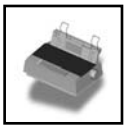
VESPEL®

CP LINE

TYPICAL PROPERTIES OF VESPEL® PARTS & SHAPES







INTRODUCTION

Vespel® CP parts & shapes are a family of fiber-reinforced polymers that exhibit excellent strength to weight ratios. This family employs a variety of forms of fiber reinforcements singularly or in combination. The part geometry and production volumes generally guide the selection of the type of reinforcement from woven fabric to chopped fiber. The selection of the fiber material(s) (carbon, graphite, glass, aramid) and the polymer matrix (polyimide, phenolic, epoxy) is based upon the application's operating conditions (thermal & mechanical). Because of the wide selection of reinforcing structures, fiber materials, and polymers, the Vespel® CP family of parts and shapes offers the designer a wide array of flexibility.

FORWARD ENGINEERING

DuPont™ Vespel®
parts and shapes

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GRADES OF VESPEL® CP PARTS & SHAPES

REINFORCING STRUCTURE	WOVEN FABRIC	CYLINDRICAL BRAID	CHOPPED FIBER	WOUND FIBER
GRADES	CP-0644 CP-0648 CP-0650 CP-0664	CP-8000 CP-8001 CP-8002	CP-0301 CP-0801	
	CP-2010			
	CP-8010			
	CP-9805 – CP-9836			
GEOMETRY	Thin, Flat Laminates	Thin-walled Hollow Straight or Flanged Cylinders	Complex 3-D Shapes	Long, Hollow Cylinders
DISTINGUISHING PROPERTIES	X-Y versus Z Directionality of Properties	Hoop versus Axial Directionality of Properties	Geometrically Oriented Properties	Hoop versus Axial Directionality of Properties
APPLICATIONS	Washers, Wear Strips, Slide Blocks	Bushings	Block Clamps	





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VCP-053003

VESPEL®

CP LINE

We know. For your designs to be successful, they have to do more than work well. They have to keep on working, year after year, in some pretty harsh user environments. Wear and impact resistance are key. You want polyimide tube clamps that can replace cast aluminum or titanium, slide blocks that are stronger than powder-filled compositions, and wear strips that are self-lubricating. That's why CP was created. We have an array of fiber-enhanced composites for a range of unique design needs.

COMPOSITES DESIGNED TO OUTLAST ALUMINUM OR TITANIUM.

ACTUALLY, THEY'LL OUTLAST JUST ABOUT ANYTHING.

CP-0301 Sheet-molded and reinforced polyimide resin. Since it's lightweight yet tough, CP-0301 is ideal to use instead of aluminum or titanium in parts like aircraft brackets, gearbox adapter covers and seal plates. Plus, with CP-0301 tube clamps, you can create clamping systems that are more fatigue-resistant than those using die-cast aluminum.

CP-0644, CP-0648 & CP-0650 Washers that are lighter-weight than aluminum. Bushings that are ideal for high-temperature, high-friction, highly oxidative environments. Even self-lubricating slide blocks. CP-0644, CP-0648 and CP-0650 are fiber-reinforced composite fabrics that are stronger than powder-filled compositions, making your designs more durable.

CP-8000, CP-8001 & CP-8002 With high-temperature resistance, high oxidation resistance, and enough strength to eliminate the need for metal, CP-8000, CP-8001 and CP-8002 are ideal for bushings in gas turbine engine compressors, balls for self-aligning spherical bearing assemblies and more. That extraordinary strength comes from fiber-reinforced polymer matrices—braided into a tube or rope for maximum toughness.

CP-9800 Lightweight, new end effectors. The carbon fiber and epoxy combination make CP-9800 ideal for flat panel display and wafer handling applications. These clean, stiff effectors are more durable than traditional ceramic and aluminum end effectors.

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TYPICAL PROPERTIES

VESPEL® CP-0301 0801

SHEET MOLDING COMPOUND SERIES

The sheet molding compound series of Vespel® CP parts consist of long, chopped fibers held in a variety of polymer matrices. The discontinuous nature of the fibers allows the fibers to align with the contours of the part, permitting the molding of relatively complex shapes, while providing the reinforcing strength where needed within the part. Superior strength versus aluminum at less weight, Vespel® CP frees the designer to explore ways to improve efficiency by reducing component weight and reducing friction.

CP-0301			
MECHANICAL	**TEST METHOD**	**SI UNITS**	**ENGLISH UNITS**
ULTIMATE TENSILE STRENGTH	ASTM D-3039		
Room Temp.		340 MPa	50 ksi
260°C/500°F		320 MPa	47 ksi
TENSILE MODULUS	ASTM D-3039		
Room Temp.		47,000 MPa	6,800 ksi
260°C/500°F		45,000 MPa	6,500 ksi
ULTIMATE FLEXURAL STRENGTH	ASTM D-790		
Room Temp.		490 MPa	71 ksi
260°C/500°F		340 MPa	50 ksi
FLEXURAL MODULUS	ASTM D-790		
Room Temp.		38,000 MPa	5,500 ksi
260°C/500°F		33,000 MPa	4,800 ksi
ULTIMATE COMPRESSIVE STRENGTH[a]	ASTM D-695		
Room Temp.		370 MPa	53 ksi
260°C/500°F		240 MPa	35 ksi
NOTCHED IZOD	ASTM D-256	690 J/m	13 ft. lbs./in.
HARDNESS, ROCKWELL 15-T	ASTM D-2240	86	86

THERMAL	**TEST METHOD**	**SI UNITS**	**ENGLISH UNITS**
GLASS TRANSITION TEMPERATURE, Tg	Thermal Mechanical Analysis	335°C	635°F
THERMAL EXPANSION COEFFICIENT (21–316°C/70–600°F)	ASTM D-696	2.9×10^{-6} m/m/°C	1.6×10^{-6} in./in./°F
THERMAL EXPANSION COEFFICIENT[a] (21–316°C/70–600°F)	ASTM E-228-85	27×10^{-6} m/m/°C	15×10^{-6} in./in./°F
THERMAL CONDUCTIVITY	ASTM C-177	0.30 W/m K	0.17 Btu/hr./ft./°F
OXIDATIVE STABILITY	See note[b]	2% Weight Loss	2% Weight Loss

OTHER PROPERTIES	**TEST METHOD**	**SI UNITS**	**ENGLISH UNITS**
WATER ABSORPTION (24 hrs. at 23°C/73°F)	ASTM D-570	0.5% Weight Gain	0.5% Weight Gain

Note: All values listed are for compression-molded samples and are measured in the plane perpendicular to the direction of molding pressure unless otherwise indicated.

[a] Measured in the plane parallel to the direction of molding pressure.

[b] 100 hours, 70 psia (483 kPa), 610°F (321°C) circulating air, saturated conditions, volume/surface area = .091 in.(2.31 mm).

CP-0301 may be processed using a variety of lay-up techniques with single or multiple debulking steps to optimize process capability for each part configuration. These design considerations can cause variation from the typical values listed above. Listed properties are based upon technical data that DuPont believes to be reliable. DuPont makes no warranties, expressed or implied, and assumes no liability in connection with use of this information.

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CP-0801

MECHANICAL	TEST METHOD	SI UNITS	ENGLISH UNITS
ULTIMATE TENSILE STRENGTH	ASTM D-638		
Room Temp.		241 MPa	35 ksi
204˚C/400˚F		76 MPa	11 ksi
TENSILE MODULUS	ASTM D-638		
Room Temp.		15,900 MPa	2,800 ksi
204˚C/400˚F		11,000 MPa	1,600 ksi
ULTIMATE FLEXURAL STRENGTH	ASTM D-790		
Room Temp.		455 MPa	66 ksi
260˚C/500˚F		97 MPa	14 ksi
FLEXURAL MODULUS	ASTM D-790		
Room Temp.		18,000 MPa	2,600 ksi
260˚C/500˚F		9,700 MPa	1,400 ksi
ULTIMATE COMPRESSIVE STRENGTH[a]	ASTM D-695		
Room Temp.		172 MPa	25 ksi
204˚C/400˚F		48 MPa	7 ksi
NOTCHED IZOD	ASTM D-256	1869 J/m	35 ft. lbs./in.

THERMAL	TEST METHOD	SI UNITS	ENGLISH UNITS
GLASS TRANSITION TEMPERATURE, Tg	ASTM D-4065	175˚C	347˚F
THERMAL EXPANSION COEFFICIENT (21–316˚C/70–600˚F)	ASTM D-696	$12x10^{-6}$ m/m/˚C	$7.0x10^{-6}$ in./in./˚F
THERMAL CONDUCTIVITY	ASTM C-177	0.35 W/m K	0.20 Btu/hr./ft./˚F

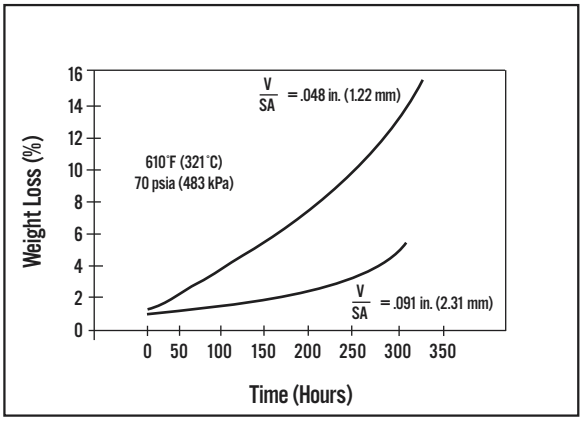
OTHER PROPERTIES	TEST METHOD	SI UNITS	ENGLISH UNITS
SPECIFIC GRAVITY	ASTM D-792	1.82 g/cc	1.82 g/cc
POISSON'S RATIO	–	0.30	0.30
WATER ABSORPTION (24 hrs. at 23˚C/73˚F)	ASTM D-570	0.5% Weight Gain	0.5% Weight Gain

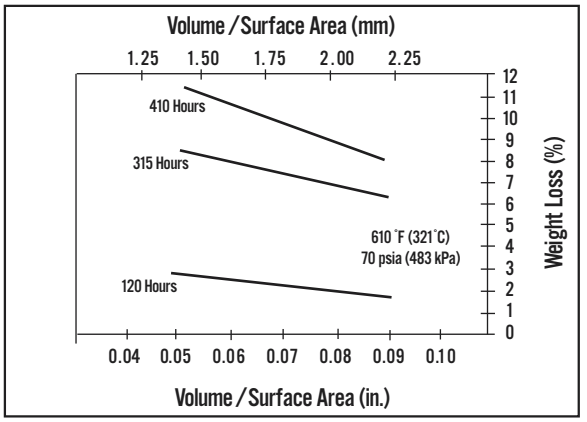
Note: All values listed are for compression-molded samples and are measured in the plane perpendicular to the direction of molding pressure unless otherwise indicated.

[a] Measured in the plane parallel to the direction of molding pressure.

CP-0801 may be processed using a variety of lay-up techniques with single or multiple debulking steps to optimize process capability for each part configuration. These design considerations can cause variation from the typical values listed above. Listed properties are based upon technical data that DuPont believes to be reliable. DuPont makes no warranties, expressed or implied, and assumes no liability in connection with use of this information.

THERMAL OXIDATION CURVES FOR CP-0301
(Tests performed in circulating air, saturated conditions.)





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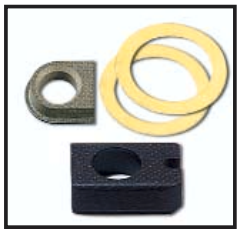
VCPI0301-053003

TYPICAL PROPERTIES

VESPEL® CP-0600 SERIES



LAMINATE SERIES

The fabric laminate series of Vespel® CP parts offer an array of fabric types consisting of woven graphite, carbon, glass, Teflon® PTFE, and/or Nomex® aramid fibers bonded together using a variety of polyimide resins, selected to optimize performance versus cost. Laminates are particularly well suited for simple geometries such as strips, wear pads, and washers, but are also used for more complex shapes that require the durability that fabrics offer.

CP-0648

MECHANICAL	TEST METHOD	SI UNITS	ENGLISH UNITS
ULTIMATE TENSILE STRENGTH	ASTM D-638		
Room Temp.		150 MPa	22 ksi
260°C/500°F		130 MPa	19 ksi
TENSILE MODULUS	ASTM D-638		
Room Temp.		21,000 MPa	3,100 ksi
260°C/500°F		19,000 MPa	2,700 ksi
ULTIMATE FLEXURAL STRENGTH	ASTM D-790		
Room Temp.		250 MPa	36 ksi
260°C/500°F		195 MPa	28 ksi
FLEXURAL MODULUS	ASTM D-790		
Room Temp.		19,000 MPa	2,800 ksi
260°C/500°F		16,000 MPa	2,300 ksi
ULTIMATE COMPRESSIVE STRENGTH[a]	ASTM D-3410		
Room Temp.		170 MPa	25 ksi
260°C/500°F		140 MPa	20 ksi
COMPRESSIVE MODULUS[a]	ASTM D-3410		
Room Temp.		23,000 MPa	3,400 ksi
260°C/500°F		20,000 MPa	2,900 ksi
SHORT-BEAM SHEAR STRENGTH[a]	ASTM D-2344		
Room Temp.		37 MPa	5.3 ksi
@ 260°C/500°F		28 MPa	4.0 ksi
NOTCHED IZOD	ASTM D-256	123 J/m	2.3 ft. lbs./in.
HARDNESS, ROCKWELL 15-T	ASTM D-2240	79	79

THERMAL	TEST METHOD	SI UNITS	ENGLISH UNITS
GLASS TRANSITION TEMPERATURE, Tg	Thermal Mechanical Analysis	330°C	626°F
THERMAL EXPANSION COEFFICIENT[a] (21–316°C/70–600°F)	ASTM E-228-85	34.6×10^{-6} m/m/°C	19.2×10^{-6} in./in./°F
THERMAL EXPANSION COEFFICIENT (21–316°C/70–600°F)	ASTM D-696	1.6×10^{-6} m/m/°C	0.9×10^{-6} in./in./°F

OTHER PROPERTIES	TEST METHOD	SI UNITS	ENGLISH UNITS
SPECIFIC GRAVITY	ASTM D-792	1.48 gm/cc	1.48 gm/cc
WATER ABSORPTION (180 hrs. @ 23°C/73°F)	ASTM D-570	2.6% Weight Gain	2.6% Weight Gain

Note: All values listed are for compression-molded samples and are measured in the plane perpendicular to the direction of molding pressure unless otherwise indicated.

[a] Measured in the plane parallel to the direction of molding pressure.

CP-0648 may be processed using a variety of lay-up techniques with single or multiple debulking steps to optimize process capability for each part configuration. These design considerations can cause variation from the typical values listed above. Listed properties are based upon technical data that DuPont believes to be reliable. DuPont makes no warranties, expressed or implied, and assumes no liability in connection with use of this information.

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CP-0650

MECHANICAL	TEST METHOD	SI UNITS	ENGLISH UNITS
ULTIMATE TENSILE STRENGTH	ASTM D-638		
Room Temp.		130 MPa	19 ksi
260°C/500°F		110 MPa	16 ksi
TENSILE MODULUS	ASTM D-638		
Room Temp.		23,000 MPa	3,300 ksi
260°C/500°F		19,000 MPa	2,800 ksi
ULTIMATE FLEXURAL STRENGTH	ASTM D-790		
Room Temp.		210 MPa	30 ksi
260°C/500°F		165 MPa	24 ksi
FLEXURAL MODULUS	ASTM D-790		
Room Temp.		18,000 MPa	2,600 ksi
260°C/500°F		15,000 MPa	2,200 ksi
ULTIMATE COMPRESSIVE STRENGTH[a]	ASTM D-3410		
Room Temp.		145 MPa	21 ksi
260°C/500°F		120 MPa	17 ksi
COMPRESSIVE MODULUS[a]	ASTM D-3410		
Room Temp.		23,000 MPa	3,400 ksi
260°C/500°F		22,000 MPa	3,200 ksi
SHORT-BEAM SHEAR STRENGTH[a]	ASTM D-2344		
Room Temp.		34 MPa	5.0 ksi
260°C/500°F		25 MPa	3.6 ksi
NOTCHED IZOD	ASTM D-256	144 J/m	2.7 ft. lbs./in.
HARDNESS, ROCKWELL 15-T	ASTM D-2240	80	80

THERMAL	TEST METHOD	SI UNITS	ENGLISH UNITS
GLASS TRANSITION TEMPERATURE, Tg	Thermal Mechanical Analysis	330°C	626°F
THERMAL EXPANSION COEFFICIENT[a] **(21–316°C/70–600°F)**	ASTM E-228-85	30.2×10^{-6} m/m/°C	16.8×10^{-6} in./in./°F
THERMAL EXPANSION COEFFICIENT (21–316°C/70–600°F)	ASTM D-696	4.0×10^{-6} m/m/°C	2.2×10^{-6} in./in./°F

OTHER PROPERTIES	TEST METHOD	SI UNITS	ENGLISH UNITS
SPECIFIC GRAVITY	ASTM D-792	1.49 gm/cc	1.49 gm/cc
WATER ABSORPTION (180 hrs. @ 23°C/73°F)	ASTM D-570	2.3% Weight Gain	2.3% Weight Gain

Note: All values listed are for compression-molded samples and are measured in the plane perpendicular to the direction of molding pressure unless otherwise indicated.

[a] Measured in the plane parallel to the direction of molding pressure.

CP-0650 may be processed using a variety of lay-up techniques with single or multiple debulking steps to optimize process capability for each part configuration. These design considerations can cause variation from the typical values listed above. Listed properties are based upon technical data that DuPont believes to be reliable. DuPont makes no warranties, expressed or implied, and assumes no liability in connection with use of this information.

CP-0644

MECHANICAL	TEST METHOD	SI UNITS	ENGLISH UNITS
ULTIMATE TENSILE STRENGTH	ASTM D-638		
Room Temp.		125 MPa	18 ksi
260°C/500°F		97 MPa	14 ksi
TENSILE MODULUS	ASTM D-638		
Room Temp.		23,000 MPa	3,400 ksi
260°C/500°F		16,000 MPa	2,300 ksi
ULTIMATE FLEXURAL STRENGTH	ASTM D-790		
Room Temp.		220 MPa	32 ksi
260°C/500°F		165 MPa	24 ksi
FLEXURAL MODULUS	ASTM D-790		
Room Temp.		21,000 MPa	3,000 ksi
260°C/500°F		17,000 MPa	2,400 ksi
ULTIMATE COMPRESSIVE STRENGTH[a]	ASTM D-3410		
Room Temp.		140 MPa	20 ksi
260°C/500°F		100 MPa	15 ksi
COMPRESSIVE MODULUS[a]	ASTM D-3410		
Room Temp.		19,000 MPa	2,700 ksi
260°C/500°F		14,000 MPa	2,100 ksi
SHORT-BEAM SHEAR STRENGTH[a]	ASTM D-2344		
Room Temp.		33 MPa	4.8 ksi
260°C/500°F		24 MPa	3.5 ksi
NOTCHED IZOD	ASTM D-256	171 J/m	3.2 ft. lbs./in.
HARDNESS, ROCKWELL 15-T	ASTM D-2240	79	79

THERMAL	TEST METHOD	SI UNITS	ENGLISH UNITS
GLASS TRANSITION TEMPERATURE, Tg	Thermal Mechanical Analysis	360°C	680°F
THERMAL EXPANSION COEFFICIENT[a] **(21–316°C/70–600°F)**	ASTM E-228-85	43.2×10^{-6} m/m/°C	24×10^{-6} in./in./°F
THERMAL EXPANSION COEFFICIENT (21–316°C/70–600°F)	ASTM D-696	2.3×10^{-6} m/m/°C	1.3×10^{-6} in./in./°F

OTHER PROPERTIES	TEST METHOD	SI UNITS	ENGLISH UNITS
SPECIFIC GRAVITY	ASTM D-792	1.51 gm/cc	1.51 gm/cc
WATER ABSORPTION (180 hrs. @ 23°C/73°F)	ASTM D-570	2.1% Weight Gain	2.1% Weight Gain

Note: All values listed are for compression-molded samples and are measured in the plane perpendicular to the direction of molding pressure unless otherwise indicated.

[a]Measured in the plane parallel to the direction of molding pressure.

CP-0644 may be processed using a variety of lay-up techniques with single or multiple debulking steps to optimize process capability for each part configuration. These design considerations can cause variation from the typical values listed above. Listed properties are based upon technical data that DuPont believes to be reliable. DuPont makes no warranties, expressed or implied, and assumes no liability in connection with use of this information.

TYPICAL PROPERTIES

VESPEL® CP-8000 SERIES

BRAIDED SERIES

From a wide selection of graphite, carbon, glass, and even Teflon® PTFE fibers, hollow braids are formed and combined with a variety of polyimides to produce bushings that offer the best combination of properties for applications that require the benefits that a composite structure offers. Toughness, thermal resistance, self-lubricity, and wear resistance are the most common requirements for these Vespel® CP products.

CP-8000

THERMAL	TEST METHOD	SI UNITS	ENGLISH UNITS
GLASS TRANSITION TEMPERATURE, Tg	Thermal Mechanical Analysis	360°C	680°F
THERMAL EXPANSION COEFFICIENT	–	8.3×10^{-6} m/m/°C	4.6×10^{-6} in./in./°F
OXIDATIVE STABILITY	See note [a]		
357°C/675°F		3.0% Weight Loss	3.0% Weight Loss
321°C/610°F		–	–

OTHER PROPERTIES	TEST METHOD	SI UNITS	ENGLISH UNITS
SPECIFIC GRAVITY	ASTM D-792	1.52 gm/cc	1.52 gm/cc

CP-8001

THERMAL	TEST METHOD	SI UNITS	ENGLISH UNITS
GLASS TRANSITION TEMPERATURE, Tg	Thermal Mechanical Analysis	349°C	660°F
THERMAL EXPANSION COEFFICIENT	–	8.3×10^{-6} m/m/°C	4.6×10^{-6} in./in./°F
OXIDATIVE STABILITY	See note [a]		
357°C/675°F		6.2% Weight Loss	6.2% Weight Loss
321°C/610°F		2.4% Weight Loss	2.4% Weight Loss

OTHER PROPERTIES	TEST METHOD	SI UNITS	ENGLISH UNITS
SPECIFIC GRAVITY	ASTM D-792	1.54 gm/cc	1.54 gm/cc

CP-8002

THERMAL	TEST METHOD	SI UNITS	ENGLISH UNITS
GLASS TRANSITION TEMPERATURE, Tg	Thermal Mechanical Analysis	330°C	626°F
THERMAL EXPANSION COEFFICIENT	–	7.2×10^{-6} m/m/°C	4.0×10^{-6} in./in./°F
OXIDATIVE STABILITY	See note [a]		
357°C/675°F		–	–
321°C/610°F		2.6% Weight Loss	2.6% Weight Loss

OTHER PROPERTIES	TEST METHOD	SI UNITS	ENGLISH UNITS
SPECIFIC GRAVITY	ASTM D-792	1.47 gm/cc	1.47 gm/cc

[a] 100 hours, 70 psia (483 kPa), circulating air, saturated conditions, volume/surface area = .024 in. (0.61 mm).

Note: Each part configuration is custom-designed to optimize process capability and part performance by adjusting resin/fiber ratios, fiber deniers, and braid construction. These design considerations can cause variation from the typical values listed above. Listed properties are based upon technical data that DuPont believes to be reliable. DuPont makes no warranties, expressed or implied, and assumes no liability in connection with use of this information.

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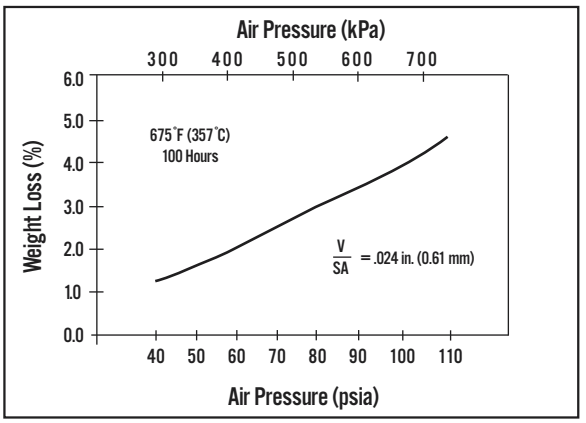
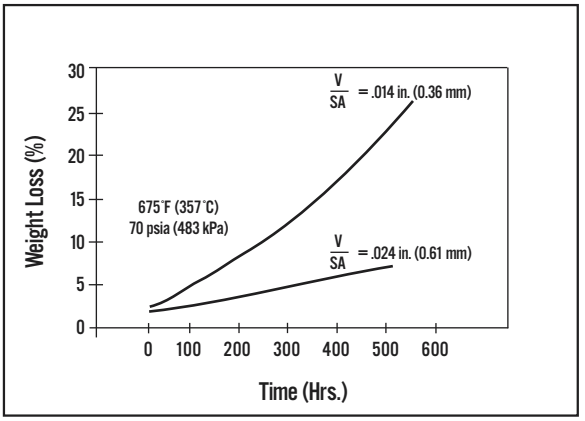
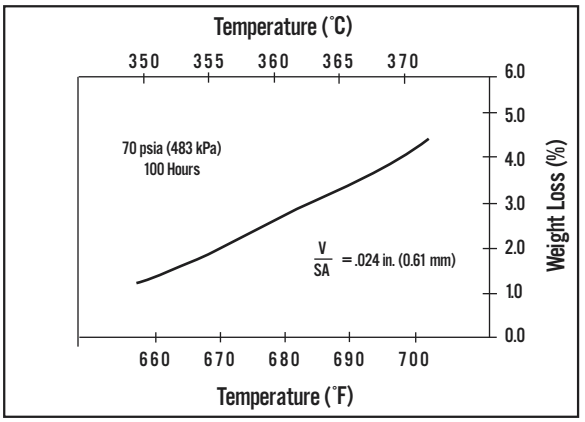
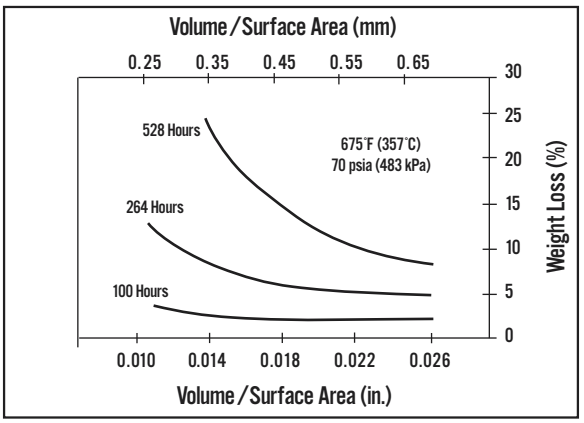
THERMAL OXIDATION CURVES FOR CP-8000

(Tests performed in circulating air, saturated conditions.)









TYPICAL PROPERTIES

VESPEL® CP-9800 SERIES END EFFECTORS

Vespel® CP-9800 is a clean, stiff, light-weight new end effector material. Custom parts made from this pitch-based carbon fiber and epoxy composite are designed specifically for the function required in the application. CP-9800 raw material is produced in a sheet form with a maximum area of 1x2m and a thickness of 2-20mm.

This composite is ideally suited for flat panel display and wafer handling applications. When compared to traditional ceramic and aluminum end effectors, CP-9800 is lighter weight, more durable, and deflects less under equivalent load. These properties make Vespel® CP-9800 the ideal choice for your next robotic end effector application.

CP-9800 SERIES PERFORMANCE COMPARISON – END EFFECTORS

PERFORMANCE/MATERIALS	ALUMINUM (Al)	CERAMIC ALUMINA (AL_2O_3)	CP-9800 ULTRA-HIGH MODULUS END EFFECTORS
DENSITY			
g/cm³	2.70	4.00	1.70
lb/ft³	169	250	106
FLEXURAL MODULUS			
GPa	72	400	300
psi	10 x 10^6	58 x 10^6	44 x 10^6
FINGER THICKNESS			
mm	3	3	3
inch	0.12	0.12	0.12
FINGER WEIGHT			
kg	0.81	1.20	0.50
lb	1.79	2.65	1.10
DEFLECTION			
SELF WEIGHT mm (inch)	6.01 (.24)	1.60 (.06)	0.83 (.03)
LOADING mm (inch)	1.48 (.06)	0.30 (.01)	0.30 (.01)
TOTAL mm (inch)	7.49 (.29)	1.90 (.07)	1.13 (.04)

CHOICE OF RIGIDITY	MODULUS	
TYPE	SI UNITS	ENGLISH UNITS
LOW MODULUS	160 GPa	23 x 10^6 psi
MEDIUM MODULUS	200 GPa	29 x 10^6 psi
HIGH MODULUS	250 GPa	36 x 10^6 psi
ULTRA HIGH MODULUS	320 GPa	46 x 10^6 psi

CHOICE OF RESIN	APPLICATION TEMPERATURE	
TYPE	SI UNITS	ENGLISH UNITS
REGULAR	80°C	176°F
HEAT-RESISTANCE–A	150°C	302°F
HEAT-RESISTANCE–B	200°C	392°F
HEAT-RESISTANCE–C	230°C	446°F

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OUTGASSING OF CP-9800 SERIES IN A VACUUM

SAMPLE	PROPERTIES	SI UNITS	ENGLISH UNITS
CP-9800	Flexural modulus Heat-resistance temperature	300 GPa 230˚C	44 x 10^6 psi 446˚F

MEASUREMENTS

1) Outgassing measurements by NASDA (The National Space Development Agency of Japan).
2) Temperature programmed desorption gas analysis.

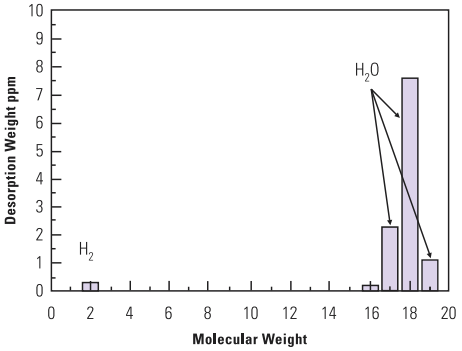
RESULTS

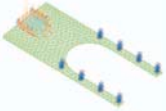
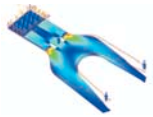
1) Outgassing measurements by NASDA:
This test is normally conducted to check the materials used for the satellites parts, especially when the outgassing is critical for the system.

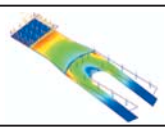
SAMPLE	PROPERTIES	SI UNITS	ENGLISH UNITS
TEST CONDITION – ASTM E595-93	Vacuum Temperature Collector plate Sample weight	7.0 x 10^{-3} Pa 125˚C 25˚C 0.25g	10^{-3} psi 257˚F 77˚F 5.5 x 10^{-4} lbs.
RESULTS	TML (Total Mass Loss) CVCM (Collected Volatile Condensable Material)	0.329% 0.002%	0.329% 0.002%
REMARKS	• Both values cleared the recommendation of NASA (TML<1%, CVCM<0.1%) for the use of satellite parts.		

2) Temperature programmed desorption gas analysis CP-9800 series:
Heat the sample from room temperature up to 250˚C (482˚F), and analyze the desorption gas by mass spectrometer.

SAMPLE	PROPERTIES	SI UNITS	ENGLISH UNITS
TEST CONDITION – TDS-M202P (ULVAC)	Temperature Ramp rate Sample weight Vacuum	Room temp-250˚C 10˚C/min. 1.0 g 10^{-5} Pa	Room temp-482˚F 10˚F 0.0022 lbs. 1.45 x 10^{-8} psi
RESULTS	The figure below shows the results of the desorption gas analysis. The main gas was identified as H_2O, and the small amount of H_2 was observed.		
REMARKS	• Although the maximum measurement temperature 250˚C (482˚F) was higher than the heat resistant temperature of CP-9800, 230˚C (446˚F), no degradation of the resin was observed.		



LCD HANDLING		CASE 1	CASE 2
MODELING			
DATA INPUT			
SIMULATION			
HAND WEIGHT kg (lbs.)		1.2 (2.65)	2.9 (6.39)
DEFLECTION mm (in.)	SELF WEIGHT	0.62 (0.0244)	0.48 (0.0189)
	LOADING BY PLATE GLASS	1.22 (0.048)	0.80 (0.0315)
	TOTAL	1.84 (0.0724)	1.28 (0.050)

WAFER HANDLING		CASE 1	CASE 2
MODELING			
DATA INPUT			
SIMULATION			
FINGER WEIGHT kg (lbs.)		0.28 (0.617)	0.24 (0.53)
DEFLECTION mm (in.)	SELF WEIGHT	0.24 (0.0094)	0.19 (0.00748)
	LOADING BY 12 IN. WAFER	0.22 (0.00866)	0.47 (0.0185)
	TOTAL	0.46 (0.01811)	0.66 (0.026)

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