

Appendix A

This appendix contains tables of properties of use to the ATM.

Table 1.

Aluminum Tubing Sizes

6061-T6 (61S-T6) Round Aluminum Tube

Tubing Diameter	Wall Thickness		ID, Inches	Approx Wt. In Pounds Per Foot	Moment of Inertia in ⁴
	Inches	Stubs Ga.			
3/16 in.	0.035	(No. 20)	0.117	0.019	5.15e-5
	0.049	(No. 18)	0.089	0.025	5.76e-5
1/4 in.	0.035	(No. 20)	0.180	0.027	1.40e-4
	0.049	(No. 18)	0.152	0.036	1.66e-4
	0.058	(No. 17)	0.134	0.041	1.76e-4
5/16 in.	0.035	(No. 20)	0.242	0.036	3.00e-4
	0.049	(No. 18)	0.214	0.047	3.65e-4
	0.058	(No. 17)	0.196	0.055	3.96e-4
3/8 in.	0.035	(No. 20)	0.305	0.043	5.46e-4
	0.049	(No. 18)	0.277	0.060	6.82e-4
	0.058	(No. 17)	0.259	0.068	7.50e-4
	0.065	(No. 16)	0.245	0.074	7.94e-4
7/16 in.	0.035	(No. 20)	0.367	0.051	9.08e-4
	0.049	(No. 18)	0.339	0.070	1.15e-3
	0.065	(No. 16)	0.307	0.089	1.36e-3
1/2 in.	0.028	(No. 22)	0.444	0.049	1.16e-3
	0.035	(No. 20)	0.430	0.059	1.39e-3
	0.049	(No. 18)	0.402	0.082	1.79e-3
	0.058	(No. 17)	0.384	0.095	2.00e-3
	0.065	(No. 16)	0.370	0.107	2.15e-3
5/8 in.	0.028	(No. 22)	0.569	0.061	2.34e-3
	0.035	(No. 20)	0.555	0.075	2.83e-3
	0.049	(No. 18)	0.527	0.106	3.70e-3
	0.058	(No. 17)	0.509	0.121	4.20e-3
3/4 in.	0.065	(No. 16)	0.495	0.137	4.54e-3
	0.035	(No. 20)	0.680	0.091	5.04e-3
	0.049	(No. 18)	0.652	0.125	6.66e-3
	0.058	(No. 17)	0.634	0.148	7.60e-3
7/8 in.	0.065	(No. 16)	0.620	0.160	8.28e-3
	0.083	(No. 14)	0.584	0.204	9.82e-3
	0.035	(No. 20)	0.805	0.108	8.16e-3
	0.049	(No. 18)	0.777	0.151	1.09e-2
	0.058	(No. 17)	0.759	0.175	1.25e-2
1 in.	0.065	(No. 16)	0.745	0.199	1.37e-2
	0.035	(No. 20)	0.930	0.123	1.24e-2
	0.049	(No. 18)	0.902	0.170	1.66e-2
	0.058	(No. 17)	0.884	0.202	1.91e-2
	0.065	(No. 16)	0.870	0.220	2.10e-2
	0.083	(No. 14)	0.834	0.281	2.53e-2

1-1/8 in.	0.035	(No. 20)	1.055	0.139	1.78e-2
	0.058	(No. 17)	1.009	0.228	2.77e-2
1-1/4 in.	0.035	(No. 20)	1.180	0.155	2.47e-2
	0.049	(No. 18)	1.152	0.210	3.34e-2
	0.058	(No. 17)	1.134	0.256	3.87e-2
	0.065	(No. 16)	1.120	0.284	4.26e-2
	0.083	(No. 14)	1.084	0.357	5.21e-2
1-3/8 in.	0.035	(No. 20)	1.305	0.173	3.31e-2
	0.058	(No. 17)	1.259	0.282	5.21e-2
1-1/2 in.	0.035	(No. 20)	1.430	0.180	4.32e-2
	0.049	(No. 18)	1.402	0.260	5.89e-2
	0.058	(No. 17)	1.384	0.309	6.84e-2
	0.065	(No. 16)	1.370	0.344	7.56e-2
	0.083	(No. 14)	1.334	0.434	9.31e-2
	*0.125	1/8 in.	1.250	0.630	1.29e-1
	*0.250	1/4 in.	1.000	1.150	1.99e-1
1-5/8 in.	0.035	(No. 20)	1.555	0.206	5.53e-2
	0.058	(No. 17)	1.509	0.336	8.78e-2
1-3/4 in.	0.058	(No. 17)	1.634	0.363	1.10e-1
	0.083	(No. 14)	1.584	0.510	1.51e-1
1-7/8 in.	0.058	(No. 17)	1.759	0.389	1.37e-1
2 in.	0.049	(No. 18)	1.902	0.350	1.43e-1
	0.065	(No. 16)	1.870	0.450	1.85e-1
	0.083	(No. 14)	1.834	0.590	2.30e-1
	*0.125	1/8 in.	1.750	0.870	3.25e-1
	*0.250	1/4 in.	1.500	1.620	5.37e-1
2-1/4 in.	0.049	(No. 18)	2.152	0.398	2.05e-1
	0.065	(No. 16)	2.120	0.520	2.67e-1
	0.083	(No. 14)	2.084	0.660	3.32e-1
2-1/2 in.	0.065	(No. 16)	2.370	0.587	3.69e-1
	0.083	(No. 14)	2.334	0.740	4.61e-1
	*0.125	1/8 in.	2.250	1.100	6.59e-1
	*0.250	1/4 in.	2.000	2.080	1.13
3 in.	0.065	(No. 16)	2.870	0.710	6.46e-1
	*0.125	1/8 in.	2.700	1.330	1.37
	*0.250	1/4 in.	2.500	2.540	2.06

*These sizes are extruded. All other sizes are drawn tubes.

Source: Hall, Gerald, Editor, ARRL Antenna Book, 1988, American Radio Relay League, Newington, CT.

Coefficients of friction for material pairs.

Material Pair	Static	Kinetic
teflon/nylon	0.055	0.050
teflon/formica	0.105	0.083
teflon/aluminum	0.12	0.095

teflon/PVC	0.13	0.13
nylon/aluminum	0.13	0.125
nylon/formica	0.20	0.19
PVC/formica	0.25	0.17
PVC/plywood	0.28	0.23
felt/formica	0.23	0.22
felt/aluminum	0.31	0.31
plywood/formica	0.37	0.20
plywood/particle board	0.45	0.30

TABLE 2: Some coefficients of friction for materials used in telescope making. From [Berry, 1980](#). Kinetic friction measured at 1 mm/sec.

Material	E-Mod. of Elasticity	Density	Tensile Strength	Yield Strength
Units	10^6 PSI	lb.s/in ³	10^3 PSI	10^3 PSI
E glass	10.5	0.092	500	
S glass	12.6	0.090	650	
Kevlar	18.0	0.052	525	
Graphite HS	40.0	0.054	400	
Graphite HM	77.0	0.069	270	
Epoxy (avg)	0.40	0.043	5	5
Glass, soda-lime	10	0.089		
Steel	29	0.284	50 (min)	35
Aluminum #6061-T6	10	0.096	42	37
Oak avg.	1.8	0.023		14.3
Plywood (3-ply)	1.4	0.026		
Douglas Fir				
with grain	2.0	0.017		12.2

across "	0.19	0.017		12.2
Pine (eastern)	1.2	0.012		8.6
Sonotube®	.18	0.065		

Table 3: Mechanical properties of TM materials. Yield strength of wood in bending. Data on Sonotube from Sonoco Products, Co., manufacturer. Other values from Mechanical Handbooks.

Table 4 Ball Bearing Approximate Static Load Ratings vs. Types and Sizes
(Ratings are in pounds)

	single-row 200 series	single-row 300 series	double-row 200 series
bore inch	C	C	C
.394	600	850	800
.472	680	1,040	1,250
.590	780	1,220	1,430
.669	1,000	1,470	1,840
.787	1,390	1,760	2,540
.984	1,560	2,350	2,858
1.18	2,250	3,120	4,110
1.38	3,070	4,020	5,600
1.57	3,520	5,020	6,430
1.77	4,000	6,130	7,320
1.97	4,450	8,010	8,130
2.17	5,630	9,400	10,300
2.36	6,950	10,902	12,700
2.56	7,660	12,516	14,000
2.76	8,410	14,240	15,400
2.95	9,190	16,080	16,900
3.15	10,010	18,020	18,300
3.35	11,750	20,080	19,500
3.54	13,630	22,250	22,100
3.74	15,650	24,530	28,600
3.94	17,800	29,430	32,500
4.33	20,100	32,040	30,500

Source: Derived from Mark's Handbook for Mechanical Engineers, 9th ed., table 8.5.2, page 8-134.

Table 5. Comparison of Fibers for Composite Construction

	Best			Worst	
Cost	E Glass	S Glass	Kevlar	Graphite	Ceramic
Weight (Density)	Kevlar	Graphite	S Glass	E Glass	Ceramic
Stiffness	Graphite	Kevlar	S Glass	Ceramic	E Glass
Heat Tolerance	Ceramic	S Glass	E Glass	Kevlar	Graphite
Toughness	Kevlar	S Glass	E Glass	Ceramic	Graphite
Impact Resistance	Kevlar	S Glass	E Glass	Ceramic	Graphite

Source: Aircraft Spruce and Specialty Co., P.O. Box 424, Fullerton, CA 92632

