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# NCAMP Material Specification

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## High Toughness and High Tensile Performance Epoxy Prepregs, Type 33.5, Class 1, Form (1, 2, and 3), Grade 192

## Toray Composite Materials America, Inc. 3960 T1100GC 24K 71E Tape

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REVISIONS:

| Rev | By | Date | Pages Revised or Added |
|---|---|---|---|
| N/C | Vinsensius Tanoto and Royal Lovingfoss | 3/30/2020 | Document Initial Release |
| A | Vinsensius Tanoto and Royal Lovingfoss | 3/3/2025 | Cover Page: Revised “Jeremiah (Jeb) Robbins (Toray)” to “Jerimiah (Jeb) Robbins (Toray, Lilium)”<br>Section 1: Additional clarification on Form 1, Form 2 and Form 3 were added.<br>Section 3: DSC test method was revised from ASTM D3418 to ASTM E1356. Added Specification limits. Additional clarification was added. Added UHPLC. Specification limits were added.<br>Section 3.5.2: “Section 14.3.6” was added to ASTM D3171. Clarification was added for DMA test method and Specification limits were added.<br>Section 3.5.3: Specification limits were added. |
| A | Vinsensius Tanoto and Royal Lovingfoss | 9/10/2025 | Cover Page: Distribution statement was revised from “This document is intended for proprietary use and will be distributed at the discretion of Toray Composite Materials America until such a time that it is decided the data and reports can be released for public distribution.” to “Distribution Statement A. Approved for public release; distribution is unlimited.”<br>This is approved by Toray CMA. |
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## 1. SCOPE:

### 1.1 Form:

This detail specification along with the base specification NMS 397 establishes the requirements for continuous unidirectional carbon fiber impregnated with a modified B-staged epoxy resin ("unidirectional tape prepreg"). The prepreg is produced using a hot-melt process.

This detail specification follows the section and table numbering scheme of the base specification. It contains additional or superseding requirements. The base specification shall govern where no additional requirement is specified; in such cases, the applicable sections are omitted from this detail specification.

Form 1 for hand layup applications is the default material form for NMS 397/1 unless specified in the purchase order. Hand lay-up is the only lay-up process that is associated with NCAMP Qualification data and specification limits. Material supplier may slit the material to Form 2 (Automated Tape Laying) or Form 3 (Automated Fiber Placement) as requested by material purchasers, however there is no NCAMP Qualification data or specification limits associated with Form 2 and Form 3 processes.

**1.3 Classification:** All products qualified to this detail specification have the following classification: Type 33.5, Class 1, Form (1, 2, and 3), Grade 192

## 3. TECHNICAL REQUIREMENTS:

Table 1 – Prepreg Physical and Chemical Properties (Form 1)

| Property | Test Method(1) | Number of Replicates(4) | Requirements(5) |
|---|---|---|---|
| Resin Content | ASTM D3529 | Every master roll of every batch(2) | 33.5±3% ind.<br>33.5±2% avg. |
| Fiber Areal Weight | ASTM D3529 | Every master roll of every batch(2) | 192±7 gsm ind.<br>192±5 gsm avg. |
| Volatile Content | ASTM D3530 | First and last master roll of every batch(2) | 2.0% max avg. |
| Flow | ASTM D3531 | First and last master roll of every batch(2) | 5.6 to 20.1%, avg. |
| Gel Time | ASTM D3532 | First and last master roll of every batch(2) | 4.6 to 16.7 min, avg. |
| Tack | See NMS 397 Section 4.6.1 | First and last master roll of every batch | Level IV |
| HPLC(6)(7) | SACMA SRM 20R-94 | First and last master roll of a batch(3) | P2/P1: 0.003 to 0.017 avg.<br>P3/P1: 0.141 to 0.201 avg.<br>P4/P1: 0.019 max avg.<br>P5/P1: 0.096 to 0.134 avg. |

| | | | |
|---|---|---|---|
| UHPLC[6][7] | See 4.6.3 | First and last master roll of a batch[3] | P2/P1: 0.002 to 0.019 avg.<br>P3/P1: 0.134 to 0.202 avg.<br>P4/P1: 0.033 max avg.<br>P5/P1: 0.091 to 0.150 avg. |
| IR[6] | ASTM E168<br>ASTM E1252 | First and last master roll of a batch[3] | 0.99% min Correlation |
| Differential Scanning Calorimetry (DSC), Tg[6] | ASTM E1356 | First and last master roll of every batch[3] | 4.76 °C max, ind. |

[1] Specific procedures should be identical to those used in the original material qualification program.
[2] Three specimens should be taken across the width of the prepreg; left, center, right.
[3] One specimen from each designated location.
[4] If a batch only has one master roll, test once per master roll.
[5] "ind." refers to individual measurements. "avg." refers to the average measurements per roll.
[6] For Batch release testing only. HPLC, UHPLC and DSC specification limits were derived within supplier out of storage allowance from manufacturing to freezer, therefore these specification limits are not suitable for evaluating the material handling life per 3.6.2.2 of NMS 397 Base Specification.
[7] Material supplier has the option to test for HPLC or UHPLC for batch release testing.

## 3.2 Constituent Material Requirements:

3.2.2 Reinforcement: Efforts to qualify the carbon fiber to NCAMP carbon fiber material specification, NMS 818, are ongoing. In the meantime, Toray will continue to provide aerospace-grade carbon fiber for this prepreg per the prepregger's carbon fiber procurement specification and Toray's internal aerospace-grade PCD. In addition, the following change control is implemented on the carbon fiber:

The carbon fiber tow product manufacturer shall establish control factors which will yield product meeting the technical requirements of this specification. The factors which are used in the production of fiber tow used in the prepreg material qualification shall constitute the approved factors; they shall be used for manufacturing production carbon fiber tow product. Control factors are Controlled Process Equipment and Controlled Process Parameters for producing the product. Control factors include, but are not limited to, the following:

a) PAN Precursor formulation (raw ingredients and ratios),
b) PAN Precursor manufacturing process, equipment, line, or site,
c) PAN Precursor acceptance requirements,
d) Carbon fiber tow processing parameters (e.g. temperature and speed),
e) Carbon fiber tow manufacturing equipment, line, or site,
f) Carbon fiber tow acceptance requirements,
g) Carbon fiber tow acceptance test methods,
h) Carbon fiber tow acceptance sampling plan,

i) Carbon fiber tow surface treatment methods and levels,
j) Carbon fiber tow sizing formulation and sizing level, and
k) Carbon fiber tow sizing application and drying methods, including equipment.

If it is necessary to make any change in the above control factors, the carbon fiber tow product manufacturer shall submit for re-approval to NCAMP through the prepreg manufacturer in accordance with NRP 101 Prepreg Process Control Document (PCD) Preparation and Maintenance Guide. NRP 102 Polyacrylonitrile-based Carbon Fiber Process Control Document (PCD) Preparation and Maintenance Guide may be used as a reference. The change shall not be incorporated prior to the receipt of re-approval notice, typically in the form of a signed Advanced Change Notice (ACN).

## 3.4 Visual and Dimensional Requirements:

3.4.4 Roll characteristics - The standard widths for this product are up to 60 inches. Specific widths may be supplied as requested by the purchaser.

## 3.5 Laminate (Cured Prepreg) Requirements:

3.5.2 Cured Laminate Physical Properties:

TABLE 3 - Cured Laminate Physical Properties (Form 1)

| Property | Test Method[1] | Requirements[2] |
|---|---|---|
| Cured Ply Thickness, CPT[3] | ASTM D3171 - Section 14.3.6[7] | 0.0068 to 0.0076 inch, avg. |
| Dry Glass Transition Temperature, Tg by DMA[4] | ASTM D7028 (by flexural loading) per Toray's calibration procedure (specific to Toray's equipment)[5] | 193 to 213 ºC, ind. |
| | ASTM D7028 (by flexural loading) per DOT/FAA/TC-15/28 calibration procedure[6] | 161 to 198 ºC, ind. |

[1] Specific procedures should be identical to those used in the original material qualification program.
[2] “ind.” refers to individual measurements. “avg.” refers to the average measurements per panel.
[3] Cured Ply Thickness of the Laminates in Table 4. Computed from actual qualification panel thicknesses and historical data variability using α=0.01 and modified CV, and theoretical Cured Ply Thickness as the nominal.
[4] Material supplier and purchasers may select one test method for batch release testing or receiving inspection. Drying at 250°F±5°F for 24 hours minimum prior to testing may be required if specimens are likely to have moisture.
[5] Limits computed using average qualification data ± 18 ºF from Qualification batches and historical data. Toray uses manufacturer’s DMA recommendation for

calibration and conduct an instrument check using polycarbonate material to identify significant changes in equipment.

(6) Limits computed using average qualification data ± 18 ºF from Qualification batches.

(7) Measure panel thickness using a 0.25 inch (6.35mm) diameter hemispherical anvil, spindle micrometer or equivalent tool/process. Test panel thickness measurements must be performed at least 1 inch (25.4 mm) from the laminate edge and uniformly distributed over the laminate surface and divided by the number of plies in the laminate.

3.5.3 Cured Laminate Mechanical Properties:

TABLE 4 - Required Cured Laminate Tests for Mechanical Properties (Class 1 - Form 1)

| Property | Test Method(1) | Number of Replicates | Requirements(3) |
|---|---|---|---|
| 0° Tension Strength and Modulus<br>Room Temperature, Ambient<br>Layup: $[0]_6$ | ASTM D3039 | 5 | Strength(2)(5): Min. Ind. ≥ 451 ksi<br>Strength(2)(5): Average ≥ 505 ksi<br>Modulus(2)(6): 23.1 to 26.8 msi, avg |
| 90/0° Compression Strength and Modulus<br>Room Temperature, Ambient<br>Layup: $[90/0/90]_5$ | ASTM D6641 | 5 | Strength(2)(6): Min. Ind. ≥ 90.5 ksi<br>Strength(2)(6): Average ≥ 104 ksi<br>Modulus(2)(6)(7): 7.6 to 8.8 msi, avg |
| 0° Short Beam Strength,<br>Room Temperature, Ambient<br>Layup: $[0]_{14}$ | ASTM D2344 | 5 | Strength(4): Min. Ind. ≥ 13.4 ksi<br>Strength(4): Average ≥ 15.3 ksi |

(1) Specific procedures should be identical to those used in the original material qualification program.

(2) Normalize the properties to a cured ply thickness value of 0.0072 inch, based on theoretical nominal CPT, using the following equation:
Normalized_Value = Measured_Value x Measured_CPT / Nominal_CPT

(3) “ind.” refers to individual measurements. “avg.” refers to the average of 5 replicates. Limits computed at α=0.01 and modified CV.

(4) Limits computed using α=0.01 and modified CV from Qualification data.

(5) Limits computed using α=0.01 and modified CV from Qualification adjusted data and historical data.

(6) Limits computed using α=0.01 and modified CV from Qualification data and historical data.

(7) Back-to-back strain gages should be used on each specimen and the average of the back-to-back strain gages is the modulus of the particular specimen.

**QUALIFIED PRODUCTS LIST**

| Supplier Product Designation | Supplier Name and Production Location | Date Qualified | Specification Callout(1) |
|---|---|---|---|
| Toray 3960 T1100GC Tape (P173EBN-19) | Supplier Name: Toray Composite Materials America, Inc.<br><br>Production Location:<br>19002 50th Ave E.<br>Tacoma, WA 98446 | 3/3/2025 | NMS 397/1<br><br>Classification callout is optional because Type 33.5, Class 1, Form (1, 2, and 3), Grade 192 is the only classification allowed in this QPL. |

(1) In accordance with NCAMP Standard Operating Procedures, NSP 100, this QPL shall not contain alternate materials/products. Additional production location may be included in the QPL only after successful equivalency demonstration and approval per NCAMP Prepreg Process Control Document (PCD) Preparation and Maintenance Guide, NRP 101.

(1) The proper specification callout for material procurement purpose is “NMS 397/1.” This specification is developed based on the material properties that are available publicly. The purchaser may specify additional requirements beyond those specified in this specification, especially when the purchaser has generated additional material properties beyond those available publicly or when the application requires additional requirements. The additional requirements are subject to supplier review and approval.