



# Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Flexible Concealed Water-Containment Membrane<sup>1</sup>

This standard is issued under the fixed designation D 4551; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

## 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 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.*<sup>2</sup>

## 2. Referenced Documents

### 2.1 ASTM Standards:

D 374 Test Methods for Thickness of Solid Electrical Insulation<sup>3</sup>

- D 412 Test Methods for Rubber Properties in Tension<sup>3</sup>  
D 543 Test Method for Resistance of Plastics to Chemical Reagents<sup>3</sup>  
D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing<sup>3</sup>  
D 883 Terminology Relating to Plastics<sup>3</sup>  
D 1004 Test Method for Initial Tear Resistance of Plastic Film and Sheeting<sup>3</sup>  
D 1203 Test Methods for Volatile Loss from Plastics Using Activated Carbon Methods<sup>3</sup>  
D 1204 Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature<sup>3</sup>  
D 1243 Test Method for Dilute Solution Viscosity of Vinyl Chloride Polymers<sup>3</sup>  
D 1898 Practice for Sampling of Plastics<sup>4</sup>  
D 3892 Practice for Packaging/Packing of Plastics<sup>5</sup>  
D 5033 Guide for the Development of Standards Relating to the Proper Use of Recycled Plastics<sup>5</sup>  
E 96 Test Methods for Water Vapor Transmission of Materials<sup>5</sup>
- 2.2 *ANSI Standard:*  
Z 26.1 Safety Code for Safety Glazing Materials for Glazing Motor Vehicles Operating on Land Highways<sup>6</sup>
- 2.3 *Military Standard:*  
MIL-STD-105 Sampling Procedures and Tables for Inspection by Attributes<sup>7</sup>

## 3. Terminology

### 3.1 Definitions:

3.1.1 *General*—Definitions are in accordance with Terminology D 883 unless otherwise indicated.

3.2 *Descriptions of Terms Specific to This Standard:* Descriptions 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.

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.24 on Plastic Building Products.

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<sup>2</sup> Paragraphs 1.2, 2.1, 5.2, and 18.1 have been revised to accommodate recycle materials.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 08.01.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 08.02.

<sup>5</sup> *Annual Book of ASTM Standards*, Vol 08.03.

<sup>6</sup> Available from the American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.

<sup>7</sup> Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

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 D 1243.
- 5.1.2 A PVC compound density of 1.26/1.29 g/cm<sup>3</sup>.
- 5.2 Recycle materials, as defined in Guide D 5033, 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 Sheetting 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 sheetting’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.

**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

7.1.1 Sheetting width tolerance shall be +0.5, -0.0 in. (+12.7, -0.0 mm).

7.1.2 The length of the sheetting 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 sheetting shall be 0.03 in. (0.765 mm) and minimum thickness of Grade 40 sheetting 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 sheetting 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 sheetting 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.

**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 <sub>2</sub> O	% weight change	+1 %, max	+1 %, max
Soapy H <sub>2</sub> 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

## 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 D 374. 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 D 412, 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 D 543, 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 D 1204.

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 D 1004.

11.10 *Volatile Loss*—Determine volatile loss in accordance with Test Methods D 1203, Method A, at 158°F (70°C) with grade AC (9/14 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 E 96) 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  $50 \pm 5$  % relative humidity for not less than 40 h prior to testing, in accordance with Method A of Methods D 618.

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 D 4551", 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 D 3892 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. Sampling for inspection and testing shall be carried out in accordance with the recommendations of Practice D 1898.**

S2. 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 1½in. (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<sup>3</sup> 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*:<sup>8</sup>

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 <sub>4</sub> NO <sub>3</sub>	3.0 g
KH <sub>2</sub> PO <sub>4</sub>	2.5 g
MgSO <sub>4</sub> ·7H <sub>2</sub> O	2.0 g
K <sub>2</sub> HPO <sub>4</sub>	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).

<sup>8</sup> Available from the American Type Culture Collection, 2209 M St., N.W., Washington, DC.