

## KEYWORDS

Corrosion Testing

Fuel Analysis

Exposure Testing of Fuels

Failure Analysis

Slow Strain Rate Testing of Ethanol

Biodiesel

Ultra-low Sulfur Diesel

Stress Corrosion Cracking

Metallurgical and Chemical Testing

Characterization of Fuels

Widespread use of biodiesels and ultra-low sulfur diesel (ULSD) fuels has raised corrosion concerns in the engine manufacturing, fuel storage and regulatory communities. Biofuels derived from vegetable oils or animal fat age rapidly during storage, leading to the formation of aggressive species that react with storage tanks or engine parts, causing corrosion. With ethanol blends, water separation (for E5-E20) and stress corrosion cracking (E85) are the main concerns. ULSD is thought to be more corrosive than diesel fuels containing higher amounts of sulfur. Microbiologically induced corrosion (MIC) is also a potential problem in all fuel systems, since they provide a readily available food source to microorganisms, including bacteria and fungi.

Southwest Research Institute® (SwRI®) has been assisting government and industry in investigating corrosion and finding mitigation techniques for corrosion problems in fuel systems. The Environmental Performance of Materials Section has been a member of an API JIP program to investigate compositional effects that lead to stress corrosion cracking (SCC) in ethanol. The group participated in the development of a NACE Standard test to measure SCC that is currently under review (Slow Strain Rate Test Method for Evaluation of Ethanol Stress Corrosion Cracking in Carbon Steel).



Low magnification microscope image of the inside surface of test specimen (4) showing corroded areas.

## Fuel Analysis

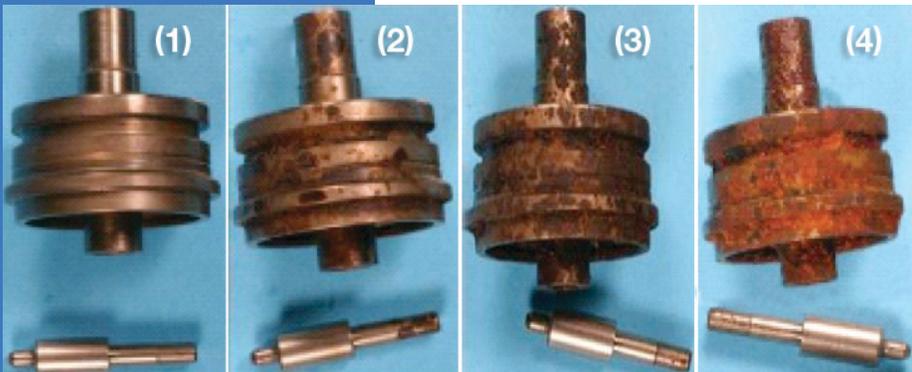
The Fuels and Lubricants Division is equipped to fully characterize fuels in its analytical laboratory, including the following measurements:

- Sulfur content
- Aromatics
- Distillation
- Acid number
- Density
- Conductivity
- DSEP (water separation characteristics)
- Karl-Fisher water content
- Rancimat storage stability
- Ethanol content
- Silver strip corrosion
- Interfacial tension

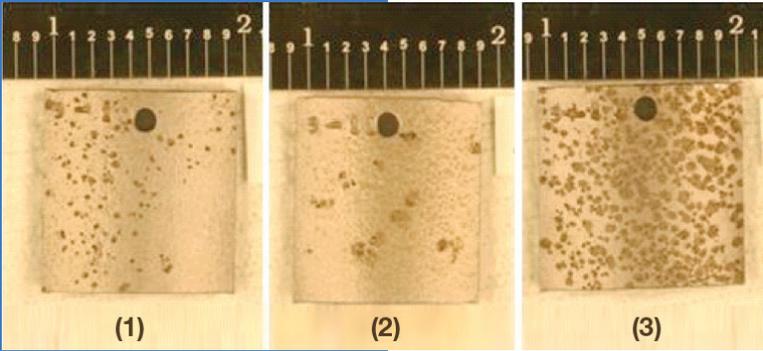
## Exposure Tests and Corrosion Measurements

The Environmental Performance of Materials Laboratory performs exposure tests customized to each client's needs and environments. Temperature cycles are often used in these tests to mimic engine operating conditions.

Mass loss measurements and visual observations and rating according to ASTM D1654 are usually performed following the exposures. Depending on the water content of the mixture, electrochemical impedance of direct corrosion rate and electrochemical potential can be measured. Accelerated exposure tests according to NACE TM0172-2001 can also be performed.

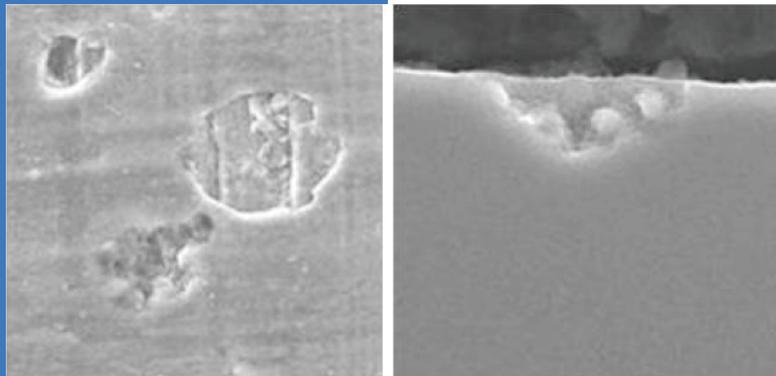


Test specimens exposed to ULSD fuels with different water contents. (1) No water; (2) 7,500 ppm distilled water; (3) 7,500 ppm tap water; (4) ULSD without additives + 105 ppm tap water.



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Test coupons after conclusion of NACE TM0172-2001 test. The fuel samples came from the (1) top, (2) middle and (3) bottom portions of an underground storage tank.



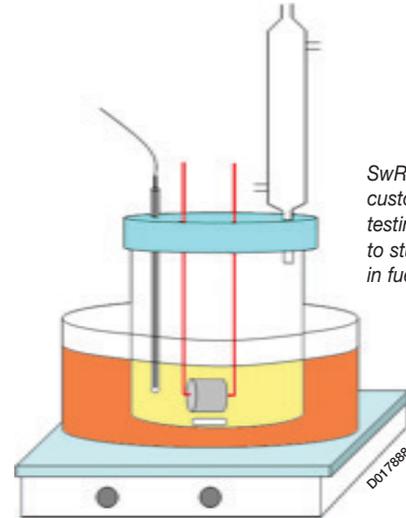
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Scanning electron microscopy to identify the type and extent of corrosion damage.

## Failure Analysis

Failure analysis of corroded parts is performed in SwRI's Metallurgy and Chemistry Laboratories. Metallurgical and chemical tests include:

- Scanning electron microscopy
- Digital 3D microscopy
- Auger electron spectroscopy
- X-ray diffraction
- Infrared spectroscopy
- Atomic absorption spectroscopy
- Ion chromatography



SwRI-designed custom exposure testing apparatus to study corrosion in fuel systems.

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