6 Things Every Transformer Owner Should Know About: Dielectric Breakdown Voltage

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When it comes to the ability of your transformer's insulating liquid to withstand electrical stress, there are some things you should know about dielectric breakdown voltage.

1

What is dielectric breakdown voltage testing?

A dielectric breakdown voltage test measures the electrical stress an insulating liquid can withstand without "breakdown"—when

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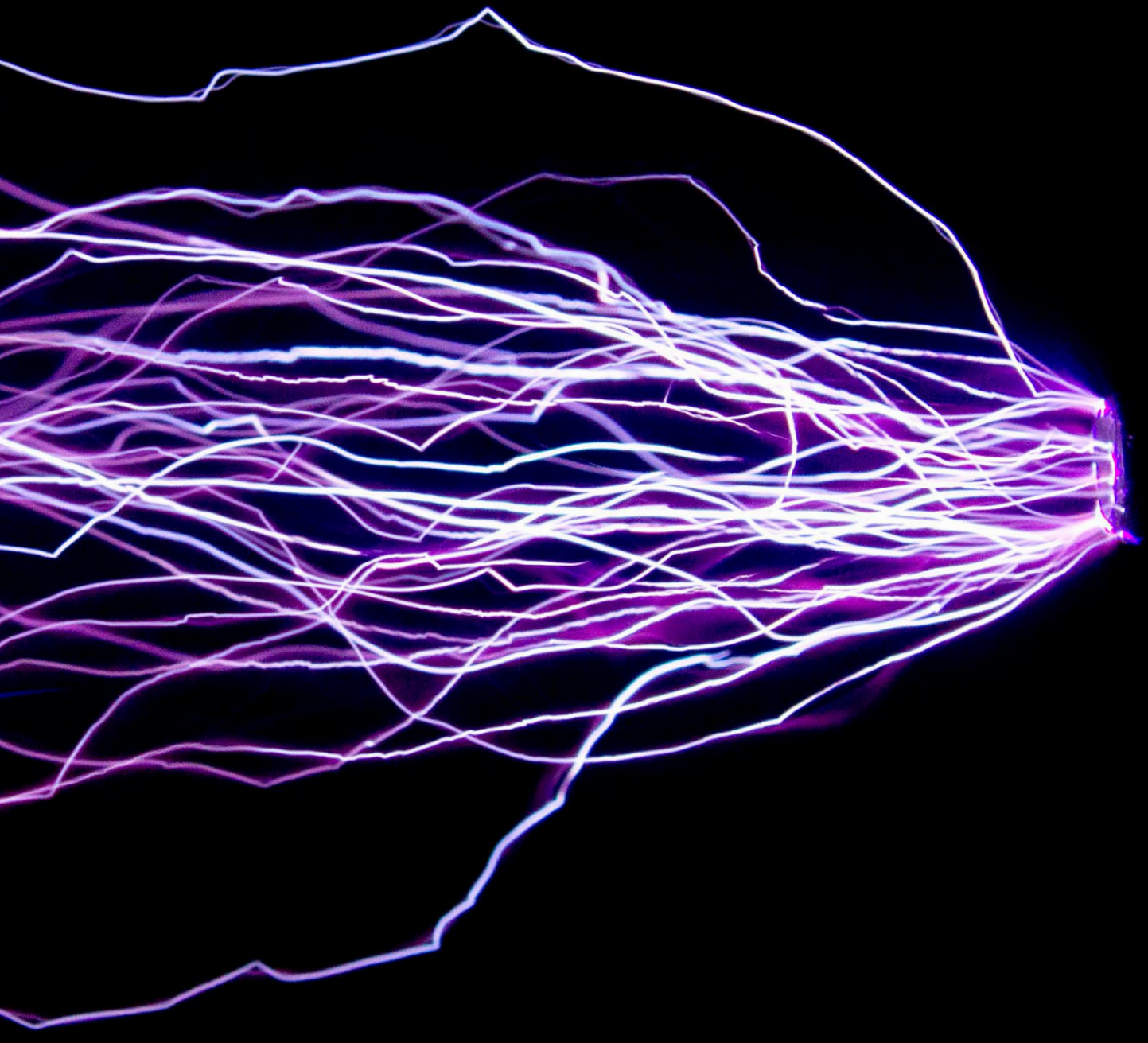


electrical potential is high enough to cause discharge through the dielectric liquid. This test is used to evaluate a liquid's ability to withstand electrical stress and can be performed for accepting new insulating liquids or evaluating in-service insulating liquids. The test is performed using a test cell with two electrodes spaced with a predetermined gap between them.

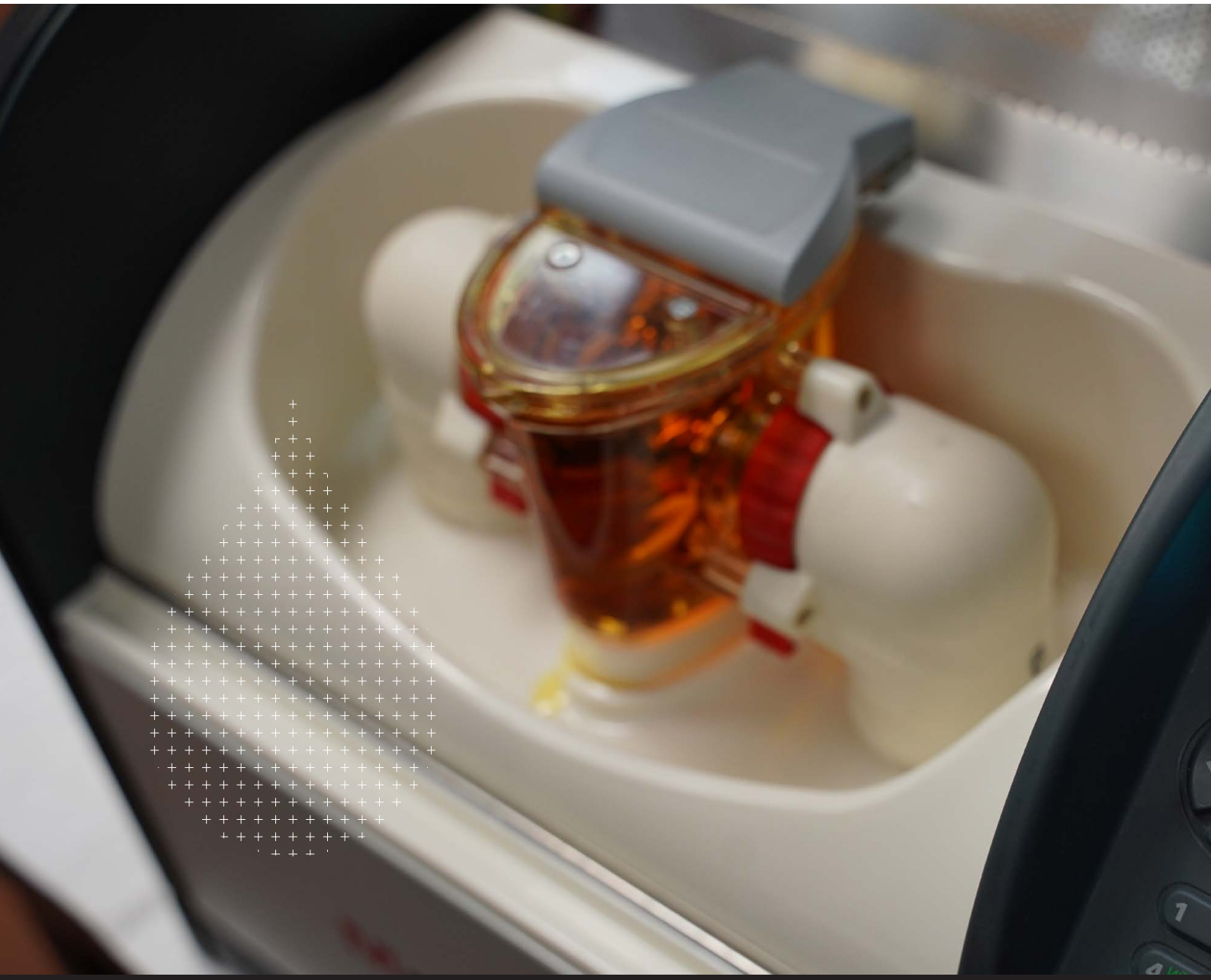
A sample of the liquid being tested fills the test cell, and the two electrodes are subjected to a steadily increasing electrical potential until there is a discharge through the liquid from one electrode to the other. The voltage level at which the breakdown occurs is recorded as the test result and compared to acceptable levels. There are different methods based on which test standard is used (D877, D1816, or IEC 60156, more on these later). The standard defines the test method and parameters required to conduct each test. These parameters are the rate at which the test voltage is increased, the size and shape of the electrodes, the gap size between the electrodes, how many times the test is repeated, and whether or not the liquid is stirred during the test.

2

Why should you perform dielectric breakdown voltage testing?

For in-service transformers, the dielectric breakdown voltage test is one way to detect contamination in the liquid before it leads to a catastrophic failure. Contamination of the liquid due to such things as fibers from the solid insulation, conductive particles, contamination by foreign matter, dirt, and water can affect the dielectric breakdown voltage. When done in conjunction with other tests, the test results can help you assess a transformer's overall reliability and lifespan.

The test can also be performed on new, reprocessed, or reconditioned insulating liquids before being used to fill equipment. Acceptable test results are necessary (but not sufficient by themselves) to ensure that the liquid was stored and transported properly.



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Which types of insulating liquids can be tested?

For a long time, our industry has used the generic terms "oil" or "fluid" when referring to a transformer's insulating liquid. Regardless of which type your transformer contains, each is subject to contamination, the presence of conductive particles, aging, and moisture. There are five common insulating liquid types found in transformers.*
They include:

- Mineral Oil
- Silicone Fluids
- Natural Ester (vegetable oil) Liquids
- Synthetic Ester Fluids
- High Molecular Weight Hydrocarbon (HMWH) Liquids

Note: This list represents broad categories of the most common liquid types. Additional types can be tested but are relatively rare. Consult a transformer specialist if you have questions.

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4 How often should I test for dielectric breakdown voltage?

Dielectric breakdown voltage testing should be essential to your regular transformer maintenance and reliability program. It is recommended that your insulating liquid is tested at least once a year, with the test results being recorded to track trending results. Understanding the trend of your data will help you identify sudden or unexpected changes and plan accordingly with preventative maintenance actions.

5 What are the different test standards?

ASTM D877 – The D877 method uses two flat disk electrodes with sharp edges spaced 0.10 inches (approximately 2.54 mm) apart. The rate of voltage increase is 3,000 volts per second. D877 has limited use in measuring water contamination in insulating liquids because it is not sensitive to moisture at saturation levels below about 60%. It is sensitive to contamination by some other materials and to the presence of particles in addition to high moisture levels. It does not do a good job of detecting oxidation decay products.

ASTM D1816 – The D1816 method has been used by many standards organizations to replace the D877 method as both a new liquid test and as an in-service liquid test because the VDE electrodes more closely resemble the geometry of conductors

inside operating electrical equipment and because the test is much more sensitive to moisture and cellulose particles. There are two possible gap settings for the electrodes: 1 mm (approximately 0.04 inches) and 2 mm (approximately 0.08 inches). The rate of voltage increase is 500 volts per second. A difficulty with this method is that it is also sensitive to dissolved gases, which may not present any operational problem at levels that affect the test. So, while an acceptable D1816 value can be interpreted as an indication of normal operation, a questionable or unacceptable value may not automatically be interpreted as a definite sign that something is wrong.

Further investigation would be required.

IEC 60156 - Standard 60156 uses electrodes that are similar geometrically to the VDE electrodes used in ASTM D1816. The spherical electrodes are spaced 2.5 mm apart, and the rate of voltage increase is 2,000 volts per second. The method in Standard 60156 allows the optional use of an impeller, operating similarly to the one used in the D1816 method, except that it operates at 250 to 300 rpm. The IEC method also allows the use of a magnetic stirrer operating at a similar rate if there is no significant chance that magnetic particles will be removed from the liquid.

The presence of magnetic particles would affect dielectric breakdown in the transformer, so removing those particles by the stirrer during the analysis would yield unrepresentative values.

For several years, the ASTM D877 test was regarded as the standard way to perform the dielectric breakdown voltage test on insulating liquids for electric power equipment. In recent years, organizations such as IEEE and ASTM have compared it to ASTM D1816 and found that the D1816 test provides more accurate results for determining the dielectric characteristics of liquid inside power equipment.

6

What does a "bad" test result mean?

When we evaluate results outside the acceptable range, the first consideration is to cross reference the results to moisture, liquid power factor, and liquid screen tests to identify possible causes for the depressed dielectric breakdown voltage values. The dissolved gas analysis is also consulted to determine whether the gas content could have depressed the levels outside the acceptable range.

Frequently, we can eliminate moisture, liquid aging, and most types of contamination as probable causes for poor dielectric breakdown voltage results. In such cases, the cause of the results would generally be either excessive gas content or an abnormally high number of suspended particles in the insulating liquid. If gas content is not excessive, the appropriate response is to repeat the dielectric breakdown voltage determination on another sample. If this second sample also has an unacceptable result, a particle count distribution test should be performed using the standard method ASTM D6786. This is generally sufficient to establish the cause of the abnormal dielectric breakdown voltage results.

Invest in Reliability

No single test is sufficient to define all known conditions and provide transformers owners with everything they need to know about the health of their equipment. Because the dielectric breakdown voltage test is all about identifying the presence of contaminants in insulating liquids, it is, however, a critical piece of the puzzle regarding your electric power system's overall reliability and performance.

When gathered over time alongside other essential tests and maintenance activities, transformer owners can use the dielectric breakdown voltage test data to track trends and act when needed. The information you gather helps you predict your equipment's lifespan, reduces the risk of failures, increases safety, and is an investment in your overall reliability. That means less downtime and saving time and money for your organization.

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