Secondary containment tanks first appeared in the United States in the early 1980's, when several local and state jurisdictions were just beginning to investigate tank leakage and promulgate rules for hazardous wastes and chemical storage. Secondary containment was one of the solutions to the problem of storage tank leaks.

California became one of the first states to require secondary containment for storage of petroleum liquids. The first secondary containment steel underground storage tanks were designated "Type II" for their double-walled construction. The two walls of steel were physically separated with angles or channels to create an annular interstice several inches thick. The goal of this design was to create an enclosure that would hold 110 percent containment of the primary tank capacity. But these systems were costly and bulky, and the industry needed a more cost effective design. The industry soon realized that there was no need to contain 110 percent of the tank's capacity - 100 percent was sufficient to contain the entire contents of the primary tank in the unlikely event of a catastrophic failure.

**First National Construction Standard for Secondary Containment Tanks**

In 1984, Steel Tank Institute (STI) introduced the first national construction standard for secondary containment tanks. It provided a design for a Type I, intimate wrap, steel secondary containment tank, with several alternative construction methods for enabling the interstice to be monitored for releases (i.e., liquid or pressure sensors, gauge stick, etc.).

The STI standard was based on German technology, which had already been in place for a number of years. The Germans were so confident that double wall tanks adequately protected the environment that they did not mandate corrosion protection. As long as secondary containment was in place to prevent a release, the need to protect the tank from corrosion was more an economic decision than an environmental concern. In 1985, Underwriters Laboratories adopted secondary containment construction into its UL 58 standard.

**Federal and State Promulgation of Underground Storage Tank Regulations**

The adoption of national standards was timely. In July of 1986, the Environmental Protection Agency issued their final rule for hazardous waste storage in the Federal Register as 40 CFR Part 265, Sub-Part J. This rule required that double wall tanks 1) be designed as an integral structure so that any release from the inner tank be contained by the outer shell, 2) protect the primary tank from corrosion, and 3) be provided with a built-in continuous leak detection system capable of detecting a release within 24 hours.
In September of 1988, EPA published further rules on underground storage tanks as 40 CFR Part 280. Under this rule, all hazardous stored substances required secondary containment, mirroring the hazardous waste rule, except it further required the secondary containment system be checked for evidence of release at least every 30 days. However, petroleum UST systems were exempted from the secondary containment requirement even though petroleum storage systems accounted for approximately 90 percent of all UST’s. The EPA focused its regulation on corrosion protection, overfill prevention, and release detection as its primary means to protect the environment. With regulated tanks incorporating these measures, EPA expected that single wall systems would adequately protect human health and the environment.

A number of states have since imposed their own requirements for secondary containment systems of underground storage tanks. A table summarizing the current state requirements for secondary containment and monitoring is included.

**Advances in Tank Technology**

The technology for secondary containment of steel underground storage tanks has significantly advanced during the past 15 years. Under today’s standards, several types of secondary containment constructions are permissible. Each of these technologies incorporates some form of corrosion control along with the secondary containment.

Among double wall steel tanks, the most common corrosion control systems are the sti-P3 tank, the ACT-100 tank, and the ACT-100-U tank. Each program utilizes a Steel Tank Institute quality control standard. The sti-P3 tank is a pre-engineered, factory-fabricated, cathodic-protected steel storage tank. The ACT-100 composite tank requires a 100 mil coating of fiberglass reinforced plastic resin (FRP) to provide complete isolation of the steel surface from the corrosive soil environment. The ACT-100-U tank makes use of sophisticated plural component polyurethane coatings to provide corrosion protection.

In 1987, the jacketed steel tank containment system was introduced. With the jacketed tank, the outer containment is not steel, but instead, is composed of a plastic material such as FRP or high density polyethylene (HDPE). The idea of using plastic as the outer layer for a steel tank was conceived many years earlier for the purpose of corrosion control, not containment. Around 1970, tanks were being wrapped with thin, overlapping plastic sheets sealed together by duct tape in the field. By keeping soil and water from the steel surface, corrosion could be successfully impeded.

Underwriter's Laboratories introduced their first corrosion control standard for steel tanks in 1989. UL 1746 incorporated a qualification test protocol for jacketed tanks. Since FRP materials had become readily accepted in the marketplace as both a corrosion control barrier and as a containment, the FRP tank jacket was a logical choice for STI. Instead of bonding the FRP to the steel primary tank to form a coating, as with the ACT-100 tank, STI separated the FRP from the steel primary tank, creating an interstitial space to monitor and contain releases. STI named their specification Permatank. By the early
1990's, several other companies had begun testing their jacketed tank products through UL to acquire a listing under the UL 1746 test standard.

**Maintaining Integrity**

Vacuum has become a common method to ensure secondary containment integrity. Many manufacturers apply a vacuum within the interstice at the factory before shipping the secondary containment tank to the installation site. By verifying that the interstice maintains the factory vacuum before backfilling the tank, the installer need not conduct a separate air pressure test of the primary tank and the interstice. The vacuum already assures that both the primary and secondary vessels are tight.

This procedure is further validated by fire codes. For example, NFPA 30, the Flammable and Combustible Liquids Code, references the UL 58 and 1746 standards, as well as the use of air pressure or vacuum as a means to assure the tank is tight before it begins to permanently store flammable liquids.

After the tank has been installed and the integrity of the tank is assured, the system is backfilled. Many installers release the vacuum and place a release detection probe into the secondary containment monitoring opening. The outer containment must be strong enough to be handled at the job site and in the excavation without losing its integrity. With the jacketed tank, the jacket material must also be capable of withstanding various chemical/soil environments.

**The Numbers are Revealing**

The trend towards secondary containment makes perfect sense. It provides containment to prevent releases into the soil or groundwater and all the undesirable elements that go with a release - report writing, cleanup, lawsuits, and business interruptions. It provides an extra insurance policy, just in case the tank was improperly installed or maintained. It offers peace of mind to the tank owner.

The numbers reflect the trend. Today, according to STI, nearly 50 percent of all steel UST’s made in the United States is believed to be secondary containment tanks. When the EPA regulations were first promulgated in 1988, this number was closer to 15 percent. Even greater strides have been made in some countries outside the United States. For example, Mexican regulations require that all UST’s have secondary containment.

**Tanks Come Out of the Ground**

As society became more aware of the hazards with non-compliant underground storage tanks, tank owners also became aware of the great costs involved in cleaning up sites underground to meet regulations. The number of regulated underground storage tanks decreased from more than two million to less than 700,000 tanks between 1988 and 2000. Where did all of our storage capacity go?
In 1988, many tanks were old and seldom used. Most of these tanks were removed and not replaced. Some tank owners simply began using their local service station for motor vehicle fueling needs rather than self-store their fuel. Also, as small "Mom and Pop" gas stations were shut down, large convenient service stations took their place, that necessitated considerably larger tank capacities. Many owner/operators began to install their tanks aboveground instead of underground. This trend became quite noticeable after 1990, as AST production doubled or tripled. Tank buyers found greater peace of mind with AST's - due to the perception of fewer regulations, and the comforting ability to visually inspect the tank for leaks.

**Fire Code Jurisdiction with Aboveground Storage Tanks**

Since many of these tanks were storing flammable and combustible liquids, fire safety codes served as the predominant regulatory documents dictating requirements for aboveground storage tanks, AST's.

The most common new use for aboveground tank installation was for motor vehicle fueling at a private fleet fueling facility. In some parts of the country, aboveground tanks were being installed aboveground at service stations for environmental reasons, but with complete disregard for the fire codes, which generally prohibited such installations.

The next decade saw a tremendous level of activity in the fire codes. New language was adopted in the codes to allow aboveground storage tank installations, with many new safety features built in. The goal was to prevent releases from taking place so that catastrophic failures would not occur. This included the use of secondary containment, insulated/protected tank construction, overfill prevention, thermal expansion and anti-siphon devices, and special emergency vents.

One of the more significant changes took place in the mid-1990's with the spill control requirements of the fire codes. The codes adopted secondary containment tanks, up to 12,000 gallons in capacity, as an equivalent to traditional concrete dike installations.

A table summarizing the motor vehicle fueling requirements of the principal fire codes is included. This includes the following national codes:

- NFPA 30A, Code for Motor Fuel Dispensing Facilities and Repair Garages, Uniform Fire Code, and
- International Fire Code, as supported by BOCA, SBCCI, and ICBO

In order to comply with the new requirements of the Codes, third party test laboratories needed to develop new tanks standards. Underwriters Laboratories developed UL 2085 for protected tank construction, UL 2080 for fire resistant tank construction, UL 2244 for AST system construction, and UL 2245 for a vault construction (to hold an AST in a below grade room). Southwest Research Institute developed similar third party test laboratory standards for some of these constructions, including SwRI 93-01 protected tank construction and 97-04 fire resistant tank construction.
The protected tank is referenced in all three codes and represents a major change in tank construction. The protected tank must be insulated to withstand a 2000 degree two hour pool fire environment exposure without leakage. All tanks must incorporate secondary containment and are normally qualified for impact by vehicles and ballistics resistance.

**New Industry Standards**

Organizations like Petroleum Equipment Institute, American Petroleum Institute, and Steel Tank Institute developed additional tank construction, installation, and maintenance standards to address the rapidly popular aboveground tank market and the new safety concerns created by their popularity. One widely acclaimed publication was PEI's RP 200, *Recommended Practices for Installation of Aboveground Storage Systems for Motor Vehicle Fueling.* A list providing many of these tank standards is provided in the back of this paper.

**Environmental Rules for Aboveground Storage Tanks**

During the past decade, environmental safety awareness, once focused primarily on underground storage tanks, began drifting towards aboveground tanks. As the new century approached, States such as Minnesota, Florida, Wisconsin, California, Oklahoma, Missouri, New Mexico, and Michigan either had adopted or were in process of adopting new regulations for aboveground storage tanks. The Environmental Protection Agency proposed revisions to their Spill Prevention Control and Countermeasure regulation (as part of the 1974 Clean Water Act) several times throughout the 1990’s and these nearly became officially promulgated as the Clinton administration concluded their reign in 2001.

The first proposed revision to the SPCC rule in 1992 was to require impermeable secondary containment for at least 72 hours after a release occurred. This created a whole new movement towards secondary contained AST's. No longer were spills and releases considered to be unacceptable only from underground tanks, but also, spills and releases could not permeate the soil, earthen dike, or concrete dike wall from aboveground tank systems. Steel became a popular option for factory built AST's due to its non-permeable nature.

The initial solution was to install the single wall or double wall aboveground tank into a steel dike. However, rain could collect in the dike and, in the presence of hydrocarbons, had to be disposed of as a hazardous material. So manufacturers began to provide rain shields over the dike opening. Some rain shields were provided completely over the tank. In order to prevent spills during fill operations from diverting over the rain shield and onto the ground, overfill limiting valves were introduced for pressurized filling operations.

Tank owners quickly realized that a double wall steel tank, similar in construction to the double wall steel underground tank, could fulfill the same function as a diked AST with
rain shield. Soon, the double wall aboveground tank became available in both horizontal and vertical construction as a popular installation option.

**AST Construction Standards**

Underwriter's Laboratories developed the UL 142 construction standard for AST's for storage of flammable liquids way back in 1922 and the UL 58 construction standard for underground tanks in 1925. But the new trend towards secondary containment tanks created a major need for a revision. In 1994, the UL 142 standard added alternative secondary containment tank construction and rectangular tank construction. Rectangular tanks became a desirable option for small tanks, 2000 gallons or smaller, as operators liked the flat top for its accessibility to perform operations and maintenance without the need for special ladders or catwalks.

STI responded to the needs of the industry to standardize construction by developing the diked AST F911 standard in 1991, the double wall AST F921 standard in 1992, the Fireguard fire-protected standard in 1994, and the Flameshield fire-resistant tank standard in 1999.

Clearly, the trend toward secondary containment tanks was a reality. Manufacturers saw their secondary contained AST construction orders increase from almost nothing in 1990 to 50 percent or more by the turn of the century, particularly with larger AST construction. In 1998 alone, STI saw its Members register nearly 5000 secondary containment AST's that were built to STI specifications.

**Future Trends**

New trends continue to evolve with the need for storage tanks. Many industries are opting for the installation of stand-by power generators. In many cases, such generators are installed directly atop generator base tanks, either in the form of single wall, double wall, or protected tank construction.

New designs have been introduced for vertical aboveground storage tank supports. As regulatory agencies further investigate releases from vertical tank floors resting on grade, the ability to see the tank bottom becomes more and more attractive.

With significant advances in secondary containment options of steel storage tanks over the past 20 years, tank owners are given many viable options. Whether or not secondary containment is mandated for their specific application, owners would be well advised to consider the investment. Coupled with release detection, secondary containment provides tank owners with an economically, and environmentally, sound tank installation.