Modern Techniques for Condition Monitoring of Circuit Breakers
Routine Testing of CBs
CONDITION ASSESSMENT TECHNIQUES

1. ON LINE CONDITION MONITORING

2. OFF LINE CONDITION ASSESSMENT
ON LINE CONDITION MONITORING TECHNIQUES

1. SF6 GAS PRESSURE MONITORING
2. TRIP COIL SUPERVISION
3. AUXILIARY CONTACTS OPERATING TIMINGS
4. CONTACT SPEED MEASUREMENT BY INSTALLING TRANSDUCERS
OFF LINE CONDITION ASSESSMENT TECHNIQUES

1. OPERATING TIMINGS OF MAIN AND AUXILIARY CONTACTS - 1 Y
2. CONTACT TRAVEL MEASUREMENT - 3Y
3. DEW POINT MEASUREMENT OF SF6 GAS - 2Y
4. DYNAMIC CONTACT RESISTANCE MEASUREMENT - 3Y
5. TAN DELTA MEASUREMENT OF GRADING CAPACITORS - 3Y
6. TRIP/CLOSE COIL CURRENTS MEASUREMENT - 1Y
7. STATIC CONTACT RESISTANCE MEASUREMENT - 2Y
8. VIBRATION MEASUREMENT
DYNAMIC CONTACT RESISTANCE MEASUREMENT (DCRM)

- CONTACT RESISTANCE MEASUREMENT DURING TRIPPING OPERATION.

- 100 AMP CURRENT IS INJECTED THROUGH CB CONTACTS.

- VOLTAGE DROP AND CURRENT IS MEASURED TO COMPUTE CONTACT RESISTANCE.

- VARIATION IN FINGER PRINT OF DCRM INDICATE PROBLEM IN ARCING CONTACTS.
NEED FOR DCRM

- DURING NORMAL CONTACT RESISTANCE MEASUREMENT, HEALTHINESS OF MAIN CONTACTS IS INDICATED.

- \[ \text{Req} = \frac{R \cdot r}{R+r} = \frac{r}{1+r/R}, \quad r = \text{MAIN CONTACT} \]
  \[ \quad R = \text{ARCING CONTACTS} \]

- DCRM SIGNATURES/FINGER PRINTS INDICATE TRUE CONDITION OF CB ARCING CONTACTS.

- DCRM ALONGWITH CONTACT TRAVEL MEASUREMENT IS HELPFUL IN COMPUTING THE ARCING CONTACT LENGTHS.
DYNAMIC CONTACT RESISTANCE MEASUREMENT

1. WHAT IS DCRM:

   IT IS A MEASUREMENT OF CONTACT RESISTANCE DURING DYNAMIC CONDITION.
DCRM CONNECTION ARRANGEMENT
Main and Arcing Contacts

“Closed” position

Opening

Interrupting

“Open” position
PROBLEMS IN CBs AFTER 7-8 YEARS
DYNAMIC CONTACT RESISTANCE MEASUREMENT (DCRM)

- 100 AMP CURRENT IS INJECTED THROUGH CB CONTACTS.
- VOLTAGE DROP AND CURRENT IS MEASURED TO COMPUTE CONTACT RESISTANCE.
- VARIATION IN FINGER PRINT OF DCRM INDICATE PROBLEM IN ARCING CONTACTS.
Equipment used...

- HISAC 2406x
- DCRM
- HISAC MB 3.0
- CB
- PC
- PRINTER
DCRM Kit
Typical DCRM Signature

Figure-2 Typical DCRM Signature

P1: Arcing contact touches
P2: Main contact touches
P3: Main contact separates
P4: Arcing contact separates
Case Study

- The CB was commissioned in 1993 and was controlling a Transmission Line.
- DCRM signatures after closing operation were not stable and wide variations were observed.
DCRM Signature of defective CB
Internal Inspection of Suspected CBs

- The CB was opened for internal inspection.
- Bearing Bush used for moving main contact to the operating lever had loosened
- This caused misalignment and subsequent damage to moving contact Finger Contact Assembly.
- Defective Components were replaced
DCRM Signatures of the Suspected CB
DCRM Signatures after rectification
CB Overhaul decisions

- Based on DCRM Tests, many CBs have been taken up for Internal inspection and following defects were observed:

1. Damage of Main Contacts
2. Pitting marks of Fixed Contact tube
3. Damage of Blast cylinders
Conclusion

- DCRM Test for CBs is very helpful in indicating condition of main contacts in respect of erosion, misalignment and looseness etc.
- Hence, major overhauling of main contacts can be decided based on DCRM signatures without opening the CB Interrupters
CONTACT TRAVEL AND ARcing CONTACT LENGTH
SOURCES OF MOISTURE IN CB

- GAS HANDLING - FILLING AND EMPTYING THE CB. AIR MAY BE LEFT DURING EVACUATION WHICH ADD TO IMPURITIES IN SF6 GAS.
- EVACUATION TO BE DONE UPTO 1 mbar (CIGRE-WG23)
- EXUDATION OF MOISTURE CONTAINED IN ORGANIC INSULATING MATERIALS.
- PERMEATION THROUGH SEALED SECTIONS
DEW POINT MEASUREMENT
DEW POINT MEASUREMENT

- IF SF6 GAS CONTAINS MOISTURE, IT IS EASILY HYDRATED TO PRODUCE HIGHLY REACTIVE H₂SO₃ AND HF (HYDROGEN FLUORIDES).

- AS THESE CHEMICALS CAUSE DEGRADATION OF INSULATION AND CORROSION IN THE INTERRUPTING CHAMBER, MONITORING OF MOISTURE CONTENT IN SF6 GAS IS VERY IMPORTANT.
CONTAMINATION OF SF6 GAS BY MOISTURE

When moisture density is low:

\[ \text{SF}_4 + \text{H}_2\text{O} \rightarrow \text{SOF}_2 + 2 \text{HF} \]
\[ \text{SOF}_2 + \text{H}_2\text{O} \rightarrow \text{SO}_2 + 2 \text{HF} \]

When Moisture density is high:

\[ \text{SF}_4 + 3\text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3 + 4 \text{HF} \]
\[ 2\text{SF}_2 + 3\text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3 + 4 \text{HF} \]
DECOMPOSITION OF SF6 GAS

ARCS DURING TRIPPING OPERATION LEADS TO A SUBSTANTIAL EROSION OF THE CONTACT AND INSULATION MATERIALS BY THE HOT ARC.

THE MAIN CAUSE FOR SF6 GAS DECOMPOSITION IS THE REACTION OF THESE EROSION PRODUCTS WITH FRAGMENTS OF THERMALLY DISSOCIATED SF6 AND OTHER TRACE GASSES SUCH AS OXYGEN AND WATER VAPOUR.

(A) \( \text{Cu} + \text{SF}_6 \rightarrow \text{CuF}_2 + \text{SF}_4 \) - COPPER POWDER
(B) \( \text{W} + 3\text{SF}_6 \rightarrow \text{WF}_6 + 3\text{SF}_4 \) - TUNGSTEN
(C) \( \text{CF}_2 + \text{SF}_6 \rightarrow \text{CF}_4 + \text{SF}_4 \) - ERODED PTFE (A CF2 POLYMER)
EFFECTS OF CONTAMINATION

1. DECOMPOSITION PRODUCTS ARE CORROSIVE AND MAY AFFECT THE SURFACE INSULATION BY THE FORMATION OF CONDUCTIVE LAYERS ALONG THE INSULATORS.

2. HUMIDITY/MOISTURE IS VERY DANGEROUS WHEN IT CONDENSES ON THEM IN LIQUID FORM CAUSING REDUCED INSULATION STRENGTH

3. CUFe2, WO3, WO2F2 ORIGINATE FROM CONTACT EROSION.

4. HEALTH RISK DUE TO BYTOXIC PRODUCTS LIKE SO2 ETC.
Preventive Maintenance

- Checking of oil leaks from Grading Capacitors - M
- Dew Point measurement of SF6 gas – 3Y
- Checking of oil pressure drop during duty cycle operation check - Y
- Checking of auto-starting/stopping of oil pump - Y
- CB Operating Timings (Main, PIR, Aux.) - Y
Preventive Maintenance

- Static Contact Resistance Measurement - 2Y
- Dynamic Contact resistance (DCRM) – 2Y
- Checking of Pole discrepancy relay - Y
- Functional checks, duty cycle operation including rapid re-closing (O-0.3s-CO) - Y
- Checking of all operation lock-outs - Y
- Checking of all interlocks - Y
Preventive Maintenance

- Checking of pressure settings Cleaning of Breaker Interrupter, Support insulators, PIRs and Grading Capacitors - Y
- Checking of close/trip coil currents - Y
- Checking of healthiness of Operation Counter - Y
- Capacitance and tanδ measurement of grading capacitors - 4Y
Thank You