

Technical Committees

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Activities of the DEIS Technical Committee on Liquid Dielectrics

Scope and Significance of the Technical Committee

Insulating liquids are used as impregnating mediums for solid insulation (paper and film) and dielectric and cooling materials in various equipment used in the transmission and distribution network: transformers (power, rectifier, distribution, traction, furnace, potential, current, etc.), resistors, reactors, capacitors, cables, bushings, circuit breakers, tap changers, thyristor cooling in power electronics, etc., thus proving the subject “Liquid Dielectrics” as an important aspect in the allied areas of IEEE Dielectrics and Electrical Insulation Society (DEIS). The DEIS technical committee (TC) on Liquid Dielectrics acts in promoting cutting edge knowledge of the state-of-the-art in the areas of liquid insulation technologies.

The TC on Liquid Dielectrics is involved in coordinating technical activities and communicating knowledge concerned with use and evaluation of liquid dielectrics. The evaluation of liquids includes assessment of long-term performance capabilities as well as of health, safety and environmental hazards associated with the use of liquids in electrical equipment. The greatest challenges are related to the applications of new insulating liquids and the need for methods to assess the condition along with the improvement of the liquid efficiency by chemical admixtures and or application of readily biodegradable liquids. Nano fluids are expected to play an important role in the next industrial revolution. Those relatively new classes of fluids are now the subject of intense research activity. Still many scientific locks need to be unlocked before the application in power equipment. It is known that smart liquids with specific nanoparticles may be customized as per the application for oil-filled equipment. The theoretical and practical developments with special emphasis on potential problems and engineering solutions in using these liquids in electrical equipment are also of concern for the TC. Even though much is known on the fundamental aspects of liquid dielectrics degradations, there is still a dearth of information to gather to improve our basic knowledge.

TC on Liquid Dielectrics and DEIS Community

The activities and field of interest of the TC on Liquid dielectrics are allied with the vision and mission of DEIS. The significant areas of this TC include aging phenomena, diagnostic/behavior characterizations, condition monitoring aspects, and testing of liquid insulating systems. Importantly, emphasis is laid on the environmental and sustainability aspects of the dielectric liquids. This enables promotion of research on

biodegradable insulating fluids, vis-à-vis existing literature on mineral insulating fluids for application in oil filled electrical apparatus. The members of the TC on Liquid Dielectrics are constantly involved in expanding the knowledge on various aspects of liquid filled apparatus. Brief details of the key concerns of the TC are listed below but are not limited to:

- **Testing and Characterizations:** It is essential to understand the behavior of the insulating fluids before and after their application in electrical apparatus. This enables the utility and design engineers to access the critical behavior of the new and existing dielectric fluids. For instance, knowledge on prebreakdown and breakdown phenomena of insulating fluids will facilitate insulation engineers to understand the behavior of insulating oils under electrical stress. As an example, the propagation of a streamer in insulation oil from the tip of a needle electrode, thus leading to a breakdown discharge condition, is presented in Figure 1. Thus an accurate dielectric safety margin of the insulation system can be maintained for effective operation of the oil filled apparatus.
- **Condition Monitoring of Oil-Filled Apparatus:** In-service condition monitoring information of oil-filled apparatus is an interesting topic of research to dielectricians and utilities. Such information is helpful for careful assessment of risk management. Condition monitoring information of insulating oils will reveal the service behavior in various operating conditions. The members of the TC on Liquid dielectrics are also individually involved in collecting and analyzing the condition monitoring information of oil filled apparatus that belong to local utilities (as for example [1, 2]).
- **Aging Phenomena:** Insulating systems are generally designed to be in service for several decades and hence understanding the aging behavior is essential to attain the designed life of the apparatus. Insulating liquids undergo several reactions and stresses even under normal service conditions. These reactions influence the integrity and functionality of the insulating fluid and thus impact the performance of the whole insulation system. The stability of the fluid under electrical discharges is one of the focuses. Figure 2 presents the stability test under electrical discharge (as per ASTM D6180) of a highly aged natural ester. It is seen that the decay particles are tending to act as conducting channels in the interior of the insulating oil. The concentration of these decay particles increases with aging and thus increases the vulnerability of the oil to streamer propagation.

Knowledge Dissemination on Liquid Dielectrics

The TC on Liquid Dielectrics aims at transferring knowledge among all individuals, industries and stakeholders interested in

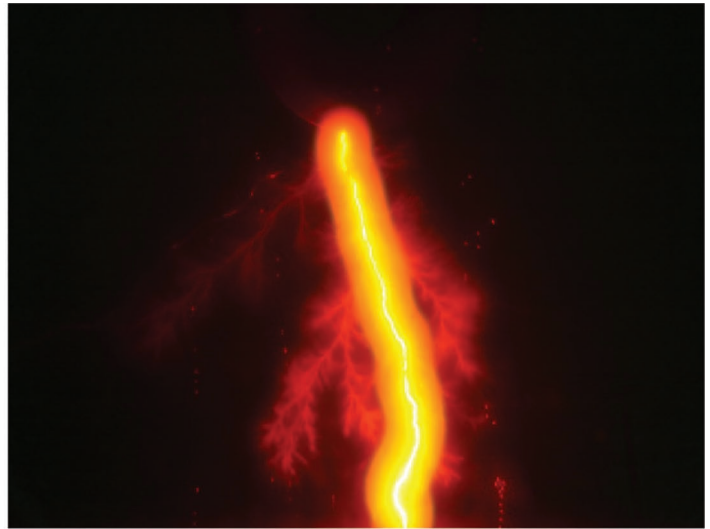
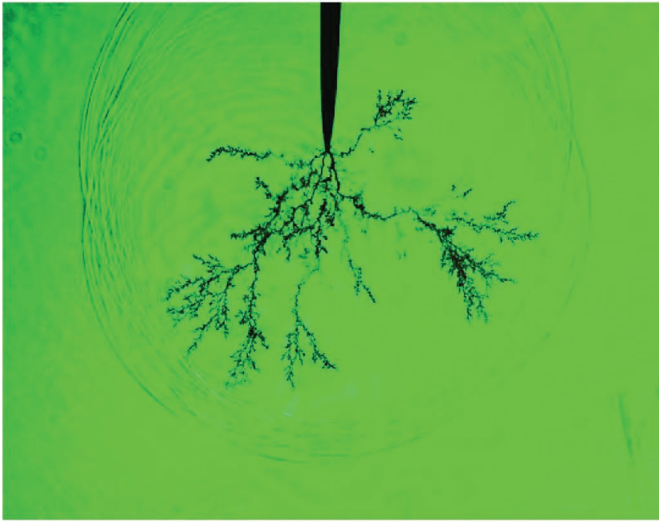


Figure 1. Streamer propagation to breakdown in insulating oil. Image courtesy of: Dr. P. Rozga, Lodz University of Technology, Poland.

dielectric fluids. The activities of this committee involves updating the knowledge on electrical insulating fluids vis-à-vis existing literature and industry needs. This will be achieved by arranging special sessions at DEIS meetings, organizing workshops, generating review articles, and publishing special issues in the journals of DEIS. Importantly, involvement of dielectric fluid manufacturers in DEIS conferences is also bringing zeal for technical discussions and conference sessions. These involvements open a gateway for critical discussions and provide a common platform for the concerned academia, researchers, and industry. Recent significant activities of the TC in this concern include the following:

- Publication of a Special issue on Liquid Dielectrics in IEEE Transactions on Dielectrics and Electrical Insulation, Volume: 25, Issue: 5, Oct. 2018 [3].

- A special session on synthetic and natural esters in TSO – DSO transformer applications, held during the Int. Conf. on Diel. Liquids (ICDL) 2019, Roma (Italy).
- A short course “Insulating Liquids and Mixed Dielectrics for Electrotechnology” was presented by Issouf Fofana at the 2019 International Workshop on Advanced Dielectrics and Applications (Campina Grande, Brazil).

Involvement in Development of Standards

The members of the TC on Liquid Dielectrics are also involved in contributing to the development and renewal of several standard test methods. These include the following:

- Collaboration in the Revision of the ASTM D-971-2: WK64753 - Standard Test Method for Interfacial Tension of Oil against Water by the Ring Method.

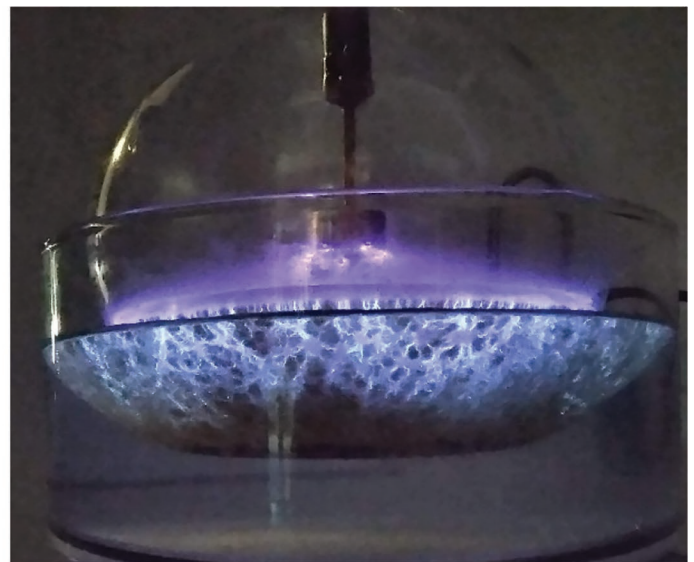


Figure 2. Surface and internal discharges in a highly aged natural ester fluid under low energy discharge. Image courtesy of: Dr. U. Mohan Rao, University of Quebec at Chicoutimi, Canada.

- Collaboration in the Revision of the ASTM D-D1934: WK68457 - Standard Test Method for Oxidative Aging of Electrical Insulating Petroleum.
- Collaboration in the development of ASTM WK46195 – New Standard Specification for Less-Flammable Synthetic Ester Liquids Used in Electrical Equipment.
- Collaboration in the development of ASTM WK68133 – Standard Test Method to Measure the Oxidation Stability of Natural and Synthetic Ester Liquids by Oxidation Induction Time (OIT) Using Differential Scanning Calorimetry.
- Collaboration in the development of ASTM WK65707 - New Standard for Partial Discharge Inception Voltage Measurement (PDIV) of Insulating Liquids Using Plane and Needle Electrodes.
- Collaboration in the development of IEC TC14 DTR 60076-26 – Power Transformers - Part 26: Functional requirements of insulating liquids for use in power transformers.

Future Activities

Due to the significance and importance of liquid dielectrics in electrotechnology, this TC is being re-vitalized and plans are afoot to move it forward over the next years. Planned activities include:

- A further Special issue on Liquid Dielectrics in IEEE Transactions on Dielectrics and Electrical Insulation, planned for October 2020 (<https://ieeexplore.ieee.org/document/8735675>).
- A review article on the topic related to “Pre-breakdown phenomena of biodegradable insulating fluids”. The con-

tents of this paper are aimed at providing knowledge on prebreakdown process in liquid insulating media. This article will also be spanned to present a state-of-the-art review and highlight the significance and scope for future research.

The TC welcomes suggestions and proposals for future workshops, seminars and papers.

References

- [1] U. M. Rao, M. L. Senoussaoui, A. Betie, I. Fofana, M. Brahami and E. Brioso, “Condition Monitoring of In-service Oil Filled Transformers - Case studies and Experience”, IEEE Electrical Insulation Magazine (in press).
- [2] Piotrowski, T.; Rozga, P.; Kozak, R. Comparative Analysis of the Results of Diagnostic Measurements with an Internal Inspection of Oil-Filled Power Transformers. *Energies* 2019, *12*, 2155.
- [3] Massimo Pompili, Luigi Calcara, “Editorial,” IEEE Trans. Dielectr. and Electr. Insul., Vol. 25, No. 5, pp: 1577-1578, 2018.

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