Analysis on the Cause of Excessive Gas Content in 1000kV Transformer Insulation Oil

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Abstract. Air tightness of syringe and sampling process were investigated, and gas content of transformer insulating oil was repeatedly measured, Based on the existing problems of excess gas content after partial discharge of 1# main transformer B phase of a 1000kV substation transformer insulating oil during the construction stage. The results show that excessive gas.

1. Introduction
As a kind of insulating medium, insulating oil is widely used in electrical equipment, especially in transformers with large capacity and high voltage grade, which is irreplaceable because insulating oil has higher dielectric constant than air(Dielectric constant: air =1.0, insulating oil =2.25 [1]).The quality of insulating oil will directly affect the dielectric strength of insulating oil and thus affect the stability of electrical equipment. As one of the test items of insulation oil quality, excessive air content may lead to air-gap discharge and accelerated oil aging, which will lead to equipment insulation reduction and even lead to the occurrence of accidents. Therefore, it is necessary to analyze and control the causes of excessive air content [2-5].

The gas in the insulating oil is mainly caused by the air entering into the transformer. The transformer of 1000kV substation belongs to the large-capacity ultra-high voltage transformer. In order to ensure the normal operation of the transformer, the insulating oil and gas content must be strictly controlled to prevent it from exceeding the standard [6, 7].In this paper, the problem of excessive amount of insulating oil and excess gas content after partial discharge of 1# main transformer B phase of a 1000kV substation transformer insulating oil during the construction stage was studied, and the air content was monitored repeatedly. According to the test results, the reasons for excessive amount of insulating oil and gas were analyzed.

2. Test methods and equipment
Test method: vacuum differential pressure method.
Test instrument: automatic measuring instrument for insulation oil and gas content. Model: ZHYQ3500
Sampling container: 100mL glass syringe (with rubber plug).
3. Judgment standard
As the test object is 1000kV substation and the substation is in the stage of infrastructure construction, the content of air in the insulating oil shall be determined according to the standard GB/T 50832-2013 “standard for the handover test of electrical equipment in 1000kV system electrical equipment installation engineering”13.0.1 test items and standards for insulating oil of oil-filled electrical equipment. See table 1 for details.

| Sample                     | Standard values | Test method                                      |
|----------------------------|----------------|-------------------------------------------------|
| Gas content in oil (V/V), % | ≤0.8           | Vacuum differential pressure method (DL/T 423)  |

4. Results and discussion
In order to ensure the safe operation of the electrical equipment, the detection steps of the gas content after partial discharge of 1# main transformer B phase are divided into two parts: after hot oil circulation and after local discharge. The sampling parts are in the upper part, middle part and under part of the equipment respectively. The sampling amount is 80mL and the sampling procedure shall be in accordance with DL/T 703 and shall be fully sealed. The detection process shall be strictly in accordance with the operation steps in DL/T 423 to ensure no external air entering. Sampling time: June 17, 2016 after hot oil circulation, and June 20, 2016 after discharge. See table 2 and table 3 for the test results of gas content in phase B insulating oil of 1# main transformer body for the first time after hot oil circulation and local discharge.

| Sample                     | The upper part | The middle part | The under part |
|----------------------------|----------------|----------------|---------------|
| Gas content in oil (V/V), % | 0.71           | 0.72           | 0.71          |

| Sample                     | The upper part (first) | The upper part (second) |
|----------------------------|------------------------|-------------------------|
| Gas content in oil (V/V), %| 1.27                   | 1.41                    |

It can be seen from table 2 and table 3 that the detected value of gas content in the upper, middle and under part of 1# main transformer B phase is significantly higher than that after the hot oil circulation, and it has exceeded the standard value by 0.8%, which is an outliers. During the process of receiving the sample, it was found that there were tiny bubbles in the insulating oil of the syringe, and no jam phenomenon was found in the glass syringe core plug during the detection of the gas content. In order to eliminate the influence of tiny bubbles in the syringe insulation oil on the detection result of gas content after local discharge, the second sampling was conducted on June 22, 2016. The sampling site was the upper part of the equipment, and two parallel oil samples were taken. See table 4 for test results of gas content.

| Sample | The upper part (first) | The upper part (second) |
|--------|------------------------|-------------------------|
| Gas content in oil (V/V), %| 1.27                   | 1.41                    |

It can be seen from table 4 that the result of the second sampling gas content test after local discharge is still unqualified, but the glass syringe core plug is found to be stuck during the gas content test. Air permeates freely through the tiny gap between the core plug and the inner wall of the glass syringe, indicating that the sampled glass syringe has not been cleaned. In this way, air may permeate into the insulating oil very slowly during sample transportation, resulting in high gas content test.
results. Therefore, the detection result of the gas content in the second sample after local discharge cannot reflect the true value of the gas content in the insulation oil of 1# main transformer B phase. In order to ensure the authenticity, reliability and persuasiveness of the test data, the third sampling was conducted on July 1, 2016. Take two oil samples from the upper part of the equipment. See Table 5 for test results of gas content.

Table 5. The results of the third gas content after partial discharge

| Sample               | The upper part (first) | The upper part (second) |
|----------------------|------------------------|-------------------------|
| Gas content in oil (V/V), % | 0.83                   | 0.89                    |

It can be seen from Table 5 that although the test result of gas content in the third sample after local discharge is unqualified, it is significantly reduced compared with the previous two tests and close to the standard value of 0.8%. In addition, the glass syringe core plug did not jam during the detection process, indicating that the glass syringe was carefully cleaned before sampling, and no bubbles were found in the oil sample during the sample acceptance process. In order to prove the authenticity of the test results of the third sampling, the fourth sampling was conducted on July 6, 2016 after local discharge. The sampling sites were in the middle and under part of the equipment, and two parallel oil samples were taken. See Table 6 for test results of gas content.

Table 6. The results of the fourth gas content after partial discharge

| Sample                  | The middle part (first) | The middle part (second) | The under part (first) | The under part (second) |
|-------------------------|-------------------------|--------------------------|------------------------|-------------------------|
| Gas content in oil (V/V), % | 1.09                   | 0.85                     | 0.93                   | 0.83                    |

It can be seen from Table 6 that although the test results of parallel samples in the middle and under part are different, the test results of four oil samples still exceed the standard value of 0.8%. Moreover, during the detection of the four oil samples, no jam was found in the glass syringe core plug, indicating that the glass syringe was clean and no bubbles were found in the accepted samples. Combined with the third and fourth test results of gas content after local discharge, there are five reasons for the over-standard detection results of the b-phase insulating oil of 1# main transformer B phase after local discharge.

1) main transformer phase B of ontology in hot oil circulation after sampling inspection, without adequate rest continue to stand for a few days later, the deep gas of the solid insulation material adsorption equipment and equipment corner gas accumulation will again slowly released into the insulating oil, it will lead to air content in insulating oil of qualified after the hot oil circulation, and discharge the air content in the insulating oil after unqualified phenomenon. as the air content in the insulating oil of 1000kV transformer is required to be high, if the sample glass syringe is not cleaned clean, there will be a gap between the core plug and the inner wall of the glass syringe. Since it takes a long time from sampling to testing (about 5 hours), the air may slowly permeate into the insulating oil sample through the cracks, resulting in a higher gas content than the actual test result.

The air tightness of the sample glass syringe is not good, including the air tightness between the core plug and the inner wall of the glass syringe and between the rubber plug and the glass syringe. The result is the same as the above point 2.

Various gases produced in the process of local discharge of the equipment lead to excessive gas content in the insulating oil. In general, the total amount of gas produced by the equipment in the local discharge test is very small, which will not make the insulation oil contain excessive amount of gas. However, if the gas content of insulation oil after hot oil circulation is qualified but very close to the standard upper limit value, then the gas produced by local discharge test may make the test result of the gas content of insulation oil after local discharge exceed the standard.
The equipment is not sealed tightly, and air penetration occurs. This requires the continuous tracking and testing of the gas content. Once it is found that there is a trend of slow increase of the gas content, it indicates that the equipment has the defect of loose sealing under the condition of eliminating internal faults of the equipment, and the equipment shall be eliminated and filled.

5. Conclusion

As the air content in the 1000 kV transformer insulation oil is strict, but also to ensure that equipment is safe and stable operation, after charged at construction stage, is the equipment of the insulating oil quality supervision in the strictly controlled, the operations to comply with relevant regulations, involving equipment insulating oil gas content in the supervision and inspection has the following Suggestions:

(1) Air tightness test should be carried out before using the sampling syringe to ensure that the syringe has good tightness.

(2) Before sampling, the sampling syringe should be cleaned and dried in accordance with the operating procedures. When sampling, the inner wall and core plug of the syringe shall be fully soaked with the sample to achieve a good sealing effect.

(3) Insulation oil in the equipment after the hot oil cycle, there should be sufficient static time (must be more than 72h static), especially large capacity equipment, in order to ensure that the equipment insulation material adsorbed by the gas completely released, the insulation oil in the amount of gas to achieve uniform.

(4) In the process of oil sample delivery, try to ensure that the sampling container is stable and free from violent vibration, and keep the air tightness of the sampling syringe intact to prevent air from penetrating into the oil sample.

(5) Always keep no bubbles in the oil sample during the detection of gas content.

(6) Different standards should be implemented for the insulation oil content of 1000kV substation after hot oil circulation and local discharge.

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