CLEANING LABORATORY EVALUATION SUMMARY

SCL #:	2005
DateRun:	10/11/2005
Experimenters:	Jason Marshall
ClientType:	Chemical Company
ProjectNumber:	Project #1
Substrates:	Aluminum
PartType:	Part
Contaminants:	None
Cleaning Methods:	Immersion/Soak
Analytical Methods:	Gravimetric
Purpose:	To conduct a corrosion test comparing compatibility of two acids with aluminum.

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 by 4 inch coupons were used that had a thickness of 0.034".

The temperature was held at 67 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 400 ml Pyrex beakers with 350 mls of each solution. Solutions used were concentrated nitric acid and Art-1 acid alternative.
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 solutions. 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:

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 x 10^6
inches per year (ipy) 3.45 x 10^3
inches per month (ipm) 2.87 x 10^2

millimeters per year (mm/y) 8.76 x 10^4
micrometers per year (um/y) 8.76 x 10^7
picometers per second (pm/s) 2.78 x 10^6

g per sq. meter per hour (g/m2-h) 1.00 x 10^4 x 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 nitric acid solution caused the coupons to become brighter looking. The aluminum foil lost its shine and looked less structured. The coupons soaked in the ART-1 Acid Replacement Technology solution turned very black after only 10 minutes of soaking. The aluminum foil was completely dissolved into solution during the same time period. Final weights were not recorded for the Art-1 soaked aluminum foil. The table below lists the weights recorded for the acid soaked substrates and the corrosion rates.

Solution	Coupon	Initial Wt	Soak Wt	Wt Loss	Ave Wt Change	Overall Observations

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Nitric Acid	4	20.7999	20.5109	0.2890	0.2879	Brighter coupons
coupon	5	20.8477	20.5510	0.2967		
	11	20.9587	20.6806	0.2781		
Art 1	12	20.9311	18.5016	2.4295	2.4057	Pitting, black in spots
coupon	15	20.8828	18.4916	2.3912		
	16	20.8535	18.4572	2.3963		
Nitric Acid	i	0.3286	0.2737	0.0549	0.0692	no shine, thinner
foil	ii	0.3607	0.2815	0.0792		
	iii	0.3698	0.2871	0.0827		
	iv	0.3308	0.2709	0.0599		
Art 1	v	0.3830	0	0.383	0.3805	Totally dissolved
foil	vi	0.3775	0	0.3775		
	vii	0.3920	0	0.392		
	viii	0.3695	0	0.3695		

Summary

Product	Corrosion Rate (g/ m2-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

*Values are different from previously sent reports. Error in formula led to incorrect values.

Summary:

Conclusion: The nitric acid solution had a slower corrosion rate for aluminum than the Art 1 acid alternative did. The Art 1 had a higher corrosion rates than previously evaluated materials and the nitric acid had a rate that was similar to the supplied stock solution.