2014

Testing and Commissioning Procedures for Electrical Components and Equipments in Power Industries

BSC-User

BEMCO Services CO

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Contents

شركة بمكو للخدمات
BEMCO SERVICES CO.
TESTING , COMMISSIONING, START UP, O&M.
INDUSTRIAL & POWER PROJECTS

Testing Procedure

Current Transformer

Document No: BSC-TP-CRT01
Rev: 0

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1.0 Task

This instruction comprises a complete description of the testing of the Current transformers, the measuring circuits for protection, and closed-loop for instrumentation.

2.0 Preconditions

2.1 Work Status

- Erection has been completed.
- Labelling of the equipment and designation of live enclosed plant sections has been carried out.

2.2 Documentation

- The Schematic and single line diagrams are available
- Relevant test sheet to be made available.
- Factory test results are available.

2.3 Personnel

- One Commissioning engineer: Engineer or technician with experience in commissioning of all the electrical equipments.
- One Helper: skilled worker with adequate on-the-job training.

2.4 Measuring Instruments and Tools

- Single-phase variable-voltage transformer (approx. 0 -1200 V secondary voltage),
- 1 Ammeter (AC), or Fluke
- 1 Voltmeter (AC), or Fluke
- Multi-meter (A, V, Ohms) or Wheatstone bridge
- Primary Injection test set
- Insulation Tester 500V dc
- Instead of above all CPC100

3.0 Precautions

The work will only proceed when a Permit to Work (PTW) in work permit area has been obtained. The PTW will be kept on site for consultation during the testing works.

- Observe the rules for handling electronic components sensitive to electrostatic discharge (ESD measures).
- Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.
- Closing of the work permit after completion of the work (if the test area is to be considered in work permit area) is necessary.

4.0 Scope

- Testing cable connections,
- Testing of CT's
- Checking that the mounting position is correct,
- Checking of the phase and core assignment,
- Checking of correct earthing,
- Checking of the function.

5.0 Execution

5.1 Visual Checks

- Checking of the cables for damage and that they are connected correctly,
- Checking of the mounting position of the current transformers (polarity),
- Checking of the labelling of the individual cores, checking of the phase/core assignment
- Inspection for cleanliness of current transformers, connections and associated cable connections
- Inspection of isolating terminals and earthing connections

5.2 Testing the Current Transformers

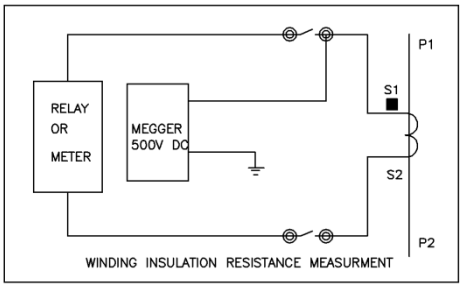
Enter the rating plate data in test sheet and compare the current transformer data with the data contained in the circuit documentation. The following test shall be carried out

1. CT Winding insulation Resistance test
2. CT Ratio test by primary injection
   a. CT Ratio
   b. Phase Angle Error
3. CT Winding Resistance Measurement
4. CT Loop Resistance Measurement
5. CT Polarity Test
6. CT Burden test
7. CT Magnetizing Current Test (Knee Voltage test)
8. Demagnetizing CT cores after above all test
9. Inter Core Coupling Test for bus differential test
10. High voltage test
11. Verifying secondary circuits, terminals, shorting/isolating links by primary injection
12. single point earthing check
13. phase identification

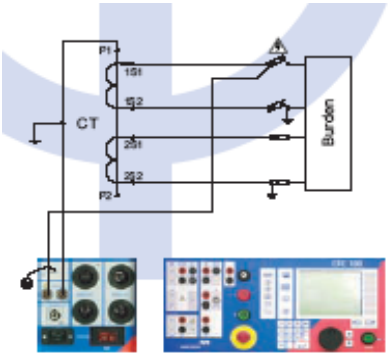
In case of multi core type current transformers each winding must be tested individually.

5.2.1 CT Winding Insulation Resistance Test

- Insulation resistance for the CT Winding is done by using 500V dc insulation resistance tester as per following schematic
- Insulation resistance shall be checked at terminal of secondary winding with respect to ground with 500V dc insulation tester.



Insulation test by CPC100



Voltage Withstand

Tests the voltage withstand capability of the insulation between primary and secondary winding or earth and secondary winding

After entering the test voltage and the duration, and pressing the Start button, the test card

- determines the leakage current flowing through the insulation.

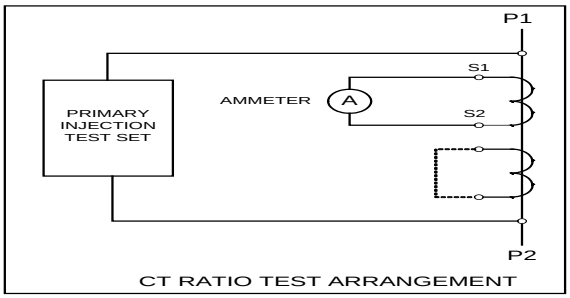
The current threshold for maximum leakage current can be entered. The CPC 100 will automatically switch off if the maximum leakage current is exceeded.

Duration of the test: can be set by the user; the test report will be created after the test automatically.
Output: up to 2 kV

5.2.2 CT Ratio Test By Primary Injection/ Phase Angle Error

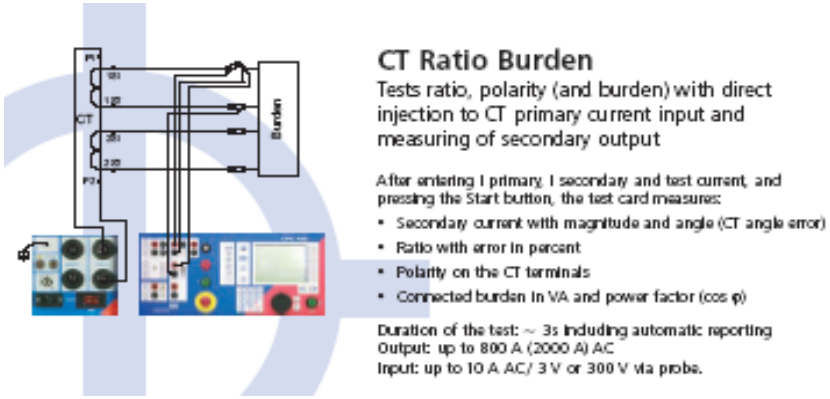
5.2.2.1 **CT Ratio**

- Current ratio test can be done by injecting current in primary circuit and measuring the current at secondary by Primary injection test set as per following schematic diagram
- Check the CT ratio by injecting current as much as near to normal current of the CT primary and measure the corresponding secondary current.
- The test is to be carried out individually for each core and phase.



Use precision clamp meter and Ammeter to measure the primary and secondary current respectively

Ratio test CPC100



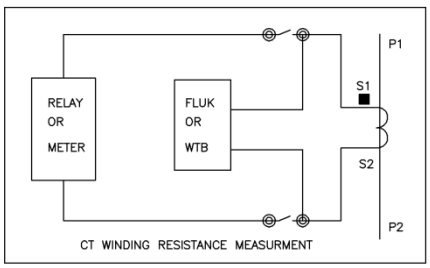
5.2.2.2 Phase Angle Error

- Phase angle can be measured by using CPC100 as shown in above figure, phase angle is the angle measured between primary current through CT and the secondary current through the relay
- This test can also be performed by injecting current in primary of the CT and angle is measured between primary and secondary current flowing in to the relay.

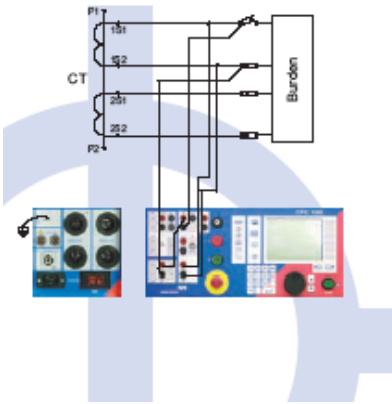
5.2.3 CT Winding Resistance Test

CT Winding Resistance can be measured either by FLUK or Wheatstone bridge as per fallowing schematic diagram

- Connect the Wheatstone bridge as shown below and measured the CT secondary resistance and compare with name plate data
- While measuring the winding resistance note down the Ambient temperature in order to correct the value to factory test results



Winding Resistance by CPC100



Winding Resistance

Measures CT winding resistance

After entering the test current and pressing the Start button, the test card

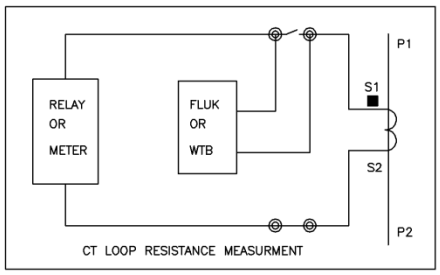
- displays the deviation of the measurement over time during the period of charging the winding
- automatically performs a discharging of the winding after saving the measurement
- measures the DC voltage
- measures the resistance
- (optionally) compensates the temperature behavior of copper, where the applied temperature compensation calculates the resistance for working temperature

Duration of the test: depending on the charging time. After the charging period, the user creates the report by pressing Save Results.
Output: up to 6 A DC
Input: up to 10 V DC and 10 A DC

5.2.4 CT Loop Resistance test

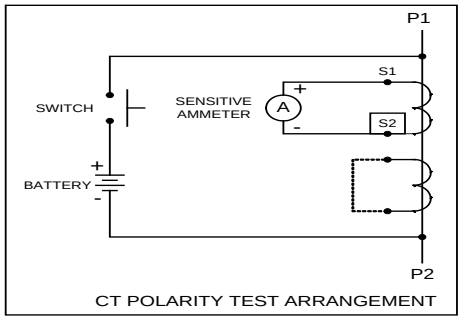
CT Loop Resistance can be measured either by FLUK or Wheatstone bridge as per fallowing schematic diagram

- Connect the Wheatstone bridge as shown below and measured the loop Resistance.



5.2.5 CT Polarity Test.

CT polarities can be checked by using 9 volts battery and a zero center galvanometer as per the following Schematic Drawing



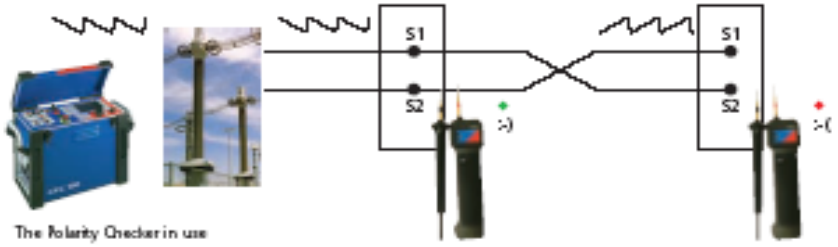
On pressing the switch momentarily in above circuit, the needle on center zero galvanometer or sensitive ammeter reads positive deflection thus polarity of the transformer is subtractive. Subtractive polarity exists when current going into the primary polarity terminal causes to go out of the secondary polarity at the same instant in time

Polarity Test by CPC 100.

Polarity Checker (Replacement for Battery Checking Method)

Checks a series of test points for correct wiring

Just inject a the special continuous test signal at one point with the CPC 100 and check the polarity at all terminals with CPOL as shown in fig. 1, getting a clear indication whether the polarity is OK (green LED) or not (red LED).
This procedure is much faster than the conventional method and can easily be performed by a single person.
Duration of the test: depending on the number of test points; 3-5 s per test point

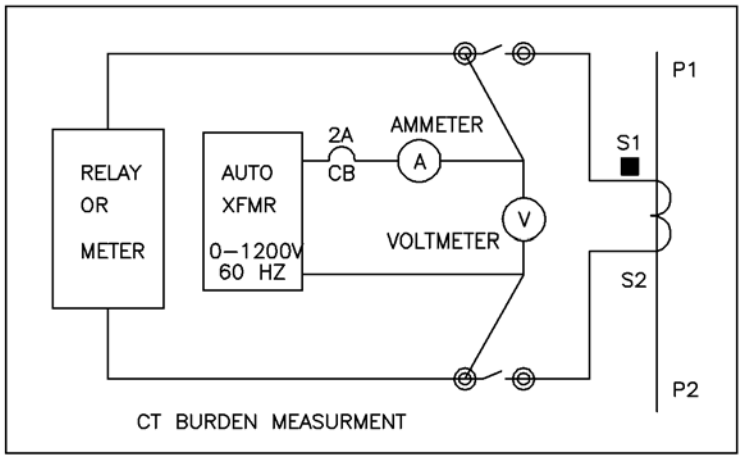


The Polarity Checker in use

5.2.6 CT Burden Test

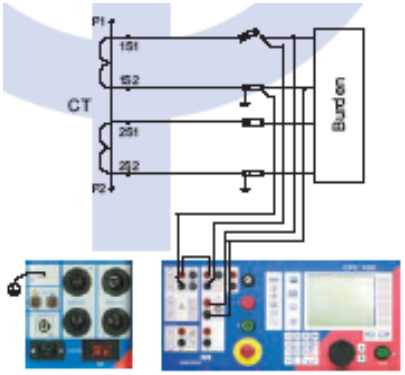
CT Burden test can be done by a variable voltage source with voltmeter and ammeter as per schematic diagram

The burden in each core of each phase is determined by injection of a current of 1 A (or 5 A as appropriate) in the direction of the load and measurement of the voltage with respect to earth. The voltage across the burden must decrease on moving from burden to burden along the current path. The measured burden should be compared with the rated data of the current transformer.



CT BURDEN MEASURMENT

Burden measurement by CPC100



CT Burden

Measures connected CT burden load with direct injection of secondary current with disconnected CT

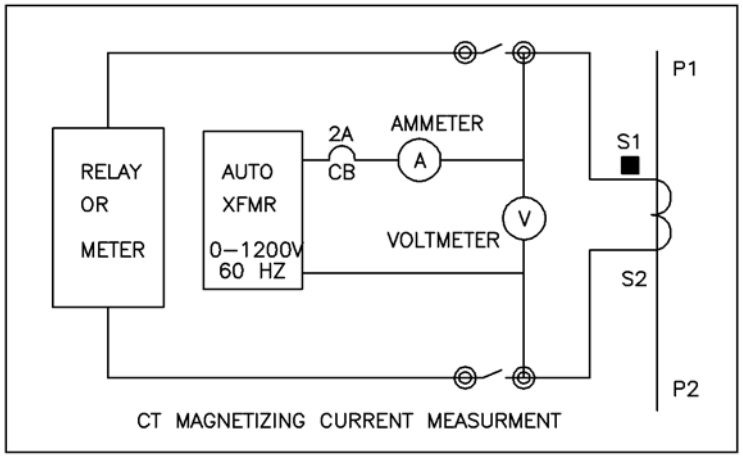
After entering the secondary nominal current and the test current, and pressing the Start button, the test card measures:

- Secondary voltage in magnitude and angle
- Connected burden in VA and power factor (cos φ)

Duration of the test: ~ 3s including automatic reporting
Output: up to 6 A AC
Input: up to 10 A AC/ 3 V via probe and 300 V

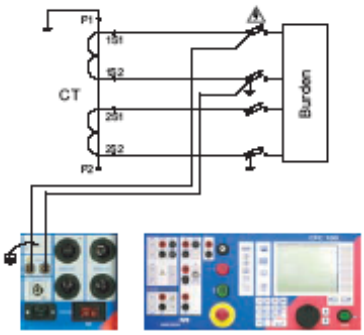
5.2.7 CT Magnetization Current test

CT Magnetization test can be done by a variable voltage source with voltmeter and ammeter as per schematic diagram



- Apply the voltage gradually in 10% increment of the knee voltage and note down the secondary excitation current
- Current values are obtained for every 10% voltage increment till the knee point. Knee point is the condition where 10% increase in voltage results in 50% increase in current
- Minimum two points over the knee point and five points below the knee point shall be taken.
- Readings are tabulated on a excel from where a graph is generated automatically

Magnetization curve By CPC100



CT Excitation

Tests the excitation curve

The necessary wiring is only two leads from the voltage output to the open secondary wiring of the CT. After entering the current and voltage limits and pressing the Start button, the test card will automatically record the CT excitation curve according to IEC, ANSI 45°, or ANSI 30° standards, and the kneepoint will be automatically calculated. After the test an automatic sequence of demagnetization is performed. The test is done using a regulated voltage source. A comparison of test results obtained using regulated and non-regulated voltage sources can be found on on our web site at www.omicron.at.

Duration of the test: ~ 30 s including automatic reporting with recorded excitation curve, and calculated kneepoint voltage.
Output: up to 2000 V AC

5.2.8 Demagnetising the CT Core

After performing the above tests, a voltage greater than knee voltage shall be applied gradually to CT secondary and reduced slowly back to zero. CPC 100 can also be used for demagnetising the CT core

5.2.9 Inter Core Coupling Test for Bus Differential CT's

In many instances several secondary windings are mounted in close proximity on the same primary lead. It is possible, through failure of grading shields or support structures, to have coupling between cores which is not detectible by excitation tests, but it is still substantial enough to improperly operate bus differential relays. The presence of abnormal coupling can be detected by reading open circuit voltage on CT's adjacent to a CT being excitation tested.

By measuring the voltage across the secondary of differential CT's when adjacent core is excited during magnetisation current test.

5.2.10 High Voltage Test

- CT's are subject to high voltage tests during High voltage test of switch gear.
- While performing high voltage test CT secondary should be isolated from load and kept shorted/grounded

5.2.11 Verification of Secondary Circuits , Terminals shorting /Isolating Links by Primary Injection

During primary injection check secondary circuit terminal shorting/isolation is working properly by closing the shorting slid link and opening the slid link, there should not be any current in direction of load.

5.2.12 Phase Identification Test

Check phase identification by injecting primary current in single phase
Check the current in all the three phase. Two phases should read zero current and third phase whose primary has a current should read a secondary current

5.2.13 Checking the Protective Earthing and Single Point Earthing

Current transformers must be earthed on the secondary side in order to afford protection to human beings. In order to avoid circulating currents such earthing is permissible at one point only of a metallically connected system. (In case of physical separation of the phases the three earthing points should be regarded as being one earthing point.)

Meeting of both requirements is verified in a simple manner by opening of the earthing point link and connection thereof to a secondary testing device while simultaneously measuring the current I=0. Subsequently the earth connection is to be restored.

6.0 Documents

Relevant test sheets to be completed for each set of instrumentation transformers.

7.0 Attachment

Test sheet for following equipment to be prepared with respect to their Main equipment

7.1 Testing of Current Transformer
7.2 Loop Resistance, Burden and phasing Checks of CT
7.5 Primary Injection of Current Transformer

*****End of the procedure *****

Testing Procedure

Voltage Transformer

Document No: BSC-TP-VOT01
Rev: 0

TABLE OF CONTENT

1.0 Task

The procedure comprises a complete description of testing of current transformer

2.0 Preconditions

2.1 Work status

- Erection has been completed.
- Labelling of the equipment is done

2.2 Documentation

- The Schematic diagrams & CPM of Switch gears are available
- Relevant test sheet to be made available

2.3 Personnel

- One commissioning engineer or technician with experience in commissioning of Protection Relays
- One Helper: skilled worker with adequate on-the-job training.

2.4 Measuring instruments and tools

- Single-phase variable-voltage transformer (approx.0-1200 V secondary voltage),
- 1 Voltmeter (AC), or Fluke
- Multimeter (A, V, Ohms) or Wheatstone bridge
- Insulation Tester 500V dc
- Instead of above all CPC100

3.0 Precautions

- The work will only proceed when a Permit to Work (PTW) in work permit area has been obtained. The PTW will be kept on site for consultation during the testing works.
- Observe the rules for handling electronic components sensitive to electrostatic discharge (ESD measures).
- Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.
- Closing of the work permit after completion of the work (if the test area is to be considered in work permit area).

4.0 Scope

- Testing of the transformer,
- Checking that the mounting position is correct,
- Checking of the phase and core assignment,
- Checking of correct earthing,
- Functional checks of VTs.

5.0 Execution

5.1 Visual checks

- Check the wires for any damage and that they are connected properly.
- Check the mounting position of the Voltage transformers (polarity).
- Check the labelling of the individual cores, check the phase/core.
- Inspect for cleanliness of voltage transformers, high voltage connections and associated cable connections.
- Inspection of isolators, support structures and earthing connections if any.
- Check tightness of all bolted connection by torque wrench method.
- Check Rack in/Rack out of V.T's along with its primary side fuse.

5.2 Testing the Voltage transformers

Enter the rating plate data in test sheet and compare the voltage transformer data with the data contained in the circuit documentation.

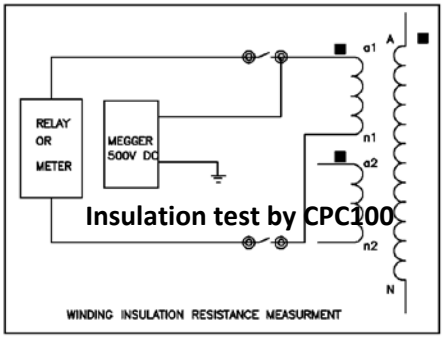
Disconnect the primary-side connections at a suitable location and also remove the secondary fuse. Following test to be carried out.

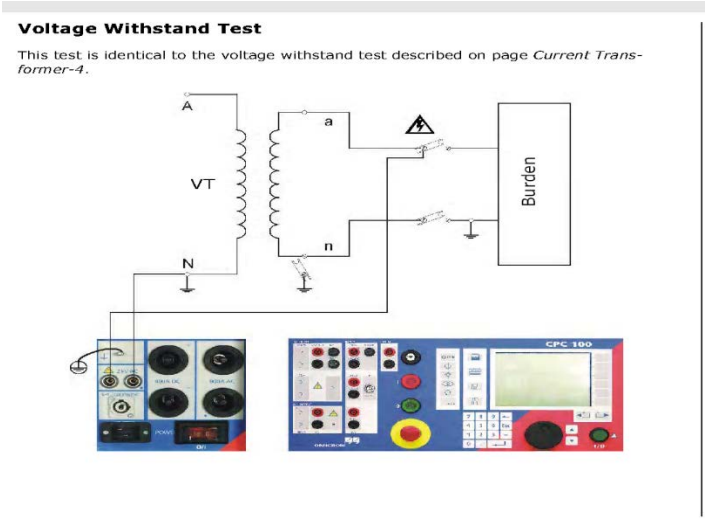
1. Winding insulation Resistance test
2. Voltage Ratio test by primary injection
3. Phase Angle Error
4. Winding Resistance Measurement
5. Polarity Test
6. Loop Resistance Measurement
7. Burden test
8. Phase Sequence test
9. Fuse Failure checks
10. Protective earthing
11. Back Energization Test at rated Voltage for 15 minutes

5.2.1 Winding insulation test

Insulation resistance for the Primary and secondary Winding is done by using 5000V dc insulation resistance tester as per following schematic

- Insulation resistance measurement is done between secondary winding and ground with primary being grounded with the help of 500V dc insulation resistance tester.
- Insulation resistance measurement is done between primary and ground with secondary being grounded with the help of 5000V dc Tester for 13.8 KV VT and 2500V dc tester for 41.6kv VT

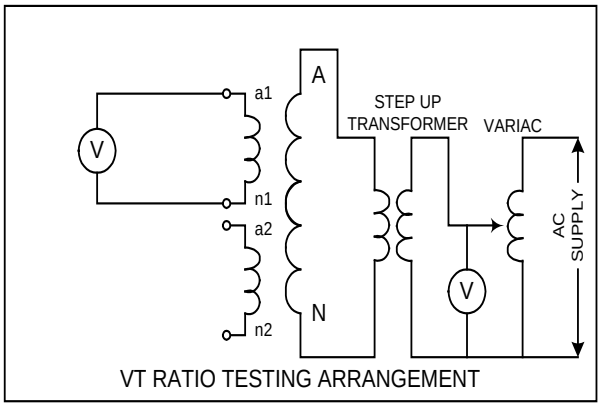




5.2.2 Voltage ratio test

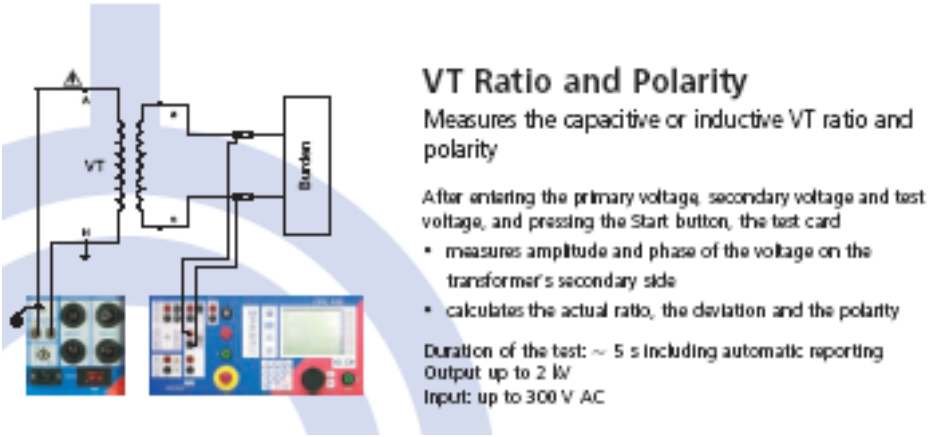
Voltage ratio can be done by applying voltage on primary circuit and measuring the voltage at secondary by variable single phase transformer as per following schematic diagram

- Apply the maximum available voltage not exceeding the rated primary Voltage to the primary winding.
- Measured the voltage at the secondary, thus primary voltage divided by secondary voltage gives VT ratio
- The test is to be carried out independently on each core and phase.
- Test has to be carried out by using precision voltmeter at both primary and secondary voltage measurement.



VT RATIO TESTING ARRANGEMENT

Ratio test can also be done by using CPC100 as below



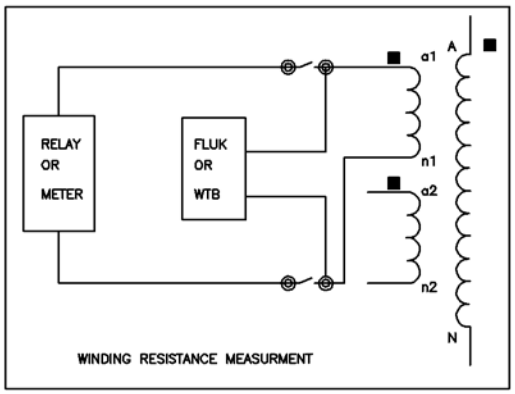
5.2.3 Phase Angle Error

- Phase angle can be measured by using CPC100 as shown in above figure , phase angle is the angle measured between Voltage across the primary winding and voltage across the secondary winding with the relay in its circuit
- This test can also be performed by Applying voltage across the primary of the VT and angle is measured between Primary and secondary voltages with relay or meters connected

5.2.4 Winding Resistance test

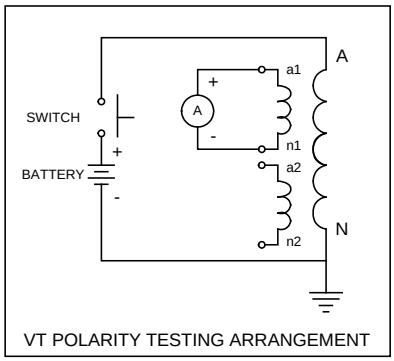
Winding resistance can be measured either by FLUK or Wheatstone bridge as per fallowing schematic diagram

- Connect the test lead on to the primary winding of the VT and measure the resistance.
- Connect the test lead on to the Secondary winding of the VT and measure the resistance.
- Repeat the test for second core if available.



5.2.5 Polarities Test.

VT polarities can be checked by 9 volts DC battery and Galvanometer as per the following Schematic Drawing



VT POLARITY TESTING ARRANGEMENT

On pressing the switch momentarily in above circuit, the needle on center zero galvanometer or sensitive ammeter reads positive deflection thus polarity of the transformer is subtractive. Subtractive polarity exists when current going into the primary polarity terminal causes to go out of the secondary polarity at the same instant in time

By CPC 100(OMICRON)

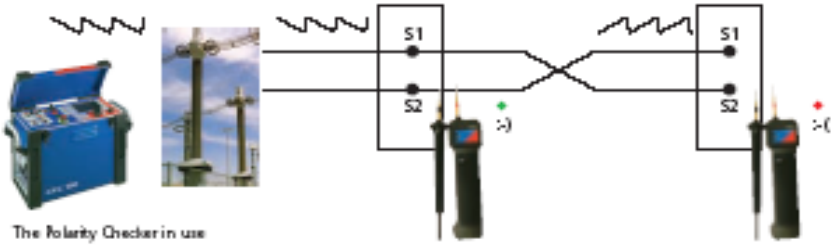
Polarity Checker (Replacement for Battery Checking Method)

Checks a series of test points for correct wiring

Just inject a the special continuous test signal at one point with the CPC 100 and check the polarity at all terminals with CPOL as shown in fig. 1, getting a clear indication whether the polarity is OK (green LED) or not (red LED).

This procedure is much faster than the conventional method and can easily be performed by a single person.

Duration of the test: depending on the number of test points; 3-5 s per test point

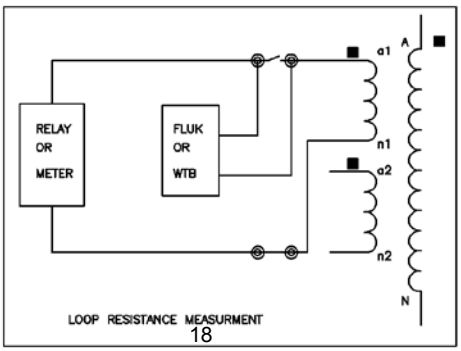


The Polarity Checker in use

5.2.6 Loop Resistance test

Loop Resistance can be measured either by FLUK or Wheatstone bridge as per fallowing schematic diagram

- Loop resistance shall be done for every used core

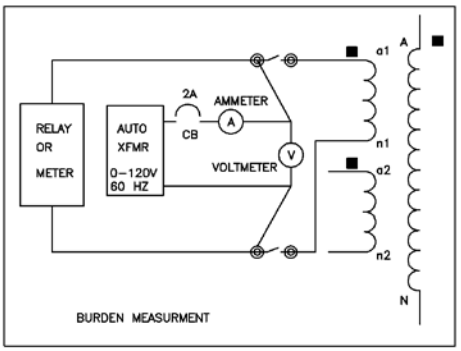


LOOP RESISTANCE MEASURMENT

5.2.7 VT Burden test

VT Burden test can be done by a variable voltage source with voltmeter and ammeter as per schematic diagram

- The burden in each core of each phase is determined by applying secondary rated voltage in the direction of the load and measure the current flowing in to the circuit. The product of current and voltage gives burden of the circuit. The measured burden should be compared with the rated data of the voltage transformer.

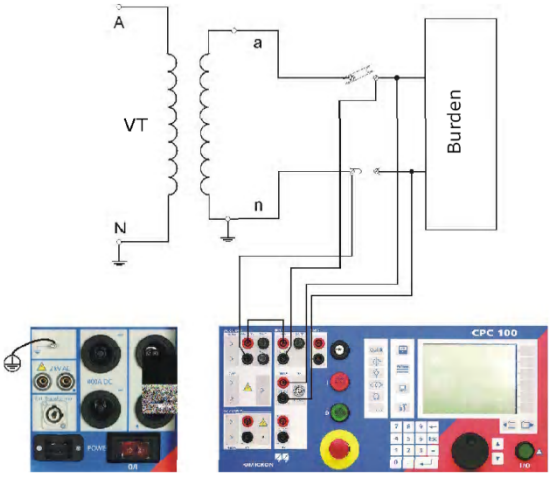


Burden measurement by CPC100

VT Burden

Use the **VTBurden** test card to measure a voltage transformer's secondary burden with voltage injection on the VT's secondary side with up to 130V from **AC OUTPUT**.

To do so, open the circuit as shown in the figure below, and inject the AC voltage from *CPC 100*'s **130V AC** output into the burden. Input **IAC** measures the current that flows into the burden, and input **V1AC** the voltage at the burden.



5.2.8 Phasing test

Phasing test can be done by applying three different voltages across the primary side bus bar or line terminals of all three phase and measuring voltage at secondary of all the three VTs

- Apply three different voltage across the bus bar or line terminals of the switch gear say A-B= 100 volts B-C = 120 volts, and C-A 150 Volts
- Measure the voltage at the secondary of VT of all the three phase,.

- Small voltage at the corresponding secondary should read in sequence as above

5.2.9 Fuse Failure Checks

5.2.9.1 Primary Fuse

- Micro switch for fuse failure shall be checked for correct operation
- If required correct alignment to be carried out
- Fuse position shall be checked for correct striker operation

5.2.9.2 Secondary fuse Failure Relay

- Relay shall be calibrated for pickup and dropout value
- Relay alarm contacts to be checked
- Alarm to remote (DCS) to be checked

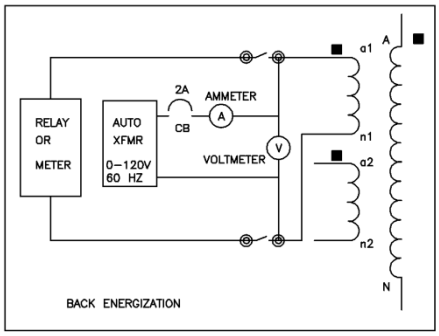
5.2.10 Checking the protective Earthing

Voltage transformers must be earthed on the secondary side in order to afford protection to human beings (In case of physical separation of the phases the three earthing points shall be regarded as being one earthing point.)

5.2.11 Back Energization Test

Back Energization of the VT can be done by energizing the secondary circuit to its rated voltage as shown in below diagram.

- In this test, load shall be disconnected and Primary fuses are removed so that no voltage can exists on bus bar or line terminal of the switch gear
- Voltage shall be applied gradually across the secondary of the VT not more than the rated voltage of the secondary winding
- When rated voltage is applied across the secondary winding, primary winding will have full rated induced voltage across it.
- Voltage is applied for 15 minutes and observe for any abnormalities



6.0 Documents

Relevant test sheet shall be completed for each set of instrumentation transformers.

7.0 Attachment

Test sheet for following equipment to be prepared with respect to their Switchgear

7.1 Testing of Voltage Transformer – Single Core
7.2 Loop Resistance, Burden and phasing Checks of VT – Single Core
7.3 Testing of Voltage Transformer – Dual Core
7.4 Loop Resistance, Burden and phasing Checks of VT – Dual Core

*****End of the procedure*****

Testing Procedure

Ammeter

Document No: BSC-TP-CRM01
Rev: 0

TABLE OF CONTENT

1. **Task**

All the moving coil, moving iron or digital ammeters shall be calibrated to check their accuracy

2. Preconditions

2.1 Work Status

- Erection has been completed.
- Labeling of the equipment has been done.

2.2 Documentation

- The circuit diagrams of the electrical equipment or panels are available
- Relevant Test sheet to be made available

2.3 Personnel

- One Commissioning engineer or technician with experience in commissioning of all types of electrical equipment & instruments.
- One Helper: skilled worker with adequate on-job training.

2.4 Measuring Instruments and Tools

- Standard Ammeter or Fluke
- Secondary Injection test set

3. Precautions

- Observe the rules for handling electronic components sensitive to electrostatic discharge (ESD measures).
- Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.

4. Scope

- Test and calibration of meter.
- Ensuring correct mounting position.
- Ensuring correct earthing.
- To ensure wiring for correct connection, feruling and numbering.

5. Execution

5.1 Visual Checks

- Inspection for physical damage / defects
- Checking of the wires for any damage and that they are connected properly.
- Inspection for physical connection as per approved drawings.
- Inspection of isolating terminals and earthing connections
- Inspection for correct tightness of all connections
- Checking ferrules as per drawing

5.2 Testing of Ammeter

Metering calibration shall be done via front panel mounted test facilities.

Enter the rating plate data in test sheet and compare the ammeter data with the data contained in the circuit documentation. The following test shall be carried out.

1. Electrical Function test
2. Secondary Injection

5.2.1 Electrical Function Test

a. Check the function of ammeter selector switch

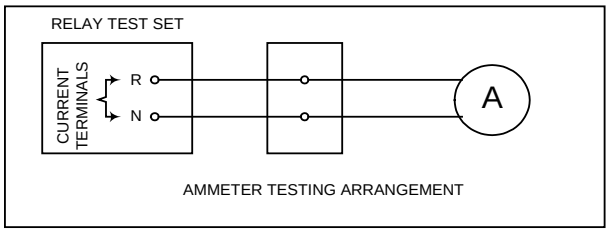
b. Check function of test switch or plug for correct function

5.2.2 Secondary Injection

- Connect the current test set on the ammeter terminals.
- Inject 25, 50, 75 & 100 % of the full-scale current of the ammeter.
- Record the corresponding ammeter readings.
- Percentage error is calculated by using following formula

% Error = Calculated value – Measured value x 100

Full scale value



5.2.3 Checking the Protective Earthing

- Check the Earthing on the meter for secured connection

6. Documents

Relevant test sheets to be completed for each and every Ammeter.

7. **Attachment**

Test sheet for following equipment to be prepared with respective their Switchgear

1.7 Test sheet for Ammeter

End of the Procedure*

Testing Procedure

Voltmeter

Document No: BSC-TP-VOM01
Rev: 0

TABLE OF CONTENT

1. **Task**

All the moving coil, moving iron or digital Voltmeters shall be calibrated to check their accuracy

2. Preconditions

2.1 Work Status

- Erection has been completed.
- Labeling of the equipment has been done.

2.2 Documentation

- The circuit diagrams of the electrical equipment or panels are available
- Relevant Test sheet to be made available

2.3 Personnel

- One Commissioning engineer or technician with experience in commissioning of all types of electrical equipment & instruments.
- One Helper: skilled worker with adequate on-job training.

2.4 Measuring Instruments and Tools

- Standard Ammeter or Fluke
- Secondary Injection test set

3. Precautions

- Observe the rules for handling electronic components sensitive to electrostatic discharge (ESD measures).
- Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.

4. Scope

- Test and calibration of meter.
- Ensuring correct mounting position.
- Ensuring correct earthing.
- To ensure wiring for correct connection, feruling and numbering.

5. Execution

5.1 Visual Checks

- Inspection for physical damage / defects
- Checking of the wires for any damage and that they are connected properly.
- Inspection for physical connection as per approved drawings.
- Inspection of isolating terminals and earthing connections
- Inspection for correct tightness of all connections
- Checking ferrules as per drawing

5.1 Testing of Voltmeter

Metering calibration shall be done via front panel mounted test facilities.

Enter the rating plate data in test sheet and compare the voltmeter data with the data contained in the circuit documentation. The following test shall be carried out

1. Electrical Function test
2. Secondary Injection

5.1.1 Electrical Function Test

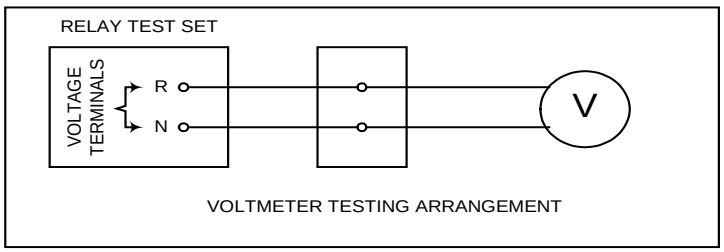
- Check the function of ammeter selector switch
- Check function of test switch or plug for correct function

5.1.2 Secondary Injection

- Connect the Voltage test set on the voltmeter terminals.
- Inject 25, 50, 75 & 100 % of the full-scale Voltage of the ammeter.
- Record the corresponding ammeter readings.
- Percentage error is calculated by using following formula

% Error = Calculated value – Measured value X 100

Full scale value



VOLTMETER TESTING ARRANGEMENT

5.1.3 Checking the Protective Earthing

- Check the earthing on the meter for secured connection.

6. **Documentation**

Relevant test sheets to be completed for each and every voltmeter.

7. **Attachment**

Test sheet for following equipment to be prepared with respect to their Switchgear

1.7 For single element voltmeter
1.8 For double element voltmeter

***End of the Procedure ***

Testing Procedure

Energy Meter

Document No: BSC-TP-ERM01
Rev: 0

TABLE OF CONTENT

1. **Task**

All analogue or digital Energy Meters shall be calibrated to check their accuracy

2. Preconditions

2.1 Work Status

- Erection has been completed.
- Labeling of the equipment has been done.

2.2 Documentation

- The circuit diagrams of the electrical equipment or panels are available
- Relevant Test sheet to be made available

2.3 Personnel

- One Commissioning engineer or technician with experience in commissioning of all types of electrical equipment & instruments.
- One Helper: skilled worker with adequate on-job training.

2.4 Measuring Instruments and Tools

- Standard Ammeter or Fluke
- Secondary Injection test set

3. Precautions

- Observe the rules for handling electronic components sensitive to electrostatic discharge (ESD measures).
- Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.

4. Scope

- Test and calibration of meter.
- Ensuring correct mounting position.
- Ensuring correct earthing.
- To ensure wiring for correct connection, feruling and numbering.

5. Execution

5.1 Visual Checks

- Inspection for physical damage / defects
- Checking of the wires for any damage and that they are connected properly.
- Inspection for physical connection as per approved drawings.
- Inspection of isolating terminals and earthing connections
- Inspection for correct tightness of all connections
- Checking ferrules as per drawing

5.2 Testing of Energy meter

Metering calibration shall be done via front panel mounted test facilities.

Enter the rating plate data in test sheet and compare the energy meter data with the data contained in the circuit documentation. The following test shall be carried out.

1. Electrical Function test
2. Secondary Injection

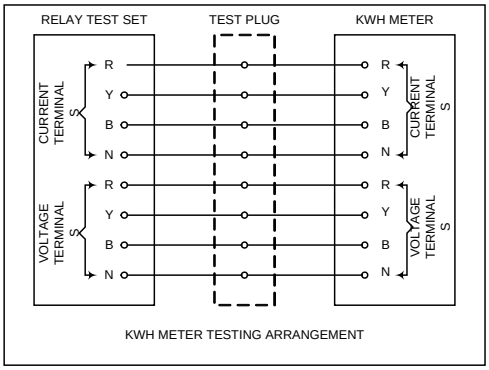
5.2.1 **Electrical Function Test**

- Check function of test switch or plug for correct function

5.2.2 Secondary Injection

- Connect the current test set terminals to the Energy meter current terminals.
- Connect the voltage test set terminals to the Energy meter voltage terminals.
- Apply 0, 25, 50, 75 &100% of rated load and with rated voltage and current at angles of 0, 45,180, 225, 270 and 315 degrees for time.
- Record the corresponding Energy meter readings and time duration.
- Compare the calculated reading with energy meter reading obtained.
- The error is calculated by using the following formula
  Error = Calculated Reading – Actual Reading x 100

  Maximum Scale Reading



5.2.3 **Checking the Protective Earthing**

- Check the earthing on the meter for secured connections

6. **Documentation**

Relevant test sheets to be completed for each and every energy meter.

7. **Attachment**

Test sheet for following equipment to be prepared with respect to their Switchgear

1.7 Test Sheet for Energy Meter

End of the Procedure

Testing Procedure

Power Factor Meter

Document No: BSC-TP-PFM01
Rev: 0

TABLE OF CONTENT

1.0 Task

The analogue or digital power factor meter shall be calibrated to check its accuracy

2.0 Preconditions

2.1 Work Status

- Erection has been completed.
- Labelling of the equipment

2.2 Documentation

- The schematic diagrams of the electrical equipment cabinets are available
- Relevant test sheet to be made available.

2.3 Personnel

- 1 Commissioning engineer: Engineer or technician with experience in commissioning of all types of the Electrical equipment,
- 1 Helper: skilled worker with adequate on-the-job training.

2.4 Measuring Instruments and Tools

- Secondary Injection test set
- Standard energy meter

3.0 Precautions

- Observe the rules for handling electronic components sensitive to electrostatic discharge (ESD measures).

- Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.

4.0 Scope

- Testing cable connections,
- Checking that the mounting position is correct,
- Checking of correct earthing,

5.0 Execution

5.1 Visual Checks

- Checking of the cables for damage and that they are connected correctly,
- Inspection for physical connection as per approved drawings.
- Inspection of isolating terminals and earthing connections
- Inspection for correct tightness for connection
- Checking ferrules

5.2 Testing of Power Factor Meter

Metering calibration shall be done via front panel mounted test facilities.

- Enter the rating plate data in Test Sheet and compare the energy meter data with the data contained in the circuit documentation. The following test shall be carried out

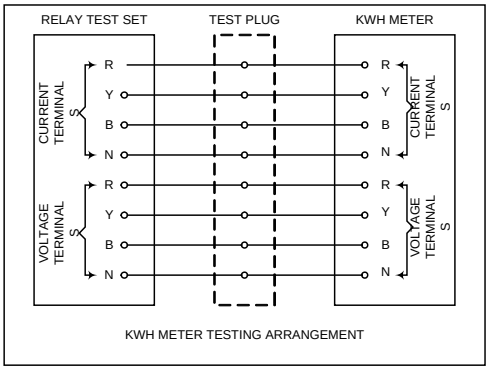
1. Electrical Function test
2. Secondary Injection

5.2.1 Electrical Function Test

- Check function pf test switch or plug for correct function

5.2.2 Secondary Injection

- Connect the current test set terminals to the Power factor meter current terminals.
- Connect the voltage test set terminals to the Power factor meter voltage terminals.
- Apply rated current and rated voltage and current at angles of 0, 30, 45, 60,180, 225, 270 and 315 degrees.
- Record the corresponding power factor meter readings.
- Compare the calculated reading with Actual meter reading obtained.



KWH METER TESTING ARRANGEMENT

5.2.3 Checking the Protective Earthing

Check the earthing on the meter

6.0 Documents

Relevant test sheets to be completed for each and every power meter.

7.0 Attachment:

Test sheet for following equipment to be prepared with respect to their Switchgearr

7.1 Test Sheet For Power Factor Meter

***** End of the Procedure *****

Testing Procedure

Power(kw) Meter

Document No: BSC-TP-PRM01
Rev: 0

TABLE OF CONTENT

1.0 Task

The all analogue or digital Power meters shall be calibrated to check their accuracy

2.0 Preconditions

2.1 Work Status

- Erection has been completed.
- Labelling of the equipment.

2.2 Documentation

- The circuit diagrams of the electrical equipment cabinets are available
- Relevant Test sheet to be made available.

2.3 Personnel

- 1 Commissioning engineer: Engineer or technician with experience in commissioning of types of the electrical equipment systems employed in the plant.
- 1 Helper: skilled worker with adequate on-the-job training.

2.4 Measuring Instruments and Tools

- Secondary Injection test set

3.0 Precautions

- Observe the rules for handling electronic components sensitive to electrostatic discharge (ESD measures).

- Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.

4.0 Scope

- Testing cable connections,
- Checking that the mounting position is correct,
- Checking of correct earthing,

5.0 Execution

5.1 Visual Checks

- Checking of the cables for damage and that they are connected correctly,
- Inspection for physical connection as per approved drawings.
- Inspection of isolating terminals and earthing connections
- Inspection for correct tightness for connection
- Checking ferrules

5.2 Testing of Power Meter

Metering calibration shall be done via front panel mounted test facilities.

Enter the rating plate data in test sheet and compare the power meter data with the data contained in the circuit documentation. The following test shall be carried out

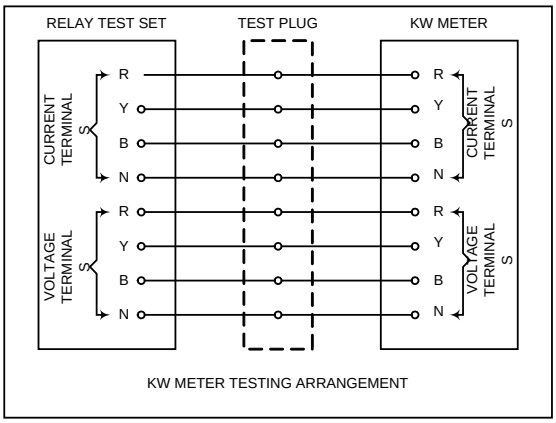
1. Electrical Function test
2. Secondary Injection

5.2.1 Electrical Function Test

- Check function of test switch or plug for correct function

5.2.2 Secondary Injection

- Connect the current test set terminals to the Power meter current terminals.
- Connect the voltage test set terminals to the Power meter voltage terminals.
- Apply 0, 25, 50, 75 &100% of rated load and with rated voltage and current at angles of 0, 45,180, 225, 270 and 315 degrees.
- Record the corresponding Power meter readings.
- Compare the calculated reading like power factor, VAR, and WATTS with meter reading.



5.2.3 Checking the protective Earthing

Check the Earthing on the meter

6.0 Documents

Relevant test sheets to be completed for each and every Power meter.

7.0 Attachment

7.1 Test Sheet for Power Meter

End of the Procedure

Testing Procedure

Current Transducer

Document No: BSC-TP-AXDR01
Rev: 0

TABLE OF CONTENT

1.0 Task

All the Current transducers shall be calibrated to check the accuracy for their output.

2.0 Preconditions

2.1 Work status

- Erection has been completed.
- Labelling of the equipment is done.

2.2 Documentation

- The schematic diagrams of the electrical equipment are available
- Relevant Test sheet to be made available

2.3 Personnel

- One commissioning engineer or technician with experience in commissioning of Protection Relays.
- 1 Helper: skilled worker with adequate on job training.

2.4 Measuring instruments and tools

- Standard Ammeter or Fluke
- Secondary Injection test set

3.0 Precautions

- Observe the rules for handling electronic components sensitive to electrostatic discharge (ESD measures).
- Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.

4.0 Scope

- Testing of Current Transducer,
- Checking that the mounting position is correct,

5.0 Execution

5.1 Visual checks

- Inspection for physical damage / defects
- Checking of the wires for any damage and that they are connected properly.
- Inspection for physical connection as per approved drawings.
- Inspection of isolating terminals and earthing connections
- Inspection for correct tightness of all connections
- Checking ferrules as per drawing

5.2 Testing of Current Transducer

Transducer calibration shall be done via front panel mounted test facilities.

Enter the rating plate data in the test sheet and compare the transducer data with the data contained in the circuit documentation. The following test shall be carried out

1. Electrical Function test
2. Secondary Injection

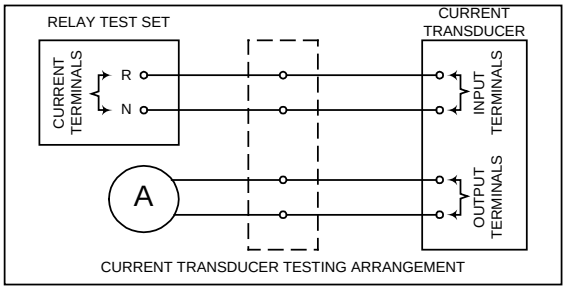
5.2.1 Electrical Function Test

- Check function of test switch or plug for correct function

5.2.2 Secondary Injection

- Connect the current test set on the Current Transducer terminals.
- Inject 25, 50, 75 & 100 % of the full-scale current of the Current Transducer.
- Record the corresponding Current Transducer output.
- Inject 100 % of the rated current.
- Record corresponding Current Transducer output.
- Error is calculated by using the below formula
  % Error = Calculated value – Actual value x 100

  Maximum scale value (span)



CURRENT TRANSDUCER TESTING ARRANGEMENT

6.0 Documents

Relevant test sheets to be completed for each and every current transducer.

7.0 Attachment

Test sheet for following equipment to be prepared with respect to their Switchgear

7.1 Test Sheet For Current Transducers

*****End of the Procedure*****

Testing Procedure

Voltage Transducer

Document No: BSC-TP-VXDR01
Rev: 0

TABLE OF CONTENT

1.0 Task

All the Voltage transducers shall be calibrated to check the accuracy for their output.

2.0 Preconditions

2.1 Work status

- Erection has been completed.
- Labelling of the equipment is done.

2.2 Documentation

- The schematic diagrams of the electrical equipment are available
- Relevant Test sheet to be made available

2.3 Personnel

- One commissioning engineer or technician with experience in commissioning of Protection Relays.
- 1 Helper: skilled worker with adequate on job training.

2.4 Measuring instruments and tools

- Standard Ammeter or Fluke
- Secondary Injection test set
- DC Milli ammeter

3.0 Precautions

- Observe the rules for handling electronic components sensitive to electrostatic discharge (ESD measures).
- Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.

4.0 Scope

- Testing of Voltage Transducer,
- Checking that the mounting position is correct,

5.0 Execution

5.1 Visual checks

- Inspection for physical damage / defects
- Checking of the wires for any damage and that they are connected properly.
- Inspection for physical connection as per approved drawings.
- Inspection of isolating terminals and earthing connections
- Inspection for correct tightness of all connections
- Checking ferrules as per drawing

5.2 Testing of Voltage Transducer

Transducer calibration shall be done via front panel mounted test facilities.

Enter the rating plate data in test sheet and compare the transducer data with the data contained in the circuit documentation. The following test shall be carried out

1. Electrical Function test
2. Secondary Injection

5.2.1 Electrical Function test

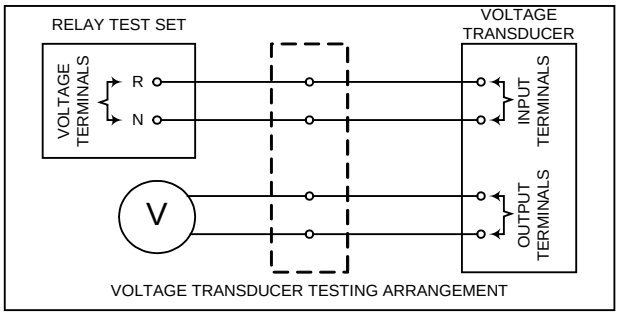
Check function of test switch or plug for correct function

5.2.2 Secondary Injection

- Connect the Voltage test set on the Voltage Transducer terminals.
- Inject 25, 50, 75 & 100 % of the full-scale Voltage of the Voltage Transducer.
- Record the corresponding Voltage Transducer output.
- Inject 100 % of the rated Voltage.
- Record corresponding Voltage Transducer output.
- Error is calculated by using the below formula

  % Error = Calculated values – Actual values x 100

  Maximum scale value (span)



VOLTAGE TRANSDUCER TESTING ARRANGEMENT

6.0 Documents

Relevant test sheets to be completed for each and every voltage transducer.

7.0 Attachment

Test sheet for following equipment to be prepared with respect to their Switchgear

7.1 Test Sheet for Voltage Transducer

*****End of the Procedure*****

Testing Procedure

Power Transducer

Document No: BSC-TP-PXDR01
Rev: 0

TABLE OF CONTENT

1.0 Task

All the Power transducers shall be calibrated to check the accuracy for their output.

2.0 Preconditions

2.1 Work status

- Erection has been completed.
- Labelling of the equipment is done.

2.2 Documentation

- The schematic diagrams of the electrical equipment are available
- Relevant Test sheet to be made available

2.3 Personnel

- One commissioning engineer or technician with experience in commissioning of Protection Relays.
- 1 Helper: skilled worker with adequate on job training.

2.4 Measuring instruments and tools

- Standard Ammeter or Fluke
- Secondary Injection test set
- DC Milli ammeter

3.0 Precautions

- Observe the rules for handling electronic components sensitive to electrostatic discharge (ESD measures).
- Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.

4.0 Scope

- Testing of Power Transducer,
- Checking that the mounting position is correct,

5.0 Execution

5.1 Visual checks

- Inspection for physical damage / defects
- Checking of the wires for any damage and that they are connected properly.
- Inspection for physical connection as per approved drawings.
- Inspection of isolating terminals and earthing connections
- Inspection for correct tightness of all connections
- Checking ferrules as per drawing

5.2 Testing of Power Transducer

Transducer calibration shall be done via front panel mounted test facilities.

Enter the rating plate data in test sheet and compare the transducer data with the data contained in the circuit documentation. The following test shall be carried out

1. Electrical Function test
2. Secondary Injection

5.2.1 Electrical Function test

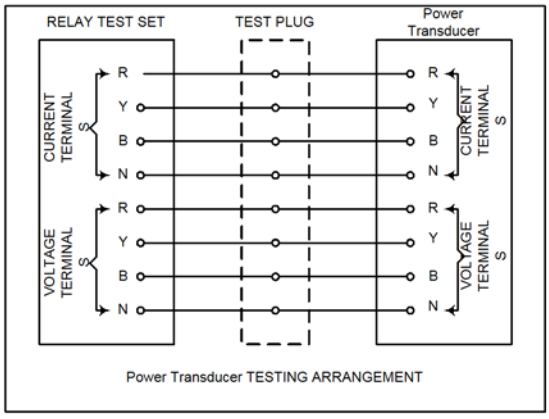
Check function of test switch or plug for correct function

5.2.2 Secondary Injection

- Connect the current test set terminals to the Power Transducer current terminals.
- Connect the voltage test set terminals to the Power Transducer voltage terminals.
- Apply 0, 25, 50, 75,100% of rated load with rated voltage and current at angles of 0, 45,180, 225, 270 and 315 degrees.
- Record the corresponding Power Transducer O/P readings.
- Percentage error is calculated using the below formula

  % Error = Calculated Value – Actual Value x 100

  Maximum Scale Value



6.0 Documents

Relevant test sheets to be completed for each and every Power transducer

7.0 Attachment

Test sheet for following equipment to be prepared with respect to their Switchgear

7.1 Test Sheet for Power Transducer

*****End of the Procedure*****

Testing Procedure

Over Current Relay

Document No: BSC-TP-OCR01
Rev: 0

TABLE OF CONTENT

1.0 Task

All the over current shall be tested to check their functions

2.0 Preconditions

2.1 Work Status

- Erection has been completed.
- Labelling of the equipment is done

2.2 Documentation

- The circuit diagrams of the electrical equipment cabinets are available
- Relevant test sheets to be made available
- Approved relay settings should be available

2.3 Personnel

- 1 Commissioning engineer: Engineer or technician with experience in commissioning of all types of the electrical equipment's.
- 1 Helper: skilled worker with adequate on-the-job training.

2.4 Measuring Instruments and Tools

- Three phase Secondary Injection test set
- Fluke

3.0 Precautions

- Observe the rules for handling electronic components sensitive to electrostatic discharge (ESD measures).
- Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.

4.0 Scope

- Testing of relays
- Checking that the mounting position is correct,

5.0 Execution

5.1 Visual Checks

- Check the cables for damage and that they are connected correctly,
- Inspect physical connection as per approved drawings.
- Remove the relay from the case and check for tightness and that all shorting terminals are making proper contact
- Check the tightness of the connection on the relay case
- Check the ferrules
- Check that all the test and setting switches operate properly and all are labelled. Properly by device number and individual function.

5.2 Testing of Phase and Ground over Current Relay.

Relay can be tested by using three or single phase secondary injection test set at the front panel mounted test facilities. Final calibration test of all protective relays must be carried out on approved settings,

Enter rating plate data in test sheet and compare the Relay data with the data contained in circuit documentation. The following test shall be carried out

1. Electrical Function test
    1. Functional check of Test Plug
    2. Shorting of links on relay case when relay is withdrawn

2. Secondary Injection
    1. Relay Power measurement
    2. Configuration of the relay
    3. Testing of LEDs
    4. Testing of output relays
    5. Testing of input Devices
    6. Metering function
    7. Over current Pickup/Dropout test
    8. Time current characteristics
        a. IEC-Normal inverse
        b. IEC-Very inverse
        c. IEC- Extremely Inverse
        d. Long-time Inverse
        e. Definite Time
    9. Testing of Instantaneous element
    10. Reduced voltage (at 90 Volts) trip test for all output relays
    11. Testing at final setting
    12. Checking the protective Earthing

5.2.1 Electrical Function Test

5.2.1.1 Functional check of Test Plug

Test Plug should be checked for its correct function, terminals should be checked for its correct current, auxiliary power and tripping assignment as per the circuit drawing.

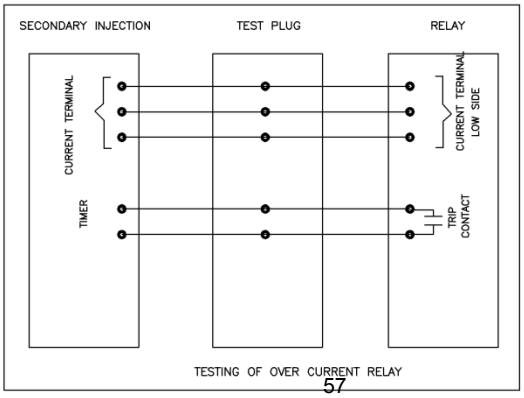
5.2.1.2 Shorting of links on relay case when Relay is Withdrawn

In case of withdrawal type relay, shorting facility on the relay case should be checked as under.

- Connect the fluke to check the continuity across the current terminal on the relay case and it shows some resistance.
- Pull the relay out and check the fluke which shows now resistance less then when relay was inside.
- Repeat the test for other two phases too.

5.2.2 Secondary Injection

Connection between the relay and secondary injection set is made as per figure below.



5.2.2.1 **Relay Power Measurement**

- Apply rated DC or AC auxiliary voltage to the power terminal of the relay through suitable ammeter and voltmeter
- Measure the current and voltage. Product of two gives power consumption of the relay.

5.2.2.2 **Configuration of the Relay**

Relay should be configured for inputs, outputs, and LED assignment as per final setting either through front panel of the relay or through lap top communicating with relay.

5.2.2.3 **Testing of LEDs**

- Check the operation of LEDs first by pressing reset button, all the LEDs should light for 2 to 3 seconds
- Check the operation of LEDs for their function by injecting current or by simulating the software.

5.2.2.4 **Testing of output Relays**

- By simulation or by performing secondary injection, check the operation of output relays as per the relay configuration.
- Measure the contact resistance of the each output relay with fluke

5.2.2.5 **Testing of Digital Inputs**

- Connect a variable auxiliary DC or AC voltage to each and every Digital input
- Increase the voltage till the digital input picks up (a temporary LED may be assigned to see the pickup) thus a minimum voltage required to operate digital input is noted.

5.2.2.6 **Metering Function**

- Configure the relay for Phase CT and neutral CT ratio.
- Apply three phase 25%, 50%, 75% and 100% of nominal current on phase over current relay and note down the corresponding readings on the relay.
- Apply Single phase 25%, 50%, 75% and 100% of nominal current on Ground over current relay and note down the corresponding readings on the relay.

5.2.2.7 **Over Current Pickup/Dropout test**

Apply the test relays setting for over current on the relay as follows.

- Definite Time Curve with minimum time delay.
- Disable all other protection elements.
- Connect the current test set on the relay current terminals one at a time as follows.
  - Red phase to Neutral.(for Phase over current relay)
  - Yellow phase to Neutral. (for Phase over current relay)
  - Blue phase to neutral. (for Phase over current relay)

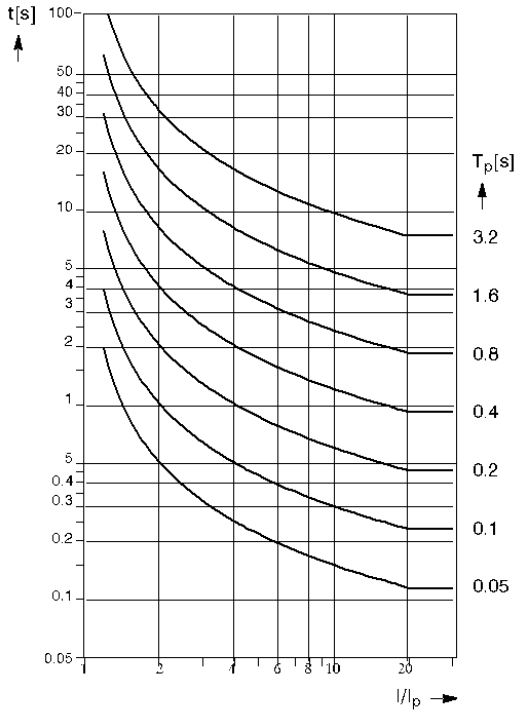
- Single phase current on Ground element(ground over current relay)
- Connect the timer to the relay tripping contact

- Slowly increase the current until the relay picked-up.
- Record the operating current.
- Slowly decrease the current until relay reset
- Record the operating current

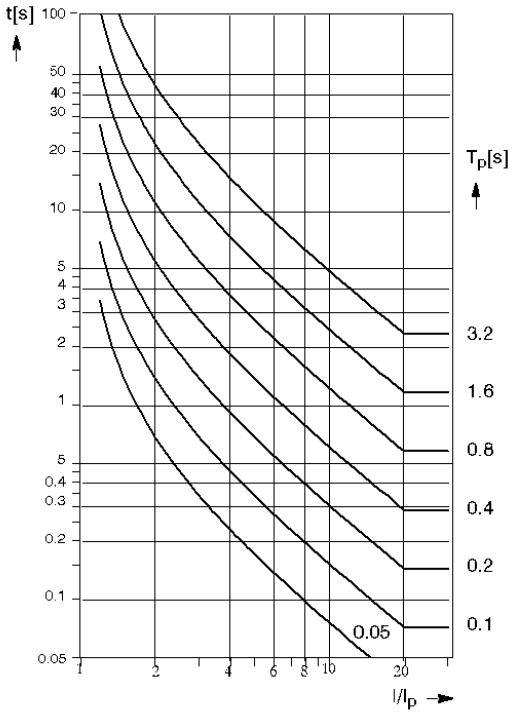
5.2.2.8 **Time Current Characteristics**

- Apply the test relay setting for over current on the relay as follows.
  - Disable all other protection elements.
  - DT curve with 500ms delay.
  - IEC NI curve with 0.1 TMS.
  - IEC VI curve with 0.1 TMS.
  - IEC EI curve with 0.1 TMS.
  - IEC LT curve with 0.1 TMS.
  - IEC DT Curve with 1.0 TMS
- Select the time over current curve one at a time on the relay.
- Connect the current test set on the relay current terminals one at a time as follows.
  - Red phase to Neutral.(for Phase over current relay)
  - Yellow phase to Neutral. (for Phase over current relay)
  - Blue phase to neutral. (for Phase over current relay)
  - Single phase current on Ground element(ground over current relay)
- Connect the timer to the relay tripping contact
- Inject testing current 2 times, 5 times and 10 times of the pickup settings and note down the operating time of the relay.
- Record the operating time.
- Cross check the time as per figure below or calculate the time using below formula.
- Test shall be done for all the characteristics and all the phase and ground element

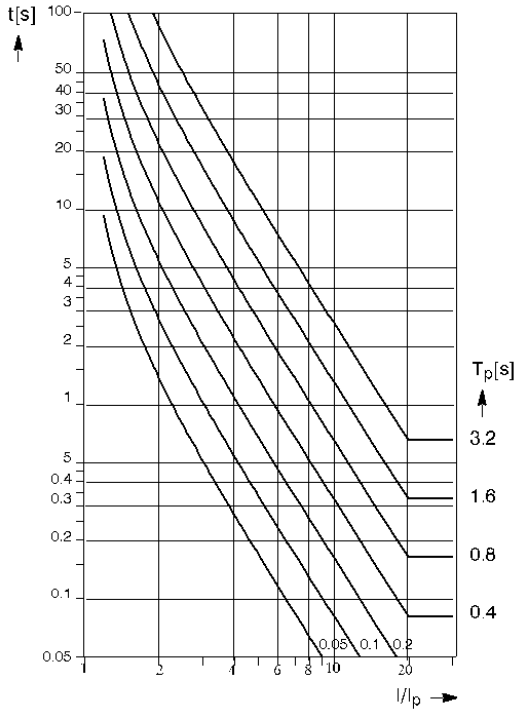
Note: Testing should be done at minimum, middle and maximum range of the setting.



Normal inverse: $t = \frac{0.14}{(I/I_p)^{0.02} - 1} \cdot T_p \ [s]$



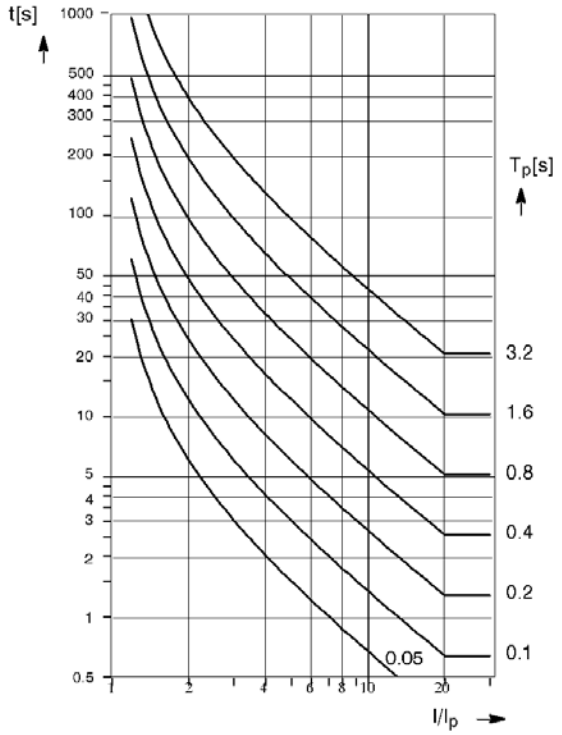
Very inverse: $t = \frac{13.5}{(I/I_p) - 1} \cdot T_p \ [s]$



Extremely inverse: $t = \frac{80}{(I/I_p)^2 - 1} \cdot T_p \ [s]$

t trip time
T_p set time multiplier
I Fault current
I_p Set pick-up current

Note: For earth faults read I_{Ep} instead of I_p and T_{Ep} instead of T_p



Long time inverse $t = \frac{120}{(I/I_p)^1 - 1} \cdot T_p$ [s]

t trip time
T_p set time multiplier
I Fault current
I_p Set pick-up current

Note: For earth faults read
I_{Ep} instead of I_p and
T_{Ep} instead of T_p

5.2.2.9 **Instantaneous Unit Verification**

- Apply the test relays setting for phase and ground over current on the relay as follows.
- Disable all other protection elements.
- Connect the current test set on the relay current terminals one at a time as follows.
    - Red phase to Neutral.(for Phase over current relay)
    - Yellow phase to Neutral. (for Phase over current relay)
    - Blue phase to neutral. (for Phase over current relay)
    - Single phase current on Ground element(ground over current relay)

➢ **Pickup/dropout test**

- Slowly increase the current until the relay picks-up.
- Record the operating current.

- Slowly decrease the current until relay reset
- Record the operating current

➢ **Timing test**

- Connect the timer to the relay tripping contact
- Inject testing current 2 times the pickup settings and note down the operating time of the relay.
- Tripping time should be actual definite time multiply by TMS setting
- Test shall be done for all the phase and ground element

5.2.2.10 **Checking the Protective Earthing**

Check the earthing connection on the relay.

6.0 Documents

Test Sheet shall be completed for each and every Phase and Ground over Current Relay.

7.0 Attachment

Test sheet for following equipment to be prepared with respect to their Switchgear

7.1 Ground Over Current Relay

7.2 Phase Over Current Relay

*****End of the Procedure*****

Testing Procedure

Voltage Relay

Document No: BSC-TP-VOR01

Rev: 0

TABLE OF CONTENT

1.0 Task

All the voltage relays shall be tested for under and over voltage function

2.0 Preconditions

2.1 Work Status

- Erection has been completed.
- Labelling of the equipment is done

2.2 Documentation

- The circuit diagrams of the electrical equipment cabinets are available
- Relevant test sheets should be available
- Approved relay settings should be available

2.3 Personnel

- 1 Commissioning engineer: Engineer or technician with experience in commissioning of Protection Relays
- 1 Helper: skilled worker with adequate on-the-job training.

2.4 Measuring Instruments and Tools

- Three or single phase Secondary Injection test set
- Fluke

3.0 Precautions

- Observe the rules for handling electronic components sensitive to electrostatic discharge (ESD measures).
- Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.

4.0 Scope

- Testing of Over & Under Voltage Relays.
- Checking that the mounting position is correct.

5.0 Execution

5.1 Visual Checks

- Checking of the cables for damage and that they are connected correctly,
- Inspection for physical connection as per approved drawings.
- Inspection for correct tightness for connection
- Checking ferrules

5.2 Testing of Over and under Voltage Relay.

Relay can be tested by using three or single phase secondary injection test set at the front panel mounted test facilities. Final calibration test of all protective relays must be carried out on approved settings,

Enter the rating plate data in test sheet and compare the Relay data with the data contained in the circuit documentation. The following test shall be carried out

1. Electrical Function test
   a. Functional check of Test Plug
2. Secondary Injection
   a. Relay Power measurement
   b. Testing of LEDs

c. Testing of output relays
d. Testing of input Devices
e. Metering function
f. Under Voltage Function
   i. Pickup/dropout test
   ii. Timing test
g. Over voltage test
   i. Pickup/dropout
   ii. Timing test

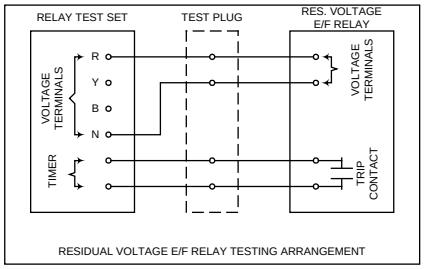
5.2.1 Electrical Function Test

5.2.1.1 Functional check of Test Plug

Test Plug should be checked for its correct function, terminals should be checked for its correct current, auxiliary power and tripping assignment as per the circuit drawing

5.2.2 Secondary Injection

Connection between the relay and secondary injection set is made as per figure below.



RESIDUAL VOLTAGE E/F RELAY TESTING ARRANGEMENT

5.2.2.1 Relay Power Measurement

Apply rated DC or AC auxiliary voltage to the power terminal of the relay through suitable ammeter and voltmeter

Measure the current and voltage. Product of two gives power consumption of the relay.

5.2.2.2 Configuration of the Relay

Relay should be configured for inputs, outputs, and LED assignment as per final setting either through front panel of the relay or through lap top, communicating with relay.

5.2.2.3 Testing of LEDs

Check the operation of LEDs first by pressing reset button, all the LEDs should light for 2 to 3 seconds

Check the operation of LEDs for their function by injecting Voltage or by simulating the software.

5.2.2.4 Testing of output Relays

By simulation or by performing secondary injection, check the operation of output relays as per the relay configuration.

Measure the contact resistance of the each output relay with fluke

5.2.2.5 **Testing of Digital Inputs**

Connect a variable auxiliary DC or AC voltage to each and every Digital input. Increase the voltage till the digital input picks up (a temporary LED may be assigned to see the pickup) thus a minimum voltage required to operate digital input is noted.

5.2.2.6 **Metering function**

Configure the relay for VT ratio.

Apply three phase 25%, 50%, 75% and 100% of nominal Voltage on Voltage relay and note down the corresponding readings on the relay.

5.2.2.7 **Under Voltage Function**

i. **Pickup/dropout test**

- Apply the testing relays setting with instantaneous tripping time on the relay
- Connect the voltage test set on the relay voltage terminals
- Connect the timer to the relay tripping contact
- Slowly Increase the applied voltage until the relay Drop out
- Record the Drop out voltage
- Slowly Decrease the applied voltage until the relay pick-up
- Record the pick-up voltage

ii. **Timing test**

- Select the operating time on the relay
- Connect the voltage test set on the relay voltage terminals
- Connect the timer to the relay tripping contact
- Apply the testing voltage(fault Voltage) and monitor the operating time of the relay
- Record the operating time.

5.2.2.8 **Over Voltage Test**

i. **Pickup/dropout test**

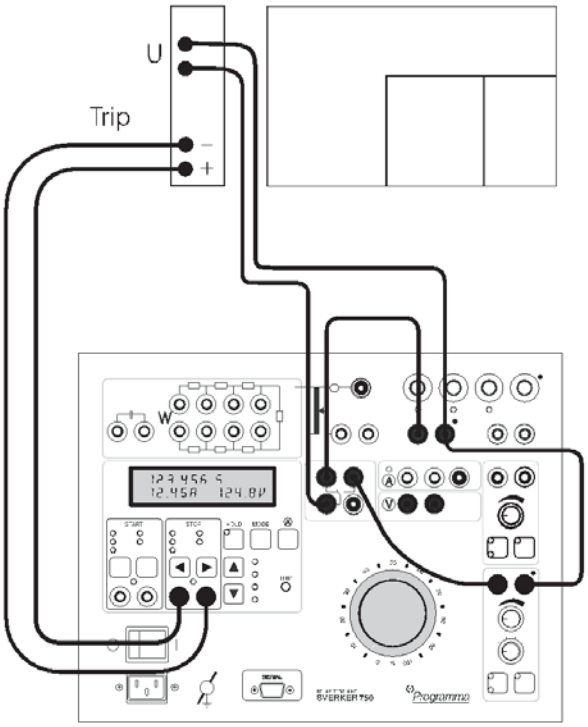
- Apply the testing relays setting with instantaneous tripping time on the relay
- Connect the voltage test set on the relay voltage terminals
- Connect the timer to the relay tripping contact
- Slowly Increase the applied voltage until the relay Picks up.
- Record the Pick-up voltage
- Slowly Decrease the applied voltage until the relay Drops out
- Record the Drop-out voltage

ii. **Timing test**

- Select the operating time on the relay
- Connect the voltage test set on the relay voltage terminals
- Connect the timer to the relay tripping contact
- Apply the testing voltage(fault voltage) and monitor the operating time of the relay
- Record the operating time.

5.2.2.9 **Voltage Relay Testing by SVERKER-750**

To test the voltage relay by SVERKER-750 follow the below procedure



Sometimes it is necessary to change between two voltage levels and measure the time that elapses until operation. This can be done using the Sverker make/break contact.

1. Connect the voltmeter input to the 0-250 V output. Activate ON using the start switch. Set the voltage that corresponds to the pre-fault voltage.
2. Set the start switch to OFF.
3. Connect the voltmeter input to the 0-120 V AC voltage source. Turn on the AC voltage source and set the voltage that corresponds to the fault voltage.
4. Turn off the AC voltage source.
5. Connect together the terminals marked with black dots on the 0-250 V output and on the AC voltage source. From this junction, make a connection to one side of the relay's voltage input.

***

6. Connect the left-hand socket terminal on the 250 V output to the upper left-hand socket terminal on the make/break contact (the one that performs a break function).
7. Connect the left-hand output socket terminal on the AC voltage source to the upper right-hand socket terminal on the make/break contact (the one that performs a make function).
8. Connect the lower left-hand socket terminal on the make/break contact to the other side of the relay voltage input.
9. Make certain that the relay tripping output is properly connected to Sverker.
10. Activate ON using the start switch, whereupon the pre-fault voltage will be applied to the relay.
11. Turn on the AC voltage source.
12. Activate OFF+TIME using the start switch, whereupon fault voltage will be applied to the relay and timing will start.
13. Read the time at which the relay operated.

6.0 Documents

Relevant Test sheet shall be completed for each and every Relay.

7.0 Attachment

7.1 Test Sheet for Voltage Relay :
7.2 Test Sheet for Under Voltage Relay :
7.3 Test sheet for Neutral over voltage relay

***End of the Procedure**

Testing Procedure

Synchronous Check Relay

Document No: BSC-TP-SYR01
Rev: 0

TABLE OF CONTENT

1. **Task:**

   All the Synchronous check relays shall be tested for their correct function.

2. **Preconditions:**

   2.1. Work status

   - Erection has been completed.
   - Labelling of the equipment

   2.2. Documentation

   - The circuit diagrams of the electrical equipment cabinets are available
   - Test sheet BS-PP10-TS-SR01 is available
   - Approved relay settings should be available

   2.3. **Personnel**

   - 1 Commissioning engineer: Engineer or technician with experience in commissioning of Protection Relays
   - 1 Helper: skilled worker with adequate on-the-job training.

   2.4. Measuring Instruments and Tools

   - Three or single phase Secondary Injection test set
   - Phase Shifter
   - Fluke

3. **Precautions**

   - Observe the rules for handling electronic components sensitive to electrostatic discharge (ESD measures).
   - Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.

4. **Scope**

   - Testing of synchronous check relay
   - Checking that the mounting position is correct,

5. **Execution**

   5.1. Visual Checks

   - Checking of the cables for damage and that they are connected correctly,
   - Inspection for physical connection as per approved drawings.
   - Inspection for correct tightness for connection
   - Checking ferrules

   5.2. **Testing of Synchronous Check Relay**.

   Relay can be tested by using three or single phase secondary injection test set at the front panel mounted test facilities. Final calibration test of all protective relays must be carried out on approved settings,

   Enter the rating plate data in test sheet and compare the Relay data with the data contained in the circuit documentation.

   The following test shall be carried out

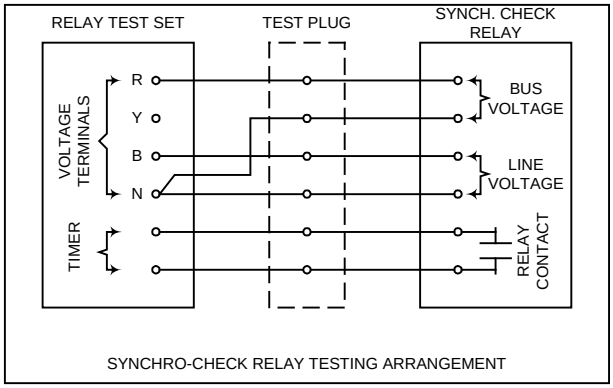
5.2..1. Electrical Function Test

- Functional check of Test Plug

  Test Plug should be checked for its correct function, terminals should be checked for its correct current, auxiliary power and tripping assignment as per the circuit drawing

5.2..2. Secondary Injection

Connection between the relay and secondary injection set is made as per figure below.



SYNCHRO-CHECK RELAY TESTING ARRANGEMENT

5.2..2..1. Relay Power Measurement

Apply rated DC or AC auxiliary voltage to the power terminal of the relay through suitable ammeter and voltmeter

Measure the current and voltage. Product of two gives power consumption of the relay.

5.2..2..2. Configuration of the Relay

Relay should be configured for inputs, outputs, and LED assignment as per final setting either through front panel of the relay or through lap top, communicating with relay.

5.2..2..3. Testing of LEDs

Check the operation of LEDs first by pressing reset button, all the LEDs should light for 2 to 3 seconds

Check the operation of LEDs for their function by injecting Voltage or by simulating the software.

5.2..2..4. Testing of out Put Relays

By simulation or by performing secondary injection, check the operation of output relays as per the relay configuration.

Measure the contact resistance of the each output relay with fluke

5.2..2..5. Testing of Digital Inputs

Connect a variable auxiliary DC or AC voltage to each and every Digital input

Increase the voltage till the digital input picks up (a temporary LED may be assigned to see the pickup) thus a minimum voltage required to operate digital input is noted.

5.2..2..6. Metering Function

Configure the relay for VT ratio

Apply three phase 25%, 50%, 75% and 100% of nominal Voltage on Voltage relay and note down the corresponding readings on the relay.

5.2..2..7. Live line- Live bus (synchronous) test

5.2..2..7.1. Difference in Voltage test

- Apply the testing relay setting on the relay noting that.
- Only live line- live bus function is enabled.
- Connect the voltage test set on the relay voltage terminals
- Connect test set stop input to the relay output contact
- Apply the line and bus voltage with
  - Zero differential voltage.
  - Zero differential frequency.
  - Zero differential phase angle.
- The relay should operate now giving CB close permissive signal.
- Slowly increase the bus voltage in order to increase the voltage difference until output relay for CB close permissive drops out.
- Record the differential voltage
- Slowly decrease the bus voltage in order to reduce voltage difference until the output relay for CB close permissive picks up.
- Slowly increase the line voltage in order to increase the voltage difference until output relay for CB close permissive drops out.
- Record the differential voltage

5.2..2..7.2. Difference in Frequency

- Apply the testing relay setting on the relay noting that.
- Only live line live bus function is enabled.
- Connect the voltage test set on the relay voltage terminals
- Connect test set stop input to the relay output contact
- Apply the line and bus voltage with
  - Zero differential voltage.
  - Zero differential frequency.
  - Zero differential phase angle.
- The relay should operate now giving CB close permissive signal.
- Slowly increase the Frequency of bus voltage in order to increase the Frequency difference until output relay for CB close permissive drops out.
- Record the differential Frequency

- Slowly decrease the Frequency of bus voltage in order to decrease the Frequency difference until output relay for CB close permissive picks out.
- Slowly increase the Frequency of line voltage in order to increase the Frequency difference until output relay for CB close permissive drops out.
- Record the differential Frequency

5.2..2..7.3. Difference in Phase Angle

- Apply the testing relay setting on the relay noting that.
- Only live line live bus function is enabled.
- Connect the voltage test set on the relay voltage terminals
- Connect test set stop input to the relay output contact
- Apply the line and bus voltage with
  - Zero differential voltage.
  - Zero differential frequency.
  - Zero differential phase angle
- The relay should operate now giving CB close permissive signal.
- Slowly increase the phase angle difference until output relay for CB close permissive drops out.
- Record the differential phase angle

5.2..2..7.4. Under Voltage blocking Test

- Apply the testing relay setting on the relay noting that.
- Only live line live bus function is enabled.
- Connect the voltage test set on the relay voltage terminals
- Connect test set stop input to the relay output contact
- Apply rated voltage to the line and bus voltage with
  - Zero differential voltage
  - Zero differential frequency
  - Zero differential phase angle
- The relay should operate now giving CB close permissive signal.
- Slowly reduce both of line and bus voltage simultaneously till the under voltage blocking output relay operate
- Record the under voltage blocking voltage

5.2..2..8. Dead line –Live Bus Test

- Apply the testing relay setting on the relay noting that.
- Enable live line live bus function
- Enable Dead line live bus function
- Connect the voltage test set on the relay voltage terminals
- Connect test set stop input to the relay output contact

- Apply rated voltage to the line and bus voltage with
  - Zero differential voltage
  - Zero differential frequency
  - Zero differential phase angle
- The relay should operate now giving CB close permissive signal.
- Slowly reduce line voltage until the output relay for CB close permissive drops out.
- Continue reducing line voltage until the output relay for CB close permissive picks up
- Record the dead line voltage

5.2..2..9. Dead Bus-Live line Test

- Apply the testing relay setting on the relay noting that.
- Enable live line live bus function
- Enable Dead bus live line function
- Connect the voltage test set on the relay voltage terminals
- Connect test set stop input to the relay output contact
- Apply rated voltage to the line and bus voltage with
  - Zero differential voltage
  - Zero differential frequency
  - Zero differential phase angle
- The relay should operate now giving CB close permissive signal.
- Slowly reduce bus voltage until the output relay for CB close permissive drops out.
- Continue reducing bus voltage until the output relay for CB close permissive picks up
- Record the dead line voltage

5.2..2..10. Dead Line – Dead Bus

- Apply the testing relay setting on the relay noting that.
- Enable live line live bus function
- Enable Dead line Dead bus function
- Connect the voltage test set on the relay voltage terminals
- Connect test set stop input to the relay output contact
- Apply rated voltage to the line and bus voltage with
  - Zero differential voltage
  - Zero differential frequency
  - Zero differential phase angle
- The relay should operate now giving CB close permissive signal.
- Slowly reduce line and bus voltage simultaneously until the output relay for CB close permissive drops out.

- Continue reducing line and bus voltage simultaneously until the output relay for CB close permissive picks up.
- Record the dead line voltage

5.2..2..11. MCB for Bus and line Voltage trip blocking

- Apply the testing relay setting on the relay noting that.
- Enable live line-live bus function
- Enable Dead Bus –live line function
- Enable Dead Line –live bus function
- Enable Dead line Dead bus function
- Connect the voltage test set on the relay voltage terminals
- Connect test set stop input to the relay output contact
- Apply rated voltage to the line and bus voltage with
  - Zero differential voltage
  - Zero differential frequency
  - Zero differential phase angle
- The relay should operate now giving CB close permissive signal.
- Simulate MCB Trip input to the relay and Reduce Bus voltage
- Check there should not be any permissive from the relay for CB close
- Repeat the test for Line voltage MCB trip

6. Documents

   Relevant Test sheet shall be completed for each and every Relay.

7. Attachment

   Test Sheet for Synchronous Relay

End of the Procedure

Testing Procedure

Differential Current Relay

Document No: BSC-TP-DCR01
Rev: 0

TABLE OF CONTENT

1.0 Task

All the Differential current Relays shall be tested to check their functions

2.0 Preconditions

2.1 Work Status

- Erection has been completed.
- Labelling of the equipment is done

2.2 Documentation

- The circuit diagrams of the electrical equipment cabinets are available
- Relevant test sheets to be made available
- Approved relay settings should be available

2.3 Personnel

- 1 Commissioning engineer: Engineer or technician with experience in commissioning protection Relays.
- 1 Helper: skilled worker with adequate on-the-job training.

2.4 Measuring Instruments and Tools

- Three phase Secondary Injection test set
- Fluke

3.0 Precautions

- Observe the rules for handling electronic components sensitive to electrostatic discharge (ESD measures).
- Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.

4.0 Scope

- Testing of Differential Current Relays
- Checking that the mounting position is correct,

5.0 Execution

5.1 Visual Checks

- Checking of the cables for damage and that they are connected correctly,
- Inspection for physical connection as per approved drawings.
- Inspection for correct tightness for connection
- Checking ferrules

5.2 Testing of Differential Current Relay.

Relay can be tested by using three or single phase secondary injection test set at the front panel mounted test facilities. Final calibration test of all protective relays must be carried out on approved settings,

Enter the rating plate data in test sheet and compare the Relay data with the data contained in the circuit documentation. The following test shall be carried out

1. Electrical Function test
   i. Functional check of Test Plug
   ii. Shorting of links on relay case when relay is withdrawn

2. Secondary Injection
   i. Relay Power measurement
   ii. Testing of LEDs

iii. Testing of output relays
iv. Testing of input Devices
v. Metering function
vi. Differential Function
    1. Differential current Function
    2. Differential restraint characteristic
    3. Harmonic Function
    4. Instantaneous Differential current function
    5. Timing Test
vii. Backup over current
    1. current Pickup/Dropout test
    2. Time current characteristics
    3. IEC-Very inverse
    4. IEC- Extremely Inverse
    5. Long-time Inverse
    6. Definite Time
    7. Testing of Instantaneous element

5.2.1 Electrical Function test

5.2.1.1 **Functional Check of Test Plug**

Test Plug should be checked for its correct function, terminals should be checked for its correct current, auxiliary power and tripping assignment as per the circuit drawing

5.2.1.2 **Shorting of links on Relay Case when relay is Withdrawn**

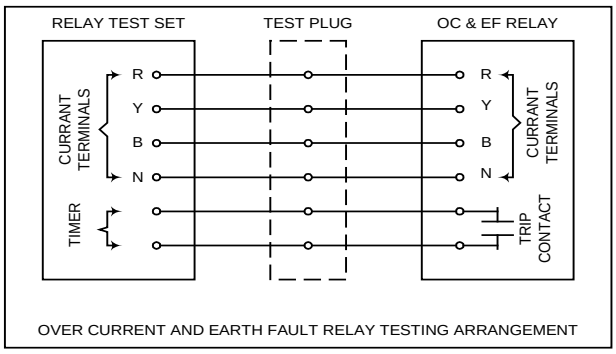
In case of withdrawal type relay, shorting facility on the relay case should be checked as under.

- Connect the fluke to check the continuity across the current terminal at low side on the relay case which shows some resistance.
- Pull the relay out and check the fluke which shows now resistance less then when relay was inside.
- Repeat the test for other two phases at low side too.
- Repeat the test for all three phases at high side current of the relay

Note: Above test can also be checked with secondary current injection. Relay can be pulled out while injecting the current and reading on the relay must show zero.

5.2.2 Secondary Injection

Connection between the relay and secondary injection set is made as per figure below.



OVER CURRENT AND EARTH FAULT RELAY TESTING ARRANGEMENT

5.2.2.1 **Relay Power Measurement**

Apply rated DC or AC auxiliary voltage to the power terminal of the relay through suitable ammeter and voltmeter

Measure the current and voltage. Product of two gives power consumption of the relay.

5.2.2.2 **Configuration of the Relay**

Relay should be configured for inputs, outputs, and LED assignment as per final setting either through front panel of the relay or through lap top communicating with relay.

5.2.2.3 **Testing of LEDs**

Check the operation of LEDs first by pressing reset button, all the LEDs should light for 2 to 3 seconds

Check the operation of LEDs for their function by injecting current or by simulating the software.

5.2.2.4 **Testing of output Relays**

By simulation or by performing secondary injection, check the operation of output relays as per the relay configuration.

Measure the contact resistance of the each output relay with fluke

5.2.2.5 **Testing of Digital Inputs**

Connect a variable auxiliary DC or AC voltage to each and every Digital input

Increase the voltage till the digital input picks up (a temporary LED may be assigned to see the pickup) thus a minimum voltage required to operate digital input is noted.

5.2.2.6 **Metering Function**

Configure the relay for Phase CT Ratio at low and high side.

Apply three phase 25%, 50%, 75% and 100% of nominal current on high and low side CT connection of the relay and note down the corresponding readings on the relay.

5.2.2.7 **Differential Function**

5.2.2.7.1 **Differential Current Function**

- Disable the harmonic restraints, and enable the differential function
- Apply the testing relays setting.

- Apply current to High side and low side windings .so that the relay will have a differential current of 0.00.
- Increase the current in the High side, and check that it trips when the differential occur.
- Check that it trips with an error margin of less than 5% for different through currents, and different sensitivity and percentage restraint settings.

5.2.2.7.2 **Differential Restraint Characteristic.**

- Disable the harmonic restraints, and enable the differential function
- Apply the testing relays setting.
- Apply current to High side and low side windings.
- Increase the current in High side, and check slope1 is achieved according to the relay specification.
- Repeat the test to check slope2 is achieved.

5.2.2.7.3 **Harmonic Function**

- Enable the harmonic restraints, and the differential function.
- Apply the testing relays setting.
- Apply current to High side and low, so that the relay will have a differential current of 0.00.
- Apply a second harmonic current at high side, besides the current it already had.
- Increase the current in the High side, and check that it trips when the differential occur.
- Check that it trips with an error margin of less than 5% for different through currents, and different sensitivity and percentage restraint settings

5.2.2.7.4 **Differential Instantaneous Function**

- Disable the harmonic restraints, and the differential function, and enable the instantaneous function.
- Set the instantaneous function to 4 times the tap.
- Apply current to High side, and check that it trips when the differential current reaches the set value.
- Check that it trips with an error margin of less than 5% for different differential currents, and different instantaneous function settings.

5.2.2.7.5 **Timing Test**

- Check that it trips with an error margin of less than 5% for different through currents, and different sensitivity and percentage restraint settings

5.2.2.8 **Backup Over Current Function**

While checking Backup over current function differential function has to be disabled

5.2.2.8.1 **Over current Pickup/Dropout test**

Apply the testing relays setting for over current on the relay as follows.

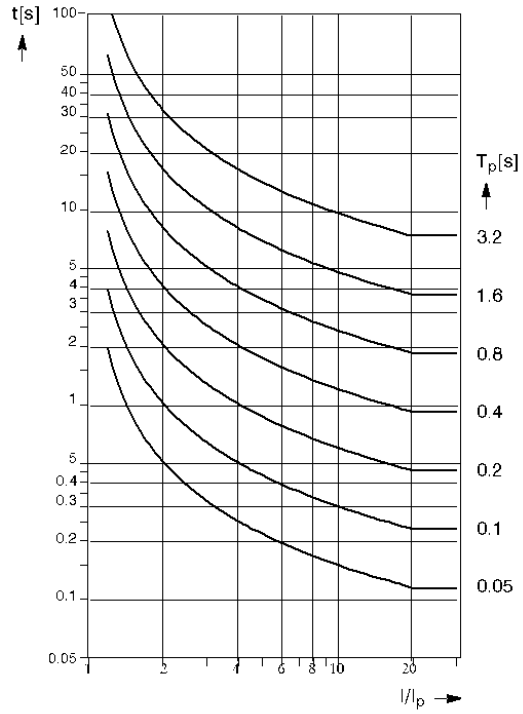
- Definite Time Curve with minimum time delay.
- Disable all other protection elements.
- Connect the current test set on the relay current terminals one at a time as follows.

- Red phase to Neutral.(for Phase over current relay)
- Yellow phase to Neutral(for Phase over current Relay)
- Blue phase to neutral. (for Phase over current relay)
- Connect the timer to the relay tripping contact
- Slowly increase the current until the relay picked-up.
- Record the operating current.
- Slowly decrease the current until relay reset
- Record the operating current

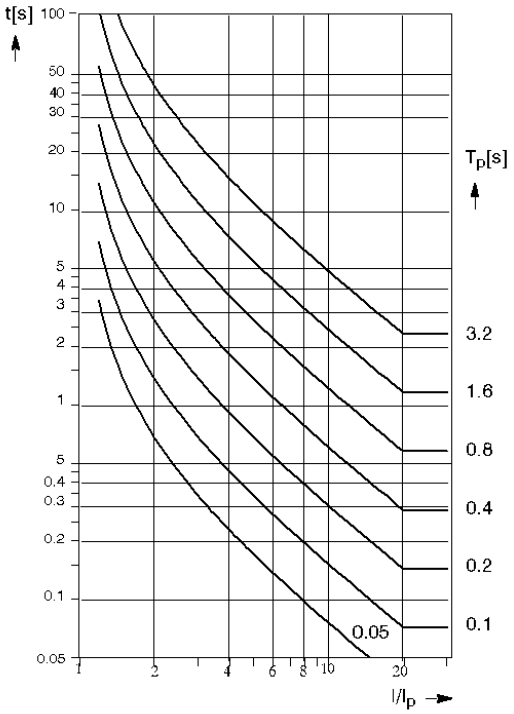
5.2.2.8.2 **Time current characteristics**

Apply the testing relays setting for over current on the relay as follows.

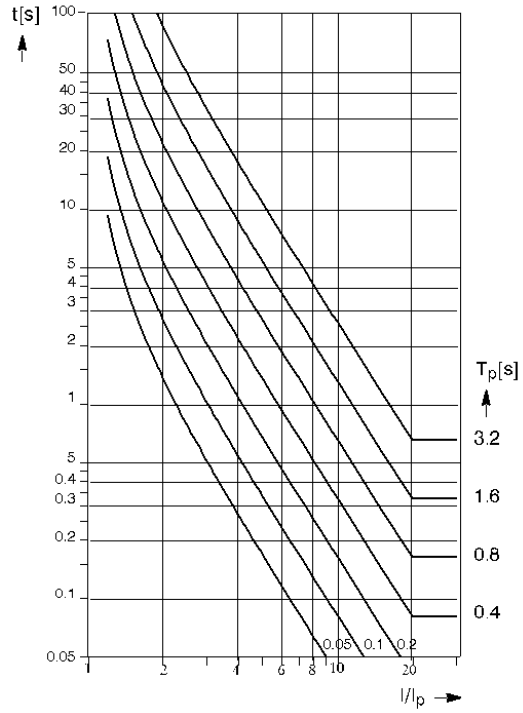
- Disable all other protection elements.
- DT curve with 500ms delay.
- IEC NI curve with 0.1 TMS.
- IEC VI curve with 0.1 TMS.
- IEC EI curve with 0.1 TMS.
- IEC LT curve with 0.1 TMS.
- IEC DT Curve with 1.0 TMS
- Select the time over current curve one at a time on the relay.
- Connect the current test set on the relay current terminals one at a time as follows.
- Red phase to Neutral.(for Phase over current relay)
- Yellow phase to Neutral. (for Phase over current relay)
- Blue phase to neutral. (for Phase over current relay)
- Single phase current on Ground element(ground over current relay)
- Connect the timer to the relay tripping contact
- Inject testing current 2 times, 5 times and 10 times of the pickup settings and note down the operating time of the relay.
- Record the operating time.
- Cross check the time as per figure below or calculate the time using below formula.
- Test shall be done for all the characteristics and all the three phases and ground element.



Normal inverse: $t = \frac{0.14}{(I/I_p)^{0.02} - 1} \cdot T_p \ [s]$



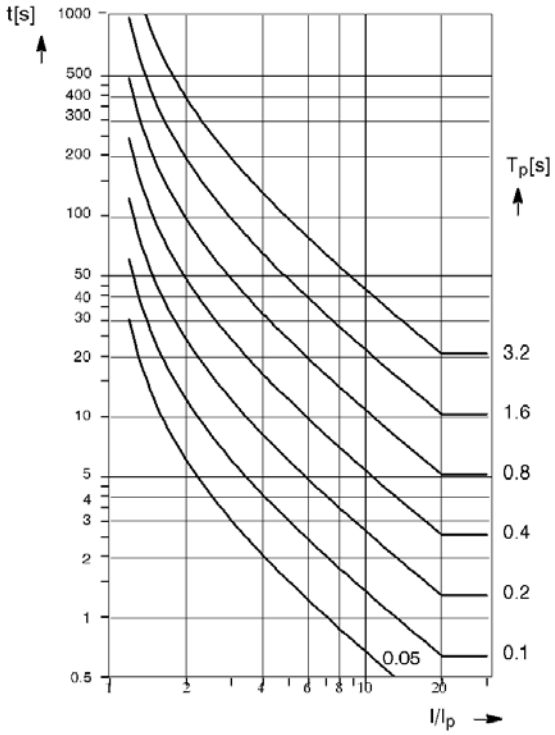
Very inverse: $t = \frac{13.5}{(I/I_p) - 1} \cdot T_p \ [s]$



Extremely inverse: $t = \frac{80}{(I/I_p)^2 - 1} \cdot T_p \ [s]$

t trip time
T_p set time multiplier
I Fault current
I_p Set pick-up current

Note: For earth faults read I_{Ep} instead of I_p and T_{Ep} instead of T_p



Long time inverse $t = \frac{120}{(I/I_p)^1 - 1} \cdot T_p$ [s]

t trip time
T_p set time multiplier
I Fault current
I_p Set pick-up current

Note: For earth faults read
I_{Ep} instead of I_p and
T_{Ep} instead of T_p

5.2.2.8.3 **Instantaneous Unit Verification**

Apply the testing relays setting for phase and ground over current on the relay as follows.

- Disable all other protection elements.
- Connect the current test set on the relay current terminals one at a time as follows.
  - Red phase to Neutral.(for Phase over current relay)
  - Yellow phase to Neutral. (for Phase over current relay)
  - Blue phase to neutral. (for Phase over current relay)
  - Single phase current on Ground element(ground over current relay)
- **Pickup/dropout test**
  - Slowly increase the current until the relay picked-up.
  - Record the operating current.
  - Slowly decrease the current until relay reset
  - Record the operating current

➢ **Timing test**

- Connect the timer to the relay tripping contact
- Inject testing current 2 times the pickup settings and note down the operating time of the relay.
- Tripping time should be actual definite time multiply by TMS setting
- Test shall be done for all the phase and ground element

6.0 Documents

Test sheet shall be completed for each and every differential Relay.

7.0 Attachment

Test sheet for following equipment to be prepared with respect to their Switchgear

7.1 Testing of High Impedance Bus Differential Relay

7.2 Testing Of Transformer Differential Relay-

*****End of the Procedure*****

Testing Procedure

Tripping/Lockout Relay

Document No: BSC-TP-TAR01
Rev: 0

TABLE OF CONTENT

1.0 Task

All the tripping or lockout relays shall be tested for correct operation

2.0 Preconditions

2.1 Work Status

- Erection has been completed.
- Labelling of the equipment is done

2.2 Documentation

- The circuit diagrams of the electrical equipment cabinets are available
- Relevant test sheet to be made available

2.3 Personnel

- 1 Commissioning engineer: Engineer or technician with experience in commissioning of Protection Relays
- 1 Helper: skilled worker with adequate on-the-job training.

2.4 Measuring Instruments and Tools

- Three or single phase Secondary Injection test set
- Fluke

3.0 Precautions

- Observe the rules for handling electronic components sensitive to electrostatic discharge (ESD measures).
- Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.

4.0 Scope

- Testing cable tripping or lockout relay.
- Checking that the mounting position is correct.

5.0 Execution

5.1 Visual Checks

- Checking of the cables for damage and that they are connected correctly,
- Inspection for physical connection as per approved drawings.
- Inspection for correct tightness for connection
- Checking ferrules

5.2 Testing of Tripping Relay.

Relay can be tested by using single phase secondary injection test set at the front panel mounted test facilities.

Enter the rating plate data in test sheet and compare the Relay data with the data contained in the circuit documentation. The following test shall be carried out

1. Electrical Function test
   a. Manual operation checks
2. Secondary Injection
   1. Minimum Voltage Pick-Up Verification
   2. Operating time Measurment
   3. Measurment of coil Resistance

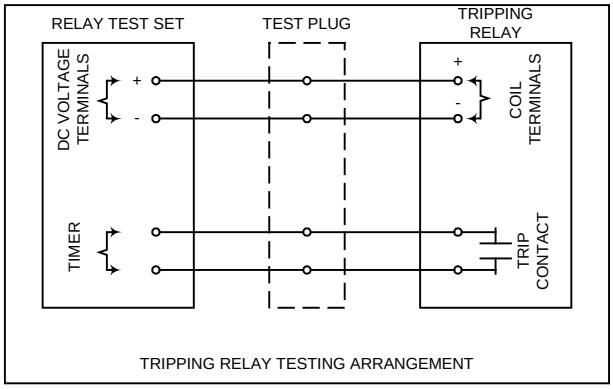
5.2.1 Electrical Function test

5.2.1.1 **Manual operation checks**

Lockout or tripping relay should be checked for manual operation by operating plunger or the lever

5.2.2 Secondary Injection

Connection between the relay and secondary injection set is made as per figure below.



TRIPPING RELAY TESTING ARRANGEMENT

5.2.2.1 **Voltage Pick-Up Verification**

- ♦ Connect the voltage test set on the relay voltage terminals
- ♦ Connect the timer to the relay tripping contact
- ♦ Slowly increase the voltage until the relay pick-up
- ♦ Record the pick-up voltage

Delay Time Verification

- ♦ Connect the voltage test set on the relay voltage terminals
- ♦ Connect the timer to the relay tripping contact
- ♦ Apply the testing voltage and monitor the operating time of the relay
- ♦ Record the operating time.

5.2.2.2 **Coil Resistance Measurement**.

- ♦ Connect the fluke across the terminal of the coil and measure the Resistance

6.0 Documents

Test sheet shall be completed for each and every lockout or tipping Relay.

7.0 Attachment

Test sheet for following equipment to be prepared with respect to their Switchgear

7.1 Test Sheet for Tripping Relays(Manual Rest) –

7.2 Test sheet for Tripping Relays (Electrical Reset)

*****End of the Procedure*****

Testing Procedure

DC Supervision Relay

Document No: BSC-TP-DAR01
Rev: 0

TABLE OF CONTENT

1.0 Task

All the DC Supervision relays shall be tested for correct operation

2.0 Preconditions

2.1 Work Status

- Erection has been completed.
- Labelling of the equipment is done

2.2 Documentation

- The circuit diagrams of the electrical equipment cabinets are available
- Test sheet is available

2.3 Personnel

- 1 Commissioning engineer: Engineer or technician with experience in commissioning of Protection Relays
- 1 Helper: skilled worker with adequate on-the-job training.

2.4 Measuring Instruments and Tools

- Three or single phase Secondary Injection test set
- Fluke

3.0 Precautions

- Observe the rules for handling electronic components sensitive to electrostatic discharge (ESD measures).
- Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.

4.0 Scope

- Testing DC Supervision relay.
- Checking that the mounting position is correct.

5.0 Execution

5.1 Visual Checks

- Checking of the cables for damage and that they are connected correctly,
- Inspection for physical connection as per approved drawings.
- Inspection for correct tightness for connection
- Checking ferrules

5.2 Testing of DC Supervision Relay.

Relay can be tested by using single phase secondary injection test set at the front panel mounted test facilities.

Enter the rating plate data in test sheet and compare the Relay data with the data contained in the circuit documentation. The following test shall be carried out

1. Electrical Function test
   a. Manual operation checks

2. Secondary Injection
   1. Minimum Voltage Pick-Up Verification
   2. Operating time Measurment
   3. Measurment of coil Resistance

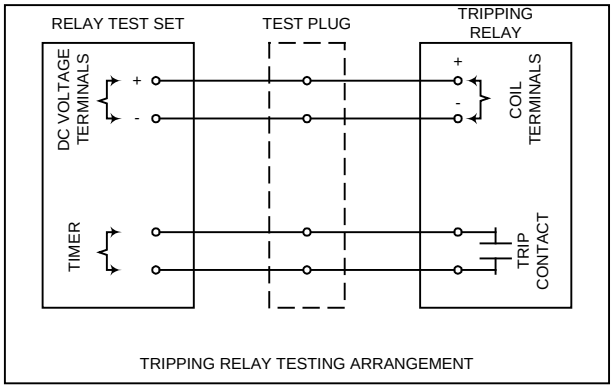
5.2.1 Electrical Function test

5.2.1.1 **Manual operation checks**

Relay should be checked for manual operation by operating plunger or the lever

5.2.2 **Secondary Injection**

Connection between the relay and secondary injection set is made as per figure below.



TRIPPING RELAY TESTING ARRANGEMENT

5.2.2.1 **Voltage Pick-Up Verification**

- ♦ Connect the voltage test set on the relay voltage terminals
- ♦ Connect the timer to the relay tripping contact
- ♦ Slowly increase the voltage until the relay pick-up
- ♦ Record the pick-up voltage

Delay Time Verification

- ♦ Connect the voltage test set on the relay voltage terminals
- ♦ Connect the timer to the relay tripping contact
- ♦ Apply the testing voltage and monitor the operating time of the relay
- ♦ Record the operating time.

5.2.2.2 **Coil Resistance Measurement**.

- ♦ Connect the fluke across the terminal of the coil and measure the Resistance

6.0 Documents

Test sheet shall be completed for each and every DC supervision Relay.

7.0 Attachment

Test sheet for following equipment to be prepared with respect to their Switchgear

7.1 Test Sheet for Tripping Relays

*****End of the Procedure*****

Testing Procedure

Trip Coil Supervision Relay

Document No: BSC-TP-SAR01

Rev: 0

TABLE OF CONTENT

1.0 Task

All the Trip circuit supervision relays shall be tested for Breaker trip circuit supervision in for both breaker open and close position

2.0 Preconditions

2.1 Work status

- Erection has been completed.
- Labelling of the equipment to be done

2.2 Documentation

- The circuit diagrams of the electrical equipment cabinets are available
- Required test sheet to be available

2.3 Personnel

- 1 Commissioning engineer: Engineer or technician with experience in commissioning of all types of Electrical equipment's.
- 1 Helper: skilled worker with adequate on-the-job training.

2.4 Measuring Instruments and Tools

- Three or single phase Secondary Injection test set
- Fluke

3.0 Precautions

- Observe the rules for handling electronic components sensitive to electrostatic discharge (ESD measures).
- Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.

4.0 Scope

- Testing trip circuit supervision relay,
- Checking that the mounting position is correct,

5.0 Execution

5.1 Visual Checks

- Checking of the cables for damage and that they are connected correctly,
- Inspection for physical connection as per approved drawings.
- Inspection for correct tightness for connection
- Checking ferrules

5.2 Testing of Trip Circuit Supervision Relay.

Relay can be tested by using single phase secondary injection test set at the front panel mounted test facilities.

Enter the rating plate data in test sheet and compare the Relay data with the data contained in the circuit documentation. The following test shall be carried out

1. Electrical Function test
   a. Functional check of Test Plug
2. Secondary Injection
   a. Voltage Pick-Up Verification
   b. Voltage Drop-Out Verification
   c. Function Check
      a. The CB Is In Open Position
      b. The CB In Close Position

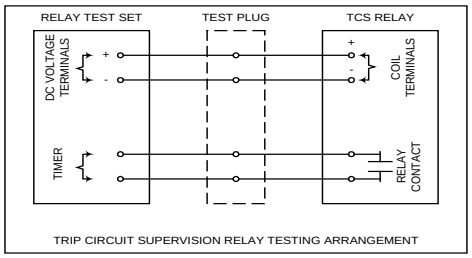
5.2.1 Electrical Function Test

5.2.1.1 **Functional check of Test Plug**

Test Plug should be checked for its correct function. Terminals should be checked for its correct, auxiliary power and tripping assignment as per the circuit drawing

5.2.2 Secondary Injection

Connection between the relay and secondary injection set is made as per figure below.



TRIP CIRCUIT SUPERVISION RELAY TESTING ARRANGEMENT

5.2.2.1 **Voltage Pick-Up Verification**

- Slowly increase the voltage until the relay pick-up
- Record the pick-up voltage.

5.2.2.2 Voltage Drop-Out Verification

- Slowly increase the voltage until the relay pick-up
- While relay is still picking-up, slowly reduce the voltage until the relay dropout.
- Record the dropout voltage.

5.2.2.3 **Function Check**

All the internal and external wiring should be completed

5.2.2.3.1 When CB Is In Open Position

- At the CB control panel / box open tripping coil circuit.
- The trip circuit supervision relay should operate.

5.2.2.3.2 **When CB in Close Position.**

- At the CB control panel / box open tripping coil circuit.
- The trip circuit supervision relay should operate.

6.0 Documents

Test sheet shall be completed for each and every Trip circuit supervision Relay.

7.0 Attachment

Test sheet for following equipment to be prepared with respect to their Switchgear

7.1 Test Sheet for Trip Coil Supervision Relay –

*****End of the Procedure*****

Testing Procedure

Timing Relay

Document No: BSC-TP-HAR01

Rev: 0

TABLE OF CONTENT

1.0 Task

All the Timing or Timer Relays shall be tested for correct operation

2.0 Preconditions

2.1 Work status

- Erection has been completed.
- Labelling of the equipment

2.2 Documentation

- The circuit diagrams of the electrical equipment cabinets are available
- Test sheet is available

2.3 Personnel

- 1 Commissioning engineer: Engineer or technician with experience in commissioning of Protection Relays.
- 1 Helper: skilled worker with adequate on-the-job training.

2.4 Measuring instruments and tools

- Three or single phase Secondary Injection test set
- Fluke

3.0 Precautions

- Observe the rules for handling electronic components sensitive to electrostatic discharge (ESD measures).
- Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.

4.0 Scope

- Testing cable connections,
- Checking that the mounting position is correct,

5.0 Execution

5.1 Visual Checks

- Checking of the cables for damage and that they are connected correctly,
- Inspection for physical connection as per approved drawings.
- Inspection for correct tightness for connection
- Checking ferrules

5.2 Testing of Timing Relay.

Relay can be tested by using single phase secondary injection test set at the front panel mounted test facilities.

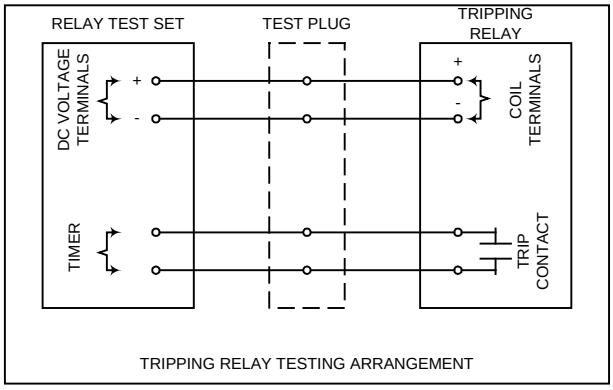
Enter the rating plate data in test sheet and compare the Relay data with the data contained in the circuit documentation. The following test shall be carried out

Secondary Injection

1. Minimum Voltage Pick-Up Verification
2. Operating time Measurment

5.2.1 Secondary Injection

Connection between the relay and secondary injection set is made as per figure below.



TRIPPING RELAY TESTING ARRANGEMENT

5.2.1.1 **Voltage Pick-Up Verification**

- Connect the voltage test set on the relay voltage terminals
- Set Timing dial to minimum or zero
- Connect the timer to the relay output contact
- Slowly increase the voltage until the relay pick-up
- Record the pick-up voltage

5.2.1.2 **Delay Time Verification**

- Connect the voltage test set on the relay voltage terminals
- Connect the timer to the relay tripping contact
- Set the time on time dial
- Apply the Rated voltage and monitor the operating time of the relay
- Record the operating time.
- Repeat the test for different time dial.

6.0 Documents

Test sheet shall be completed for each and every timing Relay.

7.0 Attachment

Test sheet for following equipment to be prepared with respect to their Switchgear

7.1 Test Sheet for timing Relays

*****End of the Procedure*****

Testing Procedure

Distribution Transformer

Document No: BSC-TP-DPT01
Rev: 0

TABLE OF CONTENT

1. Task

This instruction comprises a complete description of the testing of oil and dry type distribution and auxiliary transformers.

2. Preconditions

2.1. Work status

- Erection has been completed.
- Labelling of the equipment and designation of live enclosed plant sections has been carried out.

2.2. Documentation

- The circuit diagram of Electrical equipment ,cabinets, etc. are available at site
- Test Sheet for object transformer is available at site
- O&M manual of the transformer is Available at site
- Factory Test Results of the transformer is available at site

2.3. personnel

- Testing and Commissioning engineer: - (1) engineer with minimum two years' experience in testing and commissioning of the transformer.
- Technician or helper:- (2) skilled worker with adequate on -the-job training
- Witness from the client's concern department

2.4. Measuring instrument

- Ratio meter (calibrated)---1
- Multi Meter (calibrated)—2
- Insulation resistance meter –Megger(calibrated)—1
- CT tester-CPC100 or CT Analyzer (calibrated)-1
- DC shunt 100 amps or winding resistance meter 50 Amps(calibrated)--1
- Mini clamp(calibrated)—2
- Tan delta measurement test equipment—1
- Current injection set(calibrated)—1
- 3 phase relay tester(calibrated)—1

3. Precautions

The work will only proceed when a Permit to Work (PTW) in work permit area has been obtained. The PTW will be kept on site for consultation during the test.

- Observe the rules for handling electronic components sensitive to electrostatic discharge (ESD measures).
- Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.
- Closing of the work permit after completion of the work (if the test area is to be considered in work permit area) is necessary.

- Before test voltages are applied a check shall be carried out to ensure that no unauthorized persons are working at the corresponding load, where ever necessary, barriers should be provided.

4. Scope

- Testing of Transformer(core and winding)
- Checking all the mechanical protective devices
- Checking Auxiliaries and cooling system
- Testing of bushing CT
- Checking of correct Earthing,

5. Execution

5.1. Visual Inspection.

Prior to carrying out electrical tests, a visual check of the transformer should be carried out paying particular attention to the following points

- Correct labeling of devices and cables
- Equipment and cables are undamaged
- Correct execution of the cable gland/sealing end
- Name plate data, match with drawing and ambient condition
- Firm cable termination/terminal connection and ferruling

5.2. Testing of Transformer

Following tests to be carried out

1. insulation resistance / Polarization index test
2. Voltage Ratio Measurement
3. Vector Group/Phase Displacement
4. Winding Resistance Test
5. Excitation current Measurement
6. Temperature indicator and sensor Calibration
   a. Winding Temperature
   b. Oil Temperature
7. Bushing Current Transformer
8. Testing and commissioning of cooler control cabinet
9. Transformer protection devices functional check
10. Protective Earthing Checks

5.2.1. Insulation resistance/polarization index test

Checking of the insulation resistance and polarization index should be carried out as under

Apply the test voltage on following Connection and note down the readings

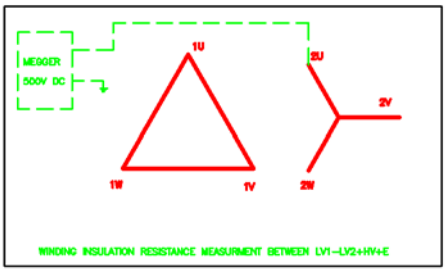
<u>Two Winding Transformers</u>

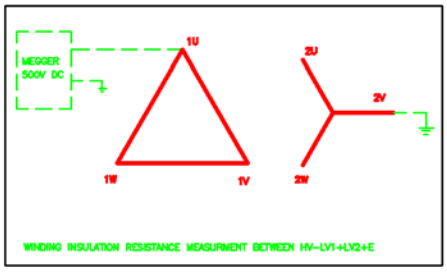
HV – LV + Earth

LV – HV + Earth

The insulation resistance Measurement is done from 15 seconds to 1 minute with 15 seconds interval and then for every minute up to ten minutes. Value obtained at 10 minute divided by value at 1 minute gives polarization index

Please refer below for connection and test arrangement

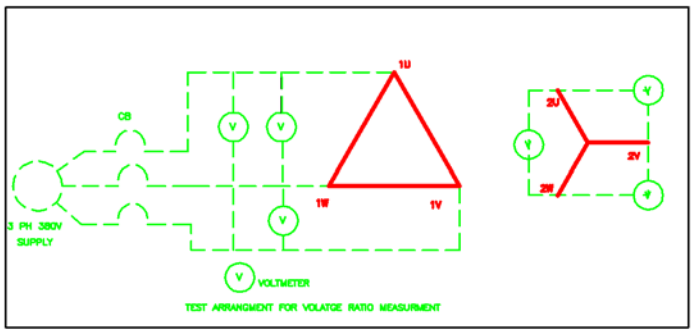




5.2.2. Voltage Ratio Measurement

The voltage ratio measurement for two or three winding power transformer can be done either by conventional method by using Voltmeters or by using Turns ratio Meter

The test shall be done for each and every phase at all tap position as follows.



For Two winding Transformer

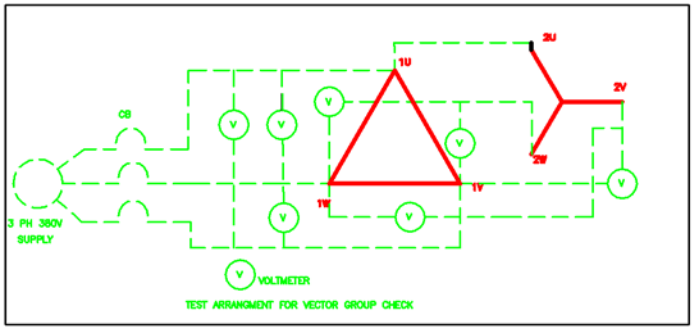
- Apply 3 phase Voltage more than 220V on HV Winding and measured the corresponding voltages at the LV winding
- Note down both HV and LV winding side voltages on all the three phases and all tap positions.

5.2.3. Vector group check

The vector group or phase relationship can be checked by injecting three phase supply and measuring the voltages as per the figure below.

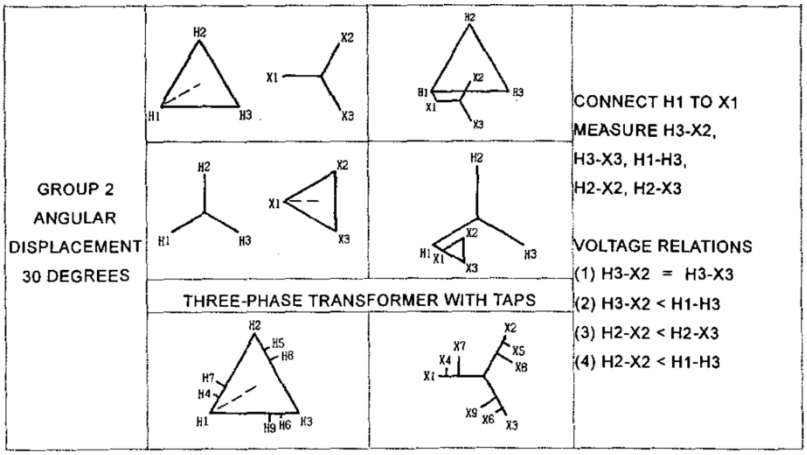
One of the phase say 1U and 2U between HV and LV should be shorted together and three phase low voltage is applied on HV terminals.

Then the voltage between various pairs of line terminal should be measured and compared



Example: condition for Dyn11 is, the voltage between

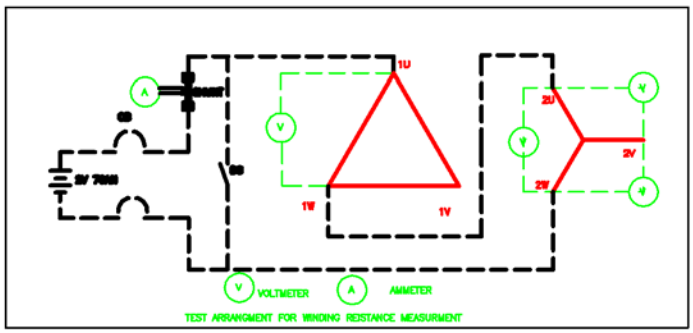
1W-2V> 1W-2W=1V-2W=1V-2V

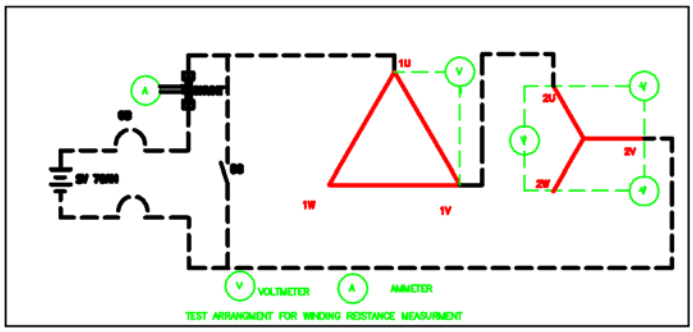


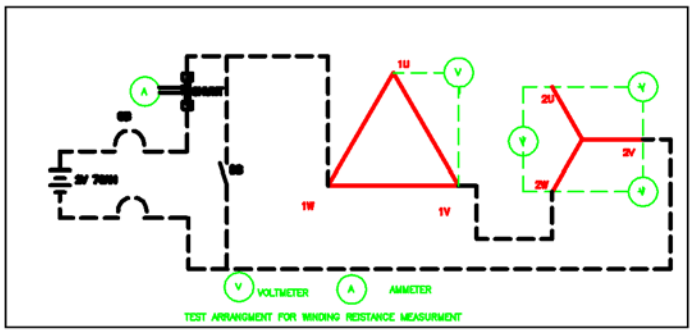
5.2.4. Winding Resistance Measurement

The Winding resistance measurement can be done by either conventional method using 2V DC battery with voltmeter and Ammeter or by Transformer resistance meter.

The winding resistance will be measured by a drop of potential method on all windings by injecting direct current through the phase winding as shown below.







For the Y connected transformer the measurement should be made between each line bushing and single phase value is half of the measured value. For the delta connection, the measurement should be made between each pair of bushing and then single phase value is three half of the measured value.

The measured values should be compared with factory value, for that, a conversion for the temperature correction should be done by following formula.

$$R_{75} = Ra \times \frac{234.5+75}{234.5+Ra}$$

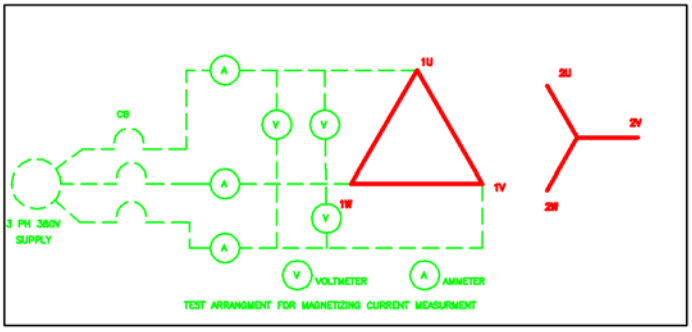
Whereas R75 = Corrected Resistance in ohms

Ra = Measured Resistance at ambient temperature in ohms

Ta = Ambient temperature in ^{0} C

5.2.5. Magnetization Current Measurement.

The test connection is done as shown in the following drawing. Apply 200 V to the transformer HV terminals and measure the current and corresponding voltage for all the tap position.



5.2.6. Oil Testing

Oil sample should be taken from bottom, top of the main tank, OLTC chamber and also from the conservator tank,

De-electric test for the oil should be performed as per IEC 156 using de-electric test machine

5.2.7. Temperature indicator and sensor.

5.2.7.1. Oil Temperature

The oil and winding temperature indicators shall be calibrated by heat sink with thermometer.

5.2.7.2. Winding Temperature

The winding temperature indicator shall be checked by current injection at the heater element.

5.2.8. Bushing current transformer

Following tests should be done on all the bushing transformers

- Ratio test
- Magnetization curve
- Polarity test
- Insulation test
- Winding resistance test
- Loop resistance test

All the test results shall be entered in the CT test. Refer TP-CRT01 for the test procedure

5.2.9. Testing and commissioning of cooler control cabinet

Prior to power up cooler control cabinet with auxiliary 3 phase/single phase/dc voltage, following checkups shall be carried out.

- ❖ Winding insulation resistance and winding resistance for the fan motors should be carried out.
- ❖ Insulation resistance test for the control circuit should be carried out.
- ❖ After obtaining all the results and found satisfactory auxiliary power can be switched on and voltage/phase sequence measurement should be carried out.
- ❖ Manual/auto operation of the fans should be checked
- ❖ Heater and lighting circuit should be checked and made functional.

5.2.10. Transformer protection devices functional check

- ❖ Trip and alarm should be simulated from buchholz relay. tripping of protection relay and breakers should be observed, alarms on local and remote annunciation shall be observed
- ❖ Trip and alarm should be simulated from pressure relay. tripping of protection relay and breakers should be observed, alarms on local and remote annunciation shall be observed
- ❖ Trip and alarm should be simulated from pressure relief relay. tripping of protection relay and breakers should be observed, alarms on local and remote annunciation shall be observed
- ❖ Trip and alarm should be simulated from oil and winding temperature indicator. tripping of protection relay and breakers should be observed, alarms on local and remote annunciation shall be observed
- ❖ Results for above tests shall be entered in the test form No.TS-AT01 of the power transformer.

5.2.11. Protective Earthing Check

Transformer protective earthing bond must be earthed in order to afford protection to human beings.

6. Documents

Relevant Test sheets to be prepared according to the size and type of the transformer.

7. References:

8. Attachment

8.1. Test Sheet for oil filled transformer 13.8/4.16KV

8.2. Test Sheet for oil filled transformer 13.8/0.480KV:

8.3. Test Sheet for oil filled transformer 4.16/0.48KV

8.4. Test for Dry Type transformer

*****End of the procedure*****

Testing Procedure

Power Transformers

Document No: BSC-TP-MPT01
Rev: 0

TABLE OF CONTENT

1. **Task**

This instruction comprises a complete description of the testing of the generator step up transformer **GSU**

2. **Preconditions**

2.1 Work Status

- Erection has been completed.
- Labelling of the equipment and designation of live enclosed plant sections has been carried out.

2.2 Documentation

- The Schematic diagrams of the electrical equipment cabinets are available
- Test report to be made available
- Product manual of the transformer
- *Drawing number shall be specified along with electrical diagram*
- *Factory acceptance report (FAT) shall be in hand during testing in order to refer reference value*
- *SEC approved manufactured drawings shall be available at site during field testing*
- *Valid Calibration Certificates for the test equipment to be used shall be available at site before starting the tests.*

2.3 Personnel

- Commissioning engineer: - (1) engineer with experience in commissioning of transformer and switch gear.
- Technician or helper:- (2) skilled worker with adequate on -the-job training
- Witness from the client's concern department

2.4 Measuring Instruments

- Ratio meter (calibrated)---1
- Multi meter(calibrated)—2
- Insulation resistance meter –megger(calibrated)—1
- CT tester(calibrated)-1
- DC shunt 100 amps(calibrated)--1
- Mini clamp(calibrated)—2
- Tan delta measurement test equipment—1
- Current injection set(calibrated)—1
- phase relay tester(calibrated)—1
- *Voltmeter*
- *Transformer resistance meter*
- *Sweep frequency Response Analyzer (SFRA)*
- *Power Analyzer which can also record the in rush current*

3. **Precautions**

The work will only proceed when a Permit to Work (PTW) in work permit area has been obtained. The PTW will be kept on site for consultation during the testing works.

- Observe the rules for handling electronic components sensitive to electrostatic discharge (ESD measures).
- Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.
- Closing of the work permit after completion of the work (if the test area is to be considered in work permit area) is necessary.

- Before test voltages are applied a check shall be carried out to ensure that no unauthorized persons are working at the corresponding load-where ever necessary barriers should be provided

4. Scope

- Testing of Transformer
- Checking Auxiliaries and cooling system
- Checking that the mounting position is correct,
- Testing of bushing CT
- Checking of correct earthing,
- Testing of Protective devices
- Adjustment of OLTC AVR for final operation

5. Execution

5.1 Visual Inspection.

Prior to carrying out electrical tests, a visual check of the transformer should be carried out paying particular attention to the following points

- Equipment and cables are undamaged
- Correct execution of the cable gland/sealing end
- Firm cable termination/terminal connection and ferruling
- Check name Plate data for correctness in accordance with approved drawings
- Check all components are installed
- Check for any damages, oil leakage, defectives
- Check all groundings are securely connected “at least two points
- Check that piping for Buchholz relay has proper slope and direction towards the conservator
- Check that Inlet &Outlet valves of Buchholz relay are OPEN
- Check that the valves for Protective relay of OLTC are OPEN
- Check all valves between main tank and radiator are OPEN
- Check the color and quantity of Silica gel in the breather and oil pot level
- Check labeling of both High & Low Voltage Bushings
- Check labeling of all Aux. Devices and cables in accordance with drawings
- Check proper Installation of all Aux. Devices
- Check Oil level in the conservator and Bushings.
- Check tightness of all wiring
- Check installation of Gas Monitoring Unit “CALISTO” , sample valves are open
- Check installation of On Load Tap Changer
- Records from the impact recorder shall be checked once the transformer is in position for any abnormalities caused during transportation, if recorder is electronic then stored data shall be sent to vendor for analyzing (this is part of the erection activity)
- Tightness of all bolted connection to be checked and torque according to the manufacture recommendation (this is part of the erection activity)
- Horizontal and vertical clearance of live parts to adjacent ground part to shall be checked and confirm to the standard (this is part of the erection activity)
- Bushing and Neutral CT’s shall be checked for damages on connections

5.1.1 Commissioning of OLTC

Commissioning of OLTC will ease the testing of transformer as tap changer can be operated electrically. Prior to power up OLTC control panel with auxiliary 3 phase/single phase/dc voltage, following checkups shall be carried out.

- Winding insulation resistance and winding resistance for the motor should be carried out.
- Insulation resistance test for the control circuit should be carried out.
- After obtaining all the results and found satisfactory auxiliary power can be switched on
- voltage/phase sequence measurement shall be entered in test form
- Complete operational check including interlock and alarm shall be checked

5.2 Testing of Transformer

Following tests to be carried out

1. Pressure or leak test for the transformer tank.(this is part of erection activity)
   a. Vacuum with stand test
   b. Pressure test
2. Core insulation test
3. Insulation resistance / Polarization index test
4. Voltage Ratio Measurement
5. Vector Group/Phase Displacement
6. Magnetic Balance test
7. Winding Resistance Test
8. Impedance measurement
   a. Single phase impedance measurement
   b. Zero sequence impendence measurement
9. Excitation current Measurement
10. Insulation Power factor or Tan delta measurement
11. Measurement of capacitance and tan delta of transformer bushing at voltage of 2kv to 12kv in steps of 2kv
12. Measurement of breakdown voltage , moisture content of transformer insulating oil
13. Temperature indicator and sensor Calibration
    i. Winding Temperature
    b. Oil Temperature
14. Bushing Current Transformer
15. Sweep Frequency Response Analysis
16. Testing and commissioning of cooler control cabinet
17. Functional checks
    a. Functional checks of protection devices
    b. Functional checks of alarms
    c. Functional check of measuring devices
18. Testing and commissioning of Remote tap changer control panel
19. Measurement of inrush Current and inrush current withstand test
20. Measurement of Neutral current in no load and load condition
21. Particulate content of transformer oil after completion of testing and three days of Energization

22. DGA shall be carried out transformer insulating oil after three days and after month of Energization.

5.2.1 Pressure or Leak Test for the Transformer Tank.(this is part of erection activity)

5.2.1.1 Vacuum with Stand Test

After complete assembly including coolers, bushings, conservator and other accessories, transformer tank has to be vacuumed to <1 mbar or 750 tar and maintain for minimum six hours

5.2.1.2 Pressure Test /Leak Test

After complete assembly including coolers, bushings, conservator and other accessories and oil filled, the transformer tank has to be filled with nitrogen or dry air and maintain pressure to 0.3kgf/cm^2 for 12 hours

5.2.2 Core Insulation Test

The insulation resistance between core and earth shall be done for one minute with 3500 V dc megger, as per following connection

Core – Earth

5.2.3 Insulation Resistance/Polarization Index Test

Testing of insulation resistance and polarization index shall be carried out as under

Apply the test voltage (5KV DC) on following Connection and note down the readings

<u>Two Winding Transformer</u>

HV – Earth

LV – Earth

HV-LV

<u>Three Winding Transformer</u>

HV – Earth

LV1 –Earth

LV2 –Earth

HV -LV1

HV -LV2

LV1 -LV2

The insulation resistance measurement is done from 15 seconds to 1 minute with 15 seconds interval and then for every minute up to ten minutes. Value obtained at 10 minute divided by value at 1 minute gives polarization index

Please refer below figures for connection and test arrangement

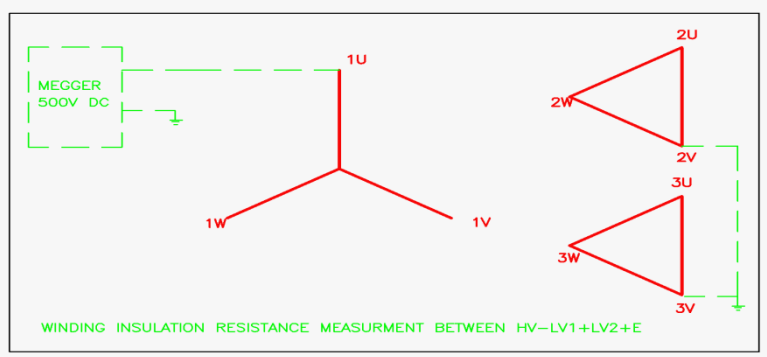


Figure-1

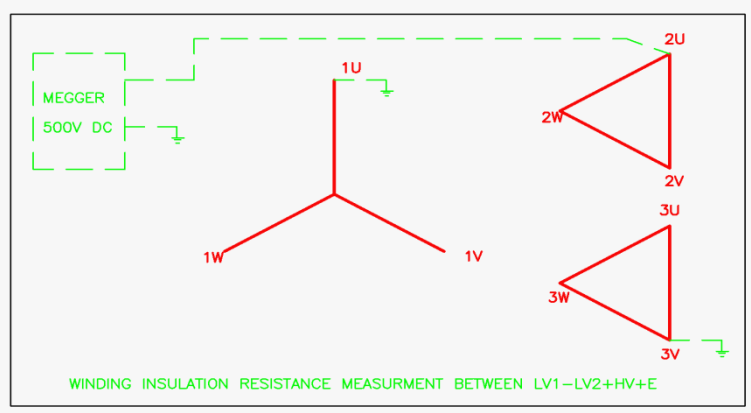


Figure-2

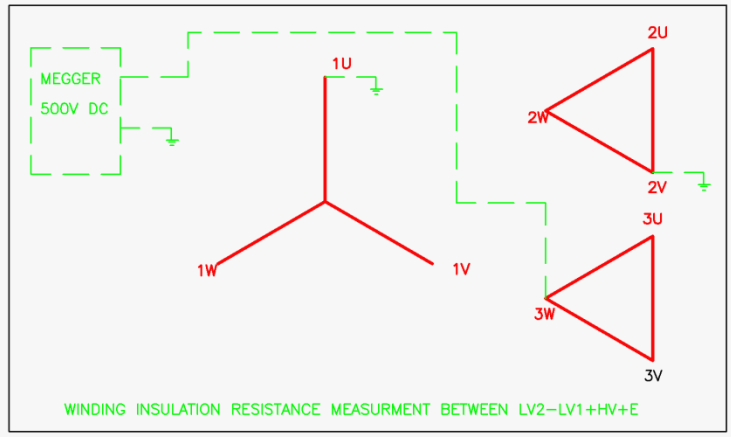


Figure-3

5.2.4 Voltage Ratio Measurement

The voltage ratio measurement for two or three winding power transformer can be done either by conventional method using Voltmeters or by using Turns ratio Meter

The test will be mad for each and every phase at all tap position as follows.

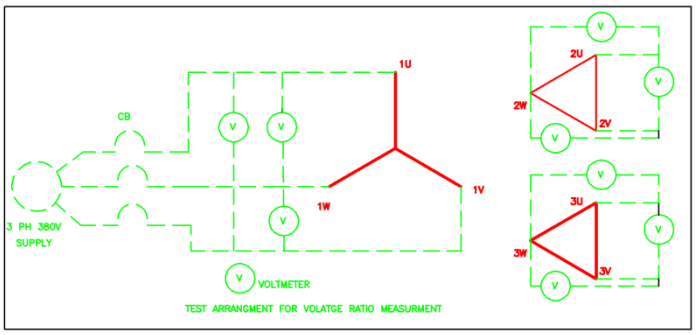


Figure -4

<u>For Two winding Transformer</u>

- Apply 3 phase Voltage more than 220V on HV Winding and measure the corresponding voltages at the LV winding
- Note down both HV and LV winding side voltages for all the three phase and at all tap position

<u>For Three winding Transformer</u>

- Apply 3 phase Voltage more then 220V on HV Winding and measured the corresponding voltages at the LV1 and LV2 windings.
- Noted HV ,LV1and LV2 winding side voltages on all the three phase and at all tap positions

5.2.5 Vector Group Check

The vector group or phase relationship can be checked by injecting three phase supply and measuring the voltages as per the figure below

One of the phase say 1U and 2U between HV and LV should be shorted together and three phase low voltage is applied on HV terminals.

Then the voltage between various pairs of line terminal should be measured and compared

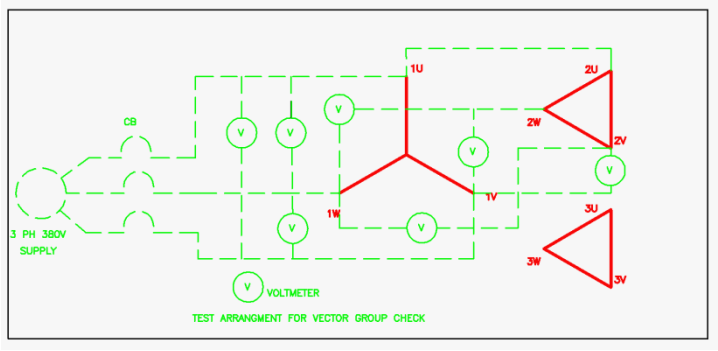


Figure-5

Example: condition for Yn1d1d1 is, the voltage between

1V-2W> 1W-2W=1W-2V=1V-2W

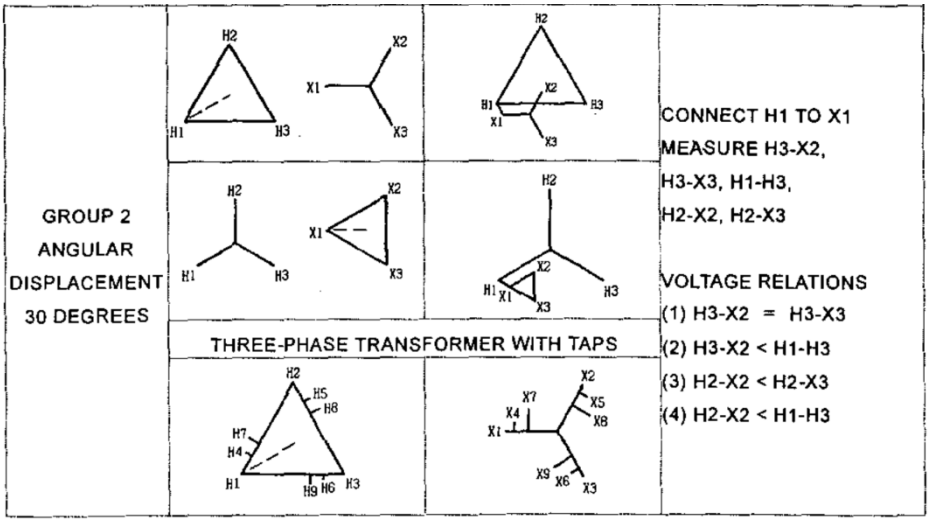


Figure-6

5.2.6 Magnetic Balance Test

This test can be done by applying 380 volts 60 Hz single phase supply across phase and neutral of HV winding and voltage induced on other two phases are measured

Test shall be carried out at lowest, middle and highest tap

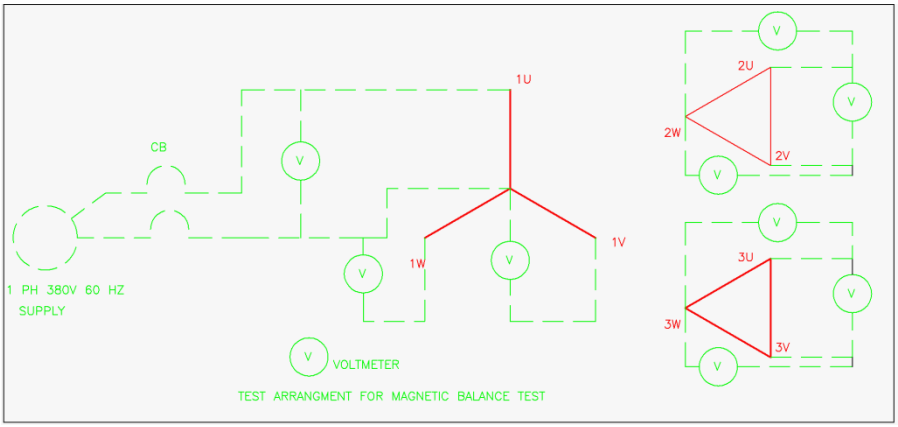


Figure-7

5.2.7 Winding Resistance Measurement

The Winding resistance measurement can be done by either conventional method using 2V /50A DC battery with voltmeter and Ammeter or by Transformer resistance meter.

The winding resistance for HV winding will be measured by a drop of potential method on all windings by injecting 50A DC through the winding as shown below.

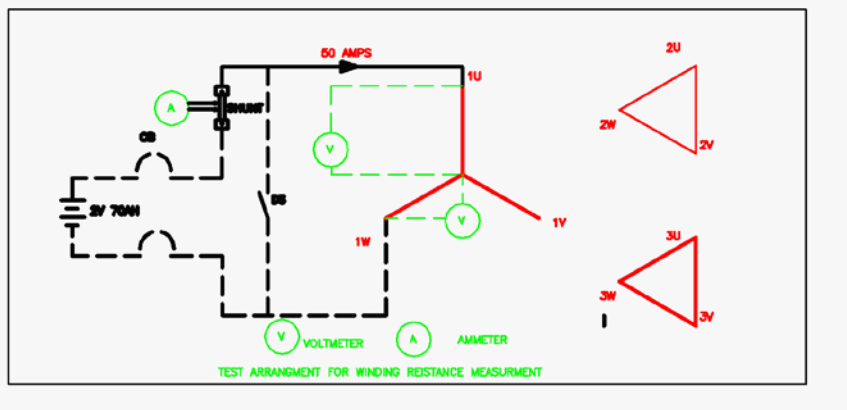


Figure-8

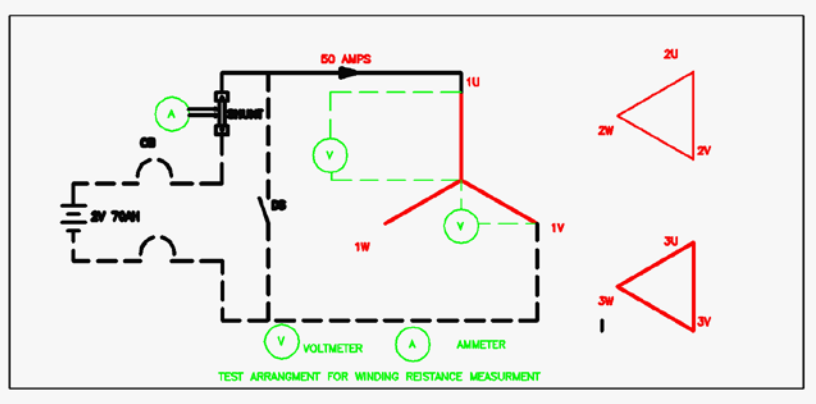


Figure-9

The winding resistance for LV winding shall be measured by a drop of potential method on all the three windings by injecting 100A DC through the winding as shown Figure-10 to 12.

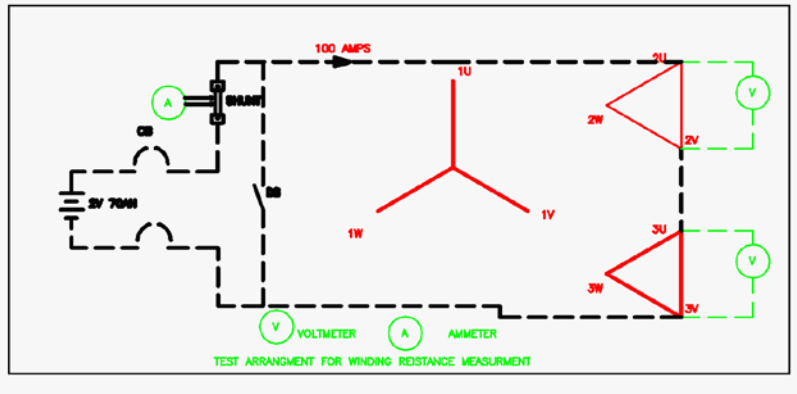


Figure-10

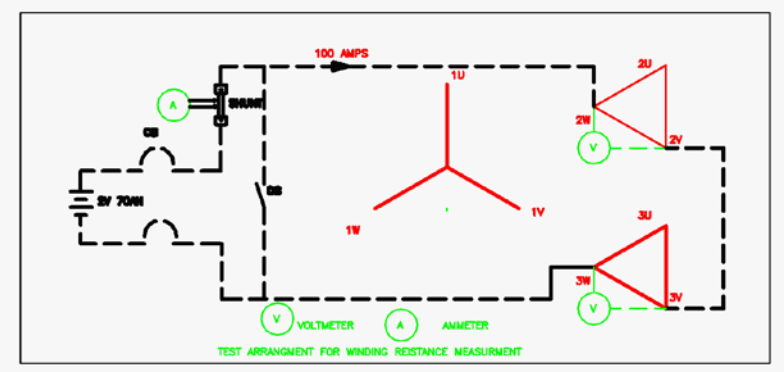


Figure-11

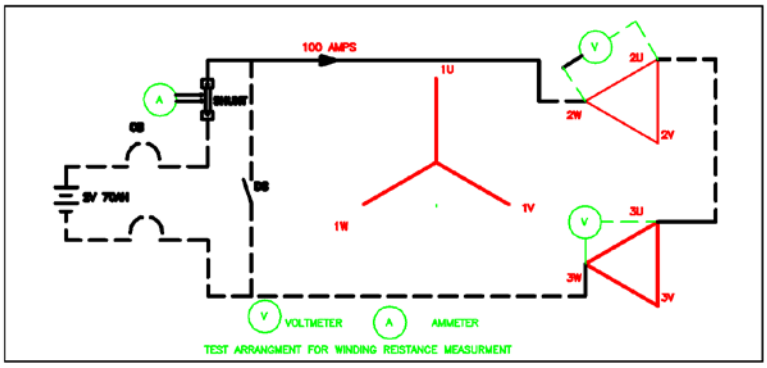


Figure-12

For the Y connected transformer the measurement should be made between each line and neutral bushing and for the delta connection, the measurement shall be made between each pair of bushing and then single phase value is equal to three half of the measured value.

The measured values should be compared with factory value, for that a conversion for the temperature correction should be done by using following formula.

$$R_{75} = Ra \times \frac{234.5+75}{234.5+Ra}$$

Whereas R75 = Corrected Resistance in ohms

Ra = Measured Resistance at ambient temperature in ohms

Ta = Ambient temperature in ^{0}C

5.2.8 Impedance Measurement

5.2.8.1 Single Phase Impedance Measurement

The impedance should be measured at lowest, nominal, and highest tap position as follows.

Connection will be made as shown in below figure. Apply about three phase 220 Vac to the transformer HV terminals and measure the current and voltages. Single phase Impedance can be calculated as follows

Zu =1/2(Zuv+Zwu-Zvw)

Zv =1/2(Zvw+Zuv-Zwu)

Zw = 1/2(Zwu+Zvw-Zuv)

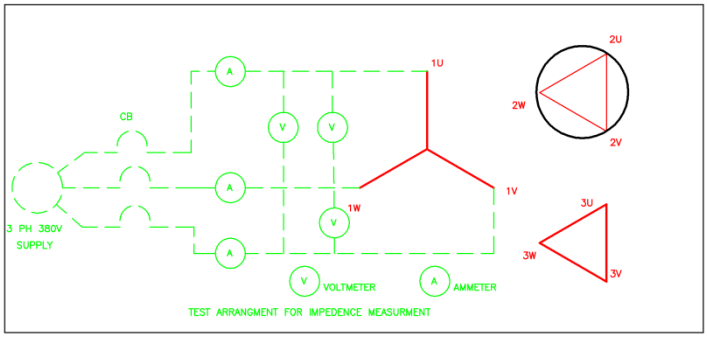


Figure-13

In case, exclusively single phase measurement is required, where some experts do not agree with above test, follow the figure given below

Impedance voltage will be calculated to the rated current.

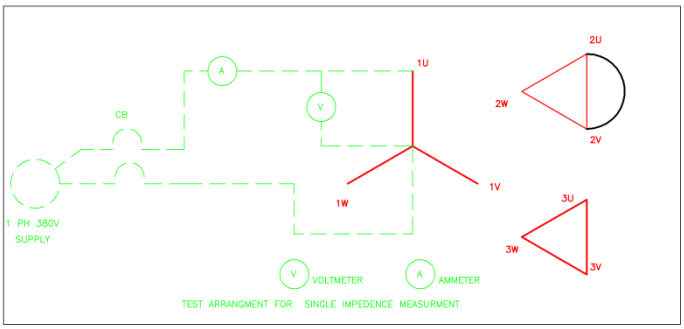


Figure-14

5.2.8.2 Zero Sequence Impedance Measurement

The Zero sequence impedance is usually measured for all-star or zigzag winding connected transformers

Open Circuit zero sequence impedance is measured by applying single phase 220V 60 Hz between neutral and all the three phases shorted with other windings open circuited

Connection shall be made as shown in figure-15.

Zzq = 3V/I

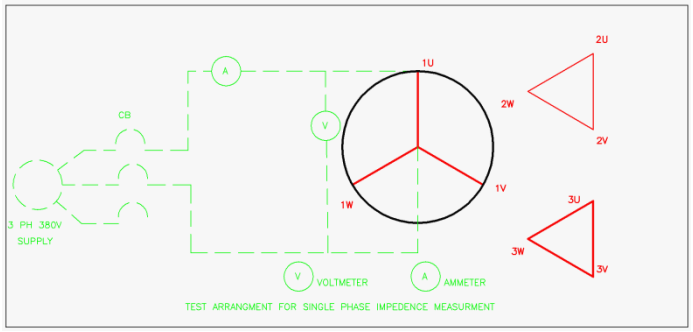


Figure-15

Short Circuit zero sequence impedance is measured by applying single phase 220V 60 Hz between neutral and all the three phases shorted with other windings short circuited

Measurement connection shall be made as shown in figure-16.

Zzq = 3V/I

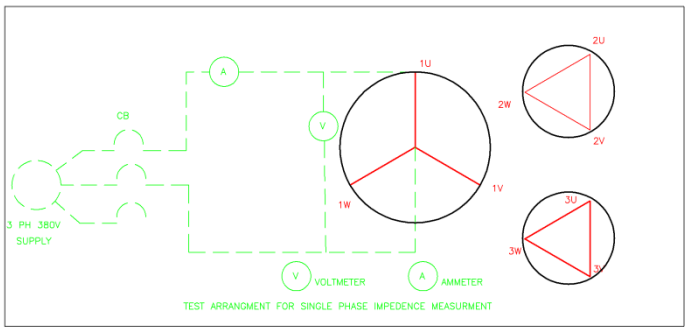


Figure-16

5.2.9 Magnetization Current Measurement.

Test connection will be done as shown in the following drawing. Apply 380V, 60 HZ to the transformer HV terminals and measure the current and corresponding voltage for all the tap position

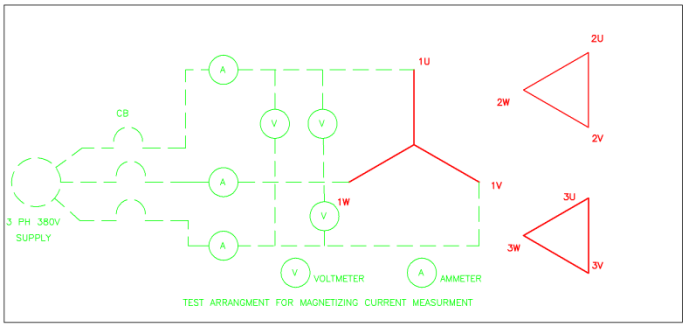


Figure-17

5.2.10 Insulation Power Factor or Tan Delta and Excitation current at 2 to 12KV Measurement

- The test shall be made on each winding to ground and between the windings with Doble or Megger tan delta equipment. Please refer the tan delta measurement equipment guide to perform the test
- Reading shall be obtained from 2KV to 12KV in every 2 kv step.
- Same time Excitation current for all the windings are noted down.

Note: SEC-ERB standard SEC-GMSS01 ask for 2-20KV but most of the equipment available in the market is only up to 12 KV even DOBLE 2H is up to 12 KV only.

5.2.11 Measurement of Capacitance and Tan Delta of Transformer Bushing at Voltage 2kv to 12kv in steps of 2kv

- Usually bushings above 23kv will have a power factor or a capacitance tap which can be used to perform capacitance and dissipation factor measurement without disconnecting the bushing from the winding.
- The test is done under UST (ungrounded specimen test) mode as shown in figure below.
- the readings of capacitance and dissipation factor for the bushings shall be obtained for the test voltage of 2kv to 12kv in steps of 2kv

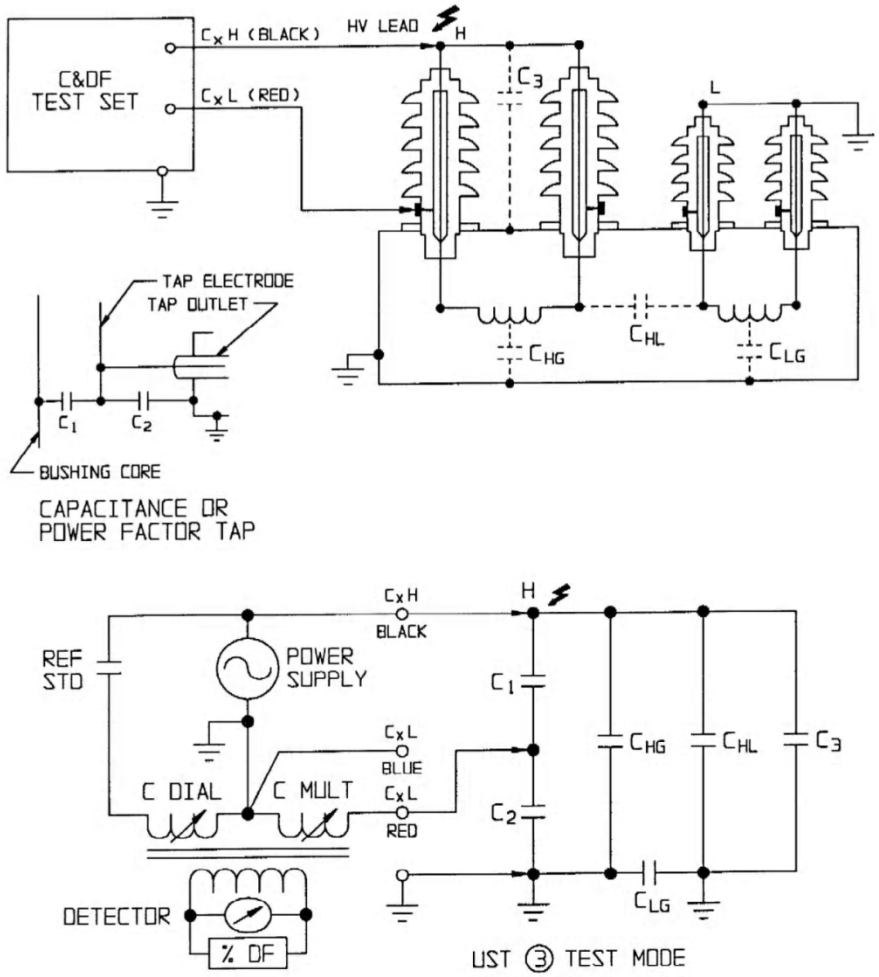


Figure-17

Above figure Measures main bushing insulation C 1

C HG , C HL , and C 3 shunt power supply, therefore no influence on measurement C 2 shunts bridge winding, therefore negligible influence if less than 5000 pF

5.2.12 Measurement of Breakdown Voltage, Moisture Content and DGA of Transformer Insulating Oil.

- Oil sample shall be taken from bottom, top of the main tank, OLTC chamber and also from the conservator tank,
- De-electric test for the oil should be performed as per IEC 156 using de-electric machine

Except for the dielectric breakdown and power factor tests all other tests must be performed at a SEC approved laboratory and the results are to be submitted to SEC-COA for review and approval.

a) Dielectric strength:

i) ASTM D 877 (with 2.5 mm gap) for unprocessed oil & for oil in OLTC

ii) ASTM D 1816 (with 1.0 mm gap) for oil in Transformer Main Tank b) Neutralization Number (ASTM D 974)

c) Interfacial tension (ASTM D 971)

d) Color (ASTM D 1500)

e) Moisture content (ASTM D 1533A)

f) Power factor test (ASTM D 924)

g) Dissolved gas in oil analysis (ASTM D 3612)

5.2.13 Temperature indicator and sensor.

5.2.13.1 Oil Temperature

The oil and winding temperature indicators shall be calibrated by heat sink with thermometer.

5.2.13.2 Winding Temperature

The winding temperature indicator shall be checked by current injection at the heater element.

5.2.14 Bushing Current Transformer

Following tests should be done on all the bushing transformers

- Ratio test
- Magnetization curve (measurement shall be for minimum 5 points below and 2 points after the knee point)
- Polarity test
- Insulation test
- Winding resistance test
- Loop resistance test

All the test results shall be entered in the test form related to CT of the transformer. Refer BS- TP-CRT01 for the test procedure

5.2.15 Sweep Frequency Response Analysis

Sweep frequency response analysis is tool which gives an indication of winding or core movement, deformation of winding axial or radial, spiraling short or open turns etc.

The test can be performed by using DOBLE M5100 test equipment (please refer M5100 manual for test procedure). Test results are stored as a baseline reference and can be verified with results obtained during factory testing or can also be verified with the results of sister transformer in case factory results are not available.

The test can also be performed once the transformer arrives and bushings are connected with no oil, provided no combustible gas in. This gives confidence in the mechanical integrity of the unit prior to further work and commissioning.

5.2.16 Testing and Commissioning of Cooler Control Cabinet

Prior to power up cooler control cabinet with auxiliary 3 phase/single phase/dc voltage, following check s shall be carried out.

- Winding insulation resistance and winding resistance for the fan motors should be carried out.
- Insulation resistance test for the control circuit should be carried out.
- After obtaining all the results and found satisfactory auxiliary power can be switched on and voltage/phase sequence measurement should be carried out.
- Manual/auto operation of the fans should be checked
- Heater and lighting circuit should be checked and made functional.
- 2KV, 60HZ, Power frequency withstand test on all control/auxiliary and CT secondary circuit shall be performed
- Measurement of power, current/inrush current for the individual fan and group shall be carried out

5.2.17 Functional Check

5.2.17.1 Functional Checks of Protective Devices

- Trip shall be simulated from buchholz relay. tripping of protection relay and breakers should be observed,
- Trip shall be simulated from pressure relay. tripping of protection relay and breakers should be observed,
- Trip shall be simulated from pressure relief relay. tripping of protection relay and breakers should be observed,
- Trip shall be simulated from oil and winding temperature indicator. Tripping of protection relay and breakers should be observed.
- Results for above tests shall be entered in the test form No.TS-PT01 of the power transformer.

5.2.17.2 Functional Checks of Alarms

- Alarm Shall be simulated from buchholz relay and observe at local and remote annunciator
- Alarm shall be simulated from pressure relay and observe at local and remote annunciator
- Alarm shall be simulated from pressure relief relay. and observe at local and remote annunciator

- Alarm shall be simulated from oil and winding temperature and observe at local and remote annunciator
- Results for above tests shall be entered in the test form No.TS-PT01 of the power transformer

5.2.17.3 Functional Checks of Measuring Devices

- Measuring devices like temperature transducer shall be checked for its functionality by using multi loop calibrators

5.2.18 Testing and Commissioning of Remote tap Changer Control panel(RTCC)

Prior to power up RTCC with auxiliary Single phase/dc voltage, following checkup shall be carried out.

- Insulation resistance test for the control circuit should be carried out.
- After obtaining all the results and found satisfactory auxiliary power can be switched on and voltage/phase sequence measurement shall be entered in test form No TS-TP01.
- AVR should be calibrated
- Manual/auto operation of the tap changer should be checked
- Alarm on annunciation shall be checked
- Remote operation that is from DCS and SCADA should be checked
- Tap position indication should be checked both on local panel and DCS/SCADA.
- Heater and lighting circuit should be checked and made functional.

5.2.19 Measurement of Inrush Current.

- Inrush current measurement shall be carried out by chart recorder or inrush current measurement instruments
- As inrush current depends on switching instant, minimum three readings shall be taken at different occasion.
- Inrush current can also be noted down from the Transformer management relay by programming the relay to trigger the oscillography for the pickup current

5.2.20 Measurement of Neutral Current in No Load and Load Condition

Neutral current under no load and load condition shall be measured once the transformer is energized, this can be measured directly on the neutral of the transformer with clamp meter

Values for no load current may be more than that of under load condition; this is due to unbalanced magnetization current.

5.2.21 Particulate Content of Transformer Oil after Completion of Testing and after three days of Energization

Please refer 5.3.12 of this procedure

5.2.22 DGA of Transformer Insulating Oil.

DGA prior to energization, three days and one month after the energization must be performed at a SEC-COA approved laboratory and the results shall o be submitted to SEC-COA review and approval.

6 Documents

Relevant test sheets to be completed for each every Power transformer.

7 References

1. **SEC-ERB Standards SCS-P-105, SEC-GMSS-01**
2. **IEC 60076**
3. **Manual of DOBLE-M5100**

8 Attachment

Test sheet for following equipment to be prepared with respect to their Size and type

8.1 Test Sheet for Three Winding Transformer

8.2 Test Sheet for Two winding Transformer

8.3 Test Sheet for auto power transformer

*****End of the procedure*****

Testing Procedure

Current Limiting Transformers

Document No: BSC-TP-CLT01
Rev: 0

TABLE OF CONTENT

1. Task.

This instruction comprises a complete description of the testing of the oil and dry type Current Limiting Reactor

2. Preconditions

2.1. Work Status

- Erection has been completed.
- Labelling of the equipment and designation of live enclosed plant sections has been carried out.

2.2. Documentation

- The circuit diagrams and Single line Drawings are available.
- Commissioning checklists TS-CL01.
- Product manual of the Current limiting Reactor is available.

2.3. personnel

- Commissioning engineer: - (1) engineer with experience in commissioning of transformer and switch gear.
- Technician or helper:- (2) skilled worker with adequate on -the-job training
- Witness from the client's concern department

2.4. Measuring Instrument

- Multi meter (calibrated)—2
- Insulation resistance meter 5KV –megger(calibrated)—1
- AC High Voltage tester up to 30 kv (calibrated)—1
- Variable Auto Transformer-----1
- Mini clamp(calibrated)—2
- Fluke

3. Precautions

The work will only proceed when a Permit to Work (PTW) in work permit area has been obtained.

The PTW will be kept on site for consultation during the testing works.

- Observe the rules for handling electronic components sensitive to electrostatic discharge (ESD measures).
- Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.
- Closing of the work permit after completion of the work (if the test area is to be considered in work permit area) is necessary.
- Before test voltages are applied a check shall be carried out to ensure that no unauthorized persons are working at the corresponding load-where ever necessary barriers should be provided

4. Scope

- Testing of Current Limiting Reactor
- Checking that the mounting position is correct,
- Checking of correct earthing,
- Checking of protection devices for oil type reactor

5. Execution

5.1. Visual Inspection.

Prior to carrying out electrical tests, a visual check of the CLR should be carried out paying particular attention to the following points

- Correct labeling of devices and cables
- Equipment and cables are undamaged
- Correct execution of the cable gland/sealing end
- Name plate data, match with drawing and ambient condition
- Firm cable termination/terminal connection and ferruling

5.2. Testing of Current Limiting Rector

Following tests to be carried out

1. Measurement of Insulation Resistance
2. Measurement of Winding Resistance.
3. Measurement of Impedance.
4. High Voltage Test for Dry or Air core Reactor
5. Testing of protection devices for oil type reactor

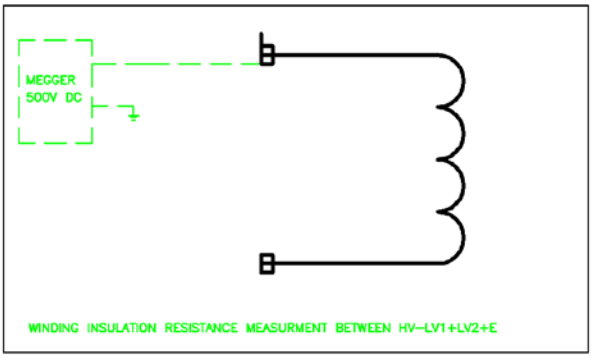
5.2.1. Insulation Resistance Before High Voltage Test

Checking of the insulation resistance should be carried out as under

Apply the test voltage between winding and ground and note down the readings

The insulation resistance measurement is done from 15 seconds to 1 minute with 15 seconds interval.

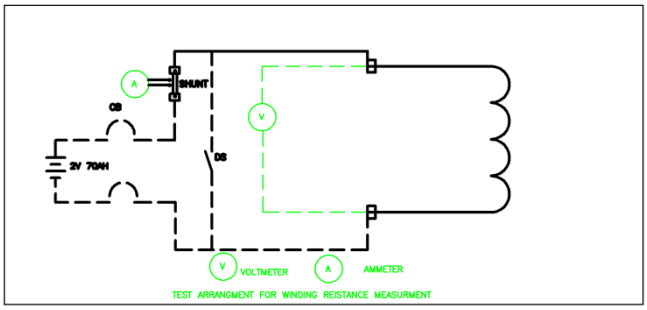
Please refer below for connection and test arrangement



5.2.2. Winding Resistance Measurement

The Winding resistance measurement can be done by either conventional method using 2V DC battery with voltmeter and Ammeter or by Micro ohmmeter.

The winding resistance will be measured by a drop of potential method by injecting direct current through the winding as shown below.



Measurement should be made between line to line bushing

The measured values should be compared with factory value, for that a conversion for the temperature correction should be done by following formula.

$R_{75} = Ra \times \frac{234.5+75}{234.5+Ra}$

Whereas R_{75} = Corrected Resistance in ohms

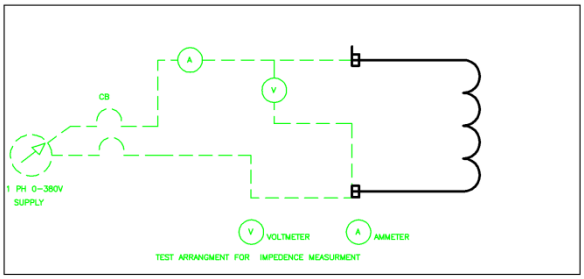
Ra = Measured Resistance at ambient temperature in ohms

Ta = Ambient temperature in ^{0}C

5.2.3. Impedance Measurement

The impedance should be measured as follows.

Test connection is done as shown in figure below. Apply about 22 0 Vac between the line terminals and measured the current, voltage divided by current gives Impedance.



5.2.4. High Voltage Test

AC high- pot test shall be carried out in accordance with IEC standard at site. The test shall be carried out on dry type or air core reactor as under

- Connect the phases Y, B to ground and apply the test voltage between phase R and ground by increasing gradually at the rate of 2kv/sec, Record the leakage current at 15 Sec, 30 sec , 45 sec and 60 sec
- Connect the phases B, R to ground and apply the test voltage between phase Y and ground by increasing gradually at the rate of 2kv/sec, Record the leakage current at 15 Sec, 30 sec , 45 sec and 60 sec
- Connect the phases R, Y to ground and apply the test voltage between phase B and ground by increasing gradually at the rate of 2kv/sec, Record the leakage current at 15 Sec, 30 sec , 45 sec and 60 sec

5.2.5. Insulation Resistance After High Voltage Test

Checking of the insulation resistance should be carried out as mention in **5.5.1**

5.2.6. Oil Testing(for oil type Reactor)

Oil sample should be taken from bottom, top of the main tank, also from the conservator tank,

De-electric test for the oil should be performed as per IEC 156 using de-electric test machine

5.2.7. Temperature Indicator and Sensor.

5.2.7.1. Oil Temperature

The oil and winding temperature indicators shall be calibrated by heat sink with thermometer.

5.2.7.2. Winding Temperature

The winding temperature indicator shall be checked by current injection at the heater element.

5.3. Protection Devices Functional Check (for oil type CLR)

- ❖ Trip and alarm should be simulated from buchholz relay. tripping of protection relay and breakers should be observed, alarms on local and remote annunciation shall be observed
- ❖ Trip and alarm should be simulated from pressure relay. tripping of protection relay and breakers should be observed, alarms on local and remote annunciation shall be observed
- ❖ Trip and alarm should be simulated from pressure relief relay. tripping of protection relay and breakers should be observed, alarms on local and remote annunciation shall be observed
- ❖ Trip and alarm should be simulated from oil and winding temperature indicator. tripping of protection relay and breakers should be observed, alarms on local and remote annunciation shall be observed

- Results for above tests shall be entered in the test form No.TS-PT01 of the power transformer.

5.4. Checking the Protective Earthing

Bus duct protective earthing bond must be earthed in order to afford protection to human beings. Protective earthing bond should be checked for continuity.

6. Documents

Relevant test sheets to be completed for each every Current Limiting Reactor

7. Attachment

Test sheet for following equipment to be prepared with respect to their Size and type

7.1. Test Sheet for Current Limiting Reactor

End of the procedure

Testing Procedure

LV Circuit Breaker and Its Feeder

Document No: BSC-TP-LCB01
Rev: 0

TABLE OF CONTENT

1.0 **Task**

The purpose of this procedure is to test, commission and document LV circuit breaker feeder in metal enclosed switchgear assemblies of 220/380/480V levels.

2.0 **Preconditions**

2.1 **Work Status**

- Erection has been completed.
- Labelling of the equipment and designation of live enclosed plant sections has been carried out.

2.2 **Documentation**

- The schematic and single line diagram of the medium voltage switchgear are available
- Relevant test sheets to be made available.

2.3 **Personnel**

- 1 Commissioning engineer: Engineer or technician with experience in commissioning of all types of Electrical equipments.
- 1 Helper: skilled worker with adequate on-the-job training.

2.4 **Measuring instruments and tools**

- Micro ohm meter 10A and 100A
- Insulation Tester 1000V dc
- High voltage tester AC (up to 2 KV)
- Discharge hot stick
- Secondary Injection
- Fluke-2 Nos

3.0 **Precautions**

The work will only proceed when a Permit to Work (PTW) in work permit area has been obtained. The PTW will be kept on site for consultation during the testing works.

Special attention will be given to:

- Due to high voltage being used, adequate safety precautions should be taken to avoid injury to personnel and damage to property.
- Cordoning off specified working area and provision of applicable safety warning sign board.
- Ensure that all the necessary test equipment are made available at the test area and with valid calibration stickers and certificate.
- Hand insulating gloves and grounding sticks / wire jumpers shall be provided for safe handling and draining of residual voltage.
- Breaker should be withdrawn from the cubicle during breaker testing.
- Immediately after testing of each phase, voltage residue shall be drain by using grounding stick / wire which is directly connected to earth.
- Closing of the work permit after completion of the work (if the test area is to be considered in work permit area) is necessary.

4.0 **Scope**

- Testing of CB
- Testing of Anti pumping facility
- Operation of CB inside the feeder
- Operation of Earting switch
- Checking CB mounting.

5.0 **Execution**

5.1 **Visual Checks**

- Check nameplate information for correctness.
- Inspect enclosures for proper alignment, foundation fixing and grounding.
- Inspect covers, panel section and door for paint work and proper fit.
- Check for smooth and proper movement of racking mechanisms for alignment, shutters, rollers, rails and guides.
- Check for proper alignment of the breaker primary and secondary contacts.
- Check operation of all mechanical interlocks.
- Check tightness of all bolted connections (torque wrench method).
- Check bus and supports for defects such as cracked welds, chipped porcelain, cracked insulation, etc., and free of dust accumulation.
- Verify that all front panel mounted devices (meters, push buttons, switches, indicator lamps, mimic buses, etc.) are installed as per drawings
- Perform mechanical check and visual inspection on the circuit breaker.
- Perform mechanical check and visual inspection on disconnect and grounding switches.
- Check for correct breaker position indication.
- Check for correct spring status indication (spring charged/discharged).
- Perform all specific checks on the breaker and spring operating mechanism.
- Check that all control wiring is correct according to the approved drawing and terminal connections are secure.

WIRING AND FERRULING CHECK

- Ensure the numbers on the ferules are from left to right beginning at the terminal block i.e. at the end of the wire and from bottom to top.
- The wire nos. should be checked against the wiring table and the schematic drawing.

5.2 **Testing of CB and Feeder**

Enter the rating plate data in test sheet and compare the CB data with the data contained in the circuit documentation. The following test shall be carried out

1. Operation and alignment Checks of breaker liftingTrolley
2. Tests on the CB
   a. Breaker Manual closing/opening, and manual spring charging
   b. Contact Resistance test
   c. Insulation resistance test before hipot
   d. High Voltage test.
   e. Insulation resistance test after hipot.
   f. Minimum operating voltage for close and trip coil.

g. Breaker operating time. (Only Main Breaker which has Synch. Facilities)
h. Spring charging motor current and time measurement.
i. Stored energy and spring charge mechanism checks.

3. Breaker operation
   a. CB Racking IN and OUT Checks
   b. CB operation in service position mechanical and electrical
   c. CB operation in test position electrical
   d. Functional test of local controls, alarm and Indication
   e. Functional Test of Remote control, alarm, and indication
4. Checks for operation of Auxiliary switches ,limit switches for test, service and
5. Functional check of interlock and limit switches.
6. Electrical control and protection/Measuring Devices
   a. Testing of protection devices
   b. Testing of CT and VT
   c. Testing of Transducers
   d. Testing of Alarm Devices
7. Protective earthing check
8. Commissioning of Heater Circuit
   a. Visual Checks
   b. Measurement of insulation resistance of heater and lamp circuit
   c. Functional checks of thermostat , Heaters,
   d. Measurement of Current and voltage
9. Checks before and After initial energization

5.2.1 **Operation and Alignment Checks of Breaker Lifting Trolley.**

Lifting trolley shall be checked for alignment, correct loading and unloading of the breaker as under

- Aligned the trolley to the breaker roller guides in the cubicle
- Engage the trolley with roller guides
- Check for correct locking and unlocking of trolley with roller guides
- Check for smooth rolling of the breaker in to the trolley
- Check locking of trolley when breaker is boarded on the trolley
- Disconnect the trolley from roller guides

5.2.2 **Tests on Circuit Breaker**

Breaker can be withdrawn from the feeder cubicle and test out side the feeder as this will ease the testing as under

5.2.2.1 **Breaker Manual Closing/Opening and Manual Spring Charging**

Mechanical operation of the breaker is checked as under

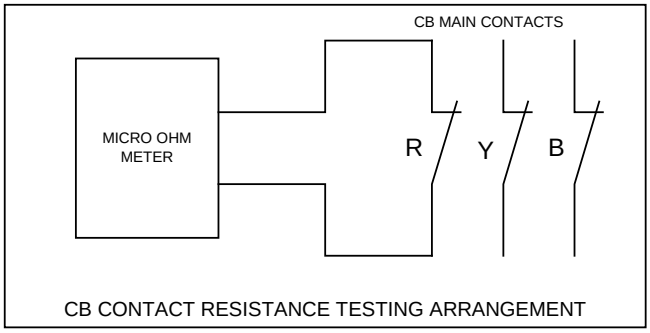
- Charge the spring manually with help of lever.
- Observe the spring charging indicator position, it should be showing spring charged.
- Push the mechanical push button for close. Breaker should be closed.
- Observe the breaker close indicator it should be red or “I”.

- Once the breaker is close spring will get discharged and indicator shows spring discharged.
- Push the mechanical push button for open. Breaker should be. opened.
- Observe the breaker opened indicator it should be Blue or "O".
- Operation shall be done several times.

5.2.2.2 **Contact Resistance Test**

Breaker Contact resistance can be measured using micro ohm meter on each pole of the breaker when breaker is closed

- Connect the current and voltage leads of the micro ohmmeter across the pole of the breaker
- Apply a current of 100 amps and note down the reading
- Repeat the test for other two pole also
- For judgment, the resistance values from one pole to another pole should not vary with big difference and the value should also be cross checked with manufacturer recommendation.



CB CONTACT RESISTANCE TESTING ARRANGEMENT

5.2.2.3 **Insulation Resistance Test Before High Voltage Test**

Before performing high voltage test, perform the Insulation resistance test with 1000Vdc insulation tester.

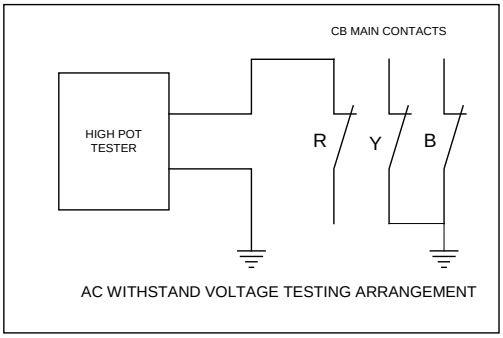
- Close the breaker.
- Connect the phases Y, B to ground and apply the test voltage between phase R and ground and note down the readings.
- Connect the phases B, R to ground and apply the test voltage between phase Y and ground and note down the readings.
- Connect the phases R, Y to ground and apply the test voltage between phase B and ground and note down the readings.
- Open the breaker,
- Connect the phases R, Y, B Cable side to the ground on all the breakers.
- Connect the phases R, Y, B Bus side to the test set.
- Record the corresponding leakage current readings.

5.2.2.4 **High Voltage Test**

Note: high voltage test shall be done only in case breaker is not tested for high voltage along with the bus

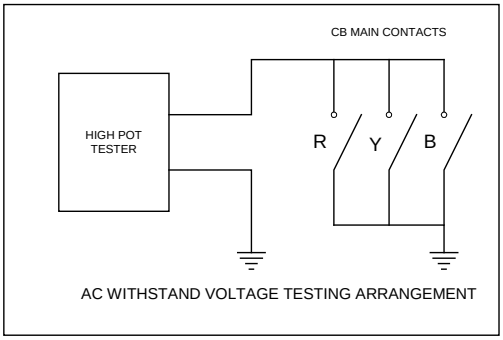
AC high- pot test shall be carried out in accordance with IEC standard at site. The test shall be carried out on LV CB in both close and open position. Test is performed as under

- **When the CB is Closed(shown in figure below)**
  - The test voltage to carry out the test is as per below table.
  - Connect the phases Y, B to ground and apply the test voltage gradually between phase R and ground. Record the leakage current
  - Connect the phases B, R to ground and apply the test voltage gradually between phase Y and ground. Record the leakage current
  - Connect the phases R, Y to ground and apply the test voltage gradually between phase B and ground. Record the leakage current



AC WITHSTAND VOLTAGE TESTING ARRANGEMENT

- **When the CB is Open(as shown in figure below)**
  - Connect the phases R, Y, B Cable side of the breakers to the ground.
  - Connect the phases R, Y, B Bus side of the breaker to the test set.
  - Apply the test voltage gradually between ground and cable side terminal of the breaker and ground
  - Record the corresponding leakage current readings.



AC WITHSTAND VOLTAGE TESTING ARRANGEMENT

5.2.2.5 **Insulation Resistance Test after High Voltage Test**

After performing high voltage test Perform the Insulation resistance test with 1000Vdc insulation tester as describe in 5.2.2

5.2.2.6 **Minimum Operating Voltage for Close and Trip Coil**

5.2.2.6.1 **Close Coil**

Minimum voltage required to close the breaker is measured by applying variable DC voltage to the closing coil of the breaker

- Connect the DC source to the closing coil of the breaker in series with dc ammeter
- Increase the voltage slowly till the breaker get closed , note down voltage and current readings

5.2.2.6.2 **Trip Coil**

Minimum voltage required to Trip the breaker is measured by applying variable DC voltage to the Trip coil of the breaker

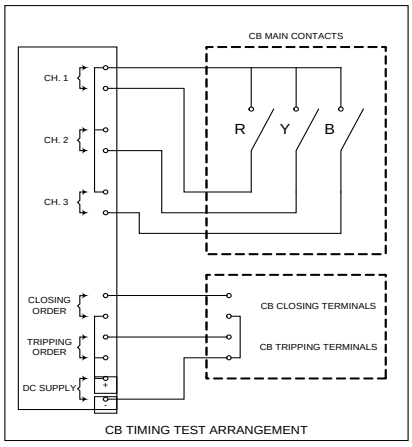
- Connect the DC source to the Trip coil of the breaker in series with dc ammeter
- Increase the voltage slowly till the breaker get opened , note down voltage and current readings
- Test should be repeated for both trip coils

5.2.2.7 **Breaker Operating Time(Only Main Breakers which has Synch Facility)**

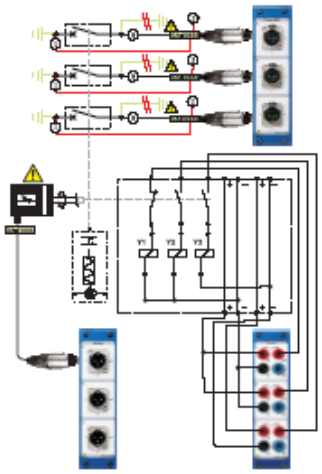
Breaker closing and tripping time can be measured either by a timer or a breaker analyzer

<u>Timing Test Using An Electronic Oscillograph.</u>

- Connect the test set to the CB.
- Perform the following operations at the rated DC
- Close (C) , Open (O) , Close - Open (C – O) & Open – Close – Open (O – C – O)
- Record the corresponding readings.



CB TIMING TEST ARRANGEMENT



5.2.2.8 **Spring Charging Time and Motor Current Measurement**

Spring charging motor current is measured by ammeter or DC clamp meter as under.

- Switch off the CB of motor circuit
- Connect the clamp meter in spring charging motor circuit
- Discharge the spring if it is charged
- Switch on the CB for motor circuit
- Note down the current

5.2.2.9 **Stored Energy and Spring Charge Mechanism Checks**

Stored energy and spring charging is checked by performing several operations.

5.2.3 **Breaker operation**

5.2.3.1 **CB Racking IN and OUT Checks**

CB Racking IN and OUT must be checked for a smooth movement. This should be checked several times

5.2.3.2 **CB Operation in Service Position Mechanical and Electrical**

- Put the breaker in service position
- Perform several Close and Open operation of the breaker manually by operating mechanical buttons
- Performer several Close and Open operation of the breaker electrically both local and remote

5.2.3.3 **CB Operation in Test Position**

- Put the breaker in Test position.
- Perform several Close and Open operation of the breaker manually by operating mechanical buttons.
- Performer several Close and Open operation of the breaker electrically from local.

5.2.3.4 **Functional Test of Local Controls, Alarm and Indication.**

- Alarm and Indication for spring charging once the spring is charged shall be checked.
- Alarm and indication for mal function of the drive should be checked by interrupting the dc power to charging motor while charging.
- Alarm and indication for DC supervision relay shall be checked.
- Alarm and indication for trip coil supervision shall be checked.
- Indication for closing, opening, rack in and rack out of the breaker shall be checked.

5.2.3.5 **Functional Test of Remote Controls, Alarm and Indication.**

- Alarm and Indication for spring charging once the spring is charged shall be checked on remote or DCS
- Alarm and indication for malfunction of the drive should be checked by interrupting the dc power to charging motor while charging shall be checked on DCS or remote

- Alarm and indication for DC supervision relay shall be checked on DCS or remote
- Alarm and indication for trip coil supervision shall be checked on DCS or remote
- Indication for closing, opening, rack in and rack out of the breaker shall be checked on DCS or Remote.

5.2.4 **Checks for Operation of Auxiliary switches, Limit Switches for Test/ Service.**

Contacts of auxiliary switches for breaker position, MOC, earth switch etc shall be checked for its correct operation, and contacts resistance is measured for each and every contacts output.

5.2.5 **Operation of Earth Switch**

Operation of earth switch for closing and opening to be checked, also indication to be checked

5.2.6 **Functional Checks of Interlocks and Limits Switches**

Following Interlock should be checked as per manufacturer instruction manual

- Positive interlock
- Negative interlock
- Spring discharge interlock
- Interference interlock
- Closing spring gag interlock

Limits switches should be checked for its proper operation and function an adjustment is made if required.

5.2.7 **Electrical Control and Protection/Measuring Devices**

5.2.7.1 **Insulation Resitance Measurement for Control Wiring and cabling with 500 V DC**

- Insulation resistance measurement shall be done for control circuit, motor circuit, tripping and closing circuit with help of 500 v dc Insulation resistance tester
- All the external control and protection cables shall be checked for loop check and insulation resistance measurement.

5.2.7.2 **Control Power and Current Measurement**

- Current on MCB of each circuit to be measured when all the devices are in service
- Mixing of voltage between the two circuits should be checked by keeping off MCB of one circuit and checking the voltage on other circuit MCB towards load side +V and –V terminals with respect to ground
- Above test should be done for closing, tripping, charging and power to the devices circuits.

5.2.7.3 **Testing of Protection Devices**

All the protection and monitoring relays to be tested, please refer related test procedure.

5.2.7.4 **Testing of CT and VT**

All the CT's and VT's shall be tested, please refer related test procedure

5.2.7.5 **Testing of Transducer**

All the current, voltage, frequency and power transducer shall be tested, please refer related test procedure

5.2.7.6 **Testing of Alarm Devices**

All the current, voltage, frequency and power transducer shall be tested, please refer related test procedure

5.2.8 **Protective earthing check**

Switch gear protective earthing bond must be earthed in order to afford protection to human beings. Minimum two point's preferable extreme end of ground bus shall be connected to the ground mesh

- Check all protective relays have been grounded
- Check the doors have been grounded

5.2.9 **Checks for interchangeable of CB of same rating for interference interlock**

CB should be checked for interference interlock

- Remove the breaker from the cubicle
- Put the breaker of same rating in to the cubicle, breaker should move freely inside.
- Remove the breaker again from the cubicle
- But the breaker of different rating , breaker should not move inside the cubicle, do not put more force in order not to damage the beaker and interface plate

5.2.10 **Commissioning of heaters**

Space heater shall be commissioned as under.

5.2.10.1 **Visual Checks of Heaters**

- Check the rating of the heater match with the supply voltage.
- Check the KW rating of the heater match with drawing.
- Check the breaker which supplying power to heater circuit for correct rating with respect to total load of the heaters.

5.2.10.2 **Measurement of Insulation Resistance**

Perform insulation resistance measurement on space heater circuit with 500 VDC megger

5.2.10.3 **Measurement of Current and Voltage**

Switch on the breaker and measured the total current and individual heater load with mini clamp meter

5.2.10.4 **Functional Checks of Thermostat**

Check the operation of the thermostat and hygrometer for cut in and cut out operation

5.2.11 **Checks After Initial Energization**

After Energization service load checks to be performed as under

- Current should be measured on all the secondary terminal of the current transformer.
- Phase to phase and phase to ground Voltage measurement should be done on all the phase and core of the voltage transformer.

- Phase sequence checks to be done on Voltage transformer.
- All the measuring devices including protective relay to be checked for their metering function.

6.0 **Documents**

Relevant test sheets to be completed for each and every breaker and its feeder.

7.0 **Attachment**

Test sheet for following equipment to be prepared with respect to their switchgear

7.1 Test sheet for testing of LV CB:

7.2 Test sheet for functional check of LV Feeder:

*****End of the Procedure *****

Testing Procedure

MV Circuit Breaker and Its Feeder

Document No: BSC-TP-MCB01

Rev: 0

TABLE OF CONTENT

1.0 **Task**

The purpose of this procedure is to test, commission and document feeder and MV circuit breaker feeder in metal enclosed switchgear assemblies of 4.16kV and 13.8 kV levels.

2.0 **Preconditions**

2.1 **Work Status**

- Erection has been completed.
- Labelling of the equipment is done

2.2 **Documentation**

- The schematic and single line diagram of the medium voltage switchgear are available
- Relevant test sheet to be made available

2.3 **Personnel**

- 1 Commissioning engineer: Engineer or technician with experience in commissioning of all types of Electrical equipments.
- 1 Helper: skilled worker with adequate on-the-job training.

2.4 **Measuring Instruments and Tools**

- Micro ohm meter 10A and 100A
- Insulation Tester 5000V dc
- High voltage tester AC (up to 50 KV or DC (up to 80 KV)
- Discharge hot stick
- Secondary Injection
- Fluke-2 Nos

3.0 **Precautions**

The work will only proceed when a Permit to Work (PTW) in work permit area has been obtained. The PTW will be kept on site for consultation during the testing works.

Special attention will be given to:

- Due to high voltage being used, adequate safety precautions should be taken to avoid injury to personnel and damage to property.
- Cordoning off specified working area and provision of applicable safety warning sign board.
- Ensure that all the necessary test equipment are made available at the test area and with valid calibration stickers and certificate.
- Hand insulating gloves and grounding sticks / wire jumpers shall be provided for safe handling and draining of residual voltage.
- Breaker should be withdrawn from the cubicle during breaker testing.
- Immediately after testing of each phase, voltage residue shall be drain by using grounding stick / wire which is directly connected to earth.
- Closing of the work permit after completion of the work (if the test area is to be considered in work permit area) is necessary.

4.0 **Scope**

- Testing of CB & Feeder
- Testing of Anti pumping facility

- Operation of CB inside the feeder
- Operation of Earting switch
- Checking CB mounting.

5.0 **Execution**

5.1 **Visual Checks**

- Check nameplate information for correctness.
- Inspect enclosures for proper alignment, foundation fixing and grounding.
- Inspect covers, panel section and door for paint work and proper fit.
- Check for smooth and proper movement of racking mechanisms for alignment, shutters, rollers, rails and guides.
- Check for proper alignment of the breaker primary and secondary contacts.
- Check operation of all mechanical interlocks.
- Check tightness of all bolted connections (torque wrench method).
- Check bus and supports for defects such as cracked welds, chipped porcelain, cracked insulation, etc., and free of dust accumulation.
- Verify that all front panel mounted devices (meters, push buttons, switches, indicator lamps, mimic buses, etc.) are installed as per drawings
- Perform mechanical check and visual inspection on the circuit breaker.
- Perform mechanical check and visual inspection on disconnect and grounding switches.
- Check for correct breaker position indication.
- Check for correct spring status indication (spring charged/discharged).
- Perform all specific checks on the breaker and spring operating mechanism.
- Check that all control wiring is correct according to the approved drawing and terminal connections are secure.

WIRING AND FERRULING CHECK

- Ensure the numbers on the ferules are from left to right beginning at the terminal block i.e. at the end of the wire and from bottom to top.
- The wire nos. should be checked against the wiring table and the schematic drawing.

5.2 **Testing of CB and Feeder**

Enter the rating plate data in test sheet and compare the CB data with the data contained in the circuit documentation. The following test shall be carried out

1. Operation and alignment Checks of breaker liftingTrolley
2. Tests on the CB
   a. Breaker Manual closing/opening, and manual spring charging
   b. Contact gap Measurement for main contact of the VCB
   c. Contact Resistance test
   d. Insulation resistance test before hipot
   e. Vacuum Integrity test on VCB
   f. High Voltage test.
   g. Insulation resistance test after hipot.
   h. Minimum operating voltage for close and trip coil.
   i. Breaker operating time.
   j. Spring charging motor current and time measurement.
   k. Stored energy and spring charge mechanism checks

l. Functional check of C.B Operation counter

3. Breaker operation

a. CB Racking IN and OUT Checks
b. CB operation in service position mechanical and electrical
c. CB operation in test position electrical
d. Anti-pumping functional check
e. Functional test of local controls, alarm and Indication
f. Functional Test of Remote control, alarm, and indication

4. Checks for operation of Auxiliary switches ,limit switches for test, service and
5. Operation of Earth Switch
6. Functional check of interlock and limit switches.
7. Electrical control and protection/Measuring Devices
   a. Testing of protection devices
   b. Testing of CT and VT
   c. Testing of Transducers
   d. Testing of Alarm Devices
8. Protective earthing check
9. Check for interchangeable of CB of same rating for Interference interlock
10. Commissioning of Heater Circuit
    a. Visual Checks
    b. Measurement of insulation resistance of heater and lamp circuit
    c. Functional checks of thermostat , Heaters,
    d. Measurement of Current and voltage
11. Checks before and After initial energization

5.2.1 **Operation and Alignment Checks of Breaker Lifting Trolley.**

Lifting trolley shall be checked for alignment, correct loading and unloading of the breaker as under

- Aligned the trolley to the breaker roller guides in the cubicle
- Engage the trolley with roller guides
- Check for correct locking and unlocking of trolley with roller guides
- Check for smooth rolling of the breaker in to the trolley
- Check locking of trolley when breaker is boarded on the trolley
- Disconnect the trolley from roller guides

5.2.2 **Tests on Circuit Breaker**

Breaker can be withdrawn from the feeder cubicle and test outside the feeder as this will ease the testing as under

5.2.2.1 **Breaker Manual Closing/Opening and Manual Spring Charging**

Mechanical operation of the breaker is checked as under

- Charge the spring manually with help of lever.
- Observe the spring charging indicator position, it should be showing spring charged.
- Push the mechanical push button for close. Breaker should be closed.
- Observe the breaker close indicator it should be red or “I”.

- Once the breaker is close spring will get discharged and indicator shows spring discharged.
- Push the mechanical push button for open. Breaker should be opened.
- Observe the breaker opened indicator it should be Blue or "O".
- Operation shall be done several times.

5.2.2.2 **Contact Gap Measurement for Main Contact VCB**

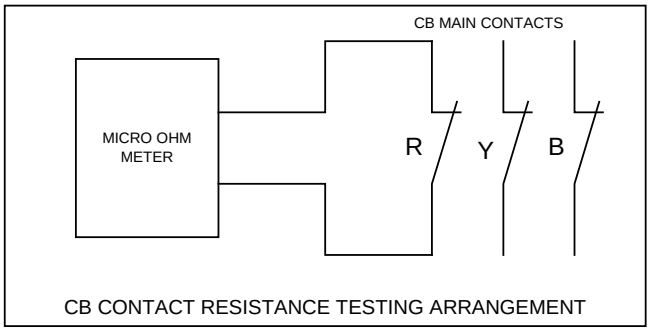
Contact gap measurement is done with the help of dialed caliper as described in Vendor Manual

Curtsey: Cutler and hammer

5.2.2.3 **Contact Resistance Test**

Breaker Contact resistance can be measured using micro ohm meter on each pole of the breaker when breaker is closed

- Connect the current and voltage leads of the micro ohmmeter across the pole of the breaker
- Apply a current of 100 amps and note down the reading
- Repeat the test for other two pole also
- For judgment, the resistance values from one pole to another pole should not vary with big difference and the value should also be cross checked with manufacturer recommendation.



CB CONTACT RESISTANCE TESTING ARRANGEMENT

5.2.2.4 **Insulation Resistance Test Before High Voltage Test**

Before performing high voltage test, perform the Insulation resistance test with 5000Vdc insulation tester.

- Close the breaker.
- Connect the phases Y, B to ground and apply the test voltage between phase R and ground and note down the readings.
- Connect the phases B, R to ground and apply the test voltage between phase Y and ground and note down the readings.
- Connect the phases R, Y to ground and apply the test voltage between phase B and ground and note down the readings.
- Open the breaker,
- Connect the phases R, Y, B Cable side to the ground on all the breakers.
- Connect the phases R, Y, B Bus side to the test set.
- Record the corresponding leakage current readings.

5.2.2.5 **Vacuum Integrity Test**

Vacuum integrity test is done when breaker is opened. In this test a dc high voltage is applied across the interrupter for around 5-10 cycles and observed healthiness of the vacuum interrupter as under

- Breaker shall be kept open
- Tester shall be connected across the vacuum bottle of one of the phase , other two phase to be grounded both at top and bottom
- Test Voltage is applied on the object to be tested for 5 cycles and condition of the vacuum bottle is observed
- Test shall be repeated for other two phases too
- Test voltage value to be noted from the vendor manual.
- Test can be done by using Programma Vacuum integrity tester

Note: the vacuum integrity tester usually are of half wave rectified DC out put which can generate X ray when it is applied across the vacuum bottle, hence maximum distance to be maintained from the test object

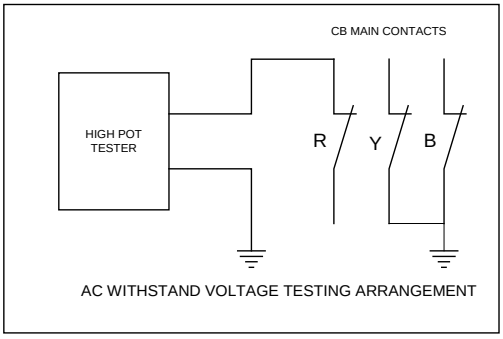
5.2.2.6 **High Voltage Test**

Note: high voltage test shall be done only in case breaker is not tested for high voltage along with the bus

AC high- pot test shall be carried out in accordance with IEC standard at site. The test shall be carried out on MV CB in both close and open position. Test is performed as under

- **When the CB is Closed(shown in figure below)**
  - The test voltage to carry out the test is as per below table.
  - Connect the phases Y, B to ground and apply the test voltage gradually between phase R and ground. Record the leakage current

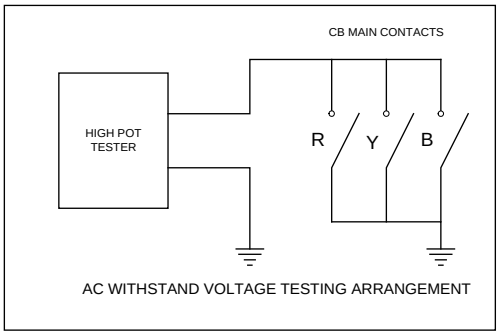
- Connect the phases B, R to ground and apply the test voltage gradually between phase Y and ground. Record the leakage current
- Connect the phases R, Y to ground and apply the test voltage gradually between phase B and ground. Record the leakage current



AC WITHSTAND VOLTAGE TESTING ARRANGEMENT

➢ **When the CB is Open(as shown in figure below)**

- Connect the phases R, Y, B Cable side of the breakers to the ground.
- Connect the phases R, Y, B Bus side of the breaker to the test set.
- Apply the test voltage gradually between ground and cable side terminal of the breaker and ground
- Record the corresponding leakage current readings.



AC WITHSTAND VOLTAGE TESTING ARRANGEMENT

Table-1

Equipment	Rated Voltage, kV	AC Testing					DC Testing	
		High-potential Test		Partial Discharge Test				
		Test Level, kV	Time, Min	Extinction Level, kV	Pulse Magnitude, pC	Time, Min	Test level, kV	Time, Min
Switchgear	4.16	14(19)	1	3.5(3.5)	100(100)	2	N/A	N/A
	13.8	27(36)	1	10.5(10.5)	100(100)	2	N/A	N/A

5.2.2.7 **Insulation Resistance Test after High Voltage Test**

After performing high voltage test Perform the Insulation resistance test with 5000Vdc insulation tester as describe in 5.2.2

5.2.2.8 **Minimum Operating Voltage for Close and Trip Coil**

5.2.2.8.1 **Close Coil**

Minimum voltage required to close the breaker is measured by applying variable DC voltage to the closing coil of the breaker

- Connect the DC source to the closing coil of the breaker in series with dc ammeter
- Increase the voltage slowly till the breaker get closed , note down voltage and current readings

5.2.2.8.2 **Trip Coil**

Minimum voltage required to Trip the breaker is measured by applying variable DC voltage to the Trip coil of the breaker

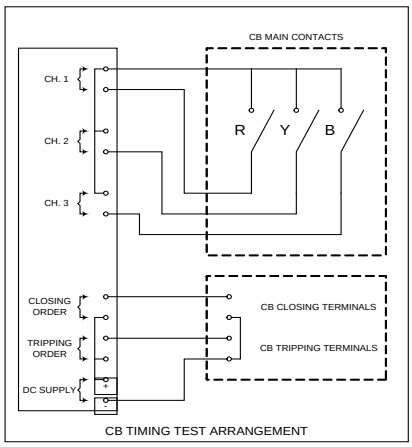
- Connect the DC source to the Trip coil of the breaker in series with dc ammeter
- Increase the voltage slowly till the breaker get opened , note down voltage and current readings
- Test should be repeated for both trip coils

5.2.2.9 **Breaker Operating Time**

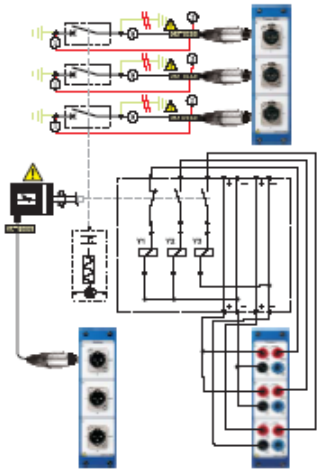
Breaker closing and tripping time can be measured either by a timer or a breaker analyzer

<u>Timing Test Using an Electronic Oscillograph.</u>

- Connect the test set to the CB.
- Perform the following operations at the rated DC
- Close (C) , Open (O) , Close - Open (C – O) & Open – Close – Open (O – C – O)
- Record the corresponding readings.



CB TIMING TEST ARRANGEMENT



5.2.2.10 **Spring Charging Time and Motor Current Measurement**

Spring charging motor current is measured by ammeter or DC clamp meter as under.

- Switch off the CB of motor circuit
- Connect the clamp meter in spring charging motor circuit
- Discharge the spring if it is charged
- Switch on the CB for motor circuit
- Note down the current

5.2.2.11 **Stored Energy and Spring Charge Mechanism Checks**

Stored energy and spring charging is checked by performing several operations.

5.2.2.12 **Functional Check of C.B Operation Counter**

Check the operation of the counter each time breaker is operated.

Reading for the counter shall be recorded as reference

5.2.3 **Breaker operation**

5.2.3.1 **CB Racking IN and OUT Checks**

CB Racking IN and OUT must be checked for a smooth movement. This should be checked several times

5.2.3.2 **CB Operation in Service Position Mechanical and Electrical**

- Put the breaker in service position
- Perform several Close and Open operation of the breaker manually by operating mechanical buttons
- Performer several Close and Open operation of the breaker electrically both local and remote

5.2.3.3 **CB Operation in Test Position**

- Put the breaker in Test position.
- Perform several Close and Open operation of the breaker manually by operating mechanical buttons.
- Performer several Close and Open operation of the breaker electrically from local.

5.2.3.4 **Anti-Pumping Functional Check**

Anti-pump Relay function should be checked as per table below

Step	Operation	Trip signal applied	Breaker Operation	Breaker status
1	Breaker control switch switched to "CLOSE" and held in CLOSE position	NO	Breaker CLOSED	Breaker remains CLOSED
2	Breaker control switch held in "CLOSE" position	YES Electrically	Breaker Trips and does not attempt to RECLOSE	Breaker remains OPENS
3	Breaker control switch returned to NORMAL	NO	None	Breaker remains OPEN
4	Breaker control switch switched to "CLOSE" and held in CLOSE position	NO	Breaker CLOSED	Breaker remains CLOSED
5	Breaker control switch held in "CLOSE" position	YES Mechanically	Breaker Trips and does not attempt to RECLOSE	Breaker OPEN

From the above table it is noted that

- When the breaker is closed and the control switch is held in CLOSE position. The breaker was still closed.
- when the breaker was tripped either Manually or Electrically, the breaker does not attempt to re close if a permanent closing signal is applied

5.2.3.5 **Functional Test of Local Controls, Alarm and Indication.**

- Alarm and Indication for spring charging once the spring is charged shall be checked.
- Alarm and indication formal function of the drive should be checked by interrupting the dc power to charging motor while charging.
- Alarm and indication for DC supervision relay shall be checked.
- Alarm and indication for trip coil supervision shall be checked.

- Indication for closing, opening, rack in and rack out of the breaker shall be checked.

5.2.3.6 **Functional test of Remote Controls, Alarm and Indication.**

- Alarm and Indication for spring charging once the spring is charged shall be checked on remote or DCS
- Alarm and indication formal function of the drive should be checked by interrupting the dc power to charging motor while charging shall be checked on DCS or remote
- Alarm and indication for DC supervision relay shall be checked on DCS or remote
- Alarm and indication for trip coil supervision shall be checked on DCS or remote
- Indication for closing, opening, rack in and rack out of the breaker shall be checked on DCS or Remote.

5.2.4 **Checks for Operation of Auxiliary Switches, Limit Switches for Test/ Service.**

Contacts of auxiliary switches for breaker position, MOC, earth switch etc shall be checked for its correct operation, and contacts resistance is measured for each and every contacts output.

5.2.5 **Operation of Earth Switch**

Operation of earth switch for closing and opening to be checked, also indication to be checked

5.2.6 **Functional Checks of Interlocks and Limits Switches**

Following Interlock should be checked as per manufacturer instruction manual

- Positive interlock
- Negative interlock
- Spring discharge interlock
- Interference interlock
- Closing spring gag interlock

Limits switches should be checked for its proper operation and function an adjustment is made if required.

5.2.7 **Electrical control and protection/Measuring Devices**

5.2.7.1 **Insulation Resistance Measurement for Control Wiring and cabling with 500 V DC**

- Insulation resistance measurement shall be done for control circuit, motor circuit , tripping and closing circuit with help of 500 v dc Insulation resistance tester
- All the external control and protection cables shall be checked for loop check and insulation resistance measurement.

5.2.7.2 **Control Power and Current Measurement**

- Current on MCB of each circuit to be measured when all the devices are in service
- Mixing of voltage between the two circuits should be checked by keeping off MCB of one circuit and checking the voltage on other circuit MCB towards load side +V and –V terminals with respect to ground

- Above test should be done for closing, tripping, charging and power to the devices circuits.

5.2.7.3 **Testing of Protection Devices**

All the protection and monitoring relays to be tested, please refer related test procedure.

5.2.7.4 **Testing of CT and VT**

All the CT's and VT's shall be tested, please refer related test procedure

5.2.7.5 **Testing of Transducer**

All the current, voltage, frequency and power transducer shall be tested, please refer related test procedure

5.2.7.6 **Testing of Alarm Devices**

All the current, voltage, frequency and power transducer shall be tested, please refer related test procedure

5.2.8 **Protective Earthing Check**

Switch gear protective earthing bond must be earthed in order to afford protection to human beings. Minimum two point's preferable extreme end of ground bus shall be connected to the ground mesh

- Check all protective relays have been grounded
- Check the doors have been grounded

5.2.9 **Checks for interchangeable of CB of same rating for interference interlock**

CB should be checked for interference interlock

- Remove the breaker from the cubicle
- Put the breaker of same rating in to the cubicle, breaker should move freely inside.
- Remove the breaker again from the cubicle
- But the breaker of different rating , breaker should not move inside the cubicle, do not put more force in order not to damage the beaker and interface plate

5.2.10 **Commissioning of Heaters**

Space heater shall be commissioned as under.

5.2.10.1 **Visual Checks of Heaters**

- Check the rating of the heater match with the supply voltage.
- Check the KW rating of the heater match with drawing.
- Check the breaker which supplying power to heater circuit for correct rating with respect to total load of the heaters.

5.2.10.2 **Measurement of Insulation Resistance**

Perform insulation resistance measurement on space heater circuit with 500 VDC megger

5.2.10.3 **Measurement of Current and Voltage**

Switch on the breaker and measured the total current and individual heater load with mini clamp meter

5.2.10.4 **Functional Checks of Thermostat**

Check the operation of the thermostat and hygrometer for cut in and cut out operation

5.2.11 **Checks After Initial Energization**

After energization service load checks to be performed as under

- Current should be measured on all the secondary terminal of the current transformer.
- Phase to phase and phase to ground Voltage measurement should be done on all the phase and core of the voltage transformer.
- Phase sequence checks to be done on Voltage transformer.
- All the measuring devices including protective relay to be checked for their metering function.

6.0 **Documents**

Relevant test sheets to be completed for each and every breaker and its feeder.

7.0 **Attachment**

Test sheet for following equipment to be prepared with respect to their switchgear

7.1 Test sheet for testing of MV CB:

7.2 Test sheet for functional check of MV Feeder:

***End of the Procedure ***

Testing Procedure

MV Disconnect Switch

Document No: BSC-TP-MDS01
Rev: 0

TABLE OF CONTENT

1.0 **Task**

The purpose of this procedure is to test, commission and document feeder and MV Disconnect and Ground switch in metal enclosed switchgear assemblies of 4.16kV and 13.8 kV levels.

2.0 **Preconditions**

2.1 **Work status**

- Erection has been completed.
- Labelling of the equipment and designation of live enclosed plant sections has been carried out.

2.2 **Documentation**

- The schematic and single line diagram of the medium voltage switchgear are available
- Commissioning checklists TS-MD01

2.3 **Personnel**

- 1 Commissioning engineer: Engineer or technician with experience in commissioning of all types of the electrical equipments.
- 1 Helper: skilled worker with adequate on-the-job training.

2.4 **Measuring Instruments and Tools**

- Micro ohm meter 10A and 100A
- Insulation Tester 5000V dc
- High voltage tester AC (up to 50 KV or DC (up to 80 KV)
- Discharge hot stick

3.0 **Precautions**

The work will only proceed when a Permit to Work (PTW) in work permit area has been obtained. The PTW will be kept on site for consultation during the testing works.

Special attention will be given to:

- Due to high voltage being used, adequate safety precautions should be taken to avoid injury to personnel and damage to property.
- Cordoning off specified working area and provision of applicable safety warning sign board.
- Ensure that all the necessary test equipment are made available at the test area and with valid calibration stickers and certificate.
- Hand insulating gloves and grounding sticks / wire jumpers shall be provided for safe handling and draining of residual voltage.
- Breaker should be withdrawn from the cubicle during breaker testing.
- Immediately after testing of each phase, voltage residue shall be drain by using grounding stick / wire which is directly connected to earth.
- Closing of the work permit after completion of the work (if the test area is to be considered in work permit area) is necessary.

4.0 **Scope**

- Testing of Disconnect switch

- Testing Ground Switch
- Operation of Disconnect switch
- Checking Disconnect switch mounting.

5.0 **Execution**

5.1 **Visual Checks**

- Check nameplate information for correctness.
- Inspect enclosures for proper alignment, foundation fixing and grounding.
- Inspect covers, panel section and door for paint work and proper fit.
- Check for smooth and proper movement of closing and opening mechanisms for alignment,.
- Check operation of all mechanical interlocks.
- Check tightness of all bolted connections (torque wrench method).
- Check bus and supports for defects such as cracked welds, chipped porcelain, cracked insulation, etc., and free of dust accumulation.
- Verify that all front panel mounted devices (meters, push buttons, switches, indicator lamps, mimic buses, etc.) are installed as per drawings.
- Perform mechanical check and visual inspection on the Disconnect switch.
- Check that all control wiring is correct according to the approved drawing and terminal connections are secure.
- Check simultaneous closing of all the three poles.
- Check that end of travels stops are correctly adjusted, set and locked in position.
- Check open gap and minimum clearance between phases and ground.
- Check that the switch can be pad locked in both closed and open position.
- Check that switch operating handle is grounded properly.

WIRING AND FERRULING CHECK

- Ensure the numbers on the ferules are from left to right beginning at the terminal block i.e. at the end of the wire and from bottom to top.
  The wire nos. should be checked against the wiring table and the schematic drawing.

5.2 **Testing of Disconnect and Feeder**

Enter the rating plate data in test sheet and compare the DS data with the data contained in the circuit documentation. The following test shall be carried out

1. Test on Disconnect switch
   a. Contact Resistance test.
   b. Insulation resistance test before hipot.
   c. High Voltage test.
   d. Insulation resistance test after hipot

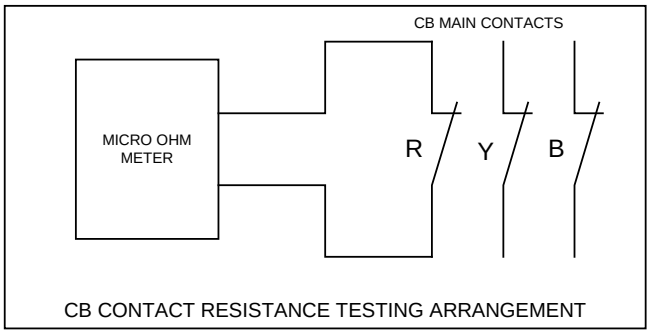
e. Switch operating time /motor current measurement
f. Minimum voltage operation (open/close) at 90V dc.

2. Disconnect switch operation
a. Disconect Switch operation at rated Voltage.
b. Functional test of local controls, alarm and indication.
c. Functional test of Remote controls, alarm and indication.
d. Correct settings of motor limit switches.
e. Check correct operation of auxiliary switches.
f. Automatic disconnection of supply to the motor on insertion of handle
g. Operation of Earth Switch.
h. Correct Functioning of Interlocks
i. Electrical control and protection/Measuring Devices
j. Insulation resistance measurement for control circuit
k. Control power and current measurement.
l. Commissioning of Heater Circuit
m. Visual Checks
n. Measurement of insulation resistance of heater and lamp circuit
o. Functional checks of thermostat , Heaters,
p. Measurement of Current and voltage
q. Protective earthing check.

5.2.1 **Contact Resistance Test.**

Disconnect switch Contact resistance can be measured using micro ohm meter on each pole of the Disconnect switch when it is closed

- Connect the current and voltage leads of the micro ohmmeter across the pole of the disconnect switch.
- Apply a current of 100 amps and note down the reading
- Repeat the test for other two pole also
- For judgment, the resistance values from one pole to another pole should not vary with big difference and the value should also be cross checked with manufacturer recommendation.



CB CONTACT RESISTANCE TESTING ARRANGEMENT

5.2.2 **Insulation Resistance Test before Hipot.**

Before performing high voltage test, perform the Insulation resistance test with 5000Vdc insulation tester.

- Close the disconnect switch.
- Connect the phases Y, B to ground and apply the test voltage between phase R and ground and note down the readings.
- Connect the phases B, R to ground and apply the test voltage between phase Y and ground and note down the readings.
- Connect the phases R, Y to ground and apply the test voltage between phase B and ground and note down the readings.

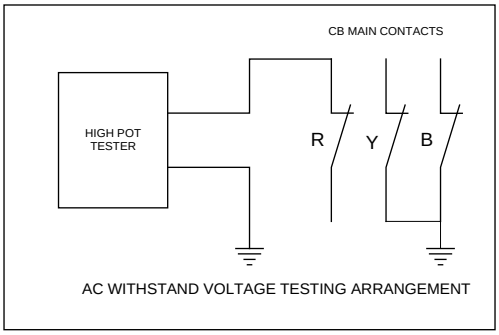
5.2.3 **High Voltage Test**

Note: high voltage test is to be done only in case disconnect switch is not tested for high voltage along with the bus.

AC high- pot test shall be carried out in accordance with IEC standard at site. The test shall be carried out on MV Disconnect switch in close position. Test is performed as under

➢ **When the Disconnect Switch is Closed(shown in figure below)**

- The test voltage to carry out the test is as per below table.
- Connect the phases Y, B to ground and apply the test voltage gradually between phase R and ground. Record the leakage current
- Connect the phases B, R to ground and apply the test voltage gradually between phase Y and ground. Record the leakage current
- Connect the phases R, Y to ground and apply the test voltage gradually between phase B and ground. Record the leakage current



AC WITHSTAND VOLTAGE TESTING ARRANGEMENT

Table-1

Equipment	Rated Voltage, kV	AC Testing					DC Testing	
		High-potential Test		Partial Discharge Test				
		Test Level, kV	Time, Min	Extinction Level, kV	Pulse Magnitude, pC	Time, Min	Test level, kV	Time Min
Switchgear	4.16	14(19)	1	3.5(3.5)	100(100)	2	N/A	N/A
	13.8	27(36)	1	10.5(10.5)	100(100)	2	N/A	N/A

5.2.4 **Insulation Resistance test after hipot**

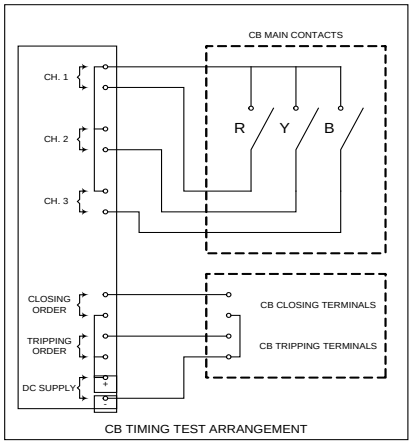
After performing high voltage test Perform the Insulation resistance test with 5000Vdc insulation tester as describe in 5.2.2

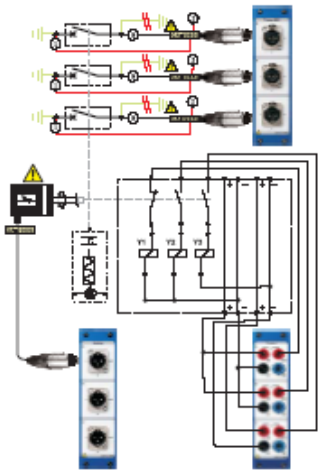
5.2.5 **Switch Operating Time/Motor Current Measurement**

DS closing and tripping time can be measured either by a timer or a breaker analyzer

Timing Test Using An Electronic Oscillo graph.

- Connect the test set to the DS.
- Perform the following operations at the rated DC
- Close (C) , Open (O)
- Record the corresponding readings.
- From the graph check the simultaneous touch of the contact of all the phases





5.2.6 **Minimum Voltage Operation (Open/Close) at 90V dc.**

5.2.6.1 **Closing**

Minimum voltage operation is checked at 90 volts

- Connect the DC source to the closing circuit of the disconnect switch in series with dc ammeter
- Maintained voltage at 90 volts and check the operation of the disconnect switch , note down the current

5.2.6.2 **Opening**

Minimum voltage operation is checked at 90 volts

- Connect the DC source to the opening circuit of the disconnect switch in series with dc ammeter
- Maintained voltage at 90 volts and check the operation of the disconnect switch , note down the current

5.2.7 **Disconnect Switch Operation Tests.**

5.2.7.1 **Switch Operation at Rated Voltage**

- Perform several Close and Open operation of the Disconnect switch manually by operating mechanical Levers
- Performer several Close and Open operation of the disconnect switch electrically both local and remote

5.2.7.2 **Functional Test of Local Controls, alarm and indication.**

- Alarm and indication for DC supervision relay shall be checked..
- Indication for closing, opening, of the disconnect switch shall be checked.

5.2.7.3 **Functional test of Remote Controls, alarm and Indication.**

- Alarm and indication for DC supervision relay shall be checked on DCS or remote
- Indication for closing, opening, of the disconnect switch shall be checked on DCS or Remote.

5.2.7.4 **Correct Settings of Motor Limit Switches.**

Limits switches should be checked for its proper operation and function an adjustment is made if required.

5.2.7.5 **Check Correct Operation of auxiliary Switches.**

Contacts of auxiliary switches for switch operation, earth switch etc shall be checked for its correct operation, and contacts resistance is measured for each and every contacts output.

5.2.7.6 **Automatic Disconnection of Supply to the Motor on Insertion of Hand**

While Operating Handle is inserted in to the notch, operation of the disconnect switch checked electrically, no operation should occur.

5.2.8 **Operation of Earth Switch.**

Operation of earth switch for closing and opening to be checked, also indication to be checked

5.2.9 **Correct Functioning of Interlocks**

Interlock should be checked as per manufacturer instruction manual

5.2.10 **Electrical control and protection/Measuring Devices**

5.2.10.1 **Insulation Resitance measurement for control wiring and cabling with 500 V DC**

Insulation resistance test for control wiring and auxiliary circuit should be done with 500V dc Insulation tester.

5.2.10.2 **Control Power and Current Measurement.**

- Current on MCB of each circuit to be measured when all the devices are in service
- Mixing of voltage between the two circuits should be checked by keeping off MCB of one circuit and checking the voltage on other circuit MCB towards load side +V and –V terminals with respect ground

5.2.11 **Commissioning of Heaters**

Space heater shall be commissioned as under.

5.2.11.1 **Visual Checks of Heaters**

- Check the rating of the heater match with the supply voltage.
- Check the KW rating of the heater match with drawing.
- Check the breaker which supplying power to heater circuit for correct rating with respect to total load of the heaters.

5.2.11.2 **Measurement of Insulation Resistance**

Perform insulation resistance measurement on space heater circuit with 500 VDC megger

5.2.11.3 **Measurement of Current and Voltage**

Switch on the breaker and measured the total current and individual heater load with mini clamp meter

5.2.11.4 **Functional Checks of Thermostat**

Check the operation of the thermostat and hygrometer for cut in and cut out operation

5.2.12 **Protective Earthing Check**

Switch gear protective earthing bond must be earthed in order to afford protection to human beings.

6.0 **Documents**

Test Sheet shall be completed.

7.0 **Attachment**

7.1 **Test Sheet for MV Disconnect Switch**

7.2 **Test Sheet for MV Earth Switch**

***End of the Procedure ***

Testing Procedure

LV Bus Bar

Document No: BSC-TP-LBB01
Rev: 0

TABLE OF CONTENT

1.0 Task

The purpose of this procedure is to test and document the integrity bus bar of metal enclosed switchgear assemblies of 480V levels using an ac/dc source.

2.0 Preconditions

2.1 Work Status

- Erection has been completed.
- Labelling of the equipment and designation of live enclosed plant sections has been carried out.

2.2 Documentation

- The bus bar diagram of the electrical equipment cabinets are available
- Relevant test sheet to be made available.

2.3 Personnel

- 1 Commissioning engineer: Engineer or technician with experience in commissioning of all types of the electrical equipments
- 1 Helper: skilled worker with adequate on-the-job training.

2.4 Measuring Instruments and Tools

- Torque wrench
- Micro ohm meter 10A and 100A
- Insulation Tester 5000V dc
- High voltage tester AC (up to 2 KV)
- Discharge hot stick

3.0 Precautions

The work will only proceed when a Permit to Work (PTW) in work permit area has been obtained. The PTW will be kept on site for consultation during the testing works.

Special attention will be given to:

- Due to high voltage being used, adequate safety precautions should be taken to avoid injury to personnel and damage to the property.
- Cordoning off specified working area and provision of applicable safety warning sign board.
- Ensure that all the necessary test equipment are made available at the test area and with valid calibration stickers and certificate.
- Hand insulating gloves and grounding sticks / wire jumpers shall be provided for safe handling and draining of residual voltage.
- Switch gear should be disconnected from the bus duct by removing the flexible braid. The bus bur of the bus duct should be connected to ground.
- Ensure that all voltage transformers are disconnected for the duration of the test and that all current transformers are short-circuited.
- Immediately after testing of each phase, voltage residue shall be drain by using grounding stick / wire which is directly connected to earth.
- Test equipment operation shall be in accordance with the manufacturer's instructions.
- Closing of the work permit after completion of the work (if the test area is to be considered in work permit area) is necessary.

4.0 Scope

- Testing of bus bar
- High voltage test on complete switch gear assembly
- Circuit resistance for complete switch gear assembly
- Checking that the bus bar mounting position is correct,
- Checking of the phase and continuity
- Checking of correct earthing,

5.0 Execution

5.1 Visual Checks

- Check the bus bar for any damage and that they are bolted correctly,
- Check the insulating boots on joints
- Inspect for cleanliness, connections etc.
- Check that complete bus bar is insulated and no damage of insulation
- Check that all bus bar joints are silver plated
- Check the enclosure for paint work

5.2 Testing the Bus Bar

Enter the rating plate data in test sheet and compare the switch gear data with the data contained in the circuit documentation. The following test shall be carried out

1. Bus continuity and phasing test
2. Torque test
3. Contact Resitance test
4. Main Circuit Contact Resitance test
5. Insulation resistance test before hipot
6. High Voltage test
7. Insulation resistance test after hipot
8. Protective earthing check

5.2.1 Bus Continuity and Phasing Test

Continuity and phasing test can be done by simple ohm meter or fluk

Connect the extreme end of the single phase of the bus with ground and check the resistance between phases and ground. All the phases should read infinity except the grounded phase. Thus the phase is identified and continuity is checked. Repeat the test on remaining two phases.

5.2.2 Torque Test

Torque shall be applied to all joints made at site. The bolts shall be tightened according to manufacturer instruction after the bus bar erection completion. Spot check shall be carried out using a calibrated torque wrench.

Following is reference in case data from manufacturer is not available

Bolt tighten maximum value,

Bolt Size	Maximum value
M 6	8 Nm
M 8	20 Nm
M 10	40 Nm
M 12	70 Nm
M 16	140 Nm

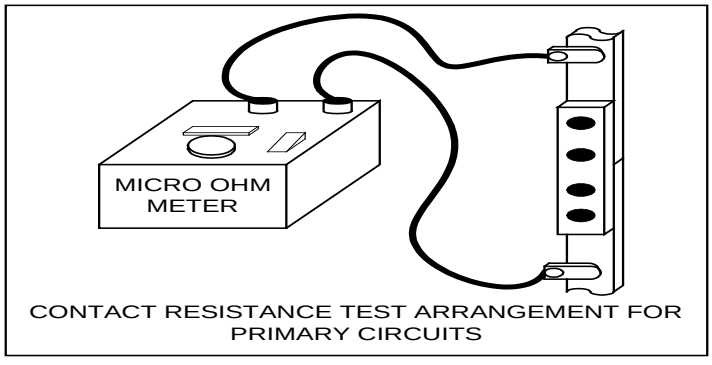
Tolerance: ± 20 %

5.2.3 Contact Resistance Test

The contact resistance test will be carried out after torque completion and will be applied to all bus bar joints. The test requires to measure very small fluctuations in resistance while simulating actual operating conditions. A DC power source will inject the test current up to 100 A and digital voltmeter will measure the voltage drop across the joints under test, Thus V/I gives Resistance

Contact resistance can also be measured using micro ohm meter as shown in figure below.

- Check the resistance for all the bus bar joints using micro-ohm meter 100 A.
- Check the overall resistance of the bus bar for each phase using micro-ohm meter 100A.

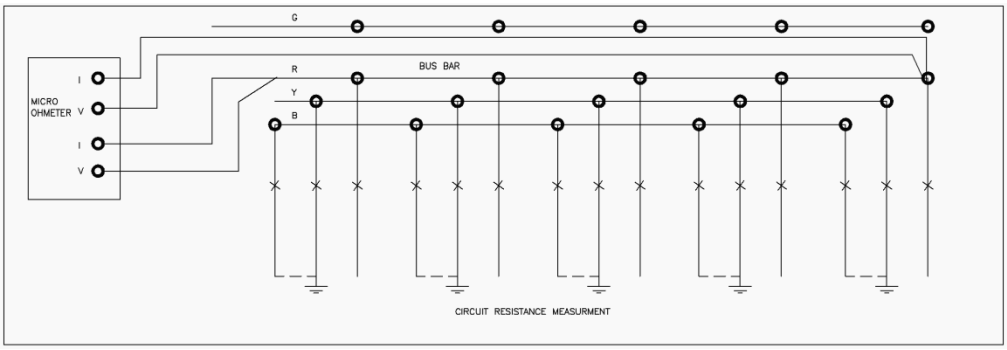


CONTACT RESISTANCE TEST ARRANGEMENT FOR PRIMARY CIRCUITS

5.2.4 Main Circuit Contact Resistance Test.

- The main circuit resistance test shall be performed by 10A or 100 Ampere DC micro-ohmmeter from panel to panel on each phase from cable spouts with all circuit breakers racked in service and close position.

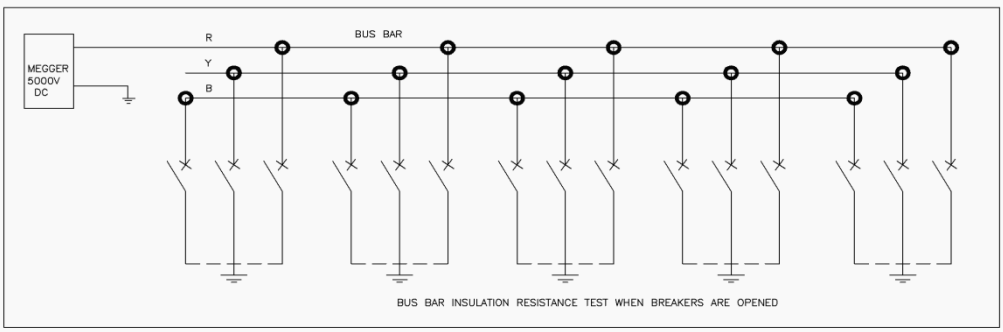
- For judgment, the resistance values from panel to panel should not vary too much if the number of joints and length of bus bar remains the same.
- Contact Resistance Measurement shall be performed on all the bus including ground bus

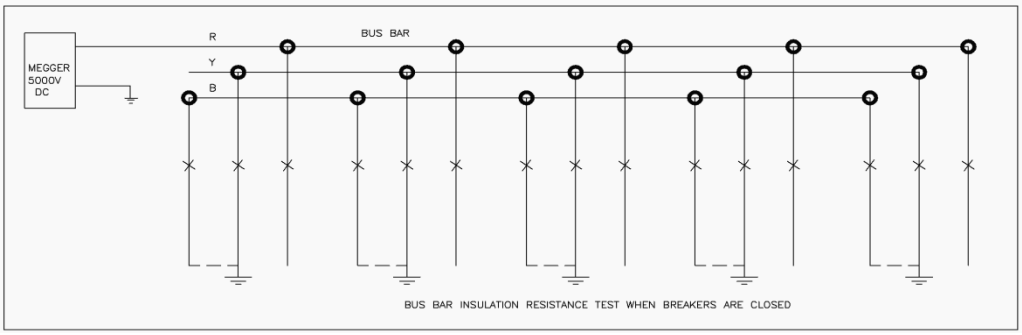


5.2.5 Insulation Resistance Test Before High Voltage Test

Before performing high voltage test perform the Insulation resistance test with 1000Vdc for LV switch gear as under

- Close all the breakers in service position make sure outgoing cables and bus duct is still not connected.
- Isolate the VTs and short the CTs secondary of all the feeders
- Connect the phases Y, B to ground and apply the test voltage between phase R and ground and note down the readings.
- Connect the phases B, R to ground and apply the test voltage between phase Y and ground and note down the readings.
- Connect the phases R, Y to ground and apply the test voltage between phase B and ground and note down the readings.
- Open all the breakers in service position,
- Connect the phases R, Y, B Cable side to the ground on all the breakers.
- Connect the phases R, Y, B Bus side to the test set.
- Record the corresponding leakage current readings.





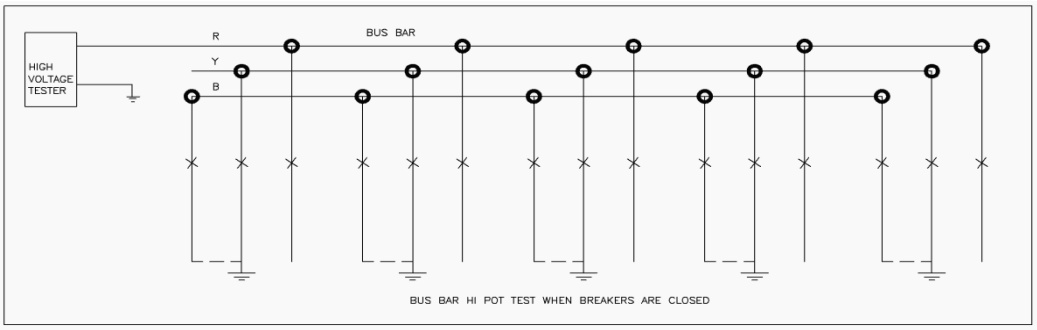
5.2.6 High Voltage Test

AC high- pot test shall be carried out in accordance with IEC standard at site. The test shall be carried out on LV Bus bar with all CB's racked in close and open position. Test is performed as under

- Incoming and outgoing cables disconnected
- Voltage transformers primary disconnected.
- Current transformer secondary shorted.
- Electronic component of measuring and control equipment, if assembled to be removed to avoid damages.
- Test voltage for LV switch gear is 2kv.

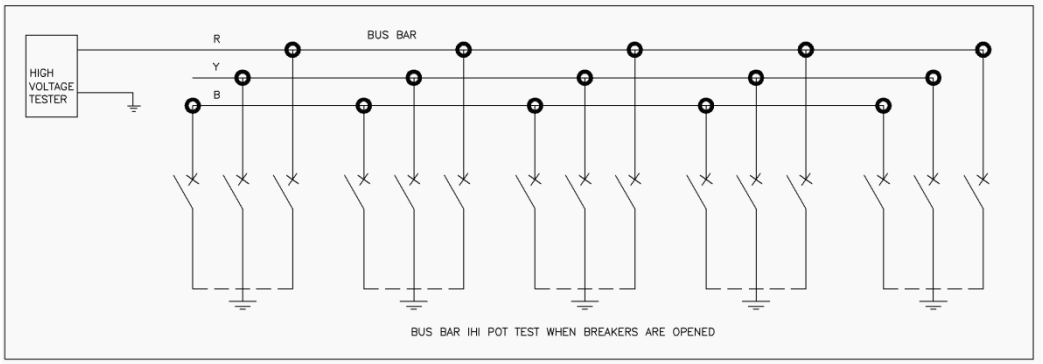
➢ **When all CBs are Closed**

- Connect the phases Y, B to ground and apply the test voltage between phase R and ground. Record the leakage current
- Connect the phases B, R to ground and apply the test voltage between phase Y and ground. Record the leakage current
- Connect the phases R, Y to ground and apply the test voltage between phase B and ground. Record the leakage current



➢ **When all CBs are Opened**

- Connect the phases R, Y, B Cable side of all the breakers to the ground.
- Connect the phases R, Y, B Bus side to the test set.
- Record the corresponding leakage current readings.



5.2.7 Insulation Resistance Test after High Voltage Test

After performing high voltage test Perform the Insulation resistance test with 1000Vdc for LV switch gear as describe in 5.2.5

5.2.8 Checking the Protective Earthing

Switch gear protective earthing bond must be earthed in order to afford protection to human beings. Protective earthing bond should be checked for it continuity between each panel, it is preferable to check total resistance of grounding bus.

6.0 Documentation

Relevant test sheets to be completed for each set Bus Bar of the switchgear..

7.0 Attachment

Test sheet for following equipment to be prepared with respect to their Switchgear

7.1 Contact Resistance test of Bus Bar for LV SWBD along with
7.2 High Voltage test of Bus Bar for LV SWBD along with CBs

*****End of the Procedure *****

Testing Procedure

MV Bus Bar

Document No: BSC-TP-MBB01
Rev: 0

TABLE OF CONTENT

1.0 Task

The purpose of this procedure is to test and document the integrity bus bar of metal enclosed switchgear assemblies of 4.16kV and 13.8 kV levels using an ac/dc source.

2.0 Preconditions

2.1 Work Status

- Erection has been completed.
- Labelling of the equipment is done

2.2 Documentation

- The bus bar diagram of the switch gear is available
- Relevant Test sheets to be made available

2.3 Personnel

- 1 Commissioning engineer: Engineer or technician with experience in commissioning of all types of the electrical equipments
- 1 Helper: skilled worker with adequate on-the-job training.

2.4 Measuring Instruments and Tools

- Torque wrench
- Micro ohm meter 10A and 100A
- Insulation Tester 5000V dc
- High voltage tester AC (up to 50 KV or DC (up to 80 KV)
- Discharge hot stick

3.0 Precautions

The work will only proceed when a Permit to Work (PTW) in work permit area has been obtained. The PTW will be kept on site for consultation during the testing works.

Special attention will be given to:

- Due to high voltage being used, adequate safety precautions should be taken to avoid injury to personnel and damage to the property.
- Cordoning off specified working area and provision of applicable safety warning sign board.
- Ensure that all the necessary test equipment are made available at the test area and with valid calibration stickers and certificate.
- Hand insulating gloves and grounding sticks / wire jumpers shall be provided for safe handling and draining of residual voltage.
- Switch gear should be disconnected from the bus duct by removing the flexible braid. The bus bur of the bus duct should be connected to ground.

- Ensure that all voltage transformers are disconnected for the duration of the test and that all current transformers are short-circuited.
- Immediately after testing of each phase, voltage residue shall be drain by using grounding stick / wire which is directly connected to earth.
- Test equipment operation shall be in accordance with the manufacturer's instructions.
- Closing of the work permit after completion of the work (if the test area is to be considered in work permit area) is necessary.

4.0 Scope

- Testing of bus bar
- High voltage test on complete switch gear assembly
- Circuit resistance for complete switch gear assembly
- Checking that the bus bar mounting position is correct,
- Checking of the phase and continuity
- Checking of correct earthing,

5.0 Execution

5.1 Visual Checks

- Check the bus bar for any damage and that they are bolted correctly
- Check the insulator for any cracks or damage
- Check the insulating boots on joints are in place
- Check that complete bus bar is insulated and no damage of insulation
- Check that all bus bar joints are silver plated
- Check the enclosure for paint work
- Check the anti-condensation heaters are mounted at the bottom

5.2 Testing the Bus Bar

Enter the rating plate data in test sheet and compare the switch gear data with the data contained in the circuit documentation. The following test shall be carried out

1. Torque test
2. Bus continuity and phasing test
3. Contact Resistance test
4. Main Circuit Contact Resistance test
5. Insulation resistance test before hipot
6. High Voltage test
7. Insulation resistance test after hipot
8. Protective earthing check

5.2.1 Torque Test

Torque shall be applied to all joints made at site. The bolts shall be tightened according to manufacturer instruction after the bus bar erection completion. Spot check shall be carried out using a calibrated torque wrench.

Following is reference in case data from manufacturer is not available

Bolt tighten maximum value,

Bolt Size	Maximum value
M 6	8 Nm
M 8	20 Nm
M 10	40 Nm
M 12	70 Nm
M 16	140 Nm

Tolerance: ± 20 %

5.2.2 Bus Continuity and Phasing Test

Continuity and phasing test can be done by simple ohm meter or fluke.

Connect the extreme end of the single phase of the bus with ground and check the resistance between phases and ground. All the phases should read infinity except the grounded phase. Thus the phase is identified and continuity is checked. Repeat the test on remaining two phases.

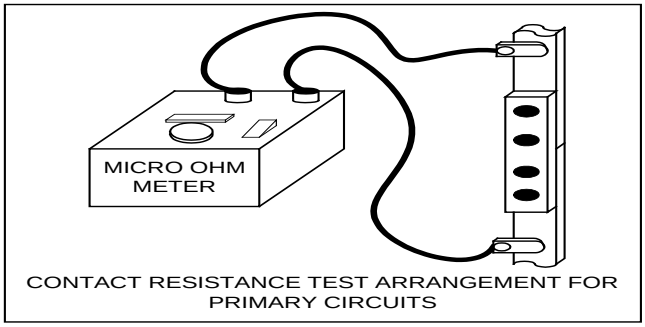
5.2.3 Contact Resistance Test

The contact resistance test will be carried out after torque completion and will be applied to all bus bar joints. The test requires to measure very small fluctuations in resistance while simulating actual operating conditions. A DC power source will inject the test current up to 100 A and digital voltmeter will measure the voltage drop across the joints under test, Thus V/I gives Resistance

Contact resistance can also be measured using micro ohm meter as shown in figure below.

- Check the resistance for all the bus bar joints using micro-ohm meter 100 A.

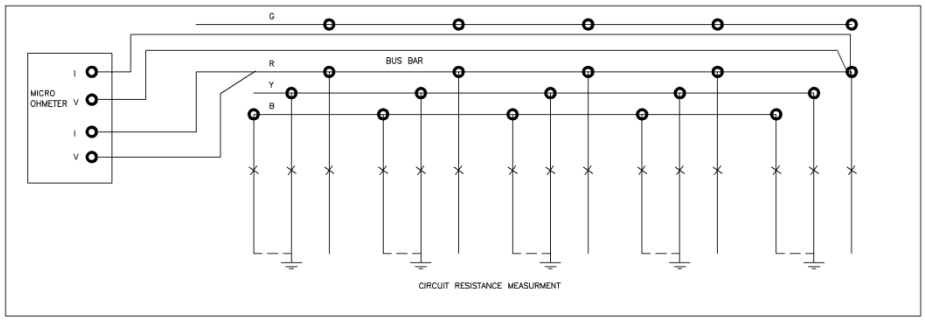
- Check the overall resistance of the bus bar for each phase using micro-ohm meter 100A.



CONTACT RESISTANCE TEST ARRANGEMENT FOR PRIMARY CIRCUITS

5.2.4 Main Circuit Contact Resistance Test.

- The main circuit resistance test shall be performed by 10A or 100 Ampere DC micro-ohmmeter from panel to panel on each phase from cable spouts with all circuit breakers racked in service and close position.
- For judgment, the resistance values from panel to panel should not vary too much if the number of joints and length of bus bar remains the same.
- Contact Resistance Measurement shall be performed on all the bus including ground bus



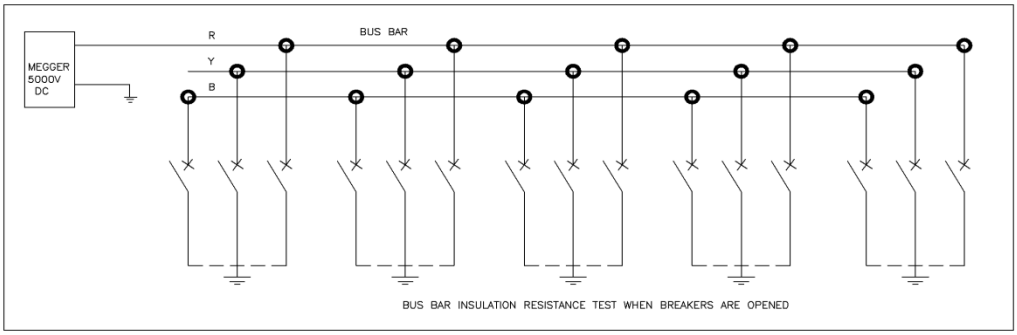
CIRCUIT RESISTANCE MEASURMENT

5.2.5 Insulation Resistance Test Before High Voltage Test

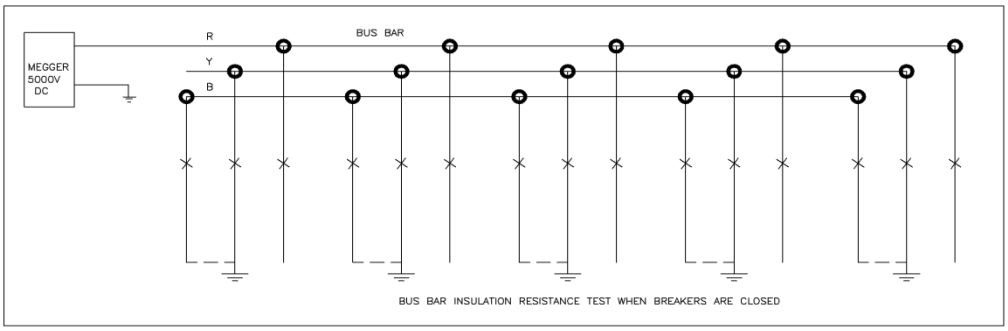
Before performing high voltage test Perform the Insulation resistance test with 1000Vdc for LV switch gear and 5000Vdc for MV switch gear as under

- Close all the breakers in service position make sure out going cables and bus duct is still not connected.
- Isolate the VTs and short the CTs secondary of all the feeders
- Connect the phases Y, B to ground and apply the test voltage between phase R and ground and note down the readings.
- Connect the phases B, R to ground and apply the test voltage between phase Y and ground and note down the readings.

- Connect the phases R, Y to ground and apply the test voltage between phase B and ground and note down the readings.
- Open all the breakers in service position,
- Connect the phases R, Y, B Cable side to the ground on all the breakers.
- Connect the phases R, Y, B Bus side to the test set.
- Record the corresponding leakage current readings.



BUS BAR INSULATION RESISTANCE TEST WHEN BREAKERS ARE OPENED



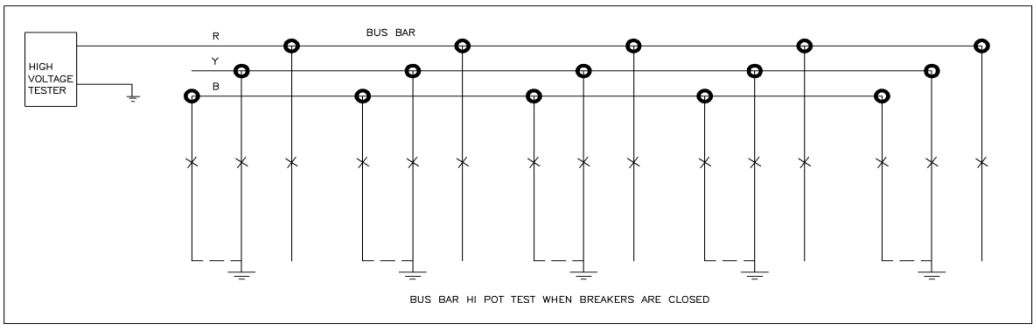
BUS BAR INSULATION RESISTANCE TEST WHEN BREAKERS ARE CLOSED

5.2.6 High Voltage Test

AC high- pot test shall be carried out in accordance with IEC standard at site. The test shall be carried out on MV Bus bar with all CB's racked in close and open position. In LV panel all Breakers to be kept racked out. Test is performed as under

- Incoming and outgoing cables disconnected
- Voltage transformers primary disconnected.
- Current transformer secondary shorted.
- Electronic component of measuring and control equipment, if assembled to be removed to avoid damages.
- The test voltage to carry out the test is as per table below for different voltage levels
- Test voltage for MV switch gear is as per below table.
  - **When all the CB are Closed**

- Connect the phases Y, B to ground and apply the test voltage between phase R and ground. Record the leakage current
- Connect the phases B, R to ground and apply the test voltage between phase Y and ground. Record the leakage current
- Connect the phases R, Y to ground and apply the test voltage between phase B and ground. Record the leakage current



➢ **When all the CBs are Opened**

- Connect the phases R, Y, B Cable side of all the breakers to the ground.
- Connect the phases R, Y, B Bus side to the test set.
- Record the corresponding leakage current readings.

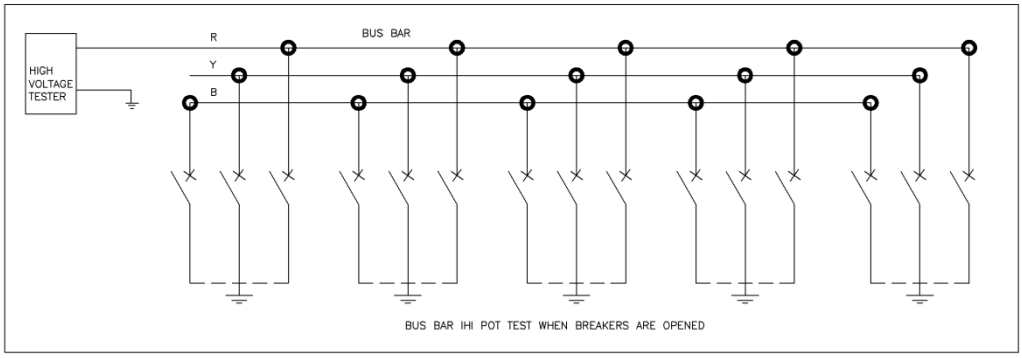


Table-1

Equipment	Rated Voltage kV	AC Testing					DC Testing	
		High-potential Test		Partial Discharge Test				
		Test Level kV	Time Min	Extinction Level, kV	Pulse Magnitude, pC	Time Min	Test level, kV	Time, Min
Bus Duct : Isolated phase Bus (IPB)	25	45(60)	1	19	100	2	64	1
Metal-Enclosed Rigid Bus	13.8	27(36)	1	10.5(10.5)	100(100)	2	37(50)	1
Switchgear	4.16	14(19)	1	3.5(3.5)	100(100)	2	N/A	N/A
	13.8	27(36)	1	10.5(10.5)	100(100)	2	N/A	N/A

5.2.7 Insulation Resistance test after High Voltage Test

After performing high voltage test Perform the Insulation resistance test with 1000Vdc for LV switch gear and 5000Vdc for MV switch gear as describe in 5.2.5

5.2.8 Checking the protective earthing

Switch gear protective earthing bond must be earthed in order to afford protection to human beings. Protective earthing bond should be checked for it continuity between each panel, it is preferable to check total resistance of grounding bus.

6.0 Documents

Relevant Test Sheets shall be completed.

7.0 Attachment

7.1 Contact Resistance test for MV Bus Bar

7.2 High Voltage test for MV Bus Bar

*****End of the Procedure *****

Testing Procedure

LV Bus Duct

Document No: BSC-TP-LBD01
Rev: 0

TABLE OF CONTENT

1.0 Task

The purpose of this procedure is to test and document the integrity of bus bar of metal enclosed assemblies of non-segregated bus duct of 380V and 480V, levels using an ac/dc source.

2.0 Preconditions

2.1 Work Status

- Erection has been completed.
- Labelling of the equipment and designation of live enclosed plant sections has been carried out.

2.2 Documentation

- The bus duct diagram and single line diagram are available
- Relevant Test Sheet to be made Available

2.3 Personnel

- 1 Commissioning engineer: Engineer or technician with experience in commissioning of all types of electrical equipment.
- 1 Helper: skilled worker with adequate on-the-job training.

2.4 Measuring Instruments and Tools

- Torque wrench
- Micro ohm meter 10A and 100A
- Insulation Tester 1000V dc
- High voltage tester AC (up to 2 KV)
- Discharge hot stick

3.0 Precautions

The work will only proceed when a Permit to Work (PTW) in work permit area has been obtained. The PTW will be kept on site for consultation during the testing works.

Special attention will be given to:

- Due to high voltage being used, adequate safety precautions should be taken to avoid injury to personnel and damage to property.
- Cordoning off specified working area and provision of applicable safety warning sign board.
- Ensure that all the necessary test equipment are made available at the test area and with valid calibration stickers and certificate.
- Hand insulating gloves and grounding sticks / wire jumpers shall be provided for safe handling and draining of residual voltage.
- Switch gear and transformer flexible brad should be disconnected from the bus duct. Switchgear end and transformer end should be shorted and grounded.
- Ensure that all voltage transformers are disconnected for the duration of the test and that all current transformers are short-circuited.

- Immediately after testing of each phase, voltage residue shall be drain by using grounding stick / wire which is directly connected to earth.
- Test equipment operation shall be in accordance with the manufacturer's instructions.
- Closing of the work permit after completion of the work (if the test area is to be considered in work permit area) is necessary.

4.0 Scope

- Testing of bus bar
- High voltage test on complete bus duct assembly
- Circuit resistance for complete bus duct assembly
- Checking that the bus bar mounting position is correct,
- Checking of the phase and continuity
- Checking of correct earthing,

5.0 Execution

5.1 Visual Checks

- Check that the bus bar is not damage and that they are bolted correctly,
- Check that insulator does not have any cracks or damage.
- Inspect for cleanliness, connections etc.
- Check for water tight seals at all joints including expanding interface points
- Check for quality of paint work both inside and out side
- Check that ventilation openings are not blocked and that they are screened against ingress of insects and rain
- Check that moisture drain holes are available at the bottom of enclosure
- Check anti-condensation heaters are mounted at bottom

5.2 Testing the LV Bus Duct

Enter the rating plate data in test Sheet and compare the bus duct data with the data contained in the circuit documentation. The following test shall be carried out

1. Bus continuity and phasing test.
2. Torque test.
3. Contact Resistance test
4. Main Circuit Contact Resistance test
5. Insulation resistance test before hipot
6. High Voltage test
7. Insulation resistance test after hipot
8. Commissioning of Heater Circuit
    a. Visual Checks
    b. Measurement of insulation resistance of heater and lamp circuit
    c. Functional checks of thermostat , Heaters,
    d. Measurement of Current and voltage
9. Protective earthing check

5.2.1 Continuity and Phasing Test

Continuity and phasing test can be done by simple ohm meter or fluk

Connect the extreme end of the single phase of the bus with ground and check the resistance between phases and ground. All the phases should read Infinity except the grounded phase. Thus the phase is identified and continuity is checked. Repeat the test on remaining two phases.

5.2.2 Torque Test

Torque test shall be applied to all joints made at site. The bolts shall be tightened according to manufacturer instruction after the bus duct erection completion. Spot check shall be carried out using a calibrated torque wrench.

Following is the reference value in case data from manufacturer is not available

Bolt tighten maximum value,

Bolt Size	Maximum value
M 6	8 Nm
M 8	20 Nm
M 10	40 Nm
M 12	70 Nm
M 16	140 Nm

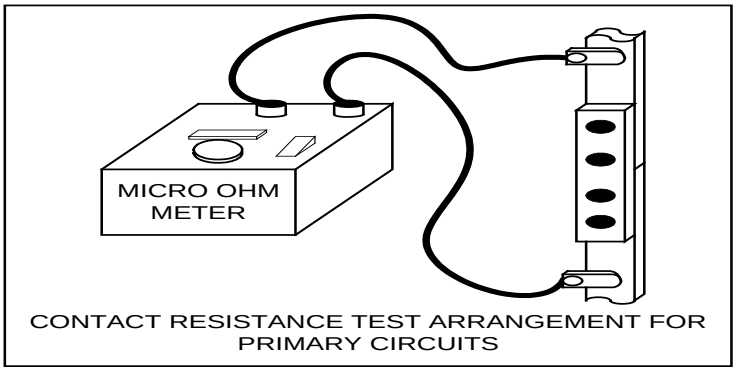
Tolerance : ± 20 %

5.2.3 Contact Resistance Test

The contact resistance test will be carried out after torque completion and will be applied to all bus bar joints. The test requires to measure very small fluctuations in resistance while simulating actual operating conditions. A DC power source will inject the test current up to 100 A and digital voltmeter will measure the voltage drop across the joints under test, Thus V/I gives Resistance

Contact resistance can also be measured using micro ohm meter as shown in figure below.

- Check the resistance for all the bus bar joints using micro-ohm meter at 100 Amps.
- Check the overall resistance of the bus bar for each phase using micro-ohm meter 100Amps.



CONTACT RESISTANCE TEST ARRANGEMENT FOR PRIMARY CIRCUITS

5.2.4 Insulation Resistance test Before High Voltage Test

Before performing high voltage test, perform the Insulation resistance test for one minute with 5000Vdc insulation tester as under

- Isolate the VTs and short the CTs secondary if installed on bus duct
- Connect the phases Y, B to ground and apply the test voltage between phase R and ground and note down the readings after I minute of application.
- Connect the phases B, R to ground and apply the test voltage between phase Y and ground and note down the readings after I minute of application

  Connect the phases R, Y to ground and apply the test voltage between phase B and ground and note down the readings after I minute of application

- Connect the phases R, Y to ground and apply the test voltage between phase B and ground and note down the readings.
- Insulation resistance measurement shall also be made of heater circuit by applying 500V dc for one minute

5.2.5 High Voltage Test

AC high- pot test shall be carried out in accordance with IEC standard at site. The test shall be carried out on LV Bus bar.

- Bus duct is isolated from the transformer and switch gear
- Voltage transformers primary is disconnected if it is installed on the bus duct.
- Current transformer secondary is shorted if it is installed on the bus duct.
- The test voltage to carry out the test is mention in table below against different voltage levels
- Connect the phases Y, B to ground and apply the test voltage between phase R and ground by increasing gradually to 2kv, Record the leakage current at 15 Sec, 30 sec , 45 sec and 60 sec

- Connect the phases B, R to ground and apply the test voltage between phase Y and ground by increasing gradually to 2kv, Record the leakage current at 15 Sec, 30 sec , 45 sec and 60 sec
- Connect the phases R, Y to ground and apply the test voltage between phase B and ground by increasing gradually to 2kv, Record the leakage current at 15 Sec, 30 sec , 45 sec and 60 sec

5.2.6 Insulation Résistance Test after High Voltage Test

After performing high voltage test, perform the Insulation resistance test with 1000Vdc for LV Bus as describe in 5.2.4

5.2.7 Commissioning of Heaters

Space heater shall be commissioned as under.

5.2.7.1 **Visual Checks of Heaters**

- Check the rating of the heater match with the supply voltage.
- Check the KW rating of the heater match with drawing.
- Check the breaker which supplying power to heater circuit for correct rating with respect to total load of the heaters.

5.2.7.2 **Measurement of Insulation Resistance**

Perform insulation resistance measurement on space heater circuit with 500 VDC megger

5.2.7.3 **Measurement of Current and Voltage**

Switch on the breaker and measured the total current and individual heater load with mini clamp meter

5.2.7.4 **Functional Checks of Thermostat**

Check the operation of the thermostat and hygrometer for cut in and cut out operation

5.2.8 Checking the Protective Earthing

Bus duct protective earthing bond must be earthed in order to afford protection to human beings. Protective earthing bond should be checked for its continuity.

6.0 Documents

Relevant test sheets to be completed for each every LV Bus Duct.

7.0 Attachment

Test sheet for following equipment to be prepared

7.1 Test Sheet for LV Bus duct

*****end of the procedure *****

Testing Procedure

MV Bus Duct

Document No: BSC-TP-MBD01
Rev: 0

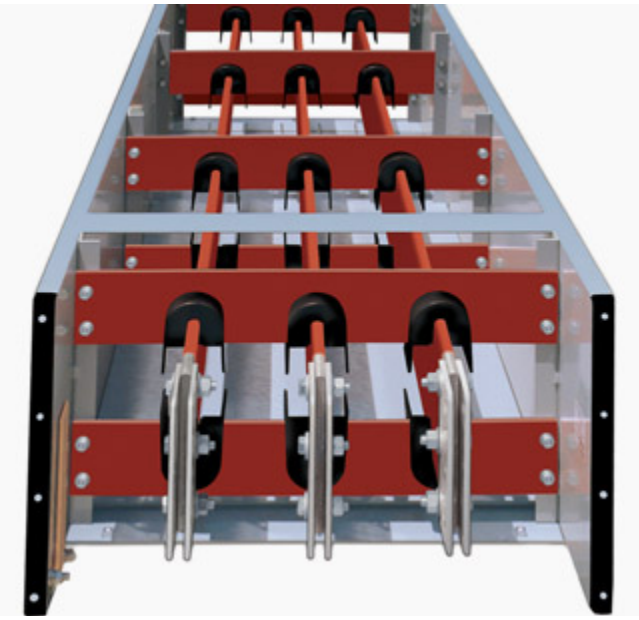


TABLE OF CONTENT

1.0 Task

The purpose of this procedure is to test and document the integrity of metal enclosed medium voltage bus duct assemblies of 13.8 kV and 4.16kv level using an ac/dc source.

2.0 Preconditions

2.1 Work Status

- Erection has been completed.
- Labelling of the equipment and designation of live enclosed plant sections has been carried out.

2.2 Documentation

- The bus duct diagram is available
- Relevant test sheets to be made available

2.3 Personnel

- 1 Commissioning engineer: Engineer or technician with experience in commissioning of all types of electrical equipments.
- 1 Helper: skilled worker with adequate on-the-job training.

2.4Measuring Instruments and Tools

- Torque wrench
- Micro ohm meter 10A and 100A
- Insulation Tester 5000V dc
- High voltage tester (AC up to 50 KV or DC up to 80 KV)
- Discharge hot stick

3.0 Precautions

The work will only proceed when a Permit to Work (PTW) in work permit area has been obtained. The PTW will be kept on site for consultation during the testing works.

Special attention will be given to:

- Due to high voltage being used, adequate safety precautions should be taken to avoid injury to personnel and damage to property.
- Cordoning off specified working area and provision of applicable safety warning sign board.
- Ensure that all the necessary test equipment are made available at the test area and with valid calibration stickers and certificate.
- Hand insulating gloves and grounding sticks / wire jumpers shall be provided for safe handling and draining of residual voltage.
- Switch gear and transformer should be disconnected from flexible connection with the bus duct. Switchgear and transformer should be connected to ground.
- Ensure that all voltage transformers are disconnected for the duration of the test and that all current transformers are short-circuited.

- Immediately after testing of each phase, voltage residue shall be drain by using grounding stick / wire which is directly connected to earth.
- Test equipment operation shall be in accordance with the manufacturer's instructions.
- Closing of the work permit after completion of the work (if the test area is to be considered in work permit area) is necessary.

4.0 Scope

- Testing of bus bar
- High voltage test on complete Bus duct assembly
- Circuit resistance for complete Bus duct assembly
- Checking that the bus bar mounting position is correct,
- Checking of the phase and continuity
- Checking of correct earthing,

5.0 Execution

5.1 Visual Checks

- Check that the bus bar for any damage and that they are bolted correctly,
- Check that insulator does not have any cracks or damage.
- Inspect for cleanliness, connections etc.
- Check for water tight seals at all joints including expanding interface points
- Check the insulating boots on joints are in place
- Check that complete bus bar is insulated and no damage of insulation
- Check that all bus bar joints are silver plated
- Check the enclosure for paint work
- Check anti-condensation heaters are mounted at bottom

5.2 Testing of the MV Bus Duct

Enter the rating plate data in test sheet and compare the bus duct data with the data contained in the diagram. The following test shall be carried out

1. Bus continuity and phasing test
2. Torque test
3. Contact Resitance test
4. Main Circuit Contact Resitance test
5. Insulation resistance test before hipot
6. High Voltage test
7. Insulation resistance test after hipot
8. Commissioning of Heater Circuit
   a. Visual Checks
   b. Measurement of insulation resistance of heater and lamp circuit
   c. Functional checks of thermostat , Heaters,
   d. Measurement of Current and voltage
9. Protective earthing check

5.2.1 Continuity and Phasing Test

Continuity and phasing test can be done by simple ohm meter or fluk

Connect the extreme end of the single phase of the bus with ground and check the resistance between phases and ground. All the phases should read infinity except the

grounded phase. Thus the phase is identified and continuity is checked. Repeat the test on remaining two phases.

5.2.2 Torque Test

Torque shall be applied to all joints made at site. The bolts shall be tightened according to manufacturer instruction after the bus bar erection completion. Spot check shall be carried out using a calibrated torque wrench.

Following is the reference Value in case data from manufacturer is not available

Bolt tighten maximum value,

Bolt Size	Maximum value
M 6	8 Nm
M 8	20 Nm
M 10	40 Nm
M 12	70 Nm
M 16	140 Nm

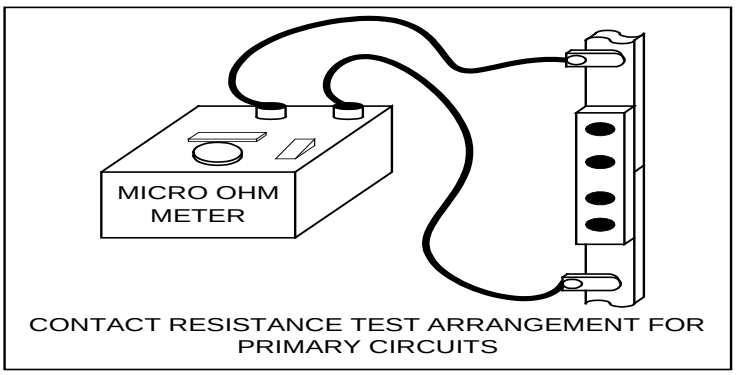
Tolerance: ± 20 %

5.2.3 Contact Resistance Test

The contact resistance test will be carried out after torque completion and will be applied to all bus bar joints. The test requires to measure very small fluctuations in resistance while simulating actual operating conditions. A DC power source will inject the test current up to 100 A and digital voltmeter will measure the voltage drop across the joints under test, Thus V/I gives Resistance

Contact resistance can also be measured using micro ohm meter as shown in figure below.

- Check the resistance for all the bus bar joints using micro-ohm meter at 100 Amps.
- Check the overall resistance of the bus bar for each phase using micro-ohm meter at 100Amps.



CONTACT RESISTANCE TEST ARRANGEMENT FOR PRIMARY CIRCUITS

5.2.4 Insulation Resistance Test Before High Voltage Test

Before performing high voltage test, perform the Insulation resistance test for one minute with 5000Vdc insulation tester as under

- Isolate the VTs and short the CTs secondary if installed on bus duct
- Connect the phases Y, B to ground and apply the test voltage between phase R and ground and note down the readings after I minute of application.
- Connect the phases B, R to ground and apply the test voltage between phase Y and ground and note down the readings after I minute of application
- Connect the phases R, Y to ground and apply the test voltage between phase B and ground and note down the readings after I minute of application
- Insulation resistance measurement shall also be made of heater circuit by applying 500V dc for one minute

5.2.5 High Voltage Test

AC high- pot test shall be carried out in accordance with IEC standard at site. The test shall be carried out on MV Bus bar as under

- Bus duct is isolated from the transformer and switch gear
- Voltage transformers primary is disconnected if it is installed on the bus duct.
- Current transformer secondary is shorted if it is installed on the bus duct.
- The test voltage to carry out the test is mention in table below against different voltage levels
- Connect the phases Y, B to ground and apply the test voltage between phase R and ground by increasing gradually at the rate of 2kv/sec, Record the leakage current at 15 Sec, 30 sec , 45 sec and 60 sec
- Connect the phases B, R to ground and apply the test voltage between phase Y and ground by increasing gradually at the rate of 2kv/sec, Record the leakage current at 15 Sec, 30 sec , 45 sec and 60 sec
- Connect the phases R, Y to ground and apply the test voltage between phase B and ground by increasing gradually at the rate of 2kv/sec, Record the leakage current at 15 Sec, 30 sec , 45 sec and 60 sec

Table-1

Equipment	Rated Voltage, kV	AC Testing					DC Testing	
		High-potential Test		Partial Discharge Test				
		Test Level, kV	Time, Min	Extinction Level, kV	Pulse Magnitude, pC	Time, Min	Test level, kV	Time, Min
Bus Duct : Isolated phase Bus (IPB)	25	45(60)	1	19	100	2	64	1
Metal-Enclosed Rigid Bus	13.8	27(36)	1	10.5(10.5)	100(100)	2	37(50)	1
Switchgear	4.16	14(19)	1	3.5(3.5)	100(100)	2	N/A	N/A
	13.8	27(36)	1	10.5(10.5)	100(100)	2	N/A	N/A

Voltages shown in parenthesis are factory test value

5.2.6 Insulation Resistance Test after High Voltage Test

After performing high voltage test Perform the Insulation resistance test with 5000Vdc for MV switch gear as describe in 5.2.4

5.2.7 Commissioning of Heaters

Space heater shall be commissioned as under.

5.2.7.1 Visual Checks of Heaters

- Check the rating of the heater match with the supply voltage.
- Check the KW rating of the heater match with drawing.
- Check the breaker which supplying power to heater circuit for correct rating with respect to total load of the heaters.

5.2.7.2 Measurement of Insulation Resistance

Perform insulation resistance measurement on space heater circuit with 500 VDC megger

5.2.7.3 Measurement of Current and Voltage

Switch on the breaker and measured the total current and individual heater load with mini clamp meter

5.2.7.4 **Functional Checks of Thermostat**

Check the operation of the thermostat and hygrometer for cut in and cut out operation

5.2.8 Checking the Protective Earthing

Bus duct protective earthing bond must be earthed in order to afford protection to human beings. Protective earthing bond should be checked for its continuity.

Shorting plate between the bus duct enclosures at transformer end and switch gear end should be checked for firm connection and grounding. The shorting bar between bus duct enclosures carries the circulating current induced on the bus enclosures.

6.0 Documents

Relevant test sheets to be completed for each every MV Bus Duct.

7.0 Attachment

Test sheet for following equipment to be prepared with respect to their Type

7.1 Torque & CR test of Bus bar of MV Segregated Bus Duct:
7.2 High Voltage test of Bus Bar of MV Segregated Bus Duct:
7.3 Torque & CR test of Bus bar of MV Non Segregated Bus Duct:
7.4 High Voltage test of Bus Bar of MV Non Segregated Bus Duct:
7.5 Torque & CR test of Bus bar of MV Iso-Phase Bus Duct:
7.6 High Voltage test of Bus Bar of MV Iso-Phase Bus Duct:

***** End of the procedure*****

Testing Procedure

Induction Motor

Document No: BSC-TP-OMT01
Rev: 0

TABLE OF CONTENT

1. Task

This instruction comprises a complete description of the testing of the MV and LV Motors.

2. Preconditions

2.1 Work Status

- Erection has been completed.
- Labelling of the equipment and designation of live enclosed plant sections has been carried out.

2.2 Documentation

- The circuit diagrams of Motor is available
- Relevant test sheet to be made available
- Product manual of the Motor is available

2.3 Personnel

- Commissioning engineer: - (1) engineer with experience in commissioning of Motors and its control.
- Technician or helper:- (2) skilled worker with adequate on -the-job training
- Witness from the client's concern department

2.4 Measuring Instrument

- Multi meter (calibrated)—2
- Insulation resistance meter –megger(calibrated)—1
- Wheat stone bridge to measure the winding resistance
- Vibration Meter

3. Precautions

The work will only proceed when a Permit to Work (PTW) in work permit area has been obtained. The PTW will be kept on site for consultation during the testing works.

- Observe the rules for handling electronic components sensitive to electrostatic discharge (ESD measures).
- Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.
- Closing of the work permit after completion of the work (if the test area is to be considered in work permit area) is necessary.
- Before test voltages are applied a check shall be carried out to ensure that no unauthorized persons are working at the corresponding load-where ever necessary barriers should be provided

4. Scope

- Testing of Motors
- Checking RTD's and Thermocouple
- Checking of the mounting pad,
- Checking of correct Earthing,

5. Execution

5.1. Visual Inspection.

Prior to carrying out electrical tests, a visual check of the transformer should be carried out paying particular attention to the following points

1. Compare equipment nameplate data with drawings and specifications.
2. Inspect physical and mechanical condition.
3. Inspect anchorage, alignment, and grounding.
4. Inspect air baffles, filter media, cooling fans, slip rings, brushes, and brush rigging.
5. Verify the unit is clean.
6. Inspect bolted electrical connections for high resistance using one of the following methods:
    a. Use of low-resistance ohmmeter.
    b. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench
7. Verify correct application of appropriate lubrication and lubrication systems.
8. Verify the absence of unusual mechanical or electrical noise or signs of overheating during initial test run.
9. Verify that resistance temperature detector (RTD) circuits conform to drawings.
10. Verify that metering or relaying devices utilizing RTDs have the correct rating.

5.2. Testing of Motors

Following tests to be carried out

1. Resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable
2. Insulation-resistance tests
    a. Motors larger than 200 horsepower: Test duration shall be for ten minutes. Calculate polarization index.
    b. Motors 200 horsepower and less: Test duration shall be for one minute. Calculate the dielectric-absorption ratio.
3. Stator resistance test phase-to-phase.
4. Insulation-resistance test on bearing pedestal in accordance with manufacturer's published data, if applicable.
5. Resistance tests on RTDs.
6. Commissioning of Heater Circuit. If applicable
    a. Visual Checks
    b. Measurement of insulation resistance of heater.
    c. Measurement of Current and voltage
7. Rotation test to insure correct shaft direction.
8. Measurement of current and voltages
9. Vibration baseline test

5.2.1 Resistance Measurements through bolted connections with a low-Resistance Ohmmeter.

Bolted connection shall be torque and contact resistance measurement shall be done with the help of low resistance meter

5.2.2 Insulation-Resistance Tests

The test voltage for LV Motors is 1000 V dc and For MV motors 5000V dc

Apply the test voltage between Phase to ground and then phase to phase.

Checking of the insulation resistance shall be carried out as under

5.2.2.1 Motors larger than 200 horsepower: Test duration shall be for ten minutes. Polarization index.

The insulation resistance measurement is done from 15 seconds to 1 minute with 15 seconds interval and then for every one minute up to ten minutes. Value obtained at 10 minute divided by value at 1 minute gives polarization index

5.2.2.2 Motors 200 horsepower and less: Test duration shall be for one minute. Dielectric-absorption ratio.

The insulation resistance measurement is done from 15 seconds to 1 minute with 15 seconds interval and then for every one minute up to ten minutes. Value obtained at 60 seconds divided by value at 15 seconds gives Dielectric absorption ratio

5.2.3 Perform Stator Resistance Test Phase-to-Phase.

Winding Resistance Test shall be done with wheat stone bridge or fluke

In this test the resistance measurement is done on each phase winding

5.2.4 Insulation-Resistance Test on Bearing Pedestal in accordance with manufacturer's published data, if applicable.

This test is done by measuring the insulation resistance between the rotor shaft and ground in accordance with manufacturer's manual. The test voltage in this case is 500v dc

5.2.5 Resistance Tests on RTDs.

Resistance measurement shall be carried out for all the RTD's and compare with corresponding temperature. For this test a multi loop calibrator can be used

5.2.6 Commissioning of Heaters. If Applicable

Space heater shall be commissioned as under

5.2.6.1 Visual Checks of Heaters

- Check the rating of the heater on name plate match with the supply voltage.
- Check the KW rating of the heater match with drawing.
- Check the breaker which supplying power to heater circuit for correct rating with respect to total load of the heaters.

5.2.6.2 Measurement of Insulation Resistance

Perform insulation resistance measurement on space heater circuit with 500 VDC megger

5.2.6.3 Measurement of Current and Voltage

Switch on the breaker and measured the total current and individual heater load with mini clamp meter

5.2.7 Rotation or Bump Test to Insure Correct shaft Direction.

Direction of rotation shall be checked by running the motor momentarily on uncoupled motor. Direction of rotation should match with mark on the motor enclosure

5.2.8 Measurement Current and Voltages

5.2.8.1 No load Measurement

Voltage, running Current, inrush current and vibration shall be checked by running the motor uncoupled

5.2.8.2 No load Measurement

Voltage, running current, inrush current and vibration shall be checked by running the motor coupled to the load

5.2.9 Vibration Baseline Test.

Vibration measurement is done when motor is running on full load; the following table gives the approximate acceptable values.

5.2.10 Protective Earthing Check

Motor protective earthing bond must be earthed in order to afford protection to human beings. Protective earthing bond should be checked for it continuity between motor and the grid,

6 Documents

Relevant test sheets to be completed for each and every motor

7 Attachment

Test sheet for following equipment to be prepared with respect to their Switchgear

7.1 **Test Sheet for MV** Motor

7.2 **Test Sheet for LV** Motor

*****End of the procedure*****

Testing Procedure

AC Generator

Document No: BSC-TP-OGT01
Rev: 0

TABLE OF CONTENT

1. Task

This instruction comprises a complete description of the testing of the MV and LV Generators.

2. Preconditions

2.1. Work Status

- Erection has been completed.
- Labelling of the equipment and designation of live enclosed plant sections has been carried out.

2.2. Documentation

- The circuit diagrams of Motor is available
- Test Sheet TS-GT01 is available
- Product manual of the Motor

2.3. Personnel

- Commissioning engineer: - (1) engineer with experience in commissioning of Motors and its control.
- Technician or helper:- (2) skilled worker with adequate on -the-job training
- Witness from the client‘s concern department

2.4. Measuring Instruments

- Multi meter (calibrated)—2
- Insulation resistance meter –megger(calibrated)—1
- Wheat stone bridge to measure the winding resistance
- Vibration Meter

3. Precautions

The work will only proceed when a Permit to Work (PTW) in work permit area has been obtained. The PTW will be kept on site for consultation during the testing works.

- Observe the rules for handling electronic components sensitive to electrostatic discharge (ESD measures).
- Special safety arrangements shall be made for all areas which are not explicitly designated as” electrical operating areas” when performing tests at voltages in excess of 50V.
- Closing of the work permit after completion of the work (if the test area is to be considered in work permit area) is necessary.
- Before test voltages are applied a check shall be carried out to ensure that no unauthorized persons are working at the corresponding load-where ever necessary barriers should be provided

4. Scope

- Testing of Generator
- Checking RTD's and Thermocouple
- Checking of the mounting pad,
- Checking of correct Earthing,

5. Execution

5.1. Visual Inspection.

Prior to carrying out electrical tests, a visual check of the transformer should be carried out paying particular attention to the following points

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Inspect air baffles, filter media, cooling fans, slip rings, brushes, and brush rigging.

5. Verify the unit is clean.

6. Inspect bolted electrical connections for high resistance using one of the following methods:

    1. Use of low-resistance ohmmeter.

    2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench

7. Verify correct application of appropriate lubrication and lubrication systems.

8. Verify the absence of unusual mechanical or electrical noise or signs of overheating during initial test run.

9. Verify that resistance temperature detector (RTD) circuits conform to drawings.

10. Verify that metering or relaying devices utilizing RTDs have the correct rating.

5.2. Testing of Generator

Following tests to be carried out

1. Resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable
2. Insulation-resistance tests
    a. Generators larger than 15O KVA: Test duration shall be for ten minutes. Calculate polarization index.

b. Generators 150 KVA horsepower and less: Test duration shall be for one minute. Calculate the dielectric-absorption ratio.

3. Stator resistance test phase-to-phase.
4. Insulation-resistance test on bearing pedestal in accordance with manufacturer's published data, if applicable.
5. Resistance tests on RTDs. If Applicable
6. Commissioning of Heater Circuit. If applicable
   a. Visual Checks
   b. Measurement of insulation resistance of heater.
   c. Measurement of Current and voltage
7. Insulation-resistance tests on the main rotating field winding, the exciter-field winding, and the exciter-armature winding

5.2.1. Resistance Measurements through Bolted Connections with a Low-Resistance Ohmmeter.

Bolted connection shall be torque and contact resistance measurement shall be done with the help of low resistance meter

5.2.2. Insulation-Resistance Tests

The test voltage for LV Generators is 1000 V dc and For MV Generators is 5000V dc

Apply the test voltage between Phase to ground and then phase to phase.

Checking of the insulation resistance shall be carried out as under

5.2.2.1. Generator Larger than 150 KVA: Test duration shall be for ten minutes. Polarization index.

The insulation resistance measurement is done from 15 seconds to 1 minute with 15 seconds interval and then for every one minute up to ten minutes. Value obtained at 10 minute divided by value at 1 minute gives polarization index

5.2.2.2. Generators 150 KVA and less: Test duration shall be for one minute. Dielectric-absorption ratio.

The insulation resistance measurement is done from 15 seconds to 1 minute with 15 seconds interval and then for every one minute up to ten minutes. Value obtained at 60 seconds divided by value at 15 seconds gives Dielectric absorption ratio

5.2.3. Stator Resistance Test Phase-to-Phase.

Winding Resistance Test shall be done with wheat stone bridge or fluke.

In this test the resistance measurement is done on each phase winding

5.2.4. Insulation-Resistance Test on Bearing Pedestal in accordance with manufacturer's published data, if applicable.

This test is done by measuring the insulation resistance between the rotor shaft and ground in accordance with manufacturer's manual. The test voltage in this case is 500V dc

5.2.5. Resistance Tests on RTDs. If Applicable

Resistance measurement shall be carried out for all the RTD's and compare with corresponding temperature. For this test a multi loop calibrator can be used

5.2.6. Commissioning of Heaters. If Applicable

Space heater shall be commissioned as under

5.2.6.1. Visual Checks of Heaters

- Check the rating of the heater on name plate match with the supply voltage.
- Check the KW rating of the heater match with drawing.
- Check the breaker which supplying power to heater circuit for correct rating with respect to total load of the heaters.

5.2.6.2. Measurement of Insulation Resistance

Perform insulation resistance measurement on space heater circuit with 500 VDC megger

5.2.6.3. Measurement of Current and Voltage

Switch on the breaker and measured the total current and individual heater load with mini clamp meter

5.2.7. **Insulation-Resistance Tests on the Main Rotating Field Winding, the Exciter-Field Winding, and the Exciter-Armature Winding**

Insulation resistance measurement shall be done with 500v dc megger between Rotor winding and Rotor Shaft, Exciter –field winding and ground, and Exciter Armature winding and ground

5.2.8. Protective Earthing Check

Motor protective earthing bond must be earthed in order to afford protection to human beings. Protective earthing bond should be checked for it continuity between motor and the grid,

6. Documents

Relevant test sheets to be completed for every Generator according to the size and type

7. Reference

8. Attachment

8.1. Test Sheet for Generator to be prepared and attached

*****End of the procedure*****

Testing Procedure

Low Voltage Cable

Document No: BSC-TP-LVC01
Rev: 0

TABLE OF CONTENT

1.0 Task

All newly installed power and control cable (1KV) in the electrical system requires field testing.

2.0 Preconditions

2.1 Work Status

- Erection has been completed.
- Labelling of the equipment is complete

2.2 Documentation

- Test Sheet TS-CM01

2.3 Personnel

- 1 Testing engineer: Engineer or technician with experience in high voltage testing of electrical equipment.
- 1 Helper: skilled worker with adequate on-the-job training.

2.4 Measuring Instruments and Tools

- Fluke
- Insulation Tester 5KV

3.0 Precautions

- The work will only proceed when a Permit to Work (PTW) in work permit area has been obtained. The PTW will be kept on site for consultation during the testing works.
- Closing of the work permit after completion of the work (if the test area is to be considered in work permit area) is necessary.
- The test site shall have sufficient protective barriers and warning signs to conduct the tests.
- All cable section ends under test shall be grounded from accidental contact. Also the minimum separation from all ends or elements not being subject to test shall be 25.4mm/10kV of test voltage.
- Before cable test operation started, conductor under test and all cable accessories shall be checked as being de-energized using reliable voltage indicator. The voltage indicator should be tested for proper operation with an independent voltage source prior to operation.
- While the voltage indicator is still in contact with each component and is showing de-energized, a hot line grounded device for the purpose shall be continuously attached to all conductors under examination except while test equipment is ready for energization.
- All adjacent conductors in cable circuit not on test should be de-energized and left grounded while testing the other conductor.

4.0 Scope

- Checking termination,
- Checking shield
- Checking of correct earthing,

5.0 Execution

5.1 Visual Checks

- Checking of the cables for any damage
- Inspection for termination.
- Inspection for correct tightness for connection
- Checking labels

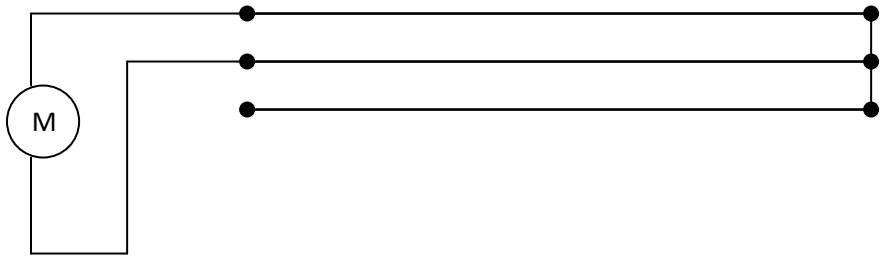
5.2 Testing of Cable

Enter the rating plate data in check list TS-CM01. The following test shall be carried out

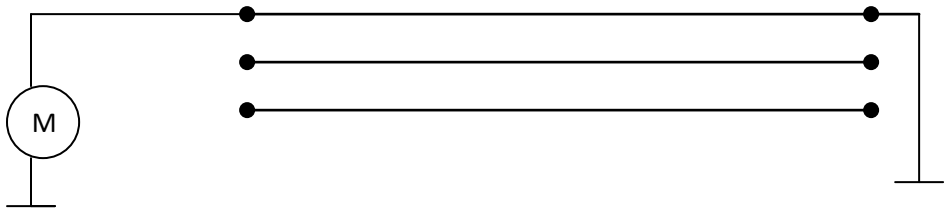
1. Conductor continuity and phasing test.
2. Insulation Resistance test Before Hipot.

5.2.1 Conductor Continuity and Phasing Test

To ensure the continuity and phasing of the cable conductor from terminal to terminal, the cable conductor shall be tested by using a 500VDC megger or a fluke as per figure below; tests results shall be noted down.



Conductor continuity test

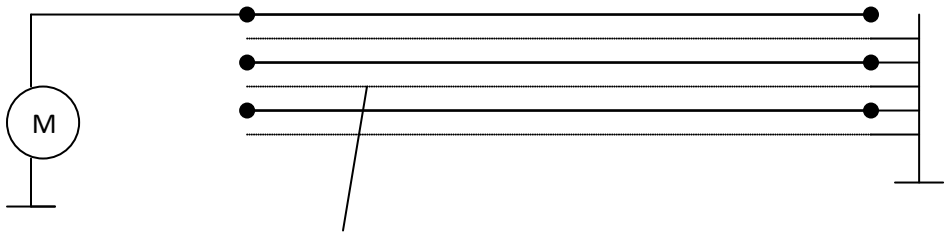


Phase verification

FIGURE-5-1

5.2.2 **Insulation Resistance test**

Insulation resistance test by mega ohmmeter at 500VDC shall be performed for one minute on each cable, between the conductor and the metallic shield with the adjacent cable conductors and shield grounded as per figure below.



Grounding sheet

Insulation Resistance Test

FIGURE: 5-2

Minimum insulation resistance of conductor for new cables shall be determined by the following.

$$R = \frac{\rho}{2\pi l} \times \log_e \frac{D}{d}$$

Where, R = Insulation Resistance, in Ω;
ρ = Volume resistivity of the insulation at 20°C, in Ω-m;
l = Length of the cable, in meter;
D = Outer diameter of the insulation, in mm;
D = Inner diameter of the insulation, in mm;

[Consider $\rho = 10^{14}$ Ω-m for XLPE insulation; and 10^{12} Ω-m for PVC and impregnated paper insulation]

5.2.3 **Checking the protective Earthing**

Check the earthing for the armour and shield is properly connected

6.0 Documents

Relevant test sheet to be completed for each set of three phase cable

7.0 Attachment:

7.1 **Test Sheet of Cable**

*** End of the procedure ***

Testing Procedure

Medium Voltage Cable

Document No: BSC-TP-MVC01
Rev: 0

TABLE OF CONTENT

1.0 Task

All newly installed power cable (1-33kV) in the electrical system requires field testing.

2.0 Preconditions

2.1 Work Status

- Erection has been completed.
- Labelling of the equipment is complete

2.2 Documentation

- Test Sheet TS-CM01

2.3 Personnel

- 1 Testing engineer: Engineer or technician with experience in high voltage testing of electrical equipment.
- 1 Helper: skilled worker with adequate on-the-job training.

2.4 Measuring Instruments and Tools

- Fluke
- High Voltage Tester Up to 100KV AC/DC or VLF
- Insulation Tester 5KV

3.0 Precautions

- The work will only proceed when a Permit to Work (PTW) in work permit area has been obtained. The PTW will be kept on site for consultation during the testing works.
- Closing of the work permit after completion of the work (if the test area is to be considered in work permit area) is necessary.
- The test site shall have sufficient protective barriers and warning signs to conduct the tests.
- All cable section ends under test shall be grounded from accidental contact. Also the minimum separation from all ends or elements not being subject to test shall be 25.4mm/10kV of test voltage.
- Before cable test operation started, conductor under test and all cable accessories shall be checked as being de-energized using reliable voltage indicator. The voltage indicator should be tested for proper operation with an independent voltage source prior to operation.
- While the voltage indicator is still in contact with each component and is showing de-energized, a hot line grounded device for the purpose shall be continuously attached to all conductors under examination except while test equipment is ready for energization.
- All adjacent conductors in cable circuit not on test should be de-energized and left grounded while testing the other conductor.

4.0 Scope

- Checking termination,
- Checking shield
- Checking of correct earthing,

5.0 Execution

5.1 Visual Checks

- Checking of the cables for any damage
- Inspection for termination.
- Inspection for correct tightness for connection
- Checking labels

5.2 Testing of Cable

Enter the rating plate data in check list TS-CM01. The following test shall be carried out

1. Cable Sheath Testing
2. Conductor continuity and phasing test.
3. Insulation Resistance test Before Hipot.
4. High voltage AC test for XLPE cable.
5. Insulation Resistance test After Hipot

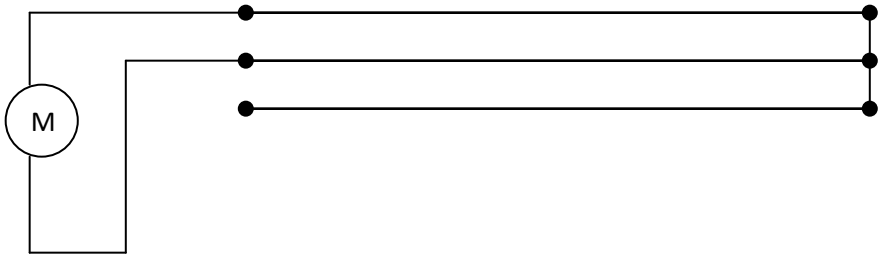
5.2.1 Cable Sheath Testing

Cable sheath testing is carried out in order to detect damage to cable sheath. To do this DC test is carried out.

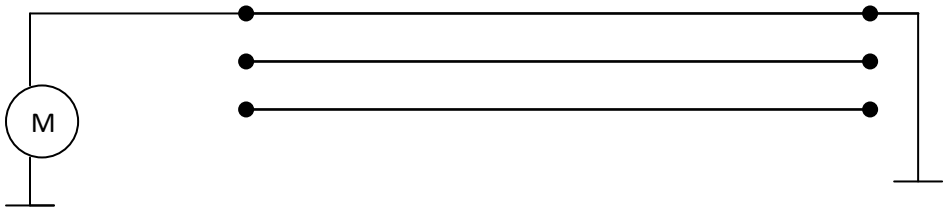
Test voltage 3kv is applied between PVC sheath and ground provided shield is grounded and insulation resistance or leakage current is measured.

5.2.2 Conductor Continuity and Phasing Test

To ensure the continuity and phasing of the cable conductor from terminal to terminal, the cable conductor shall be tested by using a minimum 500VDC megger as per figure below; tests results shall be noted down in the test sheet.



Conductor continuity test

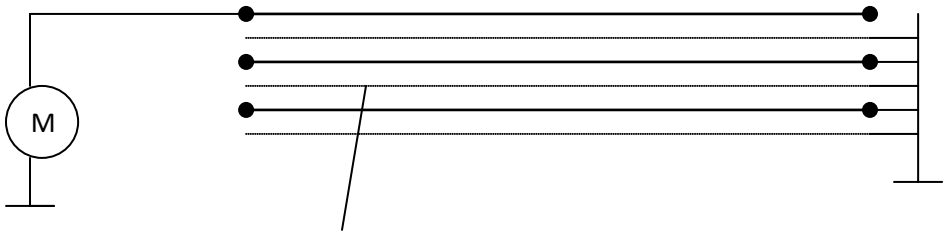


Phase verification

FIGURE-5-1

5.2.3 **Insulation Resistance test Before High Voltage Test**

Prior to performing the high voltage test on the cable, insulation resistance test by mega ohmmeter at 5000VDC shall be performed for one minute on each cable, between the conductor and the metallic shield with the adjacent cable conductors and shield grounded as per figure below.



Grounding sheet

Insulation Resistance Test

FIGURE: 5-2

Minimum insulation resistance of conductor for new cables shall be determined by the following.

$$R = \frac{\rho}{2\pi l} \text{ x } \log_e \frac{D}{d}$$

Where, R = Insulation Resistance, in Ω;
ρ = Volume resistivity of the insulation at 20°C, in Ω-m;
l = Length of the cable, in meter;
D = Outer diameter of the insulation, in mm;
D = Inner diameter of the insulation, in mm;
[Consider ρ = 10^{14} Ω-m for XLPE insulation; and 10^{12} Ω-m for PVC and impregnated paper insulation]

5.2.4 **High Voltage Test**

High Voltage test for medium voltage cable can be accomplished either of the following method in agreement with the SEC/Consultant

5.2.4.1 **AC High Voltage Testing**

The AC power frequency voltage shall be applied through the test set as per figure 5-3. While test, all cable conductors and shield not on test shall be grounded. The test voltage shall be pure sinusoidal wave shape. As per IEC 60840 the test voltages are as follows

The maximum phase to phase voltage of the system shall be maintained for line to ground for five minutes,

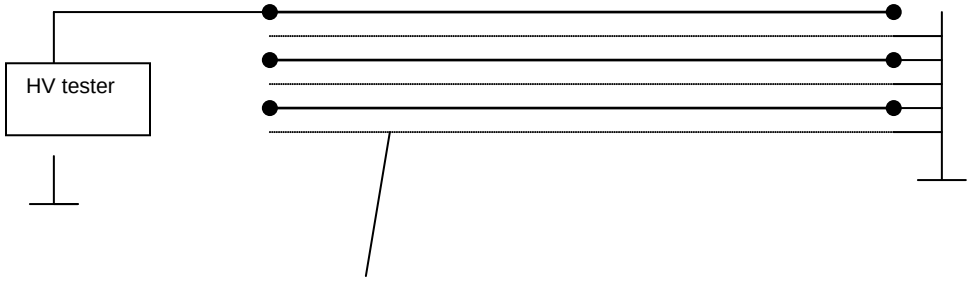
OR

2 X U_0 for 60 Minutes

OR

A. C. test volts = .75(2 X equipment maximum voltage + 1kV) for one minute (as per ARMCO)

In all cases voltage at the rate of 1 kV per second shall be increased until the maximum recommended test voltage is reached and maintained for required time duration.
The AC high potential test results are evaluated on a go, no-go basis by slowly raising the test voltage to the required value of final test voltage and maintaining for required duration



Grounding sheet

AC High voltage Test

FIGURE: 5-3

AC test set shall have adequate volt-ampere capacity to supply the required cable charging current. The KVA capacity of the test set shall be determined by the following

$$KVA= 2\pi fCE^2X10^{-3}$$

C= Cable capacitance in µf/km

f= Supply frequency

E=Test voltage

5.2.4.2 **C High Voltage Testing**

The high voltage DC shall be applied to each individual cable of a 3-phase circuit. All cable conductors and shield not on test shall be grounded.

High voltage DC test shall be as per IEC 60502 that is **$4XU_0$ for 15 minutes**.

OR

1.7[.75(2 X equipment maximum voltage + 1kV)] for 15 Minutes (ARMCO)

The test connections are as shown in figure 5-3.

A DC high potential test (controlled over voltage test) is one in which the increase of applied direct voltage is controlled. The measured current is continuously observed for abnormalities with the intention of stopping the test before breakdown occurs

The initially applied voltage shall not exceed 1.8 times the rated AC phase to phase voltage of the cable. After that the rate of increase of the test voltage shall be approximately uniform and shall not more than the maximum test voltage in 10 seconds or less than the maximum test voltage in 60 seconds.

The maximum test voltage shall be maintained for 15 minutes, leakage current shall be recorded in TS-CMO2. No breakdown of the insulation shall occur.

Maximum allowable leakage current for new cables shall be determined by the following

$$I_L=E/RX10^{-3} \text{ Amps}$$

Where I_L= Leakage current in Amps

E= DC test voltage in Kv

R= Insulation resistance in MΩ

OR

5.2.4.3 **VLF High Voltage Testing**

VLF is used for the cable testing where power requirement for the test is high; VLF uses very low frequency (0.01 to 0.1 HZ) that's why power requirement for the cable under test is less.

Test voltage equal to $3U_0$ is applied through the test set as shown in figure 5.3. While test, all cable conductors and shield not on test shall be grounded.

Test voltage is applied at the rate 1KV/second till the maximum test voltage is reached and maintain for 60 Minutes. Leakage current is recorded.

5.2.5 **Insulation Resistance Test After High Voltage Test**

Insulation resistance test by mega ohmmeter at 5000VDC shall be performed for one minute on each cable, between the conductor and the metallic shield with the adjacent cable conductors and shield grounded after the high voltage test.

Recommended Field Test Levels

Equipment	d Voltage, kV	AC Testing							DC Testing	
		otential Test(PF)		Partial Discharge Test			VLF @0.1HZ			
		Level, kV	ne, Min	nction Level, kV	e Magnitude, pC	ne, Min	level, kV	ne, Min	level, kV	ne, Min
Power Cable: Unshielded	4.16	N/A	N/A	N/A	N/A	N/A	3XUo	60	$4XU_0$ 9.6	5
	4.16	9(13)	5	4.5(4.5)	3(3)	2	7.2	60	9.6	15
Shielded	8	13(18)	5	7.5(7.5)	3(3)	2	13.85	60	19	15
ding Cable Bus)	13.8	19(27)	5	13(13)	3(3)	2	23.9	60	32	15

NOTES:

1. Factory tests are shown in brackets.
2. The values recommended for field ac high-potential tests are at 75 percent of the factory levels, for switchgear assemblies 70 percent of factory levels.
3. The values recommended for field dc high-potential testing of cable as per IEC-60502 is 4times U_0 Whereas U_o is U/1.732.
4. The value recommended for field AC VLF testing is 3Uo for 60 minutes
5. above values shall be used in case Vendor recommended values are not available otherwise

5.2.6 **Checking the protective Earthing**

Check the earthing for the armour and shield is properly connected

6.0 Documents

Relevant test sheet to be completed for each three phase cable

7.0 Attachment:

7.1 **Test Sheet of Cable**

*** End of the procedure ***

Testing Procedure

Liquid Batteries

Document No: BSC-TP-BTA01
Rev: 0

TABLE OF CONTENT

1. Task

This instruction comprises a complete description of the testing of Batteries

2. Preconditions

2.1. Work Satus

- Erection has been completed.
- Labelling of the equipment and designation of live enclosed plant sections has been carried out.

2.2. Documentation

- The single line diagram for the battery system, charger schematic drawings
- Test Sheet TS-BT01 is available
- Product manual of the Batteries

2.3. Personnel

- Commissioning engineer: - (1) engineer with experience in commissioning of Battery and Chargers usually
- Technician or helper:- (2) skilled worker with adequate on -the-job training
- Witness from the client's concern department

2.4. Measuring Instruments

- Multi meter (calibrated)—2
- Clamp Meter DC(calibrated)—1
- Hydro Meter to Check Specific Gravity
- Battery Tester
- Load Bank up to 300 Amps

3. Precautions

The work will only proceed when a Permit to Work (PTW) in work permit area has been obtained. The PTW will be kept on site for consultation during the testing works.

- Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.
- Closing of the work permit after completion of the work (if the test area is to be considered in work permit area) is necessary.
- Nickel Cadmium Batteries contain a corrosive alkali causing chemical burns if it comes into contact with skin or eyes. Eye wash and safety facilities must be in place prior to any work on the batteries. Also operators working on batteries must wear protective clothing like rubber, gloves, face mask, etc. and eye protection and use insulated tools and correct working techniques, which forbids lone working.
- As part of the charging cycle the cells will give off hydrogen gas. Hydrogen/ Air mixture is an incendiary mixture that can be ignited by electrical sparking/ arcing / naked flame. For this reason correct ventilation of cells and the battery room is essential to prevent the build up and ignition of hydrogen / air mixtures.

4. Scope

- Testing of Batteries
- Checking that the mounting,
- Testing of Cables

- Checking of correct Earthing,

5. Execution

5.1. Visual Inspection.

Prior to carrying out electrical tests, a visual check of the transformer should be carried out paying particular attention to the following points

- Correct labeling of devices and cables
- Equipment and cables are undamaged
- Correct execution of the cable gland/sealing end
- Name plate data, match with drawing and ambient condition
- Firm cable termination/terminal connection and ferruling
- Battery Rack is in good condition
- Vent Plugs are Installed correct
- Inter-cell Connections are checked and torque
- Electrolyte Level in all cells is correct
- Battery and Bus are free of grounds
- Battery Room has Proper Ventilation and in service

5.2. Testing of Batteries

Following tests to be carried out

1. Torque for the battery inter-cell connection
2. Battery Internal Resistance Measurement
3. Battery Initial Charging
4. Battery Discharge Test
5. Protective Earthing

5.2.1. Torque for the Battery Inter-Cell Connection

Tightness of the bolt on inter cell connection shall be checked and torque to the value recommended by the manufacturer**.**

5.2.2. Battery Internal Resistance Measurement

Battery internal resistance can be measured by the battery tester

5.2.3. Battery Initial Charging

For those batteries which were delivered pre-filled perform a new or initial commissioning charge with a constant Voltage at 1.63V/Cell for duration of 20 hours with a current limit to 0.2itA and electrolyte temp within 20 degC with Specific Gravity of 1.19-1.22.

If the charger has a limit to deliver the charging current, then duration for charging to meet 100% battery capacity can be calculated by Battery 2*Ah * 1.63/Charging current

Cell voltage gradually rises with progress of the charging, so that it is necessary to raise the rectifier's output voltage accordingly by means of its manual output voltage regulator in order to maintain the charging current constant at the specified rate

When the charging is to be carried out online where charger is supplying power to the load as well and the voltage cannot be controlled. The charging shall be done on a part of the bank at a time, say half the bank (48 cells) per charge.

Also, if the discharge test fails the first time, then a second test shall be done after another commissioning charge.

After Constant charging the batteries shall be kept on float charging at the rate 1.43/cell for at least 1 hour.

5.2.4. Battery Discharge Test

Ensure that all the preliminary tests listed above are completed. Also ensure that the battery has been fully charged to 100% Capacity before the discharge test start. The discharge test shall be made on each individual battery bank.

The duration of the test is five hours and the discharge current shall be the battery AHr capacity divided by 5. The voltage per cell at the end of discharge shall be at least 1.0 Volt (or as per Manufacturer's data). This is true for cells which are 5 hour rated. For cells which are 8 hour rated, the discharge time may be less than 5 hours and this has to be taken into consideration while interpreting the results.

The step by step procedure is as follows:

- Open battery disconnect switch or disconnect battery supply cable from 125 volts terminals of the charger.
- Connect battery discharge resistance bank, but leave open circuit.
- Measure and record individual cell voltage and ensure each cell is within tolerance as stated in 5.2.3,
- Record Individual cell specific gravity, and temperature of electrolyte
- Put on load which is equal to 0.2C; Take the readings of cell voltage, specific gravity for 1st, 2nd, 3rd, 4th and every 15 minutes after 4^{th} hour till 5^{th} hour.
- At the end of the test, total battery voltage is recorded

6. Documents

Relevant Test Sheet to be completed for each every battery bank

7. Attachment

7.1. Test Sheet for Battery Testing to be prepared.

End of the procedure

Testing Procedure

Lux Level Measurement

Document No: BSC-TP-LUL01

Rev: 0

TABLE OF CONTENT

1.0 Task

This instruction deal with the measurement of illuminance in lighting installation indoors and outdoors of power plant/substations

2.0 Preconditions

2.1 **Work Status**

- Erection has been completed.
- Lights are illumenated
- Diffusers are cleaned

2.2 **Documentation**

- Lighting layouts are available
- Test sheets TS-LT01

2.3 **Personnel**

- 1 Engineer or technician with experience in measurement of lux level
- 1 Helper: skilled worker with adequate on-the-job training.

2.4 **Measuring Instruments and Tools**

- Lux Level Meter or photo cell
- Measurement Tape

3.0 Precautions

- In order to carry out test , a PTW shall be obtained from the concern department where ever test to be carried out
- Room or building occupants shall be informed before start the test and where ever switching of lights is required.

4.0 Scope

- Lux level measurement of indoor lighting installation
- Lux level measurement of outdoor installation
- Lux level measurement of street or road lights,

5.0 Execution

5.1 **Visual Checks**

- Inspection for physical installation as per approved drawings.
- Inspection for damages of the lighting fixture or diffusers
- Inspection for Correct Ratings, type, and model of the lighting fixture
- Checking for correct labelling and circuit numbers

5.2 **illuminance Measurement**

Illumination measured values that is illuminance are mean values which refer to the over all empty or furnished room or work place, outdoors and which are measured 0.85 Meter above the ground and if working planes are involved, directly on them or on the work piece.

Regarding transportation routes indoors and outdoors measurement are made 0.2 meter above the floor or ground at several places in the middle of the track.

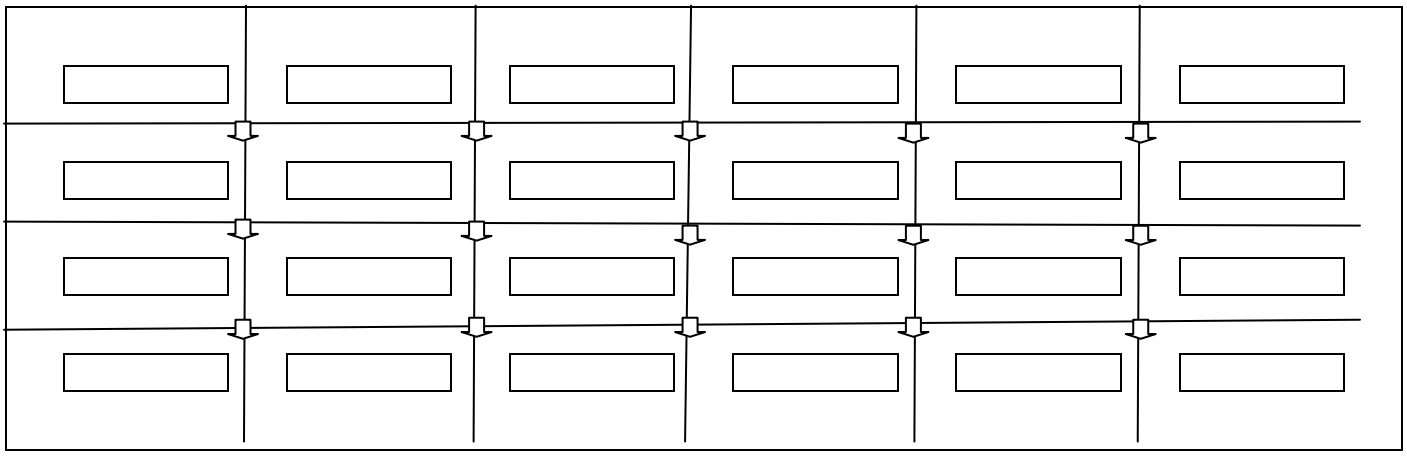
Clean lamps and lighting fittings, reflectors and glass covers are a basic requirement for accurate illuminance measurement, unless the actual operating state to be determined. The air should be free from dust and vapour etc. the nominal voltage U_n of the lighting installation (measured at the distribution board) should be adhered to and the actual value recorded for determining the operating state.

At the instant of measurement fluorescent lamps and discharge lamps of new lighting installation should have a service life of at least 100 hours and incandescent lamp of 10 hours but not more than 20% of their mean life should be over

In order to achieve stable lighting characteristics of the lamps the lighting installation should be switched on about 15 minutes and approximate 30 minutes in case of discharge lamps, before measurements are made.

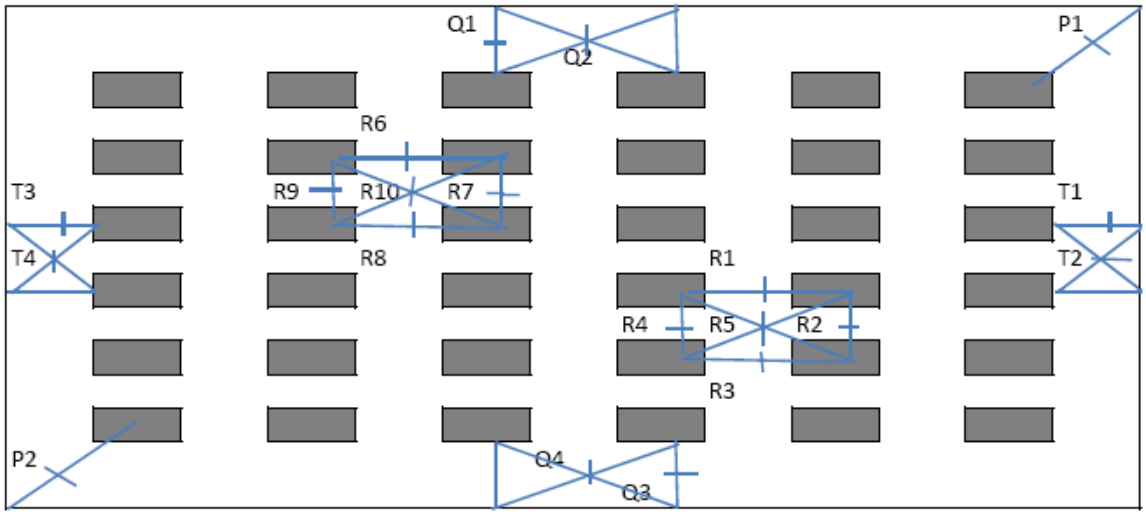
5.2.1 Illuminance measurement for interior and exterior lighting

To measure the illuminance, subdivide the room, particular zones thereof or areas into measuring grids with square of section of equal size (See the figure below) the centres(measuring points) of the grid sections should be 1 to 2 meters apart. The usual grid dimensions for the halls, major luminaire mounting heights and spacing are up to 5 meters. The grid sections must not coincide with grid dimension of the luminaire arrangement in longitudinal or transverse direction.
Measurement shall be done in the middle of the grid sections. The photocell for the measurement shall be held parallel to the area to be measured or horizontally above the floor at the measuring level. Additional illuminance measurements are required for peripheral zones of the room or working planes outdoors.



The Arithmetic mean of the values obtained is the illuminance En in lux to be compared with the nominal illuminance specified.

OR if more accurate results are required then following method can be implemented



$$T = \frac{T1+T2+T3+T4}{4}$$

$$P = \frac{P1+P2}{2}$$

$$Q = \frac{Q1+Q2+Q3+Q4}{4}$$

Where M- Number of Fixture/ colum
N-Number of Fixture/ Row

$$R = \frac{R1+R2+R3+R4+R5+R6+R7+R8+R9+R10}{10}$$

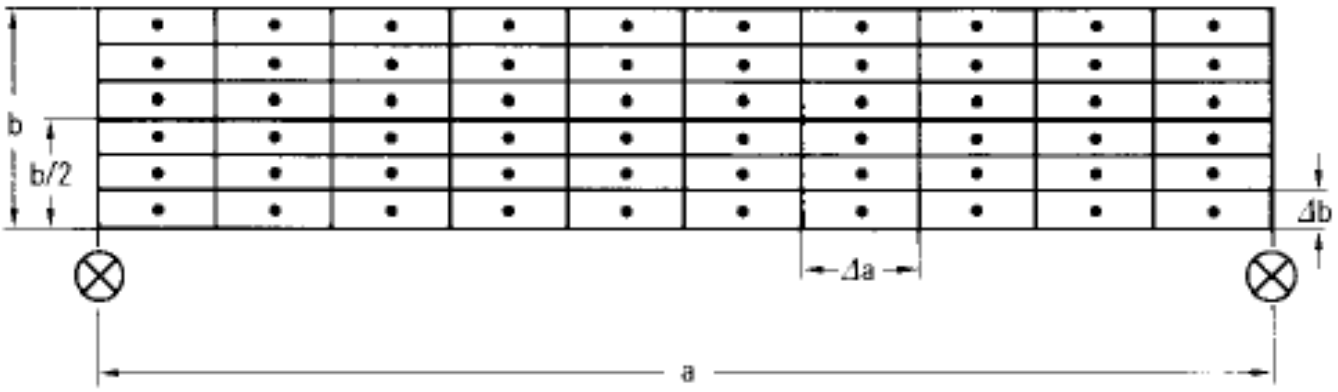
$$\text{Average Lux} = \frac{P+Q(N-1)+T(M-1)+R(M-1)(N-1)}{N \times M}$$

If Fixtures are continues with out gap

$$\text{Average Lux} = \frac{P+Q(N)+T(M)+R(M)(N)}{N \times M}$$

5.2.2 **Illuminance measurement for Road lighting**

For illuminance measurement, the assessment scheme must be divided in to subsection, the size of these subsections is determined by luminaire spacing “a” and width “b” of the carriage ways or illuminated



a Luminaire Spacing in m
Δa Subsection length in m
Δb Subsection width in m

Length of the Subsection Δa must not be greater then 5 meters
Luminaire spacing “a” of up to 50m.
Length of the subsection Δa =a/10
Subsection length should be selected at Δa ≤ 5 m at luminaire spacing “a” greater than 50m

For determining subsection width Δb , the carriageway width b/2 is divided by 3

The illuminance is measured in the middle of the subsection at a level of ≤ 0.20m above the carriageway. Interference from shadows and other light sources should be avoided

The arithmetic mean of the measured values E in lux is the horizontal illuminance.

The uniformity of illuminance g1= Emin/E

Emin is minimum value in assessment scheme

Reference Valve of illuminanace

Type of interior or activity	Nominal illuminance E_n lx	Colour appearance	Colour rendering group
Smelting plants, steelworks, rolling mills and large foundries			
Productions plants not requiring manual intervention	50		3
Production plants requiring occasional intervention	100		3
Permanently occupied work stations in production plants	200	w, i	3
Measuring stations, control platforms and control rooms	300		2
Test and quality control stations	500	w, i, c	2
Working and treatment of metals			
engl. ?	200		3
Welding	300		3
Rough and medium machining, such as turning, milling planing per. deviation ≥ 0.1 mm	300		3
Fine machining per. deviation > 0.1 mm	500	w, i	3
Marking out and quality control stations, measuring stations	750	w, i	3
Cold rolling mills	200		3
Wire and tube drawing, manufacture of cold-rolled sectional strip	300		3
Manufacture of hand tools and cutlery	500		3
Power stations			
Charging plants	50		3
Boiler house	100		3
Pressure equalizing chamber in nuclear power stations	200		2
Machine rooms	100		3
Adjoining rooms, e.g. pump rooms, condenser rooms	50	w, i	3
Switchgear – Indoors Outdoors	 100 20		 2 –
Electrical control rooms	300		2
Repair and inspection work on turbines and generators	500		2

6.0 Documents

Relevant test sheet shall be completed for each and every Lighting Installation.

7.0 References:

A. Electrical Engineers Portable hand book by MCGraw-Hill
B. Measurement of illuminanace installation instruction by SEIMENS dated1985

8.0 Attachment

8.1 Test sheet for Lux Level measurement)

*****End of the Procedure******

Testing Procedure

DC Distribution Board

Document No: BSC-TP-DCDB 01
Rev: 0

TABLE OF CONTENT

1.0 Task

The purpose of this procedure is to test, commission and document the 125V DC Switch board

2.0 Preconditions

2.1 Work Status

- Erection has been completed.
- Labelling of the equipment and designation of live enclosed plant sections has been carried out.

2.2 Documentation

- The schematic and single line diagram of the low voltage motor control centre are available
- Commissioning checklists TS-DB01

2.3 Personnel

- 1 Commissioning engineer: Engineer or technician with experience in commissioning of all types of Electrical equipments.
- 1 Helper: skilled worker with adequate on-the-job training.

2.4 Measuring instruments and tools

- Micro ohm meter 10A and 100A
- Insulation Tester 1000V dc
- Primary injection test set
- Secondary Injection test set
- Fluke-2 Nos

3.0 Precautions

The work will only proceed when a Permit to Work (PTW) in work permit area has been obtained. The PTW will be kept on site for consultation during the testing works.

Special attention will be given to:

- Due to high voltage being used, adequate safety precautions should be taken to avoid injury to personnel and damage to property.
- Cordoning off specified working area and provision of applicable safety warning sign board.
- Ensure that all the necessary test equipment are made available at the test area and with valid calibration stickers and certificate.
- Hand insulating gloves and grounding sticks / wire jumpers shall be provided for safe handling and draining of residual voltage.
- Immediately after testing of each phase, voltage residue shall be drain by using grounding stick / wire which is directly connected to earth.
- Closing of the work permit after completion of the work (if the test area is to be considered in work permit area) is necessary.

4.0 Scope

- Testing of Bus Bar
- Testing of MCCB
- Operation of MCCB inside the feeder
- Checking CB mounting.

5.0 Execution

5.1 Visual Checks

- Check nameplate information for correctness.
- Inspect enclosures for proper alignment, foundation fixing and grounding.
- Inspect covers, panel section and door for paint work and proper fit.
- Check operation of all mechanical interlocks.
- Check tightness of all bolted connections (torque wrench method).
- Check bus and supports for defects such as cracked welds, chipped porcelain, cracked insulation, etc., and free of dust accumulation.
- Verify that all front panel mounted devices (meters, push buttons, switches, indicator lamps, mimic buses, etc.) are installed as per drawings
- Perform mechanical check and visual inspection on the circuit breaker.
- Check for correct breaker position indication.
- Check that all control wiring is correct according to the approved drawing and terminal connections are secure.

WIRING AND FERRULING CHECK

- Ensure the numbers on the ferules are from left to right beginning at the terminal block i.e. at the end of the wire and from bottom to top.
- The wire nos. should be checked against the wiring table and the schematic drawing.

5.2 Testing MCC(Motor Control Centre)

Enter the rating plate data in check list relevant test sheet and compare the data with the data contained in the circuit documentation. The following test shall be carried out on whole DC Switch board

1. Testing of Bus Bar
   a. Bus Continuity and phasing test
   b. Torque Test
   c. Contact Resistance test
   d. Main Circuit Resistance Test
   e. Insulation Resiatnce Measurment
2. Testing of Circuit breakers(MCCB)
   a. Breaker Manual closing/opening
   b. Tripping by trip test button
   c. Primary Injection and Trip time measurement
3. Functional Test of Local Controls, Alarm and Indication.
4. Functional Test of Remote Controls, Alarm and Indication.
5. Control Power ,Current and Voltage Measurement of the MCC

6. Electrical control and protection/Measuring Devices
    d. Testing of protection devices
    e. Testing of Transducers
    f. Testing of Alarm Devices
7. Protective earthing check
8. Commissioning of Heater Circuit
    g. Visual Checks
    h. Measurement of insulation resistance of heater and lamp circuit
    i. Functional checks of thermostat , Heaters,
    j. Measurement of Current and voltage
9. Checks before and After initial energization

5.2.1 Testing of Bus Bar

5.2.1.1 Bus Continuity and Phasing Test

Continuity and phasing test can be done by simple ohm meter or fluk

Connect the extreme end of the single phase of the bus with ground and check the resistance between phases and ground. All the phases should read infinity except the grounded phase, thus the phase is identified and continuity is checked. Repeat the test on remaining two phases.

5.2.1.2 Torque Test

Torque shall be applied to all joints which are made at site. The bolts shall be tightened according to the manufacturer instructions after the bus bar erection is completed. Spot check shall be carried out using a calibrated torque wrench.

Following is reference in case data from the manufacturer is not available,

Bolt shall be tighten to maximum value,

Bolt Size	Maximum value
M 6	8 Nm
M 8	20 Nm
M 10	40 Nm
M 12	70 Nm

M 16 140 Nm

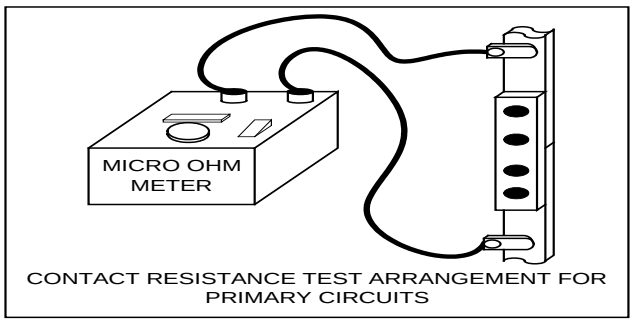
Tolerance: ± 20 %

5.2.1.3 **Contact Resistance Test**

The contact resistance test shall be carried out after torque check is done on all the bus bar joints. The test requires to measure very small fluctuations in resistance while simulating actual operating conditions. A DC power source will inject the test current up to 100 A and digital voltmeter will measure the voltage drop across the joints under test, thus V/I gives Resistance

Contact resistance can also be measured using micro ohm meter as shown in figure below.

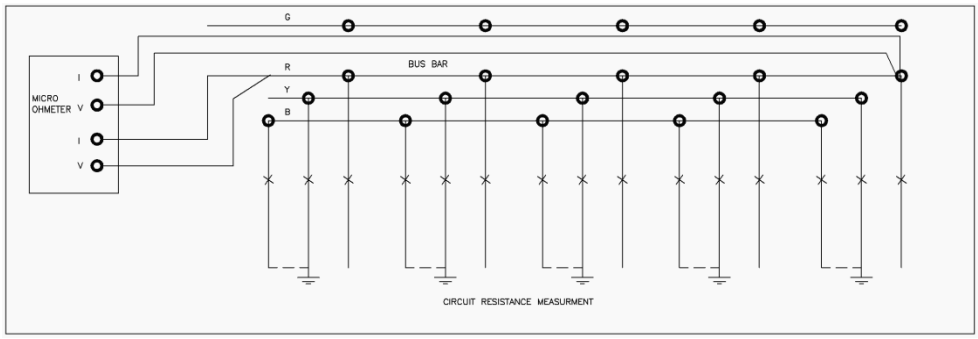
- Check the resistance for all the bus bar joints using micro-ohm meter of 100 Amps.
- Check the overall resistance of the bus bar for each phase and a ground by using micro-ohm meter of 100 Amps.



CONTACT RESISTANCE TEST ARRANGEMENT FOR PRIMARY CIRCUITS

5.2.2 **Main Circuit Resistance Test.**

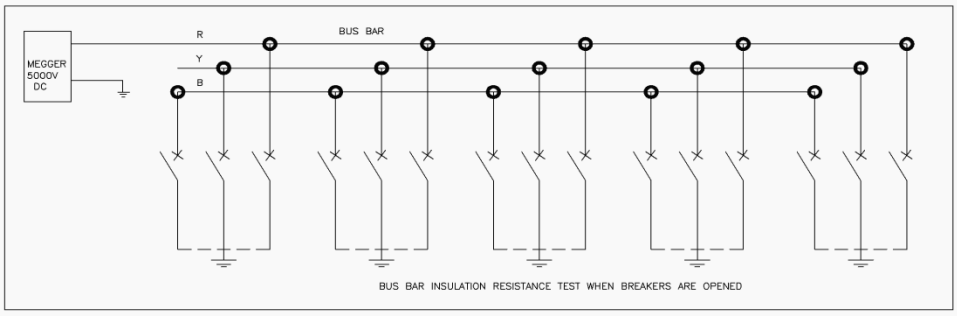
- The main circuit resistance test shall be performed by 10A or 100 Ampere DC micro-ohmmeter from panel to panel on each phase from cable spouts with all circuit breakers racked in (service) and close position.
- For judgment, the resistance values from panel to panel should not vary too much if the number of joints and length of bus bar remains the same.
- Contact Resistance Measurement shall be performed on all the bus including ground bus



5.2.3 **Insulation Resistance Test**

Perform Insulation resistance test with 1000Vdc for LV MCC bus and Breakers as below

- Close all the breakers in service position make sure out going cables and bus duct is still not connected.
- Isolate the VTs and short the CTs secondary of all the feeders
- Connect the phases Y, B to ground and apply the test voltage between phase R and ground and note down the readings.
- Connect the phases B, R to ground and apply the test voltage between phase Y and ground and note down the readings.
- Connect the phases R, Y to ground and apply the test voltage between phase B and ground and note down the readings.
- Open all the breakers in service position,
- Connect the phases R, Y, B Cable side to the ground on all the breakers.
- Connect the phases R, Y, B Bus side to the test set.
- Record the corresponding leakage current readings.



5.2.4 **Testing of Circuit breakers(MCCB)**

5.2.4.1 **Breaker Manual closing/opening**

All the MCCB's (Moulded Circuit breaker) shall be checked for its operation by closing and opening the breakers several times

5.2.4.2 **Tripping by trip test button**

All the MCCB's (Moulded Circuit breaker) shall be checked for tripping by pressing the test button and at the same time resetting of the breaker shall be checked.

5.2.4.3 **Primary Injection and Trip time measurement(for the breaker 100 amps and high)**

All the MCCB's (Moulded Circuit breaker) shall be checked for tripping by injecting the primary current equivalent to 2 or 3 times of breaker rated current

In this the test current is injected through the phases of the breaker and tripping time is noted. Trip time shall be verified with the manufactures thermal curve.

Test shall be done for all the three phases

Note: Only breaker 100 Amps and above will be tested for time test

5.2.5 **Functional Test of Local Controls, Alarm and Indication.**

- Alarm and indication for DC supervision relay shall be checked.
- Indication for closing, opening, of the breaker shall be checked.

5.2.6 **Functional Test of Remote Controls, Alarm and Indication.**

- Alarm and indication for DC supervision relay shall be checked on DCS or remote
- Alarm and indication for trip coil supervision shall be checked on DCS or remote
- Indication for closing, opening of the breaker shall be checked on DCS or Remote.

5.2.7 **Control Power ,Current and Voltage Measurement of the DC Switch board**

- Current on MCB of each circuit to be measured when all the devices are in service
- Mixing of voltage between the two circuits should be checked by keeping off MCB of one circuit and checking the voltage on other circuit MCB towards load side +V and –V terminals with respect to ground

5.2.8 **Testing of Protection Devices**

All the protection and monitoring relays shall be tested for their functionality and integrity, please refer related test procedure.

5.2.8.1 **Testing of Over/Under Voltage, and Ground relays**

All the voltage and ground relays shall be tested, please refer related test procedure

5.2.8.2 **Testing of Transducer**

All the current and voltage transducer shall be tested, please refer related test procedure

5.2.8.3 **Testing of Alarm Devices**

All alarms from the voltage and ground detection relays shall be checked, please refer related test procedure

5.2.9 **Protective Earthing check**

Switch gear protective Earthing bond must be earthed in order to afford protection to human beings. Minimum two point's preferable extreme end of ground bus shall be connected to the ground mesh

- Check all protective relays have been grounded

- Check the doors have been grounded

5.2.10 **Commissioning of heaters**

Space heater shall be commissioned as under.

5.2.10.1 **Visual Checks of Heaters**

- Check the rating of the heater match with the supply voltage.
- Check the KW rating of the heater match with drawing.
- Check the breaker which supplying power to heater circuit for correct rating with respect to total load of the heaters.

5.2.10.2 **Measurement of Insulation Resistance**

Perform insulation resistance measurement on space heater circuit with 500 VDC megger

5.2.10.3 **Measurement of Current and Voltage**

Switch on the breaker and measured the total current and individual heater load with mini clamp meter

5.2.10.4 **Functional Checks of Thermostat**

Check the operation of the thermostat and hygrometer for cut in and cut out operation

5.2.11 **Checks After Initial Energization**

After energization service load checks to be performed as under

- +V to –V and phase to ground Voltage measurement shall be done.
- All the measuring devices including protective relay to be checked for their metering function.

6.0 Documents

Relevant Test sheet to be completed for each and every DC DB

7.0 Attachment

7.1 Test Sheet for MCC

7.2 Test Sheet for DC DB

*****End of the Procedure *****

Testing Procedure

AC MCC

Document No: BSC-TP-ACMCC 01
Rev: 0

TABLE OF CONTENT

1.0 Task

The purpose of this procedure is to test, commission and document the motor control center of 220/380/480V levels.

2.0 Preconditions

2.1 Work Status

- Erection has been completed.
- Labelling of the equipment and designation of live enclosed plant sections has been carried out.

2.2 Documentation

- The schematic and single line diagram of the low voltage motor control centre are available
- Commissioning checklists TS-MM01

2.3 Personnel

- 1 Commissioning engineer: Engineer or technician with experience in commissioning of all types of Electrical equipments.
- 1 Helper: skilled worker with adequate on-the-job training.

2.4 Measuring instruments and tools

- Micro ohm meter 10A and 100A
- Insulation Tester 1000V dc
- Primary injection test set
- Secondary Injection test set
- Fluke-2 Nos

3.0 Precautions

The work will only proceed when a Permit to Work (PTW) in work permit area has been obtained. The PTW will be kept on site for consultation during the testing works.

Special attention will be given to:

- Due to high voltage being used, adequate safety precautions should be taken to avoid injury to personnel and damage to property.
- Cordoning off specified working area and provision of applicable safety warning sign board.
- Ensure that all the necessary test equipment are made available at the test area and with valid calibration stickers and certificate.
- Hand insulating gloves and grounding sticks / wire jumpers shall be provided for safe handling and draining of residual voltage.
- Immediately after testing of each phase, voltage residue shall be drain by using grounding stick / wire which is directly connected to earth.

- Closing of the work permit after completion of the work (if the test area is to be considered in work permit area) is necessary.

4.0 Scope

- Testing of Bus Bar
- Testing of MCCB
- Operation of MCCB inside the feeder
- Testing Of ATS
- Operation of Earting switch
- Checking CB mounting.

5.0 Execution

5.1 Visual Checks

- Check nameplate information for correctness.
- Inspect enclosures for proper alignment, foundation fixing and grounding.
- Inspect covers, panel section and door for paint work and proper fit.
- Check operation of all mechanical interlocks.
- Check tightness of all bolted connections (torque wrench method).
- Check bus and supports for defects such as cracked welds, chipped porcelain, cracked insulation, etc., and free of dust accumulation.
- Verify that all front panel mounted devices (meters, push buttons, switches, indicator lamps, mimic buses, etc.) are installed as per drawings
- Perform mechanical check and visual inspection on the circuit breaker.
- Check for correct breaker position indication.
- Check that all control wiring is correct according to the approved drawing and terminal connections are secure.

WIRING AND FERRULING CHECK

- Ensure the numbers on the ferules are from left to right beginning at the terminal block i.e. at the end of the wire and from bottom to top.
- The wire nos. should be checked against the wiring table and the schematic drawing.

5.2 Testing MCC(Motor Control Centre)

Enter the rating plate data in relevant test sheet and compare the data with the data contained in the circuit documentation. The following test shall be carried out on whole MCC

1. Testing of Bus Bar
   a. Bus Continuity and phasing test
   b. Torque Test
   c. Contact Resistance test
   d. Main Circuit Resistance Test
   e. Insulation Resiatnce Measurment
2. Testing of Circuit breakers(MCCB)
   a. Breaker Manual closing/opening
   b. Tripping by trip test button
   c. Primary Injection and Trip time measurement

3. ATS functional check
4. Functional Test of Local Controls, Alarm and Indication.
5. Functional Test of Remote Controls, Alarm and Indication.
6. Control Power ,Current and Voltage Measurement of the MCC
7. Electrical control and protection/Measuring Devices
    d. Testing of protection devices
    e. Testing of CT and VT
    f. Testing of Transducers
    g. Testing of Alarm Devices
8. Protective earthing check
9. Commissioning of Heater Circuit
    h. Visual Checks
    i. Measurement of insulation resistance of heater and lamp circuit
    j. Functional checks of thermostat , Heaters,
    k. Measurement of Current and voltage
10. Checks before and After initial energization

5.2.1 Testing of Bus Bar

5.2.1.1 Bus Continuity and Phasing Test

Continuity and phasing test can be done by simple ohm meter or fluk

Connect the extreme end of the single phase of the bus with ground and check the resistance between phases and ground. All the phases should read infinity except the grounded phase, thus the phase is identified and continuity is checked. Repeat the test on remaining two phases.

5.2.1.2 Torque Test

Torque shall be applied to all joints which are made at site. The bolts shall be tightened according to the manufacturer instructions after the bus bar erection is completed. Spot check shall be carried out using a calibrated torque wrench.

Following is reference in case data from the manufacturer is not available,

Bolt shall be tighten to maximum value,

Bolt Size	Maximum value
M 6	8 Nm

M 8	20 Nm
M 10	40 Nm
M 12	70 Nm
M 16	140 Nm

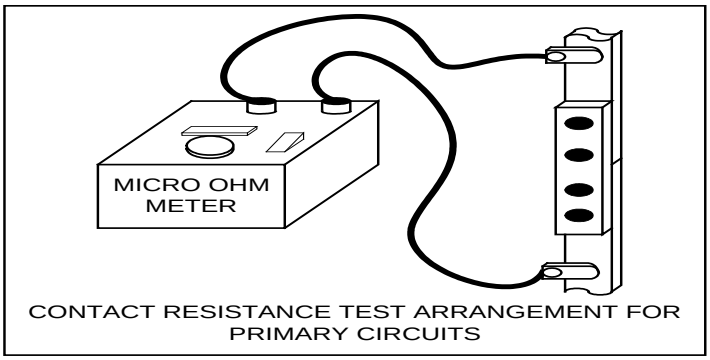
Tolerance: ± 20 %

5.2.1.3 **Contact Resistance Test**

The contact resistance test shall be carried out after torque check is done on all the bus bar joints. The test requires to measure very small fluctuations in resistance while simulating actual operating conditions. A DC power source will inject the test current up to 100 A and digital voltmeter will measure the voltage drop across the joints under test, thus V/I gives Resistance

Contact resistance can also be measured using micro ohm meter as shown in figure below.

- Check the resistance for all the bus bar joints using micro-ohm meter of 100 Amps.
- Check the over all resistance of the bus bar for each phase and a ground by using micro-ohm meter of 100 Amps.

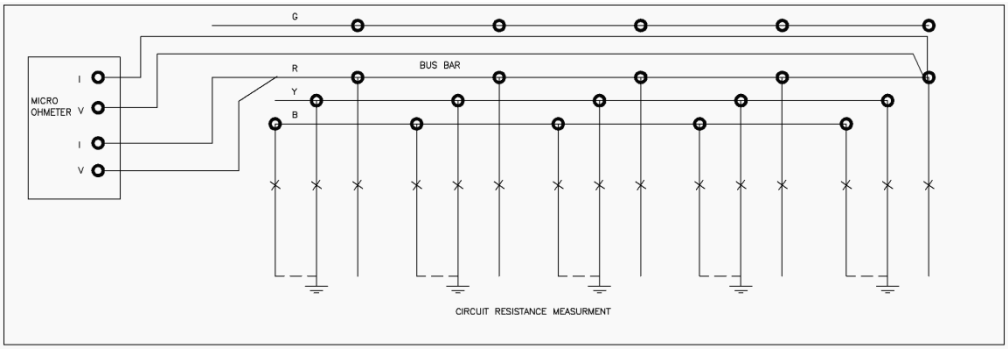


CONTACT RESISTANCE TEST ARRANGEMENT FOR PRIMARY CIRCUITS

5.2.2 **Main Circuit Resistance Test.**

- The main circuit resistance test shall be performed by 10A or 100 Ampere DC micro-ohmmeter from panel to panel on each phase from cable spouts with all circuit breakers racked in (service) and close position.
- For judgment, the resistance values from panel to panel should not vary too much if the number of joints and length of bus bar remains the same.

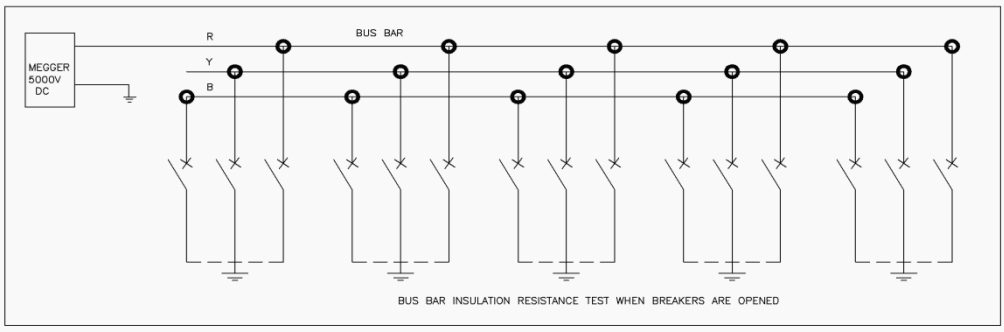
- Contact Resistance Measurement shall be performed on all the bus including ground bus



5.2.3 **Insulation Resistance Test**

Perform Insulation resistance test with 1000Vdc for LV MCC bus and Breakers as below

- Close all the breakers in service position make sure out going cables and bus duct is still not connected.
- Isolate the VTs and short the CTs secondary of all the feeders
- Connect the phases Y, B to ground and apply the test voltage between phase R and ground and note down the readings.
- Connect the phases B, R to ground and apply the test voltage between phase Y and ground and note down the readings.
- Connect the phases R, Y to ground and apply the test voltage between phase B and ground and note down the readings.
- Open all the breakers in service position,
- Connect the phases R, Y, B Cable side to the ground on all the breakers.
- Connect the phases R, Y, B Bus side to the test set.
- Record the corresponding leakage current readings.



5.2.4 **Testing of Circuit breakers(MCCB)**

5.2.4.1 **Breaker Manual closing/opening**

All the MCCB's (Moulded Circuit breaker) shall be checked for its operation by closing and opening the breakers several times

5.2.4.2 **Tripping by trip test button**

All the MCCB's (Moulded Circuit breaker) shall be checked for tripping by pressing the test button and at the same time resetting of the breaker shall be checked.

5.2.4.3 **Primary Injection and Trip time measurement(for the breaker 100 amps and high)**

All the MCCB's (Moulded Circuit breaker) shall be checked for tripping by injecting the primary current equivalent to 2 or 3 times of breaker rated current

In this the test current is injected through the phases of the breaker and tripping time is noted. Trip time shall be verified with the manufactures thermal curve.

Test shall be done for all the three phases

Note: Only breaker 100 Amps and above will be tested for time test

5.2.5 **ATS functional check**

If ATS (Automatic Transfer System) is provided on the MCC needs to be checked as per the circuit diagrams

5.2.6 **Functional Test of Local Controls, Alarm and Indication.**

- Alarm and indication for DC supervision relay shall be checked.
- Indication for closing, opening, of the breaker shall be checked.

5.2.7 **Functional Test of Remote Controls, Alarm and Indication.**

- Alarm and indication for DC supervision relay shall be checked on DCS or remote
- Alarm and indication for trip coil supervision shall be checked on DCS or remote
- Indication for closing, opening of the breaker shall be checked on DCS or Remote.

5.2.8 **Control Power ,Current and Voltage Measurement of the MCC**

- Current on MCB of each circuit to be measured when all the devices are in service
- Mixing of voltage between the two circuits should be checked by keeping off MCB of one circuit and checking the voltage on other circuit MCB towards load side +V and –V terminals with respect to ground

5.2.9 **Testing of Protection Devices**

All the protection and monitoring relays shall be tested for their functionality and integrity, please refer related test procedure.

5.2.9.1 **Testing of CT's and VT's**

All the CT's and VT's shall be tested, please refer related test procedure

5.2.9.2 **Testing of Transducer**

All the current, voltage, frequency and power transducer shall be tested, please refer related test procedure

5.2.9.3 **Testing of Alarm Devices**

Alarms for DC supervision, trip coil supervision**,** spring charging etc shall be checked up to the DCS

5.2.10 **Protective Earthing check**

Switch gear protective Earthing bond must be earthed in order to afford protection to human beings. Minimum two point's preferable extreme end of ground bus shall be connected to the ground mesh

- Check all protective relays have been grounded
- Check the doors have been grounded

5.2.11 **Commissioning of heaters**

Space heater shall be commissioned as under.

5.2.11.1 **Visual Checks of Heaters**

- Check the rating of the heater match with the supply voltage.
- Check the KW rating of the heater match with drawing.
- Check the breaker which supplying power to heater circuit for correct rating with respect to total load of the heaters.

5.2.11.2 **Measurement of Insulation Resistance**

Perform insulation resistance measurement on space heater circuit with 500 VDC megger

5.2.11.3 **Measurement of Current and Voltage**

Switch on the breaker and measured the total current and individual heater load with mini clamp meter

5.2.11.4 **Functional Checks of Thermostat**

Check the operation of the thermostat and hygrometer for cut in and cut out operation

5.2.12 **Checks After Initial Energization**

After energization service load checks to be performed as under

- Current should be measured on all the secondary terminal of the current transformer.
- Phase to phase and phase to ground Voltage measurement should be done on all the phase and core of the voltage transformer.
- Phase sequence checks to be done on Voltage transformer.
- All the measuring devices including protective relay to be checked for their metering function.

6.0 Documents

Relevant test sheets to be completed for each and every MCC

7.0 Attachment

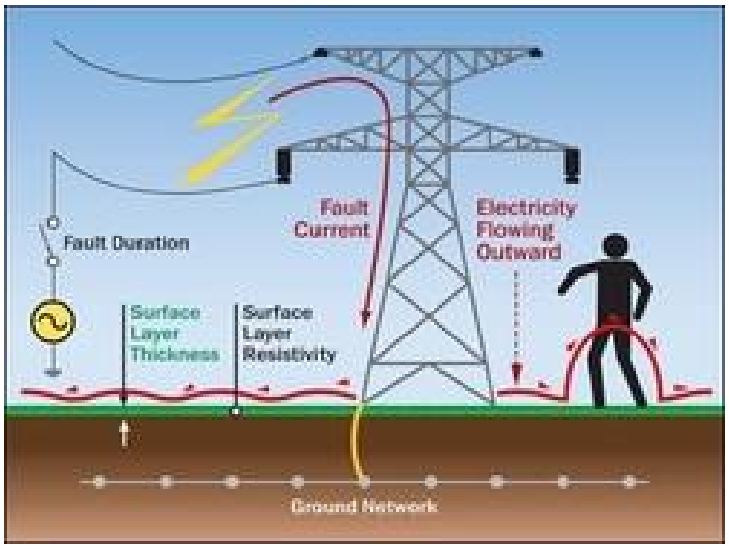
7.1 **Test Sheet for MCC**

*****End of the Procedure *****

Testing Procedure

Grounding System

Document No: BSC-TP-GRD01
Rev: 0



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1. **PURPOSE**

The purpose of this procedure is to test and document the integrity of Grounding Grid, Ground Impedance, and touch and step potential for power plant and substation grounding in accordance to the IEEE 80 and 81.

2. **SCOPE**

This procedure applies to large ground of power plant and substation newly built where following tests are done

a. Potential Rise Measurement
b. Step Potential Measurement
c. Touch Potential Measurement

3. **REFERENCES**

3.1 IEEE Standard 80 and 81

4. **GENERAL INFORMATION**

4.1 Ground Impedance

Ground impedance measurement are made

(1) To determine the actual impedance of the ground connections
(2) As a check on calculations
(3) To determine
  (a) The rise in ground potential and its variation throughout an area, that results from ground fault current in a power system.
  (b) The suitability of a grounding connection for lightning protection, and
  (c) The suitability of grounding connection for radio-frequency transmission at a transmitter.
(4) To obtain data necessary for the design of protection for buildings, the equipment therein, and any personnel that may be involved.

4.1.1 Method of Measuring ground impedance

4.1.1.1 Two-Point Method (Ammeter-Voltmeter Method).

In this method the total resistance of the unknown and an auxiliary ground is measured. The resistance of the auxiliary ground is presumed to be negligible in comparison with the resistance of the unknown ground, and the measured value in ohms is called the resistance of the unknown ground.

The usual application of this method is to determine the resistance of a single rod-driven ground near a residence that also has a common municipal water supply system that uses metal pipe without insulating joints. The water pipe is the auxiliary ground and its ground resistance is assumed to be in the order of 1 Ω and must be low in relation to the permissible driven ground maximum resistance which is usually in the order of 25 Ω.

Obviously, this method is subject to large errors for low-valued driven grounds but is very useful and adequate where a go, no-go, type of test is all that is required.

4.1.1.2 Three-Point Method.

This method involves the use of two test electrodes with the resistances of the test electrodes designated r_2 and r_3 and with the electrode to be measured designated r_1. The resistance between each pair of electrodes is measured and designated r_{12}, r_{13}, and r_{23},

Where

$r_{12} = r_1 + r_2$, $r23 = r_2 + r_3$, $r_{13} = r_1 + r_3$

Solving the simultaneous equations,

$$r_1 = \frac{(r_{12}) - (r_{23}) + (r_{13})}{2}$$

For the measurement, the electrodes must be at some distance from each other; otherwise absurdities may arise in the calculations, such as zero or even negative resistance. In measuring the resistance of a single-driven electrode the distance between the three separate ground electrodes should be at least 5 m with a preferable spacing of 10 m or more. For larger area grounding systems, which are presumably of lower resistances, spacing in the order of the dimensions of the grounding systems are required as a minimum, This method becomes awkward for large substations and power plants, and some form of the fall-of-potential method is preferred, if high accuracy is required.

4.1.1.3 Fall of Potential Method

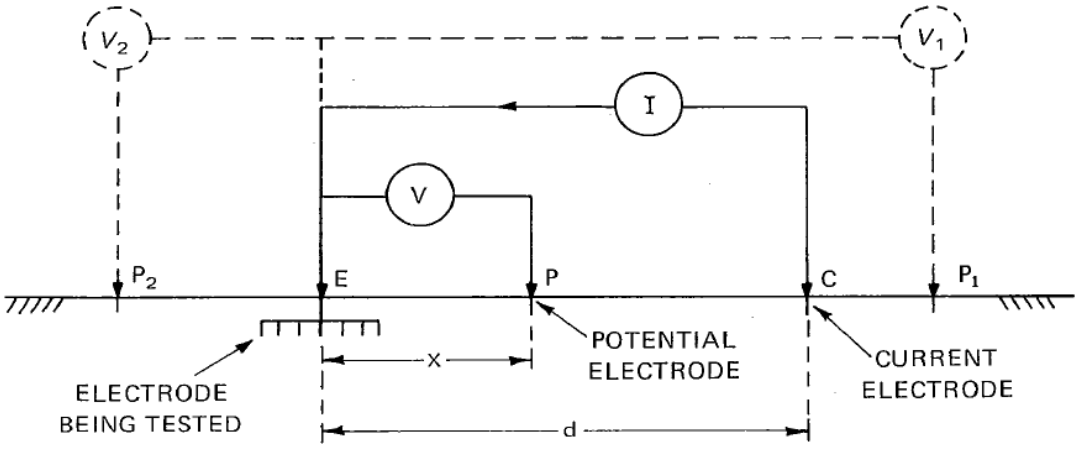

Figure-1
Fall –Of – Potential Method

The method involves passing a current into the electrode to be measured and noting the influence of this current in terms of voltage between the ground under test and a test potential electrode.

A test current electrode is used to permit passing a current into the electrode to be tested (see Fig 1),
The current I through the tested electrode E and the current electrode C, results in earth surface potential variations. The potential profile along the C, P, E, direction will look as in Fig 2. Potentials are measured with respect to the ground under test, E, which is assumed for convenience at zero potential.

The fall-of-potential method consists of plotting the ratio of V/I = R, as a function of probe spacing X. The potential electrode is moved away from the ground under test in steps. A value of impedance is obtained at each step. This impedance is plotted as a function of distance, and the value in ohms at which this plotted curve appears to level out is taken as the impedance value of the ground under test (see Fig 3).

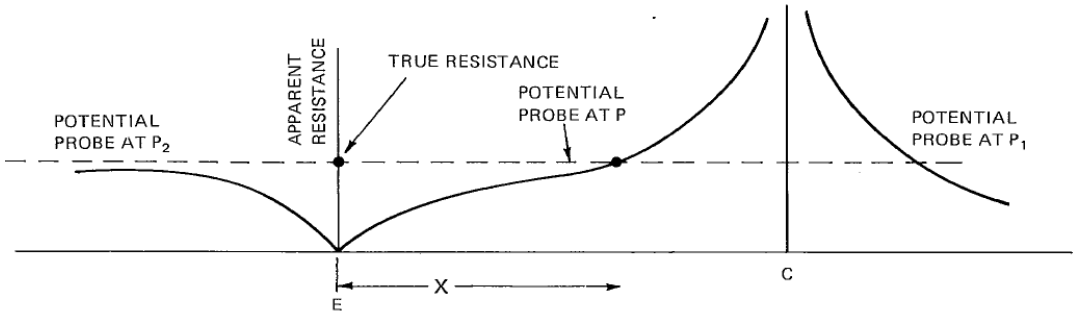

Figure-2
Apparent Resistance for Various spacing X

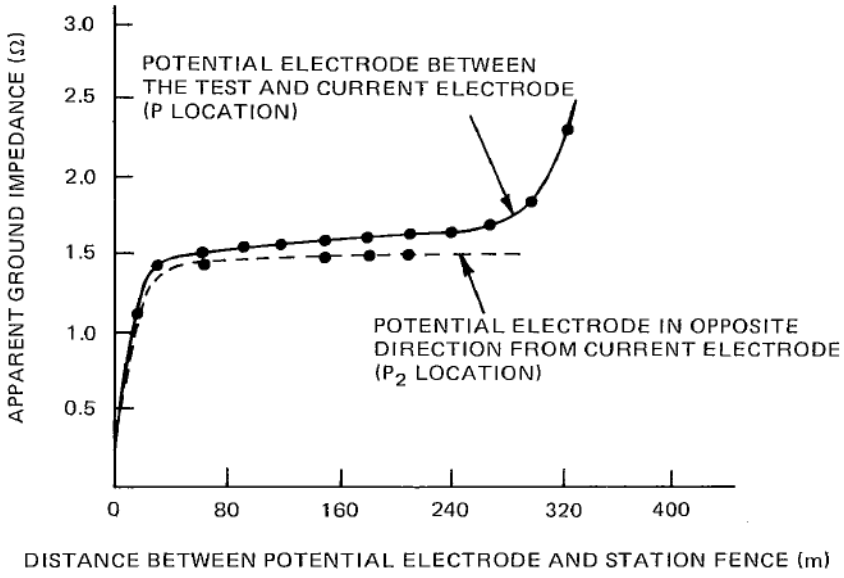

Figure-3
Impedance verses distance

In order to obtain a flat portion of the curve it is necessary that the current electrode be effectively outside the influence of the ground to be tested. This influence is sometimes

called extent of station ground and may be considered as the distance beyond which there is a negligible effect on the measured rise of ground voltage caused by ground current. Theoretically the influence extends to infinity; but practically there is a limit, because the influence varies inversely as some power of the distance from the ground to be tested.

4.1.1.4 Step and Touch Potential

The magnitude of step and touch voltage (see Fig 4) may be scaled off of a potential contour map of the site or actually measured by the voltmeter- ammeter method. These values are proportional to the earth current and (provided that the deep soil resistivity is constant) to the top soil resistivity.

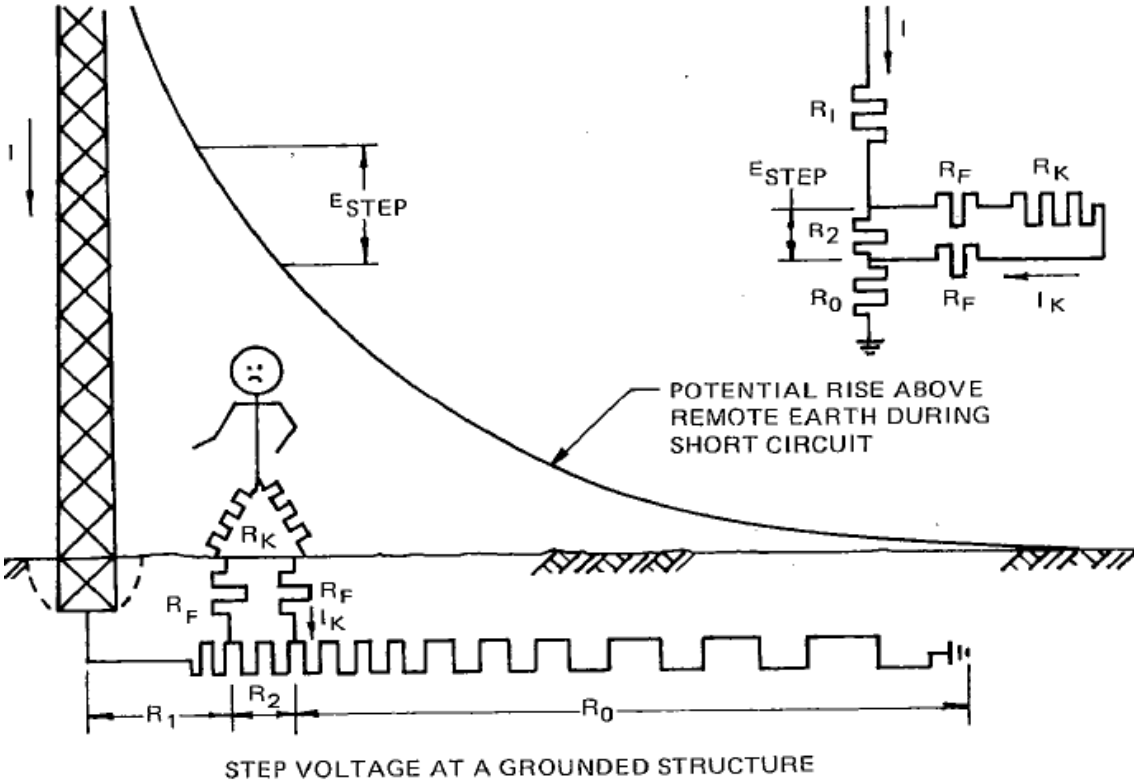

Figure-4
Step Potential

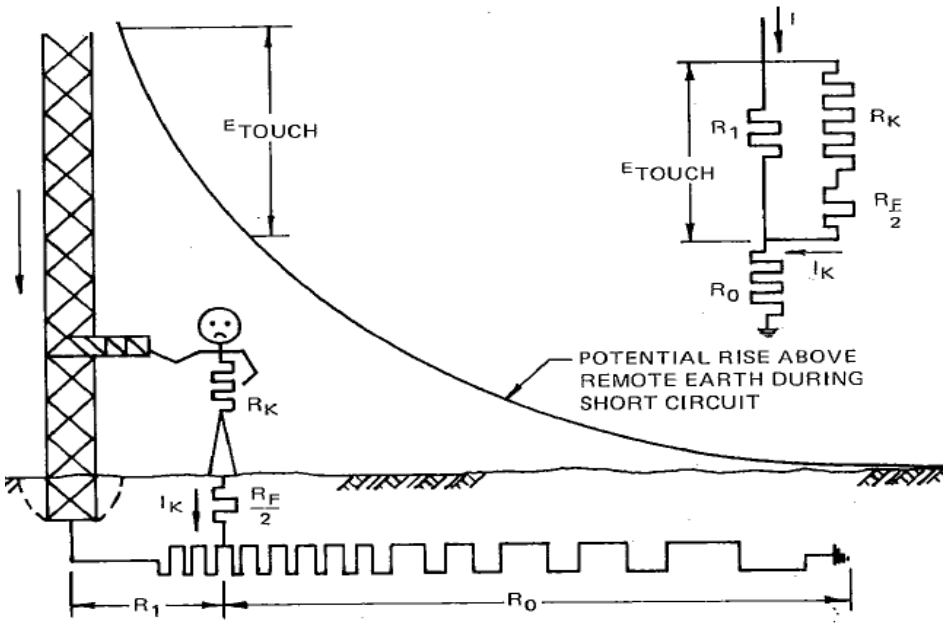

Figure-5
Touch Potential

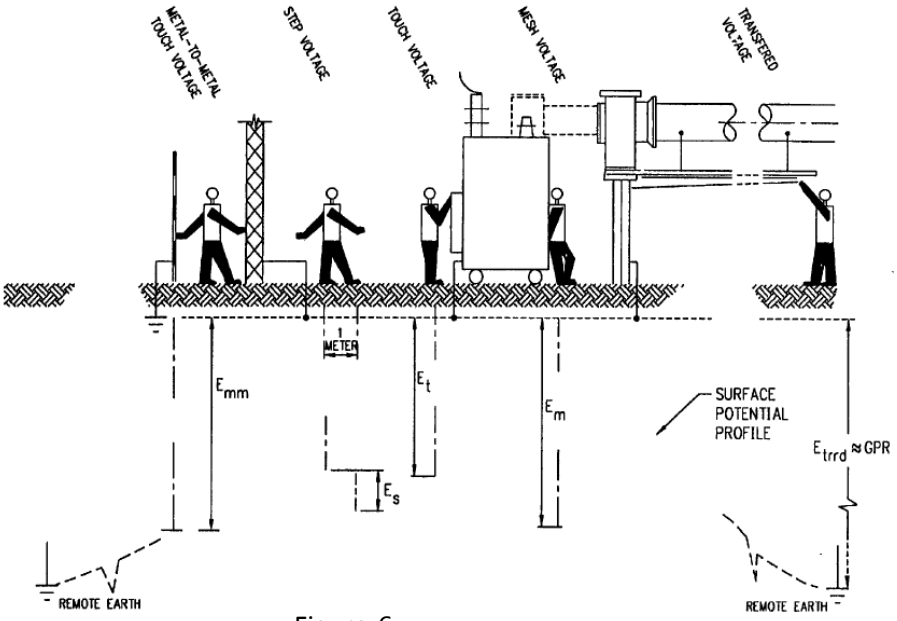

Figure-6

Basic Shock situation

4.2 **Ground Potential Rise (GPR):**

The maximum electrical potential that a substation grounding grid may attain relative to a distant grounding point assumed to be at the potential of remote earth. This voltage (GPR) is equal to the maximum grid current times the grid resistance.

NOTE— under normal conditions, the grounded electrical equipment operates at near zero ground potential. That is, the potential of a grounded neutral conductor is nearly identical to the potential of remote earth, during a ground fault the portion of fault current that is conducted by a substation or power plant grounding grid into the earth causes the rise of the grid potential with respect to remote earth.

4.3 **Mesh Voltage:**

Maximum touch voltage within a mesh of a ground grid.

4.4 **Metal-to-Metal Touch Voltage**:

The difference in potential between metallic objects or structures within the substation or power plant site that may be bridged by direct hand-to-hand or hand-to-feet contact.

4.6 Step Voltage:

The difference in surface potential experienced by a person bridging a distance of 1 m with the feet without contacting any other grounded object.

4.7 Touch Voltage:

The potential difference between the ground potential rise (GPR) and the surface potential at the point where a person is standing while at the same time having a hand in contact with a grounded structure.

4.8 Transferred Voltage:

A special case of the touch voltage where a voltage is transferred into or out of the substation from or to a remote point external to the substation site.

4.9 Effect of frequency on human body:

Humans are very vulnerable to the effects of electric current at frequencies of 50 to 60 Hz. Current of approximately 0.1A can be lethal. Research indicates that human body can tolerate s slightly higher 25 HZ current and approximately five times higher than direct current. At frequency of 3000 to 10 000 Hz even higher current can be tolerated.

4.10 Effect of Magnitude and duration on human body

The most common physiological effects of electric current on the body, stated in order of

increasing current magnitude, are threshold perception, muscular contraction, unconsciousness, fibrillation of the heart, respiratory nerve blockage and burning.

Current of 1 mA is generally recognized as the threshold of perception; that is. The current magnitude at which a person is just able to detect a slight tingling sensation in his hands or fingertips caused by the passing current.

Currents of 1—6 mA, often termed let-go currents, though unpleasant to sustain, generally do not impair the ability of a person holding an energized object to control his muscles and release it.

In the 9—25 mA range, currents may be painful and can make it difficult or impossible to release energized objects grasped by the hand. For still higher currents muscular contractions could make breathing difficult. These effects are not permanent and disappear when the current is interrupted, unless the contraction is very severe and breathing is stopped for minutes rather than seconds. Yet even such cases often respond to resuscitation.

It is not until current magnitudes in the range of 60-100 mA are reached that ventricular fibrillation, stoppage of the heart, or inhibition of respiration might occur and cause injury or death. A person trained in cardiopulmonary resuscitation (CPR) should administer CPR until the victim can be treated at a medical facility.

Hence, Grounding system shall be designed to keep fibrillation threshold below the above values of shock current in order to prevent injury or death.

the non-fibrillating current of magnitude ‘ at durations ranging from 0.03—3.0 s is related to the energy absorbed by the body as described by the following equation:

$$S_B = (I_B)^2 \times t_S$$

Where,
I_B is the rms magnitude of the current through the body in A
t_S, is the duration of the current exposure in
S_B is the empirical constant related to the electric shock energy tolerated by a certain percent of a given population

Hence Tolerable Body Current Limit According to IES-80 for 50 to 60 Hz Current is

$$I_B = \frac{0.116}{\sqrt{t_S}}$$ for 50 Kg Body Weight

And

$$I_B = \frac{0.157}{\sqrt{t_S}}$$ for 70 Kg Body Weight

4.11 Step and touch voltage criteria

The safety of a person depends on preventing the critical amount of shock energy from being absorbed before the fault is cleared and the system de-energized. The maximum driving voltage of any accidental circuit should not exceed the limits defined as follows.

For step voltage the limit is

$$E_{Step} = (R_B + 2R_f) .I_B$$

For body weight of 50 kg Step Voltage is

$$E_{Step50} = (1000 + 6C_S .\rho_S).\frac{0.116}{\sqrt{t_S}}$$

For body weight of 70 kg Step Voltage is

$$E_{Step70} = (1000 + 6C_S .\rho_S).\frac{0.157}{\sqrt{t_S}}$$

Similarly, the touch voltage limit is

$$E_{Touch} = (R_B + R_f/2) .I_B$$

For body weight of 50 kg Touch Voltage is

$$E_{Touch50} = (1000 + 1.5C_S .\rho_S).\frac{0.116}{\sqrt{t_S}}$$

For body weight of 70 kg Step Voltage is

$$E_{STouch70} = (1000 + 1.5C_S .\rho_S).\frac{0.157}{\sqrt{t_S}}$$

Where

E_{step}	is the step voltage in V
E_{Touch}	is the touch voltage in V
C_S	is determined from Figure II or Equation (27)
ρ_S	is the resistivity of the surface material in Q-m
t_s	is the duration of shock current in seconds

If no protective surface layer is used, then C_S =1 and $\rho_S = \rho$.
The metal-to-metal touch voltage limits are derived from the touch voltage equations, Metal-to-metal contact, both hand-to-hand and hand-to-feet, will result in ρ, = 0. Therefore, the total resistance of the accidental circuit is equal to the body resistance. R_B,
With the substitution of $\rho_S = 0$ in the foot resistance E touch voltages equations the metal-to-metal touch voltage limit is

$$E_{mm\text{-}touch50} = \frac{116}{}$$ for 50 Kg Body Weight

$$E_{mm\text{-}touch70} = \frac{\sqrt{t_s}}{\sqrt{t_s}} \frac{157}{} \quad \text{for 70 Kg Body Weight}$$

Where

E_{mm} is the metal-to-metal touch voltage in V

The actual step voltage, touch voltage, or metal-to-metal touch voltage should be less than the respective maximum allowable voltage limits to ensure safety. Hazards from external transferred voltages are best avoided by isolation or neutralizing devices and labeling these danger points as being equivalent to live lines.

5. PREREQUISITE

- Grounding mesh installation should be completed.
- All the Electrical equipment should have connected to the grounding grid.
- Grating and gravelling work should be over for all the transformers.
- Leveling of the soil for the complete plant shall be over.
- Permit to work shall be sought from the concern department
- *Transformer Neutral to be disconnected from the transformer with transformer shutdown.*

6. PRECAUTIONS

The work will only proceed when a Permit to Work (PTW) in work permit area has been obtained. The PTW will be kept on site for consultation during the testing works

a. Special safety arrangements shall be made for all areas which are not explicitly designated as" electrical operating areas" when performing tests at voltages in excess of 50V.

b. Closing of the work permit after completion of the work (if the test area is to be considered in work permit area) is necessary.

c. Before test voltages are applied a check shall be carried out to ensure that no unauthorized persons are working at the corresponding load-where ever necessary barriers should be provided

d. This test should be performed only by personnel who are properly trained on the test equipment. Safety rules, testing procedures and interpretation of the results.

7. PROCEDURE

Test is done by injecting current of 100- 150 A to grounding mesh by using a long cable who's length shall be equal to 3 times of the radius of the grounding grid as shown in following figures.

In order to get a flat portion of the curve it is necessary that the current electrode be effectively outside the influence of the ground to be tested

Cable Size Requirment:

In order to have 150A injection the cable size is
Total Resistance to be = 277/150 =1.85 Ohms
Cable Resistance =(1.85- R_{ground}) = 1.85-0.1 = 1.75 Ohms hence single core 185 mm2 cable to be used

7.1 Potential Rise Measurement

7.1.1 Convention Method

Connections are made as shown in figure-7 below, where current injection (100-150Amps) is made between the neutral point of the generator transformer and current electrode at remote end (West of the plant- around 500 Meters outside of the plant)

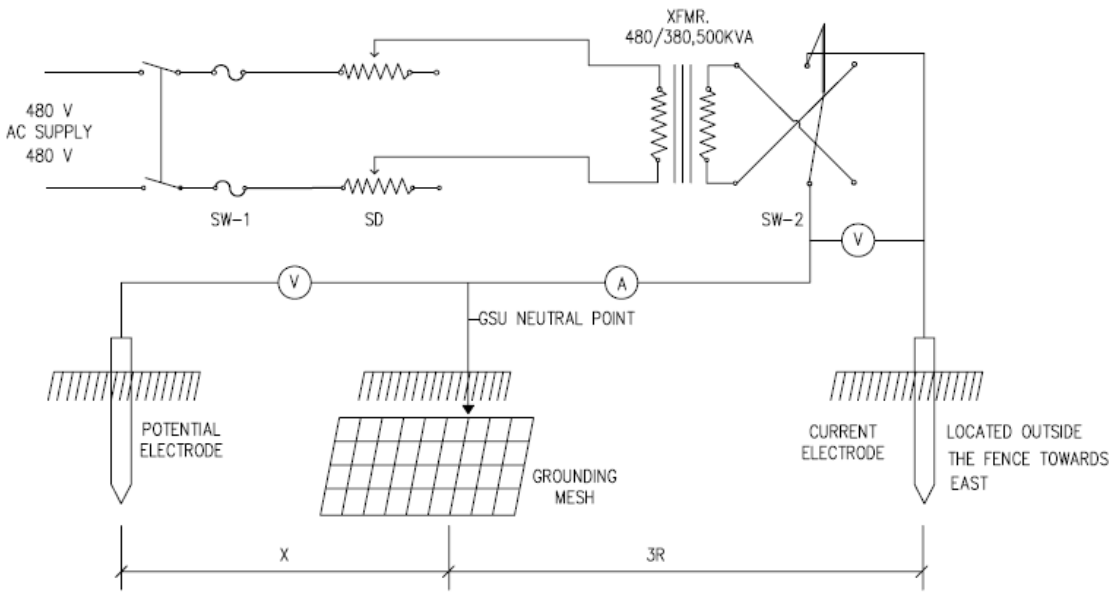

Figure-7
Test Circuit for Ground potential Rise Measurement

SW-1 Fuse Switch
SW-2 Change over Switch (Polarity)
SD Variable Transformer

- Voltage readings are taken for different spacing in all the three direction of the plant for forward current direction (Polarity)
- Voltage readings are repeated for the same spacing in all the three direction of the plant for Reverse current direction (Polarity)
- Readings are tabulated and corrected to actual fault current and then Graph is plotted as Potential rise verses Distance

7.1.2 Ground Impedance by SGM

This section illustrates the procedure for performing ground impedance measurements with the SGM. The general configuration of the SGM setup is illustrated in figure.11. Step-by-step instructions for setting up and performing this measurement are given next.

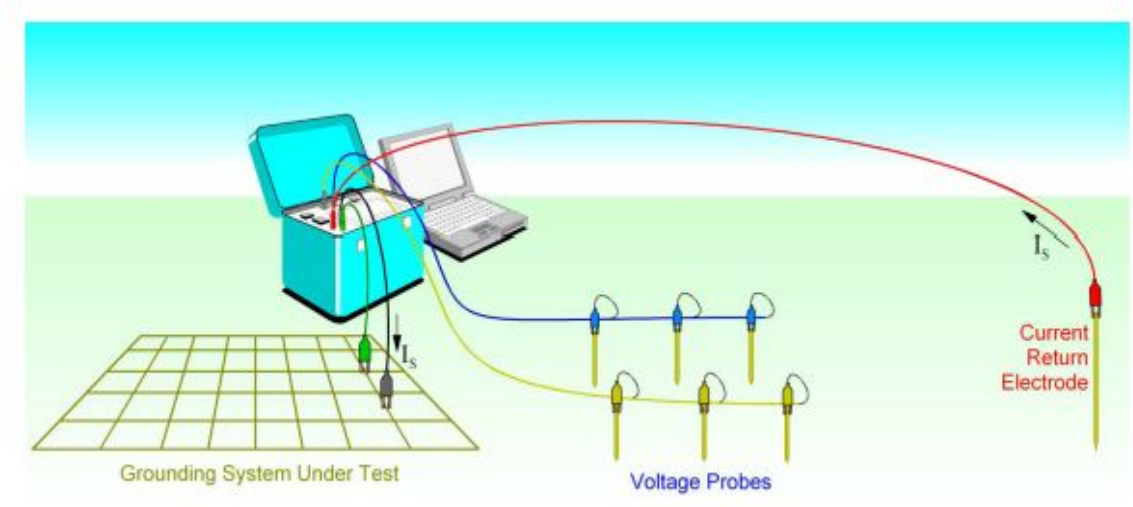

Figure 11. SGM setup for Ground Impedance Measurement for Probe location Guidelines.

Caution: Do not power the SGM or the computer before all connections have been made.

7.1.2.1 Install the voltage probes 1Y, 2Y, 3Y (yellow assembly), B1, B2, B3 (blue assembly) and the current return electrode. It is recommended that the current return electrode be placed at a distance from the substation fence of at least 2 times the maximum diagonal length of the substation. The voltage probes should be placed at a distance of at least 100 feet from the substation fence in a radial direction and no further than 60% of the distance to the current return electrode. In many cases there are space limitations around a substation. In these cases, the voltage probes can be placed in any available space. In any case, try to locate all probes at least 100 feet away from the perimeter of the substation, in a radial direction if possible, and as far as possible from other ground structures such as lines, pipes, etc. In addition, make sure that the six voltage probes are closer to the grounding system under test than the current return electrode. Figure 3.2 illustrates the area where the voltage probes must be placed relative to the grounding system under test and the current return electrode. Practical Hint: Allow several feet of cable slack at every voltage probe to facilitate the relocation of the probe if it is necessary.

7.1.2.2 Connect the black and green terminals to a grounding conductor of the grounding system under test. Practical Hint: Cleaning the grounding conductor with a wire brush or sand paper before attaching the SGM alligator clips.

7.1.2.3 Setup and connect the Smart Ground Multi meter and computer via the RS23 (serial port) cable. **Do not power the SGM or the computer before all connections have been made**.

7.1.2.4 Connect the voltage probe assemblies Y (yellow) and B (blue), as well as the current return electrode cable to the corresponding SGM receptacles. All connectors are color-coded.

7.1.2.5 Turn on the SGM power switch, turn on the personal computer and execute the program.

7.1.2.6 Setup a new measurement case file as follows:

Click on the New Case icon (). In the pop-up dialog type the name of the measurement case in the Case Name entry field. The case name must not contain any tabs or spaces. Also do not type a file name extension, since the SGM software automatically assigns extensions. Select the measurement Function: "Ground Impedance". You may optionally select the directory where the case files are to be stored by clicking on the Browse button.

Click on the OK button to proceed. A new pop-up dialog appears with the measurement parameter options. Modify the measurement parameters as desired, and click on the OK button to proceed. Note that in most cases the default measurement parameters should be accepted without any modification.

Enter the approximate shape of the grounding system under test and the relative positions of the SGM, the voltage probes, and current return electrode. (See Appendix F: Using the Ground System Editor). For further information on how to select various options and parameters see also Appendix E: User Selectable Controls and Parameters.

7.1.2.7 At this point you are ready to perform the measurement. However, before initiating the measurement, in order to ensure safety, make sure that no persons may touch the current electrode during the measurement process. Initiate the measurement by clicking on the button MEASURE.

During the measurement process you can monitor the measured data quality via dynamically updated screen plots. Note that the measurement process consists of two phases. The first phase collects data for the purpose of voltage probe calibration. The second phase collects the ground potential difference data with which the ground system impedance is computed.

See section 1.1 Important Recommendations for additional guidance for successfully completing this test.

After completion of the measurement process and data analysis, the final report

window will appear. An example final report is illustrated in Figures 3.6 and 3.7. The first report window provides the system ground impedance as a function of frequency. The red curve is the impedance magnitude and the blue curve is the impedance phase angle. The numerical values for a specific frequency can be obtained by placing the cursor (mouse) at the desired location of the graph.

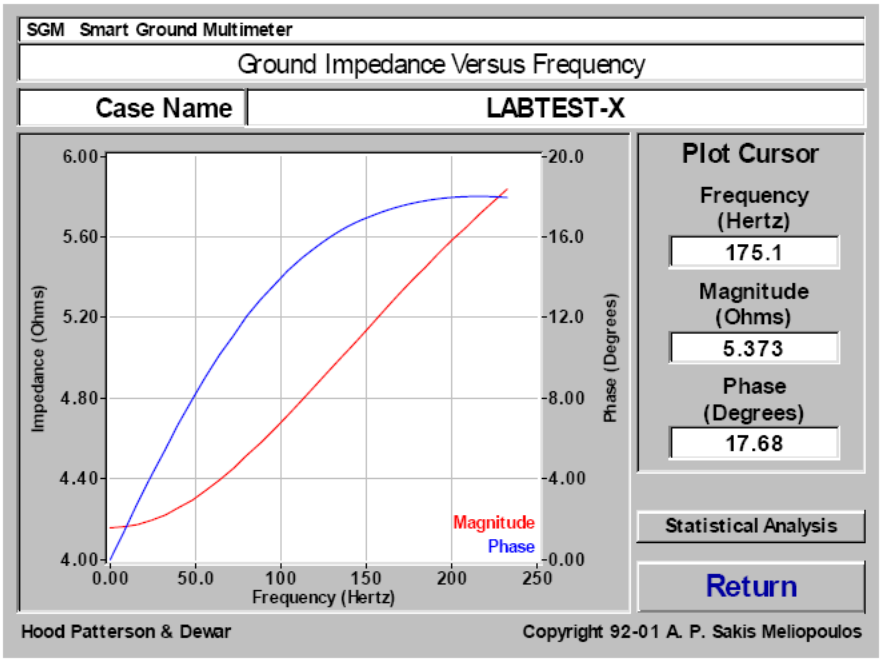

Figure 3.6

The statistical analysis button opens a statistical analysis report window, which is illustrated in

Figure 3.7 this report provides the Probe Performance Index (PPI) and the expected error (Error %) for specific values of confidence levels (Conf %).

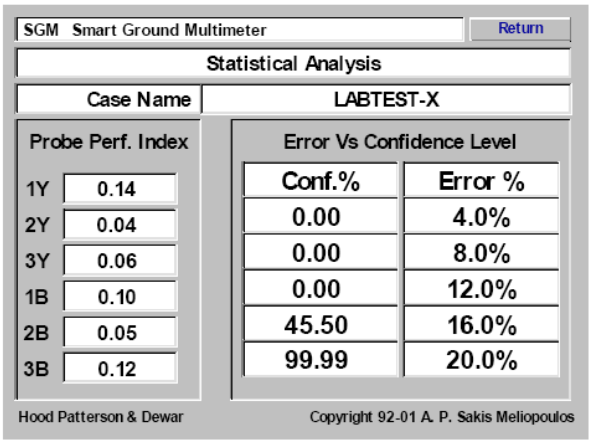

Figure 3.7

Note that all data collected during measurements are automatically stored in several data files. These data files are named as follows:

File Name	Description
scname.AQG	Raw Measurements File
scname.CLG	Autocalibration Data File
scname.DTG	Measurement Parameters File
scname.CQG	Raw Probe Calibration Data File
scname.FCG	Factory calibration file
scname.NMF	Measurement System Network Data
scname.001	Grounding System and Probe Placement Data

Where "scname" is the user selected case name. These files contain the raw acquired data. Using these data files the SGM software can "play back" the field measurements for the purpose of closer examination, incorporating measurement results in reports etc.

7.2 Step Potential Measurement

7.2.1 Convention Method

Connections are made as shown in figure-8 below, where current injection (100-150Amps) is made between the neutral point of the generator transformer and current electrode at remote end (West of the plant- around 500 Meters outside of the plant)

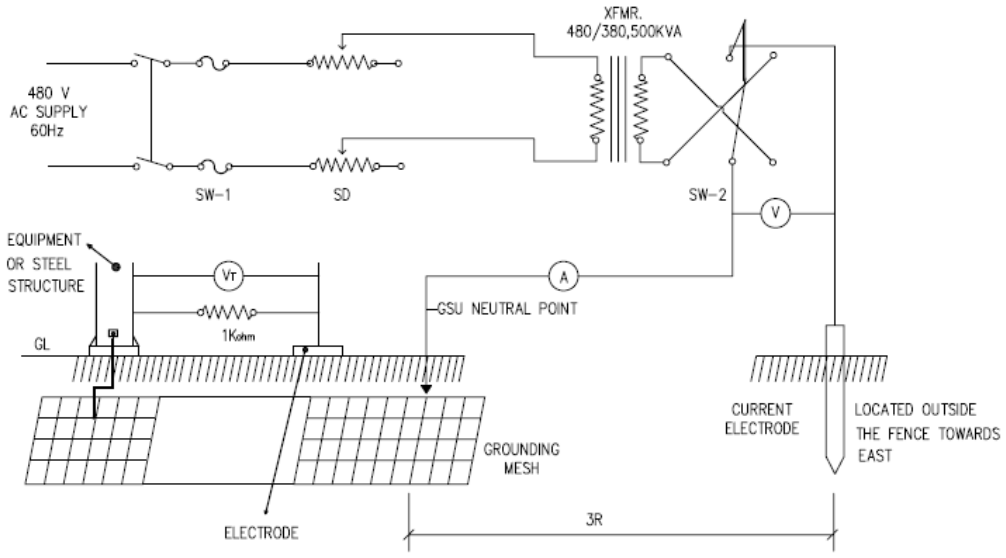

Figure-8
Test Circuit for Step potential Measurement

SW-1 Fuse Switch
SW-2 Change over Switch (Polarity)
SD Variable Transformer

- Voltage readings are taken between two electrodes weighing 35 Kgs each (weight of human body considered as 70 Kg) and they are kept on the ground at 1 meter apart.
- Measurements are done at different places
- Readings are tabulated and corrected to actual fault current

7.2.2. Step Potential Measurement by SGM

This section illustrates the procedure for performing step voltage measurements with the SGM. The general configuration of the SGM setup is illustrated in figure.9. Step-by-step instructions for setting up and performing this measurement are given next.

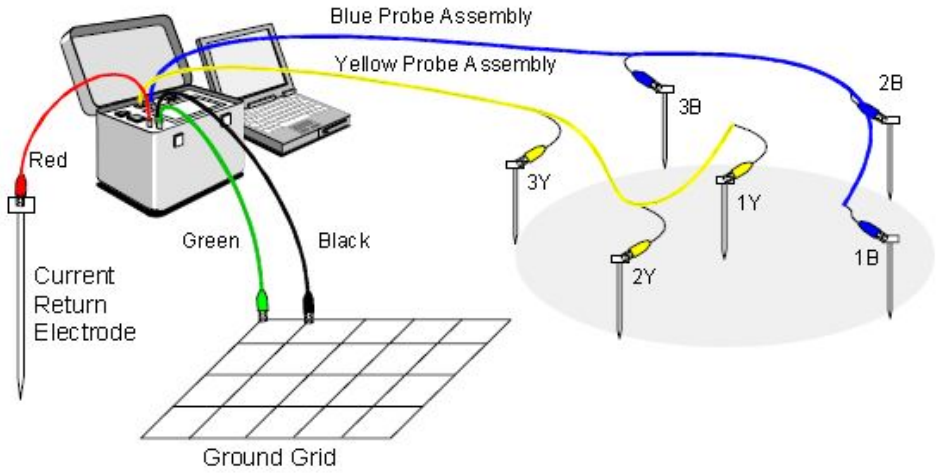

Figure.9. Standard Probe Arrangement for Step Voltage Measurements

Caution: Do not power the SGM or the computer before all connections have been made.

Note: It is recommended that this test performed immediately after the ground impedance measurement test using the already installed current return electrode. The voltage probes must be placed at the locations where the step voltage is to be measured. This can be any locations, as long as the coordinates of these locations are accurately entered the program via the “Edit Geometry” function.

1. Install the voltage probe assemblies Y (yellow) and B (blue) and the current return electrode (see note above). Use the standard arrangement ST1, which is illustrated in Figure 9. Note that voltage prove 1Y is placed at the location where the step voltage is to be measured and the remaining voltage probes are arranged in a circle around voltage probe 1Y with radius about 3 feet. The current return electrode should be a distance of at least 2.0 times the

maximum linear length of the grounding system.

2. Connect the black and green terminals to a grounding conductor of the grounding system under test. Practical Hint: Cleaning the grounding conductor with a wire brush or sand paper before attaching the SGM alligator clips.

3. Setup and connect the Smart Ground Multi meter and computer via the RS23 (serial port) cable. **Do not power the SGM or the computer before all connections have been made**.

4. Connect the voltage probe assemblies Y (yellow) and B (blue), as well as the current return electrode cable to the corresponding SGM receptacles. All connectors are color-coded.

5. Turn on the SGM power switch, turn on the personal computer and execute the program.

7.3 Touch Potential Measurement

7.3.1 Convention Method

Connections are made as shown in figure below-9, where current injection (100-150Amps) is made between the neutral point of the generator transformer and current electrode at remote end (East of the plant- around 500 Meters outside of the plant)

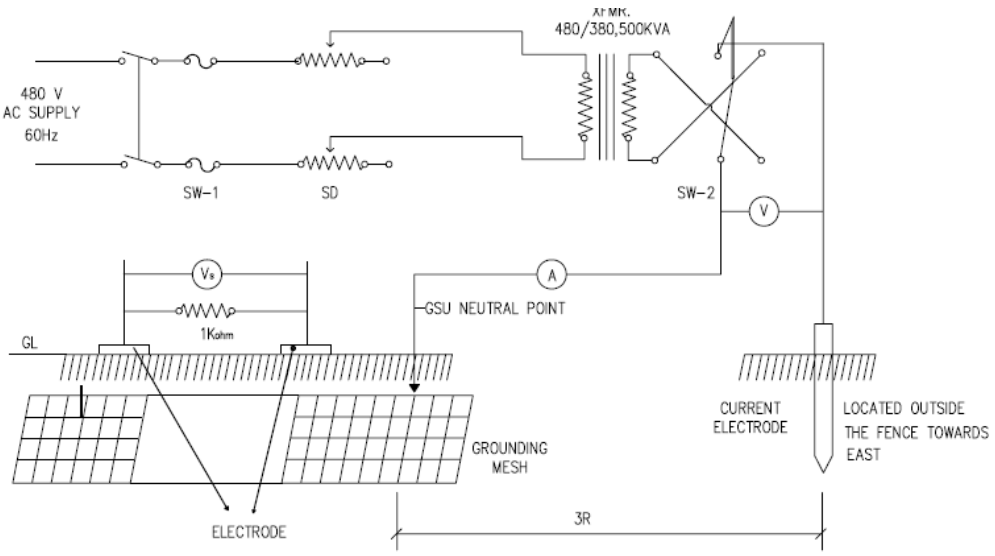

Figure-8
Test Circuit for Touch potential Measurement

SW-1 Fuse Switch
SW-2 Change over Switch (Polarity)

SD Variable Transformer

- Voltage readings are taken between two electrodes weighing 35 Kgs each (weight of human body considered as 70 Kgs) and they are kept on the ground at 1 meter apart.
- Voltage readings are taken between the equipment or structure and the electrode whose weight is about 70 Kgs (weight of human body considered as 70 Kg) kept on the ground at 1 meter height.
- Measurements are done at different equipments or Structure
- Readings are tabulated and corrected to actual fault current

7.3.2 Touch Potential Measurement by SGM

This section illustrates the procedure for performing touch voltage measurements with the SGM. The general configuration of the SGM setup is illustrated in figure10. Step-by-step instructions for setting up and performing this measurement are given next.

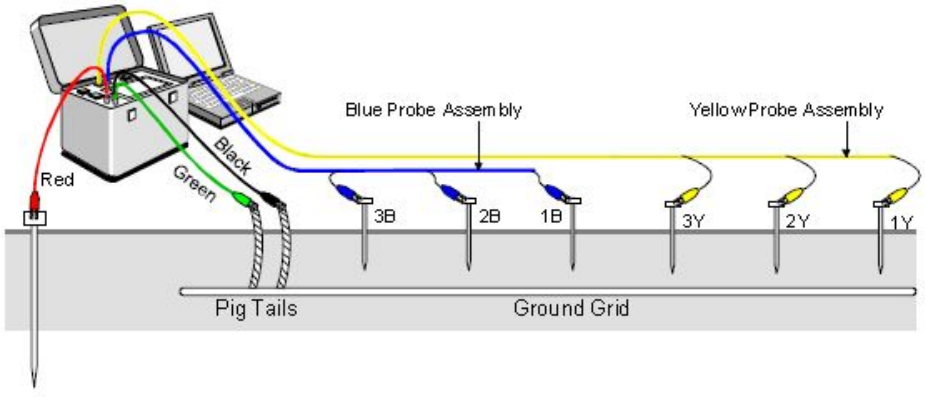

Figure10. Slandered Probe Arrangements for Touch Voltage Measurements

Caution: Do not power the SGM or the computer before all connections have been made.

Note: It is the recommended that this test performed immediately after the ground impedance measurement test using the already installed current return electrode. The voltage probes must be placed at the locations where the step voltage is to be measured. This can be any locations, as long as the coordinates of these locations are accurately entered the program via the “Edit Geometry” commend.

1. Install the voltage probe assemblies Y (yellow) and B (blue) and the current return electrode (see note above). Use the standard arrangement ST1, which is illustrated in Figure 10. Install the current return electrode at an approximate distance of at least 2.0 times the maximum linear length of the grounding system.

2. Connect the black and green terminals to a grounding conductor of the grounding system under test. Practical Hint: Cleaning the grounding conductor with a wire brush or sand paper before attaching the SGM alligator clips.

3. Setup and connect the Smart Ground Multi meter and computer via the RS23 (serial port) cable. **Do not power the SGM or the computer before all connections have been made**.

4. Connect the voltage probe assemblies Y (yellow) and B (blue), as well as the current return electrode cable to the corresponding SGM receptacles. All connectors are color-coded.

5. Turn on the SGM power switch, turn on the personal computer and execute the program.

8 ACCEPTANCE CRITERIA

Please Refer
Grounding Calculation of Site to be tested

8.1 Results and Conclusion

9 ATTACHMENT

Following Test Sheets to made and filled during and end of the test.

9.1 Testing of Grounding System
9.2 Earth Resistance Measurement

*****End of the procedure *****