Designation: F964 – 13

Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Exterior Profiles Used for Fencing and Railing[1]

This standard is issued under the fixed designation F964; 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 establishes requirements for the material properties and physical properties, including dimensional tolerances, extrusion quality, and weatherability, of rigid poly vinyl-chloride (PVC) exterior profiles used for agricultural, commercial, residential fencing and railing. Methods for testing and for identifying exterior profile extrusions that comply with this specification are also provided.

NOTE 1—Information with regard to application, assembly, and installation should be obtained from the manufacturer or in accordance with Practice F1999, or both.

NOTE 2—Loadbearing characteristics for fence and railing assemblies are not addressed within this specification (for example, windload, horizontal or vertical guardrail loading).

1.2 The material used in these exterior profiles is limited to rigid poly (vinyl chloride) (PVC) compounds in a single homogeneous extrusion or in a coextrusion of two or more PVC compounds in distinct layers.

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

1.4 *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]

D618 Practice for Conditioning Plastics for Testing

D635 Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position

D696 Test Method for Coefficient of Linear Thermal Expansion of Plastics Between −30°C and 30°C with a Vitreous Silica Dilatometer

D883 Terminology Relating to Plastics

D1435 Practice for Outdoor Weathering of Plastics

D1600 Terminology for Abbreviated Terms Relating to Plastics

D1898 Practice for Sampling of Plastics (Withdrawn 1998)[3]

D2565 Practice for Xenon-Arc Exposure of Plastics Intended for Outdoor Applications

D4216 Specification for Rigid Poly(Vinyl Chloride) (PVC) and Related PVC and Chlorinated Poly(Vinyl Chloride) (CPVC) Building Products Compounds

D4226 Test Methods for Impact Resistance of Rigid Poly-(Vinyl Chloride) (PVC) Building Products

D4726 Specification for Rigid Poly(Vinyl Chloride) (PVC) Exterior-Profile Extrusions Used for Assembled Windows and Doors

F1999 Practice for Installation of Rigid Poly(Vinyl Chloride) (PVC) Fence Systems

G154 Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials

3. Terminology

3.1 *General*—Definitions are in accordance with Terminologies D883 and D1600, unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *capstock*—the outer layer in a coextrusion exposed to weathering.

3.2.2 *coextrusion*—the process of coextruding profiles from two or more concentric streams of PVC compounds.

NOTE 3—Separate PVC materials may be coextruded to form a multi-layered profile with each layer having different physical characteristics such as strength and weathering.

3.2.3 *color-hold guidelines*—predictive target color regions within a three-dimensional model which constitute acceptable appearance retention levels of color change resulting from weathering of specific product type and color.

[1] This specification is under the jurisdiction of ASTM Committee F14 on Fences and is the direct responsibility of Subcommittee F14.30 on Rigid Polymer Fence Systems.

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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.

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

NOTE 4—Commercial products which demonstrate weathering behavior within reasonable conformance to these target guidelines during a 2–year test period can be anticipated to weather without exhibiting unacceptable color changes during the service life of the product.

3.2.4 *longitudinal bow*—refers to bow along the span. Longitude is measured along the span.

3.2.5 *reworked material*—material from the manufacturer's facility of known, compatible composition meeting the material requirement of this specification that has been reground, pelletized, or solvated after having been previously processed by molding, extrusion, and so forth.

3.2.6 *single layer profile*—profiles extruded from a single PVC compound. Weathering and other physical characteristics are uniform throughout the profile.

3.2.7 *substrate*—inner layer(s) of a coextrusion not exposed to weathering.

3.2.8 *temperate northern climate*—in weather testing, a North American metropolitan area testing site located within 73 to 100° W longitude and 37 to 45° N latitude.

4. Significance and Use

4.1 The purpose of this specification is to establish a recognized standard of quality for rigid poly vinyl chloride (PVC) exterior profiles for use in assembling agricultural, commercial, and residential fencing and railing. The term "PVC fence" refers to complete fencing and railings systems in which the primary structural members such as posts, rails, spindles, pickets, and gates are made from PVC exterior profiles. Accessory components (not included in this specification), including bolts, screws, hinges, latches, caps, and brackets, may be made from PVC or non-PVC materials, or both. The information contained in this specification is intended to be helpful to producers, distributors, and users and to promote understanding between purchasers and sellers.

5. Materials and Manufacture

5.1 The rigid poly vinyl chloride (PVC) compound for exterior-profile extrusions meeting the requirements of this specification are categorized by the cell class requirements in accordance with Specification D4216.

5.2 The PVC compounds used for the products meeting this specification shall meet a minimum cell class of 1-20233-23 for PVC profiles and 3-20233-23 for PVC substrate with alernate capstock materials as defined in Specification D4216. Compounds that have higher cell classification because one or more properties are superior to those in the specified compound are acceptable.

5.3 *Color*—The color of the profiles shall be as agreed upon between the purchaser and the seller. The color specified shall be uniform throughout a single material extrusion or throughout the capstock layer of a coextruded profile for profiles intended to be of uniform color.

5.4 The extruded profiles shall be free from visible cracks, voids, or foreign inclusions.

5.5 The PVC compound, when tested in accordance with Test Method D635, shall not exceed an average extent of burn of 4 in. (100 mm), with an average time of burn not to exceed 10 s. A sample thickness of 0.090 ± 0.009 in. (2.3 ± 0.2 mm) shall be used.

NOTE 5—The flammability testing data, conclusions, and recommendations of Test Method D635 relate solely to the measurement and description of the properties of materials, products, or systems in response to heat and flame under controlled laboratory conditions and should not be used for the description or appraisal of the fire hazard of materials, products, or systems under actual fire conditions.

NOTE 6—No recycled (post consumer waste) may be used in the production of fence profiles.

5.6 *Reworked Material*—Clean reworked material may be used, provided that the fence profiles produced in whole or in part from the reworked materials meet all of the requirements of this specification.

5.7 The PVC compound in extruded section shall maintain uniform color and be free of any visual surface or structural changes, such as peeling, chipping, cracking, flaking, or pitting after weathering for six months and one year for white and for six months, one year, and two years for all other colors in hot, dry climate such as Phoenix, AZ; a hot humid climate, such as Miami, FL; and a temperate northern climate, when tested in accordance with 7.1.1 – 7.1.4.

5.8 The PVC compound shall have a minimum impact resistance of 0.6 in.-lb/mil (2670 J/m) after weathering six months and one year in a hot, dry climate such as Phoenix, AZ; a hot, humid climate, such as Miami, FL; and a temperate northern climate, when tested in accordance with 7.1.1 – 7.1.4.

5.9 The PVC compound shall have successfully met the weathering requirements prescribed in 5.7 and 5.8 for six months at each climatic testing site prior to use in production of exterior-profile extrusions, when tested in accordance with 7.1.1 – 7.1.4.

NOTE 7—The six-month test requirement constitutes a screening process to eliminate catastrophic failure.

6. Physical Requirements

6.1 *Length, Height, and Width*—The specified length, height, and width of the fencing profiles shall be as agreed upon between the purchaser and the seller, or by established internal process control standards. The actual length shall be within ±¼ in. (6.4 mm) of the specified length and the actual height and width shall be within 1/16 in. (1.6 mm) of the specified height and width when measured in accordance with 8.4 and 8.5.

6.2 *Weight Tolerance*—Profile extrusion weight shall not be more than 10 % below the specified profile weight indicated in the manufacturer's specifications.

6.3 *Impact Resistance*—All profiles are to be tested in accordance with Test Method D4226, Procedure "B," using impactor C.125. Flat sections of the profile extrusion shall have a minimum impact failure of 1.5 in. lb/mil (6675 J/m).

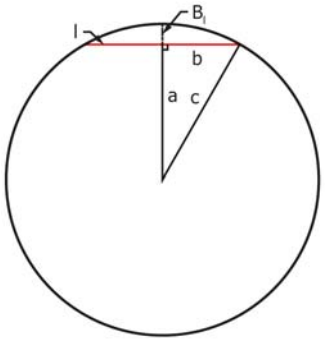
6.4 *Longitudinal Bow*—The maximum longitudinal bow allowable shall be calculated using the following formula:

$$B = 4608.125 - \sqrt{(4608.125^2 - (0.5\,l)^2)}$$

where

B = longitudinal bow
r = radius of bow circle
l = length of extruded profile

NOTE 8—The Longitudinal Bow formula was derived from the Pythagorean Theorem using a right triangle inscribed within a circle with the radius equivilant to the arc formed by a 96 in. line with a 0.25 in. bow at the center of the line. See Fig. 1 for more detail.



Pythagorean Theorem — $a^2 + b^2 = c^2$

The length of "a" is calculated using Pythagorean Theorem

$$a^2 + b^2 = c^2$$
$$a^2 = c^2 - b^2$$
$$a = c - \sqrt{(c - b)}$$

The Longitudinal Bow is calculated by the diagram above by:

$$B_l = c - \sqrt{(c^2 - b^2)}$$

or simplified to convential terms where
B_l = longitudinal bow
r = radius of bow circle ("c")
l = length of extruded profile ("a")

$$B_l = r - \sqrt{(r^2 - (0.5\ l)^2)}$$

or simplified further where:
r = 4608.125 in.

$$B_l = 4608.125 - \sqrt{(4608.125^2 - (0.5\ l)^2)}$$

FIG. 1 Diagram for Calculation of Longitudinal Bow

TABLE 1 Allowable Bow for Common Length Extrusions as Measured per 8.7

Profile Length	Allowable Bow per Piece
72 in.	0.141 in.
96 in.	0.250 in.
144 in.	0.563 in.
192 in.	1.000 in.
240 in.	1.563 in.

6.5 *Dimensional Stability*—The dimensional stability of the profile extrusions shall be determined in accordance with 8.9. Extrusions shall have a maximum average shrinkage of 2.4 % for all sides measured, with no single value exceeding 3 %.

NOTE 9—Expansion and contraction of the fence profile lengths must be taken in consideration in the design of the fencing system.

6.6 *Coefficient of Linear Expansion*—The fencing profiles shall have a coefficient of linear expansion not greater than 4.4 × 10^{-5} in./in. · °F (7.9 × 10^{-5} mm/mm · °C) when tested in accordance with Test Method D696.

NOTE 10—Expansion and contraction of the fence profile lengths must be taken in consideration in the design of the fencing system.

6.7 *Thickness of PVC Capstock*—PVC extruded profiles produced by coextrusion, which contain two or more layers, shall have an outer layer (capstock) that is no less than 0.010 in. (0.25 mm) thick at any point on all surfaces exposed to UV rays upon completed installation.

6.8 *Bond*—For PVC profiles produced by coextrusion, the bond between the layers shall be strong and uniform. It shall not be possible to separate any two layers with a probe or point of a knife blade so that the layers separate at any point.

7. Performance Requirements

7.1 *Weathering*

7.1.1 The exposures listed in Table 2 shall be conducted in order to meet the requirements of this specification. All exposures shall be conducted at an angle of 45 degrees South, plywood backed, in accordance with Practice D1435.

7.1.2 After six months and one year exposure times, the minimum mean impact for 20 measurements conducted on the exposed specimens shall be at least 0.6 in. lb/mil (2670 J/m) in accordance with 8.9.

7.1.3 After each exposure time, the tested specimens shall maintain a uniform color and be free of any visual surface or structural changes such as peeling, chipping, cracking, flaking, and pitting when tested in accordance with Practice D1435.

7.1.4 Weatherability conformance testing requirements are to reflect performance of a "typical" extrusion system profile representing a specific PVC compound and a specific extrusion technology. In no case is there an implied requirement for testing all the various shaped profiles. The profile extrusion producer shall immediately respond in terms of compound change or extrusion technology change to unsatisfactory weatherability behavior of the profiles under test in any climatic test site at any stage of the weatherability testing.

NOTE 11—It is recommended that manufacturers utilize the color-hold guidelines in Appendix X1 of Specification D4726 to ensure quality performance.

8. Test Methods

8.1 *General*—The inspection and test procedures contained in this section are used to determine the conformance of products to the requirements of this specification. Each producer who represents his products as conforming to this specification may utilize statistically based sampling plans that are appropriate for each manufacturing process. The producer shall keep the essential records necessary to document with a

TABLE 2 Required Exposures for PVC Extrusions

Color of PVC Extrusions	Exposure Climate	Required Exposure Times, months[A]
White	hot, dry (Phoenix, AZ)	6 and 12
	hot, humid (Miami, FL)	6 and 12
	northern temperate	6 and 12
Any other color	hot, dry (Phoenix, AZ)	6, 12 and 24
	hot, humid (Miami, FL)	6, 12 and 24
	northern temperate	6, 12 and 24

[A] It is recommended that separate specimens be used for each exposure time.

high degree of assurance his claim that all the requirements of this specification have been met. Additional sampling and testing of the products, as may be agreed upon between the purchaser and the seller at the time of the execution of the sales agreement, are not precluded by this section.

8.2 *Conditioning and Test Conditions:*

8.2.1 Specimens to be tested at 73.4° ± 3.6°F (23° ± 2°C) shall be conditioned in accordance with Practice D618 for no less than one hour. Specimens to be tested at 32° ± 3.6°F (0° ± 2°C) shall be continued in accordance with Practice D618 for no less than one hour.

8.3 *Sampling*—The selection of sample or samples of fence profiles shall be as agreed upon between the purchaser and the seller. In the absence of any prior agreement, the selection of sample or samples of fence shall be in accordance with the pertinent considerations outlined in Practice D1898.

8.3.1 *Sample Marking*—Samples being tested at a test laboratory, not at the manufacturer's location, shall be marked with a verifiable and permanent marking that shall identify the manufacturer.

8.3.2 The number of specimens or the size of the specimen must be sufficient to obtain 20 impact locations of the dropped dart for each weathering interval.

8.3.3 The thickness of any profile tested must not differ from the manufacturer's published specification of the same profile.

8.4 *Length*—With the sample lying on a flat surface, measure the length to the nearest 1⁄16 in. (1.5 mm) with a steel tape. The average of three samples shall be within ±1⁄4 in. (6.3 mm) of the published length with no single sample deviating more than 3⁄8 in. (9.5 mm) from the nominal length.

8.5 *Height and Width*—Lay three samples on a flat surface and measure each to the nearest 1⁄16 in. (1.5 mm) with a steel tape or vernier calipers. The average of the three samples shall be within ±1⁄16 in. (1.5 mm) of the nominal height and width with no single sample deviating more than 3⁄32 in. (2.4 mm) from the nominal height and width.

8.6 *Impact Resistance*—Condition ten specimens, not less than 6 in. long (152 ± 1.5 mm), at either 73.4° ± 3.6°F (23° ± 2°C) or 32° ± 3.6°F (0° ± 2°C) and test with the apparatus described in Test Method D4226, Procedure "B" impactor C.125. The ten specimens should be taken from as many sides of the profile as possible. Seven of ten specimens must pass at whichever test conditioning temperature is used. Specimens shall be temperature conditioned in accordance with 8.2. Any visible cracking, shattering, or breaking shall constitute a failure.

8.6.1 *Retest*—Should more than three specimens fail the initial impact test, select and condition ten more samples and test in accordance with 8.6. If 14 or more samples pass from the combined two samplings, the last shall pass. If seven or more specimens fail, sampling and testing should be conducted backward through the production run until it can be established that the balance of the production run will pass impact testing.

8.7 *Longitudinal Bow*—Longitudinal bow shall be determined when all sides of the specimen are at the same temperature. Place a full-length specimen on a flat surface alongside a straightedge that is at least as long as the specimen. Measure any space between the specimen and the straightedge to the nearest 1⁄32 in. (0.79 mm).

NOTE 12—Testing in accordance with Section 8 is intended to be done as quality control testing at the time of manufacture to ensure conformance with this specification. Testing performed on profiles after prolonged storage, shipment, or installation may produce results at variance with the values determined at the time of manufacture.

8.8 *Dimensional Stability*—Determine the dimensional stability in accordance with Test Method D1042, except that the test cycle shall consist of heating the specimens for 30 min in a uniformly heated water bath at a temperature of 180° ± 1.8°F (82° ± 1.0°C), then conditioning the specimens for no less than 1 h in accordance with Procedure A of Practice D618, followed by measurement.

8.9 *Impact Test on Weathered Specimens*—Determine the impact strength in accordance with Test Method D4226, Procedure B, using the C.125 impactor.

9. Retest and Rejection

9.1 If the results of any test(s) do not meet the requirements of this specification, the test(s) may be conducted again in accordance with an agreement between the purchaser and the seller. There shall be no agreement to lower the minimum requirement of the specification by such means as omitting tests that are a part of the specification, substituting or modifying a test method, or by changing the specification limits. In retesting, the product requirements of this specification shall be met, and the test methods designated in this specification shall be followed. If, upon retest, failure occurs, the quantity of product represented by the test(s) shall be rejected.

10. Accessories Tests

10.1 Test methods and values for all PVC profile accessories, such as caps, plugs, and rail mounting devices, may or may not be available for the manufacturer and are subject to agreement between the purchaser and the seller.

11. Marking of Fence Profiles

11.1 Permanent marking of the extruded profiles and accessories are at the option of the manufacturer or subject to agreement between the purchaser and the manufacturer.

11.1.1 Marking, if used, may be in the form of ink printing, decals, or embossing and may be applied internally or externally to the fence profiles. If applied to the external surface of the profile, the marking shall not mar or detract from the appearance of the fence profile.

11.1.2 Injection-molded or fabricated parts may include the manufacturer's name or symbol.

11.1.3 Marking, if used, should include the manufacturer's name and location, code or date of manufacture, and ASTM F964.

12. Marking of Literature and Packaging

12.1 In order that the purchaser may identify PVC fencing profiles that conform to all requirements of this specification,

producers and distributors shall include a statement of compliance in conjunction with their name and address on product labels, invoices, sales literature, and the like. The following statement is suggested (not mandatory) when sufficient space is available: "These fencing profiles conform to all of the requirements established in ASTM F964, developed cooperatively with the industry and published by the American Society for Testing and Materials. Full responsibility for the conformance of this product to the specifications assumed by (name and address of producer or distributor)."

12.2 The following abbreviated statement is suggested when available space on labels or other printed matter is insufficient for the full statement: "Conforms to ASTM. (name and address of producer or distributor)."

12.3 The PVC acronym should be specified for recyclable information.

13. Keywords

13.1 capstock; coextrusion; exterior-profile; fencing profiles; poly vinyl chloride; PVC fence

APPENDIXES

(Nonmandatory Information)

X1. ACCELERATED WEATHERABILITY

X1.1 Laboratory-accelerated weathering methods are available but cannot be equated successfully with outdoor weathering. These tests are valuable aids for process control evaluations and compound development studies but should never be used for qualification testing purposes.

X1.2 Laboratory-accelerated ultraviolet testing may be done in commercial equipment provided with ultraviolet light and humidity controls for process control or development studies. It should always be conducted in conjunction with outdoor weathering studies since no correlation between the two practices has been established.

X1.3 When conducting laboratory-accelerated ultraviolet testing using Xenon Arc, use Practice D2565 for 2000 hours cycling between the following conditions:

8 hours light only	
Irradiance:	0.72 ± 0.2 W/(m^2·nm) at 340 nm
Uninsulated Black Panel Temperature	158 ± 5°F (70 ± 2.8°C)
4 hours no light with condensation	
Irradiance:	Not applicable
Uninsulated Black Panel Temperature	Not applicable

X1.4 When conducting laboratory-accelerated ultraviolet testing using QUV, use G154 for 2000 hours using UVA-340 bulbs and cycling between the following conditions:

8 hours UV exposure at 60°C
4 hour condensation at 50°C

X1.5 Weathering samples should change color only slightly and uniformly. White PVC will tend to yellow, but should not streak or turn brown under exposure in the natural weathering tests.

X2. SUGGESTED MANUFACTURER'S QUALITY ASSURANCE PROGRAM

X2.1 Each manufacturer should establish a formal and written procedure for an ongoing quality assurance program. Records of quality assurance tests should be retained for a minimum of two to five years for the benefit of both the customer and the manufacturer.

X2.2 *In-plant Test Frequencies*—Certain tests described in this specification should be done on a qualification basis while others should be performed on a daily basis:

X2.2.1 Cell classification tests should be performed at the initiation of production of extruded profiles, when any changes are made in the formulations of the PVC materials, when compounding equipment is replaced or modified, or at least once annually for each material or coextruded materials.

X2.2.2 Coefficient of expansion tests should be performed at the initiation of production of profiles, at the initiation of a new compound, or when significant changes in filler levels are made in a compound.

X2.2.3 Dimensional tests should be made at the startup of a production run and every 2 h thereafter.

X2.2.4 Flattening, extrusion quality, impact resistance, warp, color comparison with standard color samples, capstock thickness, and bond testing should be done at the startup of a

production and once per shift thereafter with a minimum of two tests per 24 h of production.

X2.2.5 Artificial weathering tests should be performed for any new compound or when formulation changes are made in existing compounds. Production from a new or modified compound should be withheld until the samples have successfully passed 30 days of artificial weathering in accordance with X1.3.