Steel Tank Institute®

EXECUTIVE SUMMARY CORROSION ANALYSIS OF METHANOL/FUEL BLENDS ON CARBON STEEL

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EXECUTIVE SUMMARY

CORROSION ANALYSIS OF METHANOL/FUEL BLENDS ON CARBON STEEL

Steel Tank Institute (STI) determined a need to investigate the possible corrosive effects of methanol addition to fuel on steel underground storage tanks.

Corrpro Companies was hired to do this investigation. Specifically, they were to determine the corrosive effects on steel of eight methanol/fuel mixtures. Because methanol/fuel mixtures will contain water, water was added to four of the eight solutions. Table 1, below, shows the composition of the eight test solutions. Reference Fuel C was used because commercial fuels can have many different additives which might increase or decrease possible corrosion.

Table 1

Composition of Test Solutions

Solution Number	Methanol % by Volume	Reference Fuel C % by Volume	Water % by Volume
1	0	100	0
2	15	85	0
3	50	50	0
4	85	15	0
5	85	15	0
6	50	48.3	1.7
7	15	84.6	0.4
8	84	14	2

Water was added to solutions 5–8 in quantities to create a bottom phase separation corresponding to a 1/2" level of steel exposure. Since the methanol concentration of Solution 8, 84% methanol, is too high to create a 1/2" phase separation, a 2% water concentration was used. 2% water was chosen because some authorities have suggested that this is the maximum water concentration found in 85% methanol in gasoline.

Corrpro utilized two methods of investigation. The first method to be discussed is an immersion weight loss study. The second, electrochemical methods, were evaluated to determine if they could be used in place of the more standard weight loss tests. Electrochemical methods, never before used with alcohol/fuel blends, provide a short term procedure to obtain corrosion rates of steel within various environments.

Weight Loss Study

Eight plain and eight welded panels were immersed in each of the eight test solutions. These panels were constructed of ASTM A36HRCQ steel with natural mill scale. The steel was taken directly from a tank fabricator's stock. Overall dimensions of the plain panels were 13" x 4" x 10 Ga. (0.135 inch). The welded panels were approximately 13" x 6" x 10 Ga. Ten gage steel is the minimum thickness used in the manufacture of underground storage tanks per STI standards. All panels were shear cut. The panels were immersed to the 10–1/2" level, exposing the upper 2–1/2" of steel to the vapor phase of the solutions.

On a weekly basis, the phase separations, solution levels and methanol contents were determined. Also, the solution levels were lowered to half their height and refilled to simulate the emptying and refilling of storage tanks.

Every four weeks, one plain and one welded panel were removed from each of the eight solutions. These panels were photographed, cleaned, weighed and rephotographed. Panels were evaluated for pitting, welded areas were inspected and percent weight losses were determined.

The corrosivity of the test solution was evaluated by the change in appearance of the panels after immersion, weight losses of the panels, pit evaluations of the panels and resistivities of the test solutions.

After evaluation of immersion tests, six of the eight panels exhibited no measurable corrosion that could be attributed to solution exposure. Test panels immersed in Solution 5, 96% Reference Fuel C/4% water, indicated that the bottom phase of this solution was a more corrosive environment than all other solutions. Results with this fuel indicated that slight corrosion occurred during the first four weeks of testing and decreased to an immeasurable rate after that on the bottom 1/2 inch of the panel. No measurable corrosion occurred on the upper phase of this solution.

Test panels exposed to Solution 7, 15% Methanol/84.6% Reference Fuel C /0.4% water, produced results which indicated that no measurable corrosion occurred on the upper phase. However, the metal surface exposed to the lower phase, mostly methanol and water, exhibited a loss of mill scale in areas.

This phase was not as aggressive as the water phase at the bottom of the 96% Reference Fuel C/ 4% water, discussed above.

All other solutions did not provide any evidence of corrosion.

Table 2
Corrosion Rate Determination – Electrochemical Methods

Original Composition			Surface Area	Corrosion Current in	Average Corrosion
% MeOH	% Fuel	% H_2O	Sq. Cm.	Microamp	Rate, IPY
15	85	TR*	31.2	1.2	1.8 exp–5
50	50	TR	31.2	1.5	2.2 exp–5
85	0	15	161	2.5	(1) 7.1 exp–6
85	0	15	161	2.5	(2) 7.1 exp–6
85	0	15	161	1.1	(3) 3.1 exp–6
85	0	15	161	1.2	(4) 3.4 exp–6

* Trace of Water

1) Start of Test period, polarization test, 9–18–89
2) After 1 day exposure, polarization test, 9–18–90
3) After 16 days exposure, polarization test, 10–4–89
4) After 16 days exposure, polarization test, 10–4–89

IPY Inches Per Year

Looking at line marked (3) in Table 2 (Solution 85% methanol/15% water, exposed for 16 days), it can be seen that the average rate of corrosion was calculated to be 7.1 x 10 –6 inches per year. In the worst case, assuming corrosion is not occurring evenly across the entire surface, but instead is concentrated in certain areas (pits), the average rate of corrosion would be higher 9.3 x 10 –4 inches per year. For 10 gage steel, the smallest thickness of steel used in the production of STI registered tanks, this corresponds to a service life of 150 years.

Electrochemical Corrosion Rate Study

Electrochemical test methods proved to be a quick and dependable method for determining the relative corrosiveness of liquids with adequate conductivity.

Electrochemical corrosion methods are based on the relationship between the weight of metal lost by corrosion and the amount of current exchanged during the time corrosion occurred. This relationship is expressed mathematically as:

$$W = kIt$$

where W = weight in grams
k = constant specific to each metal
I = average current flow in amperes
t = time in seconds during which the corrosion takes place

The two techniques, polarization and oxygen–reduction, evaluated in this study measure the value of current associated with the corrosion process. Neither technique is capable of indicating whether the metal loss is general or of the pitting type. A further limitation is that the electrochemical tests measure only the corrosion occurring in the liquid, not in the gas above the liquid, and only at the rate of corrosion occurring at the time of the test.

For electrochemical testing to succeed, the liquid must have some ability to conduct an electric current. Upon assessing the fuel mixtures, phases with at least 15% methanol provided adequate conductivity.

The corrosion rates determined for both techniques are listed in Table 2. In the polarization technique, a steel coupon measuring 4.5 cm x 2.6 cm x 0.4 cm, with a total surface area of 31.2 cm^2 was used. In the oxygen reduction current method, a welded steel coupon measuring 12.7 cm x 6.4 cm with epoxy coated edges was used. The immersed surface area was 161 cm^2.