Loss prevention standards

Electrical Maintenance:

Partial Discharge Testing and Monitoring

Guidance for organisations on partial discharge testing as part of a robust electrical preventative maintenance schedule.

AVIVA

Electrical Maintenance: Partial Discharge Testing and Monitoring

Introduction

Electrical systems are critical to the continued activities of most equipment and buildings and without an adequate electrical supply, the majority of machinery and equipment will cease to operate. However, from the moment an electrical system is installed it is ageing and performing essentially invisibly within insulation and behind enclosures and cabinets. What is the impact of wear, electrical balance, loading and cycling, temperature, moisture, and other environmental conditions, etc. on the system and the insulating materials?

As a result, there are many variables, tools and devices used to monitor whether a system is operating as intended. Partial discharge (PD) testing is one such technique. It is a non-destructive technique/tool that should be considered alongside other measures and as part of a comprehensive electrical maintenance programme for medium voltage (MV) and high voltage (HV) electrical systems.

What is a Partial Discharge?

A partial discharge is defined by International Electrotechnical Commission (IEC) 60270: 2000 + AMD1:2015 CSV High-Voltage Test Techniques - Partial Discharge Measurements, as "*a localised electrical discharge that only partially bridges the insulation between conductors and which can or cannot occur adjacent to a conductor*". It is evidence of a fault or deterioration within the electrical insulation.

Partial discharge activity generally relates to medium and high voltage electrical systems and equipment and in simplistic terms, describes an electrical discharge within or across an area of electrical insulation. Examples of the materials and equipment that may be affected by partial discharge activity include:

- Cables and accessories, e.g. terminations, joints, etc.
- Switchgear
- Transformers (oil filled and dry)
- Bushings
- Motors
- Instrument transformers
- Generators
- Capacitors

Why Does Partial Discharge Activity Occur?

Partial discharge occurs in electrically stressed insulation materials or mediums. It usually arises and further develops from a defect of the electrical insulation material or medium, whether gaseous, liquid or solid, for example due to:

- Manufacturing defects or imperfections with the original equipment
- Poor workmanship associated with the electrical system and/or equipment installation and/or commissioning
- Poor maintenance of the electrical system and/or equipment
- Natural deterioration of materials due to age/lifecycle
- Damage to equipment during usual service life
- Voltage stresses whether through normal or increased loads
- Contaminants in insulation materials or mediums

The defect, in whatever form, effectively compromises the breakdown strength of the surrounding insulation material or medium and the resulting partial discharge activity could be:

- Through a gas-filled void in a solid insulation
- Across the surface of an insulation, commonly referred to as ‘tracking’
- Within a gas bubble in a liquid insulation
- Around an electrode in a fluid/gas, commonly referred to as ‘corona’

Effects of a Partial Discharge

Partial discharge activity is widely regarded as a significant cause of failures associated with medium voltage and high voltage equipment and systems.

The partial discharge activity is typically localised, it may be repetitive and will always continue to occur leading to mechanical, thermal and/or chemical change and damage to insulation materials or mediums.

Over time, the continued and progressive deterioration of the insulating media could ultimately result in the sudden and catastrophic loss or failure of the electrical system and/or the equipment. As a consequence of this, significant interruption to business-critical systems and operations can occur.

Identifying Partial Discharge – Test Methods

Partial discharge activity is identifiable. The basis for partial discharge testing is to ensure that the test method employed is reproducible and that the results obtained are comparable. This enables accurate trending and condition monitoring of the materials or equipment concerned.

Partial discharge testing can be conducted in either a ‘conventional’ (offline) or a ‘non-conventional’ (online) way, and the techniques used are non-destructive and non-intrusive.

Offline testing can initially be undertaken by equipment manufacturers to establish a partial discharge condition baseline, as well as forming part of manufacturing quality controls and inspections.

Offline field testing typically requires that the materials or equipment subject to the test are taken out of service/disconnected to allow a controlled external electrical supply to be introduced. Depending on the field-specific circumstances, this could prove problematic where business-critical systems cannot be readily isolated without causing operational disruption.

Online testing is undertaken in the field and allows equipment to remain in service. Various technologies and sensors can be used to monitor partial discharge activity online, by identifying for example:

- Transient earth voltages (where the partial discharge generates spikes)
- Ultrasonic/acoustic emissions (where the partial discharge emits soundwaves)
- Electro-magnetic fields (where the partial discharge emits radio-waves)

Both offline and online testing can be undertaken at the commissioning stage of the installation/equipment and subsequently as part of future condition monitoring. Permanent sensors/devices can also be installed for continual monitoring, which can notify users in real-time of any partial discharge activity and changes.

Alternatively, or in addition to, periodic sample testing can be completed. The results can be compared with historical records to help identify any partial discharge activity and any associated change/deterioration in the condition of the electrical equipment or systems.

The Benefits of Partial Discharge Testing

Partial discharge testing and condition monitoring is an incredibly valuable tool to help minimise property damage and business impact. It can establish the presence and location of any partial discharge activity and through subsequent monitoring (whether on a periodic or a continuous basis), the potential for faults, breakdowns, failures, etc. can be identified, monitored, and repaired prior to a possible catastrophic failure.

This in turn allows a more predictive approach to maintenance to be developed, targeting assets and systems through preventative maintenance of business-critical electrical systems and equipment. As a result, this can help avoid unplanned outages, equipment failures, reactive maintenance and the associated business costs and disruption directly from this or any escalating event.

Further benefits of partial discharge testing and condition monitoring may include:

- Benchmarking and in-depth analysis of assets and equipment
- Potential for extended service life of electrical equipment and systems versus routine replacement
- Management of ageing assets based on real data
- Reduction in downtime associated with inspections – as it can be done online
- Improved inspection capability, particularly where physical access may be an issue
- Helping to manage maintenance budgets and the identification/holding of spares
- Preventing ‘knock-on’ damage for the sudden shock of a catastrophically failing electrical supply
- Improved operational safety and reduced operator exposures
- Reduced exposure from fire
- Reduced potential for associated business interruption losses

Note: The Electricity at Work Regulations requires: "*electrical equipment, which includes switchgear, for use at work to be constructed, maintained and operated in such a way as to prevent, so far as is reasonably practicable, danger. People who work on or near to electrical equipment, and those responsible for managing such work activities, must be suitably competent for the activity to be undertaken*".

Whichever identification method is employed (which could be a combination of both offline and online to suit site specific requirements), partial discharge testing and monitoring should be considered as an extension to and another tool in the testing, inspection, and maintenance programme of electrical equipment. This could be considered alongside other well accepted electrical loss prevention techniques such as thermography, dielectric fluid testing exercising circuit breakers, etc.

Who Should Consider Partial Discharge Testing and Associated Condition Monitoring?

Ideally, one would recommend that everyone with a medium voltage or high voltage electrical system should consider testing to identify partial discharge activity. In reality, this type of maintenance activity should be considered following formal risk and business impact assessments, where the exposure to electrical failure is considered too great for the business. Some examples of occupancies and instances which may suggest that this testing may be beneficial, include:

- Where the integrity of the electrical supply is critical
- Sites with older electrical systems or where the electrical systems and insulating media could be exposed to damage, high temperatures, high moisture, etc.
- Sites with a history of electrical failures
- Utility companies
- Hospitals or those facilities with life-supporting functions
- Cold storage facilities
- Companies that operate 24-hours per day and cannot simply switch their production activities off
- Sites where electrical failure would have a large business impact including an organisation's supply chain/product portfolio
- Regional or national distribution centres
- Sites where the occupancy has changed from one industry group to another
- Sites that have been idle/obsolete for a significant period of time and then plan to reopen
- Sites with large property values

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Sources and Useful Links

Health and Safety Executive (HSE) Publications:

- Keeping Electrical Switchgear Safe – HSG230
- The Electricity at Work Regulations 1989 – HSR25
- Electrical Switchgear Safety: A guide for owners and Users - INDG 372

Additional Information

Relevant Loss Prevention Standards include:

- Electrical Installations – Inspection and Testing
- Thermographic Surveys

To find out more, please visit Aviva Risk Management Solutions or speak to one of our advisors.

Email us at riskadvice@aviva.com or call 0345 366 6666.*

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