SECTION - XII

PERFORMANCE TESTING OF SMALL HYDRO POWER STATIONS TO BE CONDUCTED BY AUTHORISED AGENCY OF MNES IF DESIRED BY DEPARTMENT OF HYDRO POWER DEVELOPMENT

Scope

The overall scope of performance testing is listed below:

(a) Inspection of all parts, stems and station auxiliaries.
(b) Functional checks on simpler devices and systems.
(c) Error checks on measuring instruments.
(d) Secondary injection tests on protective relays.
(e) Operational tests on control systems.
(f) Measurement of the parameters critical for generation.
(g) Measurement of maximum power output of generating units.
(h) Verification of efficiency of generating units.
(i) Verification of efficiency variation curve of turbines.

Different Parameters to be tested in E & M works

1. GENERATOR

1.1 **Currents and Voltages**

The following quantities are measured on each generator at different loads to verify the working of the generators :

(a) Line currents
(b) Terminal voltages
(c) Power
(d) Power factor
(c) Excitation voltage / current

1.2 **Temperature Rise**

Any overheating in the generators would be revealed in the following temperature rise measurements:

(a) Temperature rise of stator
(b) Temperature rise of rotor
(c) Temperature rise of cooling medium

2. **TURBINE - GENERATOR UNIT**

2.1 **General Health**

Temperature rise, sound level and vibration levels are the good indicators

of the general health of any machine. To that end, the following measurements are carried out on each generating unit. subject to the accessibility of the relevant part for fixing sensor(s):

(a) Temperature rise of bearing oil

(b) Sound level

(c) Machine vibrations (measurement as per IS: 11726 and IS: 11727)

2.2 **Performance Measurement**

(a) Maximum Power Output

The maximum electrical power output actually available from the generating unit should match the value specified by the manufacturer. The test is conducted at rated head and discharge as far as possible.

(b) Unit Efficiency Test

The test aims at determining the absolute (actual) efficiency of the generating unit or the turbine under specified conditions according to IS/lEC:41. It involves measurement of absolute value of the discharge through the turbine, the net water head available at the turbine and the electrical power output of the machine, all under specified operating conditions and each **with high accuracy**. Efficiency can be determined alternatively from the water temperature rise due to the losses in the turbine using thermodynamic method in case water head is 500 m or more.

IS/IEC: 41 specifies the following methods of discharge measurement:

(a) Current-meter method
(b) Pitot-tube method
(c) Pressure-tune method
(d) Tracer method
(e) Weirs
(f) Differential pressure devices
(g) Volumetric gauging method
(h) Ultrasonic transit-tune flowmeter

The choice of the method of measurement may be affected, as per IS/IEC-41, by the following factors :

(a) Limitations imposed by the design of the plant

(b) Cost of special equipment and its installation

(c) Limitations imposed by plant operating conditions, for example draining of the system, constant load or discharge operation, etc.

While IS/IEC:41 makes the unit efficiency test mandatory, IEC:61116

(that addresses SHP installations) makes the test optional in the following cases :

(i) The machine size is small not justifying the high cost of performing this test.

(ii) The efficiency value is not of real use as the available water flow greatly exceeds the usuable flow.

(iii) It is technically difficult to carry out the test.

(c) Index Test

The test involves the measurement of relative (index) discharge as opposed to the absolute discharge measurement for the unit efficiency test. As per IS/IEC-41, the test aims at evaluating or verifying:

(i) the relative variation in the unit efficiency with the load or the gate / valve opening, or
(ii) relationship between runner blade angle and guide vane opening in the case of a double regulated machine, or

The relative discharge measurement required for the index test is made as per IS/IEC:41 by one of the following methods:

(i) Measurement of pressure difference between suitably located taps on the turbine spiral case (Winter-Kennedy method).
(ii) Measurement of pressure difference between suitably located taps in tubular turbines.
(iii) Measurement of pressure difference between suitably located taps on a bend or taper section of the penstock.
(iv) Single-path ultrasonic transit-time flowmeter.
(v) Measurement of needle stroke on pelton turbines.
(vi) Measurement by means of a single current meter.

3. MEASURING INSTRUMENTS AND INSTRUMENT TRANSFORMERS

3.1 Error Checks

All **electrical panel** meters (ammeters, voltmeters, kilowatt and power factor meters, energy meters, frequency meters and multi-function meters) are subjected to a limited error check. The readings of these meters at the respective operating points are compared against a portable reference meter to measure their errors at the most important point (s), that is the points around which they are usually required to measure. If a meter is found to have an error beyond its accuracy class, further testing would be desirable.

A similar check is carried out on **speed indicator.** Comparison may be made against a reference frequency meter (as also recommended in IEC L 60308) because of the high resolution and accuracy of reference frequency meters.

3.2 Functional Checks

In view of the non-critical nature of the parameters measured / recorded and difficulty in placing transducers, error measurement on the following instruments are normally not carried out. Instead, simple checks on their functioning and validity of their current readings suffice.

(a) Gate / valve / needle position indicators
(b) Temperature indicators
(c) Temperature scanners
(d) Recorders

3.3 Ratio Tests

The CT and VT ratios need not to be tested normally. However, these may be verified, if in doubt, either on-line by measuring the primary and secondary currents / voltages, or off-line by measuring the turns ratio using a digital turns ratio tester with reference to IS:2705 and IS:3156

4. PROTECTIVE RELAYS

4.1 Secondary Injection Tests

A portable secondary injection test set is used to test all the measuring relays (or relay functions of multi-function digital relays / management relays) as per IS:3231. Normally it is considered sufficient to carry out operating value and operating time tests (the latter for time delay relays and delay elements only) at the current (prevailing) relay setting. In case of the doubtful working of a relay, a more detailed secondary injection test is conducted.

4.2 Functional Checks

Functional checks are carried out as per IS L 3231 on the following parts :

(a) Tripping / master relays
(b) Auxiliary relays
(c) Fault annunciators

5. CONTROL PANELS AND SYSTEMS

5.1 Control Panels

Before testing control systems, an inspection and functional checks on various parts / accessories of the control panels and desks are carried out to identify the defective parts or accessories, if any.

5.2 Regulation / Control Systems

The following regulation and control systems are tested to verify their overall functioning :

(a) Flow regulation
(b) Level regulation
(c) Field regulation
(d) Manual synchronization
(e) Automatic synchronization
(f) Manual and automatic start / stop sequences
(g) Emergency stop sequence

6. GOVERNOR

The governor, being one of the most critical control systems in the power plant, is subjected to the following tests if the necessary test provisions are available and the data on parameters / characteristics are already available for verification:

(a) All functions of the governor
(b) Governor sensitivity test
(c) Governor stability test
(d) Load rejection or overspeed test
(e) Oil temperature test
(f) Pressure tank capacity test

The tests are conducted generally as per IEC-61116 and IEC-60308

7. EXCITATION CONTROL SYSTEM

The voltage regulator and excitation system are subjected to the following tests if necessary test provision are available and the specified values of the parameters are available for verification:

(a) All functions of AVR
(b) Excitation control stability test
(c) Excitation system ceiling voltage
(d) Excitation system response ratio
(e) Excitation system response time

The tests are carried out generally as per IEEE-421A.]

8. POWER TRANSFORMERS

8.1 Temperature Rise

Off all the major power equipment in a power station, power transformer is least troublesome. Unless a problem has been experienced with a transformer, its general condition is checked simply by measuring the temperature rise of the main and conservator tanks.

8.2 Ratio Test

If there is a reason to doubt the transformer ratio (possibly due to shorted turns), transformer ratio test can be carried out. A portable digital turns ratio tester can measure this ratio with a high accuracy. However, the test requires a shutdown and complete isolation of the power transformer from the system.

9. STATION AUXILIARIES

A through inspection of all the station auxiliaries is carried out to verify that these are functioning normally. They may include station AC supply, station DC supply, oil pumping units, cooling systems, vacuum pumps, air compressors, drainage system, dewatering system, earthing system(s), equipment handling crane, hoists etc.

RELEVANT STANDARDS

1. IS/IEC:41 (1991): “Field Acceptance Tests to Determine the Hydraulic Performance of Turbines, Storage Pumps and Pump Turbines”.

2. IEC:61116(1992):”Electromechanical Equipment Guide for Small Hydroelectric Installations”.

3. IEC:60308(1970): “International Code for Testing of Speed of Governing Systems for Hydraulic Turbines”.

4. IS:3231 (1986): “Specification of Electrical Relays for Power System Protection”.

5. IEEE:421A(1978) “IEEE Guide for Identification, Testing and Evaluation of the Dynamic Performance of Excitation System”.

6. IS: 11726 (1985) (ISO) 2954:1975): “ Requirements for Instruments Measuring Vibration Severity of Rotating and Reciprocating Machines”.

7. IS:11727 (1985) (ISO 3945:1985): “ Measurement and Evaluation of Vibration Severity in Situ of Large Rotating Machines with Speed Range from 10 to 200 rev/s”.

8. IS : 2705(1992) : “Specifications of Current Transformers”.

Part 1	:	General Requirements
Part 2	:	Measuring Current Transformers
Part 3	:	Protective Current Transformers
Part 4	:	Protective Current Transformers for Special Purpose Applications.

9. IS : 3156(1992): “Specification of Voltage Transformers”.

Part 1	:	General Requirements
Part 2	:	Measuring Voltage Transformers
Part 3	:	Protective Voltage Transformers
Part 4	:	Capacitor Voltage Transformers

IS	:	Indian Standard, Bureau of Indian Standard
IEC	:	International Electrotechnical Commission, Geneva
IEEE	:	Institute of Electrical and Electronics Engineers, USA

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PROVISIONS TO BE MADE AT THE HYDEL STATION FOR PERFORMANCE TESTING

1. Pressure taps along with suitable manifolds shall be provided at the inlet and outlet of turbines for pressure measurement according to IS/IEC 41 :

2. Measurement wells shall be constructed for measuring free water level at the intake and tailrace as per the design specified in IS/lEC-41.

3. Provisions shall be made for discharge measurement by two of the following eight methods specified in IS/lEC-41 :
   (a) Current Meter method
   (b) Pitot tube
   (c) Pressure time method
   (d) Tracer method
   (e) Weir
   (t) Standardized differential pressure devices
   (g) Volumetric gauging
   (h) Accoustic transit-time flow meter method

4. A straight length of penstock along with a small exposed portion shall be provided to facilitate discharge measurement by current meters / ultrasonic transit -time flow meter as per IS/IEC-41.

5. For the measurement of differential pressure (for calculating relative discharge for index test), two pairs of pressure taps shall be provided on spiral casing of Francis turbines/casing of tubular and bulb turbines / semi-spiral concrete casing of Kaplan turbines/ taper section of penstock / bend in penstock etc., as the case may be, in compliance ofIS/IEC-41.

6. Test terminal blocks shall be provided on the front of metering panels to facilitate connection of external precision wattmeter / reference meter without shutting down the power station or tripping the circuit breakers.

7. The turbine manufacturers agreed to provide pressure taps at the inlet and outlet of the turbine required for the measurement of pressure and on the spiral case/bulb for the measurement of relative discharge (index test), as required in terms of IS/IEC-41. The manufacturers shall make these provisions as the standard features of their products and include them in the product specifications (irrespective of whether mentioned specifically in the tender technical documents).

8. Periodic testing and checking of protective relays shall be carried out (as or not practice in large power stations) to ensure safety of the power plant. Necessary portable secondary injection test sets should be procured for individual or a

group of power stations and the maintenance engineers of the power station be trained for the purpose.

9. Permanent benchmarks for reference shall be placed at the powerhouse building. tail race channel and intake during the civil construction.

10. The following performance tests will be conducted on the generating units preferably within 6 months of their commissioning as per IEC, subject to the availability of adequate water head and discharge for these tests:

- Maximum power output test
- Efficiency test
- Index test

11. The equipment supplier/ manufacturer shall get the model testing done for the non-standard / new designs. However in every case a report of model testing (as per IEC requirement) for similar turbine shall be made available to the buyer before execution of the supply. In any case, this will not be a substitute to the performance tests on the power station required as per MNES notification.

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