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Sustainable Initiative - Go Green Conception Testing of High Voltage Cables

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Abstract: ***This paper presents a general overview about innovative testing method by optimization of SF6 gas handling in DEWA (Dubai Electricity and Water Authority PJSC) substation during high voltage testing of 132Kilo Volt cables between transformer and gas insulated switchgear. There are 300+ DEWA substations in operation feeding electricity to900, 000 consumer. DEWA substation is fully indoor and Gas insulated switchgear filled with SF6 gas is used in 400KV and 132kV substation. Using the conventional standard practice of High voltage testing method, there are high possibilities of SF6 gas emission to atmosphere. Initial aim focused on how to optimize the SF6 gas handling in DEWA substation and to predict these radiated fields and examine their compliance with international standards. An innovative model using the same technology with change in work nature has been identified as an alternative. An exposure assessment of a new innovative testing method conducted practically at DEWA substation with the one of the makes of gas insulated switchgear available in system. In a second step, we studied the technical viability confirming with the international standard and obtaining stakeholder confirmation which helped to implement the developed idea to deployment.***

Keywords: Gas insulated switchgear, cables, High voltage testing method and Test adaptor device

1. Introduction

132 - Kilo volt/ 11 Kilo volt standard substation in DEWA consists of 132kV Gas insulated switchgear of 8 number of feeder bays and 3 number of transformers. Gas insulated switchgear is filled with SF6 (Sulphur Hexa fluoride) gas.132kV cables are connected to transfer power from Gas insulated switchgear (GIS) to transformer.

Scope of work
132kV cable connected between Gas insulated switchgear and transformer has to be tested after installation at site.

Gas - insulated high - voltage switchgear (GIS) is a compact metal encapsulated switchgear consisting of high - voltage components such as circuit - breakers, Earth Switches and disconnectors, which can be safely operated in confined spaces. GIS offers outstanding reliability, operational safety and environmental compatibility. It provides a complete range of products for all ratings and applications from 72.5 kV to 1200kV with the rated current and future requirements for modern switchgears. DEWA substations are built with 145kV GIS and 420kV GIS for extra high voltage transmission.

Sulphur hexafluoride (SF6 gas): SF6 is an excellent dielectric gas for high voltage applications. It is chemically inert, gaseous even at low temperature, non - flammable, non - toxic, non - corrosive. Its combined chemical, thermal and electrical properties allow many advantages to be achieved. However, SF6 gas its dangerous greenhouse gas impact to Global warming.

High - voltage cable (**HV cable**): HV cable is used for electric power transmission at high voltage. Cable consists of conductor and insulation, and is suitable for being run underground. Cable joints and terminals must be designed to withstand the high - voltage stress to prevent breakdown of the insulation. Often high - voltage cable will have a metallic shield layer over the insulation, connected to the ground and designed to equalize the dielectric stress on the insulation layer.

Any equipment installed at site has to be tested to verify the healthiness of equipment and to ensure free from defects due to manufacturing, transportation and installation.

Cable High voltage test: The purpose of the test is to ensure that the cable and its terminations are fit for service and safe to energize. The testing method used to apply a sinusoidal voltage between each cable conductor and insulation shield (ground) in turn for a period of time.

The voltage level and application duration shall be as specified by IEC - 60840 (132kV for 1hour) or as agreed with client and will stress the cable and its accessories at the same levels encountered in normal service. Three phases of the same group will be tested together provided that the GIS Manufacturer can install three test bushing simultaneously.

High voltage testing will commence with the measurement of cable insulation resistance, between conductor and insulation shield, one phase at a time, by the use of a 5kV Insulation resistance tester (Megger). The measured value of insulation resistance will be recorded at the completion of one minute of measurement. Each conductor will be reconnected to ground upon the completion of the insulation resistance measurement for that phase. The ground will be disconnected from all the cable before starting the HVAC test. The cable terminals to be connected to HV terminal of the test kit. Following a final check of safety precautions, the voltage regulator will then be raised to increase the voltage gradually to the test voltage. The voltage will be brought to 50kV and held for one minute, after completion of one -

minute test voltage will be raised to 76kV and held for Partial Discharge measurement until the time the Partial Discharge (PD) operator gives clearance, after getting PD operator clearance test will be raised to 114kV for PD measurement, upon completion of PD measurement at 114kV, test voltage will be raised to 132kV for HV test.

The test period will commence when the specified test voltage has been achieved. After Completion of 132kV for one hour, test voltage will be reduced to 114kV and then again to 76kV for PD measurement after HV test.

After Completion of PD, Insulation resistance will be measured again at 5kV/1min and test will be completed. When all phases have been AC High voltage tested the insulation resistance measurement procedure will be repeated. The tested cables will remain connected to ground until immediately prior to being put into service.

Previous method of testing of High voltage cables

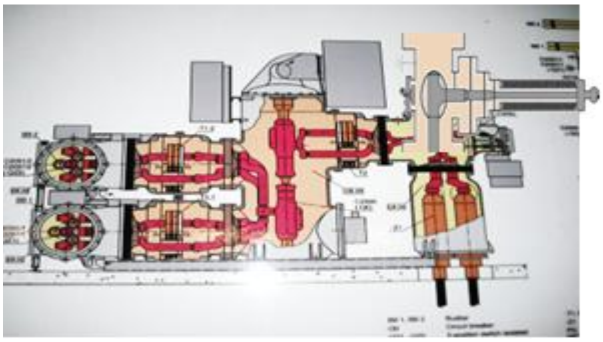


Figure 1: Siemens make Gas insulated switchgear with test adaptor mounted

In order to test 132kV cables connected between GIS and transformer. DEWA followed the standard recognized 25 years of practice of performing the cable High voltage test (To check the healthiness of cable) between Gas Insulated Switchgear and transformer by mounting test adaptor device on each bay independently (total 3 times since 3 number of bays) which involves 428 KG's of SF6 gas works per substation.

Previous method of testing
Bus bar

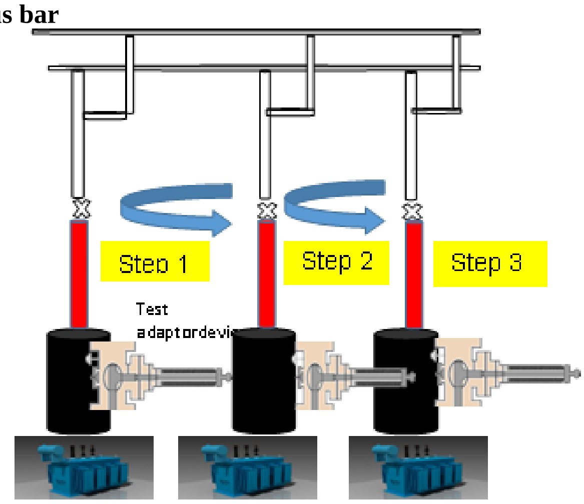


Figure 2: Block diagram of old testing method process

- Case Study: Did a case study on present practices and developed the innovative method on testing of High Voltage cables in 132 - kilo volt DEWA substation. The main objective was to reduce the environmental impact due to DEWA substation day to day business practice (to reduce the usage of SF6 gas with present practice). In addition to main objectives, we also focused in cost saving, optimize risk, happy stakeholder and happy society. Action plan was prepared for the pilot project. Studied in detail about pros and cons of new methods with different option to reduce the usage of SF6 gas

Many challenges were faced in implementing the new innovative method. Since the old testing method were proven and standard worldwide practice of 25 years. In addition to that, there were many disadvantage like usage of more SF6 gas since repeating the works for similar bays, high risk like additional installation, more consumable, complicated process, non - availability of resources and high cost issues were faced. Before conducting an experiment technical viability was confirmed and verified with international standards.

2. Experimental Studies

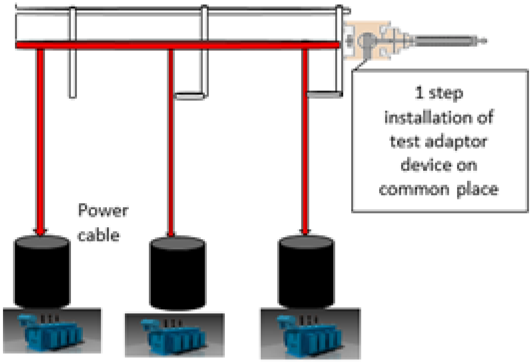
New Innovative method of testing

Developed a new innovative method by combining all bays cable High Voltage test together by mounting test adaptor device on common place in the switchgear instead of 3 times, once in each bay independently which simplified the process and reduced the usage of SF6 gas works to two - thirds (2/3) compared to the earlier method. Detailed study conducted on new testing method with each manufacturer.

New innovation has streamlined the testing of high - voltage cable cables in the transmission stations between the transformer and the gas - insulated switches in addition to reducing the cost and limiting the work that includes the use of SF6 gas by two – thirds in the gas - insulated switchgear common location rather than installing multiple test adapters in multiple areas, thereby simplifying test operations.

In earlier used method, gassing works of 486 Kg's of SF6 gas handling works required, whereas the new innovative testing method required only 52 Kg's of SF6 gas works. Imagine if whatsoever reason if minor gas leakage happens, it will bring a major effect in environment For example, if 1 Kg of SF6 gas leaks that is equal to 22 tonnes of Carbon dioxide CO_2. In addition to optimization of SF6 gas handling, various other benefits like cost and resources saving saved.

Present Innovative method



Power transformers

Figure 3: New innovative testing method illustrative single line diagram

In the new innovative testing method, number of feeder's bays can be selected by switching operation with the required bays. Experimental test done for each original equipment manufacturers and one of the test procedure shown in the Figure - 3.

Installation of HV test adaptor on common location:
Test adaptor device will be installed on a common point of gas insulated switchgear. Three transformer cables between GIS and transformer will be tested together with the required switching in the gas insulated switchgear bays. In case of any abnormalities found, this can be separated and tested individually.

Test voltages will be applied to all the cables through gas insulated switchgear with respective switching operation. Gassing and degassing works limited since the complete cables i. e 3 numbers of transformer cable are testing in single application.

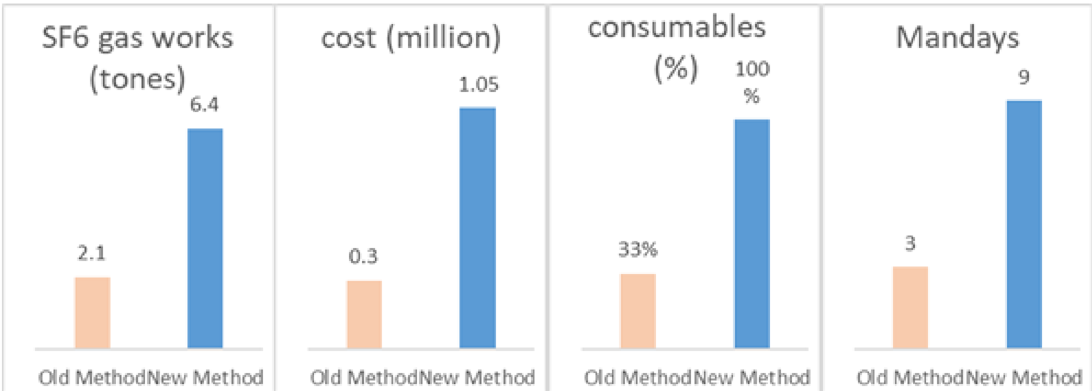
After completion of high voltage test of cables, will be normalized by degassing the chamber and then removing the test adaptor.

Outcome
Feedback and confirmation obtained from all stakeholders to implement the test method (sustainable solution) for all ongoing and future DEWA substation. Challenges like technical vulnerability, original manufacturer confirmation on newly proposed method were overcome. Team initially plan to implement the project for 10 numbers of selected on - going substation, which was successfully tested and completed.

Accordingly, as per the project master plan, DEWA implemented the new innovative method of testing in running projects after getting concurrence from concerned stakeholders.

Achievements
1) Usage of SF6 gas works reduced by two - thirds (2/3) i. e.4280 Kg's of SF6 gas works reduced per 10 Substation equals to 97, 584 tonnes of CO2 avoided.
2) Green Environment (21, 400 cars emission avoided in Dubai city for a whole year)
3) Cost saving of USD 1.9 million per 10 numbers of Substation.
4) Happy stakeholders
5) Happy society (21, 400 cars emission avoided in the Dubai city for a whole year).

Statistical Analysis



3. Conclusion

New innovation has streamlined the testing of high - voltage cable in the transmission stations between the transformer and the gas - insulated switches in addition to reducing the cost and reducingthe usage of SF6 gas by two - thirds in the gas - insulated Switchgear compared to test adapter in multiple locations, thereby reduced the test preparation time and total test duration

This project is a breakthrough and globally it isfirst kind of new innovative testing methodology of high voltage cables which is contributing to environment. This project contributed to global sustainable development goals of responsible consumption and production, climate action.

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