Designation: D4551 – 12

An American National Standard

Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Flexible Concealed Water-Containment Membrane[1]

This standard is issued under the fixed designation D4551; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This specification covers poly(vinyl chloride) (PVC) flexible sheeting which is used without mastic, bedding, or coating for construction of concealed water-containment-membranes in applications where there is potential for costly secondary damage from water leakage and very long-term reliable performance is essential. Examples are fountains, pools, planters, shower and safe pans, tile tubs, or similar wet installations where the membrane is inaccessible once the construction is complete. Included are requirements for materials and sheeting, test methods, workmanship criteria, and methods of marking.

1.2 Recycled materials may be used in this product in accordance with the requirements in Section 5.

1.3 The tests are intended to ensure quality and performance and are not intended for design purposes. Tests have been selected to be conducted primarily with liquids that simulate the environment to which the membrane will be subjected during actual use.

1.4 This specification does not cover water-containment membranes exposed to ultraviolet light.

1.5 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 There is no known ISO equivalent to this standard.

1.7 The following precautionary caveat pertains only to the test method portion, Section 13, of this specification:*This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D374 Test Methods for Thickness of Solid Electrical Insulation (Withdrawn 2013)[3]

D412 Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D618 Practice for Conditioning Plastics for Testing

D883 Terminology Relating to Plastics

D1004 Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting

D1203 Test Methods for Volatile Loss From Plastics Using Activated Carbon Methods

D1204 Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature

D1243 Test Method for Dilute Solution Viscosity of Vinyl Chloride Polymers

D3892 Practice for Packaging/Packing of Plastics

D7209 Guide for Waste Reduction, Resource Recovery, and Use of Recycled Polymeric Materials and Products

E96/E96M Test Methods for Water Vapor Transmission of Materials

2.2 *ANSI Standard:*

Z 26.1 Safety Code for Safety Glazing Materials for Glazing Motor Vehicles Operating on Land Highways[4]

2.3 *Military Standard:*

MIL-STD-105 Sampling Procedures and Tables for Inspection by Attributes[5]

3. Terminology

3.1 *Definitions:*

[1] This specification is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.24 on Plastic Building Products.

Current edition approved Oct. 1, 2012. Published November 2012. Originally approved in 1986. Last previous edition approved in 2008 as D4551 – 96(2008). DOI: 10.1520/D4551-12.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[5] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

***A Summary of Changes section appears at the end of this standard**

3.1.1 *General*—Definitions are in accordance with Terminology D883 unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *water-containment membrane*—a non-porous membrane impervious to water and resistant to permeation by water vapor to an extent that it provides a high degree of certainty that secondary damage from leakage shall not occur.

3.2.2 *homogeneous sheeting*—sheeting that is of uniform composition throughout its thickness.

4. Classification

4.1 The sheeting will be subdivided by grades based on thickness:

4.1.1 *Grade 30*—0.03 in. (0.765 mm).

4.1.2 *Grade 40*—0.04 in. (1.02 mm).

5. Materials and Manufacture

5.1 This specification covers poly(vinyl chloride) (PVC) water-containment membrane formulated from PVC materials meeting the following requirements:

5.1.1 A PVC resin with an inherent viscosity (logarithmic viscosity number) of not less than 0.92 as determined by Test Method D1243.

5.1.2 A PVC compound density of 1.26/1.29 g/cm^3 .

5.2 Recycle materials, as defined in Guide D7209, may be used in this product if all the requirements in Sections 3, 5, 6, and 9 are met by the recycle material.

5.3 The use of water-soluble compounding ingredients shall be prohibited.

5.4 Plasticizers that are resistant to migration, mildew, and bacterial degradation shall be used.

6. Physical Properties

6.1 The sheeting shall conform to the physical requirements prescribed in Section 9 (Table 1) and Section 17 (Table 2).

6.2 Sheeting shall be compounded so that bonds between sheets used in fabrication of large water-containment membranes can be accomplished in the field without reducing the overall resistance of the membrane to permeation or leakage or significantly reducing the sheeting's physical strength. The manufacturer shall specify recommended bonding procedures in its product literature.

6.3 The sheeting shall be colored as agreed upon between the purchaser and the seller as part of the purchase contract.

6.4 The sheeting shall be monolithic and homogeneous.

TABLE 2 Quality Assurance Requirements

Property	Unit	Specification Grade 30	Specification Grade 40
Thickness	in. (mm)	0.030 (0.765), min	0.040 (1.02), min
Pinholes	number	none	none
Shrinkage at 158°F	% of original	5 %, max	5 %, max
Width	in. (cm)	+0.5 (1.27), –0.0	+0.5 (1.27), –0.0

7. Dimensions

7.1 The actual width and length of the sheeting shall be as agreed upon between the purchaser and the seller.

7.1.1 Sheeting width tolerance shall be +0.5, –0.0 in. (+12.7, –0.0 mm).

7.1.2 The length of the sheeting after unrolling and relaxing for 10 min at 73 ± 3.6°F (23 ± 2°C) shall be no less than that specified in the purchase order.

7.2 Minimum thickness of Grade 30 sheeting shall be 0.03 in. (0.765 mm) and minimum thickness of Grade 40 sheeting shall be 0.04 in. (1.02 mm).

8. Workmanship

8.1 If not monitored continuously, a minimum of every hour production shall be sampled and inspected for appearance, thickness, width, and workmanship. The material shall be free of pin holes, foreign inclusions, undispersed materials, or other defects that could affect serviceability.

TABLE 1 Qualification Tests

Property	Unit	Specification	
		Grade 30	Grade 40
Thickness	in. (mm)	0.030 (0.765), min	0.040 (1.02), min
Tensile strength	lbf/in. (kN/m) of width	60 (10.45), min	80 (14.05), min
Tensile stress at 100 % elongation	lbf/in. (kN/m) of width	30 (5.23), min	40 (7.03), min
Elongation at break	%	300, min	300, min
Tear resistance	lbf/in. (kN/m) of width	185 (32.5), min	250 (43.7), min
Pinholes	number	none	none
Micro-organism resistance	specimen, pass/fail	12 of 12 pass	12 of 12 pass
Puncture resistance	specimen, pass/fail	6 of 6 pass	6 of 6 pass
Indentation resistance	specimen, pass/fail	3 of 3 pass	3 of 3 pass
Folding resistance	specimen, pass/fail	3 of 3 pass	3 of 3 pass
Chemical resistance			
Distilled H_2O	% weight change	+1 %, max	+1 %, max
Soapy H_2O	% weight change	+2 %, max	+2 %, max
Alkali	specimen, pass/fail	3 of 3 pass	3 of 3 pass
Hydrostatic pressure test	specimen, pass/fail	3 of 3 pass	3 of 3 pass
Shrinkage	% original	5 %, max	5 %, max
Volatile loss at 158°F	% loss	1.5 max	1.5 max

9. Qualification Tests

9.1 The PVC sheeting shall pass all the qualification tests prescribed in Section 11 and Table 1.

9.1.1 Any modification of this compound shall require that the sheeting be retested for conformance to this specification. In addition, retesting shall be done every 3 years whether the compound has been modified or not to assess cumulative effects of switching suppliers, grades of raw materials, or processing changes.

10. Sampling

10.1 Test specimens shall be selected at random from production stock. In each roll selected, units comprising the required number of specimens shall be taken from a portion not including the first or last foot of the roll or portions within 6 in. of the edge of the roll.

11. Test Methods

11.1 *Thickness*—Test five specimens obtained from locations equidistant across the width of the sheet in accordance with Method C of Test Methods D374. Report thickness of each specimen and location in sheet.

11.2 *Stress-Strain Properties*—Determine tensile stress at 100 % elongation (modulus), tensile strength, and ultimate elongation in accordance with Method A of Test Methods D412, using a dumbbell specimen (Die C). Report physical properties as the average value from testing of 6 specimens.

11.3 *Pinholes*—Examine sheeting for pinholes by viewing the surface of the sheeting while held under slight-hand tension. Position a bright light source behind the film so as to clearly illuminate the surface without producing glare in the observer's eyes. A pinhole is defined as any opening observed in the sheet under the conditions specified. Examine a 12-in. (305-mm) strip from the entire width of the sheet and report the presence or absence of pinholes.

11.4 *Resistance to Chemical Reagents*—Conduct this test in accordance with Test Method D543, Procedure 1.

11.4.1 Weigh loss after immersion in distilled water at 120°F (49°C) for 24 h.

11.4.2 Weigh loss after immersion in a 1 % soapy water solution at 120°F (49°C) for 24 h.

11.4.3 *Alkali Resistance Test*—This test indicates the effect of hot alkali solutions on the plastic membrane materials.

11.4.3.1 *Specimens*—Each test unit shall consist of three specimens of flat material 3 by 3 in. (76 by 76 mm) selected in accordance with 12.1.

11.4.3.2 *Procedure*—Make a solution by dissolving 5.0 g of reagent-grade sodium hydroxide and 5.0 g of reagent-grade potassium hydroxide in 1 L of distilled water in a beaker. The solution shall be maintained at a temperature of 150°F (66°C).

11.4.3.3 Immerse each specimen in its own individual beaker of solution in accordance with 11.4.3.2. Immerse the specimen for 72 h, and completely change the solution every 24 h. Before immersion of a specimen in the new solution, the solution shall be at a temperature of 150°F (66°C).

11.4.3.4 Test each specimen for waterproofness in accordance with 11.8 for hydrostatic pressure test.

11.5 *Microorganism Resistance Test*—Determine the resistance of PVC membrane to mold growth in accordance with Annex A1.

11.6 *Strength and Toughness Tests:*

11.6.1 *Puncture Resistance Test*—Determine the resistance of the material to mechanical damage which might occur during the installation of the water-containment membrane in accordance with the procedure described in Annex A2.

11.6.2 *Indentational Resistance Test*—Determine the ability of the material to withstand nail-head indentation without impairing waterproofness. Conduct the test in accordance with the procedure detailed in Annex A3.

11.6.3 *Folding Resistance Test*—Determine the ability of the material to withstand corner folding without impairing waterproofness in accordance with the procedure outlined in Annex A4.

11.7 *Shrinkage*—Test for 1 h at 158°F (70°C) in accordance with Test Method D1204.

11.8 *Hydrostatic Pressure Test*—Determine the ability of plastic membrane material to withstand water pressure without leaking in accordance with the test procedure in Annex A5.

11.9 *Tear Resistance*—Determine the average value for six specimens in accordance with Test Method D1004.

11.10 *Volatile Loss*—Determine volatile loss in accordance with Test Methods D1203, Method A, at 158°F (70°C) with grade AC (6/14 mesh) activated carbon. Test specimens shall be nominal thickness sheeting.

NOTE 1—Requirement for Water—Vapor Transmission of Materials in Sheet Form (Procedure E of Test Methods E96/E96M) has been deleted until the test method is improved to the extent that it can be reproducibly run by commercial laboratories.

12. Conditioning

12.1 Condition all qualification test specimens at 73 ± 4°F (23 ± 2°C) and 50 ± 10 % relative humidity for not less than 40 h prior to testing, in accordance with Method A of Methods D618.

12.2 In-plant quality control specimens shall be conditioned at 73 ± 4°F (23 ± 2°C) for 2 h in air.

13. Inspection

13.1 Inspection of the material shall be made as agreed upon between the purchaser and the seller as part of the purchase contract.

14. Certification

14.1 When specified in the purchase order or contract, the manufacturer's or the supplier's certification shall be furnished to the purchaser stating that samples representing each lot have been manufactured, tested, and inspected in accordance with this specification and the requirements have been met. When specified in the purchase order or contract, a report of the test results shall be furnished.

15. Product Marking

15.1 Material complying with this specification shall be continuously marked and shall include the following spaced out at intervals of not more than 2 ft (610 mm).

15.1.1 Manufacturer's name (or brand name or trademark).

15.1.2 Material designation.

15.1.3 Designation, Grade 30 or Grade 40, with which the sheet complies.

15.1.4 Designation, "ASTM D4551", with which the sheet complies.

15.1.5 The production code shall be included inside the core of all shipping units.

16. Packaging and Package Marking

16.1 The material shall be rolled on a substantial core and packaged in standard commercial containers, so constructed as to ensure acceptance by common or other carriers for safe transportation to the point of delivery, unless otherwise specified in the contract or order.

16.2 Shipping containers shall be marked as agreed upon between the purchaser and the seller.

16.3 Packaging provisions for government/military procurement.

16.4 All packing, packaging, and marking provisions of Practice D3892 shall apply to this specification.

17. Quality Assurance

17.1 Sheeting manufactured from compound qualified by Section 9 shall pass the quality assurance and control requirements prescribed in Table 2.

17.1.1 In addition to the in-plant quality control inspections specified in Section 8, at least annually samples shall be tested and certified as complying with the requirements of Table 2.

17.2 If the results of any tests do not conform to the requirements of this specification, retesting to determine conformity may be performed as agreed upon between the purchaser and the seller.

18. Keywords

18.1 flexible sheeting; fountains; planters; pools; poly(vinyl chloride); PVC; recycle usage; shower and safe pans; tile tubs; water containment membrane; water leakage resistance; water permeation

SUPPLEMENTARY REQUIREMENTS

QUALITY ASSURANCE PROVISIONS FOR GOVERNMENT/MILITARY PROCUREMENT

These requirements apply *only* Federal/Military procurement, not domestic sales or transfers.

S1. Selection of Acceptable Quality Level (AQL) and of Inspection Level (IL) shall be made with consideration of the specific use requirements. This is discussed in Sections 7 and 8 of the above document, with reference to MIL-STD-105.

S3. In the absence of contrary requirements the following values shall apply:

	IL	AQL
Defects in material and workmanship	II	2.5
Defects of preparation for delivery	S-2	2.5
Testing (products)	S-1	1.5
Testing (polymer, unfabricated)	S-1	...

ANNEXES

(Mandatory Information)

A1. MICROORGANISM RESISTANCE TEST

A1.1 *Specimens*—Each unit of specimens shall consist of twelve samples of material each 1½ by 1½ in. (38 by 38 mm) square, selected in accordance with 11.1.

A1.2 *Apparatus*, medium and test fungi.

A1.2.1 Apparatus shall consist of:

A1.2.1.1 *Autoclave,* capable of maintaining an interior temperature of 251 ± 3.6°F (122 ± 2°C) at a pressure of 15.5 ± 0.5 lb psig (107 ± 3.5 kPa) for the purpose of sterilizing glassware and the medium.

A1.2.1.2 *Erlenmeyer Flask,* 100-cm^2 capacity.

A1.2.1.3 *Glass Beads,* ¼ in. (6 mm) in diameter, 5 pieces.

A1.2.1.4 *Glass Pipettes,* two required.

A1.2.1.5 *Wire Loop,* of nichrome wire.

A1.2.1.6 *Petri Dishes* (4 in.) 10 cm in diameter with covers capable of being sealed with cellophane tape. One petri dish is required for each of the twelve samples comprising a test unit.

A1.2.1.7 *Incubation Chamber,* capable of maintaining a temperature of 84.5 ± 1.8°F (29± 1°C) and a relative humidity of at least 50 %.

A1.2.1.8 *Sterile Room,* dust-free, using sterilamps, antiseptic spray, or air filtration under pressure to maintain sterile conditions.

A1.2.2 *Test Fungi:*

A1.2.2.1 *Chaetomium globosum,* ATCC 6205.

A1.2.2.2 *Aspergillus niger,* ATCC 6275.

A1.2.3 *Medium*—A culture medium of the following composition:

NH_4NO_3	3.0 g
KH_2PO_4	2.5 g
$MgSO_47H_2O$	2.0 g
K_2HPO_4	2.0 g
Agar	20.0 g

Distilled water to make 1000 mL

Adjust the pH to a range from 6.4 to 6.8 with HCl or NaOH, as required. This is the base medium for both fungus cultures. However, the medium to be used for the Aspergillus niger shall be enriched by adding 30 g of brown sugar.

A1.3 *Procedure:*

A1.3.1 Prepare medium as specified in A1.2.3 and pour in the required number of petri dishes to a depth of ⅜ in. (9.5 mm).

A1.3.2 Sterilize in the autoclave, all of the apparatus in A1.2.1 including the medium contained in the petri dishes by retention in the autoclave at the temperature and pressure prescribed in A1.2.1.1 for 60 min. After sterilization, remove to sterile room of A1.2.1.8, taking care not to contaminate the sterilized equipment and medium. Use the sterile room for all preparation procedures.

A1.3.3 *Cultures, Stock and Substocks, and Inoculum:*

A1.3.3.1 Carefully maintain *Chaetomium globosum fungus stock cultures* on strips or squares of sterile porous filter paper, or blotting paper, on a sterilized culture medium as specified in A1.2.3 and A1.3.2. If there is evidence of contamination, promptly renew the culture. The culture may be kept for not more than four months in a refrigerator at approximately 37.5 to 50°F (3 to 10°C).

(1) Prepare subcultures from a stock culture by transferring spores from the stock culture to a sterilized covered petri dish containing sterilized medium. Incubate the subculture for a period of 7 to 21 days at 84.5 ± 1.8°F (29 ± 1°C) in the incubation chamber until in a ripe fruiting condition.

(2) Prepare inoculum by transferring the spores with the sterilized wire loop to a sterilized Erlenmeyer flask containing five sterilized glass beads and 10 mL of distilled water. Shake this mixture sufficiently to break up the spores, after which the solution shall be diluted to 200 mL.

A1.3.3.2 Carefully maintain *Aspergillus niger fungus stock cultures* as specified in A1.3.3.1 (*1*) on a medium as specified in A1.3.3.1.

(1) Prepare subcultures and incubate as in A1.3.3.1 (*1*) using a medium as specified in A1.3.3.1.

(2) Prepare inoculum as specified in A1.3.3.1 (*2*).

A1.3.4 Inoculate six specimens of each test unit as defined in A1.1 with each of the two varieties of fungi. Inoculate three with the face side up and three with the back side up.

A1.3.4.1 *Preparation*—Handle each specimen under aseptic conditions and sterilize by dipping in 70 % ethanol for a few seconds followed by a thorough rinse in distilled water after which place each firmly in the center of the solidified agar medium in its respective petri dish. Test six of the specimens with one fungi and six with the other. Of each subunit of six, test three with one surface in contact with the medium and three in contact with the opposite surface as stated under A1.3.4.

A1.3.4.2 Place controls in each petri dish along with the specimen. Each control shall be a strip of sterile blotting paper or filter paper placed on the agar separated from the specimen. The purpose of the control is to provide a medium for the fungi, thus proving that the fungi is active.

A1.3.4.3 Make inoculation with a particular fungus by using a sterile pipette individual to the fungus. With the pipette, distribute approximately 1.5 mL of inoculum over the specimen, the control, and the surrounding medium.

A1.3.5 Incubate the inoculated specimens for a period of 28 days at a temperature of 84.5 ± 1.8°F (29 ± 1°C) and a relative humidity of 90 %. An appropriate incubation condition is obtained by placing the covered and sealed petri dishes in a room or chamber maintained at 85°F (29.5°C) and 50 % relative humidity.

A1.3.6 *Results*—Reject test dishes with controls that do not exhibit a substantial growth of fungi after 7 days of incubation and start anew. Examine a unit test, the controls of which indicate a substantial fungus growth, after the required 28-day incubation period. If after this period any one of the specimens show evidence of evenly distributed or intense localized fungus growth under 16X magnification of either side of the sample (excluding growth overlapping the edges), the test sample shall be considered to have failed the test.

A1.3.6.1 Photographs of the specimen taken at the end of the 28 day incubation period are required as a part of the test on fungus resistance. Take each photograph with a scale laid beside the specimen to indicate its size, allowing the light conditions of the photographs to reveal the nature and height of the fungus growth on the surface of the material. Enlarge the photographs so the specimen will be a 6 by 6 in. (152 by 152 mm) size.

A2. PUNCTURE-RESISTANCE TEST

A2.1 *Specimens*—Six 10 by 10 in. (254 by 254 mm) pieces of material shall make up each test unit.

A2.2 *Apparatus:*[6]

A2.2.1 *Specimen Holder* (Fig. A2.1), shall consist of two 10 by 10 in. (254 by 254-mm) square pieces of ¾ in. (19 mm) smooth surface hard maple. One of these pieces shall contain a symmetrically located 6 by 6-in. (152 by 152-mm) opening in the center. Sandwich the specimen between two specimen holders, placing the holder with the opening on top. Three thumb screws or bolts located in the center of each side are used to securely clamp the specimen within the holder.

A2.2.2 *Impact Dart*—A7 ± 1-oz (196 to 201-g) steel dart as described in Fig. A2.2.

A2.3 *Procedure:*

A2.3.1 Test three specimens with one side up and three with the opposite side up.

A2.3.2 Place a single specimen between the holding frame halves and clamp securely by tightening the thumb screws. Suspend the impact dart vertically above the center of the specimen with a vertical distance of 3 ft (0.91 m) between the nose of the dart and the surface of the specimen.

A2.3.3 Release the dart for one free fall on each specimen.

A2.4 *Results:*

A2.4.1 Visible rupture of any specimens shall require rejection of the materials in accordance with 17.2.

A2.4.2 All specimens passing this test for rupture shall be further hydrostatically tested in accordance with 11.8 with the point of impact in the center of the test apparatus.

[6] Photographs of apparatus described are published in Federal Housing Administration Document 4900.1, Appendix D, available from the U.S. Department of Housing and Urban Development, 451 7th St., SW, Washington, DC 20410.

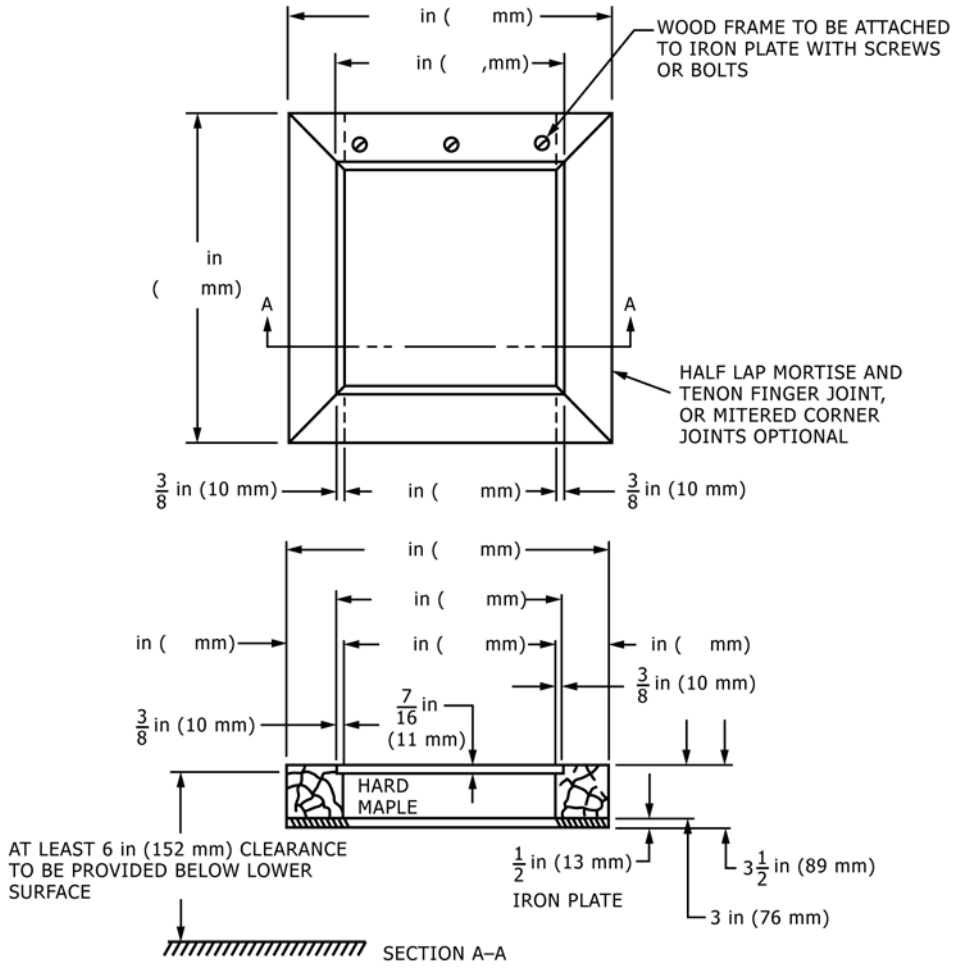
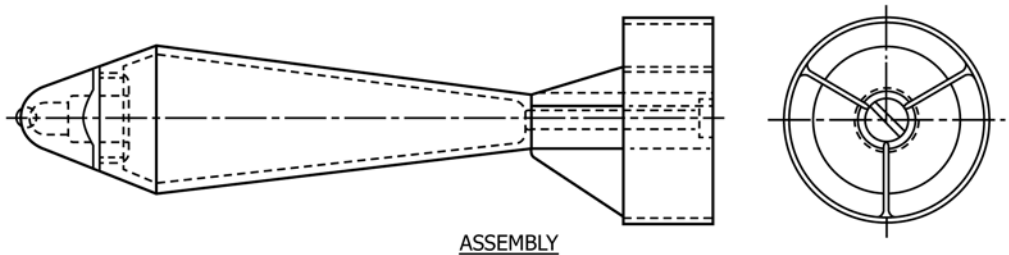
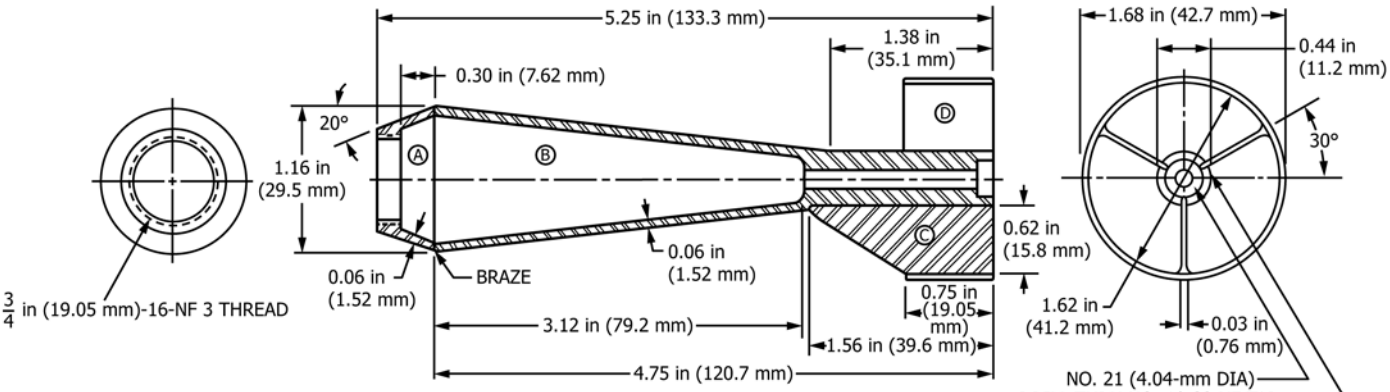


FIG. A2.1 Wood Holding Fixture for Drop Test



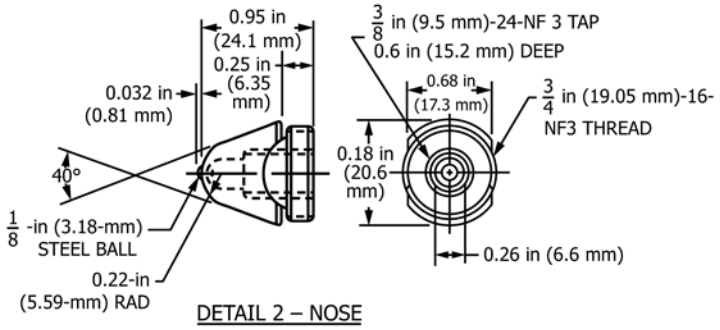
ASSEMBLY
WEIGHT: 7 oz ± 0.1 oz (196 TO 201 g) (ADJUST WITH LEAD SHOT)



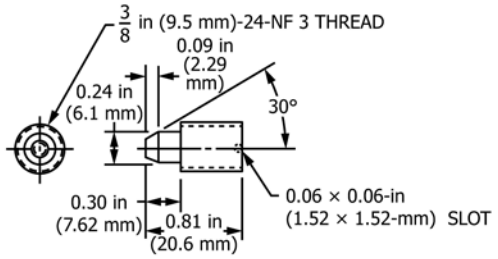
DETAIL 1 – BODY
1 - WELDED CONSTRUCTION

STOCK	1 – PIECE	Ⓐ 1 3/8-in (34.9-mm) DIA MACHINE STEEL
	1 – PIECE	Ⓑ 1 3/8-in (34.9-mm) DIA MACHINE STEEL
	3 – PIECES	Ⓒ NO. 21 GAGE (0.0329-in) (0.836-mm) SHEET STEEL
	1 – PIECE	Ⓓ 1 1/2-in (38.1-mm) EXTRA-HEAVY PIPE

NOTE: Not to scale.



DETAIL 2 – NOSE
AISI TYPE A-6 STEEL
STOCK 1.0-in (25.4 mm) DIAMETER
HEAT TREATMENT: AUSTENIZE
AIR COOL, TEMPER TO ROCKWELL 52–56 C



DETAIL 3 – SCREW
AISI TYPE A-6 STEEL
STOCK 1/2-in (1.27-mm) DIAMETER
HEAT TREATMENT: AUSTENIZE
AIR COOL, TEMPER TO ROCKWELL 58–62 C

NOTE: Not to scale.

FIG. A2.2 Dart for Safety Glass Tests

A3. TEST FOR RESISTANCE TO INDENTATION

A3.1 *Specimens*—The specimens shall be in accordance with 11.1.

A3.2 *Apparatus*[6]—The apparatus shall consist of an indenter acting under a total weight of 120 lb (54.4 kg), a smooth steel plate as a specimen support, and a rigid form for supporting the indenter and the imposed weight. The indenting head shall be a 0.178-in. (4.5-mm) diameter steel bar with the pressing face buffed smooth, but not rounded. The rigid support shall hold the indenter vertically so that the indenting face shall contact the specimen in the plane of the contact surface of the specimen when the specimen is placed on the horizontal steel plate. The shaft of the indenter shall be capable of vertical motion along its axis without friction when the weight causing indentation is imposed thereon.

A3.3 *Procedure*—Place the specimen on the supporting plate of the apparatus with the bottom surface up, and lower the indenter gently until its face contacts the surface of the specimen. Within 1 or 2 s, apply the total load of 120 lb (54.4 kg) to the specimen and maintain for a period of 60 min.

A3.4 *Results*—Test each specimen of the test unit hydrostatically, in accordance with 11.8, with the water contacting each of the specimens on the side opposite the indentation and with the indentation centered in the hydrostatic test specimen holder.

A4. FOLDING RESISTANCE TEST

A4.1 *Specimens*—The specimens shall be in accordance with 12.1.

A4.2 *Apparatus*—The apparatus shall consist of a 10-lb (4.5-kg) weight having a smooth, flat surface, a¼-in. (6.3-mm) diameter mandrel, and a constant temperature chamber to be maintained at 0 ± 2°F (−17 ± 1°C).

A4.3 *Procedure*—Place the specimen, weight, and mandrel in the constant-temperature chamber and accomplish all operations for the bend test therein. After temperature conditioning the apparatus and the test unit of specimens for 4 h at within ±2°F (±1°C) of the temperature indicated in A4.2, bend each specimen over the mandrel through an angle of 180°. Make the bend in the middle of each specimen and complete it within 1 s. Then, remove the specimen from the mandrel without unfolding and place on a smooth, hard surface for support while the weight is placed on the fold for 30 s. Place the weight so that its force is evenly distributed over the full length of the fold. Unfold each specimen and repeat the bending and weighing operation on each specimen with the second bend being at 90° to the first and on the same side. Note that all bends shall be made with the surface of the material intended to be toward the water exposure on the inside of the bend.

A4.4 *Results*—After unfolding, test each specimen of the test unit hydrostatically, in accordance with 11.8, with each specimen placed so that the inside of the folds are in contact with the water and with the intersection of the two folds centered in the hydrostatic test specimen holder.

A5. HYDROSTATIC PRESSURE TEST

A5.1 *Specimens*—Each test unit shall consist of three specimens of flat material 3 by 3 in. (76 by 76 mm) selected in accordance with 12.1.

A5.2 *Apparatus*[6]—The apparatus for the hydrostatic pressure test shall consist essentially of a pressure tube connected to a specimen holder. The inner diameter of the pressure tube shall be 2 in. (51 mm) and the outer diameter 3 in. (76 mm) with a means for introducing water for below the specimen. Connect an extension tube to permit a water head of 2 ft (610 mm) with a cutoff valve or other suitable device at the water inlet to the pressure tube for isolating the sample until the desired head is reached.

A5.3 *Procedure*—Clamp the test specimen face down in the holder, which has been previously filled with water, the face being that surface which is intended to be installed toward the water receptor. Take care to avoid trapped air between the specimen and the water. This is done by filling the holder with water and sliding the specimen onto the holder in direct contact

with the water after having used a piece of transparent material for practice and for becoming familiar with the technique. Fill the tube to achieve a 2-ft (610-mm) head.

A5.4 *Requirement*—Make observations at 10-min intervals for the first hour, and at hourly intervals for the succeeding 7 h, after which leave the specimen under hydrostatic pressure for 40 h and examine again. Any evidence of wetness on top of the material or the formation of a droplet shall cause the material to be rejected.

A6. PRECISION AND BIAS FOR ANNEX TEST METHODS

A6.1 *Precision*—Precision testing has not been possible on any of the annex test methods because there are presently an inadequate number of product producers to permit statistically valid precision studies.

A6.2 *Bias*—No determination of bias is possible in any of the annex test methods since no referee methods are available.

SUMMARY OF CHANGES

Committee D20 has identified the location of selected changes to this standard since the last issue (D4551–96(2008)) that may impact the use of this standard.

(1) Removed D4968 reference in Section 2.

(2) Updated sections 12.1 and 12.2 per D618–08.

Committee D20 has identified the location of selected changes to this standard since the last issue (D4551–96(2001)) that may impact the use of this standard.

(1) Added ISO equivalency note per Guide D4968.
(2) Deleted reference to Practice D1898 and Guide D5033 and added reference to Guide D7209.

(3) Reworded 5.2.