Journal of Physics: Conference Series **1449** (2020) 012048 doi:10.1088/1742-6596/1449/1/012048

Maloperation Analysis and Preventive Measures of 500 kV Reactor Protection

Li Haisheng, Yang Xuefei,Yang Shaoyuan

Liuzhou Bureau, China Southern Power Grid EHV Power Transmission Company, Liuzhou, 545006, China

Corresponding author's e-mail: 57116626@qq.com

Abstract. This paper introduces the process of checking, analyzing and dealing with the causes of maloperation of the first set protection of 500 kV reactor in a substation. By checking the secondary circuit of 500 kV reactor protection for power outage, it is analyzed that the main cause of reactor protection malfunction is that the cable core of the current circuit of the first set protection is damaged at the secondary terminal box of TA of the high voltage casing pipes, which causes the induction current to enter in series, the abnormal sampling of the first set of protection B phase, and the protection outlet action. Aiming at the existing problems, this paper gives corresponding treatment methods and preventive measures.

1. Abnormal conditions

At 21:13:46 on May 2, 2015, the first set of electrical quantities protection of a 500 kV line tripped, and the second set of electrical quantities protection, non-electricity protection and line protection did not take action. The on-site watcher checked out that the appearance of the primary equipments within the reactor protection range were without abnormalities. The B-phase current differential and zero-sequence current differential protection of the first set of electric quantity protection of the reactor have been found to act. This reactor was produced by Shenyang Transformer Co., Ltd. in September 2002. With the model number of BKD-50000/500 and a capacity of 50000 kvar, it was put into production in June 2003. On May 25, 2014, this reactor body and its secondary circuit were tested to check that the insulation resistance of the secondary circuit of the high-voltage and low-voltage casing pipes TA was greater than 10 MΩ, which meeting the insulation requirements.

2. On-site checking and testing results

After the reactor was transformed into overhaul state, the maintainers checked out that the reactor body was without abnormality, and there was no gas in the gas relay; the three-phase reactor was tested by off-line oil chromatography and dielectric loss, and no abnormalities were found in the test results.The maintainers compared and analyzed the two sets of reactor protection wave shape and fault recording wave shape (the high-voltage sides of two sets of reactor protection casing pipes TA sampled from different windings), finding that the three-phase reactor voltage was three-phased balanced at about 61V before the circuit breaker tripped. The first set of TA current wave shape of reactor protection B-phase high-voltage side showed irregular changes, and the low-voltage side TA currents did not differ much. The B-phase current differential and the zero-sequence current differential returned in multiple actions, which lasted for 2 seconds. According to the wave recording figure, it can be initially seen that the secondary loop of the first set of reactor protection B-phase high-voltage side TA current is abnormal (As Figure 1).

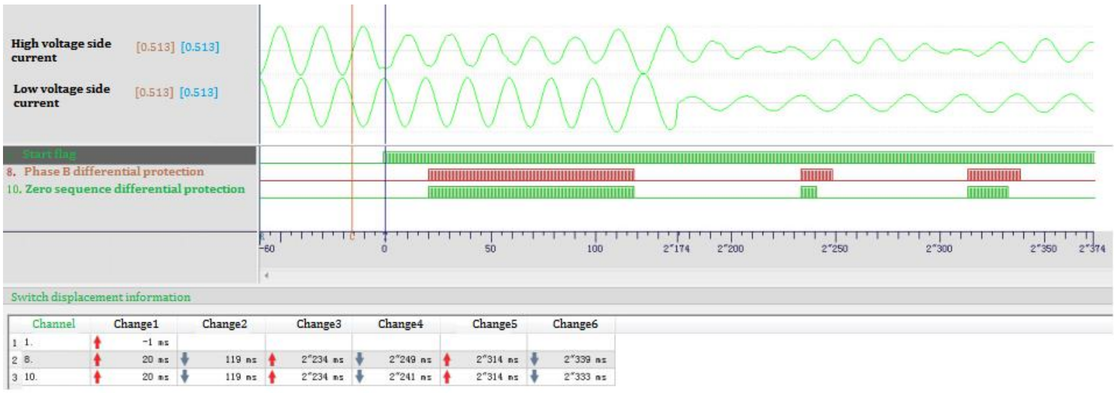

Figure 1: The wave recording figure of the first set of reactor electric quantities

The maintainers inspected the first set of reactor secondary circuits. When the reactor is in the overhaul state, they found that the secondary current sampling values of the high voltage side of the A, B, and C phases of the first set of reactor protection device were 0A, 0.259 A, and 0A, and the secondary current sampling values of the low-voltage side were all 0A. They also found that the high-voltage side of the second set of reactor protection device and the secondary current sampling value of the low-voltage side were both 0A. The current secondary terminal was opened at the first reactor protection cubicle, and the sampling function of the first protection device was checked, which was normal. In the Phase B reactor body terminal box, the current clamp meter was used for the loop cable, and the display value was 0.254A. When we opened the current terminal connection piece,the current of the reactor terminal box to the protection cabinet was 0A, but when the current connection piece was closed, the current was 0.193A. When we short-circuited the current terminal, and measured the cable from the rising base to the body terminal box, the current increased to 0.345A, so we judged that the fault location was between the terminal box and the rising base.We open the secondary terminal box of bushing TA at high voltage side of phase B. During the opening process, it was found that the reactor first protection sampling abnormality was changing, while the second protection sampling did not change. After the cover was opened, the current disappeared to zero. The maintainers checked that the wiring of the terminal in the TA secondary terminal box is normal. After pulled out the cable , it was found that the iron piece of the fixed ferrule of the cable protection sleeve from the raised base of the high-voltage bushing to the terminal box of the body cuts into the cable core, which caused the insulation rubber of the cable core to be damaged (the broken cable was the first set of protection TA secondary cable) (As Figure 2).

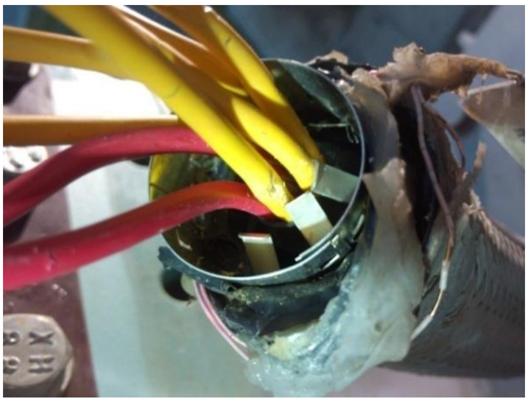

Figure 2: The damaged part of cable insulation

The measurement value of the voltage of the cable sheathed tube to ground by a multimeter was 0.180V, and the measurement value of the secondary resistance of the current loop was about 1Ω. The calculated induced current was about 0.180 ÷ 1 = 0.180 A, which was close to the field current clamp test value of 0.176A.

3. Cause analysis and treatment measures

3.1. Cause analysis
In summary of the inspection and analysis,the reason for the misoperation of the first set of electrical quantity protection of 500kV reactor protection is that the design of the secondary cable ferrule of TA secondary terminal box of the high-voltage bushing of phase B reactor is unreasonable. As a result, the cable core of the first protective current circuit of phase B reactor at the secondary terminal box of high-voltage bushing TA constantly rubs against the ferrule under the action of vibration force, thus damaged the insulation of cable core.In this way, the induced current was connected to the current circuit of the first set of protection of B-phase reactor in series, resulting in abnormal current sampling, making the differential current and zero sequence current reach the action setting value, and then the protection acted.

3.2. Treatment measures
Replace the cable with reactor to B-phase insulation and damage, and eliminate the metal ferrule, increase the protection of the PVC pipe to the lashing interface, block the terminal box, conduct the up-flow test on the body terminal box, and test the entire loop resistance. The coil windings are all above 100 MΩ.

4. Exposed problems and preventive measures

4.1. Exposed problems

4.1.1. The design of the TA secondary terminal box is unreasonable. Since the secondary must pass through the cover of the secondary terminal box, the cable will inevitably shift when the cover of the terminal box is opened and closed, causing the ferrule to wear the cable. After the cover is restored, it is impossible to confirm whether the internal cable is worn or not, and only the insulation test can be checked.

4.1.2. In order to fix the cable in the TA secondary terminal box and prevent the cable from falling, use a metal fixed ferrule to prevent the cable from falling, reactor to the body to the TA secondary terminal box cable protection sleeve and the edge of the fixed ferrule is sharp, the manufacturer does not carry out the factory. Passivation treatment. During the operation, it is affected by external force, and there is a risk that the fixed ferrule will wear the cable core insulation rubber.

4.1.3. When the manufacturer was wiring the main body cable, The cable head was not protruded into the terminal box,as a result, the fixed ferrule failed to press on the outer rubber of the cable and directly on the cable core.

4.1.4. The manufacturer's manual does not provide detailed requirements for the inspection of the TA secondary terminal box. Therefore, the secondary cable in the secondary cable protection cover is not inspected during maintenance. Due to the design of the terminal box, the secondary cable may not be found to be damaged.

4.2. Preventive measures

4.2.1. The high anti-A and C phases of the Shanhejia line were investigated to deal with the problems found.

4.2.2. For transformers and high-resistance equipment with similar conditions, check and rectify in conjunction with power-off maintenance.

4.2.3. Improve the technical specifications for high-resistance equipment bidding, and put forward specific requirements for cable casings.

4.2.4. Accept the cable in strict accordance with the equipment acceptance specification.

4.2.5. Improve the primary equipment maintenance work instructions for the main transformer and high-resistance equipment body accessory related cables, and incorporate the secondary cable inspection into the maintenance work.

5. Summary

This paper introduces the process of inspection and analysis of high-resistance protection misoperation caused by secondary circuit anomaly, and expounds the cause of failure through on-site inspection and test, and puts forward the problems of exposure and preventive measures. In order to prevent similar faults in the secondary circuit, a feasible device fault judgment and inspection method is provided to help ensure the safe and stable operation of the power system.

References

[1] Power transformer, oil immersed reactor, transformer construction and acceptance specifications, GBJ 148—90, Article 2.4.5
[2] Huang Weihong, Relay protection secondary circuit abnormality and fault handling[J]. Power and Electrical Engineering. 2014(24):118-119.
[3] Liu Huanzhang. A novel impedance protection analysis method based on the transform from the voltage plane to the impedance plane[J]. Proceedings of the CSEE,2004,24(1): 40-43.
[4] Gu Songlin, Wang Zengping, Ma Jing. Control strategy to prevent cascading trips based on related protection area[J]. Proceedings of the CSEE,2013,33(31): 155-161.
[5] Liu Huanzhang,Zhou Zexin. Post-fault over-load maloperation countermeasure of transmission line distance protection[J]. Proceedings of the CSEE,2011,31(25): 112-117.