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Ultra High Voltage Research Laboratory, Hyderabad

Establishing an experimental UHV transmission line facility in India was undertaken, with funding from Government of India, to carry out studies facilitating possible introduction of UHV lines in the voltage range of 800–1200 kV AC of and to establish high-voltage test facility for the development of equipment by Indian manufacturers and also for the purpose of quality assurance testing of these apparatus. Research facilities at UHVRL have been set up mainly to undertake major electrotechnical and biological research and development studies and also to undertake testing activities for equipment ranging up to 1200 kV. The Impulse laboratory facilities available at UHV Research laboratory, CPRI, Hyderabad are of world class and at par with international laboratories like-CESI, EdF, KEEMA laboratories etc. Power equipment manufacturers, EHV/UHV transmission grid operators and utilities can avail the services to evaluate their equipment and sponsor the research work of their interest.

1.0 INTRODUCTION

Power supply demand in developing countries, more so in India, need not be overemphasized. Demand has to be met by installing generating stations, erecting transmission lines and building distribution substations. In view of long distances between resources of generation to load centers, the power has be transmitted in bulk by AC and/or DC transmission lines. High reliability of power supply has to be maintained by using proper lines and equipments. The quality and adequacy of these equipments have to be demonstrated through testing of the designs of such equipments.

The crucial importance of a robust transmission system for evacuating power from energy-plus to energy-deficit regions is ample justification for strengthening the system and creating a national grid. Given expected generation capacity additions of over 100 GW in the next 7 years, the transmission system must meet the challenges of dealing with increased load and network complexity.

Most of the electrical parameters like radio noise, audible noise, corona power loss which govern the UHV line design are weather-dependent and may be different from those that standardized in other countries. Thus, the need for establishing an experimental UHV transmission line facility in India was felt. Accordingly, a research project was undertaken, with funding from Government of India, to carry out studies facilitating possible introduction of UHV lines in the voltage range of 800–1200 kV AC of and to establish high-voltage test facility for the development of equipment by Indian manufacturers and also for the purpose of quality assurance testing of these apparatus.

2.0 MAJOR FACILITIES AT UHVRL, HYDERABAD

The foundation stone for construction of UHVRL was laid in the year 1987 and the facility was commissioned in the year 1993. Pictures 1 and 2 show the foundation stone and inauguration of the facility, respectively.

The facilities at UHVRL have been set up mainly to undertake major electrotechnical and biological research and development studies and also to undertake testing activities for equipment ranging up to 1200 kV. With this in view, following laboratories and facilities have been set up for undertaking various types of research and testing:

- Impulse laboratory
- Power frequency laboratory

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PICTURE 1 FOUNDATION STONE OF UHVRL

PICTURE. 2 INAUGURATION OF UHVRL TEST FACILITY

- Pollution laboratory
- Bio-monitoring laboratory
- Experimental transmission Line
- Mock up tower facility
- Corona cage facility

In the above laboratories, major electrical research and development studies conducted are corona loss; electric field and field effects; radio and TV interference; audible noise; breakdown characteristics of air insulation; optimization of window clearance and transmission lines; pollution performance of insulators and surge arresters; and very low frequency electric and magnetic field effects.

3.0 RESEARCH AND DEVELOPMENT

UHVRL is contributing to the development of power sector. It has completed 23 research projects initiated by in-house and few of them were funded by CBI and P, New Delhi. The results of these projects were published in 125 technical papers in various national and international journals and conferences. Some important papers are listed in references.

Major electrical and mechanical studies conducted under this project were:

(i) Evaluation of the adequacy of conductor bundle for 1200 kV transmission lines with regard to corona-related aspects of transmission line, namely, Radio interference, Audible noise, Corona power loss and Electric field, under different atmospheric conditions and subsequent optimization of conductor bundle configuration.

(ii) Optimization of conductor-ground, conductor-tower window clearances for 1200 kV transmission system.

(iii) Evaluation of pollution performance of 'I', 'V' and horizontal insulator strings.

(iv) Study of biological effect of electric and magnetic fields.

(v) Design of optimum tower structure configuration for UHV lines.

(vi) RTV Coating on insulators for pollution Performance studies

(vii) Frequency response analysis of power transformers, etc.

4.0 TEST FACILITIES AND MAJOR RESEARCH WORKS

4.1 Impulse Laboratory

The impulse laboratory has been set up at UHVRL, Hyderabad, to undertake research and development studies for breakdown characteristics of air insulation, optimization of window clearance and transmission lines in EHV/UHV range. Accordingly, research projects were also undertaken, to carryout studies facilitating the introduction of EHV/UHV lines in the voltage range of 765 kV to 1200 kV AC lines. The facility is also used for the purpose of quality assurance testing which will help in the development of EHV/UHV apparatus by Indian manufacturers.

FIG. 1 A VIEW OF OUTDOOR IMPULSE GENERATOR DURING ITS ERECTION

Figure 1 shows a view of the derricks arrangement being made to erect the impulse voltage generator. This outdoor 5 MV/500 kJ impulse voltage generator is 23 m in height having 25 stages at 200 kV per stage. The whole generator is enclosed in fiber glass enclosure of 6 m diameter.

Outdoor-type damped capacitive voltage divider is rated as 4800 kV/600 pF. Figure 2 shows a view of this divider during its erection for the first time. It comprise, of ten numbers of R-C stacks with top electrode. It can be seen in Figure 2 that top six stacks with top electrodes being lifted with derrick arrangement and coupled to the bottom four stacks. The height of the divider is 25 m and the top electrodes are 6 m in diameter. The whole divider is on base frame with polyurethane-based wheels and it is possible to move the divider. The load capacitor has similar dimensions and is rated as 4800 kV/2 nF which can be seen in the background of Figures 9 and 10.

FIG. 2 ERECTION OF 4800 kV DAMPED CAPACITIVE DIVIDER IN PROGRESS

Figure 3 shows the full view of the impulse voltage generator along with the damped capacitive voltage divider which was commissioned in 1993. The impulse voltage generator can generate 4.4 MV standard lightning impulse of 1.2/50 us under dry condition and 3.2 MV switching impulse of 250/2500 us with the standard load of 2 nF. In addition to these, High Resolution Impulse Measuring and Analyzing system, Reference Impulse Calibrator, Recurrent Surge Generator, Unit Step Generator, 50 cm standard sphere gap, etc., equipment are available in the laboratory to carry out testing activities and conducting performance tests on measuring system to meet the requirements of the standards. Brief review of the some research studies and development work carried out are outlined in subsequent section and papers published are listed in References. As far impulse voltage testing is concerned, the generator is one among a few in the world with regard to its rating, and there is no limitation on the impulse testing of electrical equipment of any rating up to 1200 kV class voltage levels.

FIG. 3 AN EXTERNAL VIEW OF OUTDOOR IMPULSE VOLTAGE GENERATOR AND DIVIDER

4.1.1 Optimization of Air Clearances for EHV and UHV Transmission lines

Systematic study was conducted on 400, 800, 1200 kV transmission lines with an aim to optimize the air clearances. Laboratory investigations were carried out to evolve the switching impulse performance of phase-to-earth air insulation line configurations in addition to the reference rod plane air gap lengths in UHV range. Tests were conducted on 400, 800 and 1200 kV line configurations of “I”, “V”, double “V”, etc. by simulating the tower windows.

Figures 4 and 5 show the view of the test set up used for 800 kV and 1200 kV tower window optimization studies respectively. The test program me was specifically conceived to generate UHV tower design data. Some important test data on required clearances obtained from the study for standard insulation levels as well as the reduced insulation levels, with and without the consideration of mechanical swing, which can be used as critical optimum values in the transmission line air gap clearances, are reported in [8].

FIG. 4 A VIEW OF 800 kV INSULATOR STRING WITH SIMULATED TOWER

FIG. 5 A VIEW OF 1200 INSULATOR STRING WITH SIMULATED TOWER

4.1.2 Optimization of Conductor-Window air Insulation Clearances for 1200 kV Test Station at BINA of Power Grid

Studies on switching surge flashover characteristics of long insulators strings and their equivalent air-gaps, the results of which are essential for the coordination of EHV and UHV transmission systems, have been carried out. A study on optimization of conductor-tower air insulation clearances for adoption in 1200 kV AC transmission lines using 8 bersimis conductor bundle was carried out [21] for establishment of 1200 kV Test Station at BINA, Madhya Pradesh by Power Grid Corporation of India. The arrangement of the total setup with bundle conductor along with insulator string and tower window simulation is shown in the photograph given in Figure 6.

FIG. 6 TEST SET UP WITH BUNDLE CONDUCTOR ALONG WITH INSULATOR STRING AND TOWER WINDOW SIMULATION

From the experimental results [25], air clearances of 8 m seems to be the optimized air clearances for tower window configuration in 1200 kV transmission lines with BSL requirement of 1800 kVp.

4.1.3 The Mock up Tower Facility

The laboratory has 80-meter span mockup towers with a central portal to simulate phase-to-phase and tower window clearances. Figure 7 shows the stringing of one of the conductors in the mockup test area. The ten sub-conductor bundles and arranged with double tension string with 110 numbers of 170 mm spacing/210 kN anti-fog porcelain disc insulators in the insulator string.

FIG. 7 STRINGING OF 10 SUB-CONDUCTOR BUNDLE IN MOCK UP TEST FACILITY

In this mock-up tower test facility, arrangements have also been made to conduct lightning impulse, switching impulse (dry and wet), power frequencies (dry and wet) withstand/flashover voltage tests up to 1200 kV system insulator strings. Figures 8–10 show photographs taken during the air insulation studies conducted on rod plane gap, phase-to-ground and phase to phase insulation in this facility.

FIG. 8 FLASHOVER OF 25 m ROD-PLANE GAP UNDER SWITCHING IMPULSE

FIG. 9 CONDUCTOR TO TOWER FLASHOVER WITH LOAD CAPACITOR SEEN IN BACKGROUND

FIG. 10 CONDUCTOR-CONDUCTOR FLASHOVER

4.1.4 Development of Capacitive Divider for Lightning Impulse Voltage Measurements

The voltage divider used for tests and measurements in the mega volt range will have limitations while-using in the lower voltage ranges, e.g. 50 500 kV for a 5 MV impulse measuring system which will have about 25 m height. A low-voltage capacitive divider suitable for measuring lightning impulses was developed with suitable high voltage and low voltage capacitor rated for 500 kV peak lightning impulse voltage. A view of the 500 kV lightning impulse voltage divider developed is shown in the photograph given in Figure 11. This divider is being continuously used for lightning impulse tests on all equipment for LI voltage levels up to 500 kV peak.

FIG. 11 A VIEW OF 500 kV LIGHTNING IMPULSE VOLTAGE DIVIDER

4.1.5 Development of Digital Technique for Resistive Peak Leakage Current for Zinc Oxide Arresters

Zinc oxide (ZnO) surge arresters are being used extensively for protecting electrical power apparatus, which includes equipment in distribution and transmission systems. The most common reason for failure of ZnO arresters is increase in the element temperature, above the normal operating temperature, due to increased internal element current, thereby changing the chemical structure of the ZnO grains which ultimately causes aging. The aging is therefore characterized by increased power loss in the ZnO elements or in other words increases in the amplitude of the resistive currents of the non-linear ZnO elements. Monitoring of resistive current amplitude is thus a good index of the aging of ZnO elements.

Presently, measurement resistive current is generally resorted to the measurement of the third harmonic component of the total leakage current of the arrester. A novel digital technique (Indian Patent No 201476/2006) to measure the amplitude of the resistive current of ZnO arrester, which could be adapted to the arresters in service, was developed. A technique of reconstruction of complex waveform in phase harmonic components of the total leakage current was employed. It was demonstrated through theoretical and actual measurements in the laboratory, as shown in Table 1. The proposed method is simple and cost-effective and it can be used for monitoring ZnO arrester in service.

TABLE 1

COMPARISON OF PEAK MAGNITUDES OF MEASURED AND RECONSTRUCTED RESISTIVE CURRENTS

Sl. No.	Voltage (kV)	i_r Measured (mA, Peak)	i_r Reconstructed (mA, Peak)	% Error
1	15.75	0.183	0.175	4.57
2	21.00	0.265	0.255	3.98
3	27.00	2.900	2.833	2.35
4	27.50	6.800	6.668	1.97

4.1.6 In-House Development of Impulse Measuring System

Customized commercially available channels, 12 bit with 200 MSa/s are very costly. Presently, high-resolution fast digitizers with 12 bit/200 MSa/s are also available. These digitizers are used with suitable controller integrated and programmed with suitable software to make it 4 channel, 12 bit/200 MSa/s impulse measuring system. The whole measuring system is embedded into EMI/EMC compatible chassis to make it suitable to work in high-voltage environment. The Digital signal Processing and mathematical tools in the software are used to smoothen and de-noise the data and evaluate the various impulse parameters according to the definitions given in the standards. The software for evaluating the parameters (Lightning Impulse, Switching Impulse and Impulse current) the definitions given in relevant IEC was implemented. Figure 12 gives a full view of the impulse measuring system developed in-house.

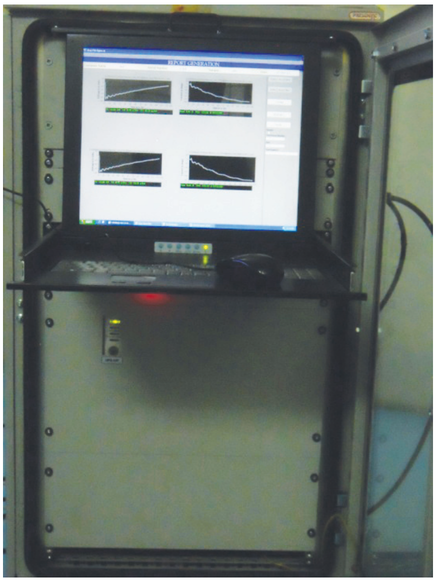

FIG. 12 A VIEW OF THE IMPULSE MEASURING SYSTEM

4.1.7 Sweep Frequency Response Analysis (SFRA) Measurements

Large power transformers are most expensive and the important components of any power generation and transmission system. Outages in Transformer have a considerable economic impact on the operation of an electrical network. Deformation/movements of winding assemblies are caused by electromagnetic forces caused by external short-circuit currents or by aging of the transformers in service or by stresses originating from mechanical vibrations during transport.

The Sweep Frequency Response Analysis is an emerging diagnostic tool to detect the internal condition of transformers caused by short circuits, faults because of transport, etc. Research works to understand the various aspects of the FRA and to evolve, different tests, measurements and interpretation guidelines were carried out. Theoretical and experimental investigations were carried on model transformers to evolve FRA testing, measurement and interpretation guidelines to unambiguously detect transformer winding deformations and movements. Investigations were also carried out by SFRA measurements on number of transformers at various substations as a part of condition monitoring of the transformers and as a part of consultancy work. Results of various studies were published in number of papers which are listed in references. The Sweep Frequency Response Analyzer used in conducting SFRA measurements is given in Figure 13.

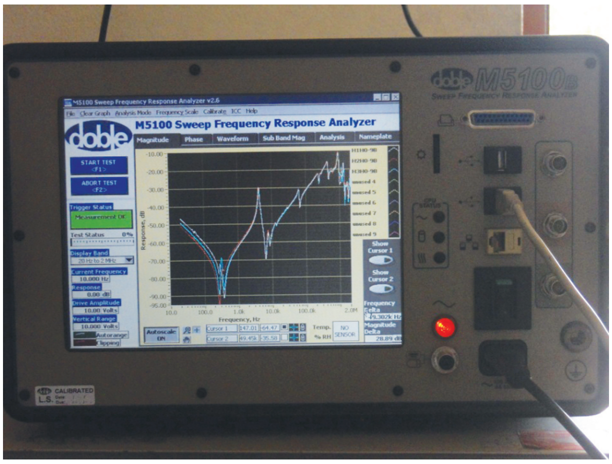

FIG. 13 SWEEP FREQUENCY RESPONSE ANALYZER FOR DIAGNOSING TRANSFORMER WINDING MOVEMENTS AND DEFORMATION

4.2 Power Frequency Laboratory

The power frequency laboratory at UHVRL was setup mainly to undertake major electrotechnical and mechanical research and development studies and also to undertake testing activities for equipment ranging up to 1200 kV. Major electrical research and development studies undertaken are-corona loss, electric field and field effects, radio and TV interference, audible noise, etc.

Figure 14 shows a view of 1600 kV/6 A (continuous) Power frequency voltage source. Two 800 kV transformers are connected in cascade. The tests performed in this laboratory are one-minute dry and wet withstand test, flashover test, Radio interference voltage test, visible corona test, capacitance and tan δ measurements, voltage distribution tests, Ferro resonance tests, transient response test, etc. The system is also used for carrying out R&D work on experimental transmission line and conduct pollution testing and research. Test voltage is derived by means of AC testing system either single or cascade arrangement of transformers depending on voltage levels required. For measurement of voltage, capacitive voltage dividers are used. Thus, the measuring system consists of a converting device like divider and an indicating instrument. The system conforms to IEC:60060.

FIG. 14 A VIEW OF 1600 kV/6 A CASCADE TRANSFORMER

4.2.1 Experimental Transmission Line

The experimental transmission line as shown in Figure 15 consists of a single-phase ten sub-conductor as shown in Figure 16 with 360 m suspension span and 180 m dead-end spans on either side. The ten sub-conductor bundle is arranged with double I-string with 76 numbers of 210 kN anti-fog disc insulators in suspension as shown in Figure 17 and with ten insulator strings on both dead end towers with insulators in tension mode as seen in Figure 18 with suitable corona suppression hardware which can be seen in these Figures. The ten conductor bundle is provided with

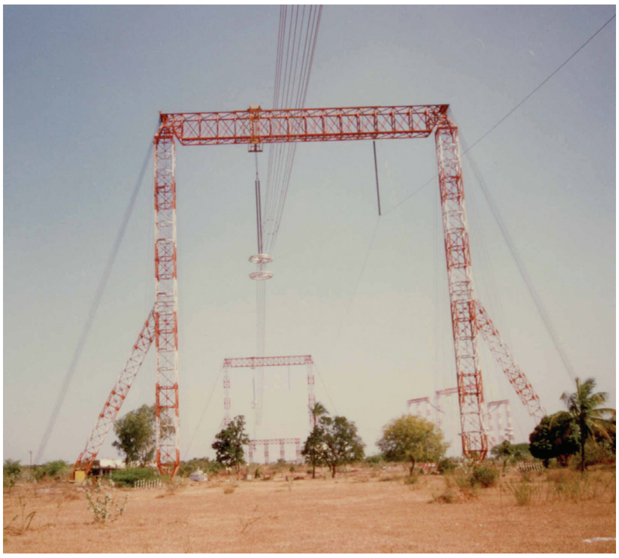

FIG. 15 A VIEW OF EXPERIMENTAL TRANSMISSION LINE

spacers at an interval of 30 m. Figure 19 shows a view of spacer being lifted from ground during its erection in the experimental transmission line. ACSR Moose conductors have been used in both the lines. The main dimensions of the towers are determined on the

FIG. 17 SUSPENSION STRING

FIG. 16 CONDUCTOR BUNDLE WITH TEN SUB-CONDUCTORS

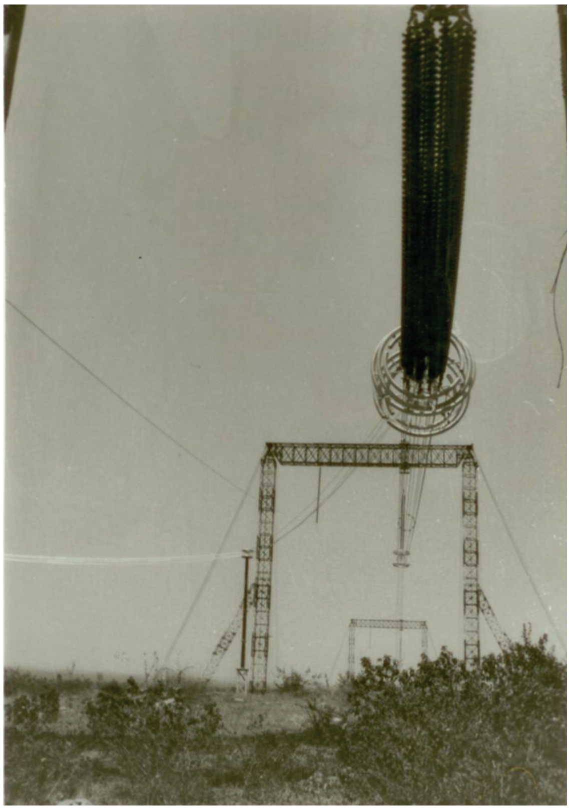

FIG. 18 TENSION STRING

FIG. 19 A VIEW OF CONDUCTOR SPACER BEING ERECTED

basis that they must permit testing and research at the highest AC transmission system voltage of 1200 kV.

The overall experimental line tower dimensions are designed for conductor to tower clearance of 13 m conductor to ground clearance of about 23 m at mid-span and clearances at the dead ends of about 22 m. At present, the conductor bundle line to ground clearance is 17.8 m at the maximum sag point and the clearance of single conductor line is 21 m at similar location. Vertical and horizontal movements of the bundle conductor are possible with crab and winch arrangement provided on each tower.

4.2.2 Corona Performance of Bundled Conductors Measured in Corona Cage

One of the major design factors, at voltage above 400 kV, is the effect of corona discharges at the conductors. The corona discharges cause power loss, Electromagnetic Interference, Audible Noise. It is important to evaluate these parameters, at the design stage itself, so that the Radio interference and audible noise at the Right of Way are within the specified limits.

Corona cage is an effective tool for rapid evaluation of conductors for the corona performance. A corona cage is built to study the performance of bundle conductors. The instrumentation systems and software are developed to compute corona loss. The measurement scheme takes advantage of the high speed digitizers to acquire the corona signals and a dedicated computer computes the corona loss. The Radio Interference and audible noise are measured with the standard measuring instruments. The measured corona performance is used to estimate these parameters for the operating transmission lines. The facility will be useful for comparative study of different bundle configurations or with different types of conductors with reference to their corona performance.

The corona cage is of 6.15 m × 6.15 m, and 18 m long as shown in Figure 20. A total of 11 portal frames are fabricated and erected with guy ropes

FIG. 20 A VIEW OF CORONA CAGE

to withstand the wind load prevailing at the site. Wire mesh frames were fixed to the sides and top and bottom of the portal frames to form a square cross-section. Seven portal frames at the center were insalated from the wire mesh frame, by insulators fixed to the sides and the top and bottom of the seven portal frames. This insulated central mesh section forms the measurement section. On both ends of this measurement section guard sections each of 1.5 m long were provided. The guard sections are provided to avoid the end effects and ensure that the conductor surface gradient is uniform throughout the length of the measurement section.

The central measurement section is insulated from ground for corona current measurements. The end sections are grounded. A number of nozzles are provided at the top for creating artificial rain. The water pipe lines to these nozzles are provided with suitable valves to control the precipitation rate. Two End towers are erected, on both sides of the cage along the axis, to facilitate stringing of conductors. The conductor was energized from the AC test transformer. The feeder and support insulator are designed to be corona-free up to about 450 kV (RMS).

A study was successfully conducted for optimizing the sub-conductor spacing for ACSR bersimis octagonal conductor bundle for use in 1200 kV A transmission system in this cage for M/s. Power Grid Corporation of India Ltd.

4.2.3 Optimization of Grading Rings for 1200 kV Single 'V' Suspension string

A study was conducted for optimizing the size of the grading rings to be used in 1200 kV Single 'V' suspension string for M/s. PGCIL. A view of this string is shown in Figure 21. Voltage distributed across each disc of the string was measured for different sizes of grading ring. The string consisting of 1×2×46 numbers of 420 kV normal porcelain disc insulators was suspended from a cross-arm of 30 m length. Octagonal bersimis conductor was simulated at the line end of the string. The height of the conductor was 12 m above the ground.

FIG. 21 A VIEW OF 1200 kV SINGLE 'V' SUSPENSION STRING

4.2.4 Field Measurement of Audible Noise, Radio and TV Interference

The laboratory has the required instrumentation and antennas to measure on site Audible Noise, Radio and TV noise from transmission lines and substations according to the ANSI/IEEE and CISPR standards. Measurements of these parameters were successfully carried out for many utilities some of which are listed below:

1. Figure 22 shows Sipat-Seoni 765 kV line and substation at Seoni.
2. Talcher-Kolar, ±500 kV DC bi-pole line and substations.
3. Chandrapur-Phadge HVDC Bipole line and substation at Phadge.
4. HVDC converter station at Visakhapatnam.

FIG. 22 RIV MEASUREMENTS AT 765 kV TRANSMISSION LINE

4.3 Pollution Laboratory

The pollution laboratory is established to conduct pollution tests and research on performance of insulator strings, lightning arresters and other power equipments under polluted conditions. Two methods described in the standards, Viz., salt fog and solid layer methods, are used depending on the requirements. The AC testing system described in earlier section is the main test source, which meets the requirement of test source for conducting pollution test in accordance with IEC:60507/1991. The laboratory has conducted pollution tests by salt-fog method on insulators up to 765 kV rating.

The pollution laboratory is a cylindrical concrete shell structure with 27 m height and 24 m diameter and is one of the largest pollution laboratories. The pollution spraying system conforms to the international IEC:60507 standards. Figure 23 shows an external view of the pollution laboratory. The AC test voltage source is outside the pollution laboratory and a wall mounted bushing, rated at 850 kV/100 A, leads the supply to the test object inside the laboratory. The bushing is at 15 m above ground. The laboratory is located at an altitude of 540 m above mean sea level.

FIG. 23 AN OUTSIDE VIEW OF POLLUTION

Commissioning tests were carried out to prove the adequacy of the test voltage source, laboratory infrastructure and to show that the results obtained in this laboratory on specific type of insulators lie in the range as specified in the IEC 60507 standard.

The AC test voltage source as shown in Figure 16 consists of two high-voltage transformers, 800 kV each, which can be connected in cascade to obtain maximum output of 1600 kV. Two of cascade connections, 1S and 1P, can give maximum output voltages of 400 kV and 800 kV, respectively, for the first transformer. Both modes can deliver 15 A maximum continuous current. These two modes are used for pollution tests.

The IEC:507 has clearly stipulated the minimum short circuit current for testing insulators of different specific creepage lengths (Ls). According to this, the minimum short circuit current of 6 A is required up to test sample Ls of 16 mm/kV and for any higher Ls, the increased requirement is 1 A/mm/kV. Short circuit current at the output of first stage of cascade transformer was measured by flashing rod gap of different gap distances so that the full range of voltage of the transformers is considered. The short circuit current was monitored using a suitable current transformer and digital oscilloscope. The results of the short circuit test indicate that 1S configuration can be used for test voltage between 50 kV and 360 kV and 1Pconfiguration for voltages between 100 kV and 720 kV to meet the requirement on the minimum short circuit current for the testing plant as stipulated in the IEC.

1. The power frequency voltage source at the UHV Research laboratory of CPRI in Hyderabad, India, meets the requirement of IEC-507 for conducting artificial pollution tests in EHV and UHV range.
2. The repeatability and reproducibility of test results were found to be good.
3. The results obtained in this laboratory are comparable with those obtained in a few other pollution laboratories.

4.3.1 Performance of RTV Coated Insulators

The pollution laboratory has conducted extensive research work on evaluation of performance of RTV–coated porcelain insulators under pollution conditions in an aging chamber. The aging chamber with dedicated AC test source is shown in Figure 24.

FIG. 24 SALT-FOG AGING CHAMBER

The laboratory has developed data acquisition system (Figure 25) for continuous on-line monitoring of leakage current of RTV–coated porcelain disc insulators under pollution chamber. The results are published in reputed international journals and conferences and a few of them are listed in references.


FIG. 25 DATA ACQUISITION SYSTEM FOR ON-LINE LEAKAGE CURRENT MEASUREMENT

4.4 Bio-Monitoring Lab

There is a growing concern about the possible biological effects of electric and magnetic fields. To examine this aspect, studies were carried out to find the biological effects of electric and magnetic field by subjecting biological model systems to various levels of field for short time and long time. The studies were conducted to assess metabolic, biochemical, physiological and genotoxic effects of fields. This study has been taken up as a CBI and P–sponsored project, in association with Biochemistry Department of Osmania University. The results are published in reputed international journals and conferences and a few of them are listed in the references.

5.0 TESTING OF EHV/UHV EQUIPMENT

This laboratory is fully equipped with sophisticated facilities to achieve this task. Since its inception, the UHV laboratory is serving the industry by conducting dielectric tests.

As it has been pointed out earlier, the purpose of setting up the laboratory is also to undertake testing and certification for high-voltage equipment up to 1200 kV class. The UHV Laboratory is thus helping the manufacturers' in the development of the EHV/UHV equipment by fulfilling the needs of testing according to the national and international standards and thereby serving the country to ingeniously develop and test EHV/UHV equipment to meet the power demand. The laboratory has successfully tested many 1200 kV and 765 kV equipment, viz. Instrument Transformers, Switchgear and Insulators. Many transmission line hardware and accessories for use in 765 kV lines and substations were also evaluated for their radio-interference voltage, corona inception and extinction voltage tests.

Photographs of some of EHV/UHV class equipment used in the upcoming 765 kV AC, ±500 kV DC transmission systems and 1200 kV experimental station at PGCIL, BINA, which are tested for various dielectric and special performance tests conducted in the UHV Research Laboratory at Hyderabad, are given in Figures 26–38.

FIG. 26 765 kV CURRENT TRANSFORMER UNDERGOING RIV TEST

FIG. 27 1200 kV CAPACITOR VOLTAGE TRANSFORMER UNDER TEST IN PF LABORATORY

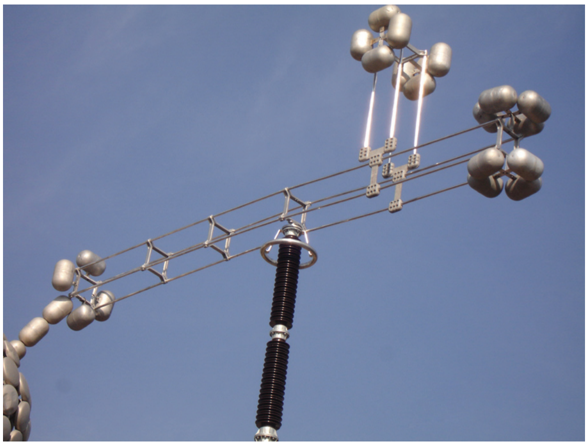

FIG. 28 765 kV POWER CONNECTORS UNDER TEST

FIG. 29 765 kV CURRENT TRANSFORMERS

FIG. 30 1200 kV SURGE ARRESTOR

FIG. 31 765 kV - SF_6 GAS CIRCUIT BREAKER

FIG. 32 800 kV DC - “Y” INSULATOR STRING

FIG. 33 765 kV - KNEE TYPE DISCONNECTOR

FIG. 34 1200 kV CAPACITIVE VOLTAGE TRANSFORMER

FIG. 35 100 MVA, 230/110/11 kV AUTO TRANSFORMER

FIG. 36 SUPPORT INSULATOR OF 765 kV GCB UNDERGOING POLLUTION TEST

FIG. 37 765 kV SINGLE ‘V’ INSULATOR STRING UNDERGOING POLLUTION TEST

6.0 LABORATORY ACCREDITATION

The UHVRL has developed quality management system for quality, administrative and technical operations in line with international standards to test the power equipment since 1994. The laboratory is accredited by National Accreditation Board for Testing and Calibration laboratories (NABL). The accreditation was awarded way back in 1998 according NABL 101 (EN-45000 and ISO Guide 25). Thereafter, it was reassessed regularly to the quality system standard ISO/IEC-17025-2005.

FIG. 38 FINAL VIEW OF THE UNDER CONSTRUCTION NEW INDOOR SHIELDED UHV LABORATORY

7.0 UHV INDOOR SHIELDED LABORATORY

UHV Research Laboratory at Hyderabad is establishing a new 50 m (L) X35 m (B) X35 m (H) doubly shielded Indoor UHV Laboratory with a separate 1200 kV AC source along with control, measuring and material handling equipment to fill the gap in testing for Partial discharge measurements, Radio interference voltage measurements, corona and wet tests on all electrical equipments rated up to 1200 kV class. Additional facilities for measurement of accuracy of instrument transformers are also planned to be added and the procurement of necessary equipments is in progress. The final view of the under construction new Indoor shielded UHV Laboratory is shown in Figure 38. This facility is scheduled to be ready by March, 2012.

8.0 CONCLUSIONS

The Impulse laboratory facilities available at UHV Research laboratory, CPRI, Hyderabad are of world class and at par with international laboratories like–CESI, EdF, KEEMA laboratories etc. Power equipment manufacturers, EHV/ UHV transmission grid operators and utilities can avail the services to evaluate their equipment and sponsor the research work of their interest.

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