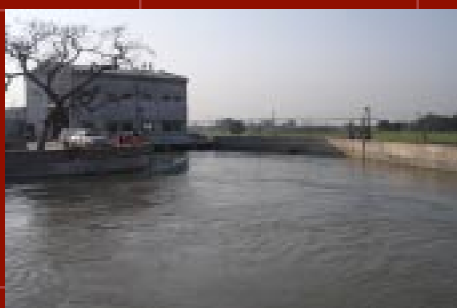
Information Booklet

Performance Testing of SHP Stations



Supported By:

Ministry of Non-Conventional Energy Sources
Government of India
New Delhi

Implemented By:

Alternate Hydro Energy Centre
Indian Institute of Technology Roorkee
Roorkee-247 667

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The booklet may also be downloaded from website:

www.iitr.ernet.in/centers/AHEC/index.htm,   www.ahec.org.in

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DISCLAIMER

This publication aims to disseminate information about the policy of government, institutional arrangements and facilities available for carrying out the performance testing of small hydropower stations for the benefit of power producers, equipment manufacturers, consultants, government utilities, financial institutions and policy makers. AHEC, IIT Roorkee does not accept any liability for errors and omissions. The contents in the publication may be used freely with acknowledgment.

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Information on

Performance Testing of SHP Stations

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SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF NON-CONVENTIONAL ENERGY SOURCES

9th June 2005

FOREWORD

One of the major development aims of this Ministry is to facilitate manufacturers of new and renewable energy equpment that meets the requirements in terms of standards, specifications and performance parameter, which are at par or higher than international elvels, AHEC is setting up testing facilities for the purpose

The need for comprehensive set of instructions on performance testing has been felt for some time now. I am glad that this gap is now sought to be bridged through the publication of set of such instructions.

AHEC needs to complemented on bringing out this remarkable little publication titled 'Performance Testing of SHP Stations' which has been written, I am informed, keeping the policy maker, banker, manufacturer and developer, and of course, the testing teams in view.

I am confident that not only will this publication be of immense use to persons associated with SHP development but would spreahead a spate of similar publications for other renewable sources.

(A.M. Gokhale)

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PREFACE

Any small hydropower (SHP) station, which has been installed and commissioned recently, should be tested to confirm that all its parts and systems are performing their assigned functions correctly and that the generating units are operating efficiently. However the testing needs professional skills and expertise of very high order, which are generally not available in-house to the power station owner. Even the costs of hiring such expertise and the necessary test equipment from any commercial test house are prohibitive.

The Ministry of Non-conventional Energy Sources (MNES), Government of India, with its concern to improve the quality and performance of SHP stations in the country, felt for long a need to create a system of performance evaluation by a neutral agency at low costs. In July 2003, the MNES issued a notification linking its subsidy support for SHP projects to their performance. The Alternate Hydro Energy Centre (AHEC) of the Indian Institute of Technology Roorkee (IITR) was identified as the test agency for this purpose for two reasons: Firstly, AHEC has a long and vast experience in SHP, right from pre-feasibility surveys and feasibility studies to preparation of DPRs and designing complete SHP stations. Secondly, it has the support of highly qualified and experienced faculty of IITR in every related discipline, be that hydraulics, fluid dynamics, hydraulic machinery, electrical machines, power plant design, control or instrumentation.

Under the scheme announced by MNES, the Ministry is meeting the entire one-time cost of the test equipment required for the performance testing, which is highly sophisticated and therefore very expensive. In doing so, MNES subsidised the cost of performance testing and brought it within the affordability limit of the smallest SHP owner.

At IITR, a multi-disciplinary team was formed to carry out performance testing of SHP stations in India and necessary portable test equipment procured. The test charges for the small hydropower station were fixed in consultation with MNES.

The performance testing is expected to be carried out in all areas of this vast country on a large number of SHP stations every year. To meet the need, IITR has associated three highly reputed institutions, namely Jadavpur University at Kolkata, National Institute of Technology at Trichurapally and Maulana Azad National Institute of Technology at Bhopal. However, the coordination of the entire activity remains with AHEC.

This information brochure explains the objective, scope and methodology of preformance testing and list the relevant national and international standards. A list of major test equipments available with AHEC and other networking institutions is also given. For convenience of the power station owner, formats for supplying the power station data and generation details are included. Fee schedule for testing and details of the networking teams are also given. MNES recently organized a consultative meeting with equipment manufacturers and independent power producers. Recommendations of the meeting, for making necessary provisions while manufacturing and installing the equipment/works, to facilitate performance testing have been placed at the end of the brochure.

H.K. Verma and Arun Kumar

PERFORMANCE TESTING OF SHP STATIONS : SCOPE, TESTS AND METHODOLOGY

1. OBJECTIVE

Objective of the performance testing of SHP stations can be stated broadly:

(a) To confirm that all parts, systems and auxiliaries in the power station are performing their assigned functions **correctly**.

(b) To confirm that the generating units are operating **efficiently**.

The objective at (a) is to check the qualitative working of the power station, while that of (b) is to find out whether the power station is meeting the efficiency requirements in quantitative terms.

2. SCOPE

The overall scope of performance testing is listed below:

(a) Inspection of all parts, systems 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.

Thus, performance testing comprises inspection, functional checks, tests, measurements and analysis as necessary to meet the broad objectives laid down above. Further detailing in respect of the testing of each individual major component/system is given in the following sections. It should be understood that the tests mentioned here are carried out subject to the technical feasibility. Furthermore, detailed diagnostic investigations on any faulty component/system are outside the scope of performance testing.

3. WATER CONDUCTOR SYSTEM

3.1 Overall Inspection

To begin with, the complete water conductor system is inspected to observe any apparent problems or deficiencies in its design or construction.

3.2 Measurement

The following measurements are made if instruments are already installed in station with a view to make an initial assessment.

(a) Different water levels/pressures
(b) Gross head available to turbines
(c) Discharge available through turbines

4. GENERATOR

4.1 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

4.2 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

5. TURBINE – GENERATOR UNIT

5.1 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)

5.2 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/IEC: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

6. MEASURING INSTRUMENTS AND INSTRUMENT TRANSFORMERS

6.1 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:60308) because of the high resolution and accuracy of reference frequency meters.

6.2 Functional Checks

In view of the non-critical nature of the parameters measured/recorded and difficultly 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

6.3 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.

7. PROTECTIVE RELAYS

7.1 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 settings. In case of the doubtful working of a relay, a more detailed secondary injection test is conducted.

7.2 Functional Checks

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

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

8. CONTROL PANELS AND SYSTEMS

8.1 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.

8.2 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

9. 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.

10. EXCITATION CONTROL SYSTEM

The voltage regulator and excitation system are subjected to the following tests if necessary test provisions 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.

11. POWER TRANSFORMERS

11.1 Temperature Rise

Of 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.

11.2 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.

12. STATION AUXILIARIES

A thorough 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.

13. METHODOLOGY

The performance testing of SHP station comprises five stages as follows:

13.1 Power Station and Generation Data

All important data and drawings of the SHP station, needed for inspection, checking and testing of the power station, are obtained from its owner. The owner can collect this data from the design consultant, contractor and equipment manufactures concerned. In addition, the generation data for the period starting with commissioning date and the projected generation as per DPR are obtained from the owner.

13.2 Planning

Based on the data and drawings obtained, the test agency then plans inspection, checks and tests that need to be carried out, and prepare a complete schedule of checks/tests. Constraints like non-availability of provisions for certain difficult tests, like index test and unit efficiency test, and inadequacy of water etc. can considerably affect the methods and timing of tests. Where necessary, site is visited for assessment.

13.3 Instrument Checking / Recalibration

The test instruments are checked and recalibrated where necessary so that they are fit for conducting tests at site.

13.4 Site Tests

Inspection, functional checks and tests in the power station are then conducted as per the schedule. Where possible, **vital parameters** are measured by two independent methods.

13.5 Test Report

Finally, a test report is prepared. For each major test or measurement, the report mentions the method and instrument used alongwith the test results. For critical measurements, an assessment of the uncertainities of measurement is made. Remarks and conclusions on the test results are given for the benefit of the end users of the report.

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 for 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 India Standard

IEC: International Electrotechnical Commission, Geneva

IEEE: Institute of Electrical and Electronics Engineers, USA

LIST OF MAJOR TEST EQUIPMENT AVAILABLE/BEING PROCURED

Sl. No.	Test equipment	Number
1.	Portable Ultrasonic Transit-Time flowmeter for pipes, 8-Path measurement, with 16 wet-type transducers	1 set
2.	Portable Ultrasonic Transit-Time flowmeter for open channels, 8-Path measurement, with 16 wet-type transducers	1 set
3.	Portable Ultrasonic Transit-Time flowmeter for pipes, 4-Path measurement, with 8 wet-type transducers	4 sets
4.	Portable Ultrasonic Transit-Time flowmeter for open channels, 4-Path measurement, with 8 wet-type transducers	4 sets
5.	Portable Ultrasonic Transit-Time flowmeter for pipes, with clamp-on transducers	2 sets
6.	High Precision Propeller Current Meter	1
7.	High Precision Electromagnetic Current Meter	1
8.	Propeller Current Meter with Electronic Reading Unit	11
9.	Set of 8 Propeller Current Meters with 8-channel Microprocessor Based Flow Indicator and Logging Unit	8 sets
10.	Ultrasonic Level Transmitters	10
11.	Gauge-Pressure Transmitters	15
12.	Differential-Pressure Transmitters	6
13.	Immersible-Pressure Transmitters	8
14.	Portable Pressure Calibrators	4
15.	Dead-Weight Pressure Calibrator	1
16.	Distributed Data Acquisition Systems	4 sets
17.	Radio Data Communication Units	12 sets
18.	Portable High-Precision Power & Energy Meter	5
19.	Power and Energy Reference Meter	2
20.	Portable High-Precision True-RMS Digital Multimeters	4
21.	Hand-Held True-RMS Digital Multimeters	8
22.	Programmable Vibration Test Set	5 sets
23.	500 V Insulation Resistance Tester	5
24.	5 kV Insulation Resistance Tester	5
25.	Portable Secondary Injection Relay Test Sets	5 sets
26.	Portable Relay Test Set	1 set
27.	Portable Low-Resistance Testers	5 sets
28.	Portable Resistance Test Sets	5 sets
29.	High-Voltage Probes	8

30.	Sound Level Meters	8
31.	AC/DC Current Probes	8
32.	Clamp-on Power Meter	1
33.	Clamp-on Digital Multimeter	1
34.	Non-contact Thermometers	8
35.	Non-contact Tachometers	8
36.	Electronic Total Station	1
37.	Global Positioning System	1
38.	Hand-Held digital Altimeter	1
39.	High-Current Portable Contact Resistance Tester	1
40.	Earth Resistivity Tester	1
41.	Cable Fault Locator	1
42.	High-Voltage Capacitance and Tan-Delta Test Set	1 set
43.	ELCID Tester	1 set
44.	Portable Partial Discharge Detector	1
45.	High-Pot Tester	1
46.	Ultrasonic Flaw Detector	1
47.	Ultrasonic Thickness Meter	1
48.	Eddy-Current Crack Detector	1
49.	Micro Cover Meter	1
50.	Ultrasonic Concrete Tester	1
51.	Concrete Hammer, M type	1
52.	Concrete Hammer, N type	1

FORMAT FOR POWER STATION DATA TO BE SUPPLIED BY OWNER

(1) *To be provided by the Power Station Owner Interested in Performance Testing by AHEC, IIT Roorkee)*
(2) *Equipment supplier/contractor may be consulted to obtain relevant information/drawing if not readily available)*
(3) *Soft copy of these format sheets can be obtained from AHEC)*
(4) *Please donot leave any column blank, write NA for Not Applicable and DNA for Data Not Available).*

A. GENERAL

1. Name of Power Station:
2. Owner of Power Station:
   (with tel/fax/email and postal)
3. Location *(Enclose location/route map)*
   - Nearest Town with Distance:
   - District:
   - State:
   - Longitude:
   - Latitude:
   - Altitude:

4 Nearest Guest-House/Hotel with Address and Distance:
5. Type of Power Station: Run-of-River/Dam based/Canal based
6. Source of Water:
7. No. of Generating Units with Capacities:
8. Commissioning Date(for each unit):

B. GENERATING UNITS *(Enclose drawing of generating unit (Rs.))*

1. Turbine
- Type:
- Shaft: Vertical/Horizontal
- Make:
- Rated Head:
- Rated Discharge:
- Rated Power Output:
- Rated Speed:
- Speed Increaser Used: None/Gear Box/Bevel Gear/Belt and Pulley/_ _ _ _
- Flywheel Provided?: Yes/No
- Pressure Taps Provided?: Yes/No

  If Yes,

Number:	Yes	(enclosed drawings)
Size:	No	
Locations:	No	

2. **Generator**

- Make:
- Type:
- Rated Speed: Synchronous / Induction
- Generator Ratings: ______________ kW, ____ pf, ____ kVA, ____ Hz, ____ kV, Y or D
- Designed Overloading (%):
- Run-away Speed:
- Excitation System: Brushless / Static / Brush-type rotating exciter
- Exciter Ratings:

3. **Voltage Regulator:**

- Type: Digital electronic / Analog electronic / Motorised field Rheostat
- Make:
- Response Time:
- Sensitivity:

4. **Governor**

- Type: Digital electronic / Analog electronic / Mechanical-Hydraulic
- Make:
- Response Time:
- Sensitivity:

5. **Main Inlet Valve**

- Make:
- Type:
- Closing time:

6. **Guide Vanes/Wicket Gates**

- Number:
- Closing time:

7. **Efficiency of Generating Units**

(Enclose unit efficiency curves/tables from the manufacturers)

8. **Any problem observed?** If yes, give details:

- Turbine:
- Generator:
- Main Inlet Valve:
- Speed Increaser:
- Governor:
- Exciter:
- Voltage Regulator:
- Bearings:
- Others:

C. WATER CONDUCTOR SYSTEM *(Enclose relevant drawings)*

1. Head-race Details:
2. Tail-race Details:
3. Designed Discharge (in m^3/s):
4. Maximum Head (in m): Minimum Head (in m):
5. Single Intake or Individual Intakes for Machines:
6. Number and Type of Intake Gates:

7. Common Penstock

- Length:
- Diameter (inside):
- Thickness:
- Material:

8. Individual Penstocks

- Length:
- Diameter (inside):
- Thickness:
- Material:

9. Spilling Arrangement and Capacity:

D. DISCHARGE MEASUREMENT PROVISIONS

1. Do you measure discharge? Yes / No
   - If no, how do you know the discharge?
   - If yes,
     - o How frequently?
     - o By what method?
     - o Total or individual machine?
     - o Location of Measurement?
     - o Details of Instrument/Method?

   (Please enclose relevant drawings and results of measurement, if any)

2. Do you have provision for relative discharge measurement? Yes/No
   - If yes,
     - o Method possible: Taper section/Winter-Kennedy/Venturi/______
     - o Location of Measurement:
     - o Locations of Pressure Taps:
     - o Diameter of Taps:

   (Please enclose relevant drawings and results of measurement, if any)

E. HEAD / LEVEL MEASUREMENT PROVISIONS

1. Do you have provisions for head or pressure measurement? Yes / No

   If yes,
   - Locations:
   - Method/ instrument Used:

2. Do you have provisions for level measurement on upstream side? Yes / No
If yes,
- Locations:
- Method/ Instrument Used:

3. Do you have provisions for level measurement on downstream side? Yes / No
If yes,
- Locations:
- Method/ Instrument Used:

4. Level Gauge Staff at Head-Race Available? Yes / No
If yes,
- Type:
- Range:
- Number & Locations:

5. Level Gauge Staff at Tail-Race Available? Yes / No
If yes,
- Type:
- Range:
- Number & Locations:

6. Reference level marked? Yes / No
If yes,
- Locations:
- Levels:

7. Centre-line of Penstock Marked? Yes / No
- If yes, its level:

8. Centre line of Turbine Marked? Yes / No
- If yes, its level:

F. POWER TRANSFORMERS *(Enclose Single-line Power Diagram of Power Station)*

1. Unit Transformers or Common Transformer?
2. Make:
3. Transformer Ratings:
4. Winding Connections:
5. Cooling type:
6. Tap Changer Type: Off-load/on-load
7. Tap changer make:
8. Any Problem Observed? If yes, give details:
   - LV Windings:
   - HV Windings:
   - Tank:
   - Conservator:
   - Cooling System:
   - Others:

G. PANEL INSTRUMENTS *(Enclose Instrument Panel Drawings)*

1. Meters

Sl. No.	*Meter Name*	*Panel Name*	*Analog (A)/ Digital (D)*	*Range*	*Accuracy Class*	*Quantity*	*Type/Model*	*Make*

2. Details of Temperature Scanner:
3. Details of Recorders (if any):
4. Details of Data Acquisition System (if any):

5. Details of Test Terminal Blocks for Connecting External Power Meter/Analyser

Sl. No.	*Name of panel*	*Type: 3P 3W or 3P 4W*	*CTR*	*VTR*	*Quantity*	*Make*

Note: CTR = CT Ratio VTR = Voltage Transformer Ratio

6. Details of Instrument Transformers

Sl. No.	*Name (CT or VT)*	*Location*	*Ratio*	*Accuracy Class*	*Quantity*	*Make*

H. PROTECTION SYSTEM *(Enclose Relevant Panel Drawings)*

1. Measuring Relays

Sl. No.	*Name of Relay*	*Name of Panel*	*Ratings*	*Type / model*	*Make*

2. **Master/Trip Relays**

Sl. No.	*Name of Relay*	**Name of Panel**	*Rated voltage*	*Type/Model*	*Make*

3. **Circuit Breakers**

Sl. No.	*Breakers Name*	*Panel Name*	*Breakers Specs.*	*Type/Model*	*Make*

4. **Details of Fault Annunciator (if any):**

- Type:
- Make:
- No. of Inputs:

I. STATION / PLANT AUXILIARIES *(enclose drawings)*:

Sl. No.	**Name of Auxiliary**	**Particulars**
1.	Station AC Supply	
2.	Station DC Supply	
3.	Oil Pumping Units	
4.	Bearing Cooling System	
5.	Generator Cooling System	
6.	Transformer Cooling System	
7.	Vacuum Pumps	
8.	Air Compressors	
9.	Drainage System	
10.	Dewatering System	
11.	Inverters	
12.	Earth System(s)	
13.	Equipment Handling Crane	
14.	Hoists	
15.	(Others)	

J. TESTS CONDUCTED AT SITE, IF ANY *(Enclose report)*

K. DETAILS OF ANY OTHER EQUIPMENT not covered above (like SCADA, PLC unit, Communication Equipment) or any other information relevant to the Performance Testing of your Power Station:

L. DATA REGARDING CONFORMITY TO STANDARDS

Sl.	Name of equipment	Make	Standard(s) it confirms to	Certificate available? Yes/No	Certification Mark Present? Yes/No
1.	Turbines				
2.	Generators				
3.	Power Transformers				
4.	CTs				
5.	VTs				
6.	Protective Relays				
7.	HT Circuit Breakers				
8.	LT Circuit Breakers				
9.	PLC				
10.	SCADA System				
11.	Governor				
12.	Excitation System				
13.	AVR				
14.	Auto Synchronizer				
15.	Panel Meters				
16.	Motors				
17.	Cables				
18.	Batteries				
19.	Pumps				
20.	Crane				
21.	(Others)				
22.	(Others)				
23.	(Others)				

M. CHECK LIST OF ENCLOSURES *(Serial no. / nos. may please be filled in)*

Section No.	*Name of enclosure*	*Enclosure No.*
A-3	Location / route map	
B-1	Drawings showing pressure taps, if any	
B-3	Drawing of excitation system	
B-7	Unit efficiency curves/tables	
C	Drawings of water conductor system	
D-1	Drawings showing provision for discharge measurement, if any	
D-1	Results of discharge measurements available, if any	
D-2	Drawings showing provisions for relative discharge measurement, if any	

D-2	Results of relative discharge measurements available, if any	
F	Single-line power diagram	
G	Drawings of instrument panels	
H	Drawings of relay panels	
I	Drawings of station auxiliaries	
J	Report of tests conducted earlier, if any	
K	(Others)	

Place: ______________

Date: ______________

Signature: ______________________

Name: ______________________

Designation: ______________________

FORMAT FOR GENERATION DATA TO BE SUPPLIED BY OWNER

A. **Daily Generation Record for ___________________** ***(specify month & year)*** ***(one sheet for each month)***

Date	**Actual Generation (in million units)**			**Remarks (if any)**
	Machine#1	**Machine#2**	**Total**	

B. **Summary of Month-Wise Actual and Projected Generations**

Month	**Actual Total Generation (in million units)**	**Projected Generation as per DPR (in million units)**	**Remarks (if any)**
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

Place: ______________

Date: ______________

Signature: ______________________

Name: ______________________

Designation: ______________________

Seal : ___________________________

MANDATORY INFORMATION TO BE SUPPLIED BY POWER STATION OWNER FOR PERFORMANCE TESTING

1. Power Station Data

- ❖ Complete in all aspects

2. Conformity to Standards

- ❖ Last two columns must be filled and at least one of them should be "yes"

3. Drawings

- ❖ General layout of works showing from diversion to tail race
- ❖ L-section of water conductor system
- ❖ Details of intake gates
- ❖ Plan of Power House Building
- ❖ X-Section of Power House
- ❖ L-Section of Power House
- ❖ Single line diagram

4. Equipment Data

- ❖ Hill & Efficiency curves of turbine
- ❖ Efficiency curves/data of generators

5. DPR Abstract

- ❖ Water power studies
- ❖ Flow duration curve and tabulated data

6. Generation Data

- ❖ Daily generation data (Unit wise and total) since conformity to 80% requirement of MNES in Format A.
- ❖ Summary statement of monthly generation compared with the projected generation as per DPR (month wise) in Format B.

Format A:

Date	Generation of unit-1	Generation of unit-2	Generation of unit-3	Total generation

Format B:

Month	Projected generation as per DPR	Actual generation	Ratio of actual generation to projected generation (%)	Remarks if any

Note: One signed hard copy alongwith a soft copy on hard disk (or by e-mail) of the above must be submitted

SCHEDULE OF TEST FEES FOR PERFORMANCE TESTING

Capacity of SHP Station	Charges (Rs in Lacs)			Additional Costs Involved
	Testing Charges	Towards Replacement Fund	Total Charges[$]	
Upto 200 kW*	1.00	Nil	**1.00**	+ service tax as applicable (at present @ 12.36%). + Cost of local travel, boarding and lodging of the visiting team during the site visit from nearest airport/railhead/headquarters.
Above 200 kW and upto 2 MW	3.60	0.40	**4.00**	
Above 2 MW and upto 5 MW	5.40	0.60	**6.00**	
Above 5 MW and upto 25 MW	9.00	1.00	**10.00**	

*Testing will not include unit efficiency test in such SHP stations.
[$]Total charges to be paid in advance by the station owner to AHEC, IIT Roorkee through bank draft payable in favor of Dean (SRIC), IIT Roorkee, Roorkee.

<u>Other terms and conditions</u>:

1. These charges shall be enhanced by 40% for every additional unit in case there are more than two units in the station for testing.
2. The responsibility of the station owner (SEB/Power Corporation/NGO/Cooperation/ Independent Private Producer) shall be as follows:
   a. All the drawings of station/equipment, specifications of equipment, generation and historical records, records of pre-commissioning and re-commissioning tests and any other data, as needed in advance/at site shall be made available to the testing team as and when asked for.
   b. Free and easy access to station.
   c. Make possible the variations of discharge to conduct different load tests.
   d. Make available the service of station staff to the testing team as needed at the station.
   e. Active cooperation of the management and staff will be essential.
   f. Provide boarding/lodging/local travel.
3. The Test Report shall not be used for any techno-legal purposes.

TEAMS AND NETWORKING INSTITUTIONS

AHEC, IIT, Roorkee (UA)

1. Dr. H.K. Verma, Professor, Electrical Engg Deptt., Team Leader
2. Sh. Arun Kumar, Head, AHEC and Coordinator

Jadavpur University, Kolkata (WB)

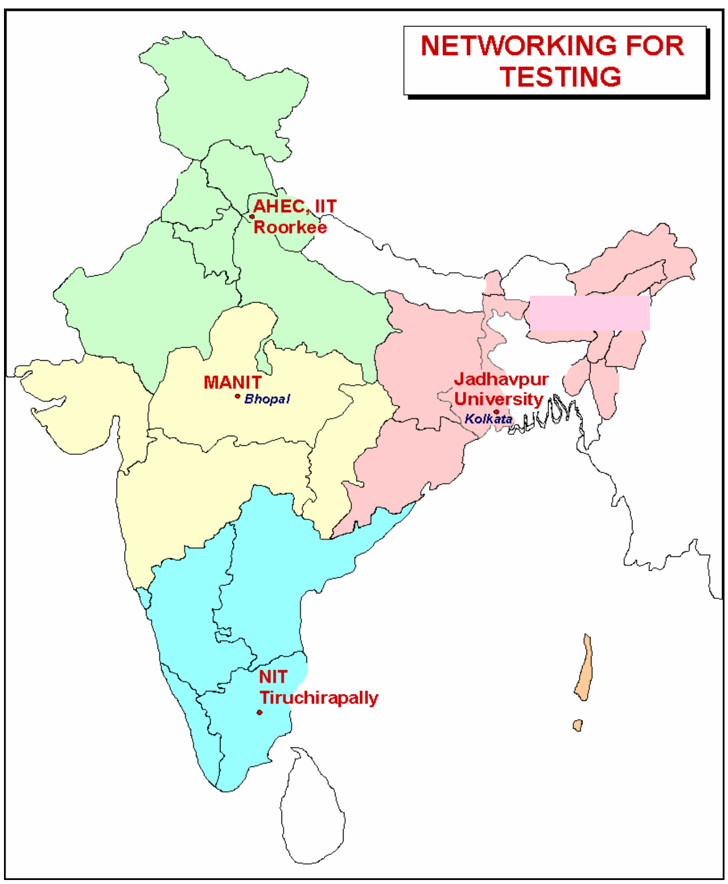
1. Dr. B. Majumdar, Team Leader
2. Dr. Niledhi Chakroborty, Dy. Team Leader

Maulana Azad National Institute of Technology, Bhopal (MP)

1. Dr. Kuldeep Singh Sayann, Professor, Team Leader
1. Dr. Saroj Ragnekar, Professor, Dy. Team Leader

National Institute of Technology, Tiruchirappalli (TN)

1. Dr. P. Subramanian, Professor, Team Leader
2. Smt. M. Premlatha, Senior Lecturer in CEESAT, Dy. Team Leader



CONSULTATIVE MEETING WITH SMALL HYDROPOWER EQUIPMENT MANUFACTURERS AND DEVELOPERS ON "PERFORMANCE TESTING OF SHP STATIONS"

Convened By

MINISTRY OF NON-CONVENTIONAL ENERGY SOURCES (MNES)

Government of India

ON 21 APRIL 2005 At New Delhi

1. A consultative meeting with SHP equipment manufacturers and developers on "Performance Testing of SHP Stations" was held at 11.30 AM on 21 April 2005 in MNES. Name of participants going appended. The meeting was addressed by Shri A.M. Gokhale, Secretary, MNES. AHEC, IIT Roorkee made a detailed presentation on various aspects of performance testing of SHP stations with respect to international/national standards relating to small hydroelectric installations.

2. It was indicated in the meeting that the Ministry's medium-term aim is that 2% of the additional capacity in power generation in the country should come from SHP during the 10th and 11th Plan periods. Consequently, a target of 2000 MW has been set for the 10-year period (2002-2012), of which 266 MW has been achieved in the first 3 years of the 10th Plan (i.e.1.4.2002-31.3.2005). Projects aggregating over 300 MW capacities are expected to be commissioned by 31.3.2007. Most of this capacity is coming up through private investment.

3. The Ministry has been providing subsidy for SHP deployment. The subsidy is released to the Financial Institution (FI) as prepayment of loan on successful completion of the project. The Ministry has made it mandatory for carrying out performance tests on small hydropower stations to determine whether a project has attained DPR and/or design parameters. The project when tested should demonstrate the capability to generate at least 80%of the DPR estimates for 90 consecutive days.

4. The responsibility of conducting performance tests has been entrusted to AHEC, IIT, Roorkee Accordingly; the Ministry has given financial support for the creation of an onsite-testing facility with AHEC, IIT, Roorkee. The equipment manufacturers are expected to adopt notified international/national standards and make due provisions in design and manufacturing of equipment for carrying out necessary testing.

5. AHEC in its presentation detailed the objectives and scope of performance testing, methodology and necessary provisions required for carrying out tests as per IS/IEC standards.

6. After detailed deliberations, the following conclusions/recommendations emerged:

    1. There is an immediate necessity and desirability to introduce performance testing of SHP stations. This will bring about contractual discipline, transparency and quality assurance in respect to equipment and civil works. To facilities the process, MNES would organize interaction

meetings between SHP developers, consultants and equipment manufacturers. In addition, a paper on performance testing would circulate by MNES.

2. The equipment manufacturers should make due and adequate provisions for testing in the design & manufacturing of equipment. This will ensure adherence to national and international standards in terms of the requirements of the performance testing, improve accuracies and reduce uncertainties related to measurements. In addition, testing would be facilitated and time and cost of testing would be reduced. Moreover, the number and duration of shutdowns necessary for testing will reduce, thereby reducing the loss of power generation.

3. IS/IEC-41, the standard on "field acceptance tests to determine the hydraulic performance of turbines", spells out clearly the requirements of three critical performance tests, viz: maximum power output, unit efficiency and index tests. The standard also emphasizes on various provisions in the equipment and power station necessary to facilitate the conduct of these tests. IEC-61116, the standard on "small hydroelectric installations", underlines the necessity of making similar provisions in the installation.

4. Based on elaborate discussions and deliberations on the necessity, feasibility and economic viability of making such provisions, the following emerged:

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

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

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

   4.4 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.

   4.5 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 of IS/IEC-41.

4.6 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.

5. The above requirements of provisions in the equipment/electro-mechanical works/civil works shall be stipulated while preparing the DPR/detailed designs for the SHP project, and shall form part of the tender specifications.

6. 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).

7. 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. AHEC, IITR agreed to arrange necessary training on request.

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

9. 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

10. 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.

MINISTRY OF NON-CONVENTIONAL ENERGY SOURCES

MEETING WITH EQUIPMENT MANUFACTURERS AND DEVELOPERS
ON
"PERFORMANCE TESTING OF SHP STATIONS"
ON 21 APRIL 2005 AT MNES

LIST OF PARTICIPANTS

	Company/Developer	Designation
Ministry of Non-Conventional Energy Sources		
	Shri Sunil Khatri	Joint Secretary
	Dr. Praveen Saxena	Director
	Shri A.K. Chopra	Director
	Shri Anand Narvane	SSO-I
IIT Roorkee		
	Prof. H.K. Verma	Electrical Engineering Deptt
	Shri Arun Kumar	Head, AHEC
BHEL Ltd., New Delhi		
	Shri A.K. Dixit	Sr. DGM
	Shri A.K. Chaudhary	CMG
VA Tech Escher Wyss Flovel Ltd		
	Shri Maharaj Kar	Managing Director
	Shri Arun Gupta	Dy. GM
Jyoti Ltd.		
	Shri K.J. Gupta	Sr. G.M.
	Shri T.K. Modak	General Manager
	Shri Pankaj Patel	Engineer
	Shri Mahesh Satanee	Engineer
Boving Fouress Ltd.		
	Shri Ashok K.C.	Chief Operating Officer
	Shri C.S. Narendra	Sr Engineer
Kirloskar Brothers Ltd.		
	Shri J. Tkshaspar	Vice president Designs
Alstom Projects India Ltd.		
	Shri Ashwani Kumar	Engineer (SHP)
Matronics – I PL		
	Dr. Hariom Nada	Director
HPP Energy (I) Pvt. Ltd.		
	Shri Amarjeet Singh	Vice-President
	Shri S.S. Sidhu	CGM

Ushmil Hydro		
	Shri A. Roy Choudhary	General Manager
Gita Flopumps India Pvt. Ltd.		
	Shri B.S. Saini	MD
Polyplex Corporation Ltd.		
	Shri Pramod Kumar Arora	Dy. GM
	Shri Carl Sabbarwal	
	Shri Rakesh Pandita	Sr Engineer
Indusree Power Pvt. Ltd.		
	Shri S.K. Sharma	Managing Director
	Shri Vinod Bhardwaj	
Himalayan Crest Power Ltd.		
	Shri A.K. Verma	Director
	Shri Sanjay Choudhary	Director
	Shri Kunal Kathuria	Engineer (M)
	Shri Prateek Kashyap	A.M (Mechanical)
Small Hydro Engineering Consultants Pvt. Ltd.		
	Shri A.K. Goel	Advisor
Regency Acqua Electro & Hotel Resort Ltd.		
	Shri Gaurav Narula	ED