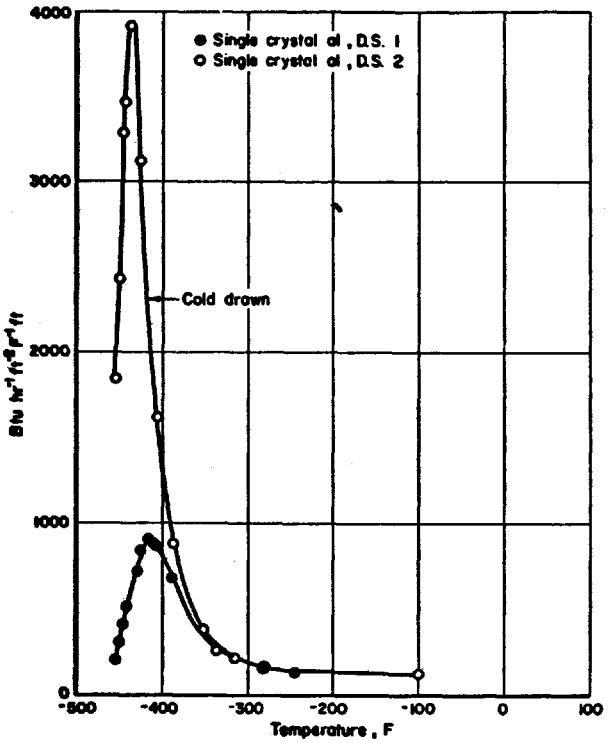
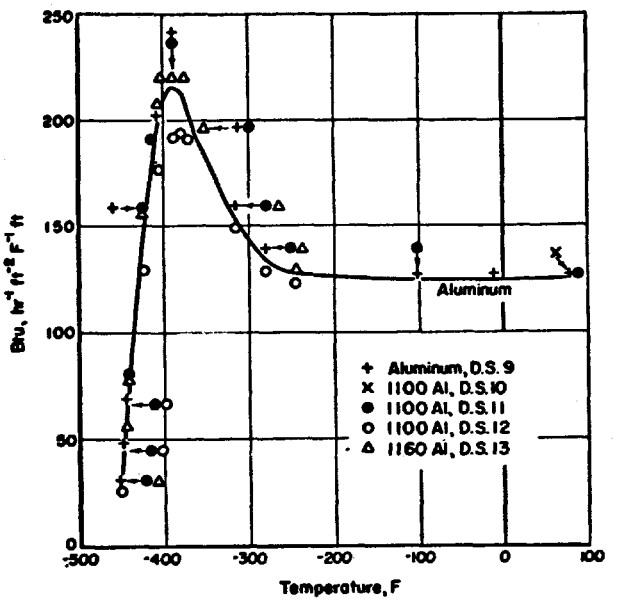
ALUMINUM AND ITS ALLOYS

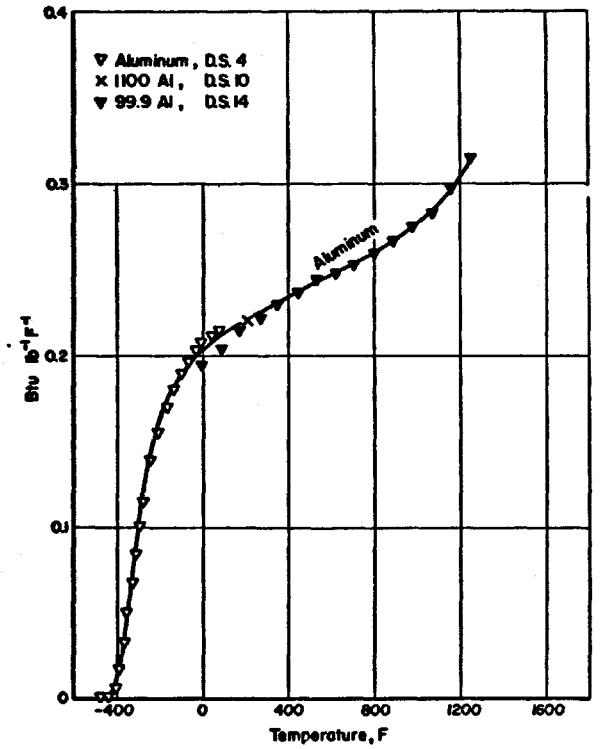
ALUMINUM



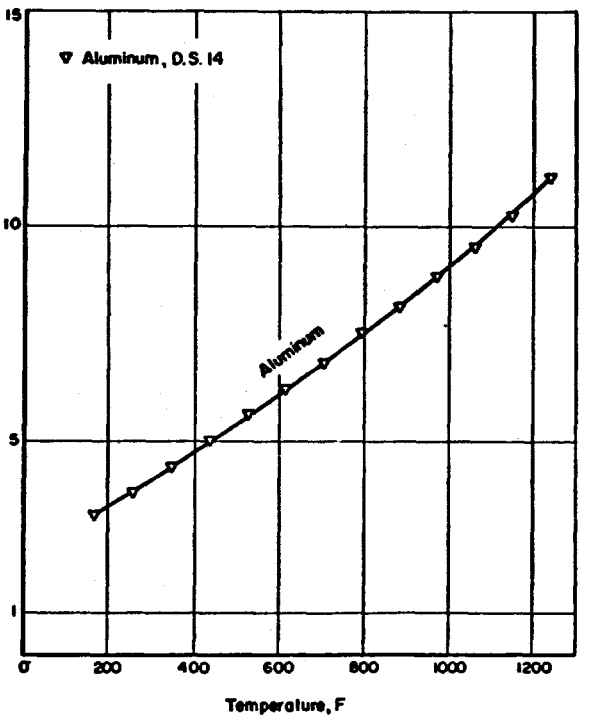
THERMAL CONDUCTIVITY OF ALUMINUM (SINGLE CRYSTAL)



THERMAL CONDUCTIVITY OF ALUMINUM



SPECIFIC HEAT OF ALUMINUM



ELECTRICAL RESISTIVITY OF ALUMINUM

(1)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

MATERIAL	Aluminum					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Al								
	99.9								
FORM	single crystal								
HEAT TREATMENT									
REFERENCE	Cryogenic Engineering Laboratories, National Bureau of Standards, Boulder Colorado.								

THERMAL CONDUCTIVITY

TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT
-453	208	-442	518	-415	913	-334	260
-449	313	-433	717	-406	884	-280	166
-445	419	-424	855	-388	688	-244	149

ELECTRICAL RESISTIVITY

TEMP, F	MICROHM-CM	TEMP, F	MICROHM-CM	TEMP, F	MICROHM-CM	TEMP, F	MICROHM-CM
-453	0.0253	-424	0.028	-370	0.088	-280	0.48
-442	0.0253	-406	0.039	-334	0.190	80	2.63
-433	0.0257						

(2)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

MATERIAL	Aluminum					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Al								
	99.99								
FORM									
REFERENCE	Andrews, R. A., Webber, R. T. and Spohr, D. A., Physics Review, 84, (1951) pp. 994-996; Powers, R. W., Schwartz, D. and Johnston, H. L, TR 264-5, Cryogenic Laboratory, Ohio State University (1951) p. 11; as found in "A Compendium of the Properties of Materials at Low Temperatures, Phase I", Part II, edited by Victor J. Johnson, NBS Cryogenic Engineering Laboratory, Boulder, Colorado (December, 1959).								

THERMAL CONDUCTIVITY

TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT
-453	1850	-442	3470	-406	1620	-316	225
-449	2430	-435	3930	-388	896	-280	173
-445	3290	-424	3120	-352	376	-100	139
Values interpolated from graph.							

(3)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

MATERIAL	Aluminum					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT									
FORM									
HEAT TREATMENT									
REFERENCE	Altman, Rubin and Johnston, (1954). Data found in "A Compendium of the Properties of Materials at Low Temperatures, Phase I", Part II, edited by Victor J. Johnson, NBS Cryogenic Engineering Lab., Boulder, Colorado (December, 1959)								
REMARKS									

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$
-459	0	-352	3.1	-208	9.17	8	12.3
-442	0.028	-334	4.1	-172	9.94	32	12.5
-424	0.11	-316	5.1	-136	10.6	44	12.6
-406	0.50	-298	5.94	-100	11.1	68	12.8
-388	1.2	-280	6.78	- 64	11.6	80	12.9
-370	2.1	-244	8.11	- 28	11.9		

(4)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

MATERIAL	Aluminum					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT									
FORM									
HEAT TREATMENT									
REFERENCE	"A Compendium of the Properties of Materials at Low Temperatures, Phase I", Part II, edited by Victor J. Johnson, N.B.S. Cryogenic Engineering Laboratory, Boulder, Colorado (December, 1959).								
REMARKS									

SPECIFIC HEAT

TEMP, F	BTU LB-1 F-1	TEMP, F	BTU LB-1 F-1	TEMP, F	BTU LB-1 F-1	TEMP, F	BTU LB-1 F-1
-458 *	0.000024	-433	0.0010	-334	0.0686	-136	0.181
-458	0.000012	-424	0.0021	-316	0.0853	-100	0.190
-456	0.000026	-415	0.0042	-298	0.101	- 64	0.197
-454	0.000042	-406	0.0075	-280	0.115	- 28	0.203
-453	0.000062	-397	0.0123	-244	0.139	- 8	0.208
-449	0.00012	-388	0.0184	-208	0.156	44	0.212
-445	0.00021	-370	0.0339	-172	0.170	81	0.215
-442	0.0003	-352	0.0511				
* Superconducting							

(5)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

MATERIAL	Aluminum					HEAT NUMBER				
CHEMICAL COMPOSITION PER CENT										
FORM										
HEAT TREATMENT										
REFERENCE	Data received from V. J. Johnson, NBS Cryogenic Engineering Laboratory, Boulder, Colorado.									
REMARKS										

ELECTRICAL RESISTIVITY

TEMP, F	MICROHM-CM	TEMP, F	MICROHM-CM	TEMP, F	MICROHM-CM	TEMP, F	MICROHM-CM
-109	1.62	-220	0.9425	-313	0.37125	-364	0.1775
-112	1.6025	-256	0.7225	-315	0.36225	-400	0.1225
-148	1.380	-292	0.5050	-328	0.3000	-423	0.10675
-184	1.160						

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

(6)

MATERIAL	Aluminum								HEAT NUMBER
CHEMICAL COMPOSITION PER CENT									
FORM									
HEAT TREATMENT									
REFERENCE	Thomas and Mendosa; received from V. J. Johnson, NBS Cryogenic Engineering Laboratory, Boulder, Colorado.								
REMARKS									

ELECTRICAL RESISTIVITY

TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM
-453	0.0065						

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

(7)

MATERIAL	Aluminum								HEAT NUMBER
CHEMICAL COMPOSITION PER CENT									
FORM									
HEAT TREATMENT									
REFERENCE	Justi and Schiffers; received from V. J. Johnson, NBS Cryogenic Engineering Laboratory, Boulder, Colorado.								
REMARKS									

ELECTRICAL RESISTIVITY

TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM
-424	0.0045	-435	0.0035				

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

(8)

MATERIAL	Aluminum								HEAT NUMBER
CHEMICAL COMPOSITION PER CENT									
FORM									
HEAT TREATMENT									
REFERENCE	Meissner and Voigt; received from V. J. Johnson, NBS Cryogenic Engineering Laboratory, Boulder, Colorado.								
REMARKS									

ELECTRICAL RESISTIVITY

TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM
-320	0.252	-423	0.01875	-451	0.01625	-457	0.01675

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

(9)

MATERIAL	Commercial Pure Aluminum								HEAT NUMBER
CHEMICAL COMPOSITION PER CENT	Al								
	99								
FORM									
HEAT TREATMENT									
REFERENCE	Powell, R. L., Hall, W. F. and Roder, H. M., to be published; as found in "A Compendium of the Properties of Materials at Low Temperatures, Phase I", Part II, edited by Victor J. Johnson, NBS Cryogenic Engineering Laboratory, Boulder, Colorado (December, 1959).								

THERMAL CONDUCTIVITY

TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT
-453	31.8	-424	159	-352	196	-100	127
-449	48.5	-406	202	-316	159	- 10	127
-445	69.3	-388	220	-280	139	80	127
Values interpolated from graph.							

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

(10)

MATERIAL	Aluminum Alloy--1100								HEAT NUMBER
CHEMICAL COMPOSITION PER CENT	Al								
	99.0								
FORM									
HEAT TREATMENT	Annealing temperature: 650 F; Hot working temperature range: 500-950 F; Melting temperature range: 1190-1215 F.								
REFERENCE	"Materials in Design Engineering", Materials Selector, edited by H. R. Clauser, Vol 46, No. 4 (September, 1957).								

THERMAL CONDUCTIVITY

TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT
77	128						

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	F-1 X 10^6	TEMP RANGE, F	F-1 X 10^6	TEMP RANGE, F	F-1 X 10^6	TEMP RANGE, F	F-1 X 10^6
68-212	13.1						

SPECIFIC HEAT

TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1
212	0.22						

ELECTRICAL RESISTIVITY

TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM
68	2.92						

DENSITY

TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1
Room	0.098						
Data assumed to be at room temperature.							

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS (11)

MATERIAL	Aluminum--1100 F					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT									
FORM	As fabricated.								
HEAT TREATMENT									
REFERENCE	Powell, R. L., Hall, W. J. and Roder, H. M., to be published (1958); as found in "A Compendium of the Properties of Materials at Low Temperatures, Phase I", Part II, edited by Victor J. Johnson, NBS Cryogenic Engineering Laboratory Boulder, Colorado (December, 1959).								

THERMAL CONDUCTIVITY

TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT
-453	31.2	-442	81.5	-388	220	-280	142
-449	43.9	-424	159	-352	196	-100	127
-445	65.3	-415	191	-316	162	88	127
Values interpolated from graph.							

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS (12)

MATERIAL	Aluminum -- 1100 Alcoa					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Al	Fe	Si						
	99	0.41	0.22						
FORM									
HEAT TREATMENT	Annealed for 2 hours at 400 C.								
REFERENCE	Cryogenic Engineering Laboratories, National Bureau of Standards, Boulder, Colorado.								
REMARKS	Grain size--longitudinal 0.040 x 0.032 mm, Transverse 0.036 mm, Diamond point hardness - longitudinal - 36, Transverse - 34.								

THERMAL CONDUCTIVITY

TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT
-453	26	-424	129	-379	194	-280	129
-447	46	-406	176	-370	191	-244	123
-442	66	-388	192	-316	149		

ELECTRICAL RESISTIVITY

TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM
-453	0.205	-406	0.223	-352	0.34	-280	0.69
-442	0.206	-388	0.25	-316	0.49	80	2.93
-424	0.211	-370	0.29				

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS (13)

MATERIAL	Aluminum--1160 Alcoa					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Al	Si							
	99	0.13							
FORM									
HEAT TREATMENT	As fabricated.								
REFERENCE	Cryogenic Engineering Laboratories, National Bureau of Standards, Boulder, Colorado.								
REMARKS	Grain size: longitudinal--0.024 x 0.008 mm , transverse--0.012mm Diamond point hardness--longitudinal--45, transverse--44.								

THERMAL CONDUCTIVITY

TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT
-453	32	-424	156	-388	220	-316	159
-447	56	-406	208	-379	220	-280	138
-442	80	-398	219	-352	197	-244	129

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS (14)

MATERIAL	Aluminum					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Al	Si	B						
	99.9	0.05	0.03						
FORM	Slope of initial temp. rise curve in resistance heated wire.								
REFERENCE	Pochapsky, T. E., "Heat Capacity and Resistance Measurements for Aluminum and Lead Wires", ACTA Met. I, pp. 747-51; as found in WADC Technical Report 58-476, "Thermophysical Properties of Solid Materials" January, 1959, Armour Research Foundation.								
REMARKS	Author estimates accuracy ± 5%.								

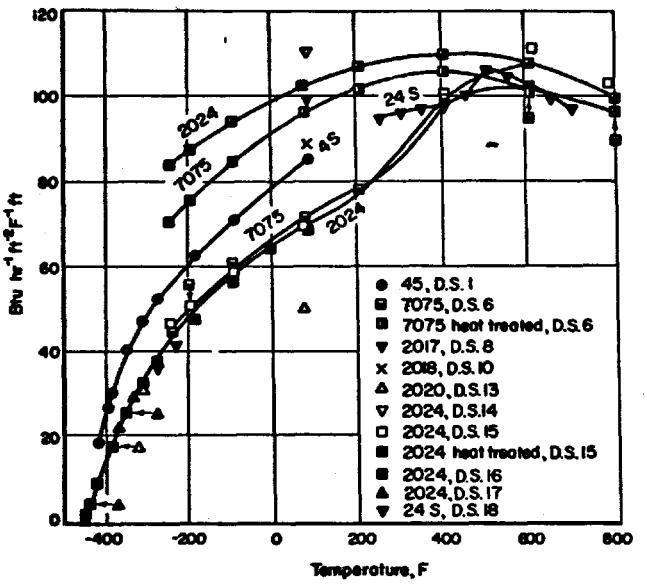
ELECTRICAL RESISTIVITY

TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM
170	3.3	530	5.6	800	7.5	1070	9.5
260	3.8	620	6.2	890	8.1	1160	10.2
350	4.4	710	6.8	980	8.8	1250	11.1
440	5.0						

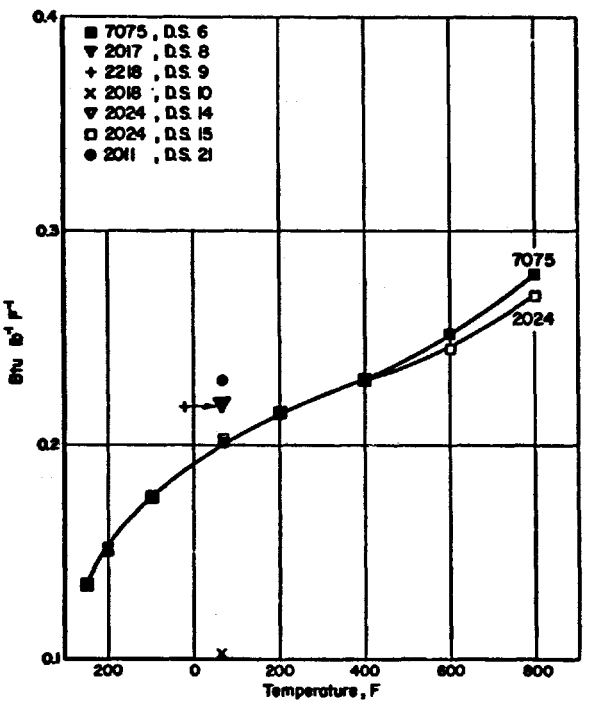
SPECIFIC HEAT

TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1
-10	0.196	350	0.230	710	0.253	1070	0.283
80	0.205	440	0.237	800	0.260	1160	0.297
170	0.214	530	0.244	890	0.267	1250	0.314
260	0.222	620	0.248	980	0.274		

ALUMINUM-COPPER ALLOYS



THERMAL CONDUCTIVITY OF ALUMINUM-COPPER ALLOYS



SPECIFIC HEAT OF ALUMINUM-COPPER ALLOYS

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS (1)

MATERIAL	Aluminum Alloy--4S								HEAT NUMBER
CHEMICAL COMPOSITION PER CENT	Mn	Mg	Fe	Cu	Si	Cr	Ti	Al	
	1.20	1.02	0.52	0.16	0.13	0.02	0.02	Bal	
FORM									
HEAT TREATMENT									
REFERENCE	Powers, R. W., Ziegler, J. B. and Johnston, H. L., TR 264-7, Cryogenics Laboratory, Ohio State University, p. 10 (1951); as found in "A Compendium of the Properties of Materials at Low Temperatures, Phase I", Part II, edited by Victor J. Johnson, NBS Cryogenic Engineering Laboratory, Boulder, Colorado (December, 1959).								

THERMAL CONDUCTIVITY

TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT
-419	19.1	-352	40.5	-280	52.6	-100	71.1
-397	27.7	-316	47.4	-190	63.0	80	85.5
-388	30.6						
Values interpolated from graph.							

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS (2)

MATERIAL	Aluminum Alloy--AMS 4127								HEAT NUMBER
CHEMICAL COMPOSITION PER CENT	Cu	Mg	Cr	Si	Al				
	0.3	1.0	0.25	0.6	Bal				
FORM	Forged								
HEAT TREATMENT	Temper--T6.								
REFERENCE	"Report on Materials for Use at Liquid Hydrogen Temperature", Prepared for the 63rd Annual Meeting of the American Society for Testing Materials,								

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$
78-(-104)	11.8	78-(-320)	10.3	78-(-410)	8.9		

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS (3)

MATERIAL	Aluminum Alloy--AMS 4212								HEAT NUMBER
CHEMICAL COMPOSITION PER CENT	Cu	Mg	Si	Al					
	1.2	0.5	5.0	Bal					
FORM	Sand-cast.								
HEAT TREATMENT	Temper--T6.								
REFERENCE	"Report on Materials for Use at Liquid Hydrogen Temperature", Prepared for the 63rd annual meeting of the American Society for Testing Materials.								

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$
78-(-104)	11.2	78-(-320)	9.9	78-(-410)	8.9		

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS (4)

MATERIAL	Aluminum Alloy--AMS 4241								HEAT NUMBER
CHEMICAL COMPOSITION PER CENT	Si	Cu	Mg	Al					
	5.0	1.2	0.5	Bal					
FORM	Permanent mold cast.								
HEAT TREATMENT	Temper--T6.								
REFERENCE	"Report on Materials for Use at Liquid Hydrogen Temperature", Prepared for the 63rd annual meeting of the American Society for Testing Materials.								

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$
78-(-104)	11.2	78-(-320)	9.9	78-(-410)	9.0		

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS (5)

MATERIAL	Aluminum Alloy--AMS 4122								HEAT NUMBER
CHEMICAL COMPOSITION PER CENT	Zn	Mg	Cu	Cr	Al				
	5.6	2.5	1.6	0.3	Bal				
FORM	Rolled								
HEAT TREATMENT	Temper--T6.								
REFERENCE	"Report on Materials for Use at Liquid Hydrogen Temperatures", Prepared for the 63rd annual meeting of the American Society for Testing Materials,								

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$
78-(-104)	11.9	78-(-320)	10.7	78-(-410)	9.4		

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS (6)

MATERIAL	Aluminum Alloy--7075								HEAT NUMBER
CHEMICAL COMPOSITION PER CENT	Zn	Mg	Cu	Cr	Al				
	5.6	2.5	1.6	0.3	Bal				
FORM									
HEAT TREATMENT	Temper--T6.								
REFERENCE	Lucks, C. F. and Deem, H. W., "Thermal Properties of Thirteen Metals", ASTM Special Technical Publication, No. 227.								

THERMAL CONDUCTIVITY

TEMP, F	(1) BTU HR-1 FT-2 F-1 FT			TEMP, F	(2) BTU HR-1 FT-2 F-1 FT		
-250	45			-250	71		
-200	51			-200	76		
-100	60			-100	85		
68	72			68	97		
200	79			200	102		
400	99			400	106		
600	102			600	102		
800	97			800	97		
(1) As received. (2) After heating above 575 F.							

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$
68-(-250)	9.87	68-(-100)	11.01	68-200	12.35	68-600	14.38
68-(-200)	10.30	68	--	68-400	13.55	68-800	15.12

SPECIFIC HEAT

TEMP, F	BTU LB^{-1} F^{-1}	TEMP, F	BTU LB^{-1} F^{-1}	TEMP, F	BTU LB^{-1} F^{-1}	TEMP, F	BTU LB^{-1} F^{-1}
-250	0.137*	-100	0.176	200	0.215	600	0.252
-200	0.152	68	0.201	400	0.230	800	0.280
* Extrapolated.							

DENSITY

TEMP, F	LB CU IN^{-1}	TEMP, F	LB CU IN^{-1}	TEMP, F	LB CU IN^{-1}	TEMP, F	LB CU IN^{-1}
-250	0.1023	-100	0.1017	200	0.1006	600	0.0989
-200	0.1022	68	0.1012	400	0.0998	800	0.0980
Calculated from thermal expansion data and measured density of 0.1013 lb in^{-3} at 32 F.							

DIFFUSIVITY

TEMP, F	(1) FT^2 HR^{-1}			TEMP, F	(2) FT^2 HR^{-1}		
-250	1.86			-250	2.93*		
-200	1.91			-200	2.83		
-100	1.94			-100	2.77		
68	2.03			68	2.77		
200	2.11			200	2.75		
400	2.50			400	2.68		
600	2.39			600	2.39		
800	2.05			800	2.05		
(1) As received. (2) After heating above 575 F. * Extrapolated.							

(7)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

MATERIAL	Aluminum Alloy--7075					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Cr	Mg	Cu	Zn	Al				
	0.3	2.5	1.6	5.6	Bal				
FORM	Sheet (0.025 in.)								
HEAT TREATMENT	Temper--T6.								
REFERENCE	Weiss, V., Schaeffer, G. T., Saule, A., and Sachs, G., "Thermal Cycling Under Constant Load to Low Temperatures of Aluminum and Magnesium Alloys, presented at 63rd Annual Meeting of ASTM, June 26-July 1, 1960.								
REMARKS									

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$
68-(-328)	10.0	68-212	13.2	68-392	13.5		

(8)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

MATERIAL	Aluminum Alloy--2017					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Cu	Mn	Mg	Al					
	3.5-4.5	0.4-1.0	0.2-0.8	Bal					
FORM									
HEAT TREATMENT	Annealing temperature: 775 F; Solution temperature: 940 F.								
REFERENCE	"Materials in Design Engineering", Materials Selector, edited by H. R. Clauser, Vol 46, No. 4 (September, 1957) p. 82.								

THERMAL CONDUCTIVITY

TEMP, F	BTU HR^{-1} FT^{-2} F^{-1} FT	TEMP, F	BTU HR^{-1} FT^{-2} F^{-1} FT	TEMP, F	BTU HR^{-1} FT^{-2} F^{-1} FT	TEMP, F	BTU HR^{-1} FT^{-2} F^{-1} FT
77	99.4						

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$
68-212	12.7	68-572	13.9				

SPECIFIC HEAT

TEMP, F	BTU LB^{-1} F^{-1}	TEMP, F	BTU LB^{-1} F^{-1}	TEMP, F	BTU LB^{-1} F^{-1}	TEMP, F	BTU LB^{-1} F^{-1}
Room	0.22						
Data assumed to be at room temperature.							

ELECTRICAL RESISTIVITY

TEMP, F	MICROHM-CM	TEMP, F	MICROHM-CM	TEMP, F	MICROHM-CM	TEMP, F	MICROHM-CM
68	3.83						

DENSITY

TEMP, F	LB CU IN^{-1}	TEMP, F	LB CU IN^{-1}	TEMP, F	LB CU IN^{-1}	TEMP, F	LB CU IN^{-1}
Room	0.101						
Data assumed to be at room temperature.							

(9)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

MATERIAL	Aluminum Alloy--2218					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Cu	Ni	Mg	Al					
	3.5-4.5	1.7-2.3	1.2-1.8	Bal					
FORM									
HEAT TREATMENT	Annealing temperature: 775 F; Solution temperature: 950 F; Aging temperature: 460 F.								
REFERENCE	"Materials in Design Engineering", Materials Selector, edited by H. R. Clauser, Vol 46, No. 4 (September, 1957) p. 83.								
REMARKS									

THERMAL CONDUCTIVITY

TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT
77	97.0						

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	F-1 X 10^6	TEMP RANGE, F	F-1 X 10^6	TEMP RANGE, F	F-1 X 10^6	TEMP RANGE, F	F-1 X 10^6
68-212	12.4	68-572	13.5				

SPECIFIC HEAT

TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1
Room	0.22						
Data assumed to be at room temperature.							

DENSITY

TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1
Room	0.102						
Data assumed to be at room temperature.							

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS (10)

MATERIAL	Aluminum Alloy--2018				HEAT NUMBER				
CHEMICAL COMPOSITION PER CENT	Cu	Ni	Mg	Al					
	3.5-4.5	1.7-2.3	0.45-0.9	Bal					
FORM									
HEAT TREATMENT	Annealing temperature: 775 F; Solution temperature: 950 F; Aging temperature: 340 F.								
REFERENCE	"Materials in Design Engineering", Materials Selector, edited by H. R. Clauser, Vol 46, No. 4 (September, 1957) p. 83.								

THERMAL CONDUCTIVITY

TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT
77	89.0						

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	F-1 X 10^6	TEMP RANGE, F	F-1 X 10^6	TEMP RANGE, F	F-1 X 10^6	TEMP RANGE, F	F-1 X 10^6
68-212	12.4	68-572	13.4				

SPECIFIC HEAT

TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1
Room	0.101						
Data assumed to be at room temperature.							

DENSITY

TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1
Room	0.101						
Data assumed to be at room temperature.							

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS (11)

MATERIAL	Aluminum Alloy--2014					HEAT NUMBER				
CHEMICAL COMPOSITION PER CENT	Cu	Si	Mn	Mg	Al					
	3.9-5.0	0.5-1.2	0.4-1.2	0.2-0.8	Bal					
FORM										
HEAT TREATMENT	Annealing temperature: 775 F, Solution temperature: 950 F, Aging temperature: 340 F.									
REFERENCE	"Materials in Design Engineering", Materials Selector, edited by H. R. Clauser, Vol 46, No. 4 (September, 1957).									
REMARKS	Melting temperature range: 950-1180 F.									

THERMAL CONDUCTIVITY

TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT
72	111.0						

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	F-1 X 10^6	TEMP RANGE, F	F-1 X 10^6	TEMP RANGE, F	F-1 X 10^6	TEMP RANGE, F	F-1 X 10^6
68-212	12.5	68-572	13.6				

SPECIFIC HEAT

TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1
Room	0.22						
Data assumed to be at room temperature.							

ELECTRICAL RESISTIVITY

TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM
68	3.45						

DENSITY

TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1
Room	0.101						
Data assumed to be at room temperature.							

(12)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

MATERIAL	Aluminum Alloy--AMS 4135					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Cu	Si	Mn	Mg	Al				
	4.5	0.9	0.8	0.5	Bal				
FORM	Forged.								
HEAT TREATMENT									
REFERENCE	"Report on Materials for Use at Liquid Hydrogen Temperature" Prepared for the 63rd annual meeting of the American Society for Testing Materials.								
REMARKS									

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$
78-(-164)	11.3	78-(-320)	10.1	78-(-410)	8.8		

(13)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

MATERIAL	Aluminum Alloy--2020					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Cu	Li	Mn	Cd	Al				
	4.5	1.1	0.5	0.2	Bal				
FORM	Sheet (0.028 in.)								
HEAT TREATMENT									
REFERENCE	Weiss, V., Schaeffer, G. T., Saule, H., and Sachs, G., "Thermal Cycling Under Constant Load to Low Temperatures of Aluminum and Magnesium Alloys.								
REMARKS									

THERMAL CONDUCTIVITY

TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT
68	50.8						

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$
68-(-328)	9.8	68-212	12.8	68-392	13.3		

ELECTRICAL RESISTIVITY

TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM
68	7.8						

DENSITY

TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1
Room	0.98						
Data assumed to be at room temperature.							

(14)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

MATERIAL	Aluminum Alloy--2024					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Cu	Mg	Mn	Al					
	3.8-4.9	1.2-1.8	0.3-0.9	Bal					
FORM									
HEAT TREATMENT	Annealing temperature: 775 F, Solution temperature: 920 F, Aging temperature: 375 F.								
REFERENCE	"Materials in Design Engineering", Materials Selector, edited by H. R. Clauser, Vol 46, No. 4 (September, 1957).								
REMARKS	Melting temperature range: 935-1180 F.								

THERMAL CONDUCTIVITY

TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT
77	111.0						

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$
68-212	12.6	68-572	13.7				

SPECIFIC HEAT

TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1
Room	0.22						
Data assumed to be at room temperature.							

ELECTRICAL RESISTIVITY

TEMP., F	(1) MICROHM-CM			TEMP., F	(2) MICROHM-CM		
68	3.45			68	5.75		
(1) Temper O.							
(2) Temper 4.							

DENSITY

TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1
Room	0.100						
Data assumed to be at room temperature.							

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

(15)

MATERIAL	Aluminum Alloy--2024					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Al	Cu	Mg						
	93	4.54	1.79						
FORM									
HEAT TREATMENT	Temper--T4.								
REFERENCE	Lucks, C. F. and Deem, H. W., "Thermal Properties of Thirteen Metals", ASTM Special Technical Publication No. 227.								
REMARKS									

THERMAL CONDUCTIVITY

TEMP., F	(1) BTU HR-1 FT-2 F-1 FT			TEMP., F	(2) BTU HR-1 FT-2 F-1 FT		
-250	46			-250	84		
-200	51			-200	88		
-100	59			-100	95		
68	70			68	103		
200	78			200	107		
400	100			400	110		
600	108			600	108		
800	100			800	100		

(1) As received.
(2) After heating above 575 F.

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$
-250	10.85	-100	11.55	200	13.18	600	14.19
-200	10.97	68	--	400	13.98	800	14.54

SPECIFIC HEAT

TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1
-250	0.115	-100	0.176	200	0.217	600	0.245
-200	0.151	68	0.203	400	0.231	800	0.270

DENSITY

TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1
-250	0.1015	-100	0.1010	200	0.1000	600	0.0983
-200	0.1014	68	0.1004	400	0.0992	800	0.0973

Calculated from thermal expansion and measured density of 0.1006 lb in.$^{-3}$ at 32° F.

DIFFUSIVITY

TEMP., F	(1) FT2 HR-1	TEMP., F	FT2 HR-1	TEMP., F	(2) FT2 HR-1	TEMP., F	FT2 HR-1
-250	1.95			-250	3.54		
-200	1.93			-200	3.34		
-100	1.93			-100	3.10		
68	2.00			68	2.91		
200	2.07			200	2.84		
400	2.53			400	2.78		
600	2.61			600	2.61		
800	2.20			800	2.20		

(1) As received.
(2) After heating above 575 F.

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

(16)

MATERIAL	Aluminum Alloy--2024					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Al	Cu	Mg	Mn					
	93	4.5	1.5	0.6					
FORM									
HEAT TREATMENT	Solution heat treated.								
REFERENCE	Powell, R. L., Hall, W. J. and Roder, H. M., to be published (1958); as found in "A Compendium of the Properties of Materials at Low Temperatures, Phase I", Part II, edited by Victor J. Johnson, NBS Cryogenic Engineering Laboratory, Boulder, Colorado (December, 1959).								

THERMAL CONDUCTIVITY

TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT
-451	2.37	-424	9.54	-316	33	-100	57
-449	2.83	-388	18	-280	38	- 10	64.7
-442	4.80	-352	26.0	-190	48	80	69.3

Values interpolated from graph.

(17)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

MATERIAL	Aluminum Alloy--2024 Alcoa					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Al	Cu	Mg						
	93	4.58	1.70						
FORM									
HEAT TREATMENT	Solution heat treated at factory.								
REFERENCE	Cryogenic Engineering Laboratories, National Bureau of Standards, Boulder, Colorado.								
REMARKS									

THERMAL CONDUCTIVITY

TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT
-453	1.85	-442	4.80	-370	22.5	-316	32.0
-449	2.83	-424	9.65	-352	25.9	-280	37.1
-445	3.81	-388	18.7	-334	29.2	-234	41.7

ELECTRICAL RESISTIVITY

TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM
4	3.10	20	3.10	70	3.34	300	5.8
10	3.10	40	3.17	100	3.61		

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS (18)

MATERIAL	Aluminum Alloy--24S								HEAT NUMBER
CHEMICAL COMPOSITION PER CENT	Cu	Mg	Mn	Al					
	4.5	1.5	0.6	Bal					
FORM									
HEAT TREATMENT									
REFERENCE	Evans, J. E., Jr. Lewis Flight Propulsion Laboratory. "Thermal Conductivity of 14 Metals and Alloys Up to 1100 F". NACA Research Memorandum CRME50L07 (Mar 2, 1951).								

THERMAL CONDUCTIVITY

TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT
250	95.5	400	98.4	550	105	650	99.8
300	96.5	450	101	600	102.5	700	97.4
350	97.5	500	106.8				

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS (19)

MATERIAL	Aluminum Alloy--24S								HEAT NUMBER
CHEMICAL COMPOSITION PER CENT	Cu	Mg	Mn	Al					
	4.5	1.5	0.6	Bal					
FORM									
HEAT TREATMENT									
REFERENCE	General Electric Company, Handbook No. 1.								
REMARKS	Nominal Composition taken from DMIC Memo 42.								

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$
100	12.12	300	13.14	400	13.40	500	13.58
200	12.77						

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS (20)

MATERIAL	Aluminum Alloy--AMS 4120								HEAT NUMBER
CHEMICAL COMPOSITION PER CENT	Cu	Mg	Mn	Al					
	4.5	1.5	0.6	Bal					
FORM	Rolled								
HEAT TREATMENT									
REFERENCE	"Report on Materials for Use at Liquid Hydrogen Temperature", Prepared for the 63rd annual meeting of the American Society for Testing Materials.								

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$
78-(-104)	11.9	78-(-320)	10.4	78-(-410)	9.1		

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS (21)

MATERIAL	Aluminum Alloy--2011								HEAT NUMBER
CHEMICAL COMPOSITION PER CENT	Cu	Pb	Bi	Al					
	5.0-6.0	0.2-0.6	0.2-0.6	Bal					
FORM									
HEAT TREATMENT	Annealing temperature: 775 F; Solution temperature: 950 F; Aging temperature: 320 F.								
REFERENCE	"Materials in Design Engineering", Materials Selector, edited by H. R. Clauser, Vol 46, No. 4 (September, 1957) p. 82.								
REMARKS	Melting temperature range: 995-1190 F.								

THERMAL CONDUCTIVITY

TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT
77	81.7						

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$
68-212	12.8	68-572	13.9				

SPECIFIC HEAT

TEMP, F	BTU LB-1 F-1	TEMP, F	BTU LB-1 F-1	TEMP, F	BTU LB-1 F-1	TEMP, F	BTU LB-1 F-1
Room	0.23						
Data assumed to be at room temperature.							

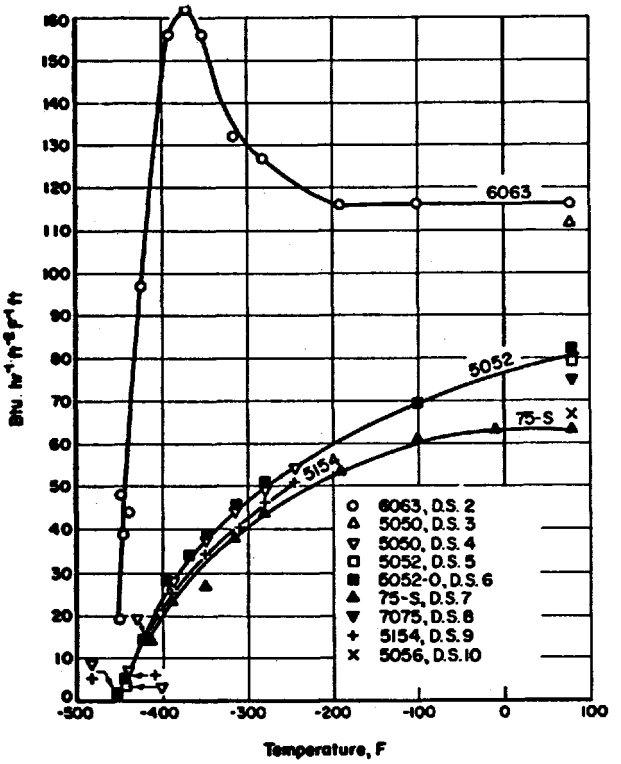
ELECTRICAL RESISTIVITY

TEMP, F	MICROHM-CM	TEMP, F	MICROHM-CM	TEMP, F	MICROHM-CM	TEMP, F	MICROHM-CM
68	4.31						

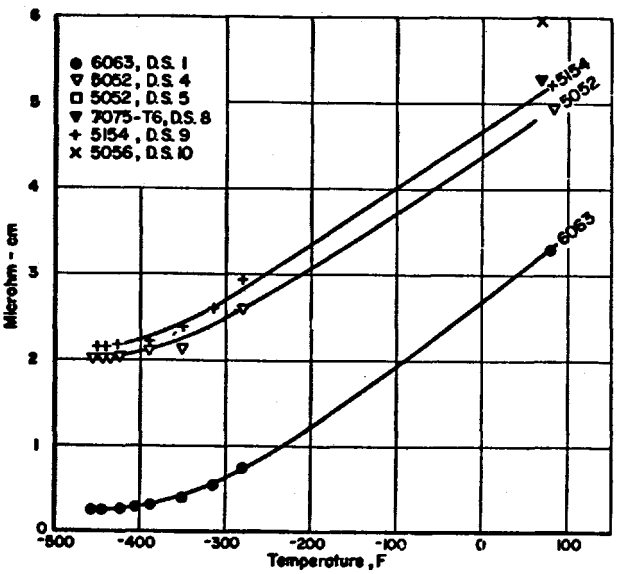
DENSITY

TEMP, F	LB CU IN-1	TEMP, F	LB CU IN-1	TEMP, F	LB CU IN-1	TEMP, F	LB CU IN-1
Room	0.102						
Data assumed to be at room temperature.							

ALUMINUM-MAGNESIUM ALLOYS



THERMAL CONDUCTIVITY OF ALUMINUM-MAGNESIUM ALLOYS



ELECTRICAL RESISTIVITY OF ALUMINUM-MAGNESIUM ALLOYS

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

(1)

MATERIAL	Aluminum--6061 Alcoa					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Al	Mg	Si						
	98.5	0.38	0.65						
FORM									
HEAT TREATMENT	Factory heat treated.								
REFERENCE	Cryogenic Engineering Laboratories, National Bureau of Standards, Boulder, Colorado.								
REMARKS	Grain size: longitudinal--0.052 x 0.048 mm, transverse--0.052 mm Diamond point hardness: longitudinal--71, transverse--64.								

ELECTRICAL RESISTIVITY

TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM
-453	0.278	-406	0.302	-316	0.56		
-445	0.278	-388	0.323	-280	0.76		
-424	0.284	-352	0.416	80	3.34		

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

(2)

MATERIAL	Aluminum Alloy--6063					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Al	Mg	Si						
	98.5	0.7	0.4						
FORM	As fabricated								
HEAT TREATMENT									
REFERENCE	Powell, R. L., Hall, W. J. and Roder, H. M., to be published (1958); as found in "A Compendium of the Properties of Materials at Low Temperatures, Phase I", Part II, edited by Victor J. Johnson, NBS Cryogenic Engineering Laboratory, Boulder, Colorado (December, 1959).								

THERMAL CONDUCTIVITY

TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT
-453	19.6	-424	97.0	-352	156	-190	116
-449	48.0	-388	156.0	-316	132	-100	116
-445	39.2	-370	162.0	-280	127	80	116+
-442	44.5						
Values interpolated from graph.							

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

(3)

MATERIAL	Aluminum Alloy--5050					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Mg	Al							
	1.0-1.8	Bal							
FORM									
HEAT TREATMENT	Annealing temperature: 650 F.								
REFERENCE	"Materials in Design Engineering", Materials Selector, edited by H. R. Clauser, Vol 46, No. 4 (September, 1957).								
REMARKS	Melting temperature range: 1160-1205 F.								

THERMAL CONDUCTIVITY

TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT
77	111						

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$
68-212	13.2	68-572	14.2				

SPECIFIC HEAT

TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1	TEMP., F	BTU LB-1 F-1
212	0.22						

DENSITY

TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1	TEMP., F	LB CU IN-1
Room	0.097						
Data assumed to be at room temperature.							

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

(4)

MATERIAL	Aluminum Alloy--5052 Alcoa					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Al	Mg	Cr						
	97	2.46	0.22						
FORM									
HEAT TREATMENT	Annealed for 2 hours at 400 C.								
REFERENCE	Cryogenic Engineering Laboratories, National Bureau of Standards, Boulder, Colorado.								

THERMAL CONDUCTIVITY

TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT	TEMP., F	BTU HR-1 FT-2 F-1 FT
-453	2.60	-424	14.5	-352	37.7	-280	49.8
-447	4.74	-406	21.7	-316	44.6	-244	54.3
-442	6.93	-388	28.0				

ELECTRICAL RESISTIVITY

TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM	TEMP., F	MICROHM-CM
-453	2.05	-442	2.05	-388	2.11	-280	2.66
-449	2.05	-424	2.06	-352	2.19	80	4.95

MATERIAL	Aluminum--5052								HEAT NUMBER
CHEMICAL COMPOSITION PER CENT	Mg	Cr	Al						
	2.2-2.8	0.15-0.35	Bal						
FORM									
HEAT TREATMENT	Annealing temperature: 650 F. Hot working temperature range: 500-950 F.								
REFERENCE	"Materials in Design Engineering", Materials Selector, edited by H. R. Clauser, Vol 46, No. 4 (September, 1957) p. 81.								
REMARKS	Melting temperature range: 1100-1200 F.								

THERMAL CONDUCTIVITY

TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT
77	79.2						

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$	TEMP RANGE, F	$F^{-1} \times 10^6$
68-212	13.2	68-572	14.3				

SPECIFIC HEAT

TEMP, F	BTU LB-1 F-1	TEMP, F	BTU LB-1 F-1	TEMP, F	BTU LB-1 F-1	TEMP, F	BTU LB-1 F-1
212	0.22						

ELECTRICAL RESISTIVITY

TEMP, F	MICROHM-CM	TEMP, F	MICROHM-CM	TEMP, F	MICROHM-CM	TEMP, F	MICROHM-CM
68	4.93						

DENSITY

TEMP, F	LB CU IN-1	TEMP, F	LB CU IN-1	TEMP, F	LB CU IN-1	TEMP, F	LB CU IN-1
Room	0.097						
Data assumed to be at room temperature.							

MATERIAL	Aluminum Alloy--505 2-0								HEAT NUMBER
CHEMICAL COMPOSITION PER CENT	Al	Mg	Cr						
	97	2.5	0.25						
FORM									
HEAT TREATMENT	Annealed.								
REFERENCE	Powell, R. L., Hall, W. J. and Roder, H. M., to be published (1958); as found in "A Compendium of the Properties of Materials a at Low Temperatures, Phase I", Part II, edited by Victor J. Johnson, NBS Cryogenic Engineering Laboratory, Boulder, Colorado (December, 1959).								

THERMAL CONDUCTIVITY

TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT
-453	2.83	-442	6.88	-370	34.0	-280	50.8
-449	4.04	-424	14.4	-352	38.7	-100	69.3
-445	5.37	-388	28.9	-316	45.6	80	82.0
Values interpolated from graph.							

MATERIAL	Aluminum Alloy--75-S								HEAT NUMBER
CHEMICAL COMPOSITION PER CENT	Zn	Mg	Cu	Cr	Mn	Al			
	5.5	2.5	1.5	0.3	0.2	Bal			
FORM									
HEAT TREATMENT									
REFERENCE	Powell, R. L., Hall, W. J. and Roder, H. M., to be published (1958); as found in "A Compendium of the Properties of Materials at Low Temperatures, Phase I", Part II, edited by Victor J. Johnson, NBS Cryogenic Engineering Laboratory, Boulder, Colorado (December, 1959).								

THERMAL CONDUCTIVITY

TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT
-424	--	-352	31.8	-190	53.7	-10	63.6
-415	14.4	-316	38.7	-100	60.1	80	63.6+
-388	23.7						
Values interpolated from graph.							

MATERIAL	Aluminum--7075								HEAT NUMBER
CHEMICAL COMPOSITION PER CENT	Zn	Mg	Cu	Cr	Al				
	5.6	2.5	1.6	0.3	Bal				
FORM	Sheet (0.025 in.).								
HEAT TREATMENT									
REFERENCE	Weiss, V., Schaeffer, G. T., Saule, A. and Sachs, G., "Thermal Cycling under Constant Load to Low Temperatures of Aluminum and Magnesium Alloys".								
REMARKS									

THERMAL CONDUCTIVITY

TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT
77	75						

ELECTRICAL RESISTIVITY

TEMP, F	MICROHM-CM	TEMP, F	MICROHM-CM	TEMP, F	MICROHM-CM	TEMP, F	MICROHM-CM
68	52.9						

DENSITY

TEMP, F	LB CU IN-1	TEMP, F	LB CU IN-1	TEMP, F	LB CU IN-1	TEMP, F	LB CU IN-1
Room	0.101						

Data assumed to be at room temperature.

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS (9)

MATERIAL	Aluminum -- 5154 Alcoa					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Al	Mg	Cr						
	96	3.32	0.21						
FORM									
HEAT TREATMENT	Annealed for 2 hours at 400 C.								
REFERENCE	Cryogenic Engineering Laboratories, Bureau of Standards, Boulder, Colorado.								
REMARKS	Grain size: longitudinal--0.036 x 0.028 mm, transverse--0.032 mm Diamond point hardness: longitudinal--68, transverse--64.								

THERMAL CONDUCTIVITY

TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT
-453	2.4	-442	6.30	-352	34.1	-244	50.9
-449	3.6	-424	13.1	-316	40.5		
-445	4.9	-388	25.4	-280	46.2		

ELECTRICAL RESISTIVITY

TEMP, F	MICROHM-CM	TEMP, F	MICROHM-CM	TEMP, F	MICROHM-CM	TEMP, F	MICROHM-CM
-453	2.14	-424	2.17	-352	2.39	-280	2.95
-442	2.15	-388	2.22	-316	2.62	80	5.2

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS (10)

MATERIAL	Aluminum Alloy--5056					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Mg	Mn	Cr	Al					
	4.7-5.6	0.05-0.20	0.05-0.20	Bal					
FORM									
HEAT TREATMENT	Annealing temperature: 650 F, Hot working temperature range: 500-950 F.								
REFERENCE	"Materials in Design Engineering", Materials Selector, edited by H. R. Clauser, Vol 46, No. 4 (September, 1957).								
REMARKS	Melting temperature range: 1055-1180 F.								

THERMAL CONDUCTIVITY

TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT
77	67.4						

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	F-1 X 10^6	TEMP RANGE, F	F-1 X 10^6	TEMP RANGE, F	F-1 X 10^6	TEMP RANGE, F	F-1 X 10^6
68-212	13.4	68-572	14.5				

SPECIFIC HEAT

TEMP, F	BTU LB-1 F-1	TEMP, F	BTU LB-1 F-1	TEMP, F	BTU LB-1 F-1	TEMP, F	BTU LB-1 F-1
212	0.22						

ELECTRICAL RESISTIVITY

TEMP, F	MICROHM-CM			TEMP, F	MICROHM-CM		
68	5.94 (1)			68	6.39 (2)		

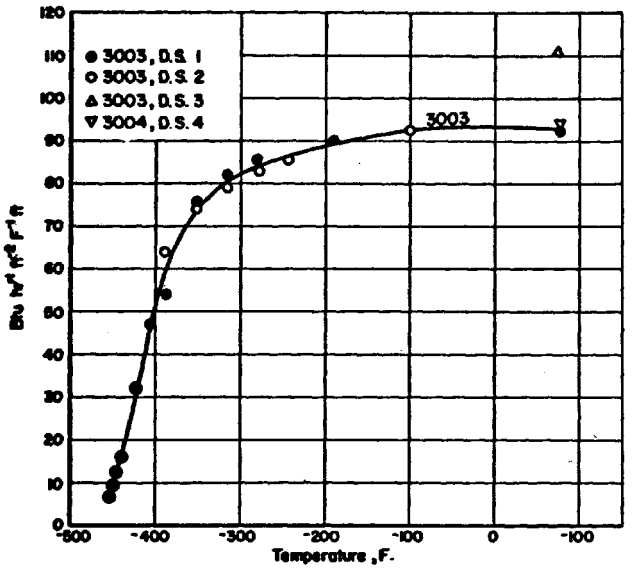
(1) Annealed
(2) Hard

DENSITY

TEMP, F	LB CU IN-1	TEMP, F	LB CU IN-1	TEMP, F	LB CU IN-1	TEMP, F	LB CU IN-1
Room	0.095						

Data assumed to be at room temperature.

ALUMINUM-MANGANESE ALLOYS



THERMAL CONDUCTIVITY OF ALUMINUM-MANGANESE ALLOYS

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS (1)

MATERIAL	Aluminum Alloy--3003					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Al	Mn							
	98.5	1.2							
FORM	As fabricated.								
HEAT TREATMENT									
REFERENCE	Powell, R. L., Hall, W. J., and Roder, H. M., to be published (1958); as found in "A Compendium of the Properties of Materials at Low Temperatures, Phase I", Part II, edited by Victor J. Johnson, NBS Cryogenic Engineering Laboratory, Boulder, Colorado (December, 1959).								

THERMAL CONDUCTIVITY

TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT
-453	6.36	-442	16.2	-352	75.7	-190	90.1
-449	9.53	-424	32.4	-316	82.0	-100	92.5
-445	12.7+	-406	47.4	-280	85.5	80	92+
-444	14.4	-388	54.3				

Values interpolated from graph.

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS (2)

MATERIAL	Aluminum--3003 Alcoa					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Al	Mn	Fe	Si					
	98	1.23	0.48	0.15					
FORM									
HEAT TREATMENT	As fabricated.								
REFERENCE	Cryogenic Engineering Laboratories, National Bureau of Standards, Boulder, Colorado.								
REMARKS	Grain size: longitudinal--0.016 x 0.008 mm, transverse--0.012 mm. Diamond point hardness: longitudinal--57, transverse--56.								

THERMAL CONDUCTIVITY

TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT	TEMP, F	BTU HR-1 FT-2 F-1 FT
-453	6.36	-442	16.2	-352	74.0	-280	83.2
-449	9.25	-424	32.9	-316	79.8	-244	85.5
-445	12.7	-388	64.1				

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

(3)

MATERIAL	Aluminum Alloy--3003					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Mn	Al							
	1.0-1.5	Bal							
FORM									
HEAT TREATMENT	Annealing temperature: 775 F, Hot working temperature range: 500-950 F.								
REFERENCE	"Materials in Design Engineering". Materials Selector, edited by H. R. Clauser, Vol 46, No. 4 (September, 1957).								
REMARKS	Melting temperature range: 1190-1210 F.								

THERMAL CONDUCTIVITY

TEMP. F	BTU HR^{-1} FT^{-2} F^{-1} FT	TEMP. F	BTU HR^{-1} FT^{-2} F^{-1} FT	TEMP. F	BTU HR^{-1} FT^{-2} F^{-1} FT	TEMP. F	BTU HR^{-1} FT^{-2} F^{-1} FT
77	111						

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	F^{-1} X 10^{6}	TEMP RANGE, F	F^{-1} X 10^{6}	TEMP RANGE, F	F^{-1} X 10^{6}	TEMP RANGE, F	F^{-1} X 10^{6}
68-212	12.9						

SPECIFIC HEAT

TEMP. F	BTU LB^{-1} F^{-1}	TEMP. F	BTU LB^{-1} F^{-1}	TEMP. F	BTU LB^{-1} F^{-1}	TEMP. F	BTU LB^{-1} F^{-1}
212	0.22						

ELECTRICAL RESISTIVITY

TEMP. F	MICROHM-CM	TEMP. F	MICROHM-CM	TEMP. F	MICROHM-CM	TEMP. F	MICROHM-CM
68	3.45						

DENSITY

TEMP. F	LB CU IN^{-1}	TEMP. F	LB CU IN^{-1}	TEMP. F	LB CU IN^{-1}	TEMP. F	LB CU IN^{-1}
Room	0.099						
Data assumed to be at room temperature.							

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

(4)

MATERIAL	Aluminum Alloy--3004					HEAT NUMBER			
CHEMICAL COMPOSITION PER CENT	Mn	Mg	Al						
	1.0-1.5	0.8-1.3	Bal						
FORM									
HEAT TREATMENT	Annealing temperature: 650 F, hot working temperature range: 500-950 F.								
REFERENCE	"Materials in Design Engineering", Materials Selector, edited by H. R. Clauser, Vol 46, No. 4 (September, 1957).								
REMARKS	Melting temperature range: 1165-1205 F.								

THERMAL CONDUCTIVITY

TEMP. F	BTU HR^{-1} FT^{-2} F^{-1} FT	TEMP. F	BTU HR^{-1} FT^{-2} F^{-1} FT	TEMP. F	BTU HR^{-1} FT^{-2} F^{-1} FT	TEMP. F	BTU HR^{-1} FT^{-2} F^{-1} FT
77	93.8						

COEFFICIENT OF LINEAR THERMAL EXPANSION

TEMP RANGE, F	F^{-1} X 10^{6}	TEMP RANGE, F	F^{-1} X 10^{6}	TEMP RANGE, F	F^{-1} X 10^{6}	TEMP RANGE, F	F^{-1} X 10^{6}
68-212	12.9						

SPECIFIC HEAT

TEMP. F	BTU LB^{-1} F^{-1}	TEMP. F	BTU LB^{-1} F^{-1}	TEMP. F	BTU LB^{-1} F^{-1}	TEMP. F	BTU LB^{-1} F^{-1}
212	0.22						

ELECTRICAL RESISTIVITY

TEMP. F	MICROHM-CM	TEMP. F	MICROHM-CM	TEMP. F	MICROHM-CM	TEMP. F	MICROHM-CM
68	4.10						

DENSITY

TEMP. F	LB CU IN^{-1}	TEMP. F	LB CU IN^{-1}	TEMP. F	LB CU IN^{-1}	TEMP. F	LB CU IN^{-1}
Room	0.098						
Data assumed to be at room temperature.							