



Standard Practice for Classifying Visual Defects in Thermosetting Reinforced Plastic Pultruded Products¹

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 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

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.

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.

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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.

3.2 *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 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.

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.

4.3 *Allowable Defects*—Defects that by nature, number, or frequency of occurrence do not affect the serviceability of the product. Allowable defects shall be fully described as to the type, size, number, extent allowed, and spacing. Defects in excess of those listed as allowable defects in the product specifications, drawings, or contracts, for the products, shall be cause for rejection.

4.4 *Repairable Defects*—Visual defects (for example, chips, exposed reinforcement, fiber bridging, fiber prominence, and

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

scuffing) that do not affect the structural serviceability that are permitted to be repaired if agreed upon between the manufacturer and the 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 magnifi-

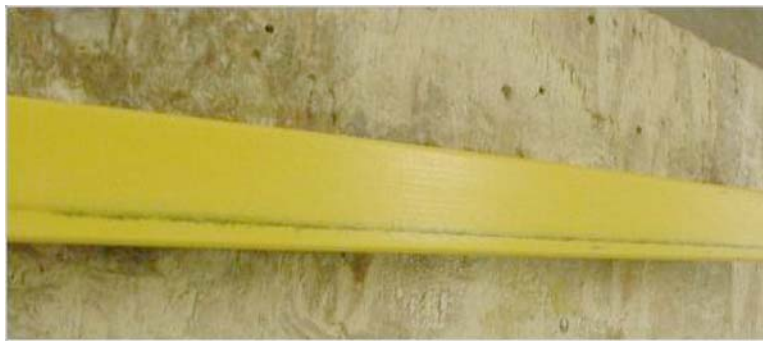
cation. Any defect not meeting the requirements of this standard, shall be cause for rejection. Any defect not covered in this specification shall be resolved between the purchaser and the seller and shall be fully described in the specification and contractual documents.

6. Keywords

6.1 pultrusion; structural shapes; visual

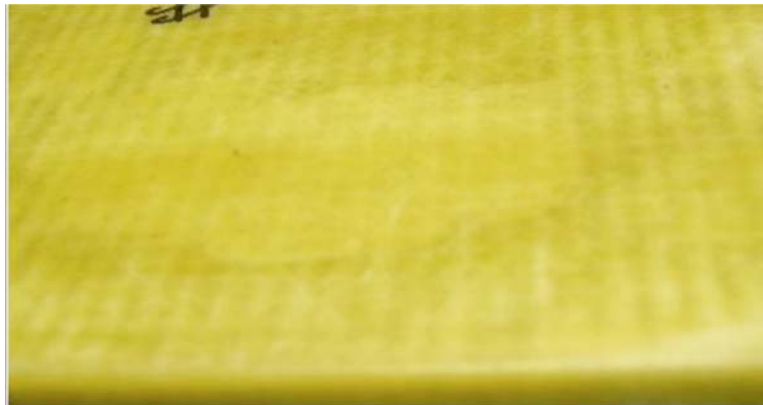
TABLE 1 Acceptance Criteria

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.
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Note: Photo shown depicts profile not meeting the specification.

TABLE 1 Continued

Name	Definition	Acceptance/Rejection Criteria
Burn or Thermal Decomposition	<p>A discoloration, distortion, or destruction of the pultruded surface as a result of thermal decomposition.</p> <p>Note—This defect affects the structural serviceability.</p>	Not acceptable.



Note: Photo shown depicts profile not meeting the specification.

Chips (Gouges)	<p>Minor damage to the pultruded surface that removes material but does not cause a crack or craze.</p> <p>Note—This defect is cosmetic in nature and does not affect the structural serviceability.</p>	<p>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.</p>
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Note: Photo shown depicts profile meeting the specification.

TABLE 1 Continued

Name	Definition	Acceptance/Rejection Criteria
Crack	<p>A visual separation that penetrates down from the pultruded surface to the equivalent of one full ply or more reinforcement 0.02 in. (0.508 mm). Reference Internal Shrinkage Cracks.</p> <p>Note—This defect affects the structural serviceability.</p>	Not acceptable.



Note: Photo shown depicts profile not meeting the specification.

Crater	<p>A small, shallow pultrusion surface imperfection.</p> <p>Note—This defect is cosmetic in nature and does not affect the structural serviceability.</p>	Acceptable if it does not reduce the part thickness below the minimum specification.
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Note: Photo shown depicts profile meeting the specification.

TABLE 1 Continued

Name	Definition	Acceptance/Rejection Criteria
Craze	<p>Multiple fine separation cracks at the pultruded surface not penetrating into the reinforcement or to the equivalent depth of one ply of reinforcement.</p> <p>Note—This condition is usually due to resin shrinkage during cure in resin-rich areas.</p> <p>Note—This defect is cosmetic in nature and does not affect the structural serviceability.</p>	Acceptable and can be over the entire length of the part.



Note: Photo shown depicts profile meeting the specification.

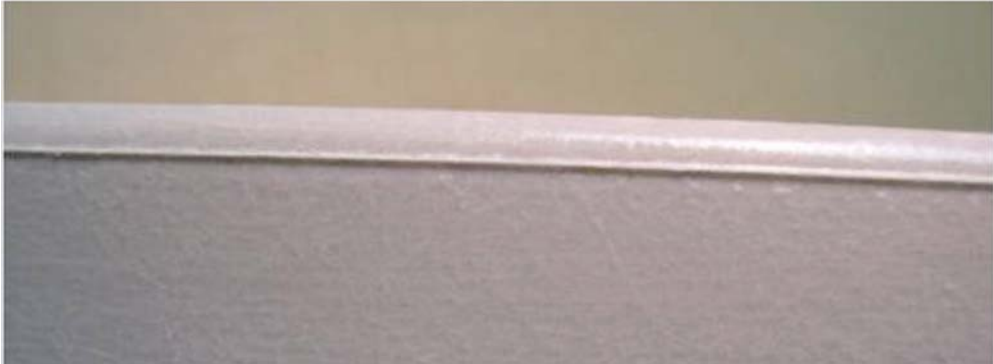
Delamination	<p>The separation of two or more layers or plies of reinforcing material within a pultrusion.</p> <p>Note—This defect affects the structural serviceability.</p>	Not acceptable.
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Note: Photo shown depicts profile not meeting the specification.

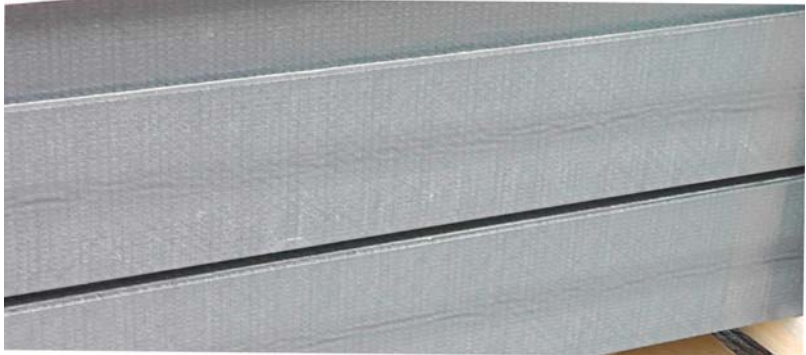
TABLE 1 Continued

Name	Definition	Acceptance/Rejection Criteria
Die Parting Line	<p>A lengthwise flash or depression on the surface of a pultruded plastic part. The die parting line is not part of the dimensional tolerance.</p> <p>Note—The die parting line is associated with the area where separate pieces of the die join together to form the cavity.</p> <p>Note—This defect is cosmetic in nature and does not affect the structural serviceability.</p>	<p>The line projection caused by the die parting line shall not extend past the product's surface by more than 0.02 in. (0.508 mm). It shall not create a sharp feeling or have loose reinforcement fibers.</p>



Note: Photo shown depicts profile meeting the specification.

Discoloration	<p>A streak or other pattern on the surface that causes a noticeable change of color from the rest of the pultruded surface that has not been exposed to the weather.</p> <p>Note—This defect is cosmetic in nature and does not affect the structural serviceability.</p>	<p>Spots of any color not over 0.75 in. (19.05 mm) in diameter or eight per 10 ft (3.048 m) of length are permitted. Streaks or longitudinal stains permitted if not over 0.75 in. (19.05 mm) wide, 10 in. (25.4 cm) long, or more than six per 10 ft (3.048 m) of length. Continuous discolorations caused by a veil overlap or resin rich areas are permitted. Mat discolorations are not rejectable.</p>
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Note: Photo shown depicts profile meeting the specification.

TABLE 1 Continued

Name	Definition	Acceptance/Rejection Criteria
Dry Fiber (Lack of Resin Fillout)	<p>A condition in which fibers are not fully saturated by resin during pultrusion.</p> <p>Note—This does not include surfacing veil.</p> <p>Note—This defect affects the structural serviceability.</p>	Not acceptable.



Note: Photo shown depicts profile not meeting the specification.

Dullness	<p>A lack of normal pultruded surface gloss or shine.</p> <p>Note—This condition can be caused by insufficient cure (typically in large areas), or a stop mark, (more defined and abbreviated in size), which result in a dull area on a pultruded profile.</p> <p>Note—Where the condition has been determined to have been caused by insufficient cure, reference the “Insufficient Cure” section for direction and disposition. Where it has been determined as associated with a stop mark, the condition is purely cosmetic in nature and does not affect the structural serviceability, reference the “Stop Mark” section.</p>	Determine cause of condition and reference the “Insufficient Cure” section or “Stop Mark” section for direction.
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Note: Photo shown depicts profile not meeting the specification.

TABLE 1 Continued

Name	Definition	Acceptance/Rejection Criteria
Exposed Reinforcement/Veil Slippage	<p>The underlying layer of roving not covered by surface material in a pultrusion.</p> <p>Note—This defect is cosmetic in nature and does not affect the structural serviceability. Can lead to fiber blooming when exposed to sunlight.</p>	<p>Permitted if surfacing material covers all but 0.4375 in. (11.112 mm) from each free edge, but not to exceed 25 % of the width of the surface being inspected or 10 % of the circumference of a round product. Carrier rovings can be used on the inside surface of a tube without rejection. Connection areas can have exposed rovings.</p>



Note: Photo shown depicts profile not meeting the specification.

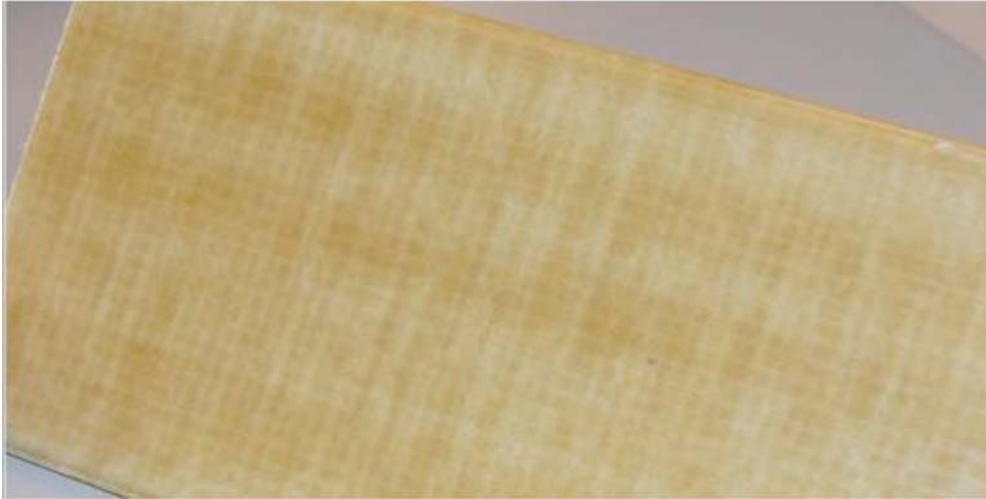
Fiber Bridging	<p>Reinforcing fiber material that is found bridging across on an inside radius of a pultruded shape.</p> <p>Note—This condition is caused by shrinkage stresses around such a radius during cure.</p> <p>Note—This defect is cosmetic in nature and does not affect the structural serviceability if Acceptance Criteria are met.</p>	<p>Permitted if reinforcing fibers are encapsulated by resin, no corner cracks exist, and there is no evidence of delamination.</p>
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Note: Photo shown depicts profile meeting the specification.

TABLE 1 Continued

Name	Definition	Acceptance/Rejection Criteria
Fiber Prominence	<p>A visible and measurable pattern of the reinforcing material on the surface of a pultruded plastic part.</p> <p>Note—This defect is cosmetic in nature and does not affect the structural serviceability if fibers are encapsulated by resin.</p>	Permitted if reinforcing fibers are encapsulated by resin.



Note: Photo shown depicts profile meeting the specification.

Folded Reinforcement	<p>An unintentional or unspecified misalignment of mat or fabric reinforcing material in relation to the contour of a pultruded section.</p> <p>Note—It is possible that such folds will affect the surface appearance of the pultrusion and will be visible in a cut cross section of the product.</p> <p>Note—It is possible that this condition is unavoidable and does affect the strength of a pultruded profile.</p>	Permitted if properties meet the minimum mechanical and physical properties as published by manufacturer or properties agreed upon between pultruder and purchaser. Other visual requirements caused by mat folds must satisfy the specification.
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Note: Photo shown depicts profile meeting the specification.

TABLE 1 Continued

Name	Definition	Acceptance/Rejection Criteria
Fracture	Cracks, crazing, or delamination, or a combination thereof, resulting from physical damage to the pultrusion.	Not acceptable.

Note—This defect affects the structural serviceability.



Note: Photo shown depicts profile not meeting the specification.

Grooving	Long narrow grooves or depressions in a surface of a pultrusion parallel to its length.	Permitted if material thickness reduction is not over 10 % and the groove width is 0.125 in. (3.175 mm) or less. Grooves on opposing surfaces of the cross sectional thickness are not permitted. Intermittent and continuous grooves are acceptable as long as the profile satisfies dimensional and mechanical requirements.
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Note—This defect is cosmetic in nature and does not affect the structural serviceability if Acceptance Criteria are met.



Note: Photo shown depicts profile meeting the specification.

TABLE 1 Continued

Name	Definition	Acceptance/Rejection Criteria
Inclusion	<p>Any foreign matter or particles that are either encapsulated or imbedded in the pultrusion.</p> <p>Note—This defect is cosmetic in nature and does not affect the structural serviceability if Acceptance Criteria are met.</p>	<p>Permitted if product meets test requirements. None in excess of 0.50 in. (12.7 mm) in diameter or no more than six per 10 ft (3.048 m) of length. No inclusion should create a surface blemish above the resin.</p>



Note: Photo shown depicts profile not meeting the specification.

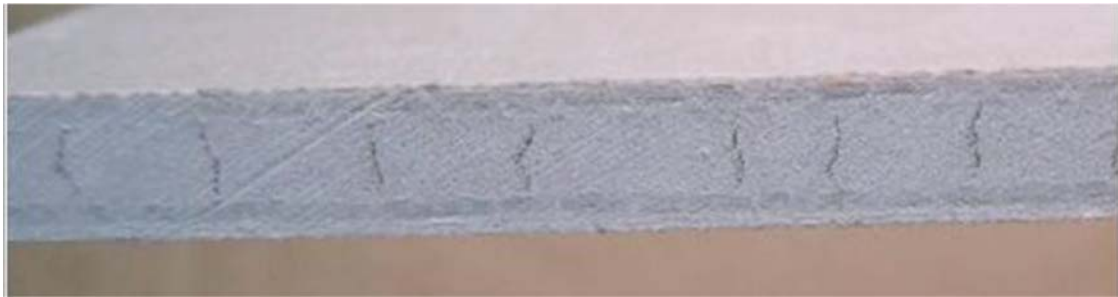
Insufficient Cure	<p>A pultruded part abnormally created by lack of, or incomplete, crosslinking of the resin.</p> <p>Note—This condition can usually be detected by dull surface appearance, low Barcol hardness, and low physical properties. Thick sections, cured from the outside in, can reveal insufficient 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.</p> <p>Note—This defect affects the structural serviceability.</p>	<p>Repair by postcure if test requirements can be met and surface appearance is acceptable.</p>
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Note: Photo shown depicts profile not meeting the specification.

TABLE 1 Continued

Name	Definition	Acceptance/Rejection Criteria
Internal Shrinkage Cracks	<p>Cracks in the pultrusion that are found within areas of roving reinforcement and terminate in the off-axis reinforcement.</p> <p>Note—This condition is caused by shrinkage strains during cure that appear in the roving portion of the pultrusion where transverse strength is low.</p> <p>Note—This defect is cosmetic in nature and does not affect the structural serviceability if Acceptance Criteria are met.</p>	<p>Permitted without numerical limit if the crack does not reach the surface of the product or penetrate through an internal layer of reinforcement and the product meets test requirements.</p>



Note: Photo shown depicts profile meeting the specification.

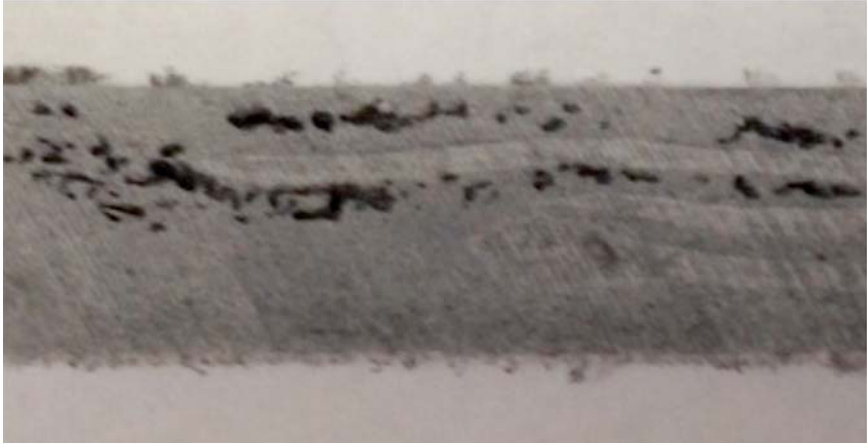
Mat Splice	<p>Stitching on or near the surface of the part that is utilized to splice mat reinforcements.</p> <p>Note—This defect is cosmetic in nature and does not affect the structural serviceability if Acceptance Criteria are met.</p>	<p>Permitted if dimensional requirements are met.</p>
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Note: Photo shown depicts profile meeting the specification.

TABLE 1 Continued

Name	Definition	Acceptance/Rejection Criteria
Porosity, Internal (Void)	<p>The presence of numerous pits or pinholes beneath the pultruded surface, usually observable only in a cut cross section.</p> <p>Note—This defect is cosmetic in nature and does not affect the structural serviceability if Acceptance Criteria are met.</p>	<p>No more than two pits/pinholes for every 0.0625 in. (1.6 mm) of thickness per 1.0 in. (25.4 mm) width.</p> <p>Shapes exceeding the limits can be accepted if the properties including water absorption are satisfied.</p>



Note: Photo shown depicts profile not meeting the specification.

Porosity, Surface (Void)	<p>The presence of numerous visible pits or pinholes at or near the pultruded surface.</p> <p>Note—This defect is cosmetic in nature and does not affect the structural serviceability if Acceptance Criteria are met.</p>	<p>Permitted if pits are less than 0.030 in. (0.762 mm) in diameter and 0.02 in. (0.508 mm) deep. Maximum of ten pits per 10 in.² (64.52 cm²) of area and no more than 4 % of cross-sectional area per 12 in. (305 mm) of product. Any surface porosity is permitted if the customer specifies that no surfacing veil is to be used. Reference the “Resin Voids” section.</p>
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Note: Photo shown depicts profile, with veil, not meeting the specification.

TABLE 1 Continued

Name	Definition	Acceptance/Rejection Criteria
Reinforcement Distortion	<p>Knotted, tangled, widely spaced, or otherwise abnormal but local irregularities in reinforcement distribution throughout the pultruded cross section.</p> <p>Note—This condition usually causes noticeable changes in the local reinforcement content with crushing of the reinforcement or resin-richness in isolated areas.</p> <p>Note—This defect affects the structural serviceability.</p>	<p>Permitted if defect fits in a 3 in. (76.2 mm) circle. Multiple occurrences permitted.</p>



Note: Photo shown depicts profile not meeting the specification.

Resin Rich Area	<p>An area of the pultrusion that lacks sufficient reinforcement.</p> <p>Note—It is possible that the fiber pattern will not be visible.</p> <p>Note—This defect is cosmetic in nature and does not affect the structural serviceability if Acceptance Criteria are met.</p>	<p>Permitted if product meets test requirement.</p>
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Note: Photo shown depicts profile meeting the specification.

TABLE 1 Continued

Name	Definition	Acceptance/Rejection Criteria
Resin Voids	<p>Resin voids appearing as multiple surface interruptions that conform to the pattern of cloth weave or continuous strand mat. These defects occur only on the surface layer of resin in contact with the pultrusion die or mold that do not contain a veil.</p> <p>Note—This defect is cosmetic in nature and does not affect the structural serviceability.</p>	<p>Acceptable on products that do not contain a surface veil. Not acceptable on parts containing a surface veil.</p>



Note: Photo shown depicts profile meeting the specification.

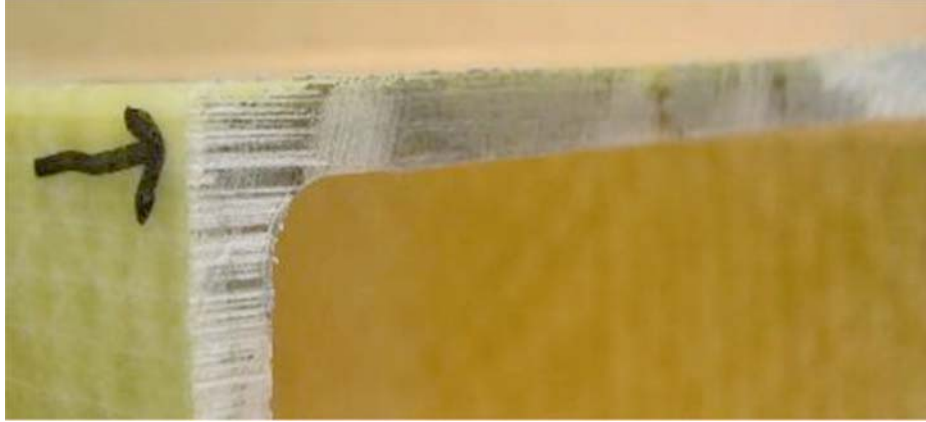
Roving Knot	<p>A knotted or entangled section of roving found in a pultrusion.</p> <p>Note—It is possible that such a knot will cause high fiber concentration locally and that it will be visible as a white or light spot on the surface of the section.</p> <p>Note—This defect is cosmetic in nature and does not affect the structural serviceability.</p>	<p>Permitted if encapsulated with resin and product meets test requirements and dimensional tolerances.</p>
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Note: Photo shown depicts profile meeting the specification.

TABLE 1 Continued

Name	Definition	Acceptance/Rejection Criteria
Saw Burn	Blackening or carbonization of a cut surface of a pultruded section. Note —This defect is cosmetic in nature and does not affect the structural serviceability if Acceptance Criteria are met and not caused by dry fiber.	Permitted unless caused by dry fiber.



Note: Photo shown depicts profile meeting the specification.

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. Note —This defect is cosmetic in nature and does not affect the structural serviceability if Acceptance Criteria are met.	Permitted if removal does not expose dry fibers and dimensional tolerances are met.
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Note: Photo shown depicts profile meeting the specification.

TABLE 1 Continued

Name	Definition	Acceptance/Rejection Criteria
Scuffing	<p>Long white scrape marks on the surface of the pultrusion.</p> <p>Note—This condition usually results from mechanical scraping or scratching of the pultrusion in the machine or in handling it afterwards.</p> <p>Note—This defect is cosmetic in nature and does not affect the structural serviceability if Acceptance Criteria are met.</p>	<p>Permitted if not over 0.75 in. (19.05 mm) wide or 12 in. (30.48 cm) long and not over five such marks per 10 ft (3.048 m) of length. On inside radius, permitted if not over 0.125 in. (3.175 mm) wide or 6.0 in. (15.24 cm) long even if they appear intermittently along each length.</p>



Note: Photo shown depicts profile not meeting the specification.

Shrink Mark	<p>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.</p> <p>Note—This defect is cosmetic in nature and does not affect the structural serviceability.</p>	<p>Permitted if dimensional tolerances are met.</p>
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Note: Photo shown depicts profile meeting the specification.

TABLE 1 Continued

Name	Definition	Acceptance/Rejection Criteria
Sluffing	<p>A condition wherein scales peel off or become loose, either partially or entirely, from the pultrusion.</p> <p>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. <i>Sluffing</i> is sometimes spelled <i>sloughing</i>.</p> <p>Note—This defect is cosmetic in nature and does not affect the structural serviceability if Acceptance Criteria are met.</p>	Permitted if dimensional tolerances are met.



Note: Photo shown depicts profile meeting the specification.

Stop Mark	<p>A band, either dull or glossy, on the surface, approximately 0.5 in. to 4 in. (12.7 to 101.6 mm) long and extending around the periphery of a pultruded shape.</p> <p>Note—This condition is the result of an interruption in the normal continuous pulling operation.</p> <p>Note—This defect is cosmetic in nature and does not affect the structural serviceability unless a burn or thermal decomposition occurs. Reference the "Burn or Thermal Decomposition" section.</p>	Permitted, unless a burn or thermal decomposition occurs.
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Note: Photo shown depicts profile meeting the specification.

TABLE 1 Continued

Name	Definition	Acceptance/Rejection Criteria
Undercure	<p>Insufficient cross linking of polymer chains. Can appear as dull and bleached surface color evident in pultruded material not exposed to the weather. It could be caused by inadequate process temperature and or catalyst chemistry.</p> <p>Note—This defect affects the structural serviceability.</p>	Not acceptable.



Note: Photo shown depicts profile not meeting the specification.

Wrinkle Depression	<p>An undulation or series of undulations or waves on the surface of the pultruded part.</p> <p>Note—This condition can occur in either the lengthwise or crosswise direction of the pultrusion and is caused by reinforcement shifting and crowding. Reference the “Folded Reinforcement” section. Wrinkles affect the flatness of the surface.</p> <p>Note—This defect is cosmetic in nature and does not affect the structural serviceability if Acceptance Criteria are met.</p>	Depressions are permitted if less than 15 % of shape thickness and the minimum shape thickness and flatness specification are satisfied.
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Note: Photo shown depicts profile meeting the specification.

SUMMARY OF CHANGES

Committee D20 has identified the location of selected changes to this standard since the last issue (D4385 - 10) that may impact the use of this standard. (November 15, 2013)

- (1) Deleted Level 1 and 2 in acceptance criteria.
- (2) Added pictures depicting the defects along with the notes on acceptability of the product.
- (3) Added quantifiable definitions to **Table 1**.
- (4) Added defect related to veil slippage.

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