Tanks A Lot: A Look at the Frail Nature of Tanks

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According to Dr. Trevor A. Kletz

in all four editions of:

**What Went Wrong?**

“No Item of equipment is involved in more accidents than the storage tank, probably because storage tanks are fragile and easily damaged by slight overpressure and vacuum.”
This paper will look at some tank failures from the past to help us remember what we should be looking for in the future.

Sam Levenson


“You must learn from the mistakes of others. You can’t possibly live long enough to make them all yourself.”
Classification of Tanks

• Low Pressure Tanks
  (Shaped like a Soup Can or Tuna Fish Can)
  – API 650 Welded Steel Tanks – These are large, with typically near atmospheric ratings
  – API 620 Welded Low Pressure - Rated to 15 PSIG
  – API 12 D & 12 F Smaller Tanks for Production Liquids

• Pressure Vessels
  – ASME Code 15 to 3,000 PSIG
  (Shaped like a Fat Sausage or Sphere)

• Others
  (Transportation, Shop Built, Underground, Plastic, Cylinders, Non-Code etc.)
Low Pressure Tank Ratings

Many Low Pressure Storage Tanks are designed for:

- 3 to 10 in of water pressure
- 2 ½ in of water vacuum
Low Pressure Tank Ratings
It is Hard to Believe that a Can of Soup or Can of Beans Will Withstand 10 to 50 times more Pressure than a Low Pressure Tank
AIChE’s excellent monthly “Beacon” showed Tank Failures in about a Quarter of the Incidents, since it was first published.
Overfilling Tanks – What Happened?

On Sunday December 11, 2005, gasoline (petrol) was being pumped into a storage tank at the Buncefield Oil Storage Depot in Hertfordshire, England. At about 1:30 AM a stock check of the tanks showed nothing abnormal. From about 3 AM, the level gauge in one of the tanks recorded no change in reading, even though flow was continuing at a rate of about 550 cu. meters/hour (2400 US gallons/minute). Calculations show that the tank would have been full at about 5:20 AM, and that it would then overflow. Pumping continued and the excess gasoline overflowed from the top of the tank and cascaded down the sides, forming a liquid pool and a cloud of flammable gasoline vapor. At about 6:00 AM the cloud ignited and the first explosion occurred, followed by additional explosions and a fire which engulfed 20 storage tanks. Fortunately there were no fatalities, but 43 people were injured. 2000 people were evacuated, there was significant damage to property in the area, and a major highway was closed. The fires burned for several days, destroying most of the site and releasing large clouds of black smoke which impacted the environment over a large area.

Did you know?

➢ Overfilling of process vessels has been one of the causes of a number of serious incidents in the oil and chemical industries in recent years – for example, the explosion at an oil refinery in Texas City, Texas in March 2005.

➢ The tank involved in this incident had an independent high level alarm and interlock, but it did not work – the cause of the failure is still under investigation.

➢ A spill of flammable material such as gasoline can form a dense flammable vapor cloud which can grow and spread at ground level until it finds an ignition source which can cause the cloud to explode.

What can you do?

➢ When you transfer material, make sure that you know where it is going.

➢ When you are pumping into a tank, if the level or weight indicator in that tank does not increase as you would expect, stop the transfer and find out what is happening.

➢ Make sure that all safety alarms and interlocks are tested at the frequency recommended by the plant process safety management procedures.

➢ If you have alarms and interlocks which are not regularly tested, ask if they are safety critical and should be on a regular testing program.

➢ Read the reports about this incident at http://www.buncefieldinvestigation.gov.uk
Simple Overfilling of Tanks
Buncefield Oil Storage - England
Simple Overfilling of Tanks
Simple Overfilling of Tanks
Simple Overfilling of Tanks
Simple Overfilling of Tanks

Low Pressure Storage Tank Levels

Not Designed to Hold Liquid

Caution

Acceptable Liquid Levels
Simple Overfilling of Tanks

- Operating Personnel must Have Process Safety Information & Understand Liquid Level Limits.
- Strong Consideration Must be Made for Overflow Protection including Hi-Hi Level Protection.
Simple Overfilling of Tanks
Simple Overfilling of Tanks
Simple Overfilling of Tanks
Simple Overfilling of Tanks
Simple Overfilling of Tanks

• This is a Small Tank.
• Need Separate Vent and Separate Overflow lines.
• Need Vacuum and Over Pressure Protection.
• Perhaps a More Robust Tank.
Over-Pressure Case Histories
Over-Pressure Case Histories

- 100 foot Diameter Remote Dock Tank
- Tank was Basically Empty
- All Product lines Blinded
- Occurred after a Hurricane Threat many years ago
Over-Pressure Case Histories

- The Tank Depended Upon a Tank Vent Device for Pressure & Vacuum.
- The Tank Nitrogen Padding System was in Operation.
- The Tank Vent Device was Tampered with as a “Precaution” for a Threat of a Hurricane.
Over-Pressure Case Histories

- There were Concerns that Winds Could Open these Hatches and Allow Torrential Rains to Enter.
- The Lid Should have been Tethered & Documented.
Over-Pressure Case Histories

• A Cold Front Passed thru the Area
• A Two Dollar Piece of Rope Resulted in $56,000 in Repairs

Costly Lesson

• Never Tamper with a Vent Without a Type of Management of Change
Under-Pressure Case Histories

• An 82 Foot Tall SS Stripper Column Topples as Water is Drained from this 5 ½ foot Diameter Vessel.
Under-Pressure Case Histories

• This was a Pre-Op of a Brand New Unit.

• The Process was to be Operated with Water, but the System was Accidentally Flooded.

• The Stripper was Vented to the Reabsorber.
Under-Pressure Case Histories

• Full Vacuum Design of Process Vessels Should be Considered.

• Vent Systems Must Be Properly Engineered.

• HazOps Must Be Used to Search for Potential Design Weaknesses.
Under-Pressure Case Histories

Environmental
“Improvement” Triggers
Tank Collapse

- Solvents Tank Size
  - 20 Feet in Diameter
  - 30 Feet High

- Tank Was Destroyed
  Beyond Repair
Under Pressure Case Histories

Diagram:
- Existing N2 Regulator
- Vent Compressors (Pre Start-Up Status)
- PS-2 (20'Ø x 30'H)
- P/V (SRV)
Under Pressure Case Histories

Diagram:
- **EXISTING N2 REGULATOR**
- **VENT COMPRESSORS (PRE START-UP STATUS)**
- **PS-2 (20'Ø x 30'H)**
- **P/V (SRV)**
Over-Pressure Case Histories

• Make sure Training is Complete and Fully Understood on MOC’s.

• If Small Impulse Valves Control Over-Pressure Devices and/or Vacuum Protection they must be locked.
Low Pressure Tanks Can & Do Collapse

Vent Systems Must Be Properly Designed & Properly Maintained.

The Feb 2007 “Beacon” states:

• Recognize that Vents Can Be blocked by well-intended People
• Never Cover or Block the Atmospheric Vent of an Operating Tank
• Inspect the Vents of Tanks Routinely for Plugging when in Fouling Service
Understand Local Hazards!
Fire Protection Approaches Must Be Evaluated
Understand Local Hazards!

“Consider Natural Hazards in PSM”
CEP – July 2008
Frank Liserio Jr. & Alan Svoboda
Beware of Local Conditions
Look Halfway Up the Stairs
Watch for Local Hazards
Need to think About Hurricanes & Floods
Need to think About Hurricanes & Floods
Low Pressure Tanks Can & Do Collapse

Sources of Good Information on Tanks

• Tank Farm and (Un)Loading Safe Operations Process Safety Booklet No.12 – BP’s Safety Sharing the Experience
• The AIChE “Beacons”
• Dr. Ronald Willey’s “Seminar on Tank Failures”
• API – 650 and API - 620
An Excellent Source of Basic Practical Information on Tanks & Tank Farms

Published 2004
Tanks Can Suffer from Corrosion
Tanks Can Suffer from Corrosion

• Tanks Must Be Inspected for Both Internal and External Corrosion.
An Internal Inspection often takes lots of preparation, but can be very revealing.
Inspections Can Be a Challenge

Here is a 90 foot tall process vessel with a funnel bottom.

How Do You Inspect It?
Tank Bottoms Do Corrode from Beneath the Tank Floor & You Can Not Easily Detect It
Magnetic Flux Leakage for Testing Tank Bottoms
Summary of Tanks A Lot

- Tanks, especially Low Pressure Storage Tanks, are Fragile.
- Such Tanks Can be Damaged by Slight Pressures or Vacuum.
- Follow Codes on Layout & Design.
- Routine Vessel Inspection and Maintenance is a Must.
Summary of Tanks A Lot
Follow Up with Paper Work is Critical
Any Questions ??