On-site Assessment of High Voltage Motors Insulation Operating in Oil Facilities

Antonio Carvajal, V. R. García-Colon

Department of Electrical Equipment
Electrical Research Institute
Av. Reforma 113, Col. Palmira Edif. 26 PB
62490 Cuernavaca, Morelos, México
Phone:+52 777 3623811, fax:+52 777 3623825, e-mail: carvajal@iie.org.mx , gcolon@iie.org.mx

Abstract. Thirteen motors rated at 13,8 kV and 2500 H. P. of capacity installed and operating in a critical Oil Pumping Plant, were evaluated on-site, to determine the insulation system condition and schedule a maintenance program. This on-site assessment was based on a non-invasive and non standardized ultra-wide band partial discharge technique developed. The results obtained allowed motors insulation system status classification, according to partial discharges measured on ground connection of the main cables of the motor, employing near field sensors. A traditional N-Q-Φ Partial Discharge pattern is obtained to facilitate motor insulation system problems identification. The results of this on-site motor assessment, during normal operation, and its application on maintenance programs are presented and discussed in the paper.

Key words:

High voltage motors, on-site Assessment, ultra wide band, partial discharge.

1. Introduction

The high voltage induction motor, up to 13,8 kV, is a equipment widely used in the Mexican oil industry. A sudden failure of the insulation system of this machine can result catastrophic, especially in dangerous classified areas. Hence, it is necessary to ensure its operational continuity, through the timely detection of incipient failures emerging due to the stresses, which are being subjected during its operation[1]. In the last years the Mexican Electrical Research Institute (IIE), have been working in the development and implementation of diagnostic techniques for power electrical equipment, based on Partial Discharges (PD) measurements[2]. As it is well known, the Partial Discharges (PD) is a consequence associated to failures in high voltage motors, a high level of partial discharges in the machine, is an indication of problems in the insulation system, these problems over the time can evolve into a failure. Hence, the detection of PD is very important to know the motor condition [3].

2. Assessed motors

Thirteen induction squirrel cage, horizontal motors, rated at 13,8 kV and 2500 H.P., installed and operating in a critical Oil Pumping Plant, were evaluated. It is important to mention that those motors are operating continuously, and off-line PD detection may take more than one shift and therefore it is considered an unacceptable outage, due to the large economical implication. These motors have at least 20 years of operation and during this time, have been subjected to continuous starts and shutdowns.

3. On-site assessment circuit set up

The Partial Discharge detection in motors based on ultra wide band techniques is a not standardized method. The electrical circuit for the motor evaluation, is shown in Figure 1.

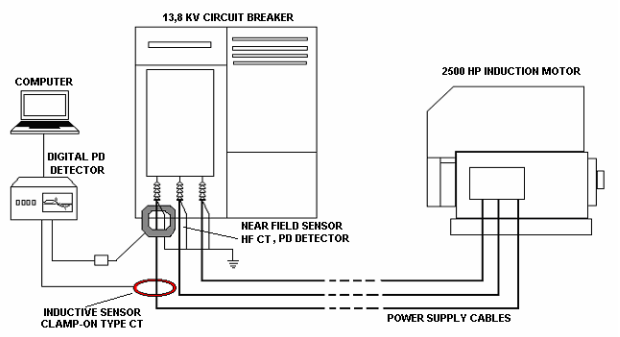

Fig. 1. Test circuit for high voltage motors PD detection.

4. Results Analysis

This on-site assessment was based on a non standardized ultra-wide band partial discharge technique, because of this as a first step in the application of this technique, the results analyses are based on the criteria of the IERE [4]**.** PD patterns obtained were compared with those included in the reference generated by CIGRE [5]. The Table I, shows the classification of the evaluated motors. Of this analysis it is concluded the following:

A. Motors in good conditions

The PD activity measured in phase 1 of motor M-1, was a maximum charge of 10 nC, which was the lowest PD level measured on-site. This value indicates that the motor insulation system is in good conditions and can operate normally.

B. Motors with slot partial discharges problem

The PD pattern shown in Figure 2, shows the PD activity map obtained in phase 3 of motor M-14. It distinguishes that PD in the negative semi cycle are greater than those of positive in 5:1 relationship. This pattern and the high

level of DP (570 nC) according to [5], is typical of the activity of slot partial discharges (PD between coil surface and stator core laminations). This mechanism of deterioration is the most severe, from the electrical insulation point of view.

Table I. Motors classification based on PD magnitude measured

MOTOR ID.	INSPECTION AND MAINTENANCE PRIORITY	PHASES	Qmax nC	CLASSIFICATION
M-14	IMMEDIATELY	A	180	INSPECTION REQUIRED
		B	180	
		C	570	
M-9	1	A	75	INSPECTION REQUIRED
		B	75	
		C	112	
M-2	1	A	70	INSPECTION REQUIRED
		B	70	
		C	120	
M-13	1	A	60	INSPECTION REQUIRED
		B	120	
		C	60	
M-5	1	A	22	INSPECTION REQUIRED
		B	28	
		C	100	
M-10	2	A	36	OBSERVE
		B	48	
		C	48	
M-8	2	A	36	OBSERVE
		B	36	
		C	48	
M-11	2	A	30	OBSERVE
		B	30	
		C	48	
M-12	3	A	27	GOOD
		B	26	
		C	36	
M-4	3	A	23	GOOD
		B	25	
		C	36	
M-3	3	A	16	GOOD
		B	18	
		C	36	
M-7	3	A	15	GOOD
		B	20	
		C	28	
M-1	3	A	10	GOOD
		B	14	
		C	24	

C. Motors with field graduation problems

The Figure 3, shows the pattern of the PD activity map obtained in phase 2 of motor M-13. The partial discharges have similar magnitudes in both semi cycles. The pollution deposited in the end windings can be the PD cause; the pollution avoids the correct graduation of electric field. Another cause may be the deterioration or incorrect stress grading coating application.

5. Conclusion

Measurements carried out for the motors assessment, have the sensitivity to allow an insulation system classification of similar motors, according to the PD magnitude measured. The comparison of the PD patterns obtained and PD reference patterns was found coincidence between the two, relate to the mechanisms of deterioration that cause it. The ultra-wide band partial discharge technique for high voltage motors insulation system assessment, used at oil facilities, has the advantage to be non-invasive, with high sensitivity, selectivity and ease of use. Based on the results we consider the employed technique a diagnostic tool that can be used to improve the predictive maintenance programs.

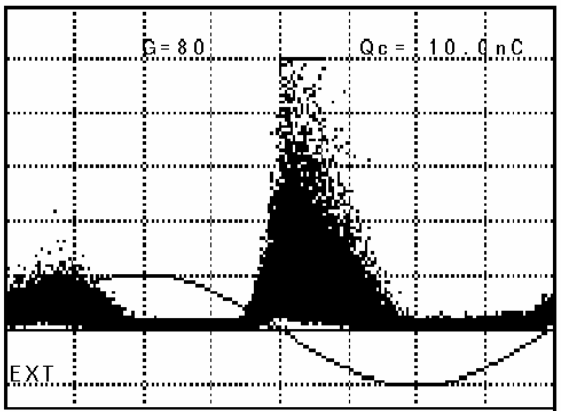

Fig. 2. Motor M-14 PD pattern, 570 nC Max.

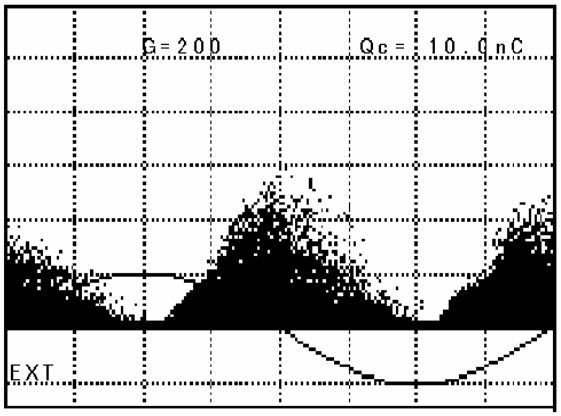

Fig. 3. Motor M-13 PD pattern 120 nC

References

[1] Gleichman, R. C., "Failure Modes and Field Testing of Medium-Voltage Motor Windings", IEEE Transactions on Industry Applications, Vol. 38, No. 5, 1473-1476, 2002.

[2] García-Colón, V. R., "Distributed PD Measuring Techniques (D-PM) for Installed Power Equipment Diagnosis", *Annual Report, IEEE Conference on Electrical Insulation and Dielectric Phenomena*, 442-445, 2002.

[3] Stone, G. C. y V. Warren, "Objective Methods to interpret Partial Discharge Data on Rotating-Machine Stator Windings", IEEE Transactions on Industry Applications, Vol. 42, No. 1, 299-303, 2006.

[4] Central Research Institute of Electric Power Industry, "An insulation deterioration diagnostic method for generator windings", Aki, Shuichi, Special Document for IERE members (R9019), Japan, 1991.

[5] CIGRE Working Group 21.03, *Recognition of Discharges*, Electra, CIGRE Publication No. 11, 61-98, 1969.