Steel Tank Maintenance

Fluid Fertilizer Foundation

December 4, 2012

Tank Failure History

- Storage tank failure is as old as storage tank usage…
  - On **January 15, 1919** a U.S. Industrial Alcohol Company's tank which had received a shipment of molasses ruptured. It emptied 2.5 million gallons of molasses in the space of a few seconds.
  - The cast iron tank was filled to the top. 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**. 3,000 witnesses testified during 300 days of hearings, the courts found the company liable, concluding shoddy construction and overfilling of the tank was to blame, along with the apparent sudden expansion of the molasses -- the temperature had only been 2 degrees above zero the previous day. **The company paid almost $1 million to settle the claims.**

Tank Failure History (Cont.)

- 1987 – South Dakota, a school was evacuated and closed after a nearby AST had leakage from the bottom of the tank. South Dakota legislature starts process to implement controls on use of AST's.
- 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.
- 2008 – Virginia, catastrophic failure of a 2 M gall UAN tank. Updating TFI guidelines as well as a proposed fertilizer tank law in Virginia are direct results (note: passed API inspection 2 years prior to failure).

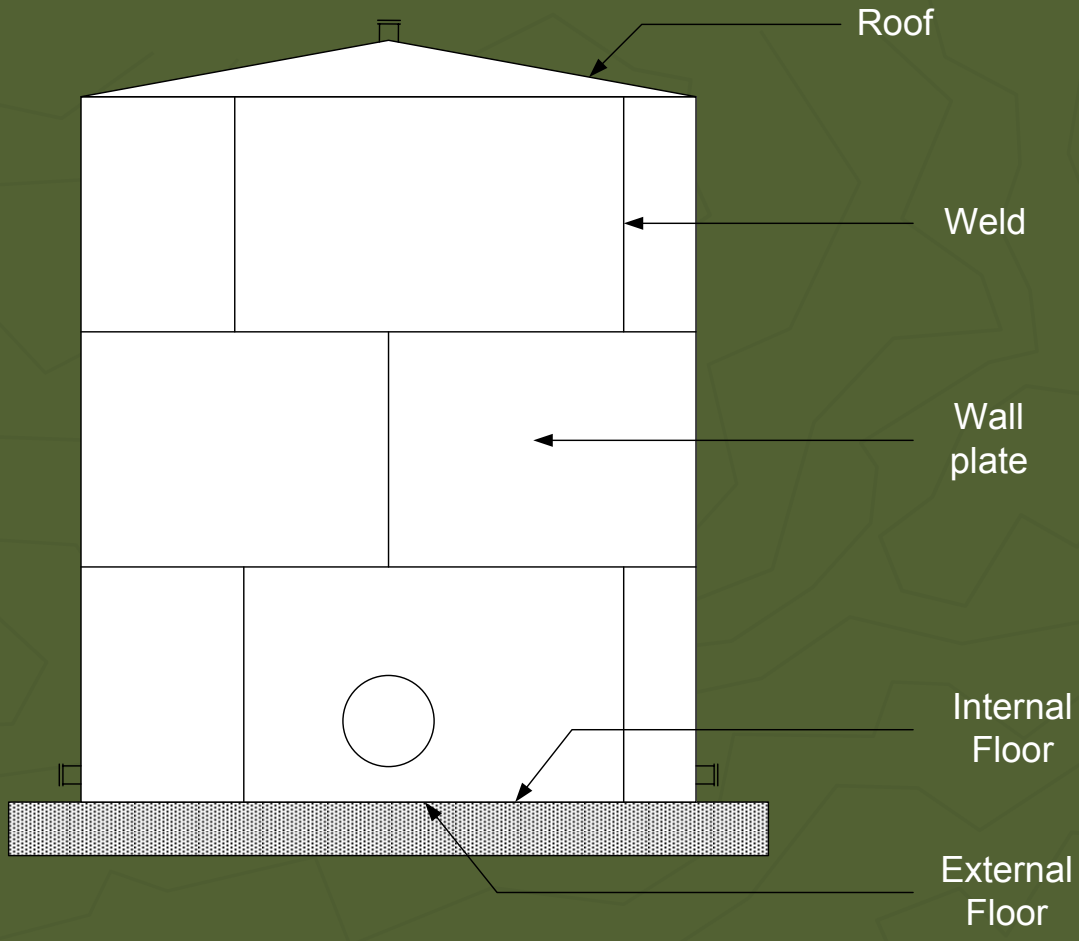
So Why Do Tanks Fail?

- Corrosion
- Improper Construction
- Specific Gravity of fluid incompatible with tank wall
- Internal/External forces or events (fire, flood, impact, etc.)
- Seismic zone design not compatible with area

How Do Tanks Fail?

- Catastrophically – Can happen very quickly, can cause damage or loss in adjacent equipment and dangerous to personnel.
  - Wall blowout
  - Explosion
  - 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?



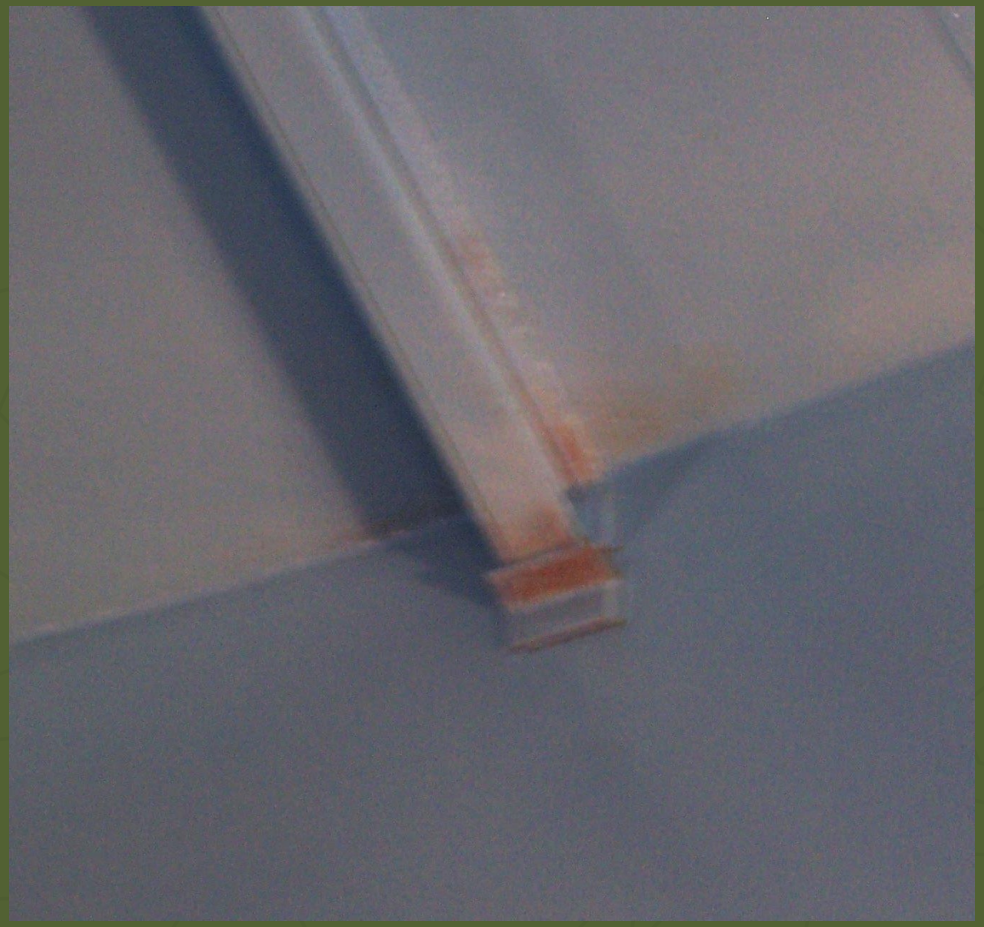
Roof Failures

- Internal Beam Failure
- Corrosion due to build up of moisture, acids, salts, etc.

Roof Failure

Build up of solids which are acidic in nature on internal of tank roof

Roof Failure



- Corrosion starting to form on support beam. Not an issue…..yet. This was a case of poor surface preparation prior to coating.

Roof Failures

- Vent Failures – a plugged vent can cause vacuums or overpressure to damage tanks

Vent plugging can be catastrophic

Self Supporting Roof

Roof Failure Prevention

- External Rafters, self supporting roof, internal coatings reduces corrosion
- PVRV (Pressure Vacuum Relief Valves), Goose neck vents with screens to prevent bird nesting*.

- * Make sure screens can be inspected and cleaned.

Wall and Weld Failures

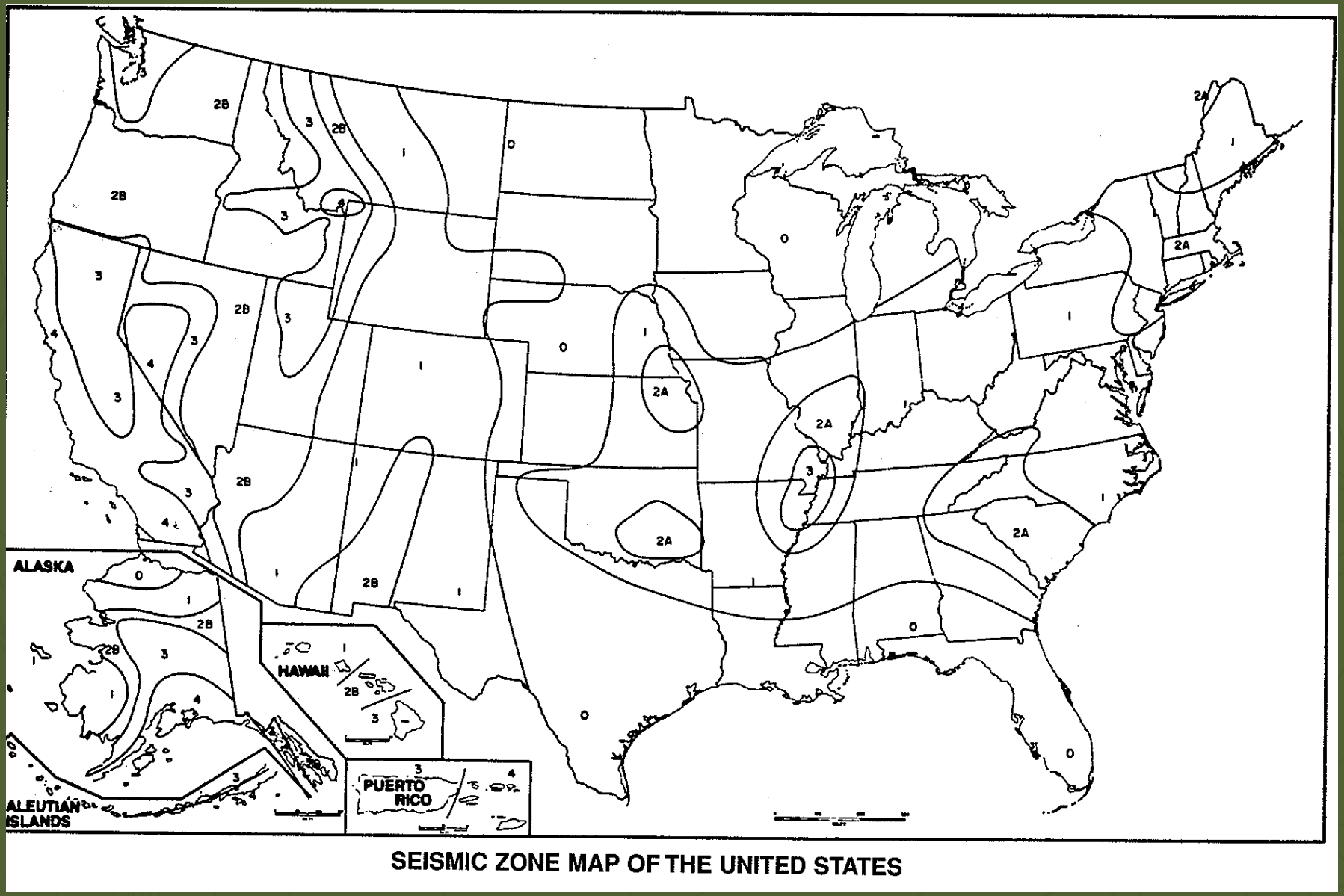
- Poor welding procedures are main culprit on weld failure
- Specific gravity of liquid to heavy for tank's wall thickness
- Corrosion – pitting, cracking, general thinning can cause loss of containment

Weld and Wall Failure

This failure occurred just above a bladder on the SOUTH side of the tank only – daily temperature fluctuations contributed to accelerated corrosion

Weld and Wall Failure Prevention

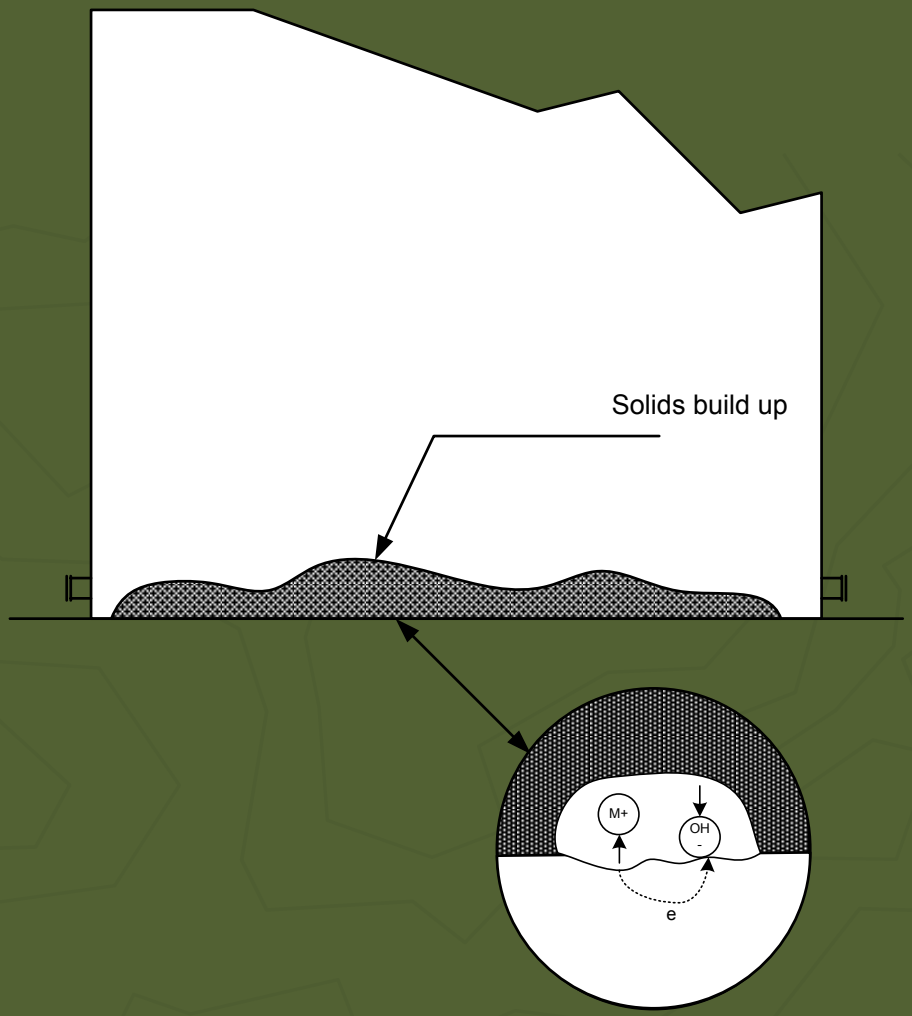
- Coatings – Epoxy Phenolics, Fiberglass
- Bladders – Rubber
- Material of Construction – Stainless, Fiberglass, poly
- Certified welders based on recommended construction and repair procedures i.e. API 650 and API 653
- Regular Inspections
- Wall thickness rated for the liquid specific gravity



SEISMIC ZONE MAP OF THE UNITED STATES

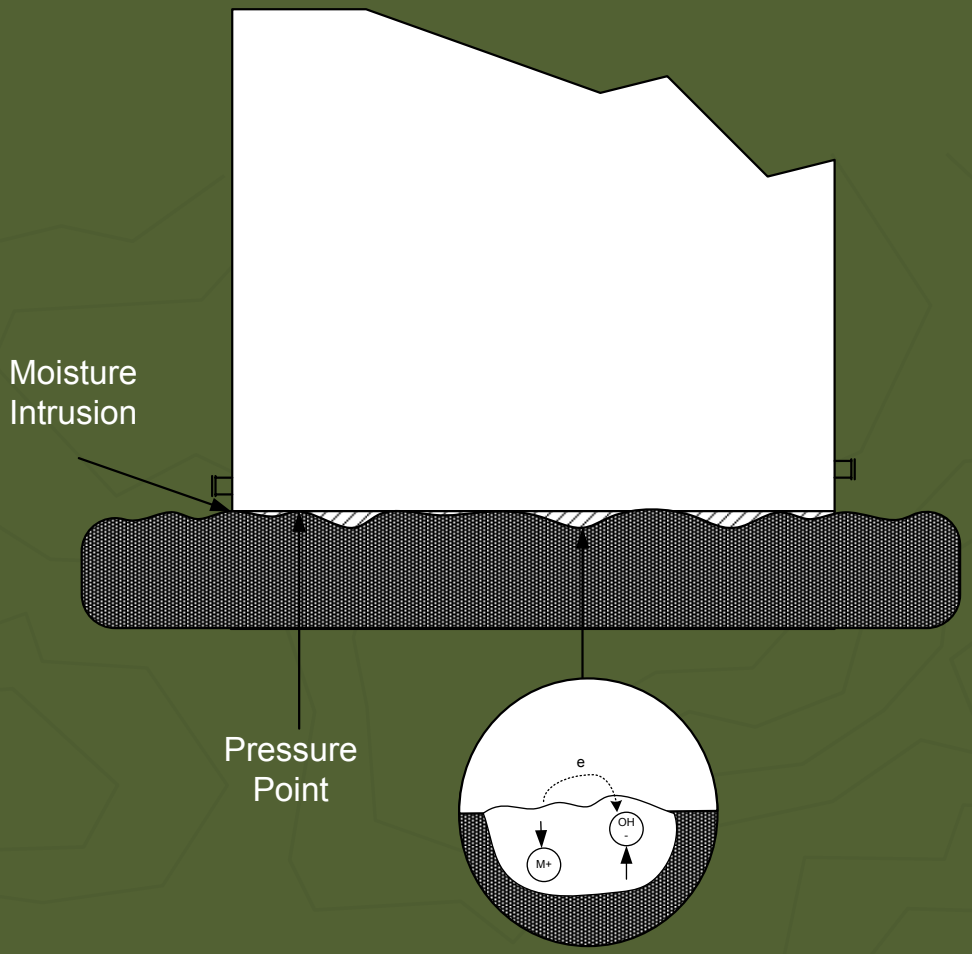
California has seismic zones 3 & 4.

Floor Failures - Internal



Built up solids can create stagnant voids where accelerated corrosion can take place – pitting ensues

Floor Failures - External



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

Remove excess gravel and dirt from bottom seam of tank

Floor Failure Prevention

- Concrete Foundations – Best practice for new tanks
- Internal Coatings
- Full draining of liquids/thorough circulation of liquids
- Routine solids removal
- Cathodic protection
- Moisture barriers at floor/foundation joint

Floor Failure Prevention

Foundation for new tanks

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.

Tank Failure Prevention Summary

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

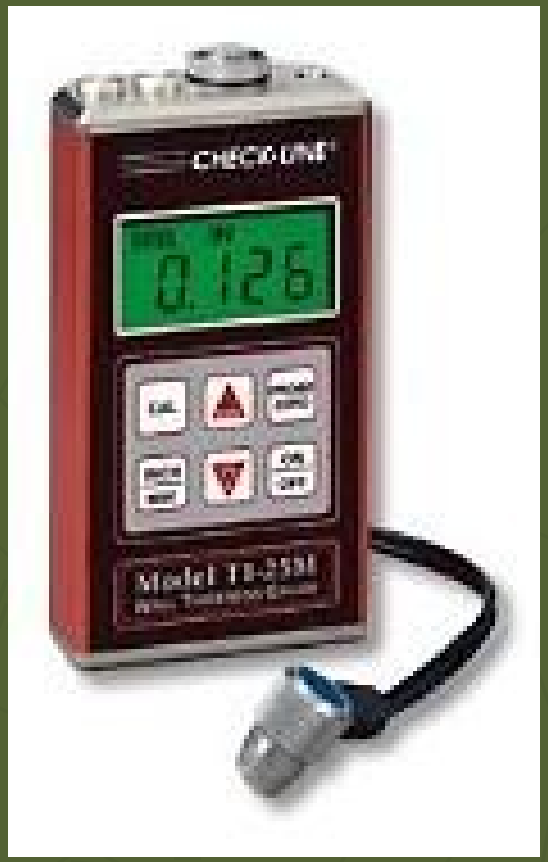
New Tank Best Practices

- Externally Painted
- Built to API 650
- Proper Metallurgy
- Concrete foundation
- Internally coated
- Wall thickness meets SG guidelines
- Solids removal capabilities/minimization

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

Testing Equipment



Hand held Ultrasonic Thickness Gauges – inexpensive <$2,000

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 Containing Liquid Fertilizer
  Recommended Mechanical Integrity Practices

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

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