Maintenance Best Practices & Intervals for Substation Equipment

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Background - 40 Years in the Industry

• Education
  • NWTC (Northeast WI Technical College)

• Work History
  • Wisconsin Public Service (WPS) – 24 years
  • American Transmission Company (ATC) – 6 years
  • Energis High Voltage Resources, Inc. – 10 years
No One Right Way

• There’s no one answer to a perfect Substation Maintenance Schedule. Today we’ll be using our industry and utility experience, but your engineering firm, the manufactures equipment spec’s, insurance requirements, and NETA Standards should also be considered.

• Along with our recommendations, we’ve included survey results of maintenance schedules from individuals within the electrical utility. The information is included in the handout for your review, but because of today’s time limitations we won’t discuss.

• Electronic copies of this presentation are available.
Why Perform Substation Equipment Testing?

• Safety
  • Public
  • Employees

• Improve Reliability
  • Reduce customer outages

• Reduce Costs
  • Reduce unplanned maintenance cost
  • Reduce insurance/liability cost

• Plan and budget asset upgrades
Transformer Testing

- Power Factor
- Ratio
- Insulation
- Winding Resistance
- SFRA (Sweep Frequency Response Analysis)
- DGA and Oil Quality
Transformer Maintenance

- Verify oil level in main tank & LTC
- Verify oil level in bushing
- Verify insulator integrity
- Verify tank integrity and free of oil leak
- Inspect surge arrestors
- Verify paint is in good condition
- Record winding/liquid temperatures (current & max)
- Record LTC position indicator & operation counter (current & max raise/lower)
- Verify correct operation of fans and free of bird nests
- Verify correct operation pumps (if applicable)
- Verify nitrogen pressure (if applicable)
- Verify transformer and pad are level
- Verify control cabinet is free of moisture
- Verify cabinet heater operation

Frequency

- Monthly
- Monthly
- Monthly
- Monthly
- Monthly
- Monthly
- Monthly
- Monthly
Transformer Maintenance

- Thermographic Imaging (Infrared)
- Transformer oil analysis (DGA)
- Power factor
- Winding resistance test
- Transformer turns ratio test
- Insulation test
- Calibrate temperature gauge
- Verify alarms points
- Verify Bucholtz relay operation
- Verify rapid pressure rise relay operation
- SFRA (sweep frequency response analysis)
- Vibration & acoustic testing

Frequency

- Annual
- Annual
- Every 5 years
- Every 5 years
- Every 5 years
- Every 5 years
- Every 5 years
- Every 5 years
- New install & after fault operation
- Dependent on criticality of equipment
Industry Survey Results
Transformers

Power Transformer Oil Tests

Power Transformer DGA
Circuit Breakers Testing

- Power Factor
- Speed
- Micro-ohm
- Ratio Bushing Current Transformer
- SF6 Gas
- Installation Testing (e.g. Air Mag)
Circuit Breaker Maintenance

- Verify breaker is level
- Verify paint is in good condition
- Verify insulator integrity
- Verify SF6 gas pressure (check oil level in oil breaker)
- Record operation counter number
- Verify control cabinet is free of moisture and cabinet is working
- Check control voltages & operation of breaker
- Thermographic Imaging (Infrared)
- Verify tank heaters (if applicable)
- Motion testing (speed test)
- Micro-Ohm (ductor) contacts
- Test SF6 gas for moisture, purity & SO2 content
- Check alarm points in control house

Frequency

- Monthly
- Monthly
- Monthly
- Monthly
- Monthly
- Annual
- Annual
- Annual
- Every 5 years
- Every 5 years
Battery & Charger Testing

- Specific Gravity
- Cell Strap Connection Resistance
- Internal Cell Resistance
- Voltage Readings
Batteries & Charger Maintenance

- Visual inspection of electrolyte levels
- Visual inspection of battery jars
- Verify no battery grounds exist
- Record battery voltage & current
- Specific gravity
- Intercell impedance/resistance
- Strap resistance
- Individual cell voltages/total cell voltage
- Equalize voltages
- Verify charger alarms
- Check voltage ripple

Frequency

- Monthly
- Monthly
- Monthly
- Monthly
- Annual
- Annual
- Annual
- Annual
- Dependent on battery test results
- Annual
- Annual
Vacuum Breaker Testing

- Thermographic Imaging (Infrared)
- Insulation Resistance Test
- Micro-ohm Contact Resistance
- Hi-pot Vacuum Bottles
Vacuum Breaker Maintenance

- Verify insulator integrity
- Verify control cabinet is free of moisture
- Verify cabinet heater operation
- Record operation counter number
- Thermographic Imaging (Infrared)
- Insulation resistance test
- Hi-pot vacuum bottles

Frequency

- Monthly
- Monthly
- Monthly
- Every 5 years
- Every 5 years
- Every 5 years
• Perform as found test
• Perform as left test
• Test relays to installed setting
• Trip test relays
**Relay Maintenance**

- Check relays for damage
- Found test
- Left test
- Trip test relays

**Frequency**

- Monthly
- 5-10 years
- 5-10 years
Voltage Regulator Testing

- Maintenance usually based on manufacturers recommended operations and load.
- DGA Oil Analysis
  - Frequency - Annual or Biannual
Circuit Switcher Testing

- Micro-ohm
- Insulation Test
- Verify Mechanical Operation
- Verify Electrical Operation

Frequency for All – Every 5 years
Questions to Think About

• If asked by a lawyer that is suing you because of a piece of equipment that did not trip, how would you provide the information asked?

• How do you document the performed maintenance & testing results?

• What type of test forms do you have?

• Where do you have this information at your facility?
Testing to NETA Specifications

NETA is an organization that serves the electrical testing industry by offering accreditations of 3rd party electrical testing firms, certifying electrical testing technician and producing American National Standards.

Free download available: Appendix B – Frequency of Maintenance Test

netaworld.org
Want a Copy of this Presentation?

• Talk to Paul, Brad, or Bill.
  or
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Questions

Thank you for your time and attention.