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A Successful Journey of Fifty Years: Switchgear Testing and Development Station, Bhopal

As a member of CPRI family, the Switchgear Testing and Development Station, Bhopal has become an independent knowledge leader of high quality services, research and development. From a small entity at the beginning it has developed to cater the requirement of Testing and Certification needs of Electrical Equipments manufacturers and utilities in India as well as foreign countries within five decades. This article briefs about features of different STDS laboratories and their growth from the grass root level. Some of the nostalgic memories are also shared upon.

1.0 INTRODUCTION

CPRI, STDS, Bhopal was incorporated by Govt. of India under UNDP project in the year 1960's with an authorized capital of cost value ₹ 279.14 Lakhs whereas, the present total assets of STDS is of cost values ₹ 11,607 Lakhs. At the onset CPRI was functioning under the department of Central Water and Power Commission (Power Wing) and later it was re-organized into an autonomous society under Ministry of Power, Government of India in year 1978.

Initially the lab was set up with an objective to test, plan and promote the short circuit testing of electrical equipments among the Indian manufacturers efficiently. This had ensured reliability in the power system and also facilitated the innovation and development of new products.

The STDS has a prolonged track record of testing and certification services running into sixth decade (52 years) and its laboratories are at par with any other international laboratory engaged in testing and certification of power system apparatus of manufacturers and utilities. Presently, the STDS caters to the developmental and testing requirements for quality assurance of the electrical equipment of its customers who hail from both small and large scale industries and utilities and as such the STDS is determined to make the power sector in the country self reliant.

From its genesis in the early 1970's to its current incarnation, STDS is best in terms of volume of testing and certification.

2.0 ACCREDITATION

The STDS has been accredited as a Testing Laboratory as per ISO/IEC: 17025 by National Accreditation Board for Testing and Calibration Laboratories (NABL) under Department of Science & Technology, Govt. of India, New Delhi. STDS is also recognized by Bureau of Indian Standards (BIS) and ASTA INTERTEK (Association for Short Circuit Testing Authorities), UK.

Testing Laboratores of CPRI Bhopal are also recognized by prestigious International Body STL (Short Circuit Testing Liaison).

3.0 KNOWLEDGE SHARING

A knowledge-intensive organization like CPRI has a great deal of expertise in many fields. On regular basis, our experts and consultants are invited to publish and present papers at national and international conferences and seminars frequently. We believe that sharing knowledge with all the stake holders is a vital part of being a leading authority responsible for social developments.

4.0 HISTORICAL PERSPECTIVE FOR STDS: THE SIGNIFICANT STEPS

1965: (Station-I)

1500 MVA short circuit testing station of STDS, CPRI, Bhopal was founded with the support of Govt. of India under UNDP Project (Figures 1–2). The United Nation special fund authorities came forward to provide technical and financial support during the first stage of establishment of the institute and it include necessary foreign exchange required for import of special machinery and equipments. The main object of setting up the Institute was to serve as a National Laboratory for undertaking applied research in Electrical Power Engineering besides functioning as an independent National Testing and Certification Authority for electrical equipment and components. In 1970's the institute has been able to meet more than two-thirds of the establishment expenditure from the revenue realized through testing and consultancy. The balance amounts are being received as grant-in-aid from Government of India through Ministry of energy.

FIG. 1 OERLIKON MAKE 1500 MVA SC GENERATOR

FIG. 2 VISIT OF DIGNITARIES FROM MoP

1971: Set up of Short Time Current Test for 100 kArms for one second at Station-I.

1976: Set up of Capacitive current switching test facility at Station-I.

- *125 A,3 Phase,12 kV*
- *500 A, Single Phase,12 kV.*

1980: **Set up of "Supplementary Test Lab".**

The laboratory was started in the mid-eighties for providing the variety of tests required supplementary to the main SC tests, to be conducted prior to or on completion of the main Short Circuit tests as required in the respective standards. Initially, the tests conducted in the laboratory were the small tests for verification, namely, Accuracy, tripping, operation, dielectric and temperature rise of equipments like MCB, fuses, current and voltage transformers, isolators, panels and distribution transformers.

1982: Set up of 350 kV High Voltage Power Frequency test facility at supplementary lab.

Set up of 800 kV, 20 kJ Impulse Lab at supplementary lab (Figure 3).

Set up of Test Cell-4 dedicated for various Transformers testing at station-1.

FIG. 3 IMPULSE LAB

1983: Set up of Short Time Current Test for 200 kArms for one second at Station-I.

Set up of Routine Test facility as per IS/IEC for distribution and power transformer at Station-I.

1985: (Station-II)

The reliability of power system also depends on the availability of high quality low voltage reliable equipments. This demands availability of facilities for testing of low voltage equipments as per national and international standards. STDS, CPRI, Installed and Commissioned *100 MVA on line testing station* in Nov. 1985 (Figures 4–6). The On Line Testing Station is engaged basically with the Short Circuit Testing of low voltage equipments and distribution transformers supported by Supplementary Test facilities.

FIG. 4 CONSTRUCTION WORK IN STN-2

FIG. 5 INAUGURATION OF STN-2 (23.11.85) BY HONOURABLE MoS POWER SH. ARIF MOHAMMED KHAN

FIG. 6 DR. M. RAMAMURTHY (DG CPRI) WITH HIGH LEVEL DIGNITARIES FROM MoP DURING INAUGURATION OF STN.2.

1988: Setup of "Calibration Laboratory"

Calibration Laboratory at CPRI, Bhopal is equipped with high precision state of the art Reference Standards to cater the in-house calibration needs for various measuring instruments being used in the test labs in the field of Electro-technical (ET) and Thermal discipline and having NABL accreditation (Figures 7–8). The facilities are also open to outside customers.

FIG. 7 MULTI-PRODUCT CALIBRATOR

FIG. 8 DIGITAL THERMOMETER WITH OIL BATH

1992: Setup of Inductive Load Current Test Facility at Station-I. *6.6 kV, 300 As.*

1995: Set up of Making and Breaking capacity test for DC MCB/DC MCCB at Station-I. Test Setup of Line trap/Pantograph/Spacers for bundle conductors at Station-1.

1996: Installed and Commissioned Additional 1500 MVA M/s Alstom, France Make Short Circuit Alternator with static drive, excitation system and plant auxiliaries, with cost value of ₹ 6356.42 Lakhs (Figure 9).

FIG. 9 ALSTOM MAKE 1500 MVA SC GENERATOR

1997: Set up of High Voltage Power Frequency Test Facility at Station-I.

1998: Set up of Induced over voltage Test Facility at Station-I.

1999: *(A) Set up of "25 kA Temperature Rise Test Lab".*

The temperature rise range is extended upto tests at 25000 A and temperature rise tests facilities on power transformers upto 25 MVA were added to this laboratory (Figures 10–11).

(B) Set up of "Energy meter test laboratory".

Energy meter test laboratory of CPRI, Bhopal has state of the art high precision test facilities

FIG. 10 TEMPERATURE RISE LAB (25 kA)

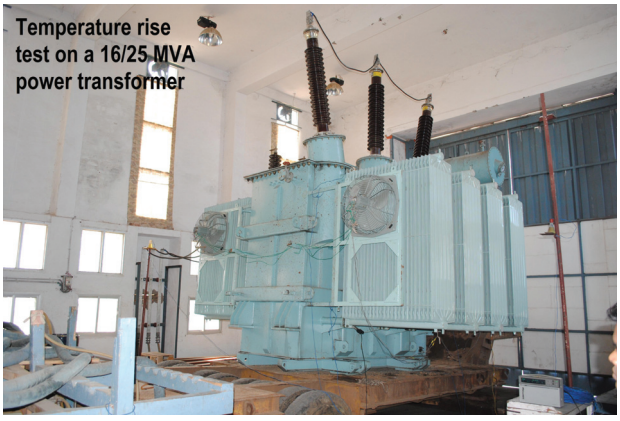

FIG. 11 TEMPERATURE RISE TEST

for carrying out all type tests as per IS and IEC standards (Figure 12–13). The laboratory was started to cater to the need of Utilities and manufacturers for quality product of energy meters. With commencement of APDRP and subsequently RAPDRP the requirement of

FIG. 12 SIX POSITION TEST BENCH WITH 0.008 CLASS ACCURACY

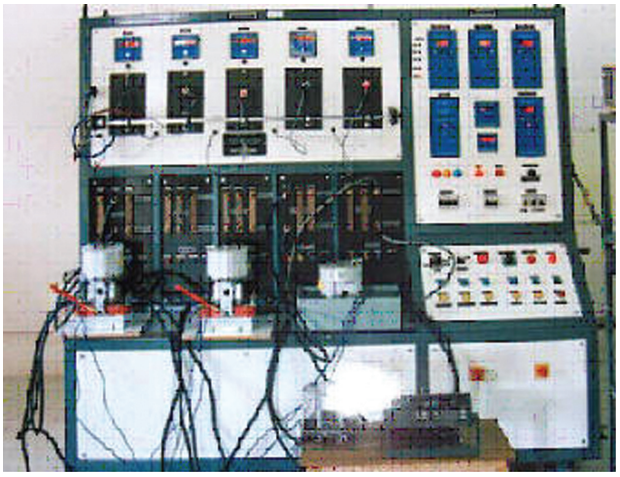

FIG. 13 TEMPERATURE RISE TEST ON METERS REFERENCE STANDARD

electronic energy meters has been grown tremendously. Energy Meter test laboratory at STDS is one of the earliest laboratory to give full type test certificate. The laboratory has served the large numbers of utilities. The laboratory was augmented thrice during past ten years as the testing requirement has been growing. The laboratory has complete type test facility for energy meters as per National and International Standards. Laboratory has also has facility to test communication protocol as per Indian standard.

2007:

- Setup of Capacitive current switching test facility at Station-I.
  400 A, 3 Phase, 12 kV.
  1200 A, Single Phase, 12 kV.
- Set up of Load loss and No-Load loss measurement up to 25 MVA at Station-I.
- Set up DVDF Test for Power Transformer at Station-I.
- Set up HV Power Frequency Test for High Voltage equipments at Station-I.
- Set up of *Oil Test Laboratory*.

The *Oil Test Lab* at CPRI Bhopal unit was established in year 2007 in order to cater the need of testing of transformer oil samples by the utilities situated in the Central region of India (Figures 14–15).

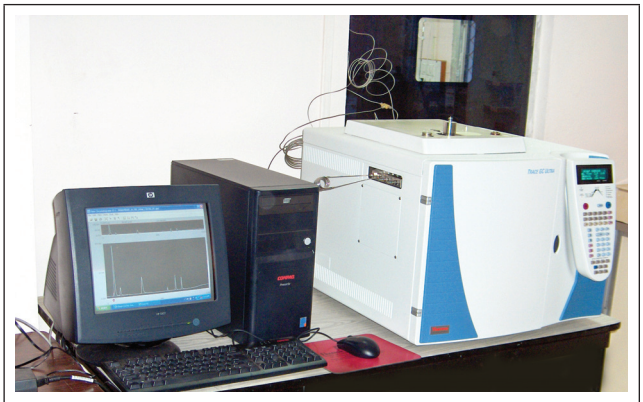

FIG. 14 A VIEW OF GAS CHROMATOGRAPH

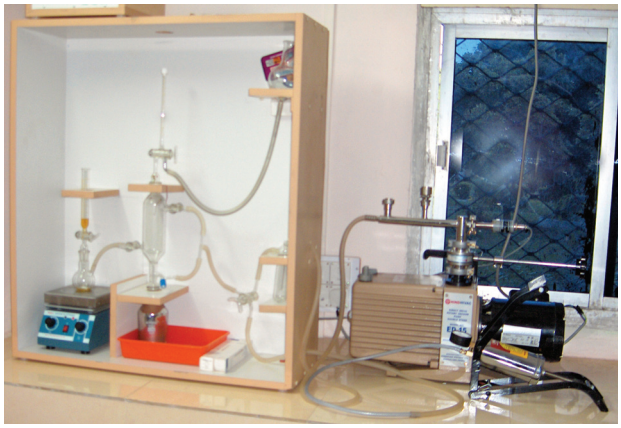

FIG. 15 GAS EXTRACTION SET UP FOR DGA TESTING

With the, state of art equipments we provide the best services to the transformer oil manufacturing units, refineries, utilities and industries to utilize the test facilities for transformer oil testing as per National and International standards. We have complete testing facilities for the serviced class of transformer oil as per IS:1866-2000 for proper maintenance of transformers and electrical equipments in the field. The tests like Breakdown Voltage test, Moisture content, Acidity, Sludge, Tan-delta, Resistivity, Flash Point, Interfacial tension and Dissolved Gas Analysis for serviced class of transformer oil samples are carried out regularly. The DGA is one of the most important and popular diagnostic test for the monitoring and maintenance of power transformers. The test facility for new transformer oil as per IS:335-1993 is also available. Our test equipments are well maintained and calibrated to carry out testing as per standards.

2010: A Great Leap into 800 kV and 1200 kV Test facility.

Successfully tested for the first time 800 kV Disconnector, 800 kV Power Connectors and 800 kV Current Transformer, as per IS/IEC standards and also tested Lightening Arresters and Line Accessories for 1200 kV Power system (Figures 16–18).

FIG. 16 800 kV, 3150 A KNEE TYPE DISCONNECTOR

FIG. 17 800 kV, 4000 A POWER CONNECTORS

2010–11: Setup of On Load Tap Changer Test Facility (Figure 19) for Switching Duty Tests upto 2000 As, 12 kV Recovery Voltage as per IS and IEC Standards.

2011–12: Augmentation of High Voltage and Impulse Test Facilities for 400 kV class Power Equipments as IS and IEC Standards.

FIG. 18 800 kV CURRENT TRANSFORMER

FIG. 19 OLTC UNDER TEST

5.0 TECHNOLOGY UP-GRADATION

(A) "Upgradation of 1500 MVA, 12 kV Alstom Make Short Circuit Generator"

With the evolution of new technology, the control system for Alstom make SC generator was upgraded for Motor-less operation

FIG. 20 MOTOR-LESS SC GENERATOR

(Figure 20) in the year 2006. With the removal of driving motor the maintenance cost and downtime is reduced.

(B) "Refurbishment of Oerlikon make Short Circuit Generator"

This Generator was in operation since almost 40 years and such long operation has resulted in rotor insulation deterioration and significant looseness of stator slot wedges.

A complete rewind of the rotor with new class 'F' insulation and replacement of all the slot wedges/packers of the stator were carried out (Figures 21–22).

FIG. 21 SC GENERATOR STATOR

FIG. 22 INSPECTION OF GENERATOR ROTOR AT THE WORKS OF M/S. ALSTOM, VADODARA

6.0 RESEARCH AND DEVELOPMENT

STDS has done significant research work and also helped Indian manufacturing industries in the development of indigenous know-how, import substitution of materials, export promotion, etc. Some of the R&D projects undertaken are listed below:

- Simulation of 6.6 kV/11 kV Motor Switching Test Circuit.
- Analysis of impact forces on the support insulator used in the metal enclosed switchgear during short circuit test.
- Partial discharge measurement of various electrical equipments upto 36 kV.
- Design and Fabrication of 100 kA Co-Axial shunts.
- Design and Fabrication of 12 kV, 400 As Air Break Load Break Switch.
- Transient Response of 36 kV, 50 kA Resin Cast Current Transformer including designing and fabrication.
- Design and Fabrication 11 kV, 40 As Drop Out Fuses with Fiber Glass tubes.
- Study of short circuit performance of MCBs and their co-ordination with HRC fuses.
- Optimization of LT control panel design using various insulating supports.
- Design and Fabrication of 200 kA Co-Axial shunts (Figure 23).

FIG. 23 CO-AXIAL SHUNTS (200 kA)

7.0 REVENUE

In the field of testing, consultancy and third party inspection the activities of the institute have been quite impressive. The electrical manufacturing

industries and electricity supply utilities have been increasingly coming forward to avail the test facilities and expertise built up in CPRI. STDS is the maximum foreign currency revenue earner among the CPRI units. Approximately 10% of the total revenue earned is generated through testing of equipments pertaining to customers from countries of Middle East, South Asian and South African region.

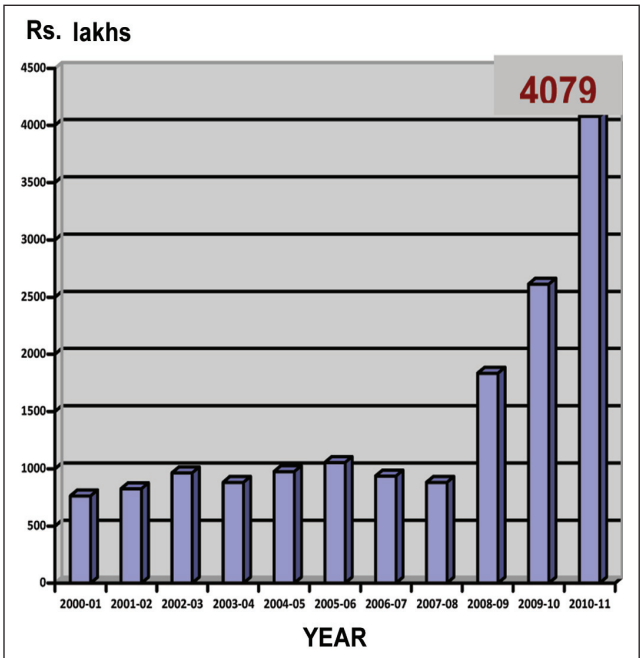

FIG. 24 REVENUE CHART

The total revenue realised by STDS through testing and consultancy for the year 2010–11 was ₹ 4079 Lakhs (Figure 24).

8.0 TECHNICAL PAPERS PRESENTED IN INTERNATIONAL/NATIONAL CONFERENCES AND SEMINARS

- A Practical approach to the short circuit testing of Transformers.
- Current status of Transformer testing facilities in India.
- Short-Circuit Testing Experience.
- Renewable Energy Resources and their Utilisation.
- Capacitor Current Switching Tests on Medium Voltage Vacuum Circuit Breaker - A CPRI Experience.
- Short-Circuit Test Experiences and critical review of the IEC Standard.
- Internal arc test on metal enclosed switchgear and motor terminal box – A review.
- Miniature Circuit Breakers; Short Circuit Tests and Arc quenching.
- EMC compliance of LT Switchgears and Control-gears.
- Trends in design and short circuit performance of Residual Current Operated Circuit Breakers.
- Communication structure and requirements for fast function of substations.
- Switchgear maintenance in a generator based short circuit testing plant.
- Protection of Electrical Equipments in enclosures against environmental hazards.
- Trends and Advances in computation and Engineering.
- Motor-less Generator CPRI experience.
- CPRI, Bhopal uses new testing technology for 400 kV class Disconnectors.
- Modernisation and Upgradation of Transformer Technology.
- Study of behavior of Medium Voltage Vacuum Circuit Breaker during Capacitor Current Switching test - A CPRI experience.
- Factor affecting the short circuit performance of Transformer and failure Analysis - A CPRI experience.
- Design, performance evaluation and short circuit testing of Residual Current Operated Circuit Breaker.
- Short Circuit Capability of current transformer and factors affecting the design.
- Special Considerations while performing Short Circuit test on Transformers.
- A Laboratory Analysis on performance of Transformer under short circuit conditions.

- Performance of 3 Phase Power Transformers during short circuit testing.
- Short circuit performance of MCBs and their co-ordination with HRC fuses.
- Optimisation of LT Panel Design.
- Internal Arc Fault test in metal enclosed switchgears and safety of operating personnel.
- Performance of Transformers against short circuit and excessive flux density.
- Short Circuit and impulse testing of Current Transformer.
- The latest Requirement of Switchgear Testing and Statistical failure Analysis.
- Test requirements and test methods for testing transformer and LT Switchgear - facilities at CPRI.
- New generation transformer oils; material aspects.
- Motor-less operation of short circuit generator-A CPRI perspective.
- High Voltage circuit breaker testing.
- Maintenance and Condition Monitoring of Short Circuit Testing Plant: 40 Years Experience of CPRI.
- Simulation of field conditions for reliability Evaluation of Electronic Energy Meters.
- Testing of low voltage current limiting HRC fuses with reference to maximum energy condition.
- Synthetic testing of circuit breaker: relative severity.
- Transient recovery voltage for high power circuit breaker testing.
- Recent development in the synthetic test circuit of AC circuit breaker.
- Need for harmonizing tender specifications of Energy Meters.
- Energy Efficient Lighting Systems.

FIG. 25 (L-R) Sh. B. V. RAGHAVAIAH, (AD, CPRI) Sh. M. K. DUBEY (ED, BHEL, BHOPAL), Sh. S. SHUKLA (IAS, CMD, MP DISCOM), Sh. N. MURUGESAN (DG, CPRI), Sh. S. DUKKAIAPPAN (VP, ABB).

FIG. 26 Sh. N. MURUGESAN (DG, CPRI), DELIVERING THE KEY-NOTE ADDRESS

9.0 SIGNIFICANT ADVANCES IN KNOWLEDGE AND THEIR APPLICATION

Indian power system is expanding at high rate with present installed capacity is about 1,64,000 MW. Power demand is expected to further increase to about 220 GW by 2017 and 370 GW by 2022 in next 10–12 years for which total installed capacity of about 480 GW is envisaged. However optimal utilization of unevenly distributed energy resources in the country along with severe right of way issue and phase-wise development of transmission infrastructure necessitates establishment of high power transmission corridors. Towards this, a number of transmission corridors comprising

765 kV AC, 1200 kV AC, 800 kV, 6000 MW HVDC system have been planned/under implementation. To cater the development and testing needs, CPRI is sincerely exerting efforts and up-gradation has been carried out in the lab. At STDS 800 kV CT, 800 kV disconnector, 800 kV Power connector and Lightening Arresters and Line Accessories for 1200 kV Power system have been tested.

10.0 FUTURE PLAN

The institute has ambitious expansion programme to fulfil the task envisaged in the perspective plan for CPRI. Twelfth plan proposal of CPRI has been prepared keeping in view the importance of R&D and testing facilities play in the accelerated growth in the power sector.

Upcoming projects:

- High Power Short Circuit Testing Laboratory of 2500 MVA.
- Additional Routine Test Facility for Distribution Transformer.
- Up-gradation of measurement and recording system.
- PD Test Facilities upto 220 kV Class.
- Augmentation and Modernization of Ingress Protection Lab.
- Augmentation and Modernisation of Electrical Endurance and Overload Test Facilities for LV Protective Switchgears and Fuses.
- Augmentation and Modernisation of Mechanical Endurance Test Facility for LT & HT Switchgears.
- Augmentation and Modernisation of CT-VT Test Facilities.
- Calibration of Power and Energy meter with an accuracy of 100 ppm.
- Augmentation of calibration facility for Thermometers with temperature range of (–)40°C–1460°C.

11.0 REMEMBERING OUR PAST ASSOCIATES OF CPRI STDS

At this moment it is our privilege to remember the retired senior officers and staff members who have served for a long period of time (20–30 years) and contributed significantly to build CPRI STDS into an iconic institution in the field of Electrical power. Most of them had been associated since beginning of work at CPRI Bhopal. As STDS is better half of CPRI some of its senior most officers elevated to top management post and steered CPRI to even further greater heights. STDS salutes them all for their dedication and devotion to the work.

At this juncture it is not possible to mention all the names still we acknowledge Shri S. Anantha Krishnan, Shri P. J. Ingle, Shri K. N. S. Murthy, Shri A. Bhaskaran, Shri P. K. Kognolkar, Shri G. Sengupta, Shri R. M. Sahu, Shri M. L. Unhale, Shri A. P. Kulkarni and Shri K.A.N.Talpasai for their services.

12.0 CONCLUSION

CPRI, STDS has a major role to play in ensuring the availability, reliability, sustain ability and profitability of energy and related products and processes. Our mission is to act as an independent, leading authority that delivers added value for its customers by providing performance and quality management services linked to the production and use of electricity.

ACKNOWLEDGMENT

This article is prepared by:

Shri B. V. Raghavaiah, Shri N. R. Mondal, Shri M.A. Ansari and Shri Arun Kumar Datta.

Photograph courtesy:

Shri Anees Qureshi.

GLIMPSES OF SOME IMPORTANT EVENTS/OCCASIONS

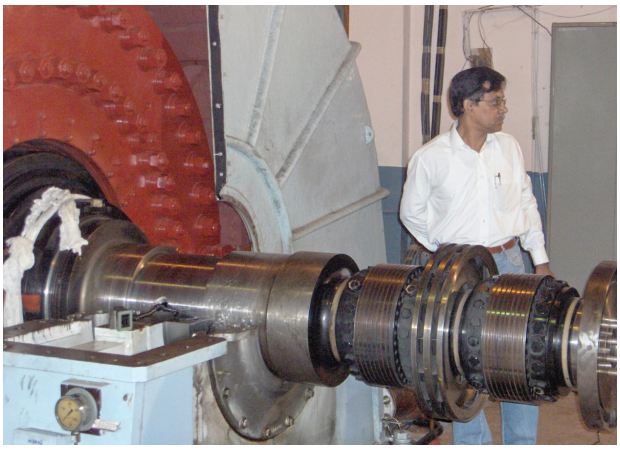

FIG. 27 Sh. G. SENGUPTA, AD, INSPECTION OF BEARING

FIG. 28 CONSTRUCTION OF STN-2

FIG. 29 Dr. M. RAMAMURTHY (DG CPRI) AND Sh. K.N.S. MURTHY, AD WITH HIGH LEVEL DIGNITARIES FROM MoP

FIG. 30 Dr. M. RAMAMURTHY (DG CPRI) ADDRESSING THE GATHERING

FIG. 31 Dr. M. RAMAMURTHY (DG CPRI), Sh. S. ANANTHAKRISHNAN, AD & SH. P. J. INGLE, JD WITH HIGH LEVEL DIGNITARIES FROM MoP

FIG. 32 VISIT OF LAB BY DIGNITARIES OF MoP

FIG. 33 FOUNDATION STONE CEREMONY FOR R&D COMPLEX

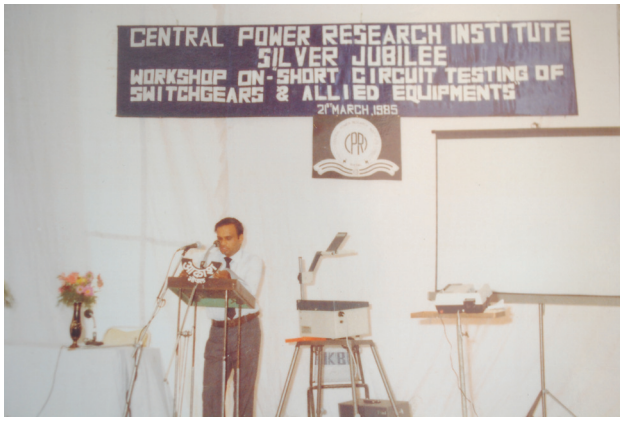

FIG. 34 Sh. P. K. KOGNOLKAR AT SILVER JUBILEE CELEBRATION

PICTORIAL VIEW OF LABORATORIES AT STDS

FIG. 35 MAIN BUILDING OF STDS

FIG. 37 1500 MVA SC TESTING STN (STATION-1)

FIG. 36 100 MVA ON-LINE TESTING STN (STATION-2)

FIG. 38 SUPPLEMENTARY TEST LAB AND ENERGY METER TEST LAB

FIG. 39 CALIBRATION TEST LAB

FIG. 40 OIL TEST LABORATORY