Objective

- Analysis of present Monitoring technique.
- Evaluation of technologies
  - IR Thermography
  - Resistive leakage current
  - Insulation resistance
  - C-tan delta
- When to replace (Ageing factor)
Surge Arrester Cross section

Cross section of LA

MO element

Sealing gasket
Technologies

- Surge counters
- Online leakage current Monitoring LCM
- IR Thermography
- C-Tan Delta Monitoring
- Insulation resistance
<table>
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<tr>
<th>DESIGN FACTOR</th>
<th>TECHNIQUE</th>
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<td>THERMOGRAPHY</td>
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<tr>
<td>RESISTANCE</td>
<td>TAN DELTA</td>
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<tr>
<td>DIELECTRIC</td>
<td>CAPACITANCE</td>
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<tr>
<td>DIELECTRIC LOSS</td>
<td>TAN DELTA</td>
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<tr>
<td>TOTAL LOSS</td>
<td>RESISTIVE CURRENT</td>
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SURGE COUNTERS

- OPERATES:
  - IMPULSE CURRENT ABOVE AMPLITUDE.
  - IMPULSE CURRENT DURATION

- DISADVANTAGE:
  - NEGLECT SHORT IMPULSE <50 ms.
  - NO SPECIFIC INFORMATION ABOUT THE CONDITION OF THE ARRESTER.
  - HEALTHINESS OF MONITOR?
Third harmonic current monitoring with compensation: IEC-99-5

- **Principle**: Non-linear property of Metal Oxide generate third harmonic current.

- **DISADVANTAGE**:
  - Manufacturer in India do not specify design safe value.
  - Presence of third harmonic in system.
  - Wide variation in Temperature.
  - Wide Voltage variation.
  - Require expertise for analysis of data.
LCM : Leakage Current monitoring

Trend of leak current

LA LEAKAGE CURRENT GT -1 R phase

TIME MICRO A

Series1
Series2
Series3
Series4
Series5
THERMAL IMAGING

- INSTRUMENT USED: THERMOVISION CAMERA
- METHODOLOGY:
  - Thermal image of each LA taken from a close distance and stored in computer. Delta temperature is analysed.
  - Max temperature span is 10 to 20 c.
  - Images are taken when ambient temperature is stabilised (night time) & Calm weather with less humidity.
THERMAL IMAGE OF HEALTHY STACK

UNIFORM TEMPERATURE GRADIENT.

GRADIENT LESS THAN 6 C.

TOP STACK COMPARATIVELY MORE HOT
THERMAL IMAGE OF DEFECTIVE LA.
CASE STUDY: 1 DADRI-MANDULA1 -Y- PH

DELTA > 8 C
**400 KV LINE LA TOP STACK**

**BALLABHGURH -1 LINE LA -Y- PH**

- Max 78.4
- Diff. 14 Max. 28.7
- Max 49.6

* >70.0°C

* <= -20.0°C
CAPACITANCE AND TAN DELTA

- PARAMETER                      INDICATION
- CAPACITANCE        PHYSICAL
  INTEGRITY.
- TAN DELTA                      RESISTIVE LOSS,
  CONTAMINATION.
- DEL-TANDELTA       AGEING
METHODOLOGY

- BENCH MARKING
- CLASSIFICATION OF EXISTING LA
- TESTING OF OLD LA STACKS FOR TAN DELTA, C AND IR VALUE.
- TESTING OF NEW LA FOR TAN DELTA, C AND IR VALUE.
- TESTING OF INSTALLED LA PERIODICALLY AND TRENDING.
- BENCH MARKING C, TANDELTA, IR VALUE FOR DIFFERENT TYPE.
TEST RESULTS: TAN DELTA VALUE 220 KV - Make OLD AND NEW

GT-3-Y- PH BOTTOM STACK

NEW

DEFECTIVE

38.79
CAPACITANCE VALUE OF 220 KV - Make LA OLD AND NEW

GT-3-Y-PH BOTTOM STACK

DEFECTIVE

NEW
IR VALUE OF 220 KV Make LA OLD AND NEW

DEFECTIVE

NEW
400 KV make: TAN DELTA OLD AND NEW.
CASE STUDY -2-
400 KV: IR VALUE OLD AND NEW CASE
ANALYSIS OF TEST RESULT

- LA WITH TEMPERATURE GRADIENT OF MORE THAN 8 C ARE ABNORMAL.
- STACK WITH HIGH TEMP SHOWS VERY HIGH TAN DELTA VALUE AND HIGH CAPACITANCE VALUE.
- STACKS WITH HIGH “C” AND “TAN DELTA” HAVE SHOWN LOW IR.
- TEST RESULTS COMPLIMENTING EACH OTHER
C0-Relation Max temp and resistive Leakage Current
INTERNAL INSPECTION

Dismantled LA 400 kv WSI

Internal Parts
ELPRO 220 KV LA GT3 -Y- PH BOTTOM STACK
ELPRO -GT-3 -Y- PHASE BOTTOM STACK
ELPRO MAKE 220 KV GT-3- -Y- PHASE BOTTOM STACK

SURFACE DISCHARGE MARK ON ELEMENTS IDENTICAL TO PARTIAL DISCHARGE
WSI 400 KV MANDULA -Y-PHASE TOP STACK

HEALTHY LA

DEFECTIVE LA
WSI MAKE 400 KV MANDULA -Y- PH TOP STACK

DEFECTIVE ELEMENT

HEALTHY ELEMENT
BENCHMARKING OF TEST RESULT

- **Make-1** 220 KV CLASS
  - TAN DELTA: 3 TO 5%
  - CAPACITANCE MAX 115 PF
  - IR VALUE > 20000 M OHM (CLEAN)
  - THERMAL IMAGING DELTA \( t \leq 6^\circ C \)

- **Make-2** 400 KV CLASS
  - TAN DELTA 10 TO 15%
  - CAPACITANCE 130 PF
  - IR VALUE >20000 M OHM
  - THERMAL IMAGING DELTA \( t \leq 8^\circ C \)
Replacement Criteria

Online Monitoring

Decision Tree

Online Leakage Current (3 month) (R-1 month)

>120 H
>500 HH

OK

not ok

Arrester OK

Thermography

>3 c H
>5 c HH

Not OK

OK

Thermography (4 month)
T max

Capacitance
Tan Delta
Insulation resistance
Cauter Red Zone after

C>120 pf
TanDelta>10%
IR<20000

OK

Not Ok
Replace

Revise Schedule
Under Observation

Off Line Technology
Schedule 2 year

Master Schedule
Resistive leakage current and IR thermography are complimenting technology. Insulation Resistance or C-Tan delta test can be used for replacement decision. Contamination of middle stack may not give sufficient indication related to degradation in either technology. Sudden rise in resistive leakage current indicate water contamination.
Conclusion

• Arresters should be periodically tested for IR or C-Tandelta value off line.
• A single threshold value of 500 micro amp will not fit all arresters.
• There is no normal aging of arresters. Hence time based replacement criteria is not relevant.
Conclusion

• Most of the failures are due to water ingress into stacks hence there is risk of sudden death. This can be eliminated by proper timing of measurement.
• For arresters close to Power Transformers where failure tolerance is zero thresholds limit should be fixed based on analysis of the population. A 3 sigma upper value of 200 micro amp for Indian Make is more appropriate
Thank you

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