

## NEW DEVELOPMENTS IN EXTERNAL COATING TECHNOLOGIES FOR UNDERGROUND AND ABOVEGROUND FUEL STORAGE TANKS

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**Abstract:** New developments in coating technologies for the external protection of underground and aboveground fuel storage tanks are discussed. These include a new 100% solids aromatic polyurethane system under UL 1746 Part IV for underground fuel storage tanks and three new high solids or 100% solids aliphatic polyurethane systems for aboveground fuel storage tanks. Performance testing results and case histories are given.

new category - Part IV of the UL1746 Standard - to approve their use. To date, over 3,000 underground fuel storage tanks have used the new coatings technology.

New developments have also been made in the external coatings technologies for aboveground storage tanks. There are three new direct-to-steel aliphatic polyurethane coatings available to and being used by the industry: a single component, 60% solids, partially moisture-cured aliphatic polyurethane, a 1:4 plural component, 70 % solids, fast chemically-cure aliphatic polyurethane, and a 1:1 plural component, 100% solids, rigid, instant setting aliphatic polyurethane. To date, new polyurethane coatings have become the dominant coating technology for the external application of underground and aboveground fuel storage tanks in North America.

### INTRODUCTION

Since the early 1900s, steel has been and still is the dominant material of construction for underground and aboveground fuel storage tanks because of its strength. Unfortunately, steel is susceptible to corrosion, so protective coatings and/or other protective measures must be applied to a steel tank before it is installed.

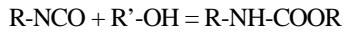
Older and some existing protective coatings for underground and aboveground steel tanks have a few drawbacks. Some of the coating/cladding systems are environmentally unfriendly, hazardous to the applicator and the environment, and contain carcinogens. In addition, due to the VOC's being released into the atmosphere and community objections, some manufacturing locations are having their production curtailed. The flammability of some existing systems has resulted in fires that have destroyed several manufacturing facilities as well. Safer and less polluting (low VOC's) coating systems with better performance and faster application characteristics are thus required by the industry.

The Standard for External Corrosion Protection Systems for Flammable and Combustible Liquid Underground Storage Tanks is known as UL1746 under the catalog of Underwriters Laboratories. Recent developments in polyurethane technology have resulted in new 100% solids, instant setting, two component, rigid aromatic polyurethane coatings, in respect of which UL has created a

This article begins with a discussion of the basic aromatic and aliphatic polyurethane chemistry. It then reviews the evolution of various coating technologies used in the underground and aboveground fuel storage tank industry and discusses the safety, application and performance characteristics of the new high solids and/or 100% solids polyurethane coatings. Case histories of the polyurethane coatings are given.

### AROMATIC AND ALIPHATIC POLYURETHANE CHEMISTRY

Very high solids (both aromatic and aliphatic) polyurethanes are usually in a two-component format. One component is a polyisocyanate rich liquid, and the other is hydroxyl functional coreactants. To form an aliphatic polyurethane, aliphatic isocyanates such as HDI and IPDI as well as acrylic or polyester polyols may be used. To form an aromatic polyurethane, aromatic isocyanates such as TDI and MDI as well as polyether polyols may be used. A coating film is formed when the two components are combined: a rapid and exothermic chemical polymerization takes place:



Isocyanate + Polyol = Urethane linkage

The exothermic nature of the above reaction provides the polyurethane systems (especially aromatic polyurethanes) with a low temperature curing ability. This is a significant advantage over many of the other reactive resin systems used in the coatings industry, such as epoxies. The reaction speed of a polyurethane depends on many factors including the type of the isocyanate resin used. Aliphatic isocyanates are considerably less reactive than aromatic isocyanates.

Aliphatic polyurethane chemistry presents the industry with a durable, ambient curing, thermosetting protective coating combining long-term gloss with UV and color stability. Many aliphatic polyurethane coatings are, however, relatively more expensive because of the higher cost of raw materials. In addition, high viscosity of aliphatic polyurethane components brings a great challenge to coatings chemists to develop very high solids or 100% solids aliphatic polyurethane coatings.

In contrast, although not being color stable, 100% solids aromatic polyurethane coatings have been developed and commercially used for about twenty five years in many industries, such as storage tanks, municipal and oil and gas pipelines, transportation and marine facilities. They provide excellent corrosion protection for the structures in these industries.

The evolution of various coating technologies used in the underground and above fuel storage tank industry offers a perfect example of how the advances in the polyurethane coating chemistry can help and change an industry's performance in corrosion protection.

## REVIEW OF UNDERGROUND FUEL STORAGE TANK COATINGS HISTORY

The North American steel tank industry is governed by two standards organizations, Underwriters Laboratories (UL in the US or ULC in Canada) and the Steel Tank Institute (STI). There are two areas that each standard of UL and STI addresses. The first is the steel tank construction and the second area is steel tank anti-corrosion protection. The Underwriters Laboratories standards apply to all tank manufacturers regardless of whether they are members of the Steel Tank Institute or not. However, it should be noted that Steel Tank Institute (STI) standards meet the Underwriters Laboratories (UL) standards as a minimum and may be more stringent in some areas.

Over the past 50 years, underground steel storage tanks have progressed from unprotected steel to the most modern coating systems that provide superior anti-corrosion protection while being environmentally friendly. Various corrosion protective coatings have been used, which include: bitumen, tape coatings, coal tar epoxy, and other coatings covered by the Underwriters Laboratories UL 1746 Standard.

Bitumen was the first anti-corrosion coating used in the external protection of underground storage tanks. Its main use today, however, is for waterproofing in the construction industry for below grade structures. It is easy to apply and relatively inexpensive, but is environmentally unfriendly and can be removed and damaged by casual contact.

Tape coatings were then used to reduce underground steel tanks' exposure to corrosion from the surrounding soil. Tape coatings did offer some extent of corrosion protection, they were however difficult to apply properly, labor intensive, easily damaged and did not offer long term protection. Tape coatings have disappeared from the underground steel tank industry because of their inherent disadvantages.

Coal tar epoxy was then introduced as an external coating for underground steel tanks. The coating itself provided superior anti-corrosion protection compared to tape coatings. Other advantages include more efficient and less expensive application, speed of application and long term protection. One of coal tar epoxy's greatest disadvantages is, however, its slow curing time particularly during cold ambient temperatures, creating bottlenecks and delays in production.

The introduction of coal tar epoxy brought up the issue of resistance to cathodic disbondment. The epoxy coatings were required to have the backup of a cathodic protection system in the form of sacrificial anodes. If there is a pinhole with the coating or a surface point of the coating is broken due to corrosion or damage, it is important to know the resistance of the coating to disbondment or undercutting due to the cathodic current. Poor cathodic disbondment resistance would result in serious undercutting of the protective coal tar epoxy coating, the potential for large areas of coating to fall off and exposure of these areas to corrosion. Unfortunately the cathodic disbondment resistance of coal tar epoxy was not very good.

Amongst the other disadvantages of the coal tar epoxy are its environmental and safety issues (e.g., coal tar is a known carcinogen), its lack of long term protection (e.g. brittleness of the coating) and its relatively high VOC content. The coating process itself was more complex than

tape coatings. It used more sophisticated equipment than tape coating and better operator training was required.

100% solids aromatic polyurethane coatings were first developed specifically for the underground storage tanks in the early 1970s. In 1975, ULC (Underwriters Laboratories of Canada) issued the first listing for cathodically protected steel tanks with a polyurethane coating. In 1981, the aromatic polyurethane coating technology was approved for use in the StIP<sub>3</sub><sup>®</sup> tank by the Steel Tank Institute (STI), and American tank fabricators began to enjoy the same 100% solids aromatic polyurethane technology as their Canadian cousins.

The use of a 10 to 15 mil coating of either coal tar epoxy or 100% solids aromatic polyurethane, together with isolating bushings and a sacrificial anode (such as the StIP<sub>3</sub><sup>®</sup> tank) is covered by Part I of the UL 1746 Standard - "External Corrosion Protection Systems for Steel Underground Storage Tanks". The requirements under UL 1746 cover factory-applied corrosion protection systems over carbon steel tanks whose construction complies with the UL Standard for Steel Underground Tanks for Flammable and Combustible Liquids, UL 58.

The UL1746 Part I tanks or the StIP<sub>3</sub><sup>®</sup> tanks have the longest history and an excellent record of good performance. This corrosion protection system is generally considered to be the least expensive to fabricate. However, this type of underground tank system is required as per EPA regulations, to be continuously monitored for 6 months after installation and then have a periodic inspection every three years in most jurisdictions.

Since the late 1980s, 100% solids aromatic polyurethane technology has almost completely replaced coal tar epoxy and other coatings technologies in manufacturing UL 1746 Part I tanks or StIP<sub>3</sub><sup>®</sup> tanks.

Composite tank technology, initially developed in the 1960's and standardized in the late 1980s, employs a 100 mil thick fiberglass-reinforced plastic (FRP) laminate that is bonded to the exterior surface of a steel tank. Known in some circles as "clad" tank technology, composite tanks most often are built to the STI "ACT-100<sup>®</sup>" Standard "Specification for External Corrosion Protection of FRP Composite Steel Tanks (F894-91)" or to UL 1746 Part II. Composite tanks are tested at the factory prior to shipping for "holidays" using a high voltage of 35,000 volts. Composite tanks are made in both single and dual-wall configurations. Typically, a UL 1746 Part II or STI ACT-100<sup>®</sup> tank is 30 to 40% more expensive than a Part I or StIP<sub>3</sub><sup>®</sup> tank, but no on-going monitoring is required.

A secondary containment design was developed in the late 1980s and finalized in the early 1990s as an

alternative to the traditional dual wall sti-P<sub>3</sub><sup>®</sup> and composite tanks discussed above. The technology offers secondary containment through incorporation of a primary tank built of steel and an outer wall fabricated of other materials. One such design is the STI Permatank<sup>®</sup> with an outer wall of 100 mil thick FRP, built to Steel Tank Institute "Specification for Permatank<sup>®</sup> (F922-92)" and UL 1746 Part III. Several similar designs are being marketed by steel tank fabricators, such as one utilizing a 100-mil thick high-density polyethylene (HDPE) material. The FRP or HDPE materials are sometimes called jackets, and therefore these types of tanks mentioned above are also referred to as "jacketed" tanks. The tank and jacket are separated by an interstitial space with the jacket as a secondary containment. A permanent monitoring sensor in the interstitial space connects to an alerting device in the service station or control room. The cost of a jacketed or UL 1746 Part III tank is the highest amongst all types of underground storage tanks.

In 1996, a fourth category (Part IV) of the UL 1746 Standard was added, based on a new 100% solids aromatic polyurethane technology. Similar to the systems listed under UL 1746 Part II, the new system listed under Part IV is a 70-mil thick aromatic polyurethane coating/cladding direct-to-steel substrate and requires no anode. No monitoring is required. The performance test requirements for Part IV include all those for Part II plus additional test requirements, but the 70 mil-thick polyurethane performs equally or exceeds the 100-mil FRP in many of those tests. The new 100% solids aromatic polyurethane technology is marketed by STI tank fabricators under the ACT-100-U<sup>®</sup> and various other trademarks with a 30-year warranty.

Since 1997, the new 100% solids polyurethane technology has been also approved by both UL and STI as an alternative to the traditional FRP laminate material for UL 1746 Part II or STI ACT-100<sup>®</sup> tanks. To make these tanks, however, only less than 2% of fiberglass is allowed to be added into the polyurethane coating. This is to avoid any potential change of physical property to the polyurethane should too many glass-fibers be used. The new polyurethane technology has obtained both UL and STI approvals as a coating for STI-P<sub>3</sub><sup>®</sup> tanks as well.

Table 1 summaries all the external corrosion systems used by the underground storage tank industry.

#### 100% SOLIDS POLYURETHANE COATINGS FOR UNDERGROUND STORAGE TANKS

The steel storage tank industry has chosen the new 100% solids aromatic polyurethanes as the dominant coating

technology for underground fuel storage tanks for many reasons:

**Table 1 Summary of External Corrosion Protection Systems for Steel Underground Storage Tanks**

| UL Designation   | UL 1746 Part I  | UL 1746 Part II   | UL 1746 Part III  | UL 1746 Part IV             |
|--|---|---|---|-----------------------------|
| STI Designation  | STI-P <sub>3</sub> <sup>®</sup>   | ACT-100 <sup>®</sup>  | Permatank <sup>®</sup>  | ACT-100-U <sup>®</sup>      |
| Approved systems by UL and STI                             | 10- to 15- mil polyurethane or coal tar epoxy coating with sacrificial anode  | 100-mil fiberglass reinforced polyester (FRP) / 100-mil polyurethane coating plus less than 2% fiberglass | Sensor between the steel tank and a jacket of 100-mil FRP or high density polyethylene (HDPE) | 70-mil polyurethane coating |
| The protective system being currently used or will be used | 10- to 15- mil polyurethane   | 100-mil polyurethane coating plus less than 2% fiberglass   | Sensor between the steel tank and a jacket of 100-mil FRP or high density polyethylene (HDPE) | 70-mil polyurethane coating |
| Monitoring requirement                                     | Initial continuous monitoring for 6 months after installation and then a periodic physical inspection every three years | Not required  | Permanent monitoring in place   | Not required                |
| Relative total cost (4 = most expensive)                   | 1   | 3   | 4   | 2                           |

1). The new 100% solids aromatic polyurethanes are safer and more environmentally friendly than traditional anti-corrosion coatings. The 100% solids polyurethanes contain no solvent, styrene, amine, tar or other carcinogens. The over-spray is non-hazardous waste when cured. The polyurethanes are not affected by EPA, OSHA, and DOT scrutiny over the health and safety hazards associated with other polymer systems.

2). Because of the rapid curing speed of the 100% solids aromatic polyurethane coatings, the tanks can be quickly and easily coated. The cold temperature curing ability of the 100% solids aromatic polyurethane makes it possible to apply it at ambient temperatures as low as -40°C (-40°F), which is impossible for other types of coatings. Therefore, production throughput and labor cost are largely improved. For example, a 25,000-gallon FRP coated ACT-100<sup>®</sup> tank may take over 4 hours to finish, whereas the 100% solids polyurethane coating can go on in under 1.5 hours. As a result, even though polyurethane resins are more expensive than other coating resins, the total cost of the polyurethane cladding is lower due to the savings on labor cost.

The rapid curing speed of the 100% solids aromatic polyurethanes also enables their self-inspecting capability. If the coating is not applied correctly or the surface is not

properly prepared, the 100% solids polyurethane will signal the problem within a few hours to several days after application before the tank is buried.

3). Differing from other available polyurethane elastomeric polyurethanes, the new 100% solids aromatic polyurethane technology is a highly cross-linked and rigid system. The high cross-link density of the cured polyurethane resin is such that it forms its own reinforcement. This makes it even tougher than resin systems that rely on an external reinforcement, such as fiberglass reinforced polyester (FRP). This phenomenon is described by the industry as “self-reinforcing”.

The exceptional strength of the new 100% solids polyurethanes enables them to meet and exceed the UL 1746 Part II and Part IV standards at a thickness of only 70 mils, compared to FRP at 100 mils. A comparison of the typical testing results of the new 100% solids polyurethane coatings versus those required by the UL 1746 Part II for FRP technology is given in Table 2. Of particular interest is the amount by which the new 100% solids polyurethane coatings exceeds the minimum values of the standards, the high performance of the coating systems and the fact that all this is accomplished at a thickness of 70 mils versus a 100 mils thickness.

**Table 2 UL Test results of the 100% solids aromatic polyurethanes vs. UL 1746, Part II standard for FRP**

| PROPERTY   | TEST  | UL1746 PART II STANDARD FOR FRP   | 70-MIL 100% SOLIDS POLYURETHANES   |
|--|---|---|--|
| Initial physical strength  | UL 1746.14.2/14.3                           | <3000 PSI   | 3307 PSI   |
| Heat Aging at 70°C (158°F), 180 days   | UL 1746.14.2/14.3                           | 80% strength retention  | 100% strength retention  |
| Resistance to environmental Fluids 180 days  | UL 1746.14.4 (Sulfuric Acid, pH-3)          | 50% strength retention  | 100% strength retention  |
| Resistance to environmental Fluids 180 days  | UL 1746.14.4 (Saturated NaCl)               | 50% strength retention  | 100% strength retention  |
| Resistance to environmental Fluids 180 days  | UL 1746.14.4 (Distilled Water)              | 30% strength retention  | 100% strength retention  |
| Resistance to environmental Fluids 180 days  | UL 1746.14.4 (1% HCl)                       | 30% strength retention  | 94% strength retention   |
| Resistance to environmental Fluids 180 days  | UL 1746.14.4 (Nitric Acid)                  | 30% strength retention  | 99% strength retention   |
| Resistance to environmental Fluids 180 days  | UL 1746.14.4 (Sodium Carbonate-Bicarbonate) | 30% strength retention  | 100% strength retention  |
| Resistance to environmental Fluids 180 days  | UL 1746.14.4 (NaOH, pH-12)                  | 30% strength retention  | 99% strength retention   |
| Light & water exposure (360 hours)   | UL 1746.14.5                                | 80% strength retention  | 94% strength retention   |
| Impact & cold exposure at -2°C (-20°F) for 16 hours                                  | UL 1746.14.6                                | Passes @ 100 mils   | Passes @ 70 mils   |
| Corrosion evaluation for 180 or 270 days at 38°C (100°F)                             | UL 1746.15.2                                | No corrosion-however poor adhesion  | No corrosion-excellent adhesion  |
| Permeation-cladding dissolution 38°C (100°F)   | UL 1746.15.3                                | Passes with weight loss > 1%  | Passes -with weight loss of <0.39%   |
| Pipe fitting test  | UL 1746.16.2/16.3                           | Passes @ 100 mils   | Passes @ 70 mils   |
| Lifting fitting strength test  | UL 1746.16.4                                | Passes @ 100 mils   | Passes @ 70 mils   |
| Tank impact test (a 12 pound or 5.4 kg steel ball at impact heights of 10-72 inches) | UL 1746.16.5                                | Holidays may be identified visually for impact heights as low as 40 inches @ 100 mils | No holidays detected visually or with 35kV tester at height of 70 inches @ 70 mils |
| Leakage test at 5 psig (35 kPa)  | UL 1746.16.6                                | Passes @ 100 mils   | Passes @ 70 mils   |
| Holiday test at 35 kV  | UL 1746.16.7                                | Passes @ 100 mils @ 35kV  | Passes @ 70 mils @ 35kV  |

The new 100% solids aromatic polyurethane also showed superiority in other tests. It achieved three times the adhesion of FRP to steel substrate and, unlike FRP, did not take on water or lose its adhesion over time. Abrasion and impact resistances were also superior with the new polyurethanes.

In addition to the above performance advantages over FRP, the new 100% solids aromatic polyurethanes also make the tank more resistant to damage during handling, transportation and installation.

By January of 1998 the Steel Tank Institute reported that over 250,000 STI-P<sub>3</sub> underground steel fuel

storage tanks had been registered and installed in the U.S. In addition, the Steel Tank Association of Canada estimated that 100,000 steel tanks had been installed in Canada. In total, these tanks involved approximately 200 million square feet of steel, and over 80% of that area was coated with 100% solids aromatic polyurethane coatings (Figure 1).

The Steel Tank Insurance company, which warrants many of the STI-P<sub>3</sub> underground steel fuel storage tanks for 30 years, has reported that no polyurethane coated tanks has ever failed due to external corrosion.

Since 1997, about 3,000 STI ACT-100-U<sup>®</sup> or UL 1746 Part IV underground fuel storage tanks have been



Figure 1 The STI-P<sub>3</sub> underground steel fuel storage tanks



Figure 2 Installation of the STI ACT-100-U<sup>®</sup> Tanks

installed, protected with the newest 100% solids aromatic polyurethane coatings. More of the polyurethane-coated tanks are currently manufactured, replacing tanks made of FRP or FRP coated steel tanks from the market (Figure 2).

#### HIGH SOLIDS OR 100% SOLIDS POLYURETHANE FOR ABOVEGROUND FUEL STORAGE TANKS

Aboveground fuel storage tanks require their external coating to have the excellent weather resistance, and UV and color stability. Over the past several decades, the industry has used various external coating systems for aboveground fuel storage tanks, which are typically two to three coat enamels, epoxy, and aliphatic polyurethane. In the past 8 years, one of the most commonly used technologies is a three-coat system consisting of an epoxy primer coat, an intermediate coat, plus an aliphatic polyurethane top coat.

Since 1995, most aboveground fuel storage tank manufacturers have gradually switched to the use of some direct-to-steel aliphatic polyurethane systems, because of

the breakthroughs made in high solids and 100% solids aliphatic polyurethane coating chemistry.

There are three different formats of the self-priming, direct-to-steel aliphatic polyurethane coatings available to and used by the aboveground fuel storage tank industry. One is a single component, 60% solids, partially moisture-cured aliphatic polyurethane, one is a 1:4 plural component, 70 % solids, fast chemically-cure aliphatic polyurethane, and one is a 1:1 plural component, 100% solids, rigid, instant setting aliphatic polyurethane. All are VOC compliant.

The single component aliphatic polyurethane system is technologically the most advanced but the easiest to use. It is blend of resins, pigment, solvent and inhibitors. The curing process is partially due to the reaction between the aliphatic resins and the moisture in the air. When this paint-like product is applied, the inhibitors evaporate and the product cures to form the kind of tough film normally expected from plural component aliphatic polyurethane technology – truly, “Saran in a can”. Just open, stir and apply in two coats of 3-5 wet mils.

The mix-and-apply system is faster setting than the single component system but still paint-like to apply. Like the single component aliphatic polyurethane, the mix-and-apply polyurethane is applied with a single component spray gun. Because it involves premixing two ingredients prior to application, the per-coat film build is higher. The pot life of the polyurethane is about two hours, and the coating has an initial cure time of approximately 1 hour.

The 1:1 plural component aliphatic polyurethane coating system is the industry’s newest innovation of 100% solids polyurethane technology. Having zero VOC’s, a ten minute setting time, cold temperature capability, high build ability and the same toughness and adhesion as aromatic polyurethanes, this rigid aliphatic polyurethane is the only product of its type on the market. It is the excellent answer for high-speed production situations required by industries such as the aboveground fuel storage tank industry.

Table 3 outlines the physical properties of the three new high solids or 100% solids aliphatic polyurethane systems.

A nationally recognized steel tank manufacturer had been using a commercial high-solids coating to coat the exterior of their aboveground fuel storage tanks. This gave a satisfactory finish when cured but, in production, needed too long between coats and drying time was also too long, especially at cold winter temperatures. This slowed production considerably. With the new 100% solids aliphatic polyurethane technology, however, a number of

**Table 3 Performance properties of the three new high solids or 100% solids aliphatic polyurethane coatings for aboveground fuel storage tanks.**

| Properties  | Single component aliphatic polyurethane   | Mix-and-apply aliphatic polyurethane  | 1:1 plural component aliphatic polyurethane  |
|---|---|---|--|
| Application temperature                                     | 0°C to 50°C (32°F to 120°F)   | 0°C to 50°C (32°F to 120°F)   | -10°C to 65°C (10°F to 150°F)  |
| Initial setting time @ 20°C /70°F                           | 4 hours   | 1 hour  | 10 to 45 minutes (user's choice)   |
| Curing time before handling @ 20°C /70°F                    | 6 hours   | 4 hours   | 20 to 60 minutes   |
| Solids content by volume                                    | 60  | 72  | 100  |
| Adhesion direct-to-steel                                    | 800 psi   | 1000 psi  | 2000 psi   |
| Hardness  | 40 Shore D  | 50 Shore D  | 65 Shore D   |
| Impact resistance   | 60 in.lbs   | 80 in.lbs   | 100 in.lbs   |
| Abrasion resistance (Taber CS17 wheels, 1kg, 1000 cycles)   | 60 mg loss  | 60 mg loss  | 40 mg loss   |
| Initial gloss 60° and Gloss retention (5000 hours QUV 313B) | 83 (initial)<br>90 (retention)  | 86 (initial)<br>92 (retention)  | 92 (initial)<br>90 (retention)   |
| Chemical resistance after 96 hour immersion exposure        | No color change, slightly softened in 10% H <sub>2</sub> SO <sub>4</sub> and 25% NaOH | No color change, slightly softened in 10% H <sub>2</sub> SO <sub>4</sub> and 25% NaOH | No color change, very slightly softened in 10% H <sub>2</sub> SO <sub>4</sub> and 25% NaOH |

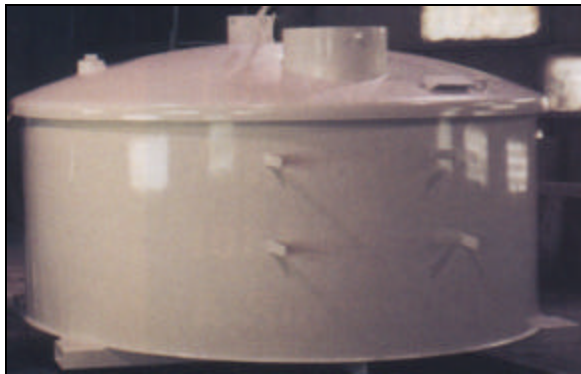


Figure 3 An aboveground fuel tank coated with a direct-to-steel 100% solids aliphatic polyurethane coating

advantages became apparent. Only one coat was required to completely cover a tank without primer. The new coating set dry-to-touch in about 10 minutes at ambient temperature and the tank could be moved out of the painting room in less than one hour (Figure 3).

Figure 4 and 5 show two 10,000 gallon aboveground fuel storage tanks just coated with the new aliphatic polyurethane coatings and then after 4 years in service. After 4 year of storing fuel for a city's municipal vehicles, the two tanks looked almost as good as the day they had been delivered. Even though one of the support saddles was repeatedly immersed in rainwater due to an



Figure 4 Two aboveground storage tanks newly coated with a direct-to-steel aliphatic polyurethane coating



Figure 5 The same two aboveground tanks after 4 years in service

uneven concrete pad, there were no signs of corrosion and the aliphatic polyurethane was intact. The interior surface of the overflow spill containment area, where there lay a thick layer of gasoline and sludge, showed absolutely no coating damage.

### SUMMARY

Breakthroughs in high solids and 100% solids aromatic and aliphatic polyurethane coatings technology have produced environmentally friendly and worker safe solutions to the external corrosion protection of underground and aboveground fuel storage tanks. They offer high physical properties, substantial performance, safety and environmental benefits, as well as fast application throughput advantages over older and other current coating systems. The evolution of various coating technologies used in the underground and aboveground fuel storage tank industry is a perfect example of how the advances in the polyurethane coating chemistry can help and change an industry's performance in corrosion protection.

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