

Best Porcelain Enamel Tank in the World for Liquid Storage Tanks

**ENGINEERED STORAGE
PRODUCTS COMPANY**



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INTRODUCTION

Engineered Storage Products Company (ESPC) is the premier leader in the design and manufacture of glass-fused-to-steel storage tanks. Our success is evidenced by 60 years of manufacturing experience and more than 100,000 installations worldwide. But time and experience alone do not qualify a company to be an industry leader. It is Engineered Storage Products additional commitment to quality and customer service, and dedication to advancing product development through R&D and world-class manufacturing that sets it apart from other tank manufacturers and ensures continued success into the future. As a result, Aquastore® tanks are simply the best quality, lowest maintenance and most flexible tank available.

This paper contains detailed information on what makes Engineered Storage Products Aquastore glass-fused-to-steel tanks unique:

- Glass quality
- Our patented coating process known as Vitrium®
- Our custom, proprietary sheet edge coating process Edgecoat™
- Glass testing procedures
- Quality control
- Compliance with the American Recovery and Reinvestment Act of 2009
- Authorized dealer network

Engineered Storage Products tank applications range from the storage of livestock feed and manure to potable water and digesters. Our in-house engineering group, sales team and authorized dealers will work with our customers to design standard and custom tanks that meet a variety of storage requirements.

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Engineered Storage Products Company's glass-fused-to-steel tanks offer the longest product life and greatest value because of:

- High Glass Quality

Glass coating thickness range of 10–18 mils. This holiday free glass coating thickness provides the lowest maintenance requirement over the life of the tank, thus a greater lifetime value compared to alternative materials.

- Patented Coating Process

Vitrium Glass combines outstanding chemical and physical resistant properties of titanium–reinforced glass with highly engineered, ultra-fine bubble structure. This translates to longer tank life, durability at competitive pricing, maximum coating effectiveness without excess coating thickness and 100% holiday free sheets.

- Exclusive Edgecoat Process

Edgecoat is a proprietary process developed in 1996 by Engineered Storage Products that is designed to reinforce and enhance the sheet edges by thermally applying a protective alloy to the edge of shell sheets and rectangular floor sheets.

- Factory Glass Testing

Engineered Storage Products Company conducts a 1100 volt dry test to assure sheets are 100% holiday free and that there is no damage to the glass coating.

- Product Quality Control

Engineered Storage Products Company has a state of the art in house lab where the most stringent tests for fish scaling, spalling, bubble structure and impact/adhesion are conducted on all porcelain enamel products.



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- American Made Steel

Engineered Storage Products Company uses American made iron and steel in our tanks and manufactured goods; American made aluminum dome materials and American made glass frit to produce a glass-fused-to-steel tank that complies with Section 1605 of the American Recovery and Reinvestment Act of 2009.

- Authorized Dealer Network

Our products are sold by authorized independent dealers. In addition to selling and erecting glass-fused-to-steel tanks, our dealers offer design and layout services, budget analysis, site preparation, concrete work and more for a complete turn-key solution. From the design phase through turn-key installation Engineered Storage Products authorized dealers assure customers they have made the correct buying decision with the selection of a porcelain enamel, chemically bonded to steel tank manufactured by Engineered Storage Products Company.

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GLASS QUALITY

Over our 60 year history, we have built 100,000+ installations around the world. These structures have been built using glass coatings with thicknesses of 10-18 mils. This holiday free glass coating thickness is one of the specification details that provide confidence, the lowest maintenance requirements, greater lifetime value, and an allowable service range of 140°F at 2-11 pH depending on specific products stored. It isn't just the coating thickness, but the quality of the glass (porcelain enamel coating) as well.

Engineered Storage Products Company's glass coating combines the outstanding chemical and physical resistant properties of titanium-reinforced glass with a highly engineered, ultra-fine bubble structure. This process results in high performance glass-fused-to-steel technology also known as porcelain enamel coating chemically bonded to steel.

The combination of tough Titanium Dioxide (TiO₂) glass formulations provide:

- Longer tank life
- Base coat of glass frit containing nickel oxide ensures consistent quality
- Maximum coating effectiveness without requiring excess coating thickness in order to provide the needed durability at competitive pricing
- Unique process technologies and 1100v dry testing provide factory certified 100% holiday free sheets.

The combination of glass quality and glass thickness provide the assurance that over 60 years of experience and 100,000+ structures successfully installed around the world will continue with each and every new structure installed.

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TITANIUM DIOXIDE

In 1998 Engineered Storage Products launched an R&D project to develop a process for the direct application of our proprietary Titanium Dioxide (TiO₂) Glass. Through this research the goal of increasing value by providing Glass 97 toughness with a single pass through the furnace was achieved. The result is a totally new, patented "three-coat-one-fire" (3c1f) process for applying TiO₂ Glass. The patented process and coating has been trademarked as **Vitrium** (from **Vitreous** and **Titanium**).

TiO₂ is a very common ingredient used by many coating manufacturers for various reasons:

- It is considered inert and at high level in porcelain enamel, gives unique properties.
- In the case of the interior coating, Vitrium, with its higher percentage of TiO₂ in the final white layer, allows Engineered Storage Products to provide an exceptional enamel surface.
- During firing, the white layer's higher viscosity has the effect of controlling bubble structure in addition to making the top TiO₂ rich layer harder, more chemical resistant and the bubble structure finer. This high TiO₂ content is unique to Aquastore and provides exceptional properties to fit colder conditions common to the North American market.

As a result of using higher amounts of TiO₂ in the final white layer, a unique visual marker on the glass known as “Vitrium threading” becomes apparent. This is caused by thicker areas of the top white layer interspersed with thinner areas allowing the underlying bluecoat to show through opaquely. This immediately identifies the coating as Vitrium.

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Figure 1 – Vitrium Threading. Opaqueness of whitecoat to show underlying Vitrium bluecoat

What should be emphasized is the incredible effectiveness of the white glass layer in containing the blue layer even with the variation in white coat thickness. Figures 2 and 3 show cross sections of the glass and steel interface at 100X magnification. Note the glass bubble structure and how the top white layer is providing a very fine structure at the surface of the glass. This is the real value of the TiO₂ impregnated white glass.

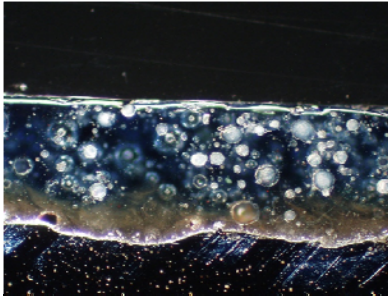


Figure 2 – 100X magnification showing a Two-Coat-One-Fire (2c1f) without Titanium Dioxide

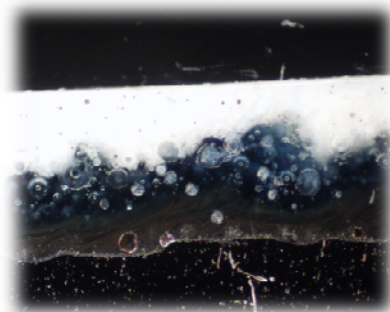


Figure 3 – 100X magnification showing the Three-Coat-One-Fire (3c1f) with Titanium Dioxide (Vitrium)

Figure 2 is a typical cross-section of a “two-coat-one-fire” (2c1f) process that does not contain a final layer of TiO_2 rich porcelain. Comparing this cross-section to Vitrium (3c1f) in Figure 3, one can see significant differences. First, the bubble structure for Vitrium is very fine which allows flexibility yet provides a tenacious coating. The 2c1f process without TiO_2 results in large bubble structure allowing a potential direct path for corrosion. Second, by its very nature, a 2c1f process cannot have the thickness of a 3c1f enamel. Utilizing a 2c1f process for an interior coating would make the coating more prone to long-term damage from liquids.

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EDGECOAT

The Edgecoat process was developed in 1996. Edgecoat is a machined reinforced and thermally enhanced sheet edge and is an excellent example of Engineered Storage Product’s attention to detail and of being an innovator of leading edge technology. Engineered Storage Products Edgecoat process is another benefit and advantage of Aquastore tank and is hard to beat.

Milled or sheared edges are the most difficult areas to coat with glass. The custom built, proprietary machine is designed to reinforce and enhance the sheet edges. To date this Edgecoat process is the only such machined reinforced edge process in the world.

The Edgecoat process consists of several operations being performed on all of Engineered Storage Product's full height shell sheets and our rectangular floor sheets. Each sheet edge is uniformly beveled to remove sharp and rough edges, followed by a special design edge blast profile.

The final step in the Edgecoat process thermally applies a protective, proprietary, alloy to the edges so that a greater deposition of glass (porcelain enamel coating) wraps the edge. Then glass is added to this process, thus doubling the protective barrier added to each sheet edge for maximum protection. This added protection is also beneficial during the packing and construction of the tank.

Once the tank is erected, all full height shell sheets and rectangular floor sheets will have triple protection; Thermally applied proprietary alloy coating, porcelain enamel chemically bonded to steel and field applied seam sealant.

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Figure 4 – Thermally applied proprietary alloy coating

HOLIDAY TESTING

Holiday testing, as it is commonly called, is known more accurately as discontinuity detection. Its purpose is to test for the presence and location of discontinuities, voids, and/or thin spots in an otherwise non-conductive surface. Holiday testing is separate from a coating thickness test, however, both tests are used to confirm quality of the final porcelain enamel coating.

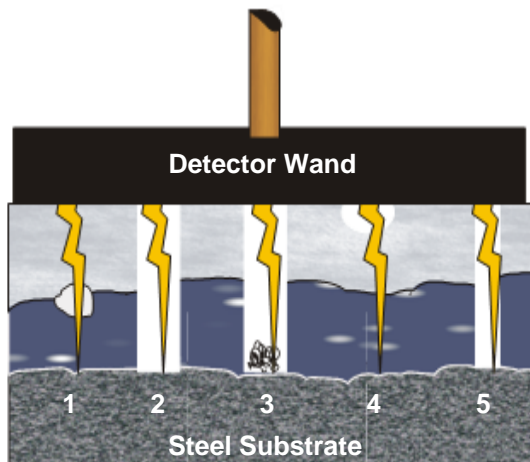


Figure 5 - Test Sheet with Defects

- 1 - Current passes through defect below surface
- 2 - Current passes through pin hole
- 3 - Current passes through grease
- 4 - Current passes through thin spot
- 5 - Current passes through small pin hole

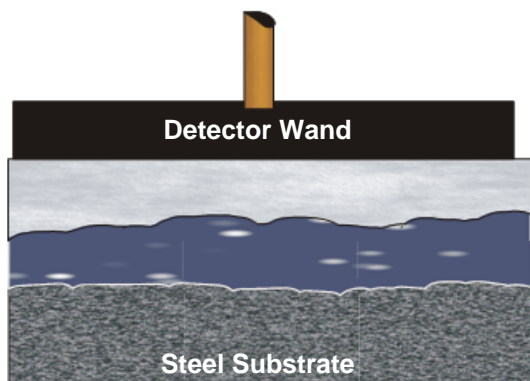


Figure 6 - Test Sheet with No Defects.
Current DOES NOT pass through a uniform, continuous, quality coating layer.

Holiday testing is performed by generating a DC voltage potential or difference between the glass surface and the steel substrate, and then detecting any current flow that occurs between the two surfaces. If testing Vitrium, Engineered Storage Product's 3c1fs system, an 1100 VDC is applied to the dry, glass surface while monitoring for any return signal that may be detected on the steel substrate. This circuit must be recreated for each and every sheet tested. Any sheet that is found with interior holidays is reblasted and recoated. Touch-up is never allowed.

QUALITY CONTROL

The stringent testing of Engineered Storage Products coatings is an extensive process and covers all aspects of the ISO certified plant. Analysis of the steel, steel surface, frit, slip, slip application, firing, color, consistency, coating thickness and coating defects are combined to provide a coating that is specified to be holiday free.

All steel that enters the Engineered Storage Products plant undergoes external and internal inspections prior to the application of the enamel coating:

- All incoming steel is accompanied by a steel batch report confirming composition and yield strength
- Sheet tolerances, thickness and squareness are confirmed.
- Once the sheets pass inspection, they are blasted and the surface roughness is measured. The surface is taken to a NACE (National Association of Corrosion Engineers) specification of at least SP-10, near white cleanliness, that is checked with a visual NACE comparator.

All of the Aquastore porcelain enamel surfaces, Vitrium as well as Glass 97, adhere to the requirements of International Standard EN15282:2007 and to AWWA D103:97.

Furthermore, Engineered Storage Products complies with its own published standards that have been formed from over 60 years of experience dealing with many different liquids and field conditions throughout the world.

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The testing methodology employed by Engineered Storage Products is proprietary to Aquastore and takes into account the exceptional material properties that fit the colder conditions common to the North American market. The Aquastore product is subjected to several critical tests that go beyond AWWA D103:97 as well as the requirements of any international standard. Fish scale, spalling and cross-sectioning microphotography are used to confirm the quality of the coating and are done on both Vitrium and Glass 97.

Each sheet is stamped with a unique serial number. This numbering system allows Engineer Storage Products to track and trace every sheet through the manufacturing, testing, shipping and erection processes.

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FISH SCALE TESTING

A test for hydrogen gas-caused fish scaling is very common within the enameling industry and is done by varying methods. At Engineered Storage Products, fish scale testing is done on every sheet gauge change made within a given day. This means that the test is literally done hundreds of times a year. The fact that a highly advanced coating system can be provided on high strength low alloy steel that is free of fish scaling defects is the result of decades of research and experience into the field of enamel coatings.

FREEZE THAW TESTING

Utilizing a Thermatron freeze/thaw test to check for spalling in our coating allows for better control of the product in a setting that models field conditions. Samples are cycled hundreds of times to test their resiliency to temperature changes. Only testing to the international standard of a simple thermal shock test once yearly does not thoroughly recreate inherent freeze/thaw issues.

BUBBLE STRUCTURE TESTING

In order to confirm an ultra-fine bubble structure that is so critical to Aquastore glass, cross sectioning and microphotography are utilized. Bubble structure cannot be left up to field evaluation to determine success. Engineered Storage Products incorporates microphotography into its testing regime in order to confirm bubble structure and consistency.

IMPACT TESTING

Impact testing is done to check coating bond strength with the steel and is critical in evaluating high quality porcelain enamel. A sheet fails if underlying steel is exposed after the test is performed.

International standards only require testing monthly or per batch change and intensity does not vary with sheet thickness. The intent of the international standards is to check the surface coating resistance to impacts and does not fully consider bond strength. Engineered Storage Products testing is performed hundreds of times a year and intensity is varied based upon the sheet thickness.

FACTORY TESTING OF GLASS

Over the last decade, significant improvements have been made in the factory testing equipment for glass coatings. Prior to this improvement in testing, there were significant and valid concerns regarding testing results and potential damage being done to the coating during the testing operation. Currently there are several pieces of equipment on the market that can routinely test glass with dependable and repeatable results without damaging the glass coating.

The 1100v dry test conducted in Engineered Storage Products Company's factory provides assurance to a 100% holiday free glass-fused-to-steel sheet and no damage to the glass coating.

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PACKAGING

Finally, each sheet is carefully packaged on specially designed pallets with paper in-between each sheet to protect them during shipment. The packaging guarantees the tank is delivered defect and holiday free, and guarantees that exact replacement sheets can be manufactured if any were damaged in the field.

AMERICAN MADE STEEL

Today's customers are more aware than any time in recent history of the importance of buying American made products to keep our economy strong. Engineered Storage Products Company prides itself on producing products that comply with the American Recovery and Reinvestment Act of 2009.

All the below steel, glass and aluminum components make up to a glass-fused-to-steel tank with an aluminum dome that is made in the United States of America:

- Glass frit used for our premier coatings
- Sidewall, roof, steel floor material
- Aluminum dome material
- Structural steel material
- Other miscellaneous components.

Since 1949 Engineered Storage Products Company has been manufacturing glass-fused-to-steel (porcelain enamel coating chemically bonded to steel) storage tanks. The discoveries and refinements of our dedicated research are incorporated into our manufacturing processes. With over 100,000 storage tanks installed worldwide, our glass-fused-to-steel tank is backed by Engineered Storage Products Company's history and proven integrity.

For more information, please visit our website at www.aquastore.com. For an estimate on an Engineered Storage Products Company porcelain enamel (glass-fused-to-steel) tank, please visit our website and request a quote.

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