Research On Failure Detection Method of Converter Valve In 500 KV Transformer Substation Without Back-Inspection

Min Tao*, Jiahao Liang
Guangzhou Bureau, China South Grid EHV Power Transmission Company, Guangzhou 510003, Guangdong Province, China
*Corresponding author: liangjiahao2021@foxmail.com

Abstract. In order to eliminate the DC bipolar blocking fault caused by the damage of the valve plate and the lightning strike of the ground electrode line of a ± 500 kV converter station, the DC blocking fault field equipment inspection, lightning positioning system information, related wave recording and relay protection are described. Action conditions, analysis of related failure causes, and follow-up measures are proposed to ensure the safe and stable operation of the system.

Keywords: Converter valve, cause analysis, lightning strike, valve disc damage.

1. Introduction
Electricity is a clean and efficient energy source, which plays an important role in social industrial production and people's lives. Under the new economic form, people's demand for electric energy is increasing, and the problem of electric energy transmission has also been widely focused. UHV DC transmission is currently the most advanced power transmission method. It not only has the characteristics of long transmission distance and large transmission capacity, but also has a small area of infrastructure in the transmission project, less power loss, high safety efficiency, and good performance. Economic and environmental benefits. [1-13] In the new era, to further improve the efficiency of UHV DC transmission, it is necessary to pay attention to the effective control of UHV DC transmission system current conversion.

The double-pole blocking of the DC system has a greater impact on the safety of the power system. In the design of DC systems, consideration is given to avoiding a single component causing bipolar lockout. Although there are not many cases of bipolar lockout in DC systems, DC bipolar lockout failures may occur under special conditions. Based on the failure of a single component of a ± 500 kV converter station due to valve damage and lightning strikes on the ground electrode line, the cause of the DC bipolar blocking failure is analyzed, and batches of valve hidden dangers are checked and remedied. The logic optimization measures for the unbalanced protection of the grounding pole line eliminates the hidden danger of the DC bipolar blocking of the converter station, avoids the recurrence of similar faults, and improves the safe operation level of the DC system of the converter station.
2. Introduction to the DC converter valve system

The converter valve system includes converter valves, valve-based electronic equipment panels (VBE) and other equipment, which mainly complete the conversion of DC power to AC power. The composition of a single valve-level equipment is as follows:

(a). Thyristor valve disc;
(b). Valve voltage monitoring PCB board (TVM), a part of valve control;
(c). RC buffer (damping) circuit connected in parallel with the valve plate;
(d). The DC voltage divider resistor connected in parallel with the valve plate is installed on the TVM board.

The TVM board contains one piece in each valve stage. Its main function is to ensure that all thyristor units in a bridge arm are connected in series to withstand the same DC voltage. At the same time, it monitors the internal voltage of the valve stage and generates a back-check light signal, Through the optical fiber loop to send to the VBE system for analysis and processing. When the thyristor valve has a breakdown fault, it is equivalent to a short circuit of the valve-level equipment. At this time, the TVM board cannot detect the voltage and cannot generate a normal back-inspection light signal. The VBE system will send the valve-level equipment without a back-inspection failure.

3. Brief analysis of converter valve failure cases

Converter stations and DC transmission lines are the basic components of UHV DC transmission systems. In power transmission management, the UHV converter station is the core of the entire DC transmission system. It includes two basic levels: the rectifier station and the inverter station. With their cooperation, the UHV DC transmission system's current conversion can be fully realized. Effectively realize the conversion of UHV to working voltage. 2. In transmission line management, China adopts bipolar system for wiring management. In actual operation, through the coordinated operation of multiple converter zones, the efficiency of DC transmission and current conversion can be effectively improved, which fully meets the needs of social power supply. Improved people's quality of life.

On July 14, 2017, a ±500kV converter station in China reported that the pole 1 converter valve of a converter station in China successively reported A2R-V4 valve without back-check failure at 13:24:00.034 seconds, and at 13:24:00.368 seconds, it reported A3R-V18 valve without return. Check failure, report A3R-V23 valve no backcheck failure at 13:24:02.371 second, 13:24:02.612 second, report A3R-V1 valve no backcheck failure. In the pole 1 VBE system, because the D4 valve has no redundant backup valve, the tripping outlet is activated, and the Gaozhao DC pole 1 is blocked. When it is locked, the station is under thunderstorm weather and is running at full capacity.
On July 15th and 16th, 2017, a converter station monitoring background SER successively issued the valve V21 (when the OLT test) and V11 (when the standby switch of the pole 2 was locked) of the A3R of the pole 1 valve hall had no back-check signal.

4. Logic analysis of VBE system tripping
The valve-based electronic equipment (VBE) system is used to trigger and monitor the thyristor element, and send a trip signal under the following conditions to lock the corresponding pole.
(a). Both power supplies have failed;
(b). Failure of both valve control and monitoring systems;
(c). There are more than three thyristor valves in a single valve with no back-check signal failure;
(d). Five or more valve plates in a single valve are opened for protection.
From the SER signal and on-site inspection, it can be seen that when the pole 1 is locked, the pole 1VBE system produced a total of D4 valves (in the same valve) A2R-V4, A3R-V18, A3R-V23, A3R-V1 four valve chip-level equipment without return Check the signal, meet the third trip condition mentioned above, the very 1VBE system trip exit, normal action.

5. Defect inspection and handling on July 23
(a). Impedance tests were carried out on two valve chip-level devices A3R-V11 and A3R-V21. The resistance of the two valve plates is 0Ω. Since the normal resistance value of the valve plates is megohm, it can be judged that both valve plates have been broken down. The faulty valve was replaced with spare parts. After the replacement, the valve-level function test was performed, and the result was normal.
(b). Test the pressure equalizing capacitor of the valve layer of 1A phase 2R, 3R, and 3L, the left side voltage equalizing capacitor of the valve segment of the D1 arm A phase 1R valve layer, and the left side voltage equalizing capacitor of the valve segment of the Y1 bridge arm A phase 4L valve layer. The instrument tested its capacitance value and the result was normal.

Table 1. Valve segment pressure equalizing capacitance test record table

| Number | Location | Capacitance | Rated value (pF) | Tolerance scope | Relative error (%) |
|--------|----------|-------------|------------------|-----------------|-------------------|
| 1      | A1L Left section | 5457        | 5500             | ±3%             | -0.781818         |
| 2      | A2R Left section | 5525        | 5500             | ±3%             | 0.4545455         |
| 3      | A2R Right segment | 5454        | 5500             | ±3%             | -0.836364         |
| 4      | A3L Left section | 5523        | 5500             | ±3%             | 0.4181818         |
| 5      | A3L Right segment | 5455        | 5500             | ±3%             | -0.818182         |
| 6      | A3R Left section | 5518        | 5500             | ±3%             | 0.3272727         |
| 7      | A3R Right segment | 5497        | 5500             | ±3%             | -0.054545         |
| 8      | A4L Left section | 5567        | 5500             | ±3%             | 1.2181818         |

(c). The anode reactor of the valve section of the pole 1A phase 3R valve layer was tested with a special tester for its reactance value, and the result was normal.
Table 2. Anode reactor reactance test record table

| Number | Location | Reactance value (μH) | Rated value (μH) | Tolerance scope | Relative error (%) |
|--------|----------|----------------------|------------------|-----------------|-------------------|
| 1      | L1       | 612.9                | 570              | ±10%            | 7.5263158        |
| 2      | L2       | 604.5                | 570              | ±10%            | 6.0526316        |
| 3      | L3       | 595                  | 570              | ±10%            | 4.3859649        |
| 4      | L4       | 619.9                | 570              | ±10%            | 8.754386         |

According to the statistics of the defects of the valve without back-inspection, we will make a change of the breakdown of the valve in Zhaoqing station with the increase of operating years.

As the operating life of the converter valve increases, the breakdown of the valve segment shows an increasing trend.

6. Possible cause analysis
(a). The reason of the thyristor itself may be related to the batch, and it fails under the inducement of thunder and lightning.
(b). The scale of the valve tower cooling water circuit is blocked, causing the thyristor junction temperature to rise and the withstand voltage to drop. When there is scale blockage in the cooling water circuit, the cooling effect of the water circuit drops rapidly, and the temperature of the components passing by the water circuit rises rapidly; if the thyristor cooling water pipe circuit is blocked by scale, the thyristor junction temperature will rise rapidly, and the thyristor Afterwards, the junction temperature rises, the withstand voltage level of the thyristor decreases. At this time, if there is a lower overvoltage inducement, it may also cause the thyristor to malfunction. The internal cooling water circuit of the Zhaoqing converter station is fouling, which may block a single thyristor cooling circuit to a certain extent, but it is less likely to block multiple thyristor cooling circuits. Continue to observe according to the follow-up operation situation.
(c). The fiber attenuation of the VBE to MSC and MSC to thyristor is too large, or the luminous intensity of the VBE light emitting board is insufficient, resulting in a decrease in the luminous intensity of the trigger circuit.
(d). The dynamic voltage equalization of the voltage equalization capacitor causes local overvoltage.

7. Follow-up measures
(a). Complete the test test of the remaining 18 thyristors of the A3R valve layer, focusing on the withstand voltage, on-state voltage and off time. Take two thyristor spare parts stored in Zhaoqing Converter Station and Baoan Converter Station for more than 8 years to carry out comparative test tests. Xidian Power System Co., Ltd. provided the corresponding relationship between the positions and numbers of the thyristors in the Zhaoqing converter station. The Guangzhou Bureau made statistics on the damage of the thyristors in batches of 9075 and 9077.
(b). Combining the design documents and technical specifications, theoretical calculations and simulation verifications are carried out to further analyze whether the valve withstands overvoltage and withstand capability of Zhaoqing station meets the design requirements.

c). Upgrade the control of converter valves at Zhaoqing Station and incorporate it into Level I control; carry out inspections of scale, fiber tanks and fiber rate consumption in conjunction with annual maintenance; formulate emergency response plans to clarify the trigger conditions for emergency response, such as the reappearance of A3R layer valves If the valve fails, the follow-up will start the dynamic voltage equalization capacity test of the voltage equalization capacitor and the lightning arrester body test test based on the operation and failure conditions.

8. Conclusion

The failure process of bipolar sequential blocking in a ± 500 kV converter station is described, and the causes of DC bipolar blocking failure are analyzed. By analyzing system tripping, cooling water, thyristor body and other factors, a series of treatment measures are finally proposed. It has reference value for improving the operating conditions of HVDC and preventing the occurrence of similar DC bipolar blocking faults.

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