COMPATIBILITY OF STEEL WITH OXYGENATED FUELS

WAYNE B. GEYER
STEEL TANK INSTITUTE

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SYNOPSIS

Several years ago, the Steel Tank Institute determined a need to investigate the possible corrosive effects of oxygenated fuel additives and water on steel underground fuel storage tanks. Welded and non-welded carbon steel panels were partially immersed in 8 different test solutions. Mixtures of 15% (M15), 50% and 85% (M85) methanol with ASTM Reference Fuel C (50% isooctane and 50% toluene) were tested using electrochemical methods. Fuel mixtures were tested both with and without water. Water was added to some of these fuel mixtures to create a phase separation within the fuel.

After evaluation of immersion tests, the panels immersed in methanol fuel mixtures exhibited no degradation of the carbon steel. Test panels immersed in a control mixture of 96% Reference Fuel C and 4% water indicated that the bottom phase of this solution was initially a more corrosive environment than all other oxygenated fuel blend solutions. Results with this fuel indicated that moderate corrosion occurred on the bottom half of the panel in contact with the water during the first four weeks of testing, but this decreased to an immeasurable rate after the first four weeks of testing. There was a loss of mill scale during the initial 4 weeks of testing with surfaces exposed to the water phase, but subsequent tests showed no drastic change in appearance and no additional panel thickness loss. No measurable corrosion occurred on the upper vapor phase of this solution.

Steel tanks have been used to store hydrocarbons and alcohols for more than 50 years. The infrastructure to produce, contain, and transport these materials typically involve some form of metallic vessel, tank or pipeline under a wide range of pressures and flow rates. Commercial grade carbon steel has been used for storage tanks to store fuels throughout the petroleum marketing distribution network.

Carbon steel has not required any specific formulation change to accommodate the storage of reformulated fuels and oxygenated fuels containing alcohols or ethers. As a matter of fact, steel is generally taken for granted as having compatibility with such fuels. However, non-metallic components of steel tanks, such as nylon bushings used in pipe openings and fiberglass reinforced plastic materials used for secondary containment and for internal lining, are typically tested by independent third party laboratories to verify compatibility with such fuels. For example, Underwriters Laboratories will test non-metallic secondary containment materials for steel tanks in six separate mixtures of ethanol or methanol with Reference Fuel C for up to 30 days at 100 degrees F. Likewise, samples are immersed in 100% concentrated methanol and ethanol. Samples are tested
for flexural and tensile strength retention, and testing will also assure that the samples have not undergone other physical property changes, such as softening or blistering. The lack of a third party testing infrastructure to test compatibility of steel with today's oxygenated motor fuels is testimony that carbon steel is an acceptable material for such storage.

Steel Tank Institute also tested oxygenated fuel blends with ethanol in the mid-eighties, prior to the study with methanol. Both studies documented the compatibility of steel with such fuels. The methanol study itself was more comprehensive than the study of ethanol, since methanol is known to be somewhat more conductive than ethanol and gasoline. One outside study has indicated that the high concentration of methanol in M85 is conductive enough to enable corrosion cell mechanisms to form within specific fueling system components when such components have dissimilar metals in contact with each other.

The testing of Reference Fuel C with water was undertaken to establish a database by which to compare results. Data collected by STI on corrosion resistant steel underground fuel storage tanks during the past quarter century has shown that internal corrosion failure is quite rare and thereby such data provides a good comparative baseline to use. The experiences of the marketing petroleum industry in converting from standard fuels to oxygenated fuels with steel suggest that this trend will continue.

A corrosion rate for the most corrosive methanol fuel blend mixtures was also determined in STI's study using electrochemical methods. Electrochemical tests provide 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. Two techniques evaluated in this study, polarization and oxygen-reduction methods, measure the value of electrical current associated with the corrosion process within the liquid. Upon assessing the fuel mixtures, phases with at least 15% methanol provided adequate conductivity for meaningful results to be obtained from such electrochemical tests.

Assuming the worst case scenario and that corrosion would take place in concentrated areas, i.e., pitting, a fuel blend of 85% methanol and 15% water, produced the worst case test result. The corrosion rate corresponded to a 150-year life upon a 10 gage steel tank. Ten gage steel has a wall thickness of 0.134" and represents the smallest thickness of steel used in the production of STI registered underground storage tanks.

Compatibility tests usually will test some of the physical properties of the material prior to and after exposure of the liquid to ascertain any chemical/molecular composition change of the material. Not surprisingly, the study showed no evidence of any sort of chemical composition change within the steel material. For this reason, the physical properties of steel were not tested.