VOL. 11, NO. 13, JULY 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences
©2006-2016 Asian Research Publishing Network (ARPN). All rights reserved.

www.arpnjournals.com

ANALYSIS DESICCANT ADDITION TO THE QUALITY OF SF6 GAS COMPARTMENT FOR GAS INSULATED SWITCHGEAR 150KV

Titiek Suheta
Department of Electrical Engineering, Institut Teknologi Adhi Tama Surabaya, Indonesia
E-Mail: ekohita@gmail.com

ABSTRACT

In the electrical equipment with SF6 insulating gas, SF6 gas quality according to standard, is fundamental, for good insulating power, when a decline in the quality of the gas will decrease, the level of voltage insulation on electrical equipment. In this case, it was found that the aggravation of , SF6 gas in GIS Compartment Brand Ganz in the substation Darmogrande the high rate of humidity gas SF6 insulation to exceed the standard limit which is determined. In addition, GIS is not equipped with a silica gel / desiccant as, moisture absorbent material, and absorbent gas the result of switching PMT (IEEE Std 1125-1993), which resulted in a decrease in SF6 gas quality. The addition of desiccant in the GIS is needed to maintain the quality of SF6 gas. This material will be analyzed quantity and performance when applied inside the compartment so that the deterioration of the quality of SF6 gas and insulation failure can be avoided as early as possible, and SF6 retain their character with BDV of 88.4 kV /cm (according to the Critical Breakdown Voltage SF6). Hopefully, SF6 gas work according to its function as a medium of good insulation. As an application it has been done desiccant experiment on compartment GIS in the substation Darmogrande.

Keywords: GIS, SF6, moisture, desiccant.

INTRODUCTION

Darmogrande GIS is one of the substations that use SF6 gas insulated in the region of the State Electricity Company (PT PLN) Area Managing Maintenance Surabaya. Darmogrande GIS substations, including one that is very important in the metropolis of Surabaya in distributing electric energy, in which there are four (4) conductor and 3 (three) transformers. GIS requires regular monitoring and maintenance of one of them on the quality of its SF6 gas. Based on the results of SF6 gas quality testing conducted by PLN APP Surabaya, it was found that this GIS in critical categories caused by the high humidity that exist in SF6 gas. Based on the investigation of PLN APP Surabaya also found that the GIS is not equipped with a material that can stabilize the humidity or desiccant.

Research activities conducted by the authors is to find a solution, the high value of moisture, by the way, testing the desiccant material into the compartment GIS, with the aim that the GIS is able to operate with a high degree of reliability. The final results are expected to be known how much influence the desiccant material to the moisture SF6 and the potential failure of insulation on a GIS can be avoided as early as possible.

Previous studies of SF6 insulation in the Gas Insulated Switchgear (GIS) have been carried out among others by: Hiroyuki *et al* (2011), Eka (2012), Peter and Christian (2012), Danhua Mei *et al.* (2013), Raj and Sushant (2013), Weizong *et al.* (2013), and Paul *et al.* (2014). However, research on the effect of adding Desiccant the SF6 gas in the Gas Insulated Switchgear has never been done before.

LITERATURE REVIEW

Gas Insulated Switchgear (GIS)

Based IEV (International Electro technical Vocabulary) 441-11-02 switchgear is a general term covering switching devices and combination of control, measuring, protective equipment / protection where such devices have a relationship or connection to accessories compartment. As well as the supporting structure and in principle is intended for use related to distribution / transmission, distribution and energy conversion.

Gas Sulphure Hexafluoride (SF6)

SF6 gas is a gas that became the foundation insulation, parts, that voltage to the compartment or ground and this gas is selected, because it has many advantages when compared with other gases. SF6 gas is produced worldwide is used as an insulation medium in the electrical system. This is caused by the properties of SF6 gas as follows:

- Conductor heat (thermal conductivity) which is able to dissipate the heat that builds up on the equipment.
- Isolation is excellent (excellent insulating).
- Able to extinguish arcing (arc)
- Low viscosity.
- Stable, not easily react as good dielectric properties on SF6 for, the extent of cross-section, SF6 molecules and electron affinity (electro negative) which is greater than the fluorine atom.

ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences
©2006-2016 Asian Research Publishing Network (ARPN). All rights reserved.

Desiccant

Desiccant is something that can absorb water vapor; serves to remove moisture from the wide range of products that are sensitive to moisture and have a variety of types such as activated alumina, aerogel calcium sulfate and others. While often used to remove the moisture in the gas is molecular sieve.

Moisture

Moisture is the water content in the form of a gas that reacts with other gases as a result of this reaction is the declining value of insulation resistance on the main gas due to its conductive properties of humidity or moisture.

METHOD

The method used in this research is to determine : the amount or quantity of material desiccant, the determination of the gas pressure and humidity testing SF6 gas in units of ppmv (parts per million by volume) as well as the influence of moisture on the power isolation SF6 gas which is calculated in accordance with the formula

Desiccant material preparation stage experiment on compartment GIS:

a) Desiccant material experiments carried out by the findings of SF6 high humidity values at Brands Ganz in GIS Darmogrand area.

b) The data value of the high humidity in SF6 gas found in compartment other than breaker compartment (PMT) or CB (Circuit Breaker).

c) The study focused on the breaker compartment other than the compartments (PMT) the cable sealing end compartment and the compartment of the bus bar.

d) Compartment cable sealing end and the bus bar material is used as a backup because the trial design, shape, and the construction similar to existing GIS Darmogrande compartment.

e) Parts compartment was then taken to a separate warehouse for further cleaning, replacement of o-ring seal, the addition of desiccant and preparation of evacuation (vacuum) and filling SF6 gas.

f) Gas handling activities or activities related to gas, gas handling adapted to the standard issued by the US Environmental Protection Agency regarding the handling procedure.

Technical Specifications of the Materials:

a) Gas sulfur hexafluoride (SF6) In accordance with IEC 376.

b) Desiccant diameter of the pore - pore 4 angstroms or nanometers manifold molecules 4 sieve Japan's output.

c) O -Ring Seal manifold NBR (Nitrile Butyl Rubber) with catch-up (hardness) is 70.

d) Compartment backup made from aluminum, including a T-shaped compartments or (T Tank) with the type of GIS single phase or one phase per compartment.

The technical specifications of equipment research:

a. Gas handling brands dillo with the ability pressure 30-40 bar.

b. Hose, SF6 with a maximum pressure of 50 bar.

c. Vacuum gas engine with a power vacuum up to 0.5 mBar.

d. SF6 gas test equipment multi analyzer and RH System 374.

e. Regulator SF6.

f. Neppel SF6 gas valve, type DN 8 of dillo and PN69 for the standard as well as stop valves.

g. Test Equipment SF6 gas leakage, SF6 leakage detector dillo brands.

Mechanism of experiments and assembling materials and tools:

a) Installation Test compartment.

b) Determining the weight of the desiccant material.

c) The formula that is used in determining the weight desiccant compartment is as follows:

The strength of the desiccant according to the data sheet is the same as the desiccant which absorbs moisture 20-21 % of the total weight. So as to determine the ability of desiccant adsorbs per x (g) using the equation,

$$X(gr)\ desiccant = \frac{20-21}{100}.\ x\ Desiccant \quad (1)$$

The amount of moisture in the compartment determined using calculations of ppmv (parts per million volume) were converted into the unit of weight used ppmw (parts per million by weight).

VOL. 11, NO. 13, JULY 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences
©2006-2016 Asian Research Publishing Network (ARPN). All rights reserved.
www.arpnjournals.com

PPMV/8, 1 = PPMW or
PPMW x 8, 1 = PPMV (2)

Assumption 8.1 is a comparison of the molecular weight of air and SF6

All the test results are in units of ppmv will be converted into units ppmw (weight) to simplify calculations or calculations moisture. The units will be used to represent ppmw is (mgr/kg)

$$\sum moisture1 = \frac{ppmv}{8.1} \quad (3)$$

$$\sum \text{moisture2} = \sum moisture1 \ x \ \sum SF6 \quad (4)$$

$$\sum desiccant = \frac{\sum moisture2}{daya\ adsorbsi(/gr)}$$

d) vacuum compartment and filling SF6 gas into the compartment.

e) Handling of gas SF6.

f) Monitor the quality of SF6 gas on the value of moisture and its purity on test compartment as shown in the Figure-1.

Weight Dessicant	Test result	Implementation															
		Day 1						Day 2		Day 3		Day 4		Day 5		Day 6	
		9.00	11.00	13.00	15.00	17.00	19.00	8.00	16.00	8.00	21.00	8.00	21.00	8.00	21.00	8.00	21.00
	PPMV																
	PPMW																
	PURITY (%)																
	DEW POINT (DEG CELCIUS																
	PRESSURE (bar rel)																

Explanation:
Weight Dessicant equal to appropriate calculation ideal weight Dessicant
The test results equal to corresponding appointment of SF6 test equipment multianalyzer brand Dillo
Day 1 is the 1st hour until at the 4th had a delay of 2 hours
Day 2 is the 1st hour until at the 2nd had a delay of 12 hours
Day 3 is the 1st hour until at the 2nd had a delay of 12 hours

Figure-1. Form of testing the quality of the SF6 gas during the experiment process of desiccant.

g) Final process

RESULT AND DISCUSSIONS

Weight Desiccant to review conductive area is Waru 1 with phase T

Table-1. Values of moisture early in the GIS Darmogrand indicated exceeds the maximum limit of moisture on the conductive areas Waru 1.

No	compartent	Phase	1			2			3			4			5			6			7		
			2009			TAHAP RECYCLING 2010												2012			2014		
									1			2			3								
			Dew Point °C @atmp	Volume Ratio ppmv	Volume SF6 %	Dew Point °C @atmp	Volume Ratio ppmv	Volume SF6 %	Dew Point °C @atmp	Volume Ratio ppmv	Volume SF6 %	Dew Point °C @atmp	Volume Ratio ppmv	Volume SF6 %	Dew Point °C @atmp	Volume Ratio ppmv	Volume SF6 %	Dew Point °C @atmp	Volume Ratio ppmv	Volume SF6 %	Dew Point °C @atmp	Volume Ratio ppmv	Volume SF6 %
1	CT, Pms Line, PT, Pms Ground (Pergapit,Line)	R	-12.1	2136	98.2	-12.1	2136	98.2	-39.8	131	99.9	-34.7	228	99.9	-23.1	758	99.4	-13.1	1956	99.9	-22.4	810	99.9
		S	-10.7	2426	98.1	-10.7	2426	98.1	-33.8	261.6	100	-31.9	310.1	99.9	-28.6	484.6	100	-13.8	1827	100	-25.5	800	100.0
		T	-9.9	2613	98.2	-9.9	2613	98.2	-34	248.8	100	-32.6	288.8	100	-32.3	298.1	100	-11.8	2196	100	-25.1	820	100.0
2	PMS Bus A, Bus Bar A	R	-8.1	3642	99.7	-8.1	3642	99.7	-32.6	286	100	-32	306	100	-28.6	435	99.9	-10.1	2584	100	-10.1	2568	99.8
		S	-5.9	3705	99.9	-5.9	3705	99.9	-33.1	270.8	99.9	-32.6	287.3	100	-30.5	367.9	100	-10.4	2917	100	-8.2	3026	99.6
		T	-7.9	3113	99.9	-7.9	3113	99.9	-32.4	288.4	100	-31.7	316.6	100	-29.6	418.9	99.9	-11.4	2425	100	-9.6	2882	99.7
3	CT, PMS Bus B, Bus Bar B	R	-9	2833	99	-9	2833	99.0	-34.6	233	100	-32.9	277	100	-27.2	501	100	-10.7	2421	99.9	-10.7	2421	99.9
		S	-9.1	2802	99.9	-9.1	2802	99.9	-34.5	239	99.9	-33	273.7	100	-31.8	311.6	100	-10.4	2483	100	-10.4	2483	100.0
		T	-8.4	2978	98.3	-8.4	2978	98.2	-32.3	288.6	100	-32.1	308.4	100	-32.6	288.4	100	-11.4	2281	100	-11.4	2281	100.0

Moisture (rasio volume) = 2613 ppmv
Weight SF6 = 10 Kg
Absorptive capacity of the desiccant = 20% W/W

Moisture (rasio berat) = $\frac{ppmv}{8{,}1} = \frac{2613}{8{,}1}$ = 323 ppmw ($\frac{mg}{kg}$)

Total moisture = $323\frac{mg}{kg}$ x 10 Kg = 3230 mg

Total Desiccant should be added in compartment are:

Amount of desiccant $= \frac{\Sigma moisture}{dayaadsorbsi\ (/gr)} = \frac{230mg}{0{,}2} = 16150$mg

So the weight of desiccant should be added to the compartment is of 16150 mg.

The experimental results of desiccant with a weight of 16 grams and its impact on SF6 gas moisture

VOL. 11, NO. 13, JULY 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences
©2006-2016 Asian Research Publishing Network (ARPN). All rights reserved.
www.arpnjournals.com

Table-2. Results of testing the effect of desiccant with a weight of 16 grams on the quality of SF6 gas.

weight desiccant	Test Result	4 maret 2015						5-Mar-15		6-Mar-15		7-Mar-15		8-Mar-15		9-Mar-15	
		Day 1						Day 2		Day 3		Day 4		Day -5		Day 6	
		9:00	11:00	13:00	15:00	17:00	19:00	8:00	16:00	8:00	21:00	8:00	21:00	8:00	21:00	8:00	21:00
8 gr	PPMV	222	200.7	183.4	171.6	170.9	161.2	145	143.7	134.5	125.6	116.5	127.2	141.4	127.3	116.5	104.6
	PPMW	27.41	24.78	22.64	21.19	21.10	19.90	17.90	17.74	16.60	15.51	14.38	15.70	17.46	15.72	14.38	12.91
	PURITY (%)	99,9	99,9	99,9	99,9	99,9	99,9	99,9	99,9	99,9	99,9	99,9	99,9	99,9	99,9	99,9	99,9
	DEW POINT (DEG Celcius)	-35	-35.9	-36.7	-37.3	-37.4	-37.9	-38.8	-38.9	-39.5	-40.1	-40.8	-40	-39.1	-40	-40.8	-41.7
	pressure (barrel)	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2

if those results displayed in graphs would be as in Figure-2 below:

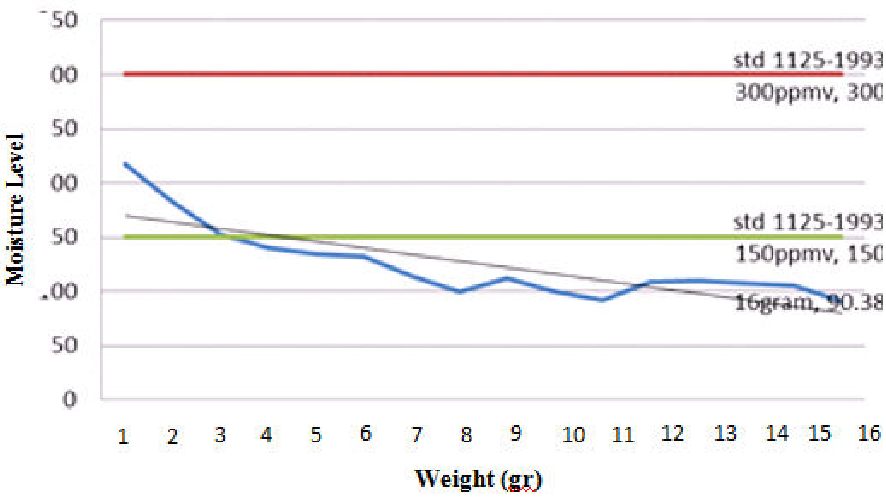

Figure-2. The graph of the test results, desiccant weighs 16gr and their effect on the quality of SF6 gas.

Results purity of SF6 gas after added the desiccant

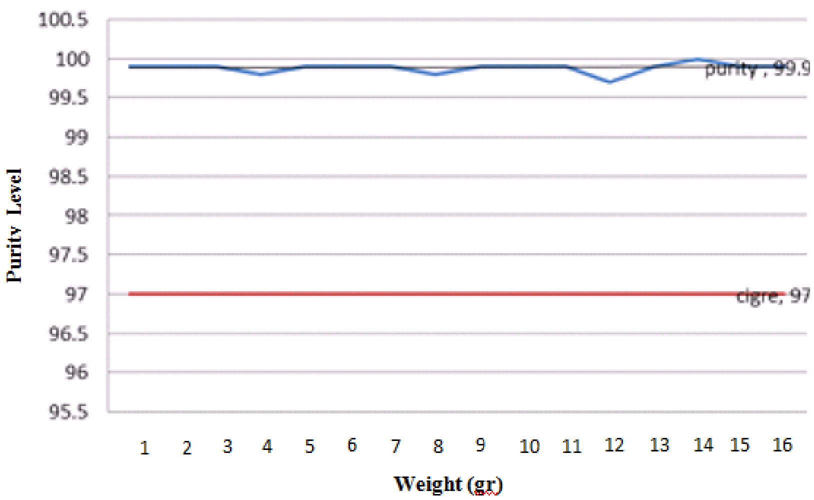

Figure-3. Results of testing of SF6 gas purity by weight of desiccant 16gr.

©2006-2016 Asian Research Publishing Network (ARPN). All rights reserved.

Figure-3 is to explain the change in the value of SF6 gas purity, and from these results it appears that although the desiccant material is added, the value of the purity of SF6 gas remains at a value above 99 % and still meet the standard.

CONCLUSIONS

Based on the results and discussion, it can be concluded that desiccant material added or applied to the compartments in the Gas Insulated Switchgear GIS Darmogrande stated for this material are very influential in reducing the level of water content in SF6 gas. This decrease was very significant to the value of 96.38%. This proves that there is an increase in the value of the quality of SF6 gas moisture content. Of the initial value, moisture content at the level of 2500 ppmv can be reduced to the level of an average of 90.38 ppmv where the moisture content value is still below the tolerance. According to the IEEE 1125-1993 standard the level of moisture content in SF6 gas must be below 300 or 150 ppmv.

REFERENCES

Danhua Mei *et al.* 2013. Dielectric breakdown properties of hot SF6/He mixtures predicted from basic data, Translation Journal. 20(11).

Eka P. H. 2012. Analysis of SF6 insulation performance of Gas Insulated Switchgear (GIS) P3B Waru based interpretation of measurement acoustic insulation analyzer (AIA) using stochastic methods, Undergraduate Thesis, Electrical Engineering of ITS.

Hiroyuki S., Hisashi G. and Masafumi Y. 2011. A study on condition assessment method of gas-insulated switchgear. Part II. Influence of moisture in the SF6, detection of a partial discharge on a spacer, repetition discharge and overheating by incomplete contact, Electric Engineering in Japan. 176(2): 174-182.

Paul TA., Porus M., Galetti B. and Kramer A. 2014. SF6 concentration sensor for gas-insulated electrical switchgear, Sensors and Actuators A: Physical. 206: 51-56.

Peter G. and Christian W. 2012. Gas-Insulated-Substations SF6 gas handling, EPA's 2012 Workshop on SF6-emission reduction strategies, Atlanta, Georgia.

Raj N. and Sushant S. 2013. Study of gas insulated substation and its comparison with air insulated substation, International Journal of Electrical Power and Energy Systems. 55: 481-485.

Weizong W., Xiu T., Danhua M., and Mingzhe R. 2013. Dielectric breakdown properties of hot SF6/He mixtures predicted from silica, Physics of Plasmas. 20, 115503(1-7).