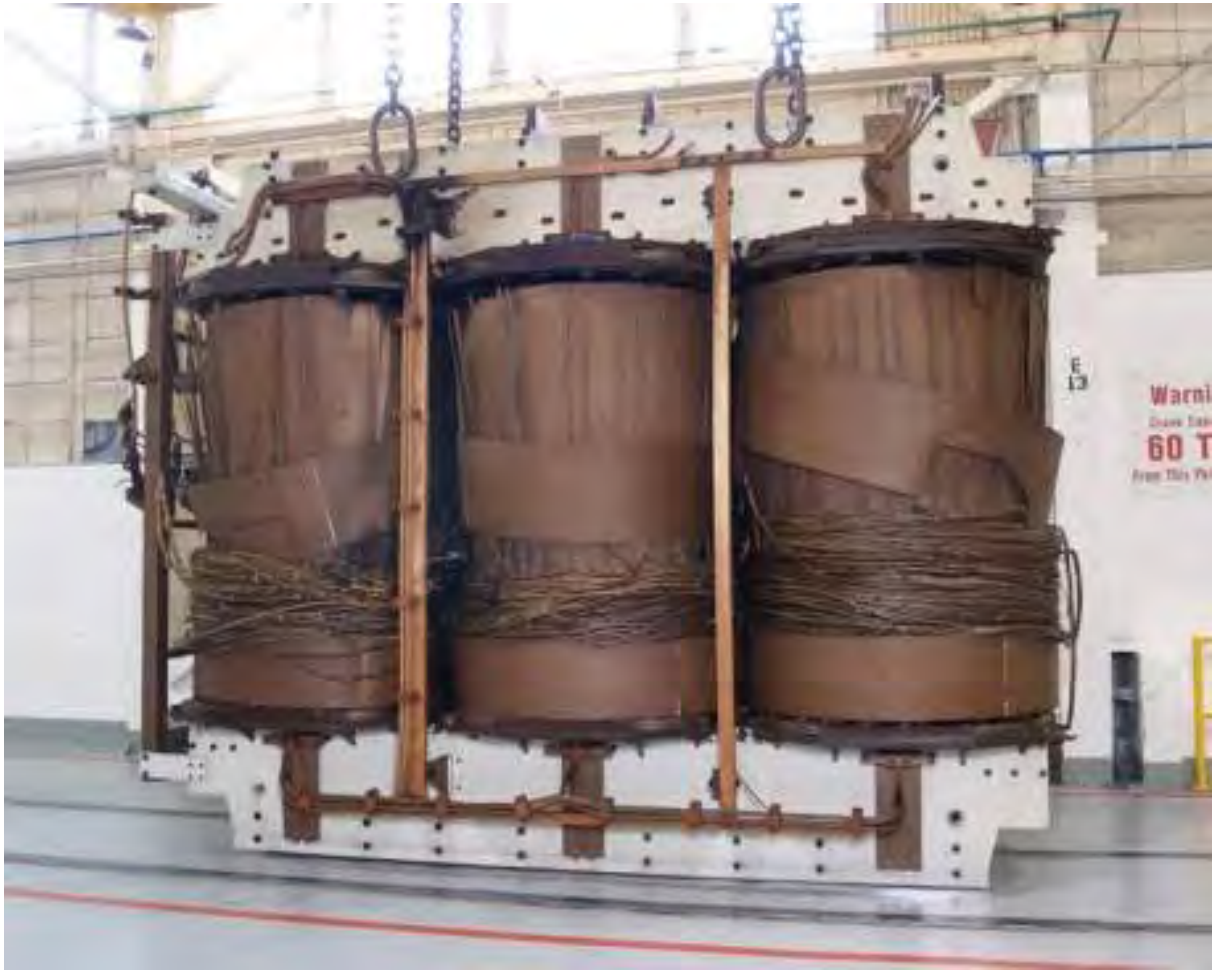
Case Study - Saving Time
TRES Remanufacturing Project

- Tank deflect as a result of explosion



Case Study - Saving Time
TRES Remanufacturing Project

- Failed active part as seen at untanking



Case Study - Saving Time
TRES Remanufacturing Project

- Remanufactured active part – LV side

Case Study - Saving Time
TRES Remanufacturing Project

- Remanufactured active part – HV Side

Case Study - Saving Time
TRES Remanufacturing Project

- Repaired tank “ready ship”

Case Study - Saving Time
TRES Remanufacturing Project

- Repaired cover at “ready ship”

Case Study - Saving Time
TRES Remanufacturing Project

- ABB TRES Engineering updated the original design to meet today's technology and standards
- The project moved forward without any issues
- The project completed (10) days early – 17 weeks from initial phone call to breaker closing
- The logistics plan was key to successful execution of the project

TRES Transformer Remanufacturing
ABB Contingency Program Assures Fastest Time to Recovery

- Pre-Engineered Solutions
  - Critical path transformers can be designed and in some cases upgraded in advance
- Reserved Factory Capacity
  - A proactive plan allows ABB to provide our customers “factory reservations”
- Advanced Procurement
  - Long-lead time commodities will no longer control the project
- Compressed Cycle Times
  - A proactive plan can provide significant reductions in the factory production schedule
- Pre-Determined Logistics Plan
  - No surprises and identified costs

TRES Transformer Remanufacturing
Factory and TrafoSiteRepair™ Options Give New Life to Old Transformers

- Factory and Site repair allows replacement of all materials that degrade with time
- TrafoSiteRepair™ may offer clear savings in time compared with factory repair. It also solves “untransportable” cases
- ABB is the global leader in site repair with more than 20 years international experience
- More than 200 transformers of various brands have been successfully repaired on-site by ABB across the globe
- All kinds of repairs can be performed, including replacement of windings, repair of the core, and refurbishment or replace of on-load tap changers – with the highest levels of quality assured

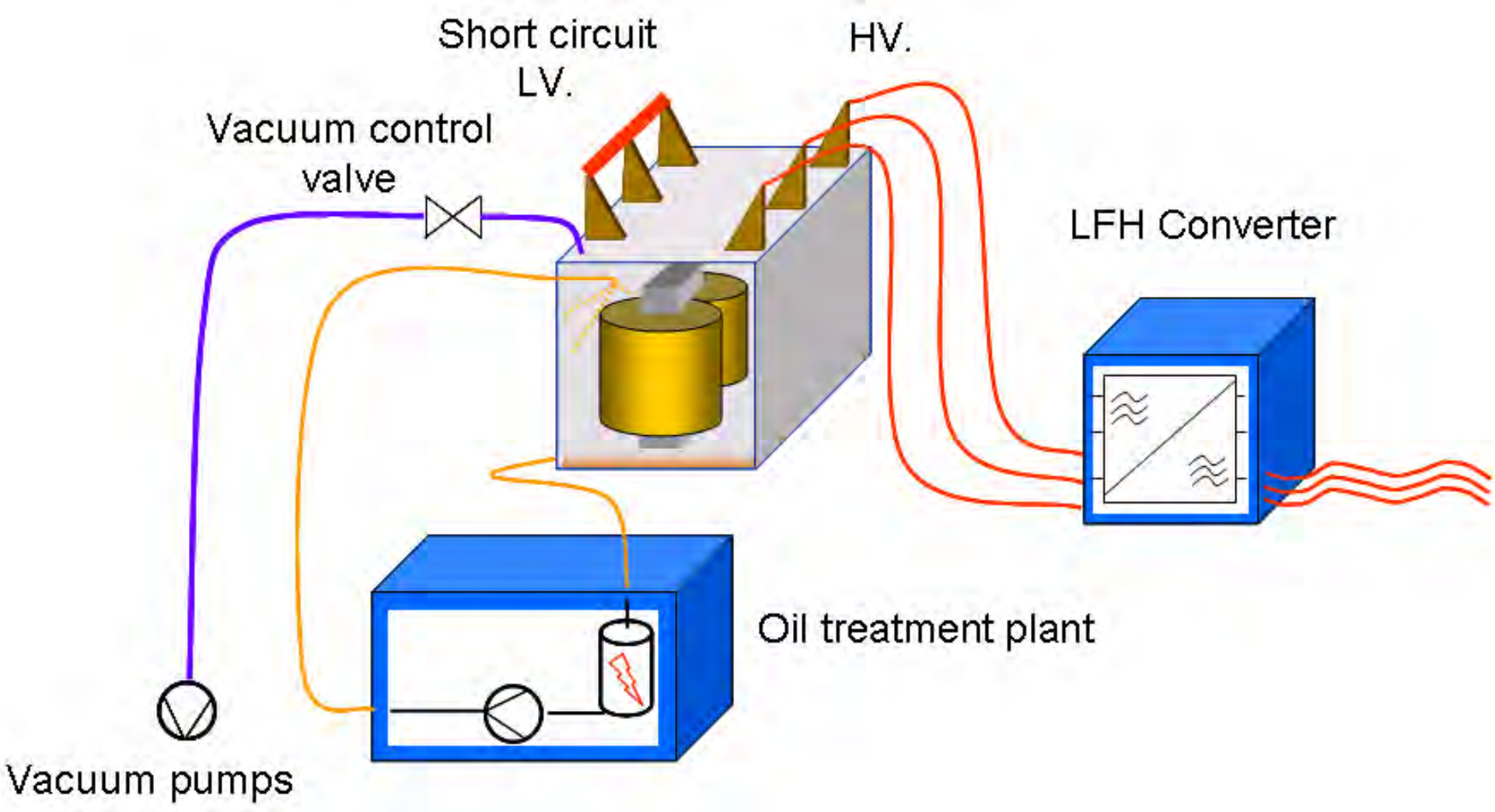
TRES Remanufacturing - TrafoSiteRepair™ Option
On-site Repair/Remanufacturing Summary

- On-site repairs restore the transformer to reliable operation
- Scope can range from bushing or tap changer to complete coil replacement
- An on-site repair often saves time compared with factory repair, especially when coordinated with a plant outage
- An on-site repair also solves “untransportable” cases
- All kinds of repairs can be performed, including replacement of windings and repair of the core
- Provisions must be taken so that “factory like” quality is assured
- Remanufacturing can be utilized to enhance performance or resolve design issues

Remanufacturing vs. Repair of Power Transformers
Field Dryout - Low Frequency Heating (LFH) Principles

- Apply a low frequency (1 - 50 mHz) current to the HV windings – approximately 20 – 50% of nominal current
- Benefits of the low frequency
  - Much lower impedance voltage so there is no risk of a flashover
  - Negligible eddy (~f2) or stray losses (~f1.5) – thus uniform heating of the windings
  - Reduced power requirement
- Temperature of the windings is carefully controlled
- Apply oil spray during LFH heating to heat non winding insulation
- LFH typical process:
  - Initial heating/circulation of core/coils using hot oil (assisted by LFH)
  - Vacuum
  - Begin cycles of LFH heating with hot oil spray followed by vacuum
  - Temperature progresses up to 110C (winding temp)
  - Final vacuum
- Shorter overall process time compared to hot oil treatment

Remanufacturing vs. Repair of Power Transformers
Field Dryout - LFH And Hot Oil Spray



Remanufacturing vs. Repair of Power Transformers
Field Dryout - Hot Oil Spray

Remanufacturing vs. Repair of Power Transformers
Field Dryout - Water Collection & Water Extraction Rate Measurement

Remanufacturing vs. Repair of Power Transformers
Field Dryout - 750 MVA Autotransformer Dried with LFH System

Remanufacturing vs. Repair of Power Transformers
Field Dryout - LFH Process Summary

- Moisture in the transformer cellulose limits the overload capability and increases the aging rate of the transformer
- Low Frequency Heating allows higher temperatures for a reduced dryout time and more effective moisture extraction
- Dried several 500kV large transformers to <1% moisture in cellulose
  - Dryout # 1 - (750 MVA) = 12 days, 150L removed, 1% reduction
  - Dryout # 2 - (300 MVA) = 12 days, 100L removed, 0.5% reduction
  - Dryout # 3 - (750 MVA) = 11 days, 160L removed, 1% reduction
  - Dryout # 4 - (400 MVA, 1ph) = 9 days, 55L, 1% reduction
  - Dryout # 5 - (750 MVA) = 10 days, 141L, 1% reduction
  - Dryout # 6 - (750 MVA) = 10 days, 110L, 1% reduction
  - Dryout # 7 – (550 MVA) = 7 days, 30L, 0.3% reduction
- Reduced outage time (compared to traditional hot oil dryout)
- Largest transformer ever dried in the field with LFH
- LFH is well suited for EHV, large or wet transformers and for facilitating field repairs
  - Dryout # 8 – 12 (250 MVA) = 7 days, 30 L,

Field Testing Capabilities - Taking the Test Floor to the Transformer

Mobile High Voltage AC Test System

- 3-phase Mobile HV Test System based on a static frequency converter
- 40’ ISO container on semi-trailer – can remain on trailer or sit on ground
- 480 volt, 3 phase, 550kVA power requirement (station service or diesel generator)

Field Testing Capabilities - Taking the Test Floor to the Transformer

Mobile High Voltage AC Test System

- **High-Voltage Tests:**
  - Applied Voltage Tests 500 kV line-ground
  - Induced Voltage Test (single- or three phase) up to 75 kV
  - Electrical and Acoustical Partial Discharge (PD) Measurements
  - Measurement of No Load Characteristics (Feasibility depends on the no load losses of the test object)
- **Routine Electrical Tests:**
  - Transformer Ratio Measurement
  - Winding Resistance
  - Short-Circuit Impedance
  - No load losses at 60 Hz and 50 Hz
- **Dielectric Tests:**
  - Insulation Resistances
  - Loss Dissipation Factor and Capacitance (of transformer and bushings)
  - Frequency Domain Spectroscopy (FDS / DFR)
- **Diagnostic Evaluation:**
  - Failure localization
  - Short-circuit impedance
  - Load testing
  - Frequency range 15Hz to 200 Hz
- **Thermal Capability Testing – Heat Run**
  - Supported by portable capacitor bank when necessary

Field Testing Capabilities - Taking the Test Floor to the Transformer

Mobile Impulse Generator

- Full impulse test capabilities through 500kV system voltage
  - Lightning impulse test up to 1800 kV
  - Switching impulse test up to 1300 kV
  - Failure localization during LI / SI test
- Development underway for system to support 800 kV transformers

ABB TRES Industry Leading Support
Transformer Service Handbook

- Copies are available from your ABB account manager or at: http://www.abb.com/transformers

Automation & Power World 2011
Past attendees input

"All the experts are in one place. It is the perfect place to attain knowledge about ABB products and services."
Keith O'Rielly, Avalon Controls Ltd

"Each time I attend I am inspired to learn more about the ABB products offered."
Colleen McDaniel, Crawford Electric Supply

"Automation & Power World is a great tool for staying on top of new technology in order to remain competitive in the market place and address any issues with all levels of management."
Barbara Young, Metropolitan Industries

Workshop Statistics
Over 400 hours of training

- ~45 customer presented case studies
- 87 sessions in the Technology and Solution Center
- 11 hours of panel discussions consisting of customers, industry experts and ABB executives
- Nearly 50 hours of hands on Technical Training

ABB Automation & Power World
Registration options

	Full Conference	Courtesy Registration
Access to ABB product developers and application experts in the 70,000 ft² (over 1.5 acre) Technology & Solution Center	✓	✓
Access to a series of complimentary and educational workshops.	✓	✓
Free Lunch and Tuesday Evening Reception	✓	✓
Access to over 300 additional educational workshops – Including ARC Analysts presentations	✓	
Up to $1,500 off a future ABB purchase*	✓	
Complimentary ARC report valued at $2,500!*	✓	
Evening Events (Monday and Wednesday)	✓	
Cost	$300 per day or $800 for all three days.	Free!

* See www.abb.com/a&pworld for more details

Top ten reasons to attend

- Become more valuable, choose from over 400 educational workshops and hands-on training sessions
- Connect with thousands of peers and industry experts from 40 countries
- Ask questions of, and give feedback to, ABB product developers and executive management
- Get up to date with new and emerging technologies and industry trends
- Learn how to maximize the value from your existing assets
- Discover how to improve grid reliability, energy efficiency and industrial productivity
- Apply lessons learned from over 45 customer-presented case studies
- Focus on critical non-technical issues facing your company in the business forums
- Succeed professionally by earning CEUs on select workshops and PDHs for every workshop you attend
- See the widest range of technologies from one company at one conference!

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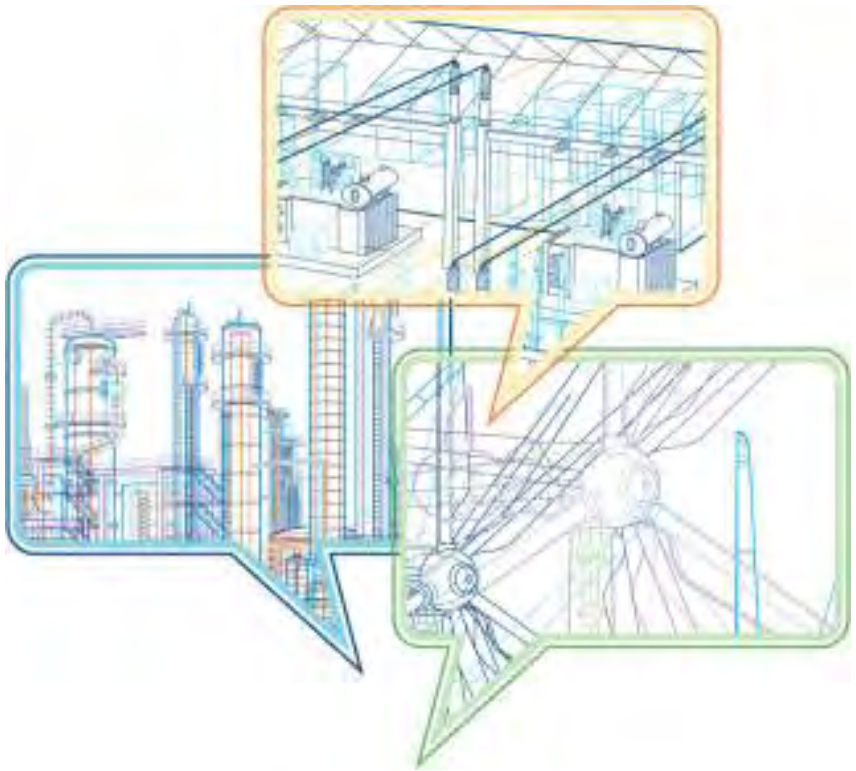

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