

TORAY

Toray Composite Materials America, Inc.

TORAYCA[®]

Technical Manual

HIGH PERFORMANCE CARBON FIBER
TORAYCA



www.toraycma.com
1-253-846-1777

Revision 4/2020



Toray Composite Materials America, Inc.

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TORAYCA[®] CARBON FIBER

Toray Industries, Inc., of Japan has been the worldwide leader in the development and production of carbon fibers for over 40 years. Trade named **TORAYCA[®]**, our carbon fibers represent the most complete selection available in the global market, with the highest standards of quality and performance.

TORAYCA[®] fiber is developed at our **Ehime** manufacturing complex in Japan – Toray’s primary center for carbon fiber and composite technology. In addition to Japan, **TORAYCA[®]** fiber is produced in the United States, France and South Korea. Global capacity is currently at 29,100 metric tons per year.

Toray is the world leader in carbon fiber technology as well as in production capacity:

- Largest carbon fiber manufacturer in the world
- Widest range and largest variety of carbon fiber
- World’s first commercial manufacturer of PAN based carbon fibers, since 1971
- Global carbon fiber manufacturing/operation (Japan, U.S., Europe, South Korea)
- One of the top patent holders in the field of carbon fiber/composites
- Most comprehensive technical support
- Highest quality carbon fiber products
- Continued investment in and expansion of R&D activities.

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FIBER SELECTION GUIDE

TORAYCA[®] carbon fibers, produced in a wide range of material properties, are specifically designed to meet your diverse and challenging applications.

This carbon fiber selection guide is helpful in determining which type of carbon fiber is suited to a particular application. **TORAYCA**[®] is grouped into two main categories, **T** series and **M** series. The **T** series has high strength carbon fibers with both regular and intermediate modulus values. The **M** series has more intermediate and high modulus carbon fibers as well as enhanced, higher strength **MJ** type fibers.

To assist you in the selection of the correct **TORAYCA**[®] carbon fiber to meet a specific application, contact our Sales and Technical team.

FIBER SELECTION GUIDE (Tensile Strength, Tensile Modulus)

T300 (512 ksi, 33.4 Msi)

Baseline carbon fiber used in aerospace applications with over 20 year service history. Has 30 year production history and is known for balanced composite properties, high quality and consistency, reliability and availability of supply. Available in 1K, 3K, 6K and 12K tow sizes.

T700S (711 ksi, 33.4 Msi)

An industry standard fiber for high strength and standard modulus, with outstanding processing characteristics for filament winding, weaving and prepregging. This never-twisted fiber is used in a variety of industrial and recreational applications, including pressure vessels such as natural gas vehicle (NGV) storage tanks and SCBA breathing tanks. Available in 6K, 12K, and 24K tow sizes.

T700G (711 ksi, 34.8 Msi)

Enhanced tensile modulus and adhesion properties over T700S. Applications of this never-twisted fiber include aircraft and high performance sporting goods where demanding conditions require superior composite properties. Available in 12K tow sizes.



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FIBER SELECTION GUIDE

T800H (796 ksi, 42.7 Msi)

An intermediate modulus, high tensile strength fiber, with high level and balance of composite properties. Designed and developed to meet the weight saving demands of aircraft applications. Is used in primary structure of commercial aircraft, including vertical fin and horizontal stabilizers. Available in 6K and 12K tow sizes.

T830H (774 ksi, 42.7 Msi)

An intermediate modulus, high tensile strength fiber with a good balance of composite properties. Is used extensively in aircraft secondary structures. Available in a 6K tow size.

T800S (853 ksi, 42.7 Msi)

A cost-effective intermediate modulus fiber with higher tensile strength compared to T800H. This never-twisted fiber has especially high tensile properties. Is used extensively in primary structure of commercial aircraft. Available in 12K and 24K tow sizes.

T1000G (924 ksi, 42.7 Msi)

A very high tensile strength carbon fiber. Suitable for lightweight, tensile strength-critical applications such as pressure vessels for aerospace vehicles and satellites as well as hydrogen storage tanks for fuel cell vehicles. Available in a 12K tow size.

T1100S (1,017 ksi, 47.0 Msi)

Next-generation intermediate modulus fiber with excellent processability and enhanced performance in demanding manufacturing methods such as filament winding. Available in a 12K and 24K tow sizes.

T1100G (1,017 ksi, 47.0 Msi)

Next-generation intermediate modulus fiber with excellent processability in high-performance manufacturing methods such as weaving, prepreg, etc. Available in a 12K and 24K tow sizes.



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FIBER SELECTION GUIDE

MJ type fibers have enhanced tensile strength and modulus. These fibers are usually selected for a specific modulus that is used for stiffness, coefficient of thermal expansion (CTE), and electrical and thermal conductivity for spacecraft and premium sporting goods. The chart below lists the typical properties of the fibers only.

| Fiber Type | Tensile Strength (ksi) | Tensile Modulus (Msi) | CTE ($\alpha \cdot 10^{-6}/^{\circ}\text{C}$) | Electrical Resistivity ($10^{-3} \Omega \cdot \text{cm}$) | Thermal Conductivity ($\text{Cal}/\text{cm} \cdot \text{s} \cdot ^{\circ}\text{C}$) |
|-------------|------------------------|-----------------------|---|---|---|
| M35J | 654 (6K) 683 (12K) | 49.8 | -0.73 | 1.1 | 0.0933 |
| M40J | 640 | 54.7 | -0.83 | 1.0 | 0.164 |
| M46J | 609 (6K) 583 (12K) | 63.3 | -0.9 | 0.9 | 0.202 |
| M50J | 597 | 69.0 | -1.0 | 0.9 | 0.234 |
| M55J | 583 | 78.2 | -1.1 | 0.8 | 0.372 |
| M60J | 554 | 85.3 | -1.1 | 0.7 | 0.363 |



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TORAYCA® CARBON FIBER PROPERTIES

TORAYCA® TYPICAL FIBER PROPERTIES (Nominal Values)

| FIBER TYPE | | Number of Filaments | Sizing Type | Tensile Strength* | | Tensile Modulus* | | Elongation % | Yield g/1000m | Density g/cm ³ | Standard Spool Size** (kg) |
|----------------------|--------|---------------------|-------------|-------------------|-------|------------------|-----|--------------|---------------|---------------------------|----------------------------|
| | | | | ksi | MPa | Msi | GPa | | | | |
| STANDARD MODULUS | T300 | 1,000 | 4,5 | 512 | 3,530 | 33.4 | 230 | 1.5 | 66 | 1.76 | 1.0 |
| | | 3,000 | 4,5 | | | | | | 198 | | 2.0 |
| | | 6,000 | 4,5 | | | | | | 396 | | 2.0 |
| | T700S | 6,000 | 5 | 711 | 4,900 | 33.4 | 230 | 2.1 | 396 | 1.80 | 2.0 |
| | | 12,000 | 5,6,F | | | | | | 800 | | 4.0, 6.0, 8.0 |
| | | 24,000 | 5,6,F | | | | | | 1,650 | | 6.0, 8.0 |
| T700G | 12,000 | 3,4,5 | 711 | 4,900 | 34.8 | 240 | 2.0 | 800 | 1.80 | 6.0 | |
| INTERMEDIATE MODULUS | T800H | 6,000 | 4 | 796 | 5,490 | 42.7 | 294 | 1.9 | 223 | 1.81 | 2.0 |
| | | 12,000 | 4,5 | | | | | | 445 | | 4.0 |
| | T830H | 6,000 | 4 | 774 | 5,340 | 42.7 | 294 | 1.8 | 223 | 1.81 | 2.0 |
| | T800S | 12,000 | 5 | 853 | 5,880 | 42.7 | 294 | 2.0 | 515 | 1.80 | 4.0 |
| | | 24,000 | 1 | | | | | | 1,030 | | 4.0 |
| | T1000G | 12,000 | 4 | 924 | 6,370 | 42.7 | 294 | 2.2 | 485 | 1.80 | 4.0 |
| | T1100G | 12,000 | 7 | 1,017 | 7,000 | 47.0 | 324 | 2.0 | 505 | 1.79 | 2.0 |
| | | 24,000 | 7 | | | | | | 1,010 | | 4.0 |
| | T1100S | 12,000 | 5 | 1,017 | 7,000 | 47.0 | 324 | 2.0 | 505 | 1.79 | 2.0 |
| | | 24,000 | 5 | | | | | | 1,010 | | 4.0 |
| HIGH MODULUS | M35J | 6,000 | 5 | 654 | 4,510 | 49.8 | 343 | 1.3 | 225 | 1.75 | 1.0 |
| | | 12,000 | 5 | 683 | 4,700 | | | | 450 | | 2.0 |
| | M40J | 6,000 | 5 | 640 | 4,400 | 54.7 | 377 | 1.2 | 225 | 1.77 | 1.0 |
| | | 12,000 | 5 | | | | | | 450 | | 2.0 |
| | M46J | 6,000 | 5 | 609 | 4,200 | 63.3 | 436 | 1.0 | 223 | 1.84 | 1.0 |
| | | 12,000 | 5 | 583 | 4,020 | | | | 0.9 | | 445 |
| | M55J | 6,000 | 5 | 583 | 4,020 | 78.2 | 540 | 0.8 | 218 | 1.91 | 0.5 |
| | M60J | 3,000 | 5 | 554 | 3,820 | 85.3 | 588 | 0.7 | 103 | 1.93 | 0.25 |
| | | 6,000 | 5 | | | | | | 206 | | 0.4 |

*Measured using the impregnated strand method. This information can be used for material selection purposes only.

**Other sizes available, refer to product data sheet.

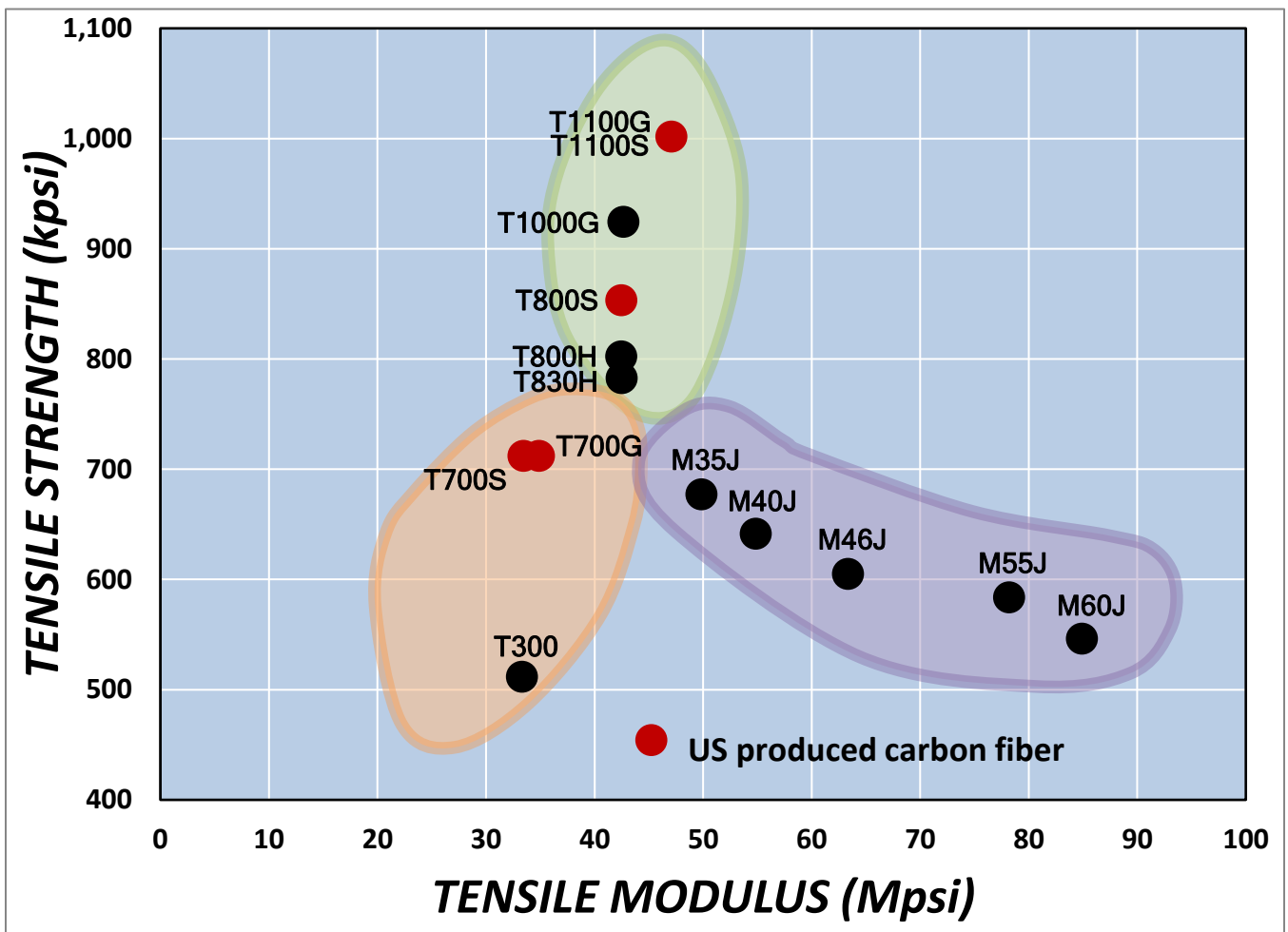


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TORAYCA[®] CARBON FIBER PROPERTIES

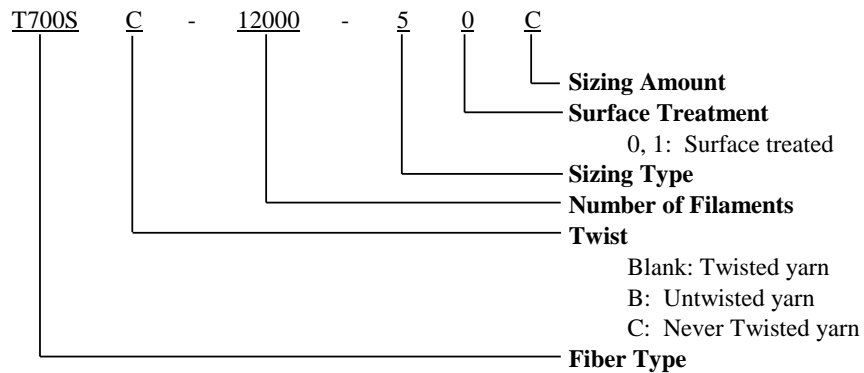


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EXPLANATION OF PRODUCT CODE



FIBER TYPE

T700SC – 24000 – 50C

Currently, **TORAYCA**[®] fibers are separated into two main series: **T** and **M**. The **T** series stands for tensile strength, while the **M** series indicates modulus. Included in the **M** series are **MJ** type fibers, which have enhanced tensile and compressive strength properties over first generation **M** series fibers.

Originally, in the **T** series, the three- or four-digit number designated the approximate tensile strength in either kg_f/mm² or kpsi. For example, T700S has a tensile strength of 711 kpsi.

In the case of **M** series fibers, the two-digit number designates the approximate modulus in SI units. For example, M55J has a tensile modulus of 55x10³ kg_f/mm².

The specific properties of each type of fiber can be found on the selection guide sheets, along with the individual data sheets.



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EXPLANATION OF PRODUCT CODE

TWIST T700SC – 24000 – 50C

Originally, **TORAYCA**[®] fibers were produced as twisted fibers. Because of other application requirements, **TORAYCA**[®] is also produced as untwisted and never twisted fiber. Twist of the fiber is designated as follows:

- (No letter) Twisted Fiber
- B Untwisted Fiber (made from a twisted fiber tow through an untwisting process)
- C Never Twisted Fiber

Please see the individual data sheets for fiber twist of each product.

TOW SIZE T700SC – 24000 – 50C

Tow sizes, or number of carbon fiber filaments per tow, vary from 1000 to 48000 filaments. **TORAYCA**[®] fibers are available in specific tow size for each product. Consult the data sheets for available tow sizes.

SIZING T700SC – 24000 – 50C

TORAYCA[®] fibers are treated with various sizing agents to enhance the handleability and bonding characteristics with various resin systems. Below are the sizing types developed for **TORAYCA**[®] fibers. Not all sizings are available with every fiber. Please see the data sheets for available sizings of a particular fiber.

| Sizing Type | Resin System Compatibility |
|-------------|--|
| 1 | Epoxy |
| 3 | Epoxy |
| 4 | Epoxy, Phenolic, BMI |
| 5 | General Purpose: Epoxy, Phenolic, Polyester, Vinyl Ester |
| 6 | Epoxy |
| 7 | Epoxy |
| F | Vinyl Ester, Epoxy |



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EXPLANATION OF PRODUCT CODE

SURFACE TREATMENT

T700SC – 24000 – 50C

TORAYCA[®] fibers are surface treated to enhance the adhesion properties with resin systems in a process known as oxidation. Oxygen atoms are chemically added to the surface of the fiber to increase the bonding characteristics.

The surface treatment is designated as follows:

0, 1 Surface treated

SIZING AMOUNT

T700SC – 24000 – 50C

To control the handleability and adhesion properties, various amounts of sizing are applied to **TORAYCA**[®] fibers. The sizing amount is designated as a letter (A to E) for a specific fiber. Because of various applications, the letter may correspond to different sizing amounts from fiber type to fiber type. See the fiber data sheet for specific sizing amounts.



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QUALITY POLICY & ASSURANCE

QUALITY POLICY

Toray Composite Materials America, Inc. will strive to provide the highest quality, innovative technology, and products that meet our customer, statutory, and regulatory requirements with emphasis on continuous process improvements through employee involvement.

QUALITY CONTROL AND ASSURANCE

A stringent integrated quality control system established for manufacturing, inspection, storage and delivery procedures has resulted in the very high quality of **TORAYCA®** products.

These quality standards are the inherited experience of Toray's synthetic fiber manufacturing processes for the past 80 plus years. This dedicated quality control system has been certified by today's aerospace manufacturers and has resulted in our Decatur, Alabama CMA facility achieving Nadcap certification in 2017. Certifications at CMA in Alabama for manufacture of Carbon Fibers are ISO 9000 certified in 2000, and was upgraded to AS 9100 in 2003. Pan fiber certification at Alabama CMA is ISO 9001 in 2008. The plant also became ISO 14001 certified in 2008.

TORAYCA® and to state the lot average values for tensile strength, tensile modulus, an ultimate strain at failure, density, yield, and sizing amount. These values are tested in accordance with Toray Test Methods. A copy of these Test Methods will be provided upon request.



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QUALITY POLICY & ASSURANCE

TORAYCA[®] carbon fiber is identified by labels attached to the Case and to the Bobbin. Examples of bobbin labels from CMA and Toray Industries are shown below.



Manufacturing records of a particular **TORAYCA**[®] carbon fiber product are easily traceable through Lot and Case numbers. Therefore, the Lot, Trace, and Case numbers are critical to the tracking of specific **TORAYCA**[®] product history. Every bobbin produced has full traceability.



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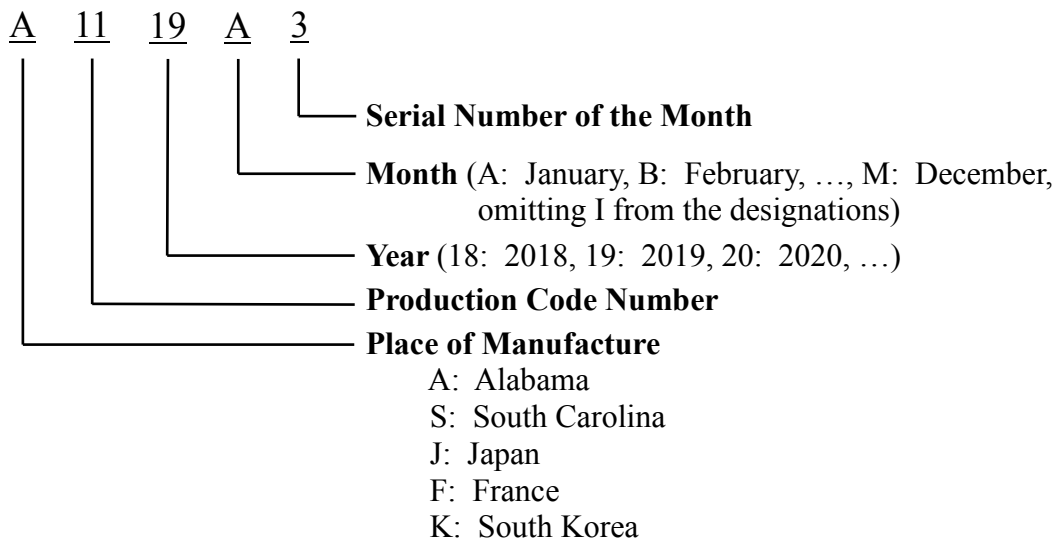


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QUALITY POLICY & ASSURANCE

The product designation is described in the Explanation of Product Code section.

The lot number contains the following information.



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SAFETY & HANDLING

Carbon fibers are composed of thin single filaments, whose diameter is in the range of 5 to 7 micrometers. During processing, these single filaments can be damaged, causing dust and broken filaments to arise which may cause potential hazards such as:

- Skin irritation and dermatitis
- Electrical hazards (Carbon fiber is electrically conductive.)
- Respiratory problems

The following safety and handling guidelines should be followed at all times to protect workers and electrical devices:

- Be sure to read through the Safety Data Sheet (SDS) before handling carbon fiber.
- Personnel should wear goggles, facemasks, gloves and protective clothing wherever dust generation is significant.
- Personal cleanliness and careful work habits are positive preventive actions.
- Rotary bars and rollers are preferred to guide fiber tows instead of stationary eye guides, pins, or bars.
- Local removal of dust at the point of generation is highly effective.
- Electrical equipment should be isolated. Protecting expensive computer systems with complete encasement and fresh air purge is highly recommended.
- Routine tests of particle concentration are recommended.
- Do not incinerate carbon fiber. Waste fibers should be packaged for burial in landfill authorized for the disposal of special waste of this nature, following local, state, and federal regulations as appropriate.
- Additional Safety & Handling information is printed on the cardboard cases.



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DISCLOSURE

We believe the information in this **TORAYCA**[®] Technical Manual is correct to the best of our current knowledge. However, no warranty is made with respect to its completeness.

This manual does not anticipate all the situations in which this material is processed or all the physical and mental characteristics of each individual who is involved in the processing. It is the user's obligation to test and use material safely in accordance with every relevant regulation and law. Unless otherwise agreed in writing, no liability is assumed by Toray Industries of Japan or Toray Composite Materials America, Inc. for any claims or damages caused in relation to the use of this material.



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DATA SHEETS

Additional carbon fiber properties and packaging information are listed on the following individual data sheets for each **TORAYCA**[®] fiber.

All values noted on these data sheets are typical properties and do not constitute any guarantee of values or warranty of any kind. These values are intended to be a general guideline for material selection purposes only. For applications requiring guaranteed values, contact our sales and technical team to establish a material specification document.



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T300

STANDARD MODULUS CARBON FIBER

Baseline carbon fiber with a 40-year production history and is known for its balanced composite properties, high quality, consistency, reliability and suppliability. Excellent processability in traditional manufacturing methods (weaving, braiding, filament winding, prepreg, etc). Manufacturing locations include Japan and France.

PRODUCT DESIGNATION

| T300 | B | 3,000 | 4 | 0 | B |
|------------|--------|----------------|-------------|-------------------|---------------|
| Fiber Type | Twist* | Filament Count | Sizing Type | Surface Treatment | Sizing Amount |

* Blank: Twisted
B: Untwisted

FIBER PROPERTIES

| PROPERTY | ENGLISH | METRIC | METHOD |
|-------------------|----------|------------------------|------------|
| Tensile Strength | 512 ksi | 3,530 MPa | TY-030B-01 |
| Tensile Modulus | 33.4 Msi | 230 GPa | TY-030B-01 |
| Strain at Failure | | 1.5% | TY-030B-01 |
| Density | | 1.76 g/cm ³ | TY-030B-02 |
| Filament Diameter | | 7 μm | |
| Yield | 1K | 66 g/1000m | TY-030B-03 |
| | 3K | 198 g/1000m | TY-030B-03 |
| | 6K | 396 g/1000m | TY-030B-03 |

FUNCTIONAL PROPERTIES

| PROPERTY | VALUE |
|------------------------------|--------------------------------|
| CTE | -0.41 α · 10 ⁻⁶ /°C |
| Specific Heat | 0.777 J/g · °C |
| Thermal Conductivity | 0.105 J/cm · s · °C |
| Electric Resistivity | 1.7 × 10 ⁻³ Ω · cm |
| Chemical Composition: Carbon | >93% |
| Na + K | <50 ppm |

RESIN SYSTEM COMPATIBILITY

| SIZING TYPE & AMOUNT | RESIN SYSTEM COMPATIBILITY | METHOD |
|----------------------|---|------------|
| 40A/B (1.0%) | Epoxy | TY-030B-05 |
| 40D (0.7%) | Epoxy | TY-030B-05 |
| 50A/B (1.0%) | Epoxy, phenolic, polyester, vinyl ester | TY-030B-05 |

COMPOSITE PROPERTIES

| PROPERTY | ENGLISH | METRIC | METHOD |
|-------------------------|---------|-----------|---------------|
| Tensile Strength* | 264 ksi | 1,820 MPa | ASTM D-3039 |
| Tensile Modulus* | 20 Msi | 140 GPa | ASTM D-3039 |
| Tensile Strain | | 1.26% | ASTM D-3039 |
| Compressive Strength* | 213 ksi | 1,470 MPa | SACMASRM1R-94 |
| Flexural Strength* | 260 ksi | 1,790 MPa | ASTM D-790 |
| Flexural Modulus* | 18 Msi | 123 GPa | ASTM D-790 |
| ILSS | 14 ksi | 94.1 MPa | SACMASRM1R-94 |
| In Plain Shear Strength | 14 ksi | 95 MPa | ASTM D-3518 |
| 90° Tensile Strength | 11 ksi | 76 MPa | ASTM D-3039 |

*Normalized to 60% fiber volume. Cured with #2500 epoxy at 130 °C.



T300

T300 Rev. 6: Updated April 13, 2018



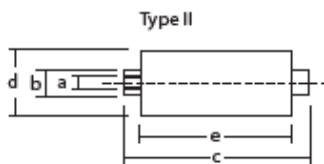
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PACKAGING

The table below summarizes the tow sizes, twists, sizing types, and packaging available for standard material. Other bobbin sizes may be available on a limited basis.

| TOW SIZES | BOBBIN NET WEIGHT (kg) | BOBBIN TYPE | BOBBIN SIZE (mm) | | | | | SPOOL PER CASE | CASE NET WEIGHT (kg) |
|-----------|------------------------|-------------|------------------|----|-----|-----|-----|----------------|----------------------|
| | | | a | b | c | d | e | | |
| 1K | 1.0 | II | 76 | 82 | 192 | 132 | 156 | 12 | 12 |
| 3K | 2.0 | II | 76 | 82 | 192 | 157 | 156 | 12 | 24 |
| 6K | | | | | | | | | |

Bobbin Type:



Please refer to SDS for handling and disposal.

For more information or purchasing inquiries:
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T700S

STANDARD MODULUS CARBON FIBER

Excellent processability in traditional manufacturing methods (weaving, braiding, filament winding, prepreg, etc). Manufacturing locations include Japan, U.S., Korea, and France.

PRODUCT DESIGNATION

| T700S | C | 12,000 | 5 | 0 | C |
|------------|--------|----------------|-------------|-------------------|---------------|
| Fiber Type | Twist* | Filament Count | Sizing Type | Surface Treatment | Sizing Amount |

* C: Never Twisted

FIBER PROPERTIES

| PROPERTY | ENGLISH | METRIC | METHOD |
|-------------------|----------|------------------------|------------|
| Tensile Strength | 711 ksi | 4,900 MPa | TY-030B-01 |
| Tensile Modulus | 33.4 Msi | 230 GPa | TY-030B-01 |
| Strain at Failure | | 2.1% | TY-030B-01 |
| Density | | 1.80 g/cm ³ | TY-030B-02 |
| Filament Diameter | | 7 μm | |
| Yield | 6K | 400 g/1000m | TY-030B-03 |
| | 12K | 800 g/1000m | TY-030B-03 |
| | 24K | 1,650 g/1000m | TY-030B-03 |

FUNCTIONAL PROPERTIES

| PROPERTY | VALUE |
|------------------------------|--------------------------------|
| CTE | -0.38 α · 10 ⁻⁶ /°C |
| Specific Heat | 0.752 J/g · °C |
| Thermal Conductivity | 0.0938 J/cm · s · °C |
| Electric Resistivity | 1.6 × 10 ⁻³ Ω · cm |
| Chemical Composition: Carbon | >93 % |
| Na + K | <50 ppm |

RESIN SYSTEM COMPATIBILITY

| SIZING TYPE & AMOUNT | RESIN SYSTEM COMPATIBILITY | METHOD |
|----------------------|---|------------|
| 50C (1.0 %) | Epoxy, phenolic, polyester, vinyl ester | TY-030B-05 |
| 60E (0.3 %) | Epoxy | TY-030B-05 |
| F0E (0.7 %) | Vinyl ester, compatible with epoxy | TY-030B-05 |

COMPOSITE PROPERTIES

| PROPERTY | ENGLISH | METRIC | METHOD |
|-------------------------|---------|-----------|---------------|
| Tensile Strength* | 415 ksi | 2,860 MPa | ASTM D-3039 |
| Tensile Modulus* | 19 Msi | 134 GPa | ASTM D-3039 |
| Tensile Strain | | 2.02% | ASTM D-3039 |
| Compressive Strength* | 210 ksi | 1,450 MPa | SACMASRM1R-94 |
| Flexural Strength* | 245 ksi | 1,690 MPa | ASTM D-790 |
| Flexural Modulus* | 17 Msi | 120 GPa | ASTM D-790 |
| ILSS | 13 ksi | 86.9 MPa | SACMASRM1R-94 |
| In Plain Shear Strength | 20 ksi | 136 MPa | ASTM D-3518 |
| 90° Tensile Strength | 12 ksi | 81 MPa | ASTM D-3039 |

*Normalized to 60% fiber volume. Cured with #2592 epoxy at 130 °C.



T700S

T700S Rev. 4: Updated April 13, 2018



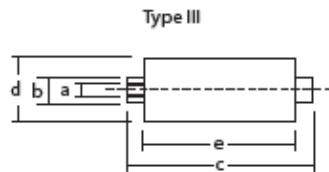
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PACKAGING

The table below summarizes the tow sizes, twists, sizing types, and packaging available for standard material. Other bobbin sizes may be available on a limited basis.

| TOW SIZES | SIZING | BOBBIN NET WEIGHT (kg) | BOBBIN TYPE | BOBBIN SIZE (mm) | | | | | SPOOL PER CASE | CASE NET WEIGHT (kg) |
|-----------|-------------|------------------------|-------------|------------------|------|-----|-----|-----|----------------|----------------------|
| | | | | a | b | c | d | e | | |
| 6K | 50C | 2.0 | III | 76.5 | 82.5 | 280 | 130 | 252 | 12 | 24 |
| 12K/24K | 50C/60E/F0E | 6.0 | III | 76.5 | 82.5 | 280 | 190 | 252 | 4 | 24 |

Bobbin Type:



Please refer to SDS for handling and disposal.

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T700S Rev. 4: Updated April 13, 2018



Toray Composite Materials America, Inc.

T700G

STANDARD MODULUS CARBON FIBER

Enhanced tensile modulus with excellent processability in traditional manufacturing methods (weaving, braiding, filament winding, prepreg, etc). Manufacturing locations include Japan, U.S., and France.

PRODUCT DESIGNATION

| T700G | C | 12,000 | 3 | 1 | E |
|------------|--------|----------------|-------------|-------------------|---------------|
| Fiber Type | Twist* | Filament Count | Sizing Type | Surface Treatment | Sizing Amount |

* C: Never twisted

FIBER PROPERTIES

| PROPERTY | ENGLISH | METRIC | METHOD |
|-------------------|----------|------------------------|------------|
| Tensile Strength | 711 ksi | 4,900 MPa | TY-030B-01 |
| Tensile Modulus | 34.8 Msi | 240 GPa | TY-030B-01 |
| Strain at Failure | | 2.0% | TY-030B-01 |
| Density | | 1.80 g/cm ³ | TY-030B-02 |
| Filament Diameter | | 7 μm | |
| Yield | 12K | 800 g/1000m | TY-030B-03 |

FUNCTIONAL PROPERTIES

| PROPERTY | VALUE |
|------------------------------|-------------------------------|
| CTE | -0.3 α · 10 ⁻⁴ /°C |
| Specific Heat | 0.752 J/g · °C |
| Thermal Conductivity | 0.096 J/cm · s · °C |
| Electric Resistivity | 1.5 × 10 ⁻³ Ω · cm |
| Chemical Composition: Carbon | >95% |
| Na + K | <50 ppm |

RESIN SYSTEM COMPATIBILITY

| SIZING TYPE & AMOUNT | RESIN SYSTEM COMPATIBILITY | METHOD |
|----------------------|---|------------|
| 31E (0.5%) | Epoxy | TY-030B-05 |
| 41E (0.5%) | Epoxy | TY-030B-05 |
| 51C (1.0%) | Epoxy, phenolic, polyester, vinyl ester | TY-030B-05 |

COMPOSITE PROPERTIES

| PROPERTY | ENGLISH | METRIC | METHOD |
|-------------------------|---------|-----------|---------------|
| Tensile Strength* | 296 ksi | 2,040 MPa | ASTM D-3039 |
| Tensile Modulus* | 20 Msi | 141 GPa | ASTM D-3039 |
| Tensile Strain | | 1.40% | ASTM D-3039 |
| Compressive Strength* | 239 ksi | 1,645 MPa | SACMASRM1R-94 |
| Flexural Strength* | 286 ksi | 1,970 MPa | ASTM D-790 |
| Flexural Modulus* | 18 Msi | 125 GPa | ASTM D-790 |
| ILSS | 15 ksi | 102.1 MPa | SACMASRM1R-94 |
| In Plain Shear Strength | 19 ksi | 128 MPa | ASTM D-3518 |
| 90° Tensile Strength | 11 ksi | 75 MPa | ASTM D-3039 |

*Normalized to 60% fiber volume. Cured with #2500 epoxy at 130 °C.



T700G

T700G Rev. 5: Updated April 13, 2018



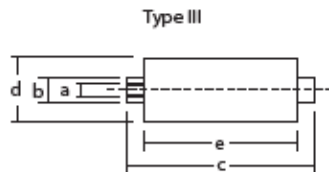
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PACKAGING

The table below summarizes the tow sizes, twists, sizing types, and packaging available for standard material. Other bobbin sizes may be available on a limited basis.

| TOW SIZES | BOBBIN NET WEIGHT (kg) | BOBBIN TYPE | BOBBIN SIZE (mm) | | | | | SPOOL PER CASE | CASE NET WEIGHT (kg) |
|-----------|------------------------|-------------|------------------|------|-----|-----|-----|----------------|----------------------|
| | | | a | b | c | d | e | | |
| 12K | 6.0 | III | 76.5 | 82.5 | 280 | 200 | 252 | 4 | 24 |

Bobbin Type:



Please refer to SDS for handling and disposal.

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T700G Rev. 5: Updated April 13, 2018



Toray Composite Materials America, Inc.

T800H

INTERMEDIATE MODULUS CARBON FIBER

Intermediate modulus, high tensile strength fiber, with excellent balanced composite properties. Designed and developed to meet the weight saving demand of aircraft. Excellent processability in traditional manufacturing methods (weaving, braiding, filament winding, prepreg, etc). Manufacturing locations include Japan and France.

PRODUCT DESIGNATION

| T800H | B | 12,000 | 4 | 0 | B |
|------------|--------|----------------|-------------|-------------------|---------------|
| Fiber Type | Twist* | Filament Count | Sizing Type | Surface Treatment | Sizing Amount |

* B: Untwisted

FIBER PROPERTIES

| PROPERTY | ENGLISH | METRIC | METHOD |
|-------------------|----------|------------------------|------------|
| Tensile Strength | 796 ksi | 5,490 MPa | TY-030B-01 |
| Tensile Modulus | 42.7 Msi | 294 GPa | TY-030B-01 |
| Strain at Failure | | 1.9% | TY-030B-01 |
| Density | | 1.81 g/cm ³ | TY-030B-02 |
| Filament Diameter | | 5 μm | |
| Yield | 6K | 223 g/1000m | TY-030B-03 |
| | 12K | 445 g/1000m | TY-030B-03 |

FUNCTIONAL PROPERTIES

| PROPERTY | VALUE |
|------------------------------|--------------------------------|
| CTE | -0.56 α · 10 ⁻⁶ /°C |
| Specific Heat | 0.752 J/g · °C |
| Thermal Conductivity | 0.10 J/cm · s · °C |
| Electric Resistivity | 1.4 x 10 ⁻³ Ω · cm |
| Chemical Composition: Carbon | >96% |
| Na + K | <50 ppm |

RESIN SYSTEM COMPATIBILITY

| SIZING TYPE & AMOUNT | RESIN SYSTEM COMPATIBILITY | METHOD |
|----------------------|---|------------|
| 40B (1.0%) | Epoxy | TY-030B-05 |
| 50B (1.0%) | Epoxy, phenolic, polyester, vinyl ester | TY-030B-05 |

COMPOSITE PROPERTIES

| PROPERTY | ENGLISH | METRIC | METHOD |
|-------------------------|---------|-----------|---------------|
| Tensile Strength* | 424 ksi | 2,920 MPa | ASTM D-3039 |
| Tensile Modulus* | 24 Msi | 168 GPa | ASTM D-3039 |
| Tensile Strain | | 1.67% | ASTM D-3039 |
| Compressive Strength* | 225 ksi | 1,550 MPa | SACMASRM1R-94 |
| Flexural Strength* | 248 ksi | 1,710 MPa | ASTM D-790 |
| Flexural Modulus* | 21 Msi | 147 GPa | ASTM D-790 |
| ILSS | 13 ksi | 88.5 MPa | SACMASRM1R-94 |
| In Plain Shear Strength | 24 ksi | 164 MPa | ASTM D-3518 |
| 90° Tensile Strength | 14 ksi | 97 MPa | ASTM D-3039 |

*Normalized to 60% fiber volume. Cured with #2592 epoxy at 130 °C.



T800H

T800H Rev. 1: Updated April 13, 2018



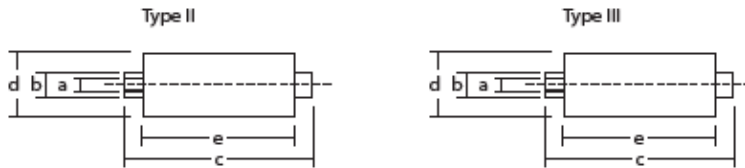
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PACKAGING

The table below summarizes the tow sizes, twists, sizing types, and packaging available for standard material. Other bobbin sizes may be available on a limited basis.

| TOW SIZES | BOBBIN NET WEIGHT (kg) | BOBBIN TYPE | BOBBIN SIZE (mm) | | | | | SPOOL PER CASE | CASE NET WEIGHT (kg) |
|-----------|------------------------|-------------|------------------|------|-----|-----|-----|----------------|----------------------|
| | | | a | b | c | d | e | | |
| 6K | 2.0 | II | 76 | 82 | 192 | 157 | 156 | 12 | 24 |
| 12K | 4.0 | III | 76.5 | 82.5 | 280 | 166 | 252 | 6 | 24 |

Bobbin Type:



Please refer to SDS for handling and disposal.

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T800H Rev. 1: Updated April 13, 2018



Toray Composite Materials America, Inc.

T800S

INTERMEDIATE MODULUS CARBON FIBER

Intermediate modulus, high tensile strength fiber, developed as a cost effective alternative to T800H. This never twisted fiber has excellent tensile composite properties and is specifically designed to meet the weight saving demand of aircraft and high performance recreational products. Excellent processability in traditional manufacturing methods (weaving, braiding, filament winding, prepreg, etc). Manufacturing locations include Japan, US, and France.

PRODUCT DESIGNATION

| T800S | C | 24,000 | 1 | 0 | E |
|------------|--------|----------------|-------------|-------------------|---------------|
| Fiber Type | Twist* | Filament Count | Sizing Type | Surface Treatment | Sizing Amount |

* C: Nevertwisted

FIBER PROPERTIES

| PROPERTY | ENGLISH | METRIC | METHOD |
|-------------------|----------|------------------------|------------|
| Tensile Strength | 853 ksi | 5,880 MPa | TY-030B-01 |
| Tensile Modulus | 42.7 Msi | 294 GPa | TY-030B-01 |
| Strain at Failure | | 2.0% | TY-030B-01 |
| Density | | 1.80 g/cm ³ | TY-030B-02 |
| Filament Diameter | | 5 μm | |
| Yield | 12K | 515 g/1000m | TY-030B-03 |
| | 24K | 1,030 g /1000m | TY-030B-03 |

FUNCTIONAL PROPERTIES

| PROPERTY | VALUE |
|------------------------------|------------------------------|
| CTE | -0.4 α ·10 ⁻⁶ /°C |
| Specific Heat | 0.740 J/g ·°C |
| Thermal Conductivity | 0.113 J/cm ·s·°C |
| Electric Resistivity | 1.3 x 10 ³ Ω·cm |
| Chemical Composition: Carbon | >96% |
| Na + K | <50 ppm |

RESIN SYSTEM COMPATIBILITY

| SIZING TYPE & AMOUNT | RESIN SYSTEM COMPATIBILITY | METHOD |
|----------------------|---|------------|
| 10E (0.5%) | Epoxy | TY-030B-05 |
| 50C (1.0%) | Epoxy, phenolic, polyester, vinyl ester | TY-030B-05 |

COMPOSITE PROPERTIES

| PROPERTY | ENGLISH | METRIC | METHOD |
|-------------------------|---------|-----------|----------------|
| Tensile Strength* | 477 ksi | 3,290 MPa | ASTM D-3039 |
| Tensile Modulus* | 24 Msi | 163 GPa | ASTM D-3039 |
| Tensile Strain | | 1.94% | ASTM D-3039 |
| Compressive Strength* | 216 ksi | 1,490 MPa | SACMASRM 1R-94 |
| Flexural Strength* | 247 ksi | 1,700 MPa | ASTM D-790 |
| Flexural Modulus* | 21 Msi | 145 GPa | ASTM D-790 |
| ILSS | 13 ksi | 87.9 MPa | SACMASRM 1R-94 |
| In Plain Shear Strength | 20 ksi | 135 MPa | ASTM D-3518 |
| 90° Tensile Strength | 11 ksi | 79 MPa | ASTM D-3039 |

*Normalized to 60% fiber volume. Cured with #2592 epoxy at 130 °C.



T800S

T800S Rev. 1: Updated April 13, 2018



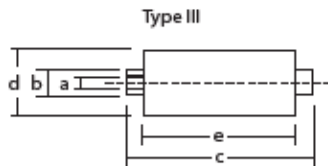
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PACKAGING

The table below summarizes the tow sizes, twists, sizing types, and packaging available for standard material. Other bobbin sizes may be available on a limited basis.

| TOW SIZES | SIZING | BOBBIN NET WEIGHT (kg) | BOBBIN TYPE | BOBBIN SIZE (mm) | | | | | SPOOL PER CASE | CASE NET WEIGHT (kg) |
|-----------|--------|------------------------|-------------|------------------|------|-----|-----|-----|----------------|----------------------|
| | | | | a | b | c | d | e | | |
| 12K | 50C | 4.0 | III | 76.5 | 82.5 | 280 | 160 | 252 | 6 | 24 |
| 24K | 10E | 7.8 | III | 76.5 | 82.5 | 280 | 198 | 252 | 4 | 31.2 |

Bobbin Type:



Please refer to SDS for handling and disposal.

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T800S Rev. 1: Updated April 13, 2018



Toray Composite Materials America, Inc.

T1000G

INTERMEDIATE MODULUS CARBON FIBER

Legacy intermediate modulus fiber with excellent processability in traditional manufacturing methods (filament winding). Manufactured in Japan.

PRODUCT DESIGNATION

| T1000G | C | 12,000 | 4 | 0 | D |
|------------|--------|----------------|-------------|-------------------|---------------|
| Fiber Type | Twist* | Filament Count | Sizing Type | Surface Treatment | Sizing Amount |

*C: Never Twisted

FIBER PROPERTIES

| PROPERTY | ENGLISH | METRIC | METHOD |
|-------------------|----------|------------------------|------------|
| Tensile Strength | 924 ksi | 6,370 MPa | TY-030B-01 |
| Tensile Modulus | 43.0 Msi | 294 GPa | TY-030B-01 |
| Strain at Failure | | 2.2% | TY-030B-01 |
| Density | | 1.80 g/cm ³ | TY-030B-02 |
| Filament Diameter | | 5 μm | |
| Yield | 12K | 485 g/1000m | TY-030B-03 |

RESIN SYSTEM COMPATIBILITY

| SIZING TYPE & AMOUNT | RESIN SYSTEM COMPATIBILITY | METHOD |
|----------------------|----------------------------|------------|
| 40D (0.7%) | Epoxy | TY-030B-05 |

FUNCTIONAL PROPERTIES

| PROPERTY | VALUE |
|------------------------------|-------------------------------|
| CTE | -0.6 α · 10 ⁻⁶ /°C |
| Specific Heat | 0.752 J/g · °C |
| Thermal Conductivity | 0.105 J/cm · s · °C |
| Electric Resistivity | 1.4 × 10 ³ Ω · cm |
| Chemical Composition: Carbon | >95% |
| Na + K | <50 ppm |

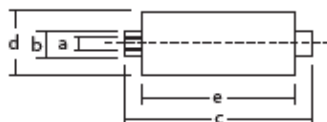
PACKAGING

The table below summarizes the tow sizes, twists, sizing types, and packaging available for standard material. Other bobbin sizes may be available on a limited basis.

| TOW SIZES | BOBBIN NET WEIGHT (kg) | BOBBIN TYPE | BOBBIN SIZE (mm) | | | | | SPOOL PER CASE | CASE NET WEIGHT (kg) |
|-----------|------------------------|-------------|------------------|------|-----|-----|-----|----------------|----------------------|
| | | | a | b | c | d | e | | |
| 12K | 2.0 | III | 76.5 | 82.5 | 280 | 140 | 252 | 12 | 24 |

Bobbin Type:

Type III



T1000G

T1000G Rev.0: Updated January 17, 2018



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Toray Composite Materials America, Inc.

T1100S

INTERMEDIATE MODULUS CARBON FIBER

Next-generation intermediate modulus fiber with excellent processability in traditional manufacturing methods (filament winding). Manufactured in the U.S.

PRODUCT DESIGNATION

| T1100S | C | 12,000 | 7 | 1 | E |
|------------|--------|----------------|-------------|-------------------|---------------|
| Fiber Type | Twist* | Filament Count | Sizing Type | Surface Treatment | Sizing Amount |

*C: Never Twisted

RESIN SYSTEM COMPATIBILITY

| SIZING TYPE & AMOUNT | RESIN SYSTEM COMPATIBILITY | METHOD |
|----------------------|---|------------|
| 50C (1.0%) | Epoxy, phenolic, polyester, vinyl ester | TY-030B-05 |

FIBER PROPERTIES

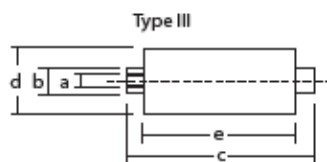
| PROPERTY | ENGLISH | METRIC | METHOD |
|-------------------|-----------|------------------------|------------|
| Tensile Strength | 1,017 ksi | 7,000 MPa | TY-030B-01 |
| Tensile Modulus | 47.0 Msi | 324 GPa | TY-030B-01 |
| Strain at Failure | | 2.0% | TY-030B-01 |
| Density | | 1.79 g/cm ³ | TY-030B-02 |
| Filament Diameter | | 5 μm | |
| Yield | 12K | 505 g/1000m | TY-030B-03 |

PACKAGING

The table below summarizes the tow sizes, twists, sizing types, and packaging available for standard material. Other bobbin sizes may be available on a limited basis.

| TOW SIZES | BOBBIN NET WEIGHT (kg) | BOBBIN TYPE | BOBBIN SIZE (mm) | | | | | SPOOL PER CASE | CASE NET WEIGHT (kg) |
|-----------|------------------------|-------------|------------------|------|-----|-----|-----|----------------|----------------------|
| | | | a | b | c | d | e | | |
| 12K | 2.0 | III | 76.5 | 82.5 | 280 | 125 | 252 | 12 | 24 |

Bobbin Type:



T1100S

T1100S Rev. 1: Updated April 4, 2018



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Toray Composite Materials America, Inc.

T1100G

INTERMEDIATE MODULUS CARBON FIBER

Next-generation intermediate modulus fiber with excellent processability in traditional manufacturing methods (weaving, prepreg, etc). Manufactured in the U.S.

PRODUCT DESIGNATION

| T1100G | C | 12,000 | 7 | 1 | E |
|------------|--------|----------------|-------------|-------------------|---------------|
| Fiber Type | Twist* | Filament Count | Sizing Type | Surface Treatment | Sizing Amount |

*C: Never Twisted

FIBER PROPERTIES

| PROPERTY | ENGLISH | METRIC | METHOD |
|-------------------|------------|------------------------|------------|
| Tensile Strength | 1,017 kpsi | 7,000 MPa | TY-030B-01 |
| Tensile Modulus | 47.0 Mpsi | 324 GPa | TY-030B-01 |
| Strain at Failure | | 2.0% | TY-030B-01 |
| Density | | 1.79 g/cm ³ | TY-030B-02 |
| Filament Diameter | | 5 μm | |
| Yield | 12K | 505 g/1000m | TY-030B-03 |
| | 24K | 1,010 g /1000m | TY-030B-03 |

FUNCTIONAL PROPERTIES

| PROPERTY | VALUE |
|------------------------------|-------------------------------|
| CTE | -0.5 α · 10 ⁻⁶ /°C |
| Specific Heat | 0.748 J/g · °C |
| Thermal Conductivity | 0.130 J/cm · s · °C |
| Electric Resistivity | 1.4 x 10 ⁻³ Ω·cm |
| Chemical Composition: Carbon | >96% |
| Na + K | <50 ppm |

RESIN SYSTEM COMPATIBILITY

| SIZING TYPE & AMOUNT | RESIN SYSTEM COMPATIBILITY | METHOD |
|----------------------|---|------------|
| 71E (0.6%) | Epoxy, phenolic, polyester, vinyl ester | TY-030B-05 |

COMPOSITE PROPERTIES

| PROPERTY | ENGLISH | METRIC | METHOD |
|-------------------------|---------|-----------|---------------|
| Tensile Strength* | 502 Ksi | 3,460 MPa | ASTM D-3039 |
| Tensile Modulus* | 27 Msi | 185 GPa | ASTM D-3039 |
| Tensile Strain | | 1.82% | ASTM D-3039 |
| Compressive Strength* | 271 Ksi | 1,870 MPa | SACMASRM1R-94 |
| Flexural Strength* | 278 Ksi | 1,920 MPa | ASTM D-790 |
| Flexural Modulus* | 23 Msi | 159 GPa | ASTM D-790 |
| ILSS | 15 Ksi | 104.5 MPa | SACMASRM1R-94 |
| In Plain Shear Strength | 23 Ksi | 160 MPa | ASTM D-3518 |
| 90° Tensile Strength | 12 Ksi | 80 MPa | ASTM D-3039 |

*Normalized to 60% fiber volume. Cured with #2574 epoxy at 130 °C.



T1100G

T1100G Rev.1: Updated April 13, 2018



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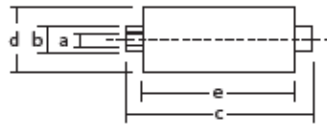
PACKAGING

The table below summarizes the tow sizes, twists, sizing types, and packaging available for standard material. Other bobbin sizes may be available on a limited basis.

| TOW SIZES | BOBBIN NET WEIGHT (kg) | BOBBIN TYPE | BOBBIN SIZE (mm) | | | | | SPOOL PER CASE | CASE NET WEIGHT (kg) |
|-----------|------------------------|-------------|------------------|------|-----|-----|-----|----------------|----------------------|
| | | | a | b | c | d | e | | |
| 12K | 2.0 | III | 76.5 | 82.5 | 280 | 125 | 252 | 12 | 24 |
| 24K | 4.0 | III | 76.5 | 82.5 | 280 | 160 | 252 | 6 | 24 |

Bobbin Type:

Type III



Please refer to SDS for handling and disposal.

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T1100G Rev. 1: Updated April 13, 2018



Toray Composite Materials America, Inc.

M35J

HIGH MODULUS CARBON FIBER

M35J carbon fiber is an MJ-type high modulus fiber with enhanced tensile and compressive strength as compared to M series fibers. Manufactured in Japan.

PRODUCT DESIGNATION

| M35J | B | 12,000 | 5 | 0 | B |
|------------|--------|----------------|-------------|-------------------|---------------|
| Fiber Type | Twist* | Filament Count | Sizing Type | Surface Treatment | Sizing Amount |

* B: Untwisted

FIBER PROPERTIES

| PROPERTY | ENGLISH | METRIC | METHOD |
|-----------------------|----------|------------------------|------------|
| Tensile Strength 6K | 654 ksi | 4,510 MPa | TY-030B-01 |
| Tensile Strength 12K | 683 ksi | 4,700 MPa | TY-030B-01 |
| Tensile Modulus | 49.8 Msi | 343 GPa | TY-030B-01 |
| Strain at Failure 6K | | 1.3% | TY-030B-01 |
| Strain at Failure 12K | | 1.4% | TY-030B-01 |
| Density | | 1.75 g/cm ³ | TY-030B-02 |
| Filament Diameter | | 5 μm | |
| Yield | 6K | 225 g/1000m | TY-030B-03 |
| | 12K | 450 g/1000m | TY-030B-03 |

FUNCTIONAL PROPERTIES

| PROPERTY | VALUE |
|------------------------------|--------------------------------|
| CTE | -0.73 α · 10 ⁻⁶ /°C |
| Specific Heat | 0.723 J/g · °C |
| Thermal Conductivity | 0.389 J/cm · s · °C |
| Electric Resistivity | 1.1 x 10 ⁻² Ω · cm |
| Chemical Composition: Carbon | >99% |
| Na + K | <50 ppm |

RESIN SYSTEM COMPATIBILITY

| SIZING TYPE & AMOUNT | RESIN SYSTEM COMPATIBILITY | METHOD |
|----------------------|---|------------|
| 50B (1.0%) | Epoxy, phenolic, polyester, vinyl ester | TY-030B-05 |

COMPOSITE PROPERTIES

| PROPERTY | ENGLISH | METRIC | METHOD |
|-------------------------|---------|-----------|---------------|
| Tensile Strength* | 390 ksi | 2,690 MPa | ASTM D-3039 |
| Tensile Modulus* | 29 Msi | 202 GPa | ASTM D-3039 |
| Tensile Strain | | 1.35% | ASTM D-3039 |
| Compressive Strength* | 203 ksi | 1,400 MPa | SACMASRM1R-94 |
| Flexural Strength* | 239 ksi | 1,650 MPa | ASTM D-790 |
| Flexural Modulus* | 25 Msi | 169 GPa | ASTM D-790 |
| ILSS | 12 ksi | 83.6 MPa | SACMASRM1R-94 |
| In Plain Shear Strength | 19 ksi | 131 MPa | ASTM D-3518 |
| 90° Tensile Strength | 10 ksi | 68 MPa | ASTM D-3039 |

*Normalized to 60% fiber volume. Cured with #2592 epoxy at 130 °C.



M35J

M35J Rev. 1: Updated April 13, 2018



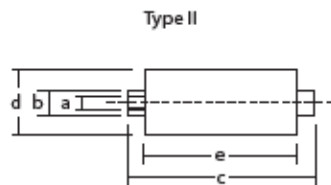
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PACKAGING

The table below summarizes the tow sizes, twists, sizing types, and packaging available for standard material. Other bobbin sizes may be available on a limited basis.

| TOW SIZES | BOBBIN NET WEIGHT (kg) | BOBBIN TYPE | BOBBIN SIZE (mm) | | | | | SPOOL PER CASE | CASE NET WEIGHT (kg) |
|-----------|------------------------|-------------|------------------|----|-----|-----|-----|----------------|----------------------|
| | | | a | b | c | d | e | | |
| 6K | 1.0 | II | 76 | 82 | 192 | 126 | 156 | 12 | 12 |
| 12K | 2.0 | II | 76 | 82 | 192 | 157 | 156 | 12 | 24 |

Bobbin Type:



Please refer to SDS for handling and disposal.

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M35J Rev. 1: Updated April 13, 2018



Toray Composite Materials America, Inc.

M40J

HIGH MODULUS CARBON FIBER

M40J carbon fiber is an MJ-type high modulus fiber with enhanced tensile and compressive strength as compared to M series fibers. Manufactured in Japan and France.

PRODUCT DESIGNATION

| M40J | B | 12,000 | 5 | 0 | B |
|------------|--------|----------------|-------------|-------------------|---------------|
| Fiber Type | Twist* | Filament Count | Sizing Type | Surface Treatment | Sizing Amount |

* B: Untwisted

FIBER PROPERTIES

| PROPERTY | ENGLISH | METRIC | METHOD |
|-------------------|----------|------------------------|------------|
| Tensile Strength | 640 ksi | 4,400 MPa | TY-030B-01 |
| Tensile Modulus | 54.7 Msi | 377 GPa | TY-030B-01 |
| Strain at Failure | | 1.2% | TY-030B-01 |
| Density | | 1.77 g/cm ³ | TY-030B-02 |
| Filament Diameter | | 5 μm | |
| Yield | 6K | 225 g /1000m | TY-030B-03 |
| | 12K | 450 g /1000m | TY-030B-03 |

FUNCTIONAL PROPERTIES

| PROPERTY | VALUE |
|------------------------------|--------------------------------|
| CTE | -0.83 α · 10 ⁻⁶ /°C |
| Specific Heat | 0.723 J/g · °C |
| Thermal Conductivity | 0.669 J/cm · s · °C |
| Electric Resistivity | 1.0 x 10 ⁻³ Ω · cm |
| Chemical Composition: Carbon | >99% |
| Na + K | <50 ppm |

RESIN SYSTEM COMPATIBILITY

| SIZING TYPE & AMOUNT | RESIN SYSTEM COMPATIBILITY | METHOD |
|----------------------|---|------------|
| 50B (1.0%) | Epoxy, phenolic, polyester, vinyl ester | TY-030B-05 |

COMPOSITE PROPERTIES

| PROPERTY | ENGLISH | METRIC | METHOD |
|-------------------------|---------|-----------|---------------|
| Tensile Strength* | 363 ksi | 2,500 MPa | ASTM D-3039 |
| Tensile Modulus* | 33 Msi | 226 GPa | ASTM D-3039 |
| Tensile Strain | | 1.11% | ASTM D-3039 |
| Compressive Strength* | 184 ksi | 1,270 MPa | SACMASRM1R-94 |
| Flexural Strength* | 226 ksi | 1,560 MPa | ASTM D-790 |
| Flexural Modulus* | 28 Msi | 190 GPa | ASTM D-790 |
| ILSS | 12 ksi | 83.1 MPa | SACMASRM1R-94 |
| In Plain Shear Strength | 18 ksi | 123 MPa | ASTM D-3518 |
| 90° Tensile Strength | 9 ksi | 63 MPa | ASTM D-3039 |

*Normalized to 60% fiber volume. Cured with #2592 epoxy at 130 °C.



M40J

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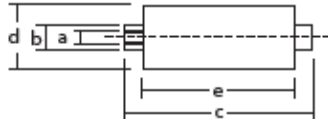
PACKAGING

The table below summarizes the tow sizes, twists, sizing types, and packaging available for standard material. Other bobbin sizes may be available on a limited basis.

| TOW SIZES | BOBBIN NET WEIGHT (kg) | BOBBIN TYPE | BOBBIN SIZE (mm) | | | | | SPOOL PER CASE | CASE NET WEIGHT (kg) |
|-----------|------------------------|-------------|------------------|----|-----|-----|-----|----------------|----------------------|
| | | | a | b | c | d | e | | |
| 6K | 1.0 | II | 76 | 82 | 192 | 126 | 156 | 12 | 12 |
| 12K | 2.0 | II | 76 | 82 | 192 | 157 | 156 | 12 | 24 |

Bobbin Type:

Type II



Please refer to SDS for handling and disposal.

For more information or purchasing inquiries:
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Toray Composite Materials America, Inc.

M46J

HIGH MODULUS CARBON FIBER

M46J carbon fiber is an MJ-type high modulus fiber with enhanced tensile and compressive strength as compared to M series fibers. Manufactured in Japan and France.

PRODUCT DESIGNATION

| M46J | B | 12,000 | 5 | O | B |
|------------|--------|----------------|-------------|-------------------|---------------|
| Fiber Type | Twist* | Filament Count | Sizing Type | Surface Treatment | Sizing Amount |

* B: Untwisted

FIBER PROPERTIES

| PROPERTY | ENGLISH | METRIC | METHOD |
|-----------------------|----------|------------------------|------------|
| Tensile Strength 6K | 609 ksi | 4,200 MPa | TY-030B-01 |
| Tensile Strength 12K | 583 ksi | 4,020 MPa | TY-030B-01 |
| Tensile Modulus | 63.3 Msi | 436 GPa | TY-030B-01 |
| Strain at Failure 6K | | 1.0% | TY-030B-01 |
| Strain at Failure 12K | | 0.9% | TY-030B-01 |
| Density | | 1.84 g/cm ³ | TY-030B-02 |
| Filament Diameter | | 5 μm | |
| Yield | 6K | 223 g/1000m | TY-030B-03 |
| | 12K | 445 g/1000m | TY-030B-03 |

FUNCTIONAL PROPERTIES

| PROPERTY | VALUE |
|------------------------------|-------------------------------|
| CTE | -0.9 α · 10 ⁻⁶ /°C |
| Specific Heat | 0.719 J/g · °C |
| Thermal Conductivity | 0.836 J/cm · s · °C |
| Electric Resistivity | 0.9 × 10 ⁻² Ω · cm |
| Chemical Composition: Carbon | >99% |
| Na + K | <50 ppm |

RESIN SYSTEM COMPATIBILITY

| SIZING TYPE & AMOUNT | RESIN SYSTEM COMPATIBILITY | METHOD |
|----------------------|---|------------|
| 50B (1.0%) | Epoxy, phenolic, polyester, vinyl ester | TY-030B-05 |

COMPOSITE PROPERTIES*

| PROPERTY | ENGLISH | METRIC | METHOD |
|-------------------------|---------|-----------|---------------|
| Tensile Strength* | 318 Ksi | 2,190 MPa | ASTM D-3039 |
| Tensile Modulus* | 39 Msi | 267 GPa | ASTM D-3039 |
| Tensile Strain | | 0.83% | ASTM D-3039 |
| Compressive Strength* | 158 ksi | 1,090 MPa | SACMASRM1R-94 |
| Flexural Strength* | 206 ksi | 1,420 MPa | ASTM D-790 |
| Flexural Modulus* | 32 Msi | 222 GPa | ASTM D-790 |
| ILSS | 12 ksi | 82.8 MPa | SACMASRM1R-94 |
| In Plain Shear Strength | 11 ksi | 77 MPa | ASTM D-3518 |
| 90° Tensile Strength | 7 ksi | 48 MPa | ASTM D-3039 |

*Normalized to 60% fiber volume. Cured with #2500 epoxy at 130 °C.



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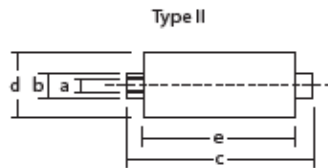
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PACKAGING

The table below summarizes the tow sizes, twists, sizing types, and packaging available for standard material. Other bobbin sizes may be available on a limited basis.

| TOW SIZES | BOBBIN NET WEIGHT (kg) | BOBBIN TYPE | BOBBIN SIZE (mm) | | | | | SPOOL PER CASE | CASE NET WEIGHT (kg) |
|-----------|------------------------|-------------|------------------|----|-----|-----|-----|----------------|----------------------|
| | | | a | b | c | d | e | | |
| 6K | 1.0 | II | 76 | 82 | 192 | 126 | 156 | 12 | 12 |
| 12K | 2.0 | II | 76 | 82 | 192 | 157 | 156 | 12 | 24 |

Bobbin Type:



Please refer to SDS for handling and disposal.

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M55J

HIGH MODULUS CARBON FIBER

M55J carbon fiber is an MJ-type high modulus fiber with enhanced tensile and compressive strength as compared to M series fibers. Manufactured in Japan.

PRODUCT DESIGNATION

| M55J | B | 6,000 | 5 | 0 | B |
|------------|--------|----------------|-------------|-------------------|---------------|
| Fiber Type | Twist* | Filament Count | Sizing Type | Surface Treatment | Sizing Amount |

* B: Untwisted

FIBER PROPERTIES

| PROPERTY | ENGLISH | METRIC | METHOD |
|-------------------|----------|------------------------|------------|
| Tensile Strength | 583 ksi | 4,020 MPa | TY-030B-01 |
| Tensile Modulus | 78.2 Msi | 540 GPa | TY-030B-01 |
| Strain at Failure | | 0.8% | TY-030B-01 |
| Density | | 1.91 g/cm ³ | TY-030B-02 |
| Filament Diameter | | 5 μm | |
| Yield | 6K | 218 g/1000m | TY-030B-03 |

FUNCTIONAL PROPERTIES

| PROPERTY | VALUE |
|------------------------------|-------------------------------|
| CTE | -1.1 α · 10 ⁻⁴ /°C |
| Specific Heat | 0.732 J/g · °C |
| Thermal Conductivity | 0.961 J/cm · s · °C |
| Electric Resistivity | 0.8 × 10 ⁻³ Ω · cm |
| Chemical Composition: Carbon | >99% |
| Na + K | <50 ppm |

RESIN SYSTEM COMPATIBILITY

| SIZING TYPE & AMOUNT | RESIN SYSTEM COMPATIBILITY | METHOD |
|----------------------|---|------------|
| 50B (1.0%) | Epoxy, phenolic, polyester, vinyl ester | TY-030B-05 |

COMPOSITE PROPERTIES

| PROPERTY | ENGLISH | METRIC | METHOD |
|-------------------------|---------|-----------|---------------|
| Tensile Strength* | 293 ksi | 2,020 MPa | ASTM D-3039 |
| Tensile Modulus* | 49 Msi | 338 GPa | ASTM D-3039 |
| Tensile Strain | | 0.61% | ASTM D-3039 |
| Compressive Strength* | 129 ksi | 890 MPa | SACMASRM1R-94 |
| Flexural Strength* | 171 ksi | 1,180 MPa | ASTM D-790 |
| Flexural Modulus* | 40 Msi | 274 GPa | ASTM D-790 |
| ILSS | 11 ksi | 73.2 MPa | SACMASRM1R-94 |
| In Plain Shear Strength | 10 ksi | 68 MPa | ASTM D-3518 |
| 90° Tensile Strength | 5 ksi | 37 MPa | ASTM D-3039 |

*Normalized to 60% fiber volume. Cured with #2500 epoxy at 130 °C.



M55J

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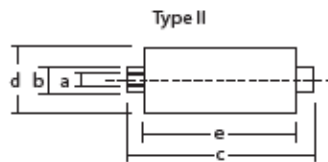
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PACKAGING

The table below summarizes the tow sizes, twists, sizing types, and packaging available for standard material. Other bobbin sizes may be available on a limited basis.

| TOW SIZES | BOBBIN NET WEIGHT (kg) | BOBBIN TYPE | BOBBIN SIZE (mm) | | | | | SPOOL PER CASE | CASE NET WEIGHT (kg) |
|-----------|------------------------|-------------|------------------|----|-----|-----|-----|----------------|----------------------|
| | | | a | b | c | d | e | | |
| 6K | 0.5 | II | 76 | 82 | 192 | 107 | 156 | 24 | 12 |

Bobbin Type:



Please refer to SDS for handling and disposal.

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Toray Composite Materials America, Inc.

M60J

HIGH MODULUS CARBON FIBER

M60J carbon fiber is an MJ-type high modulus fiber with enhanced tensile and compressive strength as compared to M series fibers. Manufactured in Japan.

PRODUCT DESIGNATION

| M60J | B | 6,000 | 5 | 0 | B |
|------------|--------|----------------|-------------|-------------------|---------------|
| Fiber Type | Twist* | Filament Count | Sizing Type | Surface Treatment | Sizing Amount |

* B: Untwisted

FIBER PROPERTIES

| PROPERTY | ENGLISH | METRIC | METHOD |
|-------------------|----------|------------------------|------------|
| Tensile Strength | 554 ksi | 3,820 MPa | TY-030B-01 |
| Tensile Modulus | 85.3 Msi | 588 GPa | TY-030B-01 |
| Strain at Failure | | 0.7% | TY-030B-01 |
| Density | | 1.93 g/cm ³ | TY-030B-02 |
| Filament Diameter | | 5 μm | |
| Yield | 3K | 103 g/1000m | TY-030B-03 |
| | 6K | 206 g/1000m | TY-030B-03 |

FUNCTIONAL PROPERTIES

| PROPERTY | VALUE |
|------------------------------|-------------------------------|
| CTE | -1.1 α · 10 ⁻⁶ /°C |
| Specific Heat | 0.732 J/g · °C |
| Thermal Conductivity | 1.505 J/cm · s · °C |
| Electric Resistivity | 0.7 × 10 ⁻³ Ω · cm |
| Chemical Composition: Carbon | >99% |
| Na + K | <50 ppm |

RESIN SYSTEM COMPATIBILITY

| SIZING TYPE & AMOUNT | RESIN SYSTEM COMPATIBILITY | METHOD |
|----------------------|---|------------|
| 50B (1.5%) | Epoxy, phenolic, polyester, vinyl ester | TY-030B-05 |

COMPOSITE PROPERTIES

| PROPERTY | ENGLISH | METRIC | METHOD |
|-------------------------|---------|-----------|---------------|
| Tensile Strength* | 292 ksi | 2,010 MPa | ASTM D-3039 |
| Tensile Modulus* | 52 Msi | 360 GPa | ASTM D-3039 |
| Tensile Strain | | 0.55% | ASTM D-3039 |
| Compressive Strength* | 115 ksi | 790 MPa | SACMASRM1R-94 |
| Flexural Strength* | 155 ksi | 1,070 MPa | ASTM D-790 |
| Flexural Modulus* | 44 Msi | 301 GPa | ASTM D-790 |
| ILSS | 10 ksi | 70.3 MPa | SACMASRM1R-94 |
| In Plain Shear Strength | 8 ksi | 55 MPa | ASTM D-3518 |
| 90° Tensile Strength | 5 ksi | 34 MPa | ASTM D-3039 |

*Normalized to 60% fiber volume. Cured with #2500 epoxy at 130 °C.



M60J

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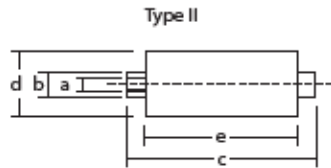
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PACKAGING

The table below summarizes the tow sizes, twists, sizing types, and packaging available for standard material. Other bobbin sizes may be available on a limited basis.

| TOW SIZES | BOBBIN NET WEIGHT (kg) | BOBBIN TYPE | BOBBIN SIZE (mm) | | | | | SPOOL PER CASE | CASE NET WEIGHT (kg) |
|-----------|------------------------|-------------|------------------|----|-----|-----|-----|----------------|----------------------|
| | | | a | b | c | d | e | | |
| 3K | 0.25 | II | 76 | 82 | 192 | 94 | 156 | 20 | 5 |
| 6K | 0.4 | II | 76 | 82 | 192 | 103 | 156 | 20 | 8 |

Bobbin Type:



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