

L.U.S.T.LINE

A Report On Federal & State Programs To Control Leaking Underground Storage Tanks



USTs—A View from Europe

by Jamie Thompson

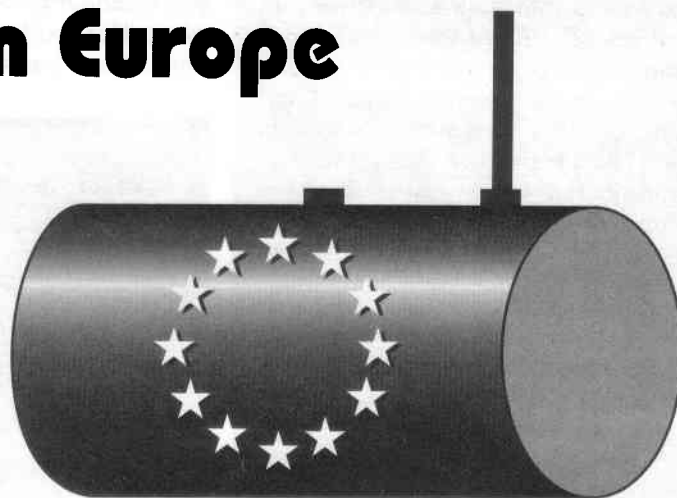
For some 60 years, fuel storage systems remained virtually unchanged. During those years, the oil industry made vast progress aboveground in modernizing their retail gasoline sites. But below ground, where the fuel storage system is buried, it was quite another story. In Europe, we estimate that a mere 5 to 7 percent of the total development cost of a gasoline station was spent on underground tanks and pipes—"out of sight, out of mind." More recently, however, spurred on by regulators and public opinion, the oil industry has recognised the need to safeguard the environment.

In the 1980s it appeared that the UST situation in the U.S. was far worse than in Europe—U.S. standards of construction and installation were such that leaks were relatively common. Federal UST legislation and the resulting regulations enabled manufacturers to provide some unique solutions to the industry, some of which we were also able to consider in Europe. We found ourselves "cherry picking" the best solutions from the U.S., using them along with some of the tried and tested systems developed in Europe.

The European Union

In the late 1980s, many of us in the U.K. were taking our first tentative steps into Europe. Although we had some knowledge of what was going on in the U.S., we knew far less of what was happening right on our doorstep. The fact that each country in Europe had completely different standards of installation came as a surprise to some of us. Others in the industry who'd been trying to build the same filling station design across national boundaries had suffered with this issue for many years.

Perhaps the most important unifying catalyst in the early 1990s was the issuing of a number of Directives (the same as federal law in the U.S.) from the European Union (EU). In addition, there was the formation of Central European Norm (CEN), the largest regional standards body in the world, which was given the task of developing standards for the effective international operation of



the industrial and service sectors, breaking down trade barriers, and stimulating competitiveness in the largest emerging trading block in the world—Europe.

In addition to this harmonization of standards, the industry itself was also changing. Oil companies were becoming more European (rather than national) in their outlook. Many began forming European operations in which common standards of construction, purchasing, and operations were to help in the harmonization process.

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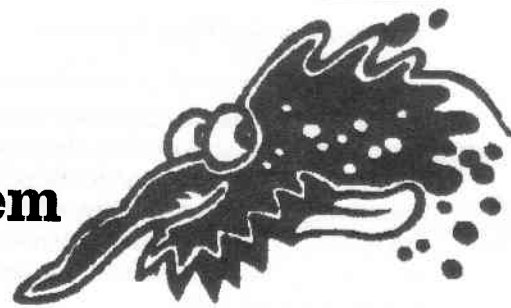
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Leak Prevention

Microbes and Fuel Systems

The Overlooked Corrosion Problem

by Fred Passman



Microbes play an indispensable role in cycling both organic and mineral molecules essential to maintaining life on earth. We depend on the activities of microbes to breakdown wastes and convert them into nutrients to sustain the food chain. We use microbes to produce foods ranging from bread to sausage. Microbes within our intestinal tracts enable us to derive nutrition from the foods we eat. Suffice it to say we derive tremendous benefit from the various processes by which organisms break down both organic and inorganic materials.

When discussing material breakdown in positive terms, we use the terms of either *biodegradation* or *bioremediation*. Biodegradation includes all processes by which organisms break down materials. Bioremediation specifically refers to processes with which microbes or other organisms are used to fix a problem. With respect to leaking underground storage tanks (LUSTs), bioremediation uses microbes to degrade fuel that has seeped into the ground.

It's a short leap of understanding, then, to recognize that the same processes that serve our needs may also cause problems. The same biological processes that enable us to clean up spilled fuel using bioremediation can also degrade fuel stored in tanks. This undesired biodegradation is called *biodeterioration*.

During the past decade, government and industry have directed considerable effort and resources toward reducing the risk of soil and groundwater contamination from LUSTs. Although leak prevention technologies don't overtly presume that tanks fail from either inside or outside, most of the preventive measures address mitigation of the risk of failure due to corrosion or other insults working from a tank's outside towards its interior. In particular, leaks caused by galvanic corrosion have received considerable attention.

But there is another underappreciated corrosion process that I'd like to discuss. It takes place in all types of UST systems, and microbes play a key role. It's called *microbially influenced corrosion* (MIC).

Fuel and Corrosion Microbiology

The first report of gasoline biodeterioration was published in 1895 [1]. Subsequently, researchers demonstrated that microbes could degrade crude oil and all grades of liquid fuel. (See Davis's excellent 1967 monograph [2] and the 1984 compilation of papers edited by Atlas [3].) Fuel biodeterioration can be grouped into four general groups of processes:

- Microbes can attack the hydrocarbon and non-hydrocarbon fuel molecules directly, thereby changing the fuel's chemical and performance properties.
- Microbes growing in bottomwaters or within biofilms (more on that in a bit) produce biosurfactants—detergent molecules—which can transport water-soluble molecules into fuel and disperse fuel molecules into water.
- Low molecular weight molecules excreted as microbial wastes may react with fuel molecules and accelerate particle formation. Some of these waste molecules are acidic and can make the fuel more corrosive.
- Microbial metabolism of sulfur molecules can make fuels more *sour* (fuel souring is directly related to the effect of reactive sulfur on its corrosivity as measured by the Doctor Test [4]).

Clearly, several of these processes change the chemistry of fuels to make the fuels potentially corrosive to materials used in UST construction. These are examples of indirect MIC.

Much of the seminal research on MIC was conducted in the 1940s. In 1945, Professor John Starkey proposed a model for MIC [5]. Starkey's model assumed that during MIC, iron ions dissolved from the metal at anodic sites on its surface. Electrons flowing from the anodic site to the cathodic site would attract hydrogen ions (protons), which would accumulate at the cathode. Were this hydrogen layer left undisturbed, electron flow would be arrested and the galvanic cell *passivated*.

According to Starkey, sulfate-reducing bacteria (SRB) used the hydrogen ions that would otherwise have accumulated at the cathodic end of a galvanic cell. This process, known as *depassivation*, accelerated the galvanic corrosion rate. As with most models, Starkey's was an oversimplification of the process; however, it was a major contribution to our understanding of MIC.

Research on the causes and dynamics of MIC remains a vital branch of microbial ecology. Today, we recognize a variety of processes that contribute to MIC. A number of microbes, in addition to SRB, depassivate metal surfaces. All of these microbes share a common class of enzymes called *hydrogenases*. The very process of colonizing surfaces creates chemical and electropotential gradients that drive corrosion. Moreover, weak organic acids can react with dissolved chloride salts to create locally high concentrations of hydrochloric acid that can acid-etch metal surfaces [6, 7]. Microbes most commonly create patterns of corrosion pits, as illustrated in Figure 1.

Microbial communities can attack polymers used in composites such as fiberglass-reinforced plastic (FRP) used for UST construction. As the polymers are attacked, gaps form between resin and fiber. Fluid seeps into these gaps and subsequent weakening of fiber integrity follows

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