Steel Tank Institute

Tank Talk, February 2014

Ask the experts

Repurposing underground tanks as aboveground tanks: A dangerous game

On December 11, 2013, one person died and two were injured in Merced County, California, when a farm tank exploded during welding operations.

"Damaged tank from explosion: Tank ends are bowed outward. No emergency venting evident. Small grinder with wire brush wheel nearby."—Hank Moore, Merced County Fire Marshal

The tank was approximately 500 gallons capacity, had two 1.5" diameter vents, capped with a tee fitting and elbows that pointed vent discharge downward toward the tank shell. A dedicated emergency vent was not provided. The vent pipes that were present were not equipped with flame arrestors or pressure vacuum vents, although this does not appear to have been a factor in the incident that occurred. The tank had reportedly previously contained a Class 2 liquid, such as diesel fuel, and was not compliant with UL 142.

California environmental laws and regulations require county authorities to inspect tanks and verify the existence of federal Spill Prevention Control and Countermeasure (SPCC) plans, which are required to be current and up-to-date.

Some farm tanks have been found to be underground storage tanks that were removed and unlawfully reused as aboveground flammable and combustible liquid storage tanks. AST rules require SPCC plans to be current, which may include modifying a tank system and its secondary containment in the field. This incident may have been a result of a tank in the process of being unlawfully converted from underground to aboveground use.

What caused this tank explosion?

Initially, it was speculated that this tank explosion may have been linked to inadequate venting, because a dedicated emergency vent had not been provided. Merced County Fire Marshal Hank Moore, who investigated this incident, contacted Wayne Geyer at STI/SPFA, and he in turn sought the opinion of several experts in the field.

The feedback that we received from industry experts is a reminder of the importance of proper precautions when performing hot work on tanks that previously contained ignitable liquids: explosions can occur REGARDLESS OF THE FLASHPOINT OF THE LIQUID PREVIOUSLY STORED IN THE TANK.

Jeffrey M. Shapiro, PE, FSFPE
at International Code Consultants

I've heard of numerous occasions where this type of incident has occurred. Tank vents are designed to relieve the pressure generated by vaporizing liquid in the tank when the tank shell is heated by an *external* fire. There is no direct correlation between that situation and an ignition of vapors inside of the tank, which in this case would have been caused by the torch. Therefore, even a compliant emergency vent size can't be relied upon to prevent a tank explosion when there's an ignition inside of the tank.

In a similar case that I'm familiar with, a large motor oil storage tank exploded the moment that a welding torch penetrated the steel shell. The contractor didn't take adequate precautions because he was dealing with motor oil, which he thought was "safe" because of its high flashpoint and because the U.S. Department of Transportation doesn't require a

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combustible liquid placard for transportation of motor oil.

What happens in a case like this is the torch causes a localized ignition, which almost instantaneously propagates inside of the tank and generates enough pressure to rupture the shell. The fact that the liquid in the tank has a high flashpoint is irrelevant when you are applying a welding torch as the heat source. Once you have a point ignition *inside* of the tank, the fire heats liquid coating the interior tank surfaces to above the flashpoint, and an explosion occurs.

Robert Benedetti,
Principal Flammable Liquids Engineer, NFPA
Jeff is right on target with his explanation. I would only add that, in the early stages of the hot work, the oil that coats the inside wall of the tank is essentially being flash vaporized. This gives you a vapor cloud inside the tank, just waiting for an ignition source.

Mark Taylor, Owner, Mosier Brothers,
tank fabricator, California
The pictures do not show brazed patches on the damaged tank, but I'm guessing that was the problem from the information we have.

A tank can be constructed so as not to fail from an external fire, but tanks are not typically made to withstand an internal explosion. Igniting a fuel-air mixture replicates a thermobaric weapon, commonly used for complete destruction inside confined areas such as tunnels and bunkers. A typical storage tank is not designed, constructed, intended, or able to contain such an explosion.

What should tank owners know about repurposing USTs as ASTs?
Wayne Geyer, STI/SPFA
Section 21.3.4 in the 2012 version of NFPA 30, Flammable and Combustible Liquids, specifically states that "Tanks designed and intended for underground use shall not be used as aboveground tanks."

The tank heads in UL 58, the most relevant steel underground storage tank standard used in our country, are not reinforced to strengthen the cylindrical head. UL 142, the aboveground tank standard, requires larger cylindrical tank heads to be reinforced with structural steel to stiffen and strengthen the head. With an underground tank, the soil provides additional resistance to the structural integrity of the tank and such reinforcement is not necessary.

The UL 142 (and UL 2085) tank standards require the manufacturer to provide openings in the top of the tank for emergency venting, along with labeling.

"Freshly repainted tank with unapproved vents, no emergency venting, unapproved hose shutoff, unapproved tank for its use. Lack of labels and emergency venting indicates no UL listing for this tank." – Hank Moore, Merced County Fire Marshal

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During a pool fire surrounding the tank, the flammable/combustible liquid inside the tank heats up and vaporizes. Such vaporization can be so rapid that the normal vent for standard filling and emptying operations is insufficient to relieve the vapors quickly enough.

These tanks are atmospheric tanks, not pressure vessels. If the liquid vaporizes quickly during a pool fire, the tank can become pressurized and potentially fail at pressures much higher than those for which it is built and tested. Hence, an emergency vent is incorporated into the tank, providing a much greater volume of space for venting to occur during a fire exposure condition.

Underground tanks have neither such emergency venting nor larger openings to allow it, because there is no risk of a fire exposing the shell of a buried tank. Therefore, if the underground tank is used aboveground and becomes subject to a pool fire, it will quickly become pressurized and possibly fail. And simply retrofitting an emergency vent on an underground tank doesn't make it suitable for aboveground use because of the structural issues mentioned above.

There is a history of explosions in tanks that lack emergency venting. The head blows off and may travel hundreds of feet at high velocity, seriously injuring anyone in its way. The literature includes several such fires where firefighters have lost their lives while trying to put out the blaze, unaware that emergency venting was not in place.

Where field modifications involving hot work are necessary on existing tanks, it is essential that the contractor be well qualified to do this work and that codes and standards governing hot work on a tank that previously contained an ignitable liquid be followed. I have heard of failures on field repairs that were made by unqualified workers, and major spills, fires and injuries resulted.

The bottom line

Jeffrey M. Shapiro, PE, FSFPE
at International Code Consultants

The take-away is twofold, in my opinion. First, neither UL 58 (underground) nor UL 142 (aboveground) tanks are designed to "vent away" an internal explosion. These tanks will rupture if an internal ignition occurs.

Second, the flashpoint of the liquid previously stored in the tank isn't indicative of any type of safety factor with respect to not having a risk. If an ignitable liquid is in the tank, even a small quantity, there is a high risk of explosion during hot work, regardless of the flashpoint or the size of the tank.

I personally demonstrated this in a laboratory setting with motor oil and a 55-gallon drum. When a flame applied to the drum shell heated the oil to above its auto ignition temperature… "BOOM!"

Tank Talk **thanks contributors to this article:**

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- Hank Moore, Merced County CA Fire Marshal
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