Asset Management of Transformer fleets - An Overview

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Dr.-Ing. Peter Werle has studied Electrical Engineering at the University of Hannover, where he afterwards received his Dr.-Ing. degree at the Schering-Institute for High Voltage Technique and Engineering.

Since 2003 he is with ABB AG, Transformer Service in Halle, Germany, where he has hold different national and international positions. Since 2010 he is the general manager of the Transformer Service Workshop in Halle with more than 200 employees. He is member of VDE, IEEE, DKE K 182 insulation liquids and CIGRÉ as liason officer A2 - IEC TC 10 and active in different working Groups. He is the author or co-author of more than 100 publications and owner of more than 20 patents in Asset Management, Diagnostic Methods, Monitoring and High Voltage Testing.

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Asset Management of Transformer Fleets An Overview

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Introduction

Transformer failures can lead to serious damages

- **Condition assessment is highly important**
  - In order to avoid outages
  - In order to spent the maintenance budget for the right transformers


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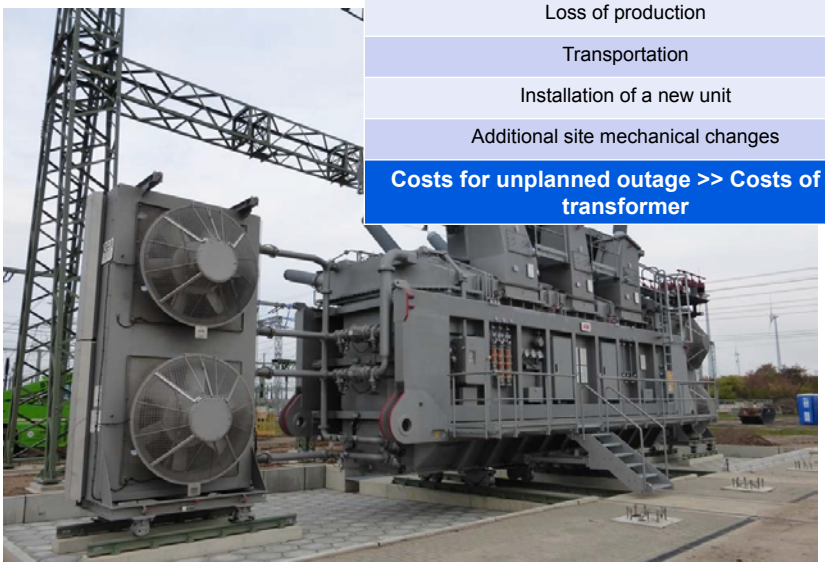
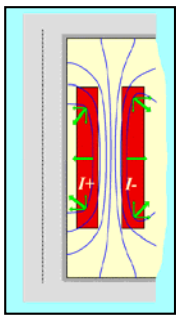
Transformer Outages
Costs of outages

What are costs of an unplanned outage?
Environmental impact
Loss of production
Transportation
Installation of a new unit
Additional site mechanical changes
Costs for unplanned outage >> Costs of the transformer



Transformer Fleets
Typical Situation

- Majority of assets are > 30 years old
- Limited maintenance
- Assets have varied loading
  - Changing stresses
  - Mechanical
  - Thermal
  - Dielectric
- Spare reliability not always known
- High reliability must be maintained
- Need to make best use of the capital & resources



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Transformer Fleets
CIGRE Study A2.WG37

Failure Rates

Substation Transformers

FAILURES & POPULATION INFORMATION	HIGHEST SYSTEM VOLTAGE [kV]						
	69 ≤ kV < 100	100 ≤ kV < 200	200 ≤ kV < 300	300 ≤ kV < 500	500 ≤ kV < 700	kV ≥ 700	All
Failures	144	280	189	152	27	10	799
Transformer-Years	15,267	64,718	37,017	25,305	4,774	2,991	150,072
FAILURE RATE	0.94%	0.43%	0.51%	0.60%	0.57%	0.33%	0.53%

Innerhalb eines Jahres haben in einer Population von 1000 Transformatoren 5,3 einen schweren Fehler.

Generator Step-Up Transformers

FAILURES & POPULATION INFORMATION	HIGHEST SYSTEM VOLTAGE [kV]						
	69 ≤ kV < 100	100 ≤ kV < 200	200 ≤ kV < 300	300 ≤ kV < 500	500 ≤ kV < 700	kV ≥ 700	All
Failures	0	20	43	89	9	4	165
Transformer-Years	153	3,278	4,639	6,740	1,837	740	17,387
FAILURE RATE	0.00%	0.61%	0.93%	1.32%	0.49%	0.54%	0.95%

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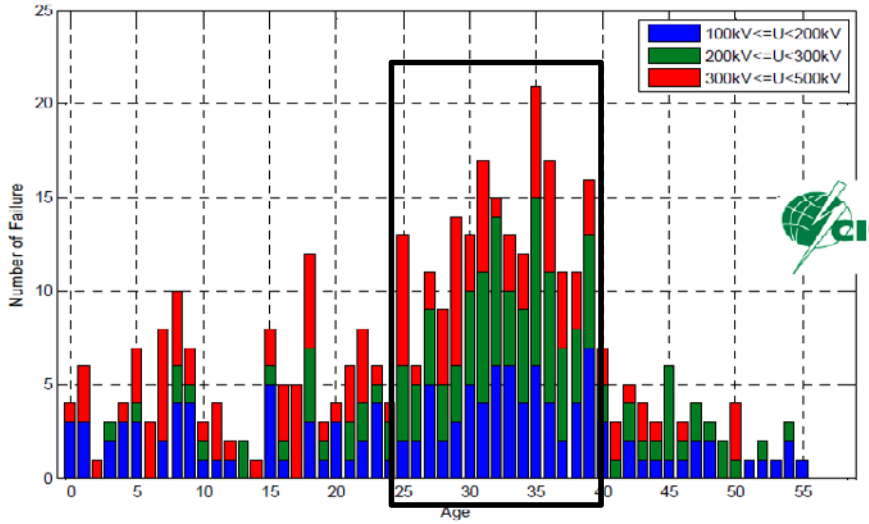
Transformer Fleets
CIGRE Study WG A2.37



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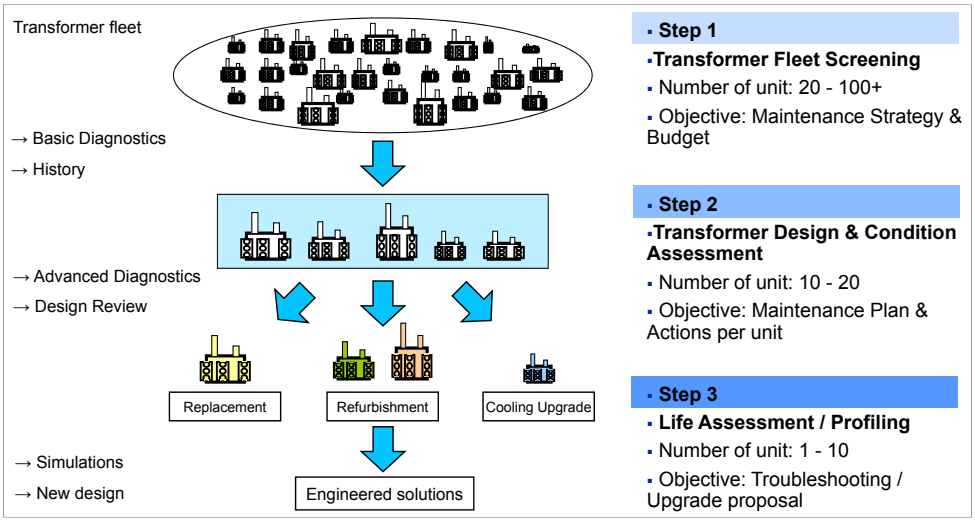
Mature Transformer Condition Assessment (MTMP™)

Three steps approach



- **Step 1**
  - **Transformer Fleet Screening**
  - Number of unit: 20 - 100+
  - Objective: Maintenance Strategy & Budget
- **Step 2**
  - **Transformer Design & Condition Assessment**
  - Number of unit: 10 - 20
  - Objective: Maintenance Plan & Actions per unit
- **Step 3**
  - **Life Assessment / Profiling**
  - Number of unit: 1 - 10
  - Objective: Troubleshooting / Upgrade proposal

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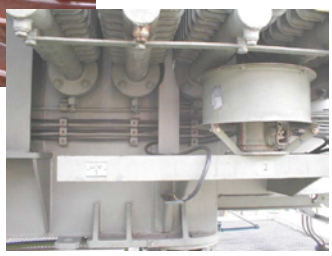
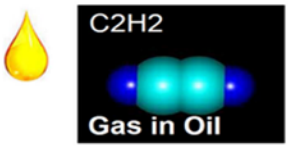
Condition Assessment

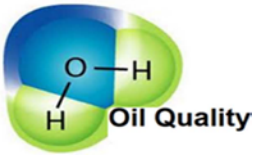
Basic Diagnostic

Name Plate, Maintenance, Repairs, Overhauls, Faults

Visuell Inspection







Standard electrical tests – insulation and winding resistance

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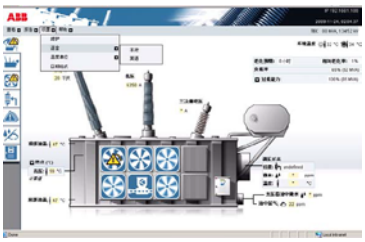
Transformer Monitoring
Core-Tec



- **ABB expertise to turn data into actionable recommendations to operate, maintain and manage transformer assets**
- **Modular platform to address low to high end applications**
- **User friendly web interface – no additional software needed on users computer**
- **Based on a microprocessor and Modular design, possible to add the sensors that the customer requests with additional hardware**
- **Very strong mechanical stability and temperature endurance => Long lifespan**
- **Reliable and proven technology (longest serving unit has >15 years in the field)**
- **Compact and easy to install**
- **Support for standard communication protocols, including IEC 61850 (certified by SGCC)**
- **1'500 installed Worldwide**

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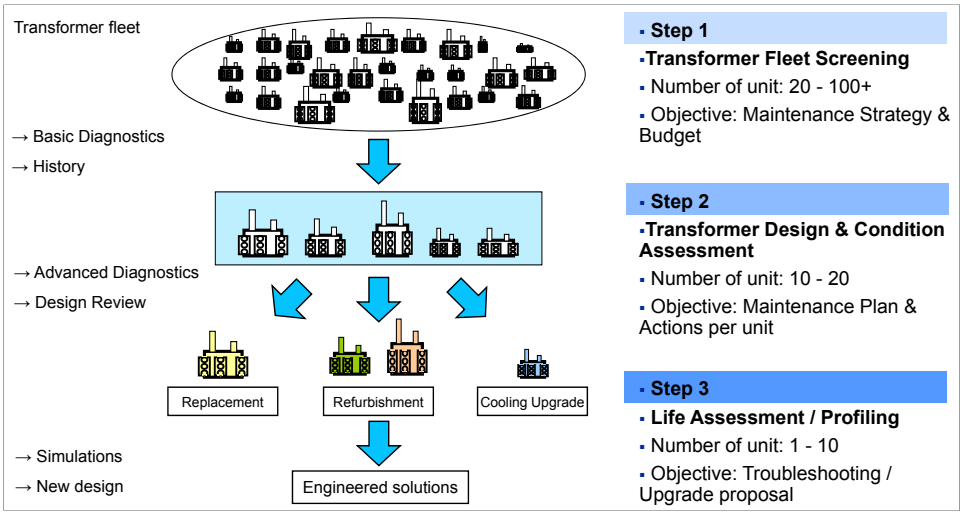
Mature Transformer Condition Assessment (MTMP™)
Three steps approach



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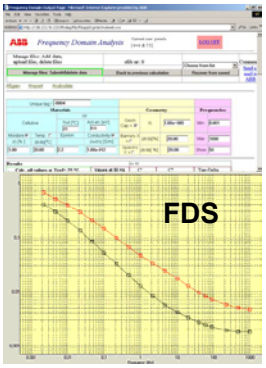
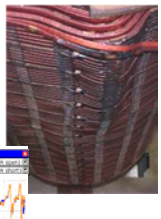
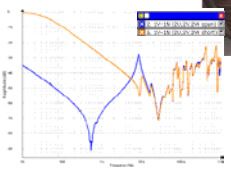
Asset Management of Transformer fleets - An Overview

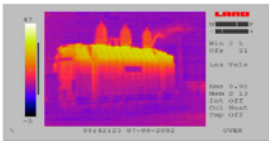
Condition Assessment
Advanced Diagnostic





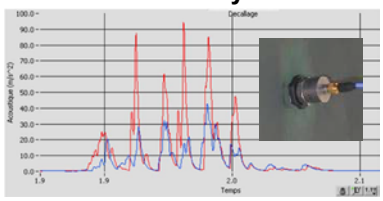
FRA



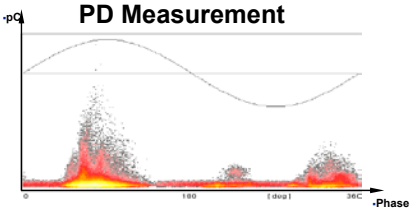


Thermovision-scan

Vibration Analysis



PD Measurement



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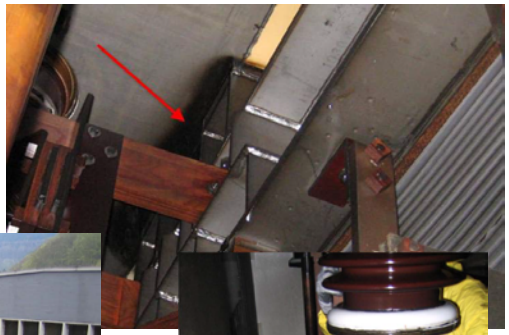
Site Options and Actions
Internal inspection



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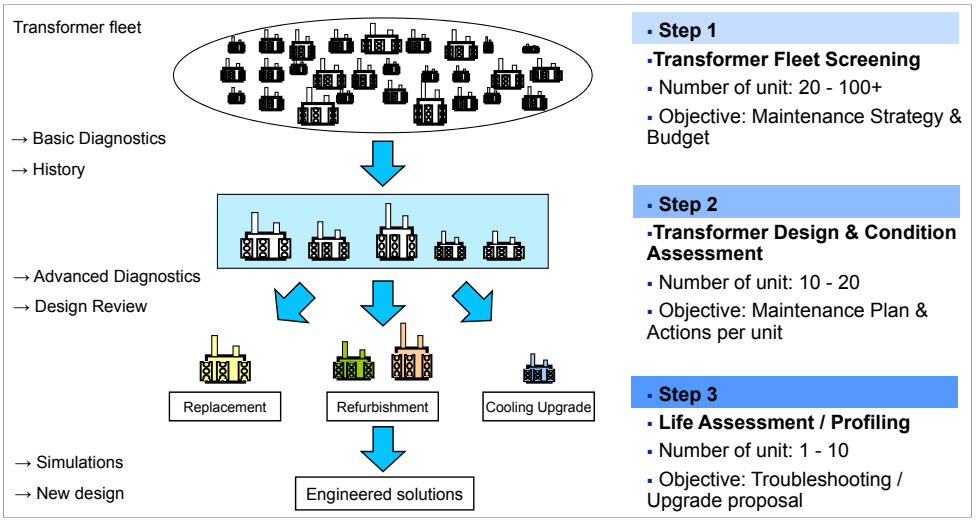

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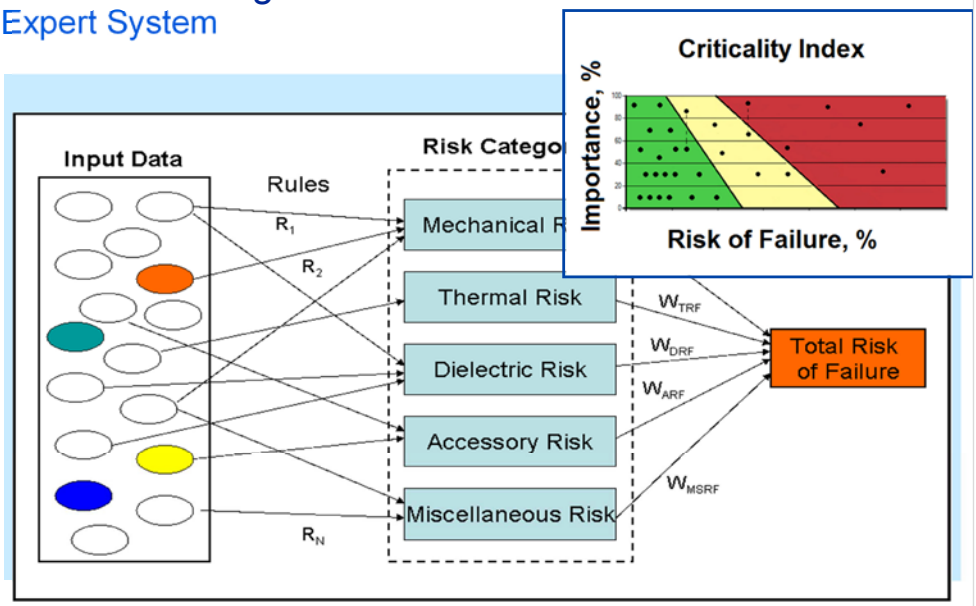
Fleet Screening

Expert System



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Mature Transformer Condition Assessment (MTMP™)
Typical output and recommendations

Plant 1 - Results of condition assessement and action plan

	Mechanical	Electrical	Thermal	Accessories	Overall	Risk Mitigation - Actions
TFO 2	Winding	Arcing	Heating		95	Visual Inspection and repair in factory / rewinding
TFO 5	Tank			OLTC heating	80	Repair on site and OLTC overhaul
TFO 1			Aged oil	Bushing	70	Oil regeneration / filtration and advanced diagnosis / change HV bushing
TFO 6		Arcing		Thermometer	50	Exchange TopOil - thermometer / on line monitoring of DGA
TFO 3				Silicagel	40	Exchange Silicagel
TFO 7					25	Standard maintenance actions and controls
TFO 8					15	Standard maintenance actions and controls / 10 % overload capabilities
TFO 4					10	Standard maintenance actions and controls / 15 % overload capabilities

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Recommendations
Site Actions

- **Site internal repairs/upgrades**
- **Cooling and Control Systems upgrade**
- **Bushing and OLTC Maintenance or replacement**

- **Oil Reprocessing**
- **Transformer Active Part Drying**
- **Biodegradable fluid retro fills**

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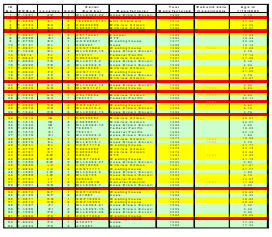
Recommendations
Contingency Planing

What to do in case of a long repair on-site or in the workshop ?

ABB response: World's first hybrid insulated 400kV mobile transformer

Mature Transformer Condition Assessment (MTMP™)
Example – US Utility



Customer need:

- Prioritization corrective **actions on a fleet of 128 units**
- Optimize yearly maintenance budget of 1.3 MUSD

ABB response:

- Assessment of the condition and risks of failure with MTMP™
- **Determine the individual risk of failure**
- Proposal for maintenance actions and budget

Customer benefits:

- The maintenance **budget was reduced by 24%** the first year
- The maintenance budget is now spent on the right units, resulting in an increased overall reliability of the fleet at a lower cost:
  - 11 risky units: budget increased from 9% to 25%
  - 47 medium risks: budget increased from 37% to 45%
  - 70 low risks: budget decreased from 54% to 30%

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Asset Management
Conclusion

- **Asset management strategies need to be based on excellent condition assessment methods**
- **The more precise the condition is known the more efficient actions can be taken**
- **Hightech like robotic applications or on-site testing optimize condition assessment methods and MTMP**
- **ABB offer a variety of technical sophisticated solutions already approved for different fleets**
- **Continuous research and development ensure that condition assessment methods getting better and better leading to optimized asset management strategies**