MEETING THE CHALLENGE: ABOVEGROUND STORAGE TANKS

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Introduction

Not too long ago, decisions about flammable and combustible liquid storage were relatively uncomplicated. In the vast majority of cases, there was only one important consideration for the safe storage of chemicals and petroleum products, that being to prevent fires and explosions. Fire chiefs permitted the storage of such products in the safest environment known to the fire service, underground. Prior to 1980 however, most tank systems were installed without adequate corrosion protection, small, continuous leakage was difficult to detect, and releases from filling operations, at times, prevailed.

An equally important consideration developed in the past decade and a half which has made the safe storage of flammable and combustible liquids ever more challenging to the fire marshall, that being a cleaner environment. The movement towards a safe environment, an environment free from pollution and contamination, has created a tremendous change in the way flammable and combustible liquids are stored. No longer are such liquids placed underground as a matter of routine. Instead, more and more storage applications are aboveground, and with it, a greater challenge to the fire service to assure the environment is also free from the threat of fires and explosions.

Since 1988, when the U.S. Environmental Protection Agency (EPA) finalized its underground storage tank requirements, the market demand for aboveground storage tanks (ASTs) has significantly increased. Industry figures show a 100 percent increase in factory-fabricated aboveground tank activity during the last four years.

This trend is expected to continue. Many tank owners take comfort in being able to visually observe and inspect an AST system. In addition, many are choosing ASTs over USTs because there are no federally-mandated financial responsibility requirements for ASTs. Some simply contend that ASTs are more cost effective. Others simply have heard too many horror stories about expensive soil clean-ups from old USTs.

There has been rapid technological advances in petroleum equipment and testing of underground storage tank systems. Underground steel tanks can be cathodically protected, composite, secondary contained, jacketed, or tanks can be non-metallic. Piping can be rigid non-metallic, cathodically protected steel, or plastic-elastomeric "flexible" pipe. Sophisticated computerized inventory control equipment and reconciliation methods have been developed, as has various forms of release detection equipment. Similar advances have been made with aboveground systems too.

The increased AST activity has prompted further revisions of fire codes as well as
technological improvements in AST system design. In their roles of assuring safe storage tank operations, fire officials are scrambling to keep pace with AST system product developments. However, confusing or even conflicting information is often encountered. This paper provides insight into various types of ASTs, including the more recent evolution of "fire-rated" technologies. It also will review some of the requirements within the various fire codes.

Definitions

Aboveground storage tanks are classified as either field-erected or factory-fabricated. Typically, if the tank is storing product in capacities of 50,000 gallons or less, the tank is factory-fabricated. Whereas field-erected tanks constitute the clear majority of all AST storage capacity, factory-fabricated aboveground storage tanks make up about 89 percent of the total number of ASTs in existence today, according to the American Petroleum Institute.

Fueling operations, particularly for private fleets, have increasingly utilized factory-fabricated ASTs during the past several years. Fire code officials and local fire jurisdictions have closely scrutinized these applications due to the nature of the product, the fueling operation and the increased potential for catastrophic consequences if not properly stored and handled.

In response to these reasonable concerns for public safety, the tank industry has developed further technological advancements in AST system design over the past several years. This discussion focuses on such factory-fabricated AST systems.

Fabrication Standards

Cylindrical or rectangular tanks storing flammable and combustible liquids will normally comply with Underwriters Laboratories Standard for Safety, UL 142. This standard encompasses storage of flammable and combustible liquids in atmospheric pressure conditions. Tanks can be fabricated for installation in either a horizontal or vertical orientation.

The UL 142 standard gives details for steel type, wall thickness, compartments and bulkheads, manways, and other fittings and appurtenances. Pressure vessels are often used to store pressurized liquid processes, but the most recent AST activity pertains to storage of petroleum-related products and, hence, UL 142-type construction.

Underwriters Laboratories expanded the UL 142, with the seventh edition, to incorporate secondary containment designs, diking and rectangular tank designs. UL has also developed the UL 2085 Standard, "Insulated Secondary Containment Aboveground Tanks for Flammable Liquids - Protected Tanks". This standard requires a 2-hour test at 2000 degrees Fahrenheit. The insulated tank, under UL 2085, was developed because some code authorities and a portion of the tank industry requested Underwriters Laboratories to develop a program to test a tank with insulation surrounding it. Industry
recognized situations in which a user might want an insulated tank. This does not imply that tanks built in accordance with UL 142 are no longer adequate for the storage of flammable and combustible liquids. The UL 142 tank is still a good, stand-alone, construction code.

But the insulated tank provides some additional safeguards in the unlikely event that a flammable liquid aboveground storage tank system becomes exposed to a fire. The insulation slows down the vaporization of the flammable liquid, and hence, the time in which the atmospheric tank could become pressurized and explode. Firefighters appreciate the extra time given with this type of construction to respond to a fire, without the additional worry of an improperly installed vent, whose purpose is to automatically relieve any pressure build-up in such circumstances. A protected tank incorporates a few additional safety features as well, such as resistance to impacts and ballistics.

**AST Secondary Containment**

Environmental considerations have led to an increased market for secondarily-contained aboveground storage tanks. While previously, very few ASTs were built at the factory with secondary containment, recent Steel Tank Institute polls show its members are building 33 to 50 percent of their AST tanks with secondary containment. Clearly, a major trend has evolved.

The increased prevalence of AST secondary containment can also be attributed to fire safety interests. Containment of product not only prevents environmental contamination but would also serve to prevent the spread of any fire. The most frequently installed ASTs in capacities of 30,000 gallons and under with integral secondary containment are protected tanks, double-wall design ASTs without insulation, and a single-wall steel tank in a steel dike.

Double-wall designs consist of a steel wrap over a horizontal or vertical steel storage tank. The steel wrap provides an intimate, secondary containment over the primary tank. One such design is the Steel Tank Institute's F921® AST. This tank is built to the STI F921® "Standard for Aboveground Tanks with Integral Secondary Containment" and is based upon UL-Listed construction for primary tank, outer containment and associated tank supports or skids.

**Diked ASTs**

A diked AST generally refers to steel tanks within a factory fabricated steel box, or dike. An example of a diked AST is the STI construction standard called F911® "Standard for Diked Aboveground Storage Tank". This standard provides construction details of an open-topped steel rectangular dike and floor providing support and secondary containment of a UL 142 steel tank. The dike will contain 110 percent containment of the tank capacity; as rainwater may already have collected in the dike, the additional 10 percent acts as freeboard should a catastrophic failure dump a full tank's contents into a dike. Some fabricators incorporate a rainshield to prevent precipitation from entering the
dike while still allowing overfills to be collected.

From an environmental standpoint, steel dikes have the advantage over earthen and concrete dikes, with its impermeability and its inherent ability to prevent seepage of hydrocarbons or chemicals into the soil. In addition to containing spills or leakage, dikes also serve as a fire break and can even be used to contain water for cooling a tank exposed to an adjacent fire.

Other Pre-Engineered Unit Tanks

Some manufacturers have geared both their diked-wall tanks and their single-wall tanks to specific markets. For example, waste-oil collection tanks are sometimes constructed as a "system" with foot-operated basin lids, high level warning gauges, slip proof steps, and large evacuation ports for removal of waste oils.

Other tank systems are designed and constructed for specific uses, such as for the dispensing of fuels, piping spill-catch basins, pumps and electrical wiring on a self-contained unit shipped in entirety from a fabrication shop.

Fire-Rated ASTs

Fire-rated, or insulated, ASTs have received much attention within the fire regulatory community, particularly for motor fuel storage and dispensing applications. National model codes have been revised to enable this type of storage aboveground to take place.

Different codes use different terminology to describe insulated tanks. The National Fire Protection Association (NFPA) refers to an insulated AST as "fire-resistant" while the Uniform Fire Code (UFC) terms it "protected". Both must pass a 2-hour fire rating. Yet another term commonly used for fire-rated tanks is "thermally protected".

An insulated tank is so named due to its ability to insulate fluid within the tank and thus slow the rapid temperature rise which takes place during a fire. Rapid vaporization could cause the tank to be over-pressurized and possibly result in an explosion. The insulation slows the vaporization process. It's important to note, however, that the insulation alone is not sufficient to prevent explosion -- emergency vents are crucial.

The insulation properties of many fire-rated ASTs marketed today are typically provided by concrete. That is, the primary steel tank is surrounded by concrete. Due to the weight of concrete, this design is normally limited to small tanks.

Another new AST technology meeting all applicable code requirements for insulated tanks is the STI Fireguard® standard. This tank uses a lightweight monolithic thermal insulation in between two walls of steel to minimize heat transfer from the outer tank to the inner tank and to make tank handling more palatable.

It is important to ask the AST manufacturer whether the tank is listed by a third party,
such as Underwriter's Laboratories, for both secondary containment and for the additional fire protection. The secondary containment must incorporate an emergency relief vent, just as the primary tank, for the remote occurrence of a breach from the inner tank and a pool fire outside the tank. This will assure the secondary containment does not become over-pressurized. The 1996 edition of NFPA 30 expands this requirement beyond the secondary containment. Emergency vents are also required for every compartment of the primary tank and for any insulated or contained area where flammable liquids might lurk and the enclosed space can become pressurized during a fire.

The UL 2085 label affixed to the AST provides proof that the tank has been evaluated for emergency venting capabilities -- as well as the 2-hour fire test and an interstitial communication test. The label should indicate the intended use of the tank.

Another important addition to the 1996 NFPA 30 Flammable and Combustible Liquids Code is with the testability of factory built tanks with secondary containment. The Code mandates that both the primary tank and the second wall be proven tight with air pressure or vacuum prior to placing the tank in service. This requirement parallels the requirements for underground storage tanks and is typical of all "dual wall" type tanks.

**Vaulted Tanks and Special Enclosures**

A concrete vault is in essence, a room that could be entered in order to inspect the tank. A vault may be either above or below-grade. Key safety features with a vaulted design require that a liquid monitoring device be included within the vault, and that a ventilation system be incorporated that is capable of terminating fuel dispensing operations if vapors reach an unsafe condition. Vaults must also be designed to be wind and earthquake resistant, and below-grade vaults must be able to withstand soil and hydrostatic loading.

NFPA 30A allows a tank up to 12,000 gallons to be installed in a vault. However, even though NFPA 30A may be referenced in regional or local codes, vaults may not be recognized. For example, the National Fire Prevention Code of the Building Officials & Code Administrators (BOCA) extensively references NFPA 30A, yet does not recognize a vault. Rather, it contains provisions for "special enclosures" as defined by NFPA 30A, which are similar to, but not synonymous with vaults.

Like a vault, a special enclosure must be substantially liquid and vapor-tight and be constructed of at least 6 inches of reinforced concrete. However, it is distinguished from a vault in that openings for inspection may only be through the top. Also, tank capacity for special enclosures is further restricted. Class I liquid tanks cannot exceed 6,000 gallons individual or 18,000 gallons aggregate capacity where tenant or customer parking facilities are provided in connection with automotive service stations. Finally, special enclosures may be installed only upon specific approval of the authority having jurisdiction (AHJ).

**Technical Design Considerations**
It's helpful to understand some fundamental design parameters relative to ASTs storing flammable and combustible liquids at atmospheric pressures. Aboveground storage tanks are exposed to greater ambient temperature fluctuations. Properly-designed and sized venting, both normal (atmospheric) and emergency, is critical. Normal venting must prevent positive or negative pressure build-up within the tank from variables such as temperature extremes, tank filling operations and dispensing activities.

Emergency venting acts to prevent explosion during a fire. A fire can generate a catastrophic amount of vapors as the product heats up and boils. These vapors must flow out of the tank to prevent pressure build-up. Normal vents are not designed to accommodate the transport of all of these additional vapors.

Therefore, all UL 142 and UL 2085 tanks must include emergency relief venting provisions, since these tanks are designed for atmospheric pressure conditions. The special cover on an emergency relief vent is designed to open upon pressurization of the tank and allow the vapors to escape without the tank rupturing from over-pressurization. Without it, during fire, a tank might explode or, possibly worse, become a missile. Hence, the authority having jurisdiction must verify that the emergency vent is properly rated for the application, installed properly, and remains in an operational mode (another new mandate within NFPA 30-1996). For instance, one type of emergency vent is a long bolted manway. The bolts are intended to allow the manway cover to pop open during an over-pressurization situation, and therefore, the bolts should never be tightened down. (Proposals are being considered by some Code bodies to mandate that long-bolt manways be free of any vapor leakage.)

With the emergency relief vent, the performance of the UL 142 tank, relative to explosions, is nearly impeccable, with little need for additional fire protection to be built into the tank. As a matter of fact, past AST tank explosions (Kansas City, Gadsden, AL, Kennedale) during fires were caused by tanks with inadequate venting. In 1957, the NFPA 30 Code allowed "venting equipment for normal operation to serve as emergency relief". Today's Code requires a "construction or device that will relieve internal pressure caused by exposure fires, in addition to normal venting". Today's Code requires emergency venting fourfold greater than that in 1957.

Nearly all of the documented major aboveground storage tank fires have been caused by either overfilling, vandalism, or human error. Another way to prevent tanks from exploding or becoming exposed to fires is to simply prevent the release from taking place to begin with. Obviously, this is a major goal of the codes, tank owners, and the local jurisdictions alike. Another concern related to tank overfilling is that product can spill out of venting and emergency venting devices, depending on the type of loading operation.

Therefore, if overfill spill-prevention equipment is not included with the tank system, product may spill outside the realm of the tank's secondary-containment area. This, of course, depends upon the vent line's location.

Certain considerations must be weighed pertaining to fuel dispensing. Fuels should not be
dispensed from an AST by gravity flow. Further, there should be a means provided to prevent the release of liquid by siphon-flow, such as with a solenoid valve. Various means of dispensing are possible but suction pumps are most commonly used. Aboveground piping should incorporate appropriate valves to enable routine maintenance on equipment and to relieve pressure within the pipe due to liquid thermal expansion caused by the radiant heat of the sun.

Applicable Fire Codes

The National Fire Protection Association (NFPA) oversees two of the more widely known codes involving aboveground storage tanks and is often referenced by many jurisdictions. The NFPA 30 code is the Flammable and Combustible Liquids Code. The NFPA 30A code is the Automotive and Marine Service Station Code, referred to for the dispensing of motor fuels for vehicles at service stations. Both codes refer to a number of construction and installation standards, such as those developed by UL, STI, PEI, and API.

Certain states and jurisdictions throughout the United States follow the BOCA National Fire Prevention Code (BNFPC). As stated earlier, NFPA 30 and 30A are extensively referenced within the BNFPC. Aboveground storage tanks are addressed in BNFPC's Chapter 32, "Flammable and Combustible Liquids", as well as certain provisions within the mechanical code and the requirements of Chapter 23, which apply to the storage, handling and processing of flammable and combustible liquids.

Yet another code-making body which has adopted NFPA 30A nearly verbatim for its fuel dispensing requirements at non-retail facilities is the Southern Building Code Congress International (SBCCI). The applicable SBCCI code is entitled the "Standard Fire Prevention Code".

The Uniform Fire Code, published by the International Fire Code Institute (IFCI), is predominant in the western half of the U.S.

In all cases, AST installations must meet the local "authority having jurisdiction" (AHJ).

While there are some differences among the codes, all of them detail similar basic AST requirements and accept new AST technologies that have increased the fuel storage options for businesses that need to store significant quantities of petroleum products. Still, code language is more extensive and restrictive for ASTs than USTs -- particularly with ASTs which dispense motor fuels.

Code Language

Under the new language of NFPA 30A, individual aboveground tank capacity is not to exceed 12,000 gallons, with total aggregate capacity limited to 42,000 gallons. The latest UFC fire code revision allows for the use of aboveground tanks up to 12,000 gallons in a
single unit, or 48,000 gallons aggregate site capacity.

Here again, it is important to carefully check the locally-adopted codes for different interpretations. For example, The BOCA National Fire Prevention Code limits AST storage capacity to 6,000 gallons individual/18,000 gallons aggregate. Further, BNFPC only allows aboveground storage tanks for "private" fueling applications such as fleets. ASTs may not be used at retail or public fueling sites.

Another very important distinction in the BNFPC is that only fire-resistant ASTs (or those within special enclosures as discussed above) may be used for fueling applications, whereas NFPA 30A allows non-insulated tanks, but with greater separation distances.

As stated earlier, spillage from tank overfilling is one of the biggest concerns with fire safety of aboveground storage tanks expressed by all model codes. Under NFPA 30, a means -- accessible to the delivery operator -- is now required for determining the level of liquid in a tank. Also, during filling operations, alarm activation is required at 90 percent capacity and shut-off activation at 95 percent capacity. Recent NFPA 30A revisions mirror this requirement. Respective capacities for UFC are 85 and 90 percent.

Piping requirements are similar in all of the codes. All connections must be above the normal liquid level and means must be provided to prevent release of liquid from the tank by siphon flow.

Protection of the AST and/or the piping against damage by vehicle impact is yet another requirement spelled out within the model fire codes. NFPA 30 language requires that secondary containment tanks be capable of resisting damage from the impact of a motor vehicle or that suitable collision barriers be provided such as guard posts. All tanks, except those enclosed in a vault, are supposed to have a 6-foot-high security fence at least 10 feet away from the tank, according to NFPA 30A.

The UFC also requires protection of tanks from vehicle impact, such as through the use of guard posts.

Separation Distances

Aboveground storage tanks must be separated from buildings, property lines, fuel dispensers and delivery trucks in accordance with the level of safety the tank design provides -- depending upon whether they are constructed of traditional steel or are vault/fire-resistant.

Certain codes, such as NFPA 30A, also allow variable separation distances depending upon whether the facility is private or public. This is an important philosophy to keep in mind with fuel storage in non-insulated assemblies: the further a tank is from important buildings and property lines, the less of a hazard it presents to the public. Here, ASTs installed at private locations (i.e., commercial, industrial, government, manufacturing facilities) require less stringent separation as they present less exposure and, hence, less
of a hazard to the public. They also tend to be better secured.

Separation distance requirements may dictate whether a tank buyer purchases a traditional steel UL 142 tank, a fire resistant tank or a tank in a vault. (For details on separation distances specific to each of the four model fire codes, please refer to the AST Code Summary Chart.)

Separation distances also are specified between tanks and dispensers and delivery trucks as a fire prevention matter. If a fire should take place at the tank or at the dispenser truck as a result of overfill, malfunctioning equipment or human error, the separation distance will serve to contain the fire in one area without immediately exposing the other element to fire and subsequent pollution.

Under NFPA 30A, dispensers may be installed directly over vaults or upon fire resistant tanks at fleet type installations, whereas a 25 to 50 foot separation distance is required at retail type service station installations. The UFC only allows motor fuel dispensing from ASTs, or special enclosures, designed with a 2-hour fire rating.

Conclusion

Aboveground tank manufacturers have addressed AST safety concerns and code compliance through innovative product technologies. Still, it is contingent upon the tank owner/operator to understand the requirements of local fire jurisdictions, as local codes will dictate which AST technologies are appropriate. Potential environmental impact from new USTs and ASTs is at the forefront of tank owners' minds, whether real or imagined. The financial implications are significant. But tank owners can install safe systems in numerous ways.

Likewise, it is contingent upon fire officials to know and to understand all of the continually-evolving technology and the requirements of national and local fire codes. Understanding what's what will improve and hasten communications with the regulated community, but more importantly, will ensure the primary goal of public safety.