Allan Reese Presents Buckling Study At ASME Conference

Allan Reese, president of Ace Tank & Equipment in Seattle, Washington, presented a paper titled “Experimental Investigation of Buckling in Full-Size Steel Underground Storage Tanks” on June 20, 1994, at the American Society of Mechanical Engineers (ASME) Pressure Vessels & Piping Conference in Minneapolis, Minnesota. This paper was based on work sponsored by the Steel Tank Institute. Key conclusions given by Dr. Reese from the study included:

1) Experimentally measured buckling pressures followed textbook equations for buckling pressures of vessels exposed to uniform external pressure. The buckling pressures were found to be proportional to the 2.55 power of the shell thickness, in excellent agreement with the theoretical value of 2.50.

2) Tanks with stiffer shell-to-shell weld joints, such as joggle joints with continuous internal welding, failed at buckling pressures up to 30 percent higher than less stiff joints, such as butt welded joints.

3) Internal stiffeners can increase the resistance to buckling considerably.

4) A bare steel 4,000 gallon tank, fabricated per UL 1746, reduced wall thickness specification, failed below 3.0 pounds per square inch (psi). Because the pressure at the bottom of these tanks can exceed 6 psi when they are buried, backfill is necessary to prevent these tanks from collapsing.

5) Experimentally, a 0.10-inch thick fiberglass reinforced plastic coating (cladding) on the outside of a 10-gauge, 4,000 gallon tank increased the buckling pressure about 5 percent compared to an unclad tank.

The study by Allan Reese is the third in three years on the issue of buckling of steel underground storage tanks, the others being done by Battelle and Utah State University.

Continues on page 6

Devastating Explosion in Texas Relived

By Mason Lankford

In retrospect, we still find it hard to believe. We know for sure that a single 10,000 gallon aboveground gasoline tank catching on fire and exploding can cause the loss of three close friends. In addition, it can cause a total of 57 fire department personnel and citizens standing by to be injured. And we know it occurred on a tragic afternoon in the summer of 1968.

The incident took place on July 31, 1968, in a rural area between the cities of Kennedale and Mansfield, Texas, southeast of Fort Worth on U.S. Highway 287. As the investigating officer, I was able to gather information and piece together the following sequence of events which led up to the massive explosion. I was personally grieved by the fact that the fatalities included Fire Chief Harry Blissard of Mansfield, Shirley Clyde Copeland of Mansfield and TV Newsman Steve Perringer, all long-time friends.

How It Started
To set the stage, a 7,000 gallon tank truck, with a power take-off transfer pump, had been assigned to go to the Red Ball station south of Kennedale and outside of their city limits, to fill an aboveground tank. There was a baffle in the tank, dividing it into 7,000 gallons at one end and 3,000 gallons at the opposite end. The truck operator started the filling process by filling the 3,000 gallon end with ethyl gasoline. He then changed his hose and started filling the regular gasoline portion of the tank.

Since the temperature was 104 degrees in the shade, he left the side of the truck and went to the cashier’s stand of the service station and bought a soft drink.

Continues on page 2
leaving the truck pump in gear and letting it continue to fill the tank. With his back to the truck as he talked with cashier, he was interrupted by a person who came to purchase some gasoline for his car, telling him that the gasoline was overflowing from the tank through the vent valve.

He immediately went to the truck and took the pump out of gear, leaving the diesel engine running. He then got a garden hose and started washing the gasoline down the slope of the driveway.

The ground around the station was made a drivable surface by pulling the tabs off of asphalt shingles, placing them on the ground and then compressing them in place by driving heavy trucks and cars over the driveway area. The gasoline, by its nature, rapidly penetrated into and under the surface of the shingles. This single fact caused the fire to look much more dense and hazardous than it really was.

With the washing down of the gasoline spill area, the fumes and vapors spread eastward, under the tank truck and toward the truck cab and engine. Approximately three minutes after cutting off the supply of gasoline, the vapors reached the engine area of the truck and were ignited.

The later investigation found that the ignition point was the alternator of the truck tractor. Once there was ignition, the three people in the area immediately ran from the scene to get as far away as possible.

Emergency Personnel Respond

Residents in the area saw the smoke arise and called the Kennedale Volunteer Fire Department. Kennedale in turn radioed Mansfield for their mutual-aid support. Eventually there were over 25 fire units from nine fire departments responding to a request for mutual-aid at the explosion scene.

The tank was a shop-built skid tank, common at self-service stations of the time. However, it had faults that indicate that the builder did not know what he was doing or what the codes and standards of the time dictated. At the 7,000 gallon end of the tank there was a 2-inch vent, which should have been at least 4-inches, through which the overflow discharged. At the opposite 3,000 gallon end there was NO vent. With the 3,000 gallon end full, and the 7,000 gallon end overflowing, the gasoline came out of the vent and ran over the top of the tank, down the sides, under the tank, and onto the apron area by and under the tank truck.

When the first unit of the Kennedale Fire Department arrived, with a single member driving the unit, the driver drove up to the scene, turned the truck around and went one-quarter mile down the road. He turned around again and parked along the shoulder of the road.

"At the opposite 3,000 gallon end there was NO (emergency) vent."

Citizens as well as members of the Tarrant County Sheriff's Patrol asked him why he did not go ahead and put his 500 gallons of water on the fire and control what he could until assistance arrived from both Kennedale and Mansfield. He replied, "There was going to be a hell of an explosion" and did nothing further.

There was a standard fire hydrant on an 8-inch circulating main less than 150 feet from the fire scene. During this time (15 to 18 minutes) the fire was building up, causing the fuel in the 7,000 gallon end of the tank to boil over and reach what is called a "percolating" condition, with the tank jumping up and down on the skids.

Meanwhile, the Mansfield Fire Department arrived at the opposite end of the fire scene and was laying out their hose, preparing to attack the fire. Chief Blissard asked his mem-

ers to delay the water attack and he called for a one and a half inch in-line foam eductor and 30 gallons of foam to be brought to the scene from the fire station in Mansfield. This would take another 12 to 15 minutes to arrive.

The Explosion

But before the foam and nozzle arrived, it happened. With the tank truck beside it burning and melting down its aluminum shell, the skid tank suddenly exploded with a terrific roar and blew out the west end of the tank and the divider baffle. The tank started moving on its skids and rapidly went through the cashier's stand some 25 feet from the east end of the tank and another 50 feet, where it hit the side of a house trailer that was the residence of the manager of the station.

The force of the forward motion of the tank was so great that it wrapped the frame of the trailer around the tank and molded the frame into a single large U-shape around the leading edge of the tank.

With the forward motion, the blast of the discharge at the rear end of the tank exploded and propelled itself by Chief Harry Blissard and Fireman Shirley Clyde Copeland. They were seriously burned and immediately transported to the John Peter Smith Hospital in Fort Worth. They were later transferred to the burn center at Parkland Memorial Hospital in Dallas. Chief Blissard and Fireman Copeland passed away the next day.

Steve Perringer, leading news photographer for CBS-TV, Channel 4 in Dallas, was always at the scene when something was happening. While in school, he would always ride his bicycle to school. When the fire siren for the River Oaks Volunteer Fire Department sounded, he would run from class and go to the emergency scene, a true devotee, to find out what was happening. Steve put that devotion into his professional job.

At the time of the blast, Steve was standing on the porch of the house just west of the tank location. The house took a solid blast from the

Continues on page 3
end of the tank as it took off like a rocket. The end of the tank came off and flew some 100 feet through the air, hitting a large oak tree some 12 to 15 feet above the ground. The divider baffle blew out, hit a tree and rolled away from the scene. Steve passed away two days later.

Today, the "Steve Perringer Award" is given annually to the outstanding TV news person of the Fort Worth/Dallas area. Each year, the members of the news profession pay their respects to Steve and remind all of the newcomers of the exploits of one who preceded them.

Later inspection of the end of the tank showed that the weld was actually a very thin strip joining the tank and the end. Experts said that the weld should not have passed any kind of test. Inspection also found that the baffle was not welded the entire perimeter of the tank but was only spot-welded about every 18 to 24 inches.

**Lessons Learned**

The trauma of the families and friends of these three individuals will never heal. Therefore, it is up to us to remain dedicated to insure that this type of incident never occur again.

Amazingly, in an area some 125 miles southwest of Fort Worth, a similar incident occurred within 4 weeks. Luckily there was not a loss of lives. There was major damage to the gasoline station and the transport truck.

Let us now evaluate each step of the Kennedale incident.

In the training process for the Fireman, all were instructed to initially attack the fire with the water that was available and attempt to hold the situation until additional help could be summoned. This was not done. This method is still being taught today and the Kennedale example is explained to all personnel.

In the training process, they were also instructed to never stand by and let an area burn, much less a major incident such as this. This was not done. Aggressive attack to the extent of available resources is mandated. When resources are expended or conditions warrant, they are to back off a safe distance so that fire personnel will not become the fire victims.

In Texas, there was a ground swell of support to do away with all aboveground tanks and put them underground where a repeat of this incident could not happen. The Texas legislature passed a law which required that tanks at retail stations be underground. Unfortunately, the law still allowed privately owned tanks to remain above ground, thus the potential problems for fire service personnel still exist.

Today, because of regulations from the Environmental Protection Agency and the Water Quality Board, there is a trend towards moving tanks aboveground.

I do not know what the future holds for the safety aspects of gasoline storage tanks. But whatever the approach taken, the interests of the fire service and emergency personnel must remain uppermost in mind. The legal and code requirements should insure that all safety provisions known to man be included in the standard requirements.

With this accomplished, no other person will ever have to go through the mental anguish and heartfelt pain that I have faced since July 31, 1968.

Mason Lankford is a consultant on public safety communications, fire department administration and operations, and emergency management. Mr. Lankford resides in Ft. Worth, Texas.

---

**PEI Convex Show Right Around the Corner**

The Steel Tank Association, a cooperative venture owned by members of Steel Tank Institute, will be exhibiting at the Petroleum Equipment Institute's annual Convention & Trade Show in Atlanta, Georgia, scheduled for October 12-14, 1994. Please stop by STA Booth #1433-1532.
New Info On Flexible Pipelines

Dear Editor:

I am writing in response to the article titled “Survey Results of Flexible Pipeline Systems,” by Ken Wilcox, which appeared in the May/June 1994 issue (Volume 9, Number 3) of Tank Talk. Since publication of the survey in October 1993, new information has become available, which I believe will be of interest to your readers.

First, I want to review highlights of the EPA-sponsored survey. Six suppliers were polled in the survey. They reported a total of 3,624 flexible piping installations in the U.S. Of that total, one supplier reported 3,000 installations. The remaining 624 were spread over the other five suppliers.

Internal and External Pressures

Fiberglass primary and secondary containment piping systems can hold the full pressure of a pressurized piping system. These systems can withstand pressure surges that are common in petroleum piping, including the introduction of high pressure submerged turbine pumps. They can withstand the weight of the soil load covering them. They can be used with suction pumping systems (i.e., negative pressure) without fear of collapse.

Interstitial Space

Releases from both fiberglass and flexible systems may be charnelled to the tank or disperser sumps for detection. As a result, fluid and vapors can accumulate in the sump or they can become trapped in the space between the primary and secondary containment pipes (if the sump penetrations are sealed). Fiberglass secondary piping containment is UL Listed for the full range of motor fuels and provides a high level of recognized safety testing.

Dispensing Rates

Fiberglass piping offers multiple advantages in terms of dispensing. It is available in UL-Listed diameters up to six inches, permitting the design of manifolded piping systems to achieve desirable dispensing rates in larger multi-dispenser facilities.

Installation Versatility

Fiberglass systems offer the ultimate in versatility. Sections can be cut and joined in an unlimited number of configurations to suit the individual parameters of a job site.

Connectors used to join the sections do not require the use of metal threads, where most pipe leaks have historically occurred.

Final Testing

Most flexible piping system manufacturers recommend that the secondary containment be tested before insertion of the primary piping. However, it is when the primary piping is in place that the secondary containment should be tested to ensure complete integrity. In some cases, the test cannot be performed.

Conclusions

Testing and Listing by third-party laboratories should be used as a reliable guide when selecting underground piping systems. Fiberglass piping systems have proven their integrity in more than 60 million feet installed successfully over the past 25 years.

Sullivan (Sully) D. Curran, P.E.
Executive Director
Fiberglass Petroleum Tank & Pipe Institute
Houston, Texas

Buckling Study continued from page 1

6) Experimentally measured buckling pressures of double-wall steel tanks were in agreement with calculated buckling pressures where the calculated pressure was obtained by summing contributions from the inner and outer walls.

7) Based on the 2.5 power dependence of buckling pressure on shell thickness, buckling pressure is reduced by more than 50 percent when shell thickness is reduced from 0.240-inch to 0.167-inch.

Editor’s Note: It is important for Tank Talk readers to have a proper perspective on the buckling issue. STI is made aware of buckling concerns through various means, such as the media, newspaper clipping services, the petroleum industry, insurance contacts, tank owners, attorneys seeking information, and its members. STI’s information on tanks built to STI specifications is based upon information it receives from warranty and insurance programs covering STI member fabricated tanks.

Based on our experience with steel tanks, tank buckling is a relatively rare occurrence for tanks fabricated with shell thicknesses as specified in UL 58. These include, among others, the sti-P®, ACT-100®, and Permatax®. Several hundred thousand of UL 58 type tanks have been installed over the past 20 years. The Institute is aware of less than 5 tanks which buckled while in service out of more than 200,000 tanks—a cumulative failure rate of less than 0.0025%, or 25 structural failures per million tanks.

Far fewer steel tanks have been built to date to the reduced wall thickness specification of UL 1746. The study shows that certain sizes of these tanks, including the most common sizes used in service stations, are more susceptible to structural failure because the buckling pressure of the tank is about one half that of corresponding UL 58 tanks.

In understanding an article of this nature it is important to have a proper perspective of steel tank structural failure compared to other materials. So how do these failure rates compare with FRP tanks? The EPA, in the September 23, 1988 Federal Register, which established the underground storage tank regulations, stated that of the nearly 200,000 FRP tanks installed nationwide, the annual failure rate had been reduced to less than 0.05% through modification of installation practices and tank design.

The Federal Register also stated that "Many tankers and other sources support the field estimates collected by EPA that less than 0.5% of the total number of existing FRP tanks have ever leaked. The most important related failure mode for these tanks is improper installation." This estimated cumulative failure rate could be up to 200 times greater than STI’s experience with full thickness UL 58 tanks. The inherent low ductility of FRP in comparison to steel may partially explain this difference in failure rates between steel and FRP. The Federal Register states that improper backfill can lead to excessive distortion resulting in rupture of the (FRP) tank.

Unfortunately, there are no independent studies available in the public domain to use to quantitatively assess the relative performance of all of these tanks.