NETA
Electrical Commissioning Specifications

Scope / Testing Organization / Responsibility / General Safety & Equipment

Commissioning Process

Low-, Medium-, High-Voltage Requirements

by

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Nomenclature[1]

AFD	Adjustable Frequency Drive	-
ALF	Accuracy Limit Factor	-
ASD	Adjustable Speed Drive	-
ATS	Acceptance Testing Specifications	-
ANSI	American National Standards Institute	-
ASTM	American Society for Testing and Materials (International)	-
BOD	Basis of Design	-
DAC	Damped Alternating Current	-
DAR	Dielectric Absorption Ratio	-
ECS	Electrical Commissioning Specifications	-
ICRP	International Commission on Radiological Protection	-
IEC	International Electrotechnical Commission	-
IEEE	Institute of Electrical and Electronics Engineers	-
ISEA	International Safety Equipment Association	-
ISO	International Organization for Standardization	-
MTS	Maintenance Testing Specifications	-
NEC	National Electrical Code	-
NECA	National Electrical Contractors Association	-
NETA	InterNational Electrical Testing Association	-
NIST	National Institute of Standards and Technology	-
NFPA	National Fire Protection Association	-
NIOSH	National Institute for Occupational Safety and Health	-
OEM	Original Equipment Manufacturer	-
OPR	Owner's Project Requirements	-
OSHA	Occupational & Safety Health Administration	29CFR1910/1926
PI	Polarization Index	-
TDR	Time Domain Reflectometer	-
UL	Underwriters Laboratories, Inc.	-
UPS	Uninterruptible Power Supply	-
VLF	Very Low Frequency	-

[1] Not all the nomenclature, symbols, or subscripts may be used in this course—but they are related and may be found when reviewing the references listed for further information. Further, all the nomenclature, symbols, or subscripts will be found in of many electrical courses (on SunCam, PDH Academy, and also in many texts). For guidance on nomenclature, symbols, and electrical graphics: IEEE 280-2021. IEEE Standard Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering. New York: IEEE; and IEEE 315-1975. Graphic Symbols for Electrical and Electronics Diagrams. New York: IEEE, approved 1975, reaffirmed 1993.

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COURSE INTRODUCTION

The information is primarily from Ref [A] as published by NETA, the National Electrical Testing Association now known as the InterNational Electrical Testing Association. Supporting information is in from Ref [B].[2] A source for electrical information and phenomena in general is Ref [C]. Technical definitions are in Ref [D]. The standards for electrical diagram and symbols are in Ref [E] and Ref [F]. The "standard" for electrical analysis is in Ref [G]. Appendices are provided with useful information for the electrical engineer.

HISTORY AND CODE OVERVIEW

NETA was founded in 1972 to establish uniform requirements for testing procedures for electrical equipment and associated apparatus. NETA is an accredited standards developer by the American National Standards Institute (ANSI). NETA standards differ from others in that in matters of testing, the relevant test and requirements derive from other standards: IEEE, IEC, NECA, NEMA, and UL. The focus initially is on acceptance testing; that is, ensuring the equipment are ready to be energized and will perform satisfactorily. *While acceptance testing provides baseline results for maintenance and equipment trending, commissioning verifies the electrical equipment and system meets the Owner's Project Requirements and Basis of Design*. The Electrical Commissioning Specifications (ECS) goes through a four year review process.[3]

The Code consists of ten different and separate sections as follows.

- Section 1: General Scope
- Section 2: Applicable References
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- Section 3: Qualification of Testing Organization and Personnel
- Section 4: Division of Responsibility
-
- Section 5: General[4]
-
- Section 6: Commissioning Process
- **Section 7: Inspection and Commissioning Procedures**
- Section 8: Source Specific Systems Commissioning
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- Section 9: Thermographic Survey

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[2] This is a Handbook for NFPA 70 that contains the Code proper. Although not required, I highly recommend using NFPA's "Handbooks" as the contain a wealth of interpretation and examples that will save and Engineer a great deal of research time.

[3] While the standard will update periodically, the information herein is useful as general guidance and for understanding. Anytime a specific piece of equipment is to be tested, one should consult the latest standard.

[4] Safety / Precautions / Test Equipment / Test Reports

- Section 10: Transfer to Owner/Operator
-
- Appendices: Informational Documents

The breaks shown in the bullet list are to resolve the ECS into relevant areas. The Scope and References are just that. Sections 3 and 4 generally applies to the testing organization. Section 5 contains safety precautions, use of proper testing equipment, and the requirements for documentation. Section 6 covers the overall process.

Section 7 is the core of the specifications, listing the required steps and procedures at a given voltage class or source specific system. Section 7 is divided into three sub-sections: 7.1 Low-; 7.2 Medium-; and 7.3 High- and Extra-High Voltage Systems. These in turn are divided into three sub-sections.

A. Pre-Energization
B. Energization
C. Post Energization

Section 8 covers source specific systems. Section 9 covers thermographic surveys. Section 10 covers the transfer process.

Manufacturer's Instruction Manuals should be considered the primary source of information for testing and maintenance—and commissioning, though in this course sometimes only the NETA values are specified. Following that would be the many applicable standards—which are incorporated into the NETA ECS. Should neither the manufacturer nor the standard contain guidance, NETA uses the particular industry consensus as a guide.. Those equipments most often encountered (meaning those not utility oriented or seldom used) are more fully covered.

The Appendices are for information only and are not mandatory for compliance with the ECS. They do provide usable forms enabling documentation of the requirements.

1. GENERAL SCOPE

This specification describes the process of documenting and placing into service newly-installed or retrofitted equipment or systems. The ECS should be used in conjunction with the ATS. The purpose is to ensure the equipment is safe, reliable, operational, and in conformance with manufacturers' tolerances, and installed per design specifications.

2. APPLICABLE REFERENCES

The list provided is extensive. Of note, one should also review state and local codes and ordinances.

3. QUALIFICATIONS OF TESTING ORGANIZATION AND PERSONNEL

The testing organization should be a third party entity that uses qualified testing technicians. The technicians are certified by ANSI/NETA ETT, *Standard for Certification of Electrical Testing Technicians*. Crew leaders should be Level 3 or higher.

4. DIVISION OF RESPONSIBILITY

This section covers the Owner's and the Testing Organization's responsibilities.

5. GENERAL

5.1 Safety and Precautions

All parties must be aware of industry-standard safety procedures. Guidance may be found in the Code of Federal Regulations (CFR) at OSHA 29CFR1910 and 29CFR1926.[5] Another useful reference is NFPA 70E, *Standard for Electrical Safety in the Workplace*.

A Safety Lead is identified prior to the commencement of work. A job hazard analysis (JHA) safety briefing precedes all work.

5.2 Suitability of Test Equipment

All test equipment shall be in good mechanical and electrical condition. It shall be accurate enough for the proposed testing.

5.3 Test Equipment Calibration

Test equipment shall be in calibration and the accuracy of such tests shall be directly traceable to the National Institute of Standards and Technology (NIST). All test equipment shall be calibrated within 12 months of the date of the test.

5.4 Documentation

[5] The CFR is normally given by Title—CFR—Part.Subpart. The Title [1, 2, 3…50] itself may divided into Chapters [I, II, III, IV…]. Subchapters [A, B, C….] though the chapters and subchapters are normally not shown in the shortened abbreviation since the Title and Part will be adequate for locating the information.

This section list all the information required for commissioning: Report; Drawing Packages; Operation & Maintenance Manuals (O&M).

6. COMMISSIONING PROCESS

6.1 Commissioning Intent

Specifies a systematic process and use of the Owner's Project Requirements (OPR) and Basis of Design (BOD).

6.2 Owner's Project Requirements

The OPR is a written document specifying the functional requirements of the project. It is written using ASHRAE Guideline 0 (American Society of Heating, Refrigeration, and Air-Conditioning Engineers).

6.3 Basis of Design

The BOD records the concepts, calculations, decisions, and product selections used to meet the OPR. It also is written using ASHRAE Guideline 0.

6.4 Commissioning Plan

This outlines the organization, schedule, resources, and documentation requirements.

7 GENERAL INSPECTION AND TEST PROCEDURES

7.1 Low-Voltage Systems (≤1 kV)

A. Pre-Energization

Tasks will be shown/described in abbreviated language. For full details refer to the ECS. **The term "verification" refers to a visual inspection confirmation; or items are in accordance with industry standards or codes; or operation; and all is in accordance plant documentation: drawings, studies, settings, et cetera.** The pre-energization phase is a detailed list which will be complex to accurately complete.

Tasks

1. Review OPR and BOD.
2. Equipment Technical Manuals and Operating Instructions shall be readily available.
3. Verify all equipment tested per NETA and the OPR.

4. Review acceptance test data.
5. Verify Nameplate Data documented and per latest drawings.
6. Verify pertinent information for completeness.
7. Visually inspect the equipment.
8. Verify equipment labels are correct and in accordance with all documents
9. Verify safety labeling in accordance with industry standards and codes.
10. Verify grounding and bonding.
11. Verify equipment can be isolated safely. Confirm isolation points can be visually confirmed.
12. Confirm equipment clearances.
13. Confirm working space.
14. Verify operation of interlocks including duplicate key destruction or retention by authorized personnel.
15. Verify operation of limit switches.
16. Verify the SCADA interfaces, control and interconnection wiring including *shipping splits*.[6]
17. Verify current transformers circuits are complete, have a single point ground, and do not have an open circuit. Shorting devices should be in proper position.
18. Verify transformer connections.
19. Verify protective settings and logic match documentation…and firmware up to date.
20. Verify arc-flash labels.
21. Verify arc energy reduction systems operation.[7]
22. Verify field marking of available fault current at service entrance.
23. Verify intelligent electronic devices operation.
24. Verify intelligent electronic devices display the correct date and time.
25. Verify communication points to end devices.
26. Verify neutral grounding per design.
27. Verify zone-selective interlocking.
28. Verify accuracy of panelboard schedules.
29. Verify start-up procedures for prime, emergency, and standby power systems.
30. Verify transfer schemes.
31. Verify lighting controls.
32. Verify emergency shutdown systems.
33. Verify sensors tested per manufacturer's data.
34. Verify fluid analysis complete and satisfactory.
35. Verify transformer insulation fluid levels and gas pressure.

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[6] Shipping splits are those items broken down and shipped separately.

[7] An arc energy reduction system reduces the intensity of an arc flash event by rapidly clearing electrical faults, typically required by National Fire Protection Association (NEC) code 240.87 for circuit breakers 1200A or higher. Common methods include maintenance switches, zone-selective interlocking, and active arc-quenching devices, which can decrease incident energy by up to 90%.

36. Verify transformer fluid alarm levels.
37. Verify valves on electrical equipment in the correct position.
38. Verify transformer taps in correct position.
39. Verify monitoring equipment operation.
40. Verify battery pre-start-up procedures complete and alarms functional (ventilation & gas).
41. Confirm initializing charge on battery systems complete.
42. Verify faults, alarms, and meters are cleared.
43. Compile as-left settings file.
44. Submit test data, as-build drawings, and relay files to Owner.
45. Develop a written energization plan.

B. Energization

Tasks

1. Restrict access.
2. Verify emergency accesses secured to prevent entrance from outside. (But allow for egress.)
3. Remove temporary grounding.
4. All switches, circuit breakers, and transfer switches in correct position.
5. Verify test switches in position per energization plan.
6. Follow Energization Plan.
7. Verify correct voltage & current to monitoring devices.
8. Verify phase angle & sequence.
9. Equipment phasing correct.
10. Verify Load Test per OPR.
11. Verify motor rotation.
12. UPS in correct mode and free of alarms.
13. Verify no alarms or fault conditions exist.
14. Verify prime, emergency, and standby power systems are free of alarms and in specified mode.

C. Post Energization

Tasks

1. Obtain post-energization fluid and gas analysis.
2. Monitoring and protective devices have established baseline parameters.
3. Perform Thermographic Survey per Section 9.
4. Warranty documentation with energization date transmitted to owner and manufacturer.
5. Verify loading per design criteria.
6. Verify balanced loading and voltage on panelboards.

7. Verify power quality survey per the OPR.
8. Confirm all equipment functions per OPR and BOD.
9. Develop Commissioning Report per Section 5.4.
10. GFCI operation verified.

7.2 Medium-Voltage Systems (>1 kV and <100 kV)

The tasks for this equipment mirrors that from the low-voltage system (though the numbering sequence varies a bit). Therefore, only those items specific to medium-voltage systems are listed. The number used is from the medium voltage requirements.

A. Pre-Energization

Tasks

11. Verify medium-voltage components have adequate means for applying temporary protective grounding equipment.
27. Verify correct operation of communication assisted protection schemes.[8]
34. Perform primary injection (though-fault) testing per the OPR.
37. Verify spill containment and signage is present around all liquid filled transformers and similar devices.

B. Energization

Tasks

The tasks in the medium-voltage section mirror those in the low-voltage section.

C. Post-Energization

Tasks

3. Verify any required regulatory compliance reports per the OPR.[9]
5. Verify the partial discharge survey per Section 9.

7.3 High-Voltage and Extra-High Voltage Systems (≥100 kV and <1,000 kV)

[8] In low-voltage systems this is stated as, “Verify communication points to end devices”.
[9] In the low-voltage systems this is stated as, “Verify power quality survey per the OPR”.

The tasks for this equipment mirrors that from the low-voltage system (though the numbering sequence varies a bit). Therefore, only those items specific to high-voltage systems are listed. The number used is from the high-voltage requirements.

A. Pre-Energization

Tasks

11. Verify medium-voltage components have adequate means for applying temporary protective grounding equipment.

B. Energization

Tasks

2. Verify medium-voltage components have adequate means for applying temporary protective grounding equipment.
11. Verify transformer load tap changer and automatic voltage regulator operation.[10]

C. Post-Energization

5. Verify the partial discharge survey per Section 9.

8 SOURCE SPECIFIC SYSTEMS

8.1 Solar Photovoltaic (PV) Commissioning Procedures

One must still complete Section 7 requirements for the applicable classes (7.1, 7.2, 7.3). Additional requirements pertaining to PV systems specifically resides in this section. Of note, many match the earlier requirements. Only a few items differ, for example, verifying polarity tests on cable and PV string container boxes and blocking diode tests. See the ECS for specific should this is an assigned tasks.

8.2 Uninterruptible Power Supply (UPS) Commissioning Procedures

One must still complete Section 7 requirements for the applicable classes (7.1, 7.2, 7.3). Additional requirements pertaining to UPS systems specifically resides in this section. Of note, many match the earlier requirements. Only a few items differ, for example, confirming points for locking and tagging a UPS. See the ECS for specific should this is an assigned tasks.

[10] The low voltage requirements does not mention voltage regulator operation.

8.3 Automatic Transfer Switch (ATS) Commissioning Procedures

Same basic philosophy as earlier Source Specific Systems. Details in ECS.

9 THERMOGRAPHIC SURVEY

9.1 Visual and Mechanical Inspection

Perform a follow-up thermographic survey within 12 months of final testing. [The test has an * before it indicating that it is optional.]

9.2 Report

Numerous items listed. Of import, one should record the temperature difference between the area of concern and a reference area [left column below]. Specify any recommended actions—see ATS Table 100.18 shown below.

Temperature Difference (ΔT) Based on Comparisons Between Similar Components Under Similar Loading	Temperature Difference (ΔT) Based Upon Comparisons Between Component and Ambient Air Temperatures	Recommended Action
1° C - 3° C	1° C - 10° C	Possible deficiency; warrants investigation
4° C - 15° C	11° - 20° C	Indicates probable deficiency; repair as time permits
- - - - -	21° - 40° C	Monitor until corrective measures can be accomplished
> 15° C	> 40° C	Major discrepancy; repair immediately

Note the corrective actions based on a comparison with the ambient temperature. For example, if the ΔT is >40°C an immediate repair is warranted.

9.3 Test Parameters

The thermograph must be cable of detecting a 1°C difference at 30°C. Loading must be a minimum of 40%.

10 TRANSFER TO OWNER/OPERATOR

A formal and documented turnover of the project shall be performed. Inform the operator receiving the turnover shall be informed of any deficiencies. Remove all commissioning locks and tags.

REFERENCES

A. ANSI/NETA ECS. Standard for Acceptance Testing Specifications for Electrical Power Equipment & Systems. Portage, MI: NETA, 2024.

B. Earley, Mark, ed. *NFPA 70, National Electrical Code Handbook*. Quincy, Massachusetts: NFPA, 2020.

NOTE

Electrical refers to something related to electricity while “electric” refers to a device or machine that runs on electricity. Nevertheless, the NEC is sometimes referred to as the National Electric Code.

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G. Grainger, John J., and William Stevenson, Jr. *Power System Analysis*. New York, McGraw Hill, 1994.