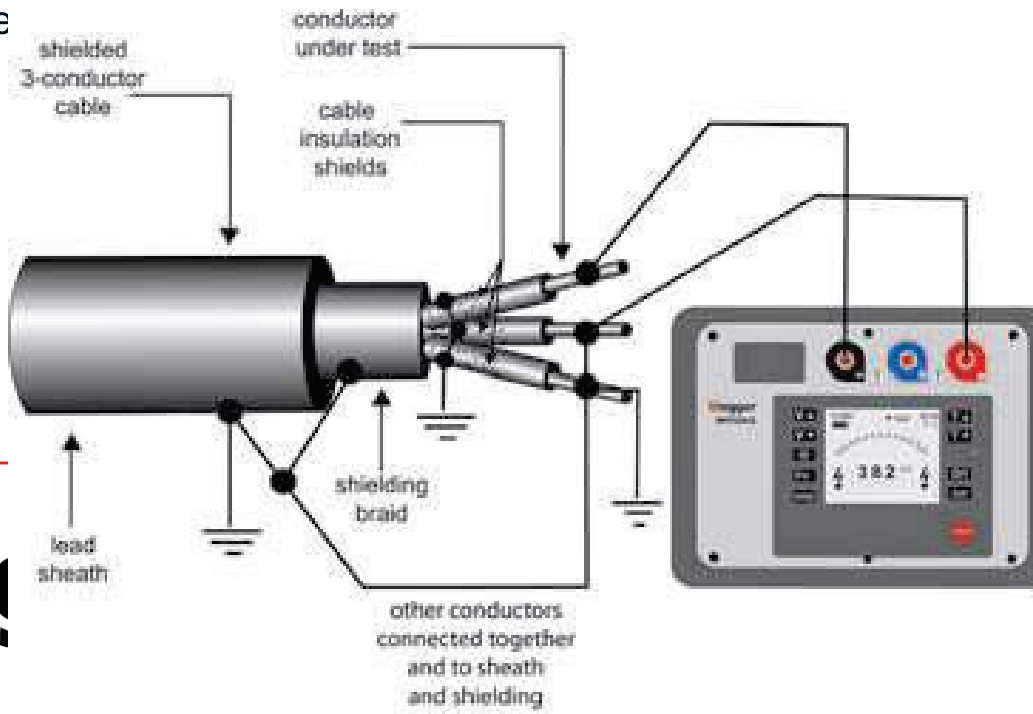
# LOW VOLTAGE CABLES ≤600V

- Thermographic survey of connections under full load
- Test bolted electrical connections with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar connections
- Test insulation resistance on each conductor between ground and adjacent conductors
  - 1000V for 600V cable; 500V for 300V cable
  - Run test for 1 minute
  - Compare with prior results and similar circuits but not less than 2MΩ
- Verify uniform resistance of parallel conductors
  - Deviations should be investigated

# MEDIUM- AND HIGH-VOLTAGE CABLES

- Thermographic survey of connections under full load
- Test bolted electrical connections with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar connections
- Test insulation resistance individually on each conductor with all other conductors and shields grounded
  - Compare to manufacturers requirements or NETA Table 100.1
  - Correct to 20°C per NETA Table 100.14
- Verify continuity of shield
  - Investigate values > 10Ω / 1000' cable

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# MEDIUM- AND HIGH-VOLTAGE CABLES (Continued)

- PREFERRED METHOD TO BE DETERMINED BY ALL PARTIES
  - Dielectric withstand (Pass / Fail or Go / No Go)
    - DC
    - VLF
    - 60Hz
  - Diagnostic (Test equipment manufacturer dictated)
    - Power Factor/Dissipation Factor (tan $\delta$)
    - 60Hz
    - VLF
  - DC insulation resistance
  - Partial discharge
    - Online
    - Offline

# INSULATED-CASE & MOLDED-CASE CIRCUIT BREAKERS

- Thermographic survey of connections under full load
- Test bolted electrical connections with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar connections
- Test insulation resistance on each pole, phase-to-phase and phase-to-ground with breaker closed and across each open pole
  - Run test for 1 minute
  - Compare to manufacturers requirements or NETA Table 100.1
  - Correct to 20°C per NETA Table 100.14
- Test contact resistance with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar breakers
- Test insulation resistance on all control wiring (optional)
  - 1000V for 600V cable; 500V for 300V cable
  - Run test for 1 minute
  - Compare with prior results but not less than 2MΩ
  - Disconnect solid state components

# INSULATED-CASE & MOLDED-CASE CIRCUIT BREAKERS (Continued)

- Primary current injection for long-time, short-time, instantaneous and ground fault pickup (Note: very rarely done)
  - Compare to manufacturers requirements or NETA Table 100.7 and 100.8
- Secondary injection for trip units (optional) (Note: more common)
- Check minimum pickup voltage for shunt trip
  - NETA table 100.20
- Check auxiliary functions

# NETA TABLE 100.20.1

## Rated Control Voltages and Their Ranges for Circuit Breakers

Operating mechanisms are designed for rated control voltages listed with operational capability throughout the indicated voltage ranges to accommodate variations in source regulation, coupled with low charge levels, as well as high charge levels maintained with floating charges. The maximum voltage is measured at the point of user connection to the circuit breaker [see notes (12) and (13)] with no operating current flowing, and the minimum voltage is measured with maximum operating current flowing.

| (11) Rated Control Voltage | Direct Current Voltage Ranges (1)(2)(3)(5) (8)(9) | | Opening Functions All Types | Rated Control Voltage (60 Hz) | Alternating Current Voltage Ranges (1)(2)(3)(4)(8) Closing, Tripping, and Auxiliary Functions |
|---|---|---|---|---|---|
| | Closing and Auxiliary Functions | | | | |
| | Indoor Circuit Breakers | Outdoor Circuit Breakers | | Single Phase | Single Phase |
| 24 (6) | -- | -- | 14–28 | 120 | 104–127 (7) |
| 48 (6) | 38–56 | 36–56 | 28–56 | 240 | 208–254 (7) |
| 125 | 100–140 | 90–140 | 70–140 | | |
| 250 | 200–280 | 180–280 | 140–280 | Polyphase | Polyphase |
| -- | -- | -- | -- | 208Y/120 | 180Y/104–220Y/127 |
| -- | -- | -- | -- | 240 | 208–254 |

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# NETA TABLE 100.20.2

## Rated Control Voltages and Their Ranges for Circuit Breakers Solenoid-Operated Devices

| Rated Voltage | Closing Voltage Ranges for Power Supply |
|---|---|
| 125 dc | 90 – 115 or 105 – 130 |
| 250 dc | 180 – 230 or 210 – 260 |
| 230 ac | 190 – 230 or 210 – 260 |

# NETA TABLE 100.7

**Molded-Case Circuit Breakers**
**Inverse Time Trip Test**
**(At 300% of Rated Continuous Current of Circuit Breaker)**

| Range of Rated Continuous Current (Amperes) | Maximum Trip Time in Seconds for Each Maximum Frame Rating [a] | |
|---|---|---|
| | ≤250 V | 251 – 600 V |
| 0-30 | 50 | 70 |
| 31-50 | 80 | 100 |
| 51-100 | 140 | 160 |
| 101-150 | 200 | 250 |
| 151-225 | 230 | 275 |
| 226-400 | 300 | 350 |
| 401-600 | - - - - - | 450 |
| 601-800 | - - - - - | 500 |
| 801-1000 | - - - - - | 600 |
| 1001 – 1200 | - - - - - | 700 |
| 1201-1600 | - - - - - | 775 |
| 1601-2000 | - - - - - | 800 |
| 2001-2500 | - - - - - | 850 |
| 2501-5000 | - - - - - | 900 |
| 6000 | - - - - - | 1000 |

# NETA TABLE 100.8

## Instantaneous Trip Tolerances for Field Testing of Circuit Breakers

| Breaker Type | Tolerance of Settings | Tolerances of Manufacturer's Published Trip Range | |
|---|---|---|---|
| | | High Side | Low Side |
| Electronic Trip Units (1) | +30% | ----- | ----- |
| Adjustable (1) | +40%<br>-30% | ----- | ----- |
| Nonadjustable (2) | ----- | +25% | -25% |

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# LOW-VOLTAGE POWER CIRCUIT BREAKERS

- Thermographic survey of connections under full load
- Test bolted electrical connections with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar connections
- Test insulation resistance on each pole, phase-to-phase and phase-to-ground with breaker closed and across each open pole
  - Run test for 1 minute
  - Compare to manufacturers requirements or NETA Table 100.1
  - Correct to 20°C per NETA Table 100.14
- Test contact resistance with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar breakers
- Test insulation resistance on all control wiring (optional)
  - 1000V for 600V cable; 500V for 300V cable
  - Run test for 1 minute
  - Compare with prior results but not less than 2MΩ
  - Disconnect solid state components

# LOW-VOLTAGE POWER CIRCUIT BREAKERS (Continued)

- Primary current injection for long-time, short-time, instantaneous and ground fault pickup (Note: not always done)
  - Compare to manufacturers requirements
- Secondary injection for trip units (optional)
- Check minimum pickup voltage for shunt trip
  - NETA table 100.20
- Check auxiliary functions

# MEDIUM-VOLTAGE AIR CIRCUIT BREAKERS

- Thermographic survey of connections under full load
- Perform first trip test (optional)
  - Compare trip time and trip-coil waveform to manufacture data and prior results
- Perform time-travel analysis (optional)
  - Compare travel and velocity to manufacture data and prior results
- Test bolted electrical connections with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar connections
- Test insulation resistance on each pole, phase-to-phase and phase-to-ground with breaker closed and across each open pole
  - Run test for 1 minute
  - Compare to manufacturers requirements or NETA Table 100.1
  - Correct to 20°C per NETA Table 100.14

# MEDIUM-VOLTAGE AIR CIRCUIT BREAKERS (Continued)

- Test insulation resistance on all control wiring (optional)
  - 1000V for 600V cable; 500V for 300V cable
  - Run test for 1 minute
  - Compare with prior results but not less than 2MΩ
  - Disconnect solid state components
- Test contact resistance with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar breakers
- With breaker in “Test” position
  - Trip & Close with control switch
  - Trip via relay
  - Verify mechanism charge, trip-free and anti-pump functions
- Check minimum pickup voltage for trip and close (optional)
  - NETA table 100.20

# MEDIUM-VOLTAGE AIR CIRCUIT BREAKERS (Continued)

- Power factor test with breaker open and closed (optional)
  - Compare with prior test results of similar breakers or manufacturers data
  - Bushing values should be within 10% of nameplate ratings
- Conduct dielectric withstand test with breaker closed and poles not under test grounded (optional)
  - Use voltage from manufacturers or NETA Table 100.19
  - Pass / Fail or Go / No Go
- Test instrument transformers (detailed in a later section) (optional – for medium voltage - why is it only required for vacuum breaker???)
- Check auxiliary functions

# NETA TABLE 100.19

## Dielectric Withstand Test Voltages for Electrical Apparatus Other than Inductive Equipment

| Nominal System (Line) Voltage [a] (kV) | Insulation Class (kV) | AC Factory Test (kV) | Maximum Field Applied AC Test (kV) | Maximum Field Applied DC Test (kV) |
|---|---|---|---|---|
| 1.2 | 1.2 | 10 | 6.0 | 8.5 |
| 2.4 | 2.5 | 15 | 9.0 | 12.7 |
| 4.8 | 5.0 | 19 | 11.4 | 16.1 |
| 8.3 | 8.7 | 26 | 15.6 | 22.1 |
| 14.4 | 15.0 | 34 | 20.4 | 28.8 |
| 18.0 | 18.0 | 40 | 24.0 | 33.9 |
| 25.0 | 25.0 | 50 | 30.0 | 42.4 |
| 34.5 | 35.0 | 70 | 42.0 | 59.4 |
| 46.0 | 46.0 | 95 | 57.0 | 80.6 |
| 69.0 | 69.0 | 140 | 84.0 | 118.8 |

# MEDIUM VOLTAGE VACUUM CIRCUIT BREAKERS

- Thermographic survey of connections under full load
- Perform first trip test (optional)
  - Compare trip time and trip-coil waveform to manufacture data and prior results
- Perform time-travel analysis (optional)
  - Compare travel and velocity to manufacture data and prior results
- Test bolted electrical connections with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar connections
- Test insulation resistance on each pole, phase-to-phase and phase-to-ground with breaker closed and across each open pole
  - Run test for 1 minute
  - Compare to manufacturers requirements or NETA Table 100.1
  - Correct to 20°C per NETA Table 100.14

# MEDIUM VOLTAGE VACUUM CIRCUIT BREAKERS
## (Continued)

- Test insulation resistance on all control wiring (optional)
  - 1000V for 600V cable; 500V for 300V cable
  - Run test for 1 minute
  - Compare with prior results but not less than 2MΩ
  - Disconnect solid state components
- Test contact resistance with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar breakers
- With breaker in “Test” position
  - Trip & Close with control switch
  - Trip via relay
  - Verify mechanism charge, trip-free and anti-pump functions
- Check minimum pickup voltage for trip and close (optional)
  - NETA table 100.20

# MEDIUM VOLTAGE VACUUM CIRCUIT BREAKERS
## (Continued)

- Power factor test with breaker open and closed (optional)
  - Compare with prior test results of similar breakers or manufacturers data
  - Bushing values should be within 10% of nameplate ratings
- Conduct vacuum integrity test across each bottle
  - AC HiPot test???  X-Rays???
  - Pass / Fail  or  Go / No Go
- Conduct dielectric withstand test with breaker closed and poles not under test grounded (optional)
  - Use voltage from manufacturers or NETA Table 100.19
  - Pass / Fail  or  Go / No Go
- Test instrument transformers (detailed in a later section) (for medium voltage - why is it only required for vacuum breaker???)

# MEDIUM- AND HIGH-VOLTAGE OIL CIRCUIT BREAKERS

- Thermographic survey of connections under full load
- Perform first trip test (optional)
  - Compare trip time and trip-coil waveform to manufacture data and prior results
- Perform time-travel analysis (unlike air & vacuum breakers, this test required) Why?
  - Compare travel and velocity to manufacture data and prior results
- Test bolted electrical connections with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar connections
- Test insulation resistance on each pole, phase-to-phase and phase-to-ground with breaker closed and across each open pole
  - Run test for 1 minute
  - Compare to manufacturers requirements or NETA Table 100.1
  - Correct to 20°C per NETA Table 100.14
- Test contact resistance with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar breakers

# MEDIUM- AND HIGH-VOLTAGE OIL CIRCUIT BREAKERS (Continued)

- Test insulation resistance on all control wiring (optional)
  - 1000V for 600V cable; 500V for 300V cable
  - Run test for 1 minute
  - Compare with prior results but not less than 2MΩ
- Remove oil sample and send for complete tests per ASTM D 923
  - Dielectric breakdown voltage: ASTM D 877
  - Color: ANSI/ASTM D 1500
  - Power factor: ASTM D 924 (optional)
  - Interfacial tension: ANSI/ASTM D 971 or ANSI/ASTM D 2285 (optional)
  - Visual condition: ASTM D 1524 (optional)
  - Compare values to NETA Table 100.4
- With breaker in “Test” position
  - Trip & Close with control switch
  - Trip via relay
  - Verify trip-free and anti-pump functions

# MEDIUM- AND HIGH-VOLTAGE OIL CIRCUIT BREAKERS (Continued)

- Check minimum pickup voltage for trip and close (optional)
  - NETA table 100.20
- Power factor test with breaker open and closed (unlike air & vacuum breakers, this test required)
  - Compare with prior test results of similar breakers or manufacturers data
  - Bushing values should be within 10% of nameplate ratings
- Conduct dielectric withstand test with breaker closed and poles not under test grounded (optional)
  - Use voltage from manufacturers or NETA Table 100.19
  - Pass / Fail or Go / No Go
- Test instrument transformers (detailed in a later section) (optional – for medium voltage - why is it only required for vacuum breaker???)

# SF6 CIRCUIT BREAKERS

- Thermographic survey of connections under full load
- Perform first trip test (optional)
  - Compare trip time and trip-coil waveform to manufacture data and prior results
- Perform time-travel analysis (unlike air & vacuum breakers, this test required) Why???
  - Compare travel and velocity to manufacture data and prior results
- Test bolted electrical connections with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar connections
- Test insulation resistance on each pole, phase-to-phase and phase-to-ground with breaker closed and across each open pole
  - Run test for 1 minute
  - Compare to manufacturers requirements or NETA Table 100.1
  - Correct to 20°C per NETA Table 100.14
- Test contact resistance with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar breakers

# SF6 CIRCUIT BREAKERS (Continued)

- Test insulation resistance on all control wiring (optional)
  - 1000V for 600V cable; 500V for 300V cable
  - Run test for 1 minute
  - Compare with prior results but not less than 2MΩ
- Remove a sample of SF6 (optional)
  - NETA Table 100.13
- With breaker in “Test” position
  - Trip & Close with control switch
  - Trip via relay
  - Verify trip-free and anti-pump functions
- Check minimum pickup voltage for trip and close (optional)
  - NETA table 100.20

# SF6 CIRCUIT BREAKERS (Continued)

- Power factor test with breaker open and closed (unlike air & vacuum breakers, this test required)
  - Compare with prior test results of similar breakers or manufacturers data
  - Bushing values should be within 10% of nameplate ratings
- Conduct dielectric withstand test (optional)
  - Per manufacturer
  - Pass / Fail or Go / No Go
- Test instrument transformers (detailed in a later section) (optional – for medium voltage - why is it only required for vacuum breaker???)

# NETA TABLE 100.13

## $SF_6$ Gas Tests

| Test | Method | Serviceability Limits [a] |
|---|---|---|
| Moisture | Hygrometer | Per manufacturer or ≥ 200 ppm [b] |
| $SF_6$ decomposition byproducts | ASTM D 2685 | ≥ 500 ppm |
| Air | ASTM D 2685 | ≥ 5000 ppm [c] |
| Dielectric breakdown hemispherical contacts | 2.54 mm (0.10 inch) gap at atmospheric pressure | 11.5 – 13.5 kV [d] |

# MEDIUM VOLTAGE METAL ENCLOSED SWITCHES

- Thermographic survey of connections under full load
- Test bolted electrical connections with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar connections
- Test contact resistance with low resistance ohmmeter
  - Switchblade assembly & fuse holder
  - Investigate values which deviate >50% from lowest value of similar breakers
- Test insulation resistance on each pole, phase-to-phase and phase-to-ground with switch closed and across each open pole
  - Run test for 1 minute
  - Compare to manufacturers requirements or NETA Table 100.1
  - Correct to 20°C per NETA Table 100.14

# MEDIUM VOLTAGE METAL ENCLOSED SWITCHES
## (Continued)

- Conduct dielectric withstand on each pole with switch closed and phases not under test grounded
  - Only if insulation resistance levels are acceptable
  - Compare to manufacturers requirements or NETA Table 100.2
  - Pass / Fail or Go / No Go
- Measure fuse resistance

# METAL ENCLOSED BUSWAY

- Thermographic survey of connections under full load
- Test bolted electrical connections with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar connections
- Test insulation resistance on each pole, phase-to-phase and phase-to-ground
  - Run test for 1 minute
  - Compare to manufacturers requirements or NETA Table 100.1
  - Correct to 20°C per NETA Table 100.14
  - Minimum values for 1000’ run
  - $R_{1000ft} = Measured\ Resistance\ X\ {}^{Length\ of\ Bus}/_{1000}$

# METAL ENCLOSED BUSWAY

- Conduct dielectric withstand on each busway with phases not under test grounded
  - Only if insulation resistance levels are acceptable
  - Compare to manufacturers requirements or NETA Table 100.17
  - Run test for 1 minute
  - Pass / Fail or Go / No Go
- Test contact resistance with low resistance ohmmeter (optional)
  - Each accessible connection point
  - For inaccessible points, measure sections
  - Investigate values which deviate >50% from lowest value of similar breakers
- Make sure heaters work!!!

# NETA TABLE 100.17

## Metal-Enclosed Bus Dielectric Withstand Test Voltages

| Type of Bus | Rated kV | Maximum Test Voltage (kV) | |
|---|---|---|---|
| | | AC | DC |
| Isolated Phase for Generator Leads | 24.5 | 37.0 | 52.0 |
| | 29.5 | 45.0 | -- |
| | 34.5 | 60.0 | -- |
| Isolated Phase for Other than Generator Leads | 15.5 | 37.0 | 52.0 |
| | 25.8 | 45.0 | -- |
| | 38.0 | 60.0 | -- |
| Nonsegregated Phase | 0.635 | 1.6 | 2.3 |
| | 4.76 | 14.2 | 20.0 |
| | 15.0 | 27.0 | 37.0 |
| | 25.8 | 45.0 | 63.0 |
| | 38.0 | 60.0 | -- |
| Segregated Phase | 15.5 | 37.0 | 52.0 |
| | 25.8 | 45.0 | 63.0 |
| | 38.0 | 60.0 | -- |
| DC Bus Duct [a] | 0.3 | 1.6 | 2.3 |
| | 0.8 | 2.7 | 3.9 |
| | 1.2 | 3.4 | 4.8 |
| | 1.6 | 4.0 | 5.7 |
| | 3.2 | 6.6 | 9.3 |

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# BATTERIES

- Test bolted electrical connections with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar connections
- Check charger float and equalizing voltages
- Measure each cell and total string voltage while in float mode
  - For flooded lead acid & vented nickel-cadmium should be within .05V of each other
  - For valve-regulated lead-acid per manufacturers data
- Measure intercell connections with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar connections
- Perform internal ohmic measurement
  - Should not vary by more than 25%
- Perform load (capacity) test
  - For flooded lead-acid per manufacturers data or ANSI/IEEE 450 (optional)
  - For vented nickel-cadmium per manufacturers data or ANSI/IEEE 1106 (optional)
  - For valve-regulated lead-acid per manufacturers data or ANSI/IEEE 1188 (required annually)

# BATTERIES

- For vented nickel-cadmium measure voltage positive-to-ground and negative-to-ground
  - Voltages should have the same magnitude
- For VLRA - measure negative post temperature
  - Temperature should be per manufacturers data or ANSI/IEEE 1188
- NERC/FERC now weighing heavily and differing requirements
- Battery Ground Faults

# PROTECTIVE RELAYS

- Test insulation resistance on each circuit to frame
  - Follow manufacturers requirements
- Check functional operation
  - 2/62 Timing Relay
  - 21 Distance Relay
  - 24 Volts/Hertz Relay
  - 25 Sync Check Relay
  - 27 Undervoltage Relay
  - 32 Directional Power Relay
  - 40 Loss of Field (Impedance) Relay
  - 46 Current Balance Relay
  - 46N Negative Sequence Current Relay
  - 47 Phase Sequence or Phase Balance Voltage Relay
  - 49R Thermal Replica Relay
  - 49T Temperature (RTD) Relay
  - 50 Instantaneous Overcurrent Relay

# PROTECTIVE RELAYS (Continued)

- Check functional operation (continued)
  - 51 Time Overcurrent
  - 55 Power Factor Relay
  - 59 Overvoltage Relay
  - 60 Voltage Balance Relay
  - 63 Transformer Sudden Pressure Relay
  - 64 Ground Detector Relay
  - 67 Directional Overcurrent Relay
  - 79 Reclosing Relay
  - 81 Frequency Relay
  - 85 Pilot Wire Monitor
  - 87 Differential

# CURRENT TRANSFORMERS

- Test bolted electrical connections with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar connections
- Test insulation resistance of each CT and wiring-to-ground and winding-to-winding
  - 1000V
  - Run test for 1 minute
  - NETA Table 100.5
  - Correct to 20°C per NETA Table 100.14
  - For solid-state components follow manufacturers recommendations for applied voltage
- Conduct dielectric withstand on primary winding with secondary winding grounded
  - NETA Table 100.9
  - Pass / Fail or Go / No Go
- Perform power factor test (optional)

# CURRENT TRANSFORMERS (Continued)

- Check polarity (optional)
- Check ratio (optional)
  - Errors per NETA Table 100.21
- Perform an excitation test when used in relay applications (optional)
- Measure burden (optional)

# NETA TABLE 100.9

**Instrument Transformer Dielectric Tests**
**Field Maintenance**

| Nominal System (kV) | BIL (kV) | Periodic Dielectric Withstand Test Field Test Voltage (kV) | |
|---|---|---|---|
| | | AC | DC [b] |
| 0.6 | 10 | 2.6 | 4 |
| 1.1 | 30 | 6.5 | 10 |
| 2.4 | 45 | 9.7 | 15 |
| 4.8 | 60 | 12.3 | 19 |
| 8.32 | 75 | 16.9 | 26 |
| 13.8 | 95 | 22.1 | 34 |
| 13.8 | 110 | 22.1 | 34 |
| 25 | 125 | 26.0 | 40 |
| 25 | 150 | 32.5 | 50 |
| 34.5 | 150 | 32.5 | 50 |
| 34.5 | 200 | 45.5 | 70 |
| 46 | 250 | 61.7 | a |
| 69 | 350 | 91.0 | a |
| 115 | 450 | 120.0 | a |
| 115 | 550 | 149.0 | a |
| 138 | 550 | 149.0 | a |
| 138 | 650 | 178.0 | a |
| 161 | 650 | 178.0 | a |
| 161 | 750 | 211.0 | a |
| 230 | 900 | 256.0 | a |
| 230 | 1050 | 299.0 | a |

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# NETA TABLE 100.21

**Accuracy of IEC Class TP Current Transformers**
**Error Limit**

| Class | At Rated Current | | At Accuracy Limit Condition |
|---|---|---|---|
| | Ratio Error (%) | Phase Displacement Minimum | Peak Instantaneous Error (%) |
| TPX | ± 0.5 | ± 30 | 10 |
| TPY | ± 1.0 | ± 60 | 10 |
| TPZ | ± 1.0 | 180 ± 18 | 10 (see note) |
| NOTE – Alternating current component error. | | | |

# POTENTIAL TRANSFORMERS

- Test bolted electrical connections with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar connections
- Test insulation resistance of each PT winding-to-winding and winding-to-ground
  - Run test for 1 minute
  - NETA Table 100.5
  - Correct to 20°C per NETA Table 100.14
  - For solid-state components follow manufacturers recommendations for applied voltage
- Conduct dielectric withstand on primary winding with secondary winding grounded (optional)
  - Run test for 1 minute
  - NETA Table 100.9
  - Pass / Fail or Go / No Go
- Perform power factor test (optional)

# POTENTIAL TRANSFORMERS (Continued)

- Check polarity (optional)
- Check ratio
  - Error for revenue metering ≤ ± .1% for ratio and ≤ ± .9mrad (3 minutes) for angle
  - Error for other ≤ 1.2% for ratio and ≤ ± 17.5mrad (one degree) for angle
- Perform an excitation test when used in relay applications (optional)
- Measure burden (optional)

# CCVT TRANSFORMERS

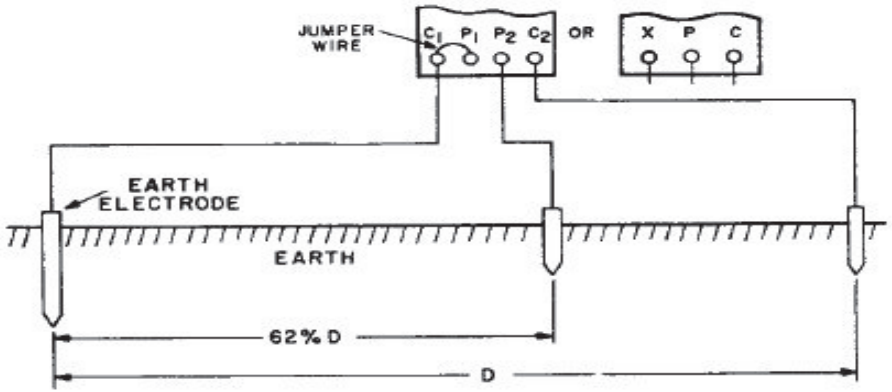
- Test bolted electrical connections with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar connections
- Test insulation resistance of each CCVT winding-to-winding and winding-to-ground
  - Run test for 1 minute
  - NETA Table 100.5
  - Correct to 20°C per NETA Table 100.14
  - For solid-state components follow manufacturers recommendations for applied voltage
- Conduct dielectric withstand on primary winding with secondary winding grounded (optional)
  - Run test for 1 minute
  - NETA Table 100.9
  - Pass / Fail or Go / No Go
- Measure capacitance

# CCVT TRANSFORMERS (Continued)

- Perform power factor test (optional)
- Check polarity (optional)
- Check ratio
  - Error for revenue metering ≤ ± .1% for ratio and ≤ ± .9mrad (3 minutes) for angle
  - Error for other ≤ 1.2% for ratio and ≤ ± 17.5mrad (one degree) for angle
- Perform an excitation test when used in relay applications (optional)
- Measure burden (optional)

# GROUNDING SYSTEMS

- Test bolted electrical connections with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar connections
- Fall-of-potential (three terminal) test on main grounding electrode
  - IEEE Standard 81
  - NETA: Resistance ≤ 5Ω for commercial/industrial
  - NETA: Resistance ≤ 1Ω for generating or transmission stations
  - NEC: Single electrode with Resistance > 25Ω should be augmented by one additional electrode
- Perform point-to-point tests on all ground connections
  - Values should be ≤ .5Ω

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# GROUND FAULT SYSTEMS

- Test bolted electrical connections with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar connections
- Test insulation resistance neutral-ground with link removed
  - Should be not less than 1MΩ
- Test insulation resistance on all control wiring (optional)
  - 1000V for 600V cable; 500V for 300V cable
  - Run test for 1 minute
  - Compare with prior results but not less than 2MΩ
  - Disconnect solid state components
- Primary current injection for ground fault pickup
  - Should be > 90% of pickup setting and < 1200A or 125% of pickup
  - Measure time delay at value ≥ 150% of pickup
- Verify capability to trip at reduced voltage
  - 55% for AC
  - 80% for DC

# SURGE ARRESTERS

- Test bolted electrical connections with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar connections
- Test insulation resistance on each arrester from terminal-to-ground
  - Compare to manufacturers requirements or NETA Table 100.1
  - Correct to 20°C per NETA Table 100.14
- Test ground resistance (detailed in an earlier section)
  - Values should be < .5 Ω
- For medium- and high-voltage arresters (optional)
  - Perform a watts-loss test per manufacturer data and similar units

# AC MOTORS & GENERATORS

- Thermographic survey of connections under full load
- Test bolted electrical connections with low resistance ohmmeter
  - Investigate values which deviate >50% from lowest value of similar connections
- Test insulation resistance
  - Correct to 40°C
  - per ANSI/IEEE Standard 43
  - > 200HP run test for 10 minutes and calculate polarization index
  - Perform Polarization Index and compare to prior values; should not be < 1
  - ≤ 200HP run test for 10 minutes and calculate dielectric absorption ratio
- Conduct DC dielectric withstand on machines > 2300V
  - per ANSI/IEEE Standard 95
- Measure phase-to-phase stator resistance on machines > 2300V
  - Investigate values which deviate >5%

# AC MOTORS & GENERATORS

- Perform power factor test (optional)
- Perform power factor tip-up test (optional)
  - Should indicate no significant increase in power factor
- Perform surge comparison test (optional)
- Test insulation resistance on insulated bearings
- Test surge protective devices (detailed in an earlier section)
- Test motor starter
- Test resistance on RTDs
- Perform vibration analysis (optional) more of a mechanical test???
  - NETA Table 100.10

# AC MOTORS & GENERATORS – Synchronous

- ADDITIONAL TESTS:
- Test insulation-resistance on main rotating field winding, exciter-field winding, and exciter-armature winding in accordance
  - Correct to 40°C
  - Per ANSI/IEEE Standard 43.
- Test AC voltage-drop on all rotating field poles (optional)
- High-potential test on excitation system
  - Per ANSI/IEEE Standard 421.3
- Measure resistance of machine-field winding, exciter-stator winding, exciter-rotor windings, and field discharge resistors
- Test front-to-back resistance on diodes and gating tests of silicon-controlled rectifiers for field application semiconductors (optional)

# NETA TABLE 100.10

**Maximum Allowable Vibration Amplitude**

| RPM (at 60 Hz) | Velocity (in/s peak) | Velocity (mm/s) | RPM (at 50 Hz) | Velocity (in/s peak) | Velocity (mm/s) |
|---|---|---|---|---|---|
| 3600 | 0.15 | 3.8 | 3000 | 0.15 | 3.8 |
| 1800 | 0.15 | 3.8 | 1500 | 0.15 | 3.8 |
| 1200 | 0.15 | 3.8 | 1000 | 0.13 | 3.3 |
| 900 | 0.12 | 3.0 | 750 | 0.10 | 2.5 |
| 720 | 0.09 | 2.3 | 600 | 0.08 | 2.0 |
| 600 | 0.08 | 2.0 | 500 | 0.07 | 1.7 |

# ADDITIONAL INFORMATION

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