High Voltage Electrical Equipment Failure Diagnosis

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Definition of High Voltage (H.V. / H.T.)

– According to IEC standard,
  
  **High voltage** is defined as those with more than 1000V (>1000V AC) for alternating current
  
  **low voltage** (50~1000V AC) and **extra-low voltage** (<50V AC) circuits, in the context of building wiring and the safety of electrical apparatus.

– In South East Asia, HV is ranging from 1kV (1000V), 3.3kV, 6.6kV, 11kV, 22kV, 33kV, 132kV, 230kV, 275kV, 400kV & 500kV.
Map of the ASEAN
High Voltage Electrical Equipment Failure Diagnosis

Characteristic of High Voltage

– Higher voltage required higher insulation level
– Ability to penetrate insulation material (air, vacuum, gas, oil, XLPE, PILC, porcelain, etc) due to deterioration / aging / interruption / human error, etc and create short circuit / discharge between phase to phase / phase to ground
– resulting severe facility damage / loss, injury / death
High Voltage Electrical Equipment Failure Diagnosis

NDT Technology of Ultrasound
- a method to detect HV fault symptom (electrical partial discharge – E.P.D.) from a safe **distance**
- Provide safe **access** via structure borne and airborne method without direct expose to the live part / component.
- Highly **sensitive** ultrasound instrument coupled with **qualified** inspector will able to detect HV fault symptom (eg: corona, tracking, arcing, mechanical looseness and etc)
E.P.D. at 33kV VCB – Cable VOID

- Cable insulation void at cable compartment
E.P.D. at 33kV VCB – Cable VOID

Cable insulation void at cable compartment

2007
Jul 2008
Oct 2008
E.P.D. at 33kV VCB – Busbar

- Busbar insulation deterioration – corona partial discharge
E.P.D. at 33kV VCB – Breaker Contact

Chemical reaction on conductor
E.P.D. at 132kV Lightning Arrester

- Internal partial discharge at porcelain
E.P.D. at 33kV Overhead Disc Isolator

- Airborne detected PD at disc isolator suspension clamp – sharp edges/
  oxidization / deterioration
High Voltage Electrical Equipment Failure Diagnosis

- mechanical vibration / looseness in HV breaker causes by
  - the resonance of electrical frequency (50Hz / 60Hz) or electrical harmonics
  - workmanship issue during on site installation (e.g., tightening / torque, panel and floor leveling, greasing, etc)
  - Operator ignorant or mechanism error (e.g., breaker misalignment, breaker arm bent, shutter jammed, etc)
Mechanical vibration / looseness in HV breaker

Looseness detected at breaker & busbar
High Voltage Electrical Equipment Failure Diagnosis

Repair urgency on partial discharge detected:

- Rate of deterioration
- Location of the PD detected
- Loading fluctuation - on/off, surge start, peak load
- Surrounding environment condition – seaside, chemical industry, dusty area…
- External factors – animal, human error…
Repair urgency on PD detected

- 11kV CT flashover during breaker surge start after maintenance due to ignorant
Repair urgency on PD detected

- Dusty and salty environment induced speedy deterioration at 33kV VCB
Repair urgency on PD detected

- High moisture environment induced oxidization & chemical reaction
Repair urgency on PD detected

PD chemical effect on metal panel

Before

After
Repair urgency on PD detected

- Close PD location increase rate of deterioration
Repair urgency on PD detected

External factor

- Minor corona partial discharge give way in 7 days due to road construction
Repair urgency on PD detected

- Client common question to inspector:
  - How long does the PD symptom can last before it flashover??
  
  - Can we arrange shut down after our production peak time, may be about 6 months later??

  - Should we shut down by tonight??
Perfect match of Ultrasound and Thermography

- **Ultrasound (US)** – hear what we cannot hear; **Thermography (IR)** – see what we cannot see.
  - Technology limitation but not weakness.

- **Integration of US & IR** will supplement the survey findings and produce a better diagnosis result.
Perfect match of Ultrasound and Thermography

11kV RMU required immediate attention
Perfect match of Ultrasound and Thermography

Localizing the fault area

Sp1: temp 44.6

Ar1: max 67.6

FLIR Systems
Perfect match of Ultrasound and Thermography

Localizing the fault area
High Voltage Electrical Equipment Failure Diagnosis

- NDT technology ease the inspector / owner to visualize & localize the faults

- How is the HV partial discharge look like in our visual view???
  - Tx HV corona ring;

![Image of HV corona ring with temperatures Ar1: max 40.1, Ar2: max 40.2, Ar3: max 30.5, and a temperature scale from 19.0°C to 43.0°C]
Tx HV Cable - corona ring partial discharge
Tx HV bushing partial discharge
Tx HV bushing partial discharge

Ar1:max 46.1
Ar2:max 49.1
Ar3:max 44.3

Temperature: 50.0 °C

Frequency (Hz):
-30 -20 -10 0
-40 -30 -20 -10 0
-50 -40 -30 -20 -10

Amplitude (dB):
-80 -70 -60 -50 -40 -30 -20 -10 0

Ultrasound World VII 2011
Electrical partial discharge effect to plant/climber
HV flashover
High Voltage Electrical Equipment Failure Diagnosis

To conduct a safe and effective inspection on high voltage electrical equipment, we should well understand and aware on:

- The safety measure of the HV equipment to be inspected;
- Our NDT instruments’ strength and limitation;
- Be observant and sensitive to the on-site condition of the HV equipment;
- “a careful inspector will live longer than a hero (fool) in HV electrical system”
230kV GIS
230KV GIS

FLIR Systems

:max 32.8
:max 30.9

°C
3MVA Pauwels Trafo
Glad to share with you,
Thank you