Comparisons of Steel Water Storage Tanks

Part of a series of documents created by Tim Guishard Enterprises discussing relevant subjects in the groundwater industry.

This document discuss differences in types of steel water storage tanks sold in the residential market of Southern California.

There are many types of steel water storage tanks sold in Southern California. This paper will attempt to discuss the many differences. For the purpose of discussion, I will only discuss:

Small, AWWA D-100 constructed welded steel tanks V/S Light gauge welded steel tanks. There are too many manufacturers to name here.

Small, AWWA D-103 constructed tanks V/S light gauge, riveted, corrugated steel tanks manufactured by American Tank, or older tanks by B.H. Tank Works/BlueScope Water, and flat panel tanks by Tim Guishard Enterprises, to name a few.

Definitions used in this discussion:

AWWA: American Water Works Association; as an organization has developed design standards used by many water companies around the world. Local water districts like; Otay, Padre Dam, and the City of San Diego use these standards.

AWWA D-100 is the standard for welded steel water storage vessels.

AWWA D-102 is the standard for field applied coatings used in D-100 water storage vessels.

AWWA D-103 is the standard for bolted steel water storage vessels and their factory applied coating systems.

Small: Means any tank with a diameter not to exceed 50' or a height of 48'

Light gauge: Means any tank constructed with metals thinner than the minimum requirements set forth by AWWA D-100 for welded steel tanks, and AWWA D-103 for bolted steel tanks.

Conversions from USS gage, or fractions, to decimal inches:

20 gauge = 0.04"	16 gauge = 0.06"	14 gauge = 0.08"	12 gauge = 0.10"
10 gauge = 0.13"	7 gauge = 0.18"	3/16" = 0.19"	¼" = 0.25"

Mill or hot dip galvanization: Both have roughly the same application process. G-90 mill galvanized steel has about 1.5 OZ of zinc per square foot with a thickness of about 2-mills, and has a smooth finish. G-185 hot dipped galvanized steel has about twice the amount of zinc per square foot with a thickness of about 4-mills, and usually has a rougher appearance. The main difference is: when is the metal galvanized; before or after fabrication?

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When using mil galvanized stock, the galvanization is on the metal before fabrication. During fabrication, portions of the metal that are cut, punched, welded, or drilled, are no longer galvanized.

Hot dipping after fabrication covers all exposed portions of the metal, that would be exposed if one were to use mil galvanized steel. More protection from corrosion is obtained with thicker zinc coatings.

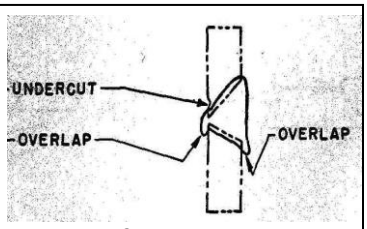
Metal thickness:

AWWA D-100 on small tanks requires a minimum metal thickness of 3/16" for metals in contact with water bearing surfaces. Metals not in contact with water (I.E. Roof) can be USS 7 gauge. Corrosion allowances are to be added where applicable or wanted by the Owner. Weld inspections (these are like x-rays for bones) and certified welders are required to confirm that the weld conforms to the applicable design standards.

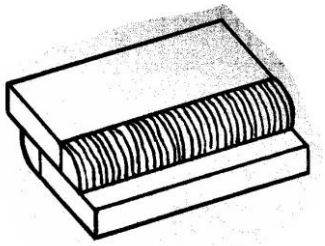
Light gage metal welded tanks are typically 14-10 gage. As welding is done on mil galvanized sheet stock, the welds are frequently porous and are rarely as thick as the original metal. Weld inspections are rarely done. Certified welders are rarely used. These factors make it impossible to confirm that the welds (or tank construction for that matter) will function as designed.

AWWA D-103 requires a minimum metal thickness of USS 12 gage for carbon steel and USS 14 gage for stainless steel. D-103 requires the use of ½" diameter bolts. Bolting allows torque testing to confirm assembly conforms to design standards.

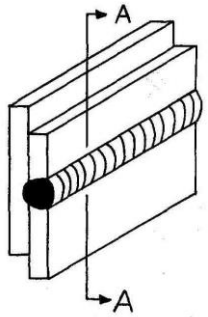
Light gage riveted tanks are typically 14-16 gauge for the shell and bottoms. 20 gage for the roof. These manufacturers use special high strength rivets are placed at the same 2" intervals used by most bolted tank manufacturers. The rivets are set using special hydraulic tooling, and are designed with a break off point similar to "pop-rivets" to confirm that they have been placed correctly. When bolts are needed, the bolts meet the minimum specifications of D-103.



TYPICAL BUTT WELD WITH NO BACKING STRIP



A-5. *Lap joint on welded plates*



A-57. *Arc seam weld*

Full joint penetration butt weld with backing strip

Seam or joint construction:

AWWA D-100 and D-103 require full joint penetration for metals less than 3/8" in butt welded configurations. If seams are butt welded from one side only, backing strips are required on the side opposite of the weld.

Bolts or rivets replace welds on D-103 and riveted tanks. Notice the gasket material between the seams.

Light gauge welded tanks are rarely welded from both sides; rarely lap welded, and rarely use backing strips when butt

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welded as required by D-100. Without a backing strip, the seams do not have full joint penetration due to undercut. Without full joint penetration, the metal at the weld is actually thinner than the rest of the tank. The structural stability is compromised by poor welding practices.

All seams in D-103 tanks, and light gauge riveted tanks are lapped, then bolted (or riveted). This effectively doubles the metal thickness at the seams.

Interior Coatings:

AWWA D-100, D-102, and D-103, recognizes general types of coatings are available to meet the specific needs of the clients. These standards require metal surfaces be sandblasted prior to application of any coating. Also, D-100 and D-103 does not allow welding of galvanized surfaces, and requires galvanization only after welding.

Effective on January 1, 2013, for potable (drinking) water applications, the internal coatings must meet NSF-61 requirements.

Light gauge metal welded tanks are rarely sandblasted prior to application of coatings. They frequently rely only on the relatively thin mill galvanization for corrosion protection. The mill galvanization at the welded seams is completely burned off during the welding process. To repair the galvanization where it has been burned off, “cold” spray galvanization or “roofing tar” are frequently used at the weld seams. If NSF approved coatings are used, a single coat of 2-part epoxy that is hand (brushed or rolled) applied is all that usually provided. Coating dry film mil thickness, and holiday, testing is rarely performed.

Dry film mil thickness testing is a process to determine how thick the actual coatings have been applied, after drying, in millionths of an inch (0.001”).

Above is an example of mil thickness testing being completed on a powder coated tank.

Holiday testing is a procedure to determine if there are any flaws in the coating that might allow water to penetrate the coating and reach the metal below. One leg of high voltage (sometimes in excess of 50,000 volts), or low voltage (usually below 250 volts), power supply is applied to the metal. A wetted sponge is attached to the other leg of the power supply. The sponge is wiped along all coated surfaces. If there is a defect in the coating, a small spark will pass through the coating, and the instrument will indicate a fault or “holiday”. If holidays are detected, the coating is repaired and tested again.

An example of 67 VDC holiday testing in progress on a TGE jobsite

AWWA D-103 requires the interior surfaces to be coated with any of the following: Thermoset 2-part liquid epoxy, thermoset powder coatings, hot dip galvanization, or fused glass. For all coatings NSF approval is required, as well as specific temperatures and humidity’s that must be adhered to. Mil thickness and holiday testing are recommended on epoxy, glass, and powder coated surfaces.

Thermosetting is a process where the coating is applied to a surface, then the materials are placed in an oven, at

temperatures between 200F and 1450F depending on the coating manufacturers requirements, and baked on. This process is far superior to any hand applied coating as the coating melts into the sandblasted and roughened surface creating a tighter bond to the base metal.

Light gage riveted tanks offer various interior surfaces: Mill or hot dip galvanization, Stainless steel that is NSF compliant, two coats of hand applied bituminous coal tar, thermoset NSF compliant powder coatings. For thermoset and hot dipped products, the materials are prepped and coated per D-103 requirements. For thermoset products, both mil and holiday testing is a part of the QC for tanks manufactured by TGE.

Exterior coatings:

Both D-102 and D103 recognize the need for external coatings. D-100 tanks use various coatings or special rust resistant metals like CorTen or stainless steel. D103 allows the similar coatings from the interior to be used on the exterior, and also allows CorTen and Stainless steel.

Light gage welded steel tanks offer the mill galvanization, or sometimes a single coat of low quality paint. Rarely do they supply two-coat enamels and cannot supply hot-dipped galvanization or thermally set coatings.

Light gage riveted tanks offer: mill or hot dip galvanization, two-coat enamels, or thermoset powder coatings.

For enamel painted tanks by TGE, the material is first acid washed to remove any oils left on the metal from manufacturing or assembly processes, then a special primer for galvanized steel is applied, then the final color coat is applied in accordance with the paint manufacturer's requirements. When Hot dipped, the metal is pickled in an acid before being dipped. For Powder coated surfaces the metal is sandblasted before coating.

Reinforcement around shell openings:

Both D-100 and D-103 Require reinforcement around shell openings greater than 4".

Light gage welded steel tanks rarely reinforce the shell at these points.

Light gage riveted tanks by TGE follow the AWWA specifications.

Example of Reinforcement at openings on a TGE tank

Roof openings:

D100 and D-103 require: "An access opening shall be placed above the Top Capacity Limit (high water level) shall have a minimum dimension of 24" or as required by the most recent OSHA requirement." "This opening shall have a curb that extends a minimum of 4" above the roof, and the cover shall have an overlap of at least 2"."

An example of the "vent" cut into the man-way cover of a light gage welded tank. Notice the corrosion around the vent hole where the galvanization was burned off.

And: "A tank center (roof) opening with a removable cover shall have a minimum dimension of 20"." "This opening may be covered,

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or be used as a vent if properly designed." The vent shall be designed to prevent the entrance of birds or animals. A downward turned; screened vent is required by the Building (CBC) and plumbing codes (CPC) of the State of California.

Light gage welded tanks rarely install openings this large, and rarely install the 4" curbs. They rarely install proper vents to prevent implosion of the tank during high water draws. Frequently they elevate the man-way hatch about 1" above the curb to allow ventilation. Sometimes they simply burn a small hole in the roof man-way calling this a vent. These practices allow small animals (mice, lizards, etc.) to be able to enter the tank, through what is effectively now an unscreened vent.

Light gage riveted tanks manufactured by TGE offer, as standard, a 24" deck opening complying with the requirements of D-103. They offer as standard offer an 8" vent opening near the tank center, and larger vents as an option. Again, all roof penetrations are reinforced as required by AWWA specifications.

Overflows:

Both D-100 and D-103 require overflows, as follows: Tank shall be equipped with an overflow sized to prevent over-pressurization at maximum inlet flow. The overflow shall terminate at the top in a weir box or other appropriate type of intake.

Light gage welded steel tanks rarely install overflows meeting this description.

Light gage riveted steel tanks manufactured by TGE offer as standard an overflow complying with D-103.

AS A NOTE: for backflow protection, the top of the overflow weir needs to be a minimum of 1" (or 2-times the inlet pipe diameter whichever is larger) below the lowest part of the outlet for the inlet piping into the tank.

Shell Man-ways:

Shell man-ways are used to perform interior maintenance of water tanks. AWWA D-100, AWWA D-103, and OSHA require shell man-ways. The requirements vary per the standard. D-100 requires: A minimum of 2-Shell man-ways shall be installed in the first ring of the tank shell. These man-ways shall have a minimum diameter of 30". D-103 requires one 24" diameter man-way described above, and recommends a second larger man-way be installed.

Light gage welded steel tanks rarely install man-ways.

Light gage riveted steel tanks by TGE offer man-ways in compliance with D013 as an available option for all our tanks. At least one man-way must be installed to properly maintain the tank and to comply with OSHA requirements.

Example of 24" TGE shell man-way

Site access limitations:

D-100 tanks over 12' diameters are almost always built on site. For tanks 12' and less, they are usually built in a factory then trucked to the site. Large cranes are required to place either a factory built

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tank or a field erected tank, due to the heavy materials.

Light gauge welded steel tanks are only built in a factory. This limits the capacity to what can be delivered on the road. Trees, narrow roads, low bridges limit the use of factory built tanks. Small cranes are necessary to place these tanks due to their weight.

D103 tanks are usually assembled on site, no matter what the size. These tanks can be placed where welded tanks cannot be placed, due to the fact that many components that can be moved by hand without cranes or other heavy equipment.

Light gauge riveted tanks offer the same advantages as AWWA D-103 tanks. Their even lighter weight allows their use where other tanks cannot be constructed. Their lighter gauge material does limit the size of the tanks, to smaller heights and diameters than what is offered by D-103.

Seismic, wind, snow design:

Both AWWA D-100 and D-103 have specific engineering criteria for seismic, wind, and snow loading. A soils report is frequently needed to design the foundations.

Light gauge welded tanks do not meet the D-100 design criteria, and frequently use bogus engineering by showing the tank is full of a solid with the weight of water. The calculations used by most light gauge welded tank manufacturers, do not account for slosh moments during a seismic event.

Upon request, light gage riveted tanks can use; seismic, wind, and snow loading calculations discussed in AWWA D-103, however due to the thinner metals they cannot meet this specification entirely.

Maintenance:

AWWA Manual M-42 states: “Tanks need to be operated properly and maintained and inspected on a regular basis to maintain their structural and sanitary integrity”.

All tanks require some type of preventative maintenance, even plastic and concrete tanks. Maintenance varies depending on: water quality, type of tank, type of interior coating, and many other factors.

Notice that water quality was listed first! Water quality is the most important subject when defining maintenance. Pure water (deionized or distilled) is a solvent that will attempt to dissolve anything it is in contact with. Certain waters will eat through mill galvanization in only a few months. Certain waters will have bacteria that will eat through steel in a short time, or contain bacteriological constituents that will cause corrosion or even allow biofilm growth (like algae) on the inside walls of tanks. Aerobic bacteria, or CO2 in the water commonly will cause accelerated corrosion at the high water line in tanks (also usually on the south facing side due to more favorable temperatures for the bacteria). Anaerobic bacteria can cause accelerated corrosion in the floor of a tank and can make the water stink (like rotten eggs).

At a minimum all tanks should have at least an annual inspection, starting with a simple visual inspection on the outside, and continuing on the inside.

Any leaks should immediately be fixed.

Any rusted areas should be thoroughly sanded and recoated with a product compatible with the original coating.

Debris (that may have washed/blown in during rain or wind events) should be removed from the outside of the tank, especially at the foundation line.

Debris from trees should be removed from the roof of the tank. This debris can cause premature failure of the roof, and provides an environment for bugs and corrosion to flourish.

Biofilm or other debris should be physically removed from the interior of the tank. Pressure washers are frequently used, so care must be taken not to damage the interior coatings. Here is where shell man-ways make the job easier and safer.

Tank design life spans:

Like maintenance, all tanks have design life spans. Plastic tanks typically have the shortest life spans, while concrete tanks typically have the longest life span. All metal tanks typically fall between the life of plastic and concrete.

AWWA D-100 Tanks with 2-part epoxies applied in accordance with AWWA D-102 specifications should be sandblasted and recoated every 10-15 years depending on the composition of the coating. Due to the metal thickness, this process can be repeated as necessary for many years. AWWA D-100 tanks typically last 80 years or more with routine maintenance.

Tanks with mill or hot-dipped galvanized surfaces have no available maintenance other than routine cleaning. Depending on water quality these tanks can last 5-20 years.

AWWA D-103 Tanks with thermoset epoxies or powder coating are designed for minimum 20 year life spans without major maintenance. The coatings in these tanks can have spot repairs made indefinitely as necessary. Depending on the thickness of the base metals, sandblasting and recoating with AWWA D-102 specification 2-part epoxies can be done to further increase tank life once the original coatings fail. AWWA D-103 tanks with thermoset coatings typically last 40 years or more with minimal maintenance.

The thermoset powder coatings used in light gauge riveted tanks manufactured by TGE, is exactly the same as AWWA D-103 tanks, and should provide the same life expectancy. The Bituminous coatings used in light gauge riveted tanks manufactured by TGE are exactly the same coatings used in AWWA D-102 coated tanks, and should provide the same life expectancy. Their major downfall to light gage tanks is that, the metal thickness prevents repeated sandblasting events, so the life of these tanks is limited to 40 years or less.

Cost of ownership:

Cost of ownership should be broken down into both initial installation and long term maintenance costs. You also need to add in the cost factors; to replace a tank at the end of its life, and inflation. In the examples below: For inflation I will use 3% per year. For residential purposes, I will use an estimated property life of 20 years. The AWWA D-100 and D-103 tanks will outlive this example, so I will only calculate the cost over the first 20 years. All maintenance costs are listed at today's values, with inflation added later in the formulas.

AWWA D-100 tanks have the highest initial cost, and moderate maintenance costs. Even though a 10,000 gallon tank may have an initial cost of $25,000.00 and current maintenance costs of $3000.00 every 10 years (extended = $ 4,277.28), during their expected life, the cost of ownership is $526.00 per year up to year 20. There is considerable scrap value for this tank at the end of 20 years, so that will bring down the cost per year.

Light gauge welded steel tanks, and mill galvanized light gauge riveted tanks have the lowest initial cost, and little or no available maintenance costs. With an initial cost of $6,000.00 for a 10,000 gallon tank, and an

average life of only 15 years, their cost of ownership is $400.00 per year for the first 10 years. Their low initial cost is offset by a short lifespan where replacement is the only option. The cost is then almost triples, as the old tank must be removed, the new tank installed and re-piped ($6000.00+ inflation at 3% per year+ removal/disposal of the old tank and reconnecting the new tank = about $10,000.00), bringing the cost of ownership to about $1000.00 per year in the final 10 years, or $800.00 per year when amortized over 20 years. The tank must be replaced again at 20 years, and there is minimal scrap value. A major disadvantage to some of these coatings is that many are no longer approved for potable water applications as of January 1, 2013, ask your vendor for NSF-61 certification in potable water applications if you are going to use these tanks in potable water applications.

AWWA D-103 tanks have a moderate initial cost, and minimal maintenance costs. With an initial cost of $17,000.00 for a 10,000 gallon tank, and an average life of 40 years, and maintenance costs of $3000.00 every 20 years, their cost of ownership is $425.00 per year for the first 20 years or $560.00 per year when extended to 40 years. There is considerable scrap value for this tank at the end of 40 years, so that will bring down the cost per year.

Light gage riveted tanks with bituminous coal tar coatings have an initial cost slightly higher than light gage welded tanks, but have better internal (maintainable) coatings. With an initial cost of 6,500.00 and a design life of 15-20 years with minimal maintenance every 10 years, these tanks have a cost of ownership of only $650.00 per year. Add minimal maintenance every 10 years at $500.00 per event. This brings the cost of ownership down to $358.00 per year when extended to 20 years. The tank must be replaced at 20 years, and there is minimal scrap value. A major disadvantage to these coatings is that they are no longer approved for potable water applications as of January 1, 2013.

Light gage riveted tanks by TGE with thermoset powder coatings have an initial cost slightly higher than light gage welded tanks, but have better internal (maintainable) coatings. These coatings are NSF-61 approved for potable water. With an initial cost of 12,000.00 and a design life, without maintenance, of 20 years, these tanks have a cost of ownership of only $600.00 per year when calculated to 20 years. Add minimal maintenance every 10 years the tank can now last 40+ years, bringing the cost of ownership down significantly. There is little scrap value at the end of 20 years.

Synopsys:

AWWA D-100 tanks have the highest initial costs, and offer the lowest long term ownership costs, but only when the tank is designed and maintained for an expected use of 80 years or more. Not cost effective for residential applications.

Light gauge welded steel and mil or hot dipped galvanized riveted tanks offer the lowest initial costs, but the long term costs to 20 years are more expensive than other alternatives.

AWWA D-103 tanks have lower initial costs than D100 tanks, and are more expensive than all other light gauge metal tanks. They offer the next lowest operating costs, but only when the tank has an expected use of 40 years or more. Probably not cost effective for residential applications.

Light gauge riveted tanks, with thermoset interior coatings, offer lower costs than D-103 tanks, but are initially more expensive than light gauge welded tanks. Their long term costs are lowest of any metal tank when calculated to 20 years.

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Tanks manufactured by Tim Guishard Enterprises **employ manufacturing techniques that have been in use for over 100 years. Improved rivet design allow special high strength rivets to be set using air/hydraulic rivet setters, ensuring proper tensions for engineering design conformance. Roofs can be designed for snow loads.**

All seams on the shell and bottom are sealed using NSF 61 approved urethane sealants. Seams are double or triple riveted when necessary for strength or to endure hoop stresses imparted by the stored water.

Internal and external coatings offered: from simple mill or hot dipped galvanized materials all the way up to Thermoset Powder coatings. Internal coatings above Bituminous coal tars are in compliance with NSF-61 and AWWA D-103 standards. Various colors of enamel, or powder epoxy, exterior coatings are available to suit the application.

Seismic designs or wind anchorage can be incorporated into any tank for an additional cost.

24" square deck man-ways and 8" deck vents are standard. Additional or larger man-ways and vents are available.

Field erecting is available for any tank of any size. This saves freight costs and makes it possible to install a tank where no one else can.

Tank repair and service is available. We service what we sell, and a few others.

Available accessories:

External or internal ladders with OSHA safety cages or anti-fall protection when required

Side shell man-ways of various sizes

Level gages

Low and high level alarms

Piping packages

Strut channel mounted on exterior of tank shell for supporting electrical conduits or water piping

Any other accessories needed for your application

We also sell and erect AWWA D-103 bolted steel tanks manufactured by CST Industries, Inc.

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