Acoustic properties of selected high strength thermosetting plastic composites at ultrasonic frequencies

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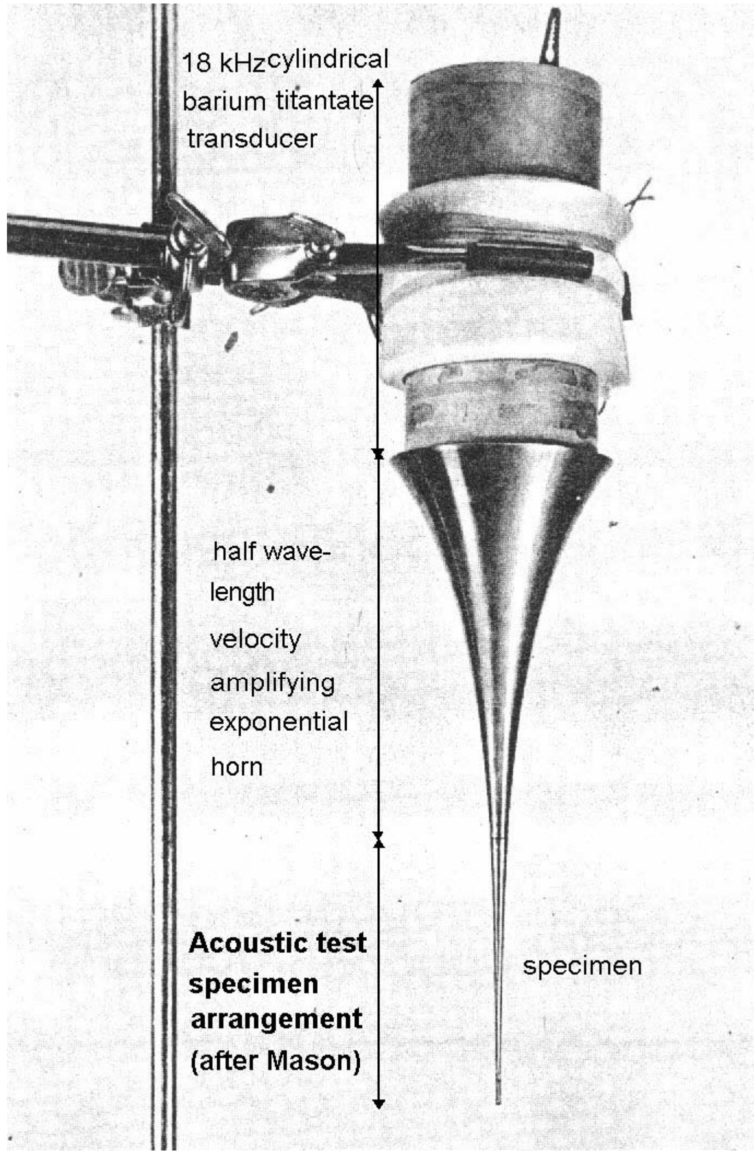
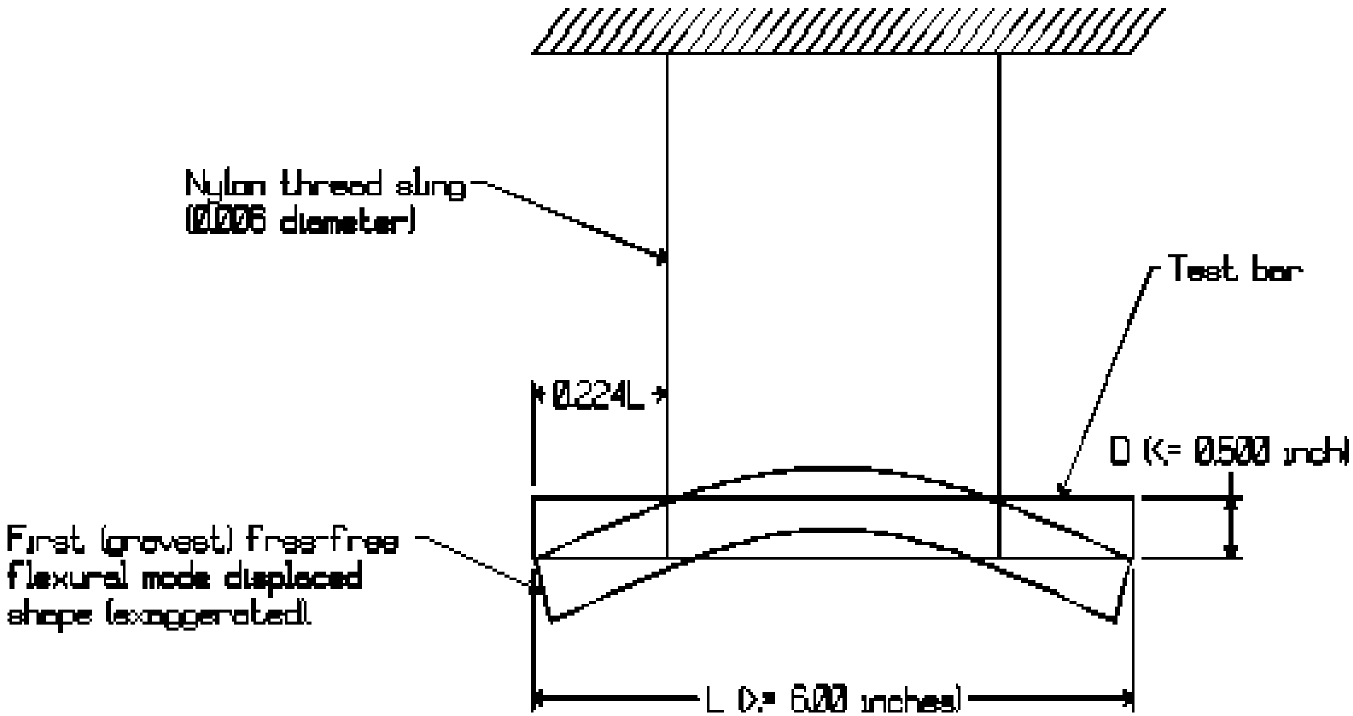
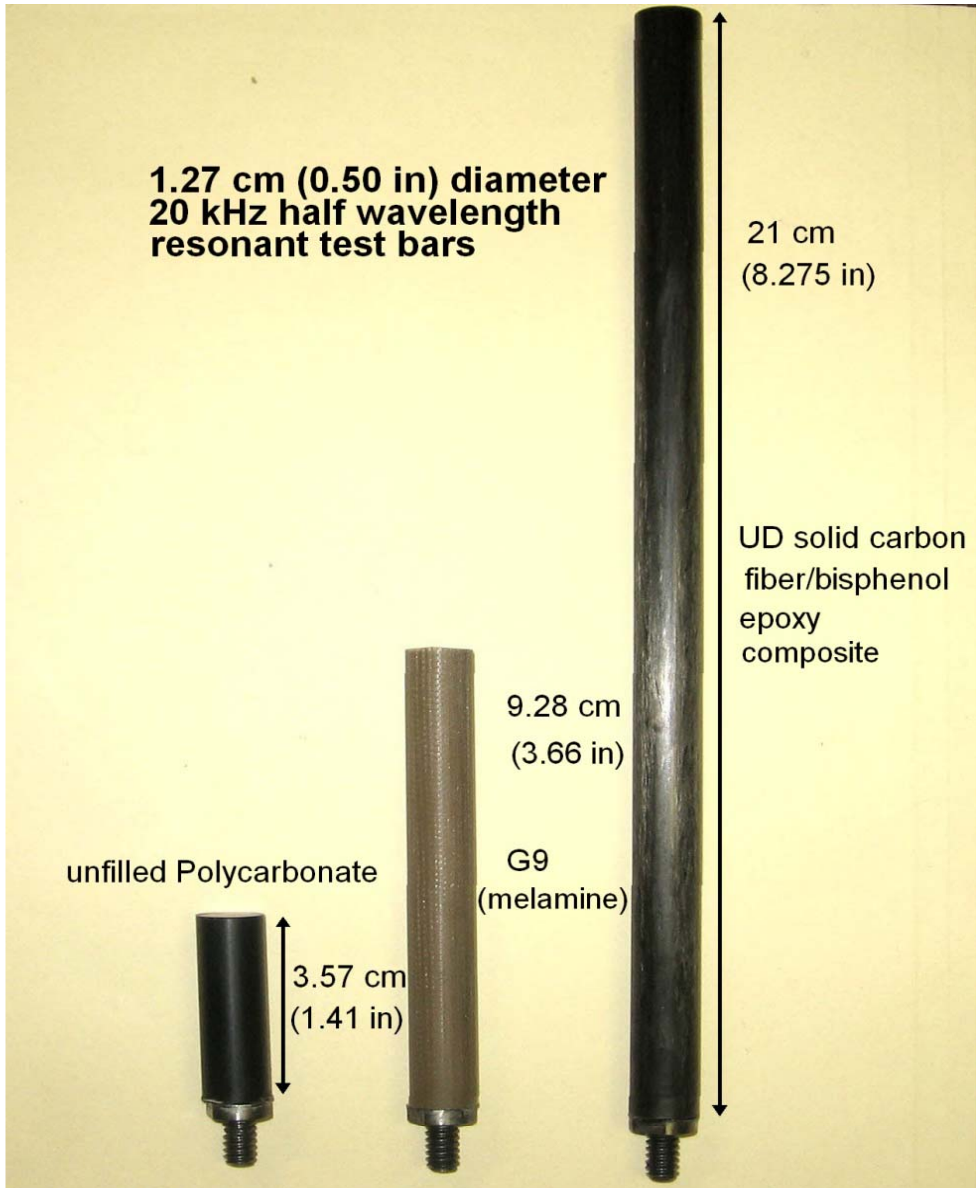
Modal Mechanics

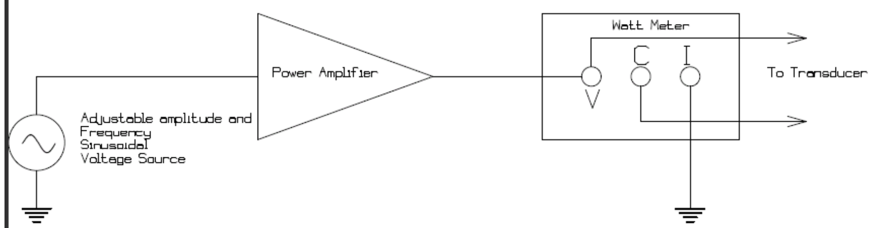


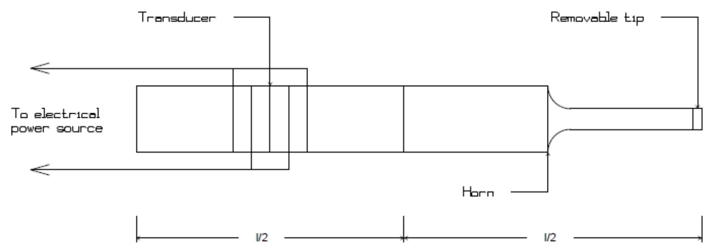
Acoustic test specimen arrangement (after Mason)



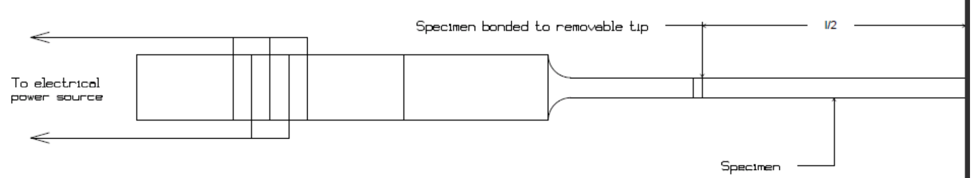
Chiming arrangement for measurement
of mechanical Q.


1.27 cm (0.50 in) diameter
20 kHz half wavelength
resonant test bars
21 cm
(8.275 in)
UD solid carbon
fiber/bisphenol
epoxy
composite
9.28 cm
(3.66 in)
G9
(melamine)
unfilled Polycarbonate
3.57 cm
(1.41 in)

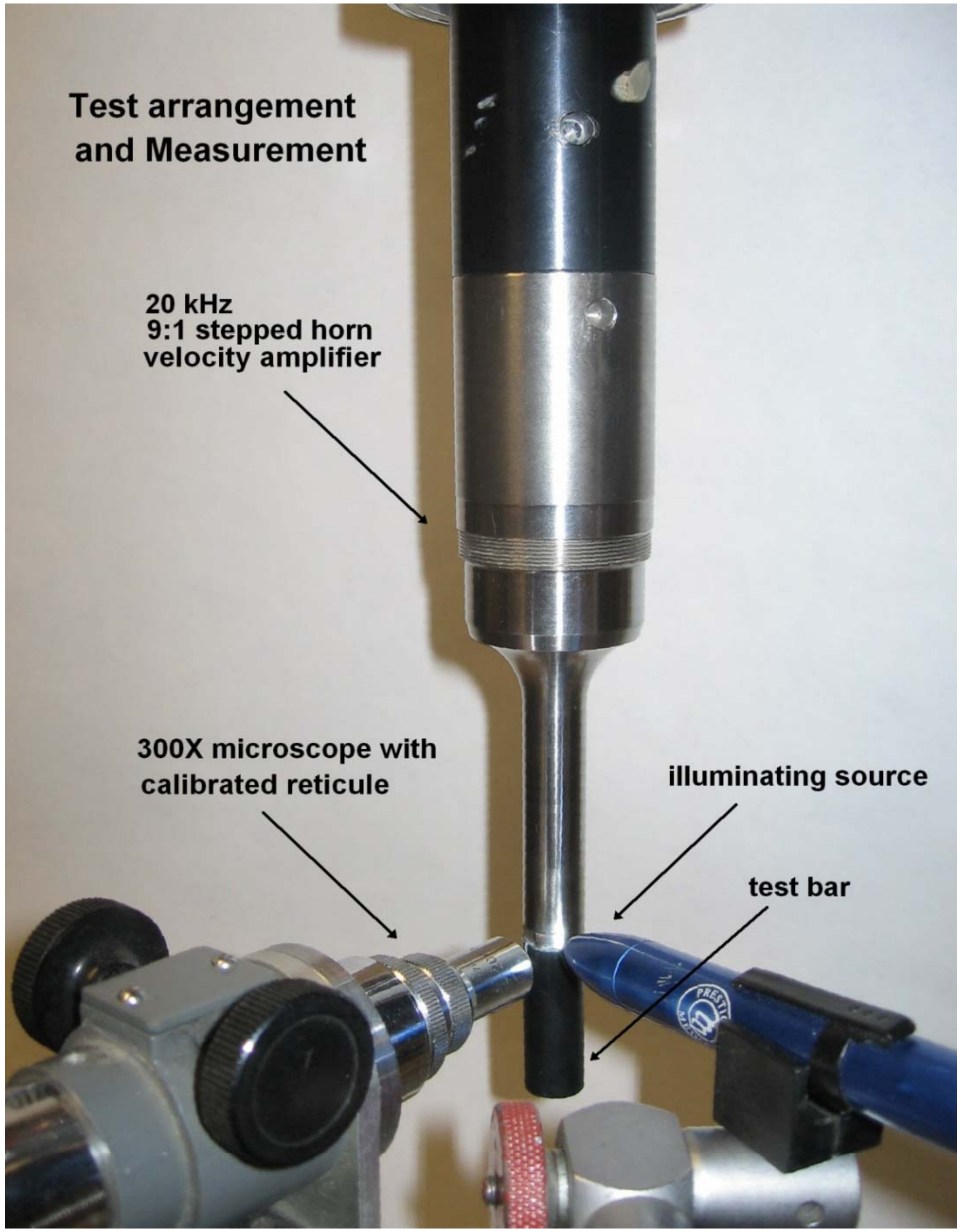




ACOUSTICAL CONNECTION FOR MEASUREMENT OF QUIESCENT POWER COMSUMPTION



ACOUSTICAL CONNECTION FOR MEASUREMENT OF SPECIMEN POWER CONSUMPTION

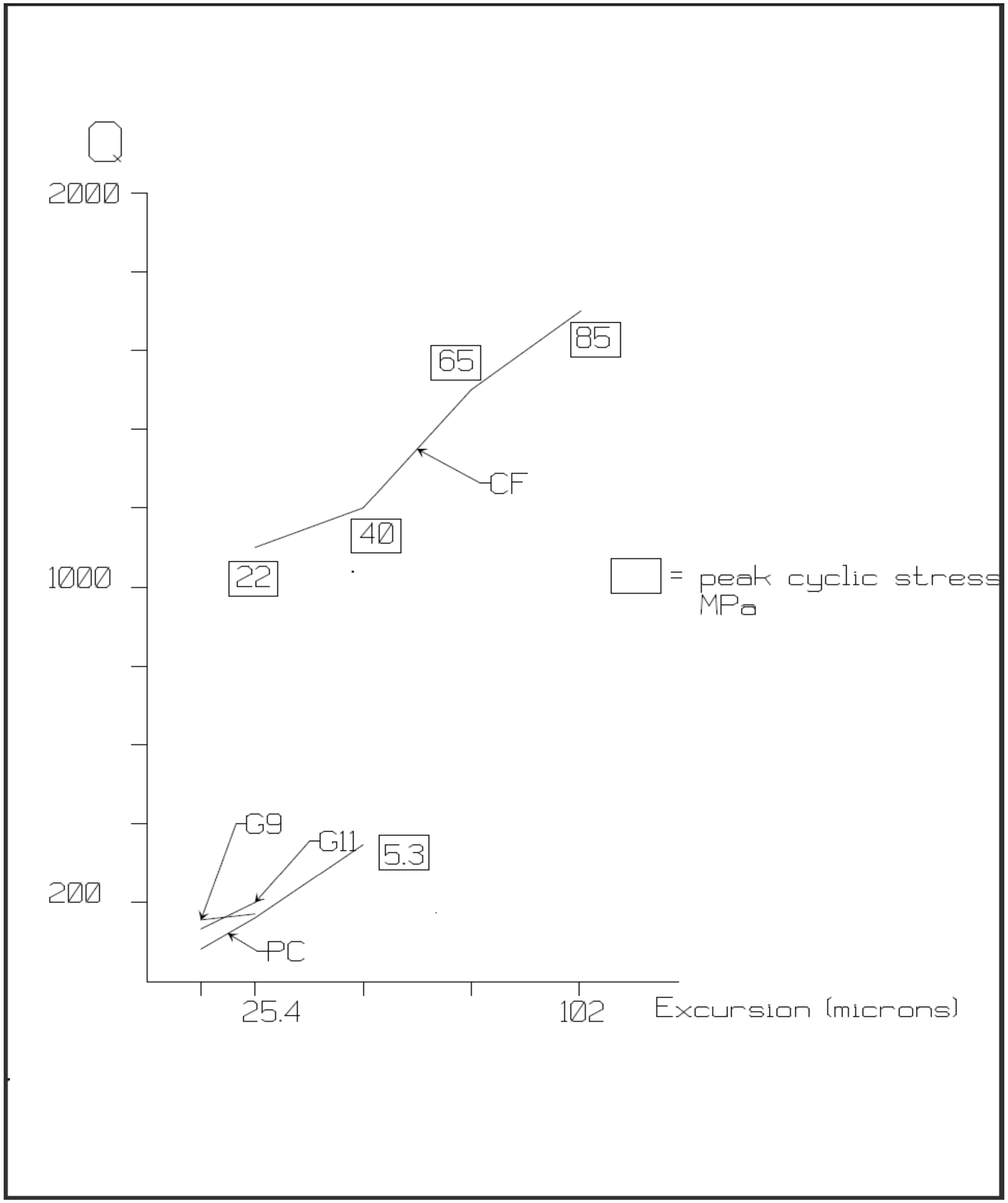

Test arrangement
and Measurement
20 kHz
9:1 stepped horn
velocity amplifier
300X microscope with
calibrated reticule
illuminating source
test bar

Q is defined as 2π(Energy, E_s, stored in vibration per cycle)/(Energy lost, E_l, per cycle of vibration). From the power measurements, the vibration amplitude, the mass of the sample and the frequency of vibration, Q can be computed as:

$$Q = 2\pi\left(\frac{\left(\frac{1}{4}\right)mv^2}{\frac{P_t - P_q}{f}}\right)$$

Where m is the mass of the specimen, v is velocity of vibration of the free faces = 2πfs/2, where s is the peak to peak excursion, P_t is the power consumption measured with the specimen attached and P_q the power at the <u>same</u> excursion measured for the transducer-horn alone and f is the resonant frequency. With the substitution, v = 2πf(s/2), s being the peak-peak excursion, made:

$$Q = \frac{\pi^3 m s^2 f^3}{2(P_t - P_q)}$$



Q
2000
1000
200
22
40
65
85
CF
G9
G11
5.3
PC
= peak cyclic stress
MPa
25.4
102
Excursion (microns)

Mechanical Properties of Carbon Fibre Composite Materials, Fibre / Epoxy resin (120°C Cure)

Fibres @ 0° (UD), 0/90° (fabric) to loading axis, Dry, Room Temperature, Vf = 60% (UD), 50% (fabric)

	Symbol	Units	Std CF Fabric	HMCF Fabric	E glass Fabric	Kevlar Fabric	Std CF UD	HMCF UD	M55** UD	E glass UD	Kevlar UD	Boron UD	Steel S97	Al. L65	Tit. dtd 5173
Young's Modulus 0°	E1	GPa	70	85	25	30	135	175	300	40	75	200	207	72	110
Young's Modulus 90°	E2	GPa	70	85	25	30	10	8	12	8	6	15	207	72	110
In-plane Shear Modulus	G12	GPa	5	5	4	5	5	5	5	4	2	5	80	25	
Major Poisson's Ratio	v12		0.10	0.10	0.20	0.20	0.30	0.30	0.30	0.25	0.34	0.23			
Ult. Tensile Strength 0°	Xt	MPa	600	350	440	480	1500	1000	1600	1000	1300	1400	990	460	
Ult. Comp. Strength 0°	Xc	MPa	570	150	425	190	1200	850	1300	600	280	2800			
Ult. Tensile Strength 90°	Yt	MPa	600	350	440	480	50	40	50	30	30	90			
Ult. Comp. Strength 90°	Yc	MPa	570	150	425	190	250	200	250	110	140	280			
Ult. In-plane Shear Stren.	S	MPa	90	35	40	50	70	60	75	40	60	140			
Ult. Tensile Strain 0°	ext	%	0.85	0.40	1.75	1.60	1.05	0.55		2.50	1.70	0.70			
Ult. Comp. Strain 0°	exc	%	0.80	0.15	1.70	0.60	0.85	0.45		1.50	0.35	1.40			
Ult. Tensile Strain 90°	eyt	%	0.85	0.40	1.75	1.60	0.50	0.50		0.35	0.50	0.60			
Ult. Comp. Strain 90°	eyc	%	0.80	0.15	1.70	0.60	2.50	2.50		1.35	2.30	1.85			
Ult. In-plane shear strain	es	%	1.80	0.70	1.00	1.00	1.40	1.20		1.00	3.00	2.80			
Thermal Exp. Co-ef. 0°	Alpha1	Strain/K	2.10	1.10	11.60	7.40	-0.30	-0.30	-0.30	6.00	4.00	18.00			
Thermal Exp. Co-ef. 90°	Alpha2	Strain/K	2.10	1.10	11.60	7.40	28.00	25.00	28.00	35.00	40.00	40.00			
Moisture Exp. Co-ef 0°	Beta1	Strain/K	0.03	0.03	0.07	0.07	0.01	0.01		0.01	0.04	0.01			
Moisture Exp. Co-ef 90°	Beta2	Strain/K	0.03	0.03	0.07	0.07	0.30	0.30		0.30	0.30	0.30			
Density		g/cc	1.60	1.60	1.90	1.40	1.60	1.60	1.65	1.90	1.40	2.00			

*** Calculated figures*

Fibres @ +/-45 Deg. to loading axis, Dry, Room Temperature, Vf = 60% (UD), 50% (fabric)

	Symbol	Units	Std. CF	HM CF	E Glass	Std. CF fabric	E Glass fabric	Steel	Al
Longitudinal Modulus	E1	GPa	17	17	12.3	19.1	12.2	207	72
Transverse Modulus	E2	GPa	17	17	12.3	19.1	12.2	207	72
In Plane Shear Modulus	G12	GPa	33	47	11	30	8	80	25
Poisson's Ratio	v12		.77	.83	.53	.74	.53		
Tensile Strength	Xt	MPa	110	110	90	120	120	990	460
Compressive Strength	Xc	MPa	110	110	90	120	120	990	460
In Plane Shear Strength	S	MPa	260	210	100	310	150		
Thermal Expansion Co-ef	Alpha1	Strain/K	2.15 E-6	0.9 E-6	12 E-6	4.9 E-6	10 E-6	11 E-6	23 E-6
Moisture Co-ef	Beta1	Strain/K	3.22 E-4	2.49 E-4	6.9 E-4				

*** Calculated figures*

These tables are for reference / information only and are **NOT** a guarantee of performance
1 GPa = 1000 MPa = 1000 N/mm² = 145,000 PSI

These tables relate to only 2 of the many fibre orientations possible. Most components are made using combinations of the above materials and with the fibre orientations being dictated by the performance requirements of the product. Performance Composites Ltd. can assist with the design of components where appropriate.

65 micron excursion, CF half wavelength resonator in water