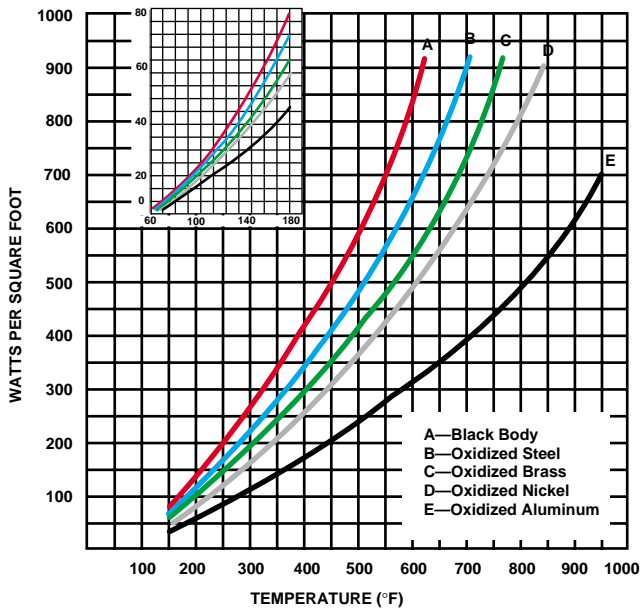


# GENERAL ENGINEERING & TECHNICAL INFORMATION

The graphs, tables and other information presented on the following pages are often all that's necessary to perform kw requirement calculations. Also included is data for radiant heating applications, quick charts, basic electrical information, a corrosion guide and many other materials useful in the design of Thermal Systems. Where information is not certain or does not exist for a particular process, contact Ogden. Numerous other sources are available that can be consulted.

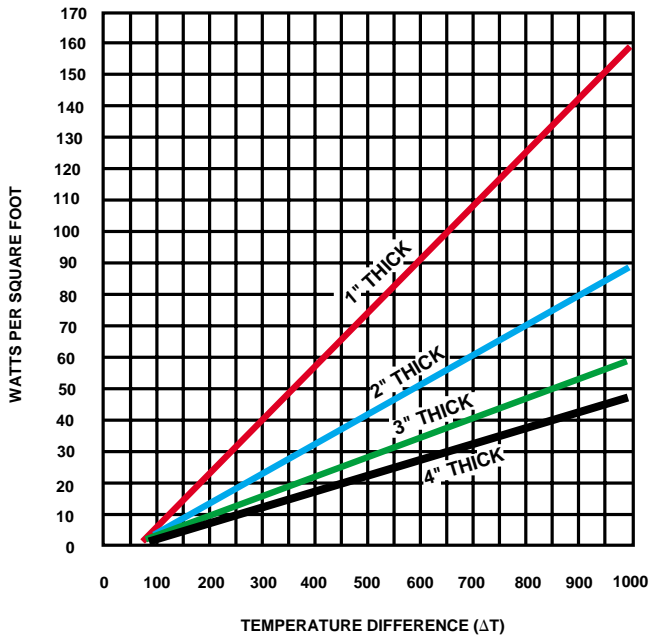
## GUIDES FOR ESTIMATING HEAT LOSSES

### 1T: Heat Losses From Uninsulated Metal Surfaces



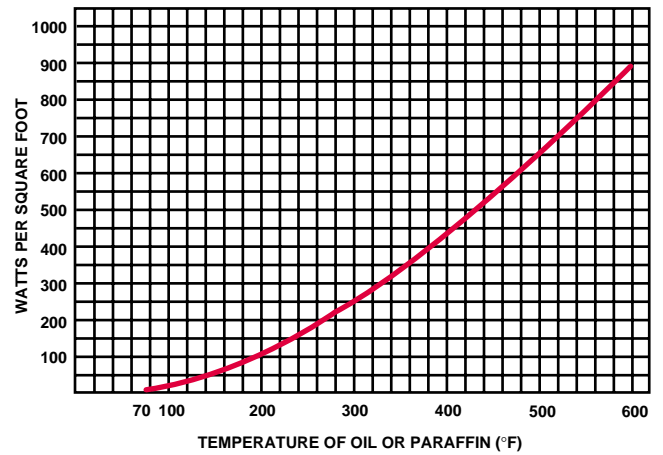
Radiant and convection heat losses are combined. Based upon 70°F ambient. For horizontal bottom surface, use ½ figure from graph.

### 2T: Heat Losses From Insulated Surfaces

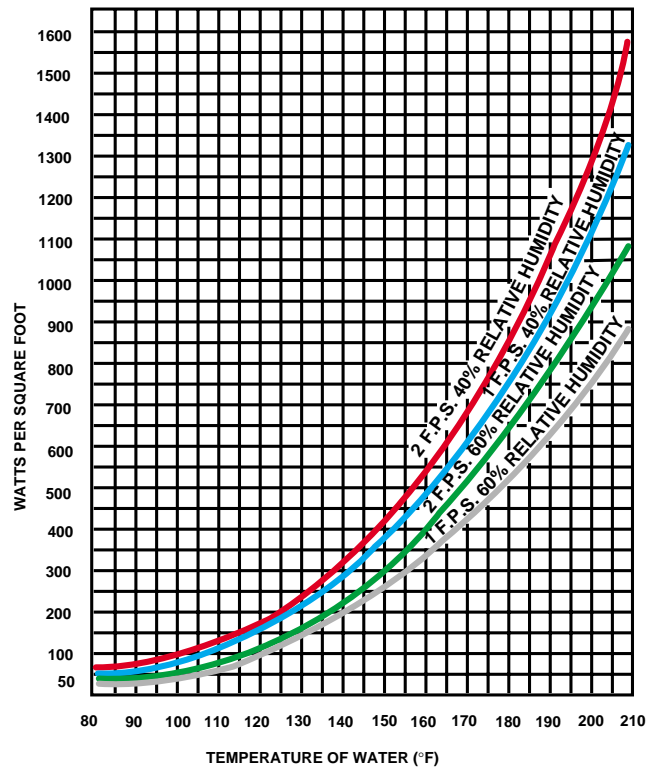


Radiant and convection heat losses are combined. Based upon 70°F ambient temperature with ceramic fiber insulation. For horizontal bottom surface, use ½ of figure from graph.

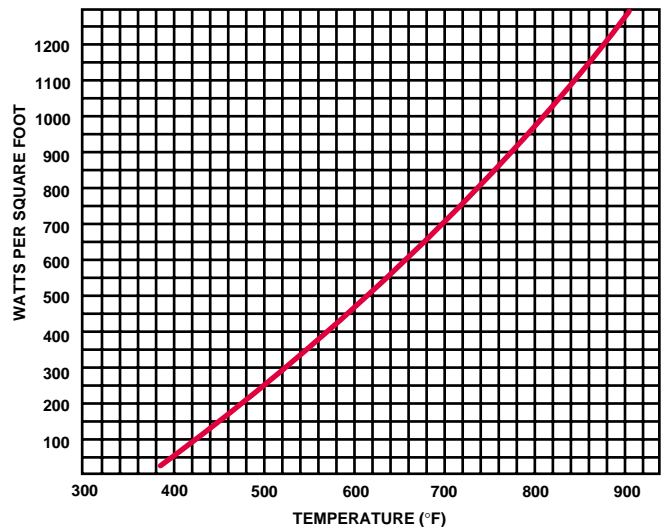
### 3T: Heat Losses From Oil and Paraffin Surfaces



### 4T: Heat Losses From Water Surfaces



### 5T Heat Losses From Molten Metal Surfaces (Lead, Babbit, Type Metal, Tin, etc.)



# PHYSICAL PROPERTIES OF MATERIALS

## 6T: Metals and non-Metallic Solids

SUBSTANCE	Specific Heat	Heat of Fusion Btu/lb.	Melting Point °F	Density—Weight in lbs./cu. ft.
Aluminum 2024-T3	.24	167	935	173
Aluminum 1100-0	.24	169	1190	169
Antimony	.23	25	1166	423
Asbestos Cement Board	.25 ±	..	...	121
Asphalt	.40	40	250	131
Bakelite Resin, Pure	.3-4	..	...	74-81
Barium	.068	..	1562	225
Beeswax	..	75	144	60.5
Beryllium	.052	..	2345	113.5
Bismuth	.031	23	520	612
Boron	.309	..	4172	144
Brass, 70%	.096	..	1750	532
Brickwork & Masonry	.220	..	...	131
Bronze (75%Cu; 25%Sn)	.082	75	1832	541
Cadmium	.055	23.8	610	540
Calcium	.149	140	1564	96.7
Calcium Chloride	.17	..	1422	157
Carbon	.280	..	6700	138
Cement, Portland, Loose	.19	..	...	94
Cerafelt Insulation	.25 @ 1000°F	..	...	3
Ceramic Fiber	.27	..	...	4-10
Chalk	.215	..	...	112-175
Chromium	.11	..	2822	450
Clay	.224	..	3160	90
Coal	.32	..	...	80
Coal Tar	.35-45	..	...	78
Cobalt	.099	115.2	2696	554
Coke	.265	..	...	62-88
Concrete, Cinder	.16	..	...	100
Concrete, Stone	.156	..	...	144
Copper	.095	91.1	1981	556
Cork	.36	..	...	13.5
Cotton (Flax, Hemp)	.31	..	...	92.4
Delrin	.350	..	...	88.1
Firebrick, Fireclay	.243	..	2900	137-150
Firebrick, Silica	.258	..	3000	144-162
Glass	.20	..	2200 ±	164
Gold	.032	29.0	1945	1206
Granite	.192	..	...	160-175
Graphite	.20	..	...	130
Ice	.53	144	32	56.0
Incoloy 800	.13	..	2475-2525	501
Inconel 600	.126	..	2500	525
Invar (36%Ni)	.126	..	2600	506
Iron, Cast	.12	..	2150	449
Iron, Wrought	.12	..	2800	480
Isoprene, Rubber	.48	..	...	58
Lead, Solid	.032	11.3	620	708
Limestone	.217	..	...	130-175
Lithium	.79	59	367	367
Manganese	.115	116	2268	463
Magnesium	.27	160	1202	109
Magnesia, 85% Mg O (Compacted)	.222	..	5070	19
Mercury	.033	5	- 38	844
Mica	.21	..	...	176
Molybdenum	.061	126	4750	638

SUBSTANCE	Specific Heat	Heat of Fusion Btu/lb.	Melting Point °F	Density—Weight in lbs./cu. ft.
Monel 400	.11	..	2370	551
Nickel 200	.12	133	2615	555
Nichrome (80% Ni-.20% Cr.)	.11	..	2550	522
Paper	.45	..	...	58.8
Paraffin	.69	63	133	55.3
Pitch (Hard)	..	..	300 ±	83
Plastics:				
ABS	.35	..	...	69-76
Acrylic	.34	..	...	69-74
Cellulose Acetate	.3-5	..	...	76-83
Cellulose Acetate Butyrate	.3-4	..	...	74
Epoxy	.25-.3	..	...	66-88
Fluoroplastics	.28	..	...	131-150
Nylon	.3-5	..	...	67-72
Phenolic	.35	..	...	85-124
Polycarbonate	.3	..	...	74-78
Polyester	.2-35	..	...	66-92
Polyethylene	.54	..	...	57-60
Polyimides	.27-.31	..	...	90
Polypropylene	.46	..	...	55-57
Polystyrene	.32	..	...	66
Polyvinyl Chloride Acetate	.2-3	..	...	72-99
Platinum	.035	49	3225	1339
Porcelain	.26	..	...	145-155
Potassium	.058	26.2	146	750
Potassium Chloride	.17	..	1454	124
Potassium Nitrate	.26	..	633	132
Quartz	.26	..	...	138
Rhodium	.059	..	3570	776
Rubber	.44	..	...	76.0
Rubber, Synthetic	.40	..	...	58
Silicone Rubber	.45	..	...	78
Silicon	.162	..	2570	14.5
Silver	.057	38	1760	665
Sodium	.295	49.5	207	60
Solder (50% Pb-50% Sn.)	.051	17	361	558
Steatite	.20	..	...	162
Steel Mild	.122	..	2760	491
Steel S. 304	.12	..	2550	494
Steel S. 430	.11	..	2650	475
Sulfur	.175	17	246	130
Sugar	.30	..	320	105
Tallow	..	..	90 ±	60.0
Tantalum	.035	..	5425	104
Teflon	.25	..	...	135
Tin, Solid	.065	261	450	454
Titanium 99.0%	.13	..	3035	283
Tungsten	.032	79	6170	1200
Type Metal (85% Pb-.13% Sb.)	.040	14 +	500	669
Uranium	.028	..	3075	1170
Vinyl	.3-5	..	...	79.5
Wood (Pine)	.45 ±	..	...	34
Wood (Oak)	.57	..	...	50
Zirconium	.066	108	3350	400
Zinc	.096	43.3	787	445

± Estimated

## 7T: Metals in Liquid State

SUBSTANCE	Specific Heat	Heat of Fusion Btu/lb.	Melting Point °F	Temperature °F	Density—Weight in lbs./cu. ft.
Aluminum	.26	173	1220.4	1220	148.6
	.26	..	..	1292	147.7
	.26	..	..	1454	..
Bismuth	.034 @ 520° F	..	..	..	..
	.0354	..	..	572	626.2
	.0376	..	..	752	618.7
	..	..	..	1112	603.1
Cadmium	.0632	23.8	609	626	500
	.0632	..	..	662	498.8
	.0632	..	..	680	..
	.0632	..	..	752	495
Gold	.0355	26.9	1945	2012	1076
Lead	.038	10.6	621	700	655.5
	.037	..	..	932	648.7
Lithium	1.0	284.4	354	392	31.7
	1.0	..	..	752	31
Magnesium	.317	148	1204	1204	98.
	..	..	..	1328	94.3
	.321	..	..	1341	..

SUBSTANCE	Specific Heat	Heat of Fusion Btu/lb.	Melting Point °F	Temperature °F	Density—Weight in lbs./cu. ft.
Mercury	.03334	5	-38	32	..
	.03279	..	..	212	833.6
	..	..	..	320	..
	.03245	..	..	392	818.8
Potassium	.1901	26.3	147	300	50.6
	.1826	..	..	752	46.6
Silver	.0692	44.8	1761	1761	580.6
	.0692	..	..	1832	578.1
	.0692	..	..	2000	574.4
Sodium	.331	48.7	208	212	57.9
	.320	..	..	400	56.2
	.301	..	..	752	53.3
Solder .5 Sn, .5 Pb	.0556	17	421	..	..
.6 Sn, .4 Pb	.0584	28	375	..	..
Tin	.058	26.1	449	482	..
	..	..	..	768	426.6
	..	..	..	783	..
Zinc	.12	43.9	787	787	432
	..	..	..	932	..
	.117	..	..	1112	425

8T: Liquids

SUBSTANCE	Specific Heat	Heat of Vaporization Btu/lb.	Boiling Point °F	Density—Weight in lbs./cu.ft.	Weight in lbs./gal.
Acetic Acid, 100%	.48	175	245	65.4	8.74
Acetone, 100%	.514	225	133	49	6.5
Allyl Alcohol	.665	293	207	55	7.35
Ammonia, 100%	1.1	589	-27	47.9	6.4
Amyl Alcohol	.65	216	280	55	7.35
Aniline	.514	198	63	64.6	8.63
Arochier Oil	.28		650	89.7	12.00
Brine Sodium Chloride, 25%	.786	730	220	74.1	9.9
Butyl Alcohol	.687	254	244	45.3	6.0
Butyric Acid	.515		345	50.4	6.73
Carbon Tetrachloride	.21		170	98.5	13.16
Corn Syrup, Dextrose	.65 ±		231	87.8	11.73
Cottonseed Oil	.47			59.2	7.9
Ether	.503	160	95	46	6.14
Ethyl Acetate	.475	183.5	180	51.5	6.88
Ethyl Alcohol, 95%	.60	370		50.4	6.74
Ethyl Bromide	.215	108	101	90.5	12.1
Ethyl Chloride	.367	166.5	54	57	7.62
Ethyl Iodide	.161	81.3	160	113	15.1
Ethylene Bromide	.172	83	270	120	16.0
Ethylene Chloride	.299	139	240	71.7	9.58
Ethylene Glycol	.555		387	70.0	9.36
Fatty Acid-Aleic	.7 ±		547	55.4	7.4
Fatty Acid-Palmitic	.653		520	53.1	7.1
Fatty Acid-Stearic	.550		721	52.8	7.06
Formic Acid	.525	216	213	69.2	9.25
Freon 11	.208		74.9	92.1	12.3
Freon 12	.232	62	-21.6	81.8	10.93
Freon 22	.300		-41.36	74.53	9.96
Fruit, Fresh, Avg.	.88			50-60	6.7-8.0
Glycerine	.58		556	78.7	10.5
Heptane	.49	137.1	210	38.2	5.1
Hexane	.6	142.5	155	38.2	5.1
Honey	.34				
Hydrochloric Acid, 10%	.93		221	66.5	8.89
Lard	.64			57.4	7.67
Linseed Oil	.44		552	57.9	7.74
Maple Syrup	.48				
Mercury	.033	117	675	845	113.0
Methyl Acetate	.47	176.5	133	54.8	7.3
Methyl Chloroform	.26	95	165	82.7	11.0
Methylene Chloride	.288	142	104	82.6	11.0
Milk, 3.5%	.90			64.2	8.58
Molasses	.60		220 ±	87.4	11.68
Nitric Acid, 7%	.92	918	220	64.7	8.65
Nitric Acid, 95%	.5	207	187	93.5	12.5
Nitrobenzene	.35	142.2	412		
Olive Oil	.47		570	58	7.75
Perchlorethylene	.21	90	250	101.3	13.54

SUBSTANCE	Specific Heat	Heat of Vaporization Btu/lb.	Boiling Point °F	Density—Weight in lbs./cu.ft.	Weight in lbs./gal.
Petroleum Products:					
Asphalt	.42			62.3	8.33
Benzene	.42	170	175	56	7.48
Fuel Oils:					
Fuel Oil #1 (Kerosene)	.47	86	**440 ±	50.5	6.75
Fuel Oil #2	.44			53.9	7.2
Fuel Oil Medium #3, #4	.425	67	**580 ±	55.7	7.44
Fuel Oil Heavy #5, #6	.41			58.9	7.87
Gasoline	.53	116	**280 ±	41-43	5.5-5.75
Machine/Lube Oils:					
SAE 10-30	.43			55.4	7.4
SAE 40-50	.43			55.4	7.4
Napthalene	.396	103	424 ±	54.1	7.23
Paraffin, Melted (150°F +)	.69	70	572	56	7.5
Propane (Compressed)	.576		-48.1	.13	.02
Toluene	.42			53.7	7.18
Transformer Oils	.42			56.3	7.5
Phenol (Carbolic Acid)	.56		346	66.6	8.9
Phosphoric Acid, 10%	.93			65.4	8.74
Phosphoric Acid, 20%	.85			69.1	9.24
Polyurethane Foam Components:					
Part A Isocyanate	.6			77	10.3
Part B Polyol Resin	.7			74.8	10.0
Potassium (1000°F)	.18	893	1400	44.6	5.96
Propionic Acid	.56	177.8	286	61.8	8.26
Propyl Alcohol	.57	295.2	208	50.2	6.7
Sea Water	.94			64.2	8.58
Sodium (1000°F)	.30	1810	1638	51.2	6.84
Sodium Hydroxide (Caustic Soda)					
30% Sol.	.84			82.9	11.08
50% Sol.	.78			95.4	12.75
Soybean Oil	.24-.33			57.4	7.67
Starch				95.4	12.75
Sucrose, 40% Sugar Syrup	.66		214	73.5	9.8
Sucrose, 60% Sugar Syrup	.74		218	80.4	10.75
Sulfur, Melted (500°F)	.24	120	832	112	14.97
Sulfuric Acid, 20%	.84		218	71	9.5
Sulfuric Acid, 60%	.52		282	93.5	12.5
Sulfuric Acid, 98%	.35	219	625	114.7	15.33
Trichloroethylene	.23	103	188	91.3	12.2
Trichloro-Trifluoroethane	.21	63	118	94.6	12.64
Turpentine	.42	133	319	54	7.2
Vegetable Oil	.43			57.5	7.69
Water	1.00	965	212	62.5	8.34
Xylene	.411	149.2	288	53.8	7.2

\* At or near room temperature.

\*\* Average value shown. Boils at various temperatures within the distillation range for the material.

9T: Gases and Vapors

SUBSTANCE	Chemical Formula or Symbol	Specific Heat at Constant Pressure	Density—Weight in lbs./cu. ft. at 70°F and Atmospheric Pressure	Specific Gravity Relative to Air
Acetylene (ethyne)	C <sub>2</sub> H <sub>2</sub>	.35	.0682	.907
Air		.24	.075	1.00
Ammonia	NH <sub>3</sub>	.523	.0448	.596
Argon	A	.124	.1037	1.379
Butane	C <sub>4</sub> H <sub>10</sub>	.395	.1554	2.067
Carbon Dioxide	CO <sub>2</sub>	.199	.115	1.529
Carbon Monoxide	CO	.248	.0727	.967
Chlorine	Cl <sub>2</sub>	.115	.1869	2.486
Ethane	C <sub>2</sub> H <sub>6</sub>	.386	.0789	1.049
Ethylene	C <sub>2</sub> H <sub>4</sub>	.40	.0733	.975
Helium	He	1.25	.0104	.1381
Hydrogen Chloride	HCl	.191	.0954	1.268
Hydrogen	H <sub>2</sub>	3.42	.0052	.0695
Hydrogen Sulphide	H <sub>2</sub> S	.243	.0895	1.19

SUBSTANCE	Chemical Formula or Symbol	Specific Heat at Constant Pressure	Density—Weight in lbs./cu. ft. at 70°F and Atmospheric Pressure	Specific Gravity Relative to Air
Methane	CH <sub>4</sub>	.593	.0417	.554
Methyl Chloride	CH <sub>3</sub> Cl	.24	.1342	1.785
Natural Gas		.56	.0502	.667
Nitric Oxide	NO	.231	.078	1.037
Nitrogen	N <sub>2</sub>	.247	.0727	.967
Nitrous Oxide	N <sub>2</sub> O	.221	.1151	1.53
Oxygen	O <sub>2</sub>	.217	.0831	1.105
Propane	C <sub>3</sub> H <sub>8</sub>	.393	.1175	1.562
Propene (propylene)	C <sub>3</sub> H <sub>6</sub>	.358	.1091	1.451
Sulphur Dioxide	SO <sub>2</sub>	.154	.1703	2.264
Water Vapor at 212 deg. F	H <sub>2</sub> O	.482	.037	.489

Natural Gas values are representative. Specific contents of samplings are required for exact characteristics.

**10T: Air Densities and Properties at Various Temperatures and Pressures**

The density of gases and vapors other than air can be determined by multiplying the figure chosen from below,

by the Specific Gravity Relative to Air column for the substance required from 9T.

Temp. ° F	Specific Heat Btu/lb.°F	Gauge Pressure, PSI at 1 Atmosphere																		
		0	5	10	20	30	40	50	60	80	100	120	140	160	180	200	230	250	275	300
0	.240	.086	.116	.145	.204	.263	.321	.380	.439	.556	.674	.791	.909	1.026	1.144	1.261	1.437	1.555	1.701	1.848
10	.240	.085	.113	.142	.199	.257	.314	.372	.429	.544	.659	.774	.889	1.004	1.119	1.234	1.407	1.522	1.665	1.808
20	.240	.083	.111	.139	.195	.252	.308	.364	.420	.533	.646	.758	.871	.983	1.096	1.208	1.377	1.490	1.631	1.771
30	.240	.081	.109	.136	.191	.246	.302	.357	.412	.522	.632	.743	.853	.963	1.073	1.184	1.349	1.459	1.597	1.735
40	.240	.079	.106	.133	.187	.242	.296	.350	.404	.512	.620	.728	.836	.944	1.052	1.160	1.322	1.430	1.565	1.700
50	.240	.078	.104	.131	.184	.237	.290	.343	.396	.502	.608	.714	.820	.925	1.031	1.137	1.296	1.402	1.535	1.667
60	.240	.076	.102	.128	.180	.232	.284	.336	.388	.492	.596	.700	.804	.908	1.012	1.115	1.271	1.375	1.505	1.635
70	.240	.075	.100	.126	.177	.228	.279	.330	.381	.483	.585	.687	.789	.890	.992	1.094	1.247	1.349	1.447	1.600
80	.240	.074	.099	.124	.174	.224	.274	.324	.374	.474	.574	.674	.774	.874	.974	1.074	1.224	1.324	1.449	1.574
90	.240	.072	.097	.121	.170	.220	.269	.318	.367	.465	.563	.662	.760	.858	.956	1.055	1.202	1.300	1.423	1.546
100	.240	.071	.095	.119	.167	.216	.264	.312	.360	.457	.553	.650	.746	.842	.939	1.036	1.181	1.277	1.398	1.518
120	.240	.068	.092	.115	.162	.208	.255	.301	.348	.441	.534	.627	.721	.814	.907	1.000	1.140	1.233	1.349	1.466
140	.240	.066	.089	.111	.156	.201	.247	.291	.336	.426	.516	.607	.697	.787	.877	.967	1.102	1.192	1.304	1.417
160	.241	.064	.086	.108	.151	.195	.239	.282	.326	.413	.500	.587	.674	.761	.848	.936	1.067	1.153	1.262	1.371
180	.241	.062	.083	.104	.146	.189	.231	.273	.315	.400	.484	.570	.653	.737	.822	.906	1.033	1.117	1.223	1.328
200	.242	.060	.081	.101	.142	.183	.224	.265	.306	.388	.470	.551	.633	.715	.797	.879	1.002	1.084	1.186	1.288
220	.242	.058	.078	.098	.138	.178	.217	.257	.297	.376	.456	.535	.615	.694	.774	.853	.972	1.052	1.151	1.250
240	.242	.057	.076	.095	.134	.173	.211	.250	.288	.365	.443	.520	.597	.674	.751	.829	.944	1.022	1.118	1.215
260	.243	.055	.074	.093	.130	.168	.205	.243	.280	.355	.430	.505	.580	.656	.731	.806	.918	.993	1.087	1.181
280	.243	.054	.072	.090	.127	.163	.200	.236	.273	.346	.419	.492	.564	.638	.711	.784	.893	.966	1.058	1.149
300	.244	.052	.070	.088	.123	.159	.194	.230	.266	.337	.408	.479	.550	.621	.692	.763	.870	.941	1.030	1.119
320	.244	.051	.068	.086	.120	.155	.189	.224	.259	.328	.397	.467	.536	.605	.674	.744	.848	.917	1.003	1.090
340	.244	.050	.067	.083	.117	.151	.185	.219	.252	.320	.387	.455	.522	.590	.658	.725	.826	.894	.978	1.063
360	.246	.048	.065	.081	.114	.147	.180	.213	.246	.312	.378	.444	.510	.576	.641	.707	.806	.872	.954	1.037
380	.246	.047	.063	.079	.112	.144	.176	.208	.240	.305	.369	.433	.498	.562	.626	.691	.787	.851	.932	1.012
400	.247	.046	.062	.078	.109	.140	.172	.203	.235	.298	.360	.423	.486	.549	.612	.674	.769	.832	.910	.989
420	.247	.045	.060	.076	.107	.137	.168	.199	.229	.291	.352	.414	.475	.536	.598	.659	.751	.813	.889	.966
440	.247	.044	.059	.074	.104	.134	.164	.194	.224	.284	.344	.404	.464	.524	.584	.644	.735	.795	.870	.945
460	.248	.043	.058	.073	.102	.131	.161	.190	.220	.278	.337	.396	.454	.513	.572	.630	.719	.777	.851	.924
480	.248	.042	.057	.071	.100	.128	.157	.186	.215	.272	.330	.387	.445	.502	.560	.617	.703	.761	.833	.905
500	.249	.041	.055	.070	.098	.126	.154	.182	.210	.267	.323	.379	.435	.492	.548	.604	.689	.745	.815	.886
520	.249	.041	.054	.068	.096	.123	.151	.178	.206	.261	.316	.371	.426	.482	.537	.592	.675	.730	.799	.868
540	.249	.040	.053	.067	.094	.121	.148	.175	.202	.256	.310	.364	.418	.472	.526	.580	.661	.715	.783	.850
560	.250	.039	.052	.065	.092	.118	.145	.171	.198	.251	.304	.357	.410	.463	.516	.569	.648	.701	.767	.834
580	.251	.038	.051	.064	.090	.116	.142	.168	.194	.246	.298	.350	.402	.454	.506	.558	.636	.688	.753	.818
600	.252	.037	.050	.063	.088	.114	.139	.165	.190	.241	.292	.343	.394	.445	.496	.547	.624	.675	.739	.802
620	.252	.037	.049	.062	.087	.112	.137	.162	.187	.237	.287	.337	.387	.437	.487	.537	.612	.662	.725	.787
640	.252	.036	.048	.061	.085	.110	.134	.159	.183	.233	.281	.331	.380	.429	.478	.527	.601	.650	.712	.773
660	.253	.035	.048	.060	.084	.108	.132	.156	.180	.228	.277	.325	.373	.421	.470	.518	.590	.639	.699	.759
680	.252	.035	.047	.059	.082	.106	.130	.153	.177	.224	.272	.319	.367	.414	.461	.509	.580	.627	.687	.746
700	.254	.034	.046	.058	.081	.104	.127	.151	.174	.221	.267	.314	.360	.407	.453	.500	.570	.616	.675	.733
720	.254	.034	.045	.057	.079	.102	.125	.148	.171	.217	.263	.308	.354	.400	.446	.492	.560	.606	.663	.721
740	.255	.033	.044	.056	.078	.101	.123	.146	.168	.213	.258	.303	.348	.393	.438	.483	.551	.596	.652	.709
760	.256	.033	.044	.055	.077	.100	.121	.143	.165	.210	.254	.298	.343	.387	.431	.475	.542	.586	.642	.697
780	.256	.032	.043	.054	.076	.097	.119	.141	.163	.206	.250	.294	.337	.381	.424	.468	.533	.577	.631	.686
800	.257	.032	.042	.053	.074	.096	.117	.139	.160	.203	.246	.289	.332	.375	.417	.460	.525	.568	.621	.675
820	.257	.031	.042	.052	.073	.094	.115	.137	.158	.200	.242	.284	.327	.369	.411	.453	.517	.559	.611	.664
840	.257	.031	.041	.051	.072	.093	.114	.134	.155	.197	.238	.280	.322	.363	.405	.446	.508	.550	.602	.654
860	.258	.030	.040	.051	.071	.091	.112	.132	.153	.194	.235	.276	.317	.358	.399	.439	.501	.542	.593	.644
880	.259	.030	.039	.050	.070	.090	.110	.130	.151	.191	.231	.272	.312	.352	.393	.433	.494	.534	.584	.634
900	.260	.029	.039	.049	.069	.089	.109	.129	.148	.188	.228	.268	.307	.347	.387	.427	.486	.526	.575	.625
920	.260	.029	.039	.048	.068	.088	.107	.127	.146	.185	.225	.264	.303	.342	.381	.420	.479	.518	.567	.616
940	.260	.028	.038	.048	.067	.086	.106	.125	.144	.183	.221	.260	.299	.337	.376	.414	.472	.511	.559	.607
960	.261	.028	.037	.047	.066	.085	.104	.123	.142	.180	.218	.256	.294	.332	.370	.408	.466	.504	.551	.599
980	.261	.028	.037	.046	.065	.084	.103	.121	.140	.178	.215	.253	.290	.328	.365	.403	.459	.497	.544	.590
1000	.262	.027	.036	.046	.064	.083	.101	.120	.138	.175	.212	.249	.286	.323	.360	.397	.453	.490	.536	.582
1020	.262	.027	.036	.045	.063	.082	.100	.118	.136	.173	.209	.245	.282	.319	.355	.392	.447	.483	.529	.574
1040	.263	.026	.035	.044	.062	.081	.099	.117	.135	.171	.207	.243	.279	.315	.351	.387	.441	.477	.522	.567
1060	.264	.026	.035	.044	.062	.079	.097	.115	.133	.168	.204	.239	.275	.311	.346	.382	.435	.470	.515	.559
1080	.264	.026	.035	.043	.060	.078	.096	.114	.131	.166	.201	.236	.271	.306	.342	.377	.429	.464	.508	.552
1100	.265	.025	.034	.043	.060	.077	.095	.112	.129	.164	.199	.233	.268	.303	.337	.372	.424	.458	.502	.545
1120	.265	.025	.034	.042	.059	.076	.094	.111	.128	.162	.196	.230	.265	.299	.333	.367	.418	.453	.495	.538
1140	.265	.025	.033	.042	.059	.075	.092	.109	.126	.160	.194	.227	.261	.295	.329	.363	.413	.447	.489	.531
1160	.266	.025	.033	.041	.058	.075	.091	.108	.125	.158	.191	.225	.258	.291	.325	.358	.408	.441	.483	.525
1180	.266	.024	.032	.041	.057	.074	.090	.107	.123	.156	.189	.222	.255	.288	.321	.354	.403	.436	.477	.518
1200	.267	.024	.032	.040	.056	.073	.089	.105	.122	.154	.187	.219	.252	.284	.317	.349	.398	.431	.471	.512

Weight in pounds per cubic foot

### 11T: Thermal Conductivity of Various Substances

The following is a listing of the ratios of how fast heat is conducted through each material. The information is useful as a comparison of one substance to another. Large numbers indicate greater conductivity characteristics.\*

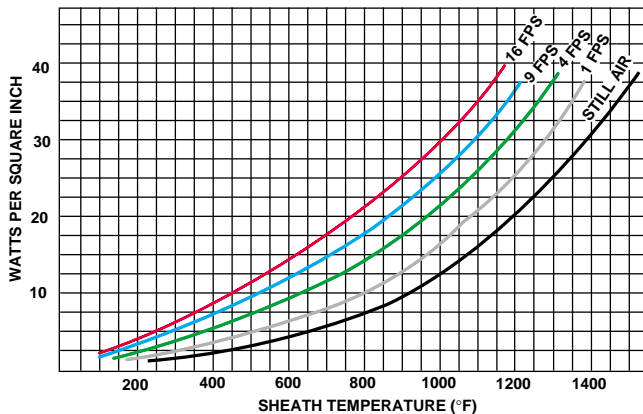
Air	.0568	Coal	.30
Aluminum	480.0	Coke, powdered	.44
Antimony	44.2	Concrete, cinder	.81
Argon	.0389	Concrete, stone	.2
Asbestos, paper	.6	Copper	.918
Bismuth	17.7	Cotton wool	.043
Blotting paper	.15	Cotton batting, loose	.11
Brass	204.0	Cotton batting, packed	.072
Brick, aluminum	.2	Earth, average	4.0
Brick, building	1.5	Eiderdown, loose	.108
Brick, carborundum	.23	Eiderdown, packed	.045
Brick, fire	3.1	Feathers	.016
Brick, graphite	.25	Felt	.022
Brick, magnesia	.71	Fiber, red	.1
Brick, silica	.2	Flannel	.035
Cadmium	222.0	German silver	.80
Carbon gas	.130	Glass, crown	.25
Carbon graphite	290.0	Glass, flint	.2
Carbon dioxide	.0307	Gold	700.0
Carbon monoxide	.0499	Granite	4.5
Carborundum	.50	Gutta percha	.48
Cardboard	.50	Gypsum	.31
Cement, portland	.17	Hair	.015
Chalk	.28	Hair cloth, felt	.042
Charcoal, powdered	.22	Helium	.339
Clinkers, small	.11	Horn	.087
		Hydrogen	.327

Ice	.39	Petroleum	.039
Iron, pure	161.0	Pumice stone	.043
Iron, cast	109.0	Quartz, pr. to axis	.30
Iron, wrought	144.0	Quartz, perp. to axis	.160
Lamp black	.07	Rubber, hard	.043
Lead	.83	Rubber, Para	.038
Leather, cowhide	.042	Sand, dry	.086
Leather, chamois	.015	Sandstone	.5
Lime	.029	Sawdust	.014
Linen	.021	Silica, fused	.255
Magnesia	.03	Silk	.013
Magnesium, carb	.023	Silver	.974
Marble	.84	Slate	.48
Mercury	.197	Snow	.060
Mica	.086	Steel	.115
Nickel	.142	Terra Cotta	.23
Nitrogen	.0524	Tin	.155
Oxygen	.0563	Water	.16
Paper	.031	Wood, fir, with grain	.030
Paraffin	.062	Wood, fir, cross grain	.009
Pasteboard	.045	Wool, sheep	.014
Plaster of Paris	.042	Wool, mineral	.011
Plaster, mortar	.13	Wool, steel	.020
Platinum	170.0	Woolen, loose, wadding	.012
Plumbago	1.0	Zinc	.265
Poplox (Na2SiO3)	.013		
Porcelain	.43		

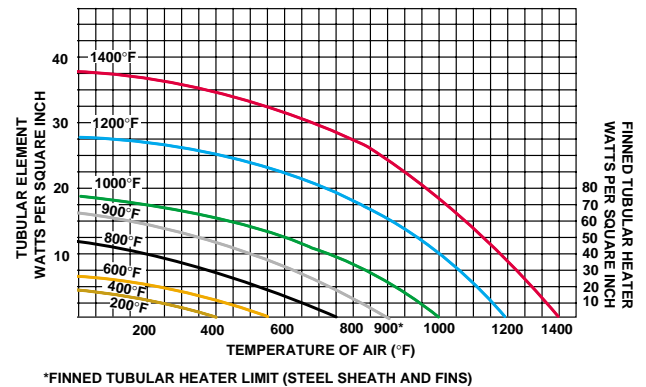
\* Expressed in gram-calories/second/square centimeter/centimeter/°C

### SHEATH TEMPERATURES RELATIVE TO WATT DENSITY

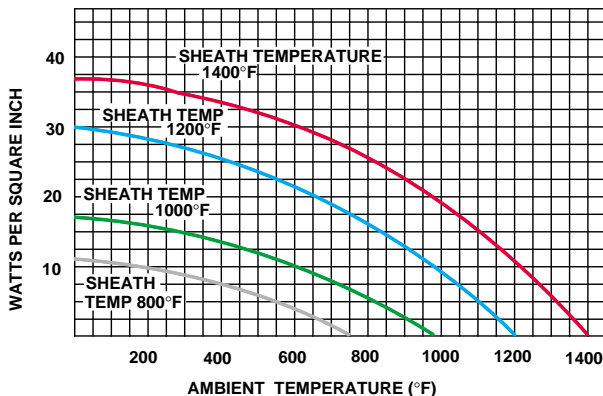
12T: Sheath Temperature of Tubular Elements at Various Watt Densities in Free or Forced Air at 80°F.



14T: Allowable Watt Density of Tubular Elements Operating at 800° to 1400°F Sheath Temperature for Various Temperatures in Distributed Air Velocity of 1 Fps.

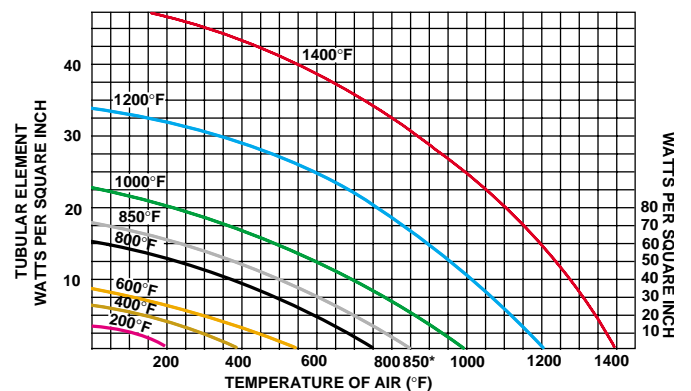


13T: Sheath Temperatures of Tubular Elements Clamped to a Surface at Various Ambient Temperatures and Watt Densities



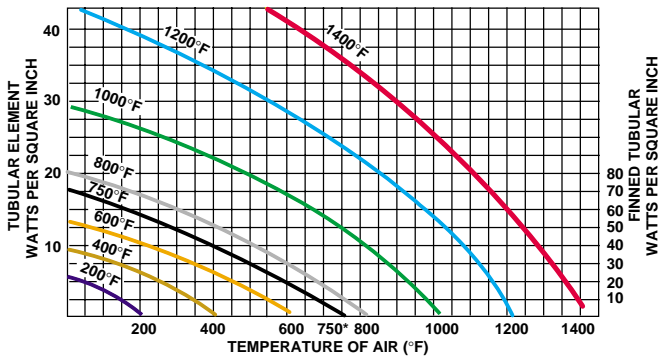
$$\text{AMBIENT TEMPERATURE} = \frac{\text{Sheath Temperature} + \text{Temperature at Process (Work)}}{2}$$

15T: Allowable Watt Density of Tubular Elements Operating at 800° to 1400°F Sheath Temperature for Various Temperatures in Distributed Air Velocity of 4 Fps.



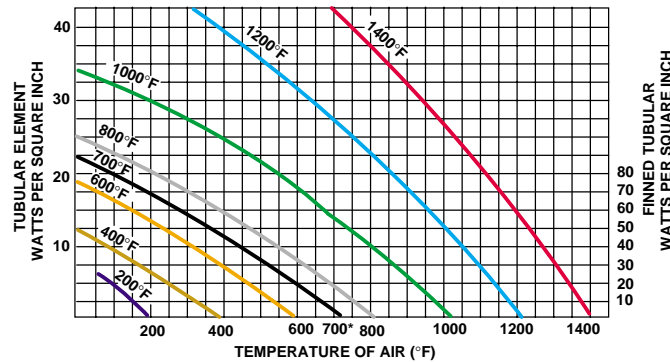
\*FINNED TUBULAR HEATER LIMIT (STEEL SHEATH AND FIN)

**16T: Allowable Watt Density of Tubular Elements Operating at 800° to 1400°F Sheath Temperature for Various Temperatures in Distributed Air Velocity of 9 Fps.**



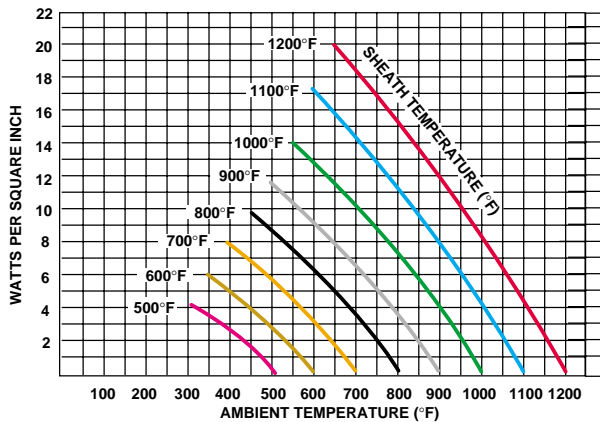
\*FINNED TUBULAR HEATER LIMIT (STEEL SHEATH AND FINS)

**17T: Allowable Watt Density of Tubular Elements Operating at 800° to 1400°F Sheath Temperature for Various Temperatures in Distributed Air Velocity of 16 Fps.**



\*FINNED TUBULAR HEATER LIMIT (STEEL SHEATH AND FINS)

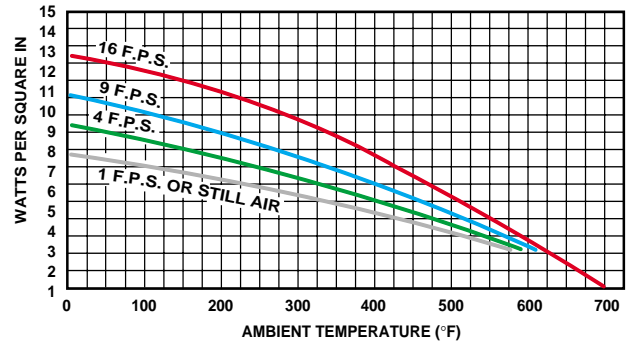
**18T: Sheath Temperature of HD Strip Heaters Clamped to a Surface at Various Ambient Temperatures and Watt Densities<sup>1</sup>**



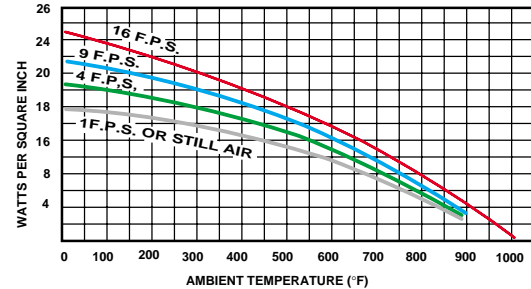
$$\text{AMBIENT TEMPERATURE} = \frac{\text{Sheath Temperature} + \text{Temperature at Process (Work)}}{2}$$

1. Use stainless steel materials (and fins) over 750°F sheath temperatures.  
2. Where element spacing is close, use 80% of values.

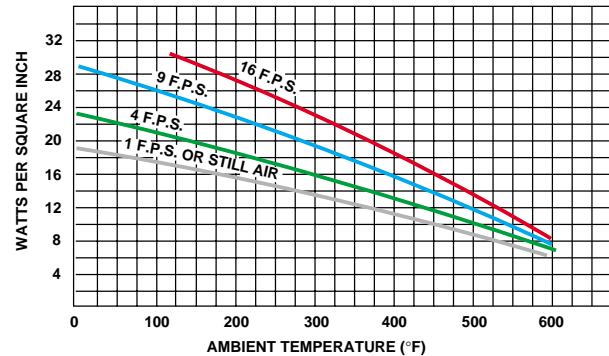
**19T: Allowable Watt Density of HD Strip Heaters to Produce 700°F Sheath Temperatures at Various Ambient Temperatures and Air Velocities<sup>2</sup>**



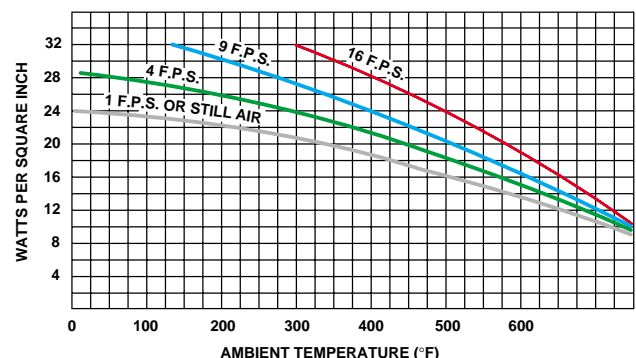
**20T: Allowable Watt Density of HD Strip Heaters to Produce 1000°F Sheath Temperatures at Various Ambient Temperatures and Air Velocities. Use Stainless Steel Sheath Material<sup>2</sup>**



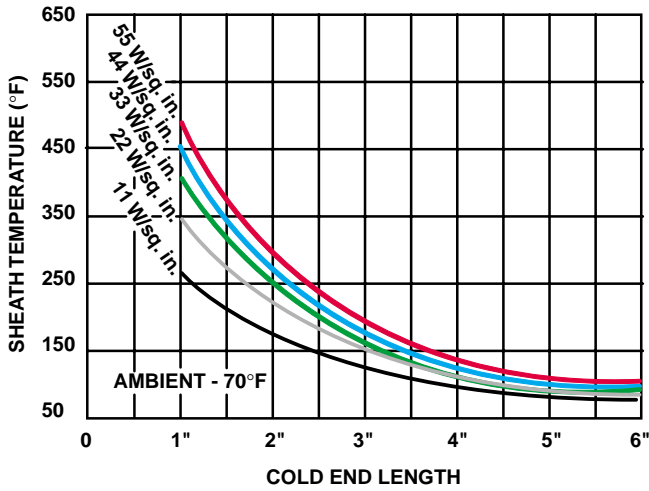
**21T: Allowable Watt Density of Finned HD Strip Heaters to Produce 600° to 700°F Sheath Temperatures at Various Ambient Temperatures and Air Velocities<sup>2</sup>**



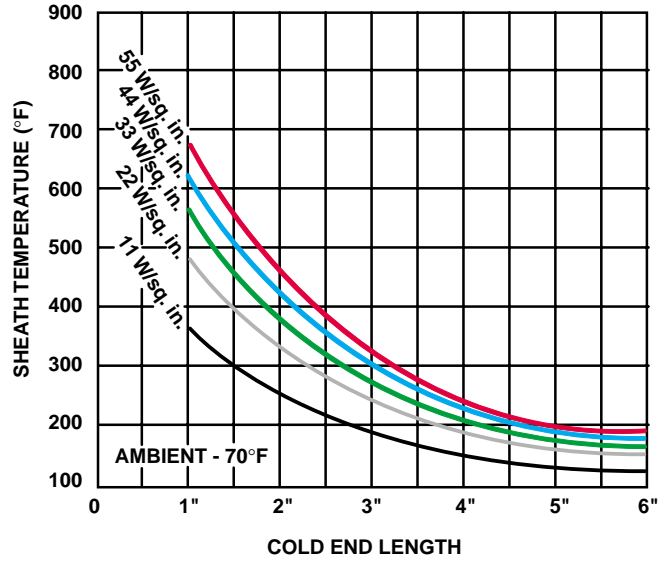
**22T: Allowable Watt Density of Finned HD Strip Heaters to Produce 800° to 900°F Sheath Temperatures at Various Ambient Temperatures and Air Velocities<sup>1,2</sup>**



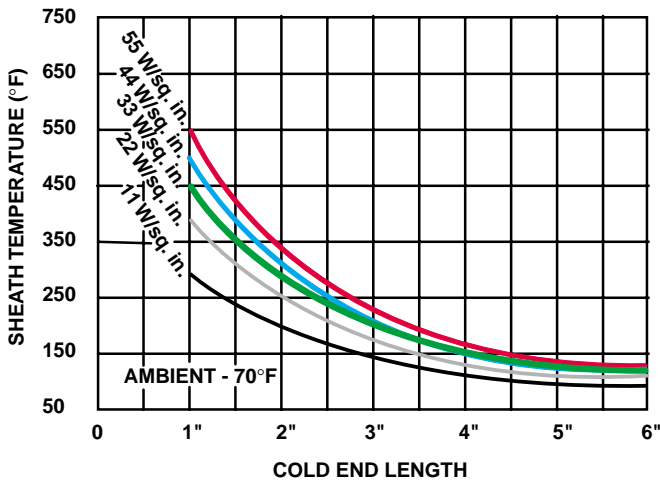
22A: Sheath Temperature vs Cold End – .25" Diameter Tubular



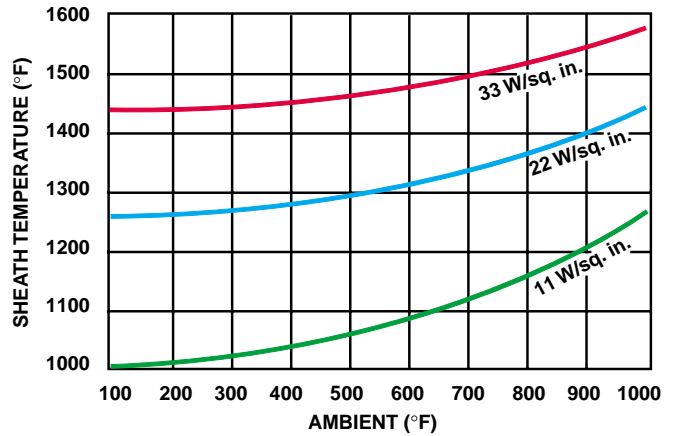
22D: Sheath Temperature vs Cold End – .475"/.490" Diameter Tubular



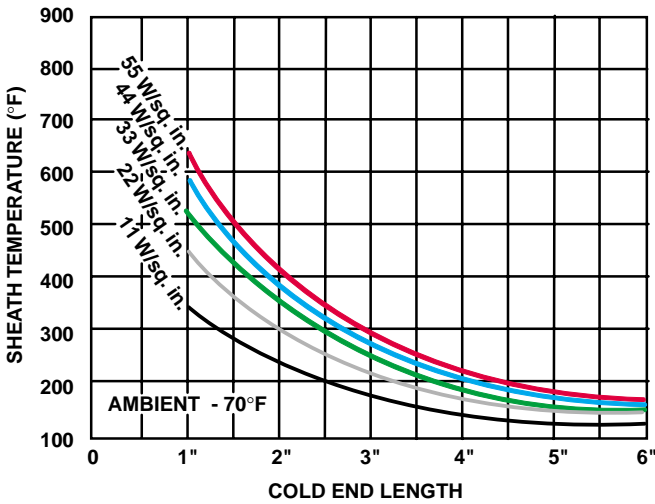
22B: Sheath Temperature vs Cold End – .312" Diameter Tubular



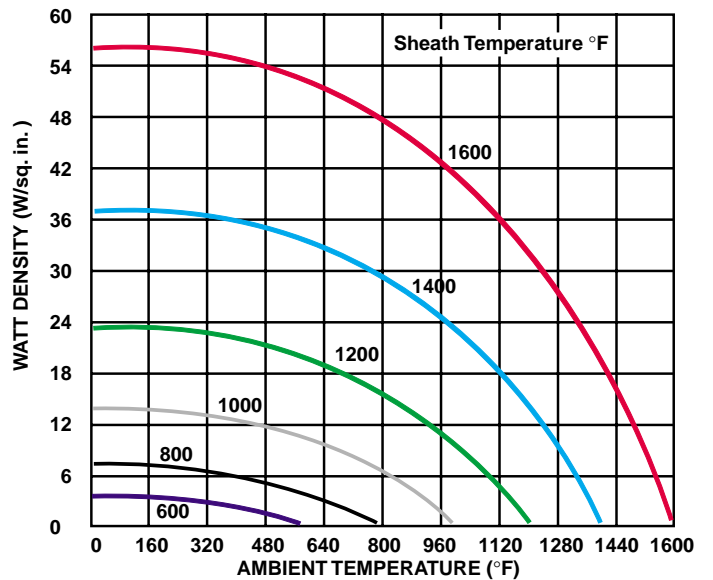
22E: Sheath Temperature vs Ambient Temperature in a Vacuum – .430" Diameter Tubular



22C: Sheath Temperature vs Cold End – .430" Diameter Tubular



22F: Tubular Heater Sheath Temperatures Operating in Different ambient temperatures at various watt densities.



**23T: Watt Density and Operating Temperature Guidelines for Various Materials**

The information presented is only intended as a guideline. Adjustments may be necessary should variations occur in heat transfer, flow rates and temperatures. The sheath material and watt density selected must be based upon the specific dynamics of the application. See complete **Corrosion Resistance of Sheath Materials (24T)**.

Material To Be Heated	Maximum Operating Temp (°F)	Max. Watt Density (W/sq. in.)	Sheath Material
Acid Solutions (Mild)			
Acetic	180	40	C-20, Quartz
Boric	257	40	Quartz
Carbonic	180	40	
Chromic	180	40	C-20, Quartz
Citric	180	23	316 S.S.
Fatty Acids	150	20	316 S.S.
Lactic	122	10	316 S.S.
Malic	122	10	316 S.S.
Nitric	167	20	Quartz
Phenol—2.4 Disulfonic	180	40	316 S.S.
Phosphoric	180	23	Quartz
Phosphoric (Aerated)	180	23	Stainless Steel
Propionic	180	40	Copper
Tannic	167/180	23/40	Quartz
Tartaric	180	40	316 S.S.
Acetaldehyde	180	10	Copper
Acetone	130	10	Incoloy
Air	C/F		Incoloy
Alcyl Alcohol	200	10	Copper
Alkaline Solutions	212	40	Steel
Aluminum Acetate	122	10	316 S.S.
Aluminum Potassium Sulfate	212	40	Copper
Ammonia Gas	C/F		Steel
Ammonium Acetate	167	23	Incoloy
Amyl Acetate	240	23	Incoloy
Amyl Alcohol	212	20	Stainless Steel
Aniline	350	23	Stainless Steel
Asphalt	200-500	4-10	Steel
Barium Hydroxide	212	40	316 S.S.
Benzene, liquid	150	10	Copper
Butyl Acetate	225	10	316 S.S.
Calcium Bisulfate	400	20	316 S.S.
Calcium Chloride	200	5-8	Quartz
Carbon Monoxide	—	23	Incoloy
Carbon Tetrachloride	160	23	Incoloy
Caustic Soda 2%	210	48	Incoloy
10%	210	25	Incoloy
75%	180	25	Incoloy
Citrus Juices	185	23	316 S.S.
Degreasing Solution	275	23	Steel
Dextrose	212	20	Stainless Steel
Dyes & Pigments	212	23	Stainless Steel
Electroplating Baths			
Cadmium	180	40	Stainless Steel
Copper	180	40	Quartz
Dilute Cyanide	180	40	316 S.S.
Potassium Cyanide	180	40	Quartz
Rochelle Cyanide	180	40	Stainless Steel
Sodium Cyanide	180	40	Stainless Steel
Ethylene Glycol	300	30	Steel
Formaldehyde	180	10	Stainless Steel
Freon gas	300	2-5	Steel

Material To Be Heated	Maximum Operating Temp (°F)	Max. Watt Density (W/sq. in.)	Sheath Material
Fuel Oils			
Grades 1 & 2 (distillate)	200	23	Steel
Grades 4 & 5 (residual)	200	13	Steel
Grades 6 & bunker C (residual)	160	8	Steel
Gasoline	300	23	Steel
Gelatin: Liquid	150	23	Stainless Steel
Solid	150	5	Stainless Steel
Glycerine	500	10	Incoloy
Glycerol	212	23	Incoloy
Grease: Liquid	—	23	Steel
Solid	—	5	Steel
Hydrazine	212	16	Stainless Steel
Hydrogen	C/F	—	Incoloy
Hydrogen Sulfide	C/F	—	316 S.S.
Linseed Oil	150	50	Steel
Lubrication Oil			
SAE 10	250	23	Steel
SAE 20	250	23	Steel
SAE 30	250	23	Steel
SAE 40	250	13	Steel
SAE 50	250	13	Steel
Magnesium Chloride	212	40	C-20, Quartz
Manganese Sulfate	212	40	Quartz
Methanol gas	C/F	—	Stainless Steel
Methylchloride	180	20	Copper
Mineral Oil	200	23	Steel
	400	16	Steel
Molasses	100	4-5	Stainless Steel
Naptha	212	10	Steel
Oil Draw Bath	600	23	Steel
Oils (see specific type)	400	24	Steel
Paraffin or Wax (liquid state)	150	16	Steel
Perchloroethylene	200	23	Steel
Potassium Chlorate	212	40	316 S.S.
Potassium Chloride	212	40	316 S.S.
Potassium Hydroxide	160	23	Monel
Soap, liquid	212	20	Stainless Steel
Sodium Acetate	212	40	Steel
Sodium Cyanide	140	40	Stainless Steel
Sodium Hydride	720	28	Incoloy
Sodium Hydroxide	—	See Caustic Soda	—
Sodium Phosphate	212	40	Quartz
Steam, flowing	300	10	Incoloy
	500	5-10	Incoloy
	700	5	Incoloy
	700	5	Incoloy
Sulfur, Molten	600	10	Incoloy
Toluene	212	23	Steel
Trichlorethylene	150	23	Steel
Turpentine	300	20	Stainless Steel
Vegetable Oil & Shortening	400	30	Stainless Steel
Water (Process)	212	60	S.S., Incoloy

**Properties of Heat Transfer Oils:** Sheath material utilized is typically steel

Material	Maximum Fluid Temperature °F	Maximum Sheath Temperature °F	Maximum w/in. <sup>2</sup>	Density Weight in lbs/cu. ft.	Specific Heat	Flammability °F			Minimum Velocity of Material Through Elements in Ft./Second			
						Flash Point	Fire Point	Auto Ignition	8 w/in. <sup>2</sup>	16 w/in. <sup>2</sup>	23 w/in. <sup>2</sup>	30 w/in. <sup>2</sup>
Caloria HT 43	475	680	12	52.0	0.43	400	—	670	1.5	2.5	3	4
Dowtherm A	725	835	20	66.0	0.38	255	275	1150	.5	1	2	3
Dowtherm J	575	650	20	54.1	0.43	145	155	806	1	2	3	4.5
Dowtherm LF	575	675	20	63.0	0.40	260	280	1020	.7	1.5	2.5	3.5
Dowtherm G	675	775	20	68.6	0.37	305	315	1150	.7	1.5	2.5	3.5
Dowtherm HT	625	700	20	60.6	0.37	—	—	—	1.5	2.5	3.5	5
Marlotherm S	675	695	12	60.8	0.43	374	—	932	1.5	3	5	7
Mobiltherm 603	550	625	20	53.9	0.44	380	—	—	1.5	3	5	7
Multitherm PG-1	565	640	12	54.2	0.45	340	385	690	1	2	3	4
Multitherm IG-2	575	650	20	54.8	0.47	440	500	700	.8	1.7	2.3	3
Syltherm XLT	475	550	12	52.6	0.40	116	130	662	1.5	2.5	4	5
Syltherm 800	725	800	12	58.7	0.38	350	380	725	1.5	3	5	7
Therminol 44	400	475	12	57.8	0.47	405	438	705	1	2	3	4
Therminol 55	560	605	12	55.2	0.46	350	410	675	1.5	2.5	3.5	5
Therminol 59	575	650	20	60.6	0.41	302	335	770	1.5	2.5	3.5	5
Therminol 60	560	655	20	62.6	0.39	310	320	835	1.5	3	5	7
Therminol 75	675	805	20	68.8	0.38	390	440	1000	1	2	3	4
Therminol LT	475	650	20	53.7	0.43	134	150	805	1.5	2.5	4	5
Therminol VP-1	725	800	20	66.7	0.37	255	280	1150	1	2	3	4
UCON 500	475	550	12	64.8	0.47	540	600	750	1	2	3	4

C/F —Consult Factory NOTE: C-20 designates Carpenter Stainless #20

### 24T: Corrosion Resistance of Sheath Materials

The following is a guideline to select an immersion heater sheath material for direct heating of corrosive materials. Based on known data and experience on the compatibility of standard materials and corrosive environments, the information should only be considered an initial step in the selection process. Other information can come from the manufacturer of the corrosive material and testing. The final selection comes from the end user's knowledge of the process. Variables to consider include:

1. Solution chemistry
2. Possible contamination of the solution from other processes
3. Process temperature
4. Flow rate (velocity) across elements
5. Reducing heater watt density to keep element temperatures as low as possible
6. Accumulating sludge can impede heat transfer from the elements to the process and can accelerate corrosion.
7. The welding or other contact of dissimilar metals could generate galvanic corrosion
8. Provision should be made to periodically inspect the elements to

insure the continuation of the process  
9. See warranty statement pertaining to corrosion

#### \*NOTES

1. This solution involves a mixture of various chemical compounds whose identity and proportions are unknown or subject to change without prior knowledge. Check supplier to confirm choice of sheath materials plus alternate sheath materials that may be used.
2. Caution – Flammable material
3. Chemical composition varies widely. Check supplier for specific recommendations.
4. Direct immersion heaters not practical. Use clamp-on heaters on outside surface.
5. Element watt density should not exceed 20 watts/sq. in.
6. For concentrations greater than 15%, element watt density should not exceed 20 watts/sq. in.
7. See suggested watt density chart.
8. Remove crusts at liquid level.
9. Clean often.
10. Do not exceed 12 watts/sq. in.
11. Passivate stainless steel, Inconel and Incoloy.

SOLUTION	SHEATH MATERIAL														
	IRON-STEEL	CAST IRON	ALUMINIUM	COPPER	MONEL-400	304-321 347 S.S.	316 S.S.	CARPENTER STAINLESS #20	INCOLOY 800	INCONEL 600	TITANIUM	QUARTZ	TEFLON		
Acetic Acid	X	X	C	X	B	C	B	A	C	C	A	A	A	Note 2	
Acetone	X	X	B	A	A	B	B	A	A	A	A	A	A	Note 1	
Alcohol	B	B	B	A	A	B	A	A	A	A	A	A	A	Note 1	
Alcorite														Note 1	
Alkaline Cleaners						B							X	Note 1, Note 9	
Alkaline Soaking Cleaners	B													Note 1	
Alodine							A					A	A	Note 1	
Aluminum Bright Dip								X				A	A	Note 1	
Aluminum Chloride	X	X	X	X	X	X	X	X	X	X	C	A	A	Note 1	
Aluminum Cleaners	C	C	X	X	A	A	A	B	A	A	B	X	X	Note 1	
Aluminum Sulphate	X	X	X	X	X	A	A	A	X	X	A	A	A	Note 1	
Alum	X	X	X	X	X	X	X	B	X	X	X	A	A	Note 1	
Ammonia	X	X	C	X	X	X	X	X	C	B	A	A	A		
Ammonium Bifluoride	X	X	X	X	X	X	X	B	X	X	X	X	A		
Ammonium Chloride	X	X	X	X	C	C	C	C	C	C	A	A	A		
Ammonium Hydroxide	A	A	X	X	A	A	A	A	A	A	A	X	A		
Ammonium Nitrate	A	X	C	X	X	A	A	A	X	X	X	A	A		
Ammonium Persulphate	X	X	X	X	X	C	B	B	C	C	A	A	A		
Ammonium Sulphate	X	X	X	X	B	C	B	B	B	B	A	A	A	Note 2	
Amyl Alcohol	A	B	C	A	B	B	B	B	B	B	A	A	A		
Aniline	B	B	B	X	B	A	A	A	B	B	A	A	A		
Anodizing	X	X	X	X	X	X	X	A	X	X	X	A	A		
ARP-28												A	A	Note 1	
ARP-80 Blackening Salt														Note 1	
Arsenic Acid	X	X	X	X	X	C	B	B	X	X	X	A	A	Note 2	
Asphalt	A	A	X	X	X	A	A	A	A	A	A	A	A		
Barium Hydroxide	B	B	X	X	B	B	A	A	B	B	X	A	A		
Barium Sulphate	B	B	B	B	B	B	B	B	B	B	A	A	A		
Black Nickel													A	Note 5	
Black Oxide						A								Note 5	
Boric Acid	X	X	X	C	C	C	C	C	C	C	A	A	A		
Brass Cyanide						A								Note 1	
Bright Copper-Acid												A	A	Note 1	
Bright Copper-Cyanide	A					A								Note 1	
Bright Nickel											A	A		Note 1, Note 5	
Bronze Plating	A					A								Note 1	
Butanol	A	A	B	A	A	A	A	A	A	A	A	A	A	Note 2	
Cadmium Black												A	A	Note 1	
Cadmium Plating						A								Note 1	
Calcium Chlorate	B	B	B	C	B	B	B	B	B	B					
Calcium Chloride	B	B	A	B	B	B	B	B	B	B	A	A	A		
Carbon Dioxide-Dry Gas	X	X	A	A	A	A	A	A	A	A	X	A	X		
Carbon Dioxide-Wet Gas	X	X	A	X	A	A	A	A	A	A	X	A	X		
Carbonic Acid	C	C	B	C	C	B	B	A	B	A	A	A	A		
Carbon Tetrachloride	X	X	X	A	A	A	A	A	A	A	A	A	A		
Castor Oil	A	A	A	A	A	A	A	A	A	A	A	A	A		
Caustic Etch	A	A	X	C	A	A	A	A	A	A	A	X	A	Note 6	
Chlorine Gas-Dry	X	X	X	X	C	C	C	B	C	B	B	A	B		
Chlorine Gas-Wet	X	X	X	X	X	X	X	X	X	X	X	A	X		
Chloroacetic Acid	X	X	X	X	C	X	X	X	C	C	A	A	A		
Chromium Plating	X	X	X	X	X	X	X	X	X	X	A	A	X		
Chromic Acetate												A	A	Note 1	
Chromic Acid	X	X	X	X	X	X	X	X	X	X	A	A	X		
Chromic Anodizing												A	A	Note 1	

A—Good

B—Fair

C—Depends upon conditions

X—Unsuitable

Blank—Data unavailable

24T (continued): Corrosion Resistance of Sheath Materials

SOLUTION	SHEATH MATERIAL													*NOTES
	IRON-STEEL	CAST IRON	ALUMINUM	COPPER	MONEL-400	304, 321, 347, S.S.	316 S.S.	CARPENTER STAINLESS #20	INCOLOY 800	INCONEL 600	TITANIUM	QUARTZ	TEFLON	
Chromylite Citric Acid Clear Chromate Cobalt Nickel Cobalt Plating Cod Liver Oil	X	X	X	X	B	B	A	A	B	B	A	A A A A	A	Note 1  Note 1 Note 1, Note 6 Note 1
Copper Acid Copper Bright Copper Bright Acid Copper Chloride Copper Cyanide Copper Fluoborate	X A	X A	X X	X X	X C B	X B B	X B B	X B B	X X B	X X B	A	A A A	A A	Note 1 Note 1 Note 1
Copper Nitrate Copper Pyrophosphate Copper Strike Copper Sulphate Creosote Cresylic Acid	X A X A C	X A X A C	X X C C	X C B C	X C B C	B A A B B B	B B B B	B A B B	C C B C	X X B C		A A A A	A A	Note 1 Note 1  Note 2 Note 2
Deionized Water Deoxidizer (Etching) Deoxidizer (3AL-13) Dichromic Seal Diethylene Glycol Diversey-DS9333	X B	X A	B	B	B	A	A	A	A	B	B	A A A	A	Note 1 Note 1, Note 5 Note 1, Non-Chromate  Note 1
Diversey-511 Dur-Nu Electro Cleaner Electro Polishing Electroless Nickel Electroless Tin (Acid)	A					A						A A A A		Note 1, Note 5 Note 1, Note 5 Note 1 Note 1 Note 1 Note 1
Electroless Tin (Alkaline) Ether Ethone Acid-80 Ethyl Chloride Ethylene Glycol Fatty Acids	B B A X	B B A X	B A A	B A X	B B B	B B B	A B A	A A B	B B B	B A B	A A A A	A A A A	A A	Note 1 Note 2 Note 1 Note 2 Note 5
Ferric Chloride Ferric Nitrate Ferric Sulphate Fluoborate (high speed) Fluorine Gas, Dry Formaldehyde	X X X C X	X X X X X	X X X B	X X X B	X X X B	X B B A	X B B A	X A B C	X X C B	X X C B	A A A A A	A A A A A	A	Note 1
Formic Acid Freon Fuel Oil-Normal Fuel Oil-Acid Gasolene-Refined Gasolene-Sour	X A A X A C	X A A X A C	B A A X A C	B A A X A C	B A A C B	A A A C B	X A A B A	A A A A A	B A B C X	B A B C X	C A	A		Note 2, Note 3, Note 7 Note 2, Note 3, Note 7 Note 2, Note 5 Note 2, Note 3, Note 5
Glycerin, Glycerol Gold Acid Gold-Cyanide Grey Nickel Hot Seal Sodium Dichromate Hydrocarbons-Aliphatic	B A  A	B  A	A  A	B  A	A  A	A  A	A  A	A  A	A  A	A  A	A  A	A  A	A	Note 1 Note 1 Note 1, Note 5 Note 1 Note 2
Hydrocarbons-Aromatic Hydrochloric Acid Hydrocyanic Acid Hydrofluoric Acid Hydrogen Peroxide Iridium	A X X X X	A X X X X	A X B X A	A X X X X	A X B X B	A X B X B	A X B X B	A X B X B	A X B X B	A X B X B	X X X A	A A A A	A	Note 2  Note 5 Note 1
Iridite-#4-75, #4-73 #14, #14-2, #14-9, #18-P Iridite #1, #2, #3, #4 C, #4PC&S, #4P-4, #4-80, #4L-1, #4-2, #4-2A, #4-2P, #5P-1, #7, #7-P, #8, #8-P, #8-2, #12-P, #15, #17P, #18P							A					A		Note 1  Note 1

A—Good

B—Fair

C—Depends upon conditions

X—Unsuitable

Blank—Data unavailable

24T (continued): Corrosion Resistance of Sheath Materials

SOLUTION	SHEATH MATERIAL											*NOTES		
	IRON-STEEL	CAST IRON	ALUMINUM	COPPER	MONEL-400	304, 321, 347, S.S.	316 S.S.	CARPENTER STAINLESS #20	INCOLOY 800	INCONEL 600	TITANIUM		QUARTZ	TEFLON
Iridite dyes- #12L-2, #40, #80 Irilac Iron Phosphate Isoprep Deoxidizer #187, #188 Isoprep Acid Aluminum Cleaner #186							A					A	A	Note 1 Note 1 Note 1 Note 1
Jeta Kerosene Lacquer Solvent Lead Acetate Lead Acid Salts Lime Saturated Water	A A X A B	A A X A B	A A X A X	A A X A B	A B A B B	A A A A B	A A A A A	A A A A B	A B A A B	A B A A B	A A A A B	A A A A X		Note 1 Note 2 Note 2 Note 1
Linseed Oil Magnesium Chloride Magnesium Hydroxide Magnesium Nitrate Magnesium Sulfate McDermid #629	A X A B B	A X A B B	B X B B B	B B A B B	B B A B A	A C A B B	A B A B B	A A A B B	B B A B B	B A A X A	A A A A A	A A A A A	A	Note 2 Note 1
Mercuric Chloride Mercury Methyl Alcohol Methanol Methyl Bromide Methyl Chloride Methylene Chloride	X A B C X X	X A B C C C	X X C X X C	X X B B A C	X B A B A C	X A B A C C	X A B A C C	X A B A A A	X A B B C C	X B A B C B	A A A A A A	A A A A A A		Note 2
Mineral Oil Muriato Naphtha Nickel Acetate Sea Nickel Chloride Nickel Plate-Bright	A A A X	A B A X	A A A X	A A A X	A A A C	A A A X	A A A C	A A A B	A A A C	A A A B	A A A C	A A A A	A A A A	Note 1 Note 2 Note 1 Note 1, Note 5 Note 1, Note 5
Nickel Plate-Dull Nickel Plate-Watts Sol. Nickel Sulphate Nickel Copper Strike (Cyanide Free) Nitric Acid	X X X X	X X X X	X X X X	C C C X	C C A C	B B A C	B B A C	B B A B	C C X X	C C X X	A A A A	A A A A	A A A A	Note 1, Note 5 Note 1, Note 5 Note 1
Nitric Hydrochloric Acid Nitric 6% Phosphoric Acid Nitric Sodium Chromate Nitrobenzene Dakite #67 Oil	X A A A	X B A A	X B B A	X B B A	X B B A	X A A A	X A A A	X A A A	X A A A	X B B A	X A A A	A A A A	A A A A	Note 1 Note 1 Note 2 Note 1 Note 7
Oleic Acid Oxalic Acid Paint Stripper (High Alkaline Type) Paint Stripper (Solvent Type) Paraffin Perchloroethylene	C X A A A	C X A A A	C X A A B	C B A A B	B B A A A	C X A A A	B X A A A	B B A A A	B X A A A	A B B A A	B X A A A	A A A A	A A A A	Note 1 Note 1, Note 2 Note 2, Note 7
Petroleum-Crude Phenol Phosphate Phosphate Cleaner Phosphatizing Phosphoric Acid	B B X	B B X	A B X	A A C	A B A	A C X	A B B	A A B	B B C	B B C	A A X	A A A	X X X A	Note 2, Note 3, Note 7 Note 1, Note 5, Note 9 Note 1, Note 5, Note 9 Note 1, Note 5, Note 9 Note 5, Note 9
Picric Acid Potassium Acid Sulphate Potassium Bichromate Potassium Chloride Potassium Cyanide Potassium Hydrochloric	X C X C	X C X X	X B X X	X A C X	X B B C	B B C B	B B A B	B B A B	C B C B	C C C B	A A A X A	A A A A A	A A A A	Note 1 Note 1
Potassium Hydroxide Potassium Nitrate Potassium Sulphate Reynolds Brightener Rhodium Hydroxide Rochelle Salt Cyanide	X B C A	X B X	X A A	X B B	B B A	C B A	C B A	C B A	C B B	B B B	C A A A A	A A A A A	A A A A	Note 1 Note 1

A—Good      B—Fair      C—Depends upon conditions      X—Unsuitable      Blank—Data unavailable

24T (continued): Corrosion Resistance of Sheath Materials

SOLUTION	SHEATH MATERIAL													*NOTES
	IRON-STEEL	CAST IRON	ALUMINUM	COPPER	MONEL-400	304, 321, 347, S.S.	316 S.S.	CARPENTER STAINLESS #20	INCOLOY 800	INCONEL 600	TITANIUM	QUARTZ	TEFLON	
Ruthenium Plating	X	X	X	X	C	X	X	C			A	A	A	Note 1
Silver Bromide	C	C	X	X	B	A	A	A			A	A	A	
Silver Cyanide						A	A		A					Note 1
Silver Lume						C	C	B	C	C	A	A		
Silver Nitrate	X	X	X	X	X	A	C	B						Note 1
Soap Solutions	A	A	X			A	A	A						Note 3
Sodium-Liquid Metal	C	X	X	X	B	A			A	A		X		
Sodium Bisulphate	X	X	C		C	X	X	B	B	C	C	A		
Sodium Bromide	B	X	X	B	B	X	B	B	B	B		A	A	
Sodium Carbonate	C	C	X	A	B	B	B	B	B	B	A	C	A	
Sodium Chlorate	X	X	B	A	A	B	B	B	B	A	A	A	A	
Sodium Chloride	X	X	X	B	A	X	X	C	B	A	C	A	A	
Sodium Citrate	X	X	X	X		B	B	B				A	A	
Sodium Cyanide	X	B	X	X	X	A	A	A				A	A	
Sodium Dichromate (Sodium Bichromate)	A	A	C	X		B	B	B			C	A		
Sodium Hydroxide	C	C	X	X	C	X	C	C	B	B	C	X	A	Note 8, Note 6
Sodium Hypochlorite	X	X	X	X	X	X	X	B	X	X	A	A	A	
Sodium Nitrate	B	B	X	C	B	A	A	A	A	A	A	A		Note 5
Sodium Peroxide	B	A	B	X	B	B								
Sodium Phosphate	B	B	X	B	B	B	B	B	B	B	A	A	A	
Sodium Salicylate	B	C			B	B	B	B	B	B	A	A	A	
Sodium Silicate	B	B	X	B	B	B	B	B	B	B	A	A	A	Note 4
Sodium Sulphate	B	X	A	B	B	X	B	B	B	B	C	A	A	
Sodium Sulphide	X	X	X	X	B	X	C	C	B	C	C	C	A	
Solder Bath	X	B	X	X	X	X	X	X	X	X	X	X	X	
Sodium Stannate	C	C			B	B	B	B	B	B		A	A	Note 1
Stanostar												A	A	
Stearic Acid	C	C	B	X	X	C	A	B	B	A	A	A	A	
Sugar Solution	A	A	A	A	A	A	A	A	A	A	A	A	A	Note 7
Sulfamate Nickel											A	A	A	Note 1
Sulfuric Acid	X	X	X	X	X	X	X	B	X	X	X	A	A	
Sulfurous Acid	X	X	C	X	X	X	X	A	X	X	A	A	A	
Sulphamic Acid	X	X	X		X	X	X				A	A	A	
Sulphur	X	X	A	X	B	A	A	A	A	A	A	A	A	
Sulphur Chloride	X	X	X	X	C	A	C	C	C	B	A	A	A	
Sulphur Dioxide	C	C	C	C	X	C	B	B	C	C	A	A		
Tannic Acid	X	X	C	X	C	B	B	B	C	C	A	A		
Tin (Molten)			X	X	X	X	X	X					X	Note 4
Tin-Nickel Plating												A	A	Note 1
Tin Plating-Alkaline	A					A	A	A	A	A	A	A		Note 1
Trichloroethane	A	A	A	A	A	A	A	A	A	A	A	A		
Trichlorethylene	A	A	A	B	B	A	A	A	A	A	A	A		
Triethylene Glycol	A	A	A	A	A	A	A	A	A	A	A	A		
Trisodium Phosphate	A	A	X	C	C	C	C	C				X	X	Note 1
Trioxide (Pickle)												A	A	Note 1
Turco 4181 (Alk. Cleaner)							A							Note 1
Turco 4008 (Descaler)							A							Note 1, Note 5
Turco 4338 (Oxidizer)							A							Note 1, Note 7
Turco Ultrasonic Solution							A							Note 1
Ubec											A	A	A	Note 1
Udylite #66											A	A	A	Note 1, Note 5
Unichrome CR-110											A	A	A	Note 1
Unichrome 5RHS											A	A	A	Note 1
Water Deionized	X	X	X	X	A	A	A	A	A	A				Note 11
Water Demineralized	X	X	X	X	A	A	A	A	A	A				Note 11
Water Pure	X	X	X	X	A	A	A	A	A	A				Note 11
Water Potable	X	C	C	B	A	C	B	A	A	A	A	A	A	
Water Sea	X	X		X	A	C	C	A	B	B	A	A	A	
Watt's Nickel Strike												A	A	Note 1
Whiskey				A	A	A	A	A						Note 2
Wood's Nickel Strike												A	A	Note 1
Yellow Dichromate								A						Note 1
Zinc (Mo-ten)			X	X	X	X	X	X	X	X	X		X	
Zinc Chloride	X	X	X	X	B	X	X	B	X	B	B	A	A	
Zinc Plating Acid												A	A	Note 1
Zinc Plating Cyanide	A					A								Note 1
Zinc Phosphate							A						X	Note 1, Note 5
Zincate	A					A								Note 1

A—Good      B—Fair      C—Depends upon conditions      X—Unsuitable      Blank—Data unavailable