



Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Flexible Concealed Water-Containment Membrane¹

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.

¹NOTE—Editorial changes were made throughout in April 2008.

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](#)

[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](#)

~~[D4968 Guide for Annual Review of Test Methods and Specifications for 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](#)

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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.

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

2.2 *ANSI Standard:*

[Z 26.1 Safety Code for Safety Glazing Materials for Glazing Motor Vehicles Operating on Land Highways](#)³

2.3 *Military Standard:*

[MIL-STD-105 Sampling Procedures and Tables for Inspection by Attributes](#)⁴

3. Terminology

3.1 *Definitions:*

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/cm³.

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](#)).

<https://standards.iteh.ai/catalog/standards/sist/3148dd51-edfe-4d9a-87ec-3d947192e1db/astm-d4551-12>

³ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

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

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 ₂ O	% weight change	+1 %, max	+1 %, max
Soapy H ₂ O	% 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

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

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.

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 $73 \pm 3.6^\circ\text{F}$ ($23 \pm 2^\circ\text{C}$) 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.

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 (%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 $73 \pm 3.6^\circ\text{F}$ ($23 \pm 2^\circ\text{C}$) and $50 \pm 5\%$ – 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 $73 \pm 3.6^\circ\text{F}$ ($23 \pm 2^\circ\text{C}$) 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	...

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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 $251 \pm 3.6^\circ\text{F}$ ($122 \pm 2^\circ\text{C}$) 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-cm² 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 $84.5 \pm 1.8^{\circ}\text{F}$ ($29 \pm 1^{\circ}\text{C}$) 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 ₄ NO ₃	3.0 g
KH ₂ PO ₄	2.5 g
MgSO ₄ ·7H ₂ O	2.0 g
K ₂ HPO 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 $\frac{3}{8}$ 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 $84.5 \pm 1.8^{\circ}\text{F}$ ($29 \pm 1^{\circ}\text{C}$) 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.