Aluminum Dome Roofs for Water Storage Facilities

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Approved by American National Standards Institute April 20, 2010.
AWWA Standard

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1 Alternate
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Foreword

This foreword is for information only and is not a part of ANSI/AWWA D108.

I. Introduction.

I.A. Background. In 1982, members of the American Water Works Association (AWWA) became aware of the increased usage of aluminum domes as roofs on water storage tanks and reservoirs. As a result of this, it was decided to incorporate a reference to aluminum domes in the AWWA standards.


In 1996, Section 15, Structurally Supported Aluminum Dome Roofs, was incorporated into D100-96, AWWA Standard for Welded Steel Tanks for Water Storage Tanks.

In 1997, Aluminum Dome Roofs left appendix status and became Section 13, Structurally Supported Aluminum Dome Roofs, in D103-97, with revisions similar to those in D100-96.

In 2005, D100-05 was issued, incorporating revisions to Section 15, Structurally Supported Aluminum Dome Roofs.

In 2009, the AWWA Standards Committee on Steel Elevated Tanks, Standpipes, and Reservoirs, as part of an initiative to reorganize the AWWA standards under its umbrella, developed a separate standard for aluminum dome roofs that would be applicable to all tanks. That standard is now designated D108, AWWA Standard for Aluminum Dome Roofs for Water Storage Facilities, and was approved by the AWWA Board of Directors on Jan. 17, 2010.

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 American Water Works Association Research Foundation (AwwaRF, now Water Research Foundation) and the Conference of State Health and Environmental Managers (COSHEM). The American Water Works Association (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 effects of products and drinking water additives from such products, state and local agencies may use various references, including

2. Specific policies of the state or local agency.
3. Two standards developed under the direction of NSF\(^\dagger\). NSF/ANSI 60, Drinking Water Treatment Chemicals—Health Effects, and NSF/ANSI 61, Drinking Water System Components—Health Effects.
4. Other references, including AWWA standards, *Food Chemicals Codex*, *Water Chemicals Codex*,\(^\S\) 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 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.

Annex A, “Toxicology Review and Evaluation Procedures,” to NSF/ANSI 61 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 Annex A procedures may not always be identical, depending on the certifier.

ANSI/AWWA D108 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 parties offering to certify products for contact with, or treatment of, drinking water.
3. Determine current information on product certification.

**II. Special Issues.** This standard has no applicable information for this section.

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\(^*\) Persons outside the United States should contact the appropriate authority having jurisdiction.
\(^\dagger\) NSF International, 789 N. Dixboro Road, Ann Arbor, MI 48105.
\(^\S\) Both publications available from National Academy of Sciences, 500 Fifth Street, N.W., Washington, DC 20001.
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.

Contractual responsibilities for items such as design, material, fabrication, construction, inspection, and testing are not included in this standard and must be addressed by the purchaser.

This standard is based on the accumulated knowledge and experience of purchasers and manufacturers of aluminum dome roofs.

Many aluminum domes built almost 40 years ago are still in service. Properly operated and maintained aluminum dome roofs can have a very long service life.

The term tanks where used in this standard shall apply to welded steel tanks, bolted steel tanks, and concrete tanks or reservoirs.

III.A. Purchaser Options and Alternatives. Proper use of this standard requires that the purchaser 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 that modifications, deletions, or amplifications be made by supplementing this standard. This standard is not intended to cover aluminum dome roofs that are to be erected in areas subject to regulations that are more stringent than the requirements contained herein. In such cases, local regulations supersede the requirements of this standard. Where local, municipal, county, or state government requirements exist, such requirements are to govern, and this standard should be interpreted to supplement them.

It is the purchaser’s responsibility to supplement or modify this standard for compliance with these local requirements. In addition, the purchaser is to provide clarification of the governing codes where they do not clearly refer to roofs, but where the purchaser intends such stipulations to apply to the tank roof under contract. As an example, if a governing code stipulates a building roof snow load of 40 lb/ft² (1,915 N/m²) and it is intended that the tank roof be designed for this load, the purchaser is to include this as a clarification.

The details of design and construction covered by this standard are minimum requirements. At a minimum, it is important that all of the design conditions in this standard be met. An aluminum dome roof cannot be represented as an ANSI/AWWA D108 roof if it does not meet the minimum requirements of this standard.

III.A.1. Information to be Provided by Purchaser for an Aluminum Dome Roof. This standard provides minimum requirements for the design, construction, inspection, and testing of an aluminum dome roof without any designation of which party must perform these tasks. For this reason, the following information should be provided by the purchaser:
2. Type of tank—whether bolted, welded, or concrete.
3. Tank details—that is, the diameter, height, and details of the top of the tank to which the aluminum dome roof is to attach.
4. Site location.
5. Desired time for completion.
6. Name of town and distance to the nearest town.
7. Type of road access available to the site.
8. Roof design loads (wind, live, and snow loads) and the applicable building code if it is different from the AWWA standard for the type of tank being covered by the aluminum dome roof.
9. Locations of all required roof accessories, including hatches, vents, and other accessories.
10. Whether roof handrails, walkways, or other safety devices are required and whether requirements in excess of OSHA CFR Part 1910 are required.
11. Details of other federal, state or provincial, and local requirements (Sec. 4.1).

III.B. Information to Be Provided With Bid.
1. Dimensions of the aluminum dome roof and design basis.
2. The number, names, and sizes of all accessories.
3. Appearance coatings or finish information if one is specified.

III.C. Modification to Standard. Any modification of the provisions, definitions, or terminology in this standard must be provided by the purchaser.

IV. Major Revisions. This is the first edition of the standard. Section 15 of ANSI/AWWA D100-05. Structurally Supported Aluminum Dome Roofs, serves as a basis for the development of this standard.

Section 15.11 of D100-05. Coatings, with modifications, was incorporated into this standard as Section 10, Coatings or Other Finishes. A provision for a nonglare mechanical finish was added for exterior surfaces.

V. Comments. If you have any comments or questions about this standard, please call the AWWA Volunteer and Technical Support Group at 303.794.7711, FAX at 303.795.7603, write to the group at 6666 West Quincy Avenue, Denver, CO 80235-3098, or e-mail the group at standards@awwa.org.
Aluminum Dome Roofs
for Water Storage Facilities

SECTION 1: GENERAL

Sec. 1.1 Scope
This standard establishes minimum criteria for the design, fabrication, and erection of structurally supported aluminum dome roofs. Aluminum dome roofs can be used on any size tank erected in accordance with AWWA standards. When this standard is specified, in the case of conflict between this standard and any other standard, the requirements of this standard shall govern.

Sec. 1.2 Description
The dome shall be a spherical structure conforming to the dimensions of the tank. The dome structure shall be a fully triangulated space truss complete with noncorrugated closure panels. The dome shall be clear span and designed to be self-supporting from the tank structure. The dome surface paneling shall be designed as a watertight system under all design load conditions. All raw edges of the aluminum panels shall be covered, sealed, and firmly clamped in an interlocking manner to prevent slipping or disengagement under all load conditions and temperature changes.
Sec. 1.3 Design Requirements

The tank shall be designed to support the aluminum dome roof. The magnitude and direction of all the forces acting on the tank due to the roof loads and details of the roof-to-shell attachment shall be provided. The tank shall be designed to support given roof loads and attachment details. Noncompatible metals shall be isolated to prevent galvanic corrosion. A signed and sealed certification shall be provided by an engineer who has reviewed the design of the tank indicating that the tank has been designed to support the aluminum dome roof. The aluminum dome roof shall be supported from the rim of the tank with the primary horizontal thrust contained by an integral roof tension ring. Provisions shall be made in the design of the connection between the roof and tank rim to allow for thermal expansion. A minimum range of −40°F to +140°F (−40°C to +60°C) shall be used for design unless a greater range is specified.

SECTION 2: REFERENCES

This standard references the following documents. These documents in the edition specified, or latest edition if not specified, 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.


AA DAF-45—Designation System for Aluminum Finishes.


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† American Architectural Manufacturers Association, 1827 Walden Office Square, Suite 550, Schaumburg, IL 60173.
‡ ASTM International, 100 Barr Harbor Dr., West Conshohocken, PA 19428.

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ASTM D2244-05—Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates.
NSF/ANSI 61—Drinking Water System Components—Health Effects

SECTION 3: DEFINITIONS

The following definitions shall apply in this standard:

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

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

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

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

5. Supplier: The party that supplies material or services. A supplier may or may not be the manufacturer.

6. 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 shall comply with the requirements of the Safe Drinking Water Act and other federal regulations for potable water, wastewater, and reclaimed water systems as applicable.

Materials provided to meet the provisions of this section shall be new and shall comply with all the requirements of this section. All aluminum alloys, properties, and tolerances shall be as defined by AA ASD. Aluminum materials shall be in accordance with the ASTM specifications listed in AA ADM Sec. 1.2. Unless otherwise specified, the aluminum dome roof materials shall have a mill finish.

Sec. 4.2 Structural Frame

All structural frame members shall be made from AA6061-T6 or AA6005A-T6.

Sec. 4.3 Roof Panels

Roof panels shall be fabricated from AA3000 series or AA5000 series aluminum with a minimum nominal thickness of 0.050 in. (1.27 mm).

Sec. 4.4 Bolts and Fasteners

All fasteners shall be AA7075-T73 aluminum, austenitic stainless steel, or other approved materials. Aluminum and austenitic stainless steel fasteners shall meet the requirements of ASTM F468 and ASTM F593, respectively. Only stainless steel fasteners shall be used to attach aluminum to carbon steel, and then only when electrical isolation is provided between noncompatible metals.

Sec. 4.5 Sealant and Gasket Material

All sealants and gaskets shall be suitable for contact with potable water without chemical extraction. Sealants and gaskets shall remain flexible over a temperature range of -40°F to +170°F (-40°C to +77°C) without tearing, cracking, or becoming brittle. Elongation, tensile strength, hardness, and adhesion shall not change significantly with aging or from exposure to ozone, ultraviolet light, or vapors from the water stored in the tank.

4.5.1 Sealants. All sealants shall be silicone compounds conforming to ASTM C920 unless another material is specified.

4.5.2 Gaskets. All preformed gasket material shall be made of silicone or neoprene unless another material is specified. Silicone gasket material shall meet Fed. Spec. A-A-59588 and ASTM C1115. Neoprene gasket material shall meet ASTM C509.

Sec. 4.6 Skylight Panels

Skylight panels, if specified, shall be clear acrylic or polycarbonate with a minimum nominal thickness of 0.25 in. (6 mm).
SECTION 5: DESIGN

Sec. 5.1 Drawings

Construction drawings for the roof shall be provided, including the following:

1. A drawing showing dimensions of the aluminum dome roof, the sizes of the principal members, the details of the tank attachment, the design loads, and the maximum loads transferred to the tank.

2. The number, names, and sizes of all accessories.

3. Appearance coatings or finish information if specified.

Sec. 5.2 Principles of Design

The roof-framing system shall be designed as a moment-resisting, three-dimensional space frame or truss with a membrane covering (roof panels) providing loads along the length of the individual members. The design shall consider the increased compression and minor axis bending induced in the framing members caused by the tension in the roof panels. The design loads shall not exceed the allowable buckling loads set forth in Sec. 5.4.1. The actual stresses in the framing members and panels under all design load conditions must be equal to or less than the allowable stresses.

The structural analysis shall include the effect of geometric irregularities such as dormer openings and perimeter support members.

For members subject to axial forces and bending moments caused by load eccentricity or lateral loads, the combined member stresses shall be determined by adding the stress component due to axial load to the stress components that result from bending in both the major and minor axes, all in accordance with the AA ADM.

All components of the aluminum dome roof shall be designed by the allowable stress design method.

Sec. 5.3 Design Loads

In addition to design loads specified in the applicable AWWA standard for the type of tank being covered and local building code, if specified, the following loads shall be considered in the design of the aluminum dome roof:

5.3.1 Unbalanced loading. Reduce the live load by 50 percent over one-half the dome.

5.3.2 Panel design load. These load cases do not act simultaneously with other design loads or with each other.
Load Case 1: Two 250-lb (113-kg) loads concentrated on two separate 1-ft² (0.093-m²) areas of any aluminum panel.

Load Case 2: A 60-psf (293-kg/m²) uniform load distributed over the total panel area.

5.3.3 Skylight design load. Skylights, if specified, shall be designed for the same loads specified for the roof.

5.3.4 Load combinations. The following load combinations shall be considered:

1. Dead load
2. Dead load + uniform live load
3. Dead load + unbalanced live load
4. Dead load + wind load
5. Dead load + uniform live load + wind load
6. Dead load + unbalanced live load + wind load
7. Dead load + seismic load

Sec. 5.4 Allowable Stresses and Allowable Loads

5.4.1 Aluminum structural members. Aluminum structural members and their connections shall be designed in accordance with the AA ADM, except as modified by this section.

Allowable dome shell buckling loads shall be determined in accordance with the following formula:

\[ w = \frac{2.258 \times 10^6 (I_x A)^{1/2}}{(SF) R^2 L} \]  

(Eq 5-1)

Where:

- \( w \) = allowable load (pressure), psf
- \( I_x \) = moment of inertia of strut about the strong axis, in.⁴
- \( A \) = cross-sectional area of strut, in.²
- \( R \) = spherical radius of dome, in.
- \( L \) = average member length, in.
- \( SF \) = safety factor = 1.65

Alternatively, the stability of the roof may be determined using nonlinear analysis modeling. A minimum safety factor of 1.95 shall be used to account for modeling variations and assumptions.

5.4.2 Aluminum panels. Aluminum panels shall be designed to support the loads specified in Sec. 5.3 without exceeding the allowable stresses specified in
Table 1  Bolts and fasteners

<table>
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<tr>
<th>Material</th>
<th>Allowable Tensile Stress</th>
<th>Allowable Shear Stress</th>
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<tbody>
<tr>
<td></td>
<td>psi</td>
<td>(MPa)</td>
</tr>
<tr>
<td>Austenitic Stainless Steel‡‡</td>
<td>30,000</td>
<td>(206.9)</td>
</tr>
<tr>
<td>Austenitic Stainless Steel§§</td>
<td>42,000</td>
<td>(289.7)</td>
</tr>
<tr>
<td>AA2024T4 Aluminum</td>
<td>26,000</td>
<td>(179.2)</td>
</tr>
<tr>
<td>AA7075 T73 Aluminum</td>
<td>28,000</td>
<td>(193.0)</td>
</tr>
</tbody>
</table>

*The root of thread area shall be used for calculating the strength of threaded parts.

†If the thread area is completely out of the shear area, the cross-sectional area of shank may be used to determine the allowable shear load.

‡For stainless steel bolts with a minimum tensile strength of 90,000 psi (620.5 MPa).

§For stainless steel bolts with a minimum tensile strength of 125,000 psi (861.8 MPa).

the AA ADM. Panel attachment fasteners shall not penetrate both the panel and flange of the structural member.

5.4.3 Bolts and fasteners. The allowable stresses for bolts and fasteners are listed in Table 1. For fasteners not listed in Table 1, the allowable stresses in bolts and fasteners shall be in accordance with AA ADM-105.

Hole diameters used for fasteners shall not exceed \( \frac{1}{8} \) in. (1.6 mm) plus the diameter of the fastener used.

Sec. 5.5 Equivalent Metric Equations

Metric equivalents of equations presented in Section 5 are as follows:

<table>
<thead>
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<th>Equivalent Metric Equation</th>
<th>Variable</th>
<th>Metric Units</th>
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<tr>
<td>5-1</td>
<td>( w = 108.1(I_x/A)^{1/2}/[(SF)R^2L] )</td>
<td>( w )</td>
<td>N/m²</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( I_x )</td>
<td>mm⁴</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( A )</td>
<td>mm²</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( R, L )</td>
<td>m</td>
</tr>
</tbody>
</table>

SECTION 6: ROOF ATTACHMENT DETAILS

The structure supports provided to support the aluminum dome roof shall be bolted or welded to the tank. An adequate number of attachment points shall be provided to preclude overloading the tank shell. The attachment detail shall be
suitable to transfer all roof loads to the tank shell, keeping local stresses within allowable limits.

Sec. 6.1 Roof Supports

The roof attachment points may incorporate a slide bearing with low-friction bearing pads to minimize the horizontal radial forces transferred to the tank. Alternatively, the roof may be attached directly to the tank and the top of the tank analyzed and designed to sustain the horizontal thrust transferred from the roof, including the thrust from differential thermal expansion and contraction.

Sec. 6.2 Separation of Carbon Steel and Aluminum

Aluminum shall be isolated from the carbon steel by an austenitic stainless steel spacer or an elastomeric isolator bearing pad, unless other methods are specified.

Sec. 6.3 Separation of Concrete and Aluminum

Aluminum shall be separated from contact with concrete through the use of acceptable coatings or tape suitable for contact with potable water.

SECTION 7: PHYSICAL CHARACTERISTICS

Unless otherwise specified, the maximum dome spherical radius shall be 1.4 times the diameter of the tank, and the minimum dome spherical radius shall be 0.7 times the tank diameter.

Sec. 7.1 Roof Accessories

Roof accessories shall conform to the provisions of the AWWA standard for the type of tank being covered, as applicable.

Sec. 7.2 Skylights

Skylights, if specified, shall be provided with a 4-in. (102-mm) or higher curb. The total skylight area to be provided shall be specified.

SECTION 8: TESTING AND SEALING

Sec. 8.1 Leak Testing

After the roof installation is complete and it is verified the underside of the roof is dry, the roof seams shall be leak tested by spraying the outside of the seams
with water using a garden hose with a minimum 50 psig (345 kPa) static head pressure at the nozzle, held at a distance between 3 and 6 ft (0.9 and 1.8 m). Potable water shall be used. The water must not be sprayed directly on any roof vents. Any water on the inside of the roof shall be evidence of leakage.

Sec. 8.2 Shell Seal

The seal between the tank shell and roof need not be airtight. The bottom of the roof flashing shall extend at least 2 in. (51 mm) below the top of the tank shell. The space between the flashing and tank shell shall be covered with a suitable noncorrosive screen or membrane to prevent the entrance of birds and insects.

SECTION 9: FABRICATION AND ERECTION

The dome shall be erected in accordance with the dome manufacturer's instructions.

Sec. 9.1 Fabrication

All roof parts shall be prefabricated for field assembly. Fabrication procedures shall be in accordance with AA ADM-105 Section 6.

Sec. 9.2 Welding

The fabrication and design of welded aluminum parts shall be in accordance with AA ADM for Aluminum Structures and Section 2 of AWS D1.2/D1.2M. All aluminum welds and components joined by welding shall be inspected by visual testing (VT), and all structural welds shall be inspected by the liquid-penetrant testing (PT) examination in accordance with Section 5 of AWS D1.2/D1.2M. Weld acceptance shall be in accordance with AWS D1.2/D1.2M Sec. 5.14, Visual Inspection, Sec. 5.14.2, Visual Inspection of Statically Loaded Non-Tubular Connections, and Sec. 5.17, PT. All structural welding of aluminum shall be performed prior to field erecting of the dome. Qualified written Welding Procedure Specifications (WPSs) and Welder Performance Qualification (WPQs) shall be provided, if requested, prior to welding. Welding Inspector qualifications shall meet AWS D1.2/D1.2M Sec. 5.1.3. Personnel performing nondestructive testing (NDT) other than visual shall be qualified in accordance with AWS D1.2/D1.2M Sec. 5.7.6.

Sec. 9.3 Shipping and Handling

Materials shall be handled, shipped, and stored in a manner that will not damage the surface of aluminum or the surface coating if one is applied.
Sec. 9.4 Quality of Work

The roof shall be installed so as to minimize internal stresses when assembling the various members or components of the structure. Field cutting, trimming, relocating of holes, or applying force to the parts or components to achieve fit-up shall not be allowed.

Sec. 9.5 Maintenance and Inspection

A maintenance and inspection manual for those items that may require maintenance or periodic inspection shall be provided.

SECTION 10: COATINGS OR OTHER FINISHES

The standard finish for aluminum dome roofs shall be a mill finish. A factory-applied baked-on color finish or a nonglare mechanical finish may be specified for exterior surfaces.

Exterior coatings may be thermosetting, acrylic, silicone polyester, or fluorocarbon.

Note: No coatings are to be applied to the interior surfaces of the dome.

If a coating is used, the coating shall meet the requirements of AAMA 2604 for high-performance organic coating on aluminum extrusions and panels. The coating shall also meet the weathering requirements specified in ASTM D2244. Mechanical finishes shall meet the requirements of the Aluminum Association AA M42/M43 Non-Directional Textured Finish as specified in AA DAF-45.

SECTION 11: AFFIDAVIT OF COMPLIANCE

The purchaser may require an affidavit from the manufacturer or supplier that the material provided complies with the applicable requirements of this standard.
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