RESEARCH & TESTING FACILITIES AT CPRI

CENTRAL POWER RESEARCH INSTITUTE
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Quality Policy

Central Power Research Institute (CPRI) is the National Institute for Research and Development in Electrical Power Engineering. CPRI is also an Independent Third Party Testing & Certification Organisation, and undertakes R&D, Consultancy projects for Power Sector.

CPRI is always committed to maintaining consistent quality in third party testing, certification and calibration activities for meeting the requirements of National and International Standards. It is committed to timely and successful completion of R & D and consultancy projects to the entire satisfaction of its sponsors and customers.

The Quest for quality and continual improvement is an on-going process at CPRI. Best professional practices of CPRI & confidence of customers in the quality of its services is a reliable base for its present and future business.

The Quality Policy & Management System is integrated and implemented through the active involvement of the entire organisation, for compliance to ISO / IEC 17025 -2005 Standard requirements in respect of its testing & certification, calibration services and to ISO 9001-2008 Standard in respect of its R&D, Training and Consultancy Services.

All facilities required for implementation of this policy will be provided.

Date : 14.03.2012
Place: Bangalore

Director General
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Central Power Research Institute (CPRI) was established with its Head office in Bangalore and a unit in Bhopal by the Government of India in 1960. It became an Autonomous Society in the year 1978 under the aegis of the Ministry of Power, Government of India.

Today, the Institute is over 53 years old and has been rendering over five decades of dedicated service to the power sector. The headquarters of the Institute is in Bangalore and its other units spread across the country are located at Bhopal, Hyderabad, Nagpur, Noida, Kolkata and Guwahati. CPRI has set up extensive test facilities for testing all characteristics of power equipment under one roof in Bangalore. The Bhopal Unit, set up simultaneously along with the Bangalore facility has exclusive facilities for Testing of Transformers and Switchgear. The unit at Hyderabad established in 1993 caters to Ultra High voltage research and evaluation. The Unit at Nagpur, established in 1993 caters to solving problems faced by the Thermal power sector. The Unit at Noida, setup earlier at Muradnagar in 1992 caters to testing of Low and Medium Voltage equipment for the Northern region. The Units at Kolkata and Guwahati, serving the Eastern and North-Eastern regions, set up in 2005 and 2007 respectively, have facilities for testing of Transformer Oil.

**OBJECTIVES OF CPRI**

- Function as a national level power research organisation for undertaking and / or sponsoring research and development projects in the fields of generation, transmission, distribution and operation of electricity supply systems.
- Provide the necessary centralised research and testing facilities for evaluation of materials and the performance of power equipment.
- Serve as a testing and certification authority at the national level, for the purpose of certification authority at the national level, for the purpose of certification of rating and performance to ensure availability of quality equipment for use under conditions prevalent in Indian power systems.
- Co-ordinate R&D activities in the various state electricity boards and utilities and maintain liaison with other institutions engaged in research connected with power systems and / or power equipment.
- Act as an apex body for initiating and coordinating the research and development in the field of electric power.
- Evolve criteria for the standards of operation under Indian conditions for various equipment, and effectively participate in the formulation of national standards.
- Identify problems in the areas of basic and applied research and arrange such studies in-house and in academic institutions.
- Collect information and maintain documentation in the field of power engineering and publish papers, periodicals or reports in furtherance of the objectives of the institute.
Central Power Research Institute

- Establish, maintain and manage laboratories, workshops and other facilities for furthering scientific and technological research and conduct experiments for exploiting the inventions or discoveries to the cause of power development in the country.

- Enter into an agreement with any enterprise or institution or person or persons and provide funds to them to carry out the research and development programme of the institute.

- Carry out consultancy projects / field studies and third party inspection of equipment and all other related activities relevant to the power utilities in India and abroad.

The Institute has several research laboratories and testing facilities engaged in different specialised fields. It has 250 engineers and scientists, along with support staff, to guide and maintain various operations within the Institute. The Head Office of CPRI is in Bangalore with units in Bhopal, Guwahati, Hyderabad, Kolkata, Nagpur and Noida.


For meeting the growing needs of the power sector, the Institute has commissioned a state-of-the-art Seismic, Real-Time Digital Simulation and Power Capacitor testing facilities. CPRI offers consultancy services too. The Institute is shortlisted as a consultant for the Power Finance Corporation, with BB+ ranking for thermal power plants and BB ranking for hydropower plants. CPRI has carried out R and M studies for several coal-fired thermal power plants and hydropower plants across the country. CPRI is recognized as a consultant by the Indian Boiler Regulatory Board to undertake condition monitoring and RLA studies on power station boilers. Under power sector reforms, CPRI is rendering valuable assistance to the Regulatory Commissions such as carrying out estimation of loss in transmission and distribution systems. State-of-the-art infrastructure facilities for undertaking collaborative research with academic institutions, utilities and industries have been established. CPRI is empanelled as SCADA / DMS Consultant for R-APDRP and is offering third party inspection and supervisory services for two states, Karnataka and Kerala, under RGG-VY Scheme. CPRI is also offering consultancy services for design and development of Smart Grid Pilot Project for BESCOM, being taken up for the first time in the country. The quest for quality is an on-going process at CPRI. CPRI facilities are accredited as per ISO / IEC 17025 norms. CPRI is a member of the group, Short Circuit Testing Liaison (STL). The research and consultancy activity is certified for ISO 9001:2008. CPRI is a corporate member in DLMS UA (Device Language Message Specification User Association) and UCA IUG (Utility Communication Architecture International User Group). CPRI is recognized as an Approved Test House by Electrical Directorate, Kingdom of Bahrain, and SEC, Saudi Arabia.

Besides, CPRI Certification is widely accepted in the Middle East, Southeast and Far East Asia, and in Africa.
The other activities of the Institute are:
A. Collaborative Research Programmes.
B. Customized Training Programmes.
C. Third Party Inspection Services.
D. Condition Monitoring and Diagnostics services.
E. Energy Audit.
F. Power System studies covering Load Flow, Short Circuit and Relay Co-ordination.
G. Seismic Qualification of Power Equipment.
H. Unique facilities for evaluation of equipment under the Standards and Labelling programme.
J. Utilisation of Industrial Solid Wastes to covert them into useful value added products for the benefits of the Industry.
K. To provide training to State / Central Power Utility engineering on various topics to manage their power system network.

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RESEARCH AND DEVELOPMENT DIVISION

The R&D Management Division of CPRI acts as the back office for coordinating and monitoring the R&D schemes of the Ministry of Power, Government of India. The three schemes of MoP are National Perspective Plan (NPP), Research Scheme on Power (RSoP) and Research Contingency (RC).

NATIONAL PERSPECTIVE PLAN (NPP)

The Ministry of Power (MoP), Government of India, under its Plan Scheme ‘National Perspective Plan (NPP) for R&D in Indian Power Sector’ is promoting research in the area of Power. The projects proposed under this scheme are focused on development of New Product / Process Development leading to field implementation. The crucial needs of Power Sector require R&D to bridge the technology gaps in various subsections of power sector (Generation, Transmission & Distribution). The Research Areas and topics are identified and prioritized. The R&D is to be aimed at either improving design of an individual plant component and/or evolving cost efficient overall process. R&D work needs to take advantage of the advances in IT, electronics and communication to improve the control & instrumentation system, data acquisition system and monitoring of system performance parameters.

The Ministry of Power constituted a Standing Committee on R&D (SCRD) to frame 15 years National Perspective Plan for R&D in Indian Power Sector, in the year 2002. Standing Committee on R&D under the Chairmanship of Chairperson CEA with members drawn from leading organizations like CEA, CPRI, NPTI, NTPC, NHPC, POWERGRID, THDC, SJVNL, DVC, BBMB and NEEPCO. Director General CPRI is the Member Convener for this committee. The mandate of this committee is to frame a perspective R&D plan.

The Indian Power Sector is facing major challenges today with the introduction of reforms, globalization and liberalization policy of the government. With the increase in system expansion, stability and security problems have become more challenging. It is of vital importance to focus attention on ways and means to build expertise within the country to find solutions for the problems existing in the system and also for the problems that may arise in the future. Research is needed to bridge the knowledge and technology gaps, more so due to changes in technology today at a more profound and faster pace.

RESEARCH SCHEME OF CPRI (RC)

R&D is very essential for sustenance of Technology and for adoption of newer and advanced Technologies. There is a need to foster strong linkages between Utilities, Industries, Academia and Research Institutes in R&D for Power Sector. Many utilities have started their own R&D Laboratories for understanding day to-day operational problems and complex situations that arise in maintenance of huge assets becomes difficult in the absence of a dedicated group for R&D in Power Utilities. Therefore, by fostering a close relationship between Industry, academia, Power Utilities and Research Laboratories, it will be easier to adopt new technologies and also maintain
the Power Systems despite various technological problems. The RC projects are for scientists and engineers of CPRI. Under this scheme, Research Projects are undertaken for:

- Augmentation of Research and testing facilities.
- Improvements / New techniques in testing / Diagnostic methods/Research studies.
- Product / Process Improvements.
- Improvement in product standardization.

**RESEARCH SCHEME ON POWER**

The Research Scheme on Power (RSoP) was initiated by the Ministry of Power (MoP) in 1961 to support research & development projects in all relevant areas of power sector by central and state utilities, quasi-government organizations, academic and research institutions and other related organizations in the country. The scheme has been funded by MoP from its plan grants.

The MoP entrusted the responsibility of management of RSOP to CPRI in April 2001. The scheme was until then managed by Central Board of Irrigation and Power (CBI&P). The aim of this Scheme is to ensure optimum utilization of the allocated fund with emphasis on maximizing the research benefits by better management of research projects under the scheme. This is in tune with the mandate of CPRI as an apex body for initiating and coordinating various research and developmental activities in the field of electric power by networking with various state electricity boards, Distribution companies and maintaining liaison with Academic Institutions engaged in research connected with power systems and/or power equipment in the country. CPRI has a significant role to play in this R&D Scheme, some of which are highlighted here:

1) Obtaining the finance approval of the MoP to the new RSoP schemes after internal scrutiny by ECRSOP and approval by Standing committee and ratification by Governing council of CPRI.

2) Preparing plan budget for the RSoP schemes

3) Obtaining release of funds from the MoP at regular intervals

4) Release of Govt. funds to various executing research agencies and keeping audited accounts thereof

5) Monitoring progress of projects through experts (Nodal officers) from CPRI, and

6) Marketing of the results of the RSoP schemes

The research proposals as recommended by the RSoP Expert Committee constituted by the Ministry of Power generally belong to the following broad areas:

1) Decentralized generation

2) Power Electronics application to power system

3) Improvements in power generation, transmission and distribution systems

4) Advanced Remaining Life Assessment (RLA) methodologies

5) Information & Communication Technology applications to power sector

6) Insulation Engineering and Technology for HTS based Power Apparatus
The Distribution Systems Division (DSD) is established in CPRI recognising the importance and need for better power distribution system in India, with greater emphasis on Reliability, Safety and Losses. The Division has a team of professional engineers with vast experience in offering Consultancy services in Electrical Distribution System for Utilities & Industries.

The Division has been rendering Consultancy services to the Electricity Regulatory Commission, Distribution Utilities and Industries of various states in estimation of losses in Distribution networks and evaluating the benefits after the implementation of various schemes to improve the Electrical Distribution System.

Monitoring of RGGVY works
Consultancy Activities:

A. Third Party Independent Agency under Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY)
B. Third Party Independent Evaluation Agency - Energy Accounting under R-APDRP
C. Third Party Independent Agency under Niranthara Jyothi Yojana (NJY)
D. Surprise Checks and inspection of complaint works attended by the utility staff
E. Third Party Inspection to ensure Safety at work place on all the works carried out by the utility
F. Third party vendor analysis for electric equipment manufacturers.
G. Design of Earth Mat for Power Stations and EHV substations.

Third Party Independent Agency under Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY)

CPRI has been appointed as Third Party Inspection Agency (TPIA) in the three tier monitoring of RGGVY programme of the Ministry of Power, Govt. of India, which aims at Electrifying all villages and habitations and providing access to electricity to all rural households.

As Third Party inspection Agency, CPRI will report the progress and quality of works as per the Monitoring and Inspection report formats specified in REC guidelines.
Third Party Independent Evaluation Agency - Energy Accounting under R-APDRP

CPRI has bagged the prestigious consultancy as “Third Party Independent Evaluation Agency - Energy Audit (TPIEA-EA)” of Karnataka state under the R-APDRP of Ministry of Power, Govt. of India.

As TPIEA-EA, CPRI shall oversee the tasks under R-APDRP through Monitoring of AT & C losses for all the ESCOMs of Karnataka. It covers 98 towns in the entire state as identified project areas under respective Distribution companies.

Third Party Independent Agency under Niranthara Jyothi Yojana (NJY)

CPRI has been appointed as the Third Party Inspection Agency (TPIA) for Supervision & Monitoring of the programme. The scheme involves bifurcating rural feeders into Nirantara Jyoti feeders and IP set feeders. Evaluation of the benefits of NJY scheme after implementation also forms part of the TPIA activity in Karnataka.

CPRI is rendering services as TPIA in various distribution companies like, BESCOM, CESC, GESCOM, HESCOM, MESCOM and HRECS, Hukkeri of Karnataka; KSEB, Kerala.

CPRI was appointed as Advisor cum Consultant for the capacity building exercises in the states of Karnataka, Andhra Pradesh and Kerala.

Training programme had provided training to utility engineers in areas of Best Practices in Distribution System, Performance Benchmarking, Quality of supply & Service, Project Development etc.

A consultancy job on Energy Accounting & Audit, “Study and Analysis of Eight numbers of 11 kV Feeders” of Bangalore Electricity Supply Company (BESCOM) is completed. These eight feeders were evaluated for their Aggregate Technical and Commercial (AT&C) losses, technical efficiency of the system, procedure up-gradation for energy accounting, identification of weak areas to improve the system performance through loss reduction.

Some of the recent research work has been in the area of Reliable two-way communication network for smart grid operation, Renewable integration with smart grid and Reliability Improvement in power distribution systems.

Expertise

Distribution Systems Division has the following expertise to cater to various problems of utilities and other industries:

- Energy Accounting/ Audit
- Analysis of the technical efficiency of the system
- Estimation of Technical and Commercial losses (AT&C losses)
- Segregation of Technical and Non-technical losses
- Identify weak areas for further course of action to improve the system performance
- Project Monitoring & Supervision
- Distribution System Planning & Analysis
- Software development and R&D for Distribution Utilities
Distribution Systems Division

- High Voltage Distribution System (HVDS)
- Distribution System Optimization (feeder reconfiguration, optimal placement of Capacitors and Switches)
- Training & Manpower development
- Design of grounding system for HV Substations
- Measurement of Soil resistivity and Earth Resistance for different electrical systems
- The software facilities available for Distribution Studies in the Division are:
  - CYMDIST
  - PSCAD
  - SYSTAT
  - GMAT

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HIGH POWER LABORATORY

The Division comprises:

i. Direct Testing Facility of 2500 MVA capacity at 36/72.5 kV in three phase and 1400 MVA capacity, up to 245 kV in single phase for testing of Circuit Breakers and short circuit withstand capability tests on other apparatus viz., Power Transformers, Wave Traps, Reactors, Insulator Strings, Lightning Arresters etc., and for short time current test up to 300 kA rms for 1 sec on Busducts, CTs, Isolators, Panels, etc.

ii. A Synthetic Testing Facility for high power testing of EHV Circuit Breakers up to 40 kA, 245 kV full pole and unit testing of EHV Circuit breakers beyond 245 kV level.

Testing Facilities

The direct testing facility was commissioned in December 1990 and the Synthetic Test Facility was commissioned in December 1992. The main equipment / facilities are as follows:

Short Circuit Generator

The 14 kV, 3 phase, 3000/3600 rpm 50/60 Hz Generator is capable of delivering 3-phase power of 2500 MVA reckoned at the end of 0.08 secs after fault initiation of 36/72.5 kV in the test cells. The Short Circuit Generator is modernized with new controllers so that the same generator works as a driving motor initially and subsequently, works as a generator. Hence, the present short circuit generator system in High Power Laboratory is driveless generator with the latest sophisticated controls. A static excitation system comprising thyristor bridges and solid state controllers provide super excitation and flux regulation to ensure that the current is maintained constant.

Conversion of 2500 MVA generator into motor less system at High Power Laboratory, Bangalore
M/s. Converteam, Belfort, France has supplied two control cubicles for the generator driving system and generator excitation system. The existing old control cubicles, the generator drive, and the exciter system were removed. The entire new cabling and, also, the power cabling between SFC to the generator stator were carried out which has helped in uninterrupted testing facility. The new motor less system was commissioned in December, 2010, which has helped in uninterrupted testing activity.

**Master Circuit Breakers (3 Nos.)**

It is a specially designed half-cycle, single pole, air-blast breaker with synchronised opening to achieve minimum arcing time. Breaking current: 120 kA rms at 14 kV; breaking time: 7 ms.

**Make Switches (3 Nos.)**

Capable of closing individually or sequentially through a synchronous test processor. Making current: 430 kA peak; making time: 6 ms.

**Air Core Reactors**

14 kV Air Core Reactors 2.7 milli-ohms to 6.0 ohms for adjustment of test currents from 120 kA to 1.34 kA rms in steps of less than 5%.

**Short Circuit Testing Transformers (6 Nos.)**

Specially designed low flux density, single phase short circuit testing transformers rated at 14/42-42 kV, 1150 MVA, ensuring distortion free recovery voltages during short circuit test duties on circuit breakers.

**Busbar System**

This enables connection of Short Circuit Generator through Master Circuit Breakers, Make Switches and also Short Circuit Testing transformers in different combinations by means of remotely controlled disconnectors to the test cell. There are three bus bar systems as follows:

- 14 kV, 3 phase bus bar system rated for 40 kA rms
- 72.5 kV, 3 phase and neutral busbar system rated for 130 kA rms
- 245 kV, single phase busbar system rated for 50 kA rms

**TRV Circuit Elements for Direct Test Facility**

To adjust TRV parameters as per IEC / Indian Standards up to a voltage class of 72.5 kV.

**Capacitor Bank of Direct Test Facility**

Range of Capacitive Current switching tests on HV Circuit Breakers and Switches for:

- 3 PHASE
  
  36 kV, 600 A  
  12 kV, 235 A

- Single phase
  
  12 kV to 36 kV, 1250 A  
  72.5 kV, 630 A  
  145 kV, 750 A  
  245 kV, 950 A
Resistor Banks

For control of peak current during short circuit making tests up to a current level of 40 kA rms/100 kA peak.

High Current Short Circuit Testing Transformer

Rating: 14/1.2 kV, 300 kA rms for 1.0 sec. for short time current tests on busducts, CTs, etc., and short circuit switching duty tests on LV circuit breakers, fuses, etc.

Control Measurement and Recording System

- Synchronous test processor, 32 channels, 100 micro sec resolution
- Co-axial shunts
  - 140 kA; 50 micro ohm,
  - 14 kA; 500 micro ohm.
  - 300 kA; 36 micro ohm
  - 100 kA; 100 micro ohm, 3 Phase shunt
- Current transformers: Upto 150kA (Transient response type)
- Capacitive Dividers:
  - Type RCR 375 kV/1500 kV
  - Type RCR 60 kV/280 kV
  - Type RC 60 kV/380 kV
- Resistive Divider: Type R 2 kV
- Thermal Array Recorder - 16 channels
- Fibre optic based Digital Data Acquisition System, 100M/s sampling rate-24 channels
- Digital oscilloscope, 100 MHz, 2 channels.
- Digital oscilloscope, 200 MHz, 4 channels
- Precision power analysers
- High speed test processor: 4 input / output channels for synchronising the high current and high voltage source during synthetic testing.
- Circuit Breaker operational Analyser with Travel Characteristics Comparison Facility.
- Calibrator: High precision 7.5 digits multi-function, characterised by wide range coverage of DC voltage, DC current, AC current, frequency and resistance functions in a single unit for daily calibration of measurement links and periodic calibration of measuring instruments used in the test.

Synthetic Testing Facility

Method: Parallel Current Injection
Injection Frequency: 350 Hz to 1000 Hz
Injection Current: 18 kA peak max.
### TRV Circuit
- For two and four parameters as per IEC/Indian Standards

### Main capacitor bank (C1)
- 400 kV, 18 µF, 1.44 MJ

### TRV capacitor bank (C2 and C3)
- 2.8 microF/500 kV and 4 microF/400 kV

### Charger
- ± 20 to ± 440 kV DC

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### Supplementary Tests
- Facilities for conducting power frequency voltage withstand test, contact resistance measurement, contact travel characteristic and contact resistance measurement on circuit breaker winding resistance and inductance measurement, transformer turns ratio measurement, load-loss and no-load loss measurement and induced over-voltage test on transformers. There is also a facility...
for conducting mechanical endurance test on circuit breakers.

**Assembly Room**

For assembling the test equipment: It is equipped with a 10T EOT Crane and necessary material handling facilities.

**Test Cells**

- Explosion-proof totally enclosed test cell of size 28M (L) x 23M (B) x 22M (H) provided with a 5T EOT crane for HV/EHV Breaker testing attached to Synthetic Test Facility.
- Outdoor test area of size 12M (L) x 10M (B) for testing of power transformers CTs, PTs and other oil filled apparatus.
- Outdoor test area exclusively for power arc tests on insulator sets and also for testing of line traps, reactors, Las, etc.
- Outdoor test area for LV switchgear and high current tests up to 300 kA rms for busducts, disconnectors, earth switches, etc.
- Medium voltage indoor test cell of size - L 20M x B 15M x H 13 M provided with 5 T EOT crane for direct test.

**Auxiliary Power Supply**

- 0 - 300 V, 15 A DC
- 0 - 415 V, 250 A AC
Compressed Air supply:  
Available up to 200 bars for operation of the test apparatus and other purpose.

SF6 Gas Handling Facilities  
Dry run compressor capacity of 5.7 cu. m/h with a final pressure of 50 bars and vacuum pump capacity of 16 cu.m/h with suction capacity less than 1 mill-bar.

Handling Facilities  
5, 10, 15T EOT cranes 
10T gantry crane 
Fork lift (5T) truck 
Exclusive bay for mounting accessories of transformers with 15T EOT crane 
360° operating elevating platform, Gini make US,

R&D Capabilities  
• Testing & Development of interrupters, Testing and development of Fault current limiters 
• Arc Research Studies 
• Short Circuit studies on power transformers and switchgear

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The Short Circuit Laboratory has facilities to undertake tests for certification and development of low voltage switchgear and controlgear and other power system apparatus. The laboratory has a 50 MVA short circuit test capacity.

The laboratory had one generator as power source until 2009 to carry out the tests. During the year, 2010, another one was added to the present set-up, which was more than 40 years old. The old SC generator is a 50 MVA 12 kV 50 Hz 3-phase machine coupled to a 3.3 kV, 750 kW slip-ring type induction motor. A DC generator is also coupled on the short-circuit generator shaft for excitation. The SC generator is a salient pole machine with two windings per phase that is connected in either series or parallel and, also, in star or delta connections as per the requirement. With this, four types of ratings, viz., 3.46, 6.0, 6.93 and 12 kV supplying short circuit currents of 8.34, 4.82, 4.17 and 2.41 kA, respectively, are achieved. The new SC generator is also of 50 MVA capacity driven by a 1350kW 690V induction motor driven through a variable frequency drive (VFD) which makes SC tests at 50/60Hz also possible. The station is also equipped with two 50 MVA short-circuit transformers to step down the voltage to the value required. One of the transformers is 12 kV/415V and a Short-circuit current of 50 kA rms can be achieved at 456 Vrms recovery voltage. The other has taps, both on primary and the secondary. With this, it is possible to test the equipment up to 866 V rating. This transformer is generally employed for testing of MCBs, RCCBs, MCCBs, starters, contactors, switches of all kinds and certain tests on fuses also. The generator and transformers are specially designed to withstand repeated
short circuits.

Apart from these, the lab has 12 kV, 1250 A, 40 kA, breaking capacity vacuum circuit breakers which is used as the master breaker and a high-speed make-switch with a point-on voltage wave closing facility. Resistor banks and reactor (air-core) banks are available for adjusting the test current, power factor of the test circuit, both on the source and load sides.

A 600V 30kA for 3.0 seconds DC short-circuit test facility is also available at the station in order to cater to DC testing for all switchgear equipment.

The laboratory also has 415V 10kA on-line testing facility for carrying SC breaking capacity tests exclusively on MCBs and RCCBs.

The laboratory is equipped with a modern digital measuring and recording systems. The high current measurements are made using non-inductive shunts (100kA, 10kA)/rogowski coils and the voltages are measured using resistive or capacitive voltage dividers or P.Ts. A digital transient recorder with associated customized data acquisition software enables processing of the test data and preparation of test reports.

**Testing and Certification**

415V 10kA On-Line Testing Facility for MCB/RCCB Testing

Type tests and Routine tests on low voltage switchgears and controlgears, distribution transformers up to 1 MVA 11 kV class and other power system apparatus can be undertaken in the Short Circuit Laboratory as per the relevant Indian Standards (IS) and International Specifications (IEC, BS, CSA, UL, ANSI, IEEE). The laboratory is accredited by ASTA
BEAB Certification Services (Intertek) that enables ASTA Certificates to be issued to the customers.

The Laboratory has facility to carry out the following tests:

- Breaking capacity LV Circuit Breakers for 50kA rms at 460V max
- Short time withstand current test up to 50kA rms for 1 s on LT / HT Panels, Bus-ducts etc.
- Dynamic / Thermal short circuit test on Distribution Transformers up to 1 MVA 11 class
- Dynamic / Thermal short circuit test on Cables & Cable accessories
- Making and breaking capacities on Contactors and Motor starters
- Breaking capacity test on LV fuses
- Short time current test on Isolators / Earth Switches
- Short time current test on CT’s up to 132 kV class

**Supplementary Test Facility**

The laboratory has supplementary test facility to carry out pre and post short-circuit tests for the acceptance criteria. It is also equipped for other tests like temperature rise test (up to 1000 A), electrical endurance test (up to 1600 A @ 433V and up to 400 A @ 690 V), mechanical endurance test and some environmental tests (with climatic chambers up to 3 cubic meter capacity, from -45°C to +150°C temperature ranges and humidity control of 20% to 98%) as per IS: 9000.

High voltage power frequency tests up to 100kV for 1 min and induced over-voltage tests up to 1000 V and up to 200 Hz are possible to conduct at the supplementary tests laboratory. An impulse voltage generator (0 to 35 kV, 1.2/50 µs) with the necessary measuring, recording systems are also available in the laboratory to perform tests as per IEC 60060, IEC 61180 and IS 2071. Surge immunity facility is available to test LV equipment up to 6000A @ 8/20 µs and impulse voltage up to 12 kV @ 1.2/50 µs as per IEC 61000-4-12. Ring wave test at 200A, 0.5 µs / 100 kHz on RCCB, RCBO also possible at supplementary lab.

Glow wire test (up to 960°C) and ball pressure test are possible as per IEC 60695 and IS 11000.

The station also has facility to carry out electrical endurance testing on switches, circuit-breakers, contactors, etc., for up to 1600A 415V rating.

Lifting and mechanical impact test on LT panel as per IEC 61439-1 and Sound level test on Distribution Transformer up to 1.5 MVA 11kV class as per IEC 60076-10 has been added recently. Temperature rise test on Distribution Transformer up to 1.5 MVA 11kV class is also possible at supplementary lab.
Research and Development Activities

The laboratory undertakes applied research and helps in the development of indigenous products, mainly on low voltage switchgears and control gears. The laboratory is also doing R&D on performance evaluation of circuit breakers used in DC applications.

Feasibility of Tests at Short Circuit Laboratory, CPRI, Bangalore for Various Equipment as per the IS / IEC Standards / Publications / Specifications

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Apparatus No.</th>
<th>Reference to</th>
<th>Nature of Test Standards</th>
<th>Range of Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Low Voltage Circuit Breaker</td>
<td>IEC:60947-2 IS/IEC 60947-2</td>
<td>• Short Circuit Making And Breaking Capacity** • Overload Performance • Short-Time Current • Electrical Endurance</td>
<td>• AC: 3 Phase – Up to 50 kA @ 460 V (max) up to 22 kA @ 800 V (max) DC: Up to 30 kA @ 600 V (max) • AC: Up to 4/2 kA rms @ 415/800V DC: Up to 3kA dc @ 600 V (max) • AC: Up to 50 kA rms for 1.0 s/30 kA rms for 3.0 s DC: Up to 30 kA for 3.0 s • AC: Up to 1600A rms @ 460 V (max) DC: Up to 600A @ 600 V (max)</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Standards</td>
<td>Short-Time Current</td>
<td>AC: Up to 50 kA rms for 1.0 s / 30 kA rms for 3.0 s</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------------------------------------------------</td>
<td>------------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td>2</td>
<td>High Voltage Circuit Breaker</td>
<td>IEC:62271-100 IS:13118</td>
<td>Short-Time Current</td>
<td><strong>Short Circuit Breaking Capacity</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>IS:13118</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Low Voltage Fuses [HRC, Rewirable etc.]</td>
<td>IEC:60269 IS: 13703</td>
<td>Short Circuit Breaking Capacity</td>
<td><strong>AC</strong>: 50 kA rms up to 415 V 22 kA rms up to 800 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IS: 13703</td>
<td></td>
<td><strong>DC</strong>: 30kA @ 600V (max)</td>
</tr>
<tr>
<td>4</td>
<td>Circuit Breaker for Household application (MCB)</td>
<td>IEC:60898 IS/IEC: 60898</td>
<td>Short Circuit Capacity, All Type and Routine Tests</td>
<td><strong>AC</strong>: Up to 25 kA rms @ 415 V (max)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IS/IEC: 60898</td>
<td></td>
<td><strong>Up to 22 kA rms @ 800 V (max)</strong> DC: Up to 30 kA @ 600 V</td>
</tr>
<tr>
<td>6</td>
<td>Low Voltage Switches, Switch Fuse Combination Units with HBC and Rewirable Fuses.</td>
<td>IEC:60947-3 IS/IEC 60947-3</td>
<td>• Rated Fused Short Circuit Current • Rated Making and Breaking Capacity • Short-Time Current • Electrical Endurance</td>
<td><strong>AC</strong>: Up to 50 kA rms @ 460 V (max) Up to 22 kA rms @ 800 V (max) DC: Up to 30 kA @ 600 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IS/IEC 60947-3</td>
<td></td>
<td><strong>AC</strong>: Up to 4/2 kA rms @ 415/800V DC: Up to 3kA @ 800 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UL:508 CSA:22.2</td>
<td></td>
<td><strong>AC</strong>: Up to 50 kA rms for 1.0 s Up to 30 kA rms for 3.0 s DC: Up to 30 kA rms for 3.0 s</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>AC</strong>: Up to 1600A. rms @ 415 V DC: Up to 600A rms @ 600 V</td>
</tr>
<tr>
<td>7</td>
<td>Low Voltage Contactors / Motor Starters</td>
<td>IEC: 60947-4-1 IS/IEC: 60947-4-1 UL:508 CSA:22.2</td>
<td>• Rated Making and Breaking Capacity • Short-Time Current • Electrical Endurance</td>
<td><strong>AC</strong>: Up to 4/2 kA rms @ 415/800V DC: Up to 3kA @ 600 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IS/IEC: 60947-4-1</td>
<td></td>
<td><strong>AC</strong>: Up to 50 kA rms for 1.0 s / 30 kA. rms for 3.0 s DC: Up to 30 kA dc for 3.0 s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UL:508 CSA:22.2</td>
<td></td>
<td><strong>AC</strong>: Up to 1600A. rms @ 415 V DC: Up to 600A rms @ 600 V</td>
</tr>
<tr>
<td>8</td>
<td>Residual Current Operated Circuit-Breakers</td>
<td>IEC:61008 IS:12640 IEC:61009</td>
<td>All Type and Routine Tests For AC Type</td>
<td>Up to 10 kA rms</td>
</tr>
<tr>
<td>9</td>
<td>Low Voltage Switchboard, Panel, Motor-Control Centre System, Distribution Boards/Pillars, LV Bus-Ducts</td>
<td>IEC:61439 IS:8623</td>
<td>Short Time Current</td>
<td><strong>AC</strong>: Up to 50 kA rms for 1.0 s / 30 kA rms for 3.0 s (3Phase) DC: Up to 30 kA. Rms for 3.0 s</td>
</tr>
</tbody>
</table>
## Short Circuit Laboratory

| 10. Reactor/Line Traps | IEC:60289 IS:5553 IEC:60353 | Short-Time Current | AC: Single phase up to 40 kA rms for 1 s @ 460V (max)  
DC: Up to 30 kA dc for 3.0 s @ 600V (max) |
| 11. Power Connectors | IS:5561 | Short-Time Current | AC: Single phase up to 40 kA rms for 1 s / 30 kA rms for 3.0s @ 460V (max)  
DC: Up to 30 kA dc for 3.0 s @ 600V (max) |
| 12. Current Transformers | IEC 61869-1 IEC 61869-2 IS / IEC 60044-1 IS:2705 IEC 61869-3 IS:3156 | Short-time Current Tests, All Other Type and Routine Tests  
Accuracy Test  
Short-Circuit Tests | Up to 40 kA rms for 1.0 s / 30 kA rms for 3.0 s  
Up to 11kV class |
| 13. Energy Meters | IEC:62052-11 62053-11 IS:13779 14697,13010, 2675,13020 | Short-Time Over Current | Up to 10 kA |
| 14. HV Switchboard / Panel | IEC:60694 / 62271-1 IEC:62271-200 IS:3427 | Short-Time Current | AC: Three phase up to 50 kA rms for 1.0 sand up to 30 kA rms for 3.0 s  
DC: Up to 30 kA dc for 3.0 s |
| 15. HV Disconnector / Isolator and Earth Switch, HV Busduct | IS:12729 IEC:62271-102 IS:9921 IS:9920 IS:8084 | Short-Time Current | AC: Up to 30 kA rms for 1.0 s / 25 kA rms for 3.0 s  
DC: Up to 30 kA dc for 3.0 s |
| 16. Underground Cables and Accessories | IS:13573 IEC 60502 IEC 61442 | Dynamic and Thermal Short-Circuit Test | Up to 35ka rms for 1.0 s |

**Except Air Circuit Breakers (ACB)**

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**For details please contact:**

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email: skdas@cpri.in
The objective of the Electrical Appliances Technology Division is to provide testing and certification services and to take up R&D activities in the field of low voltage electrical power equipment enclosures and allied equipment. The division is playing a pivotal role in the development of quality electrical apparatus in domestic, industrial and commercial sectors through the following test facilities.

**Ingress Protection Testing Facility**

Ingress protection testing laboratory (IP Lab) undertakes testing of all electrical equipment enclosures for degree of protection provided as per IS/IEC 60529; IS/IEC 60947-1:2007; IS/IEC 61439; and IEC 60529 Edn. 2.1 2001-02;, Rotating electrical equipment machinery enclosures as per IS/IEC 60034-5 and Luminaries as per IEC 60598 and IS 10322 (part 4) -1984 etc. This entire range of test facility is accredited as per IS/IEC 17025:2005 Standard.

**Fan Testing Facility**

Fan testing laboratory undertakes tests on ceiling fans and table fans as per IS 555:1979; IS 374:1979 and IS 1169:1967 and also as per BEE Schedule for star rating under BEE’s Standards and labelling program. The fan test facility is accredited as per ISO/IEC 17025:2005 standards.

**Flame Proof Testing Facility**

Flame proof testing laboratory undertakes tests on Flame proof electrical equipment enclosures meant for use in explosive hazard environments for Exd. Gas Group I, Group IIA, IIB and IIC for safety as per IS/IEC 60079-1:2007 standard.
Battery Testing Facility

Battery testing laboratory (BT Lab) undertakes tests on automotive batteries and stationery cells as per IS 7372 -1995 (3 amnd-2007) and IS 1651 -2013. Secondary cells as per IEC 61427, tubular batteries as per IS 13369 -1992 amnd 2-2003, valve regulated lead acid batteries (VRLA) as per IS 15549 -2005 and JIS C8702-1.

Air Conditioner Testing Facility

Central Power Research Institute (CPRI), Bangalore, is the only Government check testing facility for BEE star labeled products and has a state-of-the-art research and test facility ‘Balanced Ambient Calorimeter’ (BAC) for the performance evaluation of air-conditioners up to 3 TR capacity of unitary, window and split type and non-ducted type air-conditioners and heat pumps, on par with International laboratories.

Balanced Ambient Calorimeter

The BAC Design and Construction: As per ANSI /ASHRAE 41
The BAC Performance: Compliant with the following National and International Standards
IS 1391 (Part 1 and 2) 1992
- ISO 5151:1994 E
- ANSI / ASHRAE 16-1983 (RA 99)
- ANSI / ASHRAE 37-2005
- ANSI / ASHRAE 37-2005
- ANSI / ASHRAE 37-2005
- ARI 210/240
- EN 14511-2:2004 (E) and 3:2004 (E)

The BAC’s Performance Specifications: The BAC research and testing facility achieves:

- AC capacity measurement accuracy is 3% or better.
- Heat Imbalance between indoor room side and outdoor room side is 3% or better.
- Repeatability of test results for consecutive testing of a UUT at the same conditions will yield less than 1% capacity variation for at least 90% of repeat tests.

In addition, the BAC system is equipped with special feature like:

a. Psychometric Test mode, the BACs Indoor Room is provided with “Air Flow Tunnel” (code tester), for Air Side Enthalpy measurements of UUT with repeatability yield of 1% or better.

b. Testing capabilities for day time cooling - night time heating mode performance evaluation of products with Non reversing of UUT.

c. Equipped with data acquisition and supervisory control system software (SCDA) which computes capacity, EER and COP and other results.

Refrigerator Testing Facility

Central Power Research Institute (CPRI), Bangalore, is the only Government check testing facility for BEE star labeled products and Refrigerator testing laboratory has test set up with state-of-the-art Technology to test Refrigerators of Direct Cool and Frost Free type up to 600 litres capacity. This facility has been accredited as per ISO/IEC 17025:2005 to carry out tests in accordance with National and International Standards IS1476:2000, IS:1575 IS14750 and AS/NZS 4474.1:2007. The test facility can accommodate four Refrigerators of similar type at a time for testing.

For details please contact:

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HIGH VOLTAGE DIVISION

The activities of High Voltage Division are:
- Testing
- R&D
- Consultancy relevant to High Voltage Engineering

The division comprises the following laboratories:
- High Voltage Laboratory
- Pollution Laboratory
- Impulse Current Laboratory

TESTING

High Voltage Laboratory

The High Voltage Laboratory has dimensions of 54 m (L) x 52 m (W) x 42 m (H) and an Outdoor Test Bay of area 55 m x 55 m equipped with a setup of 2 units of cascade transformers. Facilities are available for taking supply into the main laboratory for indoor tests.

Equipment Available
- Impulse voltage generator of 3 million volts. 150 kJ.
- Power frequency Cascade Transformers setup of 1800 kV (i.e. 3 nos. of 600 kV).
- Power frequency Transformers of 50 kV 30 mA and 100 kV 100mA single phase, 150 kV, 500 mA.
- 600 kV AC/RIV free coupling capacitor and 500 kV AC/RIV free coupling capacitor.
- Peak voltmeters.
- High resolution impulse analysing system.
- Digital impulse measuring system.
- One meter dia sphere gap of 1 MV (Impulse and Power frequency voltages).
- Multiple chopping gap of 1.2 million volt rating.
- Artificial rain equipment (small and big) for wet tests.
- Hot and Cold bath for temperature cycle test.
- Reference voltage divider 180 kV, AC/DC, 500 kV LI/SI.
- With the equipment installed at present, it is possible to undertake following tests on all major electrical equipment like power transformers, current transformers, potential transformers, air break switches, isolators, cables, bushings, insulators, power line accessories etc. up to and including 400 kV system.
Types of Tests

This laboratory can undertake the following tests as per National and International Standards:

- Lightning impulse voltage tests up to 2,200 kV (Peak) level.
- Chopped impulse voltage tests up to 1200 kV (Peak) level.
- Switching Impulse voltage Dry and Wet Tests up to 1500 kV (Peak) level.
- Steep front Impulse puncture test for insulators up to and including 33 kV insulators.
- Steep front Impulse flash over test on polymeric insulators up to 500 mm length as per spec. requirement.
- Corona Inception and Extinction Test and RIV measurements up to and including 400 kV system.
- Power frequency voltage Dry and Wet tests up to 1,440 kV (rms) level.
- RIV and corona tests on equipment rated up to 500 kV.
- Porosity test.
- Electro-Mechanical test up to 50 tonnes.
- 96 hour mechanical test up to 50 tonnes.
- Thermo mechanical tests on insulators
- Temperature cycle test on insulators up to and including 145 kV rating.
- Residual Voltage / Reference voltage / Power Loss measurement on full arrester up to 400 kV system.
- Performance / Comparison tests on HV measuring Systems.
- Fast transient and multi chopped tests on CTs of 400 kV rating.
- Dielectric test and RIV / Corona tests on Thyristor valves up to and including 33 kV rating.

Pollution Laboratory

The Pollution Laboratory has dimensions of 12 Mx12Mx12M. An array of nozzles confirming to IEC specifications combined with a salt water pumping and air compressor provide the required salt fog. The power supply to the chamber is from one of the outdoor 600 kV, 2,000 kVA Cascade Transformers setup. Equipment Available:

- 600 kV, 3 Amperes AC source
- 100 kV, 6 Amperes AC source
- 150 kV, 1 Ampere DC source
- 50 kV, 2 Amp AC source
With these equipment / facilities, the Pollution Laboratory can carry out tests on insulators and insulator assemblies for systems up to and including 400 kV.

**Types of Tests**

This Laboratory can undertake the following tests as per National and International Standards:

- Pollution test on insulators by salt for solid layer method up to 400 kV AC and 150 kV DC.
- SF6 Puncture withstand test facility for DC insulators.
- Thermal runaway tests on insulators.
- Ion migration test on DC insulators.
- Salt for tests on cable terminations.
- Tracking and erosion tests on polymeric insulators as per IEC 61109 and IEC 62217-2012-1000 hours.
- Hydrophobicity recovery test on polymeric insulators.
- Pollution tests on single unit and two unit zinc oxide lightning arresters as per IEC-60099-4-2004/ANSI up to and including 400kV.
- Track wheel test on composite insulators as per IEC/TR 62730-2012

**Impulse Current Laboratory**

**Quality assurance Test Facilities for Gapless ZnO Surge Arresters in High Voltage Division of CPRI, Bangalore**

**Abstract:**

Surge arrester is one of the important power system network components which is neglected the most by many utility engineers. It provides highly nonlinear V-I characteristics and high protective margins and protects the equipment from various kinds of dangerous over voltages and improves the system reliability by subjecting itself to different types of electrical and mechanical stresses. It performs the intended duty by scarifying itself. Thus it becomes very important to create the various stresses in a third party laboratory and then subject the surge arresters elements and the assembled arresters to various Type and Routine tests. This brochure thus brings out the details of the test facilities available at CPRI with the aim of providing better and efficient testing services to various utilities and manufacturers in the world.

**Gapless Zinc Oxide (ZnO) Surge arresters:**

Surge arresters constitute the primary protection for all equipment of transmission and distribution systems, from the effects of lightning and switching overvoltages. The state of the art technological developments that took place in the past few decades (both in the ZnO basic material properties on one hand and in the housing material on the other hand) demands the use of metal oxide surge arresters without gaps (the so called gapless ZnO surge arresters) in AC and DC systems. Most of the arresters installed today are all ZnO arresters without gap. The distinctive feature of a ZnO gapless arrester is its extremely nonlinear voltage-current (V-I) characteristic with no follow current, higher energy handling capability, excellent protective characteristics, higher and better short circuit handling capability, better pollution performance, better capability to handle
multiple lightning strokes, stability in V-I characteristics over a long period, thus making it possible to dispense with the older Silicon Carbide (SiC) gapped arresters. Arresters integrated into disconnect switches have also been installed at some places.

Since the gapless surge arrester is permanently connected across the equipment to be protected, it is continuously energized with normal power frequency voltage. Due to this fact, surge arresters at substations are exposed to a variety of stresses originating both from the network and from their service environment which can cause premature ageing / degradation of electrical properties or even damage to their zinc Oxide (ZnO) resistor elements. The various electrical / mechanical stresses to which the MO resistor elements may be subjected to throughout its life time are:

- Continuous operating voltage
- Operation temperature
- Rain, pollution, solar radiation
- Mechanical Bending Moment and cantilever loads due to Wind and possible ice loading as well as forces from rare events but for short period like extreme wind guts, forces due to short circuit current loads etc.
- Temporary Over Voltages, TOV
- Over voltages due to transients which affect thermal stability & ageing, energy & current Withstand capability, external insulation withstand
- Large mechanical forces, e.g., earthquakes
- Severe external pollution and finally what the arrester can be subjected to only once
- Internal short-circuit

All these stresses acting together or individually affect the arrester characteristics and subsequently its performance on the long run. So the arresters shall be designed to have sufficient capability to withstand the expected electrical and mechanical stresses throughout its life time in addition to its primary task of protecting the equipment. It must also be dimensioned to handle the current through it as well as the heat generated by the over voltages and remain thermally stable after the energy absorption. So the manufacturer has to consider all these aspects while designing the surge arresters. Hence the development, manufacture and the quality control of the Metal Oxide (MO) resistors is a very important task to be fulfilled by the manufacturers. Hence quality assurance testing of arresters in compliance with National / International standards is essential to validate the performance of the arresters. The testing of the product designed as per national and international standards in an independent third party laboratory is equally important.

In order to assess the satisfactory performance of the arresters after manufacturing, National and International standards prescribe various test methods. The basic purpose of test standards is to provide industry with a means to adequately assess that a product being brought to market is capable of providing the service for which it was originally designed. The arrester is subjected to various stresses (stresses that are experienced in service conditions) which are simulated in the laboratory and the performance is evaluated.
Testing of Surge Arresters

In order to ensure safe and intended operation and an appropriate lifetime of surge arresters, type and routine tests are to be performed. The most commonly followed standards are IEC 60099-4 and IEEE C62.11. While the type tests validate the general functionality of a surge arrester design, the purpose of the routine tests is to ensure the quality of each individual arrester unit.

Impulse Current Generator

The Impulse Current Laboratory was established in 1996 as a comprehensive facility for testing of Zinc Oxide elements and ZnO arrester pro-rated sections up to 11 kV rating as per IEC 60099-4 and IS 3070 Part III. The laboratory’s superiority lies in the fact that, it has a unique Computer-controlled Impulse Current Generator of rating 100 kV, 150 kJ incorporating all conceivable features in a single consolidated design and is perhaps the only one of its kind in this part of the world at the time of its commissioning. Fig 1(a) shows the impulse current generator.

Fig. 1(a). The Impulse Current Generator for testing arrester ZnO elements

An advanced Dr. Strauss make impulse recording system (TRAS 100-12, 4 channel, 100 MS/s, 12 bit) with advanced software for recording and analyzing impulse current and voltage and impulse current superimposed with AC voltage at varying time base (which is a unique feature required for recording voltages and currents in Operating Duty tests on arrester nonlinear elements) is a part of the test facility. Fig 1(b) shows the measuring system.
Fig. 1(b). Dr. Strauss make Measuring system

The generator is capable of generating impulse currents of wave shapes stipulated in the National / International standards. Details are given in following table.

Table 1. Impulse current generator capability

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Wave Shape</th>
<th>Current Magnitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>8/20 μS Lightning impulse</td>
<td>40kA</td>
</tr>
<tr>
<td>2.</td>
<td>4/10 μS High current impulse</td>
<td>120kA</td>
</tr>
<tr>
<td>3.</td>
<td>Rectangular impulse</td>
<td>1kA with 2 to 4mS duration</td>
</tr>
<tr>
<td>4.</td>
<td>36/80 μS Switching impulse</td>
<td>2kA</td>
</tr>
<tr>
<td>5.</td>
<td>1 / &gt;20 μS Steep impulse</td>
<td>20kA</td>
</tr>
</tbody>
</table>
With this capability of the generator all type tests on ZnO arrester elements up to 6 kV voltage rating can be carried out as per National / International Standards.

**Impulse Voltage Generator as Impulse Current Generator**

CPRI has a 15 stage impulse voltage generator of 3MV and 150kJ capacity which is generally used for dielectric testing. The generator is suitably configured with series and parallel combinations of capacitors, resistors and an additional inductor to generate the impulse currents necessary to be passed through the arrester for measuring the residual voltage. The combination of these RLC elements will generate the required impulse current wave shapes of 8/20 µS and 36/80 µS corresponding to lightning impulse and Switching impulse currents. The magnitudes are 10kA of 2kA respectively.

Fig 2 shows the test set up used for the measurement of residual voltage of a 390kV surge arrester.

![Fig. 2. Test set up for Residual volatge test on 400kV system complete arreter](image)

**Test set up for Accelerated Ageing test on ZnO element:**

The accelerated ageing test set up shown in Fig. 3 consists of a 7.5kV, 1Amp harmonics free uninterrupted High voltage Transformer with regulator, three independent ovens with temperature sensors to maintain the temperature at 115 ± 4°C to age three samples at a time as per standard, designed and fabricated by CPRI and a computerized Data Acquisition and Analyzing system to compute the power loss using measured voltage and current signals.

Using this test set up, the 1000 Hour ageing test can be carried out on ZnO elements upto 6kV rated voltage.
Thermo Mechanical Test Chamber:

Fig. 4 shows the thermo mechanical chamber for carrying out Bending moment test on arrester units. The dimensions of the chamber is 45 m x 0.15m x 1m and temperature control range is from -40ºC to +60ºC with accuracy of ± 1 ºC after stratification. The rate of heating / cooling is 1ºC per minute. The chamber temperature is controlled by microprocessor based auto time programmable controller with RS 232 interface and software for configuring and monitoring. The chamber has hydraulic system provided externally and load cell with 500kN + 500kN capacity. It has got a special mounting and loading arrangement (patent pending) made inside the temperature controlled chamber to carry out bending moment test on surge arrester units of voltage rating varying from 9kV to 156kV (maximum unit length of 2000 mm approximately). The arrangement is shown in Fig. 4.

Testing Capability:

The impulse current laboratory of the High Voltage Division of CPRI, at Bangalore has the testing capability for the full range of arrester ZnO elements and full arrester upto 390kV rating. All the tests are accredited by NABL.

Tests on ZnO Elements:

The following is the list of NABL accredited tests on ZnO elements up to 6kV class V rating as per IEC 60099-4, IS 3070 Part III and IEEE C62.11 that can be carried out.
Tests on Complete Arresters:

The following is the list of NABL accredited tests on complete arrester from 9kV upto 400kV rating as per IEC 60099-4 / IS 3070 Part III and IEEE C62.11.

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Test Name</th>
<th>Clause &amp; Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>IEC</td>
</tr>
<tr>
<td>1</td>
<td>Residual Voltage Tests on elements</td>
<td>8.3</td>
</tr>
<tr>
<td></td>
<td>- Steep Current Impulse residual voltage 1/&lt;20 µS.</td>
<td>8.3.1</td>
</tr>
<tr>
<td></td>
<td>- Lightning Current Impulse 8/20 µS.</td>
<td>8.3.2</td>
</tr>
<tr>
<td></td>
<td>- Switching impulse residual voltage test</td>
<td>8.3.3</td>
</tr>
<tr>
<td>2</td>
<td>Long duration current impulse withstand test</td>
<td>8.4.2 / 8.4.3 / 10.8.4</td>
</tr>
<tr>
<td>3</td>
<td>Reference voltage measurement</td>
<td>7.2</td>
</tr>
<tr>
<td>4</td>
<td>Power loss measurement</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>Leakage current measurement</td>
<td>-</td>
</tr>
</tbody>
</table>

Tests on Arrester Housing:

The following is the list of NABL accredited tests on arrester housing.

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Test Name</th>
<th>Clause &amp; Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>IEC</td>
</tr>
<tr>
<td>1</td>
<td>Lightning impulse withstand test on arrester housings upto 400kV system arresters</td>
<td>8.2.6 / 10.8.2</td>
</tr>
<tr>
<td>2</td>
<td>Power frequency withstand ( Dry ) test on arrester housings upto 400kV system arresters</td>
<td>8.2.8 / 10.8.2</td>
</tr>
<tr>
<td>3</td>
<td>Power frequency withstand ( Wet ) test on arrester housings upto 400kV system arresters</td>
<td>8.2.8 / 10.8.2</td>
</tr>
</tbody>
</table>
Other tests:
In addition to the above tests which are accredited, the following other tests which are likely to be accredited in due course are also conducted in the laboratory.

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Test Name</th>
<th>Clause &amp; Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>High current and switching surge operating duty test on elements</td>
<td>IEC 8.5.4,8.5.5,8.5.6 &amp; 10.8.5,6.6.4 &amp; 6.6.5</td>
</tr>
<tr>
<td>2.</td>
<td>Power frequency voltage vs time characteristics / Temporary over voltage test on elements upto 6kV</td>
<td>IEC 6.10, IS 6.6.7, IEEE -</td>
</tr>
<tr>
<td>3.</td>
<td>Duty cycle test on prorated sections upto 6kV</td>
<td>IS - 8.14</td>
</tr>
<tr>
<td>4.</td>
<td>High current short duration test on prorated sections upto 6kV</td>
<td>IS - 8.12</td>
</tr>
<tr>
<td>5.</td>
<td>Low current long duration test on prorated sections upto 6kV</td>
<td>IS - 8.13</td>
</tr>
<tr>
<td>6.</td>
<td>Temporary over voltage test on prorated sections upto 6kV</td>
<td>IS - 8.15, IEEE 6.6.7</td>
</tr>
<tr>
<td>7.</td>
<td>Discharge voltage vs current curves on prorated sections upto 6kV</td>
<td>IS - 8.3.2.1</td>
</tr>
<tr>
<td>8.</td>
<td>Accelerated ageing tests on elements upto 6kV</td>
<td>IEC 8.5.2, IS 6.6.2, IEEE 8.5.2.2</td>
</tr>
<tr>
<td>9.</td>
<td>Artificial pollution test on arresters</td>
<td>Annex F, Annex I, IEEE -</td>
</tr>
<tr>
<td>10.</td>
<td>Weather ageing test on polymer arresters</td>
<td>IS 10.8.14, IS -</td>
</tr>
<tr>
<td>11.</td>
<td>Environmental test on arresters</td>
<td>IS 10.8.10, IS -</td>
</tr>
<tr>
<td>12.</td>
<td>Radio interference test on arresters</td>
<td>IS 8.12, IS 8.10</td>
</tr>
<tr>
<td>13.</td>
<td>Seal integrity test on arresters</td>
<td>IS - 8.9</td>
</tr>
<tr>
<td>14.</td>
<td>Long duration current impulse withstand test on Disconnectors</td>
<td>IEC 8.6.2.1, IS 8.8.2a, IEEE -</td>
</tr>
<tr>
<td>15.</td>
<td>Operating Duty Test on Disconnectors</td>
<td>IEC 8.6.2.2, IS 8.8.2b, IEEE -</td>
</tr>
<tr>
<td>16.</td>
<td>High current short duration test on Disconnectors</td>
<td>IS - 8.21.2.1</td>
</tr>
<tr>
<td>17.</td>
<td>Low current long duration test on Disconnectors</td>
<td>IS - 8.21.2.1</td>
</tr>
<tr>
<td>18.</td>
<td>Duty cycle test on Disconnectors</td>
<td>IS - 8.21.2.1</td>
</tr>
<tr>
<td>19.</td>
<td>Seal leak rate test as per IEC 60099-4</td>
<td>IS 8.11, IS 10.8.11, IEEE 13.4</td>
</tr>
<tr>
<td>20.</td>
<td>Accelerated ageing test on polymer arresters with exposure to salt fog</td>
<td>IS - 8.7</td>
</tr>
<tr>
<td>21.</td>
<td>Accelerated ageing test on polymer arresters with exposure to light and electrical stress</td>
<td>IS - 8.6</td>
</tr>
<tr>
<td>22.</td>
<td>Contamination test</td>
<td>IS - 8.8</td>
</tr>
</tbody>
</table>

**R&D ACTIVITIES**

- Corona and radio Interference studies
- Pollution studies under AC and DC condition on insulators
- Pollution studies on zinc oxide surge arresters
- Ageing studies on RTV coated insulators and composite insulators
- Performance evaluation of polymeric insulators for its life expectancy
- Design and development of H.V. measuring systems e.g. voltage divider, Spherical electric field strength meter, Ion current meter, low inductance resistive divider, Spherical electric steep-front impulses, Step Wave Generator, High Current shunts, Impulse measuring systems, etc.
- Studies on Ion-migration in insulator under DC voltage
- Development of HVDC Insulators for optimal performance under polluted conditions
- Development of Silicon Rubber composite insulators for high voltage transmission system

**CONSULTANCY SERVICES**

- Pollution level measurements at sites enrouting transmission line.
- AC electric and magnetic field measurements under transmission lines and sub-stations.
- DC electric and magnetic field and ionic current measurement under transmission lines and sub-stations.
- Computation of electric and magnetic fields, corona loss, radio interference, audible noise, etc., for different configurations of transmission lines.
- Online leakage current measurement of lightning arresters in generating stations/substations.

Electric field and voltage distribution around high voltage equipment like connectors, insulators, arresters, etc.,

**For details please contact:**

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email: aradya@cpri.in
The Instrumentation Division has been engaged in contemporary R&D activities, consultancy services and provide testing and certification facility for energy meters and calibration services.

Research and Development

Projects undertaken are by either CPRI or sponsored by utilities, government institutions, private organizations and small-scale industries (SSI). Technology is transferred to interested entrepreneurs.

The division has been actively involved in R&D over the past three decades and has acquired expertise in the following areas:

- Energy Metering
- Power Sector Communication
- Automatic Meter Reading

Some of the R&D projects completed are listed below:

i. Prepaid Energy Meter
ii. Street Light Controller-Stand alone & Radio sensed
iii. Time Synchronizing unit for EHV sub station
iv. Automatic Meter Reading (AMR) system
v. Communication channel on HT feeder
vi. Effect of Harmonic Influence on Electronic Energy Meters
vii. High voltage spark discharge unit for energy meter testing

Some of the products have been developed in the above areas and technology for energy meter development was transferred to several manufacturers:

Testing Facilities

The division is equipped with state-of-the-art instrumentation to cater to the testing and calibration services through the following laboratories:

- Energy Meter Testing Laboratory (EMTL)
- Calibration Lab
- Mobile Testing Lab for energy meter testing at site

The laboratories in the division are traceable to ISO/IEC 17025 Bureau of Indian Standards (BIS) has recognized Energy Meter Testing lab.

High Precision Programmable AC Power Source
Energy Meter Testing Lab (EMTL)

Accurate billing of the consumed power is important not only to the utilities but also to the consumers. It is therefore, doubly important that the meters used for recording energy consumption are accurate and reliable, which calls for compliance of meters to specified standards. Therefore, the utilities and meter manufacturers need to ensure compliance and desirable quality of supplies.

CPRI on its part facilitates in the task of achieving quality through its Energy Meter Testing Laboratory. This laboratory undertakes “TYPE TESTING” of electromechanical meters and electronic meter of accuracy class 0.2 to 2.0 as per National / International standards and also carry out performance test of sub-standard meters. Besides TYPE TESTING, the EMTL do carry out ACCEPTANCE TEST and ROUTINE TESTS as per the utility requirement.

CPRI has setup the comprehensive Energy meter test facility to cater to the needs of manufacturer / Industry. The laboratory is equipped with the state-of-the-art test equipments / systems, which meets the requirements of International standards. The accuracy testing is carried out on a fully automated system. The lab is equipped with high accuracy and high precision equipment. The lab provides test facilities for Static and Electromechanical single-phase / three-phase energy meters and Trivector meters. Multifunction meter, TOD, ABT meters etc. The lab is traceable to ISO/IEC 17025 and also recognized by Bureau of Indian Standards (BIS). The facility is extensively used by utilities and meter manufacturers. The energy meter testing facility is also extended for developmental assistance as a measure to help the manufacturer to improve and ensure their specified function before arriving at their final product.

EMTL offers credible and quality service which is being availed by utilities in India, manufacturers based in India and abroad. Foreign customers representing Saudi Electric Co. (SEC), Bangladesh, South Africa, and Sultanate of Oman have availed our services.

The EMTL provides comprehensive testing for meters as per the following National / International standards with the latest amendments.

i. IEC 62052-11:2003-General requirements, tests and test conditions Part 11: Metering equipment

ii. IEC 62053-11:2003-Electromechanical meters for active energy (classes 0.5, 1 and 2)

iii. IEC 62053-21:2003-Static meters for active energy (classes 1 and 2).

iv. IEC 62053-22:2003-Static meters for active energy (classes 0.2 S and 0.5 S)

v. IEC 62052-23: 2003-Static meters for reactive energy (classes 2 and 3)

vi. IS 13010:2002 – Electromechanical (ac WH) meters-Class 0.5, 1.0 and 2

vii. IS 13779:1999 – ac Static WH meters-Class I and 2.0 (Reaffirmed 2004)
viii. IS 14697:1999 – ac Static Transformer operated WH and VARH meters – Class 0.2 S, 0.5S (Reaffirmed 2004)
ix. CBIP Report No.304 – Standardization of AC Static Electrical Energy Meters
x. IS15884:2010-ac direct connected static prepayment meters for active energy(class 1 & 2)

Automatic Meter Test Bench

The major equipment for Energy Meter testing at CPRI are:
i. Multi position Fully Automatic meter test benches with 0.05 & 0.02 class Ref. meters.
ii. Static source capable of testing meters upto 200A
iii. Precision Reference energy standards of class 0.05 and 0.1.
iv. Combined waveform Generator(7kV).
v. Surge Generator (10 KV).
vi. EMI/EMC test set up.
vii. Glow wire Apparatus.
viii. Climatic Chamber (Dry/Cold/Humidity).
ix. AC/DC magnetic Coil.
x. Short time over current Set up.

The EMTL also provides consultancy services in the following areas:

i. Mobile Testing of energy meters at site as per IS 15707:2006 is offered from RTL, Noida. The Mobile test facility is accredited as per ISO 17025-2005

ii. Third party inspection of energy meters.

iii. Investigation and analysis of Tampered meters referred by Utilities, Judicial courts, Police department etc.

iv. **Calibration Laboratory**

CPRI has set up a state-of-the-art calibration service and traceable to IEO/IEC 17025 for energy and power parameters.

The laboratory is equipped with a digital source of 0.01% accuracy and a Ref. comparator of 0.01 Class. The lab has rendered services to many power utilities and meter manufacturers for calibrating Ref. Standard meter and issue calibration certificate.
<table>
<thead>
<tr>
<th>Reference Energy Meters</th>
<th>EMI Receiver</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multi position Fully Automatic meter test bench with 0.02 class Ref. meter.</td>
<td>Automatic portable power source with 0.05 class reference meter</td>
</tr>
<tr>
<td>Comparator of 0.01 Class</td>
<td>Digital source of 0.01% accuracy</td>
</tr>
</tbody>
</table>

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Joint Director, Instrumentation Division  
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email: hbabu@cpri.in
The activities of Utility Automation Research Centre (UARC) come under Consulting, Testing, Research and Training. The teams consisting of qualified Engineers are handling the tasks of each of those activities and are delivered through various sections described in detail.

**Laboratory**

The UARC has two unique state-of-the-art laboratories for testing of various communication protocols for conformance of products:

**A. Substation Automation System Laboratory [SAS Lab]**

This laboratory is accredited by UCA IUG [Utility Communication Architecture International User Group] as Level A (Third party independent test laboratory). The laboratory (FIG. 1) services include testing of IED [Intelligent Electronic Device] for conformance in accordance with IEC 61850, the standard titled “Communication Networks and Systems in Substations”. Many manufacturers avail the services of this laboratory.

**B. Metering Protocol Laboratory**

This laboratory carries out conformance testing of energy meters to IEC 62056 (DLMS/ COSEM) and as per IS 15959 - Indian Companion Specification for Energy Metering protocol. This Protocol Laboratory (FIG 2) is unique in its kind in this part of the world. Many Utilities, meter manufacturers and system integrators avail the services of this laboratory.

**c. DNP3 Certification Testing Laboratory [DNP Lab]**

This laboratory carries out conformance testing of DNP3 Subset Level 1 or DNP3 Subset Level 2 as per the procedure defined in DNP3 Intelligent Electronic Device (IED) Certification Procedure Subset Level 1 Version 2.6 rev1 28-October-2010 and DNP3
INTELLIGENT ELECTRONIC DEVICE (IED) CERTIFICATION PROCEDURE SUBSET LEVEL 2 VERSION 2.6 REV1 28-OCTOBER-2010. THESE TEST PROCEDURES ARE DEFINED FOR OUTSTATION DEVICES LIKE RTU/IED/PLC CERTIFICATION ONLY. CPRI IS A REGISTERED MEMBER AS A INDEPENDENT TESTING AGENCY UNDER DNP3 USERS GROUP (HTTP://WWW.DNP.ORG), A GROUP COMPOSED OF UTILITIES AND VENDORS WHO ARE UTILIZING THE PROTOCOL.

FIG 2. Metering Protocol Laboratory

Consulting

The division is in to consulting since 2005 and has been handling automation in power and hydro. CPRI was empanelled as consultant for SCADA projects under RAPDRP. Some of the important automation projects are:

- SCADA Consultancy service for the seven towns of Andhra Pradesh DISCOMs.
- Project Management Consultancy Service for Bangalore City DAS project for BESCOM, a project funded by JICA.
- Integrated Extended SCADA project for KPTCL covering over 1200 substations, 16 control centres, with main and Disaster Recovery Control Centres spread over the entire state of Karnataka with a mix of communication technologies.
- Consultancy for implementation of SCADA for water supply to Mysore for KUWSDB.
- Preparation of DPR for Cochin City Automation.

Smart Grid

The involvement in the automation and protocols has positioned CPRI to provide consultancy in to the smart grid without any difficulty. It was awarded the maiden smart grid project in India –
The design and development of smart grid pilot for BESCOM supported by USAID.

This consultancy assignment covered site selection, development of DPR, PPP model and RFP. The DPR listed the functionalities, provide the design covering complete requirements for IT architecture with feature, Communication architecture for end to end connectivity, the RE integration, Automatic Metering Infrastructure including Home Area Networking, Outage management and Peak management, Condition Based Monitoring (CBM) of Asset and consumer web portal. The DPR has also brought out the benefits in qualitative and quantitative terms.

CPRI also prepared the DPR for the smart grid project of AP CPDCL, the Utility in Andhra Pradesh. Recently this utility awarded the Project Management Consultancy work of this smart grid pilot project planned at Jeedimetla an Industrial area to CPRI.

CPRI has initiated the establishment of Smart Grid Test Bed for performance evaluation of systems, products and technologies for smart grid designs. For this USTDA [United State Trade and Development Agency] would support in the development of DPR for subsequent implementation.

Training

This division has been offering training programmes from time to time. The areas include Metering Protocol, Substation Automation Protocol, Communication for power engineers and the like. Besides, training programmes, conferences and workshops are organized on futuristic areas and topics of national importance.

Research

UARC has been working in the research projects for Advanced Metering Infrastructure by way of studying the issues associated with communication technologies and to bring out the benchmark parameters. This work also would cover specific custom designed test tools. UARC contributes significantly in the standardisation of metering and automatic metering infrastructure.

IT Services

This division also provides IT support by way of webhosting, webmail, IT infrastructure and facility management services. It also hosts and maintains a “Knowledge Management Portal (Gyanshakti)” for sharing and seeking knowledge, expertise and experience.

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The Diagnostics, Cables and Capacitors Division is mainly engaged in testing, consultancy and research and development activities relating to cables, capacitors, diagnostic testing of HV substation and power station equipment. The Division is also equipped with the facilities for temperature raise test and insulator materials testing.

The Division consists of the following laboratories:

- Insulation Diagnostics Laboratory
- Cables Laboratory
- Power Capacitors Laboratory
- Heat Run Test Laboratory
- Flame Retardant Low Smoke Laboratory
- Insulation Materials Laboratory

**DIAGNOSTICS LABORATORY**

The Laboratory is equipped with the facilities for conducting condition assessment / life evaluation of High Voltage Power Equipment like Power Transformers, Hydro & Turbo Generators, Power Cables, Large AC Motors, Current Transformers (CTs), Capacitance Voltage Transformers (CVTs), Circuit breakers, Lightning arrestors etc. in service. The Laboratory has adequate experience & expertise in conducting Diagnostic testing and Condition Assessment Studies on High Voltage Substation and Power Plant Electrical Equipment in service. Diagnostics Laboratory is an accredited laboratory as per ISO 9001:2000 Quality Management System for undertaking field engineering services and consultancy for various utilities.

**Test Equipment / Facilities:**

- Recovery Voltage Meter
- Electromagnetic Core Imperfection Detector (ELCID)
- HV Dielectric Spectroscopy
- VLF Tan delta Cable Diagnosis system
- Oscillatory Wave Testing System (OWTS) for detection & location of Partial discharge sites in long length MV power cables
- Transformer Turns Ratio Meter
- Standard Capacitor, 80kV
- Precision microprocessor based Insulation tester, up to 5 kV
- Automatic Capacitance & Tan delta test system
- Surge Comparison tester
- DC Test kit – 100kV, 5mA
- Partial Discharge Detection system
- Electronic Wedge mapping equipment
- Rotor Reflectometer
- Testing Transformers
- Winding Resistance Meter
- Current Transformer Analyser
- Primary injection system for accuracy testing of Current Transformers (Up to 2000A)
- Sweep Frequency Response Analyser
- Leakage Current Monitor for Lightning Arrestors.
- Leakage Reactance Module
- Circuit Breaker Analyser (Up to 200A)

### DIAGNOSTIC TESTS

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Product / Apparatus</th>
<th>Type of Tests Conducted</th>
</tr>
</thead>
</table>
| 01.   | **Power Transformer** | - Polarization Index Test  
- Dielectric loss angle & Capacitance at 50 Hz  
- Frequency Domain Analysis (Dielectric spectroscopy)  
- Recovery Voltage Measurement  
- Sweep Frequency Response Analysis  
- Partial Discharge Test (On-line: Acoustic Emission Technique)  
- Excitation current Measurement  
- Short Circuit Impedance measurement  
- Conductor Resistance Measurement  
- Transformer Turns Ratio Measurement |
| 02.   | **Generators / Large motors**  
**Stator** | - Dielectric loss angle at 50 Hz  
- Capacitance at 50 Hz  
- Partial Discharge Test  
- DC Leakage current Test  
- Polarization Index Test  
- Conductor resistance Test  
- Surge Comparison Test  
- Electromagnetic Core Imperfection Detector (ELCID) Test  
- Automatic Wedge mapping Test |
<table>
<thead>
<tr>
<th></th>
<th>Rotor</th>
<th>Rotor Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.</td>
<td>Rotor</td>
<td>Polarization Index Test</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recurring Surge Oscillogram (RSO Test)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Conductor Resistance Test</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Field Impedance test</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pole Drop Test</td>
</tr>
<tr>
<td>4.</td>
<td>Power cables</td>
<td>Frequency domain analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dielectric loss angle at 50 Hz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Capacitance at 50 Hz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VLF (0.1 Hz) tan delta test</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DC Leakage current test</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Partial Discharge incipient fault detection &amp; location at VLF (0.1Hz)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Partial Discharge incipient fault detection &amp; location by employing oscillatory wave (damped ac) technique</td>
</tr>
<tr>
<td>5.</td>
<td>EHV CTs/VTs</td>
<td>Dielectric loss angle at 50 Hz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Polarization Index Test</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Capacitance at 50 Hz</td>
</tr>
<tr>
<td>6.</td>
<td>Resin cast CTs (Up to 33kV)</td>
<td>Insulation Resistance / Polarization Index</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tan-delta &amp; Capacitance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Partial Discharge test</td>
</tr>
<tr>
<td>7.</td>
<td>Resin cast VTs (Up to 33kV)</td>
<td>Partial Discharge test</td>
</tr>
<tr>
<td>8.</td>
<td>Circuit Breaker</td>
<td>Dynamic Contact Resistance (wherever feasible)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Static Contact Resistance (wherever feasible)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Load Operating Timings</td>
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<tr>
<td></td>
<td></td>
<td>Simultaneous Opening of Poles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Contact Bounce During Operation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Operating Coil Resistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Operating Coil Insulation Resistance</td>
</tr>
<tr>
<td>9.</td>
<td>Lightning Arrestors (on-line Test)</td>
<td>Third Harmonic Resistive Leakage Current Measurement</td>
</tr>
</tbody>
</table>

### MOBILE TEST LABORATORY FOR ON-SITE ACCURACY TESTING CTs & VTs

CPRI has established the unique Mobile Test Laboratory for on-site accuracy testing of EHV class CTs and VTs. The mobile unit is equipped with the facilities for conducting on-site accuracy testing of CTs and VTs (up to 0.2 class) as per National / International standard. The mobile unit is fitted with high accuracy and high precision test equipment, current and voltage sources of appropriate ratings for testing of CTs and VTs up to 400kV rating both in substations and power stations. The mobile unit is also equipped with automatic system for measurement of Tan delta and Capacitance on CTs & VTs. Period testing and trend monitoring in the dielectric properties would go a long way in assessing ageing status of the CTs & VTs and thereby enhancing reliability and availability of the system.
## NATIONAL / INTERNATIONAL STANDARDS / GUIDELINES

<table>
<thead>
<tr>
<th>Apparatus / Equipment</th>
<th>Standards / Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generator / Motors</td>
<td>IEEE 43 – IEEE Recommended practice for Testing IR of Rotating Machinery</td>
</tr>
<tr>
<td>Stator</td>
<td>IEEE 95 – IEEE recommended practice for Insulation testing of AC Electric machinery with High Direct Voltage</td>
</tr>
<tr>
<td>Rotor</td>
<td>IEEE 1434 – IEEE Trial use guide to the measurement of partial discharges in rotating machinery.</td>
</tr>
<tr>
<td>Power Cables</td>
<td>As per National/International practices and as per Clients requirement, IEEE 400.2 &amp; IEEE 400.3 for VLF &amp; OWTS testing</td>
</tr>
<tr>
<td>Accuracy Testing of Current Transformers / Voltage Transformer</td>
<td>As per National/International practices and as per Clients requirement CTs-IS 2705 VTs-IS 3156</td>
</tr>
<tr>
<td>Capacitor Voltage Transformers / Potential Transformers</td>
<td>As per National/International practices and as per Clients requirement</td>
</tr>
</tbody>
</table>

### Consultancy:-

Consultancy through field testing:

- a. Test facilities for undertaking condition monitoring & diagnostic tests on HV power equipment in order to assess the state & condition of their insulation systems.
- b. Mobile Field Testing Laboratory with diagnostic test facilities for conducting diagnostic tests on HV power Equipment at site.
- c. Failure analysis of HV power equipment.
Involved in renovation & Modernization (R&M) & Residual life Assessment (RLA) / Life Extension (LE) studies on Thermal / Hydro Power Plant Electrical Equipment.

**Research Contingency Project:** “Detection and Localization of impending faults in MV power cable system employing Partial Discharge Technique”

A new on-site diagnostic test facility for Power Cables using Oscillatory Wave Technique has been recently established by CPRI. With this advanced diagnosis facility, incipient faults in MV Cables and their positions along the cable length can be detected accurately.

![A view of on-site testing of power cables by employing Oscillatory Wave Technique](image)

### Cables Laboratory

**Test Facilities:**

- Testing of underground Power Cables and accessories like indoor and outdoor terminations and straight through joints XLPE cables up to 400 kV rating
- Paper insulated lead sheathed cables, up to 33 kV rating
- Elastomer insulated cables from 3.3 kV to 33 kV rating
- PVC insulated and PVC sheathed electric cables from 1.1 kV to 11 kV rating
- P.D. tests on CTs, Las, bushing up to 132 kV rating
- Tan delta measurements on CTs, Bushing up to 220 kV rating
- Impulse tests on Power Cables, Capacitors etc., up to 66 kV rating
- Field testing of XLPE Cables. Capacitance measurement, conductor resistance and sheath resistance measurements
- Pre Qualification tests on XLPE Cable system up to 400 kV Voltage Rating

Cables laboratory carries out fire reaction tests on electric cables, insulating and composite materials like PVC/XLPE cable insulation/sheath materials, fibre reinforced composite materials used for cable tray, channels: feeder pillar boxes, bushing, supporting insulators, energy meters,
PVC conduit pipes, flooring materials, fabrics, and material used in aerospace etc. Some of the important test facilities include:

- Limiting Oxygen Index (Ignition property of Plastics) as per ASTM D2863, NCD 1410, IS10810(P-58), IS 13501.
- Temperature Index (Temp withstand before ignition) as per ASTM D2863, IS 10810 (P-64).
- HCL (Acid gas content in plastics) as per IEC 754-1.
- Zero halogen Acid Test by pH and conductivity as per IEC 754-2.
- Smoke Density (smoke evolved, and light transmission, visibility underfire). As per ASTM D 2843, ASTM E 662, IEC 601034, IS 10810 (P-63) standards.
- Fire resistance test (Circuit integrity under fire conditions) as per IEC 331.
- Flammability Test (The property of propagating fire)as per ASTM, UL, IS and Canadian standards.
- Heat Release measurements using Cone Calorimeter

**Test Equipment / Sources**

- 600 kV, 600 kVA Partial discharge free series Resonant test set
- 100 kV, 20 kVA (P.D.) Partial discharge free test source and associated accessories
- Partial discharge measuring and analysing system, ERA model and pulse discrimination system
- 500 kV, 15kJ Impulse voltage generator
- Micro processed based capacitance and tan delta bridges transformer ratio arm bridges, the standard capacitors up to 600 kV for dielectric loss measurement of High Voltage Insulation
- High Voltage A.C. sources with associated regulators and controls up to 300 kV, 120 kVA
- High Precision automatic insulation resistance measuring kit
- 200 kV water termination for testing of EHV cables
- Splicing machines for preparation of cable insulation samples for physical tests
- Electronic weighing balance 200 gm of 0.1 mg accuracy.
- Profile projector of magnification up to 100.
- Outdoor AC Test system 4200kVA, 600 kV
- Indoor 600 kV ac Resonant test system
- Impulse Voltage test system 2400kV peak, 240kJ
- 30V, 4000A, 1 ph current loading system with capacitive compensation
- Digital Micro ohmmeter
- 20 kN Tensile Testing Machine
- Data logger with Fibre Optic Sensors
- Omicron MPD 600 Partial discharge detector with 600 kV coupling Capacitor
- Soil thermal resistivity measuring instrument
Fourier Transform Infrared Spectrometer
- 500 HZ, 60 KV ac test system
- Cone Calorimeter
- Toxicity Test Apparatus
- Bunched Cables Flammability Chamber
- 3 metre cube smoke Chamber

**Consultancy**
- Failure analysis of Power Cables.
- Failure analysis of Power Cable Accessories.

**Research and Development Capabilities:**
- Any specific problem on Power Cables and accessories.
Power Capacitors Laboratory

Power Capacitors Laboratory of CPRI, Bangalore has established state-of-the-art facilities to cater to the requirements of Capacitor Manufacturers within the country and abroad for Research, Testing and Evaluation of Power Capacitors which have applications as shunt capacitors, series capacitors, surge protection capacitors, motor capacitors, fan capacitors, fluorescent capacitors, etc. Tests are carried out as per National and International Standards and also developmental tests as per Customers’ requirement. Laboratory also has facilities for undertaking tests on filter reactors and series damping reactors associated with LV capacitors. The laboratory with the unique facilities is the first of its kind in this part of the world. Recently, facilities for testing LV APFC panels have been augmented including temperature rise test.
RESOURCES

(a) Parallel Resonance Transformer of Rating: 50/40/30/20 kV ac, 6.8 MVA.
(b) Parallel Resonance Transformer rating: 70 kV ac, 1750 KVA.
(c) HVDC Source of rating: 150 kV 500 mA.
(d) Discharge current test setup for Series Capacitors

(f) 3 Phase testing transformer of rating: 2640/1760/880 V, 600 KVA ac
(g) 3 Phase Transformer of rating: 975 KVA, 2.5 kV ac.
(h) HVDC power supply: 0-35 kV, 1A
(i) High Accuracy Capacitance/tan delta bridge system: Accuracy: 3.5x10E-5.
(j) Standard Capacitor: 1000 pF, 25 kV.
(k) Precision Current Comparator up to 5000 A.
(l) Hot Air Oven: 1.8m x 1.8m x 2.0m (W x D x H), Amb to 150°C, Accuracy: 1°C.
(m) Climatic test Chamber: Size: 2.00m x 2.20m x 2.50m (WxDxH), Temp: -70°C to 100°C, Accuracy: 1°C, Humidity: 10% to 95%, Accuracy: 2% RH.
(n) Impulse generator of rating: 500 kV 15 KJ for HV capacitors
(o) Impulse generator of rating 18 kV, 250 Joules for LV Capacitors,
(p) Harmonics Generator and filter.
(q) High current probes (3000 A)
(r) Multi function digital recorder
(s) Multichannel (120) data logger

MAJOR TESTS

- Output test / Capacitance & tan delta test
- High Voltage Tests
- Short Circuit discharge test
- Test for discharge device
- Thermal stability test
• Sealing test
• Impulse voltage withstand test
• Self healing test on MPP capacitors
• Charge discharge test on LV capacitors
• Destruction test on LV capacitors
• Discharge current test for Series capacitors
• Disconnecting test on Internal fuses
• Electrical Endurance test for HV capacitors - Over voltage cycle test & Ageing test
• Endurance test on LV capacitors - Ageing test, Charge discharge cycle test & destruction test
• Dielectric tests for LV APFC panels
• Temperature test on LV APFC panels
• Environmental tests on various equipment: Electrical, Mechanical, Automobile, Medical, ATMs, etc.
• Temperature rise test on Line Traps up to 2000 Amps

TESTING OF LV APFC PANELS

Tests on LV APFC panels are carried out as per IEC 61921 and IEC 61439. The temperature rise test will be carried out on APFC panels with all capacitor units, detuned/damping reactors, if any, and other components connected. Temperature rise test can also be carried at elevated ambient temperature of 55 °C. The general ratings covered for testing are 3-phase 440 V APFC panels of output ratings 25 kvar, 75 kvar, 150 kvar, 200 kvar, 350 kvar, 375 kvar, 400 kvar, 450 kvar, 500 kvar, 800 kvar. Any other in-between ratings can also be tested.

ENVIRONMENTAL TESTS

Environmental tests are carried out on various electrical and non-electrical equipment / components / materials as per IEC 62271-100, IEC 60068-2-1, IEC 60068-2-2, IEC 60068-2-14, IEC 60068-2-30, IEC 60068-2-78, TEC-QM 333, etc.
- Low and High temperature test
- Cold test
- Dry heat test
- Damp heat - Humidity cycle test
- Thermal shock test
- Measurement of temperature co-efficient of capacitance and tan delta, etc.
- Environmental tests as per customers protocol

**TYPE & RANGE OF CAPACITOR TESTING:**

<table>
<thead>
<tr>
<th>Capacitor</th>
<th>Maximum Rating</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>HV Shunt capacitors (For Routine and Type tests)</td>
<td>3500 kvar, 16 kV, 50 µF</td>
<td>IS 13925 Pt 1 – 1998, IEC 60871 Pt 1 – 2005, IEEE Std. 18 – 2002</td>
</tr>
<tr>
<td>HV Shunt capacitors (For Endurance test)</td>
<td>1000 kvar, 20 kV, 8µF</td>
<td>IS 13925 Pt 22002 IEC 60871 Pt 2 – 1999</td>
</tr>
<tr>
<td>HV Series capacitors (For Routine and Type tests)</td>
<td>3500 kvar, 20 kV, 50 µF</td>
<td>IEC 60143 – 1: 2004 IEC 60143 – 3: 1998</td>
</tr>
<tr>
<td>HV Series capacitors (For Cold duty test)</td>
<td>1000 kvar, 16 kV, 12µF</td>
<td>IEC 60143 – 1: 2004 IEC 60143 – 3: 1998</td>
</tr>
<tr>
<td>HV Capacitors for surge Protection.</td>
<td>0.33 µF, 40 kV</td>
<td>IS 11548 – 1986 (Reaffirmed Mar 2006).</td>
</tr>
<tr>
<td>LV Motor capacitors</td>
<td>100 x 10 µF, 440 V ac</td>
<td>IS 2993 – 1998 IEC60252 -1-2001</td>
</tr>
<tr>
<td>LV fan motor Capacitors</td>
<td>100 x 10 µF, 440 V ac</td>
<td>IS 1709 – 1984 (Reaffirmed Mar 2006 Amendment No. 2)</td>
</tr>
<tr>
<td>LV APFC Panels</td>
<td>500 KVAR, 440 V</td>
<td>IEC 61921, IEC 60439</td>
</tr>
<tr>
<td><strong>CAPACITORS FOR POWER ELECTRONICS</strong></td>
<td></td>
<td>IEC 61071- 2007</td>
</tr>
<tr>
<td><strong>CAPACITORS FOR RAILWAY APPLICATIONS – ROLLING STOCK EQUIPMENT</strong></td>
<td></td>
<td>IEC 61881-1999</td>
</tr>
</tbody>
</table>
RESEARCH AND CONSULTANCY

1. Development of Indian Standard Specification for LV APFC Panels – Bureau of Indian Standards (BIS), New Delhi, Sponsored R&D project.
2. Study of switching transients associated with capacitor switching
4. Selection of appropriate type of LV capacitors for LV distribution system.
5. Review of Specification for HV and LV capacitor banks
6. Root cause analysis of premature failure of capacitors
7. New product development
8. Consultancy and field engineering services for On-Line partial discharge measurement on power transformers in services.
9. Any specific problem of Power Capacitor Manufacturers, Utilities, Academic Institutions etc.

ACCREDITATION

The facilities of CPRI are accredited as per ISO/IEC 17025 quality norms and the institute has acquired international accreditations viz., Intertek ASTA and UL. CPRI is a member of Short Circuit Liaison.

Heat Run Test Laboratory

Test Facility

Temperature rise test up to 10,000 Amps millivolt drop and resistance tests (wherever applicable) from 1.0 micro ohms to kilo Ohms can be conducted on the following equipment, as per Indian (BIS) IEC, ANSI of ASTA standards.

- Distribution Boards
- LT and HT Bus ducts
- Isolators
- Circuit Breakers
- Control Panels
- Switches and Connectors
- CTs and PTs
OLTCs
Overhead Conductors and Connectors
Heat cycle test on Conductors for Overhead Power lines metal fittings of insulators for overhead Power lines, insulator and Conductor fittings of overhead Power lines
Current cycle test on Electrical connector for Overhead conductors

The laboratory has been accredited by:

i. ISO 17025-2005
ii. IEC EE CB Scheme
iii. Bureau of Indian Standards (BIS) Scheme
iv. ASTA BEAB certification Services, U.K.

Flame Retardant Low Smoke (FRLS) Laboratory

Test Facilities

The Flame retardant low smoke cables laboratory carry out fire reaction tests on electric cables, insulating and composite materials like PVC/XLPE cable insulation / sheath materials, fibre reinforced composite materials used for cable tray, channels: feeder pillar boxes, bushing, supporting insulators, energy meters, PVC conduit pipes, flooring materials, fabrics, and material used in aerospace etc. Some of the important test facilities include:

- Limiting Oxygen Index (Ignition property of Plastics) as per ASTM D2863, NCD 1410, IS10810(P-58), IS 13501.
- Temperature Index (Temp withstand before ignition) as per ASTM D2863, IS 10810 (P-64).
- HCL (Acid gas content in plastics) as per IEC 754-1.
- Zero halogen Acid Test by pH and conductivity as per IEC 754-2.
- Smoke Density (smoke evolved, and light transmission, visibility underfire). As per ASTM D 2843, ASTM E 662, IEC 601034, IS 10810 (P-63) standards.
- Fire resistance test (Circuit integrity under fire conditions) as per IEC 331.
- Flammability Test (The property of propagating fire) as per ASTM, UL, IS and Canadian standards.

**Toxity Index Test**

To determine and quantify the various toxic gases released during combustion of electric cables as per NCD 1409 and NES 713 standards.

**Cone Calorimeter Test**

To characterize the unwanted fire by determining the various parameters like:
- Rate of heat release
- Rate of heat release per unit area
- Mass loss rates
- Time loss rates
- Time-to ignition
- Effective heat of combustion Rates of release of toxic gas release
- Critical ignition flux as per ISO 5660 and ASME 1354 standards Co, CO2 production rates etc.
INSULATION MATERIALS LABORATORY

The Insulation Materials laboratory has comprehensive, testing and evaluation facilities for solid insulating materials and systems. Insulating materials are evaluated and tested for electrical, mechanical and physical properties. This laboratory has undertaken consultancy work and sponsored projects for different power utilities and industries. Evaluation of class “H” insulation for traction motors, compatibility studies on enamelled winding wires and varnish were two projects completed for RDSO, Ministry of Railways respectively. Assistance has been rendered to BIS, in formulation of various standards on enamelled winding wires and insulating materials and systems. This laboratory has rendered consultancy employing FEM approach.

Test Facilities Available:

I. Apparatus / Equipment for Electrical Test:
   - AC Dielectric Strength/Breakdown Voltage Test apparatus up to 100 kVAC
   - Rubber glove tester
   - Higher resistance meter up to 1016 Ohms
   - Insulation Tester (kW-G)
   - Micro-Ohm Meter (iW-mW)
   - Power frequency capacitance and dissipation factor measuring bridge
   - High frequency capacitance and dissipation factor measuring bridges
   - Electrometer
   - Static Decay meter

II. Apparatus / Equipment for Mechanical Tests:
   - Microprocessor based UTM 50 KN (-70⁰ C to 200⁰ C) (Tensile, Compression, Shearing, Flexural/Cross breaking, Adhesive strength tests)
   - Tear Tester
   - Impact Tester/Stress Cracking Equipment (Izod, Charpy method)
   - Surface Roughness Meter

III. Apparatus / Equipment for Electro-chemical Tests:
   - Automatic Tracking Index Analyser up to 1000 VAC
   - Automatic Arc resistance tester
   - Liquid contaminant tracking and erosion test equipment
   - Weather-o-meter

IV. Other Facilities:
   - Environmental Facilities
   - Air circulating oven (up to 250⁰ C)
   - Compression Moulding machine (400⁰ C)
Areas of Work:

- Electrical, mechanical and chemical tests on various solid insulating materials like paper, press board, polymeric moulding materials, Insulating coating, B-stage epoxy mica, epoxy glass materials etc.
- Electrical and mechanical tests on conductor, Armour wire etc.
- Almost all tests on enamelled / winding wires including endurance tests.
- Electrical tests on cable filling compound, capacitor fluids etc.
- Electrical tests on polypropylene, polyester, kapton, Teflon films.
- Electrical tests on antistatic materials.
- Electro static field computations using FEM.
- UV Radiation and Hydrolytic stability tests.
- Environmental Conditioning of insulating materials.
- Ageing studies on insulating materials.

Clientele

Facilities are extensively used by State Electricity boards, Thermal Power Stations, Hydro Power Stations, Nuclear Power Stations, Petro Chemical Plants, Process Industries and the like.

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DIELECTRIC MATERIALS DIVISION

This division is having three laboratories, Liquid dielectric laboratory, Lubricating oil laboratory and Polymer laboratory catering to the needs of the power sector and others.

LIQUID DIELECTRICS LABORATORY (LDL)

- Transformer oil serves as a coolant, insulant and as a medium for condition monitoring of the transformer. Transformer oil deteriorates in service due to oxidation, thermal and electrical stresses and hence, has to be periodically monitored for its condition. LDL has facilities to test the new oils based on petroleum, vegetable oil esters, synthetic esters and others. The lab is popular for diagnostic evaluation of transformer oils for incipient fault diagnosis (Dissolved Gas Analysis, DGA) and also solid insulation condition assessment (Furan Analysis). Details of the testing and standard test methods are as follows.
  - Testing & Certification of New oils for transformers as per IS 335 & IS 12463 for acceptance purposes.
  - Testing of New oils for transformers as per IEC 60296 – 2012.
  - Testing of Unused synthetic organic esters for electrical purposes as per IEC 61099-2010.
  - Testing of unused natural esters for transformers and similar electrical equipment as per IEC 62770
  - Consultancy services and third party inspection for New oils.
  - Compatibility of transformer construction materials with mineral oil as per ASTM D 3455.
  - Evaluation of condition of In-Service oils as per IEC 60422 & IS 1866-2000 for maintenance purposes.
  - Analysis of furans in In-Service oils as per IEC 61198 – 1993 for assessing the condition of solid insulation of transformers.
  - Mobile test facility for carrying out tests on In-Service oils as per IS: 1866 -2000.
  - Undertaking Research Projects on transformer oils.
  - The laboratory is equipped with sophisticated test equipment like:
    - Ultra Performance Liquid chromatograph
    - Gas chromatographs with FID,TCD & ECD detectors
    - Auto titrator
    - Automatic Pour Point apparatus
    - Automatic Breakdown tester
- Wavelength Dispersive X-Ray Fluorescence Spectrometer (WDXRF)
- Megohmmeter
- Moisture meter
- Automatic Viscometer
- Automatic Interfacial Tensiometer
- Particile Sizer and counter
- Abbe Refractometer
- Oxidation stability apparatus
- High Performance Thin Layer chromatograph
- FTIR Spectrophotometer with ATR
- UV-Vis spectrophotometer
- Automatic Flash Point apparatus
- GC with ECD & MS for PCB analysis
Lubricating oils work in improving the performance of machines by reducing the friction, keeps the moving metallic parts away from rubbing each other and keeping the environment cool and clean. Lube oil lab focuses on evaluation of oils used in turbine oil lubrication and hydraulic oils used widely in power sector. Laboratory evaluates the lubricants as per ASTM D 4378 & ASTM D 4304 and Hydraulic oils as per the ASTM D 6158. Various test facilities like Foaming characteristics, water separatability, air release value, rust prevention characteristics, rotating pressure vessel oxidation stability flash point apparatus, copper strip corrosion test and other test facilities. Environmentally important tests such Gas Chromatograph with electron capture detector and mass spectroscopic detector would help in accurately evaluating the oils for hazardous chemicals such as Poly Chlorinated Biphenyls in various lubricating and other oil matrices.
Polymer Laboratory

Polymers have been used extensively in power sector. Performance of these polymeric composites need to have correct assessment in various working conditions. The laboratory has state of art facilities in evaluating the polymeric composites for their weight change profile with temperature (Thermo Gravimetry Analyser, TGA), heat evolution and absorption profile of composite with temperature (Differential Scanning Calorimetry, DSC), dimension change profile with temperature (TMA), infrared spectroscopic evaluation of polymeric materials (FTIR), heat deflection temperature evaluation (HDT) and other associated instrumentation is available in the laboratory.

Laboratory undertakes evaluation of composites for thermal, thermo mechanical and calorimetric profile evaluation with temperature which helps in identifying polymers and their performance under various operating conditions. Division is having R&D projects in high performance polymeric composites, nano dielectric composites for capacitor applications and other sponsored projects.
Sponsored and Research Projects in the Division

This division is also handling an international project co-ordinated by MOEF and UNIDO on management of Poly Chlorinated Biphenyls and their final disposal. The project aims in fulfilling the objectives of Stockholm Convention.

PCB Project progress presentation during Board of Directors meet at UNIDO Vienna Austria.

This division is also having research and developmental projects in the areas of high performance polymeric composites, vegetable ester based transformer oil development, high concentration PCBs and their de-chlorination, Transformer oil online gas chromatographic dissolved gas evaluation, sol gel chemistry and development of nano fillers and other unique research activities.

For details please contact:

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The Materials Technology Division of CPRI is equipped with advanced and sophisticated facilities aimed at providing testing, R&D capabilities and consultancy services in the areas of materials engineering for the power sector covering coal and other fuels, materials characterization, assessment of remaining life of thermal and hydro power plant components, failure analysis, wear, erosion and corrosion studies and environment studies including industrial solid waste utilization.

MTD has progressed and formed a domain of its own and is comprising of the following broad areas.

(i) **Fuel Evaluation** - coal quality characteristics, coal combustion studies, CFD modeling & performance audit for TPS.

(ii) **Materials Engineering and Characterization** – Materials evaluation using analytical Facilities viz. SEM, XRD, XRF, Microscopy, Spectroscopy and evaluation of electrical steels.

(iii) **Condition Assessment and Remaining Life Estimation** - Evaluation of thermal and hydro plant components involving advanced Nondestructive Evaluation (NDE), corrosion mapping, piping and hanger inspection, field metallography and material identification, Fibroscopy, IR thermography, internal rotary inspection system.

(iv) **Mechanical Engineering and Wear Testing** - Creep, hardness, tensile strength, fatigue, impact, residual stress, wear and erosion studies, structural Integrity & Failure Analysis Studies damage tolerance studies)

(v) **Center for Industrial Solid Waste Utilization (CISWU)** - value added products from fly ash and cenospheres, establishment of technology demonstration centers, condition assessment of civil structures of hydro and thermal plants, evaluation of Electrostatic Precipitator.

**THRUST AREAS OF RESEARCH**

- Studies on coal blends (raw, washed and imported coals) for improvement of power plant performance
- Fuel combustion reactivity and modelling studies
- Development of novel techniques for condition assessment of power plant components
- Evaluation of SC / USC materials
- Studies on CRGO and CRNGO electrical steels for transformer applications
- Development of Graphene based materials and coatings for power applications
- Thermal spray coatings for silt and cavitation erosion of hydro plant components
- Studies on improvement of life expectancy of high temperature plant components to wear, erosion and corrosion.
- Development of Value added products from fly Ash and cenospheres.
**TESTING AND CONSULTANCY SERVICES**

**I) Fuel Evaluation**
- Proximate Analysis (moisture, VM, FC, ash)
- Ultimate Analysis (C, H, N and S)
- Gross Calorific Value (GCV)
- Ash Fusion Temperature
- Ash Composition
- Mercury in coal
- Abrasion Index (YGP)
- Hard Grove Index (HGI)

**Consultancy offered:**
- Assessment of methodology of sampling and analysis of coal
- Techno-economic evaluation of use of washed coal and imported coal blend with raw coal

**Burning Profile of Fuels**
- Combustion Evaluation of Coal and Biomass using Drop Tube Reactor
- Dynamic coal balancing studies
- Combustion modelling of power plant boiler
- Coal Abrasion Index (YGP) test rigs for Coal wear parameters

**II) Materials Engineering and Characterization**
- Surface morphology, microstructure and composition analysis through SEM-EDX and X-ray Fluorescence
- Phase analysis by materials by X-Ray Diffractometry (XRD)
- Surface area analysis (BET)
- Mercury porosimetry

**Consultancy offered:**
- Plasma sprayable powders for power applications
- Evaluation of porcelain insulator materials

**III) Condition Assessment and Remaining Life Estimation**
- Remaining Life Assessment of power plant components by NDT (UT, LPI, MPI, Fibroscopy)
- IR thermography
- Corrosion Mapping of water wall tubes
- Pipes and hangers inspection and stress analysis
- Field metallography - in-situ replication and hardness
- Boiler bank tube inspection by iRis
- In-situ Material grade identification

**Consultancy offered:**
- Performance assessment of coal mills, cooling towers
- Flow modelling studies of water flow in sumps
- Optimization studies of flue gas distribution in ESP ducts
- Performance optimization studies of combine cycle plants
- Physical modelling of Electrostatic precipitators

**IV) Mechanical Engineering and Wear Testing**
- Accelerated stress rupture / creep testing of boiler components - 40kN and 1000°C
- Mechanical properties evaluation of materials (hardness, tensile strength, impact, bending, flattening)
- Fatigue and fracture properties (S-N curve, Plane strain fracture toughness (KIC), Elastic plastic fracture toughness (JIC), fatigue crack growth rate.
- Micro-structural degradation studies on in-service plant components
- Residual stress measurements on engineering components
- Corrosion behaviour of materials.
- Tribological studies using Pin-On-Disk, Rubber wheel abrasion test, Air Jet erosion, Slurry erosion, Taber abrasion, four ball wear test, silt erosion and cavitation test rigs

**Consultancy Services Offered:**
- Failure analysis of industrial and plant components
- Damage tolerance studies of rotor shafts
- Assessment of Wear and erosion life of high temperature boiler components.
- CFD Modelling studies of erosion and prediction of critical erosion intensity regions in hydro turbines, coal burners, ID fans etc.
- Design and development of high velocity silt erosion test rigs
- Creep life estimation of in-service boiler components

**V) Center for Industrial Solid Waste Utilization (CISWU)**
- Product Strength testing apparatus (100 Ton)
- Tap density
- Ultra Pycnometer for true density
- Building products manufacturing unit
- Tile making unit
- Pultruder
- Injection molding machine
- Compression molding machine
Materials Technology Division

- Autoclave
- High tempering sintering facility (1000°C)
- Comprehensive characterization of fly ash and product development

Consultancy Services Offered:
- Comprehensive characterization fly ash cenospheres
- Electroless coating on cenospheres (Nickel, Copper, Silver)
- Evaluation of collapse of ESP structure
- Condition assessment of civil structures of thermal and hydro plants
- Comprehensive Industry Document (COINDS) for coal / lignite thermal power plants
- Establishment of technology demonstration centers for fly ash utilization
- Techno-environment feasibility report on integrated waste to energy
- Evaluation of bio-mass power plants
- Studies for improvement of technology for manufacture of fly ash bricks

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MECHANICAL ENGINEERING DIVISION

This division is engaged in the study of Mechanical Engineering problems in the electric power transmission systems so as to achieve economy, reliability and also offer solutions for the recurrent problems experienced by the power utilities. Consultancy services for evolving optimized transmission line tower designs and vetting/approval of tower design are also undertaken.

In addition, this division has got the following laboratories to conduct R&D work and also to provide testing facilities to the manufacturers of transmission towers, line components and accessories etc.

The Mechanical Engineering Division of CPRI has been accredited by the “National Accreditation Board for Testing and Calibration Laboratories” (NABL), Govt. of India, on the basis of its compliance to ISO/IEC: 17025 series in the field of mechanical testing. Mechanical Engineering Division consists of the following laboratories.

TOWER TESTING STATION (TTS)

- Tower Testing Station
- Structural Material Testing Laboratory
- Design Cell/ Consultancy Services
- TOWER TESTING STATION (TTS)

VIBRATION LABORATORY

- Vibration Laboratory (40 m test span )
- Wake Simulation Laboratory (80 m test span)
- Test facilities for overhead line components
- Test facilities for substation components

Tower Testing Station (TTS)

To provide adequate tower testing facilities in Power Sector, CPRI, set up its Tower Testing Station in 1976. This Station is open for commercial tests as well as for R&D oriented tests. The decision of the CPRI in setting up the Tower Testing Station has been fully justified since there is huge demand for tower tests. Already more than 600 towers had been successfully tested within a span 35 years as per India and International Standards.

Tower Testing Station (TTS)

- Test bed with Permanent Footings to withstand the complex loads/forces like Uplift, Compression, Bending, Torsional Moments and Shear etc., encountered during testing of towers.
- Permanent Anchor Structures of adequate capacity to take Transverse, Longitudinal and Vertical pulls to be applied on to the test towers.
• Facilities for applying any combination of given loads at specified increments.
• Load and deflection measurement facilities.
• Remote and precise reading of measuring instruments.
• Facilities for calibration of the measuring instruments.

**Salient Features of Tower Testing Station (TTS)**

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<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>1. Tower Types that can be tested</td>
<td>Square, Rectangular and Triangular base</td>
</tr>
<tr>
<td>2. Maximum base width</td>
<td>26m x 26m square base</td>
</tr>
<tr>
<td></td>
<td>22 x 11m rectangular base</td>
</tr>
<tr>
<td>3. Cross arm width</td>
<td>42 m (end to end)</td>
</tr>
<tr>
<td>4. Maximum height of anchor point</td>
<td>53m (taller tower up to 75 m tested successfully)</td>
</tr>
<tr>
<td>5. Maximum overturning moment</td>
<td>25000 t-m</td>
</tr>
<tr>
<td>6. Maximum pull per conductor</td>
<td>55 T</td>
</tr>
<tr>
<td>7. Erection facility</td>
<td>Tower Crane, Cap: 16 t, Ht: 78 m and Jib: 60m</td>
</tr>
<tr>
<td>8. Load measurement</td>
<td>Strain gauge type load cells/ Digital</td>
</tr>
<tr>
<td>9. Load application and control</td>
<td>Through PLC, SCADA (48 Channel)</td>
</tr>
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<td>10. Deflection measurement</td>
<td>Optical (Electronic Theodolite)</td>
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<tr>
<td>11. Calibration facility</td>
<td>600 kN capacity UPM (AMSLER SWISS MAKE)</td>
</tr>
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<td>12. Maximum loading Capacity (Winches):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Direction</td>
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<td></td>
<td>Transverse</td>
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<td>Longitudinal</td>
</tr>
<tr>
<td></td>
<td>Vertical</td>
</tr>
<tr>
<td>13. Stub Load per Leg</td>
<td>650 T</td>
</tr>
<tr>
<td>14. Requirements</td>
<td>Conforms to IS : 802 (Part III)/ IEC : 60652</td>
</tr>
<tr>
<td></td>
<td>Customer Requirements</td>
</tr>
<tr>
<td>15. Guaranteed Accuracy</td>
<td>+/- 1% for load, +/- 5mm for deflection</td>
</tr>
</tbody>
</table>

**Facilities at TTS:**

**600 KN Universal Testing Machine** (Amsler – Wolpert make) has Traceability to National Standards. NPL, New Delhi has been used for calibration / load verification of transducers used for tower testing and other transmission line accessories and hard ware like insulators, insulator strings, clamps, cables, etc.

**Load application** through electrical winches (both remote and local operation possible) and control through PLC/SCADA with 3 channel video monitoring and auto report generation.

**Load Measurement** by strain gauge type load cells having an accuracy of less than ±1%.

**Deflection Measurement** using electronic optical theodolite and graduated scale with 5 mm accuracy.
**Video Monitoring** and recording facility using 3 cameras for all-round viewing of test tower and play back facility.

**Tower Erection** using Tower crane of 60m jib length, Ht. of 78m with a cap. of 4.8t at 60 m jib provided. An erection contractor is identified for the purpose of erection of towers. The option of engaging the erection contractor or own erection gang is left to the discretion of the customers.

**Strain Measurement of critical tower members:** Twenty channel static indicator, hooked up to a computer and a 100 channel interface system for critical member of test tower.

**Structural Fabrication Facility**

Tower Testing Station has a work shop with facilities for cutting, welding, drilling, punching, grinding, etc. also stocked good quantity of standard angle sections of both MS and HT and bolts and nuts used as immediate replacement of the failed members which can be availed on returnable basis by the client.

i. **220 kV D/C type “AAC8” tower**

The 220kV D/C type “AAC8v” tower with +12 m Leg Extension referred by Nanjing Steel Tower Manufacturing Co. Ltd, China for their end customer ISA – Transmantaro, Peru, South America has been successfully tested at Tower Testing Station of CPRI. The maximum height of the tower was **74.5m**.

![220kV D/C Type “AAC8” Tower](image)

**Fig. 1. 220kV D/C Type “AAC8” Tower**

ii. **765V S/C type “A” tower**

The 765kV S/C Type “A” tower (Vertical / Horizontal Configuration) referred by M/s. Power Grid Corporation of India Ltd, Gurgaon, for its line Salem – Madhugiri Transmission line project has been successfully tested at Tower Testing Station of CPRI. The maximum height of the tower was **65m**.
III. 66V D/C type “DD” Steel pole

The 66 kV D/C Type “DD” steel pole (single side cross arm) referred by M/s. Gee Kay Infrastructure Ranipet, Tamilnadu, for their end customer M/s. KPTCL Bangalore has been successfully tested at Tower Testing Station of CPRI.

IV. 132V D/C Suspension type steel pole

The 132 kV D/C Suspension type steel pole referred by M/s. Valmont Structures Ltd, Pune for their end customer M/s. MSTCL Nashik has been successfully tested at Tower Testing Station of CPRI.
STRUCTURAL MATERIAL TESTING LABORATORY (SMTL)

The Structural Material Testing Laboratory aptly compliments the tower testing station. A sophisticated Universal Testing Machine (UTM) with a facility of force and position control using computer has been used for the verification of test facility for load measuring devices, testing and development activities. A broad range of materials, alloys, composites and transmission line accessories has been incorporated as per relevant standards. Also, used for pre / post testing calibration of load measuring equipment, this is a pre-requisite for full scale testing of transmission towers.

<table>
<thead>
<tr>
<th><strong>SALIENT FEATURES OF UTM</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Type of Machine</strong></td>
</tr>
<tr>
<td><strong>2. Make</strong></td>
</tr>
<tr>
<td><strong>3. Capacity</strong></td>
</tr>
<tr>
<td><strong>4. Application</strong></td>
</tr>
<tr>
<td>a) Calibration</td>
</tr>
<tr>
<td>b) Possible tests</td>
</tr>
<tr>
<td><strong>5. Load Ranges (in tons)</strong></td>
</tr>
<tr>
<td><strong>6. Clamping Device</strong></td>
</tr>
<tr>
<td><strong>7. Control system</strong></td>
</tr>
<tr>
<td><strong>8. Free clamping device</strong></td>
</tr>
<tr>
<td>a) Maximum</td>
</tr>
<tr>
<td>b) Minimum</td>
</tr>
<tr>
<td><strong>9. Free Column spacing</strong></td>
</tr>
</tbody>
</table>
10. Gripping capacity
   a) Flat specimen 0 to 60 mm
   b) Cylindrical 3 to 60 mm diameter

11. Gripping Length 90 mm

12. Span for Bend tests
   a) Maximum 1150 mm
   b) Minimum 200 mm

13. Double Shear Specimens
    Diameter 5 to 25 mm in steps of 1 mm
    Length (Minimum) 135 mm

14. Hard copy facility Plot of Load Vs. Deflection / Time

**TEST RIG**

The test rig, complete with anchor, pulley blocks, electrical winches, load measuring instruments etc., provides a versatile facility to test long samples of insulators, conductors, wire ropes etc. The facility of 80 ton test rig has been used with an electrical winch. The test rig complete with anchor pulley blocks, electrical winches, load measuring instruments etc., provides a versatile facility to test ropes, insulators / insulator strings, long conductor samples, accessories and similar structures.

**Salient Features of Test Rig**

<table>
<thead>
<tr>
<th>1. Type of Sample</th>
<th>ACSR Conductor, Insulators Strings, Conductors, Insulator fittings, Long samples of steel wire ropes, guy wires and rope like structures.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Parameters</td>
<td>130 m</td>
</tr>
<tr>
<td>Maximum length</td>
<td>80 T</td>
</tr>
<tr>
<td>Maximum load</td>
<td>i) 40 T Anchorage – 2 Nos.</td>
</tr>
<tr>
<td>Equipage</td>
<td>ii) 80 T Anchorage – 1 No.</td>
</tr>
<tr>
<td></td>
<td>iii) 80 T Lead block – 1 No.</td>
</tr>
<tr>
<td></td>
<td>iv) Sheave pulley block for load Multiplication - 2 Nos.</td>
</tr>
<tr>
<td>3. Load application</td>
<td>5 T capacity electric winches with multi-sheave pulley blocks</td>
</tr>
<tr>
<td>4. Load Measurement</td>
<td>Strain gauge type load cells and Digital Indicators</td>
</tr>
<tr>
<td>5. Applications</td>
<td>a) Commercial: Testing of long samples Like ACSR conductor, Insulators Strings, Conductor / Insulator fittings and rope like Structures for ultimate strength, Testing of Long samples of steel wire ropes and rope Like structures.</td>
</tr>
</tbody>
</table>
b) R&D: The test rig can be used for determining the mechanical properties of steel wire ropes and ACSR conductors as part of Research activity.

| HYDRAULIC POWER PACK/ RAM | PLC Controlled  
|---------------------------|------------------
| Capacity : 100T           | Stroke : 750 mm  
| Speed : 1 – 50 T/Min.     |

This Hydraulic Ram provides a versatile facility to test insulator strings of all configurations (like ‘I’ ‘V’ and Quad) and other non-standard hardware samples.

**VIBRATION LABORATORY**

Vibration in transmission lines is a major concern caused due to natural wind, which cannot be eliminated but be controlled. CPRI has a well-equipped vibration laboratory for studying vibration and other mechanical problems with forced excitation systems. The laboratory has carried out extensive investigations in this field and successfully developed methods to effectively damp the vibrations. These methods relate to such aspects as location of dampers, self-damping of conductors, passive damping methods etc.

This laboratory has a test rig with a clear span of 40 m to carry out the damper efficiency test on single conductor/ earth wire. The Research and Testing on Polymer Insulators are being carried out as per relevant International Standards. The vibration laboratory of CPRI has been accredited on the basis of its compliance to ISO/IEC: 17025 in the field of mechanical testing. Vibration Laboratory is open for product development and commercial testing and certification of various types and makes of vibration dampers and other transmission line accessories.

This Laboratory is also equipped with all the mechanical facilities for the research/ product development/ testing of not only related to transmission line products but also others in general. Some of typical test facilities are shown in photographs below:

**Salient Features**

**Test Span:** 40 m  Equipped with

**Electro Dynamic Shaker System**  
Rating – 150 Kgf  
Frequency – up to 4.0 k Hz  
Displacement – 50 mm (Pk-Pk)  
Velocity – 1.8 m/Sec  
Acceleration- 1009 m/sec²

**WAKE SIMULATION LABORATORY**

The Wake Simulation Laboratory has been established to undertake R&D and testing activities on bundle conductors, spacer dampers and other transmission line accessories. This is a unique facility in the country for testing bundle conductors.
This laboratory has a test rig with a clear span of 80m confirming to IS, IEEE and IEC standards. It has suitable anchorages to string bundle conductors to appropriate tensions and also has all facilities for conducting tests on spacer dampers, bundle conductors, line accessories etc. Fatigue/Vibration testing of single, double, triple and quadruple insulator strings (both suspension and tension type) is undertaken. Facility also available for Vibration Test on Assembly insulator strings and hardware up to 765 kV HVAC and ± 800 kV HVDC transmission line with six bundle conductor configuration.

Salient Features

**Test Span:**

80 m (Bundle Conductors) Equipped with

**Electro Mechanical Shaker System**

Eccentric shaft type
DC motor operated Thyristor control drive
Frequency – 3 to 30 HZ
Amplitude – 1.0 mm to 50.0 mm (Pk-Pk)

**Test Facilities For Overhead Conductors and Accessories**

A facility has been established to take care of all the type tests of ACSR / AAAC Conductors both in-house and field testing / inspection as per relevant National / International Standards. The facility also includes:

- Tensile Testing Machine
- Torsion Testing Machine
- Hydraulic loading Equipment
- DC Resistance measuring Equipment
± 800 kV ‘Y’ Suspension Insulator String With Six Conductor Bundle Configuration
The research work carried out has the main objective of developing better design of transmission structures by the use of new configurations, new materials and new types of structures etc. The following are the some of the completed research projects.

i. Feasibility studies of six phase transmission line (mechanical aspects).
ii. Standardisation of transmission towers.
iii. Rationalisation of steel sections for tower economy.
iv. Investigation of failure of 220 / 400kV towers.
v. Probability based design of transmission of line towers.
vii. Dynamic analysis of transmission line towers.
viii. Design and development of telescopic mast.
ix. Optimum design of tower foundation using Geo grid for weak soils.
x. 132 kV Compact pole design.
xii. Development of optimal bracing pattern for transmission line towers.
xiii. Testing of full scale concrete structure.
   i. Performance evaluation of vibration dampers
   ii. Dynamic behaviour of twin / quad spacer dampers
   iii. Evaluation of self-damping capacity of ACSR conductors
   iv. Dynamic performance of conductors and line hardware
v. Fatigue performance of insulators / strings  
vi. Online monitoring and analysis of field vibration of transmission lines  
-vii. Evaluation of stress- strain curve for ACSR Conductor  
-viii. Study of vibration performance of double tension insulator string subjected to wind induced motion  
ix. Design and Development of 6-R dampers  
-x. Self-damping measurement of ACSR and AAAC conductors  
-xii. Field vibration monitoring of transmission lines for Power Grid  
-xiii. Performance evaluation of polymer insulators used in 400 kV AC and ± 500 kV HVDC Transmission lines

**DESIGNED AND DEVELOPED TRANSMISSION LINE TOWER USING FRP COMPOSITE FOR THE FIRST TIME IN INDIA**

In recent years, building new transmission lines has been difficult. Often, the biggest impediment to a transmission project is securing a ROW (Right of Way) access. It is advantageous to both transmission line developers and landowners to minimize the space required for a transmission line. Support structures play a vital role on the transmission of power from generating station to substation within the available corridor. New types of structures for a transmission line are to be developed in order to reduce the dimensions of the line both in the horizontal and vertical directions. Compact transmission line design is the result of this space-saving strategy. New transmission lines are designed to take up less lateral space by utilizing modern materials and altering tower geometries. These structure in the modern designs are simpler and required less space, reducing their visual impact. These designs reduce phase to phase and phase to structure distances, which in turn increase voltage gradients on conductors and reduced flashover voltage thresholds.

For the first time in the country, CPRI developed first full scale 66 kV D/C FRP Composite transmission tower with insulated cross arm and tested successfully by simulating all the specific loading conditions. This composite tower is also tested for electrical performance under dry and wet conditions. The weight of tower is approximately one third of steel counterpart which can be easily and rapidly assembled, transported and erected at the site. This tower can also be used as an ERS (Emergency Restoration Structure) tower and can be used as a regular power line support structure where there are constraints in ROW (Right of Way) and prone to earthquakes.

The leg members, bracings and the cross arm members of the tower are made from E-Glass and Epoxy resin through pultrusion manufacturing process. These materials were chosen based on their strength characteristics as well as their availability. Suitable structural connections have been developed to assemble and dismantle the tower structure quickly and also to ensure safe transfer of loads.

**Advantages**

1. Light weight & Easy to assemble with modular construction
2. Reduction in transportation & labor cost for erection at the site.
3. FRP tower with insulated cross arm reduces ROW requirement.
4. FRP insulated cross arm suitable for up-rating/up-grading of existing metallic tower
5. ROW savings of about 17 % and tower height reduction about 20 %
6. Reduced man hours and equipment’s to build the tower.

Although building the next generation transmission line tower from composite material is feasible, there is a need to study the long term degradation of the composite, when it is exposed to a harsh environment. The development of FRP composite tower was funded from CPRI Research Contingency grants.
DESIGN CELL / CONSULTANCY SERVICES

Design Cell caters to the design, analysis, and checking of support structures of transmission lines. With a sophisticated computer, reliable software and a team of dedicated engineers, the cell undertakes design of towers for new transmission lines, analysis and checking of towers designed earlier for further optimization of weight, checking the adequacy of existing towers for uprating a line, redesign of existing towers with least modifications for upgrading, design of special towers like multi-circuit towers, narrow based towers, rectangular based towers, triangular based towers, monopole structures etc. Several such projects were completed successfully in the past and several others are being executed.

COMPUTER SOFTWARE FACILITIES

i) CPRI TOWER ANALYSIS & DESIGN SOFTWARE (CTADS)
ii) STRUCTURAL ANALYSIS & DESIGN SOFTWARE (STAAD –Pro 2004)
iii) AutoCAD 2011
iv) FEM Software – MSC.NASTRAN / MSC.Marc
v) PLS-CADD (Tower, Pole)

LIST OF COMPLETED CONSULTANCY PROJECTS (Partial list)

2) Design of 220 kV D/C DA, DB, DC & DD type towers to M/s. ICOMM Tele Ltd, Hyderabad for M/s. Nepal Electricity Authority, Katmandu
3) Design of 220 kV D/C PV0, PV15, PV30 & PV60/DE type towers to M/s. New Modern Technomech Private Ltd, Orissa for M/s KSEB, Thiruvananthapuram
5) Design of 220 kV, 110 kV & 66 kV Multi-circuit towers to M/s. Karnataka Power Transmission Corporation Ltd, Bangalore
6) Design approval of 220 kV, 132 kV Multi-circuit & Double circuit towers to M/s. APTRANSCO Hyderabad, Bangalore

7) Design approval of 220 kV, 66 kV Multi-circuit & Double circuit towers to M/s. HVPNL Haryana

8) Design Checking / Analysis of 400 kV D/C DA, DB, DC & DD type towers to M/s. K.Ramachandra Rao Transmission & Projects Private Ltd, Hyderabad for M/s. HVPNL


10) Design Checking / Analysis of 400 kV D/C QA, QB, QC & QD type towers to M/s. Chhattisgarh State Power Transmission Company Limited, Raipur

11) Design Checking / Analysis of 400 kV D/C QA, QB, QC & QD type towers to M/s. Kalpataru Power Transmission Ltd, Gandhinagar for M/s. HVPNL

12) Design Checking / Analysis of 220 kV Quad circuit NMA, NMB, NMC & NMD type towers to M/s. K.Ramachandra Rao Transmission & Projects Private Ltd, Hyderabad for M/s. HVPNL

13) Design Checking / Analysis of 400 kV D/C DA, DB, DC & DD type towers to M/s. Larsen & Toubro Ltd, ECC, Chennai.

14) Design Checking / Analysis of 132 kV D/C DA, DB, DC & DD type towers to M/s. Aster Private Ltd, Hyderabad for M/s. HVPNL

For details please contact:

Shri. D. Revanna
Joint Director, Mechanical Engineering Division

Central Power Research Institute
Bangalore-560 080
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email: d_revanna@cpri.in
The earthquake Engineering and Vibration Research Centre is equipped with necessary facilities for providing testing, research and consultancy services in the areas of seismic and vibration qualification of instruments / electrical equipment for power plants and substations as well as manufacturers and utilities in the field of aerospace, railways and automobiles as per National and International Standards.

**TEST FACILITY FOR SEISMIC QUALIFICATION OF EQUIPMENT**

- This centre consists of state of the art Tri-axial Shaker system with 6 degrees of freedom, with 128 channel data acquisition system, experimental modal analysis software and finite element analysis software.
- The centre is capable of performing a diverse range of seismic and vibration tests on equipment, sub-assemblies and components. The centre is fully equipped to enable R&D and product development to meet the seismic requirements stipulated in national and international standards.
- The tri-axial shaker system with six degrees of freedom is capable of performing a diverse range of seismic qualification test requirements on equipment, sub-assemblies and components. These tests are intended to qualify the test samples regarding their seismic qualification requirements.
- The facility conforms to IEEE 344, IEC 60068-3-3 and other International Standards.
- The main features of the tri-axial shaker system:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Table Size</td>
<td>3.0 x 3.0 m</td>
</tr>
<tr>
<td>b. Mode of Axis</td>
<td>TRI-AXIAL</td>
</tr>
<tr>
<td>c. Degrees of Freedom</td>
<td>Six (3 translatory + 3 rotational motion)</td>
</tr>
<tr>
<td>d. Pay Load</td>
<td>10 T</td>
</tr>
<tr>
<td>e. Max. Height of the specimen</td>
<td>10 m</td>
</tr>
<tr>
<td>f. AXIS</td>
<td></td>
</tr>
<tr>
<td>Displacement</td>
<td>± 150 mm</td>
</tr>
<tr>
<td>Velocity</td>
<td>± 1000 mm/s</td>
</tr>
<tr>
<td>Acceleration</td>
<td>± 1 g</td>
</tr>
</tbody>
</table>
Earthquake Engineering & Vibration Research Centre

DYNAMICS LABORATORY

I. Vibration Test Systems

Vibration test systems are used for the design of components, equipment and for experimental verification of their safe functional capability under vibrational and shock loads in accordance with national and international standards.

**Brief Specifications**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force rating (Sine)</td>
<td>26.7 kN</td>
</tr>
<tr>
<td>Frequency range</td>
<td>5 to 3500 Hz</td>
</tr>
<tr>
<td>Displacement (Peak to Peak)</td>
<td>50.8 mm</td>
</tr>
<tr>
<td>Velocity (Peak)</td>
<td>1800 mm/s</td>
</tr>
<tr>
<td>Acceleration levels (Peak)</td>
<td>100 g (Bare Table)</td>
</tr>
<tr>
<td>Types of Vibration</td>
<td>Sine, Random, Sine on Random, Random on Random and Shock</td>
</tr>
<tr>
<td>Mode of Vibration</td>
<td>Vertical and Horizontal</td>
</tr>
</tbody>
</table>
II. Climatic chamber with vertical vibration interface

*Brief Specifications*

<table>
<thead>
<tr>
<th>Test chamber material</th>
<th>Stainless steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume</td>
<td>1000 litres</td>
</tr>
<tr>
<td>Temperature</td>
<td>-70°C to +180°C</td>
</tr>
<tr>
<td>Accuracy</td>
<td>± 0.5° K in Space and time</td>
</tr>
<tr>
<td>Humidity accuracy</td>
<td>± 5%</td>
</tr>
<tr>
<td>Rate of change of temperature</td>
<td>10° C/min. average</td>
</tr>
<tr>
<td>Maximum weight of specimen</td>
<td>100 Kg</td>
</tr>
</tbody>
</table>

The facility is useful in examining the performance of components instruments when they are subjected to change in temperature, humidity and vibration.

III. Drop Testing Machine

Drop testing machine is capable of studying behaviour of equipment and adequacy of packaging when they are subjected to Mechanical drop or sudden jerks in transportation. It is PC controlled equipment with built in calibration facility.

*Brief Specifications*

<table>
<thead>
<tr>
<th>Machine type</th>
<th>Drop testing machine with strong structure designed with guide columns and free drop platform.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight of Specimen</td>
<td>200 kg (Maximum)</td>
</tr>
<tr>
<td>Height of Specimen</td>
<td>1200 mm</td>
</tr>
<tr>
<td>Drop Height (max)</td>
<td>1800 mm</td>
</tr>
<tr>
<td>Base Plate (WxL)</td>
<td>910 x 910</td>
</tr>
<tr>
<td>Control Mechanism</td>
<td>Pneumatic – Electric Control System</td>
</tr>
</tbody>
</table>

IV. Shock testing machine

Shock testing machine is used to conduct qualification tests on equipment like energy meters, relays, electronic and electrical equipment which experiences shocks during operation handling and transportation. This is PC controlled equipment with built in calibration facility.

*Brief Specifications*

<table>
<thead>
<tr>
<th>Table Size</th>
<th>1000 x 1000 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight of specimen</td>
<td>450 kg</td>
</tr>
<tr>
<td>Acceleration (range)</td>
<td>30 to 5500 m/s²</td>
</tr>
<tr>
<td>Pulse duration</td>
<td>2 ms to 60 ms</td>
</tr>
<tr>
<td>Type of Shock Pulse</td>
<td>Half sine wave, Saw tooth wave &amp; Square wave</td>
</tr>
</tbody>
</table>
**UNI – AXIAL SERVO HYDRAULIC SHAKER SYSTEM**

This equipment can be used to conduct vibration and shock test on equipment / components as per National and International Standards.

*Brief Specifications:*

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force rating</td>
<td>100 kN</td>
</tr>
<tr>
<td>Frequency range</td>
<td>0.1 to 250 Hz</td>
</tr>
<tr>
<td>Displacement</td>
<td>± 50 mm</td>
</tr>
<tr>
<td>Table size</td>
<td>1500 x 1500 mm</td>
</tr>
<tr>
<td>Mode of vibration</td>
<td>Horizontal and Vertical</td>
</tr>
<tr>
<td>Types of vibration</td>
<td>Sine, Sine sweep, Random, Shock and FRS</td>
</tr>
</tbody>
</table>

**SINGLE AXIS ACTUATOR WITH DIGITAL CONTROLLER**

This equipment can be used to carry out fatigue tests and to evaluate the dynamic characteristics of equipment components weighing up to 100 kgs.
**Brief Specifications**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force rating</td>
<td>10 kN</td>
</tr>
<tr>
<td>Frequency range</td>
<td>0.1 to 150 Hz</td>
</tr>
<tr>
<td>Displacement</td>
<td>± 50 mm</td>
</tr>
<tr>
<td>Accuracy</td>
<td>± 1%</td>
</tr>
<tr>
<td>Operating pressure</td>
<td>280 bars</td>
</tr>
<tr>
<td>Types of vibration</td>
<td>Sine, Random, Sine Sweep, Single frequency</td>
</tr>
</tbody>
</table>

**1000 kN UNIVERSAL TESTING MACHINE**

This equipment can be used to carry out tensile, compression, bending, hardness and shear tests on specimens of ferrous, non-ferrous materials, standard conductors, cables, insulators etc., it is controlled through PC from load measurement to load control. This equipment has self-calibration facility. Specimens can be tested as per IS, BS, ANSI, ASTM and DIN STANDARDS.

**Brief Specifications:**

High precision control of loads by closed loop system.

<table>
<thead>
<tr>
<th>Load Range</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum load</td>
<td>1000 kN</td>
</tr>
<tr>
<td>Load range</td>
<td>1000, 500, 200, 100, 50 and 20 kN</td>
</tr>
</tbody>
</table>

**i. Tensile Tests**

<table>
<thead>
<tr>
<th>Test</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grip to distance</td>
<td>50 to 1800 mm</td>
</tr>
<tr>
<td>Maximum elongation</td>
<td>600 mm</td>
</tr>
<tr>
<td>Grips for rods</td>
<td>Up to 65 mm dia</td>
</tr>
</tbody>
</table>

**ii. Compression Tests**

<table>
<thead>
<tr>
<th>Test</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate dia</td>
<td>Up to 300 mm</td>
</tr>
</tbody>
</table>

**iii. Bending tests**


Length of Bending Specimen: 25 to 1150 mm

Hardness tests

- Ball dia: 10 mm
- Strain gauge extensometer: 50 mm gauge length with Variable extensions up to 105 mm.

ACCELEROMETER CALIBRATION FACILITY

Accelerometer calibration facility is equipped with an accurate and fully integrated system that performs traceable calibrations using back to back comparison method for charge mode or voltage mode accelerometers and velocity transducers. The systems allows for graphical spectrum display of Sensitivity, Deviation, Control Reference, Phase information and print a calibration certificate displaying the full frequency response and sensitivity of the test accelerometer.

NON – CONTACT TYPE LASER VIBROMETER

Non – contact type Laser Vibrometer is used to measure the two dimensional distribution of vibration velocities on the basis of laser interferometry. The measurement data is digitally recorded in the Workstation. The software controls the data acquisition and analyse the measurement data.

**Brief Specifications:**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>X and Y precise deflection mirrors</td>
<td>12 bit digitally controlled</td>
</tr>
<tr>
<td>Position resolution of mirrors</td>
<td>0.002°</td>
</tr>
<tr>
<td>Velocity range</td>
<td>0.5 µm/s to 2 m/s</td>
</tr>
<tr>
<td>Working distance</td>
<td>50 mm to 200 m</td>
</tr>
<tr>
<td>Scanning angle</td>
<td>+ 12.50°</td>
</tr>
<tr>
<td>Measurement functions</td>
<td>Time, frequency, spectrum, autopower, gross power and FRF</td>
</tr>
<tr>
<td>Data Acquisition system</td>
<td>4 channel, 20 kHz/channel, 6400 FFT lines, 2 channels with DAC to control shakers with sine, random, triangle, rectangle pulse. Multi-shaker excitation with MIMO software. Cosine correction with laser scan angle.</td>
</tr>
</tbody>
</table>

Thus, the Earthquake Engineering and Vibration Research Centre is equipped with state of the art facilities for Earthquake and Vibration Simulation, Shock and Drop Testing machines and other Vibration measurement and Analysis equipment.

For details please contact:

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POWER SYSTEMS DIVISION

Power Systems Division with its state-of-the-art facilities and latest software tools offers a wide range of power system simulation services, including real time performance analysis of various types of controllers such as FACTS, HVDC, SVC and protection relays and this division has been conducting studies for the past two decades for its own needs and at the request of utilities, manufacturers and end users of Electric Power.

To carry out such studies the division possesses Real Time Digital Simulator (RTDS), e-Megasim Electric System Simulator and different off line Power System Analysis Software Packages.

The Power Systems Division has the expertise to undertake the following studies:

- Generation & Transmission System studies
- Protection System studies

The various consultancy services offered are:

**Transmission System Studies**
- Transmission Planning and Power Evacuation
- Study of Power Swing Phenomena
- Stability
- Short circuit
- Reactive power compensation - Sizing and location of fixed and dynamic compensation
- Insulation Co-ordination
- Islanding
- Filter Design
- Performance analysis of controllers such as FACTS, HVDC, SVC
- HVDC transmission system
- Large motor starting dynamics
- Integration of large wind farms with power supply grid
- Transmission line series compensation and sub-synchronous resonance phenomena

**Protection System Studies**
- Third Party Protection Audit of 220 kV, 400 kV Substations and Generating stations
- Relay coordination
- Over current and Earth fault relays
- Distance Relay
- Equipment Protection setting calculations (Generators, Motors, transformers etc.)
- Dynamic Testing of protection schemes on RTDS
FACILITIES FOR SIMULATION

Real Time Digital Simulator (RTDS)

The all-digital Real Time Simulator is a state-of-the-art facility (from RTDS Technologies, Canada) established at the Power Systems Division of CPRI that allows accurate and reliable simulations of three-phase electromagnetic and electromechanical transient phenomenon in electric networks both for closed loop equipment testing and offline simulation studies. The RTDS works in continuous real time to provide solutions to power system equations fast enough, with a typical time step of 50 µs to accurately represent conditions in the actual power system. In addition, with the small time step feature it is possible to achieve time step as small as 2.5 µs. The real time features facilitates interfacing of physical devices - controllers and protective relays to the simulator and operate them under real life conditions.

RTDS Applications

- General AC and DC systems operations
- Interactions of AC and DC systems
- Integrated protection and control systems
- Control system for synchronous machines, HVDC, SVC, FACTS and custom power devices
- Protective relaying schemes
- Advanced Education and training

RTDS Benefits

- Increase system reliability, security, stability and efficiency of equipment and network
- Improved system understanding, knowledge and insight
- Minimize equipment failure
- Reduced project/equipment commissioning time
- Maximize quality and quantity of studies
RTDS Features

Hardware

- Five Racks (dimensioned for 18 number 3 phase nodes and up to 56 single phase switches per rack
- Four of the racks have 10 number Triple Processor Cards (3PC) and one Giga Processor Card (GPC) per rack. The remaining one rack has 6 number 3PC cards and two GPC Cards
- Each 3 PC Card has 3 SHARC type processors with a computational speed of 40-120 MFlops
- Each GPC Card has two numbers of IBMPPC750GX Risc processor and 2 numbers coprocessors with 1.0 GFlop computational speed
- Each rack can be operated independently

Input / Output Interface and Monitoring

- DOPTO (Optical isolated digital input and output card) interface up to 24 digital input and 24 digital output signals, (range +/- 10 volts peak)
- GTDO (Giga Transceiver Digital Output Card used with GPC card) facilitates 64 optically isolated digital output signals
- GTA0 (Giga Transceiver Analogue Output Card) Provides optically isolated 12 number analogue output from RTDS for use with simulations running on GPC cards
- GTDI (Giga Transceiver Digital Input Card) Provides optically isolated 64 digitally input in to the RTDS for use with simulations running on GPC cards
- GTNET (Giga Transceiver Network Communication Card) Provides real time communication to/from the RTDS. GTNET play back firmware option allows to read large data files stored on PC to play back on RTDS with a sampling frequency of up to 20 kHz
- DITS (Digital Input Time Stamp card) : interface of time critical digital signals from an external controller, Six digital input signals per DITS Card - Required for Improved Firing algorithm
- FDAC (Fibre Optic Digital to Analog converter) interfacing signals with large dynamic ranges
- OADC (Optically isolated Analogue Input) interfacing analog signals from external equipment, (range +/- 10 V true differential analog input)
- 220 Vdc Digital output interface (16 numbers dry contacts, used to bring high voltage digital inputs into the RTDS or alternatively, used to send digital outputs from the RTDS to dry contacts (with high voltage ratings)

Amplifiers

- External amplifiers connected in the test loop between RTDS and equipment under test - provides secondary level voltages and currents
- Four numbers 3 phase voltage amplifiers (frequency response :dc to 10kHz , rated 250 Vrms phase-to-ground)
- Sixteen numbers single phase Current amplifiers (frequency response: dc to 5 kHz, rated 90 Amps peak for 1 second and 18 Arms continuous)
RTDS Software

User friendly Graphical User Interface (RSCAD)
- Circuit assembly and Data entry using Draft module
- Simulation output - monitored during runtime through plots, meters
- Simulated power system operated interactively using switches, pushbuttons, sliders

Power System Software - Component Model Library and Compiler
- TLINE - Computation of transmission line parameters from tower configuration
- CABLE - Computation of cable parameters from cable configuration

Control System Software - Component Model Library and Compiler
supports standard control blocks

Simulation Models - Component Model Library
- Synchronous machines inclusive of exciter and Speed Governors
- Induction machines
- Three-phase two winding and three winding transformers (Linear and with saturation)
- Multiphase transmission lines, DC lines, Cables with distributed parameter (constant or frequency-dependent) or PI model
- Measurement Transducers - CVT, CT
- FACTS Devices including Voltage Source Converters
- Series Capacitors
- Circuit Breakers and switches (thyristors, GTOs, IGBTs)
- MOV protected Series compensation
- Faulted Line model
- Voltage and Current sources
- Passive R, L, C Impedances
- HVDC valve Groups (6 pulse and 12 pulse) with generic controls
- AC Filters
- Industrial Loads (Induction motors, DC motors, Dynamic load, Arc furnace)
- User defined models

Advanced Features
- Improved Firing Algorithm for power electronics
- Embedded Valve Groups
- Load flow initialization
- Switched Filter Component
- Model stacking capability for optimized processor usage

**Modes of Operation**

- Manual mode
- Open Loop (no feedback, COMTRADE play back)
- Closed Loop (real time feedback)
- Automatic Batch mode (Script file facility)

**EMEGA SIM Electrical System Simulator**

Matlab/Simulink based fully digital real time power grid simulator with the following features:

- Two quad processor chips and 16 AD, DA, TSDI, DSDO with equal number of RT-Event, RTeDrive, ARTEMIS, 10 nanosecond timer with 5-30 V, 100 nano opto-coupler

**Studies that can be performed:**

- Simulation of large in-land power grids
- Simulation of wind farms
- Simulation of very fast electromagnetic transients at simulation time steps below 250 nanoseconds with FPGA technology
- Real time simulation, integration and hardware-in-the-loop testing of power electronics controllers and protection devices

**Systems and Software Capabilities for Digital Simulation**

**Systems**

- DEC Alpha workstation
- SUN workstation
- Pentium IV Servers / PCs
- Printers, Plotters and Digitizer

**Software**

**SIMPOW (Windows NT Version 10.2.105)**

- Package for static and dynamic simulation of power system
- Models of all network components involving transmission elements, HVDC converter stations, static VAR components, series capacitors, prime movers and rotating machines with their controls, protection equipment, and loads
- Supports Dynamic Simulation Language a built-in high level programming language, allows user-defined modelling of any power system component such as regulators and primary components, e.g. drive systems, FACTS devices and special machines
- Optimal power flow analysis
- Stability Analysis
- Transient stability
- Small signal stability of generators and automatic control systems
- Small disturbance angle stability e.g. controller interaction, Tuning of Power System Stabilizers (PSS), Sub synchronous resonance
- Short circuit Studies
- Eigen Value Analysis

**Neplan Software V.5.4.5**

- Basic Module with graphical data base editor
- Load Flow module
- Short circuit module
- Neplan Dynamic Simulator (Transient Stability / EMT)
- Small Signal stability
- Voltage stability
- Contingency Analysis
- Optimal Power Flow
- Motor starting
- Over Current and Distance Relay coordination
- Reliability Analysis
- Harmonic Analysis

**HIWAVE**

- Design of filters - Examine and reduce harmonic disturbances in power systems
- Includes a user customized library for modelling of almost all harmonic sources
GMAT - Grounding System Software

- In-house developed software for Ground mat design for grounding system for HV / EHV substations / power stations
- Incorporates design methods that are based on latest developments and techniques in power system grounding practices including the Indian codes of practice in Earthing
- Software is written based on the method described in the latest version of ANSI/IEEE Standard 80/2000 – Guide for safety in AC substations
- Other features are incorporated based on the recommendations of CBI and P, India, and IS 3043/1987 - code of practice for earthing in India
- Non-uniform soil model is a 2-layer soil model proposed by J. Endrenyi, consisting of a top layer soil of resistivity p1 to a depth h from the surface of soil and a bottom layer of resistivity p2 extending up to infinite depth
- The effect of spreading gravel on the surface of substations can be studied using this software
- Effective placing vertical ground rods can be studied

RELAY TESTING LABORATORY (RTL)

The Relay Testing Laboratory at Power Systems Division is a comprehensive test facility for protective relays. The Laboratory is equipped with sophisticated Computerized Relay Testing Systems for testing of all kinds of Power System Protection Relays for all its characteristics / functions meeting its accuracy requirements. Additionally, software is available for testing of the Protection relays under Dynamic / Transient conditions of the system, by importing fault data from EMTP software simulation or from Digital Fault Recorder (DFR). Electro Mechanical, static, digital and Numerical relays can be tested in the RTL. The laboratory conforms to ISO/IEC 17025;2005 requirements. The RTL is also recognized by Bureau of Indian Standards.

Type Testing of Relays

Tests are conducted on Power system protection relays used to protect Generator, Transformer, Bus bar, Transmission line, Reactor, Motor, Capacitor etc., in accordance with IEC: 60255 Standard series and IS: 3231 Standard series. Electronic timers are tested as per IS: 5834 standard series. Some of the special tests recommended for Numerical relays like tests with Transient waveforms, Harmonic waveforms; Voltage Dips and Interruptions are also carried out.

Relay Test Systems

The Relay Test Laboratory is equipped with the following Computerized Relay Test Systems.
Field Testing

Field testing of protection relays is carried out at the place of installation to check the continued health of the relays deployed in a plant. Major power stations, Port trust and Industries like M/s GNDTP-Bathinda, M/s IP-New Delhi, M/s NMPT-Mangalore, M/s HTPS-Kasimpur, M/s VPT-Vizag, M/s BTPS-Bhusawal, M/s PTPS-Panipat, and M/s Ranbaxy Laboratories Lab-Mohali, M/s SgTPP, WB

Third Party Inspection

The RTL undertakes pre-dispatch Third Party Inspection (TPI) on Relay and Control panel on behalf of a buyer. The inspection is done at relay manufacturer’s works for M/s HVPNL, Panchkula, M/s RRVPNL, Jaipur and M/s Jammu and Kashmir Power Development-Jammu.

Developmental Assistance

The Relay testing facility and assistance is also offered for developmental works as a measure to help the manufacturer to improve and ensure their specified functions before arriving at their final product.
COMPLETED AND ON-GOING CONSULTANCY PROJECTS

**Transmission System Studies**

- Assess the additional transmission requirements for 10th and 11th plan period for Southern, Northern, Eastern and North Eastern regions of India for Power Finance Corporation.
- Interactions of HVDC controllers for newly planned HVDC lines using RTDS for Power Grid Corporation of India Ltd.
- SSR studies for Balia - Lucknow series compensated lines for M/s Siemens.
- Power System studies, Overvoltages and Protection coordination studies for Raichur Thermal Power Station, KPCL, Bangalore.
- Studies for SVC Sizing for MIS Sharq Steel Rolling Mills LLC, Sultanate Of Oman.
- Technical services for power line design with low loss conductor.
- Transformer charging and lightning overvoltage studies for RIL Mumbai.
- Study to investigate failures of HV motors and associated soft starters in Mangalore Chemicals and Fertilizers Ltd., Mangalore.
- Switching and Dynamic over voltages for URI Power station, NHPC, Faridabad.
- Planning studies up to 11th plan end for Himachal Pradesh State Electricity Board.
- Reactive compensation studies for proposed Wind farm projects in Kutch for M/s Suzlon.
- Reactive compensation studies for wind farms at Gudepanchgani for M/s Vestas.
- System studies for M/s Delhi Transco System.
- Sub synchronous resonance studies for series compensation on 400 kV D/C lines for M/s Siemens and M/s Jindal.
- System studies for UPPTCL for 12th plan.
- Filter design for Nirjuli substation of North Eastern Region of Power Grid Corporation of India.
- Measurement of earth resistance at Kudan Kulam Nuclear power plant, Madras Atomic power station, BHAVINI Kalpakam.

**Protection Studies**

- Dynamic testing of distance relays for M/s Siemens, GE and AREVA.
- Dynamic testing of transformer differential relays for M/s. Siemens, AREVA.
- Protection coordination studies for 400 kV series compensated lines of Gorakhpur - Muzafarpur and Gorakhpur - Purnea lines for M/s. Siemens.
- Relay co-ordination studies for Neelanchal Ispat Nigam Ltd., Orissa.
- Dynamic relay testing of REL 670 IED distance protection relay on RTDS for M/s ABB.
- Dynamic relay testing of RET 670 IED transformer protection relay on RTDS for M/s ABB.
Protection audit of DTL transmission system for Delhi Transco Ltd.
Third party Audit of Protection System of RRVPN

**Distribution System Studies**

- Estimation of technical and commercial losses in transmission and distribution systems for APERC (Andhra Pradesh Electricity Regulatory Commission).
- Estimation of 11 kV and LT line losses for SPDCL, Tirupati.
- Estimation of technical and commercial losses in distribution systems for KSERC (Kerala State Electricity Regulatory Commission).
- Developing the criterion for allotting additional distribution outlets for MERC.
- Industrial System studies for Rourkela Steel Plant.
- System studies and Energy Audit for Industrial System of Reliance India Ltd. at Hazira.

**Grounding System Studies**

- Design of Grounding system for the 1000 MW Tehri Hydro Power Project in UP. The main features are design of underground power house ground mats, 400kV, GIS grounding system and those in all the access tunnels (Ad its). Design of earth mats for power house and switchyards of 2x30MW Turial hydroelectric project, Mizoram for BHEL.
- Design of Earth mat for 4x33MW Teesta Low Dam HE Project for M/s. GEA Energy Systems India Ltd., Chennai.
- Design of Grounding system for AC/DC switchyards at Talcher and Kolar converter stations of the 2000MW, ±500kV, Talcher-Kolar HVDC east - south inter connector-II project (for Siemens, Germany).
- Design of Grounding system Tintibi 132kV substation, Bhutan.
- Design of grounding system for Rampur HE project for M/s SJVNL, Shimla.
- Measurement of Soil resistivity at Balia Bhiwadi HVDC earth electrode site for M/s Siemens, Gurgaon.
- Checking of Adequacy of Grounding system at NTPS, Nashik.
- Measurement of Earth resistance for:
  - Tehri Hydro Power Project, Tehri for M/s. THDC, Tehri.
  - Nuclear Power Plant, Kaiga for M/s. BHEL and Gammon India Ltd.
  - Rajasthan Atomic Power Plant For M/s. NPCIL, Rajasthan.
  - Raichur Thermal Power Station for M/s. KPCL.

**COMPLETED R&D PROJECTS**

- Investigation of Grid connected Wind Turbines and Diesel Generator interaction.
- Investigation of application of FACTS devices in Indian Power System.
- Study of dynamic performance of protection relays using RTDS.
• Bench marking programmes for testing the Full Spectrum Simulator development on the Real Time Digital Simulator at CPRI as a part of the Full Spectrum Simulator (sponsored under NAMPET and coordinated by CDAC).

• A Study of GPS Synchronised End-To-End Testing of Distance Protection Schemes and evolving field testing methodology

ONGOING R&D PROJECTS

• Study of stability and Reliability of Large wind farms connected to the grid.

• A study of wide area measurement based power system security of a state Transmission grid.

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Power Systems Division  
Central Power Research Institute  
Bangalore-560 080
ENERGY EFFICIENCY AND RENEWABLE ENERGY DIVISION

This Division, (ERED), has comprehensive infrastructure, computational facilities and a team of qualified Engineers for providing energy services like conducting Energy audits and training Energy Managers and ERED has been rendering the Energy audit and Energy efficiency service for a variety of customers for more than three decades and has undertaken audits in several energy intensive industries, thermal power stations (TPS), hydel power stations (HPS), captive power plants, port trusts, oil refineries, refrigeration and air conditioning plants and buildings, etc.

The services encompass the generating, distribution and utilization segments of the power sector. Besides the fuel sector is also covered.

ERED has been accredited by Bureau of Energy Efficiency (BEE), New Delhi for conducting Energy audit in thermal power plants, process industries, buildings and commercial establishments. CPRI has several BEE certified and foreign trained Energy Auditors in its team. The Energy Efficiency and Renewable Energy Division is ISO 9001:2008 certified.

The experience profile of ERED in the area of Energy Service is as follows:

Consultancy Services

Energy audit and Energy conservation studies profile indicates the consultancy services rendered to numerous industries, viz.:

- Thermal Power Stations (Coal, Gas, Atomic, Oil etc.) : 120
- Hydel Power Stations : 21
- Medium scale process and manufacturing industries : 50
- Port Trust : 10
- Water pumping stations : 6
- Building : 40
- Hospitals : 5
- Star hotels : 5
- Airports : 4

Technical energy and power audits (with aims ranging from identifying ways of improving energy efficiency to evolution of a new blue print for the energy system) provide insight into the modes of better utilization of fossil resources and high grade energy and exploration of renewable energy solutions. ERED has conducted energy audits in major thermal and hydro power stations of India. In the area of dispute resolution and generating authentic first hand database, ERED has been providing analytical and experimental service to regulatory commissions.

ERED have conducted energy efficiency studies along with other Energy Auditors and ESCOs in major buildings like Rail Bhavan, Sanchar Bhavan, IGI Airport and AIIMS, New Delhi. The studies
have identified major energy saving potentials in Lighting system, HVAC system, Water pumping system, etc. By optimizing the loading pattern and operational time of various loads, about 10-12% yearly energy consumption can be reduced / controlled.

Some of the specialized areas of energy services are:

- Boilers and combustion systems
- Steam turbines
- Hydro turbines and auxiliaries
- Auxiliaries: pumps, fans, mills blowers, etc. and associated motors
- Auxiliary power of balance of plant of thermal and hydro power plants
- Heat exchangers
- Condensers
- Cooling towers
- Utilities: compressed air, water pumping, air conditioning, refrigeration
- Gas turbines
- Hydro turbines
- Electrical distribution networks

The studies include:

- Heat rate optimization
- Benchmarking of energy parameters
- Capacity adequacy analysis
- Forced outage analysis
- Design deficiency analysis
- Reverse engineering
- Power quality
- Demand Side Management
- Power quality audits in industries and distribution system
- Electrical safety audits in process industries, buildings and establishments
- Harmonic and voltage flicker measurements of non-linear equipment and industries

**TESTING**

Following testing facilities are available with the division:

- UPS, off-grid and grid tied inverters (up to 5.0 kVA presently) as per IEC 61683 and IEC 60068. Shortly upgrading up to 500 kVA.
- Solid state control gear, electronic circuits, ballasts and driver circuits for lighting equipment
- Lighting systems like LEDs, Compact Fluorescent Lamps (CFL), Fluorescent Tubular Lamps (TFL), Induction, metal halide, high & low pressure sodium vapour, etc.
- Field testing of street light controllers, rural micro grids, etc.
RENEWABLE ENERGY APPLICATIONS

Some of the areas are:
- Solar photovoltaic testing and field evaluation of plants of 1 kW to as high as 5 MW.
- Solar, wind and rain data analysis and forecasting of performance.
- Application engineering for solar, wind and biomass energy sources.

The lab has facilities for testing and certification of energy efficient and renewable energy devices and systems. The lab also undertakes field-testing of large systems and units, which cannot be easily installed at lab. Some of the test facilities are:
- Solar photovoltaic lantern (Approved by Ministry of Non-conventional Energy Sources, Government of India).
- Solar home lighting and street light controllers.
- Solar water pumping system.

Research and Development

ERED takes up R&D projects for the energy sector. Some of the areas of R&D are energy conservation, modelling and simulation and development of energy instrumentation. Recent projects are:
- Flexibility analysis of high energy steam/water piping.
- Development of techniques for energy analysis of steam turbines.
- Development of pulverized coal flow simulator.
- Intelligent heat exchanger.
- Showcasing of energy efficiency measures in buildings.
- Studies on IGCC and USCPC.
- Energy efficiency of solar Water heaters and scale control.

Instruments available for Energy Audit and other Field Consultancy Services

- Ultrasonic flow meters (Measuring range of pipe diameter up to 10 m).
- HT and LT portable power analyser.
- Temperature indicators and probes – RTD, thermocouples, non-contact IR thermometers.
- Flue gas analysers.
- Digital RH meter.
- Digital LUX meter.
- Digital pressure gauges.
- Digital manometer.
- Digital barometer.
- Iso-kinetic coal samplers.
For details please contact:

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Additional Director, Energy Efficiency and Renewable Energy Division

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THERMAL RESEARCH CENTRE, NAGPUR

The Thermal Research Centre is located at the vicinity of Koradi Thermal Power Station of MAHAGENCO, about 12 km from Nagpur on Chhindwara Road at Koradi, Nagpur. Central Power Research Institute, Thermal Research Centre, is recognised by Central Boiler Board, New Delhi as the “Well known Remnant Life Assessment organisation” of Govt. of India for carrying out RLA studies of boilers. TRC is also recognized as ISO 9001- 2008 certified Organisation.

Objectives:

The main objective of the Thermal Research Centre is to study operation and maintenance problems of Power Stations in addition to:

- Condition assessment, life estimation and extension studies, failure / risk analysis for renovation of vital power plant components.
- Failure / Metallurgical analysis of Power plant /Process Industries components.
- Energy Conservation in power plants and improvements in efficiencies of combustion auxiliaries and interconnected systems.
- Performance evaluation of high temperature materials used for stress corrosion, fatigue and creep and materials conservation.
- Insulation audit, Steam Audit, Hot spot measurement in Boilers, Switch yards, transformers etc. i.e. Thermographic Inspection.
- Flaws /crack depth in weld joints and other parts of the equipment by ultrasonic TOFD.
- In-situ Oxide scale measurement in Super Heater and Re-heater tubes and life estimation.
- Condition assessment of condenser tubes by Eddy current method.
- Internal condition assessment of headers and tubes by Fibroscopic Inspection.
- Providing training to the Serving Engineers of Power plants, Industries and Utilities.

Divisions and Laboratories

The Thermal Research Centre is pioneer in carrying out Life Assessment, Renovation and Modernization and Life Extension studies, Non Destructive Evaluation (NDE) of Thermal Power Station plant equipment like Boilers, Turbines and Condensers etc., Condition assessment of RCC and steel structures. In order to accomplish the above goals following divisions are established with various facilities namely:

Engineering Materials Division

- Residual Life Assessment of power Plant Components
- Image analysis system for metallurgical evaluation
Thermal Research Centre, Nagpur

- In-situ (field) Metallography (Replication) Test Facility
- In-situ (field) Hardness Test facility
- In-situ Chemical Analysis / Material Grade Identification Test Facility.
- Failure analysis of power plant components.

**Mechanical Engineering Division**

- Residual Life Assessment of Boiler and Turbine, NDE based condition assessment of plant components.
- Flame Temperature measurement, hot spot survey, Switchyard inspection, Insulation audit facility i.e. Thermographic Inspection
- Eddy current testing of condenser tubes.
- Non Destructive Testing facilities for Power Plant and Process Industries
- In situ Oxide scale measurement facilities
- Ultrasonic test facility.
- Flaw characterisation by ultrasonic Time of Flight Diffraction (TOFD) technique
- High current Magnetic particle Inspection by coil wrapping method test facility.
- Dye penetrant test facility.
- Dimensional measurement test facility.
- Video Image scope for remote visual inspection for boiler, turbine, and other components.
- Studies and analysis of Heat pipe system and other heat transfer analysis.

**Civil Engineering Division**

- Condition Assessment of civil structures
- Life Evaluations studies of RCC and Steel Structures.
- Test Facilities : Ultrasonic test, Rebound Hammer test, , Half cell potential test, Resistivity measurement, Core test, Chemical tests, Cover meter and sectional verification, Gravimetric analysis for steel structures etc.

**SERVICES OFFERED TO POWER SECTOR and OTHER INDUSTRIES**

Consultancy in operational and maintenance problems of thermal power generation, RLA, R&M and the following services are provided to various clients:

i. Residual Life Assessment of all types of Boilers ranging from process Steam Boiler to 500MW capacity.
ii. Residual Life Assessment of all types of Waste Heat Recovery Boilers.
iii. Residual Life Assessment of Hydro Gas and combined cycle Power Plant components.
iv. Residual Life Assessment of Steam turbine.
v. Renovation and Modernisation and Life Extension studies of Boilers, Turbines and other plant equipment.
vi. Failure Analysis of Power Plant Components.

vii. Investigation study for root cause analysis on boiler tube failure (BTF).

viii. Health Assessment / Condition Assessment of Condenser Tubes.

ix. Detection and sizing of flaws (e.g. cracks) in complex geometric plant components.

x. Condition assessment and end of functional service life Evaluation of RCC and STEEL structures in Thermal Power Plants and Process steam Industries etc.

x. Third party Inspection of passive fire protection systems.

| MPI of 210 MW IP Rotor at one of the steam turbine. | DPT of water turbine blades at one of the Hydro-electric power plant. |
| Fibroscopic inspection of headers at one of the 210 MW boiler. | TOFD test on 210 MW steam turbine hp rotor shaft |

<table>
<thead>
<tr>
<th>Thermal Research Centre, Nagpur</th>
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<table>
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<tr>
<th>Hydrogen embrittlement checking work at Z-panel area of 210 mw plant</th>
<th>In-situ metallurgical inspection of header at 210 MW boiler.</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.jpg" alt="Image" /></td>
<td><img src="image2.jpg" alt="Image" /></td>
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<thead>
<tr>
<th>Failed boiler tube collected for failure analysis</th>
<th>Thermal image of GT Neutral flexible connection.</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3.jpg" alt="Image" /></td>
<td><img src="image4.jpg" alt="Image" /></td>
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</table>

<table>
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<tr>
<th>Coal bunker inspection using DP test</th>
<th>Coal bunker inspection using DP test</th>
</tr>
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<tbody>
<tr>
<td><img src="image5.jpg" alt="Image" /></td>
<td><img src="image6.jpg" alt="Image" /></td>
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</table>
R&D, Demonstration and Pilot Scale Studies on

1. Energy conservation in power plants and improvements in the efficiency of combustors, auxiliaries and interconnected systems.
2. Performance evaluation of high temperature materials used for stress corrosion, fatigue, creep and materials conservation.
3. Flaw characterization by ultrasonic time of flight diffraction (TOFD) technique.
4. Damage assessment in boiler tubes, drums and headers.
5. Condition assessment of complex geometry power plant components by ultrasonic TOFD technique.

For details please contact:

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Ultra High Voltage Research Laboratory (UHVRL), Hyderabad was commissioned in the year 1993, to function as a state of the art Independent laboratory for development, testing & certification of high voltage, UHV Equipment / components. The laboratory also functions as a research centre for providing design data valid for UHV transmission system in the country considering the climatic, environmental and operating conditions UHV.

The laboratories are designed & equipped to test in conformity with the latest international standards and is accredited in accordance with ISO / IEC 17025.

The following section provides the salient features of major facilities of UHVRL:

**Experimental Line**
An experimental transmission line of 720 m length, divided into central suspension span of 360 m, and two dead end spans of 180 m each. The facility has flexibility to vary the conductor to tower clearance, conductor to conductor clearances and conductor to ground clearance. This facilitates the study of radio noise, audible noise, corona loss etc.

**Mock-Up Tower**
The purpose of the Mock-up tower is to carry out air insulation studies, between conductor to tower and between conductor to conductor. The arrangement has provision to string two conductor bundles between two dead end towers 80 m apart with a mock-up tower located in between.
Pollution Test Chamber
The pollution test chamber is one of the largest in the world with a diameter of 24 m and a height of 27 m. Salt fog test can be conducted for insulators, bushings etc., up to 800 kV class.

Cascade Transformer
The cascade transformer, comprising two units rated 800 kV each (total rating is 1600 kV, 9600 KVA) is used for energizing the experimental line, pollution chamber and testing equipment. The equipment has an extension unit which can generate oscillating switching surge impulse of up to 2000 kV peak.
**Impulse Generator:**
The impulse generator is used for switching impulse and lightning impulse tests on air gaps and equipment insulation. The impulse generator rating is 5 MV, and 500 kJ with 25 stages and a height of 23 m.

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**Radio Interference and Audible Noise Measurement Facility**

The laboratory has the state of art facilities to measure the Radio and TV Noise from AC/DC overhead power lines and sub-stations as per ANSI/IEEE Std. 430-1986, ANSI/IEEE Std. 302-1981 and CISPR-18 up to 1000 MHz range. The facility comprises of two EMI test receivers ESHS-10 and ESVS-10, Loop antenna, Rod antenna, Bi-conical antenna and Log periodic antenna of Rohde and Schwarz, Germany make. A precision impulse sound level meter CEL-414/3C make; Lucas CEL Instruments Ltd., UK, is available for the audible noise measurement.

**± 1200 kV HVDC TEST SYSTEM**

A new outdoor ± 1200kV DC test system has been commissioned at UHV Research Laboratory, Hyderabad. The HVDC test system, shown in figure, essentially comprises of two separate DC sources giving positive and negative polarity voltages respectively. Each pole comprises of a two stage DC generator with an integrated DC voltage measuring divider and earthing device. The DC test system is suitable for feeding 720 m experimental transmission line with voltages up to ± 1200kV DC individually or simultaneously. The DC test system is also intended for dielectric and pollution tests on all equipment rated up to ± 800kV DC. The salient features of the outdoor HVDC test system are:

- Rated DC Voltage: ± 1200kV DC
- Rated DC current: 200mA per pole
- Ripple: ≤ 3%
- Operation mode: Continuous
The following tests are proposed to be taken up on all equipment for test voltages up to ± 1200 kV DC as per National & International standards:

- DC voltage withstand test - Dry
- DC voltage withstand test - Wet
- Corona Voltage tests
- Pollution tests with pulse currents up to 2A
- RIV tests

Research Activities

- HVDC transmission line research – Environmental effects, Line optimization etc
- Pollution performance of ceramic and composite insulators
- Corona, radio interference and audible noise measurement in experimental transmission line, operating-transmission lines, sub-stations and corona cage
- Frequency response Analysis on Power transformers.
- Air gap insulation breakdown studies.
- Pollution studies on EHV/UHV insulators and surge arresters.
- RTV coating studies.
- Insulation coordination under HVDC system

**TESTING ACTIVITIES**

The following commercial and investigatory tests can be carried out as per National and International Standards:

**Name of the Apparatus / Test**

1. **High Voltage switchgear and control gear and Alternating Current circuit breakers:** Lightning Impulse voltage test (including bias test) Switching impulse voltage test (including bias test) Dry and Wet, Power Frequency voltage test, RIV, Corona Inception and Extinction voltage test, Visible Discharge Test (dry & wet) and Mechanical Endurance tests on disconnectors up to 1200 kV class. Artificial pollution test by Salt-fog method on insulators up to 800 kV Class.

2. **Porcelain Insulators for overhead power lines, Insulator string, Post insulators, Solid core insulator, composite insulators, Pin insulator, Polycrrete housings, Hallow insulators:** Visible discharge test, Dry Power frequency voltage withstand test and Flashover test, Wet power frequency voltage withstand test and Flashover test, Voltage distribution test and power frequency puncture test, Lightning impulse voltage withstand test (dry) and 50% impulse voltage flashover test, Switching impulse voltage withstand test (dry and wet), Corona inception and extinction voltage test, Radio Interference voltage test and Voltage distribution tests on insulator strings up to 1200 kV class. Artificial pollution test by Salt-fog method up to 800 kV Class.

3. **Bushings:** Dry Power frequency voltage withstand test, Wet Power frequency voltage withstand test, Lightning impulse voltage withstands test (dry) and 50% impulse voltage flashover test, Switching impulse voltage withstand test (Dry and wet) and Radio Interference voltage test up to 1200 kV class. Artificial pollution test by Salt-fog method up to 800 kV Class.

4. **Voltage transformers and capacitor voltage transformers:** High voltage power frequency withstand tests on outdoor voltage transformers (On external insulation-wet test), Ferro resonance test, Short circuit withstand capability test (except PD and Accuracy measurement), Transient Response test, Chopped Lightning impulse voltage test on primary winding, Switching impulse voltage withstand test on primary winding (Dry and Wet), Measurement of transmitted over voltage, RIV test, Measurement of capacitance and dielectric dissipation factor (Tan delta) up to 1200 kV class.

5. **Current transformers:** High voltage power frequency test on primary winding, High voltage power frequency test on Secondary winding High voltage power frequency test on Secondary winding High voltage power frequency wet withstand voltage test on outdoor transformers.
Current transformer, Measurement of Dielectric Dissipation factor (Tan Delta), RIV test, Over voltage inter turn test, Lightning impulse voltage test on primary winding, Chopped Lightning impulse voltage test on primary winding, Measurement of transmitted over voltage, Lightning impulse voltage test on primary winding, Switching impulse voltage withstand test on primary winding (Dry and Wet). Chopped wave test/Fast Transient up to 1200 kV class.

6. Coupling capacitors and capacitor dividers:
Lightning impulse voltage test (Dry), Switching impulse voltage withstand test (Dry and Wet), Discharge test measurement of capacitance and dielectric dissipation factor (Tan delta), High frequency capacitance and ESR measurements, Stray capacitance and conductance measurements up to 1200 kV Class.

7. Combined instrument transformers:
Impulse voltage test, power frequency test up to 36 kV class.

8. On load tap changers:
Power frequency voltage test, Lightning impulse voltage withstand test up to 1200 kV class.

9. Power, Distribution, Traction, auto transformers:
Lightning impulse voltage withstand test, Chopped lightning test, Measurement of dielectric dissipation factor (tan delta) and capacitance of the windings, Separate source voltage withstand test, Sweep Frequency Response Analysis test up to 1200 kV Class.

10. Reactors:
Lightning impulse voltage withstand test up to 1200 kV Class.

11. Surge Arresters for alternating current systems:
Power frequency voltage withstand tests, Lightning impulse voltage test, Switching impulse voltage test (Dry and wet) on arrester housing, RIV test, corona test up to 1200 kV Class.

12. Aluminium conductors for overhead transmission lines, Connectors and Clamps:
Radio Interference voltage test, corona test up to 1200 kV Class.
CONSULTANCY SERVICES

i. Electromagnetic Interference studies and audible noise measurements for HV AC/DC Transmission lines.

ii. Investigation of mechanical condition of windings of the power transformers at site using Frequency Response analyser. Recording of base signature / data before commissioning of new units/before transporting to site from manufacturers works.

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Email: dev@cpri.in
SWITCHGEAR TESTING AND DEVELOPMENT STATION, GOVINDPURA, BHOPAL

The unit situated adjacent to the BHEL premises at Bhopal, the capital city of Madhya Pradesh, has two main testing stations for conducting short circuit tests.

Details of two main stations are given below:

**STATION I**

Direct short circuit test station of 1250 MVA capacity at 12kV capacity utilizing two specially designed 1500MVA short circuit alternators, G1 of M/s Orlinkon make and G2 of M/s Alstom make. This station mainly caters to short circuit tests on high and medium voltages switchgears, transformers and other allied equipment.

**STATION II**

The On line testing station is drawing power up to 100 MVA from the MPSEB grid from the Chambal substation through 132kV three single phase circuit. The fault level of 132kV bus at Chambal substation is 1900MVA at 0.2 power factor. This station mainly caters to short circuit tests on low voltage switchgears, transformers and other allied equipment.
SUPPLEMENTARY TEST FACILITIES

Prior to and subsequent to the short circuit tests, a variety of tests are to be conducted as stipulated by the standards. These are conducted at the supplementary test laboratories.

- Temperature rise test laboratory.
- ELCB, MCB, MCCB, RCCB, Contactors and Fuse test laboratory.
- Ingress protection test laboratory.
- High voltage Laboratory (for dry / wet power frequency and lightning impulse).
- CT and PT test laboratory.
- Partial discharge laboratory.
- Mechanical and electrical endurance test laboratory. These facilities are in process of continuous up-gradation to meet newer test requirements. Besides, pre and post short circuit supplementary tests, these laboratories also conduct type tests.
OTHER TEST FACILITIES

EMI /EMC and Energy Meter Testing Laboratory

Calibration Laboratory at CPRI, Bhopal is equipped with high precision state of art Reference Standards to cater the big needs of various Manufacturers, Utilities and Testing / Calibration Labs in the country.

CALIBRATION LABORATORY

Calibration Laboratory Setups
## Oil Testing Laboratory

Transformer Oil Testing Facility

<table>
<thead>
<tr>
<th>Moisture Meter</th>
<th>Tan Delta Resistivity Meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flash Point</td>
<td>Breakdown Voltage Tester</td>
</tr>
<tr>
<td>Gas Chromatograph</td>
<td>Sulphur Analyser</td>
</tr>
</tbody>
</table>
TEST FACILITIES AVAILABLE AT CPRI, BHOPAL:

- Short circuit tests up to 200kArms, 1100 Volts for LT equipment and Short time current tests up to 200kArms for one second or 100kArms for 3 seconds.
- Short circuit making and breaking capacity test facility for medium voltage and LT circuit breakers.
- Capacitor bank switching test, cable charging and line charging test facility for medium voltage circuit breakers.
- Internal arc fault test facility for metal enclosed switchgear and motor terminal boxes.
- Short circuit dynamic and thermal withstand test facility for Distribution and Power Transformers of rating maximum up to 40MVA, 132/33kV class.
- Short circuit breaking capacity test facility for LT and HT fuses.
- Making and breaking capacity test facility for air break, oil and vacuum switches.
- Short time current test facility for current transformers, power connectors, reactors, spacers and spacer dampers for bundle conductors, Isolators, earth switches and on load tap changers.
- Making and Breaking capacity test facility for medium and LT Contactor.
- High and Low short circuit current (pressure relief) test facility for Lightning Arresters.
- Short time current test facility for HT and LT busducts up to maximum current 200kArms for one second.
- DC test facility up to 80kA, 1550 V for testing DC Switchgear.
- Short circuit withstand capability test on voltage transformers (VTs) up to 132kV.
- High voltage motor current switching tests up to 6.6kV with simulated induction motor circuit for circuit breakers.
- Electrical and mechanical endurance test facility for HT/LT switches, HT/LT breakers, HT/LT contactors, MCBs, RCCBs, starters and tap changers etc.
- Test facility for degree of ingress protection (IP test).
- High voltage dry and wet power frequency withstand test facility up to 350kV.
- Temperature rise test facility up to 25kA in three phase set up.
- Temperature rise test and loss measurement facilities up to 25MVA, 132kV class Power Transformers.
- Transformer loss measurement facility up to 40MVA, 132/33kV class Power Transformers.
- Limits of current error and phase displacement test facility for Current Transformers of rating up to 12.5kA.
- Limits of voltage error and phase displacement test facility for Potential Transformers of rating up to 132kV.
- Impulse voltage test facility with impulse generator of capacity 20kJ, 800kV.
- Facilities for calibration of AC/DC voltmeters, ammeters ohmmeters, wattmeters and energy meters etc. and temperature.
- Partial discharge test facility.
- EMC/EMI test facility for full compliance as per National and International standards for electronic equipment/instruments/components.
- Energy Meter test facility.
- Transformer Meter test facility for new oil and serviced oil

### Table - 1

**THE FEASIBILITY OF TESTS FOR VARIOUS EQUIPMENTS AS PER IS/IEC STANDARDS AT CPRI, BHOPAL**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Equipment</th>
<th>Standards</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H.V. Circuit Breaker</td>
<td>IS:13118, IEC-62271-100, IS:12729, IEC:62271-1, IEC:62271-110, IS:3427, IS:14659, IEC-62271-201, IEC-62271-203, IEC-60529, IS:12063, IEC/TR 62271-308, IEC 62271-200, BS6581</td>
<td>All the tests feasible up to Test up to 50 kArms at 12 kV, 11kArms at 24 kV, 16.0kArms at 36 kV and STC test up to 200kArms for 1.0 Sec. except radio interference voltage test. Test up to 6.6 kV and 3.3 kV at 100 ^and 300 Amps Up to 50 kArms at 12 kV, 11 kArms at 24 kV, 16 kArms at 36 kV for 0.3 Sec.</td>
</tr>
</tbody>
</table>
| 3       | Alternating Current Disconnectors (Isolators) and Earthing Switches | IS:9921-1, IS:9921-2 and 3, IS:9921-4 and 5, IEC : 62271-102 | All the tests feasible except the following:
  i) Test to prove satisfactory operation under ice condition.
  ii) Test to prove satisfactory operation at minimum and maximum ambient temperature and
  iii) Measurement of radio interference level. |
<table>
<thead>
<tr>
<th>No.</th>
<th>Equipment Type</th>
<th>Standards &amp; Specifications</th>
<th>Test Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Line Traps</td>
<td>IS:8792, IS:8793, IEC:60353</td>
<td>12kV, 50 kAmps for 0.2 Sec. (depending on line trap impedance)</td>
</tr>
<tr>
<td>6</td>
<td>Spaces for Bundle Conductor</td>
<td>IS:10162, 1982/Test as per established practice of CPRI</td>
<td>Fault current test up to 50 kArms for 0.1 second</td>
</tr>
<tr>
<td>7</td>
<td>Insulator strings</td>
<td>Test as per established practice of CPRI</td>
<td>Power Arc tests 50 kArms at 12 kV 11kArms at 24 kV, 16kArms at 36 kV</td>
</tr>
<tr>
<td>8</td>
<td>Surge Arrestors</td>
<td>IS:3070-1, IS:3070-3, IEC:60099-1, IEC:60099-4, IEC:60099-5</td>
<td>Following tests are feasible: i) Power frequency voltage withstand and spark over test. ii) Pressure relief test up to 50 kArms at 12 kV, 11kArms at 24 kV, 16.0 Arms at 36 kV. For high Current test and also associated low Current test.</td>
</tr>
<tr>
<td>10</td>
<td>Motor Terminal Box</td>
<td>Test as per established practice of CPRI</td>
<td>Test Feasible are: i) Through fault current test up to rms for 1.0 Sec. ii) Internal fault current test up to 50kArms for 0.1Sec. at 12 kV, up to 11 kArms for 0.1 Sec. at 24 kV, 16 kArms for 0.1 Sec. at 36 kV.</td>
</tr>
<tr>
<td>11</td>
<td>Autoreclosures</td>
<td>IS:7567, ANSI/IEEE C-37.60, IS:13118, IS:12729</td>
<td>All ratings as per Standard, Short circuit make-break test up to 50kArms at 12 kV, 11 kArms at 24 kV, 16.0 kArms at 36 kV.</td>
</tr>
<tr>
<td>12</td>
<td>HT Contactor</td>
<td>IS:9046, IEC:62271-106, IS:5561</td>
<td>Verification of Rated making and Breaking Capacity Test</td>
</tr>
<tr>
<td>13</td>
<td>Current Transformer</td>
<td>IS:2705 (Part-1 to 4), IEC:60044-1, IEC:60044-3, IEC:60044-6</td>
<td>All tests feasible except switching impulse voltage withstand test</td>
</tr>
<tr>
<td>14</td>
<td>Voltage transformers</td>
<td>IS:3156(Part-1 to 3), IEC:60044-3</td>
<td>Short circuit withstand capability test up to 220 kV class and partial discharge up to 66kV class</td>
</tr>
<tr>
<td>15</td>
<td>Reactors</td>
<td>IS:5553-2, IS:5553-3, IS:5553-4, IS:5553-6, IS:5553-8, IEC:60076-6</td>
<td>All tests feasible except inrush current withstand test</td>
</tr>
<tr>
<td></td>
<td>Equipment Description</td>
<td>Standard(s)</td>
<td>Test Details</td>
</tr>
<tr>
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<td>--------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>16</td>
<td>Interconnecting busbar above 1000V and up to 36 kV (Busducts)</td>
<td>IS : 8084</td>
<td>All the tests feasible, Short circuit test up to 200 kArms for 1.0 sec.</td>
</tr>
<tr>
<td>17</td>
<td>Neutral Grounding Resistor units</td>
<td>Test as per established practice of CPRI</td>
<td>Short Time Current test/Temp. rise test up to 200 kArms for 1.0 sec.</td>
</tr>
<tr>
<td>18</td>
<td>LV Switchgear and Controlgear</td>
<td>IS/IEC 60947-1, IS/IEC 60947-2, IEC 60947-1, IEC 60947-2</td>
<td>All tests feasible</td>
</tr>
<tr>
<td>19</td>
<td>Control Circuit devices and switching elements not exceeding 1000 V</td>
<td>IS/IEC 60947-5-1, IEC 60947-5-1</td>
<td>All tests Feasible</td>
</tr>
<tr>
<td>20</td>
<td>Motor starters for voltage not exceeding 1000V</td>
<td>IS/IEC 60947-4-1, IEC:60947-4-1</td>
<td>All test Feasible</td>
</tr>
<tr>
<td>21</td>
<td>Air Break Switches, Air Break Connectors, Air Break Switch Disconnector fuse combinations for voltage not exceeding 1000V</td>
<td>IS/IEC 60947-1, IS/IEC 60947-3, IEC 60947-1, IEC 60947-3</td>
<td>All tests Feasible</td>
</tr>
<tr>
<td>22</td>
<td>Composite unit of air break switches for rewirable type switches for voltage not exceeding 650 V, AC-21, 100 A</td>
<td>IS:10027</td>
<td>All tests Feasible</td>
</tr>
<tr>
<td>23</td>
<td>Contactors for voltages not exceeding 1000V</td>
<td>IS/IEC 60947-4-1, IS/IEC 60947-4-2, IEC 60947-4-1, IEC 60947-4-2</td>
<td>All tests Feasible</td>
</tr>
<tr>
<td>24</td>
<td>DC Breakers</td>
<td>IS/IEC 60947-1, IS/IEC 60947-2, IEC 60947-1, IEC 60947-2</td>
<td>Test feasible are Short Circuit duty tests up to 80 kA DC, 1.55kV DC. Tripping characteristics and Temperature Rise Test</td>
</tr>
<tr>
<td>25</td>
<td>Circuit Breaker for overcurrent protection for house hold and similar installations (Miniature Circuit Breaker, MCB)</td>
<td>IS/IEC 60898-1, IEC 60898-1, IS/IEC 60898-2, IEC 60898-2</td>
<td>All tests Feasible</td>
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<tr>
<td>27</td>
<td>LV fuses for voltage not exceeding 1000V</td>
<td>IS 13703 (Part-1), IS 13703 (Part-2/Sec I), IS 13703 (Part2/ Sec2), IEC 60269-2-1, IEC 60269-3, BS:88-1, BS:88-2, BS:88-3, BS:88-5</td>
<td>All tests Feasible</td>
</tr>
<tr>
<td>28</td>
<td>Semiconductor Fuses</td>
<td>IS: 13703 (Part-1), IS:13703(Part-4), IEC:60269-1, IEC:60269-4, BS:88-4</td>
<td>All tests Feasible</td>
</tr>
<tr>
<td>29</td>
<td>Carrier Bases and Rewirable type fuses</td>
<td>IS :2086</td>
<td>All tests Feasible</td>
</tr>
<tr>
<td>30</td>
<td>D type (AC/DC) fuses</td>
<td>IS:8187</td>
<td>All tests Feasible</td>
</tr>
<tr>
<td>31</td>
<td>For enclosed distribution boards and cut-outs 1000V</td>
<td>IS:2675</td>
<td>All test Feasible</td>
</tr>
<tr>
<td>33</td>
<td>Electric Power Connectors</td>
<td>IS:5561</td>
<td>All tests Feasible except tensile and galvanising tests</td>
</tr>
<tr>
<td>34</td>
<td>On Load Tap Changer (Diverter Switch and Selector Switch)</td>
<td>IS:8468, IEC:60214-1, IEC:60214-2</td>
<td>All tests Feasible</td>
</tr>
<tr>
<td>36</td>
<td>EMC/EMI Tests on Electronic Equipment/ Components</td>
<td>IEC 61000-4-2, IEC:61000-4-3, IEC 61000-4-4, IEC: 61000-4-5, IEC 61000-4-6, IEC 61000-4-11, IEC 61000-4-12</td>
<td>Test feasible on instruments are: Electrostatic Discharge test Fast Transient burst test Immunity to electromagnetic HF field, size of EUT 400x400x400 mm (GTEM) Surge test Immunity to conducted disturbances Immunity to Oscillatory and ring wave</td>
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<tr>
<td>37</td>
<td>Oil Testing</td>
<td>IS:1866, IS:335-2000</td>
<td></td>
</tr>
</tbody>
</table>

Following tests are feasible:

i) Interfacial Tension
ii) Flashpoint
iii) Breakdown Voltage
iv) Water Content
v) Dielectric Dissipation Factor
vi) Resistivity
vii) Acidity
viii) Sludge Content
ix) Dissolved Gas Analysis
x) DBPC content
xi) ASTM ageing
xii) Density
xiii) Sulphur Content
xiv) Appearance

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Regional Testing Laboratory, which was originally situated at Muradnagar, was shifted from Muradnagar to Noida in order to provide better services to customers, during 2009.

OBJECTIVES

The laboratory was set up with a view to cater to the testing, certification and evaluation needs of electrical power equipment manufacturing industry. This unit acts as a liaison unit of CPRI with various customers in northern region and coordinate their test requirements which are beyond the scope of the Regional Laboratory but within the capabilities of Bangalore and other units.

LABORATORIES

- High Voltage Laboratory
- Liquid Dielectric laboratory
- Cables laboratory
- Diagnostics laboratory
- Meter testing laboratory

High Voltage Laboratory

Test Facilities

- Impulse Voltage generator, 1000kV, 100kJ*
- Power Frequency Testing Transformer, 350kV, 350 KVA*
- Wet Test Arrangement
- Porosity testing Machine
- Temperature Rise Test Set up 6kA
- Universal Testing Machine 600kN

Equipment that can be tested:

Standard lightning impulse voltage withstand test on: Power/Distribution transformer up to 25MVA, Instrument transformers up to 132kV, HV switch gears, Bus ducts, fuse units up to 132kV. Insulators up to 66kV.

Dry and wet power frequency voltage withstand tests on insulator up to a test voltage level of 350kV(rms). Dry, wet power frequency and standard lightning impulse voltage flashover tests, front of wave spark over tests on lightning arresters of voltage rating up to 120kV.

Liquid Dielectric Laboratory

Test Facilities for testing transformer oils as per IS: 1866.

- Dissolved gas Analysis
- Specific resistance, dissipation factor bridge
- Moisture meter
- Automatic interface tensiometer
- Flash point apparatus
- Break-down voltage tester
- Pour Point Apparatus
- Auto Titrator
- Multi extraction unit

**Cables Laboratory**

**Test Facilities**

- DC Test facility up to 5kV DC, 50mA
- AC power frequency test facility up to 60kV, 150mA
- Thermal stability test
- Universal testing machine up to 50kN
- Capacitance and tan delta measurement
- Partial discharge test up to test voltage of 100kV (rms)
- Loading Coils up to 2000A at 5volts

Cables and accessories which can be tested:

All type tests as per the relevant Indian /International standards (IS, IEC, BS).

XLPE cables up to 33kV
PVC insulated, PVC sheathed cables up to 11kV

![Hot Set Apparatus](image)

Paper Insulated, lead cover cables up to 33kV
Cables accessories like termination and joints up to 11kV

Type test on insulation mat as per IS :15652-2006

FRLS TESTS ON CABLES and INSULATING MATERIALS

- Smoke Density test as per ASTM D-2843
- Oxygen Index test as per ASTM D-2863
- Temperature Index test as per ASTM D2863
Regional Testing Laboratory, Noida

Limiting Oxygen Index Apparatus

- Halogen Acid Generation Test as per IEC 754-1
- Flammability test (Swedist Chimney method)
- Flame Retardence test for Bunched Cables.

Halogen Acid Generation Tester

DIAGNOSTIC LABORATORY

Various diagnostic tests in lab as well as in field can be carried out

- Capacitance and tan delta measurements (Megger/Doble make)
- Sweep frequency response analysis(Doble make)
- Automatic Recovery Voltage meter(Tettex make)
- Thermo Vision Camera (FLIR Make)
- Very low Frequency Tan delta/Partial Discharge on cables
- Leakage current monitoring on LA’s. (Beacon make)
- Electro magnetic Core imperfection/ Wedge Tightness Detector on generators On power equipments, substation equipments and generating equipments.

**Mobile Testing Laboratory For Energy Meter**

Instrumentation Division has established mobile testing facility for Energy Meter Testing at Consumer Premises on behalf of Power Utilities. At present, the mobile lab is situated at New Delhi and rendered services to BRPL, BYPL, NDPL, and DERC. Currently the mobile lab is rendering service to Public Grievance (PG) Dell, Govt. of India, New Delhi. More than 2500 nos. of meters were tested at consumer premises and issued field report on spot. The mobile lab is traceable to ISO/IEC 1705 and has facility to conduct tests as per IS 15707:2006.

**For details please contact:**

**Shri C.P. Jairam**  
Additional Director, Regional Testing Laboratory  
**Central Power Research Institute**  
No.3A, Sector 62,  
Institutional Area, NOIDA-201309 (UP)  
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email: rtlnoida@cpri.in / jairam@cpri.in
REGIONAL TESTING LABORATORY, KOLKATA

RTL Kolkata is set up with a view to cater to the testing, certification and evaluation needs of electrical power equipment manufacturing industries, utilities and consumers in the eastern region. It also acts as a liaison unit of CPRI with various clients in the region and coordinates their test requirements, which are beyond the scope of RTL Kolkata but within capabilities of Bangalore and other units of CPRI.

The facilities available at the laboratory are also used in research and consultancy activities.

FACILITIES

The Laboratory is equipped with facilities to carry out testing and certification of insulating oils in power transformers as per IS 1866-2000. The Dissolved Gas Analysis on power transformers, an important diagnostic tool is available at RTL Kolkata for assessing the internal condition of the transformers. The laboratory has the test facilities like Ultra High Performance Liquid Chromatography (UHPLC) to evaluate Furfural content which is an important diagnostic tool for assessing the condition of solid insulation in power transformers. The facility is also being used for assessing the Inhibitor level in the transformer oils.

MAJOR EQUIPMENT

- Break Down Voltage Tester
- Tan delta and Specific Resistance Bridge
- Tensiometer
- Gas Chromatograph
- Flash point Test Apparatus
- Moisture Analyser
- Auto Titrator
- Fourier Transform Infrared Spectrophotometer
- High Performance Liquid Chromatograph
- Oxidation Stability apparatus

DISSOLVED GAS ANALYSIS

The Centre has expertise in conducting Dissolved Gas Analysis of transformer oil, which is a powerful diagnostic technique to assess the internal condition of power transformers. Annually more than 1000 transformers are assessed for internal condition by dissolved gas analysis and more than 10% transformers are saved from destruction. The test covers preventive maintenance of transformers.
SOLID INSULATION ANALYSIS

The assessment of solid insulation in an oil filled power transformer is conducted at the laboratory using Ultra High Performance Liquid Chromatography (UHPLC). The solid insulation paper, a cellulose material produces furanic compounds on degradation. The furanic compounds dissolved in oil are analyzed by HPLC technique. This is an important diagnostic tool for assessing the condition of solid insulation in power transformers as the analysis does not involved in shut down of transformer and collection of insulating paper samples from inside the transformer. The facility is also being used for assessing the Inhibitor level in the transformer oils.

For details please contact:

Unit Head
Regional Testing Laboratory (RTL), Kolkata
Central Power Research Institute
1st Floor, CTD workshop, WBSEDCL
Abhikshan Building, BN Block, Sector V, Salt Lake City
KOLKATA - 700 091, India
Phone : 033-64511887, Fax: 033-23671477
email : rtlk@cpri.in, maiti@cpri.in
Regional Testing Laboratory Guwahati (RTL-Guwahati) was set up in the year 2007 with a view to cater to the testing, certification and evaluation requirements of electrical power equipment manufacturing industries, utilities, and consumers in the north-eastern region. RTL-Guwahati also acts as a liaison unit of CPRI with various customers in the region and coordinate the testing needs which are beyond its scope, but within the capabilities of CPRI Bangalore and other units. The facilities available at the laboratory are also utilized for Research and Development and consultancy activities.

RTL-Guwahati is equipped with facilities to carry out testing of insulating oil filled in power transformers as per IS 1866-2000 (Reaffirmed 2010). The unit is also having the facility for conducting Dissolved Gas Analysis on power transformers. This facility is an important diagnostic tool for assessing the internal condition of transformers.

The laboratory is equipped with the following instruments for conducting the testing work as per IS 1866-2000 (Reaffirmed 2010):

1. Break Down Voltage Tester
2. Tan Delta & Specific Resistance Bridge
3. Tensiometer
4. Flash Point test apparatus
5. Moisture Analyzer
6. Auto Titrator
7. Gas Chromatograph

For details please contact:

Joint Director
Central Power Research Institute
Regional Testing Laboratory, Guwahati
No: 4, Type –III (Old AT)
Guwahati: 781026
Tel/fax: 0361-2650299
e-mail: rtlg@cpri.in
In accordance with the guidelines of the Right to Information Act, 2005 enacted by Government of India, CPRI has nominated the following two officers;

<table>
<thead>
<tr>
<th>Shri. V. V. Pattanshetti</th>
<th>Shri. R. S. Kamalakar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Public Information officer</td>
<td>Assistant Public Information officer</td>
</tr>
<tr>
<td>Joint Director, Dielectric Materials Division</td>
<td>Joint Director, Planning Division</td>
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<td>Central Power Research Institute</td>
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<tr>
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### Units of Central Power Research Institute

<table>
<thead>
<tr>
<th>Bhopal Unit</th>
<th>Nagpur Unit</th>
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<tbody>
<tr>
<td>Additional Director</td>
<td>Additional Director</td>
</tr>
<tr>
<td>Switchgear Testing and Development Station</td>
<td>Thermal Research Centre</td>
</tr>
<tr>
<td>Govindpura</td>
<td>Chhindwara Road, Near MSEB Colony Gate No.2</td>
</tr>
<tr>
<td>Bhopal - 462 023</td>
<td>Koradi - 441 111</td>
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<td>Tel : 0755 -586682, Fax : 0755 – 587774</td>
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<tr>
<th>Hyderabad Unit</th>
<th>Kolkata Unit</th>
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<tbody>
<tr>
<td>Ultra High Voltage Research Laboratory(UHVRL)</td>
<td>Regional Testing Laboratory</td>
</tr>
<tr>
<td>Central Power Research Institute</td>
<td>1st Floor, CTD workshop</td>
</tr>
<tr>
<td>Post Box No. 9, Medipally, Uppal</td>
<td>WBSEB BN Block, Abhikshan Building</td>
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<tr>
<td>Warangal Highway, Hyderabad - 500 098 (A.P)-5</td>
<td>Sector - V, Salt lake city</td>
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<tr>
<td>Tel : 040 - 2720 8067, 27203622 / 2720 3112</td>
<td>Kolkata - 700091</td>
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<td>Fax: 2720 3378 / 27201127</td>
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<td>email: <a href="mailto:uhval@cpri.in">uhval@cpri.in</a>, <a href="mailto:dev@cpri.in">dev@cpri.in</a></td>
<td>email: <a href="mailto:uhval@cpri.in">uhval@cpri.in</a> / <a href="mailto:dev@cpri.in">dev@cpri.in</a></td>
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<td>Joint Director, Regional Testing Laboratory</td>
<td>Joint Director, Regional Testing Laboratory</td>
</tr>
<tr>
<td>N. 3A Sector 62, Institutional Area</td>
<td>No.4, Type -II (old A.T)</td>
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<td>Tel : 0120 - 2402823, 2402058</td>
<td>Guwahati - 781 026</td>
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