Tank Failures – Causes and Prevention

Fluid Technology Roundup

December 9-10

Fluid Fertilizer Foundation

Tank Failure Background & History

- Storage tank failure is not a new phenomenon in fact…
  - On January 15, 1919 a United States Industrial Alcohol Company's distilling tank which recently had received a shipment of molasses in from Puerto Rico, exploded. At about 12:40 p.m. the giant tank ruptured, emptying its entire contents of about 2.5 million gallons of molasses, into Commercial Street in the space of a few seconds. The tank, a 90'-0 diameter x 50-foot high cast iron tank was filled to the top with molasses. Upon failure, a 15-foot high wave of dark molasses moving about 35 miles per hour swallowed the streets of Boston's North End. Almost 150 people lie injured in the streets with the final death toll being 21. A Massachusetts court determined that insufficient safety inspections had played a part in the accident. In time, after 3,000 witnesses testify 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 Background & History (Cont.)

- 3/1997 – Washington, a 500k gallon storage tank of Potassium Thiosulfate has a weld rupture resulting in loss of 100k gallons of material.
- 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.
- 10/2000 – Montana, a 2M gallon nitrogen fertilizer intermediate tank has a massive roof failure, no loss of product, but tank is damaged significantly.

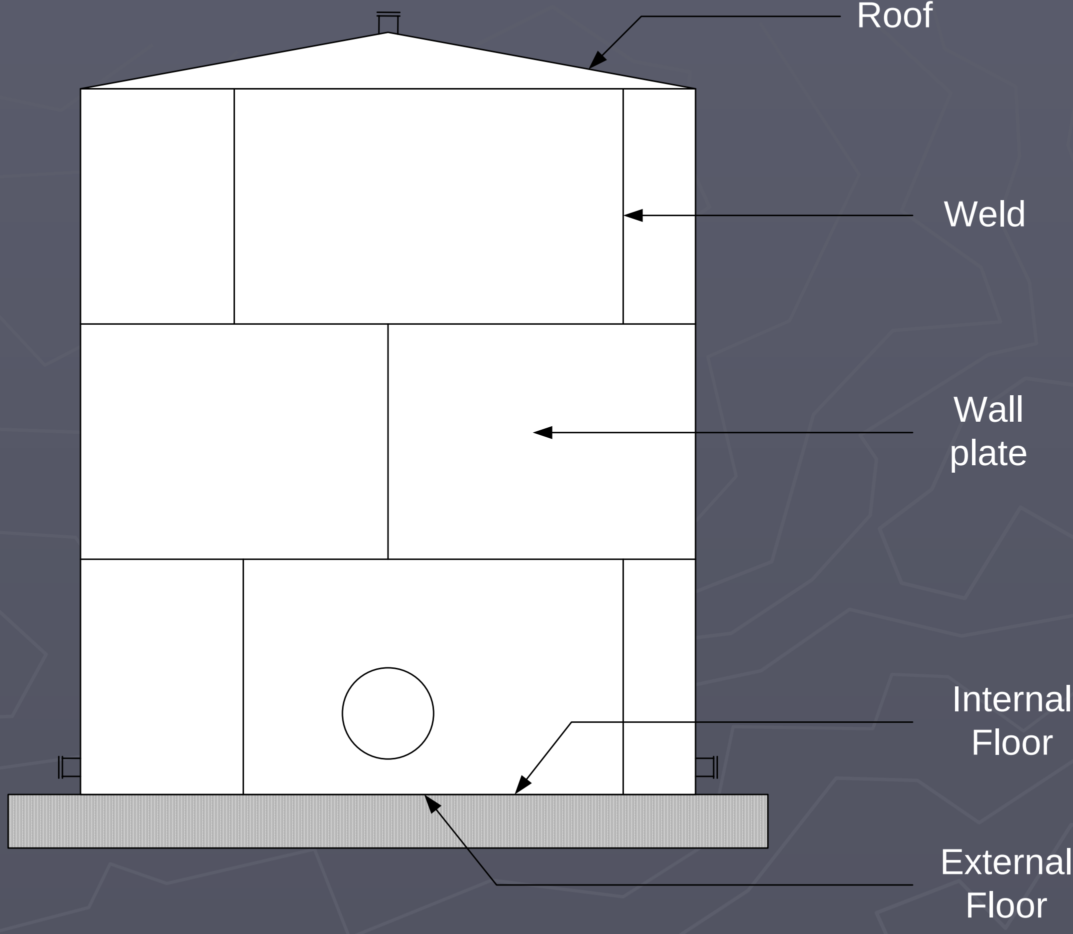
So Why Do Tanks Fail?

- Corrosion
- Improper Construction
- Specific Gravity of fluid incompatible with tank wall
- Internal/External forces or events (fire, flood, impact, etc.)
- Age/UV related issues – Poly & Fiberglass
- 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 Failures

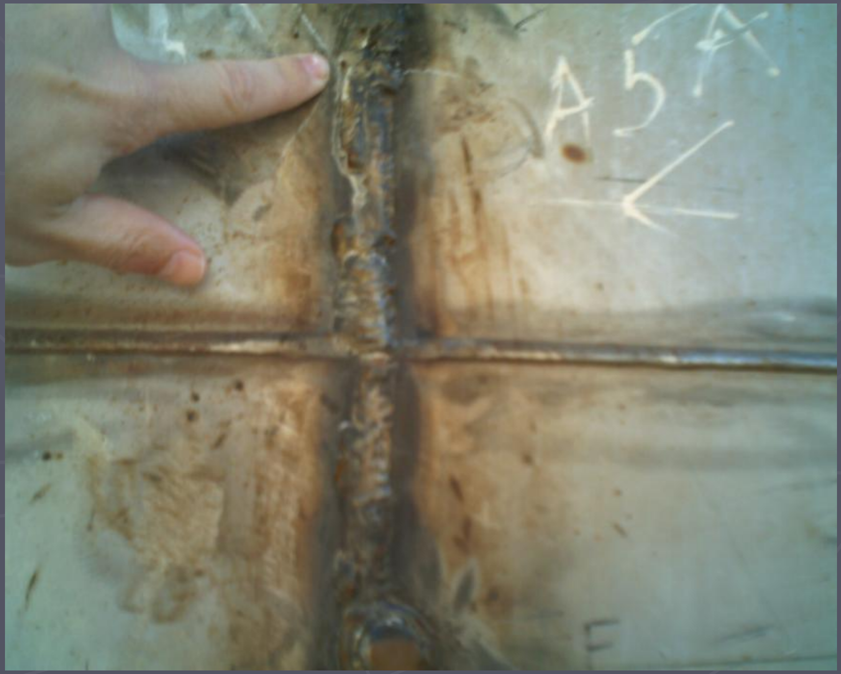
- Vent Failures – a plugged vent can cause vacuums or overpressure to damage tanks

Roof Failure Prevention

- External Rafters, nitrogen blanketing, coatings reduces corrosion likelihood

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

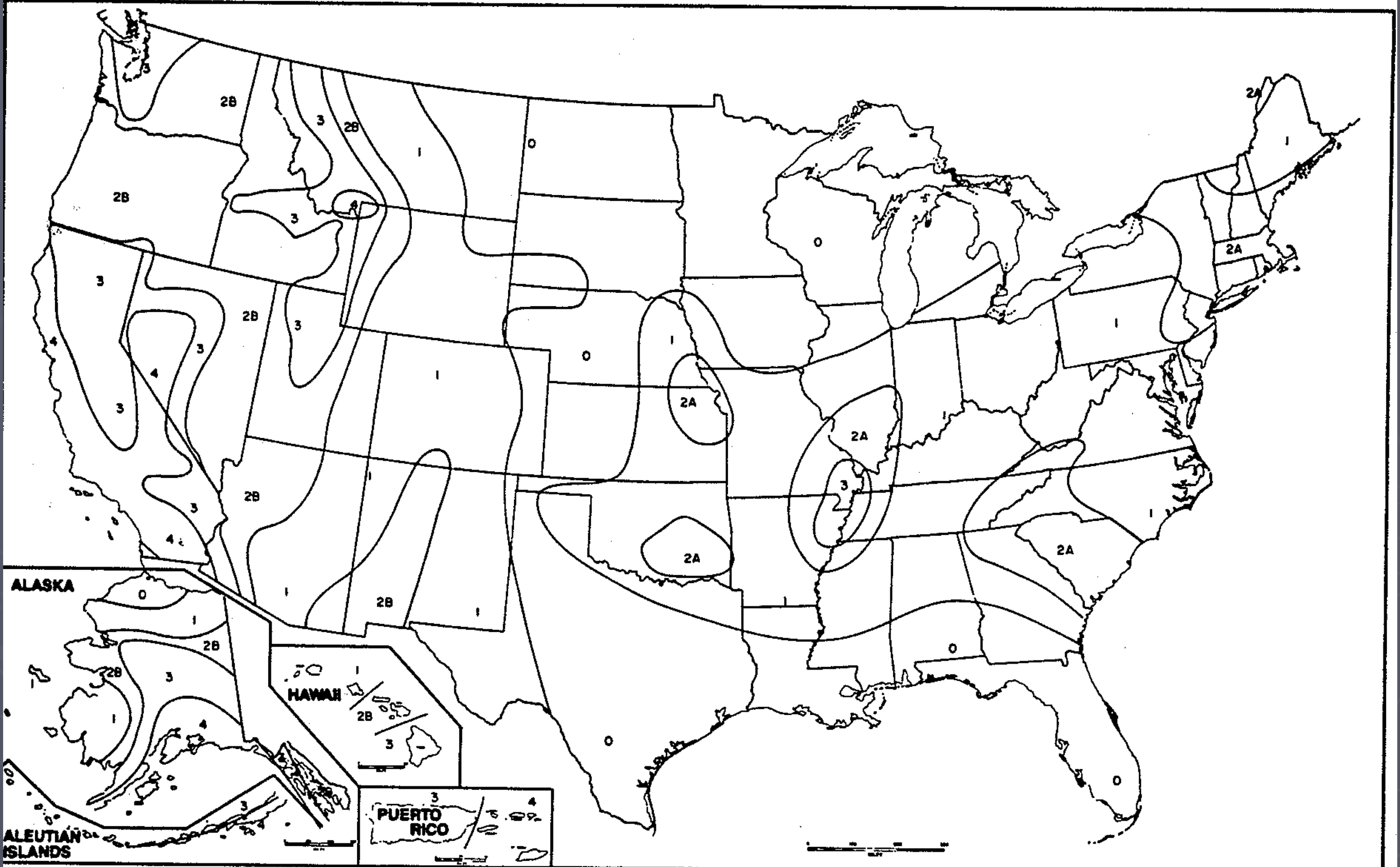
This failure occurred just above a bladder on the <u>SOUTH</u> side of the tank only – daily temperature fluctuations contributed to accelerated corrosion

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

Poly Tank Failures

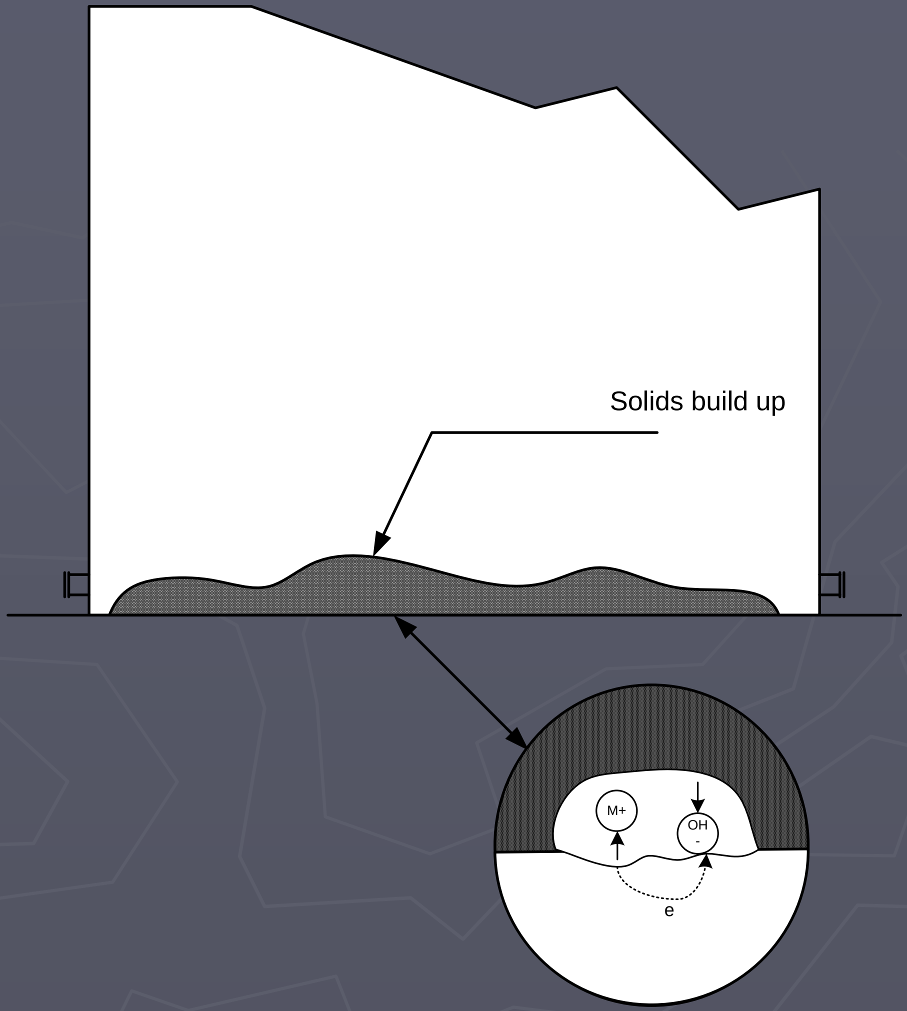
- Materials of Construction:
  - Polyethylene (HDPE & XLPE) – Exhibits good chemical resistance BUT has relatively low mechanical strength. Walls tend to be very thick. Can be used in temperatures up to 140 F.
- Seismic concerns
  - Special tanks can be purchased for high seismic zones. Double walls with tie-downs.
- UV protection
  - Varying degrees of protection available. UV protectors can be added to the plastic, but over time these can lose effectiveness. Some plastics can be painted, though it is difficult to get this to adhere. Plastic will discolor and become increasingly brittle and subject to shock and vibrations causing cracks.



SEISMIC ZONE MAP OF THE UNITED STATES

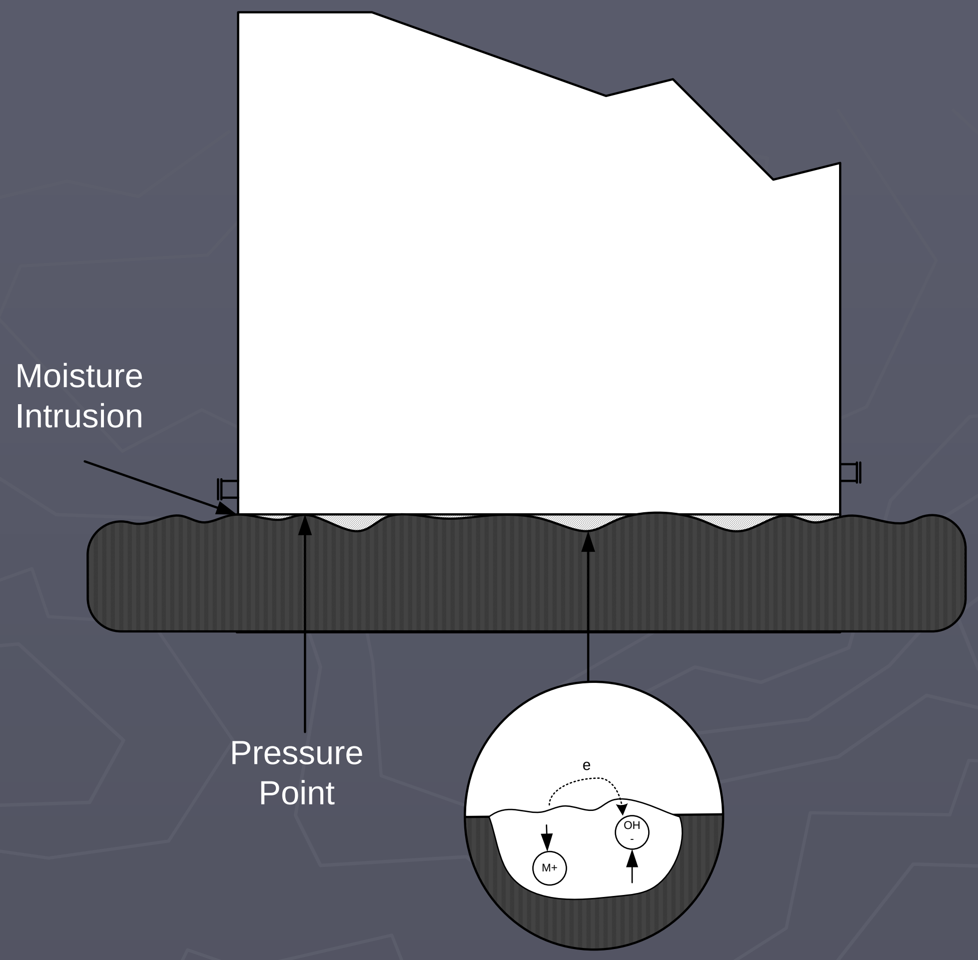
California has seismic zones 3 & 4.

Floor Failures - Internal



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

Floor Failures - External



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

Floor Failure Prevention

- Concrete Foundations
- Internal Coatings
- Full draining of liquids/thorough circulation of liquids
- Routine solids removal
- Cathodic protection

Floor Failure Prevention

Foundation for new 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

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