This document is not an ASTM standard and is intended only to provide the user of an ASTM standard an indication of what changes have been made to the previous version. Because it may not be technically possible to adequately depict all changes accurately, ASTM recommends that users consult prior editions as appropriate. In all cases only the current version of the standard as published by ASTM is to be considered the official document.

Designation: ~~D3935 – 15~~ D3935 – 21

Standard Classification System and Basis for Specification for Polycarbonate (PC) Unfilled and Reinforced Material[1]

This standard is issued under the fixed designation D3935; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This classification system covers unfilled and reinforced polycarbonate and polycarbonate copolymer materials suitable for injection molding, blow molding, and extrusion. Some of these compositions may also find use for compression molding or application from solution. This classification system allows for the use of recycled materials provided that all specification requirements are met.

1.2 The properties in this classification system are those required for identifying the compositions covered. Other requirements necessary for identifying particular characteristics important to specific applications are normally specified by using the suffixes in accordance with Section 5.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 This classification system and subsequent line callout (specification) are intended to provide a means of calling out plastic materials used in the fabrication of end items or parts. It is not intended for the selection of materials. Material selection should be made by those having expertise in the plastic field only after consideration of the design and the performance required of the part, the environment to which it will be exposed, the fabrication process to be employed, the costs involved, and the inherent properties of the material other than those covered in this standard.

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NOTE 1—This classification system and ~~ISO 7391-1~~ISO 21305-1 and ~~ISO 7391-2~~ISO 21305-2 address the same subject matter, but differ in technical content.

1.5 The following precautionary caveat pertains only to the test methods portion, Section 12, of this classification system. ~~*This*~~ *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*~~ *safety, health, and* ~~*health*~~*environmental practices and determine the applicability* ~~*or*~~*of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D256 Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics

[1] This standard is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.15 on Thermoplastic Materials.

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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.

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

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D638 Test Method for Tensile Properties of Plastics
D648 Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position
D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
D883 Terminology Relating to Plastics
D1238 Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
D1600 Terminology for Abbreviated Terms Relating to Plastics
D2584 Test Method for Ignition Loss of Cured Reinforced Resins
D3892 Practice for Packaging/Packing of Plastics
D4000 Classification System for Specifying Plastic Materials
D5630 Test Method for Ash Content in Plastics
~~D7209 Guide for Waste Reduction, Resource Recovery, and Use of Recycled Polymeric Materials and Products (Withdrawn 2015)~~[3]
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
E169 Practices for General Techniques of Ultraviolet-Visible Quantitative Analysis

2.2 *ISO Standard:*[3]

~~ISO 7391-1~~ISO 21305-1 Plastics—Polycarbonate ~~Molding~~ (PC) Moulding and Extrusion ~~Materials (Part 1: Designation—2006)~~Materials—Part 1: Designation—System and Basis for Specification
~~ISO 7391-2~~ISO 21305-2 Plastics—Polycarbonate ~~Molding~~ (PC) Moulding and Extrusion ~~Materials (Part~~ Materials—Part 2: Preparation of Test Specimens and Determination of ~~Properties)~~Properties

3. Terminology

3.1 *Definitions*—The terminology used in this classification system is in accordance with Terminologies D883 and D1600. The polycarbonate materials are to be designated PC as specified in Terminology D1600.

4. Classification

4.1 Unfilled polycarbonate materials are classified into groups according to their composition. These groups are subdivided into classes and grades as shown in Table PC

TABLE 1 PC Polycarbonate Materials and Detail Requirements

NOTE 1— The values are for naturals; colors may be different.

Group	Description	Class	Description	Grade	Description[A]	Flow Rate,[B] Test Method D1238, g/10 min	Specific Gravity, Test Method D792	Izod Impact,[C] Test Methods D256, J/m, min	Tensile Yield Stress[D]	Elongation at Break[D]	Flexural Modulus,[E] Test Methods D790, MPa, min	Deflection Temperature, Test Method D648,[F] °C, min
									Test Method D638, MPa, min	Test Method D638, %, min		
01	PC	1	general purpose	1		>24	1.19–1.22		Use Table B to define these properties.			
				2		15 to 30	1.19–1.22		Use Table B to define these properties.			
				3		12 to 20	1.19–1.22	640	55	100	2000	126
				4		9 to 18	1.19–1.22	750	60	105	2100	126
				5		6 to 13	1.19–1.22	750	60	110	2200	128
				6		4 to 8	1.19–1.22	750	60	110	2200	128
				7		<5	1.19–1.22	780	60	110	2200	130
				0	other	...	...	...	...	...	...	...
		2	flame-retarded[G]	1		>24	1.19–1.22		Use Table B to define these properties.			
				2		15 to 30	1.19–1.22		Use Table B to define these properties.			
				3		12 to 20	1.19–1.22	640	55	100	2000	126
				4		9 to 18	1.19–1.22	640	60	100	2100	126
				5		6 to 13	1.19–1.22	640	60	105	2200	128
				6		4 to 8	1.19–1.22	640	60	110	2200	128
				7		<5	1.19–1.22	640	60	110	2200	130
				0	other	...	...	...	...	...	...	...
		3	UV[H] stabilized	1		>24	1.19–1.22		Use Table B to define these properties.			
				2		15 to 30	1.19–1.22		Use Table B to define these properties.			
				3		12 to 20	1.19–1.22	640	55	100	2000	124
				4		9 to 18	1.19–1.22	750	60	105	2100	124
				5		6 to 13	1.19–1.22	750	60	110	2100	126
				6		4 to 8	1.19–1.22	750	60	110	2200	126

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

TABLE 1 *Continued*

NOTE 1— The values are for naturals; colors may be different.

Group	Description	Class	Description	Grade	Description[A]	Flow Rate,[B] Test Method D1238, g/10 min	Specific Gravity, Test Method D792	Izod Impact,[C] Test Methods D256, J/m, min	Tensile Yield Stress[D] Test Method D638, MPa, min	Elongation at Break[D] Test Method D638, %, min	Flexural Modulus,[E] Test Methods D790, MPa, min	Deflection Temperature, Test Method D648,[F] °C, min
				7		<5	1.19–1.22	750	60	110	2200	128
				0	other	...	...	...	...	...	...	...
		4	impact-modified	1		6 to 15	1.18–1.22	375[I]	50	90	1900	121
				0	other	...	...	...	...	...	...	...
		5	FDA[J] compliant formulations	1		>24	1.19–1.22		Use Table B to define these properties.			
				2		15 to 30	1.19–1.22		Use Table B to define these properties.			
				3		12 to 20	1.19–1.22	640	55	100	2000	126
				4		9 to 18	1.19–1.22	750	60	105	2100	126
				5		6 to 13	1.19–1.22	750	60	110	2200	128
				6		4 to 8	1.19–1.22	750	60	110	2200	128
				7		<5	1.19–1.22	780	60	110	2200	130
				0	other	...	...	...	...	...	...	...
		0	other	0	other	...	...	...	...	...	...	...
02	PC copolymer-flame retarded	1	general purpose	1		>24	1.22–1.26		Use Table B to define these properties.			
				2		15 to 30	1.22–1.26		Use Table B to define these properties.			
				3		12 to 20	1.22–1.26	80	60	100	2100	128
				4		9 to 18	1.22–1.26	80	60	110	2200	128
				5		6 to 13	1.22–1.26	90	60	110	2200	130
				6		4 to 8	1.22–1.26	90	60	110	2200	130
				7		<5	1.22–1.26	90	60	110	2200	132
				0	other	...	...	...	...	...	...	...
		2	UV[H] stabilized	1		>24	1.22–1.26		Use Table B to define these properties.			
				2		15 to 30	1.22–1.26		Use Table B to define these properties.			
				3		12 to 20	1.22–1.26	80	60	100	2100	126
				4		9 to 18	1.22–1.26	80	60	110	2200	126
				5		6 to 13	1.22–1.26	90	60	110	2200	128
				6		4 to 8	1.22–1.26	90	60	110	2200	130
				7		<5	1.22–1.26	90	60	110	2200	130
				0	other	...	...	...	...	...	...	...
		0	other	0	other	...	...	...	...	...	...	...
03	PC copolymer high-heat resin	1	general purpose	1		TBD	1.18–1.22	80	63	40	1700	150
				0	other	...	...	...	...	...	...	...
		2	UV[H] stabilized	1		TBD	1.18–1.22	80	63	40	1700	148
				0	other	...	...	...	...	...	...	...
		3	impact-modified	1		TBD			Use Table B to define these properties.			
				0	other	...	...	...	...	...	...	...
		4	FDA[J] compliant formulation	1		TBD	1.18–1.22	80	63	40	1700	150
				0	other	...	...	...	...	...	...	...
		0	other	0	other	...	...	...	...	...	...	...
04	PC copolymer homopolymer intermediate heat blends	1	general purpose	1		TBD	1.18–1.22	480	65	60	1900	138
				0	other	...	...	...	...	...	...	...
		2	UV[H] stabilized	1		TBD	1.18–1.22	480	65	60	1900	136
				0	other	...	...	...	...	...	...	...
		3	impact-modified	1		TBD			Use Table B to define these properties.			
				0	other	...	...	...	...	...	...	...
		4	FDA[J] compliant formulation	1		TBD	1.18–1.22	480	65	60	1900	138
				0	other	...	...	...	...	...	...	...
		0	other	0	other	...	...	...	...	...	...	...
05	PC copolymer low-heat standard flow	1	general purpose	1		>50	1.18–1.22		Use Table B to define these properties.			
				2		nominal 45	1.18–1.22	570	50	100	2070	104
				3		nominal 29	1.18–1.22	620	50	100	2070	106
				4		nominal 18	1.18–1.22	770	50	100	2160	107
				5		nominal 10	1.18–1.22	810	50	100	2200	108
				0	other	...	...	...	...	...	...	...
		2	UV[H] stabilized	1		>50	1.18–1.22		Use Table B to define these properties.			
				2		nominal 45	1.18–1.22	570	50	100	2070	102
				3		nominal 29	1.18–1.22	620	50	100	2070	104
				4		nominal 18	1.18–1.22	770	50	100	2160	105
				5		nominal 10	1.18–1.22	810	50	100	2200	106
				0	other	...	...	...	...	...	...	...
		3	impact-modified	0	other	...	...	...	...	...	...	...
		4	FDA[J] compliant formulations	1		>50	1.18–1.22		Use Table B to define these properties.			
				2		nominal 45	1.18–1.22	570	50	100	2070	104
				3		nominal 29	1.18–1.22	620	50	100	2070	106
				4		nominal 18	1.18–1.22	770	50	100	2160	107
				5		nominal 10	1.18–1.22	810	50	100	2200	108

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TABLE 1 *Continued*

NOTE 1— The values are for naturals; colors may be different.

Group	Description	Class	Description	Grade	Description[A]	Flow Rate,[B] Test Method D1238, g/10 min	Specific Gravity, Test Method D792	Izod Impact,[C] Test Methods D256, J/m, min	Tensile Yield Stress[D] Test Method D638, MPa, min	Elongation at Break[D] Test Method D638, %, min	Flexural Modulus,[E] Test Methods D790, MPa, min	Deflection Temperature, Test Method D648,[F] °C, min
				0	other	...	...	...	...	...	...	...
		5	flame-retarded[G]	1		TBD	1.18–1.22		Use Table B to define these properties.			
				0	other	...	...	...	...	...	...	...
		0	other	0	other	...	...	...	...	...	...	...
06	PC copolymer low-heat easy flow	1	general purpose	1		TBD	1.18–1.22		Use Table B to define these properties.			
				0	other	...	...	...	...	...	...	...
		2	UV stabilized[H]	1		TBD	1.18–1.22		Use Table B to define these properties.			
				0	other	...	...	...	...	...	...	...
		3	impact-modified	1		TBD	1.17–1.22		See above			
				0	other	...	...			...	...	...
		4	FDA[J] compliant formulations	1		TBD	1.18–1.22		Use Table B to define these properties.			
				0	other	...	...	...	...	...	...	...
		5	flame-retarded[G]	1		TBD	1.18–1.22		Use Table B to define these properties.			
				0	other	...	...	...	...	...	...	...
		0	other	0	other	...	...	...	...	...	...	...
99	PC other[I]	0	other	0	other	...	...	...	...	...	...	...

[A] All grades are listed by performance requirements.
[B] Use condition 300/1.2 for Groups 01, 02, and 05. Define the conditions for other groups in the suffixes as needed.
[C] Test specimens are 3.2 mm thick, with a notch radius of 0.25 mm, tested by Method A.
[D] Test specimens are Type I tensile bars, 3.2 mm thick, tested at a crosshead speed of 50 mm/min.
[E] Test specimens are 3.2 by 12.7 mm, tested by Method I, Procedure A (Tangent), at a crosshead speed of 1.3 mm/min and a span-to-depth ratio of 16 to 1.
[F] Test specimens are 3.2 mm thick, tested at 1820 kPa, and are not annealed before testing.
[G] Use suffix letter F, with the appropriate letters and digits specified in Classification D4000, to define specific requirements.
[H] Refer to Practices E169 for testing procedure. Specific requirements shall be stated in the purchase order or contract.
[I] Test specimens for Group 1, Class 4, Grade 1 are 6.4 mm thick with a notch radius of 0.25 mm and are tested by Method A.
[J] Manufactured in compliance with Food Additive Regulation 21CFR177.1580 governing polycarbonate resins for food-contact applications..

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NOTE 2—An example of this classification system is as follows: the designation PC0214 indicates:

PC	= polycarbonate as found in Terminology D1600,
02	= polycarbonate copolymer-flame retarded (group),
1	= general purpose (class), and
4	= requirements given in Table PC.

4.1.1 To facilitate the specification of new, special, or recycled materials, the "other" category (0) for class or grade, or both, is used as indicated in Table PC. The properties of these materials are specified using Tables A, B, or R as they apply.

4.2 Reinforced, pigmented, filled, and lubricated versions of polycarbonate materials are classified in accordance with Tables PC and A, B, or R. Table PC is used to specify basic materials. Table A or B is used to specify the property requirements after the addition of reinforcement, pigments, fillers, or lubricants at the nominal level indicated (see 4.2.1). Table R is used for recycled materials.

4.2.1 A single letter is used to indicate the major category of the reinforcement, along with two numbers indicating the nominal percentage of additive(s) by mass, with the tolerances as tabulated as follows:

Category	Material	Tolerance (Based on the Total Mass)
C	carbon and graphite fiber-reinforced	±2 percentage points
G	glass-reinforced	
	<15 % glass content	±2 percentage points
	>15 % glass content	±3 percentage points
L	lubricants (such as PTFE, graphite, silicone, and molybdenum disulfide)	depends on material and process—to be specified
M	mineral-reinforced	±2 percentage points
R	combination/mixtures of reinforcements or other fillers/ reinforcements	±3 percentage points based on total reinforcement

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NOTE 3—If necessary, additional requirements are specified using suffixes, in accordance with Section 5. The ash content of filled or reinforced materials is determined using Test Method D2584 where applicable.

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4.2.2 Specific requirements for reinforced, filled, or lubricated polycarbonate materials shall be shown by a six-character designation that will consist of the letter A or B and the five digits comprising the cell numbers for the property requirements in the order in which they occur in Table A or B.

4.2.2.1 Although the values listed in Tables A and B are necessary to include the range of properties available in existing materials, users should not infer that every possible combination of the properties exists or can be obtained.

4.2.3 When the grade of the basic material is not shown, or is not important, a "0" grade classification shall be used for reinforced materials in this system.

NOTE 4—An example of this classification system for reinforced polycarbonate material is as follows: the designation PC0110G10A22230 indicates:

PC0110	= general-purpose polycarbonate from Table PC,
G10	= glass reinforced at nominal 10 % level,
A	= Table A property requirements,
2	= 60-MPa tensile strength, min,
2	= 3000-MPa flexural modulus, min,
2	= 80-J/m Izod impact strength, min,
3	= 125°C deflection temperature, min, and
0	= unspecified.

If no properties are specified, the designation is PC0110G10A00000.

4.3 Table B has been incorporated into this classification system to facilitate the classification of special materials where Table PC or Table A do not reflect the required properties. Table B shall be used in the same manner as Table A.

NOTE 5—The mechanical properties of polycarbonates can be affected by the amounts and types of additives and colorants used. The most often observed effect is a change in the ductility of the material as evidenced in reductions of up to 90 % in Izod impact strength and 25 % or more in tensile elongation. A classification using Table PC and Table B should be used if properties of pigmented or specially formulated polycarbonates need to be specified.

NOTE 6—An example of the use of this classification system for a special polycarbonate material is as follows: the designation PC0110B34720 indicates:

PC0110	= general-purpose polycarbonate from Table PC,
B	= Table B property requirements,
3	= 60-MPa tensile strength, min,
4	= 2100-MPa flexural modulus, min,
7	= 640-J/m Izod impact strength, min,
2	= 105°C deflection temperature, min, and
0	= unspecified.

NOTE 7—The short- and long-term mechanical properties of polycarbonate materials can be affected adversely by their prior processing as well as end-use exposure to chemicals, weathering, and secondary finishing steps. Efforts to reuse materials may include direct feedback into the system from which they are generated, or they could involve isolation for reuse at other times into other processes or parts. Most manufacturer's literature contains recommendations regarding direct feedback practices to aid the user in maintaining the properties of the original materials as much as possible. When polycarbonate resins are isolated and reprocessed in conjunction with fillers, additives, colorants, etc., there is a special risk that the properties of the final products may not be equal to those obtained when "virgin" resins are used. While the test specimen properties called out in this classification system may be used to screen these materials, the user should take precautions to ensure that parts made from these materials meet the desired parameters. Group and class designations from Table PC, used in conjunction with Grade Designation 0, allow line callouts to be defined for recycled resins. The group, class, and grades given should be used with the property ranges from Table R, as appropriate. Table R lists two impact and two tensile properties to allow callouts for both filled and unfilled resins. It is intended that only one be used in a given callout and that the unused properties be given an 0, "unspecified," cell designation.

5. Suffixes

5.1 When requirements not covered by the basic cell tables need to be specified, suffixes shall be defined in accordance with Classification D4000.

5.2 Requirements specified by suffix references always take precedence over values from the property or cell tables for the same properties.

6. General Requirements

6.1 The plastic compositions shall be uniform and shall conform to the requirements herein.

7. Detail Requirements

7.1 Test specimens for the various materials shall conform to the requirements in accordance with Tables PC, A, B, and R and the suffix requirements, as they apply.

7.2 For the purpose of determining conformance, all specified limits for a specification (line callout) based on this classification system are absolute limits, as defined in Practice E29.

7.2.1 With the absolute method, an observed or calculated value is not rounded but is compared directly with the specified limiting value. Conformance, or lack thereof, is based on this comparison.

TABLE A Reinforced Polycarbonate Materials, Detail Requirements

Designation Order Number	Property	Cell Limits									
		0	1	2	3	4	5	6	7	8	9
1	Tensile strength, Test Method D638, MPa,[A] min at break	unspecified	40	60	80	100	120	140	160	180	[B]
2	Flexural modulus, Test Methods D790, MPa,[C] min	unspecified	2 100	3 000	4 500	6 000	7 500	9 000	10 500	12 000	[B]
3	Izod impact, Test Methods D256, Method A, J/m,[D] min	unspecified	58	80	100	120	140	160	180	200	[B]
4	Deflection temperature under load, Test Method D648, at 1.82 MPa, °C,[E] min	unspecified	105	120	125	140	145	151	157	160	[B]
5	To be determined	unspecified	...	...	...	...	...	...	...	...	...

[A] Test specimens are Type I bars at 3.2-mm thickness, tested at a crosshead speed of 5 mm/min.
[B] Specific value must be shown.
[C] Test specimens are 3.2 by 12.7 mm and tested by Method I, Procedure A (tangent), with a crosshead speed of 1.3 mm/min and a span-to-depth ratio of 16 to 1.
[D] Specimens are 3.2 mm thick with a notch radius of 0.25 mm.
[E] Test specimens are 3.2 mm thick and are not annealed before testing.

TABLE B Unreinforced Polycarbonate Materials, Detail Requirements

Designation Order Number	Property	Cell Limits									
		0	1	2	3	4	5	6	7	8	9
1	Tensile strength, Test Method D638, MPa,[A] min at yield	unspecified	40	50	60	70	80	90	100	110	[B]
2	Flexural modulus, Test Methods D790, MPa,[C] min	unspecified	1200	1500	1800	2100	2400	2700	3000	3300	[B]
3	Izod impact, Test Methods D256, Method A, J/m,[D] min	unspecified	55	105	210	315	420	530	640	750	[B]
4	Deflection temperature under load, Test Method D648, at 1.82 MPa, °C,[E] min	unspecified	100	105	120	125	130	145	157	160	[B]
5	To be determined	unspecified	...	...	...	...	...	...	...	...	...

[A] Test specimens are Type I bars at 3.2-mm thickness, tested at a crosshead speed of 5 mm/min.
[B] Specific value must be shown.
[C] Test specimens are 3.2 by 12.7 mm and tested by Method I, Procedure A (tangent), with a crosshead speed of 1.3 mm/min and a span-to-depth ratio of 16 to 1.
[D] Specimens are 3.2 mm thick with a notch radius of 0.25 mm.
[E] Test specimens are 3.2 mm thick and are not annealed before testing.

TABLE R Recycled Polycarbonate Materials, Detail Requirements

Designation Order Number	Property	Cell Limits									
		0	1	2	3	4	5	6	7	8	9
1	Izod impact,[A] Test Methods D256, Method A, J/m, min	unspecified	53	80	105	270	430	535	640	750	[B]
2	Izod impact,[A] Test Methods D256, Method E, J min force resulting in "no breaks"	unspecified	5	10	15	20	25	30	35	40	[B]
3	Flexural modulus,[C] , Test Methods D790, MPa, min Procedure A (tangent) at 1.3-mm/min test speed	unspecified	1 200	1 800	2 400	3 000	5 000	7 000	10 000	12 000	[B]
4	Tensile strength at yield,[D] Test Method D638, MPa, min (use with unreinforced resins at test speed 50 mm/min)	unspecified	40	50	60	70	80	90	100	110	[B]
5	Tensile strength at break,[D] Test Method D638, MPa, min (use with reinforced resins at test speed 5 mm/min)	unspecified	40	60	80	100	120	140	160	180	[B]

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[A] Specimens are 3.2 mm thick with a notch radius of 0.25 mm.
[B] Specific value must be shown.
[C] Test specimens are 3.2 by 12.7 mm and tested by Method I with a span-to-depth ratio of 16 to 1.
[D] Test specimens are Type I bars at 3.2-mm thickness.