

# Advanced Non-Intrusive Inspection Services

## For Circuit Breakers

Assessing the health of aging fleets of High Voltage (HV) Air or Gas-Insulated Switchgear is a critical step in implementing a condition based maintenance strategy. It helps to make the best decision between repair and maintenance, and to prioritize and plan the actions optimizing expenses. Inspections support the evaluation of the state of the asset thus helping reduce the risk of failure or an unplanned outage.

### GE solution

GE provides a comprehensive set of advanced non-intrusive inspection services including recommendation in the choice of inspection methods, onsite inspections, diagnosis and maintenance recommendations captured in a condition assessment report. Inspection of circuit breaker's internal components through advanced methods, generates accurate reliable data to evaluate the health of the asset.

To ensure a complete, fast and cost-effective measurement and diagnostic, GE offers various advanced methods which do not require the asset to be opened including:

- Digital X-Ray
- Vibration Monitoring
- Dynamic Contact Resistance Measurement
- Ultra High Frequency Analysis

The data generated is utilized to drive maintenance and replacement priorities and to ensure operational continuity.

### Applications

GE's advanced non-intrusive inspection services enable condition assessment of aging High Voltage (HV) circuit breakers from GE and 3<sup>rd</sup> party OEMs including: gas-insulated, live tank, dead tank and generator circuit breakers.

GE's advanced non-intrusive inspection services are applicable to utilities, power generation or industrial applications supporting:

- Fleet Performance Management
- Critical circuit breaker assessment
- Risk evaluation
- Routine maintenance
- Highly demanding application including shunt reactor or transformer protection
- Diagnosis of defect root cause



## Cost Effective

- No or reduced planned outage compared to standard inspection of internal components
- Eliminating unnecessary opening of asset
- Minimizing risk of failure

## Safe and Reliable

- 20% reduction in asset failure thanks to the use of non-intrusive methods
- Eliminating risk of failure during reenergizing
- No risk of SF<sub>6</sub> leakage

## Digitalized Results

- Data is transmitted remotely to expert for analysis
- Centralized data available for asset performance analytics
- Results of asset condition provided in few hours

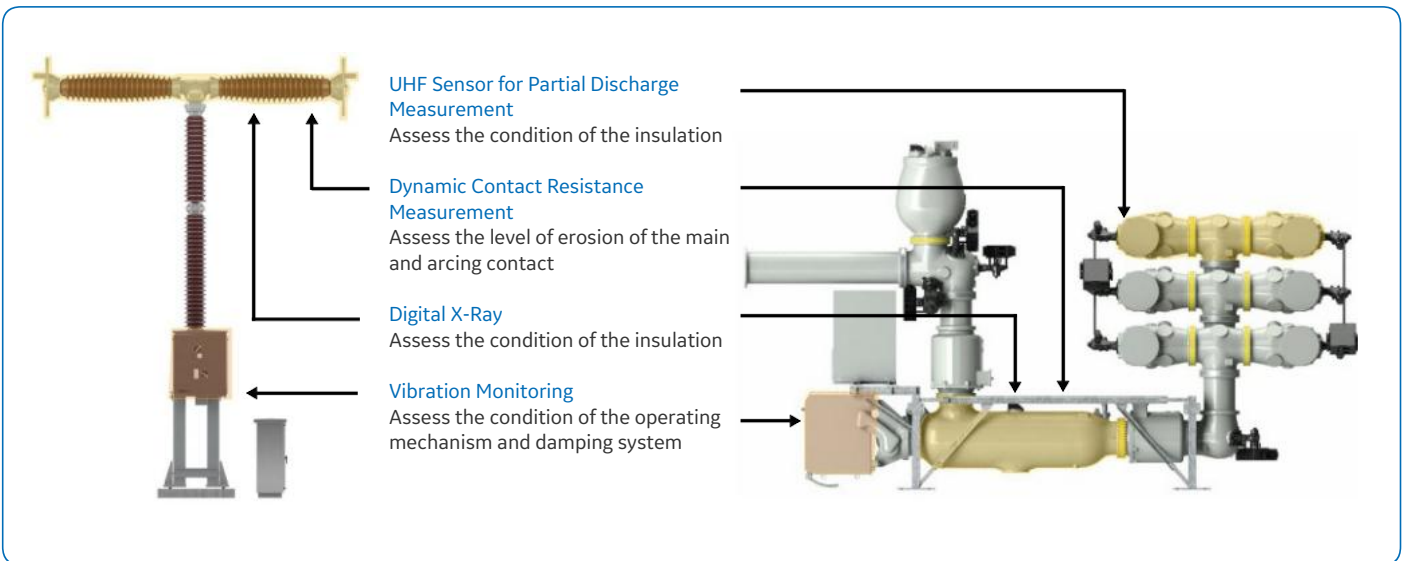
## Proven Methodologies

- Models based on +120 years of expertise in equipment design, manufacturing and service
- Proven experience in diverse industries including rotating machines
- Diagnosis and recommendations delivered by subject matter experts



## Advanced Methods for Non-Intrusive Inspection

The following detailed inspection methods can be rapidly deployed on high-voltage circuit breakers and generator circuit breakers manufactured by GE or 3<sup>rd</sup> Party. The inspections can be applied to indoor and outdoor applications. The same method is used for the assessment of a fleet of heterogeneous assets, simplifying the inspection process.



Advanced Methods for Non-Intrusive Inspection

## Digital X-Ray

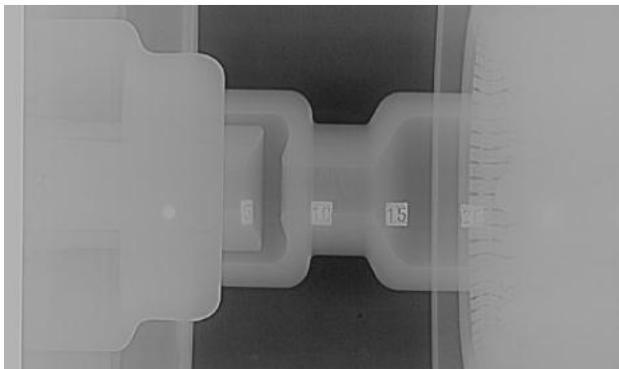
### Principle

Internal component image is printed on an imaging plate made of photosensitive phosphor and runs through a high resolution (~40 µm) laser scanner which reads and digitizes the image. The X-ray digital image produced is viewed and enhanced using a powerful image processing software. Contrast, brightness, filtration and zoom can be customized. Digital radiography uses very similar equipment to conventional radiography except the medium to create the image.

The standard file format created makes Digital X-ray easy to share by experts remotely to get an accurate diagnosis in a few hours. It eases the data storage for further inspection result comparisons.

### Default Detection

Digital X-Ray inspection is suitable to evaluate the condition of aluminum, porcelain or polymer main, arcing and moving components.



Internal component of the circuit breaker

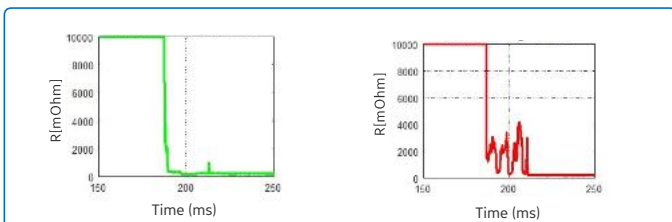
The defects that can be detected include:

- Damaged or deformed parts : crack and bent components
- Missing or loose components
- Corrosion and inclusion
- Misalignment of components
- Nozzles / Barrier / Resin insulation

## Dynamic Contact Resistance Measurement (DCRM)

### Principle

Dynamic contact resistance measurement is conducted by injecting a Direct Current through the breaker. The voltage drop is measured when the breaker operates a close-open cycle at rated speed. The acquisition unit then calculates the resistance value. During a phase of the motion, arcing contacts are the only parts which touch, the condition of these contacts can be assessed.

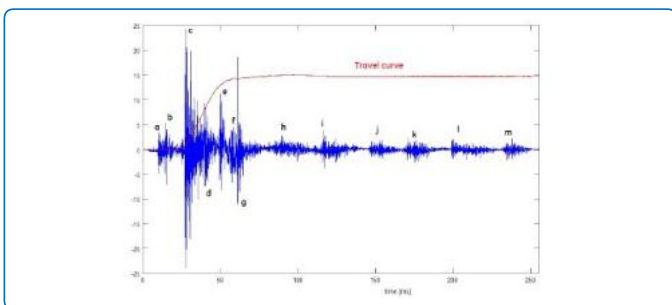


DCRM Fingerprints with new contact (left) or ageing (right)

## Vibration Monitoring

### Principle

Any mechanical movement in equipment produces sounds and/or vibrations. The resulting signals are propagated to the external structure via various parts of the mechanism and through the interrupting medium. The accelerometers positioned on the external structure of the circuit breaker measure the vibration bursts. As the vibration fingerprints are highly repeatable for a healthy circuit-breaker, a change in dynamic/frictional characteristics immediately reflects a change in the vibration pattern and thus highlights a defect.

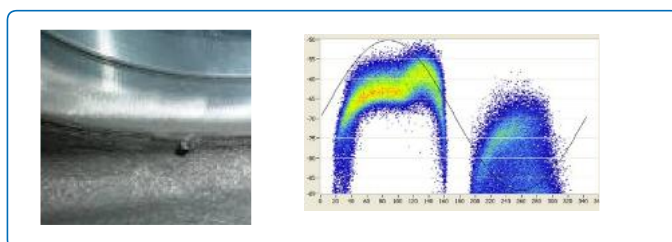


Vibration pattern of a operating mechanism

## Ultra High Frequency (UHF) Analysis

### Principle

The monitoring of the Gas-Insulated Substation (GIS) insulation health through measurement of partial discharge is the most efficient and competitive solution to prevent potential high repair cost and long downtime.



Examples of protusion

### Default Detection

The comparison between the pattern reference and the measurement curve supports the condition of the arcing contacts and the breaker chamber moving parts assessment. Any change in dynamic/frictional characteristics of the circuit breaker immediately reflects as a change in the dynamic resistance signature.

DCRM fingerprint deviation indicates various defects including:

- Misalignment of moving parts
- Contact wipe of main and arcing contacts
- Erosion of arcing and main contact
- Mechanical integrity of various components
- Measurement of the arcing contact length

### Mechanical Fault Detection

The main characteristic of vibration diagnostics is the detection of a change between a vibration fingerprints recorded during operation and the reference. Typical problems indicated by deviation in the vibration pattern include:

- Over-travel of connecting rids
- Distortion of a drive shaft
- Release of a contact / frame / mobile mechanism
- Hydraulic/spring operating mechanism defect

### Default Detection

Partial discharge is the source of electromagnetic waves in the range of ultra high frequency from 300 to 2000 MHz. The signal goes along the GIS and is easily captured by the antenna. Both UHF internal or external sensors can be installed on any type of GIS up to 800 kV. The system can monitor SF<sub>6</sub> and g<sup>3</sup> filled equipment. The frequency spectrum and time analysis of the UHF signal assist supervision of commissioning, operation and maintenance.

The pattern shape supports accurate identification of default type including:

- Presence of particle
- Free potential
- Protrusion
- Insulator void
- Coronas

## Advisory for Method Selection

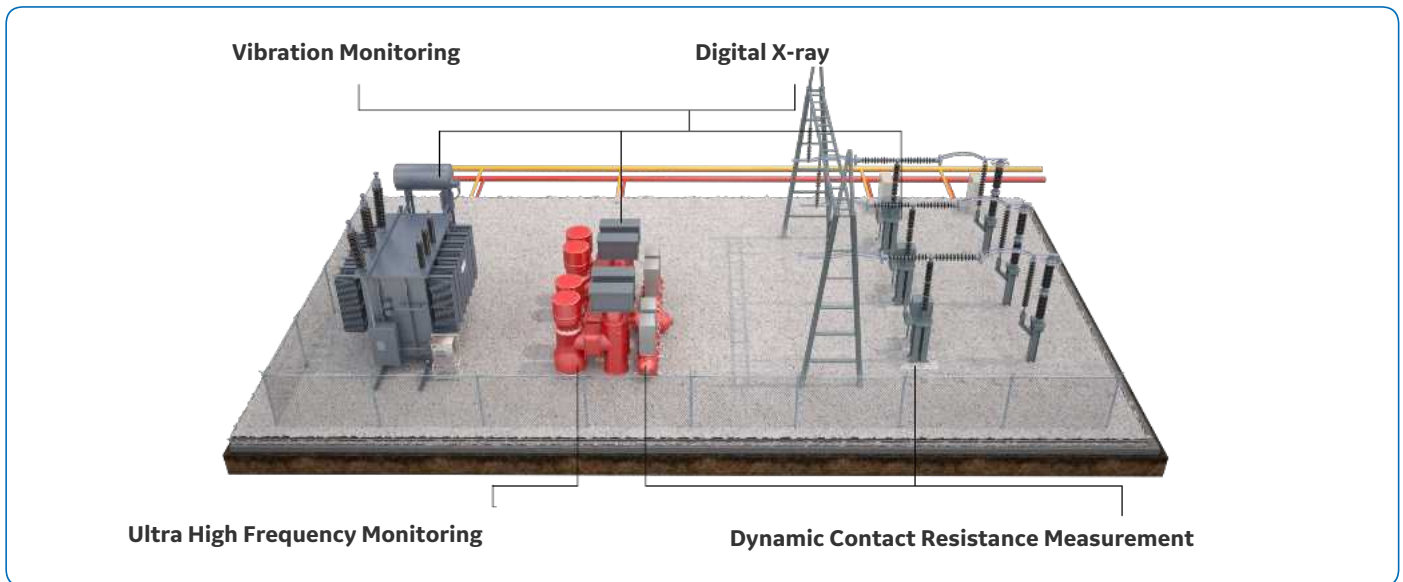
GE provides assistance in methods selection. Depending on the asset and the component to assess and the type of defect to detect, one or complementary methods of non-intrusive inspections could be recommended.

The selection of methods will take into account the application, the criticality, the history and events occurred. If the inspection required the use of several advanced non-intrusive methods, they can be performed during the same short planned outage when mandatory.

## Expert Diagnosis

In case of defect, the diagnosis can be elaborate remotely in few hours by the GE expert.

High quality measurement and data generated provides conclusive results which are compared to models created to evaluate the acceptable limits. Those models are developed by GE matter experts from R&D and manufacturing, this expertise in diagnosis is built on 125 years of experience in high voltage equipment engineering.



*Non-intrusive methods to assess circuit breakers and generation circuit breakers in air or gas-insulated substations*

## Maintenance recommendation

As part of the service GE provides a comprehensive inspection report including the results, the diagnosis, the expected remaining lifetime of the devices and a detailed recommendation to plan the necessary maintenance or replacement actions.

Advanced non-intrusive inspection enables deployment of Asset Performance Management (APM) on a fleet of circuit breakers.

For more information please contact  
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Imagination at work