COMPOSITE INSULATOR DIAGNOSTICS IN SERVICE AND CONDITION MONITORING IN VERY HARSH COASTAL ENVIRONMENT OF IRAN

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ABSTRACT

During the last decades the use of composite insulators has grown all over the world. And also diagnostic techniques for these insulators have been studied and developed.

According to DIN50019, the coastal districts of Persian Gulf are classified as extreme hydrothermal climatic zone. Unusually high saturation vapor pressure up to 53mbar observed in this zone, justify this marking, as such air humidity phenomena are unique in the free atmosphere of the earth and are absolute extremes. Intensive night falls of dew, which can occur regularly for several months, long periods of rainless and sultry weather and high level of marine pollution worsening the situation for power lines.

This paper present an applicable program for diagnostics and condition monitoring (CM) of 20 kV distribution line which is located in a coastal district which pollution level of this region is classified at very heavy category as shown in figure1.with pilot project in this area, this model of CM presented the best tool for Evaluation of reminded life of all kind of insulators.

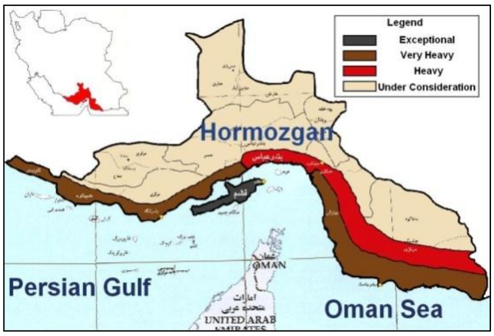

Figure.1: Pollution Map of Persian Gulf

INTRODUCTION

According to reports, the coastal districts of Persian Gulf are known as a critical utility zone for Electrical power Distribution networks. Intensive night falls of dew, which can occur regularly for several months, long periods of rainless and sultry weather and high level of marine pollution worsening the situation for power lines. The site pollution map of the region based on the ESDD-NSDD measurement level is documented Fig. 1. The pollution level of this region, for which the survey was conducted for, is classified as very heavy category In recent decades, the replacement of porcelain insulators by composite insulators has been considered as an effective approach to overcome undesirable effects of high level marine–desert pollution in the southern coastal regions of Iran. Due to the superior hydrophobicity and the resulting high withstand voltages under pollution, the use of silicone rubber insulators was chosen. Fig. 2 shows the trend of distribution composite insulator installation in region in 2001-2012.

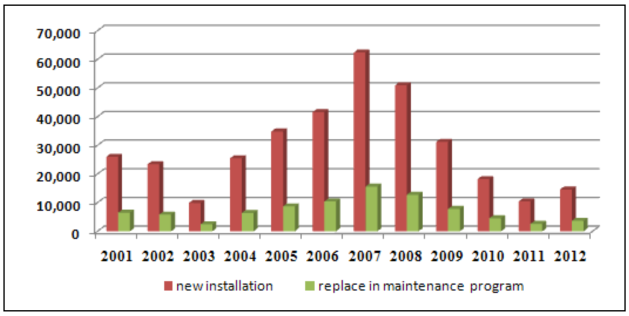

Figure.2: Number of installed composite insulators in the region investigated

Since composite insulators can suffer from ageing due to electrical stresses such as dry band activity and environmental stresses such as UV radiation and acid rain, the utilities concern about the future condition of composite insulators in their network. These stresses may cause surface, chemical and structural changes of the housing in long time service operation. In critical cases, an insulator failure can occur. As experiences with composite insulators are significantly less than with porcelain insulators, the

Application of useful methods for onsite condition assessment of composite insulators is an important duty. Table 1 shows for the period from 2004 to 2008 the failures of porcelain and composite insulators.

Table 1:Number of insulators failures in HEPDC 20KV OH Distribution Network

Also table 2 shows the number of composite insulators

Year	Number of replacements	
	Porcelain insulators	Composite insulators
2004	615	19
2005	599	19
2006	457	14
2007	425	13
2008	592	18
Total	2688	83

replacement after defect within the maintenance program for the period from 2004 to 2008 .

Year	Number. of failures		
	Total	Porcelain insulators	Composite insulators
2004	1787	1733	54
2005	2591	2513	78
2006	1110	1077	33
2007	1095	1062	33
2008	1170	1135	35
Total	7753	7520	233

Table 2: historical maintenance program for insulator replacement in HEPDC 20KV OH Distribution network

ONLINE DIAGNOSTICS METHODS

Three parameter which is needed to have a good condition monitoring are listed below:
- Precise condition monitoring
-Repeatable
-Including data to determine maintenance strategy and diagnostics of composite insulators AND applicable tool and criteria to make a good decision in maintenance .In the present standards as IEC, CIGRE, IEEE on line Diagnostics methods recommended to evaluate the condition of insulators in service. Currently, both CIGRE WG B2.21 and IEEE 15.09.04.01 are working to update the state-of-the-art of live line diagnostic techniques for composite insulators.[1] However, it is important to state that the principles of diagnostic techniques remain those identified in:

- Leakage current measurement
- Acoustic emission,
- Inspection with mirror
- Infrared (IR) thermography,
- Ultra-violet (UV) detection,
- E-field measurements,
- High frequency high voltage measurement tool

Visual inspection, acoustic and IR/UV methods can be used both from the ground and from the air. Usually a helicopter is used for aerial inspections. Despite the fact that the diagnostic technique principles are mostly the same as in [1], the diagnostic tools, like different camera systems, have been dramatically improved, making diagnostics much easier today. Furthermore, R&D activity has provided much better methods for interpretation of the measurements, which was a previous bottleneck, reducing their usage.
Studies shows there is some similarity and difference between all kinds of known diagnostic techniques for using in the coastal districts of Persian Gulf as the HEPDC is responsible for 20KV OH Distribution networks. But the principles of the new diagnostic technique are given better for comparison.[2] It is crucial that these principles are given after it's done for a sample OH network.

Expectations described by this new model for estimating the remaining lifetime of the insulator by using of advanced imaging technology, (UV detection) to monitor and measuring the number of **blobs** that emitted from insulators. In fact the new UV Cameras have the capability for corona detection in a specific time limitation when the blobs are counted by these cameras. Then the Insulators can be classified based on the results of their behavior (blobs emitting). In this model, the number of electrical discharge emitted from the surface of the insulator (photon or blob) per minutes can be use for classification according to their developmental steps of diagnostic to evaluate the remaining life time .Therefore with adaptation of collected image data during a network browsing; can classify the observed defects on insulator. For testing the model ability, therefore the implementation of a pilot study was necessary prior to the start of rainfall in November 2010 and before the natural surfaces insulator has been rinsing from salt pollution. On following this pilot project is explaining.

GESHM ISLAND PILOT PROJECT

A 50 km distribution line with 2500 installed insulator in **Geshm island** selected as a case study, there were four type insulators as described on table.3

sample	type	type	Creepage distance (mm)	Shed diameter	Number of shed	Installation year
A	Porcelain	Tension & suspension type	885	255	3*1	1972
B	Porcelain	Pin type	686	305	2	1972
C	composite	Tension & suspension type	875	125/110	9	2000
D	composite	Pin type	870	125/110	9	2000

Table.3: specification of insulators under inspection

Visual inspection is the most commonly used inspection technique. Binoculars are used to perform remote visual inspections With IR, the temperature distribution along the insulator axis is measured by means of an infrared camera, searching for hot spots associated with possible local defects as shown in figure3

Figure3.An example of IR defect detection of in-service insulators

In field inspection step long time leakage current parameters monitoring of sample (5 years) has been selected as a one of main strategy. The assessed composite insulator installed at natural pollution test station beside of other type of porcelain and composite insulators. All different leakage current parameters are also investigated.[3]

Figure 4.Online leakage current monitoring

For daylight corona cameras, the diagnostic indicator considered is the emission generated by the defects in the UV-C range (i.e. with wavelength in the range 240-280 nm), a bandwidth in which the solar light is filtered by the atmosphere. Corona emission intensity is calculated using the number of pulses of light emission. A counter gives a number proportional to the quantity of "blobs" received by the sensor.

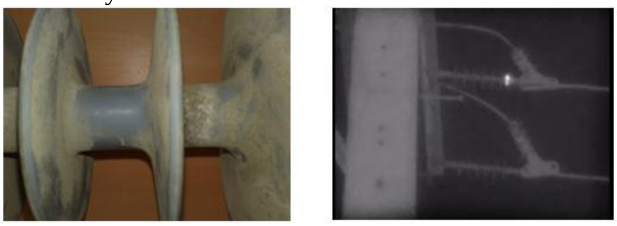

Figure5.example of "blob" counting by corona camera

The aim of diagnostic investigation on composite insulator is to assess the state of the insulators for determining maintenance strategy and finding major damages before live line working (LLW). Implementation of data bank with the measurement carried out on insulators by UV detection methods and using comparison analysis with operational history and maintenance activities define precise criteria to have more effective method for diagnostics on composite insulators as listed in table.4

DESCRIPTION	CORONA CRITERIA NUMBER OF PULSES OF LIGHT EMISSION (BLOBS) (P/S)	LEVEL
HUMIDITY AND LIGHT POLLUTION AND LIGHT	10-40	Level 1
HIGH CORONA AND WASHING MAINTENANCE IS	40-70	Level 2
COMPOSITE INSULATOR AGING PROCESS START	70-100	Level 3
ADVANCED DEFECT ONE YEAR IS LEFT TO	100-150	Level 4
FINAL DEFECT AND FAILURE NOT MORE THAN 6	150 <	Level 5

Table.4: criteria for diagnostics of composite insulators based on UV detection

Corresponding The field results obtained from UV detection is shown in table.5. From the inspection noted that between 2500 insulator under this inspection, only 18 insulators (composite ones) on service need to replace immediately and about 586 porcelain insulator are very dusty and need to wash by hot line method. Meanwhile more than 1583 insulator need no maintenance.

Ins. type	Level 1	Level 2	Level 3	Level 4	Level 5
A	388	51	0	1	0
B	720	535	6	6	0
C	147	14	12	5	2
D	328	145	92	32	16
total	1583	745	110	44	18

Table.5: the inspection results

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GAS CHROMATOGRAPHY/MASS SPECTUM TEST

Since GC/MS analysis can determine the molecular weight distribution of polymer insulating materials, evaluation of the degree of surface degradation and estimation of the remaining life of insulators may be possible. Therefore Analysis using Gas Chromatography/Mass Spectroscopy (GC/MS) for evaluation of surface degradation of silicone insulating materials are applied.

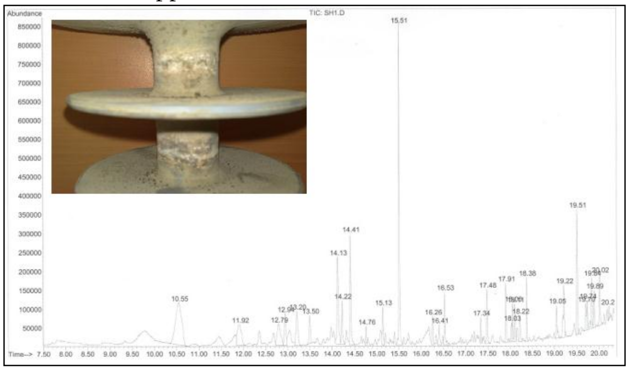

Fig.6: gas chromatograms for composite insulator sample from level 3

Fig. 6 shows a gas chromatograms for composite insulator sample from level 3. The position of each peak in GC spectrum corresponds to an increase in molecular weight of the polymer matrix by one dimethylsiloxane unit, with the molecular weight increasing from the left to the right of the spectrum. The peak height is indicative of the relative abundance of each component. The gas chromatograms have been normalized for sample weight, so that the relative peak areas or peak heights can be consider. As the polymer matrix of silicone materials is primarily formed of polydime-thylsiloxane $[SiO(CH3)2]n$ the gas chromatograms indicate the distribution of homologous short-chain siloxane in the polymer. Successive peaks for a virgin composite insulator in the spectra correspond to a unit increase in the number of dimethylsiloxane units (n = 3; 4; 5; …..) but In this figure.6, the decrease of the peak height corresponding to mid-weight siloxanes (n = 14to 16) .it comes from very heavy duty condition.

Thus a reduction in the mid-weight siloxanes and generation of low molecular weight siloxanes appears to be characteristic of surface aging of this sample . The low molecular weight species are likely produced through epolymerization of the polydimethylsiloxane matrix during the aging process.some reports says that insulators from this group had fault after two up to three year in service

Fig. 7 shows an exposed a silicone rubber insulator in a gas chromatogram analysis given from level 4 sample. Most peaks of this sample correspond to the mid-weight siloxanes (n = 16to18). its can be seen that for this type of xposed sample, the total amount of the detected ions was very small and many peaks were matched to hydrocarbon chemical species,CnH2n+1, which be derived from high polymeric diagnostic. The historical data shows that some of insulator belong to this level of diagnostics have been destroyed during of 9 month up to one year after detection.

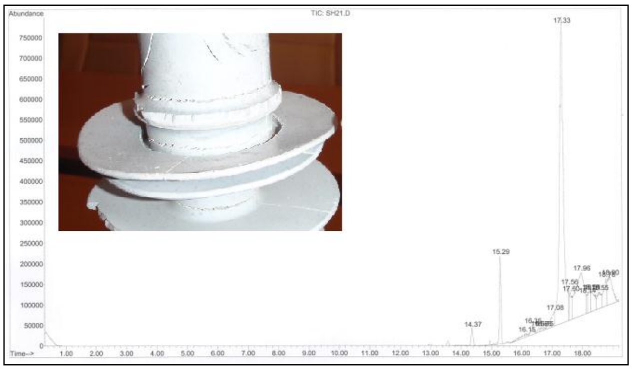

Fig.7: gas chromatograms for composite insulator sample from level 4

Fig. 8 shows a gas chromatograms for the aged composite insulator in level 5 where the decrease of the peak height corresponding to mid-weight siloxanes (n = 20to 22) and the low molecular weight siloxanes increased as a result of final aging. Thus a reduction in the mid weight siloxanes and generation of low molecular weight siloxanes appears to characteristic of surface aging of samples.

Fig8: gas chromatograms for composite insulator sample from level 5

During the aging process As the molecular weight distribution of such species is altered during aging, GC/MS is useful for evaluation of surface degradation. Also, evaluation of silicones with GC spectrum using extracted ion profiles is an effective method for determining the change of the molecular weight distribution of silicone matrix. this technique in corporate of UV detection results might be developed into a diagnostic tool for estimation of surface degradation and remaining life of the insulation. The GC/MS testing on removed samples insulators verified the UV detection results with proper accuracy.

ECONOMICAL CONSIDRATION

HEPDC annual strategic plan need to replace the porcelain insulator silicon is 60000 set due to porcelain insulator failure. Studies leads to replace about 7500KM OH network insulators .It means about 375000 set composite insulators must be consider for this plan**.** This program takes approximately 7 years with about 6 million dollar.

With this new diagnostic technique no need to replace all insulators. Instead of this plan, we can replace only insulators with the level 1 up to 3 stages of diagnostics with the lowest cost. We suppose that this can be done with about only 760000 dollar. it means that our save money will be about 5 million dollar (87%save) .

CONCLUSION

The results of QESHM ISLAND project shows that this new technique is applicable method for condition monitoring of in service composite insulators and new proposed method based on blob counting (Number of pulses of light emission) is presented. Operational history and test approved the method**.** Also this technique can use for OH transmission line composite insulators .

REFERENCES

[1] *CIGRE WG 22.03: "Review of "In service diagnostic testing of composite insulators", ELECTRA, No. 169, December 1996, p.p. 105-119*

[2] *G.R.NEMATI," composite insulator condition monitoring results in coastal urban distribution network (hormozgan province)",8th insulators seminar.* CIGRE *IRAN 2011.*

[3] M.Rezaei," Assessment of in service composite insulators in very harsh coastal environment of Iran: Laboratory & Field testing",CIRED 2011

END POINTS

H.E.P.D.C. is abbreviation of Hormozgan Electric Power Distribution Company and N.R.I. is abbreviation of Niroo Research Institute.