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# Early corrosion of mild steel in seawater

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**Abstract**

Because field studies seldom recover coupons less than 6 months from immersion they provide no information about early corrosion behaviour. Linear or power law functional behaviour for corrosion loss with time is often assumed. New field studies performed on the Australian east coast and described herein using very closely spaced recoveries of coupons show that the corrosion loss–time behaviour is initially highly non-linear and then almost linear until corrosion product formation begins to control the rate of corrosion. The reasons for this behaviour are discussed in terms of the recently introduced multi-phase phenomenological model for marine corrosion. Conventional oxygen diffusion arguments are then used to provide a mathematical model to describe the main part of this behaviour. The possible influences of seawater temperature and oxygen concentration are discussed.


*Keywords:* Corrosion; Mild steel; Seawater; Initial; Oxygen; Temperature

## 1. Introduction

There have been many laboratory studies of the corrosion of mild steel in saline waters but efforts to describe the rate of material loss with time have been limited,

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particularly for the early period of immersion [1]. This is of particular interest in developing a better scientific understanding of corrosion processes. World-wide there is increasing attention being given to deterioration of infrastructure exposed to actual hostile marine environments. As a result structural engineers and naval architects are increasingly interested in the rate of loss of strength of steel and hence in the loss of material in infrastructure systems. The loss of material even for short-term exposures is important in part because protective measures are not always wholly effective. It follows that both understanding and modelling of the early corrosion of structural steel under actual field conditions is of interest. This paper describes recent specially conducted field trials to ascertain such behaviour. It also provides a simplified mathematical description of the process based on conventional oxygen diffusion arguments.

## 2. Field observations of early corrosion

Two different trials were carried out. The first, at Swansea Public Wharf (since demolished), commenced on 12 August 1999. It used coupons $100 \times 50 \times 3$ mm attached to a hard PVC test pod suspended from the marina using procedures described earlier [2]. The metal composition was 0.052C, 0.013P, 0.23Mn, 0.004Si, 0.012S, 0.032Al, 0.015Cu. Table 1 shows the environmental conditions at the time of the trial. Standard corrosion testing procedures were carried out to clean and weigh coupons before and after exposure, including the careful use of blanks since the metal losses were very low. Also a high accuracy mass balance was used. One-sided material losses were estimated from the mass loss measurements. There were daily recoveries of one coupon for up to 28 days. Fig. 1 shows corrosion loss as a function of time. Fig. 2 shows the derived average corrosion rate (corrosion loss divided by period of exposure) and the variation of instantaneous corrosion rate with increasing period of exposure.

Table 1
Environmental conditions for corrosion trials

| Parameter | Swansea Public Wharf | Marks Point Marina | Taylors Beach |
|---|---|---|---|
| Water temperature °C | 18.7 | 24.9 | 11.8–26.4 |
| Salinity g/kg | 29.8–34.9 | 26.1–35.3 | 20.1–34.8 |
| Dissolved oxygen % saturation | 92–100 | 92–95 | 100 |
| pH | 8.1–8.3 | 8.1 | 8.1 |
| Conductivity μS/cm | 47000 | 41,000 | 45700 |
| Nitrates mg/l as N | <0.01 | <0.01 | 0.02 |
| Nitrites mg/l as N | <0.01 | <0.01 | <0.01 |
| Ammonia mg/l as N | 0.03 | <0.02 | 0.03 |
| Sulphate mg/l | 2400 | 2600 | 1700 |
| Ortho phosphorous mg/l as P | 0.005 | 0.006 | <0.005 |
| Total Phosphorous mg/l as P | 0.017 | 0.01 | 0.022 |
| Calcium mg/l | 497 | 428 | 419 |