1. Background

SGS Environment, Health & Safety, Sydney was requested by Keith Rickman of Corrizon Australasia to evaluate the effectiveness of a corrosion inhibiting treatment applied to steel. This was to be performed using an adapted version of the 7-28 day Corrosive to Metals Test (UN Test C1).

The 7-28 day Corrosion to Metals Test (UN Test C1) is used for assessing the corrosion hazards of a substance to suitably classify them for transport. This is performed by exposing a variety of metals to the substance and determining the rate of corrosion of these metals. These rates are then used to classify the substance for transport.

However, in this work, the 7-28 day Corrosive to Metals Test (UN Test C1) was adapted to assess the effectiveness of the corrosion inhibiting coating. This was performed by exposing both untreated and treated steel coupons to a solution of 33 % sulphuric acid and determining the rate of corrosion of untreated and treated steel.

Steel coupons were dispatched to Corrizon Australasia to apply their corrosion inhibiting treatment and were subsequently returned to SGS for analysis. Samples were received by SGS Environment, Health & Safety, Sydney on 22nd of June 2020 and assigned a laboratory reference number as follows:

Your Reference	Our Reference
Treated Steel Coupons	SP031922-1

SP031922-1 was kept under ambient conditions until analysed.

2. Methods Used

2.1. Corrosion to Metals Test (UN Test C1)

Untreated and treated steel coupons were tested in accordance with the relevant procedures as defined within Part III – Section 37.4 of the UN Manual (UN, 2015) using a solution of 33% sulphuric acid. For both the treated and untreated steel, three coupons were placed in receptacles containing a solution of 33% sulphuric acid. The first coupon was suspended above the solution, the second halfway submerged and the third fully submerged. These coupons were identified as S1, S2 and S3 respectively for the untreated and T1, T2 and T3 for the treated steel.

The receptacles were then placed in a test environment with a controlled temperature of 55±1 °C for a period of 7 days. Coupons were then removed from the receptables and corrosion products removed from the coupon surface. Mass loss was calculated by comparing the mass of the coupon before and after 7 days in the receptacles. For treated coupons both masses included the mass of the corrosion inhibiting treatment which coated the steel. Corrosion rate was calculated using the equation below.

$$R = \frac{\Delta M}{S \times \rho \times t}$$

Where **R** is the rate of corrosion in mm year^{-1}, **ΔM** is the 7-day mass change, **S** is the coupon surface area in mm^2, **ρ** is the coupon density in g mm^{-3} and **t** is the time in years.

2.2. Adapted Corrosion to Metals Test

An untreated steel coupon was tested using an adapted Corrosion to Metals test. This was performed as per Part III – Section 37.4 of the UN Manual (UN, 2015) using a solution of 33% sulphuric acid, however the coupon was monitored periodically until complete dissolution was achieved. This coupon was identified at S3(2). At this time point, the corrosion rate was calculated as per 2.1.

3. Analytical Results

Table 1. Time in solution, initial masses, final masses and calculated corrosion rates for untreated and treated steel coupons suspended above, half submerged and fully submerged in 33 % sulphuric acid performed in accordance with Corrosion to Metals Test.

Steel	ID	Position	Days	Initial Mass /g	Final Mass /g	Corrosion rate /mm year^{-1}
Untreated (Control)	S1	Suspended	7.0	22.8002	22.7733	<0.1
	S2	Half submerged	7.0	23.0156	9.3413	38.8
	S3	Fully submerged	7.0	22.6464	0.0000	64.3
	S3(2)	Fully submerged	0.75	27.6505	0.0000	733
Treated (SP031922)	T1	Suspended	7.0	24.5490	24.5389	<0.1
	T2	Half submerged	7.0	24.5112	16.8431	21.8
	T3	Fully submerged	7.0	25.1591	11.1266	39.9

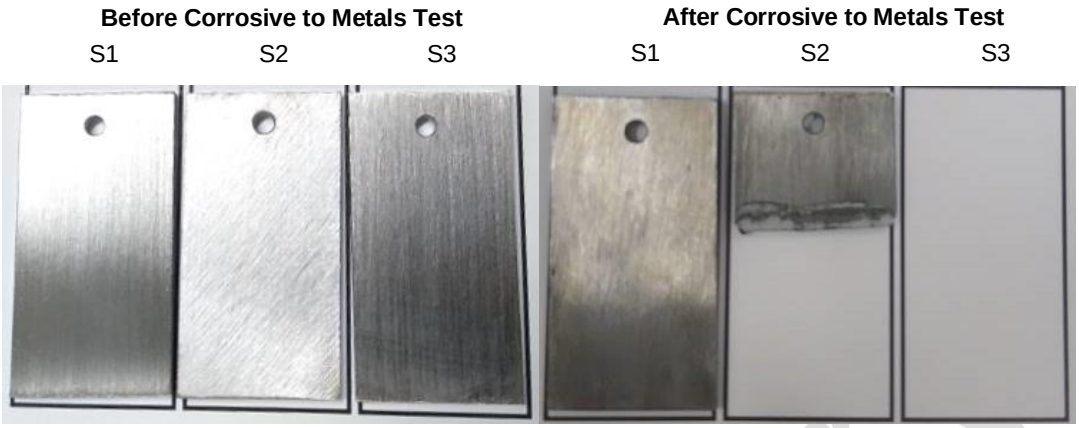

Figure 1. Images of untreated steel coupons before and after Corrosion to Metals Test (UN Test C1). Coupon ID's from left to right are S1, S2 and S3.

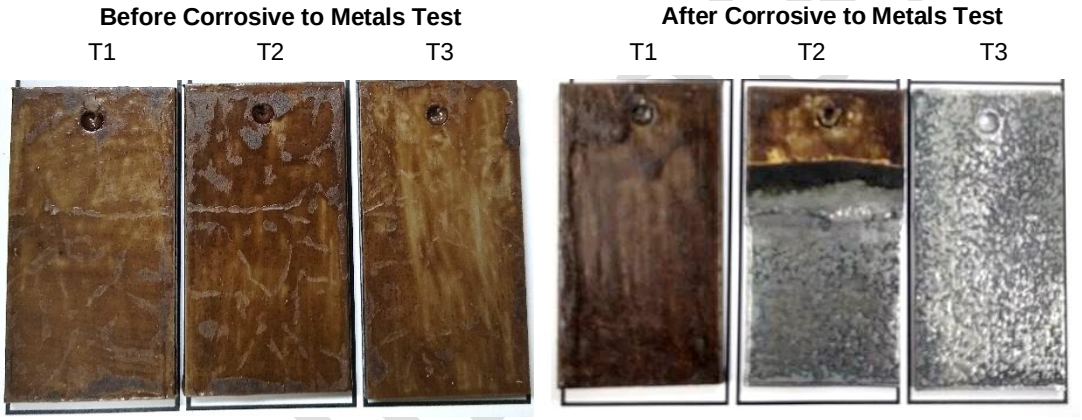

Figure 2. Image of treated steel coupons before and after Corrosion to Metals Test (UN Test C1). Coupon ID's from left to right are T1, T2 and T3.

Figure 3. Image of untreated steel coupon S3(2) before Corrosion to Metals Test.

4. Opinions and Interpretations

Observations of the coupons following their 7-day exposure to the 33 % sulphuric acid showed significant differences. The portions of the untreated steel coupons submerged in the sulphuric acid solution had completely dissolved by day 7. This corresponded to a relative 7-day mass loss of 59 % and 100 % for S2 and S3 respectively.

In contrast, the treated steel showed improved resistance to corrosion by the 33 % sulphuric acid solution. The relative 7-day mass loss of the treated coupons were significantly lower than their untreated equivalents, at 31 % and 56 % for T2 and T3 respectively.

No significant mass change was measured for the S1 and T1 coupons suspended above the 33 % sulphuric acid solution.

As the submerged portion of the untreated steel coupons were completely dissolved by day 7, the corrosion rates reported for S2 and S3 will be underestimated. Therefore, another experiment was performed using an adapted Corrosion to Metals Test. In this experiment, a fully submerged untreated coupon was monitored periodically until complete dissolution was achieved to more accurately determine its corrosion rate in 33% sulphuric acid. The coupon was found to completely dissolve within 18 hrs corresponding to a corrosion rate of 733 mm yr^{-1}. Therefore, the treatment was able to decrease the average corrosion rate by approximately 95% over a 7-day period in 33% sulphuric acid at 55°C for a fully submerged coupon.

It is important to note that the initial mass and day 7 masses of the treated coupons also included the mass of the treatment coating. This means that the 7-day mass change is inclusive of both mass loss due to corrosion of the steel and degradation of the treatment coating. Therefore, the corrosion rates for T2 and T3 presented in Table 1 are likely over estimated.