

### ***Integrated Partial Discharge Testing and Monitoring Solutions*** **Protecting Critical Assets**

Electrical systems are among the most valuable assets in your plant and can have the biggest impact on your bottom line. Their production and management costs are high, and failures almost always lead to catastrophic losses. Electrical systems are being operated at higher levels, even while systems are aging—which affects both the life and the reliability of the assets.

Today's asset managers are facing the increased challenge of maximizing their aging electrical infrastructure with fewer qualified technical in-house resources, stricter regulatory requirements for worker safety, and shrinking maintenance budgets.

Advances in technology, including the use of Partial Discharge Testing, are giving asset managers new approaches to achieve improved reliability and performance of critical electrical assets.

#### **Benefits**

- Eliminate unplanned outages and lost profit due to system downtime
- Reduce maintenance costs by extending time between planned outages
- Increase availability and operating efficiency through greater system reliability
- Improve risk management and reduce catastrophic failures
- Improve worker safety



### **Partial discharge testing provides asset managers new solutions that maximize the longevity and reliability of critical assets**

Partial discharges (PD) are small electrical sparks that occur within the insulation of medium and high voltage electrical assets. Each discrete partial discharge is the result of an electrical breakdown of an air pocket within the insulation. These discharges erode insulation and eventually result in insulation failure.

According to the National Fire Protection Association (NFPA 70B), the leading cause of electrical failures is insulation breakdown. The National Electrical Code (NEC) states that these partial discharges are the first indication of insulation deterioration. Research from the IEEE Gold Book, Table 36, indicates that cables, switchgear, and transformers suffer the greatest losses from insulation failure.

For more than 50 years, companies have performed Partial Discharge Testing on electrical assets as part of ongoing predictive maintenance programs. Data obtained through Partial Discharge Testing and Monitoring can provide critical information on the quality of insulation and its impact on overall equipment health. Because partial discharge activity is often present well in advance of insulation failure, asset managers can monitor it over time and make informed strategic decisions regarding the repair or replacement of the equipment. These predictive diagnostics help companies to prioritize capital and MRO investments before an unexpected outage occurs.

## ■ Predictive Diagnostics

Partial discharge testing results can help predict future performance and reliability of critical assets, including:

- Cables, splices, and terminations
- Power transformers and bushings
- Switchgear
- Motors and generators

Failures are not limited to service-aged equipment. Acceptance testing on newly-installed equipment builds in reliability right from startup. Acceptance Testing can:

- Verify original manufacturers test data and identify damaged insulation that occurred from improper installation, poor design, and/or poor workmanship during or after installation.
- Identify premature failures and capture baseline data to trend asset health over the asset's life cycle to ensure maximum return on investment.

### Integrated Partial Discharge Solutions

Emerson's Integrated Partial Discharge Testing and Monitoring solutions include both online and offline testing as well as periodic and continuous monitoring of your electrical assets. Depending on your specific operating requirements and application, Emerson can customize a program to best fit your needs. Choose from the following solutions:

- Online Partial Discharge Testing
  - Handheld Survey
  - Periodic Partial Discharge Testing
  - Continuous Online Monitoring
- Ultrasonics
- Offline Partial Discharge Testing
- Tan-Delta
- Very Low Frequency Testing (VLF)

### Online Partial Discharge Testing

Online testing is performed while the equipment is energized at normal operating voltages. The testing is conducted during real operating conditions, under typical temperature, voltage stresses, and vibration levels. It is a non-destructive test and does not use over voltages that could adversely affect the equipment. Online Partial Discharge Testing is relatively inexpensive compared to offline testing that requires interruption of service and production. For critical facilities that operate 24x7, this is the best solution for identifying insulation condition.

<b>Component</b>	<b>% of Insulation Failure</b>
Transformers	84%
Circuit Breakers	21%
Disconnect Switches	15%
Insulated Switchgear Bus	95%
Bus Duct	90%
Cable	89%
Cable Joints (splices)	91%
Cable Terminations	87%

Emerson conducts online periodic testing using a PD Surveyor and a Portable PD test unit with non-invasive sensors. The PD Surveyor is the first multi-purpose handheld device able to conduct the initial pre-screen to identify the critical equipment for testing. Typically only 5 to 10% of medium and high voltage assets will have significant levels of PD activity. This pre-screening will provide the required data to develop an overall test plan to ensure focus on the right assets, minimizing unnecessary spending. The pre-screen also provides a safety check prior to opening panels or performing work.

Once the assets are prioritized, Emerson's test engineers conduct the periodic PD measurements using non-invasive, calibrated PD sensors including High Frequency Current Transformer (HFCT) sensors, Transient Earth Voltage (TEV) sensors, or Airborne Acoustic sensors. These sensors are inductively, capacitively, or acoustically coupled to the equipment to provide online PD testing while the equipment remains energized. Each point of attachment is tested for just a few minutes, enabling a large number of assets to be tested quickly and easily. The technology can also provide conventional offline partial discharge measurements in accordance with International Electrotechnical Commission (IEC) requirements. Emerson's advanced test application captures the partial discharge signals synchronously across the 60Hz power cycle, allowing the test engineer to observe phase-related patterns of discharge—online and in real-time. Emerson's analysis application provides an automatic PD "criticality" level based on magnitude and number of PD pulses per power cycle. The PD reader uses easy-to-understand, knowledge-based methods to provide PD pulse discrimination regarding source of partial discharge (cable, switchgear, etc.) while automatically pre-sorting electrical "noise" pulses. The application also includes an automatic RF noise reduction function.

*If PD testing was not available, we would have no proof of cable damage and would have only one option of systematic cable replacement, which with limited funding, would probably be put off until a catastrophic failure occurred. The impact would cost us four to five times that of replacement and repair during a planned outage.*

—Ted Trimmer, Electrical Shop Supervisor  
Colorado School of Mines



### Permanently Mounted Sensors

For “hard to access areas” or areas that pose a safety concern, you can use permanently mounted sensors for periodic online PD detection. These HFCT sensors are installed by Emerson engineers and remain on the equipment for online access and diagnostic information. Often, these sensors must be installed during an outage or plant downtime. Once installed, no further outage or disruptions are required for online testing.

### Periodic Partial Discharge Testing

Sometimes, you may need to conduct continuous monitoring over a short period. A portable PD Monitor can be used to perform continuous monitoring from one hour up to three months. Through continuous monitoring, Emerson will trend your assets over a longer period of time to provide a more accurate assessment and recommendation. This solution is less expensive than installing a permanently-mounted PD monitoring system.

### Continuous Online Monitoring

For your most critical assets that have demonstrated high levels of partial discharge, including those that are nearing the end of their life, continuous online PD monitoring may be the answer. Measure and analyze data on your electrical assets and provide remote access via LAN or modem to deliver continuous and accurate data on the condition and capability of the equipment. Continuous monitoring will also provide timely alerts to maintenance and will identify impending failures before an unplanned shutdown occurs.

### Ultrasonics

When problems occur in medium and high voltage electric equipment, such as partial discharge and corona, it will produce sound waves that can be detected by Ultrasonic testing. Performed without disrupting plant or facility operations, Ultrasonic testing is a non-destructive, non-invasive predictive maintenance tool. Because it maintains insulation integrity, it is commonly employed in applications such as cable terminations, switchgear, busbars, and transformers. Ultrasonic measurement is most powerful on a comparative basis and can significantly increase the reliability of partial discharge detection when used with other Emerson partial discharge testing technologies.

### Offline Partial Discharge Testing

Offline Partial Discharge Testing offers a significant advantage over other technologies because of its ability to measure the cable system’s response to a specific stress level and predict its future performance without causing a fault. Offline testing is also known for its ability to pinpoint the exact defect location on field-aged equipment, enabling the asset manager to accurately plan for maintenance and repair. The challenge with offline testing is that the equipment must be taken offline and out of service. Offline testing is also commonly used in acceptance testing on newly-installed cables. When de-energization is preferred, Emerson can conduct offline testing as part of your predictive maintenance program.

### Tan-Delta Testing

Dissipation Factor (Tan-Delta) is one of the most powerful offline nondestructive diagnostic tools used to monitor the condition of extruded cable insulation. Capacitance and Tan-Delta values from new insulation are used as benchmark readings. By comparing periodic readings of the capacitance and Tan-Delta of your insulating material with the benchmark readings, you can measure the deterioration of the insulation, predict the life expectancy, and plan maintenance and repairs before an unexpected outage occurs. A significant advantage of Tan-Delta testing is the ability to detect water trees—a major source of insulation failures in aged, extruded cables.

Tan-Delta testing can be performed during the manufacturing process. The testing frequency depends on the rate of change of the insulation quality, history of past failures, environmental conditions, etc. High levels of environmental moisture, elevated temperature, and chemicals or pollution may require more frequent testing. Emerson's test engineers can help you evaluate your requirements and establish a program that best meets your needs.

### Very Low Frequency Testing (VLF)

VLF AC Hipot testing was developed in the early 1980s as a substitute for DC Hipot testing. DC Hipot testing is no longer an acceptable test method for field-aged extruded cables because of its destructive nature and inability to determine insulation quality. Although VLF testing is primarily used to perform hipot or withstand testing in cables, it is also suitable for testing transformers, switchgear, rotating machines, and other electrical assets, and is frequently used as a voltage source for offline testing. A VLF hipot test is a go/no-go test and is not a diagnostic test, but is one of the best ways to check the AC integrity of an electrical asset to determine a pass or fail result. Similar to offline partial discharge testing, the challenge of this test is that the equipment must be taken out of service.

### Technology Alone Doesn't Get the Job Done

While technology is important, experience has shown that technology alone won't get the job done. That's why at Emerson, we combine technology with expertise and work processes, striking an effective balance between all three.

Regardless of which solution is best for you, Emerson's proven Partial Discharge Testing and Monitoring process will ensure that your program is executed effectively to ensure the results you need—improving your bottom line.

Each Partial Discharge project begins with the initial job walk and evaluation of the current electrical single-line drawing. If an up-to-date single-line drawing is not available, Emerson can help you develop one.

Next, a Handheld Survey evaluates your electrical assets to identify the critical equipment. This pre-screening provides the required data to develop the overall test plan that includes a solution recommendation based on your operating conditions and application. Upon approval, onsite testing is scheduled and data acquisition is conducted in accordance with the test plan.

Once all the measurements have been taken, we perform offsite data analysis to correlate measurements to the single-line drawing and analyze actual PD signatures. Results are documented as a written report, with a summary outlining the work scope, findings, recommendations, and a proposed follow-up testing schedule. Test results, graphs, and signatures are also included for trending purposes.

### Maximize Uptime

Partial discharge testing plays a critical role in determining the health of your electrical assets and ensuring maximum uptime. It also provides asset managers with the critical information to target maintenance resources to the areas that require the most attention.

Depending on your specific operating requirements and application, Emerson can help you develop and implement the right combination of technology, online or offline, to meet your maintenance requirements. Improve operational efficiency and worker safety by working with the experts at Emerson.

### Ordering Information

To learn more about this service and other High Voltage Maintenance solutions, please contact your local High Voltage Maintenance sales representative office.