Maintenance Testing Specifications for Electrical Power Distribution Equipment and Systems

These specifications have been developed by the InterNational Electrical Testing Association for use by electrical power distribution system engineers.

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PREFACE

It is recognized by the Association that the needs of commercial, industrial, governmental, and other electrical power systems vary widely. Many criteria are used in determining what equipment is to be tested, at what intervals, and to what extent. Ambient conditions, availability of down time, and maintenance budgets are but a few of the considerations that go into the planning of a maintenance schedule. The owner must make many decisions each time maintenance is considered.

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

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

Section	Description
Section 1.0	General Scope
Section 2.0	Applicable References
Section 3.0	Qualifications of Testing Organization and Personnel
Section 4.0	Division of Responsibility
Section 5.0	General
Section 6.0	Power System Studies
Section 7.0	Inspection and Test Procedures
Section 8.0	System Function Test
Section 9.0	Thermographic Survey
Section 10.0	Electromagnetic Field Testing
Tables	Reference Tables
Appendices	Various Informational Documents

Section 7.0 Structure
Section 7.0 is the main body of the document with specific information on what to do relative to the inspection and maintenance of electrical power equipment and systems. It is not the intention of the document to list how to test specific pieces of equipment or systems.

Expected Test Results
Section 7.0 consists of sections specific to each particular type of equipment. Within those sections there are, typically, three main bodies of information:

1. Visual and Mechanical Inspection
2. Electrical Tests
3. Test Values

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 3.1 Test Values – Visual and Mechanical. For example, Section 7.1 Switchgear and Switchboard Assemblies, item 7.1.1.7.2 calls for verifying tightness of connections using a calibrated torque wrench method. Under the Test Values – Visual and Mechanical Section 7.1.3.1.2, the expected results for that particular task are listed within Section 3.1, with reference back to the original task description on item 7.1.1.7.2.

7. INSPECTION AND TEST PROCEDURES

7.1 Switchgear and Switchboard Assemblies

1. Visual and Mechanical Inspection

1. Inspect physical, electrical, and mechanical condition including evidence of moisture or corona
2. Inspect anchorage, alignment, grounding, and required area clearances.
3. Prior to cleaning the unit, perform as-found tests, if required.
4. Clean the unit.
5. Verify that fuse and/or 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. Inspect bolted electrical connections for high resistance using one of the following methods:
   1. Use of a low-resistance ohmmeter in accordance with Section 7.1.2.
   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.
8. Confirm correct operation and sequencing of electrical and mechanical interlock systems.
   1. Attempt closure on locked-open devices. Attempt to open locked-closed devices.
   2. Make key exchange with all devices included in the interlock scheme as applicable.
9. Use appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
10. Verify correct barrier and shutter installation and operation.
11. Exercise all active components.
12. Inspect mechanical indicating devices for correct operation.
13. Verify that filters are in place and/or vents are clear.
14. Perform visual and mechanical inspection of instrument transformers in accordance with Section 7.10.

7. INSPECTION AND TEST PROCEDURES

7.1 Switchgear and Switchboard Assemblies (cont.)

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

9. Verify operation of switchgear/switchboard heaters and their controller, if applicable.
10. Perform system function tests in accordance with Section 8.

3. Test Values

3.1 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. (7.1.1.7.1)
2. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12. (7.1.1.7.2)
3. Results of the thermographic survey shall be in accordance with Section 9. (7.1.1.7.3)

3.2 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 should 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. Overpotential tests should 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 overpotential test, the test specimen is considered to have passed the test
4. Minimum insulation-resistance values of control wiring should be comparable to previously obtained results but not less than two megohms.
5. Results of electrical tests on instrument transformers should be in accordance with Section 7.10
6. Results of ground resistance tests should be in accordance with Section 7.13.
7. Accuracy of meters should be in accordance with Section 7.11.

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 7.15.1.2.2 (item 2 within the Electrical Tests section) calls for performing an insulation-resistance test in accordance with IEEE Standard 43. Under the Test Values – Electrical section, the expected results for that particular task are listed in the Test Values section under item 2.

7. INSPECTION AND TEST PROCEDURES

7.15.1 Rotating Machinery, AC Induction Motors and Generators

1. Visual and Mechanical Inspection

1. Inspect physical and mechanical condition.
2. Inspect anchorage, alignment, and grounding.
3. Inspect air baffles, filter media, cooling fans, slip rings, brushes, and brush rigging.
4. Inspect bolted electrical connections for high resistance using one of the following methods:
   1. Use of low-resistance ohmmeter in accordance with Section 7.15.1.2.
   2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12.
   3. Perform thermographic survey in accordance with Section 9.
5. Perform special tests such as air-gap spacing and machine alignment, if applicable.
6. Verify the application of appropriate lubrication and lubrication systems.
7. Verify the absence of unusual mechanical or electrical noise or signs of overheating.
8. Verify that resistance temperature detector (RTD) circuits conform to drawings.

2. Electrical Tests – AC Induction

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable, in accordance with Section 7.15.1.1.
2. Perform insulation-resistance tests in accordance with ANSI/IEEE Standard 43.
   1. Machines larger than 200 horsepower (150 kilowatts): Test duration shall be for ten minutes. Calculate polarization index.
   2. Machines 200 horsepower (150 kilowatts) and less: Test duration shall be for one minute. Calculate the dielectric-absorption ratio.
3. Perform dc overpotential tests on machines rated at 2300 volts and greater in accordance with ANSI/IEEE Standard 95.
4. Perform phase-to-phase stator resistance test on machines 2300 volts and greater.

*5. Perform insulation power-factor or dissipation-factor tests.

7. INSPECTION AND TEST PROCEDURES

7.15.1 Rotating Machinery, AC Induction Motors and Generators (cont.)

3.2 Test Values – Electrical Tests

1. Compare bolted connection resistance values to values of similar connections. Investigate any values that deviate from similar bolted connections by more than 50 percent of the lowest value.
2. The dielectric absorption ratio or polarization shall be compared to previously obtained results and should not be less than 1.0. The recommended minimum insulation resistance ($IR_{1\,min}$) 40° C and read as follows:
   1. $IR_{1\,min}$ = kV + 1 for most windings made before 1970, all field windings, and others not described in 2.2 and 2.3.

      (kV is the rated machine terminal-to-terminal voltage, in rms kV)
   2. $IR_{1\,min}$ = 100 megohms for most dc armature and ac windings built after 1970 (form-wound coils).
   3. $IR_{1\,min}$ = 5 megohms for most machines and random-wound stator coils and form-wound coils rated below 1 kV.

      NOTE: Overpotential, high-potential, and surge comparison tests shall not be performed on machines having values lower than those indicated above.
3. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the overpotential test, the test specimen is considered to have passed the test.
4. Investigate phase-to-phase stator resistance values that deviate by more than 10 percent.
5. Power-factor or dissipation-factor values shall be compared with previous values of similar machines.
6. Tip-up values should indicate no significant increase in power factor.
7. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the overpotential test, the test specimen is considered to have passed the test.
8. Bearing insulation-resistance measurements should be within manufacturer's published tolerances. In the absence of manufacturer's published tolerances, the comparison shall be made to similar machines.
9. Test results of surge protection devices shall be in accordance with Section 7.19 and Section 7.20.

"Optional" Tests

It is the intent of this document to list a majority of the field tests available for assessing the suitability for continued service and reliability of the power distribution system. 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?
4. Does the outage time required for the particular test greatly increase the total outage time required for all maintenance?

Manufacturer's Instruction Manuals

It is important to follow the recommendations contained in the manufacturer's instruction manuals. Many of the details of a complete and effective maintenance testing procedure can only be obtained from this source.

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PREFACE (Cont.)

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.

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

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CONTENTS (cont.)

CONTENTS (cont.)

CONTENTS (cont.)

TABLES

APPENDICES

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1. GENERAL SCOPE

1.1 Maintenance Testing Specifications

1. These specifications cover the suggested field tests and inspections that are available to assess the suitability for continued service and reliability of electrical power distribution equipment and systems.

2. The purpose of these specifications is to assure that tested electrical equipment and systems are operational and within applicable standards and manufacturer's tolerances and that the equipment and systems are suitable for continued service.

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 problems associated with their use. It is the responsibility of the user to review all applicable regulatory limitations prior to the use of these specifications.