

CLEANING LABORATORY EVALUATION SUMMARY

SCL #: 2005

DateRun: 06/19/2005

Experimenters: Jason Marshall

ClientType: Chemical Company

ProjectNumber: Project #1

Substrates: Aluminum

PartType: Coupon

Contaminants:

Cleaning Methods: Immersion/Soak

Analytical Methods: Gravimetric

Purpose: To conduct corrosion test on two solutions using aluminum coupons.

Experimental Procedure: Testing was conducted following ASTM G21-72 (2004) Standard Practice for Laboratory Immersion Corrosion Testing of Metals. This practice, rather than a standardized procedure is presented as a guide so that some of the pitfalls of such testing may be avoided. Coupon corrosion testing is predominantly designed to investigate general corrosion.

Coupons with a large surface-to-mass ratio and a small ratio of edge area to total area were used. Two inch square coupons were used that had a thickness of 0.034" thick.

The temperature was held at 71 F +/- 2 F.

The volume of the test solution should be large enough to avoid any appreciable change in its corrosivity during the test, either through exhaustion of corrosive constituents or by accumulating of corrosion products that might affect further corrosion. The lab filled 600 ml Pyrex beakers with 500 mls of each solution. Solutions used were Union 1760 AU-1 (stock), Union 1760 Residue Remover, DI water, Union 1760 AU-1 (stock) with 0.25g boric acid, Union 1760 Residue Remover with 0.125g boric acid and DI water with 0.25g boric acid.

Eighteen aluminum coupons (AL-1100) were precleaned for five minutes in a 5% solution of Armakleen M Aero in an ultrasonic tank. Cleaned coupons were rinsed in tap water at 120 F for 15 seconds and dried using compressed air for 30 seconds. The coupons were then weighed to establish baseline weights. Three coupons were immersed into each solution, suspended by stainless steel hooks. Beakers were then covered with parafilm to reduce evaporation or contamination of the solutions. The soak time was set at 24 hours (1440 minutes).

At the end of the soak time, coupons were removed from the beakers and observations were made prior to cleaning. Coupons were cleaned for 15 seconds in M Aero 5% solution using immersion soaking. Coupons were not rinsed but were dried using compressed air for 15 seconds. Dry coupons were then weighed to determine the amount of weight loss if any. After reweighing, coupons were examined for the presence of pits.

Interpretation of Results

The mass loss during the test period can be used as the principal measure of corrosion. Average corrosion rate can be calculated from the following equation:

$$\text{Corrosion Rate} = (K*W)/(A*T*D)$$

K = a constant
T = time of exposure in hours to the nearest 0.01 h
A = area in cm² to the nearest 0.01 cm²
W = mass loss in g, to the nearest 1 mg (corrected for any loss during cleaning)
D = density in g/cm³

Corrosion Rate Units Desired Constant (K) in Corrosion Rate Equation

mils per year (mpy) 3.45×10^6
inches per year (ipy) 3.45×10^3
inches per month (ipm) 2.87×10^2
millimeters per year (mm/y) 8.76×10^4
micrometers per year (um/y) 8.76×10^7
picometers per second (pm/s) 2.78×10^6
g per sq. meter per hour (g/m²-h) $1.00 \times 10^4 \times D$
(Using g per sq. meter per hour will eliminate the need to use density in the calculations as the density is cancelled out.)

Results: The stock solution with and without boric acid, acted similarly on the aluminum coupons. Each set of coupons lost over 0.5 grams in mass after soaking for 24 hours at 71 F. The two Residue Remover solutions also behaved similarly, losing just over 0.05 grams.

The coupons soaked in water had no appreciable loss (or gain) in mass after soaking.

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| Solution | Coupon | Initial Wt | 24 Soak Wt | Wt Loss | Ave Wt Change | Coupon Obs. | Overall Observations |
|----------------------|--------|------------|------------|---------|---------------|-----------------------|---|
| Stock | 1 | 10.7618 | 10.2856 | 0.4762 | 0.5216 | some pitting | Top of support holes were etched away. |
| | 2 | 10.7698 | 10.4660 | 0.3038 | | little pitting | |
| | 3 | 10.7687 | 9.9839 | 0.7848 | | some pitting | |
| Residue | 4 | 10.7923 | 10.7325 | 0.0598 | 0.0547 | no visible change | Some residue build up on coupons. Rinsed/ wiped off. |
| | 5 | 10.7838 | 10.6950 | 0.0888 | | no visible change | |
| | 6 | 10.7579 | 10.7425 | 0.0154 | | no visible change | |
| Water | 8 | 10.7692 | 10.7676 | 0.0016 | 0.0002 | no visible change | No change in coupons. |
| | 9 | 10.7802 | 10.7807 | -0.0005 | | no visible change | |
| | 10 | 10.8151 | 10.8155 | -0.0004 | | no visible change | |
| Stock w/boric Acid | 11 | 10.7534 | 10.5595 | 0.1939 | 0.5397 | pitting along edge | Less visible damage to coupons than without boric acid. Only one coupon support hole etched away. |
| | 12 | 10.5097 | 9.9075 | 0.6022 | | severe pitting | |
| | 13 | 10.5168 | 9.6939 | 0.8229 | | severe pitting | |
| Residue w/boric acid | 14 | 10.6366 | 10.5840 | 0.0526 | 0.0617 | no visible change | Little to no change in appearance. |
| | 15 | 10.6195 | 10.5469 | 0.0726 | | loss of coupon luster | |
| | 16 | 10.6344 | 10.5744 | 0.0600 | | no visible change | |
| Water w/boric Acid | 17 | 10.6268 | 10.6275 | -0.0007 | -0.0004 | no visible change | No change in coupons. |
| | 18 | 10.6781 | 10.6775 | 0.0006 | | no visible change | |
| | 19 | 10.7825 | 10.7836 | -0.0011 | | no visible change | |

Summary

| Product | Corrosion Rate (g/m ² -h) |
|----------------------|--------------------------------------|
| Stock | 0.00842 |
| Residue | 0.00088 |
| Water | 0.00000 |
| Stock w/ boric Acid | 0.00872 |
| Residue w/boric acid | 0.00100 |
| Water w/ boric Acid | -0.00001 |

Summary:

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Conclusion: Both boric acid mixes lost more weight than the boric acid free solutions. The stock solution resulted in the most damage to the aluminum coupons.