Life Expectancy Analysis Program (LEAP) for HV motors and generators

Presented by: Steve Lowther

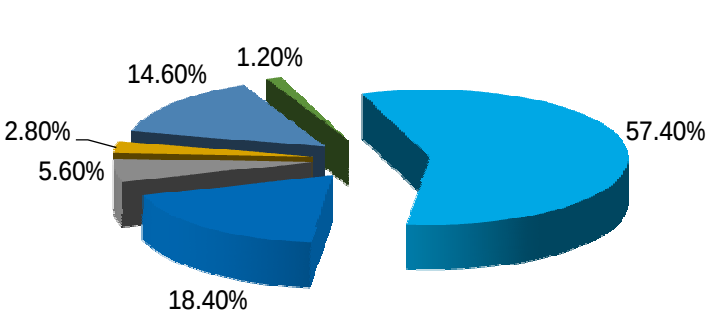
Principal Sponsor

13-15 November 2018
Rotorua, NZ

HV Motor Failure Statistics

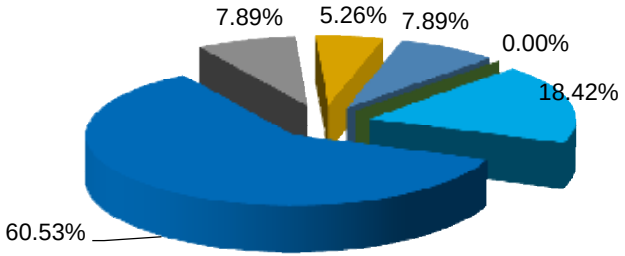
Petrochemical Industry survey

Distribution of Failures for motors of a capacity less than 2000KW



For Machines less than 2000 kW rolling element bearings are commonly used which are more likely to fail

Distribution of Failures for motors of a capacity greater than 2000KW



For Machines above 2000 kW sleeve bearings are often used which are less likely to fail

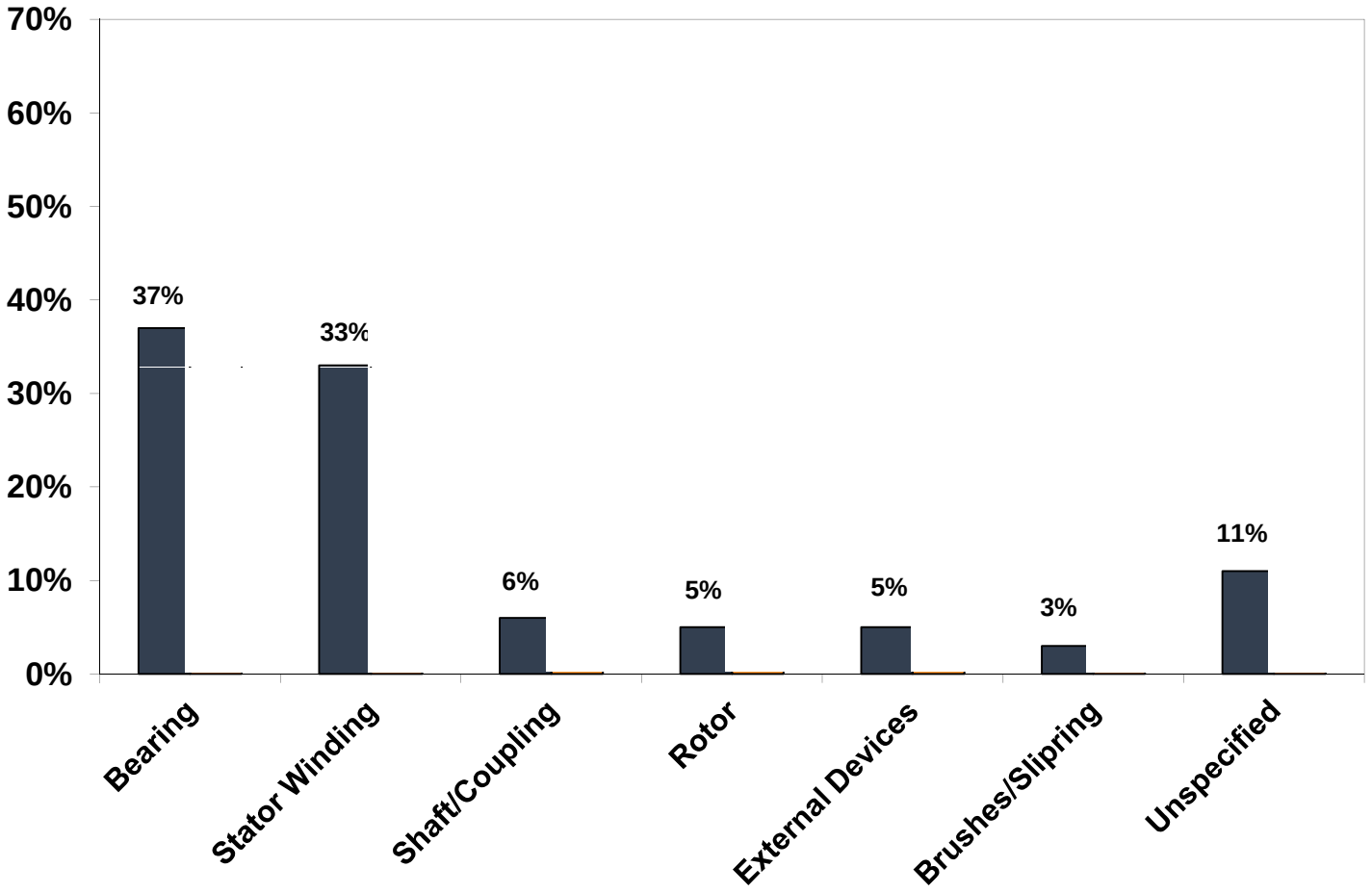
Motivation to develop ABB LEAP

Machine Failure Statistics – IEEE and EPRI

Failures observed in motor and generator during normal operating condition

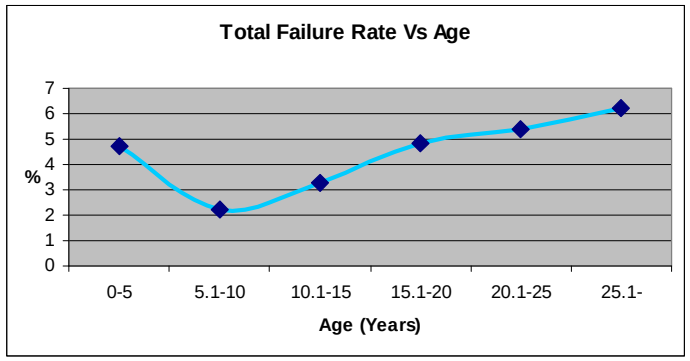
Failures identified in motor and generator when carrying out activities such as:

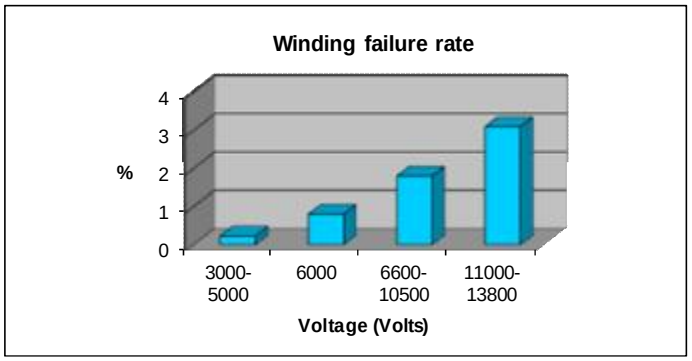
- Preventive Maintenance
- Condition Monitoring

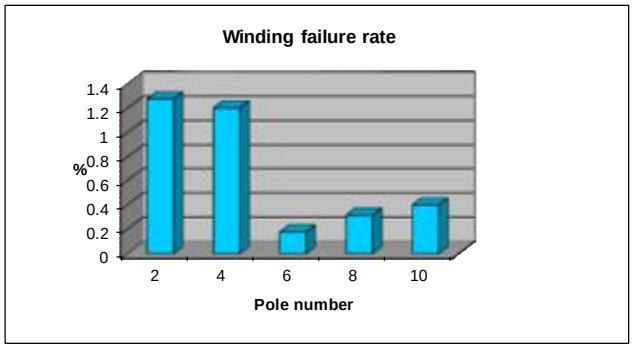


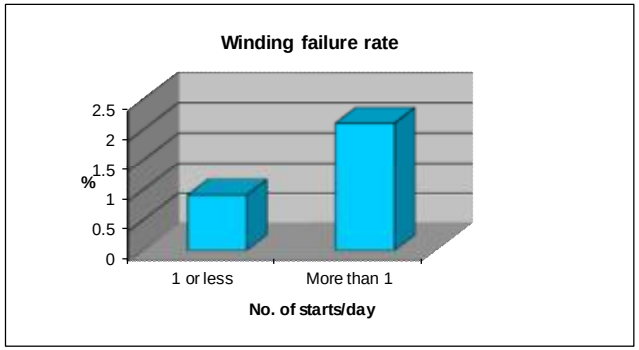
Factors influencing stator winding life

Age, voltage, speed, operation









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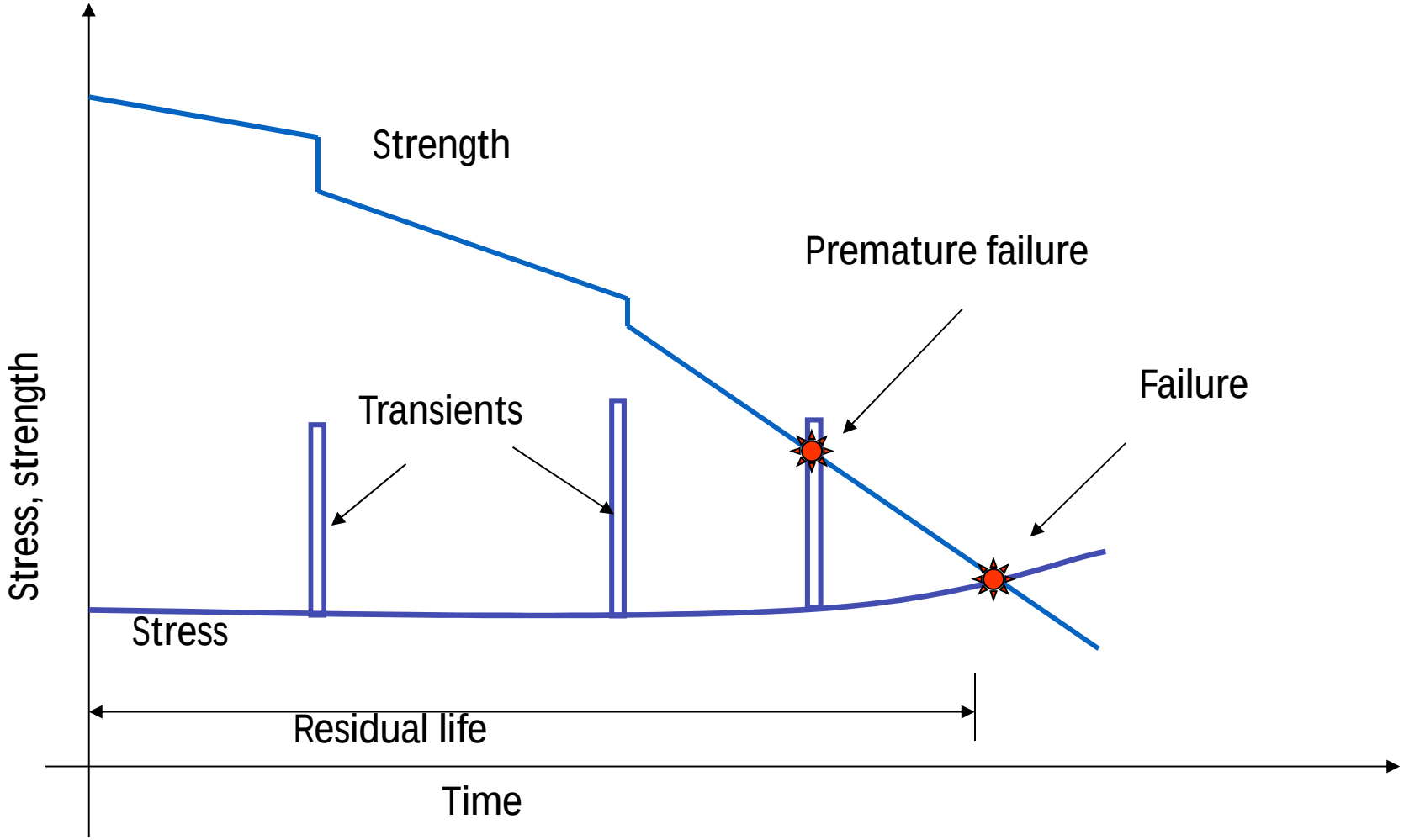
Basis of ABB LEAP

Stress and Strength vs Time



The Benefits

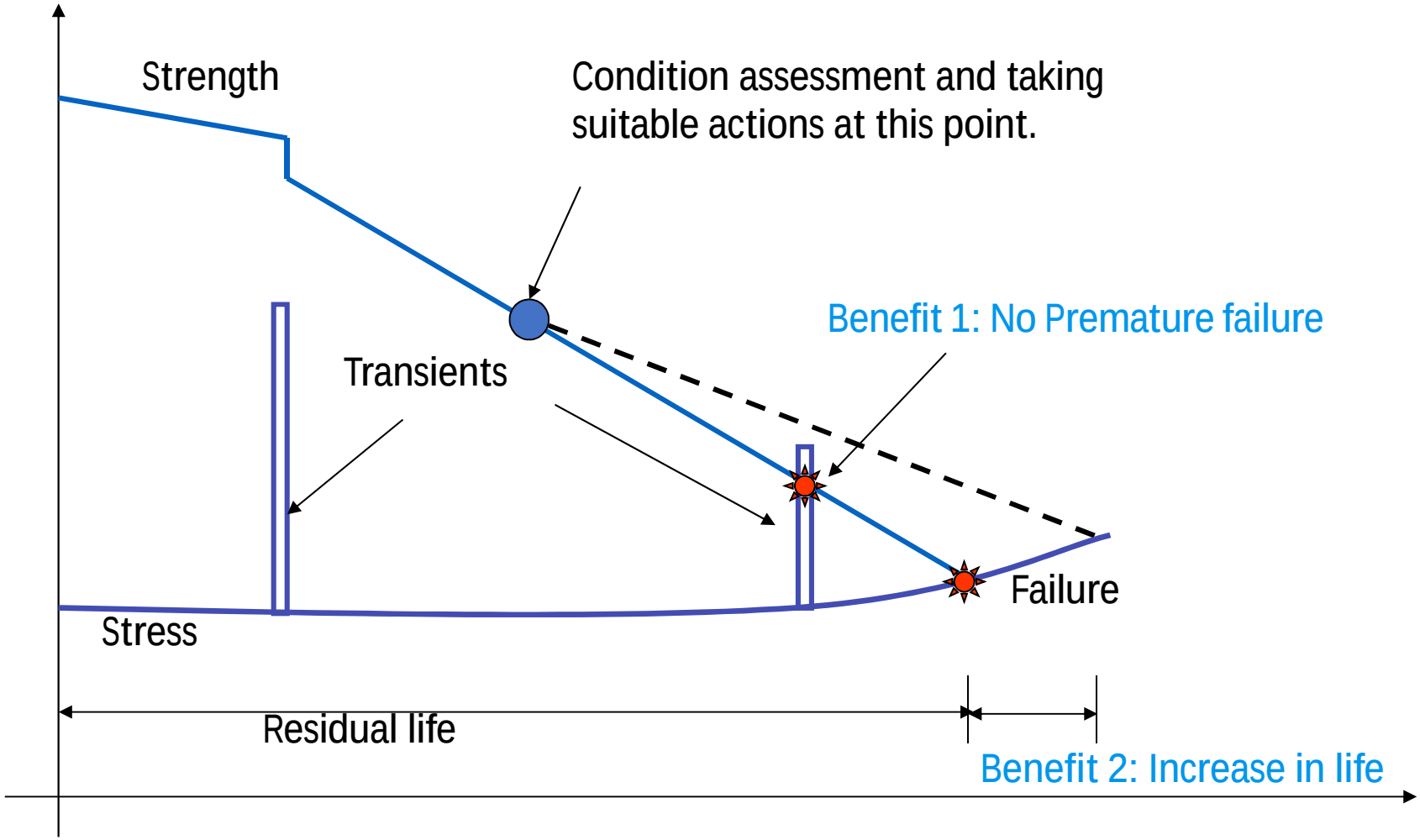


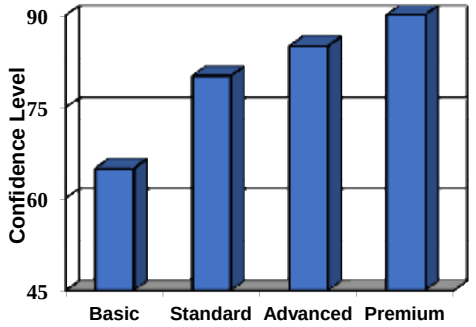
ABB LEAP – Life Expectancy Analysis Program

For Stator Windings of high voltage motors & generators

	Opportunities for Inspections	Inspection Schedule
Basic	When the motor is operating	Every 5% of the estimated lifetime
Standard	When the motor is stopped but assembled	Every 10% of the estimated lifetime
Advanced	When the motor is stopped and partially dismantled	Every 25% of the estimated lifetime
Premium	When the motor is stopped and rotor removed	Every 50% of the estimated lifetime

- ABB Life Expectancy Analysis Program is a unique maintenance and diagnostics tool for the HV stator winding insulation of motors and generators.
- LEAP provides information on the stator winding condition and expected life, and will optimize the motor and generator maintenance plans
- LEAP has been in use for over 15 years, with a database of over 10000 measurements
- Measurements are performed by Local Service Centers or LEAP hubs and data analyzed at the LEAP Center of Excellence

LEAP is not just a package of inspections; it is a systematic approach to managing motor and generator maintenance



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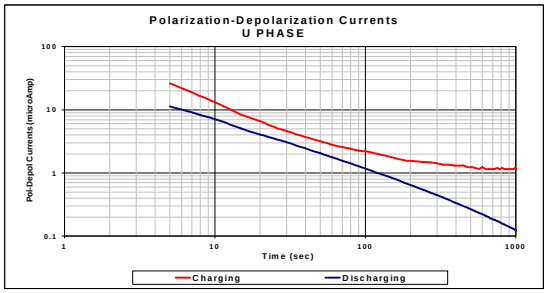
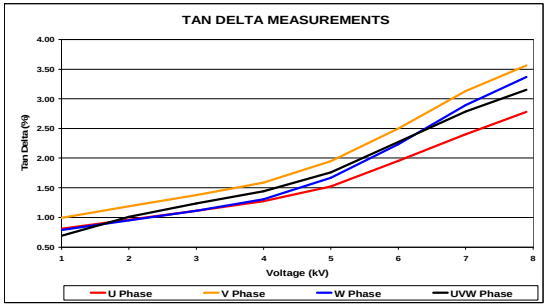
Level Based Inspections

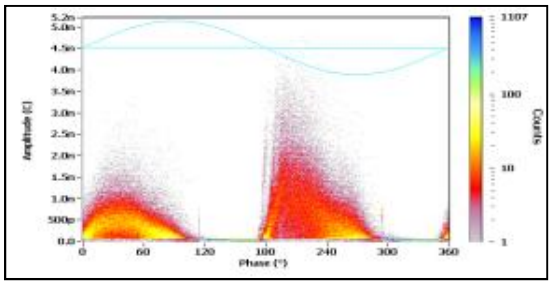
Solution Levels	Packages	Deliverables
Basic	§ Data collection (on site or remote): § Operational hours, voltage, current, power, slip, Starts/Stops, Temperature (Winding, Coolant and Ambient), Duty cycle & loading pattern, Failure and Maintenance history, Information on power supply, breaker-cable configuration, etc	§ Life Expectancy Analysis 65% Confidence Level § Condition Based Inspection and Maintenance Plan
Standard	§ Basic Data Collection § Polarization Depolarization Current Analysis PDCA § Tan Delta & capacitance Analysis § Non-Linear Insulation Behaviour Analysis § Partial Discharge Analysis	§ Condition Assessment of Stator Windings for Contamination, ageing, looseness, delamination, stress grading system § Life Expectancy Analysis 80% Confidence Level § Condition Based Inspection and Maintenance Plan
Advanced	§ Standard Data Collection § Visual Inspection on end windings § Partial Discharge Probe measurements & Dynamic Mechanical Response of Windings § Stress analysis of End-windings	§ Condition Assessment of Stator Windings with Standard Package + End-winding assessment § Life Expectancy Analysis 85% Confidence Level § Condition Based Inspection and Maintenance Plan
Premium	§Advanced Data Collection §Wedge Tightness Map & Coupling resistance measurements §Visual inspection, including slot areas §Stress analysis of Windings	§ Condition Assessment of Stator Windings with Advanced Package + slot region assessment § Life Expectancy Analysis 90% Confidence Level § Condition Based Inspection and Maintenance Plan

ABB LEAP measurements
Standard package

- DC measurements gives more information on the surface of the insulation
- AC measurements gives more information on the volume of insulation







- DC Measurements
  - Polarization De-Polarization Current Analysis
- AC Measurements
  - Non Linear Behaviour Analysis
  - Tan δ and Capacitance Analysis
  - Partial Discharge Analysis

ABB LEAP measurements

Salient points

DC measurements:

Conventional IR,PI values may be satisfactory even for highly contaminated windings

AC measurements: Conventional measurement interpretation is based on trend

- DC measurement
  - By measuring leakage and absorption current, PDCA test helps quantify and identify location of charge storage within the motor or generator
  - Identifies contamination even when IR, PI values are “acceptable”
  - Determines state of winding insulation, ageing, & contamination
- AC measurement
  - Confirm the results from DC measurements
  - Assess the condition of corona protection shield
  - Determine the extent of de-lamination, or void content, in terms of insulation volume
  - Assess condition of the stress grading system at slot ends

Why is ABB LEAP unique?

- Traditional measurement looks at values such as IR, PI, Tan δ - whereas ABB LEAP looks from point of strength aspects of insulation
- Traditional analysis requires a trending of data. With ABB LEAP finger print can be established with one set measurement
- Up to 72% of failures are related to thermal (aging) and ambient reasons which may not be detected by measurements that rely only on partial discharges. ABB's measurements and analysis focuses also on the detection of non-partial discharge related problems
- Analysis software is UNIQUE and parameters derived from analysis can be utilized in life expectancy calculations
- Can be related to time and integrated into the maintenance plan

ABB LEAP case study

Contamination

- 11 MW, 11KV, 1500 rpm synchronous motor
- Purpose of test:
  - The motor was in operation for 69,000 hours with no outage.
  - ABB LEAP Standard carried out to determine the need for L3 or Level 4 inspection
  - On-line pd alarm had appeared

- Results PDCA test:
  - IR- 2310 Meg ohm
  - PI- 2.02 (Limits)
  - Q1(%) – 9.63 (<7%)
  - Q2 (%) – 11.30 (<10%)
  - Q3 (%) – 44.54 (< 20%)
  - DR – 1.65 (<1.25) m
  - AgF – 60.12 (> 35)
  - Vol Res – $10^{13.78}$ (> 10^{14})Ohm-m

- Key findings
  - ABB LEAP **Standard** indicated presence of oil/carbonized contaminants predominantly on the overhangs
- Recommendation
  - Open the end covers and clean end windings. No immediate need of overhaul with rotor removal
- Benefits
  - Optimized maintenance plan
  - Life Extension and improve reliability

ABB LEAP case study

Run/Repair decision

- 70 MW, 10.5 kV, 3881 A, 3600 rpm
- **Purpose of Testing:** Machine is in operation for past 20 years, customer requested measurements during major outage
- **Results - PDCA Test**

IR - 1150 Mohm (> 100)

PI - 4.83 (> 2)

Q1 – 15.25 % (7%)

Q2 – 13.38 % (10%)

Q1/Q2 – 114 % (60%)

Q3 – 35.6 % (20%)

DR - 1.64 (1.25)

- **Key Findings:** LEAP Standard indicated **contamination**, **Slot** PD suspected, looseness of coil/wedges likely

Recommendation: Customer advised to rewind the generator within 10,000 hours

Benefits: *Catastrophic failure avoided*

"Tell him we haven't got time for any of his bright ideas – we've got a battle on our hands"