

InsulGard™

Continuous online discharge measurement

Optimise your electric power availability by online discharge measurement



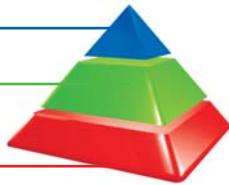
Eaton - Electrical Services & Systems

Eaton - Electrical Services & Systems (E-ESS) portfolio and scope of work has expanded beyond repair and maintenance of in-house group product on utility networks, to complete turnkey power distribution projects, for both electricity supply companies and large industrial conglomerates, indeed any body with an electrical HV/LV distribution network. In many instances we carry out projects in close co-operation with the clients in-house or designated specialist contractor.

E-ESS has been providing specialist service activities for Eaton low and medium voltage systems for many years. Commissioning, testing, maintaining, modernising and repairing virtually all types and models of switchgear is our day-to-day work, as is the supply of specifically designed, customized work.

E-ESS is a solution-oriented, driven business, we are motivated and keen to ensure our consistently high and professional levels of service fulfils and exceeds our customers expectation for safety, reliability and cost effectiveness.

- Asset management and optimisation
- Reducing operational and energy costs
- Optimising reliability and safety
- Installation of new systems
- Maintenance and support existing systems



The E-ESS pyramid

In order to arrange the large number of diverse service activities logically, we have incorporated them all in what we refer to as the E-ESS pyramid. The pyramid is built up in 3 layers. Each layer contains a number of specific service activities divided into product groups with the same type of added value for the customer.

InsulGard™: online discharge measurement

The introduction of InsulGard brings with it a new facility for condition-dependent maintenance. InsulGard is a continuous online discharge measurement facility suitable for medium-voltage applications:

- Switchgear
- Busbar ducts
- Large Power Transformers
- Generators
- Motors

Changes occurring in the insulation within systems are the most significant causes of electrical failures. InsulGard monitors insulation 24 hours a day, such that any changes are detected immediately. From now on systems need not be taken out of service for insulation tests. InsulGard is an inexpensive solution for often unnecessary downtime and rigid time based maintenance routines.



InsulGard benefits

Very high accuracy

Innovative InsulGard technology guarantees extremely accurate detection of partial discharges. InsulGard is the first predictive maintenance system that can prevent a forced outage and demonstrably increase the reliability of your systems.

Partial discharges measured live

Traditional methods for tracing partial discharge require the system to be taken out of service. Moreover, the damage has to be severe for it to be noticeable. The InsulGard system enables you to detect partial discharges online, even if these discharges are minor.

Easy to implement

InsulGard is a stand-alone system although it can also be built in. The measured data generated by InsulGard can be read out on the spot or transmitted to a computer where an in-depth analysis can be carried out with the InsulGard software specially developed for this purpose. You can use it to interpret and analyse the data.

Cuts maintenance costs and reduces outages due to maintenance

Routine preventive maintenance is an absolute necessity if you cannot determine the status of your equipment online. But why take your systems out of service when maintenance may not be necessary? InsulGard enables you to monitor and track partial discharges and then carry out appropriate maintenance at the right time. This will save on maintenance costs.

Improved planning for outages and maintenance

There is a growing overall trend from preventive to condition-dependent maintenance. InsulGard can help with strategic planning for your maintenance and repair activities.

Your system in expert hands

The E-ESS Predictive Diagnostics department has studied numerous cases of partial discharge on rotating machinery and switchgear. A great deal of experience has been built up in the intervening period on determining the seriousness of the fault, enabling guidelines to be issued for your situation.

Contracting out or doing it in-house

If so desired, you can also subcontract all monitoring, interpretation and analysis of the measured data to our Predictive Diagnostics department. We can also train your personnel to carry out this analysis themselves.



Methods of protecting electrical systems?

Trip relays protect against short circuits and overcurrents. Although they can limit very serious damage, they cannot prevent the cause of the failure. The greatest damage occurs in the first half-cycle. InsulGard is the first predictive relay system that helps you prevent a forced outage. It represents a quantum leap in increasing system uptime and reliability.

How Does InsulGard Work?

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The InsulGard system consists of a number of sensors and a monitor. The monitor can be used as a stand-alone relay or it can be wired so that it can upload data remotely to diagnostics personnel.

Detecting partial discharges

Although sensors many differ according to the application, they are all designed to detect partial discharges. This is the basis behind InsulGard technology! The term partial discharge hardly requires any explanation. It is the common name for small electrical discharges (arcs) that occur within the insulation or from one insulation material to another. Partial discharge is also referred to as corona or tracking. The visible evidence of partial discharge is a white, powdery residue, which is typically found on the ends of motor or generator windings. Tracking damage appears as jagged dendritic lines which can be encountered on switchgear, cables and busbar ducts. Partial Discharge is caused by poor insulation. Minor arcing activity on the surface of the insulation can lead ultimately to full connection.

Detection using radio frequency

The relay detects and analyses the radio frequencies emitted by the partial discharges and picked up by the sensors. InsulGard focuses on the 1 MHz to 20 MHz bandwidth range where the majority of partial discharge activity can be detected. If partial discharges are detected in a system, they could be an indication of insulation problems. A trend can also be established from the measured information. InsulGard makes a prediction which makes condition-dependent maintenance possible. Since monitoring takes place online, changes in the condition of the insulation will be noticed at once.



Corona damage to motor windings



Tracking on a busbar duct



Where can InsulGard be used?

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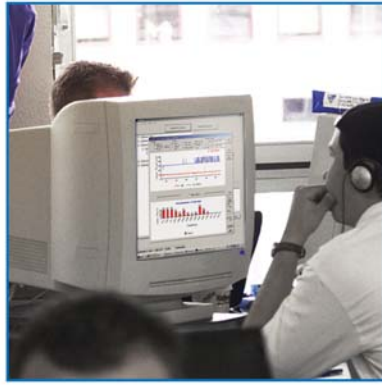
The InsulGard monitor operates at the heart of the Partial Discharge (PD) surveillance system. This monitor is the most important component in the entire surveillance system. There are just a few internal circuitry differences, depending on whether you want to monitor switchgear or rotating equipment. These differences lie in how the sensors are used. Each sensor has been designed for use in combination with the InsulGard monitor. InsulGard sensors can also be used in combination with existing temperature sensors, RTDs (Resistive Temperature Devices) in generator and motor windings.

Generators and motors

The InsulGard system is available with a variety of sensors for motors and generators. One of these is the RTD module which connects to existing Resistive Temperature Devices (RTDs) already embedded within the windings of the generator or motor. Another sensor that checks for partial discharges is the coupling capacitor which is used on the cable side. A third sensor, ideal for generators and motors, is the RFCT (Radio Frequency Current Transformer). The RFCT is fitted around the machine cable screening. The sensors are connected individually or combined to the InsulGard system.

Partial discharges and other variables such as humidity, load and temperature are monitored and saved for analysis. Analysis of partial discharges can provide you with the following information about your rotating machinery:

- Detection of the early stages of insulation deterioration
- Discharges in gaps between windings
- Corona on end windings



Internet
Intranet
Extranet

Coupling capacitor



RTD module
Resistive temperature sensor for
motors and generators



RFCT
Radio frequency Current transformer
for detecting partial discharges



Sensor connection kit for
switchgear





Switchgear

Sensors for switchgear consist of coupling capacitors or a combination of RFVSs (Radio Frequency Voltage Sensor). Coupling capacitors detect partial discharges in a panel and/or panels adjacent to it. These sensors will be fitted to the output side of the supply capacitors or to the main busbars. They are connected to the secondary neutral terminal of the current or voltage transformer. RFCTs measure partial discharges in supply cables and are fitted around the screening of the supply cable. All sensors are connected to the InsulGard system. The same sensors and monitor can be used in power transformers, cable boxes and busbar ducts.

The following partial discharges can be detected in switchgear:

- Discharges in air gaps (between a busbar and its support)
- Surface tracking (on supporting insulator or busbar insulation surface)
- Minor sparking in any insulation casting blowholes
- Insulation problems in cable terminations and connected equipment
- Poor electrical connections (floating potentials)
- Defective current transformers and voltage transformers
- Busbar ducts



BushingGard: for large power transformers

The BushingGard has been specially designed for large power transformers. 84% of defects in large power transformers are due to problems in insulating bushings or the insulation material used. The BushingGard is an online, continuous testing tool designed to monitor bushing insulation integrity on large power transformers. It allows you to evaluate the condition of your equipment at any time, in a cost effective manner.

How BushingGard Operates

Changes in bushing capacitance and power factor are indicative of insulation deterioration. The BushingGard detects these changes by summarizing and balancing the currents of a three-phase bushing set at the time of commission. It then generates a complex calculated number (Gamma). If there's an imbalance, it generates an output signal that is proportional to the relative change in the bushings' currents due to insulation deterioration. The output signal reflects changes in both power factor and capacitance of the monitored bushing set.

Display Panel

The monitor is designed to indicate insulation status in several ways. The display panel has a multi-function LED that will glow a different color depending on the severity of the problem. Alerts are classified in three categories: green (normal), warning (yellow), and alarm (red). The parameters are programmable and the device can be programmed at the panel or remotely through a computer link up (optional). The panel also contains a second multifunction LED to show monitor status: normal (green), setup mode (yellow) or error (red). The unit performs selfdiagnostics to ensure proper operation and will indicate any malfunction locally as well as remotely. Three additional LEDs indicate whether each of three bushings are currently being monitored—given they can easily be taken off line for other testing purposes. The last visual element on the display monitor is an alphanumeric display panel which indicates the actual Gamma reading expressed as a percent change and the location of the phase angle of the imbalanced vector. The phase angle vector will indicate which of the three bushings is defective.



Insulating bushing with capacitive sensor



Communication

The BushingGard is also designed to communicate with a Digital Control System (DCS) or Supervisory Control and Data Acquisition (SCADA) system. Both a warning level alarm and the error status relay will notify the operations center when and if a problem occurs. The BushingGard comes standard with an RS-485 Modbus RTU port so you can communicate with it on site. Or, it is available with a commercial-grade modem for remote communication. Diagnostic software comes standard as part of the BushingGard system.

Bushing Sensors

A three or six bushing sensor set is available with the BushingGard package. A large variety of thread sizes/configurations allow compatibility with virtually all large power transformer bushings. Customized bushing sensors are available with appropriate lead-time. Our standard sensors are designed for bushings with rated voltage of 69 – 500 kV. An optional 800 kV is available.

What the Package Includes

- Three or six universal bushing sensors, mounted on bushing capacitor taps, which condition both the power frequency, capacitance and partial discharge signals to the monitor
- Oil temperature sensor
- The BushingGard monitor
- BushingGard software

BushingGard Allows Partial Discharge Measurements

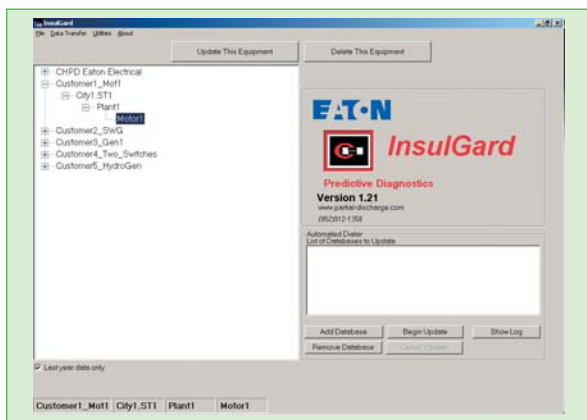
The BushingGard offers a unique and superior testing methodology because it allows you to monitor partial discharge activity in both bushings and transformer using the same sensor set. Like power factor and capacitance changes, partial discharges are also indicative of insulation breakdown. The BushingGard houses six BNC connectors—one for each phase of each winding—which allow connection to an Universal Partial Discharge Analyzer (UPDA). Online periodic monitoring of partial discharge (arcing or sparking) can help provide a root-cause analysis of internal gassing or other discharge activity related to the winding insulation, internal connections, bushings, or magnetic core iron.



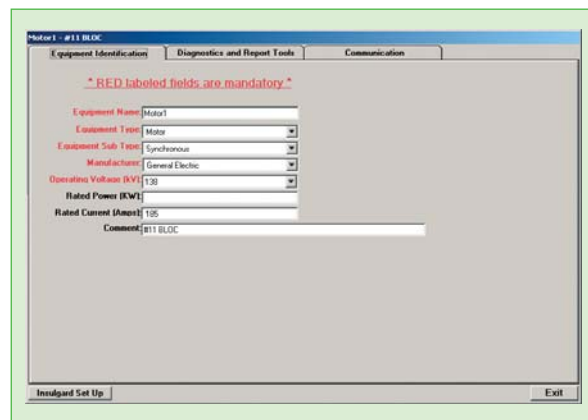
User-friendly software

InsulGard software

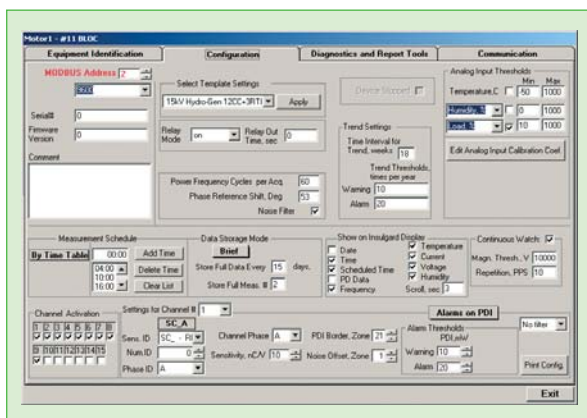
InsulGard software is part of the InsulGard system. The software enables you to examine dynamic data stored by the monitor. You can analyse the condition of the insulation and compare it with the guidelines and parameters laid down by Eaton Predictive Diagnostics department specialists. This department offers a service accessible through the Internet which you can use to compare your systems statically with those of other users who operate similar equipment. Comparison criteria are: model, manufacturer, voltage class, capacity, partial discharges, service life, etc. Condition can be determined and predicted on comparing your PD measurement results with our database and maintenance based on it. This database will not identify customer sites or locations in order to safeguard the privacy of our customers.



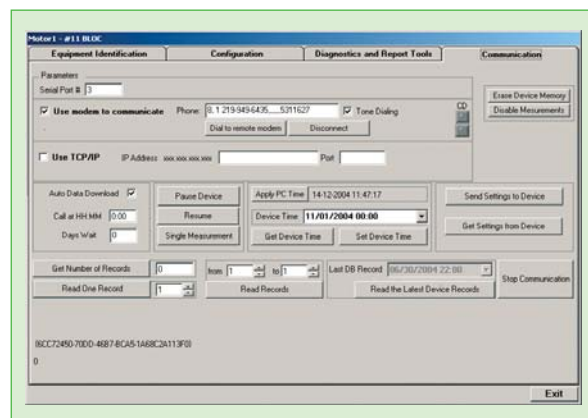
Start-up screen showing the locations where InsulGard units have been installed and descriptions of equipment (motors, transformers, etc.) being measured



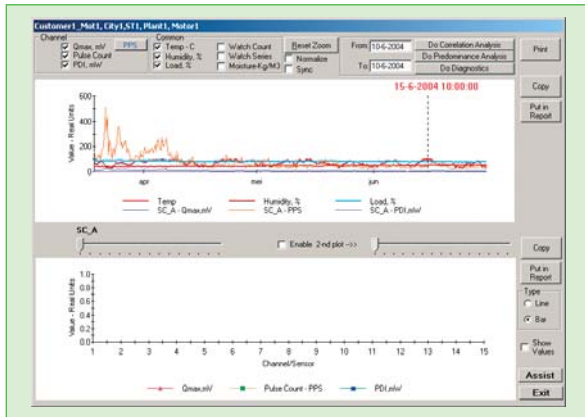
Identification of the system, transformer or machine to be measured



Settings for the various measuring channels are entered in the configuration screen, e.g. the daily frequency for carrying out a measurement



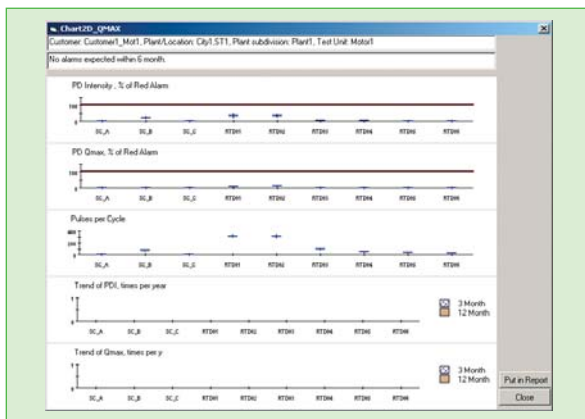
The communications screen contains settings for how communication with an InsulGard unit is to take place (directly using the RS232, through a modem or the Internet)



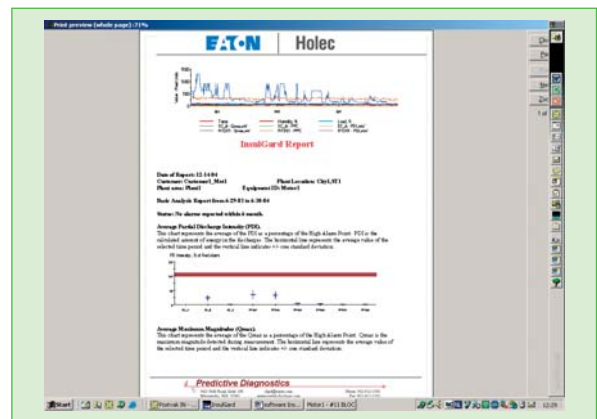
Screen showing values measured against time, such as temperature, relative humidity, load and the extent of partial discharge



Partial discharge measured for each channel



InsulGuard offers a capability to generate alarms in the event of certain limit values being exceeded. This graph indicates the relationship between measured values and limit values



To round off, the software can generate a complete measurement report

What are the alternatives to InsulGuard?

Two of the alternative online methods of detecting partial discharges are acoustic and corona testing. Whilst these methods can estimate the location and nature of insulation breakdown, the metal shielding of most electrical systems limits the precision and hence the value of these tests.

Some off-line tests include insulation resistance, polarisation index, $\tan \delta$, as well as visual inspections. However, these alternatives are expensive, in view of the fact that the systems require to be shut down and specially trained personnel are needed to carry out the tests. This test method imposes unnecessary dielectric loading, which could shorten service life. Traditional test methods will therefore restrict your ability to detect potentially very serious insulation failures.



Technical specifications

Standard outputs:

- Two dead contacts for alarms
- One dead contact indicating system status
- A 4-20 mA output for indication purposes. This is used to indicate the partial discharge percentage relative to the alarm setting (channel with the highest level of activity)
- RS-485 with MODBUS RTU protocol for network environments or remote communication
- Digital display for the unit that cycles through each channel.

Other features:

- The ability to use all types and brands of partial discharge sensors:
 - coupling capacitors
 - radio frequency current transformers (RFCTs)
 - Rogowski coils, radio frequency voltage sensors (RFVS)
 - existing resistive temperature sensors (RTDs)
- Built-in noise suppression algorithms.
- Dedicated noise channel enabling identified noise to be suppressed.
- Individually programmable channels. It is possible to programme a separate level of noise suppression for each channel.
- Programmable channel for continuous monitoring of high partial discharge levels.
- Advanced and user-friendly communications. RS485 with MODBUS RTU protocol. This enables more than one device to use one modem or computer. Local PC communications or remote communications through the industrial modem supplied. Programming and data collection can be done through this link.
- Easy to programme, operate and read out from the front.
- The display can be programmed so as to provide a continuous readout of machine settings and the latest partial discharges.

- Up to 2000 days of data storage, depending on frequency of tests. It is usual for data to be collected four times a day at set times or on the basis of set intervals.
- Storing a complete data matrix.
- Warning as well as alarm levels can be set for each channel.
- Three analogue inputs for measuring characteristic values of machines or switchgear. These might be: current, cos phi, temperature, humidity or other environmental changes that are critical to partial discharges. These inputs can also be used to shut down the InsulGard unit entirely. This will occur if the machine falls outside pre-programmed upper and/or lower limits. This will halt monitoring until the input signal returns to a value within the prescribed limits. This is important because it prevents data stored in the memory from being overwritten unnecessarily.
- User-friendly installation procedure plus complete instruction manual.
- If partial discharge sensors have already been installed, the relay can usually be installed without halting operation.
- The standard power supply is 230V AC 50 Hz.
- Non-volatile memory.
- Frequency range is 25 to 100 Hz.
- Small physical size.
- Can be installed up to 50 metres from sensors without significant signal attenuation.
- A PD matrix with 24 phase windows and 21 discrete amplitude levels for measured data definition.
- Logarithmic input which provides the relay a large dynamic range of 4 to 10,000 millivolts.
- Remote communication available in order to be able to analyse, issue periodic reports and make appropriate recommendations.
- Communications software as well as data base/analysis tools.
- Self-diagnostics. The unit self calibrates before each measurement using a built-in pulse generator. It verifies all analogue and digital components.
- Suitable for ambient temperatures ranging from -50°C to $+80^{\circ}\text{C}$.



Company information

Eaton's electrical business is a global leader in electrical control, power distribution, uninterruptible power supply and industrial automation products and services. Eaton's global electrical brands, including Cutler-Hammer®, Powerware®, Holec® and MEM®, provide customer-driven PowerChain Management™ solutions to serve the power system needs of the industrial, institutional, government, utility, commercial, residential, IT, mission critical and OEM markets worldwide.

Eaton Corporation is a diversified industrial manufacturer with 2006 sales of \$12.4 billion.

Eaton is a global leader in electrical systems and components for power quality, distribution and control; fluid power systems and services for industrial, mobile and aircraft equipment; intelligent truck drivetrain systems for safety and fuel economy; and automotive engine air management systems, powertrain solutions and specialty controls for performance, fuel economy and safety. Eaton has 60,000 employees and sells products to customers in more than 125 countries.

For more information, visit www.eaton.com.

Range of E-ESS Services

- Equipment Erection & Installation - Pre and Final Commissioning
- Technical Studies & Reports; Relay Protection, Earthing, Power Quality, Partial Discharge - On-line Service (Eaton-InsulGard), Design
- Maintenance of HV & LV Systems Networks - Capital Equipment. (All makes and models Non-Destructive, Non-Intrusive Predictive & Conventional Time based)
- Equipment Life Extension - Retrofit Equipment & Accessories including Vacuum Breakers
- Local Operational Site Control - 'SAP's' based on clients sites (SAP-Switching/Safe Systems/Safety Rules)
- Training for Competency and Authorisation of persons
- Power Systems Engineering & Integration (Protection, Control & Automation)
- Supply of Transformers, Erection & Commissioning (Cast Resin, Liquid and Oil Transformers 3.3kV - 132kV up to 500MVA)
- Crisis Response and Disaster Recovery - 24 Hour Call-Out Retainer Contracts and Emergency/Supply Failure

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