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Evolution of Insulation Materials Laboratory

The details about formation of Insulating Materials laboratory, its comprehensive growth over five decades, in research, testing and consultancy areas is presented in this article. This write up covers the historical perspective, research contributions including product development, various national and internal committees represented and allied.

1.0 HISTORIC PERSPECTIVE

Power development programme envisaged in late fifties necessitated the requirement for national R&D in the field of electrical power to carry out investigations for a systematic growth of indigenous technology and power systems. Initially, two units one in Bangalore and the other at Bhopal were set up. Insulating Materials Division is one among the twelve Divisions/ Laboratories established in the year 1960, with a prime objective of promoting small and medium scale industries that were manufacturing insulating materials which could form either an alternative or an import substitute. The identification of one such laboratory was well justified as, Insulation apparently forms an integral part of any power apparatus. This division was set up with sophisticated equipment with the assistance of United Nations Special Fund. The laboratory offered testing and consultancy services to manufacturers of insulating materials. This helped manufacturers in bringing out a quality power apparatus/equipment. The facilities used by number of organizations were on the raise year after year.

Domestic electrical appliances testing laboratory started functioning since 1978 as a part of Insulation materials division. The Indian Standards Institution in pursuance of the Quality control had then requested CPRI to establish necessary facilities for testing and evaluation of all domestic appliances as per relevant national standards. The Household Electrical Appliances (quality control) order 1976 issued by Ministry of Industry, Government of India made certification compulsory for manufacturers, sale or distribution of domestic appliances contributed testing home appliances according to the Indian Standards.

The record of annual report, 1983–1984 indicates that Insulation materials division constituted of three main laboratories viz., Insulation, Polymer and Domestic Electrical Appliances Testing Laboratories. The Division was modeled on the lines of ERA laboratories of United Kingdom. This Division has a long history and Dr. Parkman of ERA who helped the division equip itself with sophisticated equipment. The Division was headed by Mr. Arunachala Sastry, who was a key member of the Division for almost three decades. It is interesting to note that almost all officers of CPRI who were employed during the formative period have all been part of the Insulation Division.

During end of 1984, the new management brought in certain structural modifications. Although Cables and capacitors division existed since 1960, Insulation Division was formed with three Laboratories viz. Cables and capacitors laboratory (renamed Cables and capacitors division to Cables and Capacitors Laboratory), Insulation laboratory (Insulation materials division was named Insulation laboratory) and Polymers Laboratory. Presently domestic appliances laboratory is part of electrical appliances testing division. Many R&D activities were initiated besides introduction of several new testing standards. From 1984 technical activities grew manifolds. Several new equipment were

added to cater to both R&D and testing with the management directive to carryout R&D activities.

During 1992 Polymer laboratory was brought under Materials Technology Division which was set up during 1986–1987. Diagnostics laboratory started functioning under Insulation Division during 1993–1995. During later half of the nineties'', Liquid dielectrics Laboratory and Dissolved gas analysis laboratory were brought under the umbrella of Insulation division. From 2002–2003. Insulation laboratory and Polymer laboratory started functioning under Dielectric Materials Division. This division then comprised of Liquid Dielectrics Laboratory. Polymer laboratory, Insulation laboratory and Lubricating oil laboratory. Cables capacitors laboratory along with diagnostics laboratory was renamed in 2003–2004 as "Diagnostics cables and capacitors division". Once again Insulation laboratory was attached to Diagnostics cables and capacitors division during October 2006.

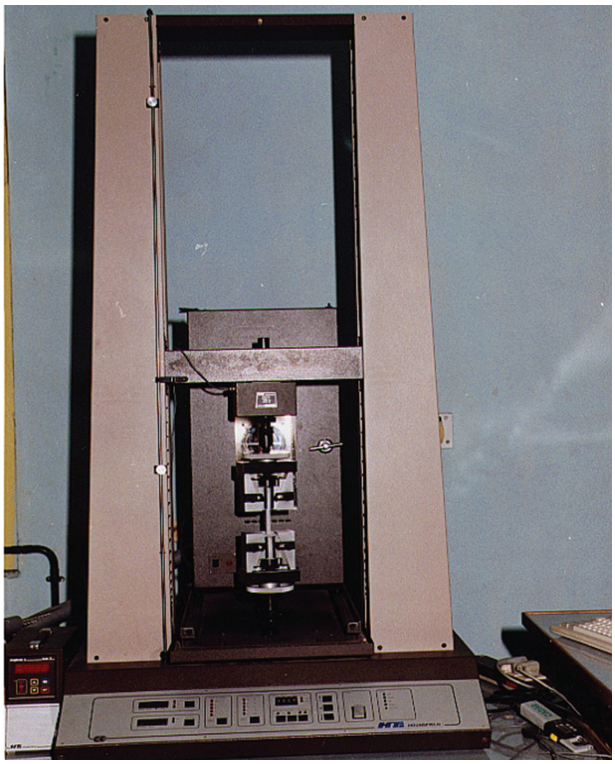
2.0 OVERVIEW OF THE GROWTH OF VARIOUS ACTIVITIES

The prime functional activities of the Insulating Materials Division were

- Testing and evaluation of Insulating materials
- Development of solid insulating materials
- Development of electrical grade polymeric materials

2.1 Research Front

In the financial year 1964–1965 there had been a significant contribution in the area of "insulation" which resulted in 10 technical reports. The first technical report no.004-INS is titled " Report on Electrical Strength Test", is on varnished cotton cloth samples submitted by M/s. Insotex Pvt. Ltd., Bombay. The report no.0007-INS, indicates an attempt for indigenization of insulating paper for electrical purposes. It is heartening to know that under the category of "insulation" the published reports numbered serially from 007-INS to 0015-INS indirectly indicate the enthusiasm, ability, devotion to work of the then scientists and engineers. The R&D attempts made by seniors are inspirational and motivational for the beginners. Further during 1965–1979 seventeen technical reports were brought out covering reclamation of transformer oil, PD study creating artificial voids in polythene dielectric, studies on motorette with indigenous class A insulation, Functional tests for class B insulation, effect of wood on transformer oil and vice versa, detection and location of incipient defect/fault in HV PVC cables, electrical grade paper from indigenous wood pulp, etc. This remarkable achievement was possible since Insulation Division alone had the unique advantage of having the best of imported equipment's for Research in insulating materials and systems mainly because of traditional insulation systems and materials which were mainly cellulose based.



UNIVERSAL TESTING MACHINE, 50 kN

It is really motivational to know from report no. 0019-INS that an apparatus was fabricated in-house for the measurement of oxygen absorption by insulating oils, under accelerated conditions

with a view to standardize a new oxidation test.

Thermal endurance studies were carried out on enameled wires for two different insulation, Polyvinyl Acetate and Polyester enamel. Their relative merits were assessed during the year 1981–1982. Attempts were made in connection with development of insulating paper with various types of wood via., Eucalyptus, Grandis, Blue Gum, Wattle and Pinua Patuala. R&D work for improvement of thermoplastic and thermo setting materials was undertaken. Various formulations were studied and developed an indigenous PVC formulation for 11 kV cable application. The material developed met the requirements of relevant IS specification for properties. The studies made to identify a suitable pine and process for manufacturing insulating paper is briefed in Annual report 1983–1984. Insulation laboratory contributed to both testing and R&D activities while Polymer's laboratory was extensively involved in research and development. Improvement on the existing processes development of new processes and techniques constituted the R&D work of this laboratory.

COMPARATIVE TRACKING INDEX ANALYZER

During 1986–1987 for the first time, life evaluation of insulating materials/insulation systems by modeling techniques were under taken and validated the results with fewer no. of experiments. Modelling studies got impetus from then on.

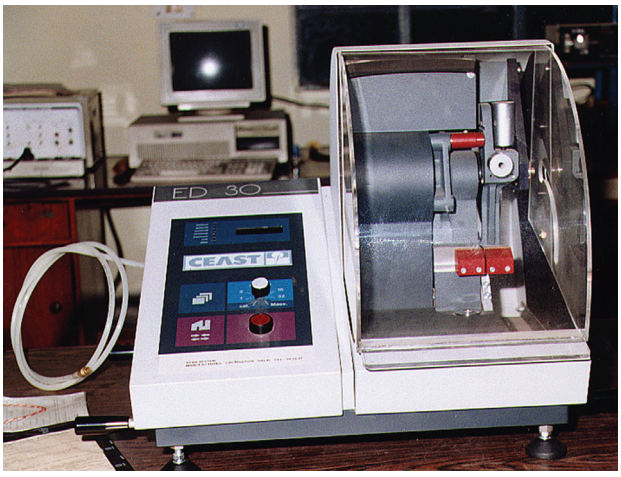
With the in house developed formulation of PVC as primary insulation, various electrical tests were performed on 11 kV cable manufactured with the support of a reputed cable manufacturer. An investigation on tracking phenomenon carried out on organic and inorganic laminates gave insight in the comparative evaluation of various types of laminates used .in electrical industry. Ageing characteristics of composite insulating materials were brought in technical report No. 112. The then Scientists and engineers published technical papers in national seminars/ conferences, participated and presented papers. Lectures were delivered in the in-house seminar series. Primarily any study, in Insulation laboratory dealt with solid and semi-solid insulating materials until 1985. Later appreciable works were carried out in gaseous insulation mainly with SF_6. Investigations on environmental stability, flammability, heat resistance, mechanical and processing properties essential for electrical applications were carried out.

The development of application software to study the material behavior under isothermal conditions for differential scanning calorimeter and thermal analysis station is worth mentioning as it saved procurement of an add on software module there by saving the foreign exchange. Development of composite mica insulation, novolac from MVP, semiconducting tapes, flame retardant PVC were some of the then developmental activities i.e. during 1987–1989. Seventeen R&D projects were on going in Insulation division perhaps the highest ever, which is a real record now. A list is provided in the Annexure I.

Insulation laboratory organized a one day workshop on Gas insulated system which was held on 28th November 1989 at the Institute. Dr. K.D. Srivastava, Vice-chairman University of Columbia delivered a series of lectures.

Every year there were presentation of technical papers and participation in national and international seminar/workshop/conference, etc. by the scientific and engineering officers.

During the period 1985–1990, the laboratory forayed into Applied Research in Gas Insulated systems. At a time when GIS was an evolving technology, efforts were made to set up facilities for breakdown characteristics of SF_6 gas. In addition, the compatibility studies of SF_6 gas with new generation of polymers were undertaken. A facility to set up fast pulse generator (Nano second pulse generator) was taken up using two different methods namely (i) Spark gap in pressurized SF_6, and (ii) Transmission line model consisting of distributed C and L. Both the methods were successfully developed and nanoseconds.

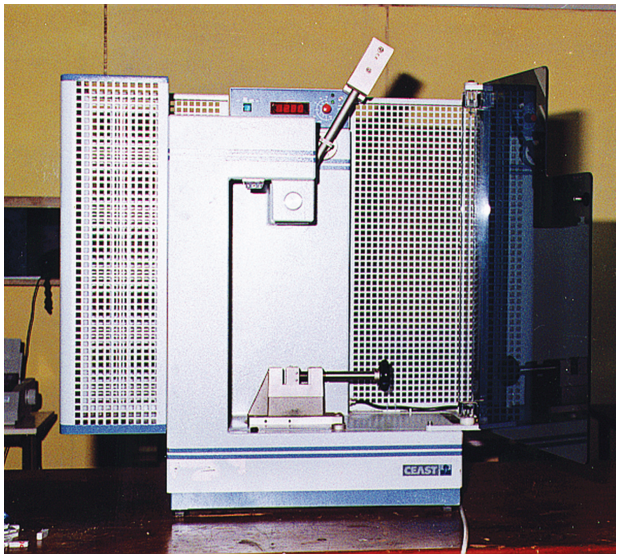


TEAR TESTER

The transmission line model was also used for breakdown studies on thin polymer films and cellulose.

Studies were also carried out on SF_6 and N_2 gas mixtures as alternatives to SF_6 gas and the effect of particles, fast transient over voltage phenomenon in SF_6-N_2 gas mixtures and effect of dielectric coating and insulating barriers were undertaken.

Measurement of Surface charge density and three dimensional distributions of surface charges were successfully completed on a number of polymers and the results were correlated to the surface breakdown of spacers in GIS.



IMPACT TESTING APPARATUS

Studies at fast transients in gas insulated systems (GIS) formed an important research activity carried out in this laboratory. The R&D activities in gaseous insulation continued. A few CBIP sponsored projects were executed which involved in development of high temperature thermoset materials for electrical applications, development and evaluation of low smoke fire retardant power cables during early 1990s. In the digital simulation front, development of new techniques to generate complete data from censored data of ageing insulating material and systems were successfully completed. There was decline in the pace of R&D after mid nineties'. However, some need based investigations were carried out. Investigations on heat shrinkable material and functionally graded material resulted in few international papers.

Development of GIS cable termination is one of the mission mode projects executed jointly by Central Power Research Institute (CPRI), Bharat Heavy Electricals Limited (BHEL) and Mahindra Electrical and Chemical Products (MECP). Technology development of flame retardant low smoke cable (FRLS) is another mission mode project successfully completed during 2001–2002. Insulation laboratory shared

its resources and man power for some of the projects executed by Polymer laboratory. The effect of corrosive sulphur and its effect on paper oil insulation of power transformers were studied in detail and efforts were made to understand the role of metal passivators in inhibiting sulphur corrosion was also studied. Measurement of Total Sulphur and Mercaptan sulphur of aged transformer oil was initiated to understand the bench mark values of these two parameters in paper oil insulation of transformers. The effect of sulphur in paper, pressboard, cork sheet, glue and other components were studied and their contributions towards increase in total and mercaptan sulphur were estimated

Evaluation of Nano filled silicone composites and EPDM composites for erosion resistance were carried out and technical papers were presented in national conferences. A few investigations made on silicone rubber for outdoor application, stressed the requirement for modification in IEC standards and few international papers were brought out.

C AND DFBRIDGE, 50 Hz

2.1.1 Strategies to improve R&D

To avoid duplication of instruments, to optimally utilize man power available and to promote inter departmental activities the laboratory/ section that is proposing RC/RSOP/NPP R&D proposal should involve other section/laboratory wherein some facilities are already available. Another added advantage is laboratory gets augmented with the latest and enhanced features of the instrument which could be used for both commercial testing and R&D. The end use oriented investigations scenario calls for a team of personnel's from various spheres with defined responsibilities. Engineering graduates who wish to gain experience in research front should be encouraged by making them a part of the project.

2.2 Testing Front

Dr. Parkman of ERA helped the Division get many equipment like Bursting test apparatus, Elmendorf's tear tester, GR Bridge, Capacitance and Dissipation Factor Bridge assembly with Guard ring electrode and many more. Perhaps the most significant contribution was setting up of a pilot Plant for Paper making facility. This facility was unique and laboratory grade electrical paper from different wood species was prepared before trial runs at the paper factory. The facility included paper digester, pulp beater, pulp disintegrator, sheet former, sheet press and other associated equipment's like driers, inclinator consistency, freeness, contaminant analysis, porosity, softness, smoothness, fiber analysis, water absorption, wet ability, ash content etc. All these facilities were set up under the UNDP Programme under the leadership of Dr. Parkman. The Marconi Dielectric test equipment was a unique facility for measurement of Capacitance and Dissipation factor over a wide frequency spectrum and versatile facility used by Professors of Indian Institute of Science and many leading Universities of India for Research in dielectric materials. The Monsanto horizontal Universal Testing machine had some rare facilities and fixtures for carrying out a number of mechanical tests on materials and systems for characterization of Materials. The speed variation, load variation, plotting facility and in-built calibration facility were incorporated nearly 5 decades ago, when these technical jargons were unheard of and it is to the credit of great luminaries and people with forethought like Dr. Parkman, Mr. Arunachala Sastry, Mr. Mahajan and many others.

During the initial years, testing activities were confined mainly to cellulosic products like

electrical grade paper, pressboard and other products like synthetic liquids, jelly etc. In the mid-70s and 80s testing of many new insulating materials that were introduced in the market were evaluated. After 1980, there was a change in material technology and the development of polymers had a revolutionary effect on insulating materials and systems. The domination of polymers due to obvious advantages in mechanical, electrical and thermal properties, Insulation Division went into new generation testing facilities and to meet the demands of the Industry, additional facilities were set up. The arc resistance test, the wet tracking tests were all established the year 1979-1981 with imported equipment's. In order to expand the testing activities new instruments/ apparatus/equipment were added year after year. During 80s diversification into testing of organic insulating materials, new dielectric test methods, evaluation of wire enamels etc. took place. Telephone and cable industry had a boom which fetched polyethylene granules and cable filling compounds from many customers to be evaluated for the required electrical properties. M/s. Indian Oil Corporation Ltd. was then developing polymeric based insulation, every batch of its production was sent for testing and insulation laboratory contributed in their product development though indirectly. Electrical grade plastic films viz. Polypropylene, Polyester, PTFE were tested for various electrical, mechanical and physical properties besides thermosetting laminates.

MEGOHMMETER

Inclined plane tracking and erosion was a facility fabricated in-house, during late 1980's with indigenously available components. This instrument is mainly used for ascertaining polymeric materials for outdoor application. The cable accessories industry, manufacturers of bus bar insulation and polymeric composite insulator sector are mainly utilizing this facility. This was in addition to the comprehensive facilities set up for evaluation of cable jointing and termination materials. The equipment has served over two decades and is still functional.

Around mid-1990's Under Writers Laboratories Inc. USA and Canadian standards Association, Canada recognized Insulation Laboratory for testing wires and cords for "UL Mark" and "CSA Mark" respectively. This accreditation added accolade to the already performed activities. With in a short span, more than 20 products in wire, cable harnessing and insulating material category, a number of unique testing facilities were created and this facility helped Indian Manufacturers export their products to USA and Europe.

During 1990's testing activities saw the major growth. The opening up of Indian economy, its globalization and the investments by major multinational companies (MNCs) in India provided an opportunity for diversification into other related areas of testing that expanded the range of activities and resulted in product testing also. Heat shrinkable component is one among other products viz. enameled wires, antistatic mats, Appliance wires and cords, Conformal coatings, etc. were regularly tested.

During the period 1995–1996, the laboratory was augmented with a microprocessor controlled Universal Testing Machine (UTM). This catered to cold elongation test on cable sheathing material, tests on fiber reinforced plastics from India and abroad. Gulf countries had

significantly contributed towards the revenue growth and compensated for the fall of revenue due to recession in telephone cable industries. The mechanical tests (tensile strength/modulus, compression strength/modulus, flexural strength/ modulus, shear strength, etc.) requirement was not only from power industry but also other industries like Automobile, consumer durables like fridge, washing machine, etc.

An acute recession was faced by telephone cable industry during 1998. Although the insulation laboratory had sophisticated and entire range of testing facilities for jelly filled cables, the poor growth of this industrial sector brought sluggishness in the manufacturing capacities. Small and medium scale Manufacturers of plastic films, winding wires (magnet wires), antistatic material, insulating mat, etc. had setup their own test facilities. This affected the revenue earnings significantly.

Nevertheless, the test "Comparative Tracking Index", CTI gained importance and was used by domestic appliances manufacturers of moulded case for TV, computer, meter box, electrical switches, panels, etc. This test added to the revenue earnings.

Moulding machine, environmental chamber, hot air ovens have also contributed to the revenue earnings of this laboratory.

During 2006 the laboratory was augmented with environmental chamber, 100 kV, 50 mA testing transformer and High resistance meter (Safelec). These are being extensively used for routine testing of insulating materials.

In connection with insulation material development related to X-ray generator, Insulation laboratory offered its services to M/s. GE Health care utilizing 100 kV, 50 mA testing transformer. Conducting breakdown voltage tests for over 200 samples fetched significant revenue contributing to laboratories total revenue during 2007–2008 as well as this testing orders helped in recovering the cost of the instrument.

Weather O meter (procured during 1996), from Materials Technology division was taken over by Insulation laboratory during late 2008, made it functional and is being used for evaluating AB cable accessories, polymeric insulating materials, cable sheathing material, etc. Recently i.e., during 2010–2011 a new test facility was created; "climatic ageing" by procuring necessary filters (during 2010) to meet the requirement of NF C standards (French standards). This being a type and long duration test is helping to generate appreciable revenue.

ARC RESISTANCE TESTER

Diversification is found necessary for additional inflow of revenue. Globalization has brought in several new industrial establishments such as INDO MIM US Tec Pvt. Ltd, AREVA, SUZLON, ENSTO, VON ROLL, WEG Industries India Pvt. Ltd., etc. to Bangalore and neighbouring places. With increase in number of R&D organization, availability of many testing and calibrating agencies and above all investment in development of in-house/internal testing facility by large industrial concerns have brought in competitiveness in the area of testing. Thus testing and certification is no longer a monopoly of Government Organization. Hither to marketing's necessity was not realized but it is high time for aggressive marketing.

2.2.1 Strategies to improve testing revenue

- Material evaluation has to be made mandatory in all tender documents.

- Differential tariff for tests on developmental samples and other developed samples.
- Liaison offices at places like Mumbai, Chennai, Pune, etc. besides setting up in existing CPRI units. Periodic updates on region wise requirements for creation of new Type test facilities could form prime objective of this office. The future investment should be based on recommendation reports by liaison officers based on their market survey.
- Hiring instruments for occasional usages.
- Leasing of portable instruments during lean periods could be another strategy to improve revenue position.
- Dual tariff for SSI and medium scale industries and MNC's whose footage is in abroad.
- Close and periodic interaction with industries, aggressive marketing and publicity.
- A tie-up with all electricity distribution companies and periodic renewal of contracts.

3.0 CONSULTANCY AND SPECIAL TESTING SERVICES RENDERED

Assistance was rendered in conducting developmental tests for evaluation of rubber gloves for electrical purposes.

Evaluation of class "H" insulation for traction motors, compatibility studies on enameled winding wires and varnish were successfully carried for RDSO and Ministry of Railways respectively.

Coating for Antistatic purpose on flooring was evaluated at customer's site comparing different types of coating.

Thermal endurance study was completed (2010–2011) for a new insulating material (identified as BCIC) of M/s. Raychem PRG Ltd. The income from this study was quite significant.

INCLINED PLANE TRACKING TEST APPARATUS

4.0 COMMITTEES REPRESENTED BY PERSONNEL'S OF INSULATION LABORATORY

Insulating Materials Sectional Committee (ETDC-18) was being represented by then Director as a Principal member and Dy. Director as Alternate member since 1980. Currently Solid Electrical insulating materials and insulating systems sectional committee, ET-02 is represented by personnel's of this laboratory. Summarizing BIS is being served by seniorofficers of this laboratory nominated either as Principal member or as an alternate member.

CIGRE (India) National Subcommittee on materials for electro-technology is another body where services have been offered.

5.0 ACCOLADES FOR INSULATION LABORATORY

Certificate of merit and cash award for best International paper

1. Paper titled "New technique for analysis of ageing data of insulation system 1991"
2. During the Third International conference on Properties and Applications of Dielectric materials held at Toyohashi University of technology, Japan.

Certificate of merit and cash award for best research paper

1. Paper titled "Design and development of 33 kV cable termination for GIS applications at the INSULEC Conference of IEEMA, 2000

2. Paper titled, "Spectroscopic studies to assess the effect of shrink temperature and duration for heat shrink materials", 6th International Technical Conference on Cables and Wires, CABLE WIRE 2008.

6.0 ACKNOWLEDGMENT

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ANNEXURE-I

INSULATION DIVISION

Sl. No.	Title of the project	Date of start period	Budget (lakh)
1.	Development of software for differential scanning calorimeter and thermal analysis data station	3/87, 2 years	0.03
2.	Development of models for analyzing insulation reliability and analysis of data	3/87, 3 years	0.03
3.	Development of ultrasonic partial discharge (PD) measuring techniques for condition monitoring of power capacitors	4/87, 2.5 years	0.03
4.	Detection of partial discharge in power capacitors using high frequency current transformers	3/87, 2 years	0.75
5.	Group rating factors for XLPE cables in accessible ducts/tunnels	4/88 3 years	1.25
6.	Study of heat transfer characteristics of gas insulated cables	4/88, 2 years	0.99
7.	Study of generation of higher harmonics in the case of traction loads	1/88, 3 years	4.40
8.	Evaluation of polymeric insulating materials for use in HVDC cables	4/89, 3 years	0.50
9.	Life estimation of coil windings on rotating machines by accelerated ageing technics	4/88, 1 year	0.75
10.	Investigation on electrical breakdown in SF_6 gas. Phase-3	4/88, 1.5 years	0.93
11.	Development of composite mica insulation from waste mica	4/87, 1.5 years	0.05

Sl. No.	Title of the project	Date of start period	Budget (lakh)
12.	Investigation of properties of polypropylene film for power capacitors	4/88, 1 year	0.05
13.	Investigation of surface breakdown in solid gas insulation system	4/88, 2 years	0.50
14.	Development of Novolac from multivalent phenol for electrical insulation	4/87, 3 years	1.00
15.	Development of flame retardant PVC compound for power cables	4/87, 3 years	0.50
16.	Studies on use of transition metals chelates as accelerators for epoxy resins	4/87, 3 years	0.45
17.	Development of organic insulators for outdoor applications	9/87, 1 year	1.00