

**ATMOSPHERIC CORROSION IN BRAZILIAN LEGAL AMAZON  
- FIELD AND LABORATORY TESTS -**

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**Abstract**

This paper presents the first results concerning tests carried out to evaluate the atmospheric corrosion in Brazilian Legal Amazon, as part of the SIVAM – Amazon Surveillance System. The aim of the present work is to determine and select materials as well as anti-rust paints, which will be employed to protect metallic structures of radar towers, equipment and buildings. Five anti-rust paints on mild and galvanised steels were tested. Field tests are supported by accelerated laboratory results in wet and drying cycles in electrolytes simulating different microclimates. These solutions were prepared in laboratory based on pH, conductivity and chloride content values of locally collected rainwater.

**Keywords:** Atmospheric corrosion, coatings, SIVAM, Brazilian Amazon

**1. INTRODUCTION**

The high pollution and deterioration process of rain forest notably at Amazon has produced strong modifications at environmental conditions. Corrosion of metals, paint structures, buildings and deterioration of art monuments are some of a lot of irreversible damages carried-out last decades. In this context, corrosion studies plays a role of a “detector” about the above phenomena. The studies on atmospheric corrosion which were carried-out during the establishment of SIVAM project at last decade of XX century, will be presented below and will emphasize the enormous impact of the natural damages on the Amazon Region.

The atmospheric corrosion processes have been studied in many places around the world [1]. Besides the main objective of protecting SIVAM's equipment against corrosion, this work aims to be an extensive atmospheric corrosion study in the whole Amazon region.

To accomplish this, outdoor and accelerated laboratory tests were carried out on mild, galvanised and weathering steels to evaluate corrosiveness of the different microclimates present in that region.

Field tests were performed by exposition of samples assembled in two roofing racks placed at 33 different sites, with six panels (100 x 150 x 1,5 mm) for each paint system analysed (three scratched ones). Bare mild steel and weathering steel were also exposed in order to gather information about rust formation in Amazon microclimates.

Laboratory tests were based upon the simulation of some typical microclimates. Samples (100 x 50 x 1,5 mm) were exposed to wet-and-dry cycles in electrolytes with similar pH and conductivity of locally collected rainwater. As in the field tests, there were painted samples (scratched or not) for each paint system as well as bare mild and weathering steels. Table 1 shows the basic characteristics of the analysed paint systems.

**2. ELECTROCHEMICAL MEASUREMENTS**

Although unusual, potential measurements in paint systems have been already proposed since 1939 [2]. In this sense, electrode potentials of scratched and bare samples have been periodically measured, in order to survey the steady-state evolution. Figures 1 and 2 show, as examples, the electrode potential behaviour of these samples exposed in two Amazon's sites, Carauari and Marabá.

**Table 1 – Paint Systems description. Final touch Aliphatic Polyurethane**

<b>Paint Sys.</b>	<b>Description</b>
1 (mild)	1 <sup>st</sup> / 2 <sup>nd</sup> coatings: primer epoxy (high solids)
2 (mild)	1 <sup>st</sup> / 2 <sup>nd</sup> coatings: zinc rich epoxy primer
3 (mild)	1 <sup>st</sup> / 2 <sup>nd</sup> coatings: magnetite pigmented epoxy
4 (galv.)	1 <sup>st</sup> coating: isocyanate epoxy primer 2 <sup>nd</sup> coating: high thickness epoxy
5 (galv.)	1 <sup>st</sup> coating: isocyanate epoxy primer 2 <sup>nd</sup> coating: high thickness polyamide epoxy

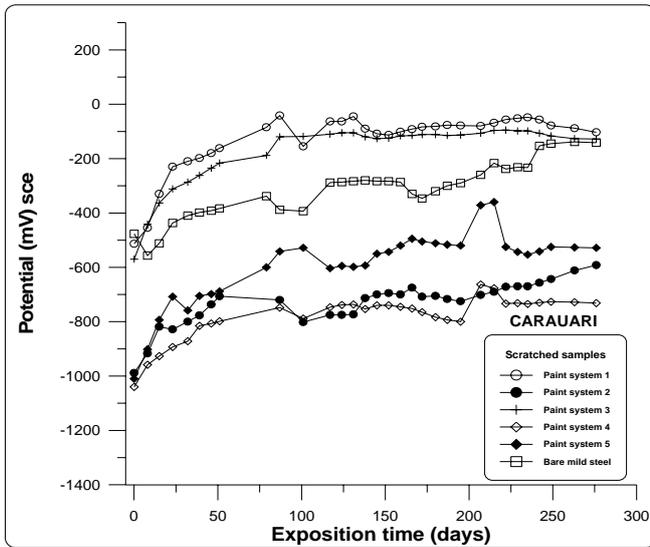


Figure 1 – Electrochemical potential values of scratched samples at Carauari

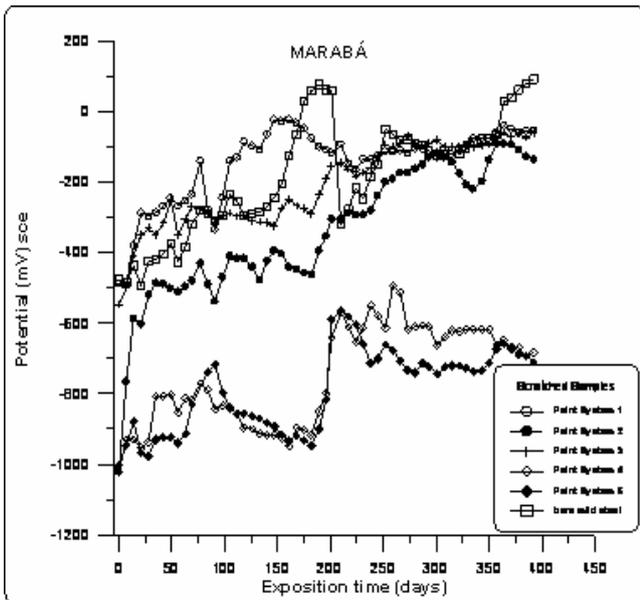


Figure 2 – Electrochemical potential values of scratched samples at Marabá.

Table 2 presents pH and resistivity values obtained for some of the sites, in order to illustrate the electrochemical characteristic of the atmosphere in amazon region. These results yield to the simulation of four electrolytes, which represent mean groups of microclimates. Chloride was not detected in any collected rainwater.

Figure 3 shows the pH and the electrode potential mean values of the mild steel scratched samples (paint system 1), obtained in twelve of the thirty-three sites. A great dispersion of results can be seen, which illustrates the

diversity of microclimates and electrochemical behaviour in the whole region.

Table 2 – Characteristics of local rainwater.

Locality	$\rho$ (ohm.cm)	pH
Cachimbo	119,000	5.5
Carauari	28,571	4.4
Cuiabá	17,391	4.3
Eirunepé	20,202	5.5
Jacareacanga	9,756	6.8
Manaus	24,390	5.3
Marabá	42,735	7.8
Rio Branco	16,949	5.5
Surucucu	11,905	6.2
Tabatinga	20,000	6.8

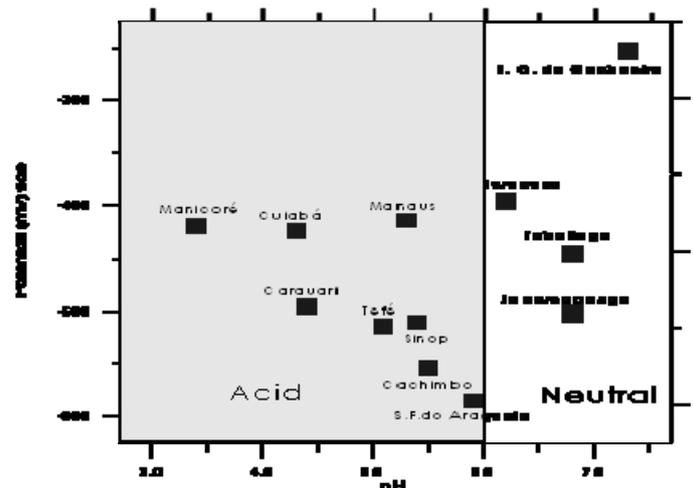


Figure 3 – pH and electrode potential mean values. Scratched samples paint system 1.

### 3. LABORATORY TESTS

Accelerated corrosion tests were carried out by means of wet (10 min) and dry (50 min) cycles in simulated electrolytes, as previously proposed by Pourbaix [3]. The electrode potentials were measured during the wet cycle. The temperature of about 44°C was maintained by using a lamp at the highest point of the sample trajectory (see Figure 4).

After experimental comparison of rust layers thickness formed in atmosphere exposition and in this kind of test, it was found a good correlation between the accelerated test and field measurements [4,5].

Table 3 presents the characteristics of the electrolytes used in the accelerated corrosion tests.

Table 3 – Electrolytes prepared in Laboratory.

Solutions	Resistivity (ohm.cm)	pH	Considered sites
Solution 1	25,000	4.5	Manaus/Carauari
Solution 2	25,000	7.0	S.Gabriel/Tabatinga
Solution 3	10,000	4.5	Cuiabá/Porto Velho
Solution 4	10,000	7.0	Jacareacanga/Surucucu

in the case of field tests, potential–time plots (Figure As 5) are obtained in order to observe the evolution of the scratched areas of the samples.



Figure 4 – Accelerated corrosion test.

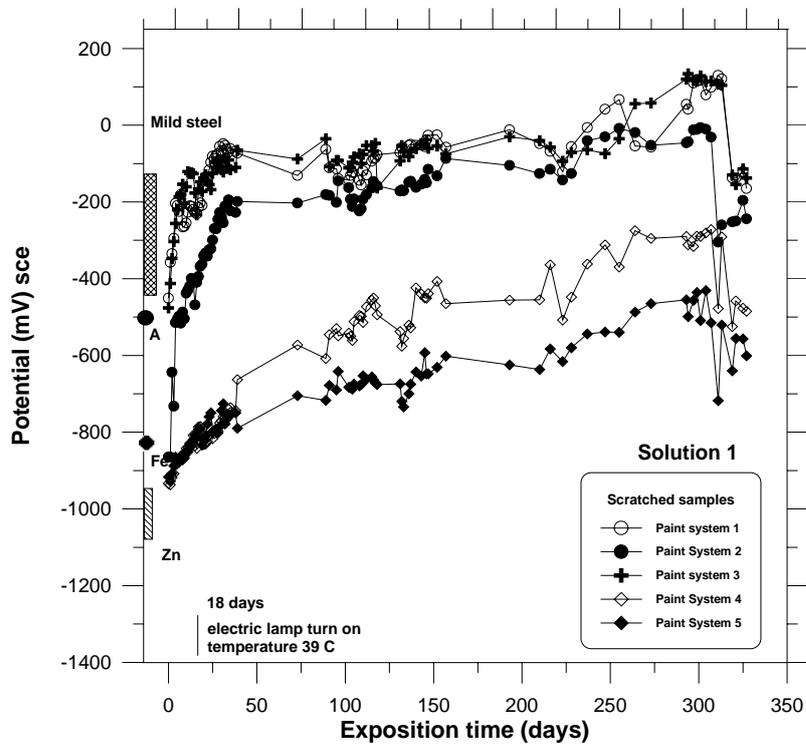


Figure 5 – Electrode potential evolution in laboratory tests, solution 1.

#### 4. VISUAL INSPECTION

Figure 6 shows the visual aspects of two samples of the same paint system after one year of exposition at two sites, Cachimbo and Jacareacanga. One can see the great difference in performance of this paint system related to the local atmosphere. This result illustrates the difficulty of

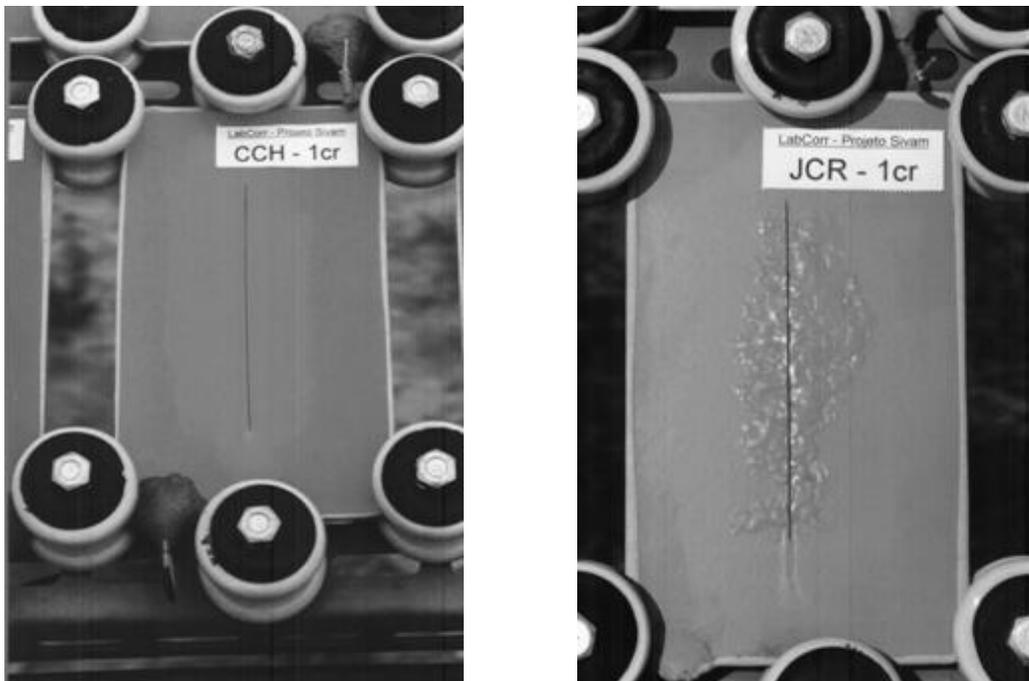


Figure 6 – Visual aspects of paint system 1 after one year of exposition. Sites: Cachimbo (left) and Jacareacanga (right)

#### Conclusions

The present study has shown some results, which could characterise the corrosion processes in rainforest environments, namely:

The strong difference among microclimates leads to great differences in performance of the corrosion resistance of paint systems. For example, sites like Cachimbo and Jacareacanga, which present dissimilar microclimates, have shown dissimilar behaviour for the same paint systems. Figure 6 illustrates quite well this fact.

When samples are not scratched, the electrode potential measurements are meaningless. Nevertheless, once scratched, the surface of the paint leads immediately to meaningful values of potentials. Those values could be an important method for monitoring and control the performance of the paints during the service life of the structures.

One of the paint systems was pigmented with magnetite, previously considered as the main constituent of rusts. However, rust layers analyses did not confirm this assumption. In fact, x-ray diffraction showed, after 120 days

considering the Amazon region as just one warm and humid climate.

These photographs correspond to the paint system 1. However, this behaviour was noted for the others paint systems.

of exposition, that this oxide is a minor component of the rust products. As results of these preliminary analyses, lepidocrocite ( $\gamma$  - FeOOH) and goethite ( $\alpha$  - FeOOH) were recognised as being the main corrosion products.

#### References

- [1] Morcillo, M., Almeida, E., Rosales, B., Uruchurtu, J., Marrocos, M., CYTED–Corrosion Y Proteccion de Metales en las Atmosferas de Iberoamerica, Gráficas Salué S.A, Spain, 1998
- [2] H. E. Haring, and R. B. Gibney, Trans. Elec. Soc., vol.76, 293 (1939)
- [3] M. Pourbaix, RT Cebelcor, 160 (1969)
- [4] A. Pourbaix and M. Pourbaix, RT Cebelcor (1968)
- [5] L. de Miranda, RT Cebelcor, 221 (1974)