STANDARD FOR
ACCEPTANCE TESTING SPECIFICATIONS
FOR ELECTRICAL POWER EQUIPMENT & SYSTEMS

ANSI/NETA ATS-2017
AMERICAN NATIONAL STANDARD

STANDARD FOR

ACCEPTANCE TESTING SPECIFICATIONS for
Electrical Power Equipment and Systems

Secretariat
InterNational Electrical Testing Association

American National Standards Institute
Errata to
ANSI/NETA ATS-2017
Standard for Acceptance Testing Specifications for
Electrical Power Equipment and Systems

Issued by the
NETA Standards Review Council
Of the
InterNational Electrical Testing Association

Correction sheet
Issued May 21, 2017
7.2.2 Transformers, Liquid-Filled

7.2.2.B.7
Perform sweep frequency response analysis tests should be marked (*) as optional.
*Original text incorrectly had the SFRA test as mandatory.*

7.2.2 Transformers, Liquid-Filled

7.2.2.D.5
Change text to read investigate bushing power factor values that vary by more than 50%.
*Original text is incorrectly shown as 150%.*

Cables, Medium- and High-Voltage

7.3.3.B.4
TDR measurements should be marked (*) as optional.
*Original text incorrectly had the TDR test as mandatory.*

Circuit Breakers, Vacuum, Medium-Voltage

7.6.3.B.5 (electrical test)
7.6.3.D.5 (test result)
Dynamic contact resistance test.
*Delete requirement and expected test results section – this test was not intended for medium-voltage vacuum breakers.*
American National Standard

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The following sections of the ANSI/NETA Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems must be incorporated by reference as part of any subsection:

3. Qualifications of Testing Organization and Personnel
   3.1 Testing Organization
   3.2 Testing Personnel
4. Division of Responsibility
   4.1 The Owner’s Representative
   4.2 The Testing Organization
5. General
   5.1 Safety and Precautions
   5.2 Suitability of Test Equipment
   5.3 Test Instrument Calibration
   5.4 Test Report
   5.5 Test Decal

The purchaser is required to include the above sections with any section(s) of 7.

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Standards Review Council

These specifications were submitted for public comment and reviewed by the NETA Standards Review Council.

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This document is subject to periodic review, and users are cautioned to obtain the latest edition. Comments and suggestions are invited from all users for consideration by the Association in connection with such review. Any such suggestions will be fully reviewed by the Association after giving the commenter, upon request, a reasonable opportunity to be heard.

This document should not be confused with federal, state, or municipal specifications or regulations, insurance requirements, or national safety codes. While the Association recommends reference to or use of this document by government agencies and others, use of this document is purely voluntary and not binding.

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The InterNational Electrical Testing Association (NETA) was formed in 1972 to establish uniform testing procedures for electrical equipment and apparatus. NETA developed specifications for the acceptance of new electrical apparatus prior to energization and for the maintenance of existing apparatus to determine its suitability to remain in service. The first NETA Acceptance Testing Specifications for Electrical Power Equipment and Systems was produced in 1972. Upon completion of this project, the NETA Technical Committee began work on a maintenance document, and Maintenance Testing Specifications for Electrical Power Equipment and Systems was published in 1975.

NETA has been an Accredited Standards Developer for the American National Standards Institute since 1996. NETA’s scope of standards activity is different from that of the IEEE, NECA, NEMA, and UL. In matters of testing electrical equipment and systems NETA continues to reference other standards developers’ documents where applicable. NETA's review and updating of presently published standards takes into account both national and international standards. 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.

The NETA Acceptance Testing Specifications was developed for use by those responsible for assessing the suitability for initial energization of electrical power equipment and systems and to specify field tests and inspections that ensure these systems and apparatus perform satisfactorily, minimizing downtime and maximizing life expectancy.

Since 1972, several revisions of the Acceptance Testing Specifications have been published; in 1989 the NETA Technical Committee, with approval of the Board of Directors, set a four-year review and revision schedule. Unless it involves a significant safety or urgent technical issue, each comment and suggestion for change is held until the appropriate review period. Each edition includes new and completely revised sections. The document uses the standard numbering system of ANSI and IEEE. Since 1989, revised editions of the Acceptance Testing Specifications have been published in 1991, 1995, 1999, 2003, 2007, 2009, and 2013.


Suggestions for improvement of this standard are welcome. They should be sent to the InterNational Electrical Testing Association, 3050 Old Centre Avenue, Suite 102, Portage, MI 49024, or emailed to neta@netaworld.org.
PREFACE

(This Preface is not part of American National Standard ANSI/NETA ATS-2017)

It is recognized by the Association that the needs for acceptance testing of commercial, industrial, governmental, and other electrical power systems vary widely. Many criteria are used in determining what equipment is to be tested and to what extent.

To help the user better understand and navigate more efficiently through this document, we offer the following information:

Notation of Changes
Material included in this edition of the document but not part of the 2013 edition is marked with a black vertical line to the left of the insertion of text, deletion of text, or alteration of text.

The Document Structure
The document is divided into thirteen separate and defined sections:

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Section 7 Structure
Section 7 is the main body of the document with specific information on what to do relative to the inspection and acceptance testing of electrical power distribution equipment and systems. It is not intended that this document list how to test specific pieces of equipment or systems.

Sequence of Tests and Inspections
The tests and inspections specified in this document are not necessarily presented in chronological order and may be performed in a different sequence.

Expected Test Results
Section 7 consists of sections specific to each particular type of equipment. Within those sections there are, typically, four main bodies of information:

A. Visual and Mechanical Inspection  
B. Electrical Tests  
C. Test Values – Visual and Mechanical  
D. Test Values – Electrical
Results of Visual and Mechanical Inspections
Some, but not all, visual and mechanical inspections have an associated test value or result. Those items with an expected result are referenced under Section C., Test Values – Visual and Mechanical. For example, Section 7.1 Switchgear and Switchboard Assemblies, item 7.1.A.8.2 calls for verifying tightness of connections using a calibrated torque wrench method. Under the Test Values – Visual and Mechanical Section 7.1.C.2, the expected results for that particular task are listed within Section C., with reference back to the original task description on item 7.1.A.8.2.
Results of Electrical Tests
Each electrical test has a corresponding expected result, and the test and the result have identical numbers. If the electrical test is item four, the expected result under the Test Values section is also item four. For example, under Section 7.15.1 Rotating Machinery, AC Induction Motors and Generators, item 7.15.1.B.2 (item 2 within the Electrical Tests section) calls for performing an insulation-resistance test in accordance with IEEE Standard 43. In section D, Test Values – Electrical, the expected results for that particular task are listed in the Test Values section under item 2.
Optional Tests
The purpose of these specifications is to assure that all tested electrical equipment and systems supplied by either contractor or owner are operational and within applicable standards and manufacturer’s published tolerances and that equipment and systems are installed in accordance with design specifications.

Certain tests are assigned an optional classification. The following considerations are used in determining the use of the optional classification:

1. Does another listed test provide similar information?
2. How does the cost of the test compare to the cost of other tests providing similar information?
3. How commonplace is the test procedure? Is it new technology?

Manufacturer’s Instruction Manuals
It is important to follow the recommendations contained in the manufacturer’s published data. Many of the details of a complete and effective testing procedure can be obtained from this source.

Summary
The guidance of an experienced testing professional should be sought when making decisions concerning the extent of testing. It is necessary to make an informed judgment for each particular system regarding how extensive a procedure is justified. The approach taken in these specifications is to present a comprehensive series of tests applicable to most industrial and larger commercial systems. In smaller systems, some of the tests can be deleted. In other cases, a number of the tests indicated as optional should be performed.

Likewise, guidance of an experienced testing professional should also be sought when making decisions concerning the results of test data and their significance to the overall analysis of the device or system under test. Careful consideration of all aspects of test and calibration data, including manufacturer’s published data and recommendations, must be included in the overall assessment of the device or system under test.

The Association encourages comment from users of this document. Please contact the NETA office or your local NETA Accredited Company.

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1. GENERAL SCOPE

1. These specifications cover the suggested field tests and inspections that are available to assess the suitability for initial energization and final acceptance of electrical power equipment and systems.

2. The purpose of these specifications is to assure that tested electrical equipment and systems are operational, are within applicable standards and manufacturer's tolerances, and are installed in accordance with design specifications.

3. The work specified in these specifications may involve hazardous voltages, materials, operations, and equipment. These specifications do not purport to address all of the safety issues associated with their use. It is the responsibility of the user to review all applicable regulatory limitations prior to the use of these specifications.
2. APPLICABLE REFERENCES

2.1 Codes, Standards, and Specifications

All inspections and field tests shall be in accordance with the latest edition of the following codes, standards, and specifications except as provided otherwise herein.

1. American National Standards Institute – ANSI

2. ASTM International - ASTM

- ASTM D92: Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
- ASTM D664: Standard Test Method for Acid Number of Petroleum Products by Potentiometric Titration
- ASTM D924: Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids
- ASTM D971: Standard Test Method for Interfacial Tension of Oil against Water by the Ring Method
- ASTM D974: Standard Test Method for Acid and Base Number by Color-Indicator Titration
- ASTM D1524: Standard Test Method for Visual Examination of Used Electrical Insulating Liquids in the Field
2. APPLICABLE REFERENCES

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3. Association of Edison Illuminating Companies - AEIC
4. Canadian Standards Association - CSA
5. Electrical Apparatus Service Association - EASA

EASA AR100 | Recommended Practice for the Repair of Rotating Electrical Apparatus
2. APPLICABLE REFERENCES

2.1 Codes, Standards, and Specifications (continued)

6. Institute of Electrical and Electronic Engineers - IEEE

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<td>IEEE C57</td>
<td>Distribution, Power, and Regulating Transformers</td>
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<td>IEEE Recommended Practice for Testing Insulation Resistance of Electric Machinery</td>
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<td>The Authoritative Dictionary of IEEE Standards Terms</td>
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<tr>
<td>IEEE 141</td>
<td>IEEE Recommended Practice for Electrical Power Distribution for Industrial Plants (IEEE Red Book)</td>
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<tr>
<td>IEEE 142</td>
<td>IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems (IEEE Green Book)</td>
</tr>
<tr>
<td>IEEE 241</td>
<td>IEEE Recommended Practice for Electric Power Systems in Commercial Buildings (Gray Book)</td>
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<tr>
<td>IEEE 242</td>
<td>IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (Buff Book)</td>
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</table>
## 2. APPLICABLE REFERENCES

### 2.1 Codes, Standards, and Specifications (continued)

<table>
<thead>
<tr>
<th>IEEE Code</th>
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<tbody>
<tr>
<td>386</td>
<td>IEEE Standard for Separable Insulated Connector Systems for Power Distribution Systems above 600 V</td>
</tr>
<tr>
<td>399</td>
<td>IEEE Recommended Practice for Power Systems Analysis (Brown Book)</td>
</tr>
<tr>
<td>400</td>
<td>IEEE Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems Rated 5 kV and Above</td>
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<tr>
<td>400.1</td>
<td>IEEE Guide for Field Testing of Laminated Dielectric, Shielded Power Cable Systems Rated 5 kV and Above with High Direct Current Voltage</td>
</tr>
<tr>
<td>400.2</td>
<td>IEEE Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)(less than 1 Hz)</td>
</tr>
<tr>
<td>400.3</td>
<td>IEEE Guide for Partial Discharge Testing of Shielded Power Cable Systems in a Field Environment</td>
</tr>
<tr>
<td>400.4</td>
<td>IEEE Guide for Field Testing of Shielded Power Cable Systems Rated 5 kV and Above with Damped Alternating Current (DAC) Voltage</td>
</tr>
<tr>
<td>421.3</td>
<td>IEEE Standard for High-Potential-Test Requirements for Excitation Systems for Synchronous Machines</td>
</tr>
<tr>
<td>446</td>
<td>IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications (Orange Book)</td>
</tr>
<tr>
<td>450</td>
<td>IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications</td>
</tr>
<tr>
<td>493</td>
<td>IEEE Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems (Gold Book)</td>
</tr>
<tr>
<td>519</td>
<td>IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems</td>
</tr>
<tr>
<td>602</td>
<td>IEEE Recommended Practice for Electric Systems in Health Care Facilities (White Book)</td>
</tr>
<tr>
<td>637</td>
<td>IEEE Guide for the Reclamation of Insulating Oil and Criteria for Its Use</td>
</tr>
<tr>
<td>644</td>
<td>Procedures for Measurement of Power Frequency Electric and Magnetic Fields from AC Power Lines</td>
</tr>
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</table>
## 2. APPLICABLE REFERENCES

### 2.1 Codes, Standards, and Specifications (continued)

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<tbody>
<tr>
<td>IEEE 739</td>
<td>IEEE Recommended Practice for Energy Management in Commercial and Industrial Facilities (Bronze Book)</td>
</tr>
<tr>
<td>IEEE 1015</td>
<td>IEEE Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems (Blue Book)</td>
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<tr>
<td>IEEE 1100</td>
<td>IEEE Recommended Practice for Powering and Grounding Sensitive Electronic Equipment (Emerald Book)</td>
</tr>
<tr>
<td>IEEE 1106</td>
<td>IEEE Recommended Practice for Maintenance, Testing, and Replacement of Nickel-Cadmium Batteries for Stationary Applications</td>
</tr>
<tr>
<td>IEEE 1159</td>
<td>IEEE Recommended Practice on Monitoring Electrical Power Quality</td>
</tr>
<tr>
<td>IEEE 1188</td>
<td>IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications</td>
</tr>
<tr>
<td>IEEE 1584</td>
<td>IEEE Guide for Arc-Flash Hazard Calculations</td>
</tr>
<tr>
<td>IEEE 3007.3</td>
<td>Recommended Practice for Electrical Safety in Industrial and Commercial Power Systems</td>
</tr>
</tbody>
</table>

### 7. Insulated Cable Engineers Association – ICEA

| ICEA S-93-639/NEMA WC 74 | 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy |
| ICEA S-94-649 | Standard for Concentric Neutral Cables Rated 5,000 - 46,000 Volts |
| ICEA S-97-682 | Standard for Utility Shielded Power Cables Rated 5,000 - 46,000 Volts |

### 8. InterNational Electrical Testing Association - NETA

| ANSI/NETA ECS | Standard for Electrical Commissioning of Electrical Power Equipment and Systems |
| ANSI/NETA ETT | Standard for Certification of Electrical Testing Technicians |
| ANSI/NETA MTS | Maintenance Testing Specifications for Electrical Power Equipment and Systems |
2. APPLICABLE REFERENCES

2.1 Codes, Standards, and Specifications (continued)

9. National Electrical Manufacturers Association - NEMA

NEMA AB4  Guidelines for Inspection and Preventive Maintenance of Molded-Case Circuit Breakers Used in Commercial and Industrial Applications

NEMA 84.1  Electrical Power Systems and Equipment Voltage Ratings (60 Hz)

NEMA MG1  Motors and Generators


NFPA 70  National Electrical Code

NFPA 70B  Recommended Practice for Electric Equipment Maintenance

NFPA 70E  Standard for Electrical Safety in the Workplace

NFPA 99  Health Care Facilities Code

NFPA 101  Life Safety Code

NFPA 110  Emergency and Standby Power Systems

NFPA 111  Standard on Stored Electrical Energy Emergency Systems and Standby Power Systems

NFPA 780  Installation of Lightning Protection Systems

11. Occupational Safety and Health Administration - OSHA

12. State and local codes and ordinances

13. Underwriters Laboratories, Inc. - UL
2. APPLICABLE REFERENCES

2.2 Other References

Manufacturer’s instruction manuals for the equipment to be tested.


Megger, *A Stitch in Time…The Complete Guide to Electrical Insulation Testing*


2.3 Contact Information

ASTM International – ASTM
100 Barr Harbor Drive
W. Conshohocken, PA 19428
(610) 832-9585
www.astm.org

Association of Edison Illuminating Companies – AEIC
600 N. 18th Street; PO Box 2641
Birmingham, AL 35291
(205) 257-2530
www.aeic.org

Canadian Standards Association – CSA
178 Rexdale Boulevard
Toronto, ON M9W 1R3
(416) 747-4000
www.csa.ca

Electrical Apparatus Service Association – EASA
1331 Baur Boulevard
St. Louis, MO 63132
(314) 993-2220
www.easa.com

Institute of Electrical and Electronic Engineers – IEEE
PO Box 1331
Piscataway, NJ 08855
(732) 981-0060
www.ieee.org

Insulated Cable Engineers Association – ICEA
c/o Global Document Engineers
15 Inverness Way East
Englewood, CO 80112
(303) 397-7956
www.icea.net
2. APPLICABLE REFERENCES

2.3 Contact Information (continued)

International Electrotechnical Commission – IEC
Contact through American National Standards Institute

InterNational Electrical Testing Association – NETA
3050 Old Centre Avenue, Suite 102
Portage, MI 49024
(269) 488-6382 or (888) 300-NETA (6382)
www.netaworld.org

Megger
4271 Bronze Way
Dallas, TX 75237
(800) 723-2861
www.megger.com

National Electrical Manufacturers Association– NEMA
1300 N. 17th St. Suite 1847
Rosslyn, VA 22209
(703) 841-3200
www.nema.org

National Fire Protection Association – NFPA
1 Battery March Park
PO Box 901
Quincy, MA 02269-9101
(617) 984-7247
www.nfpa.org

Occupational Safety and Health Administration – OSHA
U.S. Department of Labor
Occupational Safety and Health Administration
Office of Public Affairs - Room N3647
200 Constitution Avenue
Washington, D.C. 20210
(202) 693-1999
www.osha.gov

The Okonite Company
102 Hilltop Road
Ramsey, New Jersey 07446
(201) 825-0300 Fax 201-825-3524
www.okonite.com

Underwriters Laboratories, Inc. – UL
333 Pfingsten Road
Northbrook, IL 60062
(847) 272-8800
www.ul.com
3. QUALIFICATIONS OF TESTING ORGANIZATION AND PERSONNEL

3.1 Testing Organization

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.

3.2 Testing Personnel

1. Technicians performing these electrical tests and inspections shall be trained and experienced concerning the apparatus and systems being evaluated. These individuals shall be capable of conducting the tests in a safe manner and with complete knowledge of the hazards involved. They must evaluate the test data and make a judgment on the serviceability of the specific equipment.

2. Technicians shall be certified in accordance with ANSI/NETA ETT, Standard for Certification of Electrical Testing Technicians. Each on-site crew leader shall hold a current certification, Level 3 or higher, in electrical testing.
4. DIVISION OF RESPONSIBILITY

4.1 The Owner’s Representative

The owner’s representative shall provide the testing organization with the following:

1. A short-circuit analysis, a coordination study, and a protective device setting sheet as described in Section 6.

2. A complete set of electrical plans and specifications, including all change orders.

3. Drawings and instruction manuals applicable to the scope of work.

4. An itemized description of equipment to be inspected and tested.

5. A determination of who shall provide a suitable and stable source of electrical power to each test site.

6. A determination of who shall perform certain preliminary low-voltage insulation-resistance, continuity, and low-voltage motor rotation tests prior to and in addition to tests specified herein.

7. Notification of when equipment becomes available for acceptance tests. Work shall be coordinated to expedite project scheduling.

8. Site-specific hazard notification and safety training.

4.2 The Testing Organization

The testing organization 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.
5. GENERAL

5.1 Safety and Precautions
All parties involved must be cognizant of industry-standard safety procedures. This document does not contain any procedures including specific safety procedures. It is recognized that an overwhelming majority of the tests and inspections recommended in these specifications are potentially hazardous. Individuals performing these tests shall be qualified and capable of conducting the tests in a safe manner and with complete knowledge of the hazards involved.

1. Safety practices shall include, but are not limited to, the following requirements:
   2. ANSI/NFPA 70E, Standard for Electrical Safety in the Workplace.
   3. Applicable state and local safety operating procedures.
   4. Owner’s safety practices.

2. The testing organization shall have a designated safety lead person on site to supervise operations with respect to safety.

3. A job hazard analysis and a safety briefing shall be conducted prior to the commencement of work.

4. All tests shall be performed with the apparatus de-energized and grounded except where otherwise specifically required to be ungrounded or energized for certain tests.

5. The testing organization shall have a designated safety representative on the project to supervise operations with respect to safety. This individual may be the same person described in 5.1.2.

5.2 Suitability of Test Equipment
1. All test equipment shall meet the requirements in Section 5.3 and be in good mechanical and electrical condition.

2. Field test metering used to check power system meter calibration must be more accurate than the instrument being tested.

3. Accuracy of metering in test equipment shall be appropriate for the test being performed.

4. Waveshape and frequency of test equipment output waveforms shall be appropriate for the test to be performed and the equipment to be tested.
5. GENERAL

5.3 Test Instrument Calibration

1. The testing organization shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy for each test instrument calibrated.

2. The firm providing calibration service shall maintain up-to-date instrument calibration instructions and procedures for each test instrument calibrated.

3. The accuracy shall be directly traceable to the National Institute of Standards and Technology (NIST).

4. Instruments shall be calibrated in accordance with the following frequency schedule:

   1. Field instruments: Analog and Digital, 12 months maximum.
   2. Laboratory instruments: 12 months maximum.
   3. Leased specialty equipment: 12 months maximum.

5. Dated calibration labels shall be visible on all test equipment.

6. Records which show date and results of instruments calibrated or tested must be kept up to date.

7. Calibrating standard shall be of better accuracy than that of the instrument tested.
5. GENERAL

5.4 Test Report

1. The test report shall include the following:
   1. Summary of project.
   2. Description of equipment tested.
   3. Description of tests.
   5. Test data.

2. Test data records shall include the following minimum requirements:
   1. Identification of the testing organization.
   2. Equipment identification.
   3. Nameplate data.
   4. Humidity, temperature, and other conditions that may affect the results of the tests and/or calibrations.
   5. Date of inspections, tests, maintenance, and/or calibrations.
   6. Identification of the testing technician.
   7. Indication of inspections, tests, maintenance, and/or calibrations to be performed and recorded.
   8. Indication of expected results when calibrations are to be performed.
   9. Indication of as-found and as-left results, as applicable.
   10. Identification of all test results outside of specified tolerances.
   11. Sufficient spaces to allow all results and comments to be indicated.

3. The testing organization shall furnish a copy or copies of the complete report as specified in the acceptance testing contract.
5. GENERAL

5.5 Test Decal

1. The testing organization shall affix a test decal on the exterior of equipment or equipment enclosure of protective devices after performing electrical tests.

2. The test decal shall be color-coded to communicate the condition of maintenance for the protective device. Color scheme for condition of maintenance of overcurrent protective device shall be:

   1. White: electrically and mechanically acceptable.
   2. Yellow: minor deficiency not affecting fault detection and operation, but minor electrical or mechanical condition exists.

3. The decal shall include:

   1. Testing organization
   2. Project identifier
   3. Test date
   4. Technician identifier
6. POWER SYSTEM STUDIES

6.1 Short-Circuit Studies

1. Scope of Study

Determine the short-circuit current available at each component of the electrical system and the ability of the component to withstand and/or interrupt the current. Provide an analysis of all possible operating scenarios which will be or have been influenced by the proposed or completed additions or changes to the subject system.

2. Procedure


3. Study Report

Results of the short-circuit study shall be summarized in a final report containing the following items:

1. Basis, description, purpose, and scope of the study.

2. Tabulations of the data used to model the system components and a corresponding one-line diagram.

3. Descriptions of the scenarios evaluated and identification of the scenario used to evaluate equipment short-circuit current ratings.


5. Conclusions and recommendations.
6. POWER SYSTEM STUDIES

6.2 Coordination Studies

1. Scope of Study

1. Determine the extent of overcurrent protective device coordination for the scope:

   1. Selective coordination: determine the protective device types, characteristics, settings, or ampere ratings which provide selective coordination, equipment protection, and correct interrupting ratings for the full range of available short-circuit currents at points of application for each overcurrent protective device.

   2. Compromised coordination: determine protective device types, characteristics, settings, or ampere ratings which permit ranges of non-coordination of overcurrent protective devices. In this case, overcurrent protective device coordination may be compromised due to the overcurrent protective devices selected or already installed or in order to achieve protection of equipment that is selected or already installed. Objective is to maximize coordination of overcurrent protective devices to extent possible based on the type of devices. Determine protective device characteristics, settings, or sizes which provide a balance between equipment protection and selective device operation that is optimum for the electrical system.

2. Provide an analysis of all possible operating scenarios which will be or have been influenced by the proposed or completed additions or changes to the subject system.

The coordination study shall be performed in accordance with the recommended practices and procedures set forth in ANSI/IEEE 399 and ANSI/IEEE 242. Protective device selection and settings shall comply with requirements of NFPA 70 National Electrical Code.

3. Study Report

Results of the coordination study shall be summarized in a final report containing the following items:

1. Basis, description, purpose, and scope of the study and a corresponding one-line diagram.

2. Time-current curves, selective coordination ratios of fuses, or selective coordination tables of circuit breakers demonstrating the coordination of overcurrent protective devices to the scope.

3. Tabulations of protective devices identifying circuit location, manufacturer, type, range of adjustment, IEEE device number, current transformer ratios, recommended settings or device size, and referenced time-current curve.


* Optional
6. POWER SYSTEM STUDIES

6.3 Arc-Flash Hazard Analysis

1. Scope of Study

Determine arc-flash incident energy levels and flash-protection boundary distances based on the results of the short-circuit and coordination studies. Perform the analysis under worst-case arc-flash conditions for all modes of operation. Provide an analysis of all possible operating scenarios which will be or have been influenced by the proposed or completed additions to the subject system.

2. Procedure

Identify all locations and equipment to be included in the arc-flash hazard analysis.

1. Prepare a one-line diagram of the power system.

2. Perform a short-circuit study in accordance with Section 6.1.

3. Perform a coordination study in accordance with Section 6.2.

4. Identify the possible system operating modes including tie-breaker positions, and parallel generation.

5. Calculate the arcing fault current flowing through each branch for each fault location in accordance with NFPA 70E, IEEE 1584, OSHA 1910.269, or other applicable standards.

6. Determine the time required to clear the arcing fault current using the protective device settings and associated trip curves.

7. Select the working distances based on system voltage and equipment class.

8. Calculate the incident energy at each fault location at the prescribed working distance.

9. Determine the arc-flash hazard PPE category for the calculated incident energy level.

10. Calculate the flash protection boundary at each fault location.

11. Document the assessment in reports and one-line diagrams.

*12. Fabricate and install appropriate labels on the equipment.

* Optional
6. POWER SYSTEM STUDIES

6.3 Arc-Flash Hazard Analysis (continued)

3. Study Report

Results of the arc-flash study shall be summarized in a final report containing the following items:

1. Basis, method of hazard assessment, description, purpose, scope, and date of the study.

2. Tabulations of the data used to model the system components and a corresponding one-line diagram.

3. Descriptions of the scenarios evaluated and identification of the scenario used to develop incident-energy levels and arc-flash boundaries.

4. Tabulations of equipment incident energies, arc-flash hazard PPE categories, and arc-flash boundaries. The tabulation shall identify and clearly note equipment that exceeds 40 cal/cm².

5. List of required arc-flash labels and locations.

6. Conclusions and recommendations.

* Optional
6. POWER SYSTEM STUDIES

6.4 Load-Flow Studies

1. Scope of Study

   Determine active and reactive power, voltage, current, and power factor throughout the electrical system. Provide an analysis of all possible operating scenarios.

2. Procedure

   The load-flow study shall be performed in accordance with the recommended practices and procedures set forth in ANSI/IEEE 399.

3. Study Report

   Results of the load-flow study shall be summarized in a final report containing the following items:

   1. Basis, description, purpose, and scope of the study.

   2. Tabulations of the data used to model the system components and a corresponding one-line diagram.

   3. Descriptions of the scenarios evaluated and the basis for each.

   4. Tabulations of power and current flow versus equipment ratings. The tabulation shall identify percentage of rated load and the scenario for which the percentage is based. Overloaded equipment shall be clearly noted.

   5. Tabulations of system voltages versus equipment ratings. The tabulation shall identify percentage of rated voltage and the scenario for which the percentage is based. Voltage levels outside the ranges recommended by equipment manufacturers, ANSI/IEEE C84.1, or other appropriate standards shall be clearly noted.

   6. Tabulations of system real and reactive power losses with areas of concern clearly noted.

   7. Conclusions and recommendations.

* Optional
6. POWER SYSTEM STUDIES

6.5 Stability Studies

1. Scope of Study

Determine the ability of the electrical system’s synchronous machines to remain in step with one another following a disturbance. Provide an analysis of disturbances for all possible operating scenarios which will be or have been influenced by the proposed or completed additions or changes to the subject system.

2. Procedure

The stability study shall be performed in accordance with the recommended practices and procedures set forth in ANSI/IEEE 399.

3. Study Report

Results of the stability study shall be summarized in a final report containing the following items:

1. Basis, description, purpose, and scope of the study.

2. Tabulations of the data used to model the system components and a corresponding one-line diagram.

3. Descriptions of the scenarios evaluated and tabulations or graphs showing the calculation results.


* Optional
6. POWER SYSTEM STUDIES

6.6 Harmonic-Analysis Studies

1. Scope of Study

Determine the impact of nonlinear loads and their associated harmonic contributions on the voltage and currents throughout the electrical system. Provide an analysis of all possible operating scenarios which will be or have been influenced by the proposed or completed additions or changes to the subject system.

2. Procedure

The harmonic-analysis study shall be performed in accordance with the recommended practices and procedures set forth in ANSI/IEEE 399.

3. Study Report

Results of the harmonic-analysis study shall be summarized in a final report containing the following items:

1. Basis, description, purpose, and scope of the study.

2. Tabulations of the data used to model the system components and a corresponding one-line diagram.

3. Descriptions of the scenarios evaluated and the basis for each.

4. Tabulations of rms voltages, peak voltages, rms currents, and total capacitor bank loading versus associated equipment ratings. Equipment with insufficient ratings shall be clearly identified for each of the scenarios evaluated.

5. Tabulations of calculated voltage-distortion factors, current-distortion factors, and individual harmonics versus the limits specified by ANSI/IEEE 519. Calculated values exceeding the limits specified in the standard shall be clearly noted.

6. Plots of impedance versus frequency showing resonant frequencies to be avoided.

7. Tabulations of the system transformer capabilities based on the calculated nonsinusoidal load current and the procedures set forth in ANSI/IEEE C57.110. Overloaded transformers shall be clearly noted.

8. Conclusions and recommendations.

* Optional
7. INSPECTION AND TEST PROCEDURES

7.1 Switchgear and Switchboard Assemblies

A. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.
2. Inspect physical and mechanical condition.
3. Inspect anchorage, alignment, grounding, and required area clearances.
4. Verify the unit is clean and all shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.
5. Verify that fuse and circuit breaker sizes and types correspond to drawings and coordination study as well as to the circuit breaker’s address for microprocessor-communication packages.
6. Verify that current and voltage transformer ratios correspond to drawings.
7. Verify that wiring connections are tight and that wiring is secure to prevent damage during routine operation of moving parts.
8. 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 7.1.B.1.
   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 thermographic survey in accordance with Section 9.
9. Verify operation and sequencing of interlocking systems.
10. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
11. Inspect insulators for evidence of physical damage or contaminated surfaces.
12. Verify correct barrier and shutter installation and operation.
13. Exercise all active components.
15. Verify that filters are in place and vents are clear.
16. Perform visual and mechanical inspection of instrument transformers in accordance with Section 7.10.

* Optional
7. INSPECTION AND TEST PROCEDURES

7.1 Switchgear and Switchboard Assemblies (continued)

17. Perform visual and mechanical inspection of surge arresters in accordance with Section 7.19.

18. Inspect control power transformers.
   1. Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
   2. Verify that primary and secondary fuse or circuit breaker ratings match drawings.
   3. Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks.

B. Electrical Tests

1. Perform resistance measurements through bolted electrical connections with a low-resistance ohmmeter, if applicable, in accordance with Section 7.1.A.8.1.

2. Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground, for one minute in accordance with Table 100.1.

3. Perform a dielectric withstand voltage test on each bus section, each phase-to-ground with phases not under test grounded, in accordance with manufacturer’s published data. If manufacturer has no recommendation for this test, it shall be in accordance with Table 100.2. The test voltage shall be applied for one minute.

*4. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration shall be one minute. For units with solid-state components or control devices that can not tolerate the applied voltage, follow the manufacturer’s recommendation.

5. Perform electrical tests on instrument transformers in accordance with Section 7.10.

6. Perform ground-resistance tests in accordance with Section 7.13.

7. Test metering devices in accordance with Section 7.11.

8. Control Power Transformers
   1. Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground. Test voltages shall be in accordance with Table 100.1 unless otherwise specified by the manufacturer.
   2. Perform a turns-ratio test on all tap positions.
   3. Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source. Verify correct potential at all devices.

* Optional
7. INSPECTION AND TEST PROCEDURES

7.1 Switchgear and Switchboard Assemblies (continued)

4. Verify correct secondary voltage by energizing the primary winding with system voltage. Measure secondary voltage with the secondary wiring disconnected.

5. Verify correct function of control transfer relays located in the switchgear with multiple control power sources.

9. Voltage Transformers

1. Perform secondary wiring integrity test. Verify correct potential at all devices.

2. Verify secondary voltages by energizing the primary winding with system voltage.

10. Perform current-injection tests on the entire current circuit in each section of switchgear.

1. Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 ampere flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

*2. Perform current tests by primary injection with magnitudes such that a minimum of 1.0 ampere flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

11. Perform system function tests in accordance with ANSI/NETA ECS.

12. Verify operation of cubicle switchgear/switchboard space heaters.

13. Perform phasing checks on double-ended or dual-source switchgear to insure correct bus phasing from each source.

14. Perform electrical tests of surge arresters in accordance with Section 7.19.

* Optional
7. **INSPECTION AND TEST PROCEDURES**

7.1 **Switchgear and Switchboard Assemblies (continued)**

C. **Test Values – Visual and Mechanical**

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. (7.1.A.8.1)

2. Bolt-torque levels shall be in accordance with manufacturer’s published data. In the absence of manufacturer’s published data, use Table 100.12. (7.1.A.8.2)

3. Results of the thermographic survey shall be in accordance with Section 9. (7.1.A.8.3)

D. **Test Values – Electrical**

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2. Insulation-resistance values of bus insulation shall be in accordance with manufacturer’s published data. In the absence of manufacturer’s published data, use Table 100.1. Values of insulation resistance less than this table or manufacturer’s recommendations should be investigated. Dielectric withstand voltage tests shall not proceed until insulation-resistance levels are raised above minimum values.

3. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.

4. Minimum insulation-resistance values of control wiring shall not be less than two megohms.

5. Results of electrical tests on instrument transformers shall be in accordance with Section 7.10.

6. Results of ground-resistance tests shall be in accordance with Section 7.13.

7. Accuracy of metering devices shall be in accordance with Section 7.11.

* Optional
7. INSPECTION AND TEST PROCEDURES

7.1 Switchgear and Switchboard Assemblies (continued)

8. Control Power Transformers

1. Insulation-resistance values of control power transformers shall be in accordance with manufacturer’s published data. In the absence of manufacturer’s published data, use Table 100.1. Values of insulation resistance less than this table or manufacturer’s recommendations should be investigated.

2. Turns-ratio test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio.

3. Secondary wiring shall be in accordance with design drawings and specifications.

4. Secondary voltage shall be in accordance with design specifications.

5. Control transfer relays shall perform as designed.

9. Voltage transformers

1. Secondary wiring shall be in accordance with design drawings and specifications.

2. Secondary voltage shall be in accordance with design specifications

10. Current-injection tests shall prove current wiring is in accordance with design specifications.

11. Results of system function tests shall be in accordance with ANSI/NETA ECS.

12. Heaters shall be operational.

13. Phasing checks shall prove the switchgear or switchboard phasing is correct and in accordance with the system design.

14. Results of electrical tests on surge arresters shall be in accordance with Section 7.19.

* Optional