The 30th Anniversary Special Issue

Electrical Insulation News in Asia

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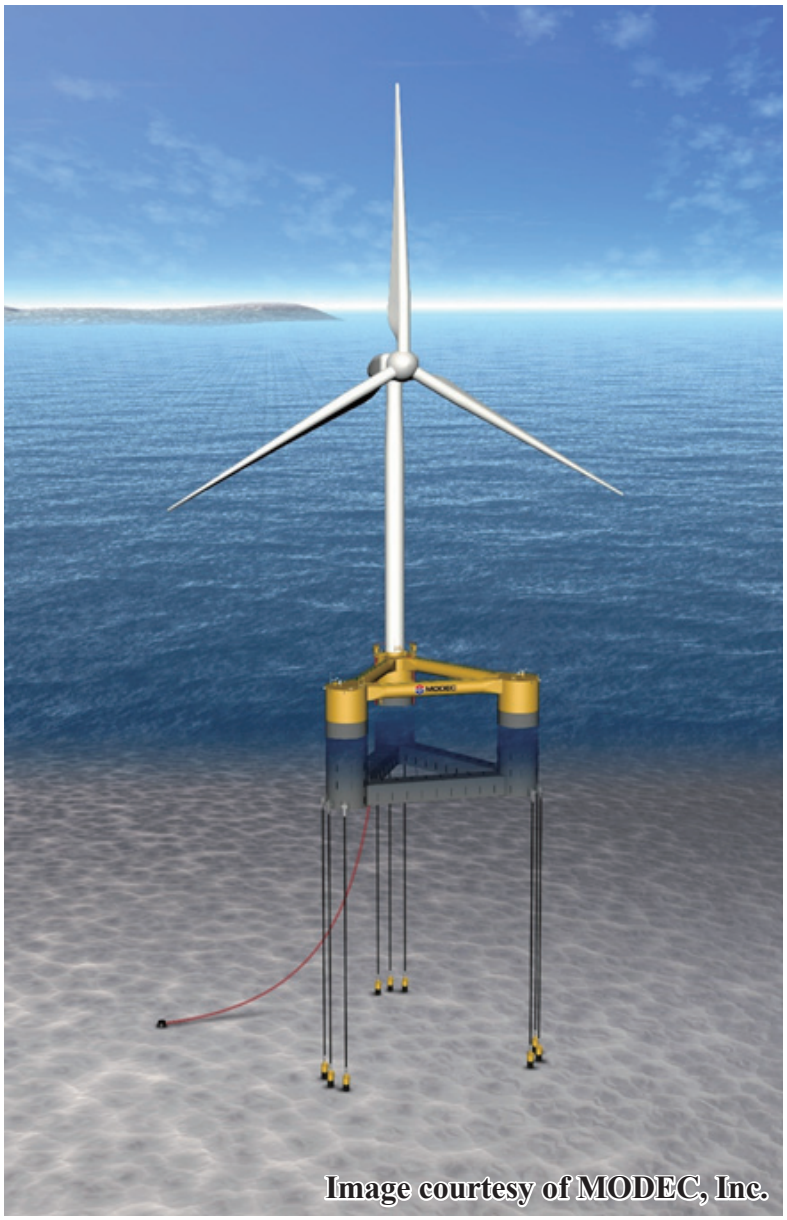

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IEEJ

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PREFACE

Prof. Akiko KUMADA

Towards Gender Equity in Academia

Promoting gender equality is a current initiative in various organizations, and this holds true for the Graduate School of Engineering at the University of Tokyo, where I am affiliated. Among the diverse strategies in place, one aims to enhance the gender balance among faculty members. Depending on the statistical scope, the current goal is to increase the percentage of female faculty members from approximately 9% to 12% in the next 5 to 6 years. This objective involves not only encouraging recruitment but also engaging in initiatives to encourage female students to pursue studies in science and engineering.

Now, albeit belatedly, there is a common inquiry: "Why is it necessary to consciously improve gender balance?" I would like to present my perspective on this question, constantly refining my response.

Firstly, within a group, the voices of minorities often struggle to reach the majority. Particularly, in the pursuit of solving societal issues—one of the key objectives of engineering—the lack of representation of female perspectives and interests in the field of science and technology results in significant societal losses.

In 2019, journalist Caroline Criado-Perez published "Invisible Women: Exposing Data Bias in a World Designed for Men." The book highlighted a longstanding deficiency in data regarding women across various fields such as urban planning, transportation systems, public health, political participation, work environments, and product development. This historical male dominance in decision-making roles and design processes, both in public and private sectors, has led to the neglect of women's opinions and needs, resulting in substantial harm to the lives, health, and careers of women.

Even when individuals responsible for decision-making harbor no ill intentions of gender discrimination, the failure to "notice" can adversely impact a significant number of people who find themselves in the minority. People tend to be less aware of the conveniences and inconveniences faced by those who are not present, making it difficult to recognize injustice or discomfort. Being physically present in a space remains crucial.

Another critical aspect is the provision of an environment conducive to healthy academic research and study, regardless of an individual's attributes. For instance, in environments that excessively favor individuals capable of working long hours, those unable to do so may be cast aside as a minority. However, individuals inevitably experience periods of transitioning into the "minority." Therefore, it is essential to introduce evaluation methods that ensure appropriate compensation for those unable to engage in long working hours. Emphasizing the importance of diversity among members, gender balance, in this case, becomes the forefront of securing a thriving community.

Prof. Akiko KUMADA
The University of Tokyo

EDITORIAL

Message from Chairman

Dear Friends!

EINA Magazine No. 30 (2023) has come out for you. You may look at this newest issue on this Website http://eina.ws.

EINA magazine has been published in printed paper form up to the No. 21 (2014) issue. Still, from the No. 22 (2015) issue, we decided to publish the magazine mainly in electronic PDF form to reduce the printing and mailing costs. Before this decision, we collected the readers' opinions, and the majorities were positive. As the chair of the EINA magazine committee, I sincerely ask you to accept our decision. If you feel some inconvenience in the electronic style, please don't hesitate to request us to send the ordinary type of EINA magazine. We continue to print the ordinary type ones for distribution at international conferences to advertise our magazine.

EINA Magazine Committee of IEE of Japan is aiming at interactive communication among R&D people in the field of electrical insulation and high voltage engineering, especially in the Asia-Pacific region. We value this activity because building an interactive channel to promote R&D in this expertise would be crucial. If you have items for the announcement, why don't you use this medium to communicate with your potential friends? Contact eina@eina.ws.

This year, EINA Magazine celebrates its 30th anniversary, and over the past 30 years, the role of Asian researchers in our field has changed considerably: after a period of stagnation during the COVID-19 disaster, the world seems to have moved on again. However, international conflicts and weather problems have emerged this year. Against this background, the new energy infrastructure that will probably be built in the next decade or so will play an essential role in determining the future of humanity. In other words, it is no exaggeration to say that the results of our research field must lay the foundations for a bright future for mankind. We are entering an era in which the purpose of research is to prioritize "environmental benefits" over "economic benefits", and a new decade is about to begin in which young researchers will play a central role in opening up a new future for human beings. Asian researchers have a significant role to play in these times, and it is increasingly necessary to stimulate exchanges between Asian researchers. We hope this journal will help play a part in this role.

I sincerely hope you will join in our EINA activities.

Thank you.

Professor Dr. Yasuhiro TANAKA
Tokyo City University

OUTLINE OF TECHNICAL COMMITTEES IN IEEJ

Dielectrics and Electrical Insulation (DEI)

Chairperson: Toshihiro Takahashi (CRIEPI*)
Secretaries: Yoitsu Sekiguchi (Sumitomo Electric Industries)
Hiroaki Miyake (Tokyo City Univ.)
Assistant Secretaries: Takahiro Umemoto (The Univ. of Tokyo)
Norimitsu Takamura (Fukuoka Univ.)
*CRIEPI: Central Research Institute of Electric Power Industry

The Technical Committee on Dielectrics and Electrical Insulation (TC-DEI) in the Fundamentals and Materials Society of the Institute of Electrical Engineers of Japan (IEEJ) has been established as a forum for discussing technical issues related to dielectrics and insulating materials in general. The TC-DEI organizes about 7 to 10 Technical Meetings per year as well as Symposium on Electrical and Electronic Insulating Materials and Applications in Systems (SEEIMAS) on an annual basis to contribute to the development of this field. ISEIM is held about once every three years as an international conference of SEEIMAS, and this year, 2023, was the year of ISEIM. This year's ISEIM, ISEIM 2023 was held at Kunibiki Messe in Matsue City, Shimane Prefecture, from September 24 to 28, 2023, with 156 participants from 12 countries and regions. For details, please refer to the report for ISEIM 2023 in this issue of EINA magazine including the reports for the demonstrative session on partial discharge measuring devices and techniques, the tutorial on assembling and understanding the PEA measuring device for thick specimen, and workshop on machine learning for dielectrics and electrical insulation.

Additionally, TC-DEI runs Investigation Committees (IC's) in order to encourage the technical information exchange and present status of the related research activities, as shown below:

(1) Advanced Nanomaterials, Organic Device Development and Life Science Application for Supporting Sustainable Growth (Oct. 2020 - Sept. 2023, Chair: Keizo Kato, Niigata Univ.)
(2) Precursor Phenomena of Electrical Breakdown in Electrical Power Apparatus and Equipment and Sensing Technologies (Apr. 2021 - Mar. 2024, Chair: Takashi Kurihara, CRIEPI)
(3) Advanced Technology Related Nano Materials and Device Development Contributing to the Post Corona Era (Oct. 2023 - Sept. 2026, Chair: Keizo Kato, Niigata Univ.)

In addition, the following two technical reports have been published this year as the products of the Investigating Committees, which worked under TC-DEI.

(1) Application of quantum chemical calculations in the field of electrical and electronic insulation materials (IEEJ Technical Report No. 1542)
(2) Advances in Tailor-made Polymer Composite Insulation Materials -Machine Learning in Insulating Materials and Application Development of Composite Insulation Materials- (IEEJ Technical Report No. 1554)

Although these reports are published in Japanese, they are available for download purchase from the IEEJ website, https://www.bookpark.ne.jp/ieej/index.asp. If you are interested, please visit the website to purchase and read them.

In addition, we are in the process of establishing a research technical committee that will specialize in inverter surge insulation, space charge and current integration methods, nanocomposite insulating materials, and liquid insulation. Once these committees are active, they will organize special sessions on topics consistent with their activities in ISEIM, SEEIMAS, and technical meetings.

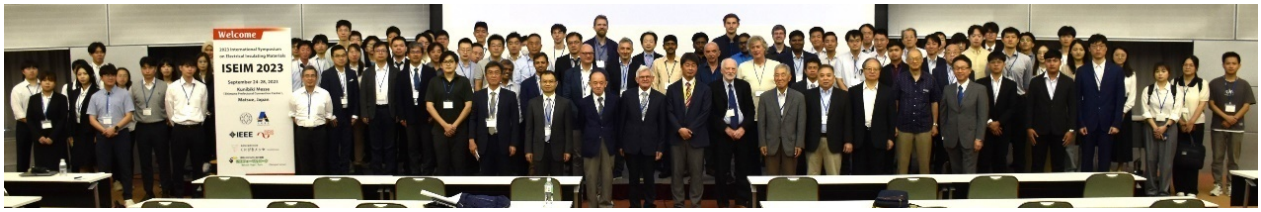

Fig. 1. Group photo at ISEIM 2023

Electrical Discharges, Plasma and Pulsed Power (EPP)

Chairperson: Hiroki Kojima (Nagoya University)
Vice-Chairperson: Toru Sasaki (Nagaoka University of Technology)
Secretaries: Katsuyuki Takahashi (Iwate University)
Yuki Inada (Saitama University)
Assistant Secretaries: Yusuke Nakagawa (Tokyo Metropolitan University)
Yusuke Nakano (Kanazawa University)

The Technical Committee on Electric Discharges, Plasma and Pulsed Power (TC-EPP) was established in January 2019 by integrating the Technical Committees on Electrical Discharge, Plasma, and Pulsed Power. Discharge, plasma, and pulsed power have been related to each other for a long time, and there have been many researchers involved in both, such as the use of pulsed discharge plasma and underwater pulsed discharge plasma for materials, environment, and bio applications, and in recent years the relationship has been increasing in various ways. Although there had already been interactions among the fields in the organization of sessions at society conferences, etc., the establishment of this technical committee has increased the number of committee members and members who are mutually involved in the areas of activities of the former technical committees, and I feel that mutual interactions are being further promoted.

The TC-EPP has been working to promote the importance and attractiveness of this technology through the followings:

(1) Advanced scientific research and systematic investigation of the science and engineering behind discharge, plasma, and pulsed power technology,
(2) Promotion of the search for new science of discharge, plasma, and pulsed power technology, and the development of new applied technology,
(3) Cooperation with other fields and research and investigation from a futuristic and international perspective.

The TC-EPP holds technical meetings four to five times a year. The technical meeting is one of the most important activities in which the integration of technical committees has resulted in technical exchanges across previous fields. Due to the influence of COVID-19, online meetings have continued to be held, but starting with the December 2021 meeting, technical meetings are now being held in a hybrid format, with in-person meetings in principle. In 2023, five technical meetings were conducted and organized:

(1) January 20–21 at Izuhara District Community Center, Tsushima, Nagasaki, with the TC of Dielectrics and Electrical Insulation (TC-DEI) and of High Voltage Engineering (TC-HVE),
(2) June 8–10 at Yamagata TERRSA, Yamagata,
(3) July 19–20 at Satellite Plaza, Kanazawa University, Ishikawa, with the TC of Stationary Devices (TC-SD) and of Switching and Protecting Engineering (TC-SPE),
(4) October 5, online
(5) November 6–7 at Himeji Citizens Hall, Hyogo, with TC-SPE and TC-HVE.

Although most of the meetings were held in a hybrid format based on face-to-face meetings, the October meeting was held online due to the size of the event.

In the meetings held in hybrid mode, approximately half to 2/3 of the participants participate locally, and the proportion of local participants has been gradually increasing since the start of hybrid meetings. In addition, the total number of participants tends to be higher than before the COVID-19 pandemic. It is considered that both the merits of the online system, in which participants can casually participate and listen to lectures, and the deep discussions involving face-to-face chats are compatible, and we can expect more active technical exchanges in this field. Moreover, the technical meetings held by the TC-EPP are supported by the IEEE NPSS Japan Chapter (NPS-05) to deepen cooperation with international activities. We also recommend that papers presented at the technical meeting in the latter half of the fiscal year be submitted to the special issue of the IEEJ Transactions on Fundamentals and Materials, we hope that they will contribute to the revitalization of the journal.

In the past, we have established investigation R&D committees with an emphasis to focus on investigating the applications of discharge, plasma, and pulsed power technologies. At the 2023 IEEJ Annual Meeting, the Investigation R&D Committee on Food Sterilization and Processing Technology by Pulsed Electric Field planned and held a symposium on “Prospects for Food Sterilization and Processing Technology by Pulsed Electric Field,” in which future prospects and required power supplies and equipment were discussed with regard to the sterilization effect of pulsed electric field and its application from the viewpoint of various application fields.

While the engineering applications of discharge, plasma, and pulsed power technologies are diverse, with the recent development of the IoT etc., it has become necessary to balance basic engineering education with the increase in the volume of advanced technology education. Especially, technical college students are highly likely to become engineers in the field of application while understanding the safety of electric discharge, plasma, and pulsed power technology, and it is necessary to clarify the current state of these technical education. Against this

background, the Investigation Committee on the Technical Education of Discharge, Plasma, and Pulse Power in Technical Colleges (chaired by Tsubasa Nakamura, National Institute of Technology, Oshima College) has been established in April 2022 to investigate the current status and trends related to the technical education of discharge, plasma, and pulse power in technical colleges. Through activities to date, information on good practices at each school has been collected, and it is expected that this will be expanded to human resource education in various areas in the future.

On the other hand, as simulation technology advances and data-driven research and development becomes more popular, the importance of elementary processes, modeling, and measurement is once again increasing in the fields of discharge, plasma, and pulse power technology. However, since discharge phenolmena mainly involve fluids such as gases and liquids, their control and reproducibility are not easy, and many issues depend on individual experience and know-how. Therefore, focusing on multifaceted observation and understanding of discharge phenolmena, the "Investigation R&D Committee for Current and Future Measurement Technology in Discharge, Plasma, and Pulsed Power" (chaired by Daisuke Ogawa, Chubu University) have been established in April 2023, expanding on the research group on measurement technology in discharge, plasma, and pulsed power that had been active prior to 2022. We hope that bringing together researchers on measurement techniques of discharge, plasma and pulse power will lead to a fundamental and evolutionary understanding of discharge phenomena from multiple perspectives.

In June 25–30, 2023, we hosted 30th The International Symposium on Discharge and Electrical Insulation in Vacuum (ISDEIV 2023) with technically co-sponsorship of IEEE DEIS in Okinawa, as reported in the other article of this magazine. In addition, in March 2024, we co-host 13th Asia-Pacific International Symposium on the Basics and Applications of Plasma Technology (APSPT-13) with 16th International Symposium on Advanced Plasma Science and its Applications for Nitrides and Nanomaterials (ISPlasma 2024) and 17th International Conference on Plasma-Nano Technology & Science (IC-PLANTS 2024). And we will cooperate in organizing ISH 2025 (24th International Symposium on High Voltage Engineering) and ICEPE-ST 2026 (8th International Conference on Electric Power Equipment – Switching Technology) to be held in Japan.

Electrical Wire and Cables (EWC)

Chairperson: Naohiro Hozumi (Toyohashi University of Technology)
Secretaries: Yoshihisa Nagoya (Furukawa Electric Co., Ltd.)
Kenichi Furusawa (Sumitomo Electric Industries, Ltd.)
Kouji Miura (SWCC Showa Cable Systems Co., Ltd.)

Technical Committee on Electrical Wire and Cables (TC-EWC) is a committee organized in the IEEJ Power and Energy Society, and is composed of members from cable manufacturers, power utilities, railway companies, universities and related research institutes such as Japan Electric Cable Technology Center (JECTEC) and Central Research Institute of Electric Power Industry (CRIEPI).

The technical committee organizes technical meetings to provide opportunities to present technical achievements and to promote R&D activities in this field. The technical committee so far held technical meeting as a joint meeting of TC-DEI (Technical Committee on Dielectrics and electrical insulation) and TC-EWC, on 'Insulation performance and degradation, characteristics of DEI materials'. As the Covid has been stabilized in Japan, we were able to hold a joint technical meeting at Tohoku University on Nov. 2, 2023 with 32 participants. The participants met each other at the venue (as well as on-line) and enjoyed the presentations and discussions.

The technical committee has hold two more technical meetings, which were jointly organized by TC-DEI and TC-EWC. One held on Feb. 13, 2023 was on "Trends in maintenance technologies for wires and cables" that was participated with 59 participants. Another one held on Mar. 3, 2023 was on "Technology trends in cable and wire systems (product technology, aging mechanism clarification, diagnostics, evaluation, judgment methods)" that was participated with 33 participants.

On Oct 27, 2023, TC-EWC participated the symposium on "Power facilities supporting Japanese lifelines," organized by the TC on Static Apparatus, and made a presentation on cable technologies. The technical committee held a forum on "Latest diagnostic technology for power cables" on Feb. 27, 2023 that was participated with 90 people.

In addition to organizing technical meetings, forums and symposia, the technical committee supervises investigation committees dealing with subjects related to electrical wire and cables. In FY2023, the investigation committee on "Advanced maintenance and security of overhead power lines using the latest technology" (started in Oct, 2022) is active.

We have realized a site visit at “Spring-8 (synchrotron radiation facility)” in the middle of December 2022 as Covid conditions has been stabilized. We strongly believe that Electric wire and cables occupy an important part of infra-structure that sustains stable supply of electric power. It is thus an important responsibility of us to clarify the social background and development process lead to the establishment of the technologies, and pass these onto the next generation.

Photo: Technical visit to the Spring-8 (synchrotron radiation) facility.

High Voltage Engineering (HV)

Chairperson: Shozo Sekioka (Shonan Institute of Technology)
Secretaries: Takeshi Iwata (Hitachi Corp.)
Yoshiki Nakazawa (Toshiba Energy Systems & Solutions Co.)
Assistant Secretary: Kensuke Teramoto (CRIEPI*)
Kazuki Obayashi (Shoden Corp.)
*CRIEPI: Central Research Institute of Electric Power Industry

Overview

The Technical Committee (TC) on High Voltage Engineering (HV) in the Power and Energy (P&E) Society of the Institute of Electrical Engineers of Japan (IEEJ) covers the research fields on the high voltage and current. “High voltage” is defined as the voltage to cause phenomena which are not observed when low voltage is applied. Thus, the TC deals with wide areas of electrical engineering. The main purpose of the TC is the promotion and exchange of information and knowledge in the field of high voltage engineering from international and domestic viewpoints. The major activities of the TC include establishing and discussing Investigating R&D Committees, publishing their IEEJ technical reports and lectures, and organizing Technical Meetings. The technical meetings were fundamentally held online. Some of the technical meetings were done by hybrid style with online and face-to-face styles in 2022.

This TC has dealt with issues related to high voltage and current engineering such as generation, measurement and evaluation of high voltages, high voltage testing, lightning phenomena, lightning protection design, overvoltages, insulation coordination, EMC/ EMI/EMF and electromagnetic transient (EMT) analysis. As of October 2023, five investigation committees are active as shown in Table 1 and two committees are planned.

The TC works on finding new themes and carrying out systematically technique succession of conventional technology on HV engineering. Furthermore, the TC established encouragement prize for young scientists, and emphasizes the development of human resources for the young scientists.

Organization

The TC on HV consists of Chairperson (1), Secretaries (2), Assistant Secretaries (2), and members belonging to the following institutes: university (5), research institute (2), electric power utility (6), rail way company (1), and manufacturer (6).

Information on IWHV

The TC on HV organizes the International Workshop on High Voltage Engineering (IWHV). One of the major missions of the IWHV is to provide researchers, engineers, etc. mainly in Asian countries with an opportunity of sharing novel findings in the

field of HV engineering. Since IWHV was first held in Okinawa, Japan in 1999, IWHV has been held in various cities in Japan. IWHV is now held once in two years. In every IWHV, participants actively discuss and exchange their knowledge and experience with each other. In addition, contributions with original findings are carefully selected and introduced in a special issue of IEEJ Transactions on Electrical and Electronic Engineering. IWHV 2024 will be planned to be held in Kagoshima, Kagoshima Prefecture. All the papers submitted to IWHV will be presented orally during two-day meeting. In accordance with the rule of IWHV, presentations and discussions will be done in English. We hope that IWHV 2024 will be a productive meeting for all the participants.

Table 1. Investigation R&D Committees in the TC on HV.

Investigation R&D Committee	Active period	Chairperson
Investigation R&D Committee on Recent Progress on Characterization of Electric and Magnetic Fields near Electric Power Facilities	3 years from 2022	Kenichi Yamazaki (CRIEPI)
Investigation R&D Committee on Technical Trends of Insulation and Immunity Design against Lightning for Electrical Infrastructure	3 years from 2022	Toshihiro Tsuboi (Tokyo Electric Power Co. Holdings, Inc.)
Investigation R&D Committee on Lightning Protection Issues for Traction Power Supply and Signaling System for Railway	4 years from 2019	Hitoshi Hayashiya (East Japan Railway Co.)
Investigation R& D Committee on Clarification of Lightning Damage Mechanism and Lightning Protection Measures on Power Distribution Lines	4 years from 2019	Tomoyuki Sato (Tohoku Electric Power Network Co., Inc.)
Investigating R&D Committee on Lightning Damage Control Measures Considering Maintenance of High Availability for Wind Turbine Generator	3 years from 2023	Nobuyuki Honjo (J-Wind Service Co., Ltd.)

Activities of Investigation Committees in the DEI Technical Committee

Precursor Phenomena of Electrical Breakdown in Electrical Power Apparatus and Equipment and Sensing Technologies

Chairperson: Takashi Kurihara (CRIEPI*)
Secretary: Hiroaki Cho (Toshiba Infrastructure Systems & Solutions Corp.)
Assistant Secretary: Naoto Shigemori (Furukawa Electric Co., Ltd.)
*CRIEPI: Central Research Institute of Electric Power Industry

Objective

In recent times, with the advent of a global advanced information society, increasingly sophisticated urban functions, and high demand for electric power, highly safe electric power systems are being sought. This includes electric power apparatus and equipment central to maintaining social infrastructure. When accidents occur at such apparatus and equipment and cause power outages, the social impact is substantial, and economic losses become significant. Therefore, the maintenance of electric power apparatus and equipment is extremely important, and diagnostic methods to ascertain deterioration and abnormalities in electric power apparatus and equipment have been utilized for a long time. The Technical Committee on Dielectrics and Electrical Insulating Materials has established investigating R&D committees 10 times since 1980, continuously investigating changes in insulating materials, insulation deterioration diagnostic methods, deterioration assessment criterion, and lifetime estimation methods for cables, transformers, rotating machines, gas-insulated switchgears, and circuit breakers at 3.3–77 kV.

Developments are underway to use nanocomposites, vegetable oils, and alternatives to SF_6 gas as new insulating materials, considering the current global environment. In addition, electric power apparatus and equipment developed overseas are used domestically; thus, insulating materials different from those used in domestically produced electric power apparatus and equipment can be used. As there is a possibility that the demand for developing new insulating materials may increase considering a carbon-free environment, insulating materials and designs will continue to change in the future.

Under such circumstances, insulation deterioration diagnosis is performed for many kinds of electric power apparatus and equipment, e.g., cables, transformers, rotating machines, gas-insulated switchgears, circuit breakers, and disconnectors. However, the precursor phenomena of electrical breakdown and process through which deterioration leads to electrical breakdown differ with changes in insulation design and usage environment of electric power apparatus and equipment. In some electric power apparatus and equipment, e.g., molded transformers, the precursor phenomena of electrical breakdown have not been sufficiently clarified. It is important to discover these precursor phenomena at an early stage, so that insulation deterioration diagnosis is properly carried out.

In addition, with the development of ICT and sensing technologies, online diagnosis in Japan and abroad have been utilized for the insulation deterioration diagnosis of electric power apparatus and equipment. Based on the requirements for early detection of insulation deterioration and labor saving in insulation deterioration diagnosis, the importance of online diagnosis is expected to increase in future. Considering the effective use of online diagnosis, it is important to develop sensing technologies to detect the precursor phenomena of electrical breakdown and ascertain the lead time to electrical breakdown.

Against this background, the objective of this committee is to investigate the precursor phenomena of electrical breakdown and the process through which deterioration leads to electrical breakdown, according to changes in the insulation design of electric power apparatus and equipment and usage environments. The other objective is to investigate the latest sensing technologies to detect such changes.

Investigative Matters

The committee will investigate the following items for 3.3–77 kV cables, transformers, rotating machines, gas-insulated switchgears, circuit breakers, and disconnectors:

(1) Changes in insulation design and usage environments
(2) Precursor phenomena of electrical breakdown and process through which deterioration leads to electrical breakdown
(3) Latest sensing technologies to detect the precursor phenomena of electrical breakdown

Term of Investigation

The term of this committee is three years from April 2021 to March 2024.

Activities

We held four meetings in 2021 and five meetings in 2022, and discussed the aforementioned items. We also held seminars on deterioration mechanisms and deterioration diagnostic technologies of insulating materials in electric power apparatus and equipment as a forum of the Fundamentals and Materials Society (FMS) on July 2, 2021, at Tokyo Branch of IEEJ on November 26, 2021, and at Tokai Branch of IEEJ on March 4, 2022. Furthermore, we held special topic sessions on the same theme in the Annual Conference of FMS on September 2, 2021, and on September 15, 2022.

Advanced Nanomaterials, Organic Device Development, and Life Science Application for Supporting Sustainable Growth

Chairperson: Keizo Kato (Niigata University)
Secretaries: Shin-ichro Nakajima (Japan Aviation Electronics Industry, Ltd.)
Yusuke Aoki (Mie University)
Assistant Secretary: Akira Baba (Niigata University)

Research in organic electronics is making great progress, including research into the electronic and optical functions of nanomaterials and thin films, and the development of devices and sensors using organic materials. Research on flexible electronics, printed electronics, bioelectronics, etc. is also been very active. In the near future, innovative devices using organic materials will be developed. In addition, research related to organic devices could be applied to life sciences. Nanomaterials and nanostructure control technology are considered important for the development of organic devices and their applications in life sciences, and various trials and research and development efforts are being carried out.

Therefore, there is a need for research into nanomaterials, organic device development, and life science applications that will create a new society and support sustainable growth.

From these points of view, this investigating R&D committee has been established to investigate and examine the most advanced nanomaterials, nanostructure control technology, evaluation techniques, high-performance/high-function organic device development and life science application. The purpose of this investigating R&D committee is to contribute to the sustainable growth of society based on the development of new electronic devices and electrical equipment and industries such as energy, environment, and biotechnology.

The Investigating R&D Committee on “Advanced Nanomaterials, Organic Device Development, and Life Science Application for Supporting Sustainable Growth” was established in October 2020, with the term of three years. The investigation has focused attention on the nanomaterials and structure control for high-performance organic devices and life science related to:

(1) Advanced nanomaterials and nanostructure control technologies
(2) Surface and interface properties and evaluation techniques for nanomaterials and devices
(3) Electronic and optical functions of nanomaterials, organic thin films, and composite films
(4) Organic device development and life science application

Since its establishment in October 2020, the committee has met a total of 10 meetings: two times in FY2020, two times in FY2021, four times in FY2022, and two times in FY2023. Due to the three years of activities during the COVID-19 pandemic, the number of events was slightly lower than planned. The meetings have been held in the Institute of Electrical Engineers of Japan (IEEJ), Karuizawa Kensyujo (Kato & Yamazaki Educational Foundation) and Karuizawa Tourism Promotion Center, Fukushima Renewable Energy Research Institute (FREA, National Institute of Advanced Industrial Science and Technology), Himakajima Island Hotel Urashima, Nagoya University, and Niigata University. At each meeting, the committee members introduced their research, and researchers other than the committee members gave lectures on recent research results related to the committee's research items, followed by question-and-answer sessions and discussions. Research trends in the most advanced nanomaterials, nanostructure control technology, high-performance and highly functional organic devices, and the development of life science applications were also investigated. In addition, a tour of the research institute was held, and various investigations were conducted on advanced nanomaterials, structural control, innovative organic device development, life science applications, etc.

Through the activities of this committee, we were

able to obtain a lot of knowledge regarding the current status and issues of advanced technologies such as nanomaterials, nanostructure control, nanointerface physical properties and evaluation technology, electronic and optical functions of nanomaterials, and device and sensor applications. These results will lead to applications in high-performance, highly functional organic devices and development in life science. In addition, new functions are expected to emerge through nanomaterials and nanostructure control technology for organic thin films and composite films, which will lead to the development of innovative electronic devices and electrical equipment, and their expansion into industries such as energy, the environment, and life. There are great expectations for its applications in science. Therefore, it has made a significant contribution to the development of dielectric and insulating materials and functional electrical and electronic materials and devices both domestically and internationally.

As a result of the above, the initial objectives have been achieved and the committee has reached the stage of compiling its findings, so the committee was disbanded as of September 2023. Some of the results of this committee were reported in the special session "Advanced Nanomaterials, Organic Devices and Life Science Application Based on Megatrends - Challenge of Organic Electronics Toward Aging Society and Carbon Neutrality -" at the 2022 Annual Conference of Fundamentals and Materials Society (FMS), IEEJ held in Tanegashima, Kagoshima Prefecture. Fig. 1 shows a landscape photo of the Nishinoomote Port near the conference venue. The final results of this committee were reported in the special session "Advanced Nanomaterials and Development of Organic Devices and Life Science Application that Challenge Sustainability" at the 2023 Annual Conference of FMS, IEEJ held at Aichi Institute of Technology. Fig. 2 shows a photo of the lecture venue at the conference.

Furthermore, since October 2023, a new Investigating R&D Committee on "Latest Technologies for Advanced Nanomaterials and Device Development Contributing to the Post-Covid-19 Era" has been established, and new activities are being carried out.

The members of the Investigating R&D Committee

Fig. 1. A landscape photo of the Nishinoomote Port seen from near the venue (Nishinoomote Civic Center in Tanegashima, Kagoshima Prefecture) of the 2022 Annual Conference of FMS, IEEJ.

Fig. 1. A photo of the lecture venue at the 2023 Annual Conference of FMS, IEEJ held at Aichi Institute of Technology Jiyugaoka Campus in Nagoya.

on "Advanced Nanomaterials, Organic Device Development, and Life Science Application for Supporting Sustainable Growth" were as follows: Takeshi Asami (Denka), Masayuki Chikamatsu (AIST), Eiji Ito (Shinshu Univ.), Satoru Iwamori (Tokai Univ.), Tomio Iwasaki (Hitachi, Ltd.), Sachiko Jonai (Niigata Univ.), Hirotake Kajii (Osaka Univ.), Takaaki Manaka (Tokyo Tech), Tatsunosuke Matsui (Mie Univ.), Yasuhiro Miura (Hamamatsu Univ. School of Medicine), Tatsuo Mori (Aichi Inst. of Tech.), Tetsushi Okamoto (TMEIC), Takashi Ota (Panasonic), Masafumi Takesue (Kao), Rumiko Yamaguchi (Akita Univ.), Hiroshi Yamamoto (Nihon Univ.), Hiroshi Yamauchi (Tokyo Denki Univ.), Norimitsu Yoshida (Gifu Univ.).

EINA Magazine Publication

Chairperson: Yasuhiro Tanaka (Tokyo City University)
Secretaries: Masahiro Kozako (Kyushu Institute of Technology)
Norikazu Fuse (CRIEPI*)
*CRIEPI: Central Research Institute of Electric Power Industry

Objective

The EINA Committee, which publishes the magazine "Electrical Insulation News in Asia", aims to construct an international interactive channel for information exchange in the field of dielectrics and electrical insulation in the Pan Pacific region. We are currently providing an annual issue of EINA magazine and making it available on the EINA Website.

Chronicle of the Committee

The Committee, with the official title "the Coope-

rative Research Committee (CRC) of Asian Interlink of Dielectrics and Electrical Insulation", was established by the late Professor M. Ieda in 1991. It played the leading role in initiating this kind of work from Jan. 1991 to Dec. 1992. The committee reviewed the present status of scientific and technological cooperation in the field of dielectrics and electrical insulation in Asian countries and sought appropriate ways to promote informative interaction among the countries.

On the basis of the former activities, the CRC of "Electrical Insulation News in Asia" was founded by Professor H. Yamashita, Keio University in April 1994. One of its key activities was the publication of the "Electrical Insulation News in Asia (EINA)" from No. 1 (Sept. 1994) up to No. 6 (Sept. 1999). This dedication contributed significantly to a mutual understanding of electrical insulation activities in Asia.

Professor T. Tanaka of Waseda University took over this role in 2000 and expanded it to accommodate information flow among Asian countries and to facilitate a more timely flow of information through its website. Three international technical exchange sessions were held in ICPADM 2000 (Xian Jiatong University, China), ISEIM 2005 (the Kitakyushu Intern'l Conf. Center, Japan), and ISEIM 2008 (Yokkaichi Cultural Hall, Japan) for the promotion of information exchange and human contact among researchers of Pan-Pacific region in the field.

Professor M. Nagao of Toyohashi University of Technology) chaired the committee from 2009 to 2021. After that, Professor Y. Tanaka of Tokyo City University became the committee chair. In the past, the EINA magazine was published both by mail and through the website. In 2015, we sent out questionnaires to readers on the way to publication. As the answers we collected coincided with our intention, we decided to publish the magazine mainly in electronic PDF form through the website. However, we continue to send printed booklets for those requesting them and authors of articles on the issue. They are also distributed at related international conferences.

Activities

Our present committee consists of 9 critical members and 18 other members. You can find the list of the committee members on the website. (You may be confused that 4 TANAKA are listed on the list! What a common name in Japan!)

One annual general meeting and secretariat meetings as needed are held to plan, carry out, and review its activities.

EINA Magazine celebrates its 30th anniversary over the past 30 years this year. No other committee has been continuously active for 30 years. We would like to take this opportunity to thank our readers for their support, which has enabled us to continue for 30 years despite several economic crises in the past.

The EINA Magazine No. 30 was published in electronic form in December 2023, as shown in Fig. 1, and uploaded to our website http://eina.ws/.

Please visit the website. It may be of interest to you.

The Committee has been financially supported by IEEJ and voluntary contributions from Japanese enterprises.

Term of Investigation

The term of this committee is two years, from April 2023 to March 2025. After that, a succeeding committee will be set up every two years.

Fig. 1. Front and rear covers of the latest issue of EINA magazine (EINA No. 29, Dec. 2022).

Activities of Other Committees Related to Electrical Insulating Materials

IEC TC 15 Japanese National Committee

Chairperson: A. Kawaguchi (JET*)
Secretary: C. Kondo (DuPont Nippon Paper Papylia)
*JET: Japan Electrical Safety & Environment Technology Laboratory

The scope of IEC TC15 is declared as follows; “To prepare international standards including specifications for solid electrical insulating materials alone and in simple combinations. This includes coatings which are applied in the liquid state but cure to solids, such as varnishes and coatings.

TC15 establishes definitions, general requirements and specification sheets for individual types of materials. The standards include test methods and guidance where these are required for the specifications”.

Although TC15 Japanese National Committee (TC 15 of JNC) has certainly the same scope as that for IEC TC15, its mission is accomplished by consulting with Japanese industrial situations and market in the world.

As shown in Table 1, the current activities of TC15 are carried out by 3 working groups (WGs), 6 maintenance teams (MTs), 1 project team and 1 Joint Maintenance Team. IEC TC15 publishes now more than 160 standards.

The kind of insulating materials concerned with TC 15 are classified by fundamental and basic category. Member of TC15 of JNC are encouraged to activate the domestic and global markets through their technologies of high levels. TC15 of JNC is contributing to the standardization works in WGs and MTs as the convenors and experts of the WGs and MTs, which are WG5 WG7 MT3, MT10, MT14, MT15 and MT16. Especially, MT3 and MT16 are managed by Japanese convenors.

TC15 Plenary Meetings were held annually. However, due to COVID-19, meeting has been held irregularly in recent years as follows.

2019 Germany, Frankfurt
2020 Cancelled
2021 Virtual meeting
2022 Cancelled
2023 USA, Saint Louis and Virtual meeting

In 2023, a plenary meeting was held in Saint Louis in October 9 to 13. It has been two years since the last plenary meeting. Face to face meeting has been 4 years. The major topic in this meeting is as follows.

Table 1. Working Groups and Maintenance Teams in TC 15

Working Groups in active		
WG No.	Title	Number of JP expert
5	Flexible insulating sleeving for electrical purposes	1
6	Rigid fibrous reinforced laminates for electrical purposes	0
7	Resins and varnishes	1

Project Team in active	
Name of project team / standard	Number of JP expert
PT 60554-3-6 / presspaper	0

Maintenance Teams in active		
MT No.	Title	Number of JP expert
3	Plastic films	3
10	Combined flexible materials	1
11	Mica products	0
14	Pressboard and related material	1
15	Cellulosic paper products	1
16	Miscellaneous	2

Joint Maintenance Teams in active	
Name of joint maintenance team / Related TC	Number of JP expert
JMT 60076-26 / TC 14 Power transformers	0

MT14 and MT15 - The plenary approved the transfer of “presspaper” sections from MT14 to MT15.

This creates eleven maintenance projects and one new project. MT14 currently handles pressboard and presspaper. Both are produced from high purity pulp. With this change, MT14 will handle only pressboard and MT15 will handle cellulosic paper products including thin presspaper.

In addition, since major changes are planned for cellulosic paper products, Japanese National Committee will be closely monitoring the revision of the standard, as it may affect Japanese products.

The plenary reviewed the opening for TC15 Chair by June 30, 2024, and the need for nominations. A letter was already sent to NCs in July 2023

Date and place of the next meeting (2024)
Vienna, Nov 14 to 17.

The plenary reviewed and accepted the Invitation from Austrian National Committee to be held at Vienna, Nov 11 to 14 with Plenary on Nov 14.

This will be in-person meeting only.

IEC TC 112 Japanese National Committee

Chairperson: Yasuhiro Tanaka (Tokyo City University)
Secretary: Takashi Kurihara (CRIEPI*)
Associate Secretary: Kenichi Yamazaki (Toshiba Infrastructure Systems & Solutions Corporation)
*CRIEPI: Central Research Institute of Electric Power Industry

IEC TC 112 deals with many international standards and specifications on “Evaluation and qualification of electrical insulating materials and systems”. TC 112 was established in 2005 based on TC 98 and the related sub-group in TC 15, which were disbanded after the establishment of TC 112. TC 112 Japanese National Committee (JNC) was also established in 2005 to correspond to the activities in TC 112 and to concern with related Japanese standards.

TC 112 involves eight working groups (WG) and dealing with more than 50 standards. TC 112 JNC includes eight corresponding WGs and one more WG that relates with the Japanese Industrial Standards (JIS). The WG structure of TC 112 JNC is shown in Table 1. 27 JNC expert members are registered to the eight international WGs and the convener of WG8 is now taken by Prof. Yasuhiro Tanaka. In this reason, Japanese members are very active in this standard region.

From October 2 to 6, 2023, IEC TC 112 Meeting was held in St. Charles, Missouri, USA and the Plenary, Advisory group and WGs meetings were scheduled during the week as shown in Fig.1. Two experts from JNC remotely participated in them. The next meetings of TC112 will be held in Fehraltorf, Switzerland from September 23 to 27, 2024.

Fig. 1. Photo of one of the meetings of TC 112 held in St. Charles, Missouri, USA on October 6, 2023.

Table 1. WG structure of TC 112 JNC

WG	Subject
1	Thermal endurance
2	Radiation
3	Electrical strength
4	Dielectric/resistive properties
5	Tracking
6	General methods of evaluation of electrical insulation
7	Statistics
8	Various material properties
9	Japanese Industrial Standards (JNC only)

Recent standards discussed in TC112 are partly listed:

A. WG1

- IEC 60216-1: Electrical insulating materials - Thermal endurance properties - Part 1: Ageing procedures and evaluation of test results.
- IEC 60216-2/AMD1: Electrical insulating materials - Thermal endurance properties - Part 2: Determination of thermal endurance properties of electrical insulating materials - Choice of test criteria.
- IEC 60216-4-1: Electrical insulating materials - Thermal endurance properties - Part 4-1: Ageing ovens - Single-chamber ovens.
- IEC 60216-4-2: Electrical insulating materials - Thermal endurance properties - Part 4-2: Ageing ovens - Precision ovens for use up to 300 °C.
- IEC 60216-4-3: Electrical insulating materials - Thermal endurance properties - Part 4-3: Ageing ovens - Multi-chamber ovens.
- IEC 60216-5: Electrical insulating materials - Thermal endurance properties - Part 5: Determination of relative thermal endurance index (RTI) of an insulating material.
- IEC 60216-6: Electrical insulating materials - Thermal endurance properties - Part 6: Determination of thermal endurance indices (TI and RTE) of an insulating material using the fixed time frame method.
- IEC TS 60216-7-1: Electrical insulation materials - Thermal endurance properties - Part 7-1: Accelerated determination of relative thermal endurence using analytical test methods (RTEA) - Instructions for calculations based on activation energy (PL: Jun Haruhara).
- IEC TR 60216-7-2: Electrical insulating materials - Thermal endurance properties - Part 7-2: Results of the round robin tests to validate procedures of IEC TS 60216-7-1 by non-isothermal kinetic analysis of thermogravimetric data (PL: Jun Haruhara).

B. WG2

- IEC 60544-4: Electrical insulating materials - Determination of the effects of ionizing radiation - Part 4: Classification system for service in radiation environments.
- IEC 60544-5: Electrical insulating materials - Determination of the effects of ionizing radiation - Part 5: Procedures for assessment of ageing in service.

C. WG3

- IEC 60243-2: Electric strength of insulating materials - Test methods - Part 2: Additional

requirements for tests using direct voltage.
- IEC 60343: Recommended test methods for determining the relative resistance of insulating materials to breakdown by surface discharges.
- IEC TS 61934: Electrical insulating materials and systems - Electrical measurement of partial discharges (PD) under short rise time and repetitive voltage impulses.
- NWIP IEC/TS 61251-2: Electrical insulating materials and systems - DC voltage endurance evaluation.

D. WG4
- IEC 62631-1: Dielectric and resistive properties of solid insulating materials - Part 1: General.
- IEC 62631-2-1: Dielectric and resistive properties of solid insulating materials - Part 2-1: Relative permittivity and dissipation factor - Technical Frequencies (0,1 Hz - 10 MHz) - AC Methods.
- IEC 62631-2-3: Dielectric and resistive properties of solid insulating materials - Part 2-3: Determination of relative permittivity and dielectric dissipation factor (AC methods) - Contact electrode method for insulating films.
- IEC 62631-3-1: Dielectric and resistive properties of solid insulating materials Part 3-1: Determination of resistive properties (DC methods) – Volume resistance and volume resis- tivity, general method (PL: Jun Haruhara).
- IEC 62631-3-2: Dielectric and resistive properties of solid insulating materials Part 3-2: Determination of resistive properties (DC methods) - Volume resistance and volume resistivity, Surface resistance and surface resistivity.
- IEC 62631-3-12: Dielectric and resistive properties of solid insulating materials - Part 3-12: Determination of resistive properties (DC Methods) - Volume resistance and volume resistivity, method for casting resins.
- NWIP IEC 62631-2-3: Test methods for Relative Permittivity and Dissipation Factor of insulating films with very thin thickness.

E. WG5
- IEC 60112: Method for the determination of the proof and the comparative tracking indices of solid insulating materials.
- IEC 60587: Electrical insulating materials used under severe ambient conditions - Test methods for evaluating resistance to tracking and erosion.
- IEC 61621: Dry, solid insulating materials - Resistance test to high-voltage, low-current arc discharges.
- IEC TR 62039: Selection guide for polymeric materials for outdoor use under HV stress.

F. WG6
- IEC 61857-33: Electrical insulation systems - Procedures for thermal evaluation - Multifactor evaluation with increased factors at elevated temperature.
- IEC 61857-41: Electrical insulation systems - Procedures for thermal evaluation - Part 41: Specific requirements for electrical insulation systems for use in dry-type high-voltage transformers with operating voltages of 1 kV and above.
- IEC 61857-42: Electrical insulation systems - Procedures for thermal evaluation - Part 42: Specific requirements for evaluation of an electrical insulation system (EIS) used for road transportation applications.
- IEC TR 61858-3: Electrical insulation systems - Thermal evaluation of modifications to an established electrical insulation system (EIS) - Part 3: Clarification of major and minor components.
- IEC 63177: Test method for compatibility of construction materials with electrical insulating liquids.

G. WG7
- IEC 62539: Guide for the statistical analysis of electrical insulation breakdown data.

H. WG8
- IEC TS 62836: Measurement of internal electric field in insulating materials - Pressure wave propagation method.
- NWIP IEC TS 62758-2: Calibration of space charge measuring equipment based on the pulsed electroacoustic (PEA) measurement principle (PL: Yasuhiro Tanaka).

CIGRE SC D1 Japanese National Committee (Materials and Emerging Test Techniques)

Chairperson: Akiko KUMADA (The University of Tokyo)
Secretary: Hideki MISAKA (CRIEPI*)
Secretary: Makoto MIYASHITA (Mitsubishi Electric Co. Ltd.)
*CRIEPI: Central Research Institute of Electric Power Industry

CIGRE (International Council on Large Electric Systems) has 16 Study Committees (SC). Among them, our SC D1 has a horizontal character and contributes to other CIGRE SC's. The activity of CIGRE SC's is principally research oriented one.

SC D1 has now following 6 Advisory Groups (AG): Strategic and Customer AG, Tutorial AG, *AG D1.01* (Liquid and liquid impregnated insulation systems),

AG D1.02 (High voltage and current testing and diagnostic), *AG D1.03* (Solid materials) and *AG D1.04* (Gases). D1 consists of these AGs and following 24 WGs listed as follows.

D1.50 Atmospheric and altitude correction factors for air gaps and clean insulators, D1.60 Trace-able measurement techniques for very fast transients, D1.61 Optical corona detection and measurement, D1.62 Surface Degradation of Polymeric Insulating Materials for Outdoor Applications, D1. 63 Partial Discharge Detection under DC voltage stress, D1.65 Mechanical properties of insulating materials and insulated conductors for oil insulated power transformers, D1.66 Requirements for partial discharge monitoring systems for gas insulated systems, D1.68 Natural and synthetic esters - Evaluation of the performance under fire and the impact on environment, D1.69 Guidelines for test techniques of High Temperature Superconducting (HTS) systems, D1.70 Functional Properties of modern insulating liquids, D1.72 Test of material resistance against surface arcing under DC, D1.73 Nanostructured dielectrics: Multi-functionality at the service of the electric power industry, D1.74 PD measurement on insulation systems stressed from HV power electronics, B1/D1.75 Interaction between cable and accessory materials in HVAC and HVDC applications, D1/B1.75 Strategies and tools for corrosion prevention for cable systems, B1/B3/D1.79 Recommendations for dielectric testing of HVDC gas insulated system cable sealing ends,B1/B3/D1.79 Recommendations for dielectric testing of HVDC gas insulated system cable sealing ends, D1/A2.77 Liquid Tests for Electrical Equipment, D1.76 nd ageing performance of cellulose insulation for power transformers, A2/D1.67 Guideline for online dissolved gas analysis monitoring, D1.78 Partial discharge properties of non-SF6 insulating gases and gas mixtures, D1/A2.79 Improved understanding of dynamic behaviour of winding insulating materials in liquid insulated power transformers, D1/A2.80 Functional properties of non-metallic solid materials for liquid filled transformers and reactors and their compatibility with insulating liquids, D1.81 Methods and common data file format for Time-Domain Reflectometry, and A2/D1.72 Retrofill of Mineral Oil in Transformers – Motivations, Considerations and Guidance.

The themes of technical sessions for coming Paris Session 2024 are as follows:

A. PS1: Testing, monitoring and diagnostics

- Testing and condition monitoring for reliability in conventional high voltage systems and power electronics applications.
- Assessment of diagnostics for equipment in re-mote or inaccessible locations.
- PD measurement under DC, rectifier, and impulse stress.

B. PS2: Materials for electrotechnical purposes and modelling

- Ageing of materials under electrical, mechanical or thermal stresses and ageing markers.
- Modelling materials and field simulations for AC and DC applications.
- Assessment of compatibility of aged and new materials resulting from refurbishment or life ex-tending activities.

C. PS3: Materials to enable the energy transition

- Alternative electrotechnical materials or manufacturing processes which reduce environmental footprint.
- Materials and systems for energy storage; batteries, charging devices, capacitors etc.

Materials to enable a hydrogen economy.

As for contributions from Japan, five were adopted by Headquarters at the submission stage of the con-tent outline.

In 2023, annual SC-D1 regular meeting was held on 6 September in Cairns. Reports were given on statistical data on CIGRE members and activities including WGs and AGs since the 2022 Paris Session, and the preparation condition for 2024 Paris session was also explained. In addition, there was a discussion on where the annual SC-D1 meeting should be held in 2025. It was suggested that it would be better to hold it in conjunction with a symposium in Jerusalem, Trondheim or Korea, but a decision was not reached, especially among these three parties.

Activity Event by Young Chapter Planning Committee

Chairperson: Takayuki Sakai (Takaoka Toko Co. Ltd.)
Vice-Chairperson: Yuichi Murakami (Meijo University)

The Young Chapter Planning (YCP) Committee in the Fundamentals and Materials Society (FMS) of the Institute of Electrical Engineers of Japan (IEEJ) was newly founded in September 2019. This committee attempted to revitalize the FMS by organizing events for young researchers. It is important to form networks among young researchers because they will promote cross-disciplinary research activities and enhance research collaboration between industry, academia and public institutions in future. During the COVID-19 pandemic (2019–2022), YCP committee held several online or hybrid style networking events. In the annual conference of FMS 2022, the YCP committee organized a special session with dialogue-style lecture

as referred by EINA Magazine No. 29.

The members of the YCP committee were changed in June 2023, as shown in Table 1. The former chairpersons and vice-chairpersons were retained as observers and adviser to the new YCP committee members. The annual conference of FMS held in September 2023 in Nagoya comprised a group discussion as the special session. This was the first event organized by the new members of the YCP committee. The session was divided into two parts; the first half of the session was in a lecture format, while the second half was a group discussion among participants. The lectures in the first half were titled "Research life of young researchers in Companies and Universities," presented by a YCP committee member, and "Recommendations for entering Doctoral programs," presented by Mr. KITA (Nagoya university) who is currently pursuing a doctoral Course. These lectures seemed to be interesting for young researchers and engineers. In the second half, the participants were divided into 4 groups (4–5 participants per group) and they freely exchanged their research interests. The theme of group work was "Achievement of SDGs via own research". All participants presented their opinions about the theme in their respective groups and prepared an A1-size poster representing the group opinions (Fig. 1). Each group summarized their opinions through the poster to other groups, (Fig. 2). After the special session, the YCP Committee conducted a survey regarding "satisfaction with this special session" among the participants. From the survey results, it seemed that almost all the participants were completely satisfied with the session. Following suggestions were received for the upcoming YCP committee events.

- Projects to create or measure some materials
- Interaction with people from different fields (chemistry, machinery, etc.)
- Panel discussion by several doctoral students

The challenges being faced by the YCP committee are to disseminate the activities of the committee, increase the number of participants, and enhance the content of the activities.

Fig. 1. Poster preparation

Fig. 2. Poster presentation

RESEARCH ACTIVITIES AND TECHNICAL EXCHANGES IN ASIAN COUNTRIES

Conference Records

10th International Symposium on Electrical Insulating Materials (ISEIM 2023)

The 10th International Symposium on Electrical Insulating Materials (ISEIM 2023) was held September 24-28, 2023 at the Kunibiki Messe in Matsue, Shimane, Japan. The situation has almost returned to its pre-COVID-19 state, as the barriers to entering Japan from abroad have been greatly reduced. For this reason, we have decided to hold the event in person only. We received 102 submissions and had 155 participants from 12 countries (Fig. 1, Table 1, and Table 2), thanks to the great efforts and understanding of those involved, despite various obstacles in the preparation phase.

The schedule for ISEIM 2023 is shown in Table 3. Similar to previous ISEIMs, we set up a Mutual Visiting type Poster (MVP) session, a poster presentation by students who present and question each other in small groups. We also set up a Sun Shine (SS) session, a poster presentation where industry participants present their product development status and application examples. In addition, a demo session, a tutorial on the assembly of a sensor for space charge measurement of DC-XLPE cables using the pulsed electroacoustic (PEA) method, and a workshop on the application of machine learning in this field were held.

A. Inuishi Memorial Lecture

This year's Inuishi Memorial Lecture Award was presented to Emeritus Professor Stanislaw Gubanski of Chalmers University of Technology in Sweden for his dedicated research in elucidating the mechanisms of partial discharge in outdoor and solid insulating materials (Fig. 1). The lecture, entitled “In a search for reliable methods to evaluate resistance to electrical treeing in materials for HVAC and HVDC cable insulations,” began with an introduction to the electrical treeing characteristics when high voltage AC or DC is applied to solid insulating materials embedded with wire electrodes. It then presented an evaluation of the electrical treeing characteristics using an electrode system with a needle electrode inserted into an insulation sampled from a ± 300 kV HVDC cable that had experienced ground faults in multiple joint boxes. It was shown that the dumping oscillating high voltage generated during the ground fault has a definite impact on the initiation voltage of the electrical tree.

Table 1. Country-wise distribution of papers

China	24
France	2
Germany	1
India	10
Indonesia	1
Italy	3
Japan	49
Republic of Korea	5
Singapore	3
Sweden	1
Thailand	3
Total	**102**

Table 2. Country-wise distribution of participants

Canada	1
China	24
France	2
Germany	2
India	9
Italy	3
Japan	90
Netherlands	1
Republic of Korea	13
Singapore	3
Sweden	2
Thailand	5
Total	**155**

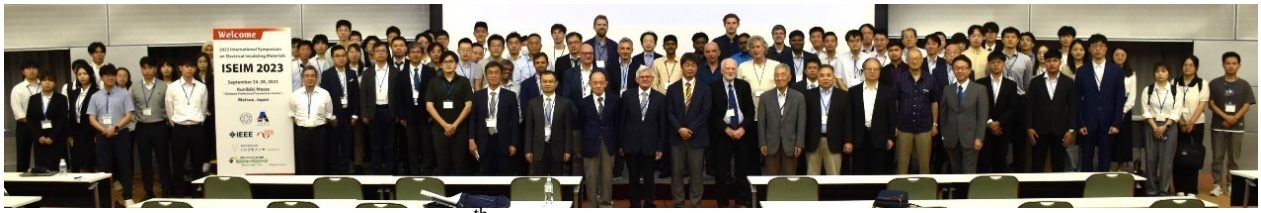

Fig. 1. Group photo taken on September 25th, 2023

Table 3. Time schedule of ISEIM 2023

Time	Sunday, Sep. 24	Monday, Sep. 25	Tuesday, Sep. 26	Wednesday, Sep. 27	Thursday, Sep. 28
9		Opening & Inuishi Memorial Lecture	Oral session	Japan-Korea Exchange Oral and poster session	Oral session
10		Coffee break	Coffee break	Coffee break	Coffee break
11		Oral session	Oral session	Oral and poster session	Oral session
12		Lunch break	Lunch break	Lunch break	Closing & Awards ceremony
13	Tutorial on Assembly of Space Charge Equipment	Oral session	Technical tours	Poster and demonstration session	Lunch and excursion to Adachi Museum or Izumo Grand Shrine (only for those who want to join)
14	Workshop for machine learning	Coffee break			
15		Poster session			
16			Banquet at Matsue Vogel park (Iwami Kagura, Japanese traditional performing art, will be performed.)		
17	Welcome party				
18					
19					
20			Head for Matsue station		
21					

Fig. 2. Inuishi memorial lecture by Emeritus Prof. Stanislaw Gubanski

B. Tutorial and Workshop

In this tutorial, attendees had the opportunity to assemble their own sensors for measuring the space charge distribution in the insulation of DC-XLPE cables using the pulsed electroacoustic (PEA) method. The tutorial was conducted by Professor Emeritus Naohiro Hozumi of Toyohashi University of Technology. It included a lecture on the principles of space charge accumulation by Dr. Morshuis of Solid Dielectric Solutions in the Netherlands (Fig. 3). After the lecture, the participants assembled the parts prepared by the organizer (Fig. 4). They then confirmed measurement signals from their self-built sensor by applying high DC voltage to an full-size XLPE cable (Fig. 5). This hands-on tutorial was well received by the attendees.

In the workshop, several speakers presented some typical applications of machine learning technology to analyze various properties of dielectrics and insulating materials (Fig. 6).

C. Oral, Poster & MVP sessions

Oral presentations were allocated 25 minutes each including Q&A. A total of 45 papers were presented (Fig. 7). The topics of presentations are shown below.

(a) Insulation design, reliability, aging and degradation, their detection and monitoring
(b) Polymeric insulators and outdoor insulation

Fig. 3. Tutorial: Discussion after the lecture by Dr. Morshuis

Fig. 4. Tutorial: Assembling their sensors helped by student staffs

Fig. 5. Tutorial: Inspecting the signals from their self-built sensor with Emeritous Professor Hozumi

Fig. 6. Workshop: Lecture by Dr. Ihori

Fig. 7. Oral session at international conference hall

(c) Space charge, surface and interfacial phenomena
(d) Electrical properties of dielectrics and measurement and testing techniques
(e) Partial discharge

First, with respect to space charge measurements, there were reports on space charge measurements and calibration for XLPE cables, simulations of space charge accumulation in insulations, and space charge behavior under the application of transient high voltages with respect to devices such as inverter modules. This is an indication of significant progress in the application of space charge measurement and simulation technologies to practical devices.

Second, the reports highlighted the partial discharge measurement technology as an electrical insulation diagnosis technique for power distribution equipment, and the characteristics and mechanisms of partial discharge for the back data in the insulation diagnosis. The main subjects of these studies were XLPE cables and molded transformers. There have also been reports on partial discharge characteristics in windings of inverter-driven motors (rotating machines). These have applications in electric vehicles. There has been an increase in related reports in this area due to recent advances in computational techniques. For example, at ISEIM 2023, there was a study on the effects of silica nanocomposites in polyethylene with the help of computational chemistry.

32 posters were presented by students in the MVP session and 13 posters were presented by general attendees in the poster session using digital signage (Fig. 8). The MVP session is designed to improve presenters' presentation and discussion skills. It also provides an opportunity to interact with other presenters. Presenters are required to present their posters to the other presenters in their session. MVP session presenters must be evaluators of other presentations in their session. 6 students were selected as winners of the Young Poster Presentation Award.

The Korea-Japan Young Researcher Exchange Program Award has been in place since ISEIM 2014 for the promotion of friendship between the Japanese and Korean societies in the technical field of electrical insulation materials. In 2023, Ms. Seol Lee from Hanyang University, Korea, was selected as the recipient in Korea (Fig. 10).

Fig. 8. Poster & MVP session with digital signages

Fig. 9. Award winners of young poster presentation award

Fig. 10. Ceremony for Japan-Korea young researcher exchange program in Korea

Fig. 11. Demo session at multipurpose hall

D. SS (Industry) & Demo sessions

12 companies participated in the SS (Industry) session. The demonstration session was a follow-up to the previous trial that was conducted at the international conference CMD 2022 held last year

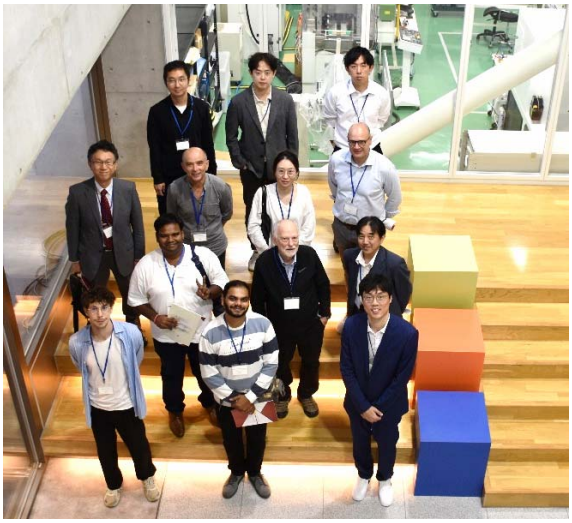

Fig. 12. Technical tour in NEXTA, Shimane University

Fig. 13. Banquet at Matsue Vogel Park

with the cooperation of 8 companies (Fig. 11). In this session, the participants were able to witness the generation of real partial discharges, and they could observe how these discharges are measured. This provided practical experience of the diagnostic process.

E. Technical Tour & Banquet

Two routes of technical tour were organized,

(a) Matsue biomass power plant
(b) NEXTA, Shimane university and Matsue innovation hub, National institute of technology, Matsue college.

Both technical tours were very interesting and inspiring. For example, at the National Institute of Technology, Matsue College, the active and excellent explanations by the students and the exchanges were highly appreciated by the participants. The banquet was held at the Matsue Bird Park (Fig. 13). At the beginning of the banquet, there was a performance of Iwami Kagura, the traditional performing art of Japan. The theme “Orochi,” a great serpent, fascinated participants with the powerful performance using fire.

F. Excursion Tour

Two routes of the excursion tour were organized.

Fig. 14. Explanation of a story regarding Izumo grand shrine by local guide

Fig. 15. Photos taken at Adachi museum of art

(a) Izumo Ooyashiro /Izumo Taisha (Izumo Grand Shrine)
(b) Adach Museum of Art

The Izumo Grand Shrine is one of the oldest and most important shrines in Japan. Participants listened with great interest to the detailed and interactive explanations provided by a local guide (Fig. 14). The Adach Art Museum houses a collection of approximately 2,000 works of art, with a focus on modern Japanese paintings. This museum is also famous for having one of the best Japanese gardens in the world (Fig. 15).

ISEIM 2023 was hosted by the IEEJ Technical Committee on Dielectrics and Electrical Insulation. In addition, ISEIM 2023 was technically co-sponsored by the IEEE Dielectrics and Electrical Insulation Society (DEIS). As the secretariat of the ISEIM 2023 organizing committee, we express our sincere appreciation to all the committee members for their great efforts in the realization of this conference. It is our expectation that all the participants and their accompanying families will be back in Japan for the next ISEIM.

Shosuke Morita
CRIEPI, Japan
Secretary of ISEIM 2023

Toshihiro Takahashi
CRIEPI, Japan
General Chair of ISEIM 2023

The 4th International Conference on High Voltage Engineering and Power Systems 2023 (ICHVEPS 2023)

The 4th International Conference on High Voltage Engineering and Power Systems 2023 (ICHVEPS 2023) was held on August 7th-9th, 2023 in Prama Sanur Beach Bali Hotel, Denpasar, Indonesia. The ICHVEPS is a biannual conference organized by the School of Electrical Engineering and Informatics (SEEI), Institut Teknologi Bandung (ITB), Indonesia and sponsored by IEEE Indonesia Section, IEEE Power and Energy Society Indonesia Chapter, IEEE Indonesia Student Branch and Indonesian Electric Power Company PT. PLN (Persero). Previously the 1st and 2nd ICHVEPS were held in Inna Grand Bali Beach Hotel Sanur, Bali in October 2017 and 2019, respect- tively. Then, due to the pandemic, the 3rd ICHVEPS was held as an online conference in October 2021.

The conference is designed to be an international forum for the exchange of ideas, discussion, and dissemination of research results as well as recent technologies in the field of High Voltage Engineering and Power Systems among power utilities, universities, research institutes as well as industries. There are 160 papers from 10 countries (Indonesia, Germany, Japan, India, Malaysia, France, Thailand, United States, Tunisia, Netherlands and Peru were presented.

The papers deal with the following aspects of high-voltage engineering and power systems:

(1) High voltage generation, measurement, and instrumentation
(2) High voltage insulation system
(3) Condition monitoring and diagnosis for power equipment and power systems
(4) Dielectric materials and their aging mechanisms
(5) New and environmental-friendly materials for high voltage application
(6) Application of high voltage in industry
(7) Degradation assessment for power equipment
(8) Lightning and transient phenomena
(9) Outdoor insulation: insulator, environmental effects
(10) HV insulation for UHV AC and HVDC system
(11) High voltage apparatus: Reliability and maintenance
(12) Grounding system and Power Quality
(13) Electromagnetic compatibility
(14) Smart grid and microgrid technology
(15) High voltage engineering education
(16) Power system planning, operation, and control
(17) FACTS and Power system stability
(18) Renewable energy, electric vehicles, and storage
(19) Asset management
(20) Energy transition
(21) Charging station

The papers were presented in 3 plenary sessions, 20 parallel sessions, and 1 poster session. On the evening of August 8th, a gala dinner was organized at the backyard of Prama Sanur Beach Hotel, the Bima Stage. Indonesian foods were served along with live Bali dances. During the gala dinner, 10 participants were selected to be The Best Paper Prize recipients. There are 6 presenters from Indonesia, 3 presenters from Germany, and 1 presenter from Malaysia.

Table 1. Number of participants from each country

Country	Number of participants
Australia	1
Austria	1
China	1
France	1
Germany	7
India	6
Indonesia	176
Japan	7
Malaysia	3
New Zealand	1
South Korea	1
Thailand	1
United States	2
Total	**208**

On the first day of August 7th, a full-day workshop with topics on High Voltage Engineering, Power Systems, and Renewable Energy to Support Energy Transition was held with 30 participants from various countries. Both the workshop event and the confe- rence were very successful. The 5th ICHVEPS will be held in 2025.

The following are the invited plenary speakers for the Workshop and the Conference of ICHVEPS 2023:

(1) Dr. Ir. Syarif Hidayat, Institut Teknologi Bandung, Indonesia
(2) Prof. Zenichiro Kawasaki, Osaka University, Japan
(3) Prof. Ahmed Abu Siada, Curtin University, Australia
(4) Prof. Masahiro Kozako, Kyushu Institute of Technology, Japan
(5) Prof. Guan-Jun Zhang, Xian Jiaotong University, China
(6) Dr. Laurent Canale, LAPLACE Universitè de Toulouse, France
(7) Dr. Nanang Hariyanto, Institut Teknologi Bandung, Indonesia

Gong for formal opening by the Dean of SEEI ITB, Dr. Tutun Juhana and General Chairman, Prof. Suwarno.

Prof. Abu-Siada delivering a lecture during the Workshop

After plenary session on August 7th, in Wantilan Ball Room Prama Sanur Bali Beach Hotel

GALA DINNER at Bima Stage, Prama Sanur Beach

Best Paper Prize Recipients at the Gala Dinner

Prof. Suwarno , Dr. Herry Nugraha (PT. PLN), Dr. Ir. Tutun Juhana (Dean SEEI), Prof. Guan-Jun Zhang (China), Dr. Canale (France), Prof. Siada (Australia), and Prof. Kozako with Bali dance dancers at Gala dinner

Prof. Dr. Suwarno
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International Conference to be held in Asia

CMD 2024 (10th International Conference on Condition Monitoring and Diagnosis)

Dates: Oct. 20-25, 2025
Venue: Gangneung, Gangwon-do, Korea
Honorary Chair: Dr. Yong Joo Kim, O&M KOREA and Prof. Ja Yoon Koo, Hanyang University
General Chair: Prof. June-Ho Lee, Hoseo University
Organized by: The Korean Institute of Electrical Engineers
URL: https://www.cmd2024.org/

The CMD 2024 will be an ideal platform where we can freely share and discuss the current status and future directions of scientific and technological achievements in condition monitoring and diagnosis. We will cover wide-ranging subjects of our field: first and foremost, electric power apparatus monitoring, fault diagnosis, and asset management. We will also explore the fast-emerging area of monitoring and diagnosis and the vast potential they may come to offer.

We anticipate your kind participation and contributions to continuously strengthening the long and proud tradition of the international, scientific, and multidisciplinary community of CMD.

We are looking forward to seeing you in October 2024!

Conference Topics:

- Condition monitoring and diagnosis for power equipment and power systems
- Condition monitoring and diagnosis for industry, innovation, and infrastructure
- Condition monitoring and diagnosis for DC power equipment and systems
- Condition monitoring and diagnosis for eco-friendly power equipment
- Condition monitoring and degradation assessment for ESS systems
- Dielectric materials and their aging mechanisms
- Degradation assessment for power equipment
- Failure phenomena for power equipment based on electrical, mechanical, chemical, and thermal causes
- Failure analysis for packaging materials for power semiconductors
- Multiphysics and multiscale modeling, computational Analysis
- Applications of AI technologies for data mining and condition assessment
- Carbon neutralization on diagnosis and monitoring on power equipment operation

Secretariat:
Dr. Yong-June Shin
Yonsei University
E-mail: secretary@cmd2024.org

ISH 2025 (24th International Symposium on High Voltage Engineering)

Dates: Aug. 24-29, 2025
Venue: Karuizawa, Japan
Chair: Prof. Akiko KUMADA, The University of Tokyo
Organized by: The University of Tokyo
Sponsored by (Scheduled): IEEE, CIGRE, IEEJ
URL: under construction

ISH is the world's largest international conference on high voltage engineering. The first ISH was held in Munich in 1972, and since then the conference has been held every odd-numbered year. The 23rd conference was held in Glasgow in 2023.

ISH2025 will be held in Japan for the second time, following the ISH1995 in Yokohama. Achieving carbon neutrality in energy system, the development of innovative hardware solutions that enable the efficient use of renewable energy is promoted. ISH2025 will provide a forum for lively discussions on the frontiers of such research.

Conference Topics:

- Electromagnetic fields
- Transient voltages
- Testing techniques
- Advanced materials and insulation systems
- Monitoring, diagnostics and managing assets
- Systems by smart technologies
- HVDC technologies and applications
- Industrial applications of high voltage
- Live-line working
- Space charges
- Other related issues

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China Corner

Research and Application Progress of Eco-friendly Polypropylene Cable in China

Prof. Shengtao Li
Xi'an Jiaotong University,
Xi'an, China

1. Introduction

In order to improve the landscape and save land resources, underground power cables have been widely used in urban power grid construction. Metal sheath is an essential structure in high-voltage cables, which has functions such as radial water resistance, short-circuit current carrying, and mechanical protection. At present, the commonly used types of metal sheaths include corrugated, smooth, and metal foil plastic composite. For cross-linked polyethylene (XLPE) insulated high voltage cables, the material of metal sheath is generally aluminum, copper, or other metals, which are only used in some special occasions. For example, corrugated aluminum or stainless steel sleeves can be selected as sheath for high voltage cables subjected to vibration or corrosion. Smooth aluminum sheath and aluminum plastic composite sheath are widely used in European and American countries; In China, almost all high-voltage XLPE cables use corrugated aluminum sheath structures, mainly utilizing their excellent bending performance to reduce the risk of mechanical damage to the cables. In recent years, corrugated aluminum sheathed XLPE cables have frequently experienced buffer layer erosion failures, posing a serious threat to line reliability and power grid safety. This type of failure has also occurred in countries such as Singapore and Japan. Although there is no conclusive research on the erosion of buffer layer, poor electrical contact between the metal sheath and insulation shield is undoubtedly one of the important reasons for the failure.

2. Comparison between corrugated and smooth aluminum sheath

Smooth aluminum sheathed cables are in a tight contact state without gaps between the aluminum sheath and buffer layer, avoiding the problem of poor electrical contact, improving the radial heat dissipation of the cable, and increasing interlayer friction. They are particularly suitable for the application of ultra-high voltage large cross-section cables in high drop environments. Compared to corrugated aluminum sheathed cables, smooth aluminum sheathed cables have a smaller outer diameter, lighter weight, and longer reel length, which can reduce the number of joints in the line and reduce the structural size of the cable corridor, with significant economic benefits. With the development of the industry and technological progress, the laying environment and construction conditions of domestic cable lines continue to improve, creating conditions for the engineering application of smooth aluminum sheathed cables and stimulating the demand for product research and development. If not designed properly, the smooth aluminum sheath may burst during full load operation of XLPE cables, wrinkle, crack, and compress the XLPE insulation inward during bending.

Table 1. Comparison of parameters between smooth aluminum sheath and corrugated aluminum sheath for 500 kV cables

Item		smooth aluminum sheath	corrugated aluminum sheath
Operating parameter		Long-term maximum temperature of conductor: 90℃; Maximum allowable temperature of conductor during short-circuit: 250℃ (The maximum time does not exceed 5 s.)	
Outside diameter/mm		152.5 ± 3.0	175.5 ± 2.0
Operating bending radius		≥20 (D+d)	≥20 (D+d)
Compressive strength/kN·m^{-1}		3000	3000
Carrying capacity/A	Parallel laying in air	2090	1902
	Trefoil laying in air	1933	1757

3. Research progress of corrugated and smooth aluminum sheath

Corrugated aluminum sheath is prone to erosion. In recent years, our research group has conducts efforts to investigate failures related to ablation in the buffer layer. As shown in Fig. 1, and close contact between the high-voltage electrode and the buffer zone, or the application of current, will accelerate the generation rate of white matter. The image of breakdown of air gap in the experiment are shown in Fig. 1(a). It can be seen from Fig. 1(b) that the buffer layer sample is severely destroyed after the experiment, where the fault site is burnt and partly disappeared. The pictures of a real cable ablation failure are presented in Fig. 1(c) and (d). Moreover, carbonization traces are also observed on the surface of the corrugated aluminum sheath, as depicted in the blue circles of Fig. 1(d). Composition analysis

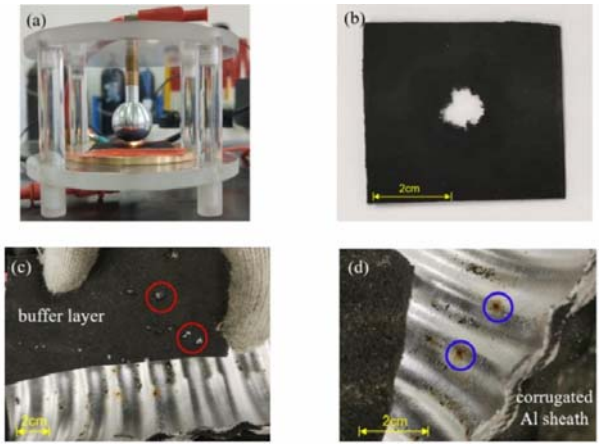

Fig. 1. (a) The air gap breakdown phenomenon. (b) The destroyed buffer layer in experiment. (c) and (d) Pictures of a real cable ablation failure.

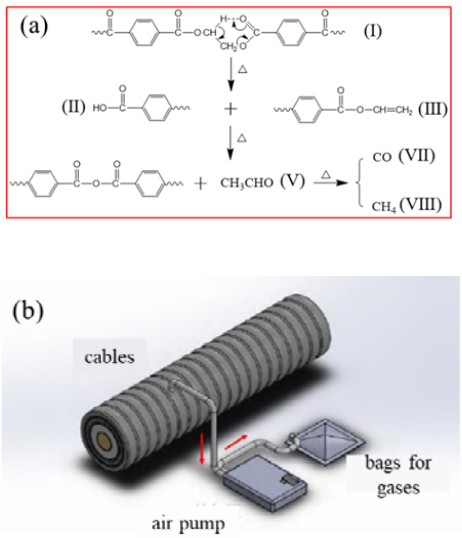

Fig. 2. Buffer layer ablation detection technology based on characteristic gas analysis (a) mechanism of gases released by heating buffer layer (b) collection of ablative gases inside cables.

shows that the white substance contains the products of chemical reactions between aluminum sheath and water blocking powder in humid environments, as well as the water blocking precipitates in the buffer zone. Besides, with regard to the detection technology for buffer layer ablation faults related to corrugated aluminum sheath, our research team has introduced a novel detection methodology grounded in gas component analysis Upon the heating and ablation of the buffer layer material, gases such as methane, ethane, ethylene, acetylene, among others, are released. In cooperation with the Beijing Electric Power Company, we conducted an empirical study involving the collection and analysis of gas components from an operational cable. Our investigation confirmed the presence of these gases and revealed evident ablation traces upon disassembly. Consequently, we propose that the method of gas analysis could serve as a potential means for detecting

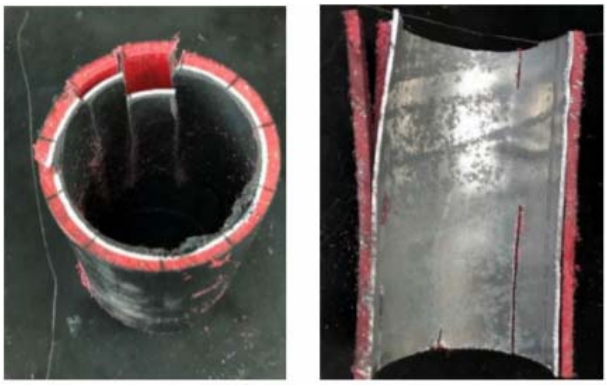

Fig. 3. Interface delamination of smooth aluminum sheath with outer layer after aging.

ablation faults.

Despite the many advantages, bending performance is one of the few weaknesses of smooth aluminum bonded sheath. The bending resistance depends on the total thickness of the bonded sheath, among which the thickness of aluminum can be designed by the short circuit capacity requirement, with the rest complemented by the outer jacket. The elastic modulus of the outer jacket of smooth aluminum sheath should be no less than 800 MPa, and the recommended thickness are as follows: 4-5 mm for 110 kV cables, 5-6 mm for 220 kV cables, and no less than 6 mm for 500 kV cables. For the cable with a higher rated voltage or a larger conductor cross section, the bending performance needs to be strengthened. The requirements of the hot melt adhesive include the peel strength no less than 0.5 N/mm as specified in IEC standards, the shear strength no less than 2.0 MPa, and the softening temperature no less than 80°C.

In addition to the performance of corrugated and smooth aluminum sheath investigated by our team, there are several other studies for aluminum sheath in China. For example, the buffer layer repair methods of buffer layer in corrugated aluminum sheath, analysis of coupled thermal-electrical of 110 kV corrugated aluminum sheathed and smooth aluminum sheathed cables based on finite element simulation method, white spot phenomenon and hydrogen evolution corrosion mechanism of water barrier buffer layer in high voltage cables, improved calculation method for the loss coefficient of corrugated sheath of high-voltage cables, the influence of aluminum sheath structure on the suspension potential of XLPE cable insulation shield layer and so on. Besides, the strain detection system for high-voltage cables with smooth aluminum sheath has also been proposed. All these researches promoted the development of aluminum sheaths for high-voltage cables in China.

4. Application progress of corrugated and smooth aluminum sheath in China

Currently, the corrugated aluminum sheath has been widely used in China, as shown in Fig. 4 where

constructing site of Hebei Fengning Project was depicted. On the contrary, the application of smooth aluminum sheath should be noticed carefully due to the development of this new product. Domestically produced 110 kV smooth aluminum sheaths have been mature and applied in multiple projects in China, for example, 100 MW Wind Power Project in Tuoli Township, Urumqi County. Domestically produced smooth aluminum sheaths operated under 330 kV have been cited through engineering demonstrations, for example, 330 kV Beixuan I Line Cable Project. Additionally, domestically produced 500 kV smooth aluminum sheaths are in the development, promotion and application stage.

The smooth aluminum sheath for high voltage cables also attracted the attention of the industry to develop the product of smooth aluminum sheath used for 500 kV XLPE cables. Generally, the product uses hot melt adhesive instead of asphalt for anti-corrosion, ensuring bending performance, while promoting low smoke, non-toxic, flame retardant, and fire resistance levels. The metal sheath of this product adopts smooth aluminum tubes, which structurally eliminates the air gap between the buffer layer and the metal sleeve, reduces the thermal resistance of the buffer layer, making it easier for heat of conductor to be transmitted to the outside, thereby improving the current carrying capacity of the product. Compared to the corrugated aluminum structure product, the current carrying capacity is increased by about 5-20%.

5. Summary

Corrugated aluminum sheath is prone to erosion where failures related to ablation in the buffer layer can be found. Compared to corrugated aluminums sheathed cables, smooth aluminum sheathed cables have a smaller outer diameter, lighter weight, and longer reel length with significant economic benefits. Despite the many advantages, bending performance is one of the few weaknesses of smooth aluminum bonded sheath. In the future, higher voltage level, thinner aluminum strip thickness (up to 1.3mm), extruded hot melt adhesive, and halogen-free flame retardant outer sheath should be paid more attention when considering the smooth aluminum sheath for high voltage cables.

Acknowledgements

Thanks to Prof. Jianying Li, Prof. Ying Liu from Xi'an Jiaotong University and Dr. Defeng Zang from TEBA Shandong Luneng Taishan Cable Co., Ltd. for their providing the relevant information.

Fig. 4. Constructing site of Hebei Fengning Project where corrugated aluminum sheath was used.

Fig. 5. Smooth aluminum sheath for 500 kV XLPE cables produced by TEBA Shandong Luneng Taishan Cable Co., Ltd.

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Korea Corner

Research Activities of the Next Generation Transmission and Substation Research Center at KEPCO Research Institute in Korea

Prof. June-Ho Lee
Hoseo University, Korea

1. Introduction

The Next Generation Transmission and Substation Research Center has been developing the advanced technologies necessary to achieve the KEPCO's mission of 'uninterrupted supply of cheap, high-quality power' for the past several decades. By focusing on the introduction and application of technology and localization research and development, we not only solve various problems occurring in the electric power industry, but also make step-by-step technological innovations.

However, in today's era when the paradigm of the electric power industry is changing, it is necessary to carry out the mission of a traditional electric power company along with innovative solutions for sustainable growth for the next 100 years.

From the perspective of a technology leader (first-mover) rather than a technology catcher (catching-up), we have established a new strategy to challenge the high degree of uncertainty and established a leader in electric power technology through organizational operation and establishment of innovation methods that are different from those of the past. In order to achieve a complete transformation, we are devoting ourselves to technological innovation with the goals of 'advancing power grid operation', 'leading high-efficiency eco-friendly transmission technology', and 'development of eco-friendly substation equipment and smartening substation facility operation'.

2. Advancing Power Grid Operation

In order to operate the power grid stably and supply electricity to customers without power outages, it is essential to always closely monitor and accurately diagnose the status of the power grid. In addition, unlike in the past, the installation of various special control facilities (HVDC, FACTS) based on high-capacity power electronics is increasing in recent power grids, and there is always a risk that failure or malfunction of these facilities may cause a wide area power outage.

In order to monitor and analyze the status of the power grid more precisely and accurately, the Next Generation Transmission and Substation Research Institute monitors various conditions of the power grid based on data hundreds of times more precise than

Fig. 1. Large scale real-time power grid simulator

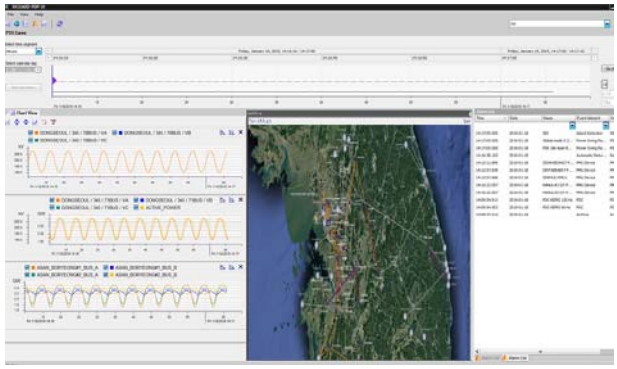

Fig. 2. WAMS

existing EMS/SCADA and uses artificial intelligence to determine abnormal signs. A wide area surveillance system (wide area monitoring system: WAMS1) was developed. In addition, research was conducted to improve the reliability of the power grid by using a real-time simulator (A-KEPS2) that can simulate Korea's entire power grid in real time to verify the performance of special control facilities under the same environment as the field.

2. Advancing Power Grid Operation

The future power network will gradually see an increase in the application of direct current transmission lines for the connection of new and renewable energy and power connection between countries, and also diversified construction and operation consisting of overhead and underground lines to increase social acceptance and eco-friendly transmission. We are demanding the environment.

In order to secure the reliability of this future transmission network, we developed operation technology for ultra-high voltage DC submarine cables

and hybrid transmission lines that are composed of a combination of DC and AC. By developing the world's highest level of precise HVDC submarine cable fault detection technology and reducing the error from the existing 3% range to less than 1%, we have achieved the desired results by continuously promoting overseas technology commercialization targeting developed countries such as North America and Europe. We have laid the foundation for commercialization of various self-secured technologies. In order to continuously develop new concept transmission facilities that further increase the efficiency and reliability of the increasingly complex transmission network and minimize factors causing environmental problems, we are building the world's best overhead and underground transmission line verification and certification infrastructure and promoting international standardization. . In addition, we aim to lead the technology development of the world's best future transmission system through convergence and development with innovative technologies of the 4th industrial revolution, such as AI-based autonomous transmission facility monitoring and diagnosis technology.

Conductor return (neutral line) ± 500 kV double bi-pole HVDC transmission is a method that has not been applied worldwide, and for successful comercialization in Korea, which has no experience in operating ultra-high voltage overhead direct current lines, tower design, insulation design, and Environmental design and new equipment development were performed. Through this, we established our own design standards for the direct current transmission method suitable for domestic conditions, built a full-scale demonstration line in Gochang, and conducted various empirical studies to verify the design standards.

We conducted verification tests on air insulation distances for abnormal over voltages that may occur internally and externally, measurement and analysis of electrical environmental disturbances through various sensors, and reliability verification through long-term verification of new equipment. We are continuously evaluating the development of operation technology and eco-friendliness of DC overhead lines to prevent civil complaints.

4. Development of Eco-friendly Substation Equipment and Smartening Substation Facility Operation

With the Kyoto Protocol coming into effect on February 16, 2005, regulations on the use of sulfur hexafluoride (SF_6) gas, which has a global warming potential 23,900 times higher than that of carbon dioxide (CO_2), were strengthened. Accordingly, developed countries are already actively participating in reducing greenhouse gases, which are essential in the energy production process, under the banner of eco-friendliness and green growth. As Korea also assumes international obligations to reduce greenhouse gases under the Paris Agreement on Climate Change,

Fig. 3. An example of HVDC cable real-time fault location detecting system

Fig. 4. Gochang Power Test Center for □500 kV HVDC

research is being conducted to develop related technologies across industries.

In the power equipment field, Eco-GIS uses fluorine-based mixed gas and air as an insulating medium that can reduce global warming potential (GWP) by more than 98% compared to SF_6 gas in order to change the paradigm from existing SF_6 gas-based insulation technology to eco-friendly insulation technology is developing. In addition, we have completed Phase I development of a low-loss transformer that can reduce the loss of existing transformers by about 20% from 461 kW to 364 kW, and in Phase II, we have developed a high-efficiency transformer that reduces energy loss by more than 42% to 264 kW, reducing the loss costs associated with power transmission. We plan to drastically reduce it.

Power facilities currently in operation are expected to reflect the latest earthquake-resistant design standards and secure earthquake-resistant performance up to magnitude 6.6 for substation buildings and up to magnitude 7.0 for transmission and distribution facilities such as steel towers. Earthquake-resistant performance has already been secured for 40,000 steel towers and transformers installed across the country, as well as 9 million electric poles, and distribution stations will undergo a seismic performance evaluation and earthquake-resistant reinforcement of inadequate facilities will be completed quickly. We plan to sequentially reinforce 65 island power plants across the country over

the next 20 years by conducting a seismic performance evaluation to ensure that power generation facilities in island areas can withstand magnitude 6.3. In addition, practical guidelines for earthquake-resistant design of transmission and distribution facilities will be published this year to meet strengthened national earthquake-resistant design standards. It is planned to be revised until.

In addition, seismic instruments have been installed in a total of 56 substations across the country, including 5,765 kV substations, 47,345 kV substations, and 4,154 kV substations, and an earthquake observation network has been established to operate an earthquake monitoring center within the Korea Electric Power Research Institute. In order to protect power facilities from earthquakes that occur on the Korean Peninsula and surrounding areas, the Earthquake Monitoring Center monitors earthquakes affecting power facilities scattered across the country based on the magnitude and seismic acceleration information observed at 56 KEPCO substations and 155 Korea Meteorological Administration observatories. By analyzing the impact in real time and providing it to operators of power facilities such as substations to enable them to respond quickly, we are securing the stability of the power system like the blood vessels of the human body. Since 2009, the Korea Meteorological Administration, Korea Institute of Nuclear Safety, Korea Institute of Geoscience and Mineral Resources have been Observation information is shared through the participating "Earthquake, Tsunami, and Volcanic Activity Observation Organization Council," and an earthquake annual report containing earthquake observation records is published every year.

Meanwhile, the Next Generation Transmission and Substation Research Institute operates a seismic test building equipped with the highest level shaking table in the country, and conducts seismic qualification tests to check whether power equipment developed and requested by industry operates properly in the event of an actual earthquake. It is being carried out. In addition, the results of various seismic performance evaluation experiments are being used in research and development such as transmission and distribution seismic design practical guidelines, establishment of detailed standards for seismic performance evaluation of buildings, and development of seismic reinforcement systems, and the test facilities will be utilized by industry, academia and research institutes for seismic-related research and product development. We are contributing to increasing product and technological competitiveness by opening up the technology so that it can be used.

5. Future Plans

In the future, we will continue to make efforts for commercialization by promoting technological innovation based on the technologies possessed by the Next Generation Transmission and Substation Research Institute. In the face of the crisis of a new paradigm in the electric power business such as the expansion of new and renewable energy sources and changes in the technological environment, we will expand transmission and substation technology into other fields. We will pursue opportunities to take a new leap forward by expanding application. The electric power industry has begun greater expansion into business areas such as electric vehicles, GTB (Grid To Battery), and micro grid through convergence technologies such as big data, robots, IoT, and cybersecurity. Accordingly, we will discover and prepare for future businesses before anyone else (First), carry out research and development suitable for leading future technology (FIT) with quick processing (Instant) and appropriate timing, and be members of the research institute with an honest heart. We will continue to work hand in hand with others to build a "world-class research institute."

Reference

[1] Han, Ki-sun, Oh, Seungryle and Kim, Min-ju, Introduction to the Next Generation Transmission and Substation Research Center at KEPCO, pp. 31~35, KIEE Magazine Vol 71, No 1, Jan. 2022 (in Korean)

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Indonesia Corner

Corrosion of Ceramic Outdoor Insulators in Java Island

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Institut Teknologi Bandung, Indonesia

1. Introduction

Indonesia is a tropical country located around the equator between 6° northern latitudes and 11° southern latitudes and 95° east longitude and 141° east longitude. This country is an archipelago with the largest number of islands and the longest coastline in the world.

To electrify of about 279 million populations, the country has developed electric power network with the extra high transmission voltages of 500 kV and 275 kV. The lower transmission voltage is 150 kV and small portion with 70 kV and 20 kV and low voltage of 220 V are being used at distribution networks. The electrification infrastructures are owned by State Electricity Company (PT PLN). Currently, the electrification of Indonesia is 99.63 % with more than 86.6 million customers.

At the end of December 2022, the total installed capacity will be 69 GW with the majority being conventional generation and 13.14% from renewable energy.

At the end of 2022, the total length of the transmission network will reach 68,205.81 km, consisting of a 500 kV network covering 6,970.92 km, a 275 kV network covering 3,828.11 km, a 150 kV network covering 51,395.60 km, a 70 kV network covering 5,910 km. .21 km and 25 & 30 kV networks of 100.95 km.

The total length of the distribution network is 1,033,662.09 km, consisting of JTM of 430,509.15 km and JTR of 603,152.94 km.

The installed capacity of substation transformers was 161,367 MVA, an increase of 3.46% from the previous year. The number of substation transformers is 2,326 units, consisting of 84 units of 500 kV system transformers, 42 units of 275 kV systems, 1,931 units of 150 kV systems, 267 units of 70 kV systems, and 2 units of < 30 kV systems.

2. Outdoor insulator corrosion in Indonesia

Indonesia has around 17,500 islands, with a coastline of 81,000 km. Around 62% of Indonesia's territory is sea and water, the land area is 1.91 million km^2 while the water area is 6.32 million km^2.

Currently, insulators for transmission and distribution systems in Indonesia are dominated by ceramics and a few are made from glass. Only a very small portion of polymer insulators have recently been introduced in transmission and distribution systems. Failure of ceramic outer insulators is dominated by flashover and corrosion. These two failures commonly take place in areas with high levels of pollution, especially along the coast where the salt content of sea water is quite high. One of the areas with high insulator corrosion problems is the southern part of Java Island.

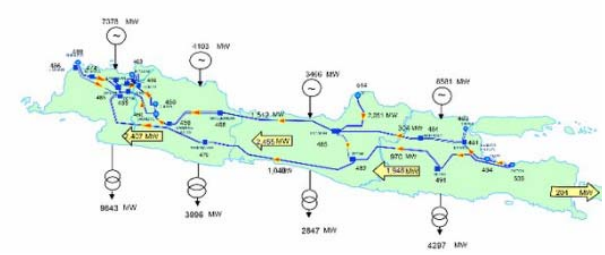

Fig. 1. Backbone of electricity network in Java Island.

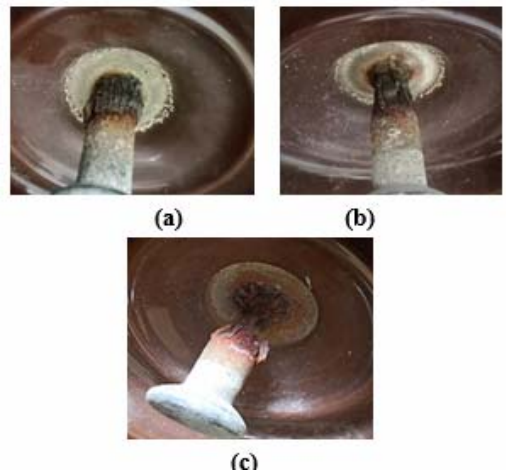

Fig. 2. Corroded porcelain insulators taken from transmission line due to corrosion. (a) early stage (b) medium (c) extreme.

The metal parts of the insulator that are susceptible to corrosion are the cap and pin. Corrosion on the insulator pins reduces their size and made them thinner. As the results the mechanical strength of the pins decreased significantly. With increasing operating hours, the number of insulators subject to corrosion will increase, which threatens the safety and stability of the power system.

The corrosion phenomenon on the insulator cap and pin is caused by electrolytic, galvanic corrosion and crevice corrosions. The corrosions can be very severe in the presence of liquids with high conductivity, such as

Fig. 3. Corroded glass insulator taken from transmission line due to corrosion.

Fig. 4. Corroded supporting metals in a substation.

sea water or salt spray resulting in high leakage current and in certain condition in certain conditions it is accompanied by corona or partial discharging with high intensity.

Several images of corroded porcelain insulators taken from transmission lines on the southern island of Java are shown in Fig. 2. While for glass insulator is shown in Fig. 3.

In reality, it is not only insulators that experience corrosion. Some supporting metals in the substation also experienced corrosion, although not as badly as the insulators as shown in Fig. 4.

3. Main factors affecting high corrosion of outdoor insulators at southern Java

A. Contamination from sea water

Sea water has a high salt content. Sea water vapor that is brought to land and hits the outer insulator that has been exposed to other pollution such as lime will increase the ESDD (equivalent Salt Deposit Density). An increase in ESDD will increase the surface conductivity of the insulator and when operating will cause large leakage currents. Through a complex process, the insulator will experience high pollution, especially at the bottom near the pins and can encourage the emergence of corona or partial discharge which accelerates the corrosion process.

To determine the sea water content, salinity and conductivity of the Indonesian ocean in the south of Java, measurements were carried out in the laboratory. The typical results are shown in Table 1.

Table 1. Typical Indonesian Ocean Seawater salt content, salinity and conductivity.

No	Parameter	Unit	Result
1	Sodium (Na)	mg/L	8,671
2	Chloride (Cl^-)	mg/L	14,113
3	Chlorine	mg/L	< 0.1
4	Salinity	‰	21.4
5	Conductivity	µS/cm	45,398

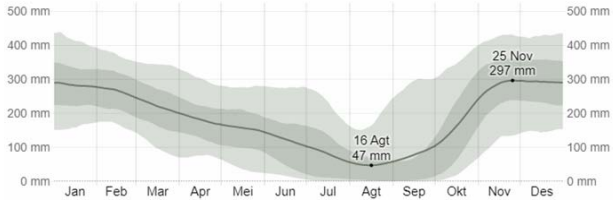

Fig. 5. Typical annual rainfall at southern Java Island.

Table 2. Typical chemical content Fly ash from thermal power station at southern Java (percent by weight).

No	Parameter	Result
1	SiO_2	46,23%
2	Al_2O_3	21,82%
3	Fe_2O_3	8,79%
4	CaO	12,01%
5	K_2O	2,77%
6	MgO	3,58%
7	Na_2O	0,34%
8	TiO_2	0,83%
9	LOI	2,32%

B. Rainfall

Rainfall and humidity greatly influence the strength of the impact of pollutants on the corrosion process. Rainfall in the southern area of Java Island is quite high. Fig. 5 shows typical annual rainfall in the southern area of Java Island where the incidence of insulator corrosion is very high.

C. Contamination due to fly ash from coal fired generating station

Apart from the environmental conditions, the pollution at southern Java is also due to the waste generated from the Pollution is also increased by dust from coal burning at thermal power plants. The results of measuring the exhaust dust content from this generating center are shown in the Table 2. From the fly ash content as shown in Table 2, it can be seen that there are ingredients that accelerate the pollution process such as CaO and Al_2O_3, accelerate corrosion such as Fe_2O_3

Table 3. Typical chemical contents of corroded metal.

Test #	NaK	SK	MnK	FeK	ZnK
1	20,34	0,29	0,78	72,78	5,82
2	47,77	0,31	0,79	45,03	6,10
3	11,61	0,19	1,18	84,63	2,40
4	9,61	0,12	2,34	86,85	1,07
5	33,17	0,20	0,83	48,46	17,34
Avg	24,5	0,22	1,184	67,55	6,54

and increase ESDD such as sodium and potassium.

4. Chemical content of corrosion

To determine the chemical content of the corroded metal pins of the insulator, a chemical test was carried out using EDAX (Energy Dispersive X-Ray). The test results for the chemical content of corrosion in percent of element weight are shown in table 3.

5. Summary

The phenomenon of corrosion in insulators used in the southern part of Java is quite high. From the study, it was found that the high level of corrosion is influenced by the high salt content of sea water on the south coast, relatively high rainfall which causes high humidity and the operation of a coal-fired thermal power plant.

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Green Distribution Transformer in Indonesia: Overview and Research Roadmap

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1. Introduction

Green house gas (GHG) emission has become one of the most frequently discussed topics in the 20th century. In 2021, 120 world leaders participated in the UN Climate Change Conference (COP 26) to address global concern regarding climate change which is mainly caused by GHG emissions [1]. All participants reaffirmed the Paris Agreement goal of limiting the increase in the global average temperature to well below 20°C above pre-industrial level and pursuing effort to limit it to 1.50°C. To achieve it, all countries agreed to a provision calling for a phase-down of coal power and a phase-out of inefficient fossil fuel subsidies. Most people refer the "phase down of coal power" as energy transition to green energy (i.e., renewable energy use) only; however, the perspective of "green" is not only limited to the generation perspective only but also transmission and distribution apparatus with "green" technology. In this paper, the overview and opportunity of green insulating material technology in distribution transformer is presented.

2. Power Distribution Network in Indonesia

PT PLN (Persero) as state owned utility company in Indonesia has total 1,033,662 km circuit distribution network with 550,852 distribution transformers (65,439 MVA total capacities) to supply approximately 85.63 billion customers in Indonesia. From the dielectric materials perspective, there are two types of insulation in distribution transformer: solid insulation (i.e., bushing insulator, paper insulator, pressboard, etc.) and liquid insulation (i.e., insulation oil). All distribution transformer in Indonesia which organized/managed by PLN uses mineral oil as the liquid insulation. This type of insulation liquid produces approximately 4.18 tons GHG/1000 gallons during its complete lifecycle and is classified as non-biodegradable material [2]. On the other hand, another liquid insulating material with green properties is available: ester oil.

3. Ester Oil as Green Insulating Liquid

Ester oil can be divided into two categories: synthetic ester and natural ester. Synthetic ester is formed from synthesis of carboxylic acid and alcohol or known as esterification process. Synthetic ester in form of Polyester and complex ester is commonly used for transformers insulating material. On the other hand, Natural ester was extracted from plant and grain (i.e., soy, canola, rapeseed, etc.) as saturated fatty acid or unsaturated fatty acid. Natural ester in form of Fatty acid ester triglycerides is commonly used for transformers insulating material. Apart from the green and biodegradable property, Ester oil also has K fire safety class (flash point above 3000°C [3]) which provide better fire safety.

4. Key Driver of Ester Oil Usage in Other Utility Company

Benchmarking other utility companies which has experience in implementing Ester Oil is an alternative way to obtain the necessary insight. According to the literature review result, most of the transition to ester oil was made due to power utility's interest in a) the green property of Ester oil, b) fire safety improvement, and c) higher loading capability. The resume of the literature benchmarking is presented as follow:

(a) Senate Bill/SB 901 (2018) mandated any utility company in California to prepare wildfire mitigation plan (WMP) [4]. Distribution network provider in California (i.e., Sacramento Municipal Utility District/SMUD, Pacific Gas & Electric/ PG&G, and South Carolina Edison/SCE) has implemented Ester oil for higher fire safety capability [5, 6, 7].

(b) SP Energy Network (SPEN) has initiated the implementation of less flammable material in their transformer after the fire accident in Edinburgh (2014). The choice of the less flammable material is synthetic ester [8].

(c) Vattenfall Hydro Power has an annual assessment toward environmental impact from their power plant. In 2011, one of their assessment points is the usage of environmentally friendly oil (synthetic ester) and dry type transformer [9].

(d) Meralco (Philippine's power utility) has conducted a study in 2019-2020 regarding possibility of ester oil usage in their distribution transformer. The results showed that the use of natural ester gave i) higher loading capability, ii) longer lifetime, iii) NPV saving, and iv) GHG reduction. Those benefits also support Meralco initiative to fulfil United Nation Sustainability Development Group (UNSDG) [10, 11].

In PLN Perspective, those benefit of Ester oil also supports the "Green" initiative which was declared by PLN. Since all of PLN's distribution transformers use Mineral Oil, the transition to ester oil will improve the green implementation in distribution fleet. On the other hand, local transformer manufacturers have numerous experiences in manufacturing distribution transformers with ester oil for private/non-PLN customers. This experience is also beneficial to support the implementtation of ester in PLN's distribution transformation fleet. Despite of the potential benefit of Ester oil in distribution transformer, several considerations should be given to i) lack of PLN's operational experience of managing distribution transformers with Ester oil, ii) relatively high capital expenditure/CAPEX of transformer with Ester oil, and iii) there's no relatable PLN standard (SPLN) to accommodate this technology.

5. Ester Oil Property as Insulation Material

Several insights of physical, electrical, and chemical properties of Ester oil compared to mineral oil can be underlined as follow:

(a) Ester oil has similar Breakdown Voltage (BDV) with mineral oil. However, it's important to note that Ester oil has higher moisture saturation level which enables it to sustain the BDV value under high moisture content [12, 13].

(b) Ester oil has higher viscosity compared to mineral oil. This characteristic becomes important during the manufacturing process, where impregnation time of ester oil requires longer time and higher temperature compared to mineral oil. Higher viscosity also affects the circulation/movement of the ester oil inside the transformer [12].

(c) Ester oil has higher flash point and fire point compared to mineral oil; this characteristic gives ester oil an advantage in better fire safety (note that ester oil has lower net calorific value which indicates itself as less flammable material) [12, 14].

(d) Ester oil is a biodegradable material (approximately 94% of ester oil will be dissolved in the soil after 28 day) with smaller carbon footprint and GHG emission compared to mineral oil [2, 15].

(e) Natural ester tends to oxidate faster than synthetic ester and mineral oil. Thus, natural ester oil should be managed carefully to minimize free air exposure [2].

6. Distribution Transformer with Ester Oil: Technical and Economical Consideration

According to tensile strength and degree of polymerization test on the insulation paper impregnated

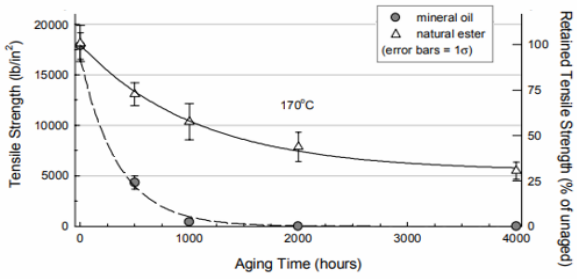

Fig. 1. Tensile strength comparison between insulation paper impregnated in ester oil and insulation paper impregnated in mineral oil.

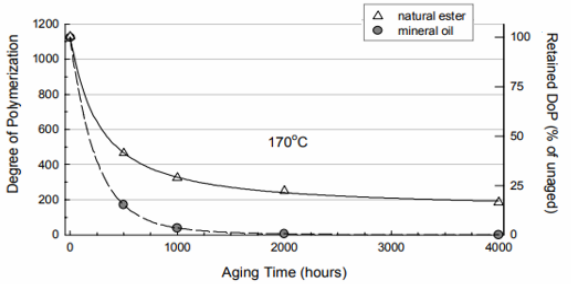

Fig. 2. Degree of Polymerization comparison between insulation paper impregnated in ester oil and insulation paper impregnated in mineral oil.

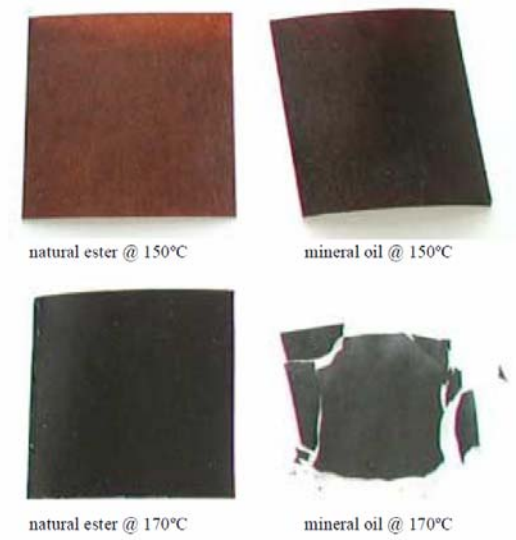

Fig. 3. Structural integrity of the impregnated insulation paper after aging test.

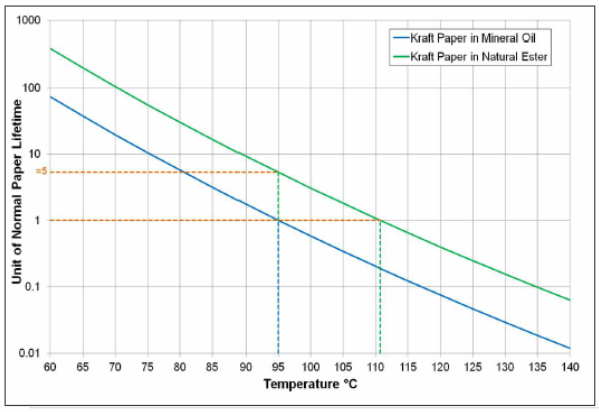

Fig. 2. Degree of Polymerization comparison between insulation paper impregnated in ester oil and insulation paper impregnated in mineral oil.

Table 2. Insulation System in Transformer (IEC 60076-14)

		Conventional insulation system	Hybrid insulation systems			High-temperature insulation system[b]
			Semi-hybrid winding	Mixed hybrid winding	Full hybrid winding	
Type of insulating component[a] Conventional (C) or high-temperature (H)	Liquid	C or H	C or H	C or H	C or H	H
	Conductor insulation	C	H	C and H combination	H	H
	Spacers/strips	C	C	C and H combination	H	H
	Barrier solid	C	C	C	C	H
Insulating component application temperature Conventional (C) or high-temperature (H)	Top liquid rise	C	C	C	C	H
	Average winding rise	C	H	C	H	H
	Hot-spot winding rise	C	H	H	H	H

a Only basic transformer parts are shown and the temperature of other parts will depend on the results of the thermal mapping.

b Since thermal gradients exist in all transformers, some conventional insulation is acceptable in locations where conventional temperatures are maintained.

in ester oil and mineral oil (Figs. 1 and 2), insulation paper impregnated in ester oil requires 5-8 longer time to reach end of life compared to insulation paper impregnated in mineral oil [16, 17]. At 170°C, insulation paper impregnated in ester oil still maintains its structural integrity while insulation paper impregnated in mineral oil has lost it (Fig. 3).

IEC 60076-14 [18] gives further comparison between insulation paper impregnated in ester oil and insulation paper impregnated in mineral oil as shown in Fig. 4. With higher Thermal index, transformer with ester oil can have two operational probabilities i) transformer with ester oil can be overloaded with similar estimated lifetime as transformer with mineral oil, or ii) transformer with ester oil can have longer estimated lifetime under similar loading as transformer with mineral oil. However, it is important to note that the effectiveness of ester oil depends on the insulation system used in the transformer, namely i) conventional insulation system, ii) hybrid insulation system, and iii) high temperature insulation system (Table 1). Conventional insulation system combined with ester oil doesn't give improvement on temperature rise of top liquid, average winding, and hot spot winding. Hybrid insulation system provides improvement on temperature rise of average winding and hot spot winding,

while high temperature insulation provides improvement on all temperature rise limit (top liquid, average winding, and hot spot winding). Thus, technical consideration for transformer with ester oil insulation should be linked to the type of insulation system intended for the transformer itself.

From an economic perspective, high pricing of ester oil results in high CAPEX of transformer with ester oil (up to 5-30%). According to Meralco study, transformer with ester oil has CAPEX 10% more expensive than transformer with mineral oil but gives Net Present Value (NPV) saving up to 17-22% [10]. By using Total Cost of Ownership approach with several assumptions from in depth discussion with local transformer manufacturers in Indonesia, transformer with ester oil with price tag 30% more than transformer with mineral oil gives 45-48% saving at 25 years of operation. However, it is also important to note that during a shorter period (i.e., 20 years), transformer with ester oil gives higher TCO up to 13-15%. In other words, transformer with ester oil will give better TCO due to its longer expected lifetime; this will give transformer with ester oil an advantage, especially when the transformer with mineral oil needs a replacement/ additional cost for CAPEX. However, this "longer lifetime" assumption should be evaluated further.

7. Discussion and Research Roadmap

Based on the evaluation of technical properties (physical, electrical, and chemical), ester oil has a potential to be used in the future distribution transformer fleet owned by PT PLN (Persero). Not only supporting PT PLN (Persero)'s green initiative, the usage of ester oil also provides better fire safety and higher temperature rise. However, there're several points which need to be considered further:

(a) Technical perspective. Optimization of several factors (i.e., selection of the insulation system, allowed losses and temperature rise, CAPEX, etc.) is needed to obtain suitable design of transformer prototype with ester oil for PT PLN (Persero) use. This process required time, effort, and resources from both PT PLN (Persero) and local transformer manufacturers. Thus, the roadmap of ester oil implementation should be defined.

(b) Risk perspective. According to gathered data, ester oil resource/availability is identified as potential risk of implementing green distribution transformer in Indonesia. Ester oil market in Indonesia is relatively small compared to another country; thus, the availability of the ester oil for distribution transformer in Indonesia is not as good as the availability of mineral oil. Small availability combined with the long process to develop optimized prototype of transformer with ester oil might affect the supply chain of PT PLN (Persero), especially under high demand of transformers with ester oil in the future. Since PT PLN (Persero) doesn't have any operational experience with ester oil, a better understanding from holistic perspective is needed for PT PLN (Persero) as the end user (i.e., ester oil handling, loading versus lifetime characteristics, knowledge of transformer insulation systems, etc.).

(c) Cost perspective. Apart from the estimated/ calculated financial benefit, there are at least two parameters which should be confirmed further a) load loss and b) estimated lifetime of the transformer prototype with ester oil. Those parameters, including another TCO's parameters, should be updated with laboratory and/or field test results to obtain more accurate TCO analysis.

In order to implement green distribution transformer in the long-term schedule, research roadmap will be conducted into 3 major steps, namely:

(a) Developing, laboratory evaluation and testing of transformer prototype with natural ester oil. Goal of the green distribution transformer prototype is to optimize the benefit of natural ester oil as transformer insulation.

(b) Field installation and long-term continuous monitoring.
Three type of distribution transformers will be installed in the similar environment and similar load. Goal of the green transformer field project is to compare the performance between mineral oil transformer and natural ester oil transformer, and between standard design and enhanced design of transformer where both of them using natural ester oil.
The result of field testing will be evaluated further as feedback for the prototype design. The result will be evaluated to obtain the feasibility of implementing ester oil in distribution transformer.

(c) Developing of local natural ester oil as transformer's liquid insulating material.
Currently, PT PLN (Persero) has conducted joint research with university to develop local source of natural ester as transformer's liquid insulating material. This joint research is expected to finish by the end of 2024. The finished natural ester oil prototype will be tested under in laboratory based on IEC 62975, and the transformer distribution with natural ester oil based on 60076 or SPLN D3.002 to obtain its characteristics (i.e., temperature rise, losses, etc.) and detailed CAPEX for single unit. Those data are important input to update TOC calculations.

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Recent activities of international exchange in Japan

Sharing My Experiences and Impressions

Affiliation in Japan: The University of Tokyo
Nationality: United Kingdom
Term: Summer 2023
Current affiliation: The University of Manchester (United Kingdom)

First, let me introduce myself. After completing my undergraduate degree in the Department of Electrical and Electronic Engineering, I have continued my studies at the University of Manchester where I am now a final year PhD student in the high voltage laboratory. This summer, I embarked on a two month research project in the University of Tokyo High Voltage Engineering Laboratory.

There, I had the privilege of working under the guidance of Professor Akiko Kumada, Professor Masahiro Sato and Professor Takahiro Umemoto.

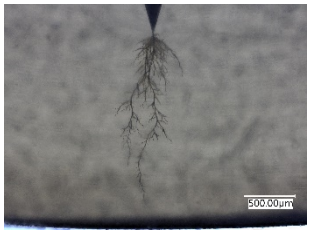
Working as a JSPS 2023 Summer Programme Fellow, my research endeavours during the placement were focused on gaining a greater understanding of electrical tree growth in cross-linked polyethylene (XLPE). Electrical trees are gaseous channels that can lead to breakdown in high voltage cables and can originate from points of high electric field stress within the dielectric.

Breakdown from electrical tree growth has the potential to impact in-service usage of high voltage cables, therefore it is important to characterise the electrical tree phenomenon. Specifically for this research, I investigated the effect of frequency and mechanical strain.

To do so, I first set up an electrical circuit capable of observing and documenting the partial discharge signals and tree growth process during each test.

During my stay at The University of Tokyo I also had the opportunity to learn a different partial discharge measurement technique, and compare it with the Omicron system used in Manchester.

I was also able to measure data for tree growth under varying frequencies and with mechanical strain. The samples and mould used were brought over from Manchester, and test samples were prepared in the same manner so that a compison could be made between samples from the two different test sites.



Microscopy image of electrical tree grown in XLPE during placement in Tokyo

From these two months I have been able to study the influence of mechanical strain and electrical frequency on electrical tree initiation and development in XLPE.

Beyond my time spent testing in the University of Tokyo Laboratory I was also able to visit Kyushu Institute of Technology, where I was able to connect with fellow researchers and discuss our research work. As well as this, I was able to enjoy spending time with laboratory members and trying delicious food Tokyo had to offer.

My two months in Tokyo have been an opportunity for cross institutional collaboration and knowledge exchange, allowing me to learn and develop new skills for data collection and analysis. I would like to extend my thanks to the researchers I had the privilege of meeting and working with in the lab. With a special acknowledgement to Kumada Sensei, Sato Sensei and Umemoto Sensei for helping me develop as a researcher, I look forward to applying these skills to my ongoing PhD studies.

Frances Hu
The University of Manchester, United Kingdom

High Voltage Laboratory group dinner

Evaluation of Electrical Insulation of PP/Elastomer Composites for DC and AC

In recent years, there has been an increase in demand for long-distance DC power transmission (DC) due to the growing demand for electricity and increased environmental awareness. This is to effectively utilize renewable energy. Currently, the most used electrical insulation material for DC is cross-linked polyethylene (XLPE). XLPE withstands the heat generated by current flow and provides flexibility as a cable through cross-linking. However, XLPE is difficult to recycle due to loss of thermoplasticity caused by cross-linking.

To address these issues, we have begun studying polypropylene (PP) as a new non-crosslinked insulator material for DC cables. PP has thermoplastic properties, however it has also higher melting points. While common PP is not suitable for cables due to its lower flexibility compared to XLPE, we have developed a PP/elastomer composite material that offers both flexibility and DC electrical insulation. This composite was obtained through melt kneading using a extruder with a screw diameter of 30 mm under temperature conditions of 200°C or higher.

Figure 1 illustrates the relationship between electric field and charge accumulation rate for the prototype PP/elastomer composite, the developed product, the PP used in the composite, and the current XLPE. While the charge storage rate may increase with the electric field when elastomers or similar materials are blended with PP, the developed product maintains a low charge storage rate even with blending. It shows its potential for DC characteristics.

Table 1 presents the results of lightning impulse breakdown voltage, tensile strength at break, tensile modulus, tensile elongation, and dielectric loss tangent which is an indicator of AC characteristics. In both cases, the prototype did not reach the target value compared to XLPE. However, the developed product showed better results than XLPE, even under higher temperature conditions. Notably, the lightning impulse breakdown voltage of the developed product at 110°C was 170 kV/mm, higher than the 150 kV/mm of XLPE at 90°C. The tensile elastic modulus was less than 300 MPa, a fraction of the PP without elastomer, and the tensile elongation was maintained at 600% or more. While the tensile modulus of XLPE is slightly lower than the composite, we believe it can be still acceptable for practical use. The dielectric loss tangent of the developed product, even at a temperature condition of 110°C, was lower than that of XLPE, indicating its potential for AC characteristics.

Based on the above findings, we have demonstrated the possibility of using PP as a non-crosslinked electrical insulation material for power cables with both DC and AC characteristics.

Table.1 Various characteristics.

	XLPE	PP	composite prototype	the developed product
Lightning impulse breakdown voltage(kV/mm)	>150 (90℃)	>150 (110℃)	<130 (110℃)	>170 (110℃)
Tensile strength at break(Mpa)	>15	>30	>30	>30
Tensile elongation(%)	>500	>600	>600	>600
Tensile modulus(Mpa)	<200	>1000	<300	<300
tan δ (Electric field 30kV/mm)	<0.1 (90℃)	>0.25 (110℃)	<0.1 (110℃)	<0.06 (110℃)

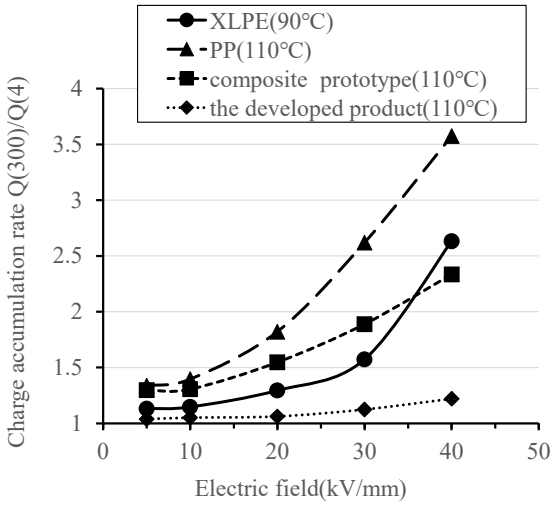


Fig. 1. Relationship between electric field and charge accumulation.

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Guidelines for Molecular Design of Insulating Materials

1. Development of high temperature and high electric field insulating materials

The insulation layers of power devices in electrical control equipment and the insulators of power cables are required to meet specifications for harsh environments with high electric fields (~100 kV/mm) and high temperatures (90°C to 200°C). For example, because large currents flow through the power devices of electric vehicles, the temperature of the devices can reach temperatures as high as 200°C. Furthermore, a high electric field is applied to thin the insulating layer for heat dissipation. Therefore, the electrical insulation industry is working to develop insulating materials that can maintain their function even under such harsh conditions.

2. Why is it necessary to develop this?

Let's consider this problem by taking up the flow of power in Fig. 1 from power supply to coaxial cable and to power device (IGBT) to motor load. The first conclusion is that power energy is carried in the insulation layers of the coaxial cable and IGBT, and never flows through the conductors.

Consider this from Eq. (1) of the Poynting Vector, which is the basic model taught in electromagnetism. When a voltage V is applied between the inner conductor and the outer conductor, an electric field E_r is generated in the radial direction within the insulating layer.

Furthermore, when a current I flow through the inner conductor, a magnetic field H_θ is generated in the insulating layer in the θ direction.

Therefore, when area integration is performed over the cross section of the insulating layer in the coaxial cable as shown in Eq. (1), the power energy value becomes $P_0 = V \times I$.

$$P_0 = \oiint (E_r \times H_\theta) dS = \int_a^b \frac{V}{r \ln(b/a)} \times \frac{I}{2\pi r} 2\pi r \, dr = V \times I \quad [W] \tag{1}$$

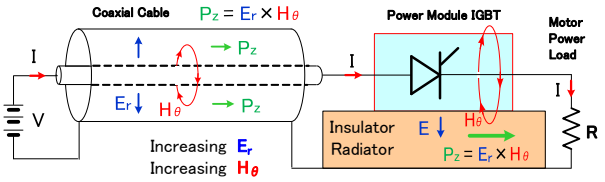

Fig. 1. Using Poynting Vector to explain that electric power is transported in the insulating layer.

3. Molecular design of insulating materials

The big problem with DC insulation is the accumulation of space charge. This accumulated charge distorts the internal electric field $E(x, t)$ [V/m], advances insulation deterioration, and leads to dielectric breakdown. The PEA method has been developed to measure this space charge accumulation distribution $\rho(x, t)$ [C/m^3], making it possible to observe charge injection and hopping movement. The next challenge is the molecular design of insulating materials that can block charge injection and transfer. The guidelines for this molecular design are the following two points *A* and *B*.

A. Align the Fermi level of the electrode with the Fermi level of the insulation

Fig. 2 depicts the Fermi level difference between the electrode and the insulating material and the generation of charge sources for electric double layer formation. The Fermi level of the electrode is the work function ϕ_W, and the Fermi level of the insulating material is E_F. Then, the electron energy

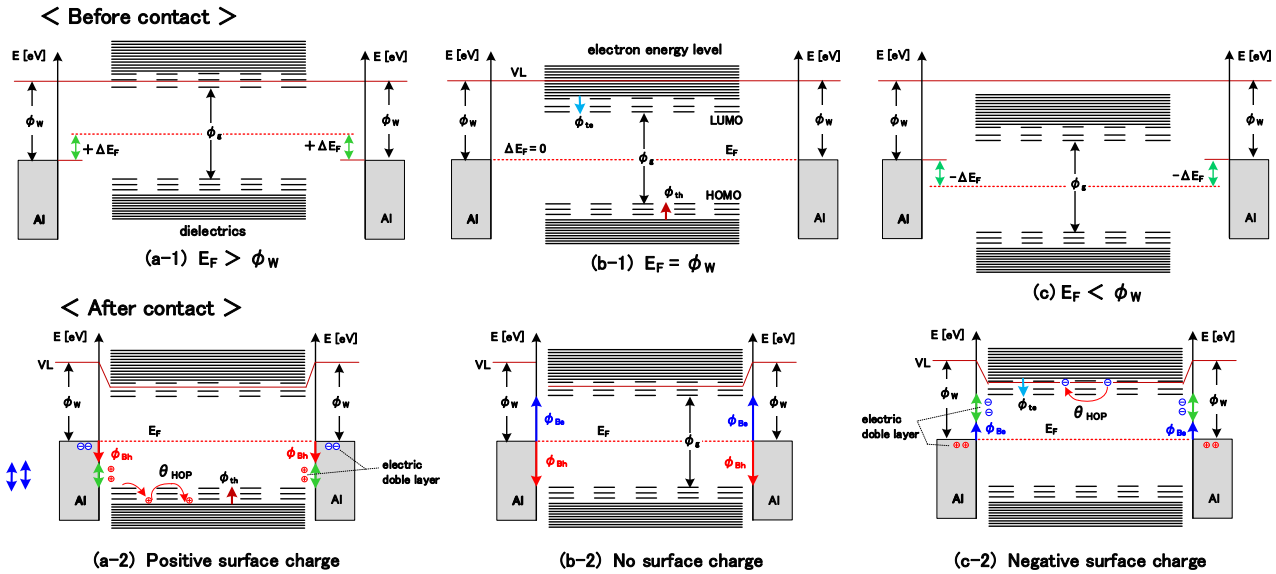

Fig. 2. Electron energy level before and after contact between specimen and electrode.

levels for the following three cases are drawn. The upper row of Fig. 3 shows the situation before the two contact each other, and the lower row shows the case after the contact.

When $\phi_W > E_F$: During the contact process, electrons move from the insulating material with a high Fermi level to the electrode with a low Fermi level. As a result, holes (positive charges) remain on the surface of the insulating material, and excess electrons (negative charges) exist on the electrode surface. Then, the hole injection barrier is lowered to $\phi_{Bh} = \phi_g/2 - (\Delta E_F)$.

When $\varphi_W = E_F$: There is no movement of electrons during the contact process. Therefore, the charge injection barrier becomes $\phi_B = \phi_g/2$.

When $\phi_W < E_F$: During the contact process, electrons move from the electrode with a high Fermi level to the insulating material with a low Fermi level. As a result, holes (positively charged) remain on the electrode surface, and excess electrons (negatively charged) exist on the surface of the insulating material. Then, the electron injection barrier is lowered to $\phi_{Be} = \phi_g/2 - (\Delta E_F)$.

What can be seen from the plot of the electronic energy levels in Fig. 2 is that (b) when $\phi_W = E_F$, no electric double layer is formed at the interface between the electrode and the insulating material. Further, the electron injection barrier ϕ_{Be} and the hole injection barrier ϕ_{Bh} are increased. On the other hand, when (a) $\phi_W > E_F$ and (c) $\phi_W < E_F$, charge carriers exist at the interface at the stage of contact. Furthermore, ϕ_{Be} and ϕ_{Bh} are decreasing. When an electric field is applied, charges in the electric double layer move as carriers through the insulating material. Therefore, one of the basics of insulating molecule design is to match the Fermi level of the electrode and the Fermi level of the insulating material.

B. Designing electron and hole traps from chemical molecular structure

Once the molecular structure of an insulating material is known, quantum chemical calculations can now be used to calculate trap formation (1) electronic energy level, (2) valence band below the HOMO level, (3) empty band above the LUMO level, and (4) energy gap ϕ_g. When observing the electron waves (molecular orbitals) at each electron energy level using quantum chemical calculations, the HOMO level group and LUMO level group are localized as shown in the figure. Hole traps and electron traps are formed there. This also makes it possible to design molecules that can be synthesized to form deeper trap sites.

For more details, please refer to the following Springer book of “Electric Charge Accumulation in Dielectrics -Measurement and Analysis-”
ISBN 978-981-19-6155-7

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BOOK REVIEW

Advances in Tailor-made Polymer Composite Insulation Materials – Machine Learning in Insulating Materials and Application Development of Composite Insulation Materials –

IEEJ Investigation R&D Committee on Advancing Tailor-made Composite Insulation Materials and Their Applications

Chairperson: Takahiro Imai, Toshiba Infrastructure Systems & Solutions Corporation

IEEJ Technical Report No. 1554 (in Japanese), Published on August 10th, 2023

IEEJ Investigation R&D committee on Advancing Tailor-made Composite Insulation Materials and Their Applications, which consists of 33 experts who work in academia, research institute, and industry as shown in Table 1, published the IEEJ Technical Report No. 1544 on August 10th, 2023.

Tailoring of polymer composite insulation materials with desired dielectric and insulation properties for electric power and industrial apparatuses is the demands of the times nowadays. Therefore, the technical report provides the cutting-edge research and applications of tailor-made composite insulation materials. Technical information is categorized in three sector as shown in Figure 1.

The first sector (I) of the report introduces new approaches in recent years in the development of composite insulation materials, including examples of the applications of machine learning and quantitative evaluation of nano-filler dispersion state.

The second sector (II) explains that new materials such as fullerene and new preparation methods such as 3D printers enable the composite materials to have high-performance and multi-functionality.

The third sector (III) summarizes the latest applications of composite insulation materials, including stator winding insulation for generator and insulation spacer for gas-insulated switchgears.

The committee hopes that this report will contribute to the development of composite insulation materials.

Table 1. Members of the Committee

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N. Hayakawa	Nagoya University
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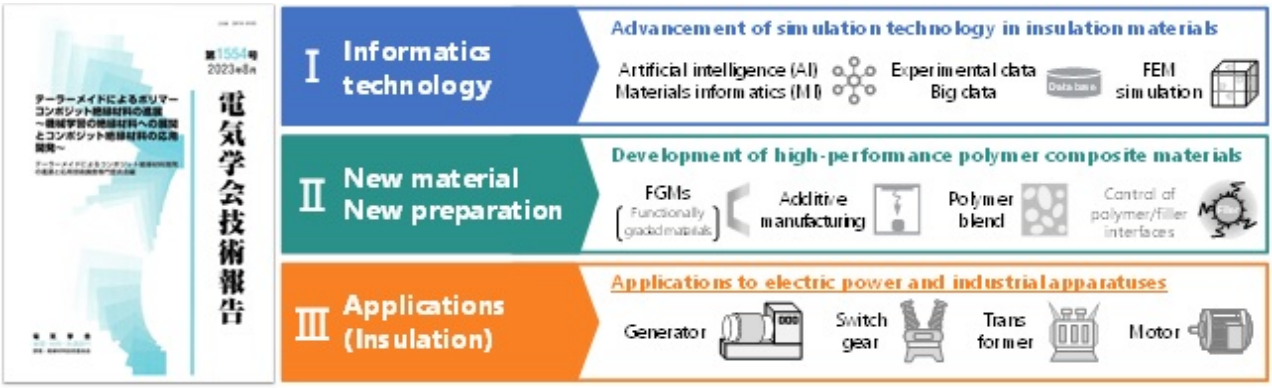


Fig. 1. Summary of the IEEJ Technical Report No. 1554.

Application of Quantum Chemical Calculations in the Field of Electrical and Electronic Insulation Materials

IEEJ Technical Committee on the Application of Quantum Chemical Calculations in the Field of Electrical and Electronic Insulation Materials

Chairperson: Satoshi Matsumoto, Shibaura Institute of Technology

IEEJ Technical Report No. 1542 (in Japanese), Published on July 21st, 2023

A quantum chemical calculation (QCC) has been noticed as an effective method for understanding the complex phenomena such as electron conduction and charge behavior under the high electric field in a polymeric insulation material having complex chemical and higher order structure in it. In this technical report, the current state of the application of QCC in the field of insulation materials is described as follows:

Chapter 1: Overview of QCC

Chapter 2: The history and future targets of QCC

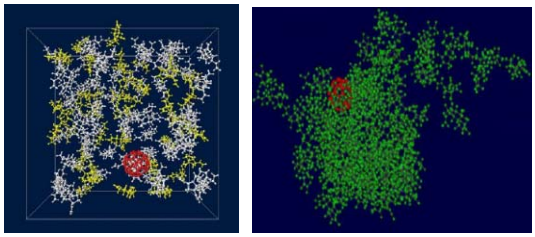
Chapter 3: Some examples of the analyzed results of insulation materials using QCC

Chapter 4: The status of application and some examples of the analyzed results of electric and electronic equipment

Chapter 5: The status of use of QCC on inorganic materials

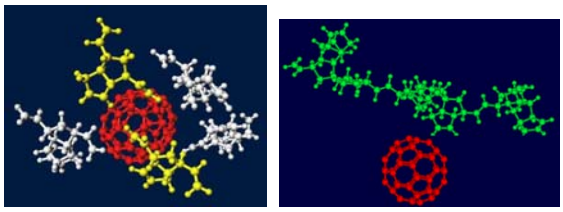
Chapter 6: Conclusion and future works

The process of using QCC in the field of insulation materials is on the road to academic and industrial success, but its fruition depends on our future efforts. It is hoped that this technical report will be utilized in the next generation of activities to open new doors in the field of insulation materials using QCC and new technologies such as machinery studies and materials informatics which are applications of quantum chemical studies.



(a) monomer/ C_{60} (b) oligomer/ C_{60}

Fig. 1. Calculation model after molecular dynamics simulation.



(a) monomer/ C_{60} (b) oligomer/ C_{60}

Fig. 2. Quantum chemical calculation model with fullerene neighborhood extracted from Fig.1.

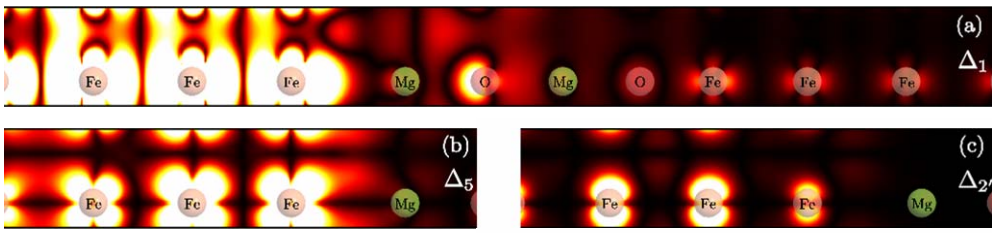


Fig. 3. Cross-sectional view of each $\Psi_{nE}(\boldsymbol{r})$ for Fe/4MgO/Fe MTJ in parallel magnetization configuration

Electric Charge Accumulation in Dielectrics – Measurement and Analysis –

Authors: T. Takada, H. Ren, J. Li, W.Wang, X . Chen and Q. Li (English version)
Tatsuo Takada (Tokyo City University) (Japanese version)

Publisher: Springer (English version)

Two books were published, one in English and one in Japanese. Both books mainly introduce how to measure and analyze charge accumulation in dielectrics. By using the PEA and Q(t) methods with the Quantum Chemical Calculation, the charge characteristics of solid dielectrics under different situations analyzed, which are never discussed in detail by other books. The book contains a large number of experimental and simulation data as illustrations, and thus the reader can understand in the book very easily. Meanwhile, the reader can learn how to use the two methods to measure charge behavior under different conditions and analyze the charge phenomena by Quantum Chemical Calculation.

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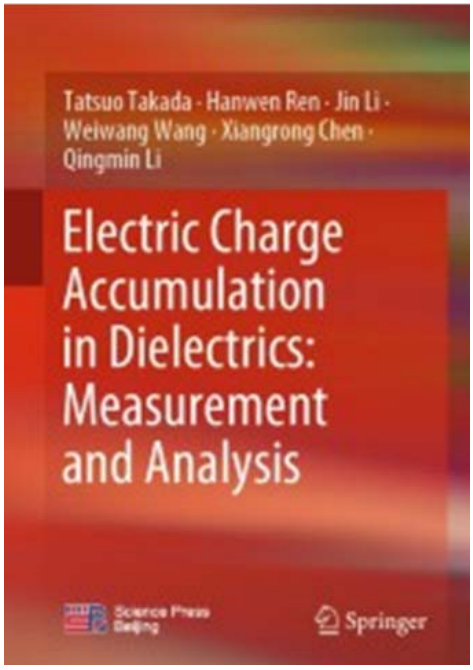
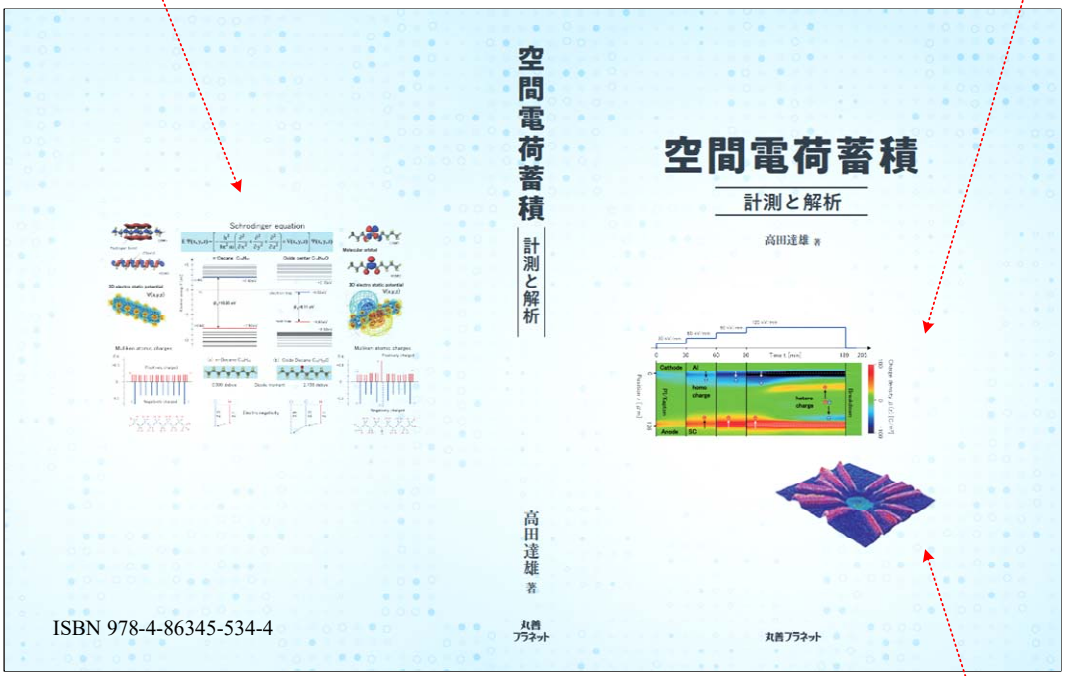


ISBN 978-981-19-6155-7

Application of DFT (Density Functional THeory)
Calculate electronic property values of polymer resin
- Electric charge trap level
- Charge injection barrier from electrode
- Electrostatic potential distribution within molecule
- Molecular orbital of polymer resin

- Applied measurement of nanosecond pulsed acoustic pressure waves
- Observe charge behavior inside dielectrics under volatge application



Be able to explain the measured charge behavior.
Beyond that, molecular design is also on the horizon.
September 2022

Measurement of surface charge distribution by Electro-optical Pockel effect

MISCELLANEOUS

Photos on Front and Rear Covers

Front Cover

Tension Leg Platform (TLP) for Large Wind Turbine Generator

TLP systems are expected to reduce the cost of power generation because the high stability of tension mooring enables installation of large 15 MW-class wind turbines, which have the potential to become mainstream in the future, on compact floating platforms. In addition, TLP mooring lines are expected to be more socially acceptable than other mooring systems because they can reduce the space occupied under the sea by 1/1,000 approximately (in case of 100m water depth, as example) and have less impact on the existing businesses such as the fishing industry and ship operations. MODEC takes part in Green Innovation Fund Phase 1 project organized by NEDO* to proceed with the development of component technologies and the basic engineering design for TLP systems with the aim of commercializing floating wind farms in the early 2030s.

Hidenobu Kobayashi
New Business Development Dept.
MODEC, Inc.
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Tokyo 103-0027

*New Energy and Industrial Technology Development Organization

Rear Cover

Charge Microscopy

A well-known 2-D or 3-D space charge measurement using the pulsed electroacoustic method is that proposed by Maeno et al. The prototype measurement system being developed at Toyohashi University of Technology based on the above example uses a polymer substrate as the acoustic coupling material, which allows observation with low aberration using a comercially available focused ultrasonic transducer. Since the measurement system is a modified ultrasonic microscope, the echo image can be viewed prior to the space charge measurement and used to identify the observation position. The insulation system shown in the figure consists of a polymer film (ethylene vinyl acetate copolymer), silicone rubber, and tapered aluminum electrode placed on a substrate coated with the grounding electrode. When a DC voltage is applied, it is observed that the charge spreads along the interface with time from the vicinity of the triple junction. We believe it can be used for screening tests of composite insulation systems and for evaluating the charge behavior in power electronics insulation systems.

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Journals of IEEJ

A Journal which is edited by the headquarters of the Institute and five transactions which are edited by five technical societies* A to E are monthly published.

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An English journal "IEEJ Journal of Industry Applications" is edited by the society D and published bimonthly. The papers can be downloaded free at present.

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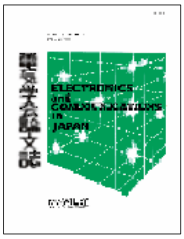

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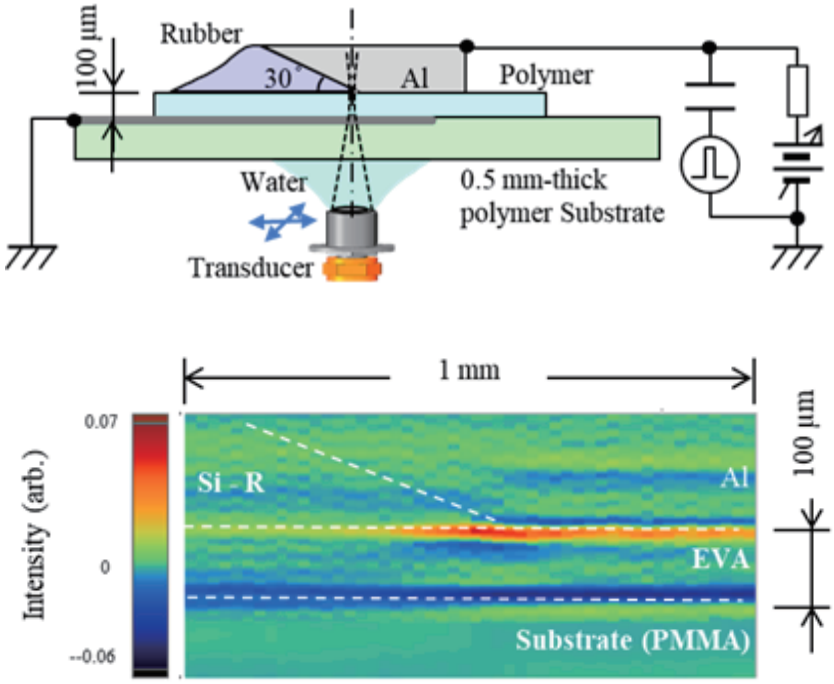

Cross sectional charge image. DC: 7 kV, pulse: 1.5 kV, 20 ns

K. Yasuda, X. Li, M. Utagawa, T. Kawashima, Y. Murakami, N. Hozumi: 9th Int'l Conf. Condition Monitoring and Diagnosis (CMD 2022).

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