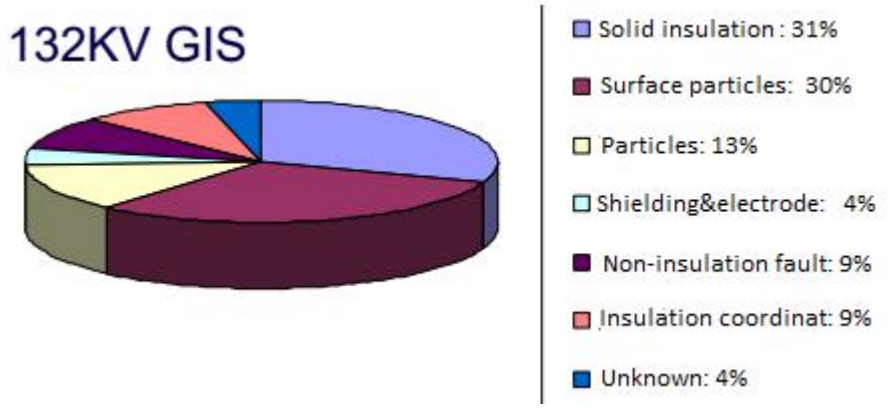
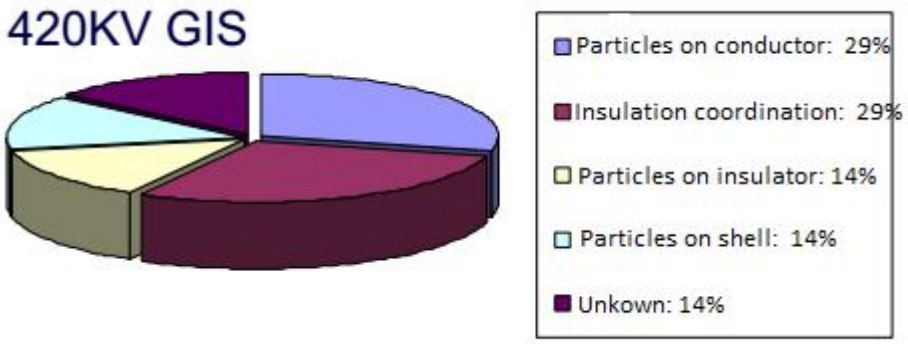
On-line Detection of GIS and Tank-type Circuit Breaker PD Defects

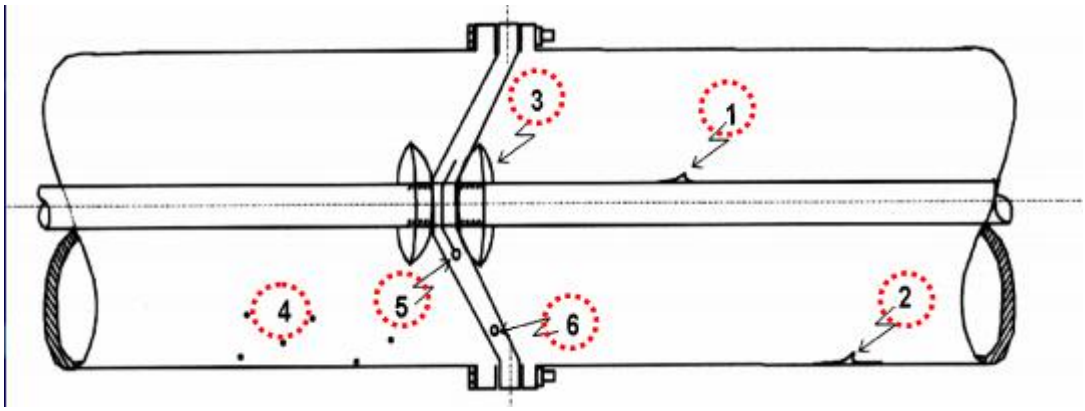
Faults Statistics for Several GIS substations





- 60%-70% of faults are detectable.
- Above 50% of faults are caused by internal particles.
- One third faults are caused by imperfect design.
- One second faults are caused by assembly and processing issues.

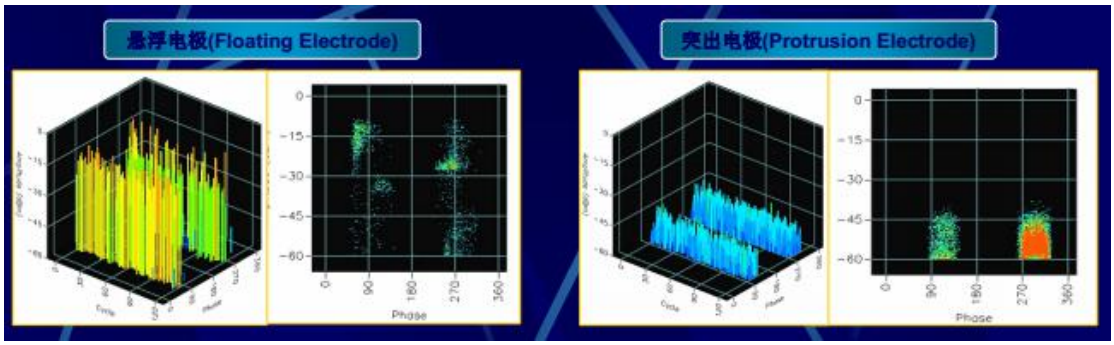
Causes for GIS Equipment Partial Discharge

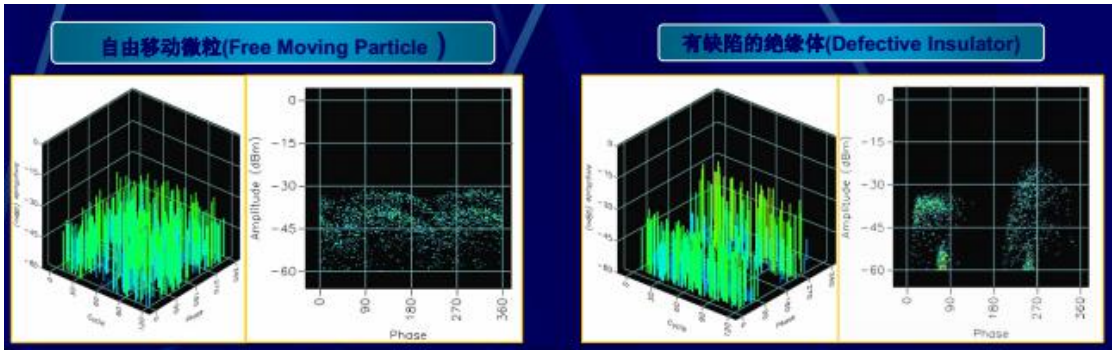


1- Burr or particle on the conductor
2 - Burr or particle on the shell
3 - Floating shield (poor contact)

4 - Moving metallic particles
5 - Particles on basin-type insulator
6 - Internal defects of basin-type insulator

Partial Discharge Characteristics of All Kinds of GIS Insulation Defects





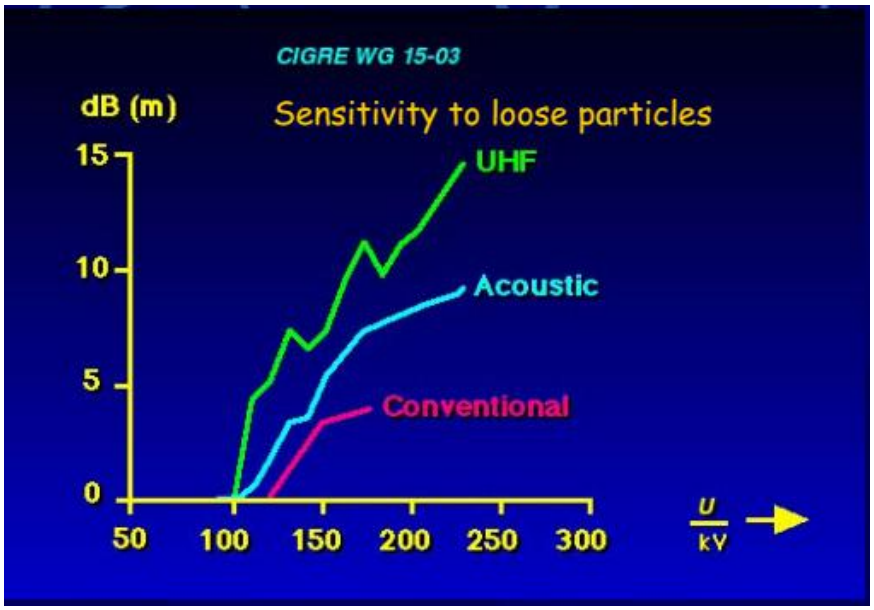
Manifestations of GIS Insulation Breakdown

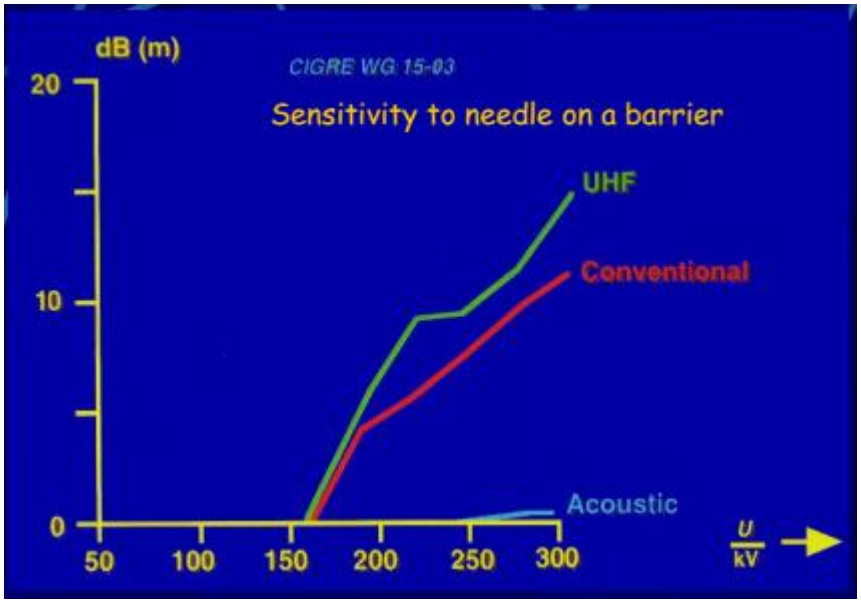
- At the Initial Stage: The insulation breakdown is mostly caused by metal particles, floating conductor, surface burr or particles. Improvement of handover test can have a preventive effect.
- At the Middle stage: Most of insulation breakdowns is caused by defects on the insulator surface (such as pollutant, charge accumulation and attached metal particles). Regular inspection can find these hidden troubles.
- The IEC specifies that when the GIS is delivered, the PD level should be less than 5pC and less than 10pC for on-site handover and operation.

PD Detection Technique (Operating GIS Equipment)

- Traditional technique: cannot solve the anti-interference problem; difficult to reach the necessary detection sensitivity; usually used in lab.
- UHF technique: detect ultra-high frequency electromagnetic signals; broad detection range and free from corona interference in the air. Sensitive to all defects, reaching pC.
- AE technique: detect ultrasonic signals and resistant to electric interference; very sensitive to free particle defects and metal part vibration; reach pC values when close to defective part.

- Gas analysis technique: It takes some time for decomposition to generate and diffuse. Hence, the response speed is slow and the sensitivity is low.





Advantages and Disadvantages of UHF Detection Technique

- Strong anti-interference capability; be not sensitive to corona discharge interference in the air but be responsive to the floating conductor discharge on the overhead lines.
- Be highly sensitive to GIS all kinds of discharge defects
- Cannot detect some defects, such as loose washer, moving dust.
- The attenuation is great and the detecting range is narrow, suitable for defect location.
- The AE signal strength depends on impulse amplitude and mode of transmission.

However, the pC is determined only by impulse amplitude for traditional method and there is no fixed relation between them.

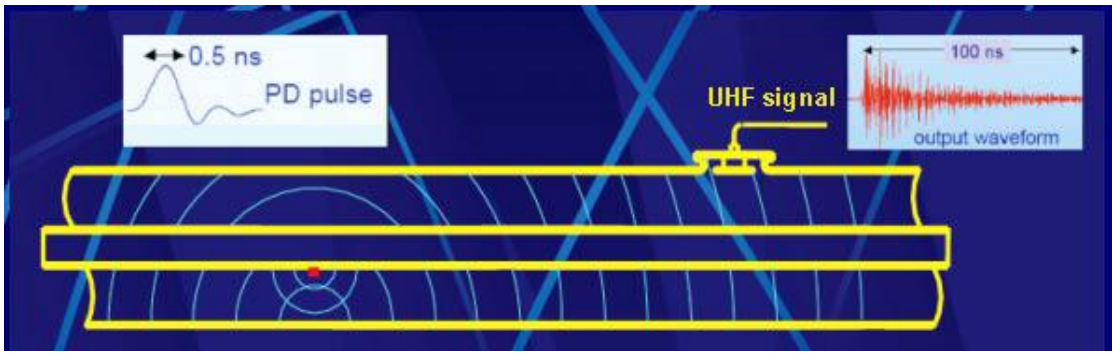
Merits and Shortcomings of AE Detection Technique

- Good anti-interference capability; be not sensitive to electric interference but be easily influenced by mechanical or electromagnetic vibration.
- Be highly sensitive to free particle defects but
- Can detect some defects, such as loose washer, moving dust.
- Great transmission attenuation; narrow detection range; suitable for defect location.
- The AE signal strength depends on impulse amplitude and mode of transmission. However, the pC is determined only by impulse amplitude for traditional method and there is no fixed relation between them.

Comparison between UHF method and AE method

	UHF	AE
Detecting Signal	UHF electromagnetic signal	Ultrasonic signal
Anti-interference	Be not sensitive to corona discharge and easily influenced by floating discharge.	Be not sensitive to electric interference and easily affected by vibration noise.
Sensitivity	To all kinds of defects	To part of defects
Detection Range	＞10m	<1m
Location Function	Be not equipped with	Equipped with
Defect Quantity	No direct relation to pC value	No direct relation to pC value

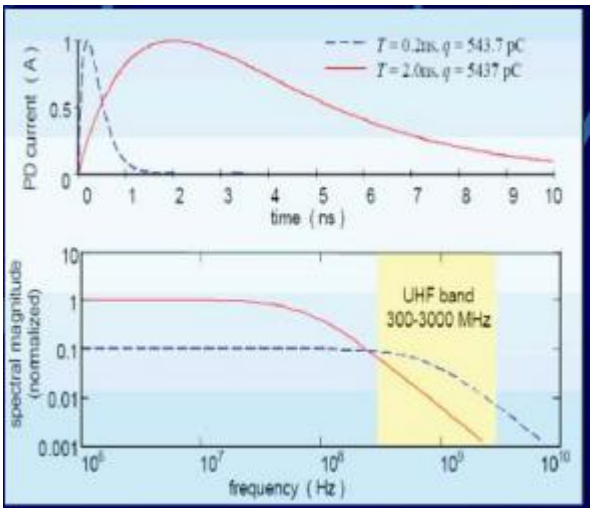
Basic Principle of UHF Method



- The higher insulation strength is, the steeper the impulse formed by PD is and shorter the duration is. Hence, the UHF electromagnetic component is becoming increasingly more.
- The UHF signals generated by PD in the air are far less than SF6. In addition, it attenuates according to the distance.
- The metal coaxial structure of GIS can be seen as a good electromagnetic wave-guide. The high-order electromagnetic wave TE and TM (f＞300MHz) can

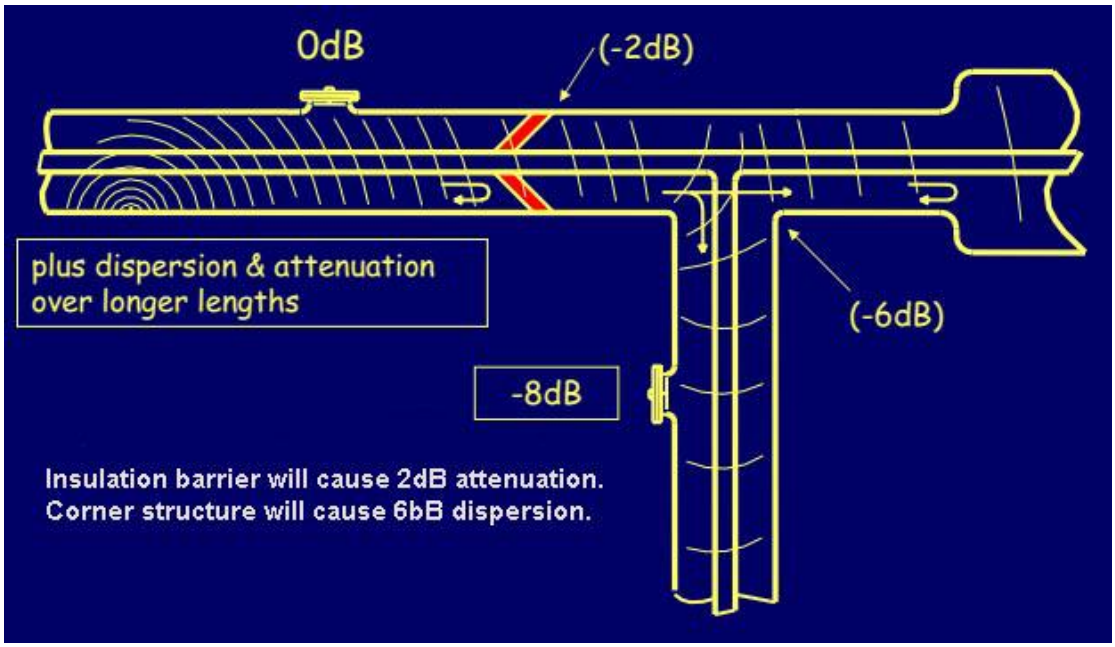
transmit in the direction of wave-guide without attenuation.

Anti-interference Principle of GIS Partial Discharge via UHF Method

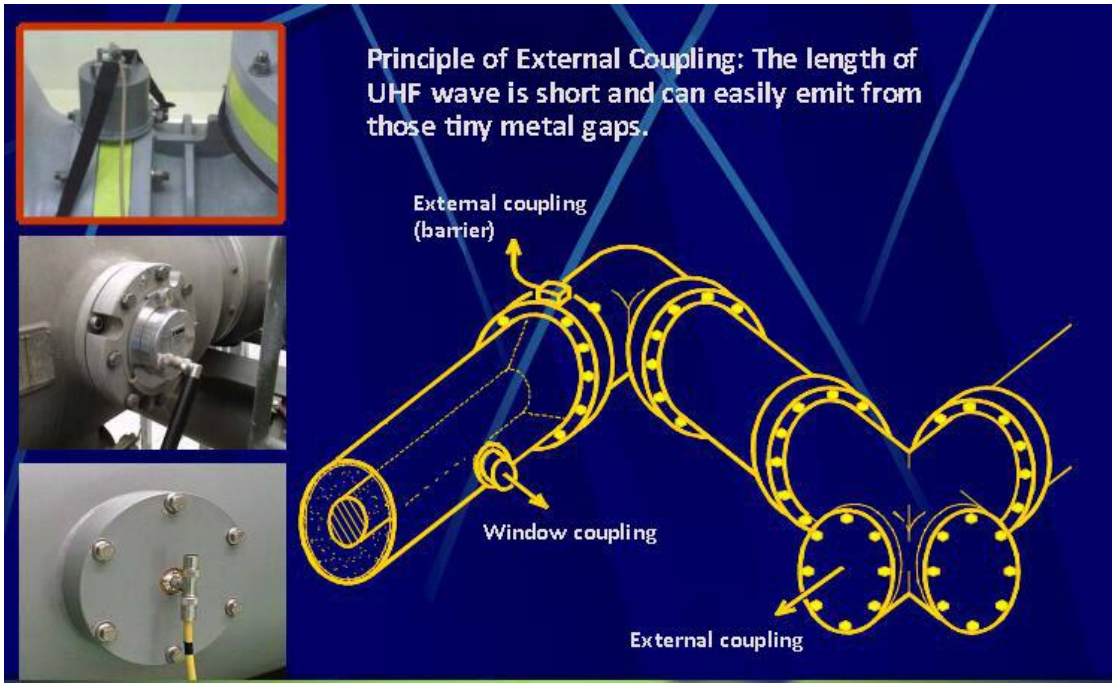


- UHF components generated by corona discharge are few; UHF components generated by internal discharge are a lot.
- The UHF signal attenuates greatly in transmission and corona interference signals reaching GIS are few.
- It is good electromagnetic wave-guide in the GIS body.
- Communication interference: the frequency is fixed and can be avoidable
- Detection frequency: 300-1500MHz
- Detection mode: Broad band, frequency-selecting
- Range: ＞10m

UHF Signal Transmitting and Attenuating in the GIS

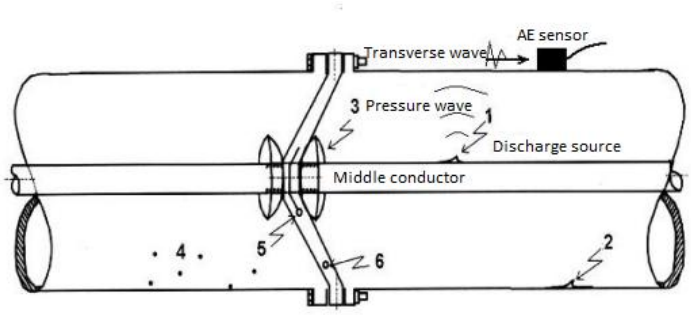


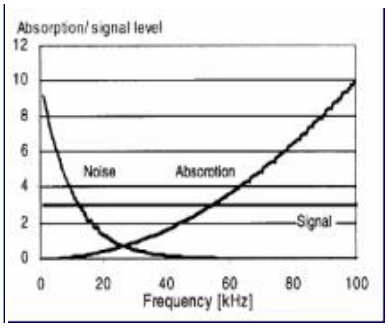
Several Coupling Methods of UHF Signals



Basic Principle of AE Method

- The discharge source generates acoustic waves, which transmit to the shell of GIS in the manner of longitudinal wave and then to AE sensor in the manner of transverse wave.
- The GIS detection frequency is 10kHz-100kHz. When the frequency is low, the sensitivity is high but be easily interfered by noise; while the frequency is high, the signal attenuation is rising increasingly.





Use AE Method to Detect GIS Partial Discharge (1m)

- Detection frequency: 10-100kHz
- Be influenced by noise
- Basically free from electric interference
- Low transmission speed: SF6 140ms steel plate 6000m/s
- Big attenuation: SF6 26dB/m in the air 0.9dB/m