

ANSI/AWWA **D121-24**
(Revision of AWWA D121-12)

AWWA Standard

Bolted Aboveground Thermosetting Fiberglass-Reinforced Plastic Panel-Type Tanks for Water Storage

Effective date: Nov. 1, 2024.

First edition approved by Board of Directors Jan. 22, 2012.

This edition approved June 8, 2024.

Approved by American National Standards Institute May 29, 2024.



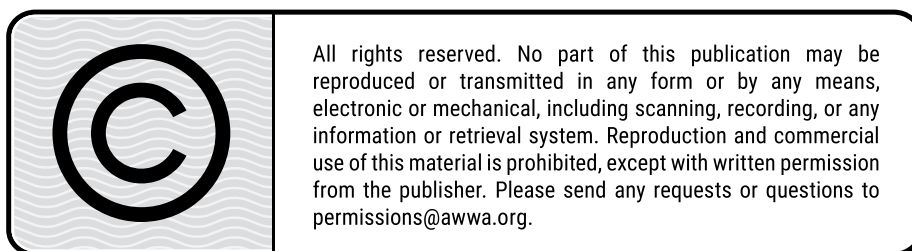
AWWA Standard

This document is an American Water Works Association (AWWA) standard. It is not a specification. AWWA standards describe minimum requirements and do not contain all of the engineering and administrative information normally contained in specifications. AWWA standards usually contain options that must be evaluated by the user of the standard. Until each optional feature is specified by the user, the product or service is not fully defined. AWWA publication of a standard does not constitute endorsement of any product or product type, nor does AWWA test, certify, or approve any product. The use of AWWA standards is entirely voluntary. This standard does not supersede or take precedence over or displace any applicable law, regulation, or code of any governmental authority. AWWA standards are intended to represent a consensus of the water industry that the product described will provide satisfactory service. When AWWA revises or withdraws this standard, an official notice of action will be placed in the Official Notice section of *Journal AWWA*. The action becomes effective on the first day of the month following the month of *Journal AWWA* publication of the official notice.

American National Standard

An American National Standard implies a consensus of those substantially concerned with its scope and provisions. An American National Standard is intended as a guide to aid the manufacturer, the consumer, and the general public. The existence of an American National Standard does not in any respect preclude anyone, whether that person has approved the standard or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standard. American National Standards are subject to periodic review, and users are cautioned to obtain the latest editions. Producers of goods made in conformity with an American National Standard are encouraged to state on their own responsibility in advertising and promotional materials or on tags or labels that the goods are produced in conformity with particular American National Standards.

CAUTION NOTICE: The American National Standards Institute (ANSI) approval date on the front cover of this standard indicates completion of the ANSI approval process. This American National Standard may be revised or withdrawn at any time. ANSI procedures require that action be taken to reaffirm, revise, or withdraw this standard no later than five years from the date of ANSI approval. Purchasers of American National Standards may receive current information on all standards by writing to the American National Standards Institute, 1180 Avenue of the Americas, 10th Floor, New York, NY 10036; calling (212) 642-4900; or e-mailing info@ansi.org.



ISBN-13, print: 978-1-64717-192-6

eISBN-13, electronic: 978-1-61300-719-8

DOI: <http://doi.org/10.12999/AWWA.D121.24>

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including scanning, recording, or any information or retrieval system. Reproduction and commercial use of this material is prohibited, except with written permission from the publisher.

Copyright © 2024 by American Water Works Association
Printed in USA

Committee Personnel

The AWWA Standards Subcommittee on Panelized FRP Tanks, which developed revisions to this standard, had the following personnel at the time:

Owen Stevens, *Chair*

A. Dail (*liaison*), AWWA Standards Engineer, Denver, Colo.

H. Hasebe, Mitsubishi Chemical America, Inc., Chesapeake, Va.

M.C. Richie, Simpson Gumpertz and Heger, Houston, Tex.

P. Shah, Balmoral Tanks Ltd., Nottingham, Nottinghamshire, U.K.

P.A. Sharff, Simpson Gumpertz and Heger, Waltham, Mass.

O. Stevens, Mulberry, Fla.

C.N. Strother, ISFS, Arvada, Colo.

C. Wilkinson, Balmoral Industrial Tanks Ltd, Caehopkin, Powys, U.K.

The AWWA Standards Committee on Thermosetting Fiberglass-Reinforced Plastic Tanks, which reviewed and approved this standard, had the following personnel at the time of approval:

Phillip A. Sharff, *Chair*

Matthew C. Richie, *Vice-Chair*

General Interest Members

E. Compton, CDM Smith, Homer Glen, Ill.

A. Dail (*liaison, nonvoting*), AWWA Standards Engineer, Denver, Colo.

J.F. Rakow, Exponent Failure Analysis Associates, Menlo Park, Calif.

M.C. Richie (*alternate*), Simpson Gumpertz & Heger, Houston, Tex.

P.A. Sharff, Simpson Gumpertz and Heger, Waltham, Mass.

G.R. Stein (*liaison, nonvoting*), Standards Council Liaison, Tank Industry Consultants, Indianapolis, Ind.

C.N. Strother, ISFS, Arvada, Colo.

Producer Members

R.N. Renkes, Fiberglass Tank and Pipe Institute, Tulsa, Okla.

J. Small, Darco Inc., Sedona, Ariz.

User Members

D. Swedensky, Lakewood, Colo.

N.C. Yarish, Denver Water, Denver, Colo.

Contents

All AWWA standards follow the general format indicated subsequently. Some variations from this format may be found in a particular standard.

SEC.	PAGE	SEC.	PAGE
<i>Foreword</i>		V	Comments xvi
I	Introduction..... ix		
I.A	Background..... ix	<i>Standard</i>	
I.B	History..... ix	1 General	
I.C	Acceptance ix	1.1	Scope..... 1
II	Special Issues. x	1.2	Purpose 2
II.A	Purchase x	1.3	Application..... 2
II.B	Design and Construction xi	1.4	Drawings to Be Furnished 2
II.C	Manufacturing Method..... xi	2 References	2
II.D	Foundation..... xi	3 Definitions	5
II.E	Tank Overflow Discharge..... xi	4 Materials	
II.F	Annual Inspection and Maintenance xi	4.1	General 6
II.G	Disinfection Procedures..... xi	4.2	Bolts for Panel Connections 7
II.H	Recommended Items to Be Furnished by the Purchaser and Manufacturer xi	4.3	Foundation-Reinforcing Steel..... 7
II.I	Chlorine and Chloramine Degradation of Elastomers xii	4.4	FRP Panels 7
III	Use of This Standard xii	4.5	Structural Shapes..... 9
III.A	Purchaser Options and Alternatives xii	4.6	Castings 9
III.B	Information to Be Furnished by the Manufacturer or Constructor..... xiii	4.7	Forgings 9
III.C	Items for Consideration by the Purchaser..... xiv	4.8	Galvanized Coatings..... 9
III.D	Modification to Standard xv	4.9	Structural Bolts 9
IV	Major Revisions..... xv	4.10	Weld Electrodes..... 10
		4.11	Gaskets and Patches..... 10
		5 Tank Design	
		5.1	Design Methodology 11
		5.2	Design Loads..... 12
		5.3	Seismic Design 13

SEC.		PAGE	SEC.		PAGE
5.4	Strength and Resistance of FRP Panels and Connections	29	9.4	Anchor Bolt Placement and Tolerance.....	42
5.5	Strength of Welds for Steel Components	30	9.5	Steel Footing	42
5.6	Foundation Anchor Bolts Between Concrete Beams and Steel Footings	30	9.6	Types of Joint	42
5.7	Roof Panels	31	9.7	Bolting.....	43
5.8	Foundation Design.....	33	9.8	Bolt Tightening Requirements.....	43
6	Sizing of Tanks	34	9.9	Gaskets and Patches.....	43
7	Accessories for Tanks		9.10	Cleanup	44
7.1	Manways	34	9.11	Marking	44
7.2	Pipe Connections	35	9.12	Protection.....	44
7.3	Overflow	35	10	Inspection and Testing	
7.4	Ladders.....	35	10.1	FRP Panel Damage.....	44
7.5	Safety Devices	36	10.2	Testing	44
7.6	Vents	36	10.3	Disposal of Test Water	44
7.7	Additional Accessories and Exceptions.....	37	10.4	Repair of Leaks.....	44
8	Fabrication		10.5	Disinfecting.....	45
8.1	Compression Molding.....	37	10.6	Inspection and Maintenance	45
8.2	Steel Footings—Welded Work.....	37	11	Verification	
8.3	Assembly and Subassemblies.....	37	11.1	Basis for Rejection	45
8.4	Welds	37	12	Delivery	
8.5	Tolerances	37	12.1	Affidavit of Compliance	45
8.6	Shipping.....	38			
8.7	Quality Standards and Control.....	38		<i>Appendixes</i>	
9	Construction		A	Metric (SI) Equivalents.....	47
9.1	General	41	B	Seismic Analysis Example	49
9.2	Foundation Construction.....	41			
9.3	Anchor Bolts	42		<i>Figures</i>	
			1	Curves for Obtaining Factors W_i / W_L and W_c / W_L for the Ratio L / H_L	25
			2	Curves for Obtaining Factors h_i / H_L and h_c / H_L for the Ratio L / H_L (EBP)	26

SEC.	PAGE	SEC.	PAGE
3	Curves for Obtaining Factors h'_i / H_L and h'_c / H_L for the Ratio L / H_L (IBP)	B.5	Curve for Obtaining Factors h'_i / H_L and h'_c / H_L for the Ratio L / H_L
	26	B.6	Curve for Obtaining the Factor $2\pi / \lambda$ for the Ratio L / H_L
4	Curves for Obtaining the Factor $2\pi / \lambda$ for the Ratio L / H_L		60
5	Wetted Width of the Roof When the Required Freeboard Is Greater than the Available Freeboard	B.7	Curve for Obtaining Factors $\bar{W}_i / W_L$ and $\bar{W}_c / W_L$ for the Ratio L / H_L
	31	B.8	Curve for Obtaining Factors h'_i / H_L and h'_c / H_L for the Ratio L / H_L
6	Elevation of Foundation		64
7	Detail at Panel Intersections	B.9	Curve for Obtaining Factors h'_i / H_L and h'_c / H_L for the Ratio L / H_L ...
B.1	Given Tank Dimensions		65
B.2	Curve for Obtaining the Factor $2\pi / \lambda$ for the Ratio L / H_L		
	51		
B.3	Curve for Obtaining Factors $\bar{W}_i / W_L$ and $\bar{W}_c / W_L$ for the Ratio L / H_L		
	53		
B.4	Curve for Obtaining Factors h'_i / H_L and h'_c / H_L for the Ratio L / H_L		
	55		

Tables	
1	Physical Requirements for SEBS Gasket Material
	10
2	Physical Requirements for EPDM Gasket Material
	11
3	Load Duration for Loading Types
	13
4	Nut Rotation from Snug-Tight Condition
	43
A.1	Metric (SI) Conversion Factors
	47

This page intentionally blank.

Foreword

This foreword is for information only and is not a part of ANSI /AWWA D121.*

I. Introduction.

I.A. *Background.* This standard covers bolted aboveground thermosetting fiberglass-reinforced plastic panel-type (BATFRPP) tanks for water storage and is based on more than two decades of accumulated knowledge and experience from installations worldwide, as well as engineering procedures and analyses generally accepted in the tank industry. BATFRPP tanks are typically field assembled from factory-produced modular panel units. Tanks ranging in size from 260 gal to 2.5 mil gal have been constructed.

I.B. *History.* In June 2007, the Standards Council authorized development of a new standard and assigned it to Standards Committee 370, Thermosetting Fiberglass-Reinforced Plastic Tanks. A subcommittee was formed to prepare this standard. Applicable publications, such as ANSI/AWWA D120, ANSI/AWWA D103, BS EN 13280:2001, SS245:1995, and JIS R3411-3417, were consulted in forming this standard, and seismic design procedures are based on current practice as reflected in ASCE/SEI 7-22, ANSI/AWWA D110, ACI 350.3-06, and US Atomic Energy Commission Technical Information Document TID 7024, Chapter 6 and Appendix F.

The first edition was approved by the AWWA Board of Directors on Jan. 22, 2012. This edition was approved by the AWWA Board of Directors on June 8, 2024.

I.C. *Acceptance.* In May 1985, the US Environmental Protection Agency (USEPA) entered into a cooperative agreement with a consortium led by NSF International (NSF) to develop voluntary third-party consensus standards and a certification program for direct and indirect drinking water additives. Other members of the original consortium included the Water Research Foundation (formerly AwwaRF) and the Conference of State Health and Environmental Managers (COSHEM). AWWA and the Association of State Drinking Water Administrators (ASDWA) joined later.

In the United States, authority to regulate products for use in or in contact with drinking water rests with individual states.[†] Local agencies may choose to impose requirements more stringent than those required by the state. To evaluate the health

* American National Standards Institute, 1180 Avenue of the Americas, 10th Floor, New York, NY 10036.

[†] Persons outside the United States should contact the appropriate authority having jurisdiction.

effects of products and drinking water additives from such products, state and local agencies may use various references, including four standards developed under the direction of NSF: NSF[‡]/ANSI/CAN[§] 60, Drinking Water Treatment Chemicals—Health Effects; NSF/ANSI/CAN 61, Drinking Water System Components—Health Effects; NSF/ANSI 372, Drinking Water System Components—Lead Content; and NSF/ANSI/CAN 600, Health Effects Evaluation and Criteria for Chemicals in Drinking Water.

3. Other references, including AWWA standards, *Food Chemicals Codex*, *Water Chemicals Codex*,[¶] and other standards considered appropriate by the state or local agency.

Various certification organizations may be involved in certifying products in accordance with NSF/ANSI/CAN 61. Individual states or local agencies have authority to accept or accredit certification organizations within their jurisdiction. Accreditation of certification organizations may vary from jurisdiction to jurisdiction.

NSF/ANSI/CAN 600 (which formerly appeared in NSF/ANSI/CAN 60 and 61 as Annex A, “Toxicology Review and Evaluation Procedures”) does not stipulate a maximum allowable level (MAL) of a contaminant for substances not regulated by a USEPA final maximum contaminant level (MCL). The MALs of an unspecified list of “unregulated contaminants” are based on toxicity testing guidelines (noncarcinogens) and risk characterization methodology (carcinogens). Use of NSF/ANSI/CAN 600 procedures may not always be identical, depending on the certifier. The maximum concentration limit in drinking water varies by producer.

ANSI/AWWA D121 does not address additives requirements. Users of this standard should consult the appropriate state or local agency having jurisdiction in order to

1. Determine additives requirements, including applicable standards.
2. Determine the status of certifications by all parties offering to certify products for contact with or treatment of drinking water.
3. Determine current information on product certification.

II. Special Issues.

II.A. *Purchase.* When tanks are purchased using this standard, the purchaser must specify certain basic requirements. The purchaser may desire to modify, delete, or amplify sections of this standard to suit special conditions. It is strongly recommended

[‡] NSF International, 789 North Dixboro Road, Ann Arbor, MI 48105.

[§] Standards Council of Canada, 55 Metcalfe Street, Suite 600, Ottawa, ON K1P 6L5 Canada

[¶] Both publications available from National Academy of Sciences, 500 Fifth Street, NW, Washington, DC 20001.

that such modifications, deletions, or amplifications be made by supplementing this standard rather than by rewriting or incorporating sections from this standard into a separate specification.

II.B. *Design and Construction.* The details of design and construction covered by this standard are minimum requirements. A tank cannot be represented as adhering to the provisions of ANSI/AWWA D121 if it does not meet the minimum requirements of this standard.

II.C. *Manufacturing Method.* Tanks covered by this standard are typically manufactured by compression molding with sheet molding compound (SMC) using the hot press method. Tanks requiring no internal or external coating and bolted construction have a long life expectancy. Regular inspection and repair of damaged or deteriorated areas may be the determining factors in the length of tank life.

II.D. *Foundation.* The tank foundation is one of the more important aspects of tank design. Detailed requirements for tank foundations are covered in Sec. 5.8 of this standard. This standard does not require the manufacturer or constructor to be responsible for the design of the tank foundation unless otherwise specified by the purchaser. Unless otherwise specified by the purchaser, the purchaser must obtain an adequate soil investigation at the tank site, including recommendations of the type of foundation to be used, the depth of foundation required, and the design soil-bearing pressure. This information, as well as specifications for an adequate soil investigation, should be established by a qualified geotechnical engineer.

II.E. *Tank Overflow Discharge.* A drainage inlet structure or suitable erosion protection should be provided to receive the discharge from the tank overflow. The overflow should not be connected directly to a sewer or a storm drain without an air break.

II.F. *Annual Inspection and Maintenance.* Inspection and maintenance are important if maximum tank life is to be attained. Inspections should be performed annually.

II.G. *Disinfection Procedures.* This standard does not cover tank disinfection procedures. ANSI/AWWA C562, Standard for Disinfection of Water-Storage Facilities, should be consulted for recommended procedures for disinfection of water-storage facilities. If the disinfecting is to be done by the tank constructor, the purchaser must specify how such disinfecting is to be done.

II.H. *Recommended Items to Be Furnished by the Purchaser and Manufacturer.* The following recommendations on items to be furnished by both the purchaser and the

manufacturer are considered good practice but are not requirements of ANSI/AWWA D121.

When a BATFRPP tank is to be purchased under the provisions of this standard, the purchaser should provide the following:

1. The site on which the tank is to be built, including sufficient space to permit the structure to be erected by customary methods.
2. Foundation design and construction unless otherwise specified.
3. Water at the proper pressure for testing as required and facilities for disposal of wastewater after testing.
4. A suitable right-of-way from the nearest public road to the erection site.
5. Materials furnished by the purchaser to be used by the constructor for construction of the tank.

The manufacturer should furnish the following:

1. Foundation layout and loads to be supported for the intended tank.
2. Anchor bolts, if required, for wind, earthquake, or other lateral loads.
3. All materials, except materials furnished by the purchaser, that are necessary to assemble the structure components, including the accessories required by this standard.

Variations in the responsibilities of both the purchaser and the manufacturer as previously outlined may be made by contractual agreement. The purchaser and the bidder should each furnish information identified in Section III below.

II.I. Chlorine and Chloramine Degradation of Elastomers. The selection of materials is critical for water service and distribution piping in locations where there is a possibility that elastomers will be in contact with chlorine or chloramines. Documented research has shown that elastomers such as gaskets, seals, valve seats, and encapsulations may be degraded when exposed to chlorine or chloramines. The impact of degradation is a function of the type of elastomeric material, chemical concentration, contact surface area, elastomer cross-section, and environmental conditions, as well as temperature. Careful selection of and specifications for elastomeric materials and the specifics of their application for each water system component should be considered to provide long-term usefulness and minimum degradation (swelling, loss of elasticity, or softening) of the elastomer specified.

III. Use of This Standard. It is the responsibility of the user of an AWWA standard to determine that the products described in that standard are suitable for use in the particular application being considered.

III.A. Purchaser Options and Alternatives. The following information should be furnished by the purchaser when taking bids for a tank:

1. Standard used—that is, ANSI/AWWA D121, Bolted Aboveground Thermosetting Fiberglass-Reinforced Plastic Panel-Type Tanks for Water Storage, of latest revision.

2. Affidavit of compliance, if required.

3. Tank capacity and dimensional restrictions, if any.

4. Maximum flow rate, either in or out.

5. Desired time for completion.

6. Site location.

7. Type of road available for access to the site and whether the road is public or private.

8. Name of and distance to the nearest town.

9. Name of and distance to the nearest railroad siding.

10. Availability of electric power; who furnishes it and at what fee, if any; what voltage is available; whether direct or alternating current; and if alternating current, what cycle and phase.

11. Availability of compressed air and at what pressure, volume, and fee, if any.

12. The bottom capacity level of the tank when empty if different from the level when the tank would be emptied through the specified discharge piping.

13. The type of pipe and fittings for fluid conductors and the type of pipe joint.

14. The preliminary freeboard.

15. Details of federal, state, and local requirements (Sec. 4.1).

16. Any additional accessories required (Section 7).

17. The number and location of pipe connections, and type and size of pipe to be accommodated.

NOTE: Connections to the piping furnished by the constructor are to be made by the purchaser (Sec. 7.2).

18. If the roof ladder for providing access to roof hatches and vents shall be omitted.

19. If safety cages, rest platforms, or other safety devices are required and on which ladders (Sec. 7.5).

III.B. *Information to Be Furnished by the Manufacturer or Constructor.* The following information shall be furnished by the manufacturer or constructor for a tank:

1. Dimensions of the tank—including the vertical load, lateral loads, and overturning moments imparted to the foundation by all loads—should also be identified at the time of the bid.

2. The number, names, and sizes of all accessories, including the type of roof ladder, if required.

III.C. *Items for Consideration by the Purchaser.* The design, construction, and final placement of a storage tank into service require cooperation between the purchaser, manufacturer, and constructor of the tank. Various practices are used to ensure successful tank placement. The following items are suggested for inclusion in the purchaser's requirements, unless local practice dictates otherwise.

Please note that this material is not stipulated in the text of ANSI/AWWA D121.

1. The purchaser may want to provide for field inspection to be performed either by the purchaser or by a commercial inspection agency. As an option, the purchaser may require that the manufacturer or constructor perform the inspection work and submit a written report at the conclusion of the work. The report should include a statement indicating that the tank has been erected according to the manufacturer's instructions, that the required testing has been performed, and that any leaks have been repaired.

2. This standard assumes that the purchaser (owner) provides sufficient water replacement and circulation to prevent freezing in the tank and piping. Where low usage may result in the possibility of freezing, the purchaser shall waste water or provide heat to prevent freezing. The purchaser is referred to National Fire Protection Association (NFPA)** document NFPA 22, Water Tanks for Private Fire Protection, for heater sizing. Purchasers are cautioned against allowing ice to build up for use as insulation because the ice may break loose and damage the tank.

3. On completion of the tank erection, it is recommended that the constructor dispose of all rubbish and other unsightly material caused by the operations and leave the premises in as good a condition as found at the start of the tank erection. It is recommended that the purchaser provide appropriate containers for placement and removal of disposed materials. Sec. 9.10 of ANSI/AWWA D121 does not list specific requirements for cleanup.

4. ANSI/AWWA D121 does not require the manufacturer or constructor to blind (i.e., temporarily seal all openings) and fill the tank to top capacity level. It is common practice for the purchaser to provide this effort. Should the purchaser require that the constructor provide this service and a supply of water, this must be provided for in the purchaser's requirements.

** National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169.

5. ANSI/AWWA D121 does not require the constructor to furnish foundation plans (only foundation layout drawings with directional details to support the tank). Should the purchaser specify that the contractor is to submit foundation plans, the purchaser must furnish adequate information relative to the type of foundation, foundation depth, and allowable soil-bearing pressure. (See Sec. II.D of the foreword and Sec. 5.8 Foundation Design for further information.)

6. ANSI/AWWA D121 does not require that the manufacturer or constructor constructs and/or installs a foundation. Should the purchaser require that a foundation be provided by the constructor, any necessary information in addition to that contained in Sec. 5.8 of this standard must also be provided by the purchaser.

7. It is recommended that the purchaser retain a qualified geotechnical consultant to conduct a geotechnical investigation.

8. The purchaser may engage a commercial inspection agency to conduct a shop inspection.

III.D. *Modification to Standard.* Any modification to the provisions, definitions, or terminology in this standard must be provided in the purchaser's documents.

IV. Major Revisions. Major revisions made to the standard in this edition include the following:

1. A section on chlorine and chloramine degradation of elastomers was added to the Foreword (Sec. II.H).

2. Reclaimed water and nonpotable water were added to the Scope (Sec. 1.1), and definitions were added for potable water, reclaimed water, and wastewater (Section 3).

3. NSF/ANSI/CAN 61 requirements were updated to include all tank parts in contact with potable water rather than call out specific parts (Sec. 4.1).

4. The bolts ASTM references were updated to remove withdrawn standards (Sec. 4.2.1 and Sec. 4.9.1).

5. The minimum compressive strength of FRP panels was updated under Sec. 4.4.4.8.

6. Bolts sections were updated to clarify the intended location of use, and a grade restriction was added for foundation anchor bolts (Sec. 4.9.1 and 4.9.2).

7. Polyvinyl chloride materials were added as acceptable roof gaskets under Sec. 4.11.1.

8. Ethylene propylene diene monomer gasket materials were added for wall and floor gasket materials (Sec. 4.11.2). Both Tables 1 and 2 have updated properties.

9. Tank design shall consider the interaction of the tank with the building or support structure (Sec. 5.1).

10. Roof live load was revised in accordance with ASCE/SEI 7-22 (Sec. 5.2.4).

11. Rain load was added to Sec. 5.2.8 and relevant equations updated.

12. Design notation was clarified and relevant equations updated (Sec. 5.3.2).

13. Added Seismic Risk Categories (Sec. 5.3.3.1) and renumbered Sec. 5.3.3 accordingly.

14. Equations were updated, including some factors, and renumbered throughout. The examples in the appendix were updated accordingly.

15. Sec. 5.4.7 was deleted.

16. Figure 5 was removed and figures renumbered accordingly.

17. The terminology regarding foundation design was revised (Sec. 5.8 and Figure 6).

18. Requirements for Occupational Safety and Health Administration compliance were added (Sec. 7.5).

19. Language regarding screening of vents was added (Sec. 7.6.2).

20. Cold exposure conditioning was reduced from 16 h to 4 h. (Sec 8.7.4).

21. Verification and delivery sections were added (Section 11 and Section 12).

V. Comments. If you have any comments or questions about this standard, please call AWWA Engineering and Technical Services at 303.794.7711; write to the department at 6666 West Quincy Avenue, Denver, CO 80235-3098; or e-mail at standards@awwa.org.



**American Water Works
Association**

Dedicated to the World's Most Vital Resource®

ANSI/AWWA D121-24
(Revision of AWWA D121-12)

AWWA Standard

Bolted Aboveground Thermosetting Fiberglass-Reinforced Plastic Panel- Type Tanks for Water Storage

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard describes the design, fabrication, construction, inspection, and testing of bolted aboveground thermosetting fiberglass-reinforced plastic panel-type (BATFRPP) tanks for potable water, reclaimed water, and nonpotable water. Requirements for the fabrication, design, construction, and testing of fiberglass-reinforced plastic (FRP) panels, concrete and steel foundation members, steel bolts, and accessories are included. Site elevation and procurement; tank sizing; post-commissioning inspection and maintenance; and the design, operation, and control of the water distribution system that connects to the BATFRPP tank are beyond the scope of this standard.

1.1.1 *Tank roofs.* Tanks storing domestic or potable water shall have roofs conforming to the requirements of this standard. Tanks storing nonpotable water may be constructed without roofs.

1.1.2 *Items not covered.* This standard does not cover all details of design and construction. Details that are not addressed shall be designed and constructed to be as adequate and as safe as those that would otherwise be provided under this standard.

1.1.3 *Local requirements.* This standard is not intended to cover storage tanks erected in areas subject to regulations more stringent than the requirements contained within this standard. In such cases, this standard should be followed where it does not conflict with more stringent requirements. Where more stringent federal, state, provincial, and local government requirements exist, such requirements shall be specified, and this standard shall be interpreted to supplement them.

Sec. 1.2 Purpose

The purpose of this standard is to provide minimum requirements for the design, manufacture, construction, and inspection of BATFRPP tanks for the storage of water.

Sec. 1.3 Application

This standard can be referenced in project documents that address the design, fabrication, construction, inspection, and testing of BATFRPP tanks for water storage. The stipulations of this standard apply when this document has been referenced and then only to BATFRPP tanks.

Sec. 1.4 Drawings to Be Furnished

Construction drawings for the BATFRPP tank and foundation shall be provided. Drawings shall show all features of the work, including the size and position of structural components, the required length or grade of materials, and construction tolerances. Where foundation and tank designs are performed by separate parties, each party shall provide construction drawings. Details of bolted joints shall be referenced on the drawings.

SECTION 2: REFERENCES

This standard references the following documents. In their latest editions (effective at the time of approval of this standard), they form a part of this standard to the extent specified within the standard. In any case of conflict, the requirements of this standard shall prevail.

ACI* 301—Specifications for Structural Concrete.

ACI 318—Building Code Requirements for Structural Concrete.

* American Concrete Institute, 38800 Country Club Drive, Farmington Hills, MI 48331.

AISC[†] 360—Specification for Structural Steel Buildings.

ANSI[‡]/AWWA C652—Disinfection of Water-Storage Facilities.

ASCE[§]/SEI 7-22—Minimum Design Loads for Buildings and Other Structures.

ASTM[¶] A36/A36M—Standard Specification for Carbon Structural Steel.

ASTM A48/A48M—Standard Specification for Gray Iron Castings.

ASTM A123/A123M—Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

ASTM A153/A153M—Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

ASTM A194/A194M—Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.

ASTM A216/A216M—Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.

ASTM A307—Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.

ASTM A563—Standard Specification for Carbon and Alloy Steel Nuts.

ASTM A668/A668M—Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use.

ASTM C581—Standard Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures Intended for Liquid Service.

ASTM D395—Standard Test Methods for Rubber Property—Compression Set.

ASTM D412—Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension.

ASTM D573—Standard Test Method for Rubber—Deterioration in an Air Oven.

ASTM D638—Standard Test Method for Tensile Properties of Plastics.

ASTM D695—Standard Test Method for Compressive Properties of Rigid Plastics.

[†] American Institute of Steel Construction, 130 East Randolph, Suite 2000, Chicago, IL 60601.

[‡] American National Standards Institute, 1180 Avenue of the Americas, 10th Floor, New York, NY 10036.

[§] American Society of Civil Engineers, 1801 Alexander Bell Drive, Reston, VA 20191.

[¶] ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428.

ASTM D732—Standard Test Method for Shear Strength of Plastics by Punch Tool.

ASTM D790—Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

ASTM D792—Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

ASTM D883—Standard Terminology Relating to Plastics.

ASTM D953—Standard Test Method for Pin-Bearing Strength of Plastics.

ASTM D1056—Standard Specification for Flexible Cellular Materials—Sponge or Expanded Rubber.

ASTM D1171—Standard Test Method for Rubber Deterioration—Surface Ozone Cracking Outdoors (Triangular Specimens).

ASTM D2240—Standard Test Method for Rubber Property—Durometer Hardness.

ASTM D2290—Standard Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe.

ASTM D2563—Standard Practice for Classifying Visual Defects in Glass-Reinforced Plastic Laminate Parts.

ASTM D2583—Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor.

ASTM D2584—Standard Test Method for Ignition Loss of Cured Reinforced Resins.

ASTM D3567—Standard Practice for Determining Dimensions of “Fiberglass” (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings.

ASTM F593—Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

ASTM F594—Standard Specification for Stainless Steel Nuts.

ASTM F1554—Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.

ASTM F3125—Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength.

ASTM G152—Standard Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials.

ASTM G153—Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials.

ASTM SI10 IEEE/ASTM SI 10—American National Standard for Metric Practice.

AWS^{**} A5.1—Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding.

AWS D1.1/D.1.M—2010, Structural Welding Code—Steel.

FTPI^{††} 2007-1—Recommended Practice for the In-service Inspection of Aboveground Atmospheric Fiberglass Reinforced Plastic (FRP) Tanks and Vessels.

FTPI RP T-95-02—Remanufacturing of Fiberglass Reinforced Plastic (FRP) Underground Storage Tanks.

ISO^{‡‡} 9001:2008—Quality Management Systems—Requirements.

NFPA^{§§} 22—Standard for Water Tanks for Private Fire Protection.

NSF^{¶¶}/ANSI/CAN 61—Drinking Water System Components—Health Effects.

OSHA^{***} 29 CFR 1910—Occupational Safety and Health Standards—General Industry.

RCSC^{†††}—Specification for Structural Joints Using High-Strength Bolts.

SECTION 3: DEFINITIONS

Unless otherwise indicated, the plastics terminology used in this standard is in accordance with ASTM D883. The following definitions shall apply in this standard:

1. *Capacity:* The net tank volume measured as the difference between the total tank volume and volume of the freeboard. (NOTE: The usable volume of water may be less than the capacity depending on the location of the tank discharge.)

^{**} American Welding Society, 8669 NW 36 Street, #130, Miami, FL 33166.

^{††} Fiberglass Tank & Pipe Institute, 11150 South Wilcrest Drive, #101, Houston, TX 77099.

^{‡‡} International Organization for Standardization, ISO Central Secretariat, Chemin de Blandonnet 8, CP 401 1214 Vernier, Geneva, Switzerland.

^{§§} National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169.

^{¶¶} NSF International, 789 North Dixboro Road, Ann Arbor, MI 48105.

^{***} US Department of Labor, Occupational Safety and Health Administration, 200 Constitution Avenue NW, Room Number N3626, Washington, DC 20210.

^{†††} Research Council on Structural Connections, 130 East Randolph, Suite 2000, Chicago, IL 60601.

2. *Constructor*: The party that provides the work and materials for construction.

3. *Freeboard*: The difference between the top of the tank and the top of the water surface.

4. *Manufacturer*: The party that manufactures, fabricates, or produces materials or products.

5. *Potable water*: Water that is safe and satisfactory for drinking and cooking.

6. *Purchaser*: The person, company, or organization that purchases any materials or work to be performed.

7. *Reclaimed water*: Wastewater that becomes suitable for beneficial use as a result of treatment.

8. *Resin*: A thermosetting polyester or vinyl ester that is crosslinked with styrene. The physical and chemical properties of resins vary greatly. Each type of resin has particular strengths and weaknesses for a given application, which require evaluation.

9. *Sloshing*: The movement of water in the tank that is attributable to external forces, such as earthquakes, that cause dynamic loading on the tank.

10. *Supplier*: The party that supplies materials or services. A supplier may or may not be the manufacturer.

11. *Surface veil*: A fine reinforcement-mat layer applied to the laminate surface.

12. *Tank*: A chamber used for water storage. Tanks covered by this standard are typically square, rectangular, U-, or L-shaped.

13. *Wastewater*: A combination of the liquid and water-carried waste from residences, commercial buildings, industrial plants, and institutions, together with any groundwater, surface water, and stormwater that may be present.

SECTION 4: MATERIALS

Sec. 4.1 General

Materials to be incorporated in any structure to meet the provisions of this standard shall be new, previously unused, and in first-class condition and shall comply with the requirements of this standard.

Materials shall comply with the requirements of the Safe Drinking Water Act and applicable federal, state, provincial, territorial, or other authoritative regulations for potable water, wastewater, and reclaimed water systems. All tank parts in contact with contained potable water shall be certified to NSF/ANSI/CAN 61. If required by the purchaser, the manufacturer shall provide an affidavit of compliance.

Sec. 4.2 Bolts for Panel Connections

4.2.1 *Bolts.* Bolts for joining tank panels shall conform to the requirements of ASTM A307, ASTM F3125, or ASTM F593 and shall comply with the requirements of AISC 360. Nuts for these bolts shall conform to ASTM A194, ASTM A563, and ASTM F594.

Sec. 4.3 Foundation-Reinforcing Steel

Reinforcing steel in foundations shall comply with the requirements of ACI 318.

Sec. 4.4 FRP Panels

Panels shall be manufactured using sheet molding compound (SMC) in accordance with Sec. 4.4.1, Sec. 4.4.2, and Sec. 4.4.3 by compression molding using a hot-pressed method with a minimum molding pressure of 2,470 psi (17 MPa) and a curing temperature of 284°F (140°C). Tests on manufactured panels shall conform to ASTM D638, ASTM D695, ASTM D790, ASTM D792, ASTM D953, ASTM D2563, ASTM D2583, ASTM D2584, and ASTM D3567.

4.4.1 *Resin.* The resin shall be a commercial grade, thermosetting plastic resin that has been evaluated in a laminate by tests in accordance with Sec. 4.4. The resin shall not contain fillers or pigments except as specified in Sec. 4.4.1.1, Sec. 4.4.1.2, Sec. 4.4.1.3, Sec. 4.4.1.4, and Sec. 4.4.1.5.

4.4.1.1 *Thixotropic agent.* Up to 5 percent (by weight) thixotropic agent that will not interfere with visual inspection may be added for viscosity control. Resin pastes used to fill crevices before overlay shall not be subject to this limitation.

4.4.1.2 *Ultraviolet (UV) absorbers.* UV absorbers may be added to the final resin coating to improve weather resistance.

4.4.1.3 *Pigments.* Resins, catalyst, and other additives may contain pigments, dyes, or colorants, provided their concentration does not prevent detection of visual defects or adversely affect performance of the FRP panel.

4.4.1.4 *Fire-retardants.* Fire-retardant agents may be added for improved fire resistance.

4.4.1.5 *Fillers.* The structural filler may contain fillers, provided that the fillers are compatible with other laminate constituents and do not adversely affect the performance of the laminate. The glass volume fraction in the filled laminate shall be no less than the glass volume fraction in an unfilled laminate based on the glass content requirements.

4.4.2 *Reinforcing materials.*

4.4.2.1 *Fiberglass.* The reinforcing material shall be a commercial-grade glass fiber having a coupling agent; it shall be compatible with the resin used and suitable for the specified fabrication technique. The reinforcing material used to fabricate the tank panels shall be comparable to that used to generate environmental-resistance and physical-property design data.

4.4.3 *Surfacing materials.*

4.4.3.1 *Surfacing veil.* The surfacing veil, when used in the interior layer, shall be commercial grade and chemical resistant, having a coupling agent.

4.4.4 *Physical and mechanical properties.*

4.4.4.1 *Wall thickness.* The average wall thickness of the FRP panel shall be measured in accordance with ASTM D3567. No FRP panel shall have a thickness of less than 0.1181 in. (3 mm).

4.4.4.2 *Surface hardness.* The surface hardness (interior and exterior) shall be at least 90 percent of the resin manufacturer's minimum specified hardness for the cured resin when tested in accordance with ASTM D2583.

4.4.4.3 *Glass content.* The design glass content of the structural layer shall be a minimum of 40 percent by weight. The average glass content, when measured in accordance with Sec. 8.7.1.2, shall be no less than 90 percent of the design glass content.

4.4.4 *Modulus of elasticity.* The modulus of elasticity of the FRP panel measured in either tension or flexure in accordance with Sec. 8.7.1.3 and Sec. 8.7.1.4 shall be no less than 1,200,000 psi (8,274 MPa). The initial, unaged flexural modulus of elasticity shall be determined for evaluating the laminate for environmental exposure and quality control.

4.4.4.5 *Tensile strength.* The initial, unaged ultimate tensile strength of the FRP panel in the weakest direction when measured in accordance with Sec. 8.7.1.3 shall be no less than 14,500 psi (100 MPa).

4.4.4.6 *Flexural strength.* The initial, unaged ultimate flexural strength of the FRP panel in the weakest direction when measured in accordance with Sec. 8.7.1.4 shall be no less than 23,900 psi (165 MPa).

4.4.4.7 Shear strength. The initial, unaged ultimate shear strength of the FRP panel in the weakest direction when measured in accordance with Sec. 8.7.1.5 shall be no less than 13,500 psi (93 MPa).

4.4.4.8 Compressive strength. The initial, unaged ultimate compressive strength of the FRP panel in the weakest direction when measured in accordance with Sec. 8.7.1.6 shall be no less than 23,200 psi (160 MPa).

4.4.4.9 Bearing strength. The initial, unaged ultimate bearing strength of the FRP panel in the weakest direction when measured in accordance with Sec. 8.7.1.7 shall be no less than 29,000 psi (200 MPa).

Sec. 4.5 Structural Shapes

Hot-rolled carbon steel structural shapes for use under the provisions of this standard shall conform to AISC 360. Material shall conform to ASTM A36.

Sec. 4.6 Castings

Iron castings shall conform to ASTM A48, class 30. Steel castings shall conform to ASTM A216, grade WCB.

Sec. 4.7 Forgings

Forgings from plate and sheet materials shall conform to ASTM A668.

Sec. 4.8 Galvanized Coatings

When hot-dip galvanized coatings are to be supplied, they can only be used on external steel footings, reinforcements, and/or external ladders in accordance with the recommended practice of the American Galvanizers Association in compliance with ASTM A123 and ASTM A153.

Sec. 4.9 Structural Bolts

4.9.1 *Bolts.* Steel bolts for panel connections and panel to steel footing connections shall be ASTM F3125 Grade A325 or Grade A490, meeting the requirements of RCSC's Specification for Structural Joints Using High-Strength Bolts.

4.9.2 *Foundation anchor bolts.* Foundation anchor bolts between concrete beams and steel footings shall conform to ASTM F1554, Grade 36, 55, or 105. ASTM F1554, Grade 105 bolts shall not be used for anchor bolts unless mild steel anchor bolts (ASTM F1554, Grades 36 or 55) exceed 2½ in. (63 mm) in diameter. Unless otherwise specified, anchor bolts shall be supplied with unified coarse threads (UNC) with a Class 2a tolerance, as permitted in ASTM F1554.

Nuts for anchor bolts shall be furnished as heavy hex nuts, ASTM A563 Grade A (for Grade 36 and 55 bolts) or Grade DH (for Grade 105 bolts).

Sec. 4.10 Weld Electrodes

Manual, shielded-metal, arc-welding electrodes shall conform to the requirements of AWS A5.1. Welding electrodes shall be of any E60XX or E70XX classification suitable for the electric current characteristics, the position of welding, and other conditions of intended use.

Sec. 4.11 Gaskets and Patches

Gaskets and patches shall be in accordance with the following requirements.

4.11.1 *Roof Gaskets.* Roof gasket material shall be of adequate tensile strength and resilience to obtain a leak-proof seal at seams and joints. Ethylene propylene diene monomer (EPDM) roof gasket material shall be resistant to weather and ozone exposure as designated by ASTM D1171 and comply with ASTM D412 (Die A) and ASTM D1056. Polyvinyl chloride roof gasket material shall be resistant to weather and UV exposure as determined by ASTM G152 and comply with ASTM D412 and D1667.

4.11.2 *Wall and Floor Gaskets.* Styrene-ethylene-butylene-styrene (SEBS) gasket material shall comply with ASTM D395 Method B, D412, D792, and D2240. SEBS physical requirements are described in Table 1. EPDM gasket material shall comply with ASTM D412 and ASTM D1056. EPDM physical requirements are described in Table 2.

4.11.3 *Patches.* Patches shall be self-adhesive EPDM cellular rubber used at main wall and floor gasket intersections. See Figure 7 for construction detail at panel intersections. EPDM shall comply with ASTM D412 (Die A), ASTM D1056, and the following requirements:

Table 1 Physical requirements for SEBS gasket material

Description	Strip and Extruded Gasket Material
Tensile strength, initial, psi minimum, ASTM D412 longitudinal direction	2,074 psi (14,300 kPa)
Tensile strength, initial, psi minimum, ASTM D412 cross direction	2,074 psi (14,300 kPa)
Ultimate elongation, initial, percent of minimum, ASTM D412 longitudinal direction	430%
Ultimate elongation, initial, percent of minimum, ASTM D412 cross direction	610%
Hardness, Shore A, ASTM D2240, min.	60
Hardness change, Shore A, after oven aging, ASTM D573	7

Table 2 Physical requirements for EPDM gasket material

Description	Strip and Extruded Gasket Material
Tensile strength, initial, psi minimum, ASTM D412 longitudinal direction	116 psi (800 kPa)
Ultimate elongation, initial, percent of minimum, ASTM D412 longitudinal direction	300% $\pm$ 100%
Compression deflection at 25% compression, initial, psi minimum, ASTM D1056	14.5 psi (100 kPa)
Compression deflection after aging, ASTM D1056	$\pm$ 20%
Compression set, ASTM D1056 (50% deflection, max, 22 h at 158°F)	15%

1. Resistance to temperature. The patches shall remain flexible when in continuous operation over a temperature range of -4°F to $+212^{\circ}\text{F}$ (-40°C to $+100^{\circ}\text{C}$).

2. Weatherability. The patches shall be resistant to hardening and cracking. The patches shall be essentially solid and contain no plasticizers or extenders that could cause shrinkage caused by weathering. The patches shall be resistant to ozone and UV light.

3. Chemical resistance. The patches shall be chemically resistant without extraction to water and shall not swell or degrade under normal water-storage conditions.

SECTION 5: TANK DESIGN

The design equations and calculations presented in this standard are for guidance only. All structural calculations shall be performed by a registered professional engineer and sealed as required.

Sec. 5.1 Design Methodology

Structural elements for the tank shall be designed for all imposed loads based on accepted structural engineering practice for FRP composites and in accordance with governing codes. Specified factored resistances shall exceed the response resulting from specified factored loads. Loads and load factors shall be as specified in Sec. 5.2. Seismic loads due to earthquake shall be as specified in Sec. 5.3. Strengths and resistance factors for FRP panels and connections shall be as specified in Sec. 5.4. The design of a tank elevated on a building or other supporting structure shall consider the structural interaction of the tank with the building or supporting structure, including the transfer of loads to and from the tank.