

Progressive Atmospheric Corrosion Study Of Metals Like Mild Steel, Zinc And Aluminium In Urban Station Of Ahmedabad District

S. P. Parekh*, A. V. Pandya And H. K. Kadiya

C. U. Shah Science College, Ashram Road, Ahmedabad-380014, Gujarat-India.

*Corres.author: parekhsp2@yahoo.co.in, hitesh_1330@yahoo.co.in

Abstract: Progressive atmospheric Corrosion rate (Progressive) of mild-steel (MS), zinc and aluminum have been determined under outdoor conditions of exposure at Ahmedabad (Middle Gujarat) representing an Urban environment. Mild steel (MS), zinc and aluminium plates exposed during November 2010 indicates corrosion rate of 51, 17 and 1.1 mg/sq.dm for one month exposure period and 2428, 597 and 21.9 mg/sq.dm for mild steel, zinc and aluminium respectively for twelve months exposure period. Mild steel panels exposed vertically suffer less corrosion than those exposed at an angle of 45°. The resistivity towards the environment was in the increasing order of mild steel < zinc < aluminium. Corrosion rate of these three metals was found more in rainy seasons than the rate of winter and summer season.

Keywords: Atmospheric Corrosion, Ahmedabad urban Station, mild-steel, zinc and aluminium.

INTRODUCTION

Atmospheric corrosion as a science has a history of almost one hundred years, starting with W. H. J. Vernon's pioneer work on sulfur dioxide (SO₂) and carbon dioxide (CO₂) induced metal corrosion. The most important indoor and outdoor corrosion stimulators are water/humidity and air pollutants. Atmospheric corrosion of metal is governed by chemical composition of thin film electrolyte on the metal surface which is dependent on air pollutants, humidity, and temperature.

Atmospheric corrosion is a very important practical process that causes deterioration of structures, machines and materials placed at external environments¹⁻⁴. It constitutes a relatively complicated electrochemical process that consists of a metal and its corrosion products, an electrolyte (a thin wet film on surface) and the atmosphere (more or less polluted). At normal temperature dry air does not have a corroding effect on metals⁵⁻⁶. However, in presence of moisture in the atmosphere, corrosion takes places and it is governed by the principle of critical

humidity developed as described in⁷ and supported in⁸⁻⁹.

D. D. N. Singh et al. reported¹⁰ corrosion rate of steel exposed for two years at different locations of India found that, Chennai (industrial) 19.0 μm/y, Jamshedpur (industrial) 12.9 μm/y. Larrabee and Ellis¹¹ reported the yearly corrosion rate of steel plate (4×6 inch) exposed in various atmospheres at different places of North America as follows: 6.52 mil/yr at New York (industrial atmosphere) and 3.30 mil/yr at Kearny (industrial atmosphere). Schikorr¹² exposed pure zinc plate for one year in various atmospheres and measured a corrosion rate as follows: 0.73 mil/yr at Bitterfeld and 0.19 to 0.24 mil/yr at Hamburg. Mattson¹³ reported the corrosion rate of aluminium in the range of 1 to 3 g.m⁻²y⁻¹ in industrial atmosphere. In India, data regarding the relative corrosivity of atmospheres at Baroda¹⁴ (industrial), Calcutta¹⁵ (industrial), Jodhpur¹⁶, Kanpur¹⁷ (semi-industrial), Surat¹⁸ (industrial), Ankleshwar¹⁹ (industrial) and Valsad²⁰ and Thailand²¹ are available.

MATERIAL AND METHODS

Test plates of mild steel, zinc and aluminium have the following chemical composition:

- a) **Mild-steel** : C (0.062%), Mn (0.291%), S (0.007%), P (0.011%), Si (0.006%), Cr (0.010%), Al (0.047%), Cu (0.002%), Mo (0.001%), Ni (0.004%) and Fe-rest.
- b) **Zinc** : 99.41 % purity, Pb (0.02% Max), Cd (0.01% Max.) and Fe (0.015% Max.)
- c) **Aluminum** : 99.19 % purity and Si (0.55%).

Test plates are individually mounted on a wooden rack. Special care should be taken that they were electrically insulated from surrounding metallic stand. The frame was placed in parallel outdoor fully exposed condition on the ground level making an angle of 45° towards the horizontal plane. Another set of mild steel (MS) panels were fully exposed vertically.

Twenty four specimens of each metal (mild steel, zinc and aluminium) were exposed at the same time (i.e. during November 2010). After completion of exposed period, the progressive weight loss of metal was determined. So, we get successive corrosion rates for one month, two months, three months upto twelve months. Similarly, another set was exposed during March 2010.

All tests were carried out in duplicate and mean of the two values were taken. After exposure period test plates were wrapped in plastic bags and brought to the laboratory for cleaning. Different cleaning solutions are to clean different metals. Hudson used Clark's solution²²⁻²³ to remove rust from mild-steel made by 2% Sb₂O₃ (antimony Oxide), 5% SnCl₂ (stannous chloride) in concentrated HCl (100 ml) at room temperature with constant stirring about 15-20 minutes. Zinc plates are derusted by 10% CrO₃ and about 0.2 gm BaCO₃ in distilled water (100 ml) at 25°C for

about 2 minutes²⁴. Corrosion products on aluminium plates were removed by using the solution of concentrated HNO₃ containing CrO₃ (chromic acid, 50 mg/lit) at a room temperature for about 10 minutes²⁵.

RESULTS AND DISCUSSION

Meteorological and pollution data:-

Generally, the rain starts in June and continuous up to September. Total annual rainfall was found 828 mm in 2011. March, April, May and June are the hot months of the year, whereas December, January and February are considered as cold months. Average maximum and minimum temperatures are about 314 K and 284 K respectively. Relative humidity is higher than the critical humidity value (70%) for corrosion of iron²⁶ for three months in a year 2011 (Fig.1).

Mild Steel (MS):-

MS plates exposed in winter months indicates that the corrosion rate increases up to five months (i.e. up to Mar-2011) and then it increased rapidly for another Seven months (i.e. from June-2011 to October-2011). The corrosion rate of mild steel indicates 51 mg/sq.dm for one month and 2428 mg/sq.dm for Twelve months exposure period.

Similarly, plates exposed in summer months (i.e. from March-2011) shows corrosion rate increase slowly for three months (i.e. from March-2011 to May-2011), then it again increase rapidly for further four months (i.e. from June-2011 to October-2011). The plates exposed in rainy season indicates initially higher corrosion rate than the plates exposed in winter season which is attributed to the corrosion product which is washed regularly by rain keeping fresh metal surface exposed to further corrosion (Fig.-2).

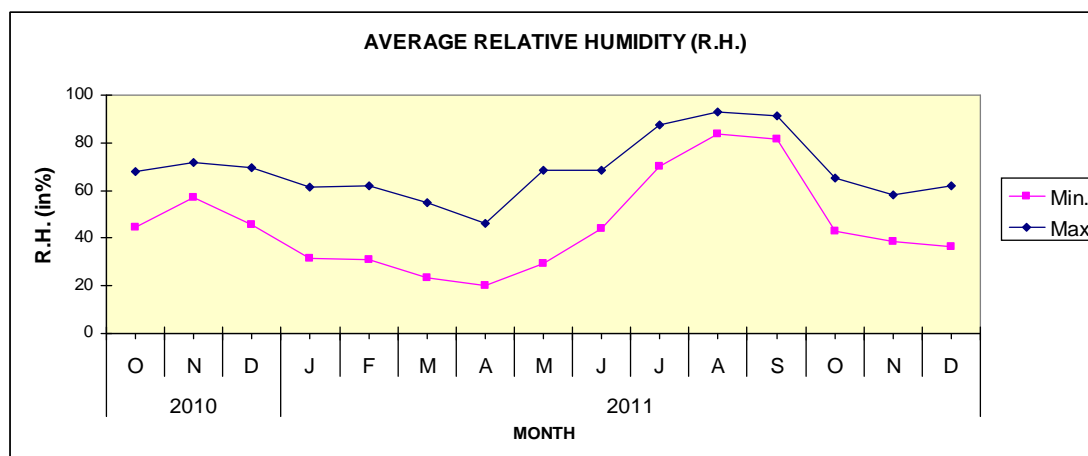


Fig. 1 Average Relative Humidity (R.H.) at Urban Station.

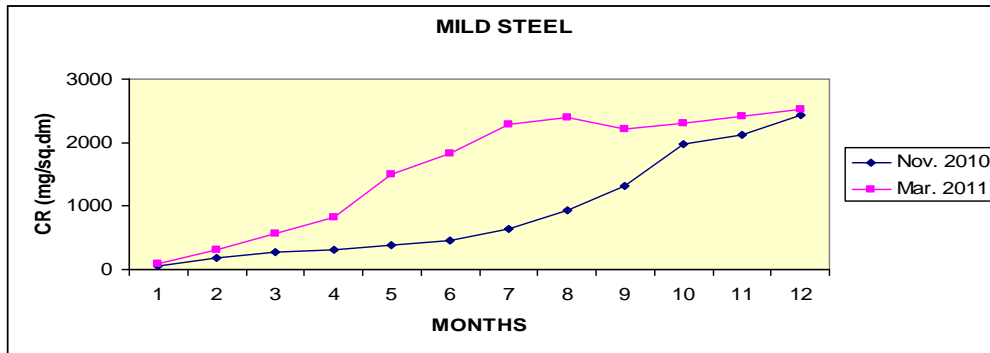


Fig. 2 Progressive corrosion rate (CR) of mild steel under outdoor exposure at urban station.

Positional effect

The results indicate that the panels exposed vertically suffer less corrosion than those exposed at an angle of 45° (Table-1).

Zinc

The observation of first set of zinc metals exposed in winter month (November-2010) indicates that the corrosion rate increases up to Seven months (i.e. up to May-2011) and then it increased rapidly for another five months (i.e. from June-2011 to October-2011). The corrosion rate of zinc indicates 17 mg/sq.dm for one month

and 597 mg/sq.dm for Twelve months exposure period. Another set exposed in summer month (March-2011) indicates corrosion rate increases for eight months (i.e. from March-2011 to December-2011), then it steadily increase for further four months (i.e. from November-2011 to February-2012). The plates exposed in rainy season indicates initially higher corrosion rate than the plates exposed in winter season which is attributed to the corrosion product which is washed regularly by rain keeping fresh metal surface exposed to further corrosion (Fig.-3).

TABLE – 1: Positional effect on corrosion rate of mild-steel at urban station of Ahmedabad

Month	Corrosion rate (mg/sq.dm)	
	Vertical	At 45°
2011		
January	79	93
February	102	109
March	91	121
April	131	156
May	206	232
June	245	306
July	561	764
August	759	811
September	525	838
October	398	431
November	71	87
December	89	98

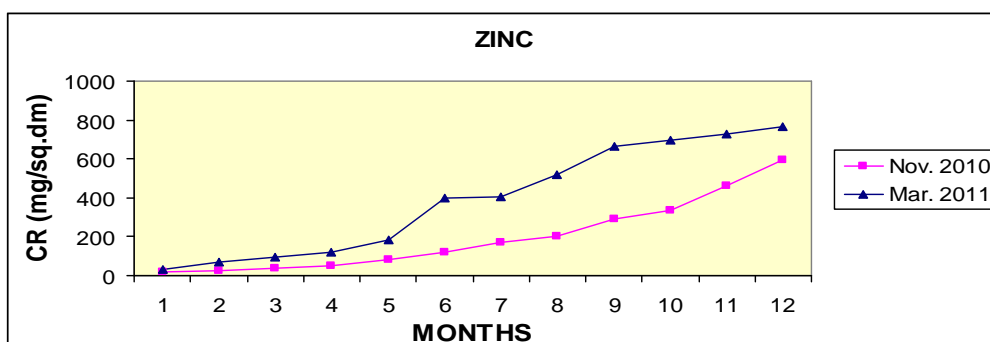


Fig. 3 Progressive corrosion rate (CR) of zinc under outdoor exposure at urban Station.

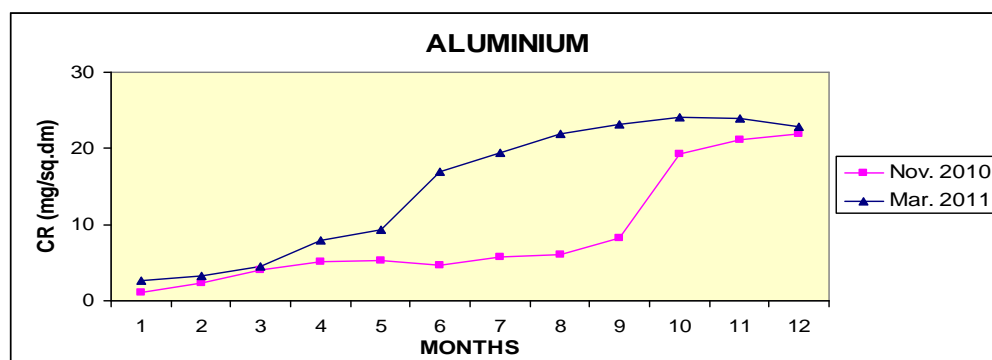


Fig. 4 Progressive corrosion rate (CR) of aluminium under outdoor exposure at urban Station.

Aluminium

Aluminum plates exposed in winter months (i.e. November-2010) indicates that the slow increases in corrosion rate up to four months (i.e. from November-2010 to April-2011) then it rapidly increases for another eight months. The corrosion rate of aluminium indicates 1.1 mg/sq.dm for one month and 21.9 mg/sq.dm for Twelve months exposure period.

Another set of plates were exposed in summer months (i.e. from March-2011). The corrosion rate increases for eight months (i.e. from March-2011 to Dec-2011), The plates exposed in rainy season indicates initially higher corrosion rate than the plates exposed in winter season which is attributed to the corrosion product which is washed regularly by rain keeping fresh metal surface exposed to further corrosion (**Fig.-4**).

PONGSAKSAWAD, W. et al. was studied the average monthly weight losses of outdoor in Thailand urban environment data shows 38.286 g/m²²¹.

CONCLUSION

The resistivity towards the environment was in the increasing order of mild steel < zinc < aluminium. So, we can say that aluminium or aluminium coated sheets would give better performance compared to mild steel or zinc.

ACKNOWLEDGEMENTS

The authors are thankful to Kadarvavishwavidhyalaya, Gandhinagar and Department of Chemistry, Biochemistry, C. U. Shah Science College Ahmedabad for providing laboratory facilities.

REFERENCES

- Viche J. R., Varela F. E., Acuna G., Condaró E. N., Rosales B. M., Moriena G. and Fernandez A., *Corros. Sci.*, 1995, 37, 941-961.
- Viche J. R., Varela F. E., Condaró E. N., Rosales B. M., Moriena G. and Fernandez A., *Corros. Sci.*, 1997, 39, 655-679.
- Corvo F., Haces C., Betancourt N., Maldonado L., Veleza L., Echevarria M., de Rincon O. T. and Rincon A., *Corros. Sci.* 1997, 9, 823-833.
- Morcillo M., Chico B., Mariaca L. and Otero E., *Mat. Perform.*, 1999, 38, 72-77.
- Speller F. N., Corrosion causes and prevention, McGraw-Hill, New York, 1961, 163.
- Uhlig H. H., Corrosion and Corrosion Control, John Wiley and Sons, New York, 1963, 139.
- Vernon W. H. J., *Trans Faraday Soc.*, 1927, 23, 162; *Trans. Electrochem. Corros.*, 1935, 35, 64.
- Hudson J. C., *Trans Faraday Soc.*, 1929, 25, 207.
- Patterson W. S. and Hebbes L., *Trans Faraday Soc.*, 1931, 27, 277.
- Singh D. D. N., Yadav Shyamjeet and Saha Jayant K., *Corros. Sci.*, 2008, 50, 93-110.
- Larrabee C. P. and Ellis O. B., Corrosiveness of various atmospheric sites as measured by specimens of steel and zinc, *Pro. ASTM*, 1959, 59, 183-201.
- Schikorr G. Corrosion behaviour of zinc, Vol. I. Behaviour of zinc in the atmosphere, metalverlag GmbH, Berlin Grunewald 72(1964); English edition published by the American Zinc Institute & Zinc Development Association (1965).
- Mattson E., *Material Performance*, 1982, No. 7, 21(9).
- Vashi R. T. and Patel H. G., Atmospheric Corrosion study of Baroda Industrial area, *Bull. Electro. chem.*, 1997, 13(8-9), 343-347.
- Sanyal B., Das Gupta B. K., Krishnamurthy P. S. V. and Singhania G. K., Atmospheric Corrosion of Metals, Pt. III, Corrosion of

- Metals in Calcutta, *J. Sci. Indust. Res.*, 1961, 20-D, 27.
16. Prajapati M. L., Singhania G. K. and Sanyal B., Atmospheric Corrosion of Metals, Pt VI, Corrosion of Metals at Jodhpur, Labdev, *J. Sci. Tech.*, 1969, 7A(1), 34.
 17. Sanyal B. and Singhania G. K., Atmospheric Corrosion of Metals, Pt. I, Corrosion of Metals in Kanpur, *J. Sci. Indus. Res.*, 1956, 15-B, 448.
 18. Vashi R. T. and Patel R. N., Corrosion of aluminium, zinc and mild-steel in an industrial atmosphere, *J. Indian chem. Soc.*, 2004, 81, 680-682,
 19. Vashi R. T., Malek, G. M., Champaneri V. A. and Patel R. N., *Bull. Electrochem*, 2002, 18(2), 91-96.
 20. Kadiya H. K. and Vashi R. T., *E-Journals of Chemistry*, 2009, 6(S₁),481-484
 21. Wanida PONGSAKSAWAD^{1*}, Ekkarut VIYANIT¹, Sikharin SORACHOT¹ and Tadashi SHINOHARA² *Journal of Metals, Materials and Minerals*, 2010,20,23-27.
 22. Clarke S. G.; *Trans. Electrochem. Soc.*, 1936, 69, 131.
 23. Stroud E. G.; *J. Appl. Chem.*, 1951, 1, 93.
 24. Whitby L.; *Trans. Faraday Soc.*, 1939,29, 527, 844.
 25. West P. W. and Gaeke G. C.; Fixation of sulfur dioxide as disulfitomercurate (11) and subsequent colorimetric determination, *Anal. Chem.*, 1956, 28, 1816-1819.
 26. Vernon W. H. J., *Trans Faraday Soc*,1927, 23,162 and 1933, 27, 264.
