U.S. CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD

INVESTIGATION REPORT

ALLIED TERMINALS, INC.– CATASTROPHIC TANK COLLAPSE

(Two Serious Injuries, Community Evacuation)

Photo courtesy of City of Chesapeake Fire Marshal

ALLIED TERMINALS, INC.

CHESAPEAKE, VIRGINIA

NOVEMBER 12, 2008

KEY ISSUES:

- LIQUID FERTILIZER STORAGE TANK STANDARDS
- TANK MODIFICATION FOR CHANGE-IN-SERVICE
- TANK INSPECTION

REPORT NO. 2009-03-I-VA

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List of Acronyms and Abbreviations

API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
AST	Aboveground Storage Tank
CEPPO	Chemical Emergency Preparedness and Prevention Office
CFR	Code of Federal Regulations
CSB	U.S. Chemical Safety and Hazard Investigation Board
CWA	Clean Water Act
DEQ	Virginia Department of Environmental Quality
DOLI	Virginia Department of Labor and Industry
EPA	U.S. Environmental Protection Agency
LOP	Lack of Penetration
OPA 90	Oil Pollution Act of 1990
TFI	The Fertilizer Institute
UAN 32	Urea Ammonium Nitrate Solution with 32 Percent Nitrogen

Executive Summary

On November 12, 2008, a 2-million-gallon liquid fertilizer tank (designated as Tank 201 by the owner) catastrophically failed at the Allied Terminals, Inc. (Allied) facility in Chesapeake, Virginia, seriously injuring two workers and partially flooding an adjacent residential neighborhood.

On the day of the incident, Allied was filling Tank 201 with liquid fertilizer to check for leaks prior to painting the tank. During the filling, a welder and his helper sealed leaking rivets on the tank.

At a fill level about 3.5 inches below the calculated maximum liquid level, the tank split apart vertically, beginning at a defective weld located midway up the tank. Within seconds, the liquid fertilizer overtopped the secondary containment, partially flooding the site and adjacent neighborhood. The collapsing tank wall injured the welder and his helper, who were working on the tank. Employees of a neighboring business responded and extricated them. At least 200,000 gallons of the liquid fertilizer were not recovered; some entered the southern branch of the Elizabeth River.

The CSB identified the following causes:

1. Allied did not ensure that welds on the plates to replace the vertical riveted joints met generally accepted industry quality standards for tank fabrication.

2. Allied had not performed post-welding inspection (spot radiography) required for the calculated maximum liquid level for the tank.

3. Allied had no safety procedures or policies for work on or around tanks that were being filled for the first time following major modifications and directed contractors to seal leaking rivets while Tank 201 was being filled to the calculated maximum liquid level for the first time.

The CSB makes recommendations to the U.S. Environmental Protection Agency, the Governor and Legislature of the Commonwealth of Virginia, Allied Terminals, Inc., HMT Inspection, Inc., and The Fertilizer Institute.

1.0 Introduction

1.1 Background

On November 12, 2008, at about 2:20 pm, a 2-million-gallon nominal capacity liquid fertilizer tank catastrophically failed at the Allied Terminals, Inc. (Allied) facility in Chesapeake, Virginia (Figure 1). The tank split open vertically and nearly instantaneously released about 2.1 million gallons of liquid fertilizer. A welder and his helper were working on the opposite side of the tank as it collapsed. Both sustained serious injuries due to the collapsing tank and immersion in the liquid fertilizer. Employees from a neighboring business (shown in upper left of Figure 1) rescued the two workers.

Photo courtesy of City of Chesapeake Fire Marshal

Figure 1. Allied collapsed tank and neighboring business.

As the liquid fertilizer released, it overtopped the secondary containment berm[1] surrounding the tank. The product flooded Rosemont Avenue, blocking egress for more than 100 employees at the adjacent business. It reached portions of the South Hill neighborhood, an adjacent residential community of 43 homes bordered on two sides by Allied's property (Figure 2). The City of Chesapeake Fire Department ordered residents to evacuate for several days. Weeks later, residents again had to leave their homes while an environmental cleanup firm repaired the damage to their property.

Photo courtesy of City of Chesapeake Fire Marshal

Figure 2. Location of South Hill neighborhood.

[1] Secondary containment for large storage tanks is usually an earthen berm surrounding the tank which has the capacity to contain the tank's contents if released slowly.

At the time of the incident, Allied was filling Tank 201, a liquid fertilizer storage tank, to its calculated "safe fill height"[2] of 27.01 feet. During the filling, the welder was to check for and repair leaking rivets. However, before the liquid reached the "safe fill height," a vertical weld seam failed and the tank ruptured.

The City of Chesapeake Fire Department and U.S. Environmental Protection Agency (EPA) On-Scene Coordinators managed the spill. Later, teams from the U. S. Chemical Safety Board (CSB), the City of Chesapeake Fire Marshal's Office, the Virginia Department of Labor, the EPA Oil and Prevention Branch, and the Virginia Department of Environmental Quality investigated.

1.2 Investigative Process

The CSB examined the collapsed tank *in situ*, photographed the incident site, interviewed eyewitnesses and responders, and made physical measurements of the failed tank. The CSB entered into a site control and evidence preservation agreement with Allied and the City of Chesapeake. The investigation team conducted additional interviews with Allied management, contractors, and tank inspection firms. In addition, the CSB met with organizations involved in the commercial fertilizer and liquid terminal industries, researched similar fertilizer tank incidents, and examined federal, Commonwealth of Virginia, and other state regulatory programs.

1.3 Liquid Fertilizer

The liquid fertilizer stored at Allied is a urea ammonium nitrate solution containing 32 percent total nitrogen (UAN 32). It is a non-flammable, stable aqueous salt solution. UAN 32 is a heavy, mildly

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[2] "Safe fill height," a term used by Allied, corresponds to the maximum liquid level as determined in API Standards 650 and 653.

corrosive, clear liquid with an ammonia odor and a density of about 11 pounds per gallon.[3] The EPA does not regulate UAN 32 fertilizer as a listed chemical.

1.4 Allied Terminals, Inc.

Allied Terminals, Inc., a subsidiary of Allied Marine Industries, Inc., is a small, privately-owned chemical storage company based in Norfolk, Virginia, that operates liquid terminals in Norfolk and Chesapeake, Virginia. The Chesapeake marine terminal (Figure 3) is adjacent to the southern branch of the Elizabeth River and provides contract storage and distribution of petroleum products and liquid fertilizers, which it receives by ship and pipeline and distributes by barge, rail, and truck. The terminal incorporates property and tanks purchased from BP Marine Terminals, ConocoPhillips, and Star Enterprises, Inc. between 1994 and 2000. The property north of Banks Street contained 10 fertilizer storage tanks, including Tank 201.

Figure 3. Allied's Chesapeake terminal.

[3] UAN has a specific gravity of 1.33, which is about 30 percent higher than the specific gravity of water.

1.5 HMT Inspection, Inc.

HMT Inspection, Inc. (HMT) is a division of HMT, Inc., an international aboveground storage tank (AST) service provider based in Houston, Texas. HMT performs tank inspection, non-destructive examination, and engineering evaluations in accordance with the requirements of American Petroleum Institute (API) Standard 653 (Section 1.7.1). HMT inspectors are certified by API and receive additional in-house inspection training.

1.6 G&T Fabricators, Inc.

G&T Fabricators, Inc. (G&T) is an independent welding company based in Wilmington, North Carolina. In the six and a half years prior to the incident, G&T performed tank modifications, pipe welding, and other maintenance work at Allied's Chesapeake and Norfolk terminals. During this period, G&T had three full-time employees and hired temporary employees as needed. The two contractors injured in the incident included one full-time and one temporary G&T employee.

1.7 Aboveground Storage Tank Standards

Several standards address industry practices for AST design, construction, maintenance, repair, and inspection. These standards, frequently codified into federal, state, or local regulations, typically apply to new construction or expansions and modifications inside an existing facility. The principal standards and organizations that address ASTs are summarized below.

1.7.1 American Petroleum Institute

API is a national trade association that includes 400 corporate members representing segments of the oil and natural gas industry. For more than 75 years, API has developed petroleum and petrochemical equipment and operating standards. API maintains more than 500 standards and recommended practices, many of which have been incorporated into state and federal regulations.

API Standard 650, *Welded Steel Tanks for Oil Storage*, dates back to 1961. This consensus standard establishes minimum requirements for material, design, fabrication, erection, and testing for vertical, cylindrical, aboveground, steel storage tanks for petroleum, petroleum products, and other liquids. Although written for the petroleum industry, this standard is widely used for the storage of both hazardous and non-hazardous liquids. Several states have incorporated API 650 by reference into their regulations for the storage of both hazardous and non-hazardous liquids, including liquid fertilizer (Section 4.4).

API Standard 653, *Tank Inspection, Repair, Alteration, and Reconstruction*, contains standards applicable to inspection, repair, alteration, and reconstruction of vertical, cylindrical, aboveground, steel storage tanks. Like API 650, API 653 is widely used and has been incorporated by reference into the storage tank regulations of several states.

API Standard 579-1/ASME FFS-1, *Fitness-For-Service* (2nd ed.), includes procedures to evaluate the integrity of a damaged or degraded component and estimate its remaining life. This standard provides techniques to evaluate flaws including, but not limited to, general and localized corrosion, weld misalignment and shell distortions, and crack-like defects.

1.7.2 The Fertilizer Institute

The Fertilizer Institute (TFI), headquartered in Washington, D.C., is a national organization representing the fertilizer industry. Two industry groups merged in 1969 to form TFI. TFI’s members include producers, transporters, distributors, retailers, and others involved in the fertilizer industry. TFI represents member interests regarding legislation and regulation, conducts studies, collects statistics, and provides information to members through conferences and newsletters. TFI membership includes 100 percent of domestic manufacturers, many of the nation’s largest retailers, and several international fertilizer manufacturers.

TFI issued *Aboveground Storage Tanks of Liquid Fertilizer, Recommended Inspection Guidelines* in 2001 in response to several catastrophic tank failures in the late 1990s and 2000 (Section 5). The guideline incorporates by reference API 650 and API 653 and includes additional fertilizer-specific requirements. Conformance with this guideline is voluntary; no state or federal regulations mandate its use.

At the time of the incident, four TFI members had contracted with Allied to store liquid fertilizer. Allied is not a TFI member.

1.8 The Elizabeth River

The Elizabeth River flows through the Cities of Norfolk, Chesapeake, and Portsmouth, Virginia.[4] This area has a long history of heavy industrialization and pollution of the waters of the river. Many liquid storage terminals, including all of the large liquid fertilizer storage tanks in Virginia, are located along the Elizabeth River.

The Elizabeth River Project is an independent non-profit organization that incorporated in 1993 to support the restoration of the river's environmental health. A board of directors, including local business and community leaders, university administrators, and present and former government officers, runs the Elizabeth River Project. The Elizabeth River Project provides technical support and recognition to businesses and industries in its "River Star" program. These businesses work to reduce pollution, create or conserve habitats, and recycle or reuse materials. Several terminals in the Elizabeth River watershed are River Star sites. Allied Terminals does not participate in the River Star program.

On September 15, 2008, the Elizabeth River Project launched a long-term initiative to make the river fishable and swimmable by 2020. One of the initiative's action items is to reduce the amount of nitrogen

[4] A portion of the Eastern Branch of the Elizabeth River also flows through the City of Virginia Beach.

fertilizer that enters the river, as it can increase algae growth and deplete the oxygen resources of aquatic species.

2.0 Incident Description

2.1 Events Preceding the November 12, 2008 Incident

Significant events preceding the November 12, 2008, catastrophic tank collapse at Allied include the following; Appendix A is an event timeline.

1. Circa 1929 – A 2-million-gallon riveted petroleum storage tank (now known as Tank 201) was constructed at a site at the end of Rosemont Avenue in what is now the City of Chesapeake.

2. Late 2000 – Allied negotiated the purchase of an idled petroleum terminal, which included Tank 201, at the end of Rosemont Avenue.

3. December 12, 2000 – Allied contracted AEC Engineering, Inc. (AEC)[5] to inspect storage tanks at the idled terminal.

4. January 2001 – AEC inspected Tank 201 and prepared a preliminary report establishing a maximum liquid level of "18.583 feet" [sic] for the liquid fertilizer Allied intended to store in the tank.

5. February 2001 – Allied canceled the AEC contract; AEC did not issue a final tank inspection report for Tank 201.

6. 2001 to 2006 – Allied used Tank 201 for liquid fertilizer storage. Allied provided no documentation with respect to the maximum liquid level ("safe fill height") used during this time.

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[5]AEC is a national tank engineering and inspection firm with a local office in Richmond, VA.

7. October 2006 – Allied contracted G&T to modify Tank 201 by replacing the vertical riveted joints with butt-welded joints.[6] This was to increase the strength of the joints, which would permit an increase in the maximum liquid level and allow more fertilizer to be stored in Tank 201.

8. January 3, 2007 – While G&T was modifying Tank 201, HMT performed an API 653 Out-of-Service inspection (Section 3.3) of the tank and calculated its "safe fill height" as 25.65 feet.[7]

9. September 18, 2007 – HMT specified a revised "safe fill height" of 27.01 feet for Tank 201 based on an April 2001metallurgical test report provided by Allied.

10. January 18, 2008 – Allied conducted a tank strength test[8] using liquid fertilizer, filling Tank 201 to a final height of 22 feet, 3 and 11/16 inches (22.31 feet).

11. January 2008 to November 2008 – Tank 201 was in service holding liquid fertilizer. Allied reported that the average fill height during this time was about five feet.

2.2 The Incident

On Tuesday November 11, 2008, Allied began filling Tank 201 with liquid fertilizer to find and repair rivet weeps[9] in preparation for painting the exterior of the tank. On Wednesday, November 12, 2008, at about 2:00 pm, while Allied continued filling the tank to a level between 26 and 27 feet, a welder and helper from G&T began sealing weeping rivets. The welder was working in a man-lift about 15 feet above ground. The helper was on the ground nearby.

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[6] A butt-weld joins two pieces of material along their entire thickness.

[7] Calculations were based on liquid with a specific gravity of 1.33.

[8] Allied filled the tank with liquid fertilizer product to test the tank. Although Allied referred to the test as a "hydrostatic test," the test performed did not conform to the API requirements for hydrostatic testing.

[9] A weep is a small leak that forms a wet spot on the tank exterior.

At about 2:20 pm, as the tank reached a level of 26.72 feet, a vertical split started midway up the shell and rapidly extended to the floor and roof of the tank on the side opposite the workers. As the pressure of the liquid fertilizer inside the tank opened the split, the tank shell separated from the bottom and roof (Figure 4), rapidly releasing the tank's contents.

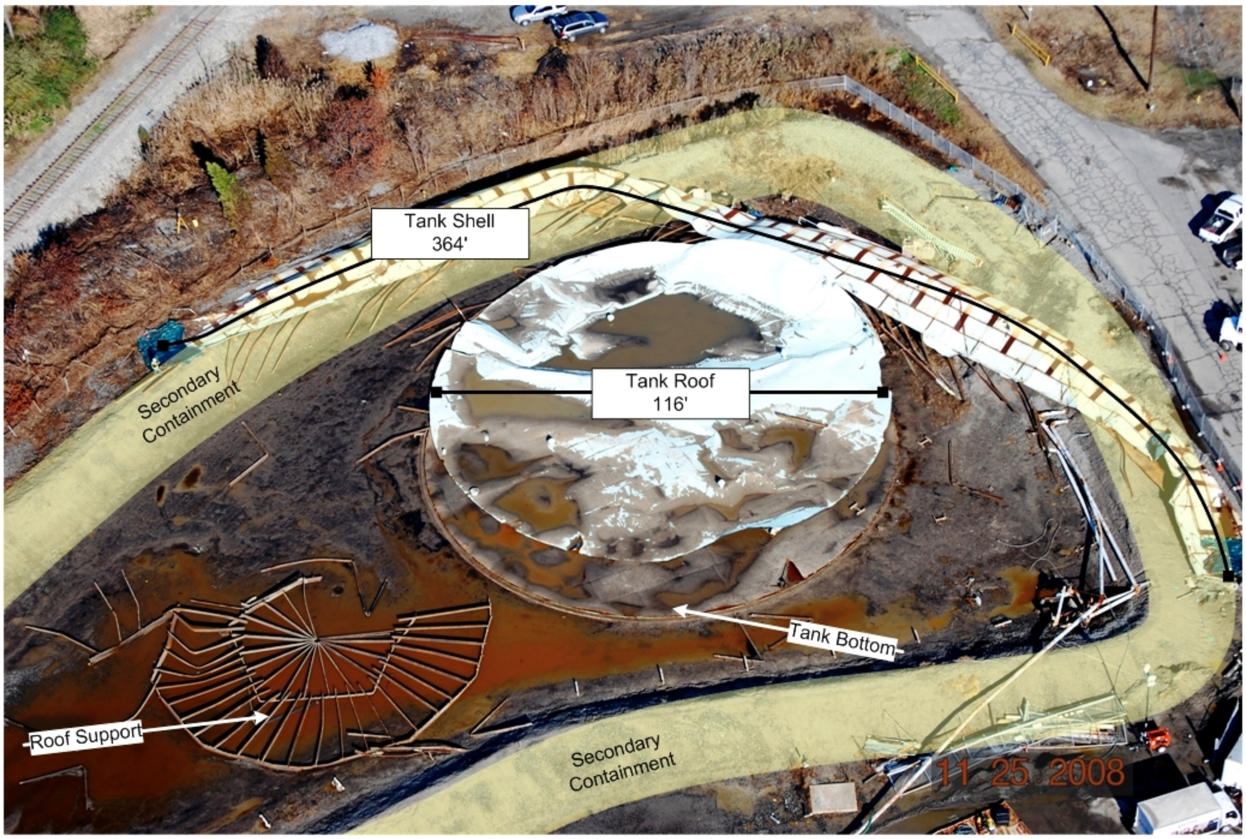


Photo courtesy of City of Chesapeake Fire Marshal

Figure 4. Tank 201.

The collapsing tank shell impacted the man-lift, seriously injuring the welder in the man-lift basket. The tank stairs fell away from the tank and pinned the helper to the ground. Both workers were briefly submerged under the liquid fertilizer. Employees from a neighboring business witnessed the accident and quickly extricated the workers. Figure 5 is a close-up of the accident scene showing the man-lift and stairs.

Figure 5. Location of injuries.

The liquid fertilizer overtopped the secondary containment, damaging a facility maintenance building and flooding portions of the facility and the South Hill neighborhood. At least 200,000 gallons[10] of the liquid fertilizer were unaccounted for following post-accident cleanup; some flowed into the nearby Elizabeth River, about 1,000 feet from the tank.

[10]As estimated by the EPA.

2.3 Post-Incident

Post-incident visual examinations of Tank 201 identified defective welds as the likely immediate cause of the tank failure. Post-incident visual examination of Tanks 202, 205, and 209 (all with welded modifications similar to Tank 201) revealed numerous welding defects similar to those observed on the remnants of the collapsed tank, including undersized welds, porosity, and weld undercut.[11]

2.3.1 CSB Urgent Recommendations

Because the potential for collapse of Tanks 202, 205, and 209 posed an unacceptably high risk of substantial property damage or injuries among the general public, the CSB made the following urgent safety recommendations to Allied on December 8, 2008.

- Take immediate action to reduce the risk of a catastrophic failure of Tanks 202, 205, and 209 at Allied Terminals Hill Street facility including but not limited to significantly reducing the maximum liquid levels ("safe fill height") based on sound engineering principles. Report the actions taken to the City of Chesapeake.

- Select and retain a qualified, independent tank engineering firm to evaluate Tanks 202, 205, and 209 and determine their fitness for continued service. The evaluation should be based on recognized and generally accepted good engineering practices, such as API 653 - *Tank Inspection, Repair Alteration, and Reconstruction* and API 579 - *Fitness for Service*.

[11] Holes in welds due to gas bubbles are called "porosity." Insufficient weld material along the edge of a weld is called "undercut."

- Within 30 days, provide the report prepared by the independent tank engineering firm to the City of Chesapeake, together with a comprehensive action plan and schedule to address any identified deficiencies.

The CSB released these urgent recommendations at a joint press conference with the City of Chesapeake.

2.3.2 Tank 209

The City of Chesapeake, through the Fire Marshal's Office, independently investigated the Allied incident. Based on the evidence collected and the concern for the safety of the residents of the South Hill neighborhood, the City of Chesapeake found Tank 209 to be an imminent danger, condemned the tank on December 22, 2008, and ordered Allied to drain it within 30 days. Allied drained the tank in accordance with the City's order.

Figure 6. Tank 209.

2.3.3 Engineering Evaluation

In response to the CSB's urgent recommendations, Allied contracted Thielsch Engineering, Inc. (Thielsch) to conduct an evaluation of the vertical weld joints on Tanks 202, 205, and 209. Thielsch performed visual and non-destructive inspections[12] of the welds. For Tank 209, the inspections indicated up to 75 percent lack of penetration (LOP) in the vertical butt-weld joint of the insert plates.[13] Based on these results, Thielsch calculated the maximum liquid level for the liquid fertilizer in Tank 209 as 10.227 feet, significantly less than the 32.14-foot maximum liquid level established in September 2007 by HMT. Thielsch's report is included as Appendix B.

Fitness-for-Service examinations for Tanks 202 and 205 also identified significant LOP in the welds. The engineering firm recommended significantly reducing the maximum liquid levels for these tanks as well.

[12] The non-destructive examination used an ultrasonic shearwave technique to examine the internal features of the welds.

[13] Lack of weld penetration refers to welds that do not penetrate the full thickness of the plates being welded (Section 4.5).

3.0 Incident Analysis

3.1 Tank 201

Tank 201, originally designed and constructed in 1929 for petroleum product storage, was 116 feet in diameter and about 30 feet high. The shell was constructed of overlapping riveted plates, each approximately 6 feet high and 14 feet long. The plates were joined end to end to form six rings (courses) that were stacked to form the tank. A single row of rivets joined the courses horizontally, while three vertical rivet rows joined the plate ends on the bottom two courses and two rows joined the plate ends on the upper four courses (Figure 7). Overlapping welded plates were used on the bottom and the cone-shaped roof. A second tank bottom was added inside the tank prior to Allied's purchase of the facility.

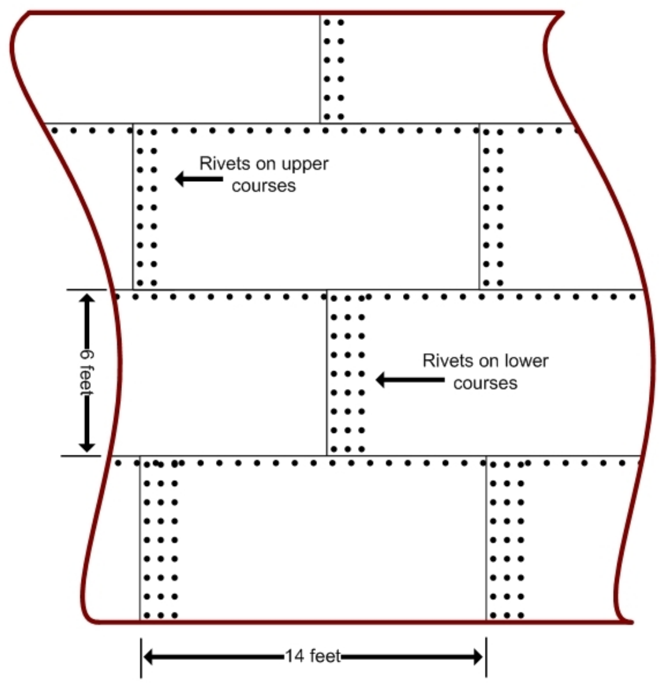


Figure 7. Tank 201 design prior to modification.

3.2 Tank Modification

The liquid fertilizer stored in Tank 201 weighed more per unit volume (density) than the petroleum products for which the tank was designed (about 11 pounds per gallon for the UAN 32 solution compared to 6 pounds per gallon for petroleum products). To increase the usable capacity of the tank, Allied contracted G&T to remove 18-inch wide sections of the shell plates containing the vertical riveted joints and replace them with butt-welded plates,[14] following the requirements of API 653 (Figure 8). Allied intended this modification to strengthen the joints and permit a higher maximum liquid level, and contracted G&T to perform the same modification on three similar tanks: Tanks 202, 205, and 209.

Allied did not have the modifications to Tanks 201, 202, 205, and 209 approved by an authorized inspector or an engineer experienced in storage tank design as required by API 653.

API 653 requires welding procedures and welders be qualified by a formal performance test in accordance with the ASME Boiler and Pressure Vessel Code Section IX: Welding And Brazing Qualifications. API 653 also requires verifying the weldability of steel from existing tanks when the type of steel is unknown. The weldability test involves welding samples removed from the tank and subjecting them to mechanical strength tests. Neither Allied nor G&T prepared and qualified a weld procedure in accordance with these requirements. In addition, while some of the G&T welders were previously qualified to weld similar materials, none qualified on Tank 201 material.

[14] A butt-welded joint can be as strong as the material it connects, while a riveted joint is generally weaker.

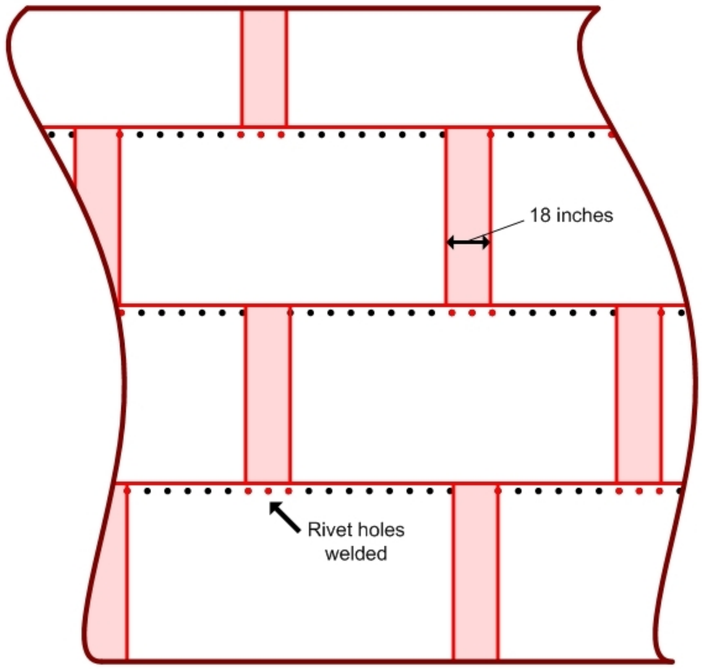


Figure 8. Tank 201 modification design.

Following the modifications, Allied paid a non-destructive testing company to examine the welds for defects using spot radiography.[15] However, Allied paid for the examination of only the lower two courses of Tanks 202 and 209. The upper courses of Tanks 202 and 209 and the entirety of Tanks 201 and 205 were not radiographed prior to returning these tanks to service. The radiography performed identified multiple weld defects in the lower courses of both 202 and 209.[16]

[15] Radiographic weld inspection uses gamma-ray technology to identify subsurface weld flaws. Spot radiography examines a small percentage of the length of each weld; full radiography examines the full length of all welds.

[16] Based on documentary evidence, it is unclear whether all of these defects were repaired.

Photo from HMT inspection report.

Figure 9. Modified Tank 201.

3.3 Tank Inspection

Allied contracted with both AEC and HMT to perform API 653 Out-of-Service inspections of Allied's fertilizer storage tanks. An API 653 Out-of-Service inspection typically includes internal and external visual inspections for corrosion and degradation; measuring tank roof, floor, and shell thicknesses; and calculating a maximum liquid level. Tank inspectors calculate the maximum liquid level based on

- minimum measured shell thicknesses,
- material type (from a list of known materials or unknown material),
- joint design (welded or riveted), and
- extent of weld inspection (full, spot, or no radiography).

AEC inspected the tanks in late 2000 and early 2001 before Allied contracted G&T to replace the vertical rivet joints with butt-welded plates. As part of the inspection, AEC determined maximum liquid levels for the tanks based on the requirements specified in API 653 for riveted construction of an unknown material type[17] using the smallest (minimum)[18] of 228 thickness measurements taken on the lowest tank course.[19]

HMT performed inspections in 2004 through 2007. As part of this effort, HMT calculated “safe fill heights” for Tanks 201, 202, 205, and 209 based on the requirements of API 653 for a spot radiographed butt-welded vertical joint of an unknown material type using the average of 10 thickness measurements from the lowest course. In September 2007, following the issuance of the inspections reports, HMT increased the “safe fill heights” for Tanks 201, 202, and 209 based on a known material type. HMT chose this material type based on the test results[20] from a single sample from each tank. Table 1 summarizes the calculated maximum liquid levels.

[17] When the material type is unknown, API requires using lower allowable limits in calculating a maximum liquid level.

[18] API 653 paragraph 4.3.3.1 specifically requires using the minimum measured thickness .

[19] For Tank 201, the thickness of the lowest course limited the maximum liquid level.

[20] Chemical composition and mechanical strength tests.

Table 1. Calculated maximum liquid levels.

Tank	AEC Engineering Pre-modification	HMT Inspection Post-modification	HMT Inspection September 2007
201	18.70	25.65	27.01
202	17.00	26.14	27.45
205	25.92	35.00[21]	--
209	19.25	30.60	32.14

HMT's use of test results from a single sample from each tank was not sufficient to establish the material type for the entire tank. The only provision in API 653 for establishing the properties of an unknown material based on testing is in paragraph 7.3 "Original Materials for Reconstructed Tanks."[22] This paragraph requires sampling and testing each individual plate. In the case of Tank 201 this would have been more than 150 samples. Additionally, HMT's use of the average of only 10 thickness measurements resulted in a higher than allowed maximum liquid level for Tank 201. Had HMT used minimum measured thickness of the plate (0.485 inches), the HMT-calculated maximum liquid level would have been about 1.5 inches less than the level at which the tank failed.

3.4 Tank 201 Failure

Welds on the plates to replace the vertical riveted joints failed because the welds (Figure 10) did not meet generally accepted industry quality standards for tank fabrication. The welds did not penetrate the full thickness of the plates. Furthermore, the welds contained defects—porosity (holes from gas bubbles in

[21] Fill height for Tank 205 was limited by the tank's physical height.
[22] A tank which is disassembled and reconstructed at a new location.

the weld) and undercut (insufficient weld material along the edge of the weld)—that significantly degraded the strength of the welds.

Figure 10. Failed tank weld on course three.

Had the welds been radiographed as required by API 653, these weld defects would most likely have been detected and should have been repaired.

3.5 Allied Safe Work Practices

Tanks are more likely to fail when being filled to the maximum level for the first time.[23] Allied had no safety procedures or policies for work on or around tanks following construction or major modifications.

[23] API 653 section 5.2.2 discusses tank failure during hydrostatic testing or first fill.

Allied directed G&T to seal leaking rivets while Tank 201 was being filled to its calculated "safe fill height" for the first time. Both G&T workers were injured when the tank collapsed.

3.6 Analysis Summary

Although Allied documents required API 653 be applied for the modification and inspection of Tank 201, key requirements were not met, including (but not limited to)

- Allied did not use an authorized inspector or an engineer experienced in storage tank design to approve the modifications to Tank 201.
- G&T did not use qualified weld procedures or welders to perform the modification in accordance with the ASME Boiler and Pressure Vessel Code, Section XI: Welding and Brazing Qualification.
- Allied did not require or perform spot radiography on Tank 201.[24]
- HMT calculated a maximum liquid level for Tank 201 using the requirements for weld joints that are spot radiographed.
- HMT calculated a maximum liquid level for Tank 201 based on an average wall thickness in lieu of a minimum wall thickness.

Had Allied, G&T, and HMT all followed the requirements of API 653, Tank 201 would not have failed.

[24] API 653 states that the owner/operator of a tank has ultimate responsibility to ensure requirements, including radiography, are met.

4.0 Regulatory Analysis

4.1 Environmental Protection Agency

The EPA regulates ASTs under the Oil Pollution Act of 1990 (OPA 90). Regulatory programs under this act require facilities, including aboveground storage facilities, to develop and implement Spill Prevention, Control, and Countermeasure (SPCC) Plans to address potential oil discharges and Facility Response Plans (FRP) for worst-case oil discharge scenarios. Allied's Chesapeake terminal is subject to these regulations for its petroleum storage tanks. Storage of other materials, including liquid fertilizer, is not covered under OPA 90.

The Clean Water Act (CWA) regulates discharge of pollutants to waters of the United States including surface waters such as the Elizabeth River. Although the CWA does not specifically address ASTs, *any* unpermitted release to waterways—even an accidental release such as the incident at Allied—is subject to CWA enforcement. However, the CWA does not mandate steps to take to prevent such releases.

No EPA program specifically regulates non-petroleum service ASTs. Individual states are responsible for any non-petroleum AST regulation. However, following a series of catastrophic liquid fertilizer tank failures between 1997 and 2000 (Section 5), EPA's Chemical Emergency Preparedness and Prevention Office (CEPPO) issued a *Rupture Hazard from Liquid Storage Tanks* Chemical Safety Alert (Appendix C). The alert summarized tank failures due to defective welding, cautioned owners of ASTs in all liquid services to be aware of rupture risks, and provided guidance for proper AST inspection and maintenance. To minimize risk, it recommended the use of API Standards 650, 653, and 579 for tank construction, inspection, and modification, respectively.

4.2 Virginia Department of Environmental Quality

The Virginia Department of Environmental Quality (DEQ) regulates petroleum ASTs under Virginia's "Facility and Aboveground Storage Tank Regulations." Neither the Commonwealth of Virginia nor the City of Chesapeake regulates non-petroleum ASTs.[25]

4.3 State Aboveground Storage Tank Regulations

The CSB identified 17 states that have regulatory programs applicable to storage of liquid fertilizer in ASTs (Appendix D). All of these have some requirement for secondary containment, and most also include inspection, recordkeeping, and facility permitting or registration requirements. Thirteen state programs are specific to fertilizer; four states enforce more general AST regulations that may include fertilizer tanks. Seven state programs incorporate API 650 or 653 standards for tank construction, inspection, and repair.

[25] Under Virginia law, local jurisdictions generally may not exercise authorities not specifically granted to them by the state. The Commonwealth of Virginia has not granted such authority with regard to regulation of ASTs.

5.0 Similar Incidents

In addition to the incident at Allied, the CSB found 16 other tank failures at nine facilities in other states between 1995 and 2008. These 16 failures resulted in one death, four hospitalizations, one community evacuation, and two releases to waterways (Appendix E). Eleven occurred due to defective welding.

In 1989, a large fertilizer tank, similar to the one at Allied, collapsed at a terminal in Chesapeake, Virginia. The tank released hundreds of thousands of gallons of UAN solution into the southern branch of the Elizabeth River.

6.0 Findings

1. Although The Fertilizer Institute issued recommended inspection guidelines for liquid fertilizer tanks in 2001, incorporating API 653 by reference, Allied was unaware of these guidelines prior to the incident.

2. HMT calculated a “safe fill height” for Tank 201 using the requirements for weld joints that are spot radiographed. Allied did not ensure spot radiography was performed on Tank 201.

3. Tank 201 failed at a liquid level of about 26.74 feet, which was less than the calculated “safe fill height” of 27.01 feet.

4. Allied had no safety procedures or policies for work on or around tanks that were being filled for the first time following construction, reconstruction, or major modification. The collapse of Tank 201 seriously injured the two contractors working on the tank.

5. The liquid fertilizer overtopped the secondary containment, flooding portions of the facility and an adjacent residential neighborhood. Liquid fertilizer also spilled into the nearby Elizabeth River.

6. Post-incident visual examination of Tank 201 identified defective welds as the likely immediate cause of the tank failure.

7.0 Causes

1. Allied did not ensure that welds on the plates to replace the vertical riveted joints met generally accepted industry quality standards for tank fabrication.

2. Allied had not performed post-welding inspection (spot radiography) required for the calculated maximum liquid level for the tank.

3. Allied had no safety procedures or policies for work on or around tanks that were being filled for the first time following major modifications and directed contractors to seal leaking rivets while Tank 201 was being filled to the calculated maximum liquid level for the first time.

8.0 Recommendations

United States Environmental Protection Agency.

2009-03-I-VA-R4

Revise and reissue the Chemical Emergency Preparedness and Prevention Office *Rupture Hazard from Liquid Storage Tanks* Chemical Safety Alert. At a minimum, revise the alert to

- Include the Allied Terminals tank failure,
- Discuss the increased rupture hazard during first fill or hydrostatic testing, and
- List The Fertilizer Institute fertilizer tank inspection guidelines in the reference section.

Governor and Legislature of the Commonwealth of Virginia

2009-03-I-VA-R5

Require state regulation of 100,000-gallon and larger fertilizer storage tanks (which presently are located solely along and in the area of the Elizabeth River) or authorize local jurisdictions to regulate these tanks. The regulations should

- Address design, construction, maintenance, and inspection of 100,000-gallon and larger liquid fertilizer storage tanks, and
- Incorporate generally recognized and accepted good engineering practice.

Allied Terminals, Inc.

2009-03-I-VA-R6

Hire a qualified independent reviewer to verify that maximum liquid levels for all tanks at Allied's Norfolk and Chesapeake terminals meet the requirements of American Petroleum Institute Standard 653, *Tank Inspection, Repair, Alteration, and Reconstruction*. At a minimum, the review should verify that all requirements for welding, inspection of welds, and In-Service and Out-of-Service tank inspections are met. Make the complete review report for both terminals available to the Cities of Norfolk, Chesapeake, and Portsmouth, Virginia, as well as the Virginia Department of Environmental Quality.

2009-03-I-VA-R7

Develop and implement worker safety procedures for initial filling of tanks following major modification or change-in-service. At a minimum, require the exclusion of all personnel from secondary containment during the initial filling.

HMT Inspection, Inc.

2009-03-I-VA-R8

Implement The Fertilizer Institute's inspection guidelines as part of tank inspector training and inspection procedures for fertilizer tank inspection.

2009-03-I-VA-R9

Revise company procedures to require tank inspectors to verify that radiography required as part of the calculation for a maximum liquid level has been performed.

The Fertilizer Institute

2009-03-I-VA-R10

Formally recommend to all member companies the incorporation of The Fertilizer Institute tank inspection guidelines into contracts for the storage of liquid fertilizer at terminals.

By the

U.S. Chemical Safety and Hazard Investigation Board

John S. Bresland

Chair

Gary Visscher

Member

William Wark

Member

William Wright

Member

Date of Board Approval

References

American Petroleum Institute (API), 2007. *Welded Steel Tanks for Oil Storage*, API 650, 11th edition.

American Petroleum Institute (API), 2008. *Tank Inspection, Repair, Alteration, and Reconstruction*, API 653, 3rd edition, Addendum 3.

American Society of Mechanical Engineers (ASME), 2004. *Boiler and Pressure Vessel Code, Section IX: Welding and Brazing Qualifications.*

Atherton, W., no date. *Catastrophic Failure of Storage Tanks and Secondary Containment*, Liverpool Moors University, School of the Build Environment. Accessed 13 February 2009 via http://www.ljmu.ac.uk/BLT/BUE_Docs/atherton.pdf

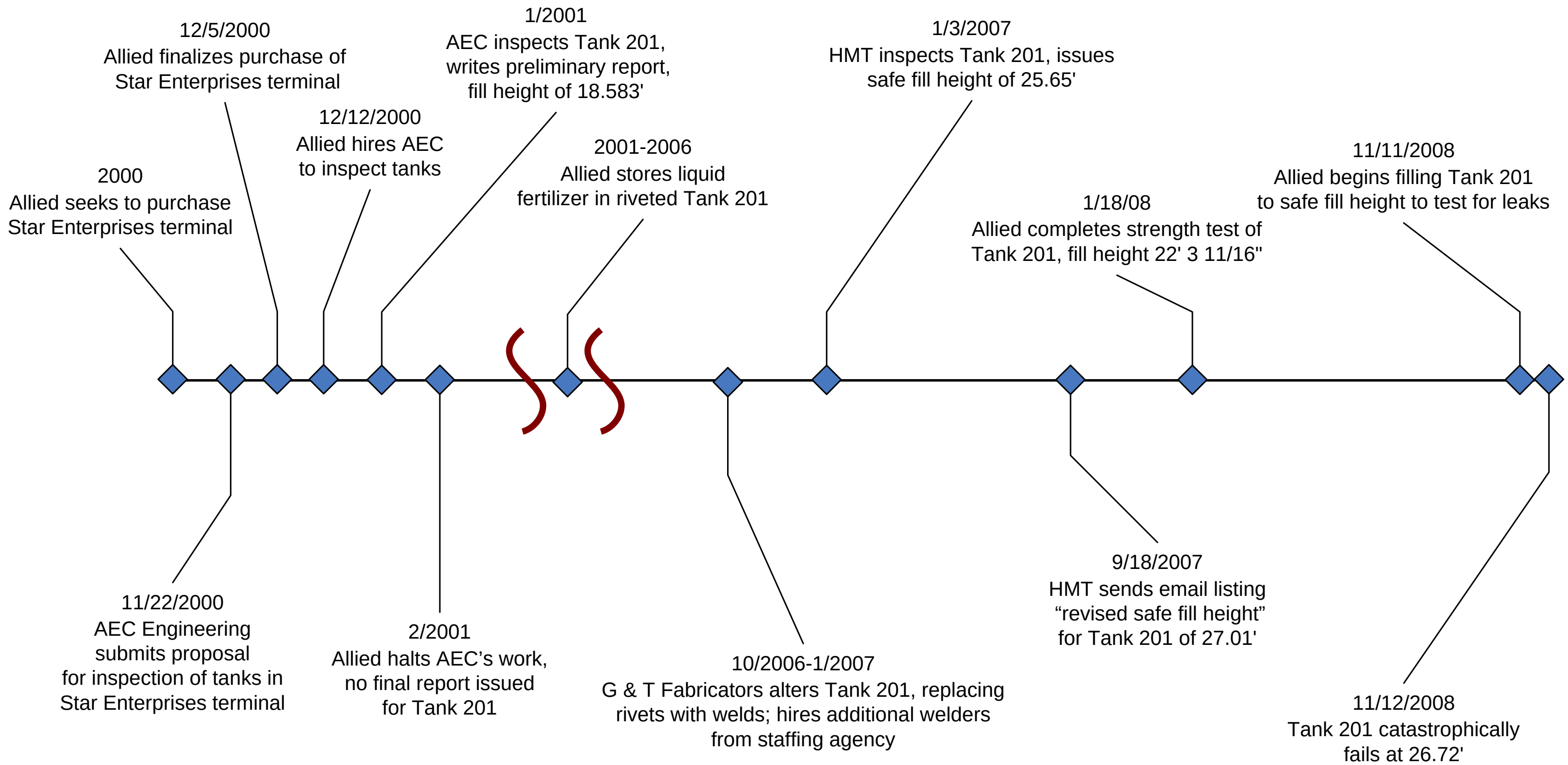
Chemical Emergency Preparedness and Prevention Office (CEPPO), 2001. *Rupture Hazard from Liquid Storage Tanks*, United States Environmental Protection Agency (EPA).

Cornell, J.R., and Baker, M.A., 2002. *Catastrophic Tank Failures: Highlights of Past Failures along with Proactive Tank Designs*, Paper presentation at U.S. EPA Fourth Biennial Freshwater Spills Symposium, March 19-21, 2002.

Myers, P. E., 1997. *Aboveground Storage Tanks*, McGraw-Hill.

Appendix A

Event Timeline


2000
Allied seeks to purchase
Star Enterprises terminal
12/5/2000
Allied finalizes purchase of
Star Enterprises terminal
12/12/2000
Allied hires AEC
to inspect tanks
1/2001
AEC inspects Tank 201,
writes preliminary report,
fill height of 18.583'
2001-2006
Allied stores liquid
fertilizer in riveted Tank 201
1/3/2007
HMT inspects Tank 201, issues
safe fill height of 25.65'
1/18/08
Allied completes strength test of
Tank 201, fill height 22' 3 11/16"
11/11/2008
Allied begins filling Tank 201
to safe fill height to test for leaks
11/22/2000
AEC Engineering
submits proposal
for inspection of tanks in
Star Enterprises terminal
2/2001
Allied halts AEC's work,
no final report issued
for Tank 201
10/2006-1/2007
G & T Fabricators alters Tank 201, replacing
rivets with welds; hires additional welders
from staffing agency
9/18/2007
HMT sends email listing
"revised safe fill height"
for Tank 201 of 27.01'
11/12/2008
Tank 201 catastrophically
fails at 26.72'

Appendix B

Tank 209 Engineering Evaluation

THIELSCH ENGINEERING, INC.

195 Frances Avenue
Cranston, Rhode Island 02910-2211
Tel. (401) 467-6454
Fax. (401) 467-2398

January 30, 2009

Patrick A. Genzler, Esq.
Vandeventer Black LLP
500 World Trade Center
Norfolk, VA 23510-1699

SUBJECT: Results of Tank 209 and "As-Is" Safe Fill Height

Dear Patrick:

We have reviewed the results of the ultrasonic (UT) inspection and visual examination of Tank 209 and performed calculations to determine a safe fill height in the "as-is" condition.

The UT test results indicated that the vertical butt-weld joint of the insert plates, in bottom course No. 1, did not show a lack of penetration (LOP) except for the 4" segment of the welds where the insert plate overlaps the upper course, which indicated 50% LOP.

The UT data from 50% of the insert plates in the bottom course No. 2 was similar to the results obtained in course No. 1. We have assumed that the remaining 50% of course No. 2 insert plate would exhibit similar UT results.

The results of the UT inspection of bottom course No. 3 indicated that the LOP is above 50%. Lack of penetration in the vertical butt-weld joints in courses Nos. 4, 5 and 6 was in the 75% range. The calculations for the safe fill height, of a liquid with 1.33 Specific Gravity, would be limited to the joint integrity of bottom course No. 3. The results of this calculation indicated that the fill height is 10.227 ft.

Please let me know if you have any questions.

Very truly yours,

THIELSCH ENGINEERING, INC.

Ara Nalbandian

Ara D. Nalbandian, P.E.
Vice President, Engineering

Note: Vandeventer Black, LLP is the law firm representing Allied.

Appendix C

Rupture Hazard from Liquid Storage Tanks

United States Environmental Protection Agency
Office of Solid Waste and Emergency Response (5104)
EPA 550-F-01-001
January 2001

EPA

CEPP

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. EPA is 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, SERCs, LEPCs, emergency responders, and others review this information and take appropriate steps to minimize risk. This document does not substitute for EPA's regulations, nor is it a regulation itself. It cannot and does not impose legally binding requirements on EPA, states, or the regulated community, and the measures it describes may not apply to a particular situation based upon circumstances. This guidance does not represent final agency action and may change in the future, as appropriate.

CHEMICAL SAFETY

ALERT

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 1.5 million-gallons. The tank failures, which prompted this alert, were all 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. Owners of tanks produced by these two manufacturers are advised to take extra precautions to guard against tank failure.

NOTE: Though all failed storage tanks cited in this alert have been produced by these two companies, owners of all storage tanks should be aware of the risks associated with operating a storage tank.

Accident History

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.

Hazard Awareness

Defective Welds

In the incidents cited, all of the above-ground liquid storage tanks that failed appeared to have had defective welds. The tanks were all produced by either Carolyn Equipment Company or Nationwide Tanks Incorporated. Both companies have since gone out of business. The 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.

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

A tank should be designed and constructed according to API-650, "*Welded Steel Tanks for Oil Storage*:" issued by the American Petroleum Institute (API). 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, "*Tank Inspection, Repair, Alteration, and Reconstruction.*"

Operational Hazards and Maintenance

Tank buyers should insist on seeing the 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 a vacuum box for 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 and 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 API-RP579 *"Fitness for Service"* methodology. Any tanks that do not meet the acceptance requirements set by API-RP579 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.

- 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.

- 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 identified problems with repairs or replacement. Inspections are otherwise useless.

- Replace, repair, or modify any and all tanks not meeting the standards set forth in API-579, *"Fitness for Service"* methodology.

- Be on the alert for new tank regulations. (There were recently changes made to API-653 that improved the suggested calculations)

- Consider better mitigation in case of a leak to separate the content of a collapsing tank from the rest of the facility, and more importantly, prevent any leakage from going offsite.

- Develop an emergency plan that addresses a catastrophic tank failure.

Information Resources

References with information about the hazards of catastrophic 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 www.epa.gov/swercepp/pubs/cat-tnks.pdf

Statutes and Regulations

Section 112(r) of the Clean Air Act focuses on prevention of chemical accidents. Facilities with regulated substances or other extremely hazardous substances have a general duty to prevent and mitigate accidental releases. Accident prevention activities include identifying hazards and operating a safe facility.

EPA's Risk Management Program (RMP) Rule [40 CAR 68] is intended to prevent and mitigate accidental releases of listed regulated substances. RAMP rule requirements include development of a hazard assessment, a prevention program, and an emergency response program.

EPA has tank inspection regulations under the Spill Prevention Countermeasure and Control Plan and Oil Pollution Control Act of 1990 [40 CFR112].

The Occupational Safety and Health Administration's (OSHA) Process Safety Management Standard [29 CAR 1910.119] includes regulations on tank inspection, and conduct during hot-work; and fire protection and prevention during welding, brazing, and cutting [29 CAR 1910.252].

Occupational Safety and Health Administration
Phone: (202) 219-8151 - Public Information Web site: http://www.osha.gov

Codes and Standards

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

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

Relevant API standards:

API Standard 620 – Design and Construction of Large, Welded, Low-Pressure Storage Tanks, ninth edition, February 1996 (includes Addendum 1, December 1996)

API Standard 650 – Welded Steel Tanks for Oil Storage, ninth edition, May 1993 (includes Addendum 1, December 1994; Addendum 2, December 1995; and Addendum 3, December 1996).

API Standard 653 – Tank Inspection, Repair, Alteration, and Reconstruction, second edition, December 1995 (inc. Addendum 1, December 1996)

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 Rd
Miami, FL 33126
Phone: (800) 443-9353 or (305) 443-9353
Web site: http://www.amweld.org

For More Information...

Contact the EPCRA Hotline at (800) 424-9346 or (703) 412-9810 TDD (800) 553-7672
Monday-Friday 9:00 a.m. to 6:00 p.m. EST
****

Visit the CEPPO Home Page at www.epa.gov/ceppo

Appendix D

State Regulations for Aboveground Fertilizer Storage Tanks

State	Program Description	Secondary Containment	Inspection	Record-keeping	Permitting/ Registration	Incorporates API 650 & 653	Reference
Delaware	Jeffrey Davis Aboveground Storage Tank Act and subsequent regulations apply to tanks converted from petroleum service after 1992, regardless of their current contents	Yes	Yes	Yes	Yes	Yes	Delaware Administrative Code Title 7 Regulations Governing Aboveground Storage Tanks
Florida	Department of Environmental Protection regulates Aboveground Storage Tank Systems containing pollutants, including substances that release ammonia when discharged	Yes	Yes	Yes	Yes	Yes	Florida Administrative Code 62-762
Illinois	Department of Agriculture regulates all agrichemical facilities storing commercial bulk fertilizer	Yes	Yes	Yes	Yes	No	8 Illinois Administrative Code (IAC) Chapter I Part 255
Indiana	Indiana State Chemist enforces Indiana Commercial Fertilizer Rules for facilities storing fluid bulk fertilizer in quantities greater than 55 gallons	Yes	No	No	Yes	No	355 Indiana Administrative Code (IAC) 2
Iowa	Agriculture and Land Stewardship Department regulates Containment of Pesticides, Fertilizers, and Soil Conditioners, including storage of fertilizer in volumes greater than 5,000 gallons	Yes	No	No	No	No	Iowa Administrative Code (IAC) 21-44(206)
Kansas	Department of Agriculture regulates bulk storage of commercial fertilizers in amounts more than 2,000 gallons	Yes	Yes	Yes	Yes	650 only	Kansas Administrative Regulations (KAR) 4-4-900
Kentucky	Department of Agriculture Division of Pesticide Regulation regulates storage and handling of bulk fertilizer in amounts greater than 5,000 gallons at commercial facilities	Yes	Yes	No	Yes	No	302 Kentucky Administrative Rules (KAR) 31:040
Massachusetts	Office of the State Fire Marshal enforces regulations requiring permitting, recordkeeping, and inspection of all aboveground storage tanks over 10,000 gallons capacity	Discretion of fire dept.	Yes	Yes	Yes	Or equal	502 Code of Massachusetts Regulations (CMR) 5.00

State	Program Description	Secondary Containment	Inspection	Record-keeping	Permitting/ Registration	Incorporates API 650 & 653	Reference
Michigan	Department of Agriculture regulates on-farm bulk storage of fertilizer of more than 2,500 gallons in one container or more than 7,500 gallons aggregate	Yes	Yes	No	No	No	Michigan Administrative Code R 285.642
Minnesota	Minnesota Pollution Control Agency regulates ASTs of greater than 1,100 gallons containing any liquid substance that may cause pollution to waters of the state; incorporates by reference API 653	Yes	Yes	Yes	Yes	Yes	Minnesota Administrative Rules Chapter 7151
Nebraska	Department of Environmental Quality implements Rules And Regulations Pertaining to Agricultural Chemical Containment for bulk fertilizer storage	Yes	Yes	Yes	No	No	Nebraska Administrative Code Title 198
Ohio	Department of Agriculture regulates all farm fertilizer tanks of 5,000 gallons or more aggregate capacity	Yes	Yes	Yes	No	653 only	Ohio Administrative Code (OAC) 901:5-2
Oklahoma	Oklahoma Fertilizer Act and Rules implemented by the Oklahoma Department of Agriculture, Food, and Forestry regulate facilities storing liquid bulk fertilizer in quantities greater than 55 gallons	Yes	Yes	No	Yes	No	Oklahoma Administrative Code (OAC) 35:45-1-10
South Dakota	Department of Agriculture enforces Bulk Commercial Fertilizer Storage Rules for facilities capable of storing more than 300 gallons	Yes	Yes	Yes	Yes	No	South Dakota Administrative Rules Chapter 12:44:05
Washington	Department of Agriculture regulates Fertilizer Bulk Storage and Operational Area Containment for greater than 500 gallons	Yes	Yes	Yes	No	No	Chapter 16-201 Washington Administrative Code (WAC)
West Virginia	Department of Agriculture regulates facilities storing over 5,000 gallons of liquid fertilizer for more than 30 days per year	Yes	Yes	Yes	Yes	No	61 WV Code of State Rules (CSR) 6B
Wisconsin	Department of Agriculture, Trade, and Consumer Protection regulates fertilizer bulk storage in quantities greater than 55 gallons	Yes	Yes	Yes	No	Yes	Agriculture, Trade, & Consumer Protection (ATCP) Chapter 33

Appendix E

Similar Incidents

Date	Location	Number of failures	Details	Cause (if known)	Consequences reported
1995	Poneto, Indiana	1	500,000-gallon fertilizer tank rupture	Faulty welds	
March 1997	Pacific Junction, Iowa	3	1-million gallon fertilizer tank rupture and cascading failure of two other tanks	Faulty welds	Temporary dike prevented release to Missouri River
February 1999	Dixon, California	1	Tank rupture during transfer out of leaking tank; 250,000 gallons released		One killed, two hospitalized
July 1999	Maumee, Ohio	2	Failure of two fertilizer storage tanks	Faulty welds	
July 1999	Webberville, Michigan	1	1-millon gallon fertilizer tank rupture at seams	Faulty welds	Two hospitalized
January 8, 2000	Cincinnati, Ohio	1	Million-gallon tank rupture, 379,000 gallons released	Faulty welds	Release to Ohio River, containing walls and two vehicles destroyed
January 26, 2000	Morral, Ohio	1	1.5-million gallon tank rupture	Faulty welds	
March 3 and March 8, 2000	Morral, Ohio	2	Two separate fertilizer tank ruptures days apart	Faulty welds	Community and school evacuation
November 7, 2008	Wilmington, North Carolina	1	Fertilizer tank failure at seam between shell and bottom	Failure at weld, corrosion	Release to waterway
November 12, 2008†	Chesapeake, Virginia	1	Catastrophic failure of fertilizer tank	Faulty welds due to lack of weld penetration	Community evacuation, two hospitalized, release to Elizabeth River
December 16, 2008	Ashkym, Illinois	3	500,000-gallon release due to storage tank catastrophic failure and cascading failure of two smaller tanks		

† Allied Terminals incident included (highlighted) for comparison.