Failure Analysis of Metal Oxide Surge Arrester on Busbar of 220kV Substation

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Abstract. MOA (Metal Oxide Arrester) is widely used in power systems because of its good nonlinear volt-ampere characteristics and current-carrying capacity. Its long-term operation may have defects such as heat generation and reduced insulation performance. This paper analyzes a 220kV substation bus lightning arrester, collects fault recording information, points out the cause of the fault and puts forward corresponding preventive measures.

Keywords: metal oxide surge arrester, fault recording, sleeve aging.

1. Introduction
As an important role of over-voltage protection, lightning arrester plays an essential role in the power grid, which is mainly used to limit the over-voltage caused by system operation and lightning stroke [1]. Generally, lightning impulse over-voltage is introduced to the substation through the transmission line. When it exceeds the protection level of the arrester, the arrester discharges and safely leads the lightning current to the earth through the grounding conductor, so as to achieve the purpose of safety protection of electrical equipment [2].

The typical failure of ZnO arrester studied in this paper is that the internal failure is caused by the aging and dampness of the internal insulation sleeve of the arrester and the sudden change of the insulation.

2. System operation status before failure
Before the fault, the 220kV East and West buses of the substation operate in parallel, the 220kV East bus with No. 1 main transformer and 220kV Xingjing line a operate, the 220kV West Bus with No. 2 main transformer, 220kV Jinghai line and 220kV Xingjing line B operate, and the 220kV bypass interval is in cold standby state.

The fault equipment information is as follows:
Faulty equipment: 220kV West Bus B-phase arrester.
Model of faulty equipment: Y10W-200/520.
Manufacturer: Nanyang Arrester Factory.
Production date: October 1995.
Operation date: September 1996.

The last test was conducted on September 16, 2019. The PT and arrester of 220kV West Bus were charged, and the porcelain bottle flaw detection and leakage current charged detection were carried out. It was found that the leakage current of phase B exceeded the standard. According to Q / GDW 1168-2013 ‘state maintenance test of power transmission and transformation equipment ’Test procedures: the normal range of test value is ± 5% of the initial value. When the resistive current increases by 0.5 times, the test cycle shall be shortened and the monitoring shall be strengthened. When the resistance current increases by more than 1 time, the power shall be cut off for inspection [2] [4]. It can be seen from the test data that the data of phase B is abnormal, and the test value is nearly 1.4 times higher than the last value of phase B. It is confirmed that phase B arrester is a general defective equipment, and has been listed in the 2020 outage maintenance plan.

Table 1. Data sheet for live detection of arrester

| Test items                | A       |       | B       |       | C       |       |
|--------------------------|---------|-------|---------|-------|---------|-------|
| Ix(Effective value of full current) | Test value | Last value | Test value | Last value | Test value | Last value |
| 231                      | 228     | 306   | 226     | 229   | 228     |
| Ir(Resistive current peak) | 35      | 32    | 43      | 31    | 33      | 29    |

3. Fault event process, monitoring information and protection action

On October 12, 2019, at 14:56:57:228 MS, the background monitoring system of the substation issued "220kV bus differential protection I, II bus differential protection outlet", "220kV Bus Differential Protection II, II bus differential protection outlet", and at the same time, 220kV side, 220kV Jinghai line, 220kV Xingjing line B and 220kV bus coupler switch of No. 2 main transformer tripped. The operator came to the site for inspection and found that the 9309b phase lightning arrester of the 220kV West bus was damaged, resulting in the single-phase grounding fault of the B phase of the West bus, and then immediately reported to the dispatcher to change the 220kV West bus from the operation state to the maintenance state, and the 2 main transformer, 220kV Jinghai line and 220kV Xingjing line B were operated from the 220kV east bus. In case of fault, the wave shape of 220kV West bus voltage recording is as follows:

![Voltage recording waveform of 220kV West Bus in case of fault](image)
The result of the accident is that the 220kV side, 220kV Jinghai line, 220kV Xingjing line B and 220kV bus couple switch of the No. 2 main transformer of the substation trip, and the 220kV West bus is cut off without load loss.

4. Failure cause analysis and treatment

4.1. On site inspection
According to the field inspection, except for the base of the 9309b phase arrester of the 220kV West bus, the upper and lower segments of the porcelain bushing and the internal valve pieces are scattered on the ground, the upper and lower segments of the porcelain bushing and the middle flange are broken and fall off at the root, the lower segment of the porcelain bushing is seriously damaged, the lower segment of the insulating sleeve has obvious burning and cracking traces, the upper segment of the insulating sleeve is burned and fall off by the electric arc, and the lower segment is seriously damaged, as shown in the following figure As follows:

Figure 2. Overall situation
Figure 3. Insulating sleeve of lower section
Figure 4. Root of lower section
Figure 5. Inner valve plate of lower section
Figure 6. Middle flange connection (Outside)
Figure 7. Middle flange connection (Inside)
Through on-site inspection, the damage degree of the insulating sleeve of the lower section of the arrester is obviously more serious than that of the upper section. It is preliminarily judged that the insulation of the insulating sleeve of the lower section of the arrester is decreased, which causes the internal fault of the arrester. The generated electric power causes the fracture of the iron porcelain joint of the arrester, and the arrester topples after the root fracture, which causes the single-phase grounding fault of the B phase of the 220kV West bus. The differential protection of the I and II bus is dynamic cut off all components on 220kV West bus.

4.2. Failure cause analysis
It can be seen from the on-site inspection that the reason for the arrester failure is the failure of the internal insulating sleeve of the lower porcelain insulator. On September 16 of this year, the resistance current of phase B of the arrester exceeded the standard, but it did not meet the requirements of outage maintenance for serious defects. When the operator inspected the arrester recently, the leakage current remained at 0.7-0.8 mA. At the same time, the arrester has been put into operation for 23 years, and the internal insulation sleeve is aging. Through on-site inspection and analysis, the cause of the accident is that the internal insulation sleeve of 9309b phase bus arrester of 220kV West Bus of Jinghua substation is aged and damp, which causes sudden change of insulation. The internal fault is caused by the discharge of insulation sleeve along the surface, the porcelain bottle is broken and the bus is grounded due to the excessive electric power.

5. Preventive measures and suggestions
According to the analysis results of arrester failure, the following preventive measures and suggestions are proposed:

Live detection is an effective way to find the latent defects of arresters, which should be paid attention to. Even if it does not exceed the standard range specified in the regulations, close monitoring shall be carried out, and comprehensive study and judgment shall be carried out for the equipment in combination with infrared, high-frequency partial discharge and other detection methods.

We should actively carry out the technical transformation and storage of arresters of various voltage levels, replace the arresters that have been in operation for more than 20 years year by year, and improve the operation level of the equipment.[2]

A special operation and maintenance plan shall be made for the old arrester to shorten the operation inspection and maintenance period, so as to discover the equipment operation problems in time and prevent such accidents from happening again.

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