



Multiply	By	To Obtain	Multiply	By	To Obtain
Atmospheres	33.9	Feet of water	Inches of water	0.1867	Cms.of mercury
Atmospheres	29.92	Inches of mercury	Inches of water (at 4°C)	$2.54 \times 10^{-3}$	Kgs./sq. cm.
Atmospheres	10332	Kilograms/sq. m.	Inches-pounds/deg.	0.66	Kilogram-meters/rad.
Atmospheres	14.7	Pounds/sq. in.	Joules	$9.486 \times 10^{-4}$	B.T.U.
Atmospheres	760	mm of mercury	Joules	0.7376	Foot-pounds
Bars	$9.869 \times 10^{-1}$	Atmospheres	Joules	$2.390 \times 10^{-4}$	Kg.-calories
Bars	$1.0 \times 10^6$	Dynes/sq. cm.	Kilograms	980665	Dynes
Bars	$1.020 \times 10^4$	Kgs./sq. meter	Kilograms	$1.0 \times 10^3$	Grams
Bars	14.5	Pounds/sq. in.	Kilograms	2.205	Pounds
British Thermal Units	777.5	Foot-pounds	Kilogram-calories	3.968	B.T.U.
British Thermal Units	1054.6	Joules	Kilogram-calories	3086	Foot-pounds
British Thermal Units	0.2520	Kg.-calories	Kilogram-calories	4186	Joules
British Thermal Units	$2.928 \times 10^{-4}$	K.W.-hours	Kilogram-meters	7.233	Foot-pounds
B.T.U./hr.	0.2520	Kg. cal/Hr.	Kilograms/cu. meters	$3.613 \times 10^{-5}$	Pounds/cu. in.
B.T.U./hr./sq. ft.	2.712	Kg.-cal/hr./sq. m.	Kilograms/sq. cm.	$9.80665 \times 10^5$	Dynes/sq. cm.
B.T.U./hr./sq. ft./deg F.	4.882	Kg. cal/hr./sq. m./deg C.	Kilograms/sq. cm.	14.226	Pounds/sq. in.
B.T.U./sq. ft.	2.712	Kg. cal./sq. m.	Kilograms/sq. meter	$9.678 \times 10^{-5}$	Atmospheres
B.T.U./sq. ft./in.	6.892	Kg. cal/sq.m./cm.	Kilograms/sq. meters	$9.804 \times 10^{-5}$	Bars
Celsius	$(C \times 1.8) + 32$	Fahrenheit	Kilometers	$1.0 \times 10^5$	Centimeters
Centimeters	0.0328	Feet	Kilometers	3281	Feet
Centimeters	0.3937	Inches	Kilometers	$3.937 \times 10^4$	Inches
Centimeters	0.01	Meters	Kilonewtons/sq. meter	0.145	Pounds/sq. in.
Centimeters	$1. \times 10^4$	Microns	Kilospascals	0.145	Pounds/sq. in.
Centimeters/sec	0.03281	Feet/sec	Liters	$1.0 \times 10^3$	Cubic centimeters
Centipoises	0.000672	Lbs./ft.-sec.	Liters	0.0351	Cubic foot
Cubic centimeters	$3.531 \times 10^{-5}$	Cubic feet	Liters	0.2642	Gallons (U.S.)
Cubic centimeters	$6.102 \times 10^{-2}$	Cubic inches	Liters	$1.0 \times 10^{-3}$	Cubic meters
Cubic centimeters	$1.0 \times 10^{-3}$	Liters	Mega pascals (mPa)	145	Pounds/sq. in.
Cubic feet	1728	Cubic inches	Meters	3.281	Feet
Cubic feet	0.03704	Cubic Yards	Meters	39.37	Inches
Cubic feet	7.481	Gallons	Meters	100	Centimeters
Cubic feet	28.32	Liters	Meters	0.001	Kilometers
Cubic feet/second	26930	Gallons/hour	Meters	1000	Millimeters
Cubic inches	$1.639 \times 10^{-5}$	Cubic meters	Meters/sec.	3.281	Feet/sec.
Cubic inches	$4.329 \times 10^{-3}$	Gallons	Microns	$3.94 \times 10^{-5}$	Inches
Cubic meters	$1.0 \times 10^6$	Cubic cm.	Millimeters	0.1	Centimeters
Cubic meters	35.31	Cubic feet	Millimeters	0.003281	Feet
Cubic meters	1.308	Cubic yards	Millimeters	0.03937	Inches
Degrees(angle)	$1.745 \times 10^{-2}$	Radians	Millimeters	$1.0 \times 10^{-6}$	Kilometers
Dynes	$1.020 \times 10^{-6}$	Kilograms	Millimeters	0.001	Meters
Dynes	$2.248 \times 10^{-6}$	Pounds	Newtons	$1.0 \times 10^5$	Dynes
Dynes/sq. cm.	$9.870 \times 10^{-7}$	Atmosphere	Newtons	0.2248	Pounds
Dynes/sq. cm.	$1 \times 10^{-6}$	Bars	Newtons/mm	5.71	Pounds/inch
Dynes/sq. cm.	0.01020	Kgs./sq. meter	Newton-Meters	8.8504	Inch-pounds
Dynes/sq.cm.	$2.089 \times 10^{-3}$	Pounds/sq. ft.	Newtons/sq. meter	1	Pascals
Dynes/sq. cm.	$1.450 \times 10^{-5}$	Pounds/sq. in.	Ounces	28.35	Grams
Fahrenheit	$5/9(F-32)$	Celsius	Ounces (fluid)	0.02957	Liters
Feet	30.48	Centimeters	Pounds	444823	Dynes
Feet	$3.048 \times 10^{-4}$	Kilometer	Pounds	453.6	Grams
Feet	0.3048	Meters	Pounds	0.4536	Kilograms
Feet	304.8	Millimeters	Pounds of water	0.01602	Cubic feet
Feet/minute	0.01667	Feet/second	Pounds of water	27.68	Cubic inches
Foot-pounds	1.356	Joules	Pounds of water	0.1198	Gallons
Foot-pounds	$3.241 \times 10^{-4}$	Kg.-calories	Pounds/cu. foot	0.01602	Grams/cu. cm.
Foot-pounds	0.1383	Kg.-meters	Pounds/cubic foot	16.02	Kgs./cu. meter
Gallons (U.S.)	0.1337	Cubic feet	Pounds/cubic foot	$5.787 \times 10^{-4}$	Pounds/cu. in.
Gallons (U.S.)	231	Cubic inches	Pounds/cu. in.	$2.768 \times 10^4$	Kgs./cu. meter
Gallons (U.S.)	$3.785 \times 10^{-3}$	Cubic meters	Pounds/cu. in.	$1.728 \times 10^3$	Pounds/cu. ft.
Gallons (U.S.)	3.785	Liters	Pounds/inch	17.86	Kilograms/meter
Gallons of water	8.337	Pounds of water	Pounds/inch	178.6	Grams/cm.
Gallons/hour	$3.71 \times 10^{-5}$	Cu. ft./sec.	Pounds/square inch	2.036	Inches of mercury
Grams	980.7	Dynes	Pounds/square inch	51.7	Mm of mercury
Grams	$2.205 \times 10^{-3}$	Pounds	Pounds/square inch	703.1	Kgs./sq. meter
Grams/cubic cm.	0.03613	Lbs./cu. in.	Radians	57.3	Degrees
Grams/sq. cm.	$1.422 \times 10^{-2}$	Lbs./sq. in.	Slugs	$3.217 \times 10^1$	Pounds
Inches	2.54	Centimeters	Square centimeters	0.1550	Square inches
Inches	0.0254	Meters	Square feet	929	Square cms.
Inches	25.4	Millimeters	Square feet	0.0929	Square meters
Inches of mercury	0.03342	Atmospheres	Square inches	645.2	Square mms.
Inches of mercury	$3.453 \times 10^{-2}$	Kgs./sq. cm.	Square inches	6.452	Square cms.
Inches of mercury	0.4912	Lbs./sq. in.	Square meters	$1.55 \times 10^3$	Square inches
Inches of water	$2.458 \times 10^{-3}$	Atmosphere	Square millimeters	$1.0 \times 10^{-2}$	Square cms.
Inches of water	0.07349	Inches of mercury	Square millimeters	$1.55 \times 10^{-3}$	Square inches
Inches of water	0.03609	Lbs./ sq. in.	Tons	0.02	Pounds/sq. in.





# Thermal Expansion Data

Linear Thermal Expansion between 70° F and Indicated Temperature, inches/100 feet

## M A T E R I A L S

Temp. deg F	Carbon Steel Carbon-Moly Low-Chrome (thru 3 Cr Mo)	Austenitic Stainless Steels 18 Cr 8 Ni	5 Cr Mo thru 9 Cr Mo	12 Cr 17 Cr 27 Cr	310SS 25 Cr 20 Ni	Monel (400) 67 Ni 30 Cr	3 1/2 Nickel	Nickel 200	Alloy 800, 825	Alloy 600, 625, 691	Copper	Brass	70 Cu 30 Ni	Aluminum	Wrought Iron
-325	-2.37	-3.85	-2.22	-2.04	-3.00	-2.62	-2.22	—	—	—	—	-3.88	-3.15	-4.68	-2.70
-300	-2.24	-3.63	-2.10	-1.92	-2.83	-2.50	-2.10	-2.44	—	—	—	-3.64	-2.87	-4.46	-2.55
-275	-2.11	-3.41	-1.98	-1.80	-2.66	-2.38	-1.98	-2.35	—	—	—	-3.40	-2.70	-4.21	-2.40
-250	-1.98	-3.19	-1.86	-1.68	-2.49	-2.26	-1.86	-2.25	—	-2.30	—	-3.16	-2.53	-3.97	-2.25
-225	-1.85	-2.96	-1.74	-1.57	-2.32	-2.14	-1.74	-2.13	—	-2.17	—	-2.93	-2.36	-3.71	-2.10
-200	-1.71	-2.73	-1.62	-1.46	-2.15	-2.02	-1.62	-2.01	—	-2.04	—	-2.70	-2.19	-3.44	-1.95
-175	-1.58	-2.50	-1.50	-1.35	-1.98	-1.90	-1.50	-1.83	—	-1.87	—	-2.47	-2.12	-3.16	-1.81
-150	-1.45	-2.27	-1.37	-1.24	-1.81	-1.79	-1.38	-1.65	—	-1.7	—	-2.24	-1.95	-2.88	-1.67
-125	-1.30	-2.01	-1.23	-1.11	-1.60	-1.59	-1.23	-1.47	—	-1.54	—	-2.00	-1.74	-2.57	-1.49
-100	-1.15	-1.75	-1.08	-0.98	-1.39	-1.38	-1.08	-1.29	—	-1.37	-1.83	-1.76	-1.53	-2.27	-1.31
-75	-1.00	-1.50	-0.94	-0.85	-1.18	-1.18	-0.93	-1.11	—	-1.17	-1.57	-1.52	-1.33	-1.97	-1.13
-50	-0.84	-1.24	-0.79	-0.72	-0.98	-0.98	-0.78	-0.93	—	-0.97	-1.31	-1.29	-1.13	-1.67	-0.96
-25	-0.68	-0.98	-0.63	-0.57	-0.78	-0.77	-0.62	-0.75	—	-0.76	-1.05	-1.02	-0.89	-1.32	-0.76
0	-0.49	-0.72	-0.46	-0.42	-0.57	-0.57	-0.46	-0.56	—	-0.56	-0.79	-0.75	-0.66	-0.97	-0.56
25	-0.32	-0.46	-0.30	-0.27	-0.37	-0.37	-0.30	-0.36	—	-0.36	-0.51	-0.48	-0.42	-0.63	-0.36
50	-0.14	-0.21	-0.13	-0.12	-0.16	-0.20	-0.14	-0.16	—	-0.16	-0.22	-0.21	-0.19	-0.28	-0.16
70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	0.23	0.34	0.22	0.20	0.32	0.28	0.22	0.25	0.28	0.26	0.34	0.35	0.31	0.46	0.26
125	0.42	0.62	0.40	0.36	0.58	0.52	0.40	0.47	0.52	0.48	0.62	0.64	0.56	0.85	0.48
150	0.61	0.90	0.58	0.53	0.84	0.75	0.58	0.69	0.76	0.70	0.90	0.94	0.82	1.23	0.70
175	0.80	1.18	0.76	0.69	1.10	0.99	0.76	0.92	0.99	0.92	1.18	1.23	1.07	1.62	0.92
200	0.99	1.46	0.94	0.86	1.37	1.22	0.94	1.15	1.23	1.15	1.48	1.52	1.33	2.00	1.14
225	1.21	1.75	1.13	1.03	1.64	1.46	1.13	1.38	1.49	1.38	1.77	1.83	1.59	2.41	1.37
250	1.40	2.03	1.33	1.21	1.91	1.71	1.32	1.61	1.76	1.61	2.05	2.14	1.86	2.83	1.60
275	1.61	2.32	1.52	1.38	2.18	1.96	1.51	1.85	2.03	1.85	2.34	2.45	2.13	3.24	1.83
300	1.82	2.61	1.71	1.56	2.45	2.21	1.69	2.08	2.30	2.09	2.62	2.76	2.40	3.67	2.06
325	2.04	2.90	1.90	1.74	2.72	2.44	1.88	2.32	2.59	2.32	2.91	3.08	2.68	4.09	2.29
350	2.26	3.20	2.10	1.93	2.99	2.68	2.08	2.56	2.88	2.56	3.19	3.41	2.96	4.52	2.53
375	2.48	3.50	2.30	2.11	3.26	2.91	2.27	2.80	3.18	2.80	3.48	3.73	3.24	4.95	2.77
400	2.70	3.80	2.50	2.30	3.53	3.25	2.47	3.05	3.48	3.05	3.88	4.05	3.52	5.39	3.01
425	2.93	4.10	2.72	2.50	3.80	3.52	2.69	3.30	3.76	3.29	4.17	4.38	—	5.83	3.25
450	3.16	4.41	2.93	2.69	4.07	3.79	2.91	3.55	4.04	3.53	4.47	4.72	—	6.28	3.50
475	3.39	4.71	3.14	2.89	4.34	4.06	3.13	3.80	4.31	3.78	4.76	5.06	—	6.72	3.74
500	3.62	5.01	3.35	3.08	4.61	4.33	3.34	4.05	4.59	4.02	5.06	5.40	—	7.17	3.99
525	3.86	5.31	3.58	3.28	4.88	4.61	3.57	4.31	4.87	4.27	5.35	5.75	—	7.63	4.25
550	4.11	5.62	3.80	3.49	5.15	4.90	3.80	4.56	5.16	4.52	5.64	6.10	—	8.10	4.50
575	4.35	5.93	4.02	3.69	5.42	5.18	4.03	4.83	5.44	4.77	—	6.45	—	8.56	4.76
600	4.60	6.24	4.24	3.90	5.69	5.46	4.27	5.09	5.72	5.02	—	6.80	—	9.03	5.01
625	4.86	6.55	4.47	4.10	5.96	5.75	4.51	5.35	6.01	5.27	—	7.16	—	—	5.27
650	5.11	6.87	4.69	4.31	6.23	6.05	4.75	5.62	6.30	5.53	—	7.53	—	—	5.53
675	5.37	7.18	4.92	4.52	6.50	6.34	4.99	5.89	6.58	5.79	—	7.89	—	—	5.80
700	5.63	7.50	5.14	4.73	6.77	6.64	5.24	6.16	6.88	6.05	—	8.26	—	—	6.06
725	5.90	7.82	5.38	4.94	7.04	6.94	5.50	6.44	7.17	6.31	—	8.64	—	—	6.32
750	6.16	8.15	5.62	5.16	7.31	7.25	5.76	6.71	7.47	6.57	—	9.02	—	—	6.59
775	6.43	8.47	5.86	5.38	7.58	7.55	6.02	6.99	7.76	6.84	—	9.40	—	—	6.85
800	6.70	8.80	6.10	5.60	7.85	7.85	6.27	7.27	8.06	7.10	—	9.78	—	—	7.12
825	6.97	9.13	6.34	5.82	8.15	8.16	6.54	7.54	8.35	7.38	—	10.17	—	—	7.40
850	7.25	9.46	6.59	6.05	8.45	8.48	6.81	7.82	8.66	7.67	—	10.57	—	—	7.69
875	7.53	9.79	6.83	6.27	8.75	8.80	7.08	8.09	8.95	7.95	—	10.96	—	—	7.97
900	7.81	10.12	7.07	6.49	9.05	9.12	7.35	8.37	9.26	8.23	—	11.35	—	—	8.26
925	8.08	10.46	7.31	6.71	9.35	9.44	7.72	8.64	9.56	8.52	—	11.75	—	—	8.53
950	8.35	10.80	7.56	6.94	9.65	9.77	8.09	8.92	9.87	8.80	—	12.16	—	—	8.81
975	8.62	11.14	7.81	7.17	9.95	10.09	8.46	9.20	10.18	9.09	—	12.57	—	—	9.08
1000	8.89	11.48	8.06	7.40	10.25	10.42	8.83	9.49	10.49	9.37	—	12.98	—	—	9.36
1025	9.17	11.82	8.30	7.62	10.55	10.75	8.98	9.77	10.80	9.66	—	13.39	—	—	—
1050	9.46	12.16	8.55	7.95	10.85	11.09	9.14	10.05	11.11	9.94	—	13.81	—	—	—
1075	9.75	12.50	8.80	8.18	11.15	11.43	9.29	10.34	11.42	10.23	—	14.23	—	—	—
1100	10.04	12.84	9.05	8.31	11.45	11.77	9.45	10.63	11.74	10.51	—	14.65	—	—	—
1125	10.31	13.18	9.28	8.53	11.78	12.11	9.78	10.92	12.05	10.80	—	—	—	—	—
1150	10.57	13.52	9.52	8.76	12.11	12.47	10.11	11.21	12.38	11.09	—	—	—	—	—
1175	10.83	13.86	9.76	8.98	12.44	12.81	10.44	11.50	12.69	11.37	—	—	—	—	—
1200	11.10	14.20	10.00	9.20	12.77	13.15	10.78	11.80	13.02	11.66	—	—	—	—	—
1225	11.38	14.54	10.26	9.42	13.10	13.50	—	12.09	13.36	11.98	—	—	—	—	—
1250	11.66	14.88	10.53	9.65	13.43	13.86	—	12.39	13.71	12.29	—	—	—	—	—
1275	11.94	15.22	10.79	9.88	13.76	14.22	—	12.69	14.04	12.61	—	—	—	—	—
1300	12.22	15.56	11.06	10.11	14.09	14.58	—	12.99	14.39	12.93	—	—	—	—	—
1325	12.50	15.90	11.30	10.33	14.39	14.94	—	13.29	14.74	13.25	—	—	—	—	—
1350	12.78	16.24	11.55	10.56	14.69	15.30	—	13.59	15.10	13.56	—	—	—	—	—
1375	13.06	16.58	11.80	10.78	14.99	15.66	—	13.90	15.44	13.88	—	—	—	—	—
1400	13.34	16.92	12.05	11.01	15.29	16.02	—	14.20	15.80	14.20	—	—	—	—	—
1425	—	17.30	—	—	—	—	—	14.51	16.16	14.51	—	—	—	—	—
1450	—	17.69	—	—	—	—	—	14.82	16.53	14.83	—	—	—	—	—
1475	—	18.08	—	—	—	—	—	15.13	16.88	15.14	—	—	—	—	—
1500	—	18.47	—	—	—	—	—	15.44	17.25	15.45	—	—	—	—	—
1525	—	—	—	—	—	—	—	15.76	17.61	15.77	—	—	—	—	—
1550	—	—	—	—	—	—	—	16.07	17.98	16.08	—	—	—	—	—
1575	—	—	—	—	—	—	—	16.39	18.35	16.40	—	—	—	—	—
1600	—	—	—	—	—	—	—	16.71	18.73	16.71	—	—	—	—	—

- Notes:
1. Table shows expansion resulting from change in temperature from 70° F to indicated temperature.
  2. This Table is for information only and it is not to be implied that materials are suitable for all temperature ranges shown.
  3. The thermal expansion values in this table may be interpolated to determine values for intermediate temperatures.



