

# TECHNICAL DATA



TENCATE ADVANCED COMPOSITES

## RS-1

### TYPICAL APPLICATIONS

- Marine Structures
- Dielectric Structures
- Aerospace Structures

### PRODUCT FORMS

- Unitape to 24 Inches Wide
- Fabric Prepreg to 50 Inches Wide

### TYPICAL CURE PARAMETERS

- Apply vacuum.  
(If Aerospace applications require autoclave or press cure, pressurize to 45 to 100 psi.)
- Heat to 200°F (93°C) (+10°F/-0°F) @ 5°F ± 3°F/min.
- Hold at 200°F (93°C) for 3 hours (+15 min/-0 min). Cool.

### SHELF LIFE

#### Tack Life

21 days at 75°F (24°C)

#### Out Life

30 days at 75°F (24°C)

#### Frozen Storage Life

6 months storage life at <0°F (-18°C)

Tack life is the time during which the prepreg retains enough tack, drape and handling for easy component lay-up.

Out life is the maximum time allowed at room temperature before cure.

### PRODUCT DESCRIPTION

RS-1 is an epoxy resin which provides an excellent balance of mechanical properties, toughness, and modulus. RS-1 has been evaluated and qualified in areas ranging from marine to aerospace and dielectric structures. RS-1 is also available in a lower temperature curing, 176°F (80°C), formulation.

### RS-1 PRODUCT BENEFITS/FEATURES

- Minimum Ambient Work Life of 4 Weeks
- Excellent Balance of Mechanical Properties, Toughness, and Modulus
- Formulated for Compatibility with UHMWPE Fiber for Low Dielectric Applications
- Flexible, Robust Range of Process Cycles
- Vacuum Bag, Autoclave, and Press Consolidation
- Excellent Matrix for Sandwich Structure Skins

### NEAT RESIN PHYSICAL PROPERTIES

Density ..... 1.24 g/cm<sup>3</sup>  
Tg (by DSC) ..... 225°F (107°C)  
Coefficient of Thermal Expansion ..... 32 ppm/°F (57.6 ppm/°C)  
Viscosity ..... 133,700 cps at 122°F (50°C)  
1,550 cps at 229°F (109°C)

### NEAT RESIN MECHANICAL PROPERTIES

Tensile Strength ..... 11.5 ksi (79 MPa)  
Tensile Modulus ..... 0.44 Msi (3.0 GPa)  
Compressive Strength ..... 17 ksi (117 GPa)  
Compressive Modulus ..... 0.43 Msi (2.9 GPa)

### LAMINATE DATA USED S2-GLASS/RS-1 UDPP LAMINATE.

| Properties                  | Condition (RTD, ETD, ETW) | Method     | Results  |          |
|-----------------------------|---------------------------|------------|----------|----------|
| Tensile Strength 0°         | RTD                       | ASTM D3039 | 281 ksi  | 1937 MPa |
| Tensile Modulus 0°          | RTD                       | ASTM D3039 | 7.1 Msi  | 49 GPa   |
| Tensile Strength 0°         | ETW                       | ASTM D3039 | 122 ksi  | 841 MPa  |
| Tensile Modulus 0°          | ETW                       | ASTM D3039 | 7.49 Msi | 52 GPa   |
| Compressive Strength 0°     | RTD                       | ASTM D6641 | 104 ksi  | 717 MPa  |
| Compressive Modulus 0°      | RTD                       | ASTM D6641 | 7.99 Msi | 55 GPa   |
| Compressive Strength 0°     | RTW                       | ASTM D6641 | 105 ksi  | 724 MPa  |
| Compressive Modulus 0°      | RTW                       | ASTM D6641 | 7.48 Msi | 52 GPa   |
| Compressive Strength 0°     | ETW                       | ASTM D6641 | 16.5 ksi | 114 MPa  |
| Compressive Modulus 0°      | ETW                       | ASTM D6641 | 6.79 Msi | 47 GPa   |
| Interlaminar Shear Strength | RTD                       | ASTM D2344 | 7.78 ksi | 54 MPa   |
| Interlaminar Shear Strength | ETW*                      | ASTM D2344 | 306 ksi  | 2110 MPa |

\* Failure mode: plastic deformation

- S2-Glass panels: 130 g/m<sup>2</sup>, tensile 14 plies, compressive and ILSS 20 plies

- All properties normalized to 56.8% FV.

- RTW: Conditioned at 176°F (80°C), 98% RH for 5 days; ETW: Conditioned at 176°F (80°C), 98% RH for 18 days.

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TENCATE ADVANCED COMPOSITES

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### LAMINATE DATA USED T-300 (12K)/RS-1 UDPP LAMINATE\*

| Properties                                  | Condition<br>(RTD, ETD, ETW) | Method     | Results  |            |
|---|------------------------------|------------|----------|------------|
|   |                              |            |          |            |
| Tensile Strength 0°                         | RTD                          | ASTM D3039 | 249 ksi  | 1716.8 MPa |
| Tensile Modulus 0°                          | RTD                          | ASTM D3039 | 17.8 Msi | 122.7 GPa  |
| Compressive Strength [0,90 crossply]        | RTD                          | ASTM D695  | 83 ksi   | 572.3 MPa  |
| Compressive Modulus [0,90 crossply]         | RTD                          | ASTM D695  | 8.1 Msi  | 55.8 GPa   |
| Interlaminar Shear Strength [0,90 crossply] | RTD                          | ASTM D2344 | 5.9 ksi  | 40.7 MPa   |

\* Laminate was heated to 200°F (93°C) at 1.5°F/min (1°C/min), cured at 200°F (93°C) for 5.5 hours.

- All properties normalized to 56.8% FV.

### LAMINATE DATA USED 7781 E GLASS/RS-1 FABRIC LAMINATE

| Properties              | Condition | Method     | Cured at<br>180°F (82°C)<br>for 5 hrs. |              | Cured at<br>205°F (96°C)<br>for 1.5 hrs. |              | Cured at<br>160°F (71°C) for<br>1 hr./205°F<br>(96°C) for 1.5<br>hrs. |              |
|-------------------------|-----------|------------|--|--------------|--|--------------|---|--------------|
|                         |           |            |  |              |  |              |   |              |
| Tensile Strength 0°     | RTD       | ASTM D3039 | 51.8<br>ksi                            | 357.2<br>MPa | 51.3<br>ksi                              | 353.7<br>MPa | 55.3<br>ksi   | 381.3<br>MPa |
| Tensile Modulus 0°      | RTD       | ASTM D3039 | 3.1<br>Msi                             | 21.4<br>GPa  | 3 Msi                                    | 20.7<br>GPa  | 3 Msi   | 20.7<br>GPa  |
| Compressive Strength 0° | RTD       | ASTM D695  | 51.9<br>ksi                            | 357.8<br>MPa | 53.6<br>ksi                              | 369.6<br>MPa | 55.9<br>ksi   | 385.4<br>MPa |
| Flexural Strength 0°    | RTD       | ASTM D2344 | 70.8<br>ksi                            | 488.2<br>MPa | 68.6<br>ksi                              | 473.0<br>MPa | 71.3<br>ksi   | 491.6<br>MPa |

- All properties normalized to 60% FV

Tg: With 180°F (82°C) 5 hour cure ..... 200°F (93°C)  
 After 72 hour water boil ..... 163°F (73°C)  
 With 205°F (96°C) 1 hour cure ..... 221°F (105°C)

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### TYPICAL RS-1 200°F CURE PARAMETERS

- Apply vacuum.  
(If aerospace applications require autoclave or press cure, pressurize to 45-100 psi.)
- Heat to 150°F (66°C) (+10°F/-0°F) @ 4°F ± 3°F/min.
- Hold at 150°F (66°C) for a minimum of 30 minutes.\*
- Heat to 200°F (93°C) (+10°F/-0°F) @ 4°F ± 3°F/min.
- Hold at 200°F (93°C) for 6 hours (+15 min/-0 min).  
Cool under vacuum.

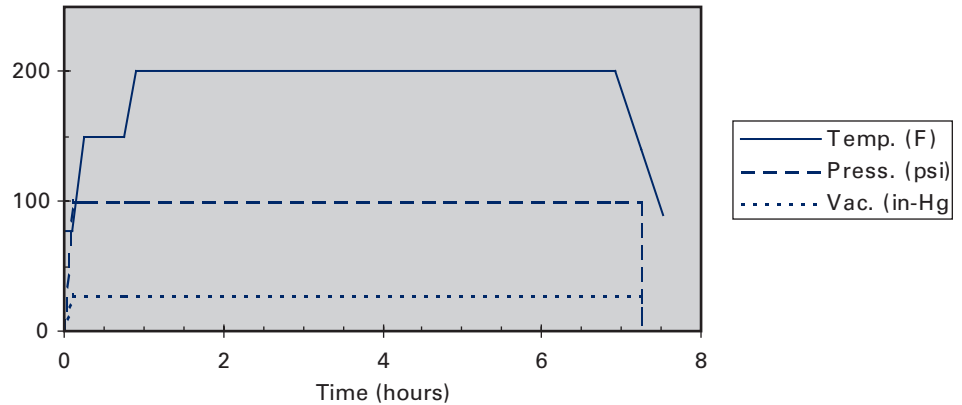
### TYPICAL RS-1 176°F CURE PARAMETERS

- Apply vacuum.  
(If aerospace applications require autoclave or press cure, pressurize to 45-100 psi.)
- Heat to 150°F (66°C) (+10°F/-0°F) @ 4°F ± 3°F/min.
- Hold at 150°F (66°C) for a minimum of 30 minutes.\*
- Heat to 176°F (80°C) (+10°F/-0°F) @ 4°F ± 3°F/min.
- Hold at 176°F (80°C) for 12 hours (+15 min/-0 min).  
Cool under vacuum.

### RS-1: 200°F (93°C) CURE, LATENT TOUGHENED EPOXY RESIN

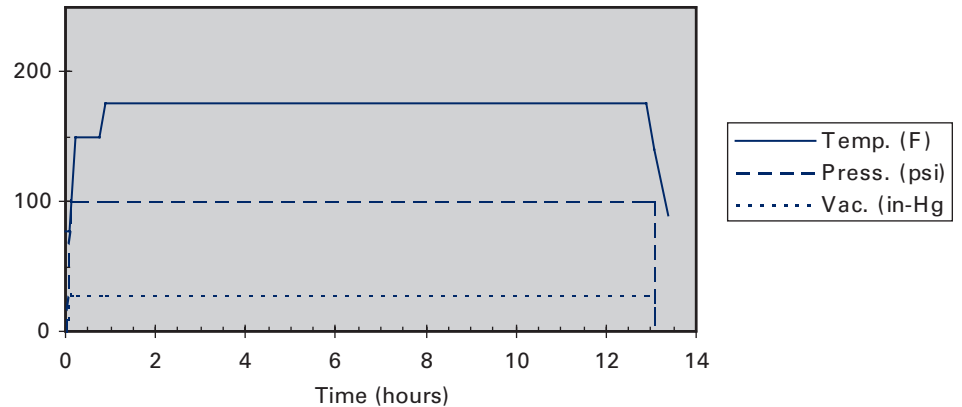
RS-1 epoxy resin provides an excellent balance of mechanical properties, toughness, and modulus with a flexible and robust range of process cycles. RS-1 may also be cured at temperatures as low as 176°F (80°C).

TYPICAL RS-1 200°F (93°C) CURE PROFILE



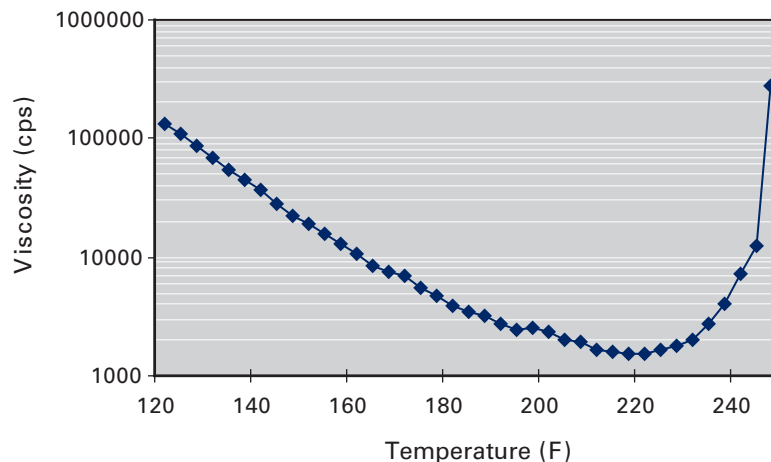
\* Some applications may not require the 150°F dwell. Please contact TenCate - Fairfield for technical assistance.

TYPICAL RS-1 176°F (80°C) CURE PROFILE



\* Some applications may not require the 150°F dwell. Please contact TenCate - Fairfield for technical assistance.

RS-1 Neat Resin Viscosity Profile



## RS-1

### PROCESSING OF RS-1 PREPREG

RS-1 is a toughened epoxy resin that has an excellent work life (minimum of 30 days at ambient conditions) yet cures at 176°F in 12 hours or 200°F in 3-6 hours (other alternative cure schedules can be furnished by TenCate). The catalyst requires elevated temperature for initiation of the cure reaction. RS-1 reaches minimum viscosity at 150°F to 160°F, yet cure reaction rate is minimal, providing excellent conditions for dwell and consolidation.

Understanding the above processing characteristics and versatility of the RS-1 system provides users with excellent success in their own specific environments. Although RS-1 is a very flexible resin system with respect to processing, certain guidelines need to be followed in order to achieve optimal mechanical properties. TenCate strongly recommends that sample/sub-scale work representative of the actual structure and process conditions be performed in the customer oven and shop environment with TenCate technical input/assistance prior to using RS-1 on large structures.

### RECOMMENDED RS-1 PROCESSING

1. Apply full vacuum (minimum of 28 inches Hg) to the debulked laminate. TenCate recommends a warm debulk if practical, but room temperature debulks can be effective (please contact TenCate for debulk recommendations on large parts). It is critical that the prepreg plies are layed-up such that wrinkling and voids are minimized. TenCate recommends use of Teflon® rollers or squeegees to remove air pockets during lay-up of the individual plies.
2. Vacuum bag lay-up sequence is as follows: (1) Tool with appropriate mold release or release film and debulked prepreg laminate; (2) 3 oz/yd<sup>2</sup> natural nylon peel ply, or equivalent; (3) perforated film ("P3" type, or equivalent); (4) 4 oz/ft<sup>2</sup> polyester breather cloth; and (5) 250°F rated nylon bagging film (PVA or cheap "poly" bag material is not recommended as it may easily leak or puncture).
3. Apply thermocouples to the part and oven every six to eight feet. TenCate recommends some thermocouples be placed inside the laminate (near an edge) if at all possible, not just on top of the laminate or outside the vacuum bag. Embedded thermocouples are extremely useful as they provide an understanding of the actual temperature profile achieved in each region of the entire part.
4. Place a vacuum port every 8 ft<sup>2</sup> or so over the part to insure good vacuum and volatile egress over the entire part area.
5. Ramp the oven at 1°F to 7°F per minute for thin laminates. The ramp rate may be adjusted, depending on the thickness of the part and the heating characteristics of the oven. For example, laminates greater than 50 plies will require a dwell at 160°F to 170°F for three hours using a slower ramp rate of 1°F to 2°F per minute. Always base the ramp rates and dwells on the "lagging" (i.e., the slowest) thermocouple.
6. When the lagging thermocouple reaches 150°F to 160°F start the dwell, i.e.; leave the oven at this temperature for at least 30 minutes based on the thickness and number of plies of laminate as noted above. As a general rule, the thicker the laminate, the longer the dwell time. The goal is to achieve laminate consolidation, de-aeration, and compaction without too much cross-linking at this stage of the cure cycle. Again, always base the start of the dwell period on the lagging thermocouple.

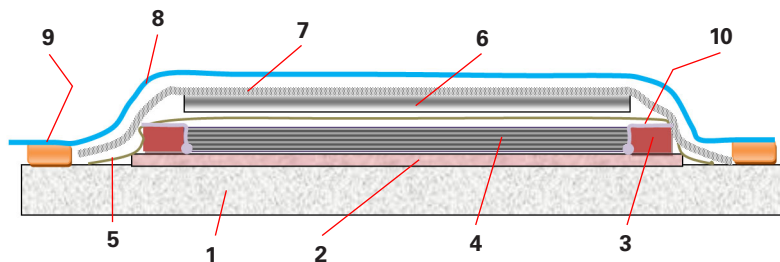
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- At the end of the dwell, ramp the oven at 1°F to 7°F per minute to either 176°F or 200°F and dwell for the appropriate time (12 hours minimum at 176°F or 3 hours minimum at 200°F). The dwell times are again based on the lagging thermocouple. Dwell time does not begin until the last thermo couple has reached the dwell temperature. The part cannot be over cured. In most cases, the longer cures mean better parts as long as the tool can take the longer cure time without distortion.
- The HDT (heat deflection temperature, representing the amount of cure) will continue to advance the longer the part is cured and the higher the cure temperature, up to a final endpoint where it will no longer increase the HDT (again depending on part size and thickness). Thinner laminates and smaller parts tend to need less time, but it is important to achieve recommended minimums for temperatures and times.
- Allow the part to cool in the oven under vacuum by simply turning off the heat source and continuing to run whatever fans or blowers have been used during the cure. Do not open the oven doors. It is best to remove the part when it can be touched comfortably (less than 110°F). This can take up to 7 hours or longer for large structures, so be patient. If the part is pulled directly from the oven when at a high temperature it can be thermally shocked and warpage, pre-release, or separations between prepreg plies or between prepreg and cores ("delaminations") can occur.

### COMPOSITE LAMINATE STACKING SEQUENCE

#### LIST OF MATERIALS

- Tool – aluminum, steel, Invar, composite  
(tool plates must be release coated or film covered)
- Release coat or film – Frekote 700NC or 770NC, FEP, TEDLAR
- Silicone Edge Dams – Thicker than laminate
- Laminate
- Release coat or film – Frekote 700NC or 770NC, FEP, TEDLAR
- Caul plate – aluminum, steel, Invar, silicone rubber sheet  
(metal caul plates must be release coated or wrapped)
- 2.2 osy polyester breather – 1 or more
- Vacuum bag
- Vacuum sealant
- Glass yarn string - (alternatively or additionally breather may wrap over top of dam to contact edge)



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All data given is based on representative samples of the materials in question. Since the method and circumstances under which these materials are processed and tested are key to their performance, and TenCate Advanced Composites has no assurance of how its customers will use the material, the corporation cannot guarantee these properties.

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