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# Catastrophic Tank Failures: Highlights of Past Failures along with Proactive Tanks Designs

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## Introduction

Catastrophic failures of aboveground storage tanks (ASTs) can occur when explosions or flaws cause the shell-to-bottom or side seam to fail. Past tank failures have ripped tanks open releasing their entire contents and in some cases tanks have been rocketed upwards into the air. Tanks up to ~ 16 meters in diameter can be designed to fail at the shell-to-roof weld. This is called a frangible joint and is designed to limit damages to the tank and minimize the extent of a resulting fire/ spill. This sacrificial joint is primary designed to ensure integrity of the AST shell-to-bottom joint in the event of an over-pressurization of a tank to assure containment of the stored liquid. API 650 provides design criteria and tank diameter restrictions for frangible roof joints. Over-pressurization is due to the inability of pressure relief vents to handle rapid pressurization during an ignition of flammable vapors.

This Paper primarily address's failures as related to ASTs designed in accordance with the American Petroleum Institute, Standard 650 which provides for a maximum operating pressure of 2.5 psig

## Historical Accidents

On January 15, 1919 a United States Industrial Alcohol Company's distilling tank which recently had received a shipment of molasses in from Puerto Rico, exploded. At about 12:40 p.m. the giant tank ruptured, emptying its entire contents of about 2.5 million gallons of molasses, into Commercial Street in the space of a few seconds. The result was a flash flood consisting of millions of gallons of sweet, sticky, deadly goo. The tank, a 90'-0 diameter x 50-foot high cast iron tank was filled to the top with molasses. Upon failure, a 15-foot high wave of dark molasses moving about 35 miles per hour swallowed the streets of Boston's North End. Almost 150 people lie injured in the streets with the final death toll being 21. A Massachusetts court determined that insufficient safety inspections had played a part in the accident. In time, after 3,000 witnesses testify during 300 days of hearings, the courts found the company liable, concluding shoddy construction and overfilling of the tank was to blame, along with the apparent sudden expansion of the molasses -- the temperature had only been 2 degrees above zero the previous day. The company paid almost $1 million to settle the claims.

## Recent incidents that drove API Standard 653

Three incidents focused this country's attention on above ground storage tanks

Incident 1

1987, a South Dakota School was closed because of leakage from the bottom of an aboveground storage tank. The associated danger and school closure sparked, in South Dakota and Congress a desire to control aboveground storage tanks.

Incident 2

January 2, 1988, a 95,000-barrel aboveground storage tank in Pennsylvania failed. The catastrophic failure spilled about 1 million gallons of oil into the Monongahela River. The spill affected the water supply of millions of people and moved control of aboveground storage tanks to the top of the congressional agenda.

Incident 3

Also in 1988, a floating roof drain on a storage tank in California failed and dumped about 1000,000 gallons of diesel fuel into a California waterway.

After these incidents, there were several congressional and state hearings, which cast doubts on the suitability of aboveground storage tank construction standards. The hearings also highlighted the fact that repair standards did not exist.

To respond to the need for industry standards for AST's, API elected to write 3 new standards.

–API RP 651 Cathodic Protection of Aboveground Petroleum Storage Tanks

–API RP 652 Lining of Aboveground Petroleum Storage Tank Bottoms

–API STD 653 Tank Inspection, Repair, Alteration, and Reconstruction

## **Additional Recent Accidents**

In more recent times, failures have occurred in a legion of forms ranging from explosions of flammable vapors inside an atmospheric tank to brittle fracture. Often workers have been performing repairs that introduced an ignition source, as a result workers have been killed or injured and the AST's contents released into the environment. A few of the more prominent failures have been listed below

On November 31, 2001, a storage tank holding almost 100,000 gallons of crude oil ignited, throwing a nearby teenager more than 100 feet and setting off a billowing fire that could be seen for miles. Officials said the tank was in a remote area west of Lafayette and there was no danger of further explosions and no need for evacuations, although the blaze burned out of control for more than an hour and a half.

On January 8, 2000 at approximately 12:30 PM, a one million-gallon bulk storage tank owned by Southside River Rail experienced a catastrophic structural failure. The tank contained approximately 990,000 gallons of Fertilizer Solution 2800. An estimated 882,000 gallons of product entered the Ohio River. Investigators said that a faulty weld caused the problem. Four other tanks adjacent to the ruptured tank suffered damage to varying degrees. Tank welds appear to not have had 100% penetration as referenced in the American Petroleum Institute (API) Standard 650.

In a 1995 incident, during a welding operation on the outside of a tank, the vapor inside two, 30-ft.diameter by 30-ft. high, tanks exploded. One tank was thrown more than

50 feet away. The stored product was released and ignited. The resulting fire caused five deaths and several injuries.

In a 1994 incident, during a grinding operation on a tank storing petroleum-based sludge, the tank was propelled upward, injuring 17 workers and spilling its contents into a nearby river.

In a 1992 incident, while workers were welding the outside of an empty tank, the residual vapor in the storage tank exploded. The tank was thrown upward and into an adjacent river. Three workers were killed and one was injured

## Areas of concern

Tank design has been improved and is constantly being revised as new technology reveals better and more cost effective ways of providing tanks that both provide an affordable means of storage for the user and assure adequate protection to the environment around and under the AST. As in the above-mentioned samples, maintenance of existing tanks including proper inspection/maintenance intervals is crucial. History has shown that a failure to inspect ASTs have and will continue to result in tank failures, negative environmental impacts and loss of life. As the industry has seen in recent tank failure, tank owners and operators are being held criminality responsible for their AST.

## *Tank design*

AST's that are designed to current standards should be expected to last for decades with out incident, if an inspection plan is implemented. This plan must be accompanied with a proactive maintenance plan to insure longevity and uninterrupted service. Tanks have historically failed at the shell-to-bottom seam. Steel storage tanks built before 1950 generally did not take into consideration frangible joint details along with adequate relief venting as required by current standards. ASTs for use in the petro-chemical industry should be designed to fail along the shell-to-roof seam or frangible joint when an explosion occurs in the tank. This prevents the tank from propelling upward or splitting along the side.

## Failure Reduction

AST's must comply Federal, State and Local regulations along with industry codes and practices. Included in these is a requirement for inspection and maintenance, along with record keeping of such items. Facilities with storage tanks that can contain flammable vapors should review their equipment and operations. Areas to review should include, but not be limited to, the following:

### *1) Construction*

Construction standards and codes are available that address recommended practices for tank design and construction.

### *2) Inspection and maintenance*

Standards such as API-653 provide proven tank inspection guidelines for periodic inspections and maintenance for tanks placed into service.

## *3) Safety*

Items as Hot Work and Confined Space are have been and will always be areas of concern to AST owners and their chosen contractors. NFPA, OSHA, API and etc. all offer guideline and standard to which we must all conform.

## Summary

After reading about all of the accidents that have occurred throughout the years one may tend to believe that tank designs lack what it takes to protect our environment and to ensure the health and prosperity for future generations. It would be wrong to leave that impression and not to instill confidence in current tank design and repair procedures that are now available to tank owners and operators. It is the authors opinion that if the use of said procedures would only be enforced, we it would be rare to see a tank failure due to anything except an event equivalent to an act of GOD. There is a constant flow of new contractors coming into the AST arena and each of them must be persuaded to follow these standards.

## *Design Statutes and Regulations*

*The American Petroleum Institute (API) has tank standards and guidelines on safe welding.*
American Petroleum Institute
1220 L St NW
Washington DC 20005
Phone: (202) 682-8000
Web site: http://www.api.org

API Standard 620 - Design and Construction of Large, Welded, Low-Pressure Storage Tanks.

API Standard 650 - Welded Steel Tanks for Oil Storage.

API Recommended Practice (RP) 651 —Cathodic Protection of Aboveground Petroleum Storage Tanks.

API RP 652 — Lining of Aboveground Petroleum Storage Tank Bottoms, first edition, April 1991.

API Standard 653 — Tank Inspection, Repair, Alteration, and Reconstruction.

API Standard 2000 — Venting Atmospheric and Low-Pressure Storage Tanks: Non refrigerated and Refrigerated.

API RP 2003 — Protection Against Ignitions Arising Out of Static, Lightning, and Stray Current.

API PUBL 2210 — Flame Arrestors for Vents of Tanks Storing Petroleum Products.

API RP 2350 — Overfill Protection for Petroleum Storage Tanks.

Others..