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Dissolved Gas Analysis (DGA) Testing For Transformer Health Monitoring 60 MVA 150kV / 20kV GIS

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Abstract— *The power transmission system is a system that functions to transmit electricity from the generator to the main power substation. This system requires much equipment that supports its effectiveness. One of the equipments that can be categorized as the main component that is considered very important in electric current transmission activities is a transformer. The transformer is a device that functions to increase or decrease the voltage in electric current transmission activities. The condition of the transformer itself can influence the value of the reliability of a transformer. Therefore, it is necessary to carry out routine maintenance of the transformer to have excellent performance. Transformer maintenance can be done by monitoring the health of the transformer insulation oil. This insulating oil acts as an insulator to prevent flashovers. Dissolved Gas Analysis (DGA) is a method that serves to monitor transformer insulation oil. In this method the gases dissolved in the oil will be detected and the results of the analysis of the dissolved gases will be a picture of the health of the transformer oil.*

Keywords— Transmission, Transformer, DGA, Dissolved gases

1. INTRODUCTION

Population growth in Indonesia is currently very fast with a population of 265 million people. With this amount, the need for natural resources is automatically increasing. The electric power distribution system is divided into two types, namely the transmission system and the distribution system. The transmission system is a link between the power plant and the substation using high voltage and extra high voltage lines. While the distribution system is a liaison between the substation using a medium-voltage network and a low-voltage network.[1]

With the demand for electrical energy that continues to increase, it is expected that the reliability of the power delivered by the power plant is the same as the power received by the load. The reliability of the system, including one of them is the performance/reliability of transmission line equipment. However, in practice, the electrical energy sent is not entirely accepted by the load. To reduce the electrical power losses, PLN overcomes them by increasing the working voltage of the transmission line.

A transformer is a device that functions to increase or decrease the voltage. If the transformer is disturbed or damaged, the supply of electrical energy will also be disrupted. One of the tests carried out for monitoring the health of transformer oil that can be done with the Dissolved Gas Analysis (DGA) method which aims to detect dissolved gases in transformer oil and to determine the presence of contaminants or oxidation processes in the oil. The condition of the transformer oil affects the performance of the transformer itself. Therefore, DGA testing on insulating oil is important to do.

2. METHODOLOGY

2.1 Power Transformer

Power transformers are static equipment. The transformer uses electromagnetic principles, namely Ampere's law and Faraday's induction, where changes in electric field current can generate a magnetic field and changes in magnetic field / magnetic field flux can generate an induced voltage. AC current flowing in the primary winding generates a magnetic flux that flows through the iron core between the two windings, the magnetic flux induces the secondary winding so that at the end of the secondary winding there will be a potential difference / induced voltage.[2]

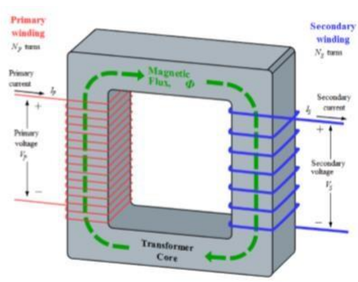

Figure 1 : *Electromagnetic in transformer*

In power transformers, the insulation uses a liquid dielectric, namely insulating oil, which functions to separate two or more high-voltage electrical conductors, so that between the voltage conductors there is no flashover.

In the manual for the application of specifications and maintenance of insulating oil, SPLN 49-1 it is stated that transformer insulator oil needs to meet certain specifications so that the insulation process from transformer oil can run optimally. The specifications of used transformer oil according to SPLN 49-1 : 1982 are as shown in table 1.

Table 1 : Standard Specification for Used Transformer Oil (SPLN 49-1 : 1982)

No	Parameter	Limit
1	Breakthrough Voltage	• 50 KV,2.5 mm, voltage >170 KV • 40 KV,2.5 mm, voltage 70 – 170 KV • 30 KV,2.5 mm, voltage <70 KV
2	Water content	• <20 mg/l for >170KV • <30 mg/l for <170KV
3	Dielectric leakage factor	<0.2-2.0
4	Prisoner type	1 G .m
5	Neutrality Score	<0.5 mg KOH/gr
6	Sediment	Not measurable
7	Flash point	Maximum drop 15oC
8	Surface tension	>0.015 N/m
9	Gas content	IEC is working on it

2.2 Dissolved Gas Transformer

Transformer oil is a complex mixture of hydrocarbon molecules. Mineral insulating oil is formed from several molecules containing the chemical groups CH3, CH2, and CH linked by carbon molecular bonds.

The cleavage of some CH and CC bonds can occur as a result of electrical and thermal disturbances, in the form of unstable small fragments, in the form of radicals or ions such as H*, CH3*, CH2*, CH* or C* which recombine rapidly through the reaction. complexes into gaseous molecules such as hydrogen (H-H), methane (CH3-H), ethane (CH3-CH3), ethylene (CH=CH2) or acetylene (CH≡CH), these gases are known as fault gases [3].

One method to find out whether there is an abnormality in a transformer is to know the impact of the abnormality of the transformer itself. To determine the impact of abnormality on the transformer used the DGA (Dissolved Gas Analysis) method. DGA is a process to calculate the levels / values of hydrocarbon gases that are formed due to abnormality. From the composition of the levels/values of the gases, it is possible to predict what abnormal effects are in the transformer, whether it is overheating, arcing or corona. [4]

Classification of individual gas concentration increases and TDCG based on IEEE C57 standard. 104-2008 is shown in table 2. Criteria for 4 levels of conditions have been developed to classify transformer conditions on the results of the insulating oil test. The combustible gases according to the IEEE are Carbon monoxide (CO), Methane (CH4), Ethane (C2H6), Ethylene (C2H4), Acetylene (C2H2), and Hydrogen (H2).

Table 2 : Individual concentration of gas and TDCG

Gas type	Condition 1	Condition 2	Condition 3	Condition 4
H2	100	100 – 700	701 – 1800	> 1800
CH4	120	121 – 400	401 – 1000	> 1000
C2H2	35	36 – 50	51 – 80	> 80
C2H4	50	51 – 100	101 – 200	> 200
C2H6	65	66 – 100	101 – 150	> 150
CO	350	351 – 571	571 – 1400	> 1400
CO2 (*)	2500	2500 – 4000	40001 – 10000	> 10000

TDCG	720	721 – 1921	1921 – 4630	> 4630

The following is a transformer condition based on the IEEE C57.104-2008 standard: Condition 1: Total flammable dissolved gas (TDCG) above indicates the transformer is operating properly or normally, condition 2: TDCG in this range indicates a high starting gas level where dissolved gases are flammable. There are possible signs of failure that must be started to watch out for. Condition 3: TDCG in this range indicates a high degree of decomposition of insulating cellulose and/or oil. One or more failures may occur.Condition 4: TDCG in this range indicates excessive decomposition of insulating cellulose and/or transformer oil is widespread.[5]

3. Result

3.1 TDCG Data Interpretation

From the TDCG interpretation method, it can be seen that the comparison of data from 4 points is as follows:

Table 3 : Result of TDCG interpretation method on 4 point transformer

Part	Results
Bottom Maintank	Normal transformer oil condition
Tubular R phase	Normal transformer oil condition
Tubular S . phase	Normal transformer oil condition
Tubular T phase	Normal transformer oil condition

The comparison results get the same results, namely normal transformer oil conditions, which can indicate that the operation of the transformer is satisfactory and still average.

3.2 Units Key Gas method data interpretation

From the Key Gas interpretation method, it can be seen that the comparison of data from 4 points is as follows:

Table 4 : The results of the Key Gas interpretation method at 4 transformer points

Part	Results
Bottom Maintank	Thermal oil fault
Tubular Phase R	Thermal oil fault
Tubular Phase S	Thermal oil fault
Tubular Phase T	Thermal oil fault

The comparison results get the same results, namely there is an indication of failure in the transformer oil, namely a thermal oil fault where there is an error with the temperature of the insulating oil which results in excessive heat in the oil. Then for very high amounts of Ethylene gas, more attention needs to be paid because it can developthe presence of acetylene which may form if the fault is severe or is followed by electrical contact. So that monitoring of ethylene gas must continue to be carried out to monitor the increase in the value of acetylene gas in insulating oil.

4. Discussion

4.1 Data Interpretation

The discussion of indications of insulating oil disturbances at 4 points of origin of the sample produces several separate indications according to their respective data interpretation methods. Based on the results of the data interpretation analysis that has been carried out, the main indications for transformer oil are obtained 60 MVA, 150 kV / 20 kV GIS is in the form of "Partial Discharge" [6]. Partial discharge (partial discharge) is the event of the release / jump of electric sparks that occur in a part of the insulation (in the inner cavity or surface) as a result of the high potential difference in the insulation. PD can eventually lead to insulation failure (breakdown). Partial Discharge can only occur when two criteria are met, namely the presence of an electric field that exceeds the breakdown value and the presence of free electrons. This phenomenon can occur in solid, liquid, and gas insulation. In solid insulation the failure is permanent while in liquid and gas insulation it is temporary. Failure mechanisms in solid insulating materials include basic (intrinsic), electro-mechanical, streamer, thermal and erosion failures. The failure of the liquid insulating material is caused by cavitation, the presence of granules in the liquid and the mixing of the liquid insulating material. On transformer 60 MVA, 150 kV / 20 kV GIS partial discharge results in excessive heat in the transformer which causes heat in the transformer and reacts with oil so that the result of the reaction produces gas that arises in excess in the transformer, namely ethylene gas which has an excessive concentration in the transformer.

4.2 Test results from DGA Tool

The data from the DGA test are taken from 4 transformer points, namely the bottom maintank, tubular R phase, tubular S phase and tubular T phase. based on the test of DGA Transformer 60 MVA, 150 kV / 20 kV GIS transmission Implementing Unit which was carried out, obtained oil samples from the bottom of the maintank with the following contents:

Table 5. Testing Sample Results Data on Bottom Maintank

No	Compound	Gas Name	Value (ppm)
1.	H2	Hydrogen	6.40
2.	CH4	Methane	16.26
3.	C2H8	ethane	16.85
4.	C2H4	Ethylene	82.93
5.	C2H2	Acetylene	0.00
6.	CO	Carbon monoxide	27.52
7.	CO2	Carbon Dioxide	638.58

Based on the DGA Transformer test carried out, an oil sample was obtained from the tubular part of the R phase with the following contents:

Table 6 : .Test Result Data on Tubular Phase R

No	Compound	Gas Name	Value (ppm)
1.	H2	Hydrogen	14.82
2.	CH4	Methane	21.91
3.	C2H8	ethane	23.10
4.	C2H4	Ethylene	112.35
5.	C2H2	Acetylene	0.00
6.	CO	Carbon monoxide	19.62
7.	CO2	Carbon Dioxide	513.52

Based on the DGA Transformer test carried out, an oil sample was obtained from the S-phase tubular section with the following contents:

Table 7 : Test Result Data on Tubular Phase S

No	Compound	Gas Name	Value (ppm)
1.	H2	Hydrogen	13.91
2.	CH4	Methane	29.45
3.	C2H8	ethane	28,88
4.	C2H4	Ethylene	139.92
5.	C2H2	Acetylene	0.00
6.	CO	Carbon monoxide	18.75
7.	CO2	Carbon Dioxide	439.19

5. CONCLUSION

The results of practical work that I have carried out, it can be concluded that the condition of the transformer oil has errors, namely partial discharge which causes insulation failure. As a result of the failure of the insulation will cause heat in the transformer. This heat will react with the insulating oil and can produce some dissolved gases in the transformer. This can be seen from several interpretations, namely the existence of a thermal fault where there is an error in the transformer, namely excessive heat in the transformer.

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