

# TURBINE GENERATORS

## *Periodic On-line Partial Discharge Monitoring of Large Turbine Generators*



### ***A User's Perspective:***

*"a 25 year-old generator, rated 700 MW, failed... This failure was found to be the result of slot discharge, since stator bar insulation had been abraded in the slot area. The damaged bars were removed, refurbished and re-installed... The post outage partial discharge tests indicated that the stator was in good condition and that there was little concern for the windings in the other two phases."*

*"We have not found another test method that produces as much decision support data for generator stator maintenance planning based on actual in-service insulation condition... Analysts were able to recommend the needed corrective maintenance before either of the maintenance outages began."*

# TGA-S™



## PERIODIC ON-LINE PARTIAL DISCHARGE MONITORING OF LARGE TURBINE GENERATORS

### *TGA-S: The Instrument of Choice for On-Line Partial Discharge Monitoring of Motors and Turbine Generators*

- The test enables predictive maintenance on motor and turbine generator stator windings, resulting in the increased availability and extension of operating life.
- The technique was introduced more than a decade ago and has since been used on over 1000 turbine generators to identify deteriorated stator windings.
- The method is non-destructive and based on sound scientific and empirical principles.
- Recommended by manufacturers and industry standards such as the IEEE std. 1434-2000.

The monitoring technique is based on the application of Stator Slot Couplers (SSCs), resulting in a high frequency measurement range and a favorable signal-to-noise (S/N) ratio. This enables the automatic separation and recording of both partial discharges and noise, so that test results can be easily interpreted.

The most common method of monitoring large turbine generators involves using a portable instrument with multiple sets of permanently installed SSCs. The instrument is controlled by means of a computer and includes Windows™- based control and data display software.

Alternatively, continuous monitoring systems are available from Iris. They can be integrated with plant SCADA and facilitate remote monitoring.

### THE TURBINE GENERATOR ANALYSER (TGA)

Iris Power Engineering, and Ontario Hydro developed the TGA-S test with funding from the Canadian Electricity Association. The method enables the detection of stator insulation problems and, it was specifically designed to monitor partial discharges under normal operating conditions, i.e. normal electrical, mechanical, thermal and environmental operating stresses. The readings are not affected by normal external interference (or noise) such as power system corona, output bus arcing or other sources. The tests are typically performed semi-annually and take about 30 minutes per generator.

### THE STATOR SLOT COUPLER (SSC)

SSCs are permanently installed in the stator windings during a scheduled outage or during generator manufacturing. The SSC is a broadband antenna customized to detect the true partial discharge pulse shapes and the direction of propagation. Consequently the TGA-S system can classify the sources of partial discharges and separate electrical noise, thereby avoiding the risks of false indications. SSCs are installed under the stator wedges, or between the top and bottom bars of the line-end coils of the generator.

The SSCs are connected with micro-coaxial cables to an external termination box. Hydrogen-cooled turbine generators are fitted with gas-tight connectors, or a standard Iris penetration.



Stator Slot Coupler Installation

## THE TGA-S TEST PROCEDURE

With the generator operating under normal service conditions, the operator connects the TGA-S instrument to the previously installed coupler termination box and to a portable computer running the Iris software. The magnitude, phase position and number of partial discharge pulses emanating from each coupler are then recorded and can be viewed immediately, or stored for a subsequent analysis. The results presented to the user include:

- Graphs depicting the nature and severity of particular insulation aging mechanisms.
- Trend curves highlighting the progression of these mechanisms over time.
- Statistical values which can be compared with historical databases of similar generators.

In most cases, the assessment of the condition of stator winding insulation, based on the on-line partial discharge measurement, can be performed independently by the user after a short training course. Iris can also assist the user with result interpretation using its unique database of over 20,000 results collected over a decade on generators of all makes and sizes.

## INTERPRETING TGA TEST RESULTS

The key factor in determining the condition of stator winding insulation is the trend in partial discharge activity. Stable TGA results indicate slow deterioration, while a doubling or tripling of the partial discharge activity over a year, indicates that the winding is deteriorating.

Good stators indicate that partial discharge activity is less than that of a severely deteriorated winding by a factor of ten or more, making it relatively easy for plant maintenance

personnel to determine which machines require maintenance. In large turbine generators, problems such as loose wedges, slot discharge, overheated insulation and polluted windings, are detected by partial discharge testing. Additional problems, namely insufficient impregnation of the winding and grading coating deterioration can also be detected.

## PLANNING PREDICTIVE MAINTENANCE USING ON-LINE PARTIAL DISCHARGE MONITORING

Stator winding insulation problems in both air and hydrogen-cooled turbine generators are one of the principal causes of forced outages, which result in lost revenues. On-line partial discharge monitoring, a proven technique developed by Ontario Hydro and the Canadian Electrical Association, helps to minimize the risks of unexpected stator winding failure. Using permanently installed couplers and a portable instrument, utility plant personnel worldwide have found this method reliable and easy to use.

Since the inception of the on-line TGA-S test, dozens of published case studies by users of this technology have confirmed the following benefits:

- The root causes of stator problems can be identified and often repaired at an earlier stage.
- The monitoring can increase the availability of generators, and can contribute to the extension of the useful life of the unit windings.
- Intervals between generator inspection outages can be increased if the TGA results are good.
- Most stator winding in-service failures can be avoided.

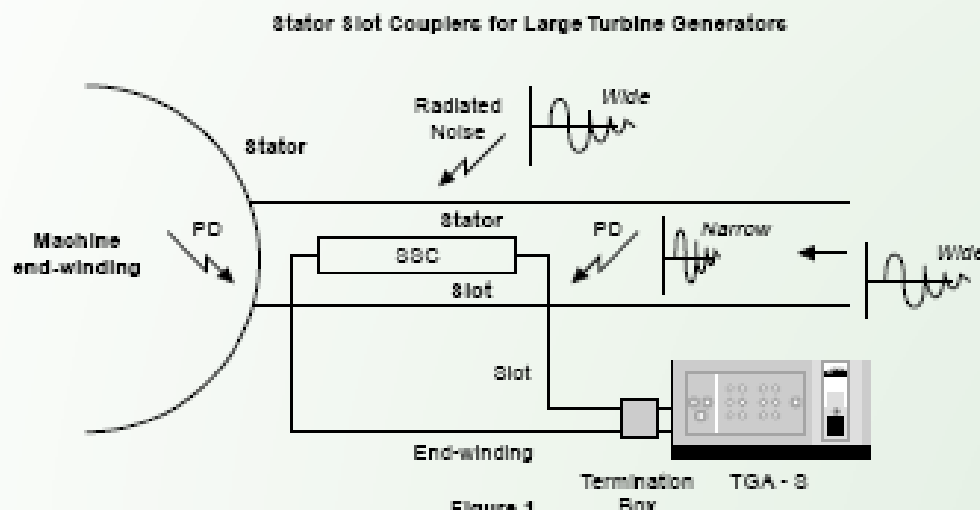
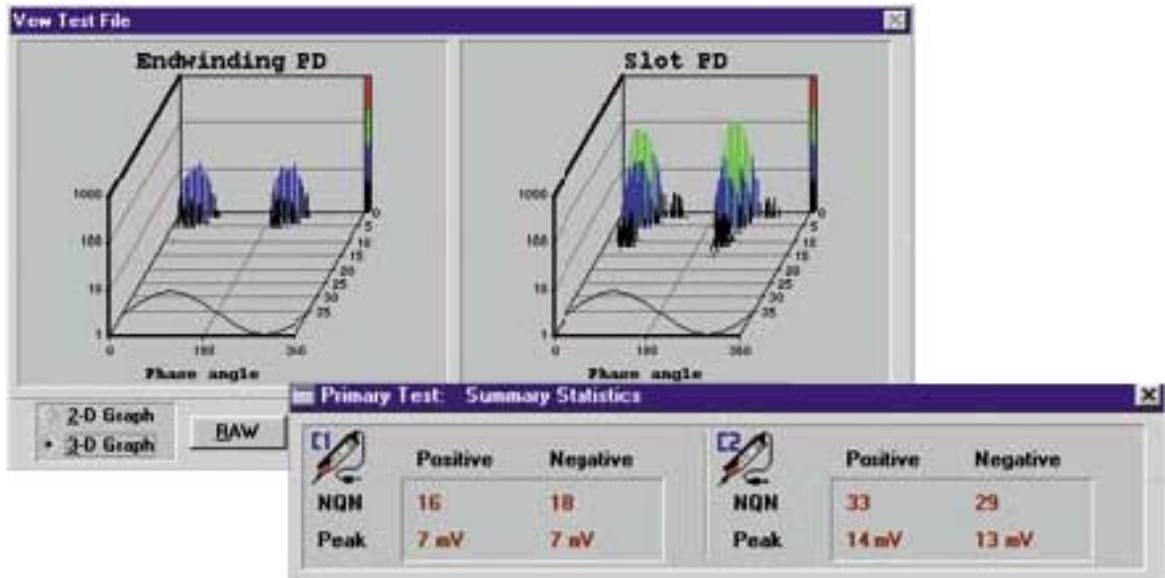


Figure 1

## Stator Winding Deterioration Causes Partial Discharges



### WORLDWIDE INDUSTRY ACCEPTANCE OF ON-LINE PD MONITORING

The partial discharge test has won worldwide acceptance with all major utilities. This general acceptance has been achieved because:

- The test has been proven effective in numerous installations, by identifying generators which require maintenance.
- The test equipment is cost-effective.
- The test is performed on-line and requires no generator shut-down.
- Generator station staff can perform the test with minimal training.