Operational Evaluation of RTV Coating Performance over 17 years on the Coastal Area at Jubail-SA

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SUMMARY

This paper will highlight a case study result that was conducted by Saudi Electricity Company- NG, in the Jubail area on outdoor ceramic insulators. The RTV coating, which was applied in this case, was done in 2004. The performance monitoring method followed up during 17 years evaluation program for RTV coated porcelain insulators will take part.

Moreover, the operational records and monitoring results of this case study will be then deeply analyzed and further evaluated through a field evaluation and a technical approach.

The outcome of this assessment will be utilized as a good reference and data to feed another in-process study concerning pollution map and will add its mark on identifying contamination levels in a specific area where the RTV coating is applied. In the end, this will help in setting up insulator best selection criteria in different region.

KEYWORDS

RTV Coating, outdoor porcelain insulators, Contamination level, Evaluation program, pollution map.

INTRODUCTION

Saudi Arabia- National Grid Network is widely spread out among very wide geographical areas. In the eastern region, there are many substations are located in the coastal area of the Gulf Sea, where the outdoor equipment insulators/ bushings are subjected to heavy pollution contamination levels, consequently affecting the overall performance of the network. With the fact that several of these S/Ss are feeding critical industrial bulk customers.

In order to secure a reliable power supply to bulk customers, SEC- NG had looked deeply for all possible remedies that would reduce the power interruption, improve the operational performance of the network, and cut the major maintenance cost on these outdoor insulators. This was done by appointing different corrective programs starting from improving specific creepage distance of the outdoor porcelain insulators, then applying silicone grease, and then performing high pressure washing demineralized water washing method to clean insulator surface.

In the end, the more effective method was introduced which is applying RTV Silicone Rubber Coating on the outdoor insulators and bushings which lead to the best insulators performance under harsh environments and consequently, no more washing activities were required and no system disturbances due to insulators performance had been recorded since then.

During the last 17 years, a performance-monitoring program of different patterns was utilized to assess the integrity of the coated materials on the outdoor porcelain insulators to track the behavior of the hydrophobicity and electrical performance and ensure the withstanding of these insulators against the harsh environment and high level of salty and saline contaminations.

The assessment methodology focused on measuring and tracking the hydrophobicity classification level using STRI guide 92/1 method and conducting various types of inspection –day and night - using the thermo-vision inspection and corona camera. In addition to that, the physical appearance (as corrosion, erosion, deterioration, and discoloring) and thickness measurement of the coating at different periods were recorded and abnormal changes were noted as well.

This tracking and operational records had helped the maintenance in National Grid SA to establish their own preventive maintenance (PM) procedure of the RTV coating (that included the Minor PM, the Major PM, and the Inspections).

LITERATURE REVIEW

Various research papers and evaluations related to RTV coating have been conducted. Two of these researches are assessing the aging levels of RTV coating using the Thermally Stimulated Current (TSC) method and Thermogravimetry (TG) respectively [1], [2].

The performance of RTV coating on different types of bushing - HVAC and HVDC under diverse harsh restrictions [3]. From field perspectives, the operational evaluation of RTV coatings over 5 years period in Shanxi province and southern China was shared [4], [5]. These case studies contain diverse factors of assessment such as physical appearance and hydrophobicity.

On the other hand, the climatic condition and behaviors surrounding the insulators play a pivotal role in the RTV coatings evaluation. That contains Ultraviolet level, chemical oxidation, ozone/O3 as well as dry and wet contaminations [6],[7]. In addition, the relation between pollution flashover attributes and damage modes was discussed and proved in the published paper [8]. Besides that, the contamination impact has been concluded in tropical areas [9].

This paper is an extension of the case study that explained the effects of utilizing RTV coatings compared to the situation before it was applied [10]. Therefore, this paper will add its mark to evaluate the RTV coating in a very harsh environment and different contamination types and levels on the Gulf Sea side over the 17years.

OBJECTIVE

Adopting RTV coating on outdoor porcelain insulators/bushings at Ghazlan P/P 230V outdoor switchyard had significantly improved the electrical performance of the outdoor insulators, improved the insulation integrity and cut the operational and maintenance cost. As long as the lifetime and integrity of RTV coating are dependent on the operational environment and other factors, it was necessary to monitor the condition of these coated insulators closely through:

- Evaluate the operational performance of RTV coated insulators by tracking the trend of hydrophobicity class level, checking the physical appearance, and Dry film thickness measurement.
- Evaluate tracking of contamination level on the insulator’s services in the Eastern Coastal Region.
- Collection data and feed this information to another in-process case study concerning pollution map that could help to fingerprint contamination type and insulator behavior helping at the end the company for best insulators selection.

METHODOLOGY

The RTV coated insulators of the case study were subjected to the following evaluation methodology, which became later part of the maintenance program and procedures as well:

- Perform hydrophobicity Classification test every 6 years using STRI 92/1 method.
- Perform Dry-Thickness measurement every 6 years.
- Perform Visual Inspection Every 2 years
- Perform Day & Night inspections every 2 years and during hi-humid days.
- Perform Thermo-vision Inspection, corona Inspection, and monitor arcing level when it exists.
- Record & track major findings and abnormalities.

RESULTS AND ANALYSIS

The paper case studies have selected three Samples from different equipment: Transformer Bushing, Circuit Breaker, and Air Disconnect Switch Insulators.

A) Case Study input data:

The overview data of selected sample insulators and specification of the utilized RTV coating material used in the case study as shown in Table 1 and Table 2 respectively.

The data of weather during the case study period have been determined in Table 3. In addition, the data of Equivalent Salt Deposit Density (ESDD) - Non-Soluble Deposit Density (NSDD) has been noted as shown in Table 4.

Table 1: Overview data of Sample Insulators:

Equipment	mm/kV	V.L	Equipment Energization Date	Year of RTV Coating Application
Sample#1 XFRM Bushing	36	230kV	1977	2004
Sample #2 BOCB Insulators	32	230kV	1977	2004
Sample#3 Disconnect	32	230kV	1977	2004

Table 2: Specification of Utilized RTV Coating martial

Property	Value
Type	One Part RTV
Appearance	Liquid Paint
Color	Gray
Specific Gravity	1.1 – 1.25
Tack Free Time	15- 45 min
Percentage Solids Contents by Weight	≥70
Dynamic Viscosity	1000 – 3500
Dry arc Res.	180-200 sec
Dielectric Strength	≥14 (kV/mm)
Volume Resistivity	$\geq 1\text{x}10^{14}$
Dissipation Factor	0.01-0.09 at 100Hz

Table 3: Weather data around the case study

Humidity Level	More than 80% for (Avr. 17 days/month) between (July –Nov.) More than 90% for (Avr. 5 days/month) between (Aug –Dec)
Wind	Speed (Max) (22- 42) km/h Direction (N & NE, NW) wind comes from inland and Gulf Sea
Rain Precipitation	Ave. 94 mm/year, Area was subjected to heavy rain on Nov.2004, Jan. 2007, and Dec. 2014 Only
Temp.	10 – 54 C

Table 4. Contamination Information and Pollution Condition:

	Degree of Pollution	Weight Composition
ESDD	0.53 mg/cm2	NaCl: 84% MgCl2: 16%
NSDD	3.06 mg/cm2	100%

Note: The environment is categorized as a harsh environment due to the degree of pollution measured in the above table.

B) Physical Appearance of Coating Paint over the Case Study period:

As a consequence of the harsh environment, the surface deterioration of RTV coating has been detected in late years (minor deterioration) and is gradually proceeding, however, it is in slow motion. In addition, minor cracks and aging on RTV coating were observed only at the portion close to the High Voltage side of some insulators.

Moreover, it was noticed that some surface discoloration changes from grey to light black at the portion close to the H.V side as these insulators were installed in the early 1970s without sufficient corona grading system while the humidity is very high forming observable (Dry Arc Band) across the insulators sheds. On the other hand, throughout 17 years, no erosion or coating chalking was detected.

It was observed that the contamination level was not consistent due to the value of rain precipitation which hit the area and was recorded three times heavily raining and recorded in Nov.2004, Dec.2007, and Jan 2014.

C) Result of Hydrophobicity Classification:

From table 5, Fig.1, and as an overall evaluation of the hydrophobicity (HC) classification test, it is clear that HC had a slight reduction in these monitored insulators but still at a good level. The results did not exceed HC3 level in 94% of the measured value during the overall test period, while HC4 appeared rarely in some Circuit Breaker & Transformer bushings as these insulators are filled with oil and subjected to minor oil leaks and they are having less specific creepage distance compared to other support insulators in disconnect switches and bus-bar insulators. It is worth mentioning that the hydrophobicity performance is usually sensitive to insulator surfaces subjected to any minor oil leaks.

D) Thickness measurements findings:

Despite being these insulators are exposed to harsh weather under unique pollutions, the thickness measurement results of RTV coated insulators as indicated in table 5 below, show minor changes in thicknesses compared to the first time applying thickness records as recommended by the RTV coating material manufacturer which was 500 microns +/- 150.

The thickness values quarantine that the hydrophobicity performance is still in good condition as coating thickness usually indicates the ability and quantity of silicone oil that could be diffused to insulator surfaces and maintained desired hydrophobic surfaces.

In 2004 In 2021

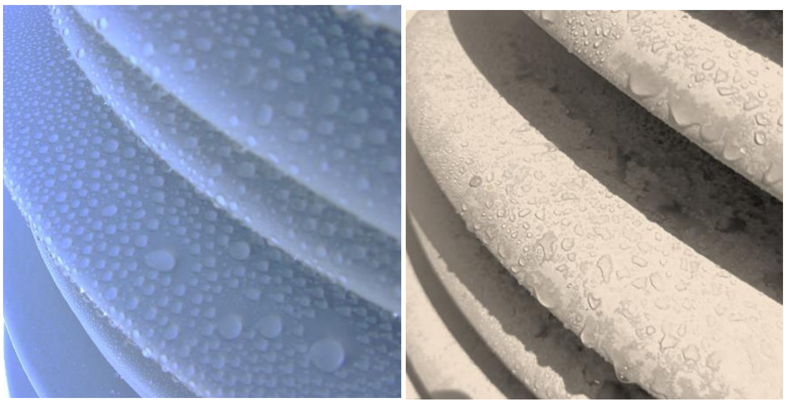

Fig.1. Conditions of RTV coatings

E) Historical operational records:

During the study period, there was no single flashover incident related to RTV performance was recorded even during rainy weather, which means the surfaces of insulators are still hydrophobic and the recovery time of hydrophobicity of these coated insulators after 17 years of operation is good and the LMW silicone oil still diffused to the surfaces of the insulators.

It is worth mentioning that any minor oil leak from transformer RTV coated bushing may affect the performance of the coating. In case of the oil leak was not treated immediately, it may then accelerate the aging of the coating and reduce the electrical integrity and the overall electrical performance of the insulators.

In the end, the High-pressure washing program stopped since the first day of RTV coating application, which in turn led to reducing operational and maintenance costs while maintaining the high reliability of the network.

Table 5. Results of the Hydrophobicity classification level, Physical Appearance, and Thickness measurements

Period	Test	XFRM			BOCB			Disconnect		
		Bottom	Center	H.V side	Bottom	Center	H.V side	Bottom	Center	H.V side
Y1	HC	HC1	HC1	HC1	HC1	HC1	HC1	HC1	HC1	HC1
	Physical Appearance	Clear Gray	Clear Gray	Clear Gray	Clear Gray	Clear Gray	Clear Gray	Clear Gray	Clear Gray	Clear Gray
	Thickness	500	500	500	480	470	480	450	460	480
Y6	HC	HC1	HC1	HC1	HC1	HC1	HC1	HC1	HC1	HC1
	Physical Appearance	Clear Gray	Clear Gray	Clear Gray	Clear Gray	Clear Gray	Clear Gray	Clear Gray	Clear Gray	Clear Gray
	Thickness	500	490	490	480	467	477	450	458	478
Y12	HC	HC1	HC2	HC2	HC1	HC2	HC2 – HC3	HC1	HC2	HC2
	Physical Appearance	Dusty Gray	Dusty Gray	Dusty light Gray	Dusty Gray	Dusty Gray	Dusty light Gray	Dusty Gray	Dusty Gray	Dusty light Gray
	Thickness	495	490	484	480	461	468	447	451	472
Y17	HC	HC2	HC2	HC3 – HC4	HC2	HC3	HC3 – HC4	HC2	HC2 – HC3	HC3
	Physical Appearance	Dusty Gray	Dusty light Gray	Discoloration	Dusty Gray	Dusty light Gray	Sign of Discoloration	Dusty Gray	Dusty light Gray	Sign of Discoloration
	Thickness	491	488	473	478	458	463	443	447	466

CONCLUSION AND RECOMMENDATION

The objectives of this case study were to track and evaluate the operational records of RTV coating in the Gulf Sea environment. From the above results and analysis, it is concluded that RTV coating performance after 17 years of operation are still performing well and maintenance would have enough time to plan their recoating work or equipment replacement if required. Moreover, the results of this study can be utilized for feeding other tasks force study concerning pollution map and setting up criteria for insulator selection in the different operating areas.

Referring to the paper case study which subjected to evaluation of RTV coting in the Gulf See -Eastern of Saudi Arabian- at Ghazlan power plant over 17 years, the results and recommendations are flowing:

- It is confirmed that the Operational performance of RTV coating and life of RTV coating is dependent on many factors such as the application method, material specification, monitoring method, and therefore any application shall be strictly in accordance with IEEE 1523 application guide.

- Continue performing minor and major preventive maintenance programs and record major changes in HC and plan for re-coating whenever HC class exceeds HC 4.

- The evaluation results indicate that Eastern Coastal Area is of a harsh environment and heavily contaminated area and any new T/L insulator shall be of SiR Insulator and S/S outdoor bushings shall be either SiR insulators as well or RTV coated Porcelain.

- It is recommended to remove one sample-coated insulator from the site and send it for laboratory testing in order to evaluate the long term performance of the RTV coating on outdoor insulators at the laboratory and to indicate the life expectancy by reviewing the mechanical, electrical and chemical test results as per below planned test procedures:

    1. Electrical Test (to measure the performance of electrical withstanding voltage)
    2. Surface Observation (against any coating surface defects, cracks, chalking, color-changing, and erosion)
    3. Hardness Test (utilizing micro-hardness tester)
    4. HC Test (including the STRI method and Contact angle measurement)
    5. Measurement of contamination level and recording the pH level at different contamination weights.
    6. Conduct Chemical Analysis on the Deteriorated portion utilizing different methods (FT-IR, SEM/EDX) and evaluate the change in chemical component comparing the results to the RTV coating virgin component.

- With long operational severity (high temperature, high humidity and arcing, heavily industrial and saline contamination), the lifetime of RTV will be directly affected. Therefore, the maintenance period shall be decreased once the lifetime exceeds 15 years of operation in a harsh environment.

- The ionization of the air around the RTV coated insulators that is developed from the corona will affect the coating surface and continuous high corona discharge may degrade its integrity and cause material erosion at the portion of the insulator close to high voltage.

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