DEPARTMENT OF THE ARMY
Corps of Engineers, Northwestern Division
P.O. Box 2870
Portland, Oregon 97208

CENWD-CM-OC
Regulation
No. 1130-2-7 30 April 2001

Project Operations
HYDROPOWER TEST AND EVALUATION FUNCTION

History. This issue publishes a revision of the former NPDR 1130-2-7 to make it an NWDR publication as a result of the restructuring of Northwestern Division.

Summary. This regulation has been revised to include all Northwestern Division (NWD) districts and project offices completing diagnostic testing of power plants and project equipment. The management information requirement reports control symbols (RCS) noted in paragraph 8 have been revised. The RCS for the quarterly and annual submission reports have been changed from NPDOP-126a, b and c to NWDCM-126a, b and c to agree with the Northwestern Division regional restructuring. The revision reduces the number of years hydropower test and evaluation documentation will be managed at the division and district. Documentation as a result of this regulation will be maintained permanently with the life of the equipment at the project office.

1. PURPOSE.

a. This regulation describes the test program for equipment at multiple purpose projects within the Northwestern Division (NWD).

b. The tests to be performed, and the frequency of performance are described in this regulation.

2. APPLICABILITY. This regulation is applicable to all elements of the Northwestern Division with responsibility for multiple purpose projects.

3. RELATED REFERENCES. EM 385-1-1, (Safety and Health Requirements Manual).

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*This regulation supersedes NPDR 1130-2-7, 1 May 1996 and MRD-R 1130-2-5, 1 August 1971.

4. RESPONSIBILITIES. The responsibilities of the Division, District, and Project Offices will be as follows:

a. Division Office.

(1) Establish policy and procedures for tests to be performed at NWD projects.

(2) Establish the basic minimum test program.

(3) Recommend minimum staffing levels for the test program at NWD Districts.

(4) Review the following: Districts test program for the upcoming year, Districts Quarterly Report of tests performed, the Districts Year-end Synopsis Report of test program, and assist in the analysis of any abnormal test results or special tests performed.

(5) Review and approve requested deviations from the basic minimum test program and procedures.

(6) Administer and oversee Division-wide contracts with entities that provide test equipment and services, or test services, to the Corps of Engineers for application within NWD boundaries.

(7) Provide the contact point and coordinator for the NWD test program amongst the Districts, and for entities outside NWD boundaries.

(8) Recommend new test procedures, coordinate Research & Development (R&D) projects within the Division and R&D projects with outside agencies.

(9) Monitor District compliance and application of the minimum testing criteria as set out in this NWDR.

b. District Offices.

(1) Provide staffing for the Hydropower Test and Evaluation (HT&E) Program adequate to perform the required tests and analyses in conformance with the test program. The District staffing criteria can be met by assigning to the Project staff the HT&E program duties.

(2) Provide training for the HT&E staff that is adequate to maintain their proficiency to perform the required testing program.

(3) Provide support for the HT&E staff that is adequate to allow them to perform the HT&E function, including clerical support and report preparation.

(4) Ensure that the District Operation & Maintenance (O&M) program makes constructive use of the results of the test program.

(5) Ensure that Projects are furnished with, review, and retain results of tests performed by the HT&E staff.

(6) Provide supervision of Projects that will ensure test results are considered and acted on.

(7) Coordinate HT&E staff test schedule with the Project Offices.

(8) Provide to the Division HT&E office and the project offices an annual test program schedule, quarterly status report, an annual synopsis of test program activities and reports on all special tests performed. The District will provide documentation, with the annual synopsis report, of the Projects constructive use of the results of the test program (as required in 5 above).

c. Project Offices.

(1) Assist HT&E staff in establishing and maintaining the overall test schedule within the District.

(2) Coordination with other Project Offices in the scheduling of tests to provide the most effective test schedule.

(3) Provide on-site assistance and support as necessary to ensure safe operation and prosecution of the test activities.

(4) Review and retain official test results and records with the equipment histories.

(5) Utilize test results in planning maintenance and repair work, and in evaluating maintenance work and practices.

(6) Request HT&E staff assistance for unusual test or operating conditions, repair, and analysis work on equipment critical to operation of the bulk regional power distribution system.

5. GENERAL. Diagnostic Testing of Power Plant and Project Equipment. The mission of the NWD HT&E Program is to ensure, by test and analysis: that equipment is suitable for initial and continuing service; to minimize risk of damage to equipment and maximize power system reliability; evaluate effectiveness of repairs, adjustments and modifications; and provide technical support for the condition indicators utilized in the justification for equipment replacement.

6. ORGANIZATION.

a. Division. The Project Operations Branch of the Operations Division will perform the HT&E function. A separate position will be maintained within the Project Operations Branch for this function.

b. District Offices. The HT&E function is assigned to the Operations Division. The District will dedicate adequate resources to the HT&E function without the unnecessary burden of duties extraneous to the HT&E function to successfully prosecute the HT&E program. Each District will coordinate with the Division Project Operations Branch the staffing proposed for the HT&E function.

c. Project Offices. The organization of the Project Offices will not be affected by the HT&E function.

7. TEST PROGRAM. As a minimum, each project will have as appropriate a test program as shown in the Appendix A to this regulation.

8. POWER GENERATING EQUIPMENT TEST REPORTS. The following reports will be made in compliance with this regulation.

a. The District HT&E personnel will prepare and submit, in writing, an exit report to the Project Manager or designee within seven (7) calendar days after completion of testing. The exit report will discuss the results of the testing performed and provide recommendations on maintenance practices and further evaluation as deemed necessary.

b. The District will prepare a written HT&E Schedule, (RCS NWDCM-126a or a highlighted copy of the Districts approved annual maintenance outage schedule) for the upcoming calendar year and submit the schedule to the Division and the Projects by 1 February. The schedule will be coordinated with the Long-Term Outage Planning schedule. The schedule will be structured so that the testing frequencies, as laid out in this regulation, can be achieved.

c. The District will prepare a HT&E Quarterly Report (RCS NWDCM-126b or compilations/summations of the exit reports, test evaluations and summaries for the previous quarter). The quarterly reports are due 1 April, 1 July, 1 October. The reporting is not intended to increase the workload of the test staff and shall contain the following:

(1) Copies of the previous quarters exit reports given to the Project Manager at the conclusion of testing.

(2) A synopsis of the outstanding (i.e. reporting by exception) tests performed and a listing of the tests not performed for reasons such as; slippage, conflicts in scheduling, emergency performance of additional unscheduled testing, environmental constraints/conflicts etc.

(3) A synopsis of any suggestions that arose during the testing (such as recommending increased maintenance or monitoring of equipment) and the subsequent actions taken by the Project Manager on the recommendation.

d. The District will prepare a fourth quarter report in conjunction with the year-end report-HT&E Year-End Report (RCS NWDCM-126c or a compilation/summation of the exit reports, test evaluations and summaries for the previous quarter). The fourth quarter report will include a synopsis of the previous years test program. The synopsis will include a listing of tests and the evaluation/recommendations provided to the Projects with a description of the follow through performed by the Projects.

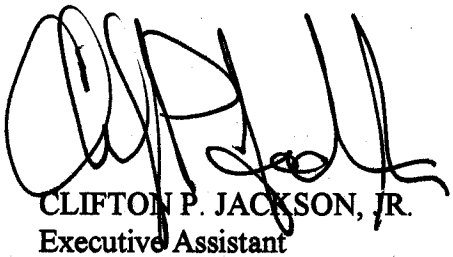
e. The following recordkeeping procedures will be in place for the Division, District, and Project Office.

(1) The Division will maintain submitted quarterly and yearly documentation in Civil Works Project Operation and Maintenance Supervisory Files (1130-2-320b). The documentation duplicates records maintained by the subordinate offices and will be disposed of when no longer required for current operations.

(2) The District office tasked with submission of required documentation to the Division will be responsible for maintaining current records in a chronological arrangement by month and year. The submission of required reports and additional documentation relating to the HT&E Program will maintained for a five year period, cut off at the end of each year, held for the specified period, and then destroyed according to file number 1130-2-320a.

(3) The project office's historical record will consist of performed scheduled tests, coordination with other project offices, requested HT&E staff assistance, and test results utilized in planning maintenance and repair work. The record will also include evaluated maintenance work and practices--equipment history. The historical record will be destroyed on disposal of specific equipment according to file number 1130-2-303a.

FOR THE COMMANDER:



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DISTRIBUTION:
http://www.nwp.usace.army.mil/im/r/regs/nwdr.html
CENWD-CM
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CENWW-OD

APPENDIX A

NWD HYDROPOWER TEST AND EVALUATION PROGRAM

A.01. TRANSFORMER AND BUSHING TESTS. (2.4 kV and above: GSU, Station Service & Distribution)

A.01.01. Transformer Insulation Dielectric Loss.
Test by Doble Method
Test Frequency: Each three years.
Records Retention: Life of transformer.

A.01.02. Transformer Excitation Current Test.
Test Frequency: Each three years.
Records Retention: Life of transformer.

A.01.03. Insulating Oil Tests.
Test by Dissolved Gas Analysis and Oil Screen method the following:
(1) Power Factor (ASTM D-924)
(2) Dielectric Breakdown (ASTM D-877 & D-1816)
(3) Moisture Content (ASTM D-1533)
(4) Interfacial Tension (ASTM D-971)
(5) Acidity/Neutralization Number (ASTM D-974)
(6) Color (ASTM D-1500)
Test Frequency: Yearly, if no problems appear, more frequently if needed.
Records Retention: Life of transformer

A.02. CIRCUIT BREAKERS AND BUSHINGS. (2.4kV and above: GSU, Station Service & Distribution)

A.02.01 Insulation Condition.
Test by Doble method.
Test Frequency: Each three years.
Records Retention: Life of circuit breaker.

A.02.02. Circuit Breaker Motion. (This test should be applied in accordance with industry standards).
Test using motion analyzer.
Test Frequency: Annually.
Records Retention: Life of circuit breaker.

A.02.03. Insulating Oil Used in Oil Circuit Breakers.

Test by using the following:

(1) Color (ASTM D-1500)
(2) Dielectric Breakdown (ASTM D-877 & D-1816)
(3) Moisture Content (ASTM D-1533)
(4) Interfacial Content (ASTM D-971)

Test Frequency: Annually, and after major fault interrupting.

Records Retention: Life of the insulating oil.

A.03. GENERATORS.

A.03.01 Physical Inspection.

See Appendix B for guideline of items needing special consideration during inspection.

Inspection Frequency:

a) One year after new winding.
b) During major overhaul.
c) When evidence of loose wedges are found.
d) Annual spot check (may include selective removal of air shrouds).

Records Retention: Life of the generator.

A.03.02. Ozone Tests.

Test Frequency: Annually, monthly if ozone odor can be detected.

Records Retention: Life of the winding.

A.03.03. Winding Megger Test.

A.03.03.01

Test Method: 3 phases tied together.

Test Frequency: Twice per overhaul schedule.

Records Retention: Life of the winding.

A.03.03.02

Test method: 1 phase energized, the other 2 phases tied together and grounded.

Test Frequency: During major overhauls.

Record Retention: Life of the winding.

A.03.05. High Potential (Hipot) Test.
Test Method: AC preferred, DC is acceptable.
Test Frequency: Prior to remedial work, and after remedial work.
Records Retention: Life of the winding.

A.03.06. Polarization Index Test.
Test Frequency: Prior to Hipot, and with the winding megger test.

A.03.07. Partial Discharge Analysis Test. (Not recommended for use on Asphaltic Windings)
Test Frequency: Annually, or more often if winding shows excessive activity.
Records Retention: Life of the winding.

A.040. PROTECTIVE RELAYS.

A.04.01. Test, Inspection, Verification of Settings.
Special emphasis on the following: Out-of-Step function, Loss-of-Field function.
Testing Frequency: Test and Inspection: once every two years including checking of the wires to the PTs and CTs (digital relays with build self diagnostic software only need to be tested and inspected during every major overhaul). Verification of system coordination and setting: Each five years.
Records Retention: Life of the equipment.

A.05. EXCITATION SYSTEM. REFER TO APPENDIX C.

A.06. GOVERNOR SYSTEM.

A.06.01 Step Response Test. REFER TO APPENDIX C.

A.06.02. 3-D Cam and Governor Function Testing.
Test Frequency: Each major overhaul.
Records Retention: Life of the equipment.

APPENDIX B

HYDROGENERATOR PHYSICAL INSPECTION GUIDELINES
Visual Inspection of the Endwinding

Grease or oil deposits: Look for dark films of material on the surface of the stator bars in the endwinding area. The films are most often oil or moisture, which has combined with dirt, coal, dust, break dust, etc. These films are sometimes slightly conductive. The films are usually over the entire endwinding, i.e., not localized.

Insulation bulging: Look for bulging or swelling (increase in dimensions) of the groundwall insulation on bars/coils in the endwinding just outside of the slot. Swollen insulation can be confirmed by squeezing the insulation to determine if it compresses.

Girth Cracking (Thermoplastic Insulation Systems only): Look for the following; Signs of stretching and separation with eventual groundwall failure at or near the end of the slot. Puffiness of the insulation, dusting of the insulation or grease (if oil is present) at cooling vents and just outside the slot. High partial discharge activity.

Deep cracks - slot ends: Look for significant tearing or parting of the groundwall insulation in the endwinding, just outside of the slot, or at the first bend of the coil/bar from the slot.

Deep cracks - at bracing: Look for significant tearing or parting of the groundwall insulation in the endwinding at points where the bars/coils are braced to the endwinding support or lashed to other coils/bars.

Loose blocking: Determine if you can move the pads between adjacent coils/bars in the endwinding with finger pressure, or light tapping with a hammer. Look for loose lashings of stator bars/coils to one another or to the endwinding support. Loose blocking is also often accompanied by dusting (i.e., small particles created by abrasion) at the blocking points. If oil is present, the dusting may appear as grease at the blocking points.

Hairline cracks - blocking: Look for shallow cracks in the surface or paint in the endwinding, especially at points where a coil/bar is braced to other coils/bars or to the endwinding support system. Insulation discoloration. Look for darkening of the insulation surface (underneath any surface films which may be present and which have not stained the surface). If necessary, lightly scratch away the surface with a pen knife to ensure that the dark spots are not due to staining. DO NOT scratch away surface material just outside of the slot, in the stress relief coating area. Discoloration is normally present over a significant portion of the endwinding.

Insulation burning: Look for very dark insulation which is easily damaged (i.e., crumbles or flakes away) with pressure from a finger or a small knife.

Carbon tracking: Look for thin channels of carbonized (black) powder at bracing points of phase end coils/bars to coil/bar in a different phase. Carbon tracks can also appear on phase end bars/coils over the stress relief coatings to the stator core.

White/gray powder: Look for light-colored powder which is the residual of partial discharging on coils/bars that operate at high voltage (i.e., connected at or near to the phase terminals). The white powder appears at blocking points between stator bars/coils which are operating at high voltage in different phases. When chemically analyzed, this powder is composed of salts, unlike the powder caused by abrasion. If the discharges are very intense, there may be pitting (dark, small shallow holes) of the surface insulation of bars/coils, immediately adjacent to the blocking.

White/gray bands: Look for light-colored powder which is the residual of partial discharging on coils/bars that operate at high voltage (i.e., connected at or near to the phase terminals). The powder occurs as a circumferential band around the coil/bar just outside of the slot, at the interface between the grading (stress relief) coating and the slot semiconductive coating.

Scarf Joint Failure: Look for separation of the joint between the wrapper and taped portions of the groundwall and evidence of surface electrical tracking. In some stator windings, the slot portion of the groundwall insulation uses a slot wrapper, while tapes are used in the endwinding region. The interface between the two regions just outside of the stator slot, called a "scarf" joint, may open up under thermal cycling stresses. The higher the operating temperature, the more likely the failure, since bonding strength decreases with temperature. Eventually, a ground fault may occur as a result of electrical tracking along the crack.

Melted copper conductors: Severe damage to the groundwall insulation in the endwinding region, including a large hole through which the copper conductors are visible. Black debris and burning of the insulation around the hole. Melted copper conductors at the bottom of the hole. The hole is often (but not always) in phase-end coils, at the first bend in the coil coming away from the slot.

Visual Inspection of the Slot

Insulation discoloration: For 4 kV and lower windings (higher voltage machines normally have a black semiconductive coating which prevents observing if the insulation underneath is

discolored). If possible, first remove some stator wedges, otherwise use a boroscope to look down the side of core air vents to see the side of the coils. Look for darkening of the insulation surface of stator coils. Discoloration is normally present over a significant portion of the winding, not just the phase end coils.

Insulation burning: Look for very dark insulation which is easily damaged (i.e., crumbles or flakes away) with pressure from a finger or a small knife. It is best to first remove a few wedges, otherwise probe down the core vents at the side of a stator coil/bar. The bottom of wedges, depth packing and sidepacking may also be discolored.

Groundwall abrasion - deep: First remove a few wedges and some of the sidepacking material. Look for thinning of the groundwall insulation where the groundwall is in contact with the stator core. The imprint of the core laminations can be seen on the insulation surface. Significant abrasion has occurred if 1 mm or more of insulation has been worn away. Little or no insulation is eroded at the vents in the stator core, giving a coil/bar the appearance of a ladder, where the intact groundwall (at the vents) are the ladder "rungs".

Insulation bulging: Look for bulging or swelling (increase in dimensions) of the groundwall insulation on bars/coils into the core vents. Swollen insulation can be confirmed by squeezing the insulation to determine if it compresses.

Semicon abrasion: Remove some wedges and sidepacking. Look for signs of the coil/bar rubbing against the stator core, with the imprint of the core laminations visible on the semiconductive coating surface. The rubbing and abrasion are usually worse at least at one of the corners of the stator coil/bar. There are no signs of rubbing at the core air vents.

Grease or oil deposits: First remove some wedges and sidepacking. Look for dark films of material on the surface of the stator bars. The films are most often oil or moisture which has combined with dirt, coal dust, break dust, etc. The films are usually over the entire winding, i.e., not localized.

White/gray powder: Valid for stators rated about 6.6 kV and above, i.e., where semiconductive coatings are present. First remove some wedges and sidepacking from slots containing phase-end coils/bars. Look for areas of the semiconductive coating which are light in color (white, gray, yellow), rather than black. The light colored areas may be somewhat circular in shape.

Pitting: Preferably remove some wedges and sidepacking from slots containing phase end coils/bars, otherwise carefully examine the side of bars/coils in the core vents. Look for small, shallow, dark holes in the groundwall surface, especially at the edge of the laminations at vents. Pitting will not occur in coils/bars in the winding which are operating at low voltage.

Melted copper conductors: First remove the wedges and sidepacking in the suspect slot. Look for severe damage to the groundwall insulation, including a large hole through which the copper conductors are visible. Black debris and burning of the insulation around the hole. Melted copper conductors at the bottom of the hole. The hole is often (but not always) in phase-end coils.

Core Lamination Tightness Check

Evaluate the tightness of stator and rotor laminated cores by attempting to insert a standard winder's knife blade (maximum thickness 0.25 mm) between laminations at several locations around the bore of core and rotor core. If the blade penetrates more than about 6 mm, then the core is soft and should be tightened by packing. Prior to trying the knife insertion, ensure that the bore surface is not covered with varnish or other coatings. Care must be taken not to break off the end of the knife tip. It is good practice to round off the tip slightly and insert the knife blade first with a rocking action rather than stabbing in the tip. This is done by holding the knife handle in one hand and carefully applying a suitable force on the back of the knife blade with the palm of the other hand. Other types of knives can be used providing they have a fairly sharp point and are sufficiently robust to exert sufficient pressure to penetrate core surface coatings.

Side Clearance Check

The stator wedges must first be removed on one or two slots. (This test can thus only be done when the rotor has been removed during a suitable outage.) A feeler gauge is then forced between the core and the bar/coil side, at several locations along the slot. When side-packed, a thermoset stator bar/coil should not allow the insertion of a 0.05 mm (2 mil) feeler gauge except for short lengths not exceeding one package length [Lyles]. Both the top and bottom bars should be checked, if the bottom bar is accessible (i.e., the top bar is removed).

Rotor Inspection

Field Pole Alignment: Look for field poles that are not in the same plane as the majority of the field poles. This effects the magnetic balance of the rotor-to-stator relationship, undue stress will be placed on the thrust and guide bearings due to the magnetic centers of the field poles not operating in the same plane.

Field Pole Interconnecting Straps: Examine the multiple leaf connectors for cracking and flexural fatigue. This is particularly important if a field pole has been removed since initial assembly of the rotor.

Amortisseur Winding: Look for movement of the amortisseur winding in the field pole faces, movement typically leaves copper or fretting corrosion dusting.

Amortisseur Winding Shorting Bar: Examine the welds between the shorting bar and the amortisseur bars. Excessive heating during the welding process can cause hydrogen imbrittlement, this can lead to stress fatigue cracking in the base material at the weld joint. Lightly tapping can typically determine cracking by the change in sound between a good weld joint and a failed weld joint.

Amortisseur Winding Shorting Bar Interconnection: On closed amortisseur windings, the solid shorting bar to shorting bar connection needs to be examined for stress cracking. Tapping with a hammer may indicate cracking of the interconnection. The recommended repair to alleviate the hoop stresses is to replace the solid connection with a braided connector.

Field Leads: The leads from the slip rings to the field poles need to be examined for carbon tracking, dirt, dust and other semi-conducting contamination.

General Inspection

Air Baffles: Look for loose parts, bolts and nuts. Washers that are made of ferrous materials will work loose and rotate on the bolts, signs of this occurring are dusting around the washer. The rubber lip on the air baffles will cause corona damage if allowed to contact the endwindings, signs of this are carbon tracking and white powder on the rubber seal and at the point of contact with the end winding.

Coolers: Check for leaks, stress fatiguing of the cooling fins, corrosion and integrity of the insulation on the pipes. Insure that the thermal detectors for the CO2 system are placed in the position they are designed for, the sensors are typically not designed to be operated in both the vertical and horizontal position.

APPENDIX C

COMPLIANCE WITH OPERATING AUTHORITY CERTIFICATION CRITERIA

In addition to the previously listed tests, the Regional Operating Authority for each power plant will be required to certify the plant and it's generators for connection to the power grid. This certification will include operation, maintenance and testing criteria. It is expected that each facility will have an individualized set of certification criteria that must be met. Those criteria for testing will become a de facto part of this regulation (as it applies to each facility). The Regional Operating Authority test requirements and results will be incorporated into the quarterly and annual reports.