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Short Circuit Laboratory

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1.0 PREAMBLE

The Central Power Research Institute (CPRI) came into existence in 1960. It was functioning as a department of the then Central Water and Power Commission (Power Wing). The recommendations of the Committee set up by the Ministry of Energy in 1975 were accepted by the Government of India and the Institute was reorganized as an autonomous society and registered under Karnataka Societies Act in January 1978.

The multi-disciplinary complex at Bangalore is devoted to testing, certification, consultancy, research and development of all types of electrical equipment used in power systems.

With the concept of creating testing facilities for Low Voltage Switchgear and control gear equipment and other power system apparatus for high current tests, the Short-Circuit laboratory, at CPRI, Bangalore was created.

The equipment and expertise were with the aid under the United Nations Development Programme (UNDP).

2.0 INITIAL DEVELOPMENTS

The Laboratory was located in a small premise behind the High-Voltage Engineering Department of Indian Institute of Science campus.

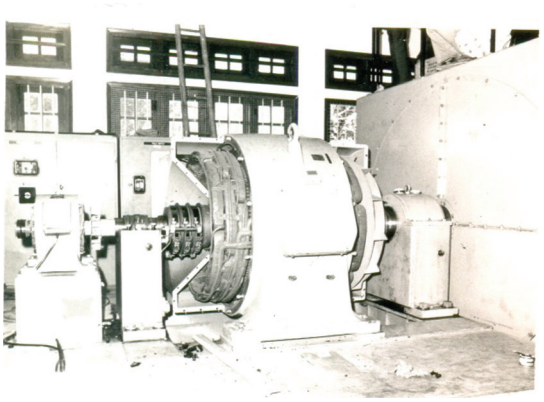
All the machinery, control and measuring equipment were from countries of Europe.

The set-up consisted of 12 kV 50 MVA Short-Circuit (SC) Generator driven by 3.3 kV induction motor and a DC shunt generator coupled to the Generator shaft. Set-up also consisted of auxiliary equipment like Air-blast Master Circuit-breaker for breaking the short-circuit current and a high speed Make Switch for initiating the short-circuit, protection system for drive motor and Generator, Control Desk, Measuring/recording system, etc. The above equipment were of ASEA, Sweden make.

The set-up also consisted of SC Transformer, HT Reactor and Resistor Banks which are from Siemens, Germany.

The laboratory equipment was installed by the CPRI personnel. The commissioning of

the laboratory was done with the assistance of ASEA Sweden's Engineers, Mr. Jinckpeterson and Mr. Lyndquist. CPRI's Engineers and technicians were associated. It was sometime during February 1972 the commissioning process of the lab started.



PHOTOGRAPH SHOWING THE ASEA MAKE 50 MVA SC GENERATOR WITH DRIVE MOTOR WHEN THE LAB WAS FIRST INSTALLED AT IISc, BANGALORE CAMPUS

LT ACBs of NGEF, MEI, English Electric, Easun Engineering, were used during the commissioning tests.

Prior to the commissioning of the SC Generator, its Driving Motor, and SC Transformer were checked for their IR and PI values. Since these were idle for quite some time warming up for improving the IR and PI values for the Generator and Oil filtration for the Transformer were to be done for long durations.

Measuring/recording system consisted of UV recorder associated with an isolation amplifier. The recording of the waveform was made by the used of UV paper imported from Kodak. After the recording, the UV paper was required to be exposed to the light in order to view the waveform. The calibration of the measuring equipment, establishing the plant parameters and checking the withstand strength of the bus-bars and cables were some of the major events.

Since the test cells were located indoor and were very close to the control desk and hence to the operating personnel (distance between the control desk and test cell walls was about 1.5 metres only), it was very risky to carry out high current tests particularly on oil filled equipment.

The first few tests after commissioning were carried out on ACBs of MEI and EE make. The tests were mainly for breaking capacity tests. Since the parameters of the lab were not fully established, the withstand test for one second were not taken. Later, when the parameters such as point on wave closing and withstand capability of SC testing Transformers, Reactors, were confirmed the Short time withstand current tests for 1.0s duration was started.

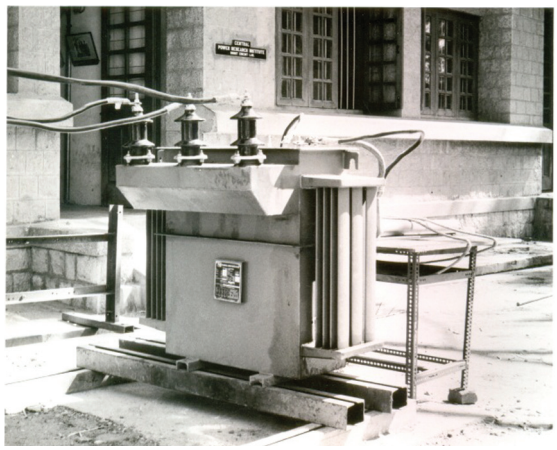
When the HRC fuse testing was undertaken for the first time we were not able to maintain the recovery voltage for 30s. It was because of the apprehension that in case the fuse fails to interrupt the short circuit current, the blast will be very serious and the Generator will be supplying the current for the entire duration. Later-on this situation was sorted out and we could maintain the recovery voltage as per the Standard's requirements.

Short time withstand current tests for CTs, Isolators, Power Connectors, ACBs were started during this period. At the initial times it was very challenging to do this test as the current was required to be maintained for the entire duration by selecting the proper super excitation setting.

During this time a request was made by M/s. Kirloskar Electric Company, Bangalore to test 315 kVA oil filled outdoor type Transformer. The testing standard for this test (Part of IEC 76) was under draft stage. Since the Test cell was indoor and it was very close proximity to the control desk and operating personnel testing oil filled Transformer was very risky. However the laboratory personnel wanted to take up this test as a challenge and at the same time the fire risk also could not be overlooked. The laboratory management suggested to the manufacturer to bring the Transformer for testing with a non-inflammable liquid such as Askarel. The suggestion was agreed and the transformer was brought for testing. It was an

interesting experience to load this transformer into the test cell as handling equipment was not available during that time. After making all necessary testing arrangements and precautions such as fire fighting equipment the Transformer was successfully tested at the laboratory.

Perhaps this was for the first time in the country a transformer was tested for Short-Circuit tests.



PHOTOGRAPH SHOWING THE DISTRIBUTION TRANSFORMER UNDERGOING SC TEST

A temporary shed was created outside the laboratory to test oil filled Transformers, CTs, etc. The laboratory had functioned at this premise for a period of about 7 years.

Shifting of the Laboratory to the present premises happened during August 1978 to November 1978.

3.0 SHORT CIRCUIT LABORATORY (1978–1995)

The shifting of the Lab to the present premise was completely done by the lab personnel with the help of services of other divisions. It was very tough task to shift the M-G set to the present location, carry out erection and commissioning of the entire equipment.

Many facilities were added from now onwards. Routine test facilities for transformers, CTs were established. Also facility was created for Electrical Endurance test on contactors, switches, MCB, etc. Temperature control ovens, Humidity chamber were also added for carrying out environmental tests.

Also an additional 50 MVA SC transformer was procured from Kirloskar during 1978. This transformer was mainly used to carry out breaking capacity tests on MCBs, MCCBs, HRF fuses, rated make-break tests on contactors, Switches, starters, etc.

A small on Line test laboratory facility was created within the premise making use of the existing equipment. This was a good addition to the laboratory. Many electrical endurance tests particularly on ACBs up to 4000 A, contactors and switches were tested.

PHOTOGRAPH SHOWING THE OLD 50 MVA SC GENERATOR

PHOTOGRAPH SHOWING THE SHORT CIRCUIT TEST BAYS

4.0 SHORT CIRCUIT LAB. (1996 TO TILL DATE)

As there was demand for the DC Short-Circuit test from the various manufacturers 600 V, 30 kA DC short-circuit test facility was created under 8th plan capital project. This is the *only unique DC short-circuit test facility available in India even today* for testing LV DC equipment like MCBs, MCCBs, switches, contractors, fuses etc. An impulse test facility for up to 30 kVp was also created under the same project for carrying impulse tests on LV equipment.

PHOTOGRAPH SHOWING THE DC TEST FACILITY

As the present SC M-G set had served to the nation for more than 40 years, taking the aging factor into consideration, it was decided to create parallel SC test facility to serve the nation in case of breakdown in the present system. Also the present system was having some drawbacks like frequency drop during withstand current tests, lack of fine control of the test current, test at 60 Hz frequency.

The project was started during the year 2008 under the 11th plan capital project and was completed during the year 2010. It was for first time the SC test facility was indigenously designed, manufactured and commissioned in the country. The new set-up consisted of 50 MVA SC generator driven by 690 V induction motor supplied through a variable frequency drive (VFD). Because of the VFD the testing can also be carried out at 60 Hz frequency which is

PHOTOGRAPH SHOWING THE NEW 50 MVA SC GENERATOR WITH DRIVE MOTOR AND VFD

very unique. This helps manufacturers to export their products to North American countries. The M-G set is coupled with a fly-wheel mainly to store the energy and compensate for the speed drop during the with stand current tests. The set-up also includes a static excitation system with microprocessor based feedback control system to have fine control of the test current. The modern control system was employed for test sequencing and machine control which makes test very fast and accurate. With this the entire operation right from starting of Motor, exciting of generator, test sequencing and data acquisition can be performed from the control desk.

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

The laboratory has supplementary test facility to carryout pre and post short-circuits 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 at 433 V and up to 400 A at 690 V) and Mechanical

endurance test and some environmental tests (with climatic chambers up to 2.25 cubic meter capacity, from 40ºC to +150ºC temperature ranges and humidity control of 40% to 98%). as per IS:9000.

PHOTOGRAPH SHOWS INAUGURATION OF THE NEW 50 MVA SC GENERATOR BY MR. P. UMASHANKAR, HONOURABLE SECRETARY, MINISTRY OF POWER

PHOTOGRAPH SHOWS CONTROL ROOM WITH NEW CONTROL DESK AND CCTV SYSTEM

High-Voltage power frequency tests up to 100 kV for 1 min. and induced over-voltage tests up to 1000 V and at 100 Hz, 200 Hz and 400 Hz are possible to conduct at the supplementary tests laboratory. An impulse voltage generator (035 kV, 1.2/50 µs) with the necessary measuring, recording systems are also available in the laboratory to perform test as per IEC 60060, IEC 61180 and IS 2071. Surge immunity facility is available to test LV equipment up to 5000A at 8/20 µs and impulse voltage up to 10 kV at 1.2/50 µs according to the IEC 61000-4-12.

Glow wire tests (up to 960ºC) and Ball Pressure tests can also be done according to the IEC 60695 and IS 11000.

PHOTOGRAPH SHOWING THE NEW 10 kA ON-LINE TEST FACILITY FOR MCB/RCCB TESTING

On-line SC test facility for up to 10kA was also created for testing MCB and RCCB during the above time. By this MCB/RCCB tests are off loaded to this facility which makes testing faster. The laboratory is equipped with high speed digital photography facility which helps customers for research and development of their products.

5.0 RESEARCH ACTIVITIES

The laboratory contributed a lot in the indigenous development of HRC fuses and Moulded Case Circuit Breakers with electronics trip circuits by English Electric Company, indigenization of Circuit Breakers used in completely self-protected (CSP) transformers, medium-voltage vacuum contractors, etc.

An exclusive arc research facility was established during 1990–1996 to study the behaviour of Vacuum and SF_6 arcs. High film camera was also procured for this purpose.

The following Studies were undertaken:

1. Studies on Permanent Power Fuse: as a protective device in LT systems

2. Frequency response analysis (FRA) method of detecting faults in Transformers subject to Short-Circuits.
3. Low-Voltage Impulse method of detecting faults in Transformers subject to Short-Circuits.
4. Mathematical modelling of Rotating Arcs in SF_6 Interrupters.
5. Voltage surges while interrupting Induction Motor Currents by VCBs.
6. Development of 11 kV Capacitor Switch
7. Automation of Transformer loss measurement and impulse test.
8. Development of data acquisition software for 8 channel digital oscilloscope

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.

6.0 FIELD ASSIGNMENTS

Routine tests on CT's and PT's were carried out at site for the following:

- Covanta Samalpatti Operating (P) Ltd., Dharmapuri, Tamilnadu during August 2003, June 2005 and August 2007.
- Karnataka Power Corporation Ltd., Jog Falls, Gerusoppa, Shimoga during January to March 2004.
- Aban Power Co. Ltd., Tanjore Dist., Tamilnadu, during January 2005.
- Covanta Madurai Pvt. Ltd., Tamilnadu during June 2005.
- NTPC Ltd., Sonebhadra, Uttar Pradesh during August 2005.
- Rourkela Steel Plant, Orissa during October 2005.
- MALCO, Mettur Dam during May 2006.
- West Bengal Electricity Transmission Company Ltd., Kasba, Jeerat, Howrah, Durgapur during February to April 2007.
- Vijai Electricals Ltd., during July 2007.
- Madurai Power Corporation Ltd., Madurai during August 2007.
- GMR Energy, Mangalore during October and November 2007.
- Damodar Valley Corporation, Durgapur during November 2007 and December 2011.

Apart from the above following Thermal Power Stations were also visited for carrying out Accuracy test on CT's during 2004 to 2007.

- Raichur, Karnataka
- Delhi
- Kasimpur, Uttar Pradesh
- Bhatinda, Punjab
- Panipat, Haryana

7.0 TESTING AND CERTIFICATION

Type tests and Routine tests on low voltage switchgears and control gears, distribution transformers up to 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) which enables ASTA Certificates to be issued to the customers.

Short Circuit Laboratory is extensively used by the Electrical Industry and the Power Utilities for testing, performance evaluation and certification of a large number of electrical equipment. The facility is also being used by the Manufacturers

for indigenous low voltage switchgear and control-gear development.

8.0 KNOWLEDGE DISSEMINATION AND TRAINING

Periodic Workshops and Seminars were being conducted to bring out new advances in technology and best practices on topics of current interest for professionals. Following Seminars/Workshops/Training programs have been conducted by the Division:

1. Seminar on High-Power and High-Voltage testing (1981).
2. Symposium on High-Voltage Switchgear (1983).
3. Workshop on arc research facility (1992).
4. Workshop on Low-Voltage Switchgear (1998).
5. Training program on testing of RCCB according to the latest standards (2005).
6. Training program on testing of LV switch-gear and control-gear equipments (2008).
7. Workshop on latest trends on LV Switchgear and control gear equipment (2010).

All these were well intended by delegates from Industries, Academic Institutions, Electricity utilities. Many topics pertinent to Switchgear were presented and debated during these meetings.

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