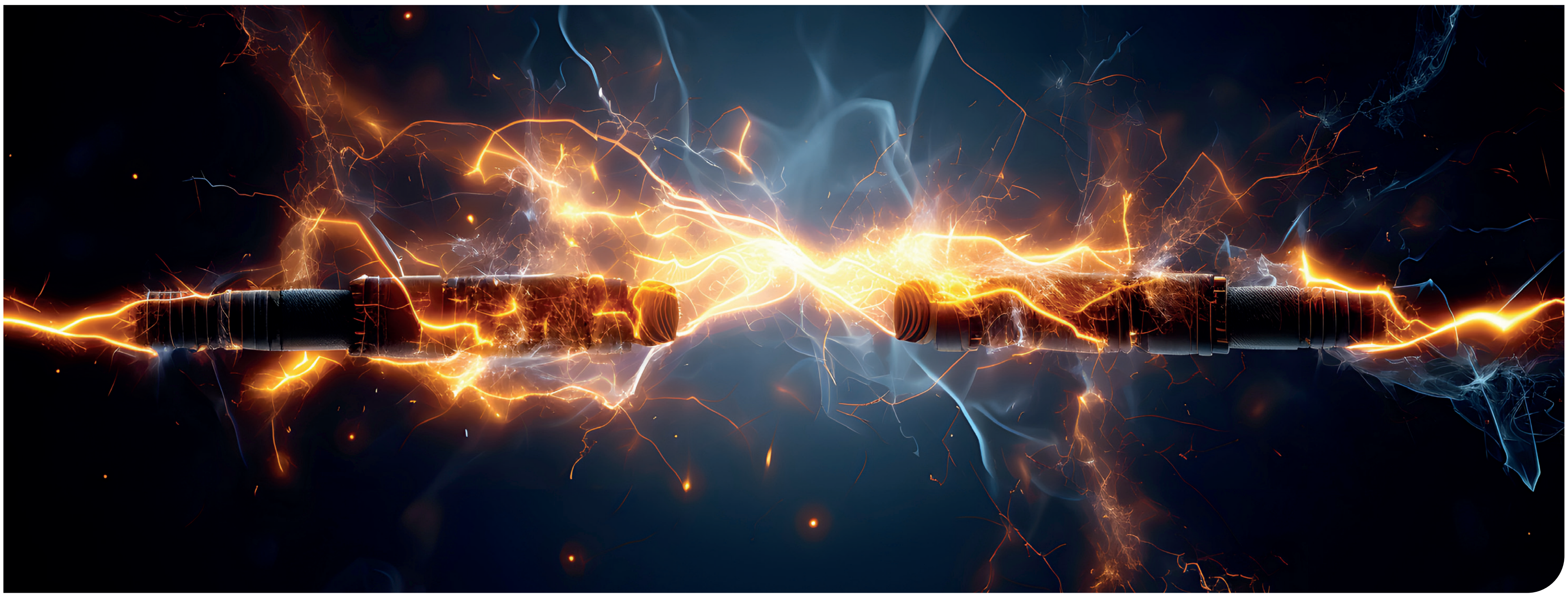
RECENT INNOVATIONS IN ELECTRICAL INSULATING FLUID TESTING



In modern iterations of transformers and other related power distribution equipment, electrical fluids are more prevalent than ever before. Unlike water and other more common liquids that corrode and damage electronics[1], electrical fluids, also known as electrical insulating fluids, are central to their operation. As the name implies, insulating fluids within a transformer functions as both an insulator and a dielectric, protecting the device from corrosion and internal short-circuiting while simultaneously acting as a cooling agent by dispersing heat as the transformer is energized[2].

Due to this dual purpose, many different insulating fluids exist simultaneously in the industry, each type possessing qualities that render them uniquely capable of filling niches in their use, as Figure 1 details. For instance, mineral oil is the oldest and most common fluid with high dielectric strength and thermal performance, but it is a flammable liquid with low biodegradability[3]. In contrast, silicone fluid is significantly less flammable and similar in dielectric strength but is more expensive and generates chemical byproducts[3]. As a result of the many different insulating fluids, other power distribution mechanisms like capacitors, circuit breakers, and switches also employ insulating fluid compatibility in their design[3].

Therefore, many procedures have emerged to ensure the quality and efficiency of electrical fluids while measuring their properties and viability in practice. Given that these fluids are immensely versatile, no single fluid source can be definitively named the most effective for its many functions[3]. As a result, many testing methods have also emerged that test individually viable traits of the fluid itself[3], each of which has experienced remarkable growth since its inception. Thus, as a reference, this article will focus primarily on electrical fluid testing regarding the fluid's dielectric strength. The advancement of dielectric strength testing will be analyzed, regarding its significance to the greater field of study, followed by an exploration of a new iteration of the established testing mechanism, with promising import to the future of electrical fluid testing.

Importance and Procedure of Electrical Fluid Testing:

An understanding of dielectric electrical fluid testing processes and their importance to electrical fluid viability is required to understand its underlying mechanisms. Dielectric strength is defined as the electrical field strength of an insulator and the maximum electrical field that the fluid can withstand before it breaks down and allows for electrical conduction[3]. The American Society for Testing and Materials (ASTM) named this process D877 and referenced as the standard method of locating the electrical breakdown voltage for specimens[5].

Using parallel disk electrodes operating at an AC voltage range from 45-65 Hz, as shown in Figure 2, the method examines whether the sample materials satisfy breakdown voltage requirements, and it separates into two different procedures depending on the behavior of the sample liquid's breakdown products[5].

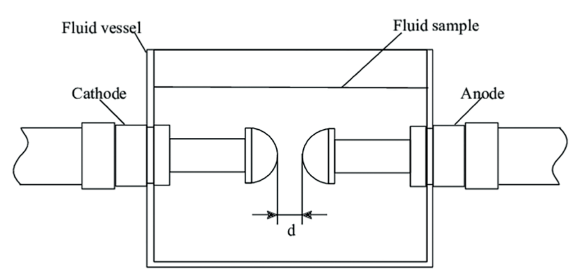


Figure 2: A diagram of an apparatus used to measure dielectric breakdown strength[6].

As an insulator, dielectric strength is paramount to the fluid's efficacy. A higher dielectric strength directly correlates with a theoretical transformer's ability to store and transfer electrical charges. Thus, an electrical insulating fluid necessitates a high dielectric strength to avoid complications and malfunctions caused by sudden fluid breakdown and unexpected conductivity[1]. However, this strength can be dampened by the presence of contaminants like fibers or conducting particles[5], requiring the need to examine such liquids to ensure purity.

Thus, ASTM exists to determine the presence of contaminants, as it induces five breakdowns of the provided fluid and considers the mean of the five dielectric breakdown voltages[5]. If the range of the breakdowns does not exceed 92 percent of the mean value, the mean value is reported as the dielectric breakdown voltage of the sample. A low breakdown voltage would indicate the presence of significant concentrations of contaminants, and a high breakdown voltage would reliably indicate a lack of contaminants, though it is noted that the procedure is not sensitive to low levels of contaminants, thus a high result does not necessarily indicate that contamination levels are acceptably low for all electrical equipment[5].

As the importance of dielectric strength relates to an electric fluid's insulating capabilities, the primary demographic for dielectric breakdown testers would be large-scale facilities like utility substations and industrial plant distribution systems that use transformers and related power distribution technologies, necessitating a constant supply of industrial quantities of insulating fluid to ensure stable performance throughout the site[7]. Because these locations are often the primary electrical supplier for thousands of smaller facilities, these plants must remain in optimal working order, as malfunctions can quickly spiral into power failures and outages. Therefore, to keep these facilities functioning, they require electrical fluid and the tools to ensure that electrical fluid operates efficiently.

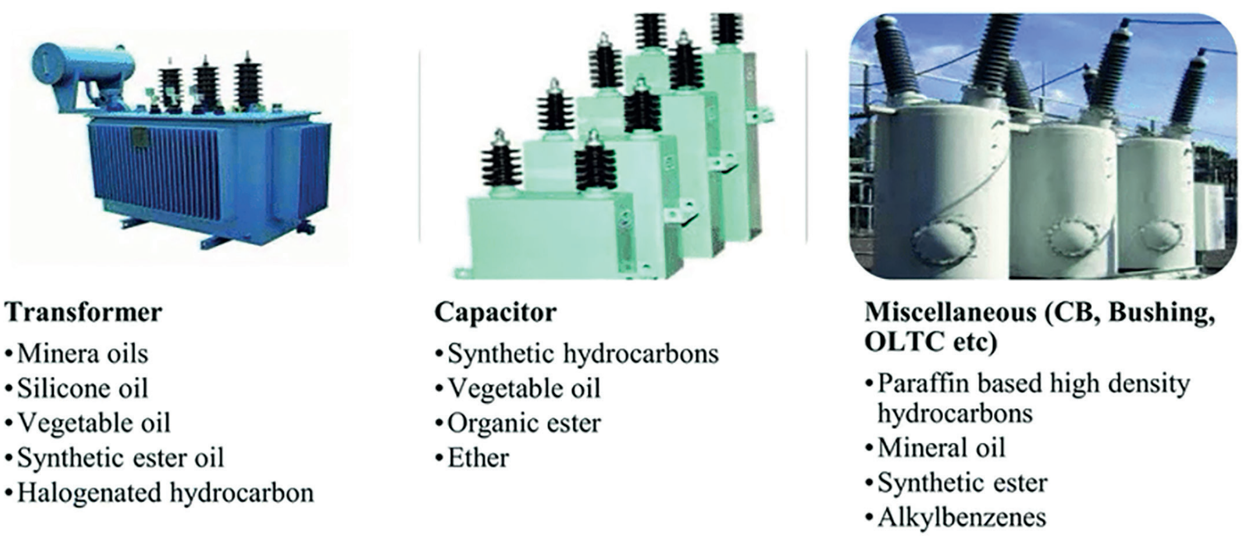


Figure 1: Three classifications for power distribution equipment and the associated insulating fluids used in application[4].

Table 1: The voltages, resolution, power frequency, and other relevant statistics regarding the K16185, K16186, and K16187 models from Koehler Instrument Company.

Specifications	ASTM D877, D1816, IE 60156, and other related procedures
Voltages	75 kV (Model K16185); 90 kV (Model K16186); 105 kV (Model K16187)
Resolution	0.1 kV
Power Frequency	48-63 Hz
Weight	22 kg
Operating Temperature	0℃-50℃
Storage Temperature	-20℃-60℃

Koehler Dielectric Breakdown Testers:

While the ASTM D877 process is well-established and remains a reliably consistent method to test dielectric strength, the equipment used in the procedure has experienced steady and constant improvement. With the innovations presented by the growing complexity of computer software, devices created to perform ASTM D877 have developed accordingly to better interface with the technology and streamline data analysis. Modern dielectric testing machines have become easier to integrate with laboratories, as devices have become more compact and easier to manage and set up. The breakdown tester shown in Figure 3, in particular, weighs only 32 kg and is considerably more compact than previous devices which stored the unit's battery in a separate module and thus required more space to construct. Furthermore, with an integrated screen and several preset techniques, this iteration demonstrates higher versatility and ease of access[8].

Figure 3: A Koehler Instrument Company Model K16177 Dielectric Breakdown Tester[8].

However, a strikingly new unit in this market promises to be a strong contender due to its size and integrability. Koehler Instrument Company, a business specializing in manufacturing research and testing equipment, has recently unveiled several new models for dielectric breakdown testers. These new units arise as an evolution of Koehler's existing K1617X line; being the K16185, K16186, and K16187 models with maximum voltage outputs of 75 kV, 90 kV, and 105 kV, respectively. At those outputs, the models exceed the previous line's maximum voltage output of 100 kV while performing at higher operating temperatures[8].

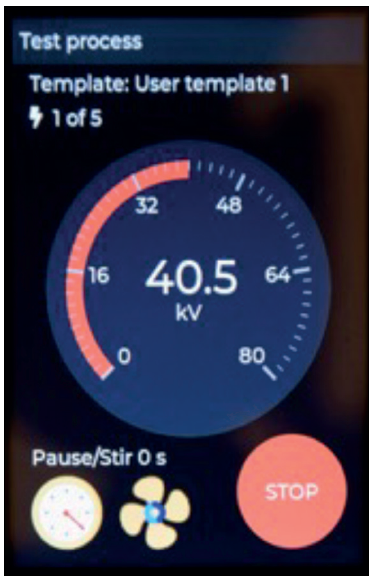


Figure 4: Measurement procedure screen of the K16186 model.

The system is an automatic device that provides testing according to the procedures defined by ASTM D877, D1816, IE 60156 and other standards, according to the user's own procedures specified in the appropriate section of the installation menu.

Figure 5: The menu for selecting the testing standard of the K16186 model.

The models have a color LCD display with an informative user-friendly menu, alongside an integrated printer and USB flash drive compatibility, allowing direct evaluation and reporting of data, or extraction onto a flash drive for further research on any USB-compatible device.

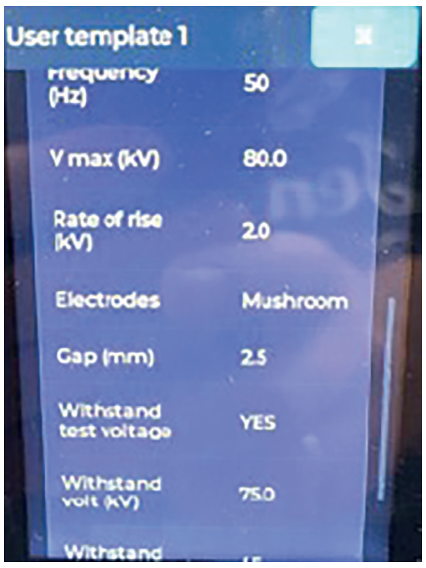


Figure 6: The testing parameter menu of the K16186 model.

Each model in the line has a voltage measurement accuracy within 1 kV of its maximum voltage output, and its compact construction and weight of 22 kg allow for simple transportation of the device between locations and other testing sites. Paired with its sleek design, shown in Figure 4, the K1618X line of dielectric breakdown testers is guaranteed to fit neatly within a laboratory setting, as its high output voltages guarantee a wide testing range with minimal measurement error. Its power usage is reasonable, and its compact dimensions guarantee easy transportation between testing sites.

If this model became an industry standard, the quality of electrical insulating fluid would remain stable and ripe for future development.

Figure 7: The K16186 model dielectric breakdown tester by Koehler Instrument Company.

Conclusion:

To conclude, the field of electric insulating fluid testing has remained strong and steadfast. New and innovative testing equipment like the K1618X line efficiently streamlines the process of testing and evaluation. While ASTM D877 remains an effective method of testing insulating fluids, the tools used to perform the procedure have repeatedly improved in efficiency and consistency. Currently, Koehler Instrument Company has established a high standard for laboratory testing equipment, and their new dielectric breakdown testers demonstrate their excellence in innovation and design. Truly, electric fluid testing is a ripe market, and further iterations of these machines will continue to improve the consistency of the ASTM D877 mechanisms, as new methods for improving a fluid's dielectric strength will inevitably be found and refined through rigorous and efficient testing.

Resources:

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About the Authors

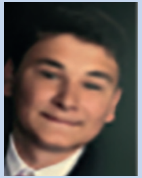
Dr. Raj Shah stands as the Director at Koehler Instrument Company in New York, showcasing an impressive 28-year tenure with the organization. Acknowledged as a Fellow by prestigious entities such as IChemE, CMI, STLE, AIC, NLGI, INSTMC, Institute of Physics, The Energy Institute, and The Royal Society of Chemistry, his contributions have earned him the esteemed ASTM Eagle award. A luminary in the field, Dr. Shah recently coedited the acclaimed "Fuels and Lubricants Handbook," a bestseller that captivates readers with its insights into the industry. Delve into the details at ASTM's Long-Awaited Fuels and Lubricants Handbook 2nd Edition Now Available (https://bit.ly/3u2e6GY).

Dr. Shah earned his doctorate in Chemical Engineering from The Pennsylvania State University and holds the distinguished title of Fellow from The Chartered Management Institute, London. He is also recognized as a Chartered Scientist by the Science Council, a Chartered Petroleum Engineer with the Energy Institute, and a Chartered Engineer with the Engineering Council, UK. Recently bestowed with the honorific of "Eminent Engineer" by Tau Beta Pi, the largest engineering society in the USA, Dr. Shah serves on the Advisory Board of Directors at Farmingdale University (Mechanical Technology), Auburn University (Tribology), SUNY Farmingdale (Engineering Management), and the State University of NY, Stony Brook (Chemical Engineering/Material Science and Engineering).

In addition to his role as an Adjunct Professor at the State University of New York, Stony Brook, within the Department of Material Science and Chemical Engineering, Dr. Shah has left an indelible mark on the energy industry, boasting a career spanning over three decades. His influence extends further through over 600 publications, solidifying his status as a thought leader in the field. **Discover more about Dr. Raj Shah at https://bit.ly/3QvfaLX. For further inquiries, please contact Dr. Shah at rshah@koehlerinstrument.com.**

In parallel, within the vibrant internship program at Koehler Instrument Company in Holtsville, **Beau Eng, William Streiber,** and **Gavin S. Thomas** shine as standout participants. These budding talents, all pursuing studies in Chemical Engineering at Stony Brook University, Long Island, NY, are under the guidance of Dr. Raj Shah, who currently holds the position of Chairman of the External Advisory Board of Directors at the university.

Beau Eng



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