A phase sequence error analysis and diagnosis of 110kV outline interval in a 220kV substation

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Abstract. With the help of digital X-ray imaging technology, a phase sequence error of conducting rod of isolation switch was diagnosed. By studying the design drawing of GIS before field testing, the typical characteristics of conducting rod arrangement was mastered. It referred to us that the digital X-ray imaging technology should be widely promoted to improve detection efficiency.

1. Introduction
GIS (Gas Insulation Switch) is a composite apparatus that seals the circuit breakers, isolation switches, ground switches, transformers, lightning arresters and other primary equipment in a metal cavity filled with certain SF6 insulation gas which is widely used in new transformation and expansion projects due to its compact structure, small footprint and high reliability[1, 2]. Before the first power transmission of the GIS system, it is necessary to check the correct phase sequence of the power source in the station and the regional power grid. The phase sequence of the GIS system in the station and the system phase sequence after the connection of the whole system in the station should also be identified, so as to ensure the success of the first power transmission of the power system[3-7]. However, according to incomplete statistics, the failure rate of GIS equipment in China has reached more than half[8, 9], and most of the failures are related to the improper installation and debugging of GIS in the early stage. Therefore, strengthening the research on the phase-sequence checking method in the installation and debugging of GIS plays an important role in the development of power grid industry[2].

2. Experimental Section
The digital ray imaging system was used in the phase sequence check of isolation switch (General Electric).

3. Failure Investigation
3.1 The failure description
On May 2020, once some line circuit breaker of 504 interval was shut, the circuit breaker of contralateral substation tripped due to inter-phase distance I action.
According to the above operation process, protection action and GIS assembly experience of manufacturers, it is preliminarily judged that there is phase sequence error in GIS, and the problem of A- and C- phase connection inversion occurs between 110kV bus isolation switch and bus. Based on the above situation, X-ray inspection is carried out on the assembly of 110kV bus isolation switch in the station.

3.2 X-ray detection method
Figure 1 shows the cross-section profile of 110kV outgoing line. As can be seen from the figure, the conductive rod connecting three phases of bus brake A, B and C and the bus is arranged in A triangular space, among which the conductive rod connecting phase A has the longest length. By inspecting the layout of conductive rod between the bus brake and bus at each interval with X-ray, it can be judged whether there is an assembly error.

3.3 Field test
The bus isolation switch tested in the field includes two intervals which is 5042 and 5062. Among which 5062 isolation switch is the reference group. The final test results are shown in Figure 3. Each green arrow is the position of the conductive rod connected between the isolation switch and the bus.
3.4 Disassembly and disposal results

The 5042 interval was disintegrated and carefully checked according to the design drawings. The inspection result is highly consistent with the X-ray detection image which is shown in Figure 4a. And the phase sequence was subsequently adjusted by factory technicians.
4. Conclusions
Due to the field application of digital X-ray imaging technology, a phase sequence error of conducting rod of isolation switch was effectively diagnosed and disposed. Because of the design drawing and reference group, the phase sequence error could just be confirmed by X-ray image identification. It indicated that the digital X-ray imaging technology should be widely promoted in fault diagnosis of the power system.

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