Analysis of Abnormal Ground Current in 110kV Cable Line

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Abstract. In recent years, with the development of economy and the rapid growth of electricity consumption, the number and length of medium and high voltage cable lines have increased rapidly. As an important part of the power transmission and distribution network, to ensure the safe and reliable operation of cable lines and reduce unplanned power outages. Based on the field test and analysis of the abnormal ground current of the 110kV Luoyong line, it is found that the cross interconnection system has many defects such as phase sequence error and identification plate indication error. It is recommended that the cable cross interconnection system carry out a segmented insulation resistance test to exclude cables. Hidden dangers such as damage to the protective layer and damage to the protective layer.

1. Introduction

Power cables are an important part of the urban power grid. High-voltage cables are used almost exclusively for large-capacity central substations entering the urban area. After the cable fails, it will not only cause economic losses and adverse social impacts, but also affect the safe and stable operation of the urban power grid, which puts forward higher requirements for the reliability of power cables [1-3].

On the afternoon of May 28, 2020, during the field test analysis of the abnormal ground current of the 110kV Luoyong line, it was found that the cross interconnection system had many defects such as phase sequence errors and identification plate indication errors [4-6].

2. Brief Description of Abnormal Situation

The 110kV Luoyong Line is an overhead-cable hybrid line. The cable model is YJLW03-64/110-1×800mm2. The line was put into operation in September 2014, with a length of about 1,220 meters. On December 27, 2016, the cable grounding system was transformed and grounded by cross-interconnection. The specific method is shown in Fig.1.
After using the cross-interconnected grounding system, the metal shielding layer of each phase cable can be connected in sections to form a complete direct grounding loop, as shown in A1-B2-C3, B1-C2-A3 and C1-A2-B3 in Figure 1. This can effectively reduce the mutual inductance current between the A, B, and C three-phase metal shielding layers of the load current of each phase, thereby reducing the grounding circulation of the entire line. At the same time, when carrying out circulation detection, the ground current values of the A1, B2 and C3 sections should be the same, and the other two sections should also correspond in turn.

On December 28, when the 110kV Luoyong line was supplied with power, Huangshi Company tested its ground current when it was no-loaded and loaded. The data is shown in Tab.1.

| Line Status | Load Current (A) | A Phase Current (A) | B Phase Current (A) | C Phase Current (A) |
|-------------|------------------|--------------------|--------------------|--------------------|
| No Load     | 5.5              | 3.84               | 3.64               | 2.85               |
| Load        | 43               | 12                 | 11                 | 10                 |

On January 9, 2017, Huangshi Company again tracked and re-tested the ground current of the outer sheath of the 110kV Luoyong line, and found that the ground current was seriously exceeded and there was a serious imbalance. The specific test data is shown in Tab.2.

| Cable Sheath Current (A) | Inside the Substation | #2 Cable Manhole |
|--------------------------|-----------------------|------------------|
| A                        | 36.9                  | 79.3             |
| B                        | 12.2                  | 33.4             |
| C                        | 42.3                  | 55.8             |
| O                        | 0.15                  | 0.51             |

| Cable Load Current (A)   | 48.1                  |

According to Q/GDW 11316 5.2.3: the ratio of grounding current to load current is less than 20%; the ratio of the maximum to minimum single-phase grounding current is less than 3. When the load current is 48.1A, the A, B, and C three-phase outer sheath currents of the direct grounding box in the station and the 2# cross interconnection box seriously exceed the requirements of the regulations, and the ratio of the maximum and minimum single-phase grounding current (42.3/12.2=3.47) is also greater than 3. Not only that, after the 1# and 2# cable maintenance wells are cross-connected, the ground currents of the outer sheaths of the phases A, B, and C inside the station should correspond to the ground currents of the phases of the 1# and 2# wells. That is to say, the ground current value of each place should be matched according to each phase, but there is no corresponding relationship between the two ground current test results in Tab.2.
3. Site Inspection and Test

On May 28, the grounding system of the line was first inspected. Fig.2 shows the identification plate of the grounding box of Luoqiao Station. The name of the identification plate is "110kV Luoyong Line Cable Protective Grounding Box". After opening the box, it is shown in Fig.3. The grounding system of the grounding box is directly grounded, and the surface of the conductor and insulator is dry and smooth without traces of ablation. Therefore, the label description is wrong and should be replaced with "110kV Luoyong line cable directly grounded box".

![Fig.2 Identification plate of the grounding box of Luoqiao Station](image)

![Fig.3 The internal structure of the grounding box at Luoqiao Station](image)

![Fig.4 The internal structure of #1 cable well grounding box](image)

![Fig.5 The internal structure of #2 cable well grounding box](image)

Fig.4 is the unpacking schematic diagram of the grounding box of #1 cable maintenance well. The internal cross interconnection mode is "Left-Left-Right", the three-phase sequence is A, B, C, and the cable sheath protector and insulating parts are not found to be damp or burnt. Eclipse traces. Fig.5 is a schematic diagram of the unpacking of the grounding box of #2 cable maintenance well. The internal cross interconnection mode is "Right-Right-Left", and the three-phase sequence is A, B, C. The cable sheath protector and insulator are also not found to be damp and Ablation marks. Fig.6 shows the structure of the direct grounding box at the #1 iron tower outside the station. The grounding box is a direct grounding box, and no signs of abnormal moisture or ablation were found.
According to the above-mentioned cross interconnection wiring method, the actual grounding of the entire line is shown in Fig.7.

![Fig.6 The internal structure of the terminal #1 iron tower direct grounding box](image)

**Fig.6 The internal structure of the terminal #1 iron tower direct grounding box**

Ground current detection was carried out in Luoqiao substation, #1 cable maintenance well and #2 cable well. The detection results are shown in Tab.3.

| Detection Location | A phase body current (A) | A phase ground current (A) | B phase body current (A) | B phase ground current (A) | C phase body current (A) | C phase ground current (A) | Total ground current (A) |
|--------------------|--------------------------|----------------------------|--------------------------|--------------------------|--------------------------|--------------------------|-------------------------|
| Luoqiao Station    | 57.8                     | 39.2                       | 33.5                     | 29.6                     | 48.5                     | 14.5                     | 2.6                     |
| #1 Cable Well      | 54.0                     | 38.2                       | 28.1                     | 28.5                     | 52.3                     | 10.2                     | 0                       |
| #2 Cable Well      | /                        | 32.7                       | /                        | 9.7                      | /                        | 37.6                     | 0                       |

**Tab.3 Ground current test results of 110kV Luoyong line**

4. Defect Cause Analysis

According to the inspection situation, the interconnection modes of the line #1 cross interconnection box and #2 cross interconnection box are "Left-Left-Right" and "Right-Right-Left" respectively. It can be seen from Fig.7 that the three-phase ground currents flow through the paths shown in Tab.4, that is, the A-phase ground current does not flow through the B-phase armor, the B-phase ground current does not flow through the C-phase armor, the C-phase ground current does not flow through the A-phase armor. The current flow direction in Table 4 is seriously unbalanced, which will cause the ground current of each item to be too large and asymmetric. As shown in the measured grounding current in Table 3: Phase A grounding current in Well 1# is 38.2A, corresponding to Phase C grounding current of Well 2# is 37.6A; Phase B grounding current in Well 1# is 28.5A, corresponding to Well A in 2# Phase grounding current is 32.7A; 1# well C phase grounding current is 10.2A, corresponding to 2# well B phase grounding current is 9.7A. Since in actual measurement, the measurement of the ground current at various places is not carried out at the same time, there is a certain measurement error, so the above measurement results are considered to be within the acceptable range.
Due to the asymmetrical grounding method, the three-phase grounding current is seriously unbalanced. You can change the grounding copper plate wiring method of the cross interconnection box to solve this problem. The correct interconnection should be "Left-Left-Right" or "Right-Right-Left".

5. Conclusion
Based on the above analysis, the reason for the abnormal ground current of the 110kV Luoyong line cable section is the wrong connection method of the copper plate of the cross interconnection box. The suggestions are as follows:

① According to the power outage plan, change the connection mode of the #2 cable well cross interconnection box to "Right-Right-Left".
② During a power outage, conduct segmented insulation resistance tests on the cable cross interconnection system to eliminate hidden dangers such as damage to the outer cable sheath and damage to the sheath protector.

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