

## C-PREG® 400 4.0

C-PREG® 400 is a heat and flame resistant prepreg, test FAR 25.853 exceeded. It is the ideal choice for high temperature applications.



**C-Preg® 400**

*Heat resistant, flame retardant,  
high temperature composite  
Excellent performance up to 400°C*

## Description

C-PREG<sup>®</sup> 400 4.0 is a high temperature, heat resistant prepreg developed for a wide variety of applications.

The special composition allows cure cycles between 165 °C and 300 °C. The cured composite has working temperature in oxidative environment up to 400 °C.

C-PREG<sup>®</sup> 400 4.0 is easy to use and is processed in the same way as other common prepreps and can be shaped using traditional compression molding or vacuum bagging techniques.

C-PREG<sup>®</sup> 400 4.0 effectively fills the void between existing prepreg systems and ceramic matrix composites, and can be used to produce thermal barriers, exhaust systems, engine parts and other components for high performance braking systems.

## Key features

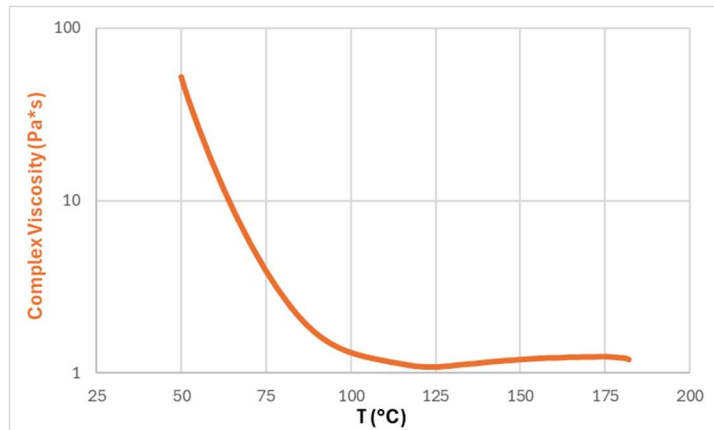
- Maximum service temperature up to 400 °C
- Suitable for autoclave, Out-of-Autoclave (OoA) cure processes
- Flexible cure characteristics between 165 °C and 300 °C
- Several available reinforcements. Carbon fibre, glass fibre, quartz fibre
- High tack
- Easy to use prepreg
- UL94-VO rated
- Compliance FAR 25.853 Appendix F
- Compliance MIL-STD-2031, 1991 Edition

## Matrix properties

| Measurement                            | Value       |
|--|-------------|
| Cured resin density, g/cm <sup>3</sup> | 1,25 ± 0,01 |
| Tack                                   | 4           |

\*Tack: 1=low; 2=low-medium; 3=medium; 4=medium-high; 5=high

### Rheological properties

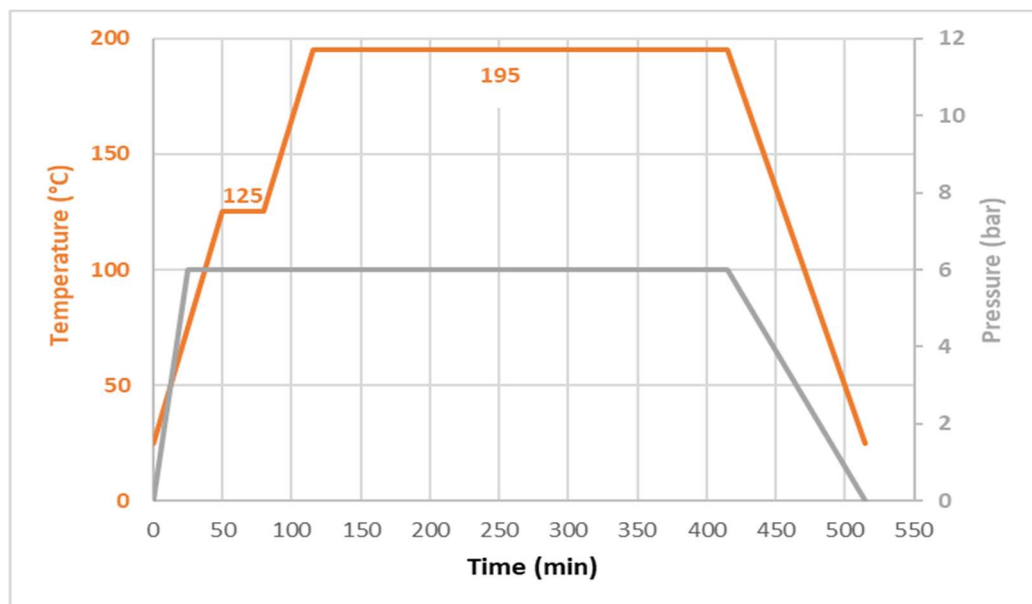


Viscosity profile at 2°C/min

### Curing process

#### Standard autoclave cure schedule

1. Apply full vacuum (1 bar)
2. Apply 6 bar autoclave pressure
3. Heat at 2 °C/min to 125 °C
4. Hold at 125 °C for 30 min
5. Heat at 2 °C/min to 195 °C
6. Hold at 195 °C for 300 minutes
7. Cool at 2 °C/min until room temperature



## Alternative autoclave cure schedule

1. Apply full vacuum (1 bar)
2. Apply 6 bar autoclave pressure
3. Heat at 2 °C/min to 125 °C
4. Hold at 125 °C for 30 min
5. Heat at 2 °C/min to 180 °C
6. Hold at 180 °C for 300 minutes
7. Cool at 2 °C/min

## Autoclave cure schedule for laminate thicknesses > 2,5 mm

1. Apply full vacuum (1 bar)
2. Heat at 2 °C/min to 135 °C
3. Hold at 135 °C for 120 min
4. Apply 6 bar autoclave pressure
5. Heat at 1 °C/min to 195 °C
6. Hold at 195 °C for 300 minutes
7. Cool at 2 °C/min

## OoA cure schedule

C-Preg<sup>®</sup> 400 prepregs can be oven cured (OoA, no pressure – vacuum only).

1. Heat at 2 °C/min to 195 °C
2. Hold at 195 °C for 300 minutes
3. Cool at 2 °C/min until room temperature

**Vacuum all along the cure cycle.**

***Post cure is mandatory to achieve maximum thermal resistance.***

## Post cure schedules

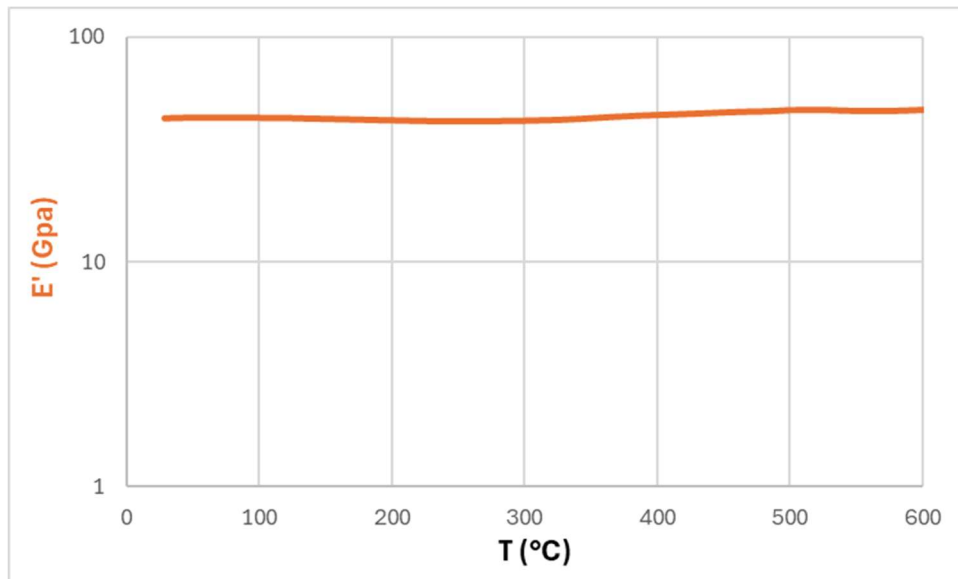
### Standard Post Cure Schedule

1. Heat at 2 - 3 °C/min to 170 °C
2. Heat at 0.3 - 0.4 °C/min to 245 °C
3. Hold at 245 °C for 10 hours
4. Cool at 5 °C/min to room temperature

OR

### Alternative Post Cure Schedule

1. Heat at 2 - 3 °C/min to 170 °C
2. Heat at 0.3 - 0.4 °C/min to 300 °C
3. Hold at 300 °C for 3 hours
4. Cool at 5 °C/min to room temperature

**DMA Trace (ASTM D7028)**

C-PREG<sup>®</sup> 400 4.0 - CF200T(HS)- 43% cured and post cured according to standard cure and post cure schedules

**Alternative cure schedule – improved aesthetic surface**

It is possible to process C-Preg<sup>®</sup>400 at lower temperature, down to 165 °C, which obviously results in a partially incomplete curing. Components processed at 165 °C are self-standing (easy to be removed from the mold) but require additional attention during handling before the post curing treatment.

When curing @ 165 °C components should be post cured right away following the cure.

**Autoclave cure schedule**

1. Apply full vacuum (1 bar)
2. Heat at 2 °C/min to 125 °C
3. Hold at 125 °C for 30 min
4. Apply 6 bar autoclave pressure
5. Heat at 2 °C/min to 165 °C
6. Hold at 165 °C for 300 min
7. Cool at 2 °C/min

## Post cure schedule

1. Heat at 2 - 3 °C/min to 170 °C
2. Heat at 0.3 - 0.4 °C/min to 205 °C
3. Hold at 205 °C for 10 hours
4. Cool at 5 °C/min to room temperature

***ATTENTION: curing and post curing, according to standard process, must be done to reach thermal resistance of 400 °C.***

**Mechanical and physical properties - C-PREG<sup>®</sup> 400 4.0 - CF200THS - 43%**

Tests were performed on 2 mm thick laminates cured at 195 °C and post cured according to standard post cure cycle.

| Physical Properties           | Unit              | CF200T2HS     |
|-------------------------------|-------------------|---------------|
| Fiber weave mass              | g/m <sup>2</sup>  | 200           |
| Nominal cured ply thickness   | mm                | (0.20 ± 0.01) |
| Nominal Laminate Density      | g/cm <sup>3</sup> | (1.50 ± 0.03) |
| Nominal Fiber Volume Fraction | %                 | (48.4 ± 0.5)  |

| Mechanical Property       | Method     | HS Twill 2/2 |
|---------------------------|------------|--------------|
| Test Temperature, °C      |            | 25 °C        |
| Tensile Modulus, 0° GPa   | ASTM D3039 | 50.5         |
| Tensile Strength 0°, MPa  | ASTM D3039 | 670          |
| Flexural Modulus, 0° GPa  | ASTM D790  | 40.2         |
| Flexural Strength 0°, MPa | ASTM D790  | 283          |
| ILSS 0°, MPa              | ASTM D2344 | 15           |
| Poisson coefficient (ν)   | ASTM D3039 | 0.024        |

| Thermal Conductivity and Specific Heat |           |                         |      |  |      |                                |      |
|--|-----------|-------------------------|------|--|------|--------------------------------|------|
| Method                                 | Temp [°C] | Specific Heat [J/(g·K)] |      | Thermal Diffusivity [mm <sup>2</sup> /s] |      | Thermal Conductivity [W/(m·K)] |      |
|  |           | Media                   | STD  | Media                                    | STD  | Media                          | STD  |
| ASTM E-1461<br>DIN EN 821              | 50        | 1.20                    | 0.00 | 0.26                                     | 0.00 | 0.45                           | 0.01 |
|  | 200       | 1.57                    | 0.02 | 0.20                                     | 0.01 | 0.44                           | 0.02 |
|  | 300       | 1.54                    | 0.01 | 0.18                                     | 0.00 | 0.38                           | 0.01 |

**Physical properties - C-PREG<sup>®</sup> 400 4.0 – QZ245-8HS - 36%**

Tests were performed on 2 mm thick laminates cured at 195 °C and post cured according to standard post cure cycle.

| Physical Properties           | Unit              | QZ245-8HS     |
|-------------------------------|-------------------|---------------|
| Fiber weave mass              | g/m <sup>2</sup>  | (250 ± 25)    |
| Nominal cured ply thickness   | mm                | (0,26 ± 0,01) |
| Nominal Laminate Density      | g/cm <sup>3</sup> | (1,86 ± 0,03) |
| Nominal Fiber Volume Fraction | %                 | (50,3 ± 0,5)  |

## Fire resistance

Material tested: C-PREG<sup>®</sup> 400 panel 1,5 mm thick with CF200T2HS  
Autoclave cured and oven post cured according to the standard cure and post cure schedules

### UL94 (2018 - 05): VO

| Test criteria  | V-0 requirement | C-Preg <sup>®</sup> 400 |
|--|-----------------|-------------------------|
| Burning time of each individual test specimen (s)<br>(after first and second flame applications) | ≤ 10            | 0 - 1                   |
| Burning and afterglow times after second flame application (s)                                   | ≤ 30            | 0 - 1                   |
| Dripping of burning specimens  | no              | no                      |
| Combustion up to holding clamp   | no              | no                      |

### FAR 25.853 Appendix F Part 1(a)(1) (ii) to CS-25 .853 - 12 sec Vertical burning test

| Properties           | Test value | Acceptance criteria | Notes    |
|----------------------|------------|---------------------|----------|
| Burn length (mm)     | 0          | <203                |          |
| After flame time (s) | 0          | <15                 |          |
| Drip flame time (s)  | 0          | <5                  | No drips |

### FAR 25.853 Appendix F-Part IV: Heat Release Rate Test

| Properties   | Test value | Acceptance criteria |
|--|------------|---------------------|
| Maximum heat release rate (kW/m <sup>2</sup> )             | 14.2       | <65                 |
| Heat release over the first 2 min (kW min/m <sup>2</sup> ) | 2.8        | <65                 |

**FAR 25.853 Appendix F-Part V: Optical smoke density**

| Properties              | Test value | Acceptance criteria |
|-------------------------|------------|---------------------|
| Maximum optical density | 0.9        | <200                |

**AITM 3-0005[Issue 2] – ABDO031[Issue G]– Toxicity**

| Test method           | Property (unit)              | Result | Acceptable limits |
|-----------------------|------------------------------|--------|-------------------|
| AITM 3-0005 – ABDO031 | CO (ppm) [2]                 | 32.5   | N/A               |
|                       | SO <sub>2</sub> (ppm) [2]    | 0.5    | 150               |
|                       | NO/NO <sub>2</sub> (ppm) [2] | 3      | 100               |
|                       | HF (ppm) [3]                 | 0      | 150               |
|                       | HCN (ppm) [4]                | 2      | 150               |

**MIL-STD-2031, 1991 Edition**

Material tested: C-PREG® 400 panel 3,5 mm thick with CF200T2HS  
 Cured in autoclave and post cured in oven following the standard cure and post cure schedules.

| Fire test / characteristic          | Test method | Requirement              | Result obtained                 | Evaluation               | Test Report     |
|-------------------------------------|-------------|--------------------------|---------------------------------|--------------------------|-----------------|
| Flame Spread (index)                | ASTM E 162  | Max. 20                  | 5                               | PASS                     | 2011.0AS0070/21 |
| Ignitability (s)                    | ASTM E 1354 | At 100 kW/m <sup>2</sup> | At 100 kW/m <sup>2</sup>        | At 100 kW/m <sup>2</sup> | 2011.0AS0070/21 |
|                                     |             | Min. 60                  | 152                             | PASS                     |                 |
|                                     |             | At 75 kW/m <sup>2</sup>  | At 75 kW/m <sup>2</sup>         | At 75 kW/m <sup>2</sup>  |                 |
|                                     |             | Min. 90                  | 203                             | PASS                     |                 |
|                                     |             | At 50 kW/m <sup>2</sup>  | At 50 kW/m <sup>2</sup>         | At 50 kW/m <sup>2</sup>  |                 |
|                                     |             | Min. 150                 | 254.0                           | PASS                     |                 |
|                                     |             | At 25 kW/m <sup>2</sup>  | At 25 kW/m <sup>2</sup>         | At 25 kW/m <sup>2</sup>  |                 |
| Heat release (kW/m <sup>2</sup> )   | ASTM E 1354 | At 100 kW/m <sup>2</sup> | At 100 kW/m <sup>2</sup>        | At 100 kW/m <sup>2</sup> | 2011.0AS0070/21 |
|                                     |             | Peak: Max 150            | 47.5                            | PASS                     |                 |
|                                     |             | Average 300 s: Max 120   | 11.6                            | PASS                     |                 |
|                                     |             | At 75 kW/m <sup>2</sup>  | At 75 kW/m <sup>2</sup>         | At 75 kW/m <sup>2</sup>  |                 |
|                                     |             | Peak: Max 100            | 49.6                            | PASS                     |                 |
|                                     |             | Average 300 s: Max 100   | 8.6                             | PASS                     |                 |
|                                     |             | At 50 kW/m <sup>2</sup>  | At 50 kW/m <sup>2</sup>         | At 50 kW/m <sup>2</sup>  |                 |
|                                     |             | Peak: Max 65             | 17.0                            | PASS                     |                 |
|                                     |             | Average 300 s: Max 50    | 8.9                             | PASS                     |                 |
|                                     |             | At 25 kW/m <sup>2</sup>  | At 25 kW/m <sup>2</sup>         | At 25 kW/m <sup>2</sup>  |                 |
|                                     |             | Peak: Max 50             | 0                               | PASS                     |                 |
|                                     |             | Average 300 s: Max 50    | 0                               | PASS                     |                 |
| Smoke obscuration Ds max occurrence | ASTM E 662  | Max. 200 s               | 0.44 at 200 s<br>48.8 at 1200 s | /                        | 2011.1AS0040/21 |

## Storage conditions

C-PREG 400 4.0 should be stored as received in a cool dry place or in refrigerator. After removal from refrigerator storage, prepreg should be allowed to reach room temperature before opening the polyethylene bag, thus preventing condensation.

## Shelf life

|                      |   |
|----------------------|---|
| Storage life, months | 12 months @ -18°C from manufacturing date |
| Out life, days       | 15 days at RT                             |

## Handling safety

Observe established precautions for handling the material. It is recommended to use clean protective gloves in order to protect the operators and avoid contamination of the components. Safety Data Sheet (SDS) of the resin mixture is available upon request and can be obtained from Nano-Tech S.p.A. or Petroceramics S.p.A. offices.

## Processing guidelines

The resin system crosslinks by means of a condensation process. Do not completely seal the release film. Allow the release of vapors during curing.

High temperature ancillary materials that withstand at least 200 °C are highly recommended.

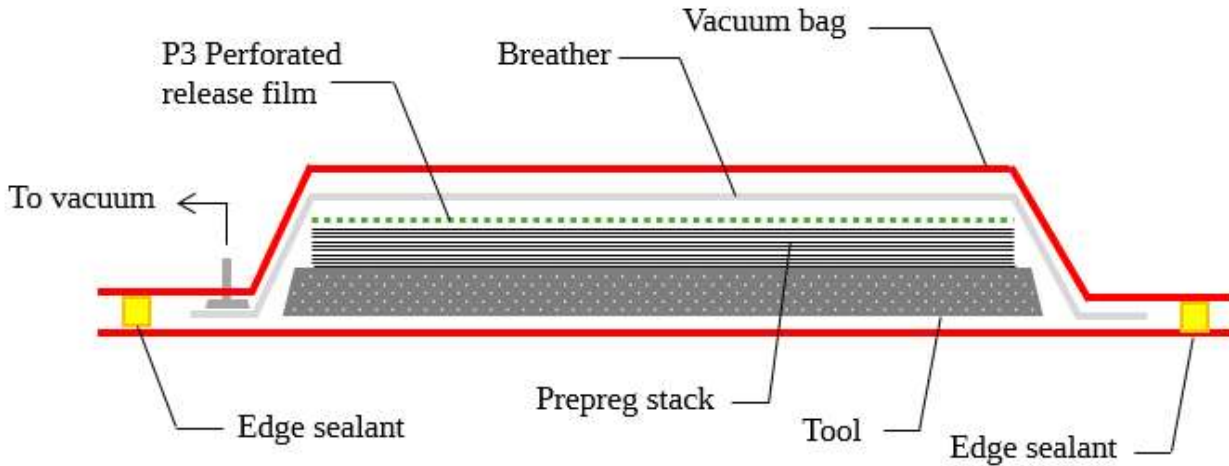
Laminate curing sequence, both for autoclave and OoA processes, is shown in the following figure.

**Tools:** Both composite and aluminium tools are suitable for C-PREG<sup>®</sup> 400 processing.

**Tool preparation:** Clean and dry tools should be treated with release agent prior to laminating.

*Do not use water-based or silicone-based release agents.*

**Debulking:** Debulking, 3 to 5 plies, is recommended for laminates thicker than 2 mm.



Please consult C-PREG® 400 Handbook for detailed information. Please contact our technical support staff for further information both at Nano-Tech S.p.A. and/or Petroceramics S.p.A.

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