



Onda Corporation
592 Weddell Drive, Suite 7, Sunnyvale, CA 94089
PH: (408) 745 - 0383 FAX: (408) 745 - 0956

Acoustic Properties Tables

Abbreviations

Units

T_c	=	Curie Temperature
ϵ_r	=	Relative dielectric constant, multiply by 8.84×10^{-12} for MKS units (F/m)
k_t	=	Coupling coefficient between E_3 and thickness mode
D	=	density in g/ml
$\tan \delta$	=	loss tangent (unit less)
Q_m	=	Mechanical Q
v_3^D	=	velocity corresponding to anti-resonance (open circuit)
v_3^E	=	velocity corresponding to resonance (short circuit)
v_s	=	shear velocity
Z_s	=	shear impedance times 10^{-6} kg.m ² /s
Z_3^D	=	longitudinal wave impedance corresponding to anti-resonance times 10^{-6} kg.m ² /s

Vendors

Please Note: If you notice any listing that is out dated, please email us at Onda.

3M	Bay Area, (415)257-2244, Los Angeles, (213)726-6305
A	Atomergic Chemetals, 91 Carolyn Blvd., Farmingdale, NY 11735 (516)694-9000 telex 6852289
Acme	Acme Chemicals, PO Box 1404, New Haven, Conn. 06505, (203)562-2171
AMD	AMD Engineering, Rockland, Ma. 02370
Amer	American Hoechst Corp., Tustin, Ca. (714)730-5051
AMPL	AMPL Prochal, Paris, France
B	Brinkman Instruments Inc., Great Neck L.I.N.Y.
BFG	B. F. Goodrich, (216)374-4123 Howard Hochrad, Karen Bird, 500 S. Main St., Akron, Ohio 44318
Borg	Borg-Warner Chemicals Inc., International Center, Parkersburg, W. Va. 26101 (304)424-5411, Colorite Plastics Co., 101 Railroad Ave., Richfield N.J. 07657
C	Cerac, PO Box 1178, Milwaukee, Wis. 53201, (414)289-9800
Ch	Chemtek, Hayward, Ca., (415)785-0330



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Chan	Channel Industries, 839 Ward Dr., Santa Barbara, CA 93111, (805)967-0171
Ciba	Ciba-Araldite Products
Corn	Corning Glass Works, S. Taaffe, Sunnyvale, Ca., (408)732-5050, also Corning Glass, Corning, N.Y.
Crys	Crystal Technology Inc., 1035 East Meadow Circle, Palo Alto, CA 94303, (415)856-7911
CVS	Local pharmacy
D	E.I. Dupont de Nemours, N8533 Freon Products Div., Wilmington, Del. 19898 (800)441-7515, Ventron Corp., Alpha Products, 2098 Pine St., San Leandro, Ca. 94577, Ventron Corp., Alpha Division, Danver, Mass., (617)777-1970x406
DC	Dow Corning, (everything is silicon based) Fresno, Ca. (209)4410201, K. R. Anderson, 136 Wolfe Rd., Sunnyvale, Ca. 94086 (408)736-6730, Bronell Elctro Products (212)924-6000
Dyna	Dynasil Corp., Cooper Rd., Berlin, N.J. 08009 (609)767-4600 Marty Saepoff
E	E. T. Horn Co., 541 66th Ave., Oakland, Ca. 94621, (415)568-2737, Dow Chemical
EBL	EBL, 91 Tolland St., East Hartford, Conn. 06108, (203)289-5428
Echo	Echo Labs, PO Box 552, Lewiston, Penn. 17044, (717)248-4993
EC	Emerson Cummings, 604 W 182nd St., Gardena, Ca. 90248, (213)329-1147, (213)321-6650x33
EDO	EDO Western Corporation, 2645 South 300 West, Salt Lake City, UT 84115, (801)486-7481 Ceramic Sales
Ferrox	Ferroxcube Corp., Saugerties, NY, (914)246-2811 extension 427 for FAX, Jan Vanderpoel
FI	Flourocarbon Process Systems, 1432 S Allec St., PO Box 3640, Anaheim, Ca. 92803, (714)956-7330
Gall	Gallagher Corp., 3966 Morrison Dr., Guerne, Ill. 60031 (312)249-3440 Richard Gallagher
GE	General Electric, Silicon Products, Waterford, N.Y. 12188, (518)237-3330, Electrical Specialty Co., 213 E. Harris Ave., So. San Francisco, Ca. (415)589-9611
GEP	General Electric, 1700 E. Gale, City of Industry, Ca. 91745
GM	E.V. Roberts and Associates, Palo Alto, Ca., (415)494-1671, E.V. Roberts and Associates, 8500 Stellar Dr., Culver City, Ca. 90230, also Hankel Corporation
Ferr	Ferroperm Piezoelectrics, Stubbeled 7, DK-2950 Vedbaek, Denmar, Tel. 02- 89 03 92, USA Distributor: Seacor Inc. 123 Woodland Ave, Westwood NJ 07675, (201)666-5600
Gul	Gulton Industries Inc., Piezo Products Division, Fullerton CA 92631 (714)871-2150
H	Hysol Divison, Dexter Corp., Olean, N.Y. 14760, Hysol Insulating Materials, 15051 E. Don Julian Rd., Industry, Ca. 91749, (213)968-6511, (415)687-4201



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Honey	Honeywell Inc. (612)536-3200 Don Basco
I	Indium Corp., PO Box 269, Utica, N.Y. 13503, (317)797-1630 Telex 937363
JM	Johns-Manville, Electrical Materials Inc., San Antonio Rd., Palo Alto, Ca. (415)494-0400
JEE	Jiang Su Electronics Equipment Co., China
Kera	Keramos Inc., 104 N. Church St., Liston IN 46149, (317)994-5194
Kodak	Eastman Chemical Products Inc., Kingsport, Tenn.
Lee	Lee Plastics, 793 E. Pico Blvd., Los Angeles, Ca. 90021, (217)746-5984
Li	Li Tungsten Co., 63 Herhill Rd., Glencove, N.Y. 11542, (516)676-1314
Loc	Koblick Supply, 2950 Bay Rd., Redwood City, Ca. 94063, (415)364-7330, Loctite, 18731 Cranwood Parkway, Cleveland, Ohio 44128, (800)321-9188,89
Mason	Harry Mason (415)592-0840, also try WESGO (415)5929440 Chuck Fogelman
Mats	Matsushita Research Institute Tokyo Inc., 3-10-1 Higashimita, Tana-Ku, Kawasaki, 214, Japan
MPC	Medical Products Corp., PO 1274, Racine, Wisc. 53405, (414)634-1556
Mobay	Mobay Chemical Corp., 16661 Von Karman Ave., Irvine, Ca. 92714
Mons	Monsanto Co. 800 N. Lindbergh Blvd., St. Louis, Mo. 63166 (314)694-1000
Mura	Murata Corp. of America, 1148 Franklin Rd. S.E., Marietta, GA 30067, (404)952-9777 Jiro Miyazaki. Also Murata Manufacturing Co. Ltd., 26-10, 2 Chrome, Tenjin, Nagaokakyo-Shi, Kyoto 617, Japan, Tel. 075-921-9111, Telex 05429-901 Murat. Recht Asso., 2251 Grant Rd., Los Altos, CA 94022, (415)964-6321 Jim Holwerda
Phil	Phillips Petroleum
Port	Port Plastics, 1047 N. Fair Oaks Ave., Sunnyvale, Ca 94086 (415)324-1391, (408)744-1111
PRC	Products Research and Chemical Copr., 5430 San Fernando, Glendale Ca. 91203
Ren	Ren Plastics, Div. of Ciba Geigy, 18424 Mt Langley, Fountain Valley, Ca., (517)351-5900
RG	Royal Glass, 450 Cambridge Ave., Palo Alto, Ca., (415)321-5510
Rohm	Rohm and Haas
RS	R. S. Hughes Co., 1162 Sonora Court, PO Box 515, Sunnyvale, Ca. 94086 (407)739-3211, Electrical Specialties Co. (415)589-9611
Schott	Schott Optical Glass, PO Box 4111, Fullerton, Ca. 92634, (714)871-0800 Bob Chamberlin, Schott Optical Glass, York Ave., Duryea, Penn. 18642, (717)457-7485



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Sh	Shell Chemical Co.
Si	Sigri Corporation, Carbon and Graphite, Route 202-206 North, PO Box 922, Somerville, NJ 08876, Tel. (201) 231-2849, H. Lee Young - Sales Manager
Ssi	Institute of Shanhai Silicon, China
SW	Sargent Welch Chemical Corp.
T	Thiokol Chemical Div., 930 Lower Ferry Rd., Trenton, N.J. 08607, (609)396-4001
Tap	Tap Plastics Inc., 1212 Alemeda, San Jose, Ca., (408)292-8685
Tech	Techform Labs, Los Angeles, Ca. 90061
Tr	Tra-con Inc., Medford, Ma. 02155
Tran	Transducer Products, Rt 63 North, Goshen CT 0675, (203)491-3251, Stan Thompson or Dr. Carol Thompson
UC	Union Carbide
Uni	Uniroyal (800)243-2719
Upj	Upjohn Co., CPR Div., 555 Alaska Ave., Torrance, Ca. 90503
USI	USI Corp. c/o Plastic Systems [Location unknown]
VF	Valpey-Fisher, 75 South St., Hopkinton, Ma 01748 (617)435-6831
VWR	Van Waters and Rogers, (408)263-9900, 2256 Junction, San Jose, Ca.
Wa	Wadsworth-Pacific, (415)321-3619, Epoxy Technology Inc., 14 Fortuna Dr., Billerica, Mass. 01821
WG	Western Gold and Platinum Co., 477 Harbor Blvd., Belmont Ca. 94002, (415)592-9440
WP	Westlake Plastics, PO Box 127, Lenni, Penn. 19052, (215)459-1000 Matsui, N.Y., N.Y., also Plastic Sales, San Francisco, CA (415)550-1848

Other Abbreviations

" Acoustic attenuation in nepers/meter. The tables adopt the convention of describing attenuation in liquids as the best fit to a frequency squared power law. To convert to dB/m, multiply " by 8.686 and multiply by the square of frequency (in Hz). To convert to dB/cm multiply by 868.6 and multiply by the square of frequency (in Hz).

Loss Acoustic attenuation in dB/cm at the stated frequency in MHz.

$(\frac{v}{T})_T$ Change in acoustic velocity per change in temperature in m/s°C referenced to 25°C



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kt	Electromechanical coupling coefficient between E ₃ and thickness mode of vibration
kp	Planar (radial) mode coupling coefficient
D	Density in g/ml
tan *	Loss tangent
Q _m	Mechanical quality factor
V ₃ ^D	Piezoelectrically stiffened velocity in piezoelectric material. Corresponds to antiresonant frequency (parallel resonance)
V ₃ ^E	Velocity in piezoelectric material with electric field in the material fixed to zero. Corresponds to resonant frequency (series resonance)
V _L	Longitudinal wave velocity in mm/: s
V _S	Shear wave velocity in mm/: s
F	Poisson's ratio given by $(1 - 2X) / (2 * (1 - X))$ where $X = (V_S / V_L)^2$
Z _L	Longitudinal wave impedance ($D * V_L$) * 10 ⁻⁶ in kg/m ² s
Z _S	Shear wave impedance ($D * V_S$) * 10 ⁻⁶ in kg/m ² s

Alumina Aluminum oxide for thin layer chromatography. Obtained from Chemistry Stores at Stanford University.

C5W A Li Tungsten product, the 6 to 10 micron powder

DEH Dow epoxy hardner

LP3 A liquid polysulfide resin from Thiokol Corporation



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DER Dow epoxy resin

MPDA Meta-phenalene-diamine, a good epoxy hardner. Use vendors D, handle, or rather don't handle with care. This product can be difficult to obtain fresh, should arrive in the form of whiteish flakes. When handling, take care to use gloves and apron, do not breath the powder. It is best stored in jars filled with dry nitrogen at 0°C. When opening a new jar, allow it to equilibrate to RT first.

PHA Parts per hundred parts by weight of A

PHE Parts per hundred parts by weight of mixed epoxy

PHR Parts per hundred parts by weight of RESIN, as opposed to total weight etc.

R1 Recipe 1: Heat the resin to 70°C, add the MPDA and keep the mixture in the oven until the MPDA melts. Sift the W through a 100 mesh screen and add to the epoxy. Stir throughly, and outgas the mixture to a 100 micron vacuum. Cure at 40°C for 1 hour, then leave in oven overnight at 70°C.

R2 Recipe 2: Mix alumina to resin. Alumina is very light and fluffy and does not need to be sifted first. It is so light in fact, that any mixture having more than about 100PHR of it will be fixatropic and hard to pour. Next add the hardner, then stir throughly and outgas to 200 microns. Use an engraving tool on the beaker to facilitate pouring. Cure at RT for 48 hours.

R3 Recipe 3: Sift the W through a 100 mesh screen before adding to the resin at RT. Stir and outgas the mixture to 150 microns vacuum. Add the hardner, stir and outgas again. We have noted that epoxy hardened by DEH20, if exposed to the atmospheric moisture, will still be sticky after curing. This is called blushing and usually does not effect the experiment.

R4 Recipe 4: Mix parts A and B and filler together, outgas to 100 microns vacuum, bake overnight at 70°C.

R5 Recipe 5: Vacuum impregnation. To make these materials a vessel is required which is vacuum tight at the bottom and open at the top, i.e. a test tube or jig. The jig is mold released and the filler material is poured into it, usually no more than a third of the way to the top. Next the jig is warmed in an oven to the specified temperature to preheat it and bake on the mold release. The resin is melted, usually in the same oven at this time, and then the MPDA is added and allowed to melt into the resin. Thiokol may also be added at this time if specified. The mixture is stirred, then poured over the filler material, usually no more than two thirds of the way to the top. This assembly is outgassed till a vacuum of 100 microns is reached, usually in about 10 minutes depending on the size of the jig etc. When the vacuum is broken, the epoxy is forced into the filler material by atmospheric pressure. Bake at 70°C overnight.

R6 Recipe 6: Parts A and B are stirred together, outgas to 100 microns vacuum, bake at 60°C overnight.



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- R7 Recipe 7: Same as R6 but the material is post baked at 200°C overnight. Material turns from red to black and the loss increases.
- R8 Recipe 8: Stir components together thoroughly, outgas to 200 microns, pour into a jig at room temperature, leave at RT for about an hour, then place jig in 72°C oven overnight.
- R9 Recipe 9: Stir components together thoroughly, outgas to 200 microns, pour in to a preheated jig and bake at 90°C overnight.
- R10 Recipe 10: Melt resin, mix in alumina, outgas mix to 1mm, add DEH20, stir, outgas again to 1mm.
- R11 Recipe 11: Stir W into RTV 560 and outgas. Then add the DBT, stir and outgas again. Pour or scrape into jig mold released with "Heavy Duty Silicon Mold Release" from Sprayon Products, Anaheim, CA. Let stand at room temperature for 4 hours to let cure, then bake at 40°C overnight. Immediate baking will cause material to stick through the mold release.
- RT Room temperature, or about 20°C
- SiC Silicon carbide, 325 mesh or about 10 to 20 microns diameter, Cerac product number S1169.
- T1167 325 mesh tungsten from Cerac, product number T1167.
- V140 Versamid V140
- W Tungsten powder, 1 to 2 microns diameter, Cerac product number T1168. This material is very fine and does not settle out of a heavier epoxy resin such as DER317 at RT.
- WO₃ 1-5 : m size 99.9% pure tungsten oxide. This material does not conduct electrically - unlike pure tungsten or tungsten carbide.