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An American National Standard

Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Exterior-Profile Extrusions Used for Assembled Windows and Doors[1]

This standard is issued under the fixed designation D 4726; 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, including dimensional stability, weatherability, and extrusion quality, of rigid poly(vinyl chloride) (PVC) exterior profile extrusions used for assembled windows and doors. Methods for testing and for identifying exterior profile extrusions that comply with this specification are also provided.

1.2 Rigid PVC recycled plastic may be used in this product in accordance with requirements in Section 5.

NOTE 1—Information with regard to application, assembly, and installation should be obtained from the manufacturers of the profiles and of the windows and doors.

NOTE 2—Refer to Specification D 3678 for interior profile extrusions.

1.3 Color-hold guidelines are provided in an appendix for the manufacturer's product development and quality performance use.

1.4 Color-hold guidelines are presently limited to white, grey, beige, light brown, and dark brown (see Figs. X1.1 through X1.5). Additional colors will be added as color guidelines are developed.

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

NOTE 3—There are no ISO standards covering the primary subject matter of this specification.

1.6 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of this standard.

1.7 The following safety hazards caveat pertains only to the test methods portion, Section 10, 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:*

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing[2]

D 883 Terminology Relating to Plastics[2]

D 1042 Test Method for Linear Dimensional Changes of Plastics Under Accelerated Service Conditions[2]

D 1435 Practice for Outdoor Weathering of Plastics[2]

D 1600 Terminology Relating to Abbreviations, Acronyms, and Codes for Terms Relating to Plastics[2]

D 1898 Practice for Sampling of Plastics[3]

D 2244 Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates[4]

D 3678 Specification for Rigid Poly(Vinyl Chloride) (PVC) Interior-Profile Extrusions[5]

D 3892 Practice for Packaging/Packing of Plastics[6]

D 4099 Specification for Poly(Vinyl Chloride) (PVC) Prime Windows[5]

D 4216 Specification for Rigid Poly(Vinyl Chloride) (PVC) and Related Plastic Building Products Compounds[5]

D 4226 Test Method for Impact Resistance of Rigid Poly-(Vinyl Chloride) (PVC) Building Products[5]

D 5033 Guide for the Development of Standards Relating to the Proper Use of Recycled Plastics[6]

E 631 Terminology of Building Constructions[7]

E 805 Practice for Identification of Instrumental Methods of Color or Color-Difference, Measurement of Materials[8]

[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.

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[2] *Annual Book of ASTM Standards*, Vol 08.01.

[3] *Annual Book of ASTM Standards*, Vol 08.02.

[4] *Annual Book of ASTM Standards*, Vol 06.01.

[5] *Annual Book of ASTM Standards*, Vol 08.04.

[6] *Annual Book of ASTM Standards*, Vol 08.03.

[7] *Annual Book of ASTM Standards*, Vol 04.07.

[8] *Annual Book of ASTM Standards*, Vol 14.02.

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

G 147 Practice for Conditioning and Handling of Nonmetallic Materials for Natural and Artificial Weathering Tests[8]

3. Terminology

3.1 *General*—Definitions are in accordance with Terminologies D 883 or E 631 and D 1600, unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *beige PVC profile*—a profile the color of which is defined by the color space falling within the parameters L_H = 61 to 87, a_H = −2.5 to 4.0, and b_H = 6.5 to 23.

3.2.2 *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 a specific product type and color.

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.

3.2.3 *dark brown PVC profile*—a profile the color of which is defined by the color space falling within the parameters L_H = 13 to 33, a_H = −1.0 to 6.0, and b_H = 1.0 to 6.5.

3.2.4 *gray PVC profile*—a profile the color of which is defined by the color space falling within the parameters L_H = 33 to 74, a_H = −3 to 4, and b_H = −5.5 to 5.5.

3.2.5 *light brown PVC profile*—a profile the color of which is defined by the color space falling within the parameters L_H = 30 to 60, a_H = −1.5 to 12.5, and b_H = 3.0 to 12.5.

3.2.6 *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.

3.2.7 *white PVC profile*—a profile the color of which is defined by the color space falling within the parameters L_H= 83 to 100, a_H= −4 to 0, and b_H= −5.5 to +5.5.

NOTE 5—L_H, a_H, b_H is determined in accordance with the Hunter L_H, a_H, b_H opponent color space system in Test Method D 2244.

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 weatherable profile extrusions for use in assembling windows and doors. The information contained in this specification is intended to be helpful to producers, distributors, and users, and to promote understanding between buyers and sellers. It is also intended to serve as the basis for specification requirements of exterior windows and doors which are made from rigid PVC profile extrusions in their construction.

NOTE 6—Refer to Specification D 4099 for PVC prime window specification.

5. Materials and Manufacture

5.1 The profile extrusions used for assembled windows and doors shall be made principally of weatherable, rigid poly(vinyl chloride) (PVC) compound classified in accordance with the properties described in Specification D 4216. Extrusions shall meet one of the following cell classifications: Class 1-10154-33, Class 1-20131-13, or Class 1-40131-13. (See the Table on Class Requirements for Rigid Poly(Vinyl Chloride) (PVC) and Related Plastic Compounds for Building Products in Specification D 4216.)

NOTE 7—Non-PVC materials may be used as a capstock.

5.2 Rigid PVC recycled plastic, as defined in Guide D 5033, may be used in this product if all the requirements in the sections on Terminology (Section 3), Materials and Manufacture (Section 5), Physical Requirements (Section 6) and Performance Requirements (Section 7) are met by the extrusions containing PVC recycled plastic.

5.3 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.

5.4 *Rework Material*—Clean, homogeneous PVC rework material or rework material containing PVC capstock generated from the manufacturer's own production of the same class compound may be used by the same manufacturer providing that the extruded profiles meet all the requirements of this specification. Clean principally PVC rework material containing non-PVC capstock may be used only in the substrate of a capstocked product by the same manufacturer, providing that the extruded profiles meet all of the requirements of this specification.

5.5 The PVC compound shall have a minimum impact resistance of 0.6 in·lb/mil (2670 J/m) after weathering for 6 months and 1 year in a hot, dry climate such as Phoenix, AZ; a hot, humid climate, such as Miami, FL; and a temperate northern climate.

5.6 The PVC compound in extruded section shall maintain uniform color and be free of any surface or structural changes, such as peeling, chipping, cracking, flaking, or pitting after weathering for 6 months and 1 year for white and for 6 months, 1 year, and 2 years for all other colors in a hot, dry climate, such as Phoenix, AZ; a hot, humid climate, such as Miami, FL; and a temperate northern climate.

5.7 The PVC compound shall have successfully met the weathering requirements prescribed in 5.4 and 5.5 for 6 months at each climatic testing site prior to use in production of exterior-profile extrusions for either market development or sales.

NOTE 8—The 6-month-test requirement constitutes a screening process to eliminate catastrophic failure in the marketplace.

6. Physical Requirements

6.1 *Dimensions*—The size, thickness, and dimensional tolerances of the exterior profiles shall be as agreed upon between the supplier and the purchaser in the purchase order, or by established internal process control standards.

6.2 *Dimensional Stability*—The dimensional stability of the exterior-profile extrusions shall be determined in accordance with 10.3. Extrusions over 0.040 in. (1.02 mm) shall have a maximum average shrinkage of 2.2 % for all sides measured, with no single value exceeding 2.4 %. Extrusions of 0.040 in. (1.02 mm) or less shall have a maximum average shrinkage of 3 %.

6.3 *Impact Resistance*—Flat sections of the exterior profile extrusion shall have a minimum brittle impact failure of 1.0

in·lb/mil (4450 J/m) when tested in accordance with Test Methods D 4226, Procedure B, using impactor C.125. Refer to 10.4.

7. Performance Requirements

7.1 *Weathering*:

7.1.1 The exposures listed in Table 1 shall be conducted in order to meet the requirements of this specification. All exposures shall be conducted at an angle of 45° S, plywood-backed, in accordance with Practice D 1435 and Practice G 147.

7.1.2 After 6-months and 1-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). Test impact in accordance with 10.4, A1.4, and A1.5.

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 Annex A1.

NOTE 9—It is recommended that manufacturers use the color-hold guidelines in Appendix X1 to ensure quality performance.

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 lengthy outdoor weatherability testing shall be performed concurrently with market development of new applications and sales of profiles to existing markets. Completion of weatherability testing prior to marketing of the product is not required. 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.

8. Workmanship, Finish, and Appearance

8.1 The extrusions shall be acceptable between the buyer and the seller or meet internal process control standards in section, color, and finish. The extrusions shall be substantially straight and free from defects that might affect appearance or serviceability.

9. Sampling

9.1 Select samples in accordance with Practice D 1898. The samples shall be representative of the compound used.

TABLE 1 Required Exposures for PVC Extrusions

Color of PVC Extrusion	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.

10. Test Methods

10.1 *General*—Use the inspection and test procedures contained in this section to determine the conformance of products to the requirements of this specification. Each producer or distributor who represents his products as conforming to this specification may use statistically based sampling plans that are appropriate to each manufacturing process, but shall keep such essential records as are necessary to document with a high degree of assurance his claim that all of the requirements of this specification have been met. Additional sampling and testing of the product, as may be agreed upon between the supplier and the purchaser, is not precluded by this section.

10.2 *Conditioning of Specimens*—Condition the test specimens in accordance with Procedure A of Practice D 618. For the purpose of quality control testing, the minimum conditioning time shall be 4 h.

10.3 *Dimensional Stability*:

10.3.1 Determine the dimensional stability in accordance with Test Method D 1042, except that one or more specimens shall be exposed to either of the following test cycles:

10.3.1.1 30 min immersed in water maintained at 180 ± 1.8° (82 ± 1.0°C), or

10.3.1.2 30 min conditioned in an oven at 180 ± 1.8°F (82 ± 1.0°C).

10.3.2 Specimens shall condition for no less than 1 h in accordance with Procedure A of Practice D 618, prior to measurement. Should a specimen fail, elect and retest two additional specimens.

10.4 *Impact Test*—Determine the impact strength in accordance with Test Methods D 4226, Procedure B, using the C.125 impactor.

11. Packing, Packaging, and Package Marking

11.1 The exterior profile extrusions shall be packaged in such a manner as to provide reasonable protection against damage in ordinary handling, transportation, and storage.

11.2 Provisions of Practice D 3892 shall apply to this specification.

11.3 Marking on each package of extruded profile extrusions shall include the following:

11.3.1 Manufacturer's name or trademark;

11.3.2 Identity of code number of extrusion profiles;

11.3.3 Class of compound (Specification D 4216) used in profiles;

11.3.4 The designation ASTM D 4726, affirming that the product so marked has been qualified to all the provisions of this specification, and

11.3.5 The date and any other relevant information, such as factory, machine, production shift, and so forth, either directly or all or partly coded.

12. Keywords

12.1 color-hold guidelines; doors; exterior-profile extrusions; poly(vinyl chloride) (PVC); recycled plastic; windows

ANNEXES

(Mandatory Information)

A1. WEATHERABILITY PROCEDURE

A1.1 Summary of Procedure of Measuring Weatherability

A1.1.1 Flat section specimens cut from finished product lineals or laboratory extruded samples are exposed in accordance with Practice D 1435 and Practice G 147 at 45° S, plywood-backed, in a hot, dry (desert) climate, such as Phoenix, AZ; a hot, humid climate such as Miami, FL; and in a northern temperate climate for periods of 6 and 12 months.

A1.1.2 Color change as a result of weather exposure at each climatic exposure site is measured after 6 months and 1 year for whites and after 6 months, 1 year, and 2 years for colors.

A1.1.3 Degree of retention of the original impact strength due to weather exposure in each exposure site is measured after 6-months and 1-year exposure.

A1.1.4 The acceptability of the color change, color uniformity, and surface or structural changes resulting from weathering at each test site and each exposure frequency is determined by visual observation in comparison to the unweathered specimens.

A1.2 Significance

A1.2.1 The processing of poly(vinyl chloride) (PVC) compounds has greater influence on impact retention and some influence on color retention. For this reason samples prepared for weathering must be processed in a manner similar to the commercial product while still permitting the use of laboratory scale equipment. Color hold guidelines are represented by ellipsoids or as an alternative, mathematical equations, both of which allow determination whether the product meets the performance criteria. In addition, the ellipsoids allow determination of the direction of color change and, therefore, may be useful in analyzing the weathering data.

A1.2.2 Poly(vinyl chloride) compounds undergo complex changes when exposed to the weather. Color changes can be due to chemical changes in the PVC or the pigments or by selective erosion of some pigments faster than others, and so forth. Changes in impact strength may be due to chemical changes in the PVC or additives, or due to physical changes on the surface as a result of erosion and crazing.

A1.2.3 When PVC compounds are brought indoors from weather exposure, the chemical nature of the surface continues to change causing an increase in yellowing. The color shall be measured as soon as possible after the samples are removed from weather exposure, but never longer than 7 days.

A1.3 Sampling and Specimen Preparation

A1.3.1 Select samples in accordance with Practice D 1898. The samples shall be representative of the product to be qualified.

A1.3.2 If commercial parts are used, they should be cut into sections so that flat test specimens at least 1.5 in. (38 mm) wide can be obtained. The specimens shall be free of obvious imperfections, grooves, ribs, and so forth. Material prepared in the laboratory by a similar process may be used as an alternate to a commercial part. If the commercial product is extruded, the laboratory specimen must be extruded; if the commercial product is a laminate of two materials, the laboratory specimen must be laminated with the two materials, and so forth.

A1.3.3 The number of specimens or the size of the specimen must be sufficient to obtain at least 20 impact locations of the dropped dart for each weathering interval.

A1.3.4 The thickness of any test specimen must differ from the average test specimen by no more than 10 %.

A1.4 Conditioning

A1.4.1 Condition the test specimens, including specimens removed from the weather exposure, at 73.4 ± 3.6°F (23 ± 2°C) and 50 ± 5 % relative humidity for not less than 24 h before testing. In no case shall weathered specimens be oven-dried before testing.

A1.5 Practice

A1.5.1 Obtain test specimens in accordance with Test A1.3.

A1.5.2 Measure the original tristimulus X, Y, and Z values in replicate for each specimen using 2° observer and Illuminant C, specular components included, in accordance with Practice E 805. Calculate the Hunter L_H, a_H, b_H units in accordance with the equations in the Section on Hunter L_H, a_H, b_H Color Space and Color-Difference Equation in Test Method D 2244. Average the calculated units from the replicate measurements and record them in a permanent record.

A1.5.3 Measure the impact resistance on an unweathered specimen in accordance with Test Methods D 4226, Procedure B, with a C.125 impactor and record permanently.

A1.5.4 Mark the specimens permanently so as to not lose their identity during weathering. Weather specimens at 45°S, plywood-backed, in accordance with Practice D 1435 in both a dry, hot (desert) climate such as Phoenix, AZ; a hot, humid climate such as Miami, FL; and a temperate northern climate. Remove specimens for testing after 6-months and 1-year exposure for white specimens and after 6-months, 1-, and 2-years exposure for colored specimens. Further testing is optional. More frequent exposure increments may be preferred to some applications.

A1.5.5 Shipping specimens from the exposure site to the testing laboratory should be as fast as practical.

A1.5.6 Wash the exposed specimens in accordance with the procedure in Annex A2.

A1.5.7 Condition in accordance with A1.4.

A1.5.8 Within 7 days after removal from exposure, measure color on the exposed specimen(s) in accordance with Test A1.5.2. Record color in L_H, a_H, b_H units and record the average change in color as compared to the unweathered specimen in L_H, a_H, b_H units.

A1.5.9 Note and record any nonuniform change in color.

A1.5.10 Measure average impact resistance of the weathered specimens, weathered side up, using the same method used for the unweathered specimen (A1.5.3).

A2. WASHING WEATHERING SPECIMENS

A2.1 Scope

A2.1.1 This procedure provides a consistent and reproducible practice for washing weathering specimens prior to instrumental color measurement. The procedure is designed to minimize any effects of altering the surface of the specimen in other than a predictable manner.

A2.2 Equipment

A2.2.1 *Mild Detergent*, such as Joy, Liquid Tide, or equivalent.

A2.2.2 *Sponge or Soft Cloth*.

A2.3 Procedure

A2.3.1 Flush the exposed specimen with distilled or deionized water.

A2.3.2 Wash the specimen lightly with mild detergent using a sponge or soft cloth.

A2.3.2.1 The scrubbing action shall not be excessive and shall be limited to back and forth scrubbing along the grain or pattern, if one exists.

A2.3.2.2 Avoid circular scrubbing.

A2.3.3 Evaluate specimen visually to determine if the specimen is "soil free."

A2.3.4 If not "soil free," lightly wipe the specimen once over the surface with a "sopping wet" sponge in the direction of the grain or pattern, if one exists.

A2.3.5 Reflush the specimen with distilled or deionized water and dry in a vertical position, placed so that water will run off with the grain or pattern, if one exists.

APPENDIX

(Nonmandatory Information)

X1. COLOR-HOLD GUIDELINES WEATHERING TEST

X1.1 Scope

X1.1.1 Color-hold guideline weatherability testing provides a predictive method for estimating the acceptability of color change in a window and door profile product over a period of years of service.

X1.1.2 It has been shown that commercial window and door profile products which demonstrate weathering behavior within reasonable conformance to these target guidelines during a two-year test program can be anticipated to weather for extended periods of many years without exhibiting unacceptable color changes.

X1.1.3 These predictive tests are designed for the window and door manufacturer's product development and quality performance use only and are not for regulatory use.

X1.2 Significance and Use

X1.2.1 Color-hold guidelines provide boundary target color regions within a three-dimensional model, which constitutes acceptable appearance retention levels of color change resulting from weathering of a specific window or door profile product type, formulation, and color.

X1.2.2 Each color region is defined by the manufacturers of vinyl window and door profiles as specific color-hold guidelines (see Note X1.1). Regardless of where a specific color falls within the region, it becomes the control on each of the three graphs plotting color difference of each manufacturer's formulation and color.

NOTE X1.1—Five color regions are presently defined as specific color-hold guidelines.

X1.2.3 Color-hold guidelines are unique and specific to a product application, such as window and door profiles and may not be transposable for use on other product applications.

NOTE X1.2—In any product application, color-hold guidelines are related to a perceived acceptable level of color change. Therefore, window and door color-hold guidelines may be acceptable for transposition for building railings or fence profile applications, but not for siding applications.

X1.3 Establishing Window and Door Color Regions

X1.3.1 The window and door manufacturer's color panel uses the following steps to establish the window and door color regions.

Step 1—All commercial unweathered window and door profile colors are divided into rational similar color regions representing a visibly definable hue (white, beige, dark brown, gray, and light brown). See Figs. X1.1-X1.5. Each color is then measured in Hunter L_H, a_H, b_H units and plotted in color space.

Step 2—The color region itself is then defined by the extreme Hunter L_H, a_H, b_H units within the population of colors. Refer to 3.2.1, 3.2.3, 3.2.4, 3.2.5, and 3.2.7.

Step 3—Any specific color being evaluated within the color region becomes the control for color-difference studies. Refer to X1.3.

Step 4—Simulated 2-year weathered samples for each color region encompassing areas within that region are prepared.

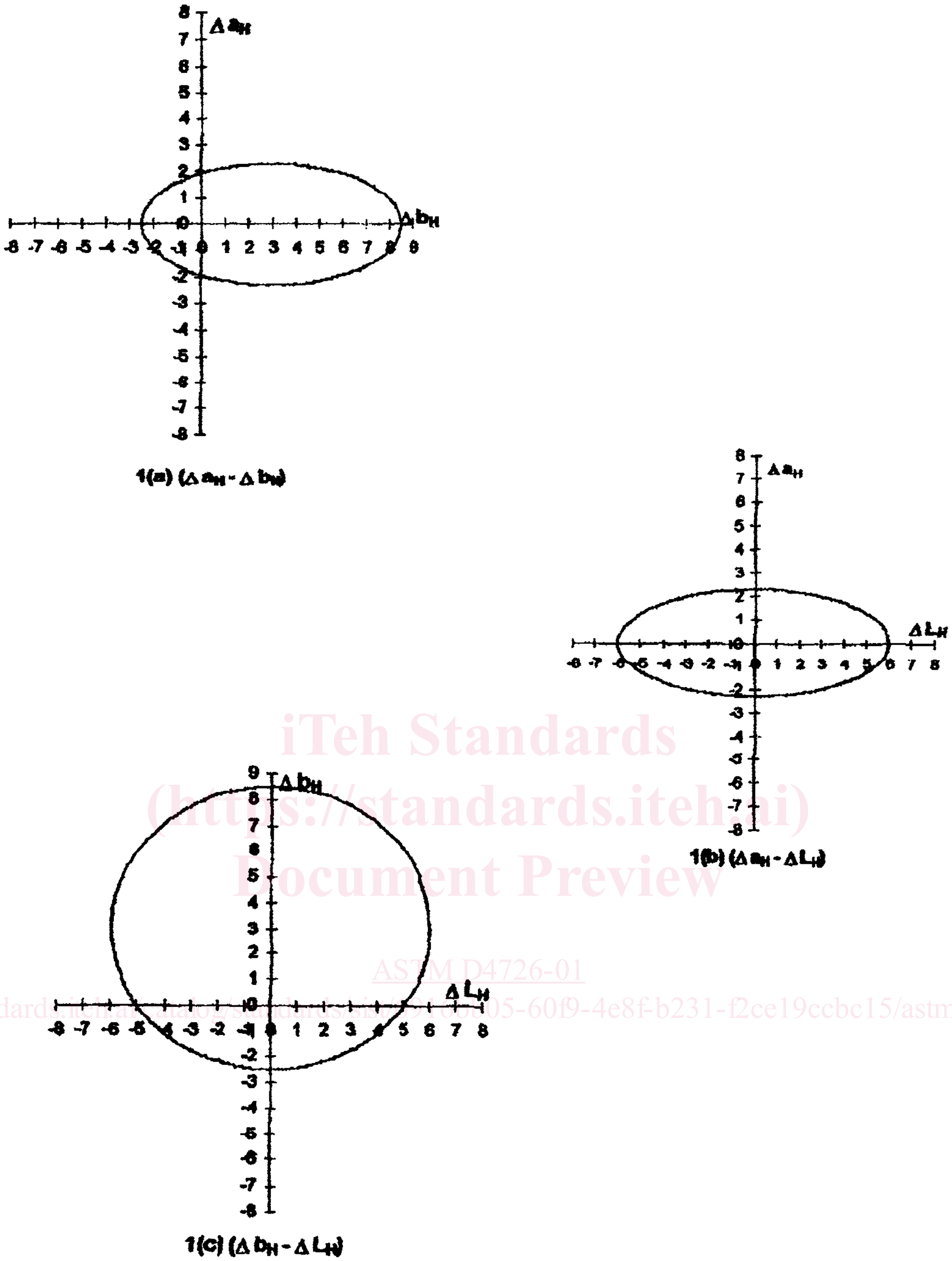

FIG. X1.1 White Color-Hold Guidelines

Step 5—A visual examination and rating of each simulated weathered sample is conducted by a panel of window and door manufacturers and color specialists to establish a visual average rating of limits of acceptability of color change for the window and door application. After visual examination, the acceptable delta (Δ) limits are plotted three dimensionally and considered preliminary limits.

Step 6—Real world data from 2-year weathering studies in Florida, Arizona, and temperate northern climate test sites are then plotted in terms of change of Hunter L_H, a_H, b_H from the control for each of the colors within that region.

Step 7—The final reference ellipses of color-hold guidelines for each region are then established by adjustment of the preliminary data by use of the real world data. Refer to X1.3. The ellipses are then normalized and the mathematical equations for each set of ellipses are developed.

Step 8—Concurrent with development of the color-hold guidelines for each color region, outdoor weathering of all commercial window and door profile samples will be continued in Florida, Arizona, and northern temperate climate sites in