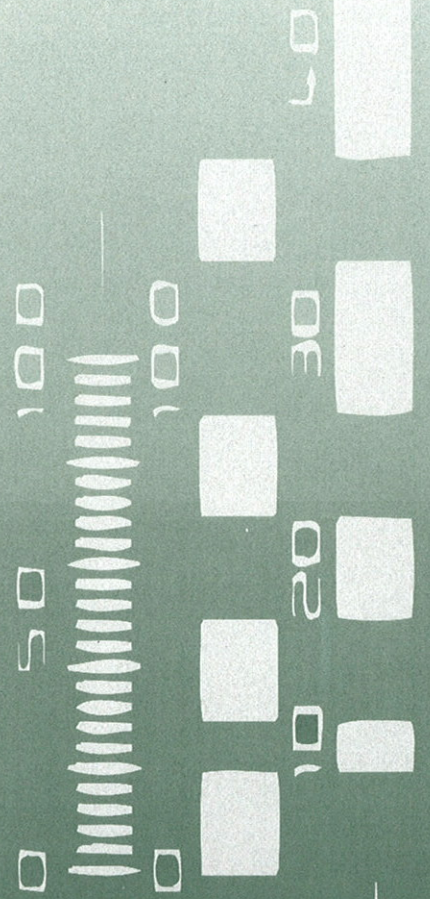


REPORT

Evaluation of the Susceptibility of a Carbon Steel Weldment to Preferential Corrosion Using the Galvanostatic Method – A Guide to Testing

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SUMMARY

This report describes an accelerated procedure for assessing the susceptibility of carbon steel welds to preferential corrosion based on application of a fixed galvanostatic current at a magnitude for which differential dissolution of regions of the weldment may be readily discerned. The document is presented in a form similar to that of an ISO standard.

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1 SCOPE

1.1 This test method describes a laboratory procedure for assessing the relative susceptibility to preferential corrosion of the weld metal, the heat affected zone and adjacent parent plate of a carbon steel weldment.

1.2 The method is aimed primarily at through-thickness welded plate or pipe section.

2 REFERENCES

A. J. Griffiths and A. Turnbull, 'Corrosion Testing of Welds', NPL Technical Review No. 4, ISSN 1368-6550, National Physical Laboratory, 1999.

ASTM D1141-98, 'Specification for substitute seawater', 1998.

W. Nimmo, A.J. Griffiths, Linda Orkney and A. Turnbull, 'Measurement of the corrosion activity of carbon steel welds', NPL Report MATC (A)34, 2001.

A. Garner, 'Predicting localised corrosion of weldments with an anodic dissolution test', Corrosion 89, Paper No. 62, NACE International, TX., USA, 1989.

3 PRINCIPLE

When a carbon steel section containing a weld is immersed in an aggressive chloride solution and a constant anodic current density is applied the steel will dissolve in order to satisfy the current demand. If there are regions of the section that are more susceptible to corrosion, these will tend to corrode preferentially as this requires the least energy. Accordingly, inspection of the section after exposure will highlight those susceptible regions. Visual inspection may be sufficient or the surface topography may be profiled. The current density for this test can be varied according to the degree of acceleration required. For tests in seawater, a current density of about 1 mA cm^{-2} will generate sufficient material loss to allow ready detection of susceptible regions after a few days of exposure. More rapid determination (about 1 h) can be undertaken with an applied current density of about 100 mA cm^{-2} but with the following caveat. The longer test tends to be more discriminating and should be used if the very high current density associated with the short term test tends to dissolve the steel too uniformly; this will be material sensitive. The latter condition can sometimes arise despite differences in susceptibility in the material if the corrosion of the more susceptible region becomes constrained by local mass transport. For this reason, a longer term exposure should be adopted if short term tests reveal no distinct variations in local susceptibility. These current densities and test durations should be considered as a basis for initial testing but may be modified based on experience with particular materials.

4 TEST ASSEMBLY

4.1 TEST CELL

4.1.1 The test cell (Figure 1) contains the welded section as the working electrode (WE) and a counter electrode (CE) to balance the current. The counter electrode may be platinum but graphite electrodes can also be used. The counter electrode should be positioned so that the potential field is uniform; i.e. the counter electrode should be positioned symmetrically around the specimen or if one side only is exposed, a length of counter electrode should be used parallel to the exposed weld section. A reference electrode such as the saturated calomel electrode (SCE) may be used optionally to monitor the electrode potential during the test but since there may be a significant potential drop this is intended only for indicative purposes.

4.1.2 The test cell can be any suitable inert material.

4.1.3 The volume of solution should be sufficient to fully immerse the specimen and to minimise solution composition changes during a test. Refreshment may be necessary if long term exposure is undertaken (see Section 7.7).

4.1.4 The test solution shall be stirred to limit local build-up of corrosion products on the specimen.

4.2 INSTRUMENTATION

4.2.1 A constant current supply is required; this may be a galvanostat or a potentiostat converted to galvanostatic mode.

4.2.2 A current measuring device with an up-to-date calibration certificate. If the potential is monitored a calibrated electrometer or high impedance voltmeter should be used.

5 SPECIMEN PREPARATION

5.1 The specimens shall be prepared with the weld metal centrally positioned and with the major axis of the specimen perpendicular to the weld direction (Figure 2). The size of specimen should be such that the total length of the exposed plate (L) relative to the width of the weld metal cap (w) is greater than 10:1 and the width of the specimen (W) relative to the width of the weld cap is greater than 4:1.

5.2 Remove pre-existing deposits on the surfaces. This may be achieved by glass bead shot blasting the specimen and cleaning using alcohol followed by acetone before storing in a dessicator. The sides of the specimen, which show the weld in cross-section may be ground to a suitable finish, such as 600 grit (P1200), and cleaned.

5.3 Insulated wire/s appropriate to the current load (to minimise heating of the wire) should be attached to the specimen remote from the weld to provide a means of both

suspending the specimen and creating electrical contact. A waterproof sealant should be applied to this area to avoid exposure of the wire and any fittings.

6 SOLUTION PREPARATION

The solution used should reflect the intended service application. For seawater exposure, ASTM substitute ocean water (ASTM D1141) is sufficient but without the heavy metal additions. The solution shall be prepared from distilled or deionised water and analytical reagent grade chemicals. The initial pH of this solution is 8.2.

7 PROCEDURE

7.1 Measure the pH of the test solution and if using a reference electrode check against other electrodes to ensure it is within calibration. Note the ambient temperature.

7.2 Measure the exposed surface area of the specimen and estimate the required total current for the intended current density.

7.3 Photograph the specimen viewed in section and in plan.

7.4 Assemble the cell and instrumentation.

7.5 Commence bubbling air through the solution. The rate is not critical but should be approximately repeatable.

7.6 Immerse the specimen and apply the current immediately (see Section 3).

7.7 For tests lasting more than 24 hours, the pH should be monitored daily and the solution refreshed if the pH deviates significantly from the initial value (for seawater, a pH below 7.9 would require solution change).

7.8 After exposure, remove the specimen, rinse with water, then alcohol and acetone and air dry.

7.9 Visually examine the specimen and photograph in section and in plan. Check qualitatively that the loss of material on the cross section and to and bottom of test specimen have similar characteristics.

7.10 Surface profiling may be carried out on the exposed cross section in the cap and root region to provide a quantitative measure of material loss in those regions.

7.11 If no susceptible corrosion regions are identified in the short-term (1 h) test, undertake the longer exposure test.

8 REPORT

The report shall refer to this test method and shall contain the following:

- a) full description of the test material from which the specimens were taken, including UNS number, composition, heat treatment, type of product;
- b) details of welding procedure (if investigating the effect of welding parameters), including heat input rate, number of passes, root gap information, weld filler and welding process;
- c) method of manufacture of the specimens and details of the surface preparation;
- d) the solution composition, pH, volume, temperature and refreshment details;
- e) area of the specimen exposed to test solution;
- f) description of cell and electrodes used;
- g) applied current density;
- h) test duration;
- i) electrode potential at start, intermediate time, and end of test if monitored;
- j) summary of visual observations, photographic records and surface profiling information as appropriate.

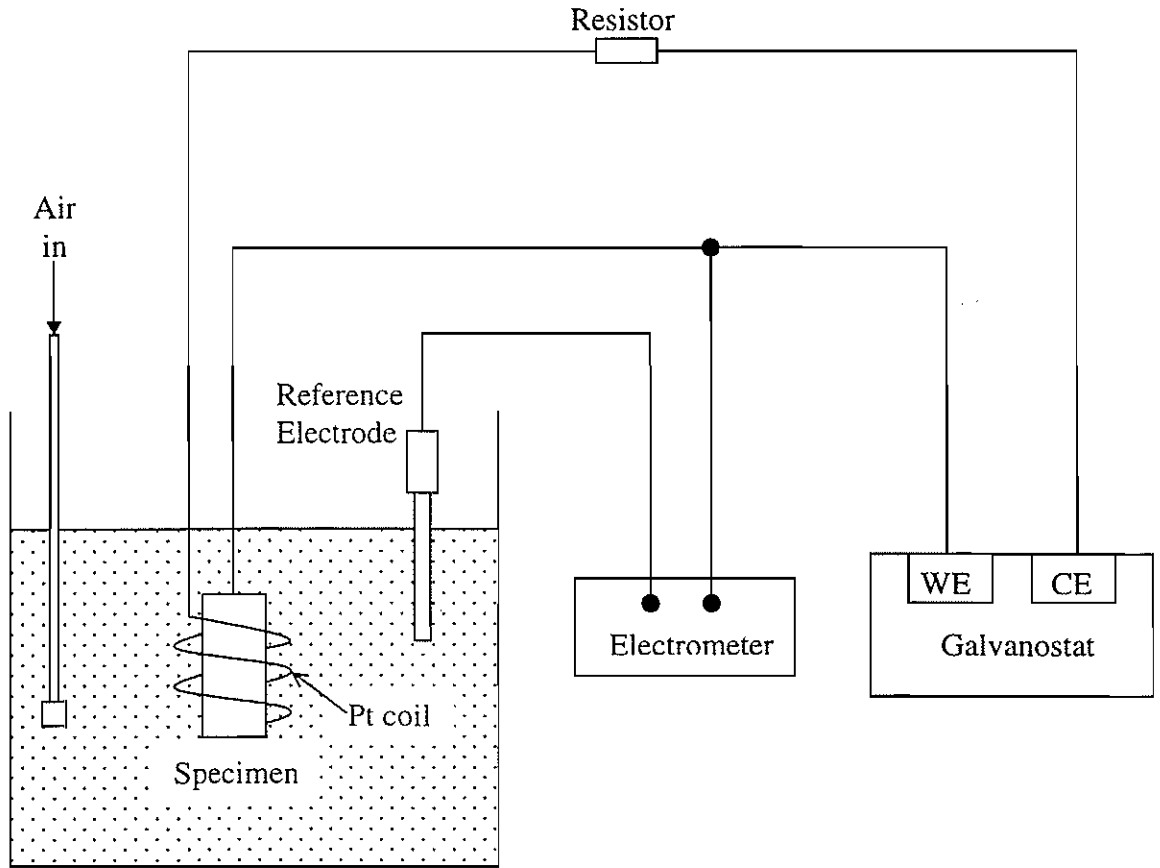


Figure 1. Schematic representation of test assembly

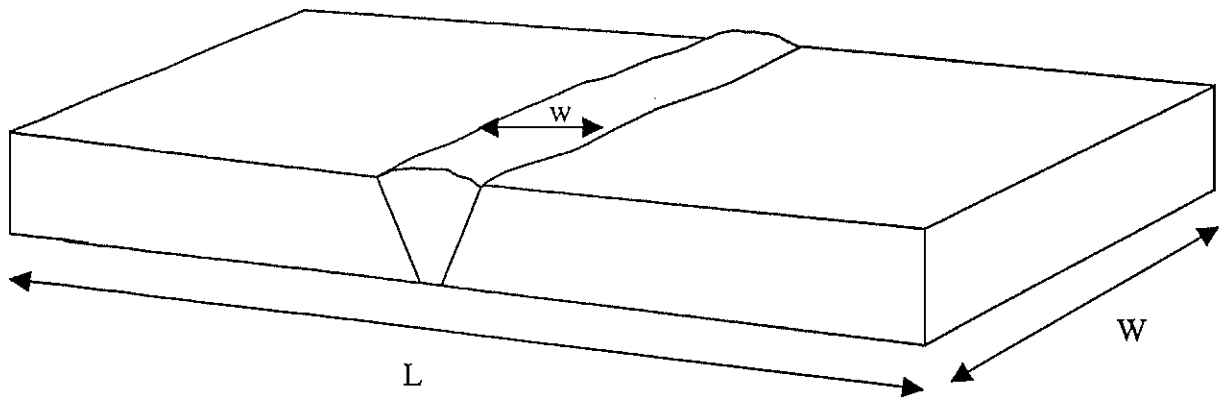


Figure 2. Illustration of specimen geometry

