Analysis of 110kV cable terminal abnormal partial discharge

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Abstract. Through the introduction of a partial discharge fault event at the end of 110kV cable, through on-site inspection and on-site acoustic-electrical test, it is determined that the partial discharge at the end of 110kV cable is abnormal, and there are defects of suspension discharge or insulation discharge; Based on the phase analysis of high-frequency current signal and UHF time series data, the fault location analysis is carried out. The analysis shows that the cable A and B have the same insulation discharge defects. According to the reason of the defect, it is suggested to carry out the overhaul of the air chamber of the interval cable immediately to prevent the cable accident caused by the defective operation. It also proposes to standardize the cable terminal installation process and strengthen the cable quality supervision, focusing on and checking the equipment of the same manufacturer and model to prevent similar defects. This study can be used to guide the operation and maintenance of partial discharge in cable terminal.

1. Introduction

The operation experience shows that the cable terminal is a region with high frequency of cable failure [1]. When the cable terminal occurs before normal, there will always be abnormal partial discharge phenomenon. Partial discharge (referred to as local discharge) is an electrical discharge that occurs when the insulation between conductors is partially connected [2]. When the insulation of equipment only produces a discharge in a local area, the conductor of the applied voltage is not broken down. This physical phenomenon can be effectively applied to the cable defect diagnosis.

As an effective detection method for cable defects and faults, partial discharge detection is often used for cable terminal defect diagnosis [3]. By means of partial discharge detection, it can effectively eliminate the hidden danger of the cable terminal, improve the efficiency of fault search, ensure the safety of power supply and avoid causing greater loss.

Partial discharge process is often accompanied by physical phenomena such as sound, light, electricity, heat and chemical decomposition, according to according to the physical feature of collecting signal and the anti-jamming measures, at present the method for detecting partial discharge high frequency current method, the method of ultra-high-frequency (UHF), capacitance coupling method, inductive coupling method, direction coupling method, finite difference method and ultrasonic method [4-6].
Based on a case of partial discharge defect in the field, this paper analyzes the application of "sono-electric" combined detection technology by ultrasonic wave + high frequency current and ultra-high frequency electromagnetic wave.

2. Defect overview
On April 9, 2016, it was found that there were UHF and ultrasonic abnormal signals in the cable terminal interval of a 110kV substation during the local discharge test of the electrified GIS equipment. The spectrum of UHF detection of PRPS and PRPD is shown in figure 1, and the cycle spectrum is shown in figure 3. Because the GIS basin insulator is with a metal flange, only a small pouring hole is reserved, no UHF abnormal signal was detected at the pouring point of the basin insulator near the cable air chamber.

![Fig.1 Abnormal UHF test map(PRPD/PRPS )](image1)

![Fig. 2 Background map](image2)

According to the spectrum of PRPS and PRPD in Figure 1, there are two clusters of signal clusters in a cycle, among which the spectrum of PRPD is distributed in different amplitude ranges, with the characteristics of suspension potential discharge or insulation discharge defects.

According to the periodic spectrum, the positive and negative cycle discharge pulse signals in the power frequency cycle are basically symmetrical, but the pulse amplitude is high. Through the field test, it is found that there is abnormal partial discharge in the terminal interval of the cable.

3. Defect type
3.1. UHF time domain analysis
Fig. 3 is the time-domain map of UHF detection. According to Fig. 3, two clusters of discharge signals gather in one cycle, and each cluster is composed of multiple signals with different root amplitudes.
3.2. Ultrasonic spectrum analysis

The location of ultrasonic signal detection is shown in Figure 4:

![Failure characteristics of specimen SJ1](image)

The ultrasonic continuous and phase diagrams of phase A (Fig. 5) and phase B (Fig. 6) were obtained through ultrasonic detection.

By comparing the ultrasonic signal spectrum in Figure 5 and Figure 6 with the background spectrum, it can be seen that the continuous ultrasonic signal spectrum in phase A and phase B has an obvious 100Hz correlation, and the phase spectrum has an obvious clustering of two clusters within A cycle, and the dots are distributed in different amplitude ranges, showing the characteristics of insulation discharge defects. Based on the above analysis, the defect type may be insulation discharge defect.
4. Defect location

The ultra-high frequency (UHF) signals detected by the UHF positioning instrument are located and analyzed to determine the source of UHF signals.

The schematic diagram of detection position of UHF planar positioning analysis is shown in Figure 7, where the distance between the yellow sensor and the green sensor is 120cm2.
In the test position, the yellow sensor signals are basically about 4ns ahead of the green sensor signals. UHF detection method is adopted to carry out positioning analysis in the vertical direction. The detection position is shown in Figure 8, and the vertical distance between the two sensors is 90cm. The location map of the detected signal delay is shown in Figure 9. The yellow sensor signal leads the green sensor signal by about 3ns.

In Figure 9, the signal of the yellow sensor is about 4ns ahead of the green sensor. According to the calculation of UHF propagation speed, the calculated distance between the two sensors is about 120cm, which is basically the same as the actual distance between the two sensors at the three test positions. In figure 12, the yellow sensor signal is about 3ns ahead of the green sensor signal. Based on the calculation of UHF propagation speed, the calculated distance between the two sensors is about 90cm, which is basically the same as the actual distance between the two sensors in the three test positions. According to the planar positioning diagram of the three test positions in Fig. 8 and the vertical direction test diagram in Fig. 9, the possibility of UHF signals coming from external interference can be excluded, and the detected UHF abnormal signals are likely to come from the cable terminal.

According to Figure 7-9, ultrasonic detection only detected ultrasonic abnormal signals at the terminals of phase A and phase B cables, and the detection signals at the terminals of phase C cables were the same as the background signals, indicating that defects were likely to occur in phase A and phase B.
5. Conclusions
According to the above analysis, the "sound + electricity" method combining ultrasonic wave method with high-frequency current and uhf method can effectively conduct defect location analysis of partial discharge, which is an effective detection method applied in the field. Finally, the following measures are recommended for similar defects:

1. Test the defect signal every month and track the signal change trend. If there is an increase trend, apply for power failure overhaul as soon as possible; If there is a power failure maintenance plan, please deal with the signal to eliminate the hidden trouble.

2. Actively carry out GIS live detection, and test the humidity and composition of sulfur hexafluoride gas for such defective equipment;

3. Strengthen the acceptance and spot check of new electrical equipment entering the network, strictly control the quality of electrical equipment, and control the handover test of new equipment in power transformation, so as to ensure that the new electrical equipment meets the operation requirements.

4. Focus on and check the equipment of the same manufacturer and model to prevent similar defects.

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