CYCOM® 5250-4

CYCOM® 5250-4 is a 375°F to 400°F (191°C to 204°C) curing bismaleimide resin with a service temperature range from -75°F to 400°F (-59°C to 204°C). CYCOM® 5250-4 is specifically formulated for use in primary structure elements and full-scale aircraft and space components. In addition, a variety of Aerospace composite structural components can take advantage of the resin's increased performance from using high-strain carbon fibers and the improved damage- resistance this system provides.

CYCOM® 5250-4 is available with either carbon fiber or glass fiber reinforcement in unidirectional tape, woven fabrics, and slit tape forms.

Typical applications for CYCOM® 5250-4 include primary and secondary aircraft structures including: wing skins, engine nacelles, fuselage skins, ribs, spars, space capsule heat-shields, and other critical load-bearing components.

Features and Benefits

- Maximum continuous service temperature up to 400°F (204°C).
- Short-term service temperature up to 450°F (232°C)
- Superior hot/wet properties at 220°F to 375°F (104°C to 191°C)
- Excellent toughness
- Void-free laminates
- High temperature resistance
- Low thermal conductivity
- Versatile cure capability
- Excellent compression strength properties displayed after impact
- Shop life greater than 28 days at room temperature, 75°F (24°C)
- Fluid/solvent resistance
- High translation of fiber properties due to unmatched BMI resin strain behavior

CHARACTERISTICS

Table 1 l Physical Properties

Property	Carbon: Unidirectional (12k)	Carbon: Woven	Glass: Style 7781/ 4581 (Quartz)/ 6781 (S2)	Test Method
Resin Content %	33	38	38	ASTM D 3171/ ASTM D 3529*
Resin Flow at 350°F (177°C) %	14	20	24	ASTM D 3531
Volatiles at 250°F (121°C) %	1 Max	2 Max	2 Max	ASTM D 3530
Shelf Life	3 months at or below 40°F (4°C) from date of shipment 12 months at or below 0°F (-18°C) from date of shipment			
Shop Life	28+ days at 75°F (24°C)			

* Method corresponds to carbon/ glass, respectively.

Table 2 l Product Availability

Property	Description
Forms	Unidirectional tape, woven fabric , and slit tape*
Roll Width	38 in to 60 in (97 cm to 152 cm) wide rolls
Roll Length	60 yds (55 m)
Slit Tape Size*	0.125 in (3.18 mm) 0.250 in (6.35 mm) 0.500 in (12.7 mm)

*Spool size for slit tape: #5.

Resin Viscosity

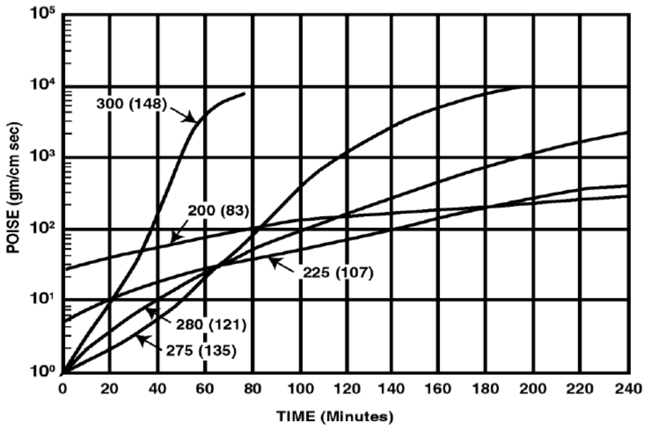


Figure 1 I CYCOM® 5250-4 Isothermal Holds

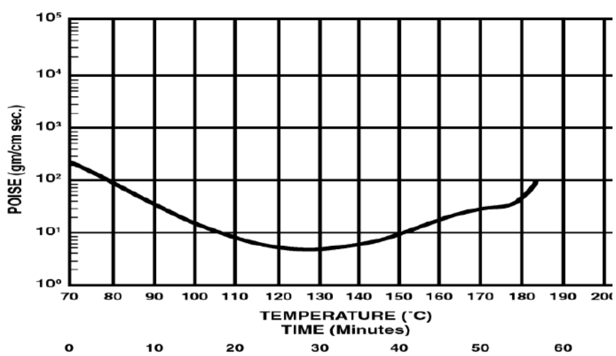


Figure 2 I CYCOM® 5250-4 Typical Viscosity Profile at 3.6°F (2°C)/min Heating Rate

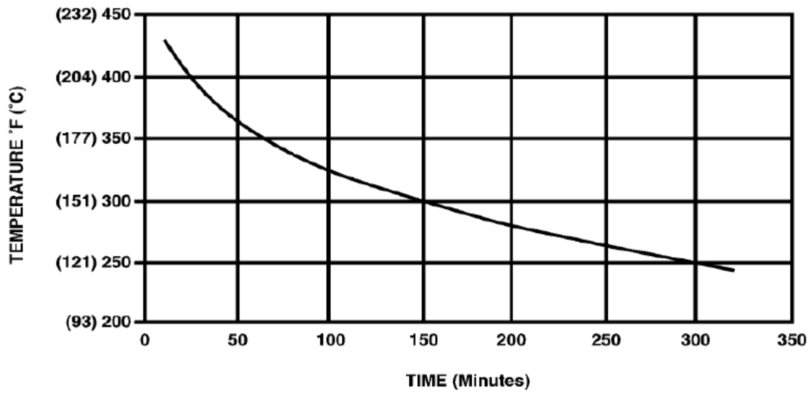


Figure 3 I CYCOM® 5250-4 Gel Time Versus Temperature (Test Tube Method) Nitrogen Atmospher

PROPERTIES

Table 3 I Technical Data, Neat Resins, Standard Cure & Standard Post-Cure

Property	Value	Test Method
Cured Density, lb/in^3 (g/cc)	0.045 (1.25)	ASTM D 792
Dry Tg, °F (°C)	482 (250)	ASTM D 7028
Wet Tg, °F (°C)	383 (195)	ASTM D 7028
Gel Time at 350°F (177°C) in nitrogen atmosphere, min	65 nominal	ASTM D 3532
Solvent Resistance 1000 hours exposure at 160°F (71°C) Water JP 4 JP 5 Hydraulic fluid (Skydrol®) Lubricant (MIL-L- 23699) 170 hours exposure at 75°F (24°C) Paint Stripper (Turco 5351) M.E.K. Anti-icing fluid % weight gain	 4.2 0.6 0.5 0.6 0.5 1.8 0.2 0.3	ASTM D 543
Tensile at 75°F (24°C) Strength, ksi (MPa) Modulus, Msi (GPa) Strain, micro-in/in (%)	 14.9 (103) 0.67 (4.6) 48000 (4.8)	ASTM D 3039
Flexure at 75°F (24°C) Strength, ksi (MPa) Strain, micro-in/in (%)	 23.6 (163) 45000 (4.5)	ASTM D 790
Strain Energy Release Rate, G_{IC} at 75°F (24°C) in-lb/in^2 (J/m^2)	0.80 (140)	ASTM D 5045
Notch sensitivity, K_{IC} at 75°F (24°C) ksi-in$^{1/2}$ (MPa/m$^{1/2}$)	0.93 (0.85)	ASTM D 5045
Charpy impact at 75°F (24°C) in-lb/in^2 (KJ/m^2)	97 (17)	ASTM D 6110
Coefficient of thermal expansion (CYCOM® 5250-4/IM7 unidirectional laminate) 11 μin/in-°F 22 μin/in-°F 33 μin/in-°F	 -0.90 16.7 23.8	ASTM D 3417 ASTM D 3418
Thermo-oxidative stability 450°F (232°C) with atmosphere replacement 1000 hours 2000 hours 3000 hours % weight loss	 1.7 4.6 9.0	ASTM D 5229

Table 4 I Mechanical Lamina Properties- Carbon Fiber, Intermediate Modulus

Property	Test Condition	Orientation	Fiber		Test Method
			IM7	IMS 60	
0° Tensile Strength ksi (MPa)	-67°F (-55°C) 75°F (24°C) 350°F (177°C) 350°F (177°C)/ wet 450°F (232°C)	[0]8	420 (2900) 380 (2620) 370 (2550) 330 (2280) 370 (2550)	400 (2760) 360 (2480) 350 (2410) - -	ASTM D 3039
0° Tensile Modulus Msi (GPa)	-67°F (-55°C) 75°F (24°C) 350°F (177°C)	[0]8	24.2 (169) 23.5 (162) 23.5 (162)	24.0 (165) - -	ASTM D3039
Poisson's Ratio -	75°F (24°C) 300°F (149°C)/ wet	[0]8	0.70 0.35	- -	ASTM D 3039
0° Compression Strength ksi (MPa)	75°F (24°C) 325°F (163°C)/ wet 350°F (177°C) 350°F (177°C)/ wet	[0]8	235 (1620) 175 (1210) 190 (1310) 140 (970)	215 (1480) 150 (1030) - -	ASTM D 695 MOD
0° Compression Modulus Msi (GPa)	75°F (24°C) 350°F (177°C)	[0]8	23.0 (158) 23.0 (158)	23.5 (162) -	ASTM D 695 MOD
90° Tensile Strength ksi (MPa)	-67°F (-55°C) 75°F (24°C) 350°F (177°C)/ wet	[90]16	9.1 (63) 9.5 (66) 4.0 (28)	- 10.0 (69) -	ASTM D 3039
90° Tensile Modulus Msi (GPa)	-67°F (-55°C) 75°F (24°C)	[90]16	1.4 (9.7) 1.4 (9.7)	- 1.3 (9.0)	ASTM D 3039
90° Compression Strength ksi (MPa)	-67°F (-55°C) 75°F (24°C) 350°F (177°C)/ wet	[90]16	46 (317) 36 (248) 35 (241)	- - -	ASTM D 6641
90° Compression Modulus Msi (GPa)	-67°F (-55°C) 75°F (24°C) 350°F (177°C)/ wet	[90]16	1.6 (11.0) 1.4 (9.7) 1.3 (9.0)	- - -	ASTM D 6641
In-Plane Shear Strength ksi (MPa)	-67°F (-55°C) 75°F (24°C) 300°F (149°C)/ wet 350°F (177°C)/ wet	[+45, -45] 2s	14.7 (102) 15.0 (103) 12.1 (83) 11.2 (77)	- - - -	ASTM D 3518
In-Plane Shear Modulus Msi (GPa)	75°F (24°C) 300°F (149°C)/ wet	[+45, -45] 2s	0.85 (5.9) 0.37 (2.6)	- -	ASTM D 3518
Short Beam Strength ksi (MPa)	75°F (24°C) 350°F (177°C) 375°F (191°C)/ wet 450°F (232°C)	[0] 16	20.2 (139) 14.2 (98) 10.4 (72) 11.3 (78)	20.0 (138) - - -	ASTM D 2344

Fiber Volume = 60% Wet=
1.1% weight gain

Table 5 I Mechanical Laminate Properties- Carbon Fiber, Intermediate Modulus cont.

Property	Test Condition	Orientation	Fibers		Test Method
			IM7	IMS 60	
Open Hole Tensile Strength w/d = 6 ksi (MPa)	-67°F (-55°C) 75°F (24°C) 350°F (177°C)/ wet	[+45,0,-45,90]2s	65 (448) 65 (448) 65 (448)	85 (586) 85 (586) 80 (551)	ASTM D 5766
Open Hole Tensile Modulus w/d = 6 Msi (GPa)	-67°F (-55°C) 75°F (24°C) 350°F (177°C)/ wet		9.3 (64) 9.2 (63) 8.6 (59)	9.3 (64) 9.2 (63) 8.6 (59)	ASTM D 5766
Open Hole Compression Strength w/d = 6 ksi (MPa)	-67°F (-55°C) 75°F (24°C) 350°F (177°C)/ wet		52 (359) 45 (310) 38 (262)	51 (352) 46 (317) 39 (267)	ASTM D 6484
Open Hole Compression Modulus w/d = 6 Msi (GPa)	-67°F (-55°C) 75°F (24°C) 350°F (177°C)/ wet		8.3 (57) 8.1 (56) 7.4 (51)	8.6 (59) 8.6 (59) 8.7 (60)	ASTM D 6484

Fiber Volume = 60%
Wet= 1.1% weight gain

Table 6 I Mechanical Properties- Compression after Impact, Intermediate Carbon Fiber, Unidirectional

Property	Test Condition	Orientation	Fibers		Test Method
			IM7	IMS 60	
Residual Strength ksi (MPa)	1.0 in-lb/in 1500 in-lb/in	[+, -, 90, 0, 0, +, 0, 0, +, -, 0] 12	36 (248) 31 (214)	35 (241) 31 (214)	ASTM D 7136/ D 7137
Strain μ-in (%)	1.0 in-lb/in 1500 in-lb/in		4900 (0.49) 3600 (0.36)	- -	ASTM D 7136/ D 7137
Damage Area in^2 (cm^2)	1.0 in-lb/in 1500 in-lb/in		1.0 (6.5) 1.8 (11.6)	1.4 (9.0) 2.7 (17.4)	ASTM D 7136/ D 7137

Fiber Volume = 60%

Table 7 | Processing Data- Carbon Fiber Unidirectional, Post-Cure Effects – Tg and Toughness

Post Cure Condition	Dry Tg	Compression After Impact Strength, 1000 in-lb/in Impact	Test Method
350°F (177°C) for 6 hours	420°F (216°C)	31 ksi (214 MPa)	ASTM D 7136/ D 7137
375°F (191°C) for 6 hours	480°F (249°C)	39 ksi (269 MPa)	ASTM D 7136/ D 7137
410°F (210°C) for 6 hours	505°F (263°C)	40 ksi (276 MPa)	ASTM D 7136/ D 7137
440°F (227°C) for 6 hours	540°F (282°C)	35 ksi (241 MPa)	ASTM D 7136/ D 7137
470°F (243°C) for 6 hours	580°F (304°C)	33 ksi (228 MPa)	ASTM D 7136/ D 7137

Fiber Volume = 60%

Table 8 | Mechanical Laminate Properties- Carbon Fiber Woven, Standard Modulus

Property	Test Condition	Orientation	Fabrics				Test Method
			AS4-3K-70PW	HTS-3K-70PW	HTS-3K-8HS	T650-3K-8HS	
0° Warp Tensile Strength ksi (MPa)	75°F (24°C) 350°F (177°C) 350°F (177°C)/ wet	[0] 12	123 (848) - -	135 (931) - -	130 (896) - 113 (779)	144 (992) 132 (910) -	ASTM D 3039
0° Warp Tensile Modulus Msi (GPa)	75°F (24°C) 350°F (177°C) 350°F (177°C)/ wet		10.2 (70) - -	10.0 (69) - -	8.9 (61) - 8.8 (61)	- 10.7 (74) 10.5 (72)	ASTM D 3039
0° Warp Tensile Poisson's Ratio	75°F (24°C)	[0] 12	-	-	-	0.046	ASTM D 3039
0° Warp Compression Strength ksi (MPa)	75°F (24°C) 325°F (163°C) 325°F (163°C)/ wet 350°F (177°C)/ wet	[0] 12	125 (862) 110 (759) - 65 (448)	135 (931) 120 (827) 60 (414) -	110 (759) - - -	119 (820) 98 (675) - -	ASTM D 6641
0° Warp Compression Modulus Msi (GPa)	75°F (24°C)		8.8 (61)	8.9 (61)	-	9.7 (67)	ASTM D 6641
0° Warp Compression Interlaminar Shear Strength ksi (MPa)	75°F (24°C) 325°F (163°C) 325°F (163°C)/ wet	[0] 12	10.1 (70) - -	9.0 (62) - 5.0 (34)	- - -	- - -	ASTM D 2344
0° Warp Short Beam Strength ksi (MPa)	75°F (24°C) 250°F (121°C) 350°F (177°C) 350°F (177°C)/ wet	[0] 12	10.4 (72) 9.2 (63) 7.1 (49) 6.0 (41)	9.2 (63) 8.1 (56) 6.4 (44) 5.0 (34)	10.4 (72) 8.3 (57) 6.8 (47) -	10.6 (73) - 6.7 (46) -	ASTM D 2344
Open Hole Compression Strength ksi (MPa)	75°F (24°C) 250°F (121°C) 300°F (149°C)/ wet 350°F (177°C)	[(+/-45), (0/90)]	45 (310) 43 (297) 35 (242) 39 (269)	44 (302) 38 (262) 33 (228) 26 (179)	- - - -	- - - -	ASTM D 6484

Fiber Volume = 58%
Wet = 1.3% weight gain

Table 9 | Mechanical Properties- Carbon Fiber Woven, Intermediate Modulus

Property	Test Condition	Orientation	Fabric	Test Method
			IM7-6K-5HS	
0° Warp Tensile Strength ksi (MPa)	75°F (24°C) 350°F (177°C)/ wet	[0] 12	125 (862) 120 (827)	ASTM D 3039
0° Warp Tensile Modulus Msi (GPa)	75°F (24°C) 350°F (177°C)/ wet		11.8 (81) 10.0 (69)	ASTM D 3039
0° Warp Flexural Strength ksi (MPa)	75°F (24°C) 350°F (177°C)/ wet	[0]12	145 (1000) 81 (558)	ASTM D 790
0° Warp Flexural Modulus Msi (GPa)	75°F (24°C) 350°F (177°C)/ wet		10.3 (71) 10.3 (71)	ASTM D 790
90° Fill Strength ksi (MPa)	75°F (24°C) 350°F (177°C) 350°F (177°C)/ wet	[90] 12	125 (862) 110 (759) 58 (400)	ASTM D 6742
90° Fill Modulus Msi (GPa)	75°F (24°C) 350°F (177°C) 350°F (177°C)/ wet		10.9 (75) 9.2 (63) 9.0 (62)	ASTM D 6742
0° Warp Short Beam Strength ksi (MPa)	75°F (24°C) 350°F (177°C)/ wet	[0] 12	16 (110) 7.1 (49)	ASTM D 2344
Open Hole Tensile Strength ksi (MPa)	75°F (24°C) 350°F (177°C)/ wet	[+, 0, 0, 90, 0]	77 (531) 70 (483)	ASTM D 5766
Open Hole Tensile Modulus Msi (GPa)	75°F (24°C) 350°F (177°C)/ wet		10.5 (72) 11.5 (79)	ASTM D 5766
Open Hole Compression Strength w/d= 6 ksi (MPa)	75°F (24°C) 300°F (149°C)/ wet 350°F (177°C)/ wet	[+, 0, 0, 90, 0]	47 (324) 36 (248) 30 (207)	ASTM D 6484
Open Hole Compression Modulus w/d= 6 Msi (GPa)	75°F (24°C) 350°F (177°C)/ wet		10.5 (72) 11.5 (79)	ASTM D 6484
Compression After Impact, Strength 1500 in-lb/in impact ksi (MPa)	75°F (24°C)	[+, 0, -, 90] 3s	32 (220)	ASTM D 7136/ ASTM D7137

Fiber Volume = 58% Wet
= 1.1% weight gain

Table 10 | Mechanical Properties- Glass Fiber Woven, Standard Cure & Standard Post-Cure

Property	Test Temperature	Fiber 6781 (S2)	Test Method
0° Warp Tensile Strength ksi (MPa)	75°F (24°C)	86 (593)	ASTM D 638
0° Warp Tensile Modulus Msi (GPa)	75°F (24°C)	4.0 (27.6)	ASTM D 638
0° Warp Compression Strength ksi (MPa)	75°F (24°C)	72 (496)	ASTM D 695
0° Warp Compression Modulus Msi (GPa)	75°F (24°C)	3.7 (25.5)	ASTM D 695
0° Warp Short Beam Strength ksi (MPa)	75°F (24°C)	9.0 (62)	ASTM D 2344

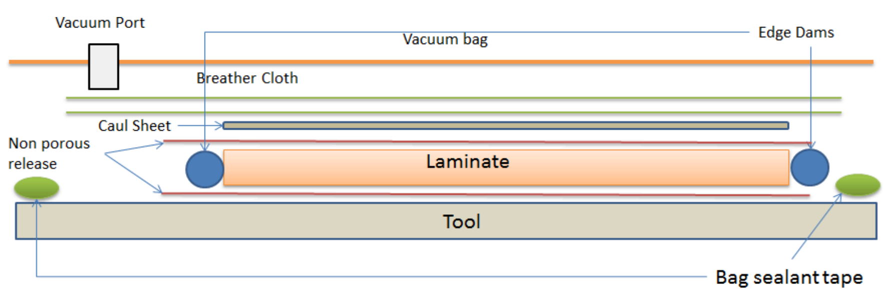
PROCESSING

Recommended Cure Cycle

Initial Cure Cycle	Apply full vacuum, 24 in Hg (0.075 MPa) minimum. Apply 85 psi to 100 psi (0.59 MPa to 0.69 MPa) autoclave pressure and don't vent vacuum. Heat from 75°F (24°C) to 375°F ± 10°F (191°C ± 6°C) at 1°F - 5°F (0.6°C - 3°C)/minute. Hold at 375°F ± 10°F (191°C ± 6°C) for 360 minutes ± 10 minutes. Cool under pressure below 120°F (49°C) at 1°F - 5°F (0.6°C - 3°C)/minute.
Post Cure	Free standing in an air circulating oven. Heat from 75°F (24°C) to 440°F ± 15°F (227°C ± 8°C) at 1°F - 5°F (0.6°C - 3°C)/minute. Hold at 440°F ± 15°F (227°C ± 8°C) for 360 minutes ± 15 minutes. Cool below 120°F (49°C) at 1°F - 5°F (0.6°C - 3°C)/minute.

Bagging Procedure

A schematic profile of the bagging procedure used for all laminates is shown in Figure 4.



1. Peel ply may be used on laminate surfaces when necessary for secondary operations
2. Optional Metal or flexible caul can be used on top of laminate

Figure 4 I Bagging Diagram Utilized in Laminate Manufacturing

NOTE: The bagging technique recommended for this resin system is a double bag arrangement. Bagging procedure is as follows:

1. Lay the release film on the tool surface and place the laminate on the release film.
2. Lay tacky tape along each edge of the laminate to form an edge dam, leaving only a very small gap between the laminate and the tacky tape.
3. Fill this gap with a glass fiber tow and extend about 2 in (5 cm) beyond the edge dam to act as a breather along each laminate edge.
4. Place strips of breather around each laminate approximately 1 in - 2 in (2.5 cm - 5 cm) from the edge dam to overlay the end of each glass strand breather.
5. Place a non-porous release film over each laminate and stick down onto the tacky tape edge dam to seal the laminate.
6. Prick small holes in the release film at opposite corners of the laminate.
7. Trim the release film so the edges lay on the surrounding strips of breather.
8. Place caul plates wrapped in non-porous PTFE release film on each laminate. The recommended caul plate size is such that a 0.2 in (0.5 cm) gap is left along each edge, preventing bowed edges that could trap air inside the laminate.
9. Place a sheet of breather over the entire bed of laminates.
10. Cover with an additional release film as a precaution against excess resin bleed which could cause the outer bag to rupture (a problem sometimes observed with BMI systems).
11. Place a vacuum bag over the bed.
12. Place valves at either end of the bed in direct contact with the breather and pushed through the release film and outer bag.
13. Seal the outer vacuum bag using tacky tape
14. Pull the vacuum to check the integrity of the bagging.

General Cure Information

CYCOM® 5250-4 can be used in numerous ways to fabricate void free parts. Most applications use autoclave procedures, but compression molding and resin transfer molding (using a modified version, CYCOM® 5250-4RTM) have been successfully used to form components. This document outlines the parameters that should be considered when designing a cure cycle for a specific part or application.

For information on a dwell cycle for sandwich construction please contact Syensqo's Technical Service Department for additional information.

Resin Flow

The key parameter for successful laminate processing is retention of the resin in the layup. CYCOM® 5250-4 is a very high flow system that allows for flexibility in processing provided the resin flow is restrained.

Bagging

Regardless of the cure cycle, the bagging of the final layup is crucial to maintaining resin in the laminate during cure. All CYCOM® 5250-4 products are supplied as net resin systems. Bleeding during cure to remove entrapped air or volatiles is not required or recommended. Proper bagging should:

- Promote removal of entrapped air by connecting the laminate edge to the vacuum source.
- Resist excessive bleeding of the laminate through the use of edge dams or tooling barriers.
- Result in a maximum resin loss of 1%.

Pressure

Standard pressure is 85 psi to 100 psi (0.59 MPa to 0.69 MPa).
Pressure is applied from the start of cure ideally in cases where:

- Flat or mildly-contoured parts have been dammed to prevent resin flow.
- The heat up rate is less than 1°F (0.6°C) per minute.

Highly contoured parts require a build in viscosity before pressure is applied to avoid excessive thinning of the plies in tight radius areas. This can be accomplished by using a dwell cycle or by using a slow heat-up rate and applying pressure at a point in the heat-up where the resin viscosity has begun to increase toward gel [approximately 275°F to 300°F (135°C to 149°C) for a 2°F (1°C)/minute ramp rate]. For further information regarding an acceptable dwell cycle, please contact the Syensqo Technical Service department.

Vacuum Compaction

Vacuum should be applied to the final assembly for at least 2 hours to 3 hours before starting the cure. Vacuum compaction during assembly assists in debulking of the part. To remove excess bulk factor, this can be performed at room temperature [75°F (24°C)] to 130°F (54°C) to promote further compaction. For warm debulking, total time at 130°F (54°C) should be 3 hours or less.

Staging of the prepreg at a temperature above 200°F (93°C) is not recommended. If the material is allowed to gel at low temperature without completion of cure, the cool-down stress will exceed the resin strength resulting in localized delamination or total breakdown (i.e. matrix cracking) of the resin.

Final Cure Temperature

CYCOM® 5250-4 reaches an acceptable cure state after 360 minutes ± 10 minutes at 375°F ± 10°F (191°C ± 6°C). Higher toughness is achieved by increasing the final cure state to 400°F ± 10°F (204°C ± 6°C) for 240 minutes ± 10 minutes. Final cure temperatures below 375°F are not recommended as they reduce toughness significantly.

Post-cure

Post-cure temperatures can be varied from post-cure of 440°F ± 15°F (227°C ± 8°C) for 360 minutes ± 15 minutes to post- cure of 470°F ± 15°F (243°C ± 8°C) for 240 minutes ± 10 minutes. The best balance of service temperature and toughness is achieved with an initial cure of 375°F ± 10°F (191°C ± 6°C) for 360 minutes ± 10minutes or 400°F ± 10°F (204°C ± 6°C) for 240 minutes ± 10 minutes with a 440°F ± 15°F (227°C ± 8°C) post cure for 360 minutes ± 15 minutes. Higher service temperature applications [above 400°F (204°C) dry] benefit from post-cure at 470°F ± 15°F (243°C ± 8°C) for 240 minutes ± 10 minutes.

HEALTH & SAFETY

Please refer to the product SDS for safe handling, personal protective equipment recommendations and disposal considerations.