REPORT

ATMOSPHERIC EXPOSURE AND ELECTROCHEMICAL EVALUATION OF ZINGA

by

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1. INTRODUCTION

The results of a previous evaluation of Zinga for Galvatech Ltd[1] showed that the galvanic protection offered to steel by Zinga was comparable to that offered by a galvanised zinc coating. These results have been confirmed by electrochemical tests described below, which have shown that Zinga provides good galvanic protection to steel but having a lower corrosion rate than a zinc coating prepared by hot dip galvanising.

2. RATIONALE

Zinga is a 98% zinc-containing protective coating for steel and galvanised sections. The initial salt-spray work[1] demonstrated that under very aggressive conditions the Zinga coating corroded and protected the underlying steel substrate in a manner very similar to a galvanised zinc coating. The present research aims to corroborate these results by direct comparison of the galvanic protection offered by Zinga and galvanised coatings to steel and by measuring the intrinsic corrosion rates of Zinga coated and galvanised steel.

The comparisons involve electrochemical measurements in a dilute chloride/sulphate media and outdoor exposure tests under marine and industrial conditions. The electrochemical tests have been completed and are detailed in this report.

3. EXPERIMENTAL

Standard electrochemical tests were conducted in a dilute (0.01 molar) sulphate and sodium chloride solution at pH6.0 ± 0.2. The open circuit voltage and galvanic current between Zinga and bare steel were measured over a range of area ratios. These results were compared with those from identical tests in which the Zinga was replaced by hot-dipped galvanised steel.

The corrosion rates were measured by linear polarisation and ac impedance. The non-Faradaic resistance of the electrochemical system under study was obtained from the ac impedance response and subtracted from the measured linear polarisation resistance of the sample to give the charge transfer resistance. The intrinsic corrosion rate of the sample was then calculated by the relationship -

$$\text{Corrosion rate} = \frac{B}{\text{charge transfer resistance}}$$

The value of B was assumed to be 30mV. The corrosion rate was converted from a corrosion current into a metal loss value in mm/year by Faradays law assuming zero porosity of the coating.

4. RESULTS

The results of the electrochemical tests are shown in Tables 1 and 2 and Figures 1-3. Table 1 shows that the potential of the mild steel/galvanised steel couples rose slightly (i.e. became more positive) with increasing exposure time and decreasing ratio of protective coating to steel.

The coated steel potentials varied between -1062mV and -1015mV, the most positive potential was measured with a galvanised steel to mild steel ratio of 1:1 after 168 hours exposure. Table 2 shows that the potential of the Zinga/mild steel couples also rose slightly with increasing exposure time and decreasing ratio of protective coating to steel. The measured potentials varied between -1073mV and -971mV.

The most electro-negative potentials for both Zinga and galvanised steel coatings were for samples coupled to mild steel; this indicates that the coupling of the protective coatings to the mild steel samples activates the anodic zinc dissolution reaction.

Tables 1 and 2 show that the galvanic protection offered to the mild steel by Zinga was very similar, though generally smaller than that conferred by the galvanised coating. This result is in accord with the results reported earlier.

5. DISCUSSION

The corrosion rate of the Zinga coated specimens after 7 days exposure was 0.035mm/year, roughly 1/3 of the corrosion rate of galvanised steel panels under similar conditions (0.11mm/year). In the tests where the Zinga coated and galvanised panels were coupled to mild steel samples, the potential of the coupled electrodes always remained below -800mV SCE, which showed that both Zinga and galvanised steel offer good galvanic protection to the steel. The galvanic protection offered by Zinga was however slightly less than that offered by the galvanised zinc coating. In practice this means that the Zinga panels would be able to offer galvanic protection to the underlying steel for a longer time than galvanised steel per gram of zinc deposited. (Increased galvanic protection above the minimum for sacrificial protction plays no part in the corrosion reaction at the steel surface - the only result is the increased rate of dissolution of the coating and the reduction of oxygen to hydroxide at the steel surface). The potential of the Zinga-to-steel couple did become more positive with time for every ratio of Zinga/mild steel studied, but this is not thought to be significant as the potential obtained fell well within the potentials required for protection of the steel (ca -800mV SCE). The galvanic currents offered to the steel by Zinga were never less than 25% of the equivalent protection offered by galvanised coatings.

The probable reason for the excellent corrosion resistance and galvanic protection characteristics of the Zinga are that the binding material present in the coating acts as a corrosion inhibitor to slow down the kinetics of zinc dissolution in the Zinga coating. The zinc present in the Zinga coating is a sacrificial anode to steel but corrodes at a much slower rate than would otherwise be expected. Zinga would therefore be expected to perform well under a majority of in-service conditions provided that the correct method of application were employed. The reduced sacrificial protection offered by Zinga could result in superficial, but not structurally damaging corrosion of the uncoated steel section of a partially zinc coated steel structure under mildly corrosive environments e.g. unpolluted atmospheric exposure.

6. CONCLUSIONS

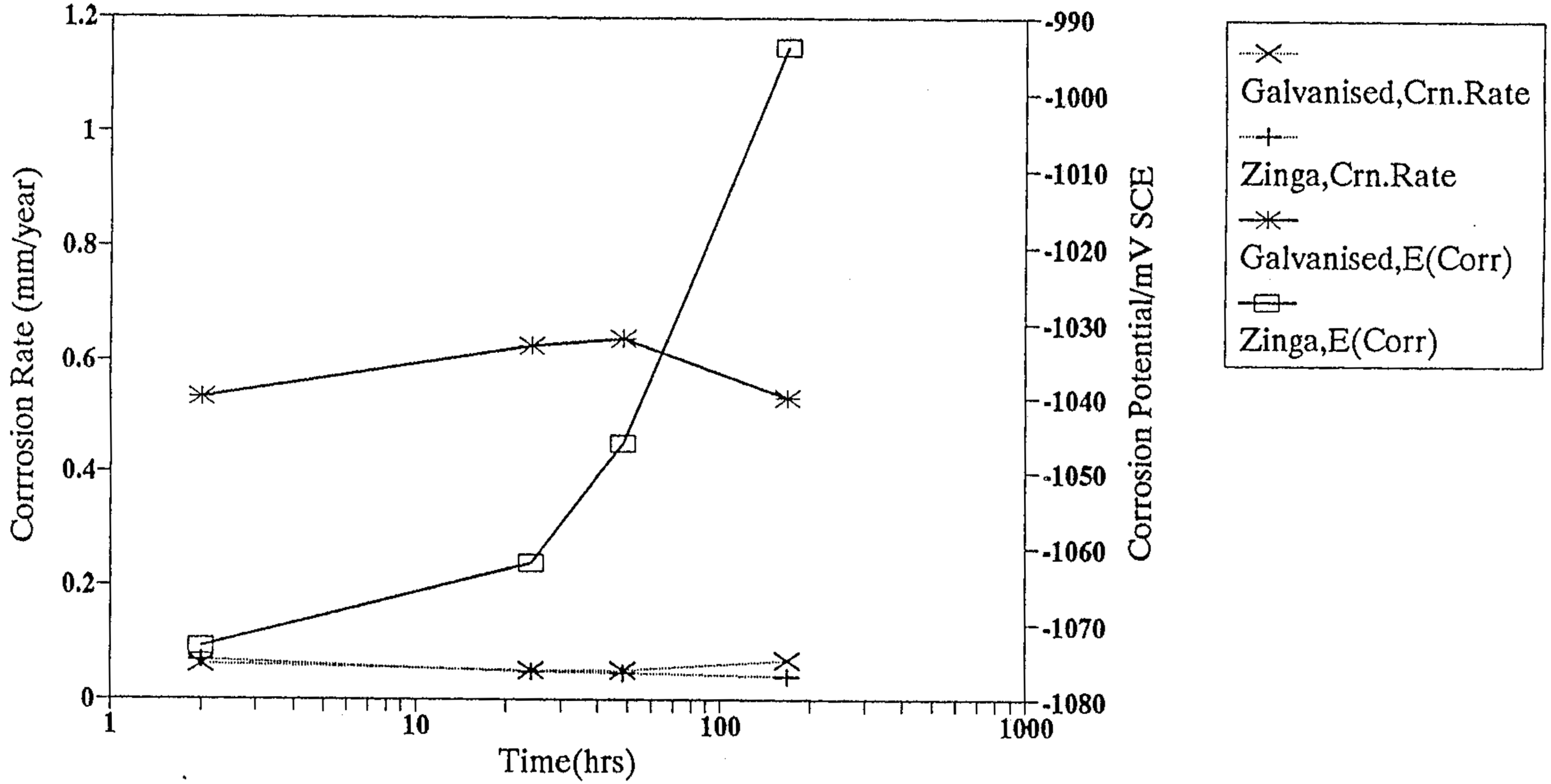
1. Zinga offers galvanic protection to steel comparable to that offered by galvanised steel.
2. Under the continuous immersion conditions studied the Zinga coated mild steel specimens corroded at a lower rate than galvanised zinc coated specimens.
3. The electrochemical work has confirmed that Zinga is a corrosion resistant zinc coating which protects mild steel effectively under simulated marine conditions.

7. REFERENCE

[1] BNF-Fulmer Research Paper STE/47/90/1, (1990).

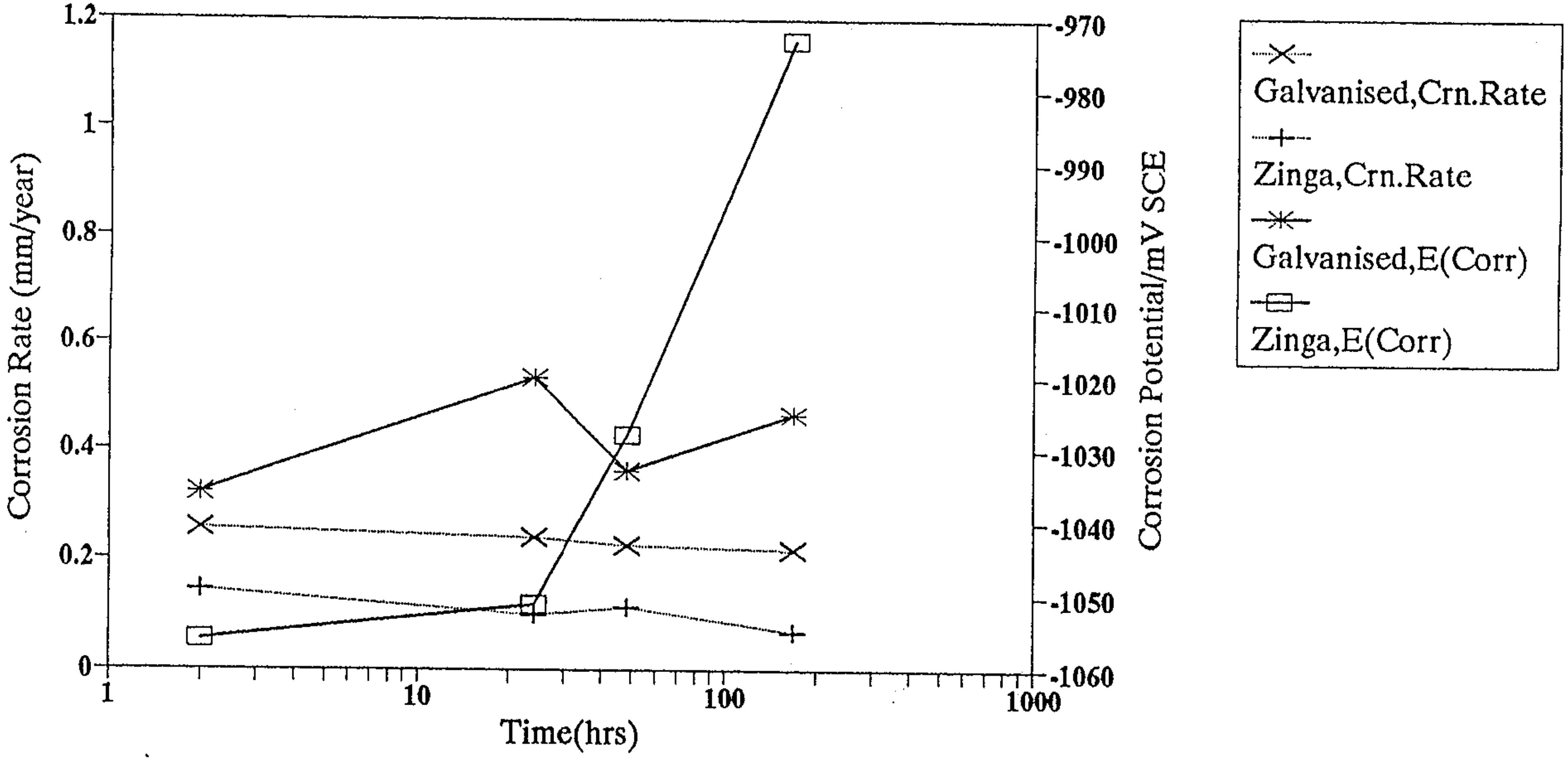
NMF/GS/D.L19

Figure 1 The variation of galvanic protection and corrosion potential with time for a protective coating to mild steel area ratio of 10:1



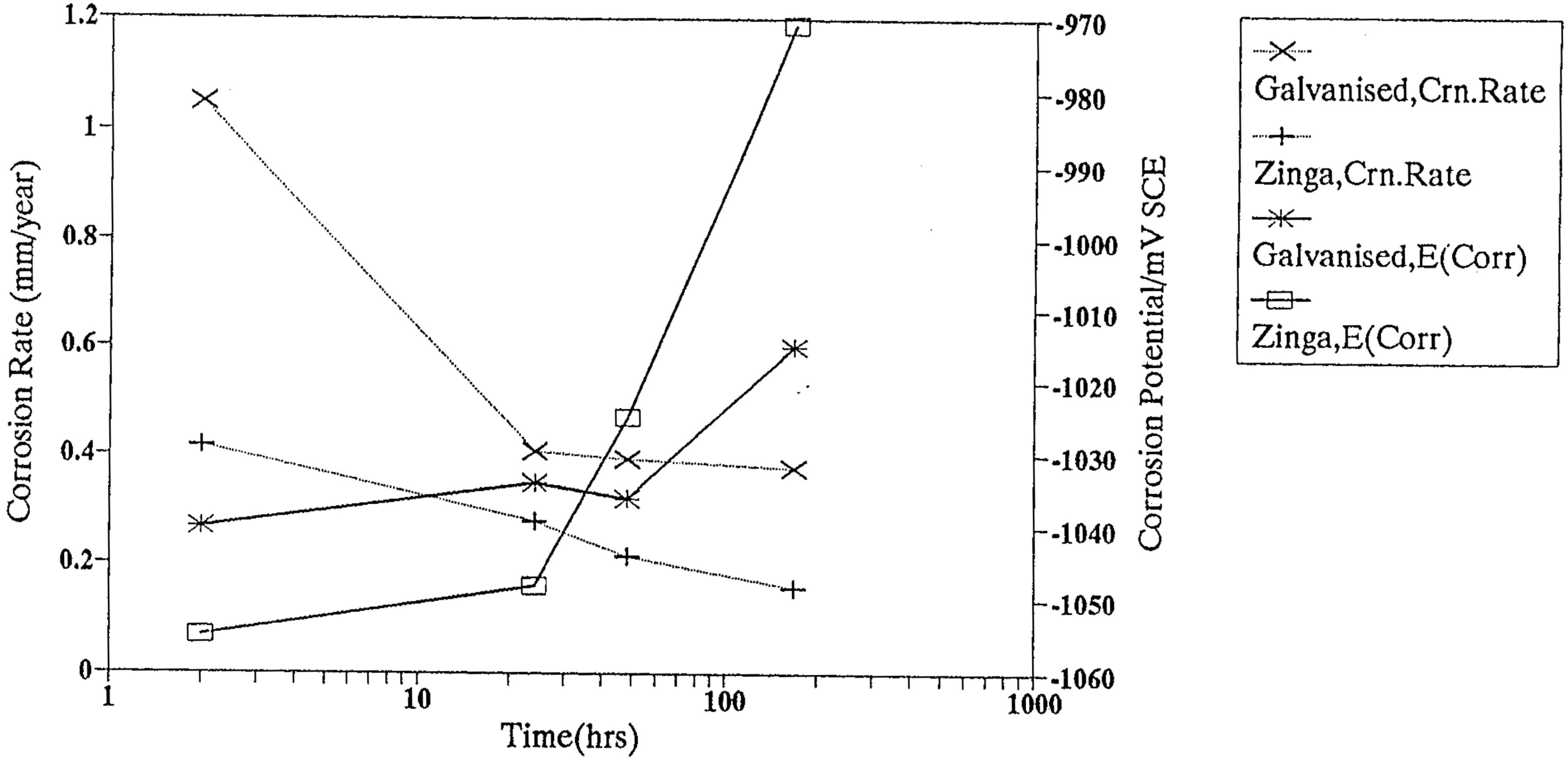
(The corrosion rate represents the flow of current from the protective coating to the mild steel,which has been converted into a value in mm/year using Faraday's Law and assuming 0% porosity of the coating)

Figure 2 The variation of galvanic protection and corrosion potential with time for a protective coating to mild steel area ratio of 2:1



(The corrosion rate represents the flow of current from the protective coating to the mild steel,which has been converted into a value in mm/year using Faraday's Law and assuming 0% porosity of the coating)

Figure 3 The variation of galvanic protection and corrosion potential with time for a protective coating to mild steel area ratio of 1:1



(The corrosion rate represents the flow of current from the protective coating to the mild steel,which has been converted into a value in mm/year using Faraday's Law and assuming 0% porosity of the coating)