



TRANSFORMER-LIFE-MANAGEMENT CONFERENCE

Asset Management of Transformer fleets - An Overview

Prof.Dr.Ing. Peter Werle

University of Hannover



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 held 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 liaison 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

**Asset Management of Transformer Fleets
An Overview**

Oleg Kuzmin, ABB Transformer Service, Germany
Peter Werle, Leibniz Universität Hannover, Schering-Institute

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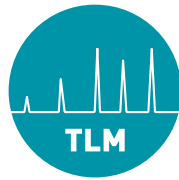
Power and productivity
for a better world™ 

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

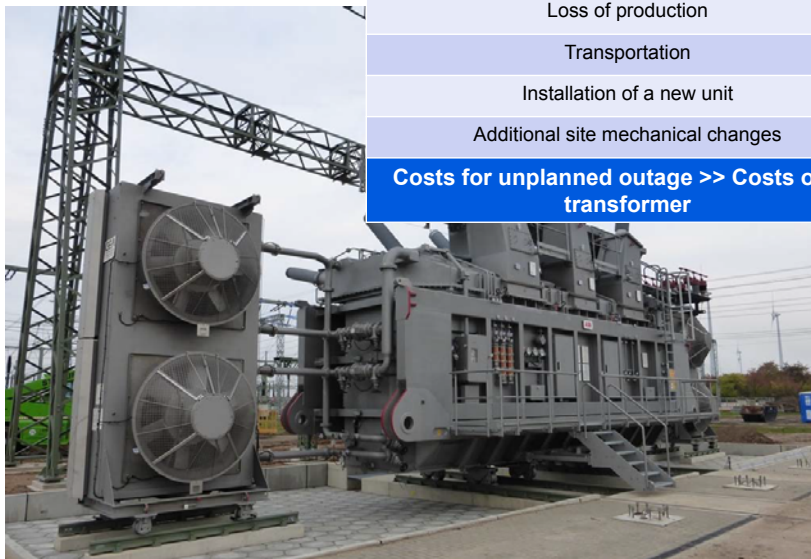




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Transformer Outages Costs of outages



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

11
102
1004

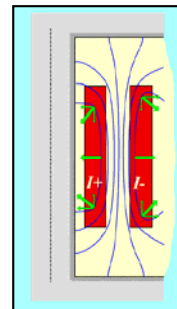
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Transformer Fleets Typical Situation

- 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%

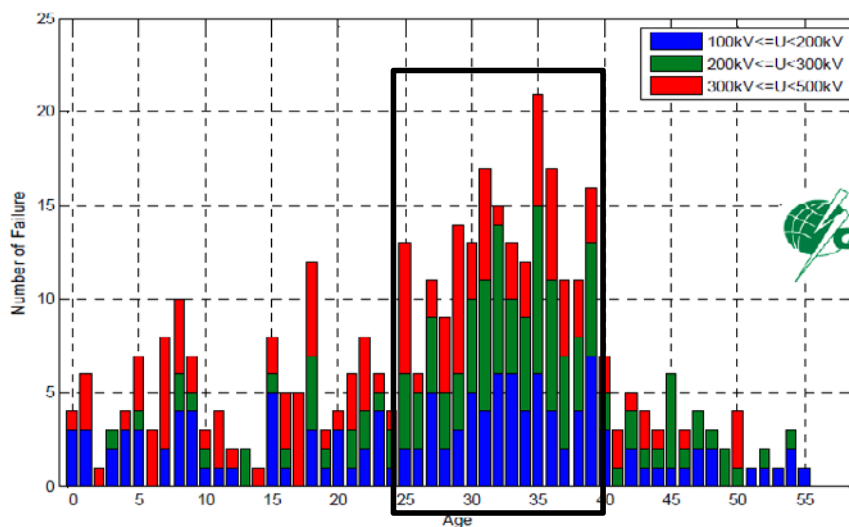
Innerhalb eines Jahres haben in einer Population von 1000 Transformatoren 5,3 einen schweren Fehler.

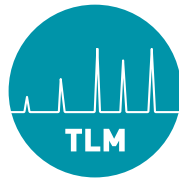
Generator Step-Up Transformers

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%



Transformer Fleets
CIGRE Study WG A2.37

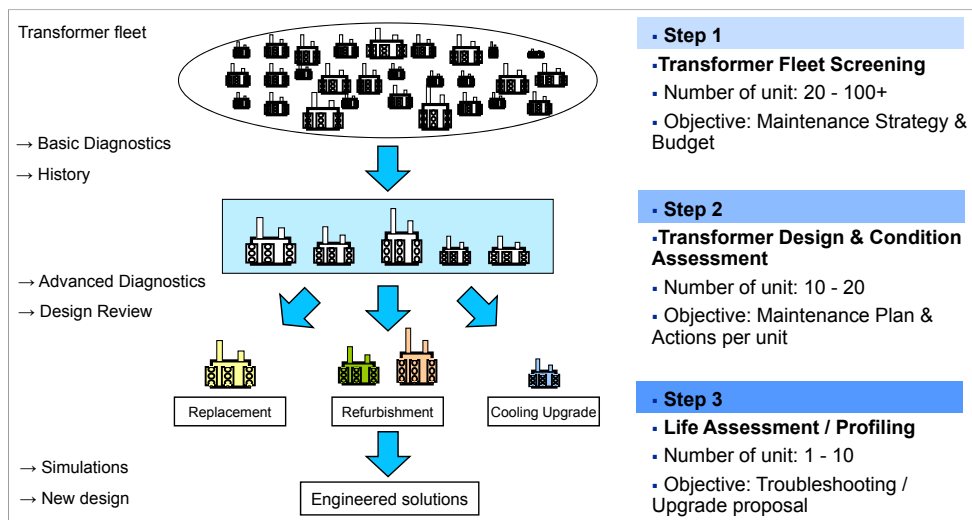




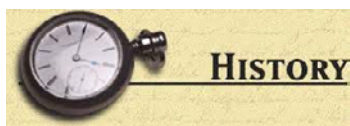
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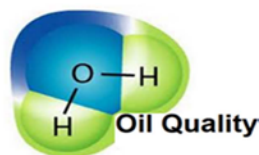
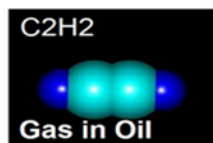
**Mature Transformer Condition Assessment (MTMP™)
Three steps approach**



**Condition Assessment
Basic Diagnostic**



Name Plate, Maintenance, Repairs, Overhauls, Faults

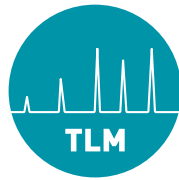


**Visuell
Inspection**



Standard electrical tests – insulation and winding resistance

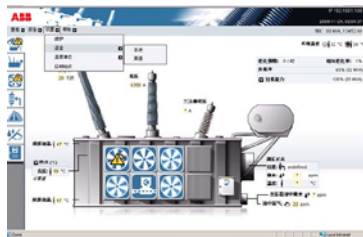




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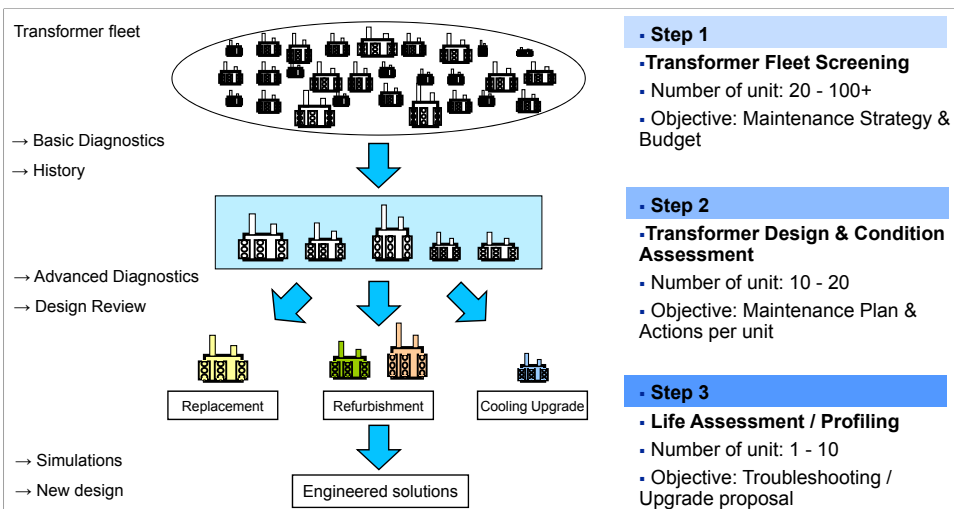
**Transformer Monitoring
Core-Tec**

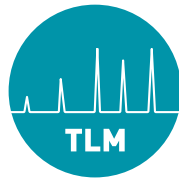


- **ABB expertise to turn data into actionable recommendations to operate, maintain and manage transformer assets**
- **Modular platform to address low to high end applications**
- **User friendly web interface – no additional software needed on users computer**
- **Based on a microprocessor and Modular 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**



**Mature Transformer Condition Assessment (MTMP™)
Three steps approach**

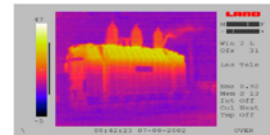
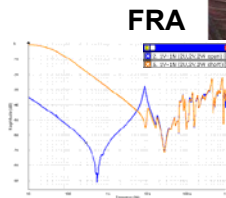
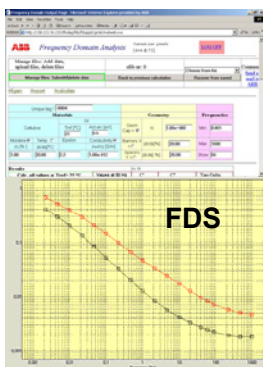




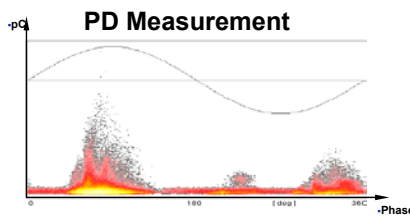
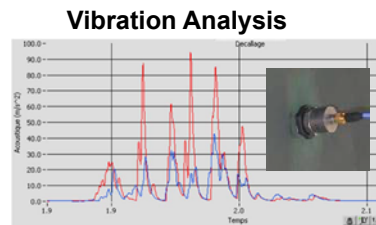
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Condition Assessment Advanced Diagnostic

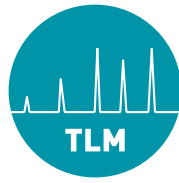


Thermovision-scan



Site Options and Actions Internal inspection

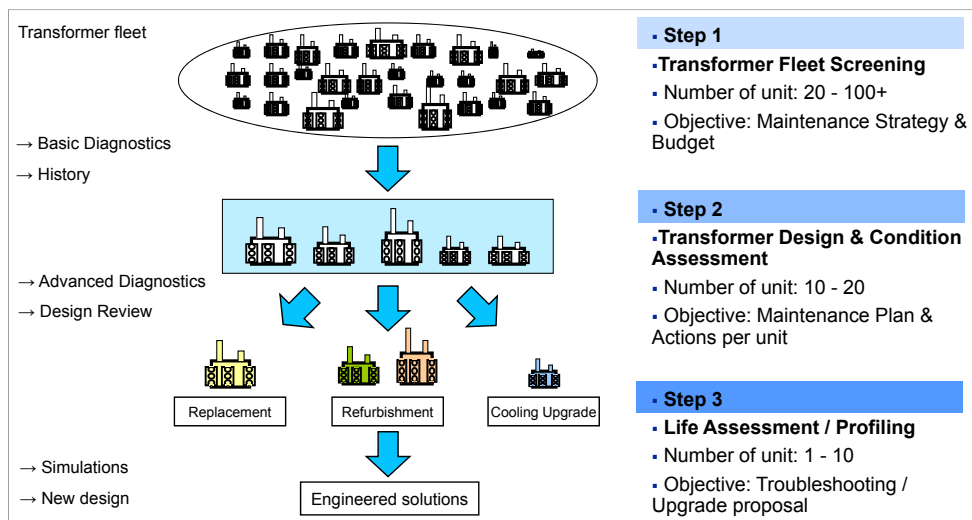




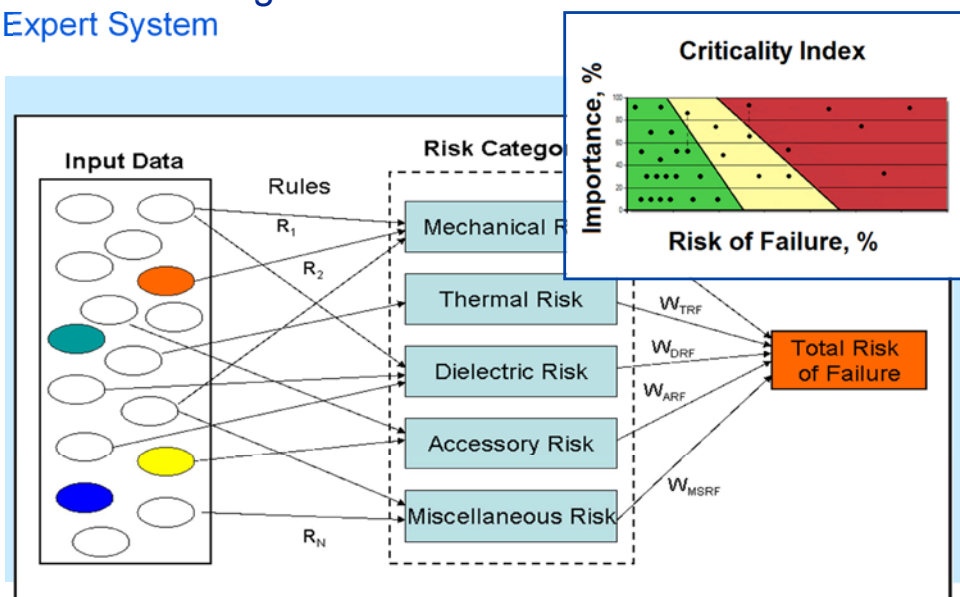
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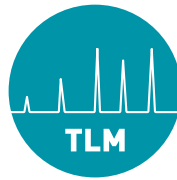
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**Mature Transformer Condition Assessment (MTMP™)
Three steps approach**



**Fleet Screening
Expert System**





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

Plant 1 - Results of condition assessment 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

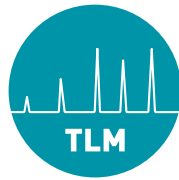


Recommendations Site Actions

- 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**

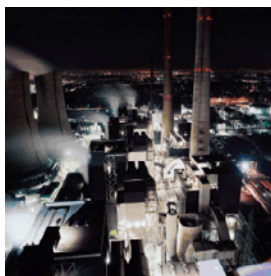
**What to do in case of a
long repair on-site or
in the workshop ?**



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:

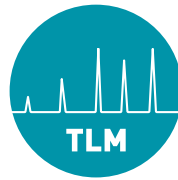
- Assessment of the condition and risks of failure with MTMP™
- **Determine the individual risk of failure**
- Proposal for maintenance actions and budget

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%

Unit ID	Condition	Risk Level	Budget Allocation	Recommended Action
001	High	Risky	25%	Immediate Repair
002	Medium	Medium	45%	Plan Maintenance
003	Low	Low	30%	Monitor
004	High	Risky	25%	Immediate Repair
005	Medium	Medium	45%	Plan Maintenance
006	Low	Low	30%	Monitor
007	High	Risky	25%	Immediate Repair
008	Medium	Medium	45%	Plan Maintenance
009	Low	Low	30%	Monitor
010	High	Risky	25%	Immediate Repair
011	Medium	Medium	45%	Plan Maintenance
012	Low	Low	30%	Monitor
013	High	Risky	25%	Immediate Repair
014	Medium	Medium	45%	Plan Maintenance
015	Low	Low	30%	Monitor
016	High	Risky	25%	Immediate Repair
017	Medium	Medium	45%	Plan Maintenance
018	Low	Low	30%	Monitor
019	High	Risky	25%	Immediate Repair
020	Medium	Medium	45%	Plan Maintenance
021	Low	Low	30%	Monitor
022	High	Risky	25%	Immediate Repair
023	Medium	Medium	45%	Plan Maintenance
024	Low	Low	30%	Monitor
025	High	Risky	25%	Immediate Repair
026	Medium	Medium	45%	Plan Maintenance
027	Low	Low	30%	Monitor
028	High	Risky	25%	Immediate Repair
029	Medium	Medium	45%	Plan Maintenance
030	Low	Low	30%	Monitor
031	High	Risky	25%	Immediate Repair
032	Medium	Medium	45%	Plan Maintenance
033	Low	Low	30%	Monitor
034	High	Risky	25%	Immediate Repair
035	Medium	Medium	45%	Plan Maintenance
036	Low	Low	30%	Monitor
037	High	Risky	25%	Immediate Repair
038	Medium	Medium	45%	Plan Maintenance
039	Low	Low	30%	Monitor
040	High	Risky	25%	Immediate Repair
041	Medium	Medium	45%	Plan Maintenance
042	Low	Low	30%	Monitor
043	High	Risky	25%	Immediate Repair
044	Medium	Medium	45%	Plan Maintenance
045	Low	Low	30%	Monitor
046	High	Risky	25%	Immediate Repair
047	Medium	Medium	45%	Plan Maintenance
048	Low	Low	30%	Monitor
049	High	Risky	25%	Immediate Repair
050	Medium	Medium	45%	Plan Maintenance
051	Low	Low	30%	Monitor
052	High	Risky	25%	Immediate Repair
053	Medium	Medium	45%	Plan Maintenance
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067	High	Risky	25%	Immediate Repair
068	Medium	Medium	45%	Plan Maintenance
069	Low	Low	30%	Monitor
070	High	Risky	25%	Immediate Repair
071	Medium	Medium	45%	Plan Maintenance
072	Low	Low	30%	Monitor
073	High	Risky	25%	Immediate Repair
074	Medium	Medium	45%	Plan Maintenance
075	Low	Low	30%	Monitor
076	High	Risky	25%	Immediate Repair
077	Medium	Medium	45%	Plan Maintenance
078	Low	Low	30%	Monitor
079	High	Risky	25%	Immediate Repair
080	Medium	Medium	45%	Plan Maintenance
081	Low	Low	30%	Monitor
082	High	Risky	25%	Immediate Repair
083	Medium	Medium	45%	Plan Maintenance
084	Low	Low	30%	Monitor
085	High	Risky	25%	Immediate Repair
086	Medium	Medium	45%	Plan Maintenance
087	Low	Low	30%	Monitor
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105	Low	Low	30%	Monitor
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111	Low	Low	30%	Monitor
112	High	Risky	25%	Immediate Repair
113	Medium	Medium	45%	Plan Maintenance
114	Low	Low	30%	Monitor
115	High	Risky	25%	Immediate Repair
116	Medium	Medium	45%	Plan Maintenance
117	Low	Low	30%	Monitor
118	High	Risky	25%	Immediate Repair
119	Medium	Medium	45%	Plan Maintenance
120	Low	Low	30%	Monitor
121	High	Risky	25%	Immediate Repair
122	Medium	Medium	45%	Plan Maintenance
123	Low	Low	30%	Monitor
124	High	Risky	25%	Immediate Repair
125	Medium	Medium	45%	Plan Maintenance
126	Low	Low	30%	Monitor
127	High	Risky	25%	Immediate Repair
128	Medium	Medium	45%	Plan Maintenance





Asset Management of Transformer fleets - An Overview

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**

