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Electronic Systems Damaged by Corrosion in The Electronics Industry of Mexicali

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ABSTRACT

Deterioration of metallic components of electronic devices (ED) used in industrial systems is of great interest. Exposure to air pollutants such as sulfurs of the industrial systems, and variations of the relative humidity (RH) and temperature indices was conducted to the damaged generated. This promoted the corrosion process and and not permitting perform the industrial operations properly. In bases of this, a study to analyze the deterioration of electronic systems was made. The research was conducted to evaluate the effect of sulfurs, which were reacted with the metallic surfaces of the industrial electronic devices. The period of the study is from July of 2013 to June of 2014, and in this evaluation an analysis of one, three and six months are presented. In this analysis was observed the corrosion process during periods in summer and winter specially. The major effects in the corrosion process occurred when the indices of RH and temperature were higher than 75% and 35°C, in the period of study.

KEYWORDS Industrial systems, electronic devices, corrosion, pollution, climatic factors

INTRODUCTION

Deterioration of ED by corrosion

Atmospheric corrosion (AC), generated by the presence of sulfurs and variations of RH and temperature, originates a destructive attack in the ED. Serious consequences of corrosion are a problem of great significance in the worldwide. An important aspect knows the kinetic process of the types of corrosion, to evaluate methods and techniques to avoid this electrochemical phenomenon[1, 2].

Factors causing corrosion

Sulfurs concentration levels that overpass the air quality standards (AQS) and indices of RH and temperature, higher than 75% and 35 ° C, are the principal factor of the corrosion in indoor of the electronic industry of Mexicali[3,4]. Sulfurs overpass the AQS, principally in the winter season, and the climatic factors are common in this city, in the majorly of periods of the year, which is a desertic region located in the northwest of Mexico.

Consequences of the corrosion process

Presence of corrosion generates economic losses by production downtime, depreciation of resources or materials considered as waste products, reduction in the production efficiency, maintenance costs, and high costs on the new designs of the manufactured products[4,5]. Many industrial plants and government agencies are engaged in the corrosion control to determine the effect and the possible causes of each problem of this electrochemical process and detect the agents that generates the corrosion[6,7]. In this study, occurred uniform corrosion (UC) and pitting corrosion (PC), in the ED of the industrial systems electrical in the company evaluated. The formation of oxides surfaces in electrical connections of the ED was an important factor in the generation of the two types of corrosion[8,9].

EXPERIMENTAL PROCEDURE

The corrosion process of ED used in the company where the analysis was, were evaluated in indoors of this industrial plant[10]. The CR was analyzed with the installation of metallic probes of carbon steel, cooper, nickel, silver and tin, installed in strategic areas of the company. The periods evaluated was mentioned above. To obtain the CR was used the gravimetric method. After each exposure period, samples were removed, weighed and cleaned, for determine the weight loss and the CR. The SO_2 was evaluated the Sulfatation Plates Technique (SPT) [13] to correlate with climatic factors and the CR. The morphology of the corrosion products was examined with the Scanning Electron Microscopy (SEM), to determine the major deterioration in each metal evaluated[10].

RESULTS AND DISCUSSION

This study presents the CR levels higher in winter period than in summer and autumn seasons. A comparative analysis of deterioration of three periods mentioned, of all metals evaluated was made and presents in table 1.

Table 1 CR of metals evaluated by period

Time, months	CR, gr.m^{2}·year				
	Ag	CS	Cu	Ni	Sn
1 (Summer)	144	81	129	58	69
3 (Autumn)	123	67	107	44	52
6 (Winter)	175	99	149	67	77

Ag-Silver, CS-Carbon steel, Cu-Copper, Ni-Nickel, Sn-Tin

In table 1, was observed the CR of each metal using the gravimetric method. Silver and copper were the metals that suffer of the major deterioration, followed by carbon steel, tin and finally nickel. This means that the corrosion resistance of silver is the least of all metals evaluated, and instead nickel has the major. After, was made the correlation with the MatLab program, of metals with major damage mentioned above and showed in tables 2 and 3.

Table 2 Correlation analysis of CR, climatic and environmental factors in period of 1, 3 and 6 months in silver

Time, months	CR, gr.m^{2} year	Climatic and environmental factors		
Periods	Type of corrosion	RH, %*	Temperature, °C*	Sulfur dioxide (SO_2), ppm*
1	144	86	42	0.3
Summer	Uniform			
3	123	77	28	0.35
Autumn	Uniform			
6	175	88	12	0.50
Winter	Pitting			

*** Values were about the average of the data evaluated**

Table 3 Correlation analysis of CR, climatic and environmental factors in period of 1, 3 and 6 months in copper

Time, months	CR, gr.m^{2} year	Climatic and environmental factors		
Periods	Type of corrosion	RH, %*	Temperature, °C*	Sulfur dioxide (SO_2), ppm*
1	129	86	42	0.3
Summer	Uniform			
3	107	77	28	0.35
Autumn	Uniform			
6	149	88	12	0.50
Winter	Pitting			

*** Values were about the average of the data evaluated**

Table 2 shows the mathematical correlation in silver probes, of the negative effect of the climatic and environmental factors in the increase of the corrosion rate. In periods with high RH, the CR was major than in seasons of low RH, being this climatic parameter an important factor in the CR. In table 3, the analysis was of copper specimens and has the same behavior about the CR presented. Values of RH higher than 75%, originates fast the deterioration of metals, and in all cases of metals analyzed, were higher 80%. Temperature levels have effect in the presence of UC or PC, where at low values (less than 10 °C), will occur UC and in high levels (higher than 35 °C), will be PC. This is for the kinetic of the electrochemical process of corrosion. Levels of HR and temperature mentioned in Mexicali are in the year. For this reason, the electronics industry of this city has microclimates controlled in indoor of manufacturing processes, especially in clean rooms. SO_2 obtained by the TPS was increasing in according to the time of the period of study.

SEM analysis

After the process of the evaluation of CR, was made the microanalysis of the deterioration of metallic probes. The UC and PC processes were observed with microphotographies obtained of the SEM analysis. SEM evaluations were made of the two metals with major deterioration, being silver and copper. In this analysis can differentiate the kinetic process of the occurrence of UC or PC, in according to the RH and temperature values.

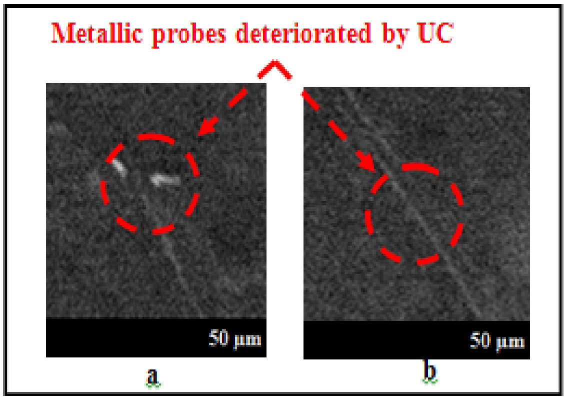

Figure 1 Metallic specimens of (a) silver and (b) copper, damaged by the corrosion process occurring uniform corrosion (February 2014-winter period).

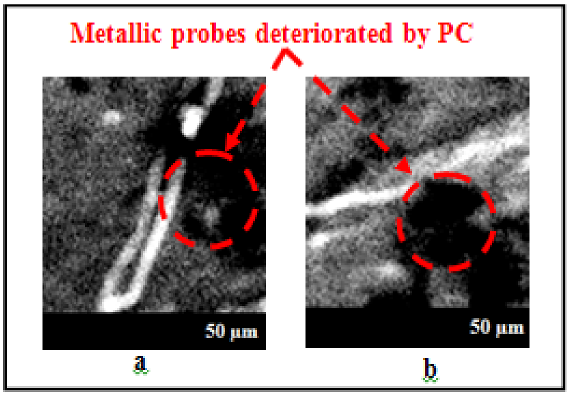

Figure 2 Metallic specimens of (a) silver and (b) copper, damaged by the corrosion process occurring uniform corrosion (August 2013-summer period).

Metallic probes evaluated at 1, 3 and 6 months showed the grade of deterioration by the atmospheric corrosion in indoors of the industrial plant where was made the study. In the microphotographies, are observed two zones detected. In figure 1 the white areas, are the metallic surfaces without corrosion products. This mean that the metal was damaged and some pieces of metals emerge, reducing it surface area. This is not good for metallic surface of electrical connections to ED, because it not permits the electrical conductivity and ED reduce their operation yielding. In figure 1, the majorly of the metallic surface is covered by the corrosion products as a uniform corrosion and occurred in six months of the study with high RH and low temperature levels. In figure 2, are observed with major intensity two zones as white and black areas of the metals evaluated. This occurred in one month, in the summer period, where levels of RH and temperature were higher. This is not good to the ED, as is mentioned in the explication of figure 1.

CONCLUSIONS

The presence of corrosion leads to the deterioration of electrical connectors of ED, and decreasing their lifetime of industrial systems. The principal air pollution agent in Mexicali is derivate of sulfur. This causes the low productive yielding of ED and is a major concern to specialized people, managers and owners. For this reason, this study is very important to determine the deterioration grade of ED used in the company evaluated. The results showed that at major air pollution concentration detected by specialized methods, the lifetime of the ED was decreased by the generation of corrosion in their electrical connectors and connections. This was caused for the levels of sulfurs as a principal corrosive agent than exceed the air quality standards in some periods of the year, added with the levels upper of relative humidity levels (RH) and temperatures higher of 70% and 30°C in winter and 80% and 35°C in summer, being a main factor of this electrochemical phenomenon.

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