

Battelle Institute Study

Corrosion in Systems Storing and Dispensing Ultra Low Sulfur Diesel (ULSD), Hypotheses Investigation, Final Report Executive Summary

Severe and rapid corrosion has been observed in systems storing and dispensing ultra-low sulfur diesel (ULSD) since 2007. In addition, the corrosion is coating the majority of metallic equipment in both the wetted and un-wetted portions of ULSD underground storage tanks (USTs). To investigate the problem in an objective manner, multiple stakeholders in the diesel industry, through the Clean Diesel Fuel Alliance, funded this research project. The design included the identification of retail fueling sites and the development of an inspection and sampling protocol to ensure uniform and thorough inspections of USTs. Fuel, water bottoms, vapor, bottom sediments, and scrape samples were taken from six sites: one that was not supposed to have symptoms (but did to a much lesser degree) and five that were to have the severe corrosion. Then, samples from the inspections were analyzed for genetic material and chemical characteristics. These data, in combination with information on additives, have allowed Battelle to draw conclusions with respect to three working hypotheses. Specifically, the hypotheses are:

- 1) Aerobic and anaerobic microbes are producing by-products that are establishing a corrosive environment in ULSD systems;
- 2) Aggressive chemical specie(s) (e.g., acetic acid) present in ULSD systems is (are) facilitating aggressive corrosion; and
- 3) Additives in the fuel are contributing to the corrosive environment in ULSD systems.

All of the sites inspected contained microbes, although at different abundances. The dominant organism identified from three of the sites, **Acetobacter**, has characteristics pertinent to the corrosion observed in all of the sites, such as acetic acid production, ethanol utilization, low pH requirements, and oxygen. Although geographically on opposite sides of the country, from different fuel suppliers, and of relatively new construction materials, the presence of the organisms was relatively uniform. The traditionally expected hydrocarbon degrading organisms were found in insignificant abundances. This indicates that the inspected ULSD USTs are selective environments for these specialized, acetic acid producing organisms. Of note from the chemical analyses is that acetic acid was found to be ubiquitous (water bottoms, fuel, vapor, and scrapings) in all of the sites inspected. In addition, ethanol was unexpectedly identified and measured at five of the six sites. Components necessary for the organisms identified to proliferate were analytically determined to be present in the majority of the samples: trace amounts of ethanol, low pH, oxygen, and water were present in the diesel USTs inspected. Finally, although additives could play a role in the corrosive environment, it is unlikely that they are the primary cause of the observed corrosion.

The project final hypothesis for this investigation is that corrosion in systems storing and dispensing ULSD is likely due to the dispersal of acetic acid throughout USTs. It is likely produced by Acetobacter bacteria feeding on low levels of ethanol contamination. Dispersed into the humid vapor space by the higher vapor pressure (0.5 psi compared to 0.1 psi for ULSD) and by disturbances during fuel deliveries, acetic acid is deposited throughout the system. This results in a cycle of wetting and drying of the equipment concentrating the acetic acid on the metallic equipment and corroding it quite severely and rapidly. (September 2012)