SECTION 33 16 13.23

BOLTED, GLASS-FUSED-TO-STEEL LIQUID STORAGE TANKS

Basis of Design: PermaFusion™ by Municipal Tank Works

SPECIFIER NOTE: This Section is written in CSI 3-Part Format and is intended for direct inclusion in the Project Manual. Edit bracketed [items] and strike-through items not applicable to the project. Coordinate with Sections 03 30 00 (Cast-in-Place Concrete for foundations), 26 05 26 (Grounding), 40 05 00 (Process piping), and 09 90 00 (exterior coatings, if field-applied touch-up is required).

PART 1 — GENERAL

1.01 SUMMARY

A. Section Includes:

1. Shop-fabricated, field-bolted, glass-fused-to-steel (GFS) liquid storage tank system, including vertical shell, floor, roof, appurtenances, and accessories.
2. Factory-applied vitreous borosilicate glass coating molecularly fused to both interior and exterior steel faces.
3. Erection, field testing, and disinfection (as applicable to service).

B. Related Sections:

1. Section 03 30 00 — Cast-in-Place Concrete (ringwall foundation).
2. Section 31 23 00 — Excavation and Fill.
3. Section 40 05 00 — Common Work Results for Process Integration Piping.
4. Section 46 00 00 — Water and Wastewater Equipment (where applicable).

1.02 REFERENCES

A. The following standards form a part of this Section to the extent referenced. Latest published edition applies unless noted.

B. American Water Works Association (AWWA):

1. AWWA D103 — Factory-Coated Bolted Carbon Steel Tanks for Water Storage.

C. NSF International:

1. NSF/ANSI 61 — Drinking Water System Components – Health Effects.

D. National Fire Protection Association (NFPA):

1. NFPA 22 — Standard for Water Tanks for Private Fire Protection.

E. International Organization for Standardization (ISO):

1. ISO 28765:2016 — Vitreous and porcelain enamels — Design of bolted steel tanks for the storage or treatment of water or municipal or industrial effluents and sludges.
2. ISO 28706 (series) — Vitreous and porcelain enamels — Determination of resistance to chemical corrosion.

F. ASTM International:

1. ASTM A1011/A1011M — Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, HSLA.

2. ASTM B117 — Operating Salt Spray (Fog) Apparatus.
3. ASTM D870 — Water Immersion Test for Coatings.
4. ASTM D2794 — Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
5. ASTM D4541 — Pull-Off Strength of Coatings Using Portable Adhesion Testers (Type V fixture).
6. ASTM G8 / G42 — Cathodic Disbonding of Pipeline Coatings.

G. SSPC / AMPP:

1. SSPC-SP10 / NACE No. 2 — Near-White Blast Cleaning.
2. NACE SP0188 — Discontinuity (Holiday) Testing of New Protective Coatings.

H. Other:

1. API 12B — Specification for Bolted Tanks for Storage of Production Liquids (where specified).
2. FM Global — Approval Standards (where FM-approved construction is required).

1.03 SUBMITTALS

A. Product Data: Manufacturer's current technical literature for the tank system, coating system, sealants, gaskets, fasteners, and all accessories.

B. Shop Drawings: Complete fabrication and erection drawings, including:

1. Plan and elevation views, panel layout, bolt pattern, and seam schedule.
2. Anchor bolt plan with forces, moments, and embedment details.
3. Ladder, platform, manway, vent, and nozzle schedule with materials, sizes, and flange ratings.
4. Roof structural framing and live/dead/wind/snow load calculations.

C. Design Calculations: Stamped by a Professional Engineer licensed in the State of the Project, demonstrating conformance with AWWA D103 (or NFPA 22 / API 12B / ISO 28765 as applicable) for:

1. Shell ring thicknesses and bolt shear/tension for specified liquid head.
2. Wind loads per ASCE 7 at the Project site.
3. Seismic loads per ASCE 7 and AWWA D103 Appendix, including impulsive and convective components, freeboard, and anchor design.

D. Coating System Certification:

1. Independent third-party verification of coating thickness (dry film) across all panel surfaces.
2. NSF/ANSI 61 certification (potable water service only).
3. ISO 28765:2016 compliance letter.
4. Per-panel QC records: holiday test results, dry film thickness (DFT) readings, and lot traceability.

E. Quality Assurance Submittals:

1. Manufacturer qualifications per Article 1.05.
2. Erector qualifications per Article 1.05.
3. Welding Procedure Specifications (WPS) and Welder Qualifications for any shop attachment welds.

F. Closeout Submittals: O&M manual, color touch-up kit, warranty certificate, as-built drawings, and disinfection certification (potable service).

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in the design, fabrication, coating, and erection of bolted glass-fused-to-steel liquid storage tanks. Manufacturer shall demonstrate, at minimum:

1. A documented quality management system governing fabrication and coating.
2. Coating system produced in accordance with ISO 28765:2016.
3. Current third-party certifications applicable to the specified service, including NSF/ANSI 61 for potable water service where applicable.
4. Independently verified coating performance data meeting every requirement of Article 2.04, including salt fog (ASTM B117, 5,000 hr), water immersion (ASTM D870), cathodic disbondment (ASTM G8/G42), impact (ASTM D2794), adhesion (ASTM D4541 Type V), and acid resistance (ISO 28706-1).
5. Design calculations stamped by a Professional Engineer licensed in the State of the Project, per Article 1.03 C.

B. Erector Qualifications: Factory-authorized, factory-trained erection crew, or single-source delivery by the Manufacturer. Erection supervisor shall hold current written Manufacturer certification for the specific tank system being installed; certification records shall be provided upon request.

C. Single-Source Responsibility: Design, fabrication, coating, and erection shall be performed under a single contract by the Manufacturer or its factory-authorized agent to the maximum extent practicable.

D. Factory Inspection: Owner's Representative reserves the right to inspect the fabrication and coating process at the manufacturing facility with 14 days' notice, at Owner's expense.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Panels shall be protected from point-loading, impact, and chemical exposure during transit. Any panel exhibiting visible coating damage exceeding 1/4 in. (6 mm) in any dimension shall be rejected at the Project site.

B. Store panels above grade on dunnage, separated by non-abrasive spacers. Do not stack panels more than manufacturer's recommended height.

C. Gaskets, sealants, and fasteners: store indoors between 40°F and 90°F until time of erection.

1.06 PROJECT CONDITIONS

A. Ambient Conditions during Erection:

1. Do not install sealant or gaskets when ambient or substrate temperature is below 40°F or above 100°F unless manufacturer certifies otherwise in writing.
2. Foundation shall be cured, dry, and level within the tolerances of AWWA D103 before erection begins.

1.07 WARRANTY

A. Manufacturer shall warrant the tank and coating system against defects in materials and workmanship for a period of not less than ten (10) years from the date of Substantial Completion. Warranty shall cover, at minimum:

1. Blistering, flaking, or delamination of the vitreous coating.
2. Corrosion perforation of the steel substrate originating from coating failure.

3. Leakage at factory seams attributable to coating or fabrication defect.

B. [Extended warranty options of fifteen (15) or twenty (20) years shall be provided as additive alternates where required by Project.]

PART 2 — PRODUCTS

2.01 SYSTEM SUPPLIER AND MANUFACTURER

A. Basis-of-Design System Supplier: PermaFusion™ Bolted Glass-Fused-to-Steel Tank System, supplied and erected by:

Municipal Tank Works

2014 Champions Gateway

Canton, Ohio 44708

(330) 970-6030 · info@municipaltankworks.com

B. Single-Source Provider: Municipal Tank Works shall serve as single-source provider for the complete tank system, responsible for engineering, furnishing, and erection. Tank fabrication and coating shall be performed by a qualified Manufacturer meeting every requirement of Article 1.04 A; the identity of the Manufacturer shall be disclosed in the Manufacturer qualifications submittal under Article 1.03 E.

C. Approved Equivalent System Suppliers: Products of other suppliers will be considered provided they meet or exceed every performance requirement of Part 2 and are submitted for approval not less than ten (10) days prior to the bid date in accordance with Section 01 25 00.

2.02 STEEL SUBSTRATE

A. Shell, floor, and roof panels: hot-rolled carbon steel conforming to ASTM A1011/A1011M, with steel thickness selected by the Manufacturer to satisfy design loads but in no case less than:

1. 3 mm (approx. 0.120 in.) minimum — top shell rings.
2. 12 mm (approx. 0.472 in.) maximum — bottom shell ring, larger tanks.

B. Surface Preparation: After fabrication and prior to coating, every surface to be coated shall be abrasive blasted to SSPC-SP10 / NACE No. 2, "Near-White Metal," with an anchor profile of 2.5 to 4.0 mil (63–102 µm). Coating shall commence within the Manufacturer's published flash-rust window.

2.03 COATING SYSTEM

A. General: The coating system shall be a five-layer symmetric composite, vitrified on both interior and exterior faces by continuous firing of the steel substrate above 1,500°F (816°C). The system shall comply with ISO 28765:2016.

B. Layer Structure (interior face → substrate → exterior face):

Layer	Specification
1. Interior Vitrified Silica Glass	125–200 µm per face, inorganic borosilicate glass enamel
2. Interior Iron-Oxide Bond Layer	< 10 µm, metallurgical fusion zone

3. Carbon Steel Substrate	3–12 mm, ASTM A1011, SSPC-SP10 prepared
4. Exterior Iron-Oxide Bond Layer	< 10 µm, metallurgical fusion zone
5. Exterior Vitrified Silica Glass	125–200 µm per face, inorganic borosilicate glass enamel

C. Glass Composition (weight-percent range):

Constituent	Range (% by weight)
Silica (SiO_2)	50 – 65%
Boron Oxide (B_2O_3)	10 – 18%
Sodium Oxide (Na_2O)	8 – 15%
Alumina (Al_2O_3)	3 – 8%
Calcium Oxide (CaO)	3 – 8%
Color-forming oxides (CoO / Cr_2O_3)	1 – 4%

D. Bond: Coating-to-steel attachment shall be a metallurgical fusion bond formed by iron diffusion into the molten glass during firing. Adhesive-bonded, thermoset, or fusion-bonded-epoxy systems are not acceptable.

E. Compression Stress Field: The cooling schedule shall generate a permanent residual compressive stress of 50–80 MPa on both glass faces to suppress crack initiation and propagation. Submittal shall document the measured or calculated compressive preload.

F. Color: Pigmentation shall be integral to the molten glass (not a surface pigment). [Specify color from Manufacturer's standard palette; cobalt blue, forest green, and charcoal are typical.]

2.04 PERFORMANCE REQUIREMENTS

A. The finished coating system shall meet or exceed the following properties when tested in accordance with the referenced standards:

Property	Requirement / Test Method
Dry Film Thickness	250 – 400 µm dual-side
Surface Hardness	≥ 7,000 Hv (Vickers)
Operating pH — continuous	3.0 – 11.0
Operating pH — intermittent (≤ 8 hr)	1.5 – 13.0
Operating Temperature	–40°F to 200°F continuous; 250°F intermittent peak
Coefficient of Thermal Expansion	~ 9 × 10^{-6} /°C, matched to carbon steel
Residual Compressive Preload	50 – 80 MPa

Adhesion (pull-off, ASTM D4541 Type V)	≥ 4.5 ISO 28706 class
Impact Resistance (ASTM D2794, direct)	≥ 30 in-lb
Permeability	Zero (non-porous)
Salt Fog (ASTM B117)	5,000 hours, no underfilm corrosion
Water Immersion (ASTM D870)	No blistering or adhesion loss
Cathodic Disbondment (ASTM G8 / G42)	No disbondment
Acid Resistance (ISO 28706-1)	Class AA
UV Stability	Inherent (inorganic); no recoating required
Design Service Life	≥ 30 years in specified service

2.05 FABRICATION

A. Panels shall be sheared, punched, rolled, and pre-drilled to Manufacturer's shop-drawings prior to coating. All edges, bolt holes, and weld-hook details shall be ground smooth to prevent coating thinning at radii.

B. Any shop welding, including lug and hook attachments, shall be completed before blasting and coating. No field welding to coated panels is permitted.

C. Shot Blast (Stage I): SSPC-SP10 near-white with a 2.5–4.0 mil profile. Blast media shall be steel shot/grit, new or recycled, meeting SSPC-AB1.

D. Frit Application (Stage II): Electrostatic application of powdered vitreous frit to both faces at a target thickness of 250–400 µm.

E. Vitrification (Stage III): Continuous furnace at 1,500–1,650°F for 8–12 minutes dwell, sufficient to fully molten the frit and develop the iron-oxide transition zone.

F. Compression & QC (Stage IV): Controlled-rate cooling to develop compressive stress field; every panel shall be holiday-tested and DFT-verified prior to release for shipment.

2.06 SOURCE (FACTORY) QUALITY CONTROL

A. Every panel shall receive:

1. 100% low-voltage wet-sponge or high-voltage spark holiday test per NACE SP0188. Any discontinuity shall result in panel rejection or touch-up by Manufacturer's approved procedure, followed by re-test.
2. Dry Film Thickness verification at no less than five (5) points per face using a calibrated eddy-current gauge.
3. Visual inspection for blisters, inclusions, and fire-pull defects.

B. Acceptance: Panels shall be accepted per the criteria of ISO 28765:2016 and the Manufacturer's written QC program. Test records for every panel shall be retained and made available with Closeout Submittals.

2.07 ACCESSORIES AND APPURTENANCES

A. Sealants and Gaskets: Manufacturer's standard, NSF/ANSI 61 certified for potable water service, chemically compatible with the stored fluid.

B. Fasteners: Cadmium-plated or mechanically zinc-plated steel bolts and nuts with encapsulated heads on the wetted side, rated for the specified design loads. [Stainless steel fasteners shall be used where Project specifies or for service with chlorides > 500 ppm.]

C. Roof: [Aluminum geodesic dome] / [Low-profile steel cone, glass-coated] / [Flat steel deck with internal rafters] / [EPDM/XR-5 flexible membrane for digester service].

D. Nozzles, Manways, and Accessories: Shall be factory-coated where possible; bolted stainless-steel flange kits for field-installed nozzles.

E. Ladders and Safety Cages: Hot-dip galvanized steel per ASTM A123, OSHA 1910.23 compliant; [fall-arrest rail where required].

PART 3 — EXECUTION

3.01 EXAMINATION

A. Prior to start of erection, verify that the concrete ringwall or foundation slab is level within the tolerances of AWWA D103 (generally ± 1/8 in. over any 30-ft chord and ± 1/4 in. maximum) and that anchor bolts are correctly located.

B. Report any deviation exceeding the stated tolerance to the Engineer in writing before proceeding. Starting erection constitutes acceptance of the foundation.

3.02 PREPARATION

A. Clean the top of the foundation of all debris, oil, and laitance. Install grout or neoprene sole-plate per Manufacturer's detail prior to setting the starter sheet.

B. Stage panels in the erection sequence order, on dunnage, within 100 ft of the tank footprint.

3.03 ERECTION

A. Install tank in strict accordance with Manufacturer's published erection manual. Do not drag, impact, or pry against coated surfaces.

B. Apply sealant continuously in the Manufacturer-defined channels of every horizontal and vertical panel lap. Wipe excess from wetted surfaces before cure.

C. Torque every bolt to the Manufacturer-specified value using a calibrated torque wrench. Document torque values on a bolt-map retained as a closeout record.

D. Field Touch-Up: Touch-up of minor transit or erection scratches shall use only the Manufacturer-furnished touch-up kit and shall not exceed 1/4 in. in any dimension. Any damage exceeding this limit shall be cause for panel replacement at no cost to Owner.

3.04 FIELD QUALITY CONTROL

A. Leak Test: Upon completion of erection, fill tank with potable water at a fill rate not exceeding Manufacturer's recommendation. Hold at maximum operating level for 24 hours minimum. No visible leakage is permitted at any panel, seam, or fitting.

B. Holiday Re-Test (optional): Where specified, perform low-voltage holiday test on all field-installed touch-up areas after cure.

C. Disinfection (potable water service only): Disinfect tank interior in accordance with AWWA C652 by the chlorination method specified by the Engineer. Deliver bacteriological clearance results to Owner before return to service.

3.05 CLEANING AND PROTECTION

A. Clean exterior surfaces of all sealant smears, boot scuffs, and adhesive residue using materials and methods approved by the Manufacturer.

B. Protect the completed tank from construction traffic, welding spatter, and incidental chemical exposure until Substantial Completion.

3.06 CAPACITY AND SERVICE ENVELOPE

A. The system is suitable for the following services; values are nominal and subject to project-specific engineering:

Service	Typical Capacity	Key Reference
Potable Water	50,000 – 5,000,000 gal	NSF/ANSI 61, AWWA D103, pH 6.5–8.5
Wastewater & Sludge	100,000 – 3,000,000 gal	AWWA D103, high H_2S tolerance
Fire Protection	100,000 – 500,000 gal	NFPA 22, FM (where specified)
Anaerobic Digesters	200,000 – 4,000,000 gal	Biogas/sludge, membrane roof
Leachate Storage	50,000 – 1,000,000 gal	pH 3.5 – 8.0, high chloride tolerance
Industrial Process	50,000 – 5,000,000+ gal	Power, oil & gas, food & beverage

B. Diameter range: 10 ft to 200+ ft. Single-tank capacity: up to 5,000,000 gal and greater where approved by Manufacturer's engineering.

3.07 CLOSEOUT

A. Submit O&M manual, as-built shop drawings, bolt-torque map, per-panel factory QC records, leak-test and disinfection certifications, warranty certificate, and Manufacturer-furnished touch-up kit (minimum one quart) to the Owner.

B. Conduct Owner training of not less than four (4) hours on routine inspection, cleaning, and periodic tightness verification.

— END OF SECTION 33 16 13.23 —