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The method of leaking detection which adopts Infrared imaging and infrared absorption joint positioning and its application

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Abstract: In order to measure the leakage of substation equipment's SF₆ gas in the charged state, the current practice is the single infrared imaging in the power industry. But there are different factors such as wind speed, leak detection position, leak imaging can only be seen a flat area on the graph, not accurate positioning. The method in this paper is to joint spot and side, and first with infrared imaging legal out a flat area roughly, then gradually narrowed the leaking range by infrared absorption method, until the biggest SF₆ gas density is detected, and it is just the leaking position. The method in the gas leakage detection of GIS substation charged is prevalent. The article has carried on the thorough analysis to the technology and successfully applied to the field of measurement.

1. Introduction

Since SF₆ gas has excellent insulation and arc extinguishing properties, in recent years, high-voltage electrical equipment using SF₆ gas as an insulating medium has made remarkable progress. With the increase of SF₆ gas equipment, the incident of SF₆ gas insulation accidents is increasing. The leakage of SF₆ gas is one of the common defects in the operation of gas-insulated high-voltage electrical equipment, which not only greatly impairs the insulation and arc extinguishing performance of the equipment. Lowering, causing unplanned power outages, will also increase the humidity of SF₆ gas in the equipment, internal insulation will be broken down, and will have a large greenhouse effect on the atmospheric environment, the greenhouse effect is 20,000 times that of carbon dioxide ^[1]. Therefore, the detection of sulfur hexafluoride gas leaks is very important.

In the power industry, the power equipment for the leakage of SF₆ gas in the substation is mainly used in the early stage, such as soap water leak detection, bandaging method, hand-held leak detector, etc. ^[1]. In recent years, the infrared characteristics of sulfur hexafluoride gas have been developed. The infrared imaging and infrared absorption leak detection method can find the leak point more quickly and intuitively. However, the single infrared absorption method has the following drawbacks: the use of a hand-held probe is not conducive to large-area inspection, and is only suitable for small-scale leak detection, and there is a problem of safe distance in the case of charging detection; a single infrared imaging method has the following defects : The use of a cooled quantum well detector does not achieve the sharpness of visible light imaging, and is affected by factors such as the wind speed at the site, the diffusion speed of the SF₆ gas, and the location of the leak detector. The leaky gas image can only be a leak point. The area around it cannot be accurately positioned. Infrared imaging and infrared



absorption combined positioning and leak detection method of GIS equipment can solve the above problems by using point-and-face combination. Firstly, the infrared leakage is used to stipulate the approximate area of the air leakage, and then the infrared absorption method is used to gradually narrow the range until the device is detected. The maximum concentration of SF₆ gas is the leak point.

2. Infrared imaging and infrared absorption combined positioning leak detection principle and system of SF₆ gas

2.1 SF₆ gas infrared imaging leak detection principle and system

The infrared imaging leak detector can detect the leakage gas absorbed by the infrared light in the infrared region defined by a narrow-band filter. When the infrared light emitted by the object passes through the SF₆ gas, the video image in the region will produce a contrast with the air. The image produces a smoke-like shadow^[1]. The greater the concentration of SF₆ gas, the greater the absorption intensity and the more pronounced the smog-like shadow, making the invisible SF₆ gas leak visible. The infrared imaging system for SF₆ gas leakage is shown in Figure 1.

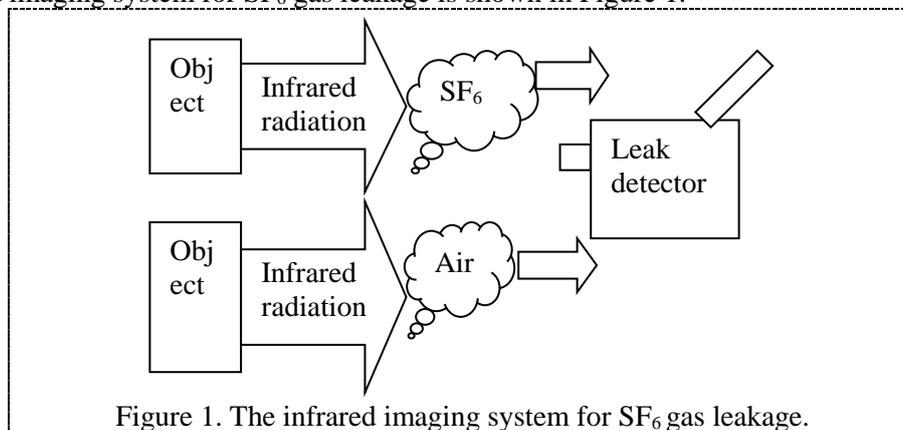


Figure 1. The infrared imaging system for SF₆ gas leakage.

2.2 SF₆ gas infrared absorption leak detection principle and system

Each substance has its own characteristic absorption spectrum, the intensity of the characteristic absorption peak and the sample material The concentration is proportional to the relationship. Therefore, the infrared concentration of gas molecules can be used to determine the concentration of the sample^[3]. A large number of experimental studies have shown that SF₆ gas has a strong absorption peak at 10.56 μm of infrared radiation^[1].

The SF₆ gas leakage infrared absorption leak detection system is shown in Figure 2. The gas collected by the gas collection pump is introduced into the double mirror gas chamber. The infrared

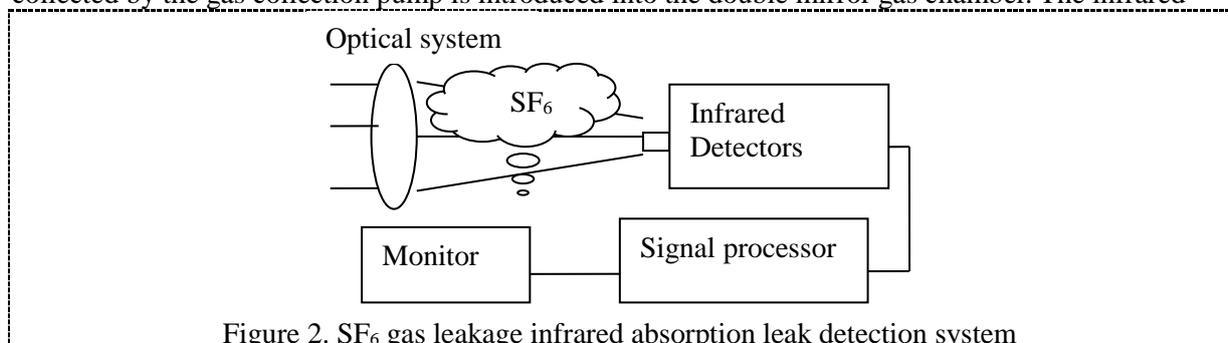


Figure 2. SF₆ gas leakage infrared absorption leak detection system

light emitted by the infrared light source transmits the gas, and the specific infrared band for the SF₆ gas. When passing the SF₆ gas, it will be attracted to a part. The infrared detector detects the change of the infrared band, and the change value is passed through the amplifier, and then input into the data processing system to display the content of the SF₆ gas^[4].

2.3 SF₆ gas Infrared imaging and infrared absorption combined positioning leak detection system

The inspection personnel hold the infrared imaging leak detector to perform imaging detection around the GIS equipment. When the air leakage smoke is detected, the infrared absorption leak detector is used to check the air leakage area, and finally the positioning of the GIS equipment leakage point is completed. Combining infrared imaging and infrared absorption to locate the air leakage point of GIS equipment is convenient and fast, and can be used on a large scale in the detection site of the substation equipment^[5].

3. Application of on-site SF₆ gas infrared imaging and infrared absorption combined positioning leak detection

3.1 Case profile

On December 25, 2015, in the 220kV** substation of the ** power supply company, the infrared thermal imaging leak detection of the 110kV upper five-line 113 circuit breaker was detected by the FLIR GF306 infrared imager, and the B-phase circuit breaker was found on the porcelain base. There is a leak in the reserved hole.

According to the equipment nameplate on the site, the rated pressure of the circuit breaker air chamber is 0.50 MPa. The information provided by the company shows that the air chamber has supplemented SF₆ gas on November 2 and December 3, 2015, respectively. The SF₆ gas pressure inspection record from December 3 to 25, 2015 decreased from 0.52 MPa to 0.49 MPa, which has a gradual downward trend. The gas pressure gauge was found to be 0.49 MPa during the electrification test on December 25, 2015. It was verified by the SF₆ gas quantitative leak detector of WIKA, Germany that the maximum concentration of SF₆ gas near the leak point was 1468 μL/L.

3.2 Test object and project

Test object: **Power supply company 220kV** substation 110kV on the SHANGWU I line 113 circuit breaker air chamber and connecting pipeline, focusing on detecting flange sealing surface, pressure gauge seat seal, bolt around, reserved hole, connecting pipeline and corresponding Connector, etc.^[2]

Test items: infrared thermal imaging leak detection, infrared absorption quantitative leak detection.

Circuit breaker equipment manufacturers: ** High-voltage switchgear Co., Ltd.; commissioning time: June 2006; circuit breaker equipment model: LTB145D1/B; gas rated pressure: 0.50 MPa, alarm pressure: 0.45 MPa, blocking pressure: 0.43 MPa.

3.3 Testing equipment and device

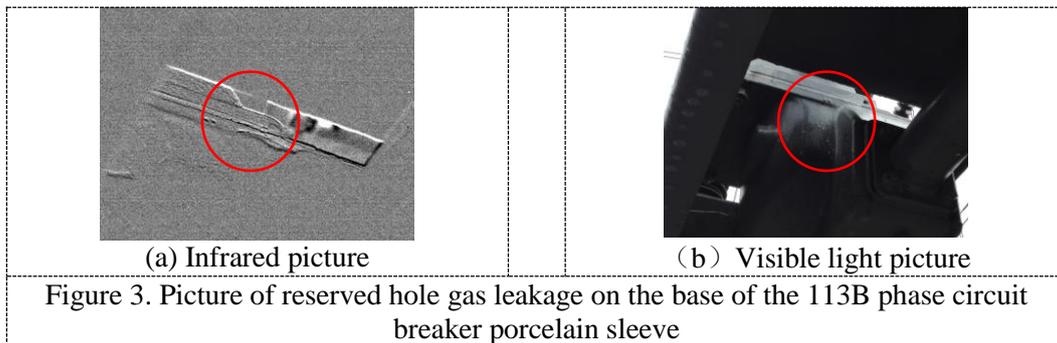
Infrared thermal imaging leak detector: the instrument model is FLIR GF306, the manufacturer is FLIR company; WIKA SF₆ gas quantitative leak detector: the instrument model is GA15 SF₆-IR-Leak, the manufacturer is Germany WIKA company.

3.4 Detection situation

On December 25th, 2015, the infrared thermal imaging leak detection and charging test was carried out on the 110kV upper five-line 113 circuit breaker of 220kV** substation. The wind speed is no more than 5 m/s, the temperature is 12 ° C, and the humidity is 57%.

3.4.1 Picture of FLIR GF306 infrared thermal imaging leak detector

Using the FLIR GF306 infrared thermal imaging leak detector, it was detected that there was a leak in the reserved hole on the base of the porcelain socket of the SHANGWU I line 113 B-phase circuit breaker of the 110kV ** substation. The SF₆ gas leakage picture is shown in Figure 3. Figure 3 (a) is the SF₆ gas leakage infrared thermal imaging picture, Figure 3 (b) is the SF₆ gas leakage visible picture, the red circle is the SF₆ gas leakage part.



3.4.2 SF₆ gas quantitative leak detector detection data

The WIKA GA15 SF₆ gas leak detector is a quantitative leak detection device with a sensitivity of 1.81×10⁻⁵mL/s and a response time of less than 1 second. During the test, the diffusion speed and orientation of the SF₆ gas are different, and the measured SF₆ gas content has a slight change. As shown in Figure 4, the measured SF₆ gas concentration value is measured at a maximum of 1468 μL/L.



3.5 Comprehensive analysis

During the charging test on December 25, 2015, the meter showed that the gas chamber pressure was close 0.49 MPa, lower than the rated pressure of the gas chamber of 0.50 MPa. By querying patrol records, the operation and maintenance personnel conducted two gas filling operations. ** The company also provided the SF₆ gas patrol records of the gas room from January to September 2015, the pressure was 0.52 MPa, but the pressure was 0.52 MPa. After October, there was a decline. The pressure on October 1 was 0.50 MPa, and the pressure on November 1 was 0.49 MPa. So on November 2 and December 3, SF₆ gas was replenished. The gas chamber was December 3, 2015. The SF₆ gas pressure inspection record from day to day 25 decreased from 0.52 MPa to 0.49 MPa, which has a gradual downward trend. The specific meter reading data is shown in Table 1. For the case where the current pressure is lower than the rated pressure, it is judged that there is a certain leak in the gas chamber.

Table 1. Ventilation pressure value of the 110kV SHANGWU I-line 113 circuit breaker in 220kV** substation

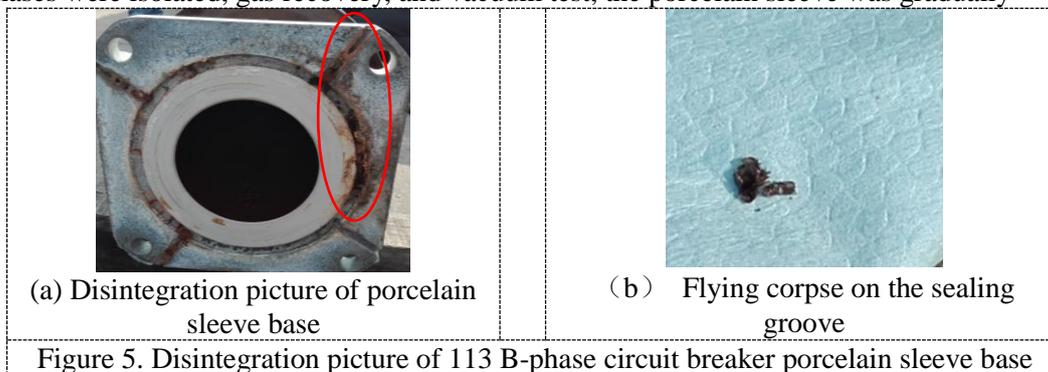
Meter reading time	Pressure value (MPa) , Rating 0.50MPa	Remarks
2015.8.1	0.52	/
2015.9.1	0.52	/
2015.10.1	0.50	/
2015.11.1	0.49	On November 2, the gas was supplied, and the pressure after the gas was 0.52 MPa.
2015.12.1	0.49	On December 3, the gas was supplied, and the pressure after the gas was 0.52 MPa.
2015.12.25	0.49	Leak test day

FLIR GF306 captures the gas diffusion after SF₆ gas leakage and has obvious leakage characteristics. For the leak detected by GF306, the WIKA SF₆ gas quantitative leak detector detected a maximum concentration of SF₆ gas of 1468 $\mu\text{L} / \text{L}$, indicating that there is obvious SF₆ gas leakage in this part, combined with the SF₆ gas leak picture captured by FLIR GF306, accurately Make sure that the leak point is in the red circle area of Figure 3(b), that is, the reserved hole on the base of the 113 B phase circuit breaker porcelain sleeve.

Analysis of the cause of air leakage: O-ring seal on the base is aging or the sealant deteriorates over time, causing damage to the seal and causing air leakage, and giving an understanding of the maintenance measures for replacing the seal.

3.6 Analysis and verification of the equipment after disintegration

The power supply company dismantled the B-phase circuit breaker on March 1, 2016. After the other two phases were isolated, gas recovery, and vacuum test, the porcelain sleeve was gradually



lifted, and it was found that a mixture of yellow mud and sealant on the base was stuck on the seal ring, and there was also a body of a flying insect, but There are no signs of aging and pressure deviation on the seal ring. See Figure 5, The red circle is the range of flying insects. It is not difficult to conclude that the above-mentioned situation is that the flying insects bring yellow mud from the reserved holes, and the excrement and climbing of the flying insects may cause the sealant to deteriorate and cause gas leakage.

3.7 Conclusions and recommendations

The leakage is due to the yellow mud, flying insects excrement brought by the flying insects from the reserved hole Corrosive mixtures, as well as irregular crawling of flying insects, can cause damage to the sealant on the O-ring; in addition, the equipment has been in operation for nearly 10 years, and the sealant applied to the seal will deteriorate and eventually cause SF₆ gas leaks.

Recommendation: This type of circuit breaker can not leave a reserved hole on the porcelain sleeve base when the equipment is processed; the four reserved holes are blocked with a mesh with a small gap to prevent the flying insects from entering the inside of the device to break the seal. During the leakage of equipment, strengthen the detection of SF₆ gas humidity to prevent water vapor from entering the equipment and affect the insulation level; in daily inspections, pay close attention to the pressure change of the air chamber to prevent the equipment from entering the locked state; During operation and maintenance, it is necessary to strengthen the protection to avoid damage to human body caused by toxic and harmful decomposition products of SF₆ gas.

4. Conclusion

Infrared detection of SF₆ gas leakage in the charged state of the device, and accurate positioning to find the leak point, and analysis of the cause of the leak, can be used to guide the state maintenance, significantly improve the operation and maintenance efficiency, Handle equipment hazards in a timely manner to avoid equipment and grid accidents.

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