Above Ground Liquid Fertilizer Storage Tanks
TFI Guidelines for Mechanical Integrity

National Agronomic Environmental Health & Safety School

August 17 - 18, 2010

Bloomington, IL

Mechanical Integrity Practices

The Why and The How

The Why
Tank Failure History

- Storage tank failure is not a new phenomenon in fact...
  - January 15, 1919: A molasses tank in Boston ruptured, emptying its 2.5 million gallon contents in a few seconds. Soon a 15-foot high wave of molasses moving about 35 miles per hour swallowed the streets of Boston's North End. Almost 150 people were injured with a final death toll of 21. A Massachusetts court determined that insufficient safety inspections had played a part in the accident. After a year of hearings, the courts found the company liable, concluding shoddy construction and overfilling of the tank was to blame. The company paid almost $1 million to settle the claims.....in 1919

Tank Failure History (Cont.)

- 3/1997 – Iowa, a 1M gallon amm phosphate tank ruptures and in turn damages two other liquid fertilizer tanks
- 7/1999 – Michigan, a 1M gallon APP ruptures and damages 3 adjacent tanks
- 1/2000 – Ohio, a 1M gallon fertilizer tank ruptures and damages 4 adjacent tanks and 5 tractor trailer rigs. More than 800k gallons spills into the Ohio River.
- 3/2000 – Ohio, a 1.5M gallon amm phosphate tank ruptures and damages 2 adjacent tanks. Some of the released liquid flows into nearby creeks.
- 11/2008 – Virginia, catastrophic failure of a UAN tank. Updating TFI guidelines as well as a proposed fertilizer tank law in Virginia are direct results (note: passed API inspection 23 months prior).

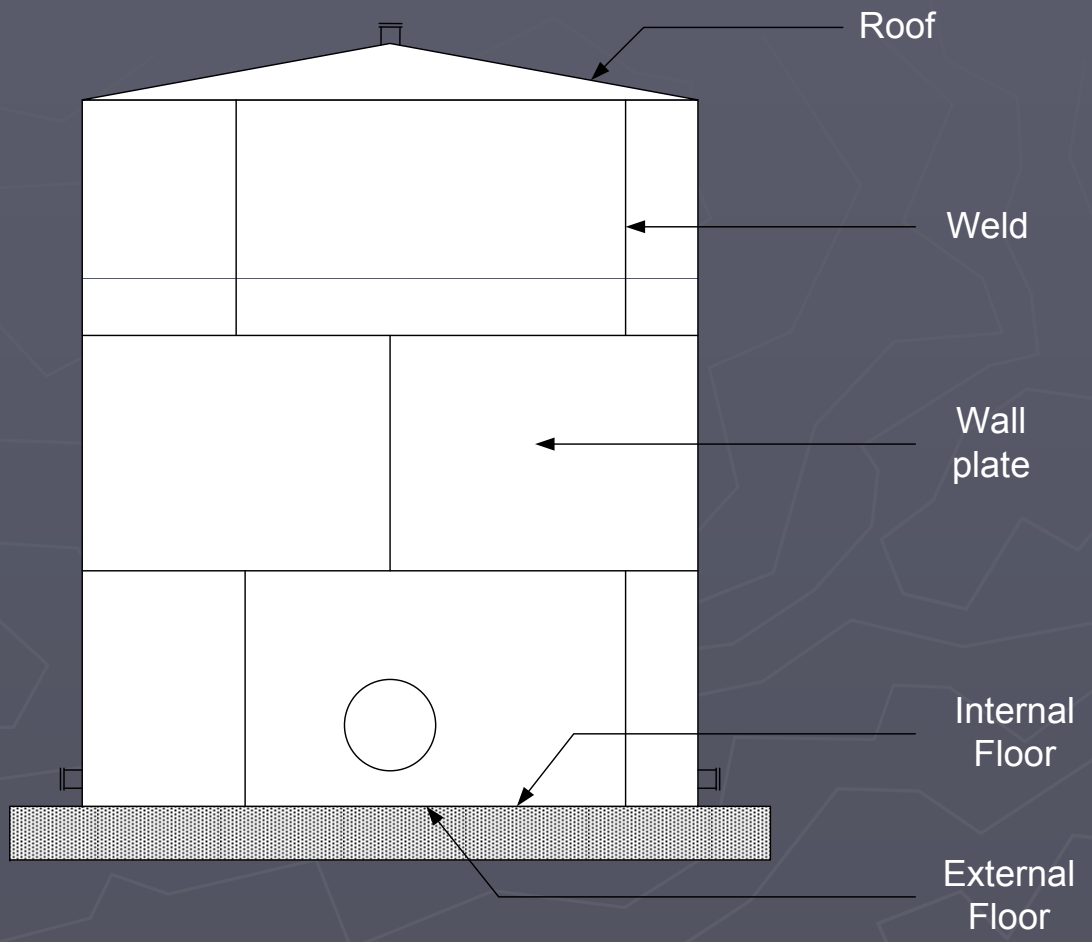
So Why Do Tanks Fail?

- Corrosion
- Improper Construction/Modifications
- Specific Gravity of fluid incompatible with tank wall
- Internal/External forces or events (fire, flood, impact, etc.)

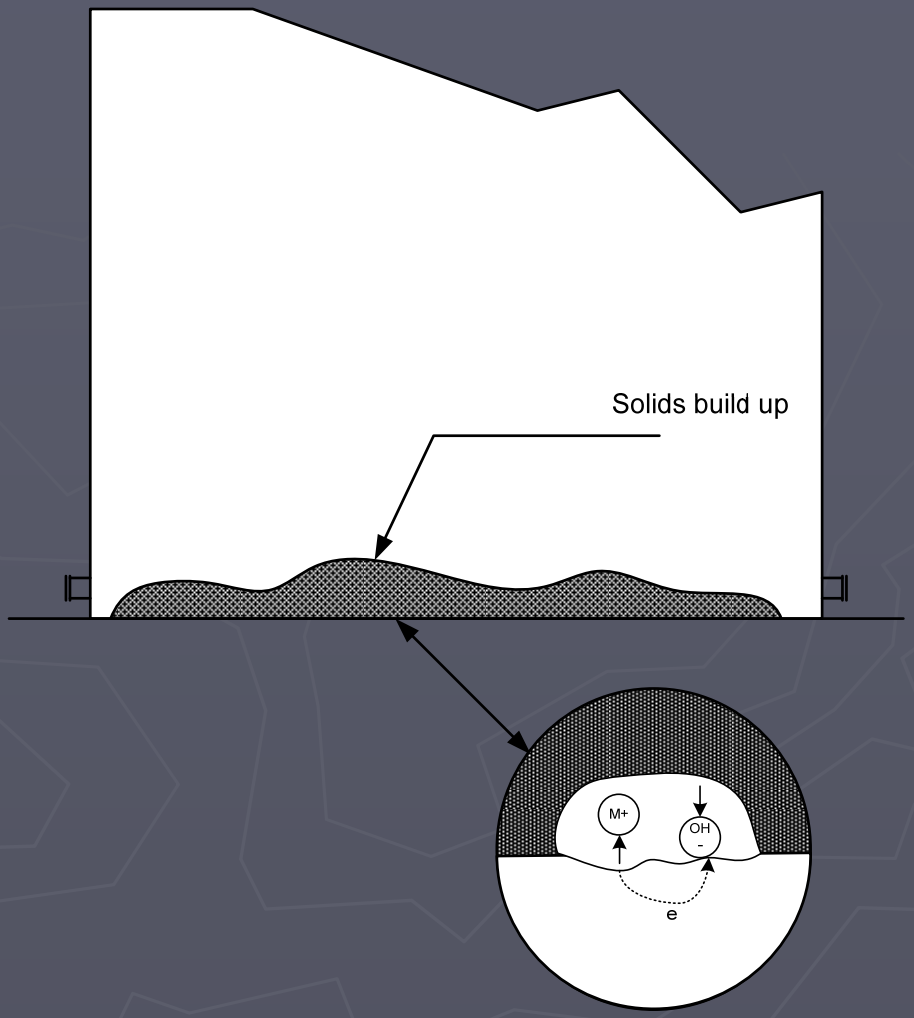
How Do Tanks Fail?

- Catastrophically – Happens very quickly, can cause damage or loss in adjacent equipment and dangerous to personnel.
  - Wall blowout
  - Explosion/Vacuum
  - Total roof collapse
- Non-catastrophically – Slow, general corrosion type failures, can often be repaired while still insignificant
  - Pinhole leaks
  - General corrosion

Where Can Tanks Fail?

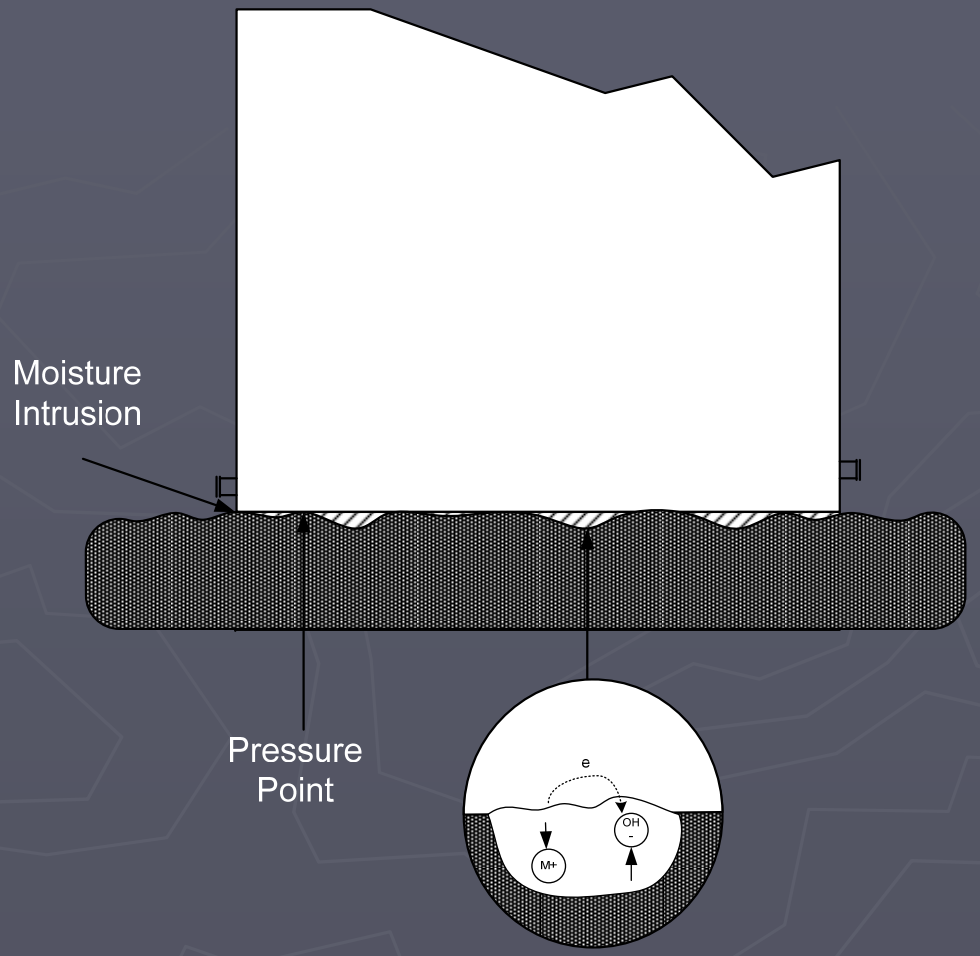


Floor Failures - Internal



Solids create stagnant voids where accelerated corrosion can take place - pitting

Floor Failures – External (Soil Side)



Non-uniform tank base can allow moisture to collect underneath tank

Other Causes of Failure

- Sulfur Reducing Bacteria (SRB). This occurs on tank floors sitting on soil or sand. Moisture, nutrients, and ideal temperatures for bacteria growth (40 F – 120 F) are required for this type of corrosion to occur.

- Chloride cracking – stainless steels are susceptible to chloride attacks. Insulation can often be the source of chlorides. If the insulation gets wet cracking can occur. “Halide – Free” insulation is the answer for all stainless tanks.

The How
Mechanical Integrity Practices

- In 2009 TFI set up a task force to update the TFI document:

  Above Ground Storage Tanks of Liquid Fertilizer - Recommended Inspection Guidelines (April 2001).

- The result was renamed to:

  Above Ground Storage Tanks of Liquid Fertilizer – Recommended Mechanical Integrity Practices (Dec 2009)

Overview of the Mechanical Integrity Practice Guidelines

The Guidelines apply to:

- Tanks of 100,000 gallons or more.
- Tanks constructed of stainless, aluminum, or carbon steel.

The Guidelines recommend:

- New tanks constructed to API Std 650
- Tanks be modified and inspected according to API Std 653
- Inspections performed by API certified personnel familiar with ASTs

The Guidelines represent the minimum recommended practices for inspection and maintenance. More stringent state/local regulations may apply

Section Review

- Section 1 – Purpose
- Section 2 – Definitions
- Section 3 – Scope
- Section 4 – Construction, Repair, Maintenance, and Inspection
- Section 5 – Bladders/Coatings
- Section 6 – Flammability
- Section 7 – Specific Gravity
- Section 8 – Inspections
- Section 9 - Record Keeping
- Section 10 – References
- Appendices A & B – Bladder & Coating Inspection Criteria

Section 4
Construction, Repair, Maintenance, & Inspection
Exterior & Interior Considerations Highlights

- Paint tanks a light color to reduce heat input and corrosion
- Tanks should be on a proper foundation, minimize moisture at base
- Repairs should be done by qualified API 653 welders to API 653 procedures or original tank standard if known
- Weld zones should be inspected thoroughly
- “Soil side” of tank bottoms should be inspected
- Roof rafters and joints should be inspected
- Avoid certain material of construction/fertilizer combinations:
  - Copper and Brass with liquid fertilizers of any type
  - Aluminum with phosphates or potassium chloride
  - Carbon steel with acidic materials, dilute thiosulfates

Section 5
Bladders/Coatings Highlights

- Keep records of bladder or coating – manufacturer, installation date, properties, installation contractor, inspection data
- Inspect bladder within two years of adoption of this guideline by authorized inspector
- Tanks with bladders should have leak detection system
- Inspect bladders every 5 years after establishing baseline
- Repairs to bladder should have bladder manufacturer providing guidance
- Tanks with coatings or liners should be inspected every 5 years after establishing baseline
- Tanks should be inspected by API inspector prior to having coating applied

Section 7
Specific Gravity Highlights

- Consideration should be given in tank design to the specific gravity of the material being stored and the rating of the walls.

Section 8
Inspection Highlights

- Establish API Baseline Inspection
- Establish monthly in-house, walk around inspections
- External API inspections 5 year interval or sooner if corrosion rate warrants
- Internal API Inspections not to exceed 10 year interval unless RBI evaluation states different timeline
- Tanks should be evaluated for suitability for service based on:
  - Inspection reports
  - Shell thickness
  - Joint efficiencies
  - SG of product stored

Section 9
Recordkeeping Highlights

- Owner/Operator should keep detailed records of each tank including:
  - Tank Calculations
  - Construction and repair drawings
  - Inspection reports
  - Materials test reports
  - Original tank construction data
  - Description of the tank (Ht., dia., service)
  - Design conditions (liquid level, SG)
  - Shell thickness by course
  - Hydro tests
  - Foundation type
  - Leak detection systems and testing/maintenance of such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Tank Mechanical Integrity Measures

- Inspection Program
- Code/Procedure Based Construction & Repair
- Proper Metallurgy
- External roof supports/self supporting roofs
- Concrete or engineered foundations
- Linings/Coatings/Bladders
- Tank thickness meets SG guidelines
- Solids removal/minimization
- Vapor barriers
- Cathodic Protection

Testing Methods

- X-Ray (New tank welds)
- Hydrostatic - holes
- Ultrasonic Thickness (UT) - pitting
- Vacuum (floors/floor joints)
- Dye Penetrant - Cracks
- Magnetic Particle - Cracks
- Magnetic Flux Leakage – pits on tank floor
- Eddy Current – flaws in structure
- Visual Examination

Tank Guidelines

- API STD 650 - Welded Steel Tanks for Oil Storage
- 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

American Petroleum Institute
1220 L St. NW
Washington DC 20005
http://www.api.org
(202) 682-8000

Tank Guidelines - continued

- The Fertilizer Institute (TFI) Publication

  Aboveground Storage Tanks of Liquid Fertilizer
  Recommended Inspection Guidelines

The Fertilizer Institute
820 First St., NE
Washington, DC 20002
http://www.tfi.org
(202) 962-0490

Tank Guidelines - continued

- The Canadian Fertilizer Institute Publication

  Canadian Fertilizer Industry Storage and Handling Guidelines 2001

Canadian Fertilizer Institute
350 Sparks Street, Suite 802
Ottawa, ON K1R 7S8

(613) 230-2600

http://www.cfi.ca

CHEMICAL COMPATIBILITY FOR LIQUIDS FERTILIZERS

Table Key:

A- Acceptable if compatible with container or appurtenances
N- Not acceptable because of chemical compatibility
1- Acceptable if product is treated with corrosion inhibitor
2- Acceptable if warranted by equipment manufacturer for the intended use
3- Acceptable if cleaned after seasonal use and is used to store materials less than three months (cumulative) annually

Product	Urea Ammonia Nitrate	Ammonium Thiosulfate	Ammonium Poly-phosphate	Potassium Phosphate	Potassium Hydroxide	Potash Solutions	Mixed Fertilizers, Starters
Container Material							
Stainless Steel	A	A	A	A	A	A	A
Mild Steel	1	1	A	N	N	3	3
Mild Steel with Liner	2	2	A	2	2	2	2
Aluminum	A	A	N	N	N	N	N
Fiberglass	A	A	A	A	2	A	A
Poly or Plastic	A	A	A	A	2	A	A
Brass or Copper Alloys	N	N	N	N	N	N	N
Plugs, Valves, Tank Inserts							
Stainless Steel	A	A	A	A	A	A	A
Nickel Stainless Insert	A	A	A	A	2	A	A
Fully Lined Metal Stainless Insert	A	A	A	A	N	A	A
Nylon Ball Valve	A	A	A	A	A	A	A
Forged Steel	A	A	A	2	N	A	A
Cast Iron/Mild Steel	N	N	A	N	N	N	N
Poly or Plastic	A	A	A	A	2	A	A
Brass or Copper Alloys	N	N	N	N	N	N	N
Plumbing							
Stainless Steel	A	A	A	A	A	A	A
Forged Steel	A	A	A	2	N	A	A
Cast Iron/Mild Steel	1	1	A	N	N	3	3
Galvanized	N	N	A	N	N	N	3
PVC/Other Synthetics	2	2	2	A	2	2	2

Source: Wisconsin Department of Agriculture, Trade and Consumer Protection