Glass Fused-To-Steel Water Storage Tanks
Introduction

The configuration and selection of a water storage tank is often something that needs to be done in the early stages of a project design. In order to apply for and secure funding that may be available, timing of construction and overall project costs will all play a factor in the determination. Because many municipalities have a single source of water storage, the tank design plays a critical role in meeting the current and future needs of the community and project. Review of community demands for current and anticipated water supply, site conditions, pressure requirements, long term maintenance, ease of access and overall costs are only some of the critical details essential to the ultimate selection of the tank configuration.

There are three types of liquid storage tanks available that are considered for municipal water storage applications: Glass coated bolted steel, welded painted steel and concrete. Tanks utilized in potable water systems are designed to AWWA (American Water Works Assoc.) standards. Tanks used in wastewater or landfill applications are designed to AISC (American Institute of Steel Construction) and fire storage tanks are typically designed to NFPA (National Fire Protection Association) standards.

The first edition of AWWA D100 for painted steel tanks was issued in 1941. The standard for bolted glass fused-to-steel AWWA D103 was issued 39 years later in 1980. Six years later AWWA issued the first edition for wire wound pre-stressed concrete tanks in 1986.

Application & History

Glass fused-to-steel tanks are used for a variety of liquid storage applications. Potable Water, Wastewater, Equalization, Sludge, Landfill Leachate, Brine, Trickling Filters, Sequential Batch Reactors (SBR), Frac Storage, Aerobic and Anaerobic Digesters are just some of the many applications that can benefit from the use of this type of tank.

The process of fusing glass to steel has been in existence for well over 100 years and began in the beer brewing industry. In the late 1800’s, the technology was used in the United States and in the 1940’s the technology was applied to agriculture by A.O. Smith Harvestore Products, Inc. storing silage and manure. These types of tanks are known as Harvestores and Slurrystores respectively. There are tens of thousands of these structures dotting the countryside on local farms.

In the early 1970’s, glass coated bolted steel tanks were recognized for their superior coating and quality and were introduced into the liquid storage market, where they dominate today.

Design & Configurations

Glass coated bolted steel tanks are used in a variety of configurations from
standpipes, reservoirs and most recently Composite Elevated (CET) designs. Standpipes are tanks where pressure is required to properly feed the system and the water is elevated in a tall column to achieve this. The tank height is larger than the tank diameter. The elevation of the water is accomplished by storing the required “water on top of water”. Standpipe height usually does not exceed 140’.

Reservoirs are the most common configuration used in water storage. With this design, the tank diameter is larger than the tank is tall and these tanks can be used with a pumping system or by gravity. The diameter of these tanks can reach 250’ with capacities up to 6 million gallons.

The CET design is used in applications similar to a standpipe, in that height is used to achieve the head pressure needed to properly operate the system. The CET column is constructed with jump form technology resulting in a hollow concrete pedestal on which the tank is then constructed. There is an enormous amount of structural rebar and steel embedded in the concrete with walls that can exceed 10” thick and a top cap of about 4’ thick concrete.

The concrete pedestal interior offers plenty of space for pump stations, municipal maintenance equipment, office space and other uses. There are theoretically no height limitations for CET’s and capacities are up to 1.5 million gallons.

The roof of glass bolted tanks varies depending upon the diameter, snow loads and other factors. They can be the same glass fused-to-steel material (Knuckle Design) as the tank or a free-span aluminum geodesic dome, consisting of panels mounted on a rigid structural frame (Geodesic Design).

The tank floors are usually constructed with a monolithic concrete pour or they can be glass fused-to-steel panels depending upon site and design conditions.

Advanced Technology – The unique manufacturing process of this equipment and advanced technology is what sets these tanks apart from typical painted steel or concrete structures. The tanks are constructed exclusively of United States materials and all of the manufacturing is completed in a U.S. plant (CST) in DeKalb, Illinois. CST Industries has the largest glass fused-to-steel tank manufacturing facility in the world. All critical manufacturing is completed in an ISO-9001 certified controlled environment. The high level of quality control ensures an exceptionally manufactured product. The uncontrolled variables, that exist for field manufactured products such as painted steel, and concrete tanks, are eliminated with the factory manufacturing.

Adverse weather, extreme temperatures, worker experience & environmental conditions that are proven to have a significant effect to onsite manufactured products, have minimal effect on the glassing process. In addition, the tanks are easily erected year around as the manufacturing itself is completed in the factory and only the assembly of the components is required in the field.

Coating – Essentially all storage tanks have a coating. The coatings’ available today consist of either concrete, paint or glass. The impermeability and unique features of the glass offer numerous advantages over the other choices.

The glass coating process begins with a glass frit that is mixed with other minerals and water to create a liquid slurry. This glass slurry is then robotically sprayed at precise amounts and thicknesses onto previously cut and rolled, punched, grit blasted and cleaned steel panels. The panels are then run through a furnace at 1500° F. This high heat melts the silica glass slip into the surface of the grit blasted steel. This completes the mechanical bond as well as the chemical bond between the steel and the silica glass. Different coatings that are
available for other tanks rely on a mechanical bond of the coating to the underlying material. In addition to the mechanical bond, the glass fusing process also provides a chemical bond of the materials. This chemical bond strength is many times the holding strength of the conventional mechanical bond and prevents any undercutting of the coating which can allow spreading of corrosion on the primary steel material. This benefit can best be explained by imagining a scratch on an automobile. Because that coating has only a mechanical bond, if the steel is exposed, corrosion will begin to occur. Left untreated this corrosion will expand and creep beneath the surrounding painted surface and compromise the remaining coating.

This is often witnessed with raised bubbles, spreading rust and weakened substrate. The chemical bond of the glass fused-to-steel coating prevents this spreading of corrosion in the event the coating was compromised.

**Tank Erection** – Erection of the glass fused-to-steel tank in the field encompasses a unique jacking system. Once the starter sheet (bottom ring) is either embedded into the concrete foundation or constructed utilizing a glass coated bolted steel floor design, the top ring of the tank is constructed on the jacks. The roof of the tank is then erected and the ring and roof are jacked up. Each additional ring is then assembled below the top ring by bolting the sheets together and applying a specially manufactured urethane sealant between the seams.

**All construction is completed at ground level ensuring a safe, fast and efficient building environment.** Tanks are normally completed within a week or two which saves significant costs to the owner if prevailing wages for onsite labor are being used. Additionally, the manufacturer requires that all building crews be factory trained and certified in the erection process, ensuring the same quality control in the field. Only fully trained erectors are used for the construction of these tanks.

### Advantages

**Maintenance Costs** - There are numerous advantages of a glass fused-to-steel liquid storage tank when compared to either a painted steel or concrete tank design. One of the most powerful economic advantages is the fact that the glass coating never requires repainting, it is permanent. The dollars saved from not having to repaint a painted tank or repair aged concrete can be funneled to other projects in a municipality.

**Flexibility** - The bolted design and erection of this product yields flexibility that no other tank can offer. Because manufacturing is completed in a factory, large staging areas needed when a product is manufactured on site are eliminated. The erection of the tank can typically be completed with a cleared area of roughly 6 – 10’ around the tank diameter. This reduced site clearing and leveling can save thousands of dollars on the overall project beyond the price of the tank itself. The panels themselves can be hand carried and assembled in tight locations when required, allowing this tank to be installed in many locations that would be impossible for other tank types.

Additionally, a panel can easily be replaced in the event extra manways, nozzles or other components are req’d. Unlike a concrete or welded tank that would need to be torn down if the structure were compromised, this type of tank structure can essentially be considered permanent since any compromised panels can always be replaced.

**Sustained Beauty** – Another benefit of the glass fused-to-steel coating is the sustained appearance. Because the glass will not chalk, fade or discolor, a community can expect the appearance of...
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Advantages (cont’d)

their tank to remain for years into the future. While painted tank coatings erode, rust and fade away over time, the glass coating will continue to hold its curb appeal. Unlike concrete tanks that require an exterior coating to prolong the concrete appearance and require the reapplication of the coating over time, to prevent the dark unsightly stains of concrete, the glass coating will hold up to the elements.

Glass fused-to-steel tanks are often placed in areas, where long term visual appearance is desired.

Expandable – Another unique and significant feature of the glass fused-to-steel bolted tank design is the ability for the tanks to be vertically expanded. If a community or industry

experiences growth and additional capacity is necessary, the tank’s unique jacking process allows the end user to gain this capacity both quickly and cost effectively. The factory certified tank erection crew simply unbolts the bottom ring from the original starter sheet, jacks the tank up and adds the number of rings necessary to achieve the new capacity.

Tank expansions can typically be completed in less than a week and at a substantial savings over having to purchase a new tank to gain the additional capacity. If the possibility of future expansion exists for any community or industry it is recommended that this be considered in the initial project design, so that adequate concrete and rebar of the tank foundation to support any additional future loading. Because of the superior glass coating, when these tanks are expanded, there is no difference in appearance between the original panels and the new panels. Several communities across the country have expanded after 25 years of service with no detectable difference in appearance.

Ancillary Items – The bolted design allows for the easy and simple installation of additional nozzles or penetrations into the tank at any time and eliminates the difficulty this can encounter with other tank designs. Insulation, baffles, special walkways, stairs, platforms and internal equipment can easily be installed if the project design requires it.

Disadvantages

Shapes - The specialized manufacturing process of fusing the glass coating to the high strength steel requires that the steel sheets are capable of being run through a furnace. Steel sheet sizes are limited as a result of this process. As a result, the only design available is a cylinder. Odd shapes are difficult to achieve with this type of construction. If odd shapes are required then welded joints must be considered.

Capacities - AWWA limits the maximum sheet thickness for bolted steel tank designs. This creates a hydrostatic loading limitation on the capacity of the tank structure. This sheet thickness restriction means that typical bolted glass-fused-to-steel tanks are only available in sizes up to approximately 6,000,000 gallons.

Other tank types should be considered for greater capacities.

Other Considerations

Bullet Holes - Because the vast majority of these tanks are found in rural areas instead of major urban areas, some communities are concerned with the possibility of the product being damaged by bullet holes. While it is possible for a bullet to penetrate the high strength steel, the probability of this happening is rare.

While still an uncommon occurrence, if the impact from a bullet were to damage the tank it would typically result in the glass coating being chipped. One could expect the chip itself to be about the size of a coin.

Because the chemical bonding of the coating to the steel will prevent any undercutting of the coating, the simple remedy for this would be to essentially cover the spot with a light layer of sealer. If the impact were significant enough to create any damage to the interior tank coating, the cathodic
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Other Considerations (con’t)

protection system inside of the tank would protect the steel until any touch-up is performed. If, somehow a bullet did actually penetrate the steel sheets, the repair however, would simply be to ream out the hole and insert a structural bolt. Overall any potential bullet damage to a glass fused-to-steel tank should be considered minimal at worst and should be far easier to repair or address than the potential of having to repaint an epoxy painted tank or to have the windings exposed and structure weakened after shotcrete is shattered from an impact on a concrete structure.

Ice – Unheated structures with little or no turnover have the potential of freezing if exposed to prolonged severe freezing temperatures. The principles of heat transfer ultimately apply to all tank construction materials.

In a typical municipal application, the system, by virtue of its operation, provides adequate turnover. If not, this requirement needs to be addressed in the design of any system to ensure that this does not occur. There are numerous solutions available for low turnover, in the event of prolonged extreme low temperature periods. One should seek the advice of their design engineer and tank manufacturer.

Manufacturing Improvements

Edge Coating - Continuing Research and Development of glass coating technology and product performance has yielded significant improvements in glass Fused-to-Steel storage tanks since the product was first introduced in the late 1940’s for dry and liquid storage. One of those improvements has been the development of sheet Edge Coating. Prior to this process, the high surface tension of the sharp edges, prevented the glass from adequately adhering to the steel edges.

Rounded sheet edges with glass coating.

The sheet edges were filleted with sealer and this became a potential future maintenance issue. As the tanks aged, it could become necessary to clean and reseal the sheet edges for protection against any future corrosion.

Sealer - Additional improvements were made to the sealer used in the erection of the tanks. The sealer was upgraded for enhanced UV exposure and 200 ppm chlorine resistance. The sealer is manufactured exclusively by Manus, Inc. for CST Industries. This improvement has extended the life of the sealer and adds to the minimal maintenance design of the tanks.

Specially formulated UV resistant Polyurethane sealer

Protective Caps - A high impact polypropylene

Exposed Nut/Washer combination prior to protective caps
Manufacturing Improvements (con’t)

copolymer protective cap is available to cover the exterior nut - washer combination on the tank of the bolted design. This ultraviolet resin material is ANSI/NSF approved and was added to control the oxidation of the bolt – nut that were previously exposed to the elements and could begin to show signs of streaking on the tank sheets. Although this streaking was capable of being cleaned, it was another potential maintenance issue that the manufacturer wanted to remove.

Maintenance

It is wise to have an inspection procedure instituted as part of the regular maintenance program for all tanks.

AWWA recommends that all potable water storage tanks be inspected every 3 to 5 years. Every system should have a periodic inspection program to ensure that the system is working properly. As with anything, the sooner an issue is addressed, the less chance it has to develop into a catastrophic event.

Scheduled inspections help to ensure that no vandalism or structural concerns have arisen.

No configuration of liquid storage tank should be installed and left to sit alone, without some type of inspection procedure in place. This way any serious problems can be avoided.

“Neglecting maintenance is the most common cause of structural failure in a storage tank”… This statement applies to ANY type of storage tank.

Glass fused-to-steel tanks have very limited long term maintenance costs. Aside from periodic inspections and powerwashing, the only maintenance item is the periodic replacement of the sacrificial anodes used in the cathodic protection system. The sacrificial anode cathodic protection system is designed specifically for each individual system.

A water sample is taken and the resistivity/conductivity of the water, area of exposed steel surfaces and many additional factors determine the exact number of anodes required to maintain the system for about ten years. Once the anodes have been depleted, they will need to be replaced. This can be accomplished easily when the tank is empty during a scheduled inspection or with the use of a diver.

The National Association of Corrosion Engineers states that as a result of the billions of dollars spent annually on failing infrastructure, that any structure that could benefit from the use of cathodic protection, should use it. Essentially, if there is any steel or rebar associated with a storage tank, cathodic protection should be considered to extend the life of the structure.

Historically, glass fused-to-steel tanks require the least amount of maintenance and associated costs, over the lifetime of the structure, than either painted steel or concrete structures.
Conclusion

Overall, glass fused-to-steel tanks should be considered as a solution to a municipalities or industries liquid storage needs.

The impermeability and chemical resistance of the glass coating means these tanks are well suited for wastewater, landfill and other aggressive industrial applications.

Initial construction costs, anticipated life and long term maintenance costs are all significant factors relative to the various tank designs and materials available today. The long term maintenance costs and life cycle during a tank evaluation all need to be considered when selecting the appropriate product for a specific project.

A properly maintained and inspected glass fused-to-steel tank should be expected to have as long a life, if not longer, than the painted steel or concrete type structures but for much less in maintenance costs. Contact us for further details.

Because project financing can vary depending on several factors, a complete analysis of initial costs and, lower maintenance should help a community decide which type of product is best suited for their needs.