Developing a Safe and Reliable Electrical Power System.

Topics for Today

- Who is NETA?
- What are the ANSI/NETA Standards?
- Specifying a NETA Accredited Company
- How can builders, contractors, architects and engineers ensure safety and reliability in electrical power system installations?
- What should an electrical preventive maintenance program look like?

What is NETA?

NETA is an association of electrical testing companies that is committed to advancing the industry's standards for power system installation and maintenance to ensure the highest level of electrical reliability and safety.

The InterNational Testing Association

- Member Companies US, Canada, Puerto Rico, Chile and Brussels
- Approximately 1,500 Certified Technicians
- Approximately 1,100 individual Affiliates
- International Associate subscriptions include representatives from over 60 countries including Columbia, India, Thailand, Hong Kong, Finland, Saudi Arabia, Sweden, Greece, England, Australia, Cuba, Mexico and many more

NETA Mission

The mission of the International Electrical Testing Association is to serve the electrical testing industry by:

- Establishing standards
- Publishing specifications
- Accrediting independent, third-party, electrical testing companies
- Certifying test technicians

NETA Mission

The Association also:

- Collects and disseminates information and data of value to the electrical industry
- Educates the public and end user about the merits of electrical acceptance and maintenance testing

InterNational Electrical Testing Association

NETA has been an Accredited Standards Developer for the American National Standards Institute (ANSI) since 1996.

ANSI recognizes NETA's industry leadership through:

- *ANSI/NETA ETT-2010*
- *ANSI/NETA ATS-2009*
- *ANSI/NETA MTS-2011*

InterNational Electrical Testing Association

- Accreditation of third-party, independent electrical testing companies
- Certification of electrical testing technicians
- 40 YEARS of on going support and education of NETA members, their technicians, and friends of NETA

NETA Education Tools

- *NETA World Journal*
- NETA Handbooks – 14 Volumes
- SPTS – Self Paced Technical Seminars
- Online Courses
- PowerTest Conference
- NETA Affiliate Program

What are ANSI/NETA Standards?

ANSI/NETA Standards

The ANSI/NETA Standards address:

- Standards for Acceptance Testing
- Standards for Maintenance Testing
- Standards for Certification of Electrical Testing Technicians

ANSI/NETA Standards

The Scope of the ANSI/NETA Standards is different from that of the IEEE, NECA, NEMA, and UL.

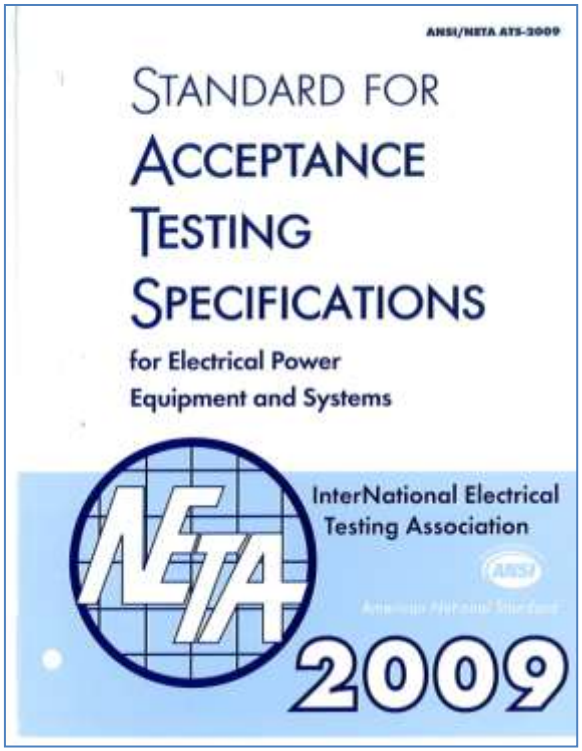
- In matters of testing electrical equipment and systems NETA Standards are more comprehensive. They reference other standards developers' documents where applicable.

- NETA's review and updating of presently published standards takes into account both national and international standards.

The Scope of the ANSI/NETA Standards is different from that of the IEEE, NECA, NEMA, and UL. (cont.)

- NETA's standards may be used internationally as well as in the United States.
- NETA firmly endorses a global standardization.
- IEC standards as well as American consensus standards are taken into consideration by NETA's section panels and reviewing committees.

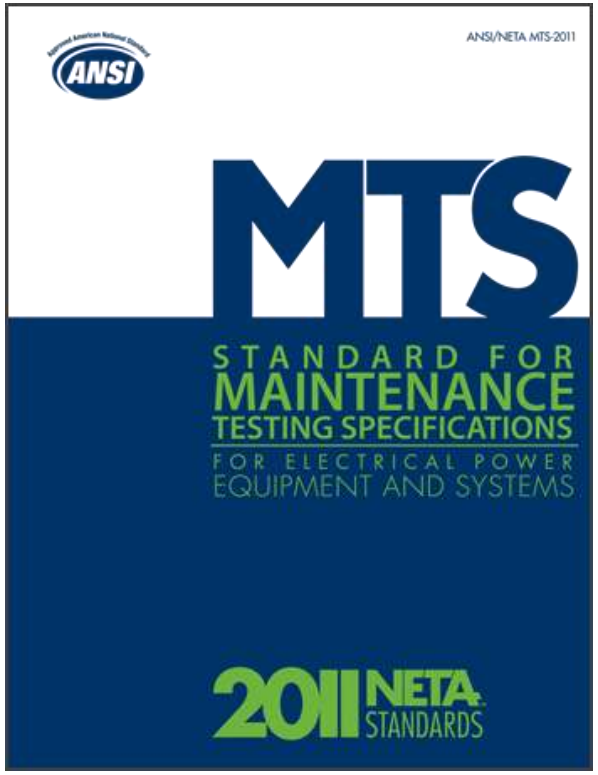
ANSI/NETA ATS-2009



ANSI/NETA *Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems*

- Developed for assessing the suitability for ***initial energization*** of electrical power equipment and systems.
- Specifies field tests and inspections that ensure these systems and apparatus perform satisfactorily, minimizing downtime and maximizing life expectancy.
- Should always be referenced in design specifications or when performing acceptance testing on power system installations.

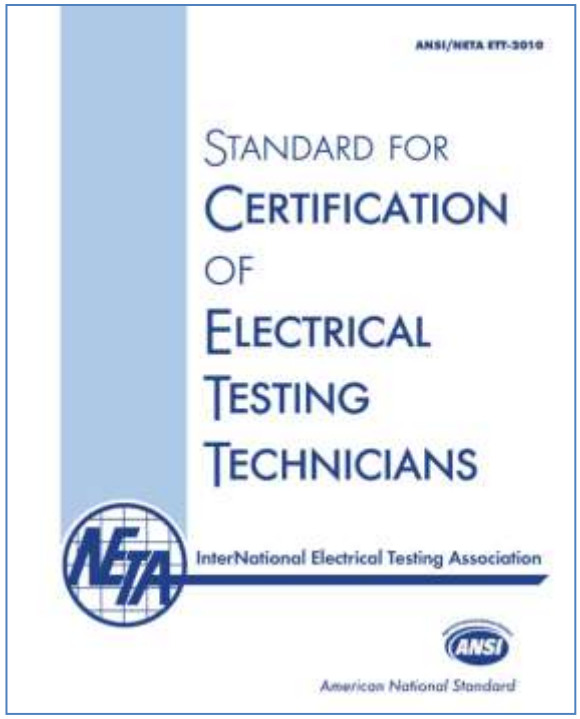
ANSI/NETA MTS-2011



ANSI/NETA *Standard for Maintenance Testing Specifications for Electrical Power Equipment and Systems* - New Edition

- Developed for use by those responsible for the continued operation of existing electrical systems and equipment.
- Provides a guide in specifying and performing the necessary tests to ensure that these systems and apparatus perform satisfactorily, thus minimizing downtime and maximizing life expectancy.
- Should always be referenced when writing maintenance specifications or performing routine testing on electrical power systems.

ANSI/NETA ETT-2010



ANSI/NETA *Standard for Certification of Electrical Testing Technicians*

- Developed to provide a standard for certification of electrical testing technicians.
- Created to codify the experience, education, and training requirements necessary for an individual to obtain a level of competency as an electrical test technician.

Why Specify a NETA Accredited Company ? (NAC)

NETA Accredited Companies

NETA's accreditation process carefully examines the qualifications of each NETA Accredited Company (NAC) in addition to certifying the individual technician employed by that NAC.

Accredited Company + Certified Technician = Quality

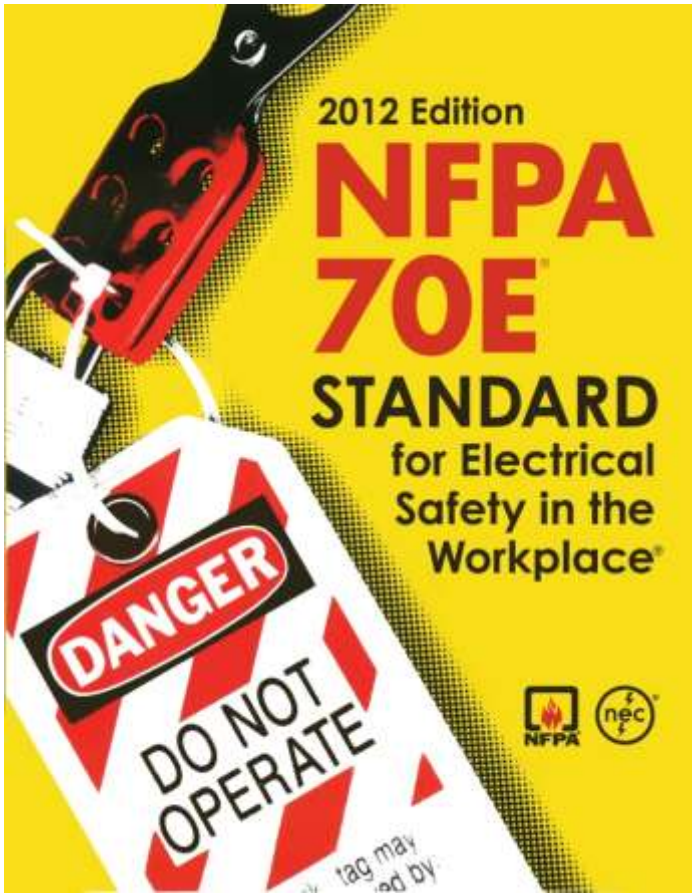
NETA Accredited Companies

NETA – NAC's Unique Qualifications

1. ***NETA CERTIFIED TECHNICIAN*** *– Field Experience, Training, and Continuing Education*
2. ***SAFETY*** *– Setting the Standard*
3. ***THIRD-PARTY, INDEPENDENT TESTING***
4. ***QUALITY ASSURANCE***
5. ***TOTAL SYSTEM EXPERIENCE*** *– Total System Service*

- Trained on NETA Testing Standards
- Technical Knowledge + Field Experience
- Broad-based
- Continuing Education Requirements
- Backed by NETA Accredited Company
- Meets ANSI/NETA ETT

Safety Assurance



- Industry leaders in safe work practices
- Trained in complex safety assessment
- Compliant with NETA and All Industry Related Safety Requirements

NAC Testing

Third-Party + Independent = Unbiased Evaluation

Quality Assurance

- NAC Corporate Infrastructure
- Calibration Program
- Report Parameters
- PE Reviewed Reports
- Continued Education and Training
- Leading Technology

Total System Experience

All voltages, all manufacturers:

- Transformers
- Switchgear and CBs
- Power Cable
- Relaying Protection

From incoming service to the mechanical load

Why Test

Why Test

Do you believe an electrical system:

- Must be designed and engineered properly.
- Quality equipment should be procured.
- It should be installed to all applicable codes and standards by qualified installing contractors and vendors.
- Verification of all above should be performed through an independent, third – party inspection process.

Why Test

But often projects fall victim to the following:

- Poorly written specifications & contracts
- Lack of understanding with respect to design and application of electrical equipment
- Budget & time constraints
- Unqualified contractors & installers
- Use of unaccredited testing & commissioning contractors

Why Test

Verify electrical & mechanical integrity as well as the functional performance of the electrical system

Electrical acceptance testing helps determine:

- If the newly-installed equipment is safe to operate
- Components and installation are in conformance with drawings and specifications
- Provides base-line testing results
- That the equipment will function properly on all taps and settings

Why Test

Third party testing offered by an unbiased and qualified entity provides an overall assessment of the system, based and national consensus standards and technical certifications.

Technician Qualifications

Total System Experience

NETA recognizes four levels of competency in the electrical testing industry

Qualifications

Level I – Trainee Technician

- Entry level to two years.
- Typical activities include:
  - Simple assistance.
  - Simple measurements
  - Test equipment set up and put away
  - Cleaning

Qualifications

Level II – Assistant Technician

- Two years minimum experience, education.
- Must pass qualifying examination.
- Typical activities include:
  - Assists
  - Inspects
  - Tests
  - Data collection
  - Test for de-energized locked out/tagged out equipment

Qualifications

Level III – Certified Technician

- Five years' minimum experience, education.
- Must pass qualifying examination.
- Typical activities include:
  - Lockout/tagout, safety grounding
  - Test for de-energized medium-voltage equipment
  - Performs moderately complex tasks
  - Interacts with other skills and operations

Qualifications

Level IV – Certified Senior Technician

- Ten years' minimum experience, education.
- Pass qualifying examination.
- Typical activities include:
  - Test for de-energized high-voltage equipment.
  - Corrects system failures.
  - Performs very complex tests.
  - Interacts with engineers and managers.

How Can You Help Ensure Safety and Reliability?

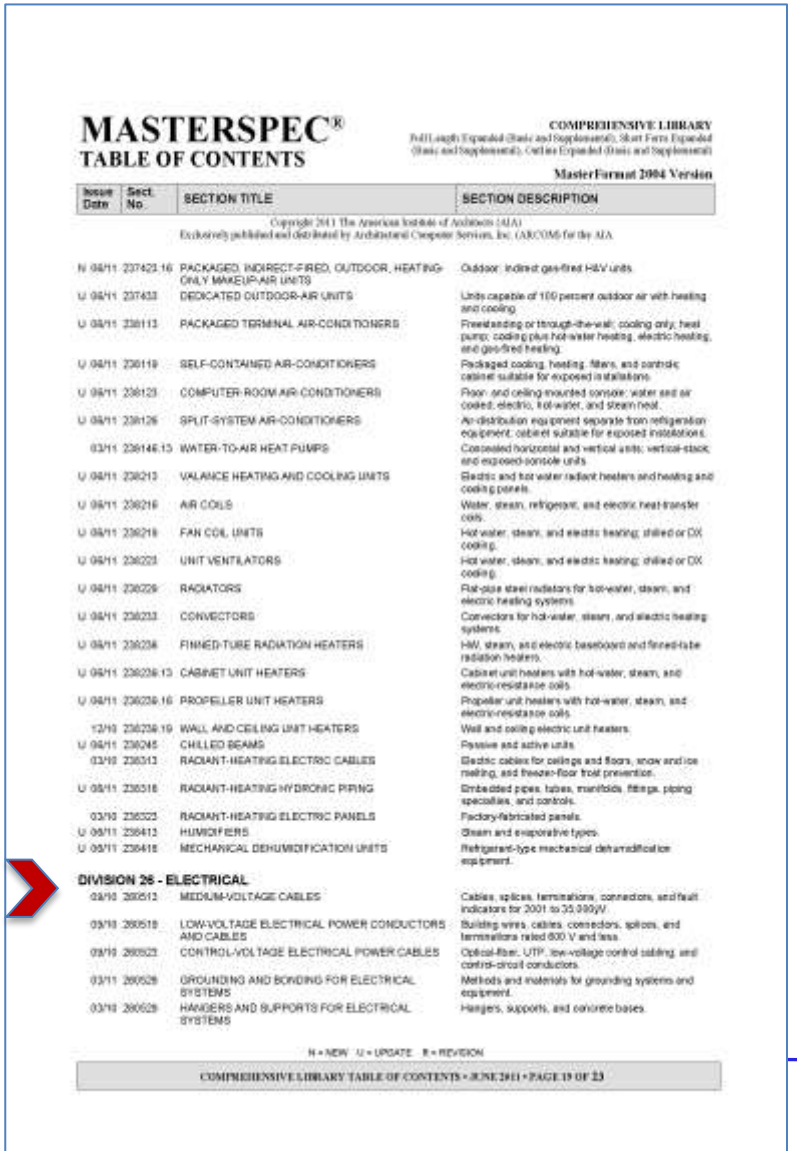
Ensure Safety and Reliability

Bid Specifications Should Include:

- Acceptance testing of all electrical equipment and systems
- Testing in accordance with the most recent ANSI/NETA ATS standard
- Testing Performed by a *NETA Accredited Company (NAC)* and *NETA Certified Technicians*
- A list of local NACs

MASTERSPEC

NETA Standards Reference



MASTERSPEC®
TABLE OF CONTENTS

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Issue Date	Sect. No.	SECTION TITLE	SECTION DESCRIPTION

N = NEW U = UPDATE R = REVISION

ANSI/NETA Standards Reference:

Division 01 – General Requirements

Division 11 – Equipment

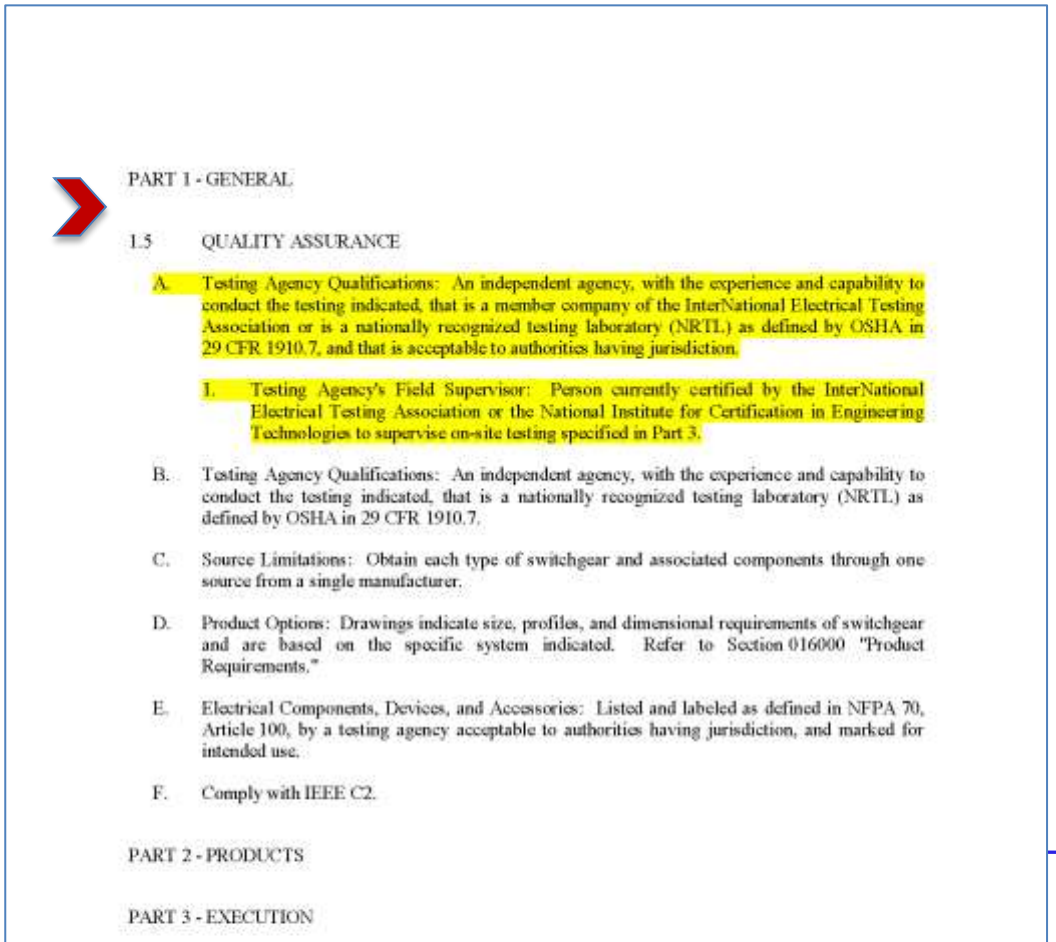
Division 21 – Fire Suppression

Division 26 – Electrical

Division 28 – Electronic Safety and Security

Division 33 – Utilities

MASTERSPEC - PART 1 GENERAL



PART 1 - GENERAL

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.

C. Source Limitations: Obtain each type of switchgear and associated components through one source from a single manufacturer.

D. Product Options: Drawings indicate size, profiles, and dimensional requirements of switchgear and are based on the specific system indicated. Refer to Section 016000 "Product Requirements."

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

F. Comply with IEEE C2.

PART 2 - PRODUCTS

PART 3 - EXECUTION

MASTERSPEC – Part 1
Current Reference

DOES:

Provide a general reference to testing agency and testing technician qualifications.

DOES NOT:

Specify compliance with the ANSI/NETA ATS Standard.

Part 1
Prequalification Statement

1.5 QUALITY ASSURANCE

A. Electrical Power Equipment and Systems: Tested as specified by the ANSI/NETA *Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems* and defined in Sections 3 – 11, by a NETA Accredited Company or equivalent third-party, independent testing agency which can function as an unbiased testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems being evaluated.

Test technicians shall be certified in accordance with ANSI/NETA ETT-2010 *Standard for Certification of Electrical Testing Technicians*. Each on-site crew leader shall hold a current certification, Level III or higher, in electrical testing.

B. Qualification of Testing Organization: In accordance with Section 3.1 of the ANSI/NETA *Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems*

1. The testing organization shall be an independent, third party entity which can function as an unbiased testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems being evaluated.
2. The testing organization shall be regularly engaged in the testing of electrical equipment devices, installations, and systems.
3. The testing organization shall use technicians who are regularly employed for testing services.
4. An organization having a designation of “NETA Accredited Company” issued by the InterNational Electrical Testing Association meets the above criteria.
5. The testing organization shall submit appropriate documentation to demonstrate that it satisfactorily complies with these requirements.

C. The testing organization in accordance with Section 4.2 of the ANSI/NETA *Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems* shall provide the following:

1.All field technical services, tooling, equipment, instrumentation, and technical supervision to perform such tests and inspections.
2.Specific power requirements for test equipment.
3.Notification to the owner’s representative prior to commencement of any testing.
4.A timely notification of any system, material, or workmanship that is found deficient based on the results of the acceptance tests.
5.A written record of all tests and a final report.

D. Safety and Precautions practices shall be in accordance with Section 5.1 of the ANSI/NETA *Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems*

Specify Acceptance Testing

1.5 QUALITY ASSURANCE

A. Electrical Power Equipment and Systems: Tested as specified by the ANSI/NETA *Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems* and defined in Sections 3 – 11

Specify Testing by a NAC

A. … by a NETA Accredited Company, or an equivalent, third-party, independent testing agency which can function as an unbiased testing authority, professionally independent of the manufacturers, suppliers and installers of equipment or systems being evaluated.

Specify Testing Agency Qualifications

B. Qualification of Testing Organization: In accordance with Section 3.1 of the ANSI/NETA *Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems*

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5. The testing organization shall submit appropriate documentation to demonstrate that it satisfactorily complies with these requirements.

Specify NETA Certified Technicians

- Test technicians shall be certified in accordance with ANSI/NETA ETT-2010 *Standard for Certification of Electrical Testing Technicians*.
- Each on-site crew leader shall hold a current certification, Level III or higher, in electrical testing.

Specify Technician Qualifications

C. The testing organization in accordance with Section 4.2 of the ANSI/NETA *Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems* shall provide the following:

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Specify Testing Requirements

1.5 QUALITY ASSURANCE

C. The testing organization shall provide the following:

- All field technical services, tooling, equipment, instrumentation, and technical supervision to perform such tests and inspections.
- Specific power requirements for test equipment.
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MASTERSPEC - PART 1 GENERAL

PART 1 - GENERAL

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

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C. Source Limitations: Obtain each type of switchgear and associated components through one source from a single manufacturer.

D. Product Options: Drawings indicate size, profiles, and dimensional requirements of switchgear and are based on the specific system indicated. Refer to Section 016000 "Product Requirements."

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

F. Comply with IEEE C2.

PART 2 - PRODUCTS

PART 3 - EXECUTION

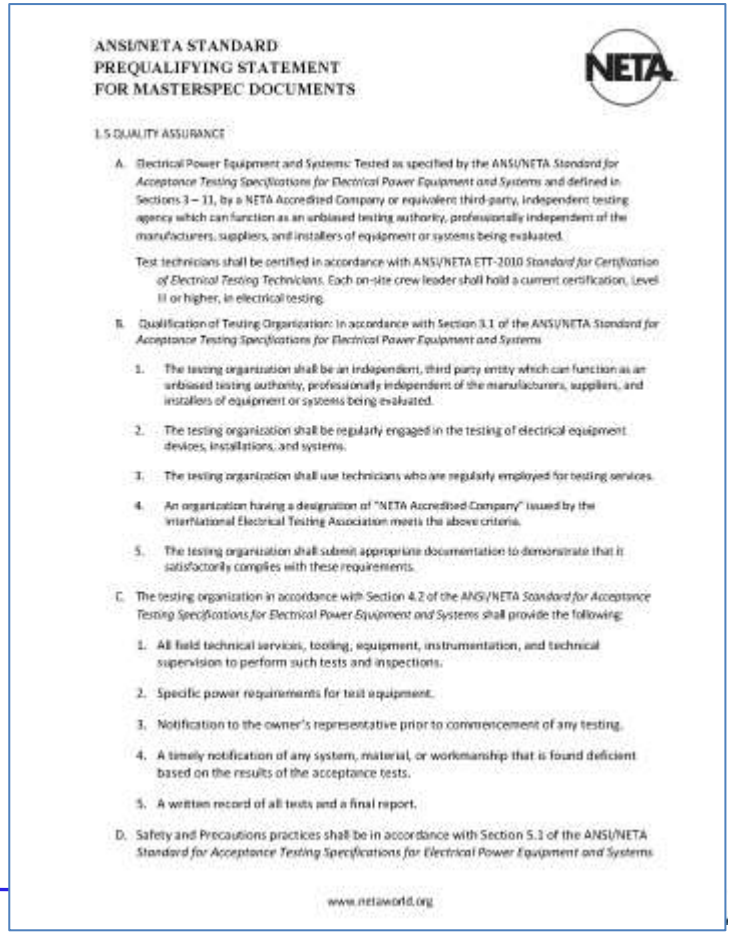
3.5 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each switchgear bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:

ANSI/NETA Prequalification STMT



ANSI/NETA STANDARD
PREQUALIFYING STATEMENT
FOR MASTERSPEC DOCUMENTS

NETA

1.5 QUALITY ASSURANCE

A. Electrical Power Equipment and Systems: Tested as specified by the ANSI/NETA *Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems* and defined in Sections 3 – 11, by a NETA Accredited Company or equivalent third-party, independent testing agency which can function as an unbiased testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems being evaluated.

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5. The testing organization shall submit appropriate documentation to demonstrate that it satisfactorily complies with these requirements.

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1. All field technical services, tooling, equipment, instrumentation, and technical supervision to perform such tests and inspections.
2. Specific power requirements for test equipment.
3. Notification to the owner's representative prior to commencement of any testing.
4. A timely notification of any system, material, or workmanship that is found deficient based on the results of the acceptance tests.
5. A written record of all tests and a final report.

D. Safety and Precautions practices shall be in accordance with Section 5.1 of the ANSI/NETA *Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems*

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MASTERSPEC – PART 3 Test Specifications

1. Sheath: PVC; except in plenum-type spaces, use sheath listed for plenums.
2. Ordinary Switching Circuits: Three conductors, unless otherwise indicated.
3. Switching Circuits with Pilot Lights or Locator Feature: Five conductors, unless otherwise indicated.

PART 3 - EXECUTION

3.1 CABLING

A. Comply with NECA 1.

B. Install cables and wiring according to requirements in Division 16 Section "Voice and Data Communication Cabling."

C. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.

D. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use NRTL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.

E. Identify components and power and control wiring according to Division 16 Section " Electrical Identification."

F. Label each power monitoring and control module with a unique designation.

G. Grounding: Comply with IEEE 1100, "Power and Grounding Sensitive Electronic Equipment."

3.2 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Electrical Tests: Use caution when testing devices containing solid-state components.
2. Continuity tests of circuits.
3. Operational Tests: Set and operate controls at workstation and at monitored and controlled devices to demonstrate their functions and capabilities. Use a methodical sequence that cues and reproduces actual operating functions as recommended by manufacturer. Submit sequences for approval. Note response to each test command and operation. Note time intervals between initiation of alarm conditions and registration of alarms at central-processing workstation.

ANSI/NETA ATS 2009

7. INSPECTION AND TEST PROCEDURES

7.3.3 Cables, Medium- and High-Voltage

1. Visual and Mechanical Inspection

1. Compare cable data with drawings and specifications.
2. Inspect exposed sections of cables for physical damage.
3. Inspect bolted electrical connections for high resistance using one or more of the following methods:
   1. Use of a low-resistance ohmmeter in accordance with Section 7.3.3.2.
   2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 100.12.
   3. Perform a thermographic survey in accordance with Section 9.
4. Inspect compression-applied connectors for correct cable match and indentation.
5. Inspect shield grounding, cable supports, and terminations.
6. Verify that visible cable bends meet or exceed ICEA and manufacturer's minimum published bending radius.
7. Inspect fireproofing in common cable areas.
8. If cables are terminated through window-type current transformers, inspect to verify that neutral and ground conductors are correctly placed and that shields are correctly terminated for operation of protective devices.
9. Inspect for correct identification and arrangements.
10. Inspect cable jacket and insulation condition.

2. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable, in accordance with Section 7.3.3.1.
2. Perform an insulation-resistance test individually on each conductor with all other conductors and shields grounded. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1.
3. Perform a shield-continuity test on each power cable.

* Optional

MASTERSPEC – PART 3

Provide Recognized Testing Agencies

1. Sheath: PVC; except in plenum-type spaces, use sheath listed for plenums.
2. Ordinary Switching Circuits: Three conductors, unless otherwise indicated.
3. Switching Circuits with Pilot Lights or Locator Feature: Five conductors, unless otherwise indicated.

PART 3 - EXECUTION

3.1 CABLING

A. Comply with NECA 1.

B. Install cables and wiring according to requirements in Division 16 Section "Voice and Data Communication Cabling."

C. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.

D. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use NRTL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.

E. Identify components and power and control wiring according to Division 16 Section " Electrical Identification."

F. Label each power monitoring and control module with a unique designation.

G. Grounding: Comply with IEEE 1100, "Power and Grounding Sensitive Electronic Equipment."

3.2 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

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NETA Accredited Company List

Ensuring Safety and Reliability

Trust in a NETA Accredited Company to provide independent, third-party electrical testing to the highest Standard: ANSI/NETA Standards.

NETA has been connecting engineers, architects, facility managers and users of electrical power equipment and systems with NETA Accredited Companies since 1972.

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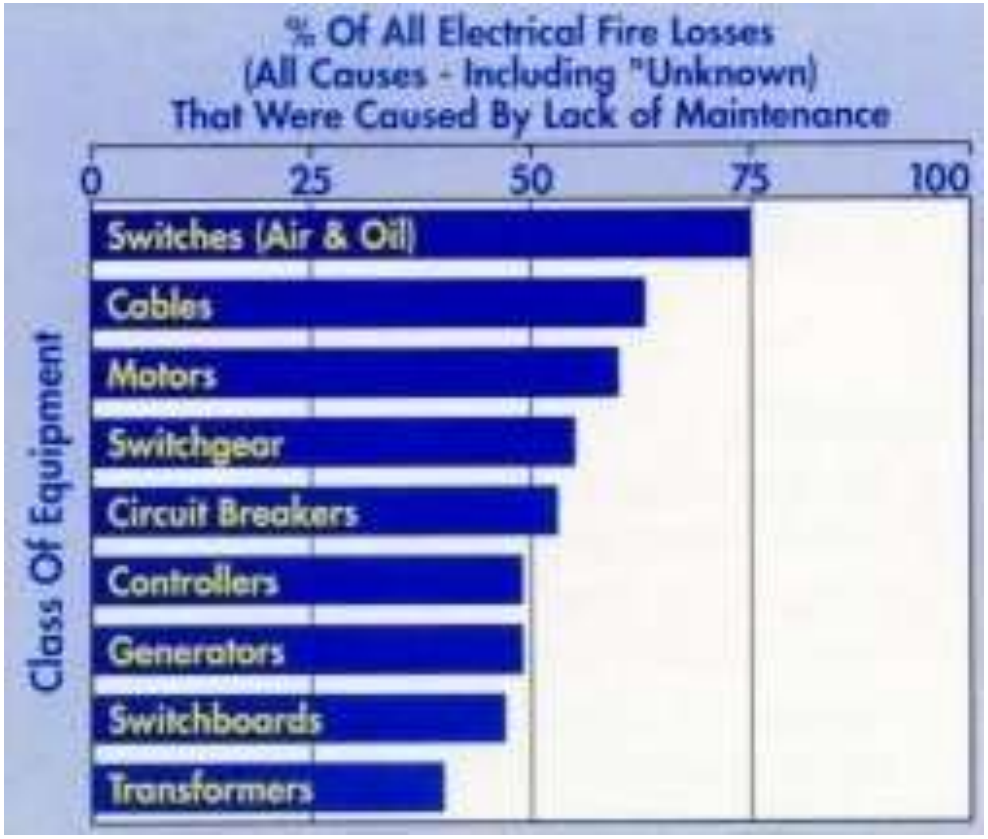
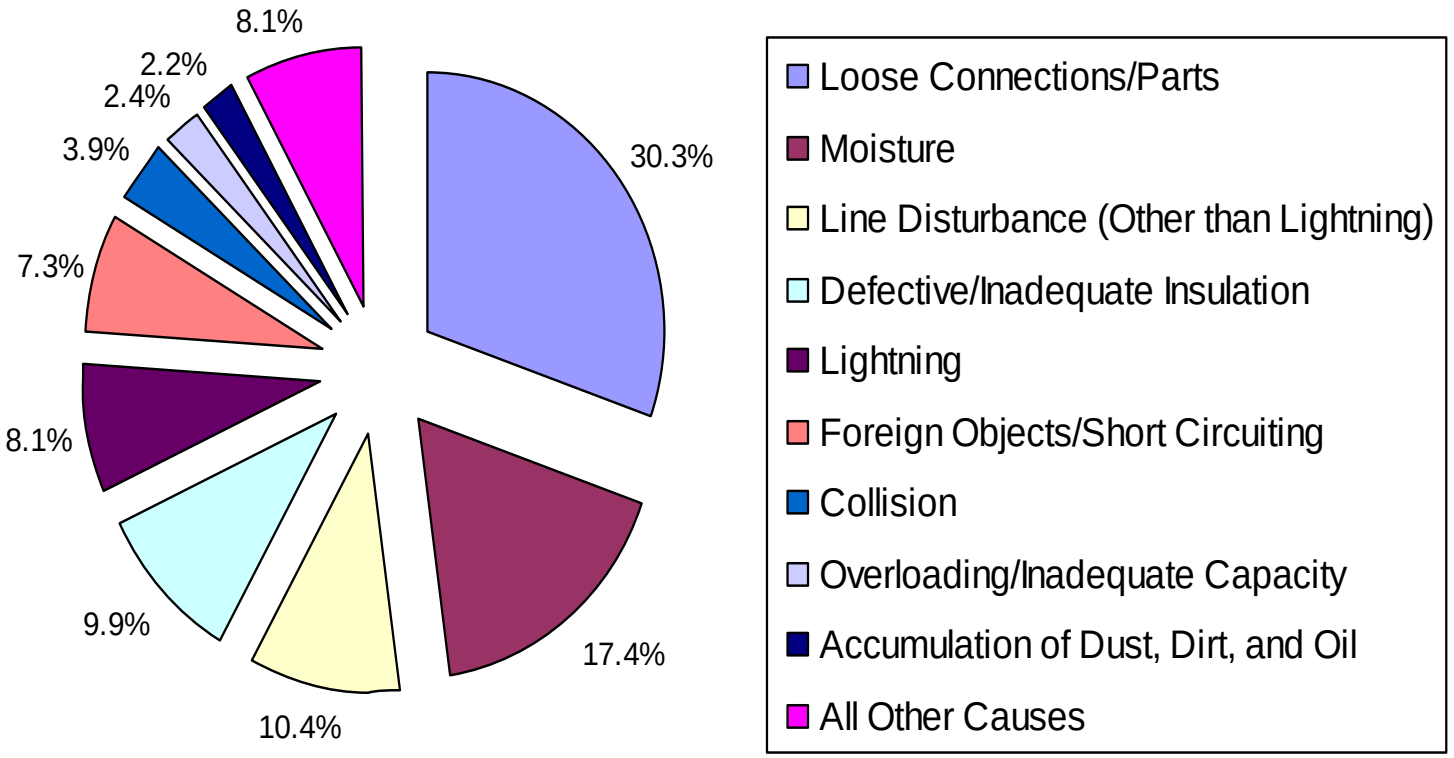
World Class Maintenance

Why Perform Electrical Preventive Maintenance?



"A study by The Factory Mutual Insurance Group Shows that an average of 56% of all electrical fire losses were due to lack of preventive maintenance."

Top Causes of Electrical Distribution System Failures



Based on Hartford Steam Boiler Claims Data

Total Failures due to Insulation Breakdown

Component	Percentage of insulation failure
Transformers	84%
Circuit Breakers	21%
Disconnect Switches	15%
Insulated Switchgear Bus	95%
Bus duct	90%
Cable	89%
Cable Joints (splices)	91%
Cable Terminations	87%

Based on IEEE Gold Book Table 36

Electrical Preventive Maintenance Program

Condition-Based Maintenance

- Maintenance Planning
- Predictive Maintenance
- Preventive Maintenance
- Proactive Maintenance
- Performance Measurement and Tracking
- Continuous Improvement

Maintenance Planning

Maintenance Planning

- Work Order System
- Written Procedures
- Planning:
  - Scope of Work
  - Budget Estimates
  - Resource Schedule

Predictive Maintenance

Predictive Maintenance (PdM)

- Non-invasive.
- Performed while plant is operating.
- Application of PdM tools and techniques.
- Identify (or predict) potential failure modes.

(NFPA 70B & NETA MTS)

Preventive Maintenance

Preventive Maintenance (PM)

- Can be invasive.
- Performed while plant is shutdown.
- Application of PM tools and techniques:
  - Inspect
  - Clean
  - Lubricate
  - Periodic and appropriate electrical testing

(NFPA 70B & NETA MTS)

Pro-active Maintenance

Pro-active Maintenance (PAM)

- Reduce maintenance costs
- Improve effective reliability
- Improve useful life
- Review operating history.
  - Uptime vs. downtime
  - Written failure analysis.
- Review maintenance history.
  - Trending test data
  - Maintenance cost control

Performance Measurement and Tracking

Performance Measurement and Tracking

- Maintenance activities evaluated
  - Reliability
  - Accountability
  - Reporting
  - Trending
- Established process
  - Tracking progress
  - Implementing corrective action

Continuous Improvement

Continuous Improvement

- Integrates EPM criteria results
- Unified focus of plant organizations
  - —Improved productivity
  - —Improved performance
  - —Improved reliability
- Employee training.
- Qualified contractors

Testing Frequency Matrix

Testing Frequency Matrix

			ONLINE TESTING — Predictive Maintenance: To Be Performed at Intervals noted below (Interval						OFFLINE TESTING — Preventive Maintenance: To Be Performed With Outage at intervals noted in Matrix below (Interval units are Years)															
		Notes:	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	N14	N15	N16	N17	N18	N19	N20	N21	N22
			Physical Inspection	Oil Sample Analysis (Oil Quality Analysis and Dissolved Gas Analysis (DGA))	Infrared Inspection	Ultrasonic Emission Survey, requires a safe line-of-sight to perform	Partial Discharge, on-line	Battery Tests	Dielectric Overpotential (Hi-Pot) (DC and/or AC Test)	VLF Tan Delta	Insulation Resistance	Contact/Connection Resistance	Fuse Resistance HV and LV >800A	Dielectric Absorption Ratio (DAR)/Polarization Index (PI)	Power Factor (Doble test / Dissipation Factor >= 5MVA	Winding Resistance Transformers >= 5 MVA	Turns Ratio Test	Vacuum Bottle Integrity.	Electrical Operability Test, Adjustment, Calibration (Example Trip Test)	Mechanical Operability Test,Lubrication (Exercise)	Capacitance Test	Ground Resistance	Continuity Test	Emergency System Operability/Load Test
Medium Voltage (MV), >1000V	A1	Transformer, Oil-Filled >500 KVA	1	1	1	1					3-5				3-5	3-5	3-5							
	A1	Transformer, Dry-Type >500 KVA	1		1	1					3-5					3-5	3-5							
	A2	Breakers, MV Air	1		1	1					3-5	3-5							3-5	1-2				
	A3	Breakers, MV Vacuum	1		1	1					3-5	3-5						3-5	3-5	1-2				
	A4	Breakers, MV Oil	1	1	1	1					3-5	3-5							3-5	1-2				
	A4	Breakers, MV SF6	1		1	1					3-5	3-5							3-5	1-2				
	A5	Switches, MV Air	1		1	1					3-5	3-5	3-5						3-5	1-2				
	A6	Switches, MV Vacuum	1		1	1					3-5	3-5	3-5					3-5	3-5	1-2				
	A7	Switchgear/Switchboard, MV	1		1	1					3-5	3-5												
	A7	Switchgear/Switchboard, SF6 MV	1		1	1					3-5	3-5												
	A6	Starters(Contactors), MV Vacuum	1		1	1					3-5	3-5						3-5	3-5	1-2				
	A5	Starters(Contactors), MV Air	1		1	1					3-5	3-5							3-5	1-2				
	A7	Buses/Bus Bar Air Insulated, MV	1		1	1			3-5		3-5	3-5												
	A8	Cables, MV >=5kV	1			1	1		3-5	3-5	3-5	3-5												
	A9	Protective Relays	1																3-5					
	A18	Grounding System	1																			3-5	3-5	
	A10	Surge/Lightning Arrestors	1		1						3-5				3-5									
	A17	MV Capacitors	1		1																3-5			
Low Voltage (LV), <1000V	A11	Breakers, LV Power >400A	1		1						3-5	3-5							3-5	1-2				
	A12	Breakers, LV Molded Case >400A	1		1						3-5	3-5							3-5	1-2				
	A12	Breakers, LV Insulated Case >400A	1		1						3-5	3-5							3-5	1-2				
	A13	Switches, LV (>400A)	1		1						3-5	3-5	3-5						3-5	3-5				
	A7	Switchgear, LV	1		1						3-5	3-5												
	A7	Buses, LV	1		1						3-5	3-5												
	A8	Cables, LV	1																					
	A14	UPS System	1		1			1																1
	A15	Batteries, Sealed	1		1			1				1-2												
	A16	Batteries, Vented	1		1			1				1-2												
	A17	Capacitors	1		1																3-5			
	A18	Grounding System	1																			3-5	3-5	
		Ground Fault Indication	1																3-5					
		Emergency Generation System	1																1	1				1

Testing Frequency Matrix

ONLINE TESTING

Predictive Maintenance To Be Performed at Intervals noted below (Interval					
Physical Inspection	Oil Sample Analysis (Oil Quality Analysis and Dissolved Gas Analysis (DGA))	Infrared Inspection	Ultrasonic Emission Survey, requires a safe line-of-sight to perform	Partial Discharge, on-ine	Battery Tests
N1	*N2*	*N3*	*N4*	*N5*	*N6*

PdM testing is typically performed at least annually

Testing Frequency Matrix

Predictive Maintenance

N1. Physical Inspections.
N2. Oil Sample Analysis.
N3. Infrared Inspection.
N4. Ultrasonic Emission (UE) Surveys.
N5. Partial Discharge (PD) Testing.
N6. Battery Tests.

Nxx Denotes Description Notes in an EPM Program

Testing Frequency Matrix

1-2 years for HV

OFFLINE TESTING

Preventive Maintenance
To Be Performed With Outage at intervals noted in Matrix below (Interval units are Years)

Dielectric Overpotential (HiPot) (DC and/or AC Test)	VLF Tan Delta	Insulation Resistance	Contact/Connection Resistance	Fuse Resistance HV and LV >800A	Dielectric Absorption Ratio (DAR)/Polarization Index (PI)	PowerFactor (Doble test / Dissipation Factor >= 5MVA	Winding Resistance Transformers >= 5 MVA	Turns Ratio Test	Vacuum Bottle Integrity.	Electrical Operability Test, Adjustment, Calibration (Example Trip Test)	Mechanical Operability Test,Lubrication (Exercise)	Capacitance Test	Ground Resistance	Continuity Test	Emergency System Operability/Load Test
N7	N8	N9	N10	N11	N12	N13	N14	N15	N16	N17	N18	N19	N20	N21	N22

Most PM testing is performed on a 3-5 year cycle

Exceptions:

1.) Every 1-2 years for Batteries

2.) Every 1 year for Generators

Testing Frequency Matrix

Preventive Maintenance

N7. Dielectric Overpotential (HiPot).
N8. VLF Tan Delta
N9. Insulation Resistance.
N10. Contact/Connection Resistance.
N11. Fuse Resistance.
N12. Dielectric Absorption Ratio/Polarization Index
N13. Power Factor/Dissipation Factor
N14. Winding Resistance.
N15. Turns Ratio Test
N16. Vacuum Bottle Integrity.
N17. Electrical Operability Test
N18. Mechanical Operability Test.
N19. Capacitance Test.
N20. Ground Resistance.
N21. Continuity Test.
N22. Emergency System Operability/Load Test

Nxx Denotes Description Notes in an EPM Program

Testing Frequency Matrix

Medium Voltage (MV), >1000V	A1	Transformer, Oil-Filled >500 KVA
	A1	Transformer, Dry-Type >500 KVA
	A2	Breakers, MV Air
	A3	Breakers, MV Vacuum
	A4	Breakers, MV Oil
	A4	Breakers, MV SF6
	A5	Switches, MV Air
	A6	Switches, MV Vacuum
	A7	Switchgear/Switchboard, MV
	A7	Switchgear/Switchboard, SF6 MV
	A6	Starters(Contactors), MV Vacuum
	A5	Starters(Contactors), MV Air
	A7	Buses/Bus Bar Air Insulated, MV
	A8	Cables, MV >=5kV
	A9	Protective Relays
	A18	Grounding System
	A10	Surge/Lightning Arrestors
	A17	MV Capacitors
Low Voltage (LV), <1000V	A11	Breakers, LV Power >400A
	A12	Breakers, LV Molded Case >400A
	A12	Breakers, LV Insulated Case >400A
	A13	Switches, LV (>400A)
	A7	Switchgear, LV
	A7	Buses, LV
	A8	Cables, LV
	A14	UPS System
	A15	Batteries, Sealed
	A16	Batteries, Vented
	A17	Capacitors
	A18	Grounding System
		Ground Fault Indication
		Emergency Generation System

Axx Denotes Procedures from the EPM Program

NFPA 70B & NETA MTS

Testing Frequency Matrix

Testing Frequency Matrix

			ONLINE TESTING: Predictive Maintenance — To Be Performed at Intervals noted below (Interval						OFFLINE TESTING: Preventive Maintenance — To Be Performed With Outage at intervals noted in Matrix below (Interval units are Years)															
		Notes:	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	N14	N15	N16	N17	N18	N19	N20	N21	N22
			Physical Inspection	Oil Sample Analysis (Oil Quality Analysis and Dissolved Gas Analysis (DGA))	Infrared Inspection	Ultrasonic Emission Survey; requires a safe line-of-sight to perform	Partial Discharge, on-line	Battery Tests	Dielectric Overpotential (Hi-Pot) (DC and/or AC Test)	VLF Tan Delta	Insulation Resistance	Contact/Connection Resistance	Fuse Resistance HV and LV >600A	Dielectric Absorption Ratio (DAR)/Polarization Index (PI)	Power Factor (Doble test / Dissipation Factor >= 5MVA	Winding Resistance Transformers >= 5 MVA	Turns Ratio Test	Vacuum Bottle Integrity.	Electrical Operability Test, Adjustment, Calibration (Example Trip Test)	Mechanical Operability Test,Lubrication (Exercise)	Capacitance Test	Ground Resistance	Continuity Test	Emergency System Operability/Load Test
Medium Voltage (MV), >1000V	A1	Transformer, Oil-Filled >500 KVA	1	1	1	1					3-5				3-5	3-5	3-5							
	A1	Transformer, Dry-Type >500 KVA	1		1	1					3-5					3-5	3-5							
	A2	Breakers, MV Air	1		1	1					3-5	3-5							3-5	1-2				
	A3	Breakers, MV Vacuum	1		1	1					3-5	3-5						3-5	3-5	1-2				
	A4	Breakers, MV Oil	1	1	1	1					3-5	3-5							3-5	1-2				
	A4	Breakers, MV SF6	1		1	1					3-5	3-5							3-5	1-2				
	A5	Switches, MV Air	1		1	1					3-5	3-5	3-5						3-5	1-2				
	A6	Switches, MV Vacuum	1		1	1					3-5	3-5	3-5					3-5	3-5	1-2				
	A7	Switchgear/Switchboard, MV	1		1	1					3-5	3-5												
	A7	Switchgear/Switchboard, SF6 MV	1		1	1					3-5	3-5												
	A6	Starters(Contactors), MV Vacuum	1		1	1					3-5	3-5						3-5	3-5	1-2				
	A5	Starters(Contactors), MV Air	1		1	1					3-5	3-5							3-5	1-2				
	A7	Buses/Bus Bar Air Insulated, MV	1		1	1			3-5		3-5	3-5												
	A8	Cables, MV >=5kV	1			1	1		3-5	3-5	3-5	3-5												
	A9	Protective Relays	1																3-5					
	A18	Grounding System	1																			3-5	3-5	
	A10	Surge/Lightning Arrestors	1		1						3-5				3-5									
	A17	MV Capacitors	1		1																3-5			
Low Voltage (LV), <1000V	A11	Breakers, LV Power >400A	1		1						3-5	3-5							3-5	1-2				
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	A12	Breakers, LV Insulated Case >400A	1		1						3-5	3-5							3-5	1-2				
	A13	Switches, LV (>400A)	1		1						3-5	3-5	3-5						3-5	3-5				
	A7	Switchgear, LV	1		1						3-5	3-5												
	A7	Buses, LV	1		1						3-5	3-5												
	A8	Cables, LV	1																					
	A14	UPS System	1		1			1																1
	A15	Batteries, Sealed	1		1			1				1-2												
	A16	Batteries, Vented	1		1			1				1-2												
	A17	Capacitors	1		1																3-5			
	A18	Grounding System	1																			3-5	3-5	
		Ground Fault Indication	1																3-5					
		Emergency Generation System	1																1	1				1

EPM Program

Discussion

- Applications
- Testing Requirements