Designation: ~~D4385 – 10~~ D4385 – 13

Standard Practice for Classifying Visual Defects in Thermosetting Reinforced Plastic Pultruded Products[1]

This standard is issued under the fixed designation D4385; 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 practice covers acceptance criteria for visual acceptance of thermosetting reinforced plastic pultruded rods, bars, shapes, and sheets.

1.2 This practice presents definitions of possible defects to serve as a guide for contracts, drawings, product specifications, and final inspection.

1.3 ~~This practice also categorizes different inspection requirements for the three of four grades of product quality identified herein.~~The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

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.*

NOTE 1—There is no known ISO equivalent to this standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

~~D3647 Practice for Classifying Reinforced Plastic Pultruded Shapes According to Composition~~

D3917 Specification for Dimensional Tolerance of Thermosetting Glass-Reinforced Plastic Pultruded Shapes

3. Terminology

3.1 *mat discoloration*—a yellowing of the reinforcing mats caused by binder migration. The discoloration can cause visual streaks on the surface of the pultrusion.

3.2 *test requirement*—minimum design, characteristic or specified values as dictated and or specified by codes, standards, industry, end customers, the manufacturer or the Engineer of Record.

3.3 *connection areas*—areas associated with a pultruded member that form a connection in some form or fashion that will not be visible after fabrication.

3.4 *fiber blooming*—exposed reinforcements on the surface of a profile as a result of veil slippage or lack of resin. Such defects can cause the exposed fiber to "bloom" when exposed to ultraviolet light.

3.5 *internal layer*—refers to individual layers of unidirectional or transverse reinforcements in the form of roving/tows, continuous filament, woven or stitched mats formed and laminated via the pultrusion process to produce a specific thickness of or as part of a pultruded profile. A stitched or woven mat is made up of individual layers of roving woven or stitched together to form a single mat

4. Acceptance Criteria

4.1 The method and frequency of ~~sampling and the quality level shall be agreed upon between the purchaser and the seller.~~inspection shall be the responsibility of the pultruder as deemed necessary to maintain compliance to this specification, unless the purchaser and seller agree on other terms.

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[1] This practice is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.18 on Reinforced Thermosetting Plastics.

Current edition approved ~~April 1, 2010~~Nov. 15, 2013. Published ~~May 2010~~December 2013. Originally approved in 1984. Last previous edition approved in ~~2008~~2010 as ~~D4385 - 08.~~D4385 - 10. DOI: ~~10.1520/D4385-10.~~10.1520/D4385-13.

[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**

4.2 *Dimensions and Tolerances*—Pultruded shapes shall be inspected for conformance with dimensions and tolerances specified on the product drawing or by Specification D3917. Products with any dimensions exceeding the specified limits shall be rejected.

3.3 *Punchability*—Products not exceeding 4.7 mm (0.185 in.) thickness, having Reinforcement Material G and Reinforcement Type M in accordance with Practice D3647, shall be capable of being punched, drilled, and riveted without causing splitting or delamination when good commercial practices are employed (for example, proper backup, adequate hole spacing, etc.).

3.4 *Critical Areas*—Areas in which the presence of imperfections is considered to be detrimental to the proper function of the part shall be designated as critical areas. The areas of a product that are critical structurally, aerodynamically, electrically, or for some other purpose shall be uniform and in accordance with the quality levels of Table 1 as stated on the product drawing. Critical areas may be designated on the product drawing by one of the following methods:

3.4.1 Encircle critical areas,

3.4.2 Cross-hatch areas to designate areas of various levels, or

3.4.3 Word description of the critical area(s).

4.3 *Allowable Defects*—Defects that by nature, number, or frequency of occurrence do not affect the serviceability of the product. These allowable Allowable defects shall be fully described as to the type, size, number, extent allowed, and spacing. The appropriate acceptance level (see Table 1) for defects in these areas must be specified. Defects in excess of those listed as allowable defects in the product specifications, drawings, or contracts, for the productproducts, shall be cause for rejection.

3.6 *Acceptable Defects*—Unless otherwise specified, the following defects shall be acceptable in all instances:

3.6.1 *Shrink-Mark*—A dimple-like depression on the surface of a pultruded shape where it has retracted from the pultrusion die, and which has well-rounded edges. A shrink-mark generally occurs on one surface of a part where there is a boss, flange, rib, or other heavy section on the opposite surface. The shrink-mark may be caused by the difference in total shrinkage when there is a sudden change in section along the surface of the part.

3.6.2 *Resin Voids*—Applicable to a number of mat- and fabric-type reinforcement systems, particularly continuous strand mat used without a surfacing material or woven fabrics. The resin voids appear as multiple surface interruptions that conform to the pattern of the cloth weave or the continuous strand mat fiber distribution. This is usually due to an insufficient flow or shrinkage of the resin that fails to fill all of the interstices of the fabric or mat reinforcement. These defects occur only on the surface layer of resin in contact with the pultrusion die or mold.

3.6.2.1 Pultrusions intended for chemical corrosion environments with pH below 5, or over 9, or for immersion applications, require a synthetic surface veil to ensure adequate resin coverage. Any resin voids shall be repaired.

4.4 *Repairable Defects*—Repairable defects are those that can be repaired without affecting the serviceability of the product unless otherwise specifically prohibited on product specifications, drawings, or contracts. The specific repairable defects include blister, chips, die-parting line, gouges, grooving, intermittent disfigurement, scale, scuffing, sluffing, stop mark, wire brush surface, and resin voids (seeVisual defects (for example, chips, exposed reinforcement, fiber bridging, fiber prominence, and scuffing) that do 3.6.2). The repaired product must conform to the limits ofnot affect the structural serviceability Table 1. Other defects may be repaired by mutual consent of the customer and the pultruder. Methods of repair shall be that are permitted to be repaired if agreed upon between the purchasermanufacturer and the seller and shall be fully described by the product specification, drawings, or contracts.purchaser. The repair procedure shall be documented and contractually agreed upon by all parties involved.

5. Acceptance Levels

5.1 *Visual Inspection*—Each sample selected in accordance with 3.1 shall be checked visually without the aid of magnification. Defects shall be classified as to type and level, as shown in Any defect not meeting Table 1. The quality level shall be determined by reference to the product specification or drawing for the applicable acceptance level for allowable defects. The inspection shall be concerned with those defects described by the product specifications, drawings, or contracts for the pultruded products. If none of these first three levels (Levels I, II, or III) is considered applicable, the level shall be Level IV, and allowable defects must be specified on the product specification or drawing including the criteria for acceptance. Any excess of defects, as specified under the required level, shall be cause for rejection. Unless otherwise specified, the dimensions in this practice are surface dimensions.the requirements of this standard, shall be cause for rejection. Any defect not covered in this specification shall be resolved between the purchaser and the seller and shall be fully described in the specification and contractual documents.

4.2 *Acceptance Level I*—Presence of any defects in excess of those listed in Table 1, Level I, shall be cause for rejection.

4.3 *Acceptance Level II*—Presence of defects in excess of those listed in Table 1, Level II, shall be cause for rejection, if defect is not repairable.

4.4 *Acceptance Level III*—Presence of defects in excess of those listed in Table 1, Level III, shall be cause for rejection, if defect is not repairable.

4.5 *Acceptance Level IV*—Any defect not specifically defined by size or shape in Levels I, II, or III that falls into a category between Levels I, II, and III or is beyond Level III and is considered acceptable, shall be designated as Level IV and shall be

specified on the product specification or drawing. Any such defect shall be fully described as to size, shape, number, extend, and spacing on the product drawing, product specification, or contracts for the products.

6. Keywords

6.1 pultrusion; structural shapes; visual

TABLE 1 Acceptance Criteria

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Name	Definition	Visual Acceptance Levels		
		Level I	Level II	Level III
Black Marking	Black smudges on the surface of the pultruded product that cannot be removed by cleaning, scrubbing, or wiping with solvent.	None	Permitted if not over 12 mm wide or 20 cm long or more than 4 marks per 3 m of length.	Permitted if not over 25 mm and all product test requirements are satisfied
Blister	A rounded elevation of the pultruded surface with boundaries that may be more or less sharply defined. **NOTE—The** rounded elevation somewhat resembles in shape a blister on the surface of human skin. Blisters may exist within the pultrusion as a hollow delaminated area (gas-filled) under a raised portion of the surface.	None Product must meet test requirements and not exceed dimensional tolerances. Repair if limits exceeded.	Permitted if not on the exterior surface formed between the surfacing veil and first layer of reinforcement. And less than 15 mm in diameter. No more than one per 3 m in length.	Permitted if formed between surfacing layer and balance of laminate, width is no greater than 40 % of surface width (but 7 cm max) and length is not over 20 cm. No more than 2 per 3 m of length. Blisters less than 19 mm in diameter are permitted on interior surfaces that are bonded. A popcorn blister (less than 1.5 mm in diameter and .25 mm high) is permitted.
Blooming, Undercure	**A** dull and bleached surface color that is evident in pultruded material not exposed to the weather.	None	None	None
Burn	A discoloration, distortion, or destruction of the pultruded surface as a result of thermal decomposition.	None	None	None
Chips (Gouges)	Minor damage to the pultruded surface that removes material but does not cause a crack or craze.	None	Not over 6 mm long or wide or 0.64 mm deep. Not more than 4 per 3 m of length. Repair if limits exceeded.	Not over 10 mm wide or long or 0.64 mm deep. Not more than 5 per 3 m of length. Repair if limits exceeded.
Crack	A visual separation that penetrates down from the pultruded surface to the equivalent of one full ply or more reinforcement (0.5 mm). See internal shrinkage cracks.	None	None	None
Crater	A small, shallow pultrusion surface imperfection.	None	Not over 1 mm in diameter and 0.64 mm deep. Maximum of 5 per 64.5 cm of area and no more than 1 such area per 0.3 m of product. Not permitted in same area of unrepaired chips and gouges.	Acceptable if it does not reduce the part thickness below the minimum specification.
Craze	Multiple fine separation cracks at the pultruded surface not penetrating into the reinforcement nor to the equivalent depth of one ply of reinforcement.	None	Not over 9 mm long or 0.4 mm wide, not more than 12 per 3 m of length.	Can be over the entire length of the part.

TABLE 1 *Continued*

Visual	Definition	Acceptance Levels		
		Level I	Level II	Level III
	NOTE—This condition is usually due to resin shrinkage during cure in resin-rich areas.			
Delamination	The separation of two or more layers or plies of reinforcing material within a pultrusion causing a localized thickness change exceeding 0.13 mm (0.005 in.)	None	None	None
Die Parting Line	A lengthwise flash or depression on the surface of a pultruded plastic part. The die parting line is not part of the dimensional tolerance. **NOTE—The** die parting line is associated with the area where separate pieces of the die join together to form the cavity.		The line projection caused by the die-parting line shall not extend past the product's surface by more than 0.20 mm for shapes less than 3.1 cm wide and 0.3 mm for shapes greater than 3.1 cm wide. It shall not create a sharp feeling or have loose fibers. Repair if limits exceeded.	The line projection caused by the die parting line shall not extend past the product's surface by more than 0.30 mm. It shall not create a sharp feeling or have loose fibers. Repair if limits are exceeded.
Discoloration	A streak of other pattern on the surface that causes a noticeable change of color from the rest of the pultruded surface.	None	Spots of any color not over 12 mm in diameter or 4 per 3 m of length are permitted. Streaks or longitudinal stains permitted if not over 12 mm wide, 20 cm long, or more than 4 per 3 m of length.	Spots of any color not over 19 mm in diameter or 8 per 3 m of length are permitted. Streaks or longitudinal stains permitted if not over 19 mm wide, 25 cm long, or more than 6 per 3 m of length. Continuous discolorations caused by a veil overlap are permitted. Mat discolorations are not rejectable
Dry Fiber (Lack of Resin—Fillout)	A condition in which fibers are not fully encapsulated by resin during pultrusion. **NOTE—This** does not include surfacing veil.	None	If internal, permitted if product meets test requirements. If on the surface, see *blooming, fiber.*	
Dullness	A lack of normal pultruded surface gloss or shine. **NOTE—This** condition can be caused by insufficient cure locally or in large areas, resulting in the dull band created on a pultruded part within the die when the pultrusion process is interrupted briefly (see stop mark).	None	Permitted unless caused by insufficient cure.	
Exposed Rovings	The underlying layer of roving not covered by surface material in a pultrusion.	None The exposed underlayment may be present intermittently along an entire length. All reinforcing fibers shall be encapsulated with resin.	Permitted if surfacing material covers all but 9.5 mm from each free edge but not to exceed 40 % of the width of the surface being inspected or 25 % of the perimeter of a round product.	Permitted if surfacing material covers all but 11 mm from each free edge, but not to exceed 40 % of the width of the surface being inspected or 30 % of the perimeter of a round product. Carrier rovings can be used on the surface of a tube without rejection. Connection areas can have exposed rovings.

TABLE 1 *Continued*

Name	Definition	Visual Acceptance Levels		
		Level I	Level II	Level III
Fiber Bridging	Reinforcing fiber material that is found bridging across on an inside radius of a pultruded shape. **NOTE—This** condition is caused by shrinkage stresses around such a radius during cure.	None	Permitted if reinforcing fibers are encapsulated by resin, no corner cracks exist, and there is no evidence of delamination.	
Fiber Prominence	A visible and measurable pattern of the reinforcing material on the surface of a pultruded plastic part.	None	Permitted if reinforcing material is encapsulated by resin.	
Folded Reinforcement	An unintentional or unspecified misalignment of mat or fabric reinforcing material in relation to the contour of a pultruded section. **NOTE—Such** folds may or may not affect the surface appearance of the pultrusion and are visible in a cut cross section of the product.	None	Not permitted when fold results in 3 or more plies affected and a reinforcement-rich area.	Permitted if test requirements are met. Other visual requirements caused by mat folds must satisfy the specification.
Fracture	Cracks, crazing, or delamination, or a combination thereof, resulting from physical damage to the pultrusion.	None	None	None
Grooving	Long narrow grooves or depressions in a surface of a pultrusion parallel to its length.	None	Permitted if material thickness reduction is not over 10 % and groove width is 3 mm or less. May be continuous in a length. Grooves on opposing surfaces are not permitted. Must satisfy dimensional requirements.	Permitted if material thickness reduction is not over 10 % and the groove width is 3 mm or less. May be continuous in length. Grooves on opposing surfaces are not permitted. Must satisfy dimensional and mechanical requirements.
Inclusion	Any foreign matter or particles that are either encapsulated or imbedded in the pultrusion.	None	No metallic inclusion is permitted if product is for electrical use. For nonelectrical application, none in excess of 9 mm in diameter. No inclusion shall create a surface blemish above the resin. Not over 4 per 3 m of length.	Permitted if product meets test requirements. None in excess of 12 mm in diameter or no more than 6 per 3 m of length. No inclusion should create a surface blemish above the resin.
Insufficient Cure	A pultrusion abnormally created by lack of, or incomplete, crosslinking of the resin.	None	None	Repair by postcure if test requirements can be met and surface appearance is acceptable.

TABLE 1 *Continued*

Name	Definition	Acceptance Levels		
		Level I	Level II	Level III
	NOTE—This condition can usually be detected by dull surface appearance, low Barcol hardness, and low physical properties. Thick sections, cured from the outside in, can reveal insufficient cure in the center of the section even though completely cured on the surface. This condition can be caused by insufficient die temperature, improper catalyst, or pulling too fast for the die temperature.			
Internal Shrinkage Cracks	Longitudinal cracks in the pultrusion that are found within areas of roving reinforcement and terminate in the off-axis reinforcement.. **NOTE—This** condition is caused by shrinkage strains during cure that appear in the roving portion of the pultrusion where transverse strength is low.	None	Permitted except for rod and bar of all roving reinforcement, if the crack does not reach the surface of the product and product meets test requirements.	Permitted without numerical limit if the crack does not reach the surface of the product and the product meets test requirements.
Porosity, Internal (Void)	The presence of numerous pits or pinholes beneath the pultruded surface, usually observable only in a cut cross section.	None	For material thicknesses below 9 mm, no more than 10 pits or pinholes per 64.5 cm^2 of cross section. Materials 9 mm and over in thickness, no more than 30 pits per 64.5 cm^2 of cross section. Sum of pinhole porosity area and void area shall be no more than 4 % of cross-sectional area.	For material thicknesses below 9 mm, no more than 20 pits or pinholes per 64.5 cm^2 of cross section. For materials 9 mm and over in thickness, no more than 60 pits or pinholes per 64.5 cm^2 of cross section. Sum of pinhole porosity area and void area shall be no more than 8 % of cross-sectional area. Shapes exceeding the limits can be accepted if the properties including water absorption are satisfied.
Porosity, Surface (Void)	The presence of numerous visible pits or pinholes at or near the pultruded surface.	None	Permitted if pits are less than 0.4 mm in diameter and 0.38 mm deep. Maximum of 5 pits per 64.5 cm^2 of area and no more than one such area per 0.3 m of product. Surface porosity is permitted if the customer specifies that no surfacing veil is to be used.	Permitted if pits are less than 0.8 mm in diameter and 0.51 mm deep. Maximum of 10 pits per 64.5 cm^2 of area and no more than 4 % of cross-sectional area per 0.3 m of product. Surface porosity is permitted if the customer specifies that no surfacing veil is to be used.
Reinforcement Distortion	Knotted, tangled, widely spaced, or otherwise abnormal but local irregularities in reinforcement distribution throughout the pultruded cross section. **NOTE—This** condition usually causes noticeable changes in the local reinforcement content with crushing of the reinforcement or resin-richness in isolated areas.	None	Permitted if product meets test requirements.	
Resin-Rich Area	An area of the pultrusion that lacks sufficient reinforcement.	None	Permitted if product meets test requirements.	

TABLE 1 *Continued*

Name	Definition	Visual Acceptance Levels		
		Level I	Level II	Level III
	NOTE—The fiber pattern may not be visible.			
Roving Knot	A knotted or entangled section of roving found in a pultrusion. **NOTE—Such** a knot may cause high fiber concentration locally and may or may not be visible as a white or light spot on the surface of the section.	None	Permitted if encapsulated with resin and product meets test requirements and dimensional tolerances.	
Saw Burn	Blackening or carbonization of a cut surface of a pultruded section.	None	Permitted if product meets test requirements.	
Scale	A condition wherein resin plates or particles are on the surface of a pultrusion. **NOTE—Scales** can often be readily removed, sometimes leaving surface voids or depressions.	None	Permitted if removal does not expose dry fibers and dimensional tolerances are met. Repair of exposed fiber permitted if dimensional tolerances are met.	
Scuffing	Long white scrape marks on the surface of the pultrusion. **NOTE—This** condition usually results from mechanical scraping or scratching of the pultrusion in the machine or in handling it afterwards.	None	Permitted if not over 12 mm wide or 20 cm long and not over 4 such marks — per 3 m of length. On inside radius, permitted if not over 1.5 mm wide or 76 mm long even if they appear intermittently along each length. Repair if limits exceeded.	Permitted if not over 19 mm wide or 30.5 cm long and not over 5 such — marks per 3 m of length. On inside radius, permitted if not over 3 mm wide or 15 cm long even if they appear intermittently along each length. Repair if limits exceeded.
Sluffing	A condition wherein scales peel off or become loose, either partially or entirely, from the pultrusion. **NOTE—This** term is applied to an occurrence during the pultrusion process and is not to be confused with scraping, prying, or physically removing the scale from the pultrusion. *Sluffing* is sometimes spelled *sloughing*.	None	Permitted if sharp feeling is not created and dimensional tolerances are met. — Repair permitted if dimensional tolerances are met.	
Stop Mark	A band, either dull or glossy, on the surface, approximately 12 to 100 mm long and extending around the periphery of a pultruded shape. **NOTE—This** condition is the result of an interruption in the normal continuous pulling operation.	None	Permitted unless other defects (such as scale, craters, chips, and gouges) result.	Permitted unless unrepairable defects result. Repair all other resulting defects.
Wire Brush Surface	A roughness due to fibers protruding above the surface of the pultruded part.	None	Permitted if protruding fibers are encapsulated with resin. They shall not create a sharp feeling. If so, repair.	

~~**TABLE 1** *Continued*~~

~~Name~~	~~Definition~~	~~Acceptance Levels~~		
		~~Level I~~	~~Level II~~	~~Level III~~
~~Wrinkle Depression~~	~~An undulation or series of undulations or waves on the surface of the pultruded part.~~ ~~**Note—This** condition can occur in either the lengthwise or crosswise direction of the pultrusion and is caused by reinforcement shifting and crowding (see folded reinforcement). Wrinkles affect the flatness of the surface.~~	~~None~~	~~Depressions are permitted if depth is less than 10 % of shape thickness (6 mm) in width and frequency of~~ ~~occurrence per 3 m of pultruded length not over 4 continuous or 8 intermittent depressions. Wrinkle-like waves shall be 3 mm wide or less.~~	~~Depressions are permitted if less than 15 % of shape thickness, (9 mm) in width and frequency of occurrence~~ ~~per 3 m of pultruded length not over 6 continuous or 10 intermittent depressions. Wave-like wrinkles on flange tips shall be 4.5 mm or less~~

~~Visual~~ **TABLE 1** *Continued*

TABLE 1 Acceptance Criteria

Name	Definition	Acceptance/Rejection Criteria
Black Marking	Black smudges on the surface of the pultruded product that cannot be removed by cleaning, scrubbing, or wiping with solvent. **Note**—This defect is cosmetic in nature and does not affect the structural serviceability.	A single smudge shall fit in a 1 in. (25.4 mm) diameter circle. Multiple smudges are permitted.
	 *Note: Photo shown depicts profile not meeting the specification.*	
Blister	A rounded elevation of the pultruded profile surface with boundaries that has the potential to be sharply defined. It is possible that blisters will exist within the pultrusion as a hollow delaminated area (gas-filled) under a raised portion of the surface. **Note**—The rounded elevation somewhat resembles in shape a blister on the surface of human skin. **Note**—This defect is cosmetic in nature and does not affect the structural serviceability.	Permitted if formed between the surfacing veil layer and balance of laminate, width is no greater than 80 % of surface width, but limited to 1.25 in. (31.75 mm) in diameter and length is not over 8 in. (20.32 cm). Not more than two per 10 ft (3.048 m) of length. Popcorn blisters less than 0.060 in. (1.524 mm) in diameter and 0.010 in. (0.254 mm) high are permitted. Blisters are not permitted within connection areas intended for bonding purposes.

TABLE 1 *Continued*

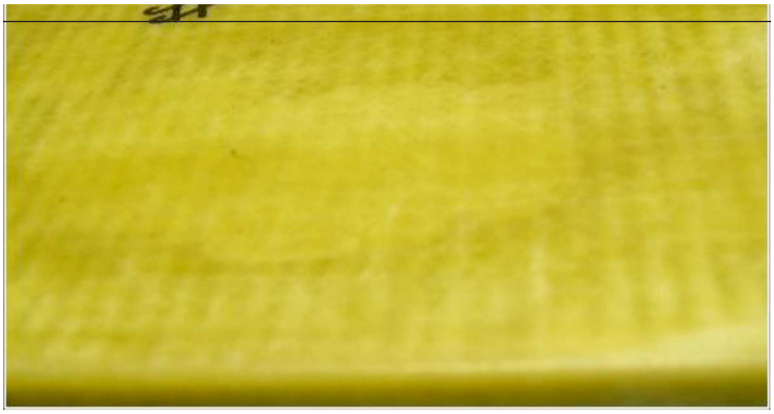
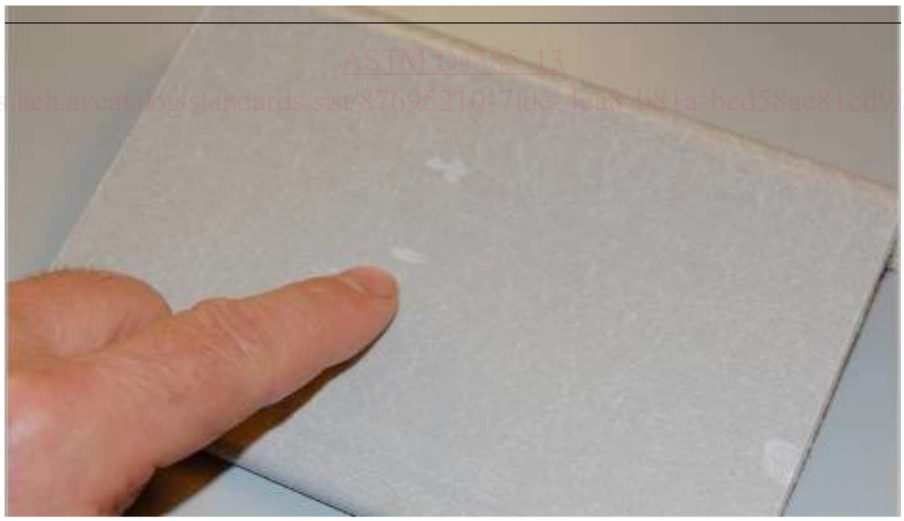
Name	Definition	Acceptance/Rejection Criteria
		
	Note: Photo shown depicts profile not meeting the specification.	

TABLE 1 *Continued*

Name	Definition	Acceptance/Rejection Criteria
Burn or Thermal Decomposition	A discoloration, distortion, or destruction of the pultruded surface as a result of thermal decomposition. **Note**—This defect affects the structural serviceability.	Not acceptable.
	 *Note: Photo shown depicts profile not meeting the specification.*	
Chips (Gouges)	Minor damage to the pultruded surface that removes material but does not cause a crack or craze. **Note**—This defect is cosmetic in nature and does not affect the structural serviceability.	Not over 0.393 in. (10 mm) wide or long. Not more than five per 10 ft (3.048 m) length. Chips that penetrate past the depth of the surface veil are not permitted.
	 *Note: Photo shown depicts profile meeting the specification.*	