~~Designation:D578–05~~ Designation: D578/D578M – 05 (Reapproved 2011)$^{\varepsilon 1}$

Standard Specification for Glass Fiber Strands[1]

This standard is issued under the fixed designation D578/D578M; 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 Department of Defense.

ε^1 NOTE—Editorial changes were made throughout in August 2011.

1. Scope

~~1.1This specification covers the requirements for continuous fiber and staple fiber glass strands, including single, plied and multiple wound. It also covers textured glass fiber yarns.~~

1.1 This specification covers the requirements for continuous fiber and staple fiber glass strands, including single, plied and multiple wound. It also covers textured glass fiber yarns. This specification is intended to assist ultimate users by designating the general nomenclature for the strand products that age generally manufactured in the glass fiber industry.

1.2 Glass fibers are produced having various compositions. General applications are identified by means of a letter designation. The letter designation represents a family of glasses that have provided acceptable performance to the end-user in the intended application. For example, the composition limits stated for E-Glass in this specification representing the glass fiber family for general and most electrical applications is designated by the letter *E*. Military specifications, such as, MIL-R-60346, recognize the composition limits described in this specification as meeting the respective requirements for E-Glass strands used in reinforced plastic structure applications. ~~This specification is intended to assist ultimate users by designating the general nomenclature for the strand products that are generally manufactured in the glass fiber industry.~~

1.3 Glass fiber strands have a variety of general uses under specific conditions, such as high physical or chemical stress, high moisture, high temperature, or electrical environments. Property requirements under specific conditions are agreed upon between the purchaser and the supplier. Electrical property requirements vary with specific end-use applications. For printed circuit board applications, other requirements may be needed such as the use of Institute for Interconnecting and Packaging Electronic Circuits (IPC) Specification ~~EG-4412~~EG 4412 A for finished fabric woven from E-Glass for printed circuit boards, or Specification MIL-P-13949 for printed wiring boards applicable to glass fabric base.

~~1.4This specification shows the values in both SI units and inch-pound units. "SI" units is the technically correct name for the system of metric units known as the International System of Units." Inch-pound units" is the technically correct name for the customary units used in the United States. The values stated in either acceptable metric units or in other units shall be regarded separately as standard. The values expressed in each system may not be exact equivalents; therefore, each system must be used independently of the other, without combining in any way.~~

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.5 This specification is one of a series to provide a substitute for Military Specifications: MIL-Y-1140 Yarn, Cord, Sleeving, Cloth and Tape-Glass; and MIL-C-9084 Cloth, Glass Finished for Resin Laminates.

1.6 Additional ASTM specifications in this series have been drafted and appear in current editions of the *Annual Book of ASTM Standards*. These include finished glass fabrics, unfinished glass fabrics, glass tapes, glass sleevings, glass cords, glass sewing threads, and finished laminates made from finished glass fabrics.

1.7 *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:*~~

[1] This specification is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.18 on Glass Fiber and its Products.

~~Current edition approved Sept. 15, 2005. Published October 2005. Originally approved in 1940. Last previous edition approved in 2000 as D578–00. DOI: 10.1520/D0578-05.~~

Current edition approved July 1, 2011. Published September 2011. Originally approved in 1940. Last previous edition approved in 2005 as D578 – 05. DOI: 10.1520/D0578-05R11E01.

D76Specification for Tensile Testing Machines for Textiles ASTM Standards:[2]
D123 Terminology Relating to Textiles
D1423 Test Method for Twist in Yarns by Direct-Counting
D1907 Test Method for Linear Density of Yarn (Yarn Number) by the Skein Method
D22562256/D2256M Test Method for Tensile Properties of Yarns by the Single-Strand Method
D2258 Practice for Sampling Yarn for Testing
D2904 Practice for Interlaboratory Testing of a Textile Test Method that Produces Normally Distributed Data
D2906 Practice for Statements on Precision and Bias for Textiles
D4963 Test Method for Ignition Loss of Glass Strands and Fabrics
D7018 Terminology Relating to Glass Fiber and Its Products
E171Specification for Atmospheres for Conditioning and Testing Flexible Barrier Materials Terminology Relating to Glass Fiber and Its Products

2.2 *ASTM Adjunct:*
TEX-PAC [3]
2.3 *ANSI Standard:*
ANSI/ASQC Z1.4 Sampling Procedures for Inspection by Attributes[4]
2.4 *Military Standards and Specifications:*
MIL-P-13949 Specification for Plastic Sheet, Laminated, Metal-Clad For Printed Wiring Board[5]
MIL-R-60346 Roving, Glass Fibrous (for Prepreg Tape, Rovings, Filament Winding, and Pultrusion Applications)[5]
MIL-G-55636B Glass Cloth, Resin Preimpreginated (B-STAGE) (For Multilayer Printed Wiring Boards)[5]
MIL-Y-1140 Specification for Yarn, Cord, Sleeving, Cloth, and Tape-Glass[5]
MIL-C-9084 Specification for Cloth Finished for Resin Laminates[5]
2.5 *Institute for Interconnecting and Packaging Circuits Standard:*
IPC-EG-4412IPC EG 4412 A Specification for Finished Fabric Woven from E-Glass for Printed Circuit Boards[6]

3. Terminology

3.1 For all terminology related to D13.18, Glass Fiber and Its Products, see Terminology D7018.
3.1.1 The following terms are relevant to this standard: atmosphere for testing textiles, chopped strand, continuous filament yarn, roving, staple glass yarn, strand, textured glass yarn.
3.2 For allother terminology related to textiles, refer to Terminology D123.

4. Classification of Glass Fiber

4.1 *"C" Glass*—A family of glasses composed primarily of the oxides of sodium, calcium, boron, aluminum, and silicon with a certified chemical composition which conforms to an applicable material specification and which produces good acid resistance (excluding HF).
4.2 *"E" Glass*—A family of glasses composed primarily of the oxides of calcium, aluminum, and silicon, which has the following certified chemical compositions.
4.2.1 The following certified chemical composition applies to glass fiber yarn products for printed circuit boards and aerospace.

Chemical	% by Weight
B_2O_3	5 to 10
CaO	16 to 25
Al_2O_3	12 to 16
SiO_2	52 to 56
MgO	0 to 5
Na_2O and K_2O	0 to 2
TiO_2	0 to 0.8
Fe_2O_3	0.05 to 0.4
Fluoride	0 to 1.0

4.2.2 The following certified chemical composition applies to glass fiber products used in general applications.

Chemical	% by Weight
B_2O_3	0 to 10
CaO	16 to 25
Al_2O_3	12 to 16

[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] PC programs on floppy disk for analyzing Committee D13 interlaboratory data are available through ASTM. Request ADJD2904.
[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.
[5] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.
[6] Available from Institute for Interconnecting and Packaging Electronic Circuits, 7380 N. Lincoln Ave., Lincolnwood, IL 60646.

SiO_2	52 to 62
MgO	0 to 5
Total alkali metal oxides	0 to 2
TiO_2	0 to 1.5
Fe_2O_3	0.05 to 0.8
Fluoride	0 to 1.0

4.2.3 Electrical applications include a wide variety of uses. The composition in 4.2.1 ~~is identical to IPC-EG-4412~~ is identical to IPC EG 4412 A for printed circuit boards and to MIL-G-55636B. Additionally, such fiber glass products often are specified for aerospace applications. Products covered by the composition range in 4.2.2 are used in general applications, such as power company equipment, high voltage devices, residential electric boxes, third rail covers, high voltage standoff rods, electrical pultrusion products, light poles, electrical tool covers, and electrical tape. Other applications include roofing, flooring, filtration, panel rovings, gun rovings, smc rovings, chopped strand reinforcements, paper yarns, and industrial yarns.

4.2.4 The nomenclature "E-CR-Glass" is used for boron-free modified E-Glass compositions for improved resistance to corrosion by most acids.

4.3 *"S" Glass*—~~A family of glasses composed primarily of the oxides of magnesium, aluminum, and silicon with a certified chemical composition which conforms to an applicable material specification and which produces high mechanical strength.~~

~~**DESCRIPTION OF GLASS STRANDS —A family of glasses composed primarily of the oxides of magnesium, aluminum, and silicon with a certified chemical composition which conforms to an applicable material specification and which produces high mechanical strength.**~~

4.4 *"R"Glass*—A family of boron-free glasses composed primarily of the oxides of silicon, aluminum, calcium and magnesium, such glasses possessing excellent acid and water durability as well as specific strength and specific modulus levels significantly greater than E glass.

DESCRIPTION OF GLASS STRANDS

5. General

5.1 The construction of glass strands is described in a series of two to four segments of alphabetical or numerical characters.

NOTE 1—In glass fiber strand designations, and in the conversion of yards per pound to tex units, the following rules are used:
(1) less than 2.50 tex—round to nearest 0.01 tex
(2) 2.50 tex to less than 5.00 tex—round to nearest 0.05 tex
(3) 5.00 tex to less than 10.0 tex—round to nearest 0.1 tex
(4) 10.0 tex to less than 250 tex—round to nearest 1.0 tex
(5) 250 tex to less than 2000 tex—round to nearest 5.0 tex
(6) 2000 tex to less than 100 000 tex—round to nearest 100 tex

5.1.1 For strands described in inch-pound units, the approximate yards per pound of the final strand can be computed by multiplying the yarn number designation of the single yarn or strand by 100 to obtain yards per pound for the single yarn or strand and then dividing by the total number of single yarns or strands in the final yarn. Actual yardage is less because of organic content and twist take-up during plying.

~~NOTE 2—Letter designations for filament diameter averages are shown in Table 1. The yards per pound stated in Table 2 is an approximate yarn number. The "As Received" yards per pound will be less than the bare glass values stated. This may be contributed by twist take-up, sizing percent, or purchaser agreement to produce to a lower yarn number to meet other requirements for a further manufactured product, or both. For example, EC9 66 1×0 (ECG 75 1/0) stated at approximately 66 tex (7500 yd/lb) will actually be about 68 tex (7300 yd/lb) in the delivered state for use in the electrical laminate industry."~~

TABLE 1 Letter Designations for Glass Strand Filament Diameters

Filament Size Designation		Nominal Range for Filament Diameter Average	
Inch-Pound System, Letter	SI System, Number	in.	μm[A]
B	3.5	0.00013 to 0.000159	3.30 to 4.05
C	4.5	0.00016 to 0.000189	4.06 to 4.82
D	5	0.00019 to 0.000229	4.83 to 5.83
DE	6	0.00023 to 0.000269	5.84 to 6.85
E	7	0.00025 to 0.000299	6.35 to 7.61
F	8	0.00030 to 0.000345	7.62 to 8.88
G	9	0.00035 to 0.000399	8.89 to 10.15
H	11	0.00040 to 0.000449	10.16 to 11.42
J	12	0.00045 to 0.000499	11.43 to 12.69
K	13	0.00050 to 0.000549	12.70 to 13.96
L	14	0.00055 to 0.000599	13.97 to 15.23
M	16	0.00060 to 0.000649	15.24 to 16.50
N	17	0.00065 to 0.000699	16.51 to 17.77
P	18	0.00070 to 0.000749	17.78 to 19.04
Q	20	0.00075 to 0.000799	19.05 to 20.31
R	21	0.00080 to 0.000849	20.32 to 21.58
S	22	0.00085 to 0.000899	21.59 to 22.85
T	23	0.00090 to 0.000949	22.86 to 24.12
U	24	0.00095 to 0.000999	24.13 to 25.40

[A] The low values stated for each micrometre range are exact equivalents to inches, rounded to the nearest hundredth micrometre. The high values stated for each micrometre range are slightly higher than exact equivalents to inches to provide continuation between ranges. They are consistent for inch-pound and SI filament size descriptions commonly used in the industry. In some publications, the SI designation for H filament size has been shown as 10.

TABLE 2 Physical Properties of Continuous Filament Yarns

Yarn Designation[A]		Nominal Twist				Approximate Yarn Number (Bare Glass)[B]		Breaking Strength, Individual Minimum	
		"Z"		"S"					
SI Unit (tex)	Inch-Pound Unit	tpm	tpi	tpm	tpi	tex	yd/lb	N	lbf
EC5 2.75 1×0	ECD 1800 1/0	20 to 40	0.5 to 1.0	...	...	2.75	180 000	1.1	0.25
EC5 2.75 1×2	ECD 1800 1/2	...	...	152 to 176	3.8 to 4.4	5.5	90 000	...	...
EC5 5.5 1×0	ECD 900 1/0	20 to 40	0.5 to 1.0	...	...	5.5	90 000	2.2	0.5
EC5 5.5 1×0	ECD 900 1/0	160 to 200	4.0 to 5.0	...	...	5.5	90 000	2.2	0.5
EC5 5.5 1×0	ECD 900 1/0	120 to 160	3.0 to 4.0	...	...	5.5	90 000	2.2	0.5
EC5 5.5 1×0	ECD 900 1/0	400	10.0	...	...	5.5	90 000	2.2	0.5
EC6 8.25	ECDE 600 1/0	20 to 40	0.5 to 1.0	...	...	8.25	60 000	3.3	0.75
EC5 5.5 1×2	ECD 900 1/2	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	11	45 000	4.9	1.1
EC5 5.5 1×2	ECD 900 1/2	...	...	340	8.5	11	45 000	4.9	1.1
EC5 11 1×0	ECD 450 1/0	20 to 40	0.5 to 1.0	...	...	11	45 000	4.9	1.1
EC5 11 1×0	ECD 450 1/0	40 to 80	1.0 to 2.0	...	...	11	45 000	4.9	1.1
EC5 11 1×0	ECD 450 1/0	80 to 120	2.0 to 3.0	...	...	11	45 000	4.9	1.1
EC5 11 1×0	ECD 450 1/0	160 to 200	4.0 to 5.0	...	...	11	45 000	4.9	1.1
EC5 11 1×0	ECD 450 1/0	400	10	...	...	11	45 000	...	...
EC6 16 1×0	ECDE 300 1/0	20 to 40	0.5 to 1.0	...	...	16	30 000	8.0	1.9
EC5 5.5 1×3	ECD 900 1/3	...	...	152 to 176	3.8 to 4.4	16.5	30 000	8.0	1.8
EC5 5.5 1×3	ECD 900 1/3	...	...	340	8.5	16.5	30 000	8.0	1.8
EC5 11 2×0	ECD 450 2/0	160 to 200	4.0 to 5.0	...	...	22	22 500	9.8	2.2
EC5 11 1×2	ECD 450 1/2	...	...	60	1.5	22	22 500	9.8	2.2
EC5 11 1×2	ECD 450 1/2	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	22	22 500	9.8	2.2
EC5 11 1×2	ECD 450 1/2	...	...	340	8.5	22	22 500	9.8	2.2
EC5 22 1×0	ECD 225 1/0	40 to 80	1.0 to 2.0	...	...	22	22 500	10.7	2.4
EC5 22 1×0	ECD 225 1/0	20 to 40	0.5 to 1.0	...	...	22	22 500	10.7	2.4
EC5 22 1×0	ECD 225 1/0	160 to 200	4.0 to 5.0	...	...	22	22 500	10.7	2.4
EC7 22 1×0	ECE 225 1/0	20 to 40	0.5 to 1.0	...	...	22	22 500	9.8	2.2
EC7 22 1×0	ECE 225 1/0	160 to 200	4.0 to 5.0	...	...	22	22 500	9.8	2.2
EC7 22 1×0	ECE 225 1/0	400	10.0	...	...	22	22 500	9.8	2.2
EC5 11 3×0	ECD 450 3/0	160 to 200	4.0 to 5.0	...	...	33	15 000	17.3	3.9
EC5 11 1×3	ECD 450 1/3	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	33	15 000	17.3	3.9
EC5 11 1×3	ECD 450 1/3	...	...	340	8.5	33	15 000	17.3	3.9
EC3.5 33 1×0	ECB 150 1/0	20 to 40	0.5 to 1.0	...	...	33	15 000	17.8	4.0
EC3.5 33 1×0	ECB 150 1/0	120 to 160	3.0 to 4.0	...	...	33	15 000	17.8	4.0
EC4.5 33 1×0	ECC 150 1/0	20 to 40	0.5 to 1.0	...	...	33	15 000	15.6	3.5
EC4.5 33 1×0	ECC 150 1/0	120 to 160	3.0 to 4.0	...	...	33	15 000	15.6	3.5
EC6 33 1×0	ECDE 150 1/0	20 to 40	0.5 to 1.0	...	...	33	15 000	15.6	3.5
EC6 33 1×0	ECDE 150 1/0	90	2.25	...	...	33	15 000	15.6	3.5
EC6 33 1×0	ECDE 150 1/0	120 to 160	3.0 to 4.0	...	...	33	15 000	15.6	3.5
EC9 33 1×0	ECG 150 1/0	20 to 40	0.5 to 1.0	...	...	33	15 000	13.3	3.0
EC9 33	ECG 150	40 to 80	1.0 to 2.0	...	...	33	15 000	13.3	3.0

TABLE 2Physical Properties of Continuous Filament Yarns

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SI Unit (tex)	Inch-Pound Unit	tpm	tpi	tpm	tpi	tex	yd/lb	N	lbf
EC5 2.75 1×0	ECD 1800 1/0	20 to 40	0.5 to 1.0	...	...	2.75	180000	1.1	0.25
EC5 2.75 1×2	ECD 1800 1/2	...	...	152 to 176	3.8 to 4.4	5.5	90000	...	...
EC5 5.5 1×0	ECD 900 1/0	20 to 40	0.5 to 1.0	...	...	5.5	90000	2.2	0.5
EC5 5.5 1×0	ECD 900 1/0	160 to 200	4.0 to 5.0	...	...	5.5	90000	2.2	0.5
EC5 5.5 1×0	ECD 900 1/0	120 to 160	3.0 to 4.0	...	...	5.5	90000	2.2	0.5
EC5 5.5 1×0	ECD 900 1/0	400	10.0	...	...	5.5	90000	2.2	0.5
EC6 8.25	ECDE 600 1/0	20 to 40	0.5 to 1.0	...	...	8.25	60000	3.3	0.75
EC5 5.5 1×2	ECD 900 1/2	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	11	45000	4.9	1.1
EC5 5.5 1×2	ECD 900 1/2	...	...	340	8.5	11	45000	4.9	1.1
EC5 11 1×0	ECD 450 1/0	20 to 40	0.5 to 1.0	...	...	11	45000	4.9	1.1
EC5 11 1×0	ECD 450 1/0	40 to 80	1.0 to 2.0	...	...	11	45000	4.9	1.1
EC5 11 1×0	ECD 450 1/0	80 to 120	2.0 to 3.0	...	...	11	45000	4.9	1.1
EC5 11 1×0	ECD 450 1/0	160 to 200	4.0 to 5.0	...	...	11	45000	4.9	1.1
EC5 11 1×0	ECD 450 1/0	400	10	...	...	11	45000	...	...
EC6 16 1×0	ECDE 300 1/0	20 to 40	0.5 to 1.0	...	...	16	30 000	8.0	1.9
EC5 5.5 1×3	ECD 900 1/3	...	...	152 to 176	3.8 to 4.4	16.5	30000	8.0	1.8
EC5 5.5 1×3	ECD 900 1/3	...	...	340	8.5	16.5	30000	8.0	1.8
EC5 11 2×0	ECD 450 2/0	160 to 200	4.0 to 5.0	...	...	22	22500	9.8	2.2
EC5 11 1×2	ECD 450 1/2	...	...	60	1.5	22	22500	9.8	2.2
EC5 11 1×2	ECD 450 1/2	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	22	22500	9.8	2.2
EC5 11 1×2	ECD 450 1/2	...	...	340	8.5	22	22500	9.8	2.2
EC5 22 1×0	ECD 225 1/0	40 to 80	1.0 to 2.0	...	...	22	22500	10.7	2.4
EC5 22 1×0	ECD 225 1/0	20 to 40	0.5 to 1.0	...	...	22	22500	10.7	2.4
EC5 22 1×0	ECD 225 1/0	160 to 200	4.0 to 5.0	...	...	22	22500	10.7	2.4
EC7 22 1×0	ECE 225 1/0	20 to 40	0.5 to 1.0	...	...	22	22500	9.8	2.2
EC7 22 1×0	ECE 225 1/0	160 to 200	4.0 to 5.0	...	...	22	22500	9.8	2.2
EC7 22 1×0	ECE 225 1/0	400	10.0	...	...	22	22500	9.8	2.2
EC5 11 3×0	ECD 450 3/0	160 to 200	4.0 to 5.0	...	...	33	15000	17.3	3.9
EC5 11 1×3	ECD 450 1/3	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	33	15000	17.3	3.9
EC5 11 1×3	ECD 450 1/3	...	...	340	8.5	33	15000	17.3	3.9
EC3.5 33 1×0	ECB 150 1/0	20 to 40	0.5 to 1.0	...	...	33	15000	17.8	4.0
EC3.5 33 1×0	ECB 150 1/0	120 to 160	3.0 to 4.0	...	...	33	15000	17.8	4.0
EC4.5 33 1×0	ECC 150 1/0	20 to 40	0.5 to 1.0	...	...	33	15000	15.6	3.5
EC4.5 33 1×0	ECC 150 1/0	120 to 160	3.0 to 4.0	...	...	33	15000	15.6	3.5
EC6 33 1×0	ECDE 150 1/0	20 to 40	0.5 to 1.0	...	...	33	15000	15.6	3.5

TABLE *Continued*

Yarn Designation[A]		Nominal Twist				Approximate Yarn Number (Bare Glass)[B]		Breaking Strength, Individual Minimum	
		"Z"		"S"					
SI Unit (tex)	Inch-Pound Unit	tpm	tpi	tpm	tpi	tex	yd/lb	N	lbf
EC6 33 1×0	ECDE 150 1/0	90	2.25	...	...	33	15000	15.6	3.5
EC6 33 1×0	ECDE 150 1/0	120 to 160	3.0 to 4.0	...	...	33	15000	15.6	3.5
EC9 33 1×0	ECG 150 1/0	20 to 40	0.5 to 1.0	...	...	33	15000	13.3	3.0
EC9 33 1×0	ECG 150 1/0	40 to 80	1.0 to 2.0	...	...	33	15000	13.3	3.0
EC9 33 1×0	ECG 150 1/0	52	1.3	...	...	33	15000	13.3	3.0
EC9 33 1×0	ECG 150 1/0	120 to 160	3.0 to 4.0	...	...	33	15000	13.3	3.0
EC9 33 1×0	ECG 150 1/0	224	5.6	...	...	33	15000	13.3	3.0
EC9 33 1×0	ECG 150 1/0	280	7.0	...	...	33	15000	13.3	3.0
EC13 40HF 1×0	ECK 125 HF 1/0	20 to 40	0.5 to 1.0	...	...	40	12 500	14.2	3.2
EC5 11 4×0	ECD 450 4/0	160 to 200	4.0 to 5.0	...	...	44	11250	19.6	4.4
EC5 11 2×2	ECD 450 2/2	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	44	11250	19.6	4.4
EC5 22 2×0	ECD 225 2/0	160 to 200	4.0 to 5.0	...	...	44	11250	21.4	4.8
EC5 22 1×2	ECD 225 1/2	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	44	11250	21.4	4.8
EC5 22 1×2	ECD 225 1/2	...	...	340	8.5	44	11250	21.4	4.8
EC7 22 2×0	ECE 225 2/0	160 to 200	4.0 to 5.0	...	...	44	11250	19.6	4.4
EC7 22 1×2	ECE 225 1/2	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	44	11250	19.6	4.4
EC7 22 1×2	ECE 225 1/2	...	...	340	8.5	44	11250	19.6	4.4
EC11 45 1×0	ECH 110 1/0	20 to 40	0.5 to 1.0	...	...	45	11000	18.2	3.9
EC6 50 1×0	ECDE 100 1/0	20 to 40	0.5 to 1.0	...	...	50	10000	17.8	4.0
EC6 50 1×0	ECDE 100 1/0	28	0.7	...	...	50	10000	17.8	4.0
EC6 50 1×0	ECDE 100 1/0	80	2.0	...	...	50	10000	17.8	4.0
EC9 50 1×0	ECG 100 1/0	20 to 40	0.5 to 1.0	...	...	50	10000	...	...
EC8 55 1×0	ECF 90 1/0	40	1.0	...	...	55	9000	27	6.0
EC5 11 3×2	ECD 450 3/2	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	66	7500	29.4	6.6
EC5 22 3×0	ECD 225 3/0	160 to 200	4.0 to 5.0	...	...	66	7500	32.0	7.2
EC5 22 1×3	ECD 225 1/3	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	66	7500	32.0	7.2
EC7 22 3×0	ECE 225 3/0	120 to 160	3.0 to 4.0	...	...	66	7500	29.4	6.6
EC7 22 3×0	ECE 225 3/0	160 to 200	4.0 to 5.0	...	...	66	7500	29.4	6.6
EC7 22 1×3	ECE 225 1/3	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	66	7500	29.4	6.6
EC3.5 33 2×0	ECB 150 2/0	80 to 120	2.0 to 3.0	...	...	66	7500	35.6	8.0
EC3.5 33 2×0	ECB 150 2/0	120 to 160	3.0 to 4.0	...	...	66	7500	35.6	8.0
EC3.5 33 1×2	ECB 150 1/2	...	...	112 to 152	2.8 to 3.8	66	7500	...	...
EC6 33 2×0	ECDE 150 2/0	120 to 160	3.0 to 4.0	...	...	66	7500	31.1	7.0
EC6 33 1×2	ECDE 150 1/2	...	...	112 to 152	2.8 to 3.8	66	7500	...	...
EC4.5 33 2×0	ECC 150 2/0	40 to 80	1.0 to 2.0	...	...	66	7500	47.2	10.6

TABLE *Continued*

Yarn Designation[A]		Nominal Twist				Approximate Yarn Number (Bare Glass)[B]		Breaking Strength, Individual Minimum	
		"Z"		"S"					
SI Unit (tex)	Inch-Pound Unit	tpm	tpi	tpm	tpi	tex	yd/lb	N	lbf
EC4.5 33 2×0	ECC 150 2/0	120 to 160	3.0 to 4.0	...	...	66	7500	33.4	7.5
EC9 33 2×0	ECG 150 2/0	120 to 160	3.0 to 4.0	...	...	66	7500	28.5	6.4
EC9 33 2×0	ECG 150 2/0	160 to 200	4.0 to 5.0	...	...	66	7500	28.5	6.4
EC9 33 2×0	ECG 150 2/0	224	5.6	...	...	66	7500	28.5	6.4
EC9 33 2×0	ECG 150 2/0	320	8.0	...	...	66	7500	28.5	6.4
EC9 33 1×2	ECG 150 1/2	120 to 160	3.0 to 4.0	112 to 152	2.8 to 3.8	66	7500	26.5	6.0
EC6 66 1×0	ECDE 75 1/0	20 to 40	0.5 to 1.0	...	...	66	7500	25.4	5.7
EC6 66 1×0	ECDE 75 1/0	28	0.7	...	...	66	7500	25.4	5.7
EC6 66 1×0	ECDE 75 1/0	40 to 80	1.0 to 2.0	...	...	66	7500	25.4	5.7
EC6 66 1×0	ECDE 75 1/0	120 to 160	3.0 to 4.0	...	...	66	7500	25.4	5.7
EC4.5 66 1×0	ECC 75 1/0	20 to 40	0.5 to 1.0	...	...	66	7500	25.4	5.7
EC4.5 66 1×0	ECC 75 1/0	40 to 80	1.0 to 2.0	...	...	66	7500	25.4	5.7
EC4.5 66 1×0	ECC 75 1/0	80 to 120	2.0 to 3.0	...	...	66	7500	25.4	5.7
EC4.5 66 1×0	ECC 75 1/0	120 to 160	3.0 to 4.0	...	...	66	7500	25.4	5.7
EC9 66 1×0	ECG 75 1/0	20 to 40	0.5 to 1.0	...	...	66	7500	25.4	5.7
EC9 66 1×0	ECG 75 1/0	78	0.7	...	...	66	7500	25.4	5.7
EC9 66 1×0	ECG 75 1/0	40 to 80	1.0 to 2.0	...	...	66	7500	25.4	5.7
EC9 66 1×0	ECG 75 1/0	120 to 160	3.0 to 4.0	...	...	66	7500	25.4	5.7
EC9 66 1×0	ECG 75 1/0	280	7.0	...	...	66	7500	25.4	5.7
EC9 66 1×0	ECG 75 1/0	320	8.0	...	...	66	7500	25.4	5.7
EC13 66 1×0	ECK 75 1/0	20 to 40	0.5 to 1.0	...	...	66	7500	25.4	5.7
EC13 66 1×0	ECK 75 1/0	80 to 120	2.0 to 3.0	...	...	66	7500	25.4	5.7
EC13 66 1×0	ECK 75 1/0	120 to 160	3.0 to 4.0	...	...	66	7500	25.4	5.7
EC5 22 4×0	ECD 225 4/0	120 to 160	3.0 to 4.0	...	...	88	5625	46.3	10.4
EC7 22 2×2	ECD 225 2/2	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	88	5625	42.7	9.6
EC7 22 2×2	ECE 225 2/2	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	88	5625	39.1	8.8
EC11 90 1×0	ECH 55 1/0	20 to 40	0.5 to 1.0	...	...	90	5500	42.3	9.5
EC13 90 1×0	ECK 55 1/0	20 to 40	0.5 to 1.0	...	...	90	5500	42.3	9.5
EC9 100 1×0	ECG 50 1/0	20 to 40	0.5 to 1.0	...	...	99	5 000	44.0	10.0
EC5 11 3×3	ECD 450 3/3	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	99	5000	44.0	9.9
EC6 33 3×0	ECDE 150 3/0	120 to 160	3.0 to 4.0	...	...	99	5000	...	...
EC6 33 1×3	ECDE 150 1/3	...	...	112 to 152	2.8 to 3.8	99	5000	46.7	10.5
EC4.5 33 3×0	ECC 150 3/0	40 to 80	1.0 to 2.0	...	...	99	5000	48.9	11.0
EC4.5 33 3×0	ECC 150 3/0	120 to 160	3.0 to 4.0	...	...	99	5000	48.9	11.0
EC9 33 3×0	ECG 150 3/0	120 to 160	3.0 to 4.0	...	...	99	5000	42.7	9.6

TABLE *Continued*

Yarn Designation[A]		Nominal Twist				Approximate Yarn Number (Bare Glass)[B]		Breaking Strength, Individual Minimum	
		"Z"		"S"					
SI Unit (tex)	Inch-Pound Unit	tpm	tpi	tpm	tpi	tex	yd/lb	N	lbf
EC9 33 3×0	ECG 150 3/0	160 to 200	4.0 to 5.0	...	...	99	5000	42.7	9.6
EC9 33 1×3	ECG 150 1/3	120 to 160	3.0 to 4.0	112 to 152	2.8 to 3.8	99	5000	40.0	9.0
EC5 11 3×4	ECD 450 3/4	...	...	152 to 176	3.8 to 4.4	132	3750	58.7	13.2
EC5 11 4×3	ECD 450 4/3	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	132	3750	58.7	13.2
EC5 22 3×2	ECD 225 3/2	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	132	3750	64.0	14.4
EC7 22 3×2	ECE 225 3/2	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	132	3750	58.7	13.2
EC3.5 33 4×0	ECB 150 4/0	40 to 80	1.0 to 2.0	...	...	132	3750	71.2	16.0
EC6 33 4×0	ECDE 150 4/0	120 to 160	3.0 to 4.0	...	...	132	3750	...	TBD
EC6 33 2×2	ECDE 150 2/2	...	...	112 to 152	2.8 to 3.8	132	3750	...	TBD
EC6 33 1×4	ECDE 150 1/4	...	...	112 to 152	2.8 to 3.8	132	3750	...	TBD
EC4.5 33 4×0	ECC 150 4/0	40 to 80	1.0 to 2.0	...	...	132	3750	62.3	14.0
EC4.5 33 1×0	ECC 150 4/0	120 to 160	3.0 to 4.0	...	...	132	3750	62.3	14.0
EC9 33 4×0	ECG 150 4/0	120 to 160	3.0 to 4.0	...	...	132	3750	56.9	12.8
EC9 33 4×0	ECG 150 4/0	160 to 200	4.0 to 5.0	...	...	132	3750	56.9	12.8
EC9 33 2×2	ECG 150 2/2	120 to 160	3.0 to 4.0	112 to 152	2.8 to 3.8	132	3750	53.4	12.0
EC4.5 66 2×0	ECC 75 2/0	80 to 120	2.0 to 3.0	...	...	132	3750	50.7	11.4
EC4.5 66 2×0	ECC 75 2/0	120 to 160	3.0 to 4.0	...	...	132	3750	50.7	11.4
EC6 66 2×0	ECDE 75 2/0	120 to 160	3.0 to 4.0	...	...	132	3750	50.7	11.4
EC9 66 2×0	ECG 75 2/0	120 to 160	3.0 to 4.0	...	...	132	3750	50.7	11.4
EC9 66 2×0	ECG 75 2/0	280	7.0	...	...	132	3750	50.7	11.4
EC9 66 2×0	ECG 75 2/0	320	8.0	...	...	132	3750	50.7	11.4
EC9 66 1×2	ECG 75 1/2	120 to 160	3.0 to 4.0	112 to 152	2.8 to 3.8	132	3750	50.7	11.4
EC13 66 2×0	ECK 75 2/0	120 to 160	3.0 to 4.0	...	...	132	3750	50.7	11.4
EC6 134 1×0	ECDE 37 1/0	20 to 40	0.5 to 1.0	...	...	134	3700	49.8	11.2
EC6 134 1×0	ECDE 37 1/0	80 to 120	2.0 to 3.0	...	...	134	3700	49.8	11.2
EC6 134 1×0	ECDE 37 1/0	120 to 160	3.0 to 4.0	...	...	134	3700	49.8	11.2
EC9 134 1×0	ECG 37 1/0	20 to 40	0.5 to 1.0	...	...	134	3700	49.8	11.2
EC9 134 1×0	ECG 37 1/0	40 to 80	1.0 to 2.0	...	...	134	3700	49.8	11.2
EC9 134 1×0	ECG 37 1/0	120 to 160	3.0 to 4.0	...	...	134	3700	49.8	11.2
EC13 134 1×0	ECK 37 1/0	20 to 40	0.5 to 1.0	...	...	134	3700	49.8	11.2
EC5 11 3×5	ECD 450 3/5	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	165	3000	70.3	15.8
EC5 11 4×4	ECD 450 4/4	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	176	2813	78.3	17.6
EC9 33 2×3	ECG 150 2/3	120 to 160	3.0 to 4.0	112 to 152	2.8 to 3.8	198	2500	80.1	18.0
EC9 33 3×2	ECG 150 3/2	120 to 160	3.0 to 4.0	112 to 152	2.8 to 3.8	198	2500	80.1	18.0
EC9 66 3×0	ECG 75 3/0	120 to 160	3.0 to 4.0	...	...	198	2500	76.1	17.1

TABLE *Continued*

Yarn Designation[A]		Nominal Twist				Approximate Yarn Number (Bare Glass)[B]		Breaking Strength, Individual Minimum	
		"Z"		"S"					
SI Unit (tex)	Inch-Pound Unit	tpm	tpi	tpm	tpi	tex	yd/lb	N	lbf
EC9 66 1×3	ECG 75 1/3	120 to 160	3.0 to 4.0	112 to 152	2.8 to 3.8	198	2500	76.1	17.1
EC9 100 1×2	ECG 50 1/2	120 to 160	3.0 to 4.0	...	...	198	2500	...	...
EC11 198 1×0	ECH 25 1/1	20 to 40	0.5 to 1.0	...	...	198	2500	75.6	17.0
EC5 11 4×5	ECD 450 4/5	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	220	2250	100	22.6
EC5 22 2×5	ECD 225 2/5	...	...	152 to 176	3.8 to 4.4	220	2250	107	24
EC7 22 2×5	ECE 225 2/5	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	220	2250	107	24
EC13 40HF 2/3	ECK 125 HF 2/3	80 to 140	2.0 to 3.5	7.6 to 136	1.9 to 3.4	238	2080	85.4	19.2
EC13 40HF 1×6	ECK 125 HF 1/6	80 to 140	2.0 to 3.5	7.6 to 136	1.9 to 3.4	238	2080	85.4	19.2
EC5 22 4×3	ECD 225 4/3	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	265	1875	128	28.8
EC7 22 4×3	ECE 225 4/3	160 to 200	4.0 to 5.0	152 to 176	3.8 to 4.4	265	1875	117	26.4
EC9 33 1×2	ECG 150 1/2	...	...	112 to 152	2.8 to 3.8	265	1875	...	...
EC9 33 4×2	ECG 150 4/2	120 to 160	3.0 to 4.0	112 to 152	2.8 to 3.8	265	1875	107	24.0
EC9 66 4×0	ECG 75 4/0	120 to 160	3.0 to 4.0	...	...	265	1875	101	22.8
EC9 66 2×2	ECG 75 2/2	120 to 160	3.0 to 4.0	112 to 152	2.8 to 3.8	265	1875	101	22.8
EC9 134 2×0	ECG 37 2/0	120 to 160	3.0 to 4.0	...	...	265	1875	101	22.8
EC13 66 2×2	ECK 75 2/2	120 to 160	3.0 to 4.0	112 to 152	2.8 to 3.8	265	1875	101	22.8
EC9 134 1×2	ECG 37 1/2	120 to 160	3.0 to 4.0	112 to 152	2.8 to 3.8	270	1850	101	22.8
EC13 275 1×0	ECK 18 1/0	20 to 40	0.5 to 1.0	...	...	275	1800	102	23.0
EC9 33 3×3	ECG 150 3/3	120 to 160	3.0 to 4.0	112 to 152	2.8 to 3.8	300	1665	120	27.0
EC9 33 3×4	ECG 150 3/4	120 to 160	3.0 to 4.0	112 to 152	2.8 to 3.8	395	1250	160	36.0
EC9 33 4×3	ECG 150 4/3	120 to 160	3.0 to 4.0	112 to 152	2.8 to 3.8	395	1250	160	36.0
EC9 66 2×3	ECG 75 2/3	120 to 160	3.0 to 4.0	112 to 152	2.8 to 3.8	395	1250	152	34.2
EC9 134 1×3	ECG 37 1/3	120 to 160	3.0 to 4.0	112 to 152	2.8 to 3.8	405	1230	152	34.2
EC9 33 4×4	ECG 150 4/4	120 to 160	3.0 to 4.0	100 to 140	2.5 to 3.5	530	938	213	48.0
EC9 66 2×4	ECG 75 2/4	...	...	112 to 152	2.8 to 3.8	530	938	203	45.6
EC9 33 4×5	ECG 150 4/5	...	...	100 to 140	2.5 to 3.5	660	750	285	64
EC9 33 4×6	ECG 150 4/6	...	...	100 to 140	2.5 to 3.5	795	625	342	76.8
EC9 33 4×7	ECG 150 4/7	...	...	100 to 140	2.5 to 3.5	925	536	399	89.6

[A] For engineering information only, and may be made by substituting other yarn equivalents, providing fiber diameter and other properties are not affected. For example, when EC9 66 2×2 (ECG 75 2/2) is substituted with EC9 112 1×2 (ECG 37 1/2), the final yarn number remains the same.

[B] The yards per pound stated in Table 1 is an approximate yarn number. The "As Received" yards per pound will be less than the bare glass values stated. This may be contributed by twist take-up, sizing percent, or purchaser agreement to produce to a lower yarn number to meet other requirements for a further manufactured product, or combination thereof. For example, EC9 66 1×0 (ECG 75 1/0) stated at approximately 66 tex (7500 yd/lb) will actually be about 68 tex (7300 yd/lb) in the delivered state for use in the electrical laminate industry. 2—Letter designations for filament diameter averages are shown in Table 1. The yards per pound stated in Table 2 is an approximate yarn number. The "As Received" yards per pound will be less than the bare glass values stated. This may be contributed by twist take-up, sizing percent, or purchaser agreement to produce to a lower yarn number to meet other requirements for a further manufactured product, or both. For example, EC9 66 1×0 (ECG 75 1/0) stated at approximately 66 tex [7500 yd/lb] will actually be about 68 tex [7300 yd/lb] in the delivered state for use in the electrical laminate industry."

6. Continuous Filament Yarns

6.1 *Descriptions of Continuous Filament Yarns*—The description of continuous filament yarns consists of the following four segments: