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CHEMICAL SAFETY *Alert*

Rupture Hazard from Liquid Storage Tanks

The Environmental Protection Agency (EPA) is issuing this *Alert* as part of its ongoing effort to protect human health and the environment by preventing chemical accidents. We are striving to learn the causes and contributing factors associated with chemical accidents and to prevent their recurrence. Major chemical accidents cannot be prevented solely through regulatory requirements. Rather, understanding the fundamental root causes, widely disseminating the lessons learned, and integrating these lessons learned into safe operations are also required. EPA publishes *Alerts* to increase awareness of possible hazards. It is important that facilities, State Emergency Response Commissions (SERCs), Local Emergency Planning Committees (LEPCs), emergency responders, and others review this information and consider whether additional action is needed to address the hazards.

Problem

Over the past few years, there have been several catastrophic failures of liquid fertilizer storage tanks resulting in property damage and environmental contamination. These ruptures have involved site-erected storage tanks with capacities ranging from 500,000 to 2 million-gallons. In several of the tank failures cited in this alert, the tanks were built by either Carolyn Equipment Company of Fairfield, Ohio, or Nationwide Tanks, Inc. of Hamilton, Ohio. Both of these companies have since gone out business (Carolyn Equipment in 1990 and Nationwide Tanks in 1995.) This alert describes some of the tank failures and identifies standards and precautions that apply to aboveground liquid storage tanks. While all users of aboveground liquid storage tanks should take appropriate steps to maintain tank integrity, owners of tanks produced by these two manufacturers are advised to take extra precautions to guard against tank failure.

Accidents

3/1997 in Iowa: A 1-million gallon tank containing ammonium phosphate ruptured and released its contents. The walls of the ruptured tank fell onto two other tanks and broke their valves. One tank contained 1-million gallons of a nitrogen liquid fertilizer and the other tank held ammonium thiosulfate. Much of the release was contained by an earthen dike, but immediate construction of a secondary, temporary dike was necessary to keep the release from flowing into the nearby Missouri River. Cleanup involved pumping the liquid out of the dikes and removing all contaminated soil.

7/1999 in Michigan: A 1-million gallon tank full of ammonium polyphosphate ruptured and damaged three other tanks. Fortunately, the tanks were surrounded by earthen dikes lined with polyethylene. This minimized the environmental damage.

1/8/2000 in Ohio: A 1-million gallon tank of liquid fertilizer ruptured and damaged four adjacent tanks. The wave of liquid broke a concrete dike wall and hit five tractor-trailer rigs, pushing two of the rigs into the river. A total of 990,000 gallons of material were released. More than 800,000 gallons of the liquid spilled into the Ohio River. Sampling detected amounts of the fertilizer mixture 100 miles downstream, which is expected to increase algae growth in the river. The company has discontinued use of seven other tanks purchased from the same manufacturer.

3/8/2000 in Ohio: At the same facility, a 1.5 million gallon tank of ammonium phosphate ruptured and damaged three nearby tanks causing them to leak. Two of the damaged tanks held phosphoric acid and the third one held 'Ice-Melt', a magnesium chloride mixture. The released liquid overflowed the dike walls into nearby creeks. The four tanks were dismantled after the incident. Over 1.8 million gallons of contaminant were recovered, with an additional 450,000 gallons of contaminated water recovered from the sewer system. The release caused evacuation of a nearby school, and the public was forced to use bottled water because of concern that the drinking water supply may be contaminated by the spilled chemicals.

11/12/2008 in Virginia: A 2-million gallon tank of urea ammonium nitrate fertilizer ruptured, seriously injuring two workers. The released liquid fertilizer overtopped the secondary containment berm surrounding the tank, partially flooded an adjacent residential neighborhood, and contaminated the southern branch of the Elizabeth River. Nearby residents were ordered to evacuate for several days.

Hazard Awareness

Defective Welds

In the incidents cited, all of the above-ground liquid storage tanks that failed appeared to have had defective welds. Several of the tanks were produced by either Carolyn Equipment Company or Nationwide Tanks Incorporated. Both companies have since gone out of business. These tanks were under warranty for only one year, and the welding of the tanks was done by subcontractors hired by the two companies. The companies built tanks in Michigan, Ohio, Indiana, Illinois, Missouri, and Iowa between 1980 and 1995. Because of increased frequency in tank failures, the Ohio Fire Division is creating a voluntary registry of liquid storage tanks to help track and prevent similar failures.

Chemicals Involved

The failed tanks have held liquid fertilizers, such as ammonium phosphate, which are not considered hazardous and are not regulated by the U.S. Environmental Protection Agency. However, the failure of these tanks can damage nearby tanks containing hazardous substances and cause releases. In some cases, accidents have involved tanks containing hazardous materials like anhydrous ammonia and phosphoric acid, which are used to produce the fertilizer ammonium phosphate.

Increased Hazard During First Fill

According to American Petroleum Institute (API) Standard 653, "Tank Inspection, Repair, Alteration, and Reconstruction," tanks are more likely to fail when being filled to the maximum level for the first time. Additionally, hydrostatic testing places greater than usual stresses on a tank shell, and therefore presents another potential failure scenario. Facilities should be aware of the additional hazard associated with initial fill and hydrostatic testing, and develop procedures or policies to prevent or mitigate failures that may occur at these times.

Hazard Identification

Facilities should evaluate their storage tanks for potential catastrophic failure. Some of the factors to consider include:

- Manufacturer's record for quality workmanship.
- Evidence of weakened or defective welds.
- Signs of corrosion around the base and direct contact with ground and exposed to moisture.
- Exposure to high winds or frequent precipitation.
- Age of the tank.
- Close proximity to other storage tanks containing hazardous chemicals.

Hazard Reduction/Prevention

The failure of liquid storage tanks can stem from inadequate tank design, construction, inspection, and maintenance. Hazard reduction and prevention starts with good design and construction. The risk to tanks already in service can be reduced through tank maintenance and weld inspection. To minimize effects from possible tank failures, there should be a secondary containment such as a dike or a berm surrounding the tank.

Tank Design and Construction

The Fertilizer Institute (TFI) has published uniform industry inspection and maintenance guidelines for aboveground liquid fertilizer storage tanks. According to the TFI guidelines, liquid fertilizer storage tanks should be designed and constructed according to API Standard 650, "Welded Steel Tanks for Oil Storage," and inspections of existing tanks should be based on API-653, but with modifications for the unique characteristics of tanks storing liquid fertilizer. API-650 specifies an allowance for corrosion and for the specific gravity of the fertilizer liquid.

In each of the tank failures mentioned, welding has been the main cause of failure. To ensure durability and integrity, it is imperative that the tank is welded correctly. Several standards and specifications outline the proper techniques and procedures for welding, including API-653.

Operational Hazards and Maintenance

Tank buyers should insist on seeing the tank's inspection record. Although tanks should undergo a rigorous inspection by a recognized inspection authority before a manufacturer's job is complete, the tanks should still be closely inspected by the buyer prior to purchasing the unit. For liquid storage tanks, the most important item to look for is complete penetration and complete fusion of the welds joining shell plates.

Once a tank has been purchased, it becomes the tank owner's duty to regularly inspect the tank. Inspection intervals may be set by using a risk-based inspection theory, as indicated by API-653.

Various inspection methods can be used for those tanks already in service. Radiography is the technique applied to all tanks designed to API-650 to ensure that complete penetration and fusion of welded joints has occurred. Unfortunately, this procedure cannot detect poor mechanical properties in the welded regions. This and other standards cover what types of joints must be checked by a radiograph, as well as the number of tests that must be done.

Additional inspections may be done visually or by several other methods. A vacuum box can identify localized problems. The vacuum box, approximately 6 inches by 30

inches, is tightly sealed to the tank surface, and pressure is applied. Automated ultrasonic testing can be applied to all shell welds to examine for cracks, fusion, penetration, and porosity with greater resolution than radiography. It is also now possible to conduct floor scanning while the tank is full. Combined with chemical analysis and hardness testing, field replication can assess the toughness, or resistance to brittle failure of a weldment.

If damage is found during an inspection, this needs to be assessed in accordance with the methodology described in API Std 579-1/ASME FFS-1 "Fitness for Service." Any tanks that do not meet the acceptance requirements set by API Std 579-1/ASME FFS-1 should be repaired or replaced.

Steps for Safety

Here are some additional ways to prevent rupture of liquid storage tanks:

- Realize the inherent risk of using and maintaining any storage tanks.
- Ensure that employees are aware of the hazards associated with the failure of a liquid storage tank.
- Avoid overfilling tanks.
- Perform regular inspections of tanks. Be sure to look for all possible risks.
- Follow up on problems identified during inspections by conducting repairs or, if necessary, replacing the tank.
- Replace, repair, or modify any and all tanks not meeting the standards set forth in API-Std 579-1/ASME FFS-1 methodology.
- Be on the alert for new tank regulations, standards, or recommended practices.
- Locate storage tanks and design and construct their secondary containment systems so as to separate the contents of a leaking or collapsing tank from the rest of the facility and to prevent any leakage from going offsite.
- Develop an emergency plan that addresses a catastrophic tank failure.
- Identify the manufacturers of the tanks on the property, being careful to identify any tanks built by either company mentioned in this alert. NOTE: If tanks were manufactured by Carolyn Equipment Company or Nationwide Tanks of Hamilton, take the following actions immediately:
  - A close external inspection should be made for leaks, corrosion, or any anomalies in the surface of the tank. Vent(s) should be checked for any blockages by foreign materials, such as snow or ice. The majority of the failures have occurred during the winter months, when steel becomes more brittle and when vents can become blocked by snow and ice. If liquid is drawn out of the tank when vents are plugged or restricted, a vacuum may be pulled on the tank causing it to collapse inward.
  - If you find evidence of leakage or corrosion during the inspection, the tank should be taken out of service and if possible, drained.
  - If there is no evidence of leakage or corrosion, arrange for an external evaluation by a qualified inspection agency.
  - Depending on the results of the evaluation, arrange for an internal inspection immediately or within the year.

Information Resources

References with information about the hazards of catastrophic storage tank failures and methods of minimizing them are listed below. Regulations potentially applicable to storage tanks and codes and standards that may be relevant are also included. A Chemical Safety Alert on catastrophic fires and explosions in storage tanks is available at: http://www.epa.gov/emergencies/docs/chem/cat-tnks.pdf.

Statutes and Regulations

- Clean Air Act Section 112(r)(1) – General Duty
- EPA's Risk Management Program Rule [40 CFR 68]
- OSHA Process Safety Management Standard [29 CFR 1910.119]
- EPA Spill Prevention, Control and Countermeasure Plan regulations [40 CFR 112]

Investigation Reports and Safety Videos

The U.S. Chemical Safety and Hazard Investigation Board (CSB) is an independent federal agency charged with investigating industrial chemical accidents. The CSB conducts root cause investigations of chemical accidents at fixed industrial facilities, publishes investigation reports, produces safety videos, and makes recommendations to plants, regulatory agencies, industry organizations, and labor groups:

Investigation Report: Allied Terminals, Inc. – Catastrophic Tank Collapse, Report No. 2009-03-I-VA

U.S. Chemical Safety and Hazard Investigation Board
2175 K Street, NW, Suite 650
Washington, DC 20037-1809
Phone: 202-261-7600
Web site: http://www.csb.gov

Codes and Standards

The Fertilizer Institute (TFI) has published guidelines for inspection and maintenance of aboveground liquid fertilizer storage tanks:

Aboveground Storage Tanks of Liquid Fertilizer: Recommended Inspection Guidelines

The Fertilizer Institute
820 First Street, N.E., Suite 430
Washington, DC 20002

The American Petroleum Institute (API) has tank standards and guidelines on safe welding:

API Standard 579-1/ASME FFS-1 – Fitness for Service

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

API Standard 650 – Welded Steel Tanks for Oil Storage

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

American Petroleum Institute
1120 L St NW
Washington DC 20005
Phone: 202-682-8000
Web site: http://www.api.org

The American Society of Mechanical Engineers (ASME) has the Pressure Vessel Code and other codes relevant to tanks and storage vessels:

American Society of Mechanical Engineers
1828 L St NW, Suite 906
Washington DC 20036
Phone: 800-843-2863
or 202-785-3756

Codes and standards: 212-705-8500
Accreditation and certification programs: 212-705-8581
Web site: http://www.asme.org

The American Society of Nondestructive Testing (ANT) certifies welding and non-destructive examination (NDE) and non-destructive testing (NDT) inspectors:

American Society of Nondestructive Testing
P.O. Box 28518
1711 Arlingate Lane
Columbus, OH 43228
Phone: 800-222-2768
Web site: http://www.asnt.org

The American Welding Society (AWS) certifies welding inspectors with the designation AWS QC-1 (Quality Control) Welding Inspector and has guidelines on safe welding.

American Welding Society
550 NW LeJeune Road
Miami, FL 33126
Phone: 800-443-9353
or 305-443-9353
Web site: http://www.amweld.org

For More Information:

Call the Superfund, TRI, EPCRA, Risk Management Program, and Oil Information Center
800-424-9346 or 703-412-9810
TDD 800-553-7672 or 703-412-3323

Visit the OEM Home Page at:
www.epa.gov/emergencies

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