

Critical Melting Points and Reference Data for Vacuum Heat Treating



SOLAR ATMOSPHERES INC.

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Acknowledgments

This work is an update of the original reference compilation by Charles F. Burns, Jr., Copyright 1997. The current booklet contains revisions to the original work as well as numerous additions. This booklet should serve as a handy reference for people that work in the metals industry.

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Limitations

This data is for reference only. Solar Atmospheres Inc. will not assume liability for accuracy.

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DEFINITIONS

ALLOY

[MET] Any of a large number of substances having metallic properties consisting of two or more elements; at least one component must be a metal.

EUTECTIC ALLOY

[Met] A material, predominantly one of a specific microstructure, made up of two or more phases formed simultaneously during solidification of two or more elements. A eutectic alloy melts to become a free running liquid at a single temperature, which is lower than the melting point of any of its components.

EMISSIVITY

The ratio defined by the radiation emitted by a surface to the radiation emitted by a blackbody at the same temperature.

MELTING OF PURE SUBSTANCES

[Chem] The temperature, at given pressure, upon which a chemically pure substance changes from a solid state to a liquid state.

MELTING POINT OF MIXTURES OR ALLOYS

[MET] Unlike pure metals, many alloys do not have a single melting point. Instead, they have a melting range in which the material is a mixture of solid and liquid phases during the melting process. The temperature at which melting begins is called the solidus, and that at which melting is complete is called the liquidus. Special alloys can be designed with a single melting point, however, and these are called eutectic mixtures.

VAPOR PRESSURE

The vapor pressure of a substance (liquid or solid) is the equilibrium pressure of a vapor above the substance; in other words the vapor (formed from evaporation or sublimation) above the substance when in a closed container.

When working in vacuum one must recognize that even if the work is not at the boiling point for the substance there is always vapor forming above the surface and excessive heating of a substance under vacuum has the possibility of evaporating the substance. For example at 760 Torr and 50 °C, if water is heated for an extended period in an open container the water will eventually evaporate. Therefore care must be used when heating under vacuum at high temperatures if one is at or near the known vapor pressure of a substance.

SUBLIMATION

A phase change process in which a material passes from a solid state to a gaseous state without becoming a liquid.

MELTING POINTS OF THE ELEMENTS

(atmospheric pressure), (s) = sublimes

ELEMENT	SYMBOL	MELTING POINT (°F)	MELTING POINT (°C)
Aluminum	Al	1220	660
Antimony	Sb	1168	631
Arsenic	As	1135 (s)	613 (s)
Barium	Ba	1341	727
Beryllium	Be	2348.6	1287
Bismuth	Bi	520	271.3
Boron	B	3767	2075
Cadmium	Cd	610	321
Calcium	Ca	1544	840
Carbon	C	6588 (s)	3642 (s)
Cerium	Ce	1468	798
Cesium	Cs	83.4	28.4
Chromium	Cr	3465	1907
Cobalt	Co	2723	1495
Copper	Cu	1981	1083
Columbium (Niobium)	Cb	4491	2477
Dysprosium	Dy	2574	1412
Erbium	Er	2784	1529
Europium	Eu	1512	822
Gallium	Ga	86	30
Germanium	Ge	1719	937
Gold	Au	1947	1064
Hafnium	Hf	4051	2233
Indium	In	314	157
Iodine	I	237	114
Iridium	Ir	4435	2446
Iron	Fe	2795	1535
Lanthanum	La	1684	918
Lead	Pb	622	328
Lithium	Li	358	181
Magnesium	Mg	1202	650
Manganese	Mn	2275	1246
Mercury	Hg	-37.97	-38.87
Molybdenum	Mo	4748	2620

MELTING POINTS OF THE ELEMENTS

(atmospheric pressure), (s) = sublimes

ELEMENT	SYMBOL	MELTING POINT (°F)	MELTING POINT (°C)
Neodymium	Nd	1870	1021
Nickel	Ni	2647	1453
Niobium (Columbium)	Nb	4491	2477
Osmium	Os	5491	3033
Palladium	Pd	2826	1552
Phosphorus	P	111	44
Platinum	Pt	3214	1768
Potassium	K	147	64
Praseodymium	Pr	1708	931
Rhenium	Re	5756	3180
Rhodium	Rh	3567	1964
Rubidium	Rb	102	39
Ruthenium	Ru	4233	2334
Scandium	Sc	2802	1539
Selenium	Se	422	217
Silicon	Si	2570	1410
Silver	Ag	1764	962
Sodium	Na	208	98
Strontium	Sr	1431	777
Sulfur	S	239	115
Tantalum	Ta	5425	2996
Tellurium	Te	842	450
Thallium	Tl	579	304
Thorium	Th	3182	1750
Tin	Sn	450	232
Titanium	Ti	3034	1668
Tungsten	W	6192	3422
Uranium	U	2070	1132
Vanadium	V	3434	1890
Yttrium	Y	2773	1523
Zinc	Zn	788	420
Zirconium	Zr	3366	1852

MELTING POINTS		
Stainless Steels		
ALLOY	MELTING RANGE °F	MELTING RANGE °C
301 S/S	2550-2590	1400-1420
302 S/S	2550-2590	1400-1420
302B S/S	2500-2550	1370-1400
303 S/S	2550-2590	1400-1420
304 S/S	2550-2650	1400-1455
305 S/S	2550-2650	1400-1455
308 S/S	2550-2650	1400-1455
309 S/S	2550-2650	1400-1455
310 S/S	2550-2650	1400-1455
314 S/S	2412-2530	1322-1388
316 S/S	2500-2550	1370-1400
317 S/S	2500-2550	1370-1400
321 S/S	2550-2600	1400-1425
330 S/S	2550-2600	1400-1425
347 S/S	2550-2600	1400-1425
384 S/S	2550-2650	1400-1455
403 S/S	2700-2790	1480-1530
405 S/S	2700-2790	1480-1530
409 S/S	2600-2750	1425-1510
410 S/S	2700-2790	1480-1530
416 S/S	2700-2790	1480-1530
420 S/S	2650-2750	1455-1510
430 S/S	2650-2750	1455-1510
430F S/S	2550-2650	1400-1455
431 S/S	2600-2700	1476-1482
440A S/S	2500-2750	1370-1510
440B S/S	2500-2750	1370-1510
440C S/S	2500-2750	1370-1510
442,443,446 S/S	2600-2750	1425-1510
501 S/S	2700-2800	1480-1540
502 S/S	2700-2800	1480-1540

MELTING POINTS		
Corrosion-Resistant Steel Castings		
ALLOY	MELTING POINT °F	MELTING POINT °C
CA-15	2750	1510
CA-40	2750	1510
CB-30	2725	1496
CC-50	2725	1496
CE-30	2650	1454
CF-8	2600	1427
CF-20	2575	1413
CF-8M	2550	1399
CF-12M	2550	1399
CF-8C	2600	1427
CF-16F	2550	1399
CH-20	2600	1427
CK-20	2600	1427
CN-7M	2650	1454

MELTING POINTS		
Heat-Resistant Alloy Castings		
ALLOY	MELTING POINT °F	MELTING POINT °C
HA	2750	1510
HC	2725	1496
HD	2700	1482
HE	2650	1454
HF	2550	1399
HH	2500	1371
HI	2550	1399
HK	2550	1399
HL	2600	1427
HN	2500	1371
HP	2450	1343
HT	2450	1343
HU	2450	1343

MELTING POINTS Heat-Resistant Alloy Castings		
ALLOY	MELTING POINT °F	MELTING POINT °C
HA	2750	1510
HC	2725	1496
HD	2700	1482
HE	2650	1454
HF	2550	1399
HH	2500	1371
HI	2550	1399
HK	2550	1399
HL	2600	1427
HN	2500	1371
HW	2350	1288
HX	2350	1288

MELTING POINTS Aluminum Alloys		
ALLOY	MELTING POINT/RANGE °F	MELTING POINT/RANGE °C
EC	1215	657
1060	1195-1215	646-657
1100	1190-1215	643-657
2011	1005-1190	541-643
2014	945-1180	507-637
2024	935-1180	507-638
2218	940-1175	504-635
3003	1190-1210	643-654
4032	990-1060	532-571
5005	1170-1210	632-654
5050	1155-1205	624-652
5052	1125-1200	607-649
5056	1055-1180	568-638
5083	1095-1180	591-638
5086	1085-1185	585-641
5154	1100-1190	545-643

MELTING POINTS		
Aluminum Alloys		
ALLOY	MELTING RANGE °F	MELTING RANGE °C
5357	1210	654
5456	1055-1180	568-638
6061	1080-1205	582-652
6063	1140-1210	616-654
6101	1150-1210	621-654
6151	1090-1200	588-649
7075	890-1175	477-635
7079	1180	637
7178	890-1165	477-629

MELTING POINTS		
Aluminum Casting Alloys		
ALLOY	MELTING RANGE °F	MELTING RANGE °C
201.0	1060-1200	570-650
206.0	1060-1200	570-650
A206.0	1060-1200	570-650
208.0	970-1170	520-630
222.0	970-1160	520-625
224.0	1020-1190	550-645
238.0	950-1110	510-600
240.0	960-1120	515-605
242.0	990-1180	530-635
295.0	970-1190	520-645
296.0	970-1170	520-630
308.0	970-1140	520-615
319.0	970-1120	520-605
324.0	1010-1120	545-605
332.0	970-1080	520-580
333.0	970-1090	520-585
336.0	1000-1060	540-570
354.0	1000-1110	540-600
355.0	1020-1150	550-620
C355.0	1020-1150	550-620
356.0	1040-1140	560-615

MELTING POINTS
Aluminum Casting Alloys

ALLOY	MELTING RANGE °F	MELTING RANGE °C
A356.0	1040-1130	560-610
357.0	1040-1140	560-615
A357.0	1030-1130	555-610
358.0	1040-1110	560-600
359.0	1050-1110	565-600
360.0	1060-1090	570-590
A360.0	1060-1090	570-590
364.0	1040-1110	560-600
380.0	970-1090	520-590
A380.0	970-1090	520-590
384.0	900-1080	480-580
390.0	950-1200	510-650
392.0	1020-1240	550-670
413.0	1070-1090	575-585
A413.0	1070-1090	575-585
443.0	1070-1170	575-630
A444.0	1070-1170	575-630
511.0	1090-1180	590-640
512.0	1090-1170	590-630
513.0	1080-1180	580-640
514.0	1110-1180	600-640
518.0	1000-1150	540-620
520.0	840-1110	450-600
535.0	1020-1170	550-630
A535.0	1020-1150	550-620
B535.0	1020-1170	550-630
705.0	1110-1180	600-640
707.0	1090-1170	585-630
710.0	1110-1200	600-650
711.0	1110-1190	600-645
712.0	1110-1180	600-640
713.0	1100-1170	595-630
850.0	440-1200	225-650
851.0	450-1170	230-630
852.0	410-1180	210-635

MELTING POINTS/RANGES		
Copper Alloys		
ALLOY	MELTING POINT/RANGE °F	MELTING POINT/RANGE °C
C10200 (Oxygen Free)	1950-1980	1065-1083
C11000 (Copper ETP)	1950-1980	1065-1083
C12000 (Copper DLP)	1981	1083
C12200 (Copper DHP)	1981	1083
C14500 (Free Machining [Te])	1924-1967	1051-1075
C17000 (Beryllium Copper)	1590-1800	805-980
C21000 (Gilding)	1920-1950	1050-1066
C22000 (Commercial Bronze [90% Cu])	1870-1910	1020-1043
C22600 (Jewelry Bronze [87.5% Cu])	1840-1890	1005-1035
C23000 (Red Brass [85% Cu])	1810-1880	990-1027
C24000 (Low Brass [80% Cu])	1770-1830	965-1000
C26000 (Cartridge Brass [70% Cu])	1680-1750	915-954
C27000 (Yellow Brass [65% Cu])	1660-1710	905-932
C280000 (Muntz Metal [60% Cu])	1650-1660	900-904
C31400 (Leaded Commercial Bronze)	1850-1900	1010-1038
C33000 Low Leaded Brass [0.5% Pb])	1660-1720	905-938
C34000 (Medium Leaded Brass [1% Pb])	1630-1700	885-927
C35300 (High Leaded Brass [1.6% Pb])	1650-1710	900-932
C34200 (High Leaded Brass [2% Pb])	1630-1670	885-910
C35600 (Extra High Leaded Brass [2.5% Pb])	1630-1660	885-904
C36000 (Free Cutting Brass)	1630-1650	885-900
C36500 (Leaded Muntz Metal)	1630-1650	885-900
C37700 (Forging Brass)	1620-1640	880-893
C38500 (Architectural Bronze)	1610-1630	875-888
C44400 (Inhibited Admiralty)	1650-1720	900-938
C46400 (Naval Brass)	1630-1650	885-900
C50500 (Phosphor Bronze [1.25% Sn])	1890-1970	1035-1077
C51000 (Phosphor Bronze [5% Sn])	1790-1940	975-1060
C52100 (Phosphor Bronze [8% Sn])	1620-1880	880-1027
C52400 (Phosphor Bronze [10% Sn])	1550-1830	845-1000
C54400 (Free Cutting Phosphor Bronze)	1710-1830	930-1000
C60600 (Aluminum Bronze [5% Al])	1920-1950	1050-1065

MELTING POINTS/RANGES		
Copper Alloys		
ALLOY	MELTING POINT/RANGE °F	MELTING POINT/RANGE °C
C61000 (Aluminum Bronze [7% Al])	1900-1910	1040-1045
C62300 (Aluminum Bronze [11% Al])	1880-1900	1025-1040
C63200 (Aluminum Bronze [9% Al])	1900-1910	1040-1045
C64200 (Aluminum Silicon Bronze)	1800-1840	985-1004
C65500 (High Silicon Bronze [3% Si])	1780-1880	970-1027
Low Silicon Bronze (1.5% Si)	1890-1940	1030-1060
C67500 (Manganese Bronze)	1630-1690	888-920
C70600 (Cupro-Nickel [10% Ni])	2010-2100	1100-1149
C71500 (Cupro-Nickel [30% Ni])	2140-2260	1170-1238
C75200 (Nickel-Silver [65% Cu])	2030	1110
C75700 (Nickel-Silver [65% Cu- 12% Ni])	1900	1038
C77000 (Nickel-Silver [55% Cu])	1930	1054

MELTING POINTS		
Copper Casting Alloys		
ALLOY	MELTING POINT/RANGE °F	MELTING POINT/RANGE °C
Chrome Copper (1% Cr)	1970-1990	1075-1085
Tin Bronze, Alloy 1A	1570-1830	834-1000
Tin Bronze, Alloy 1B	1570-1830	834-1000
Tin Bronze, Alloy SAE 65	1832	1000
Navy M Bronze, Alloy 2A	1520-1810	825-990
Leaded Tin Bronze, Alloy 2B	1570-1830	854-1000
Leaded Tin Bronze, Alloy 2C	1550-1800	845-980
High Leaded Tin Bronze, Alloy 3A	1400-1710	762-930
High Leaded Tin Bronze, Alloy 3B	1570-1790	855-975
High Leaded Tin Bronze, Alloy 3C	1570-1830	855-1000
High Leaded Tin Bronze, Alloy 3D	1570-1730	855-945
High Leaded Tin Bronze, Alloy 3E	1650-1700	900-925
Leaded Red Brass, Alloy 4A	1570-1850	855-1010
Leaded Red Brass, Alloy 4B	1550-1840	845-1005
Leaded Semi Red Brass, Alloy 5A	1540-1840	840-1005
Leaded Semi Red Brass, Alloy 5B	1530-1750	832-955
Leaded Yellow Brass, Alloy 6A	1700-1720	925-940

MELTING POINTS Copper Casting Alloys		
ALLOY	MELTING POINT/RANGE °F	MELTING POINT/RANGE °C
Leaded Yellow Brass, Alloy 6B	1700-1720	925-940
Manganese Bronze (59% Cu)	1675	913
Manganese Bronze (57.5% Cu)	1616	880
Manganese Bronze (64% Cu)	1700	937
Manganese Bronze (110,000 psi)	1693	923
Aluminum Bronze, Alloy 9A	1900-1910	1040-1045
Aluminum Bronze, Alloy 9B	1900-1910	1040-1045
Aluminum Bronze, Alloy 9C	1880-1900	1027-1040
Aluminum Bronze, Alloy 9D	1900-1930	1038-1055
Nickel Silver (12% Ni)	Max: 1900	Max: 1040
Nickel Silver (15% Ni)	1850-1970	1010-1075
Nickel Silver (18% Ni)	Max: 1930	Max: 1055
Nickel Silver (25% Ni)	2300	1260
Low-Silicon Bronze (1% Si)	1890-1940	1030-1060
High-Silicon Bronze (3% Si)	1780-1880	700-875
Silicon Brass	1510-1680	821-917

MELTING POINTS Magnesium Alloys/Casting Alloys		
ALLOY	MELTING POINT/RANGE °F	MELTING POINT/RANGE °C
AM100A	1101	594
AZ63A	1130	610
AZ81A	1132	611
AZ91A, B & C Alloys	1105	596
AZ92A	1100	593
HK31A	1090-1200	590-650
HZ32A	1020-1200	550-650
ZH42	1180	638
ZH62A	968-1170	520-630
ZK51A	1020-1180	550-640
ZE41A	977-1190	525-645
EZ33A	1010-1190	545-645
EZ30A	1184	640
EZ41A	1193	645

MELTING POINTS		
Magnesium Alloys/Wrought Alloys		
ALLOY	MELTING POINT/RANGE °F	MELTING POINT/RANGE °C
MIA	1200	649
AZ31B	1120-1170	605-632
PE	990-1170	532-632
AZ61A	785-1150	418-620
AZ80A	801-1130	421-610
ZK60A	964-1170	518-635
ZE10A	1195	646
HM21A	1120-1200	605-650
HM31A	900-1200	482-650

MELTING POINTS		
Nickel Alloys		
ALLOY	MELTING POINT/RANGE °F	MELTING POINT/RANGE °C
"A" Nickel	2642	1450
"D" Nickel	2600	1427
Duranickel	2550-2620	1400-1440
Cast Nickel	2450	1343
Monel	2370	1299
"K" Monel	2400-2460	1315-1349
Monel (Cast)	2450	1343
"H" Monel (Cast)	2315	1268
"S" Monel (Cast)	2300	1260
Inconel	2470-2580	1354-1413
Inconel (Cast)	2500	1371
Ni-O-Nel	1340-1390	727-754
Hastelloy Alloy "B"	2375-2495	1302-1368
Hastelloy Alloy "C"	2417-2498	1325-1370
Hastelloy Alloy "D"	2050	1121
Hastelloy Alloy "F"	2350	1288
Hastelloy Alloy "N"	2370-2550	1300-1400
Hastelloy Alloy "W"	2400	1316
Hastelloy Alloy "X"	2300-2470	1260-1355

MELTING POINTS/RANGES		
Superalloys		
ALLOY	MELTING POINT/RANGE °F	MELTING POINT/RANGE °C
Inconel Alloy 600	2470-2575	1354-1413
Inconel Alloy 601	2480-2571	1360-1411
Inconel Alloy 601GC	2374-2494	1301-1368
Inconel Alloy 603XL	2516-2552	1380-1400
Inconel Alloy 617	2430-2510	1332-1380
Inconel Alloy 625	2350-2460	1290-1350
Inconel Alloy 625LCF	2350-2460	1290-1350
Inconel Alloy 686	2440-2516	1338-1380
Inconel Alloy 690	2450-2510	1343-1377
Inconel Alloy 693	2403-2493	1317-1367
Inconel Alloy 706	2434-2499	1334-1371
Inconel Alloy 718	2300-2437	1260-1336
Inconel Alloy 718SPF	2300-2437	1260-1336
Inconel Alloy 725	2320-2449	1271-1343
Inconel Alloy 740	2350-2484	1288-1362
Inconel Alloy X-750	2540-2600	1393-1427
Inconel Alloy 751	2540-2600	1393-1427
Inconel Alloy MA754	2550	1400
Inconel Alloy MA758	2507	1375
Inconel Alloy 783	2437-2565	1336-1407
Inconel Alloy 230	2480-2570	1360-1410
Inconel Alloy C-276	2415-2500	1325-1370
Inconel Alloy G-3	2300-2450	1260-1343
Inconel Alloy HX	2300-2470	1260-1355
Inconel Alloy 22	2464-2529	1351-1387
Incoloy Alloy 800	2475-2525	1357-1385
Incoloy Alloy 800H/800HT	2475-2525	1357-1385
Incoloy Alloy 803	2490-2555	1365-1400
Incoloy Alloy 825	2500-2550	1370-1400
Incoloy Alloy 864	2467-2539	1353-1393

MELTING POINTS/RANGES		
Superalloys		
ALLOY	MELTING POINT/RANGE °F	MELTING POINT/RANGE °C
Incoloy Alloy 890	2388-2522	1309-1383
Incoloy Alloy 903	2405-2539	1318-1393
Incoloy Alloy 907	2440-2550	1335-1400
Incoloy Alloy 908	2482-2571	1361-1410
Incoloy Alloy 925	2392-2490	1311-1366
Incoloy Alloy MA956	2700	1482
Incoloy Alloy DS	2426-2552	1330-1400
Incoloy Alloy 330	2520-2590	1380-1420
Incoloy Alloy 25-6MO	2410-2550	1320-1400
Incoloy Alloy A-286	2500-2600	1370-1430
Brightray Alloy B	2550-2590	1400-1420
Brightray Alloy C	2520-2550	1380-1400
Brightray Alloy F	2430-2550	1330-1400
Brightray Alloy S	2550-2590	1400-1420
Brightray Alloy 35	2440-2520	1340-1380
Nimonic Alloy 75	2450-2520	1340-1380
Nimonic Alloy 80A	2410-2490	1320-1365
Nimonic Alloy 81	2381-2507	1305-1375
Nimonic Alloy 90	2390-2500	1310-1370
Nimonic Alloy 91	2372-2462	1300-1350
Nimonic Alloy 105	2354-2453	1290-1345
Nimonic Alloy 115	2300-2399	1260-1315
Nimonic Alloy 263	2372-2471	1300-1355
Nimonic Alloy 901	2336-2453	1280-1345
Nimonic Alloy PE11	2340-2460	1280-1350
Nimonic Alloy PE16	2390-2471	1310-1355
Nimonic Alloy PK33	2372-2453	1300-1345
Udimet Alloy 188	2375-2425	1300-1330
Udimet Alloy L-605	2426-2570	1330-1410

MELTING POINTS/RANGES		
Superalloys		
ALLOY	MELTING POINT/RANGE °F	MELTING POINT/RANGE °C
Udimet Alloy 520	2300-2560	1260-1405
Udimet Alloy 720	2180-2440	1194-1338
Udimet Alloy D-979	2225-2530	1220-1390
Udimet Alloy R41	2250-2535	1232-1391
Udimet Alloy 250	2600-2650	1427-1454
Udimet Alloy 300	2600-2650	1427-1454
Nilo Alloy 36	2605	1430
Nilo Alloy 42	2615	1435
Nilo Alloy 48	2640	1450
Nilo Alloy K	2640	1450

MELTING POINTS		
Tin Alloys		
ALLOY	MELTING POINT/RANGE °F	MELTING POINT/RANGE °C
Hard Tin (pure tin)	450	232
Antimonial Tin Solder	453-464	234-240
Tin-Silver Solder	430-473	221-245
Soft Solder (70% Sn)	361-378	183-192
Soft Solder (63% Sn)	361	183
Soft Solder (50% Sn)	361-421	183-216
Tin Babbitt Alloy 1	433-700	223-371
Tin Babbitt Alloy 2	466-669	241-354
Tin Babbitt Alloy 3	464-792	240-422
Tin Babbitt Alloy 4	363-583	184-306
Tin Babbitt Alloy 5	358-565	181-296
Tin Die Casting Alloy	700	371
White Metal	475	246
Pewter	471-563	244-295

MELTING POINTS		
Zinc Alloys		
ALLOY	MELTING POINT/RANGE °F	MELTING POINT/RANGE °C
Pure Zinc	787	419.6
AG40A	718-729	381-387
AC41A	716-727	380-386
Zinc-Base Slush-Casting Alloy (4.75% Al)	716-734	380-390
Zinc-Base Slush-Casting Alloy (5.5% Al)	716-743	380-395
Commercial Rolled Zinc (0.08% Pb)	786	419
Commercial Rolled Zinc (0.06% Pb)	786	419
Commercial Rolled Zinc (0.3% Pb)	786	419
Copper Hardened Rolled Zinc	786-792	419-422
Rolled Zinc Alloy (1% Cu)	786-792	419-422
Zn-Cu-Ti	786-792	419-422

MELTING POINTS		
Precious Metal Alloys		
ALLOY	MELTING POINT/RANGE °F	MELTING POINT/RANGE °C
Silver	1760	962
70% Gold – 30% Platinum	2240-2640	1228-1450
60% Pd – 40% Cu	2180-2240	1196-1224

MELTING POINTS		
Ni-Cr-Mo-Cu Alloys		
ALLOY	MELTING POINT/RANGE °F	MELTING POINT/RANGE °C
Illium "B"	-----	-----
Illium "G"	2300-2440	1260-1338
Illium "R"	2500	1371

MELTING POINTS Electrical Resistance Alloys		
ALLOY	MELTING POINT °F	MELTING POINT °C
80 Ni -20 Cr	2550	1400
60 Ni -24 Fe-16 Cr	2530	1390
35 Ni-45 Fe-20 Cr	2530	1390
Constantan	2230	1220

MELTING POINTS Titanium Alloys		
ALLOY	MELTING POINT/RANGE °F	MELTING POINT/RANGE °C
99.2%	3135	1724
99.0%	3020	1660
Ti- 6 Al - 4V	2920-3020	1604-1660
Ti – 5 Al - 2.5 Sn	Max: 2890	Max: 1590
Ti – 2 Fe – 2 Cr - 2Mo	3010	1654
Ti – 8 Mn	2370-2970	1300-1635
Ti – 4 Al -4 Mn	2820	1549

MELTING POINTS		
Eutectics		
ALLOY (Element-Wt. %)	MELTING POINT °F	MELTING POINT °C
Aluminum-Gold (Au-96)	968	520
Aluminum-Beryllium (Be-0.8)	1191	644
Aluminum-Copper (Cu-33)	1019	548
Aluminum-Iron (Fe-98)	1211	655
Aluminum-Lithium (Li-93)	351	177
Aluminum-Magnesium (Mg-66)	819	437
Aluminum-Nickel (Ni-5.7)	1182	639
Aluminum-Silicon (Si-12.6)	1071	577
Aluminum-Zinc (Zn-94)	718	381
Aluminum-Zirconium (Zr-57)	2732	1500
Beryllium-Chromium (Cr-13)	2232	122
Beryllium-Copper (Cu-94.7)	1576	858
Beryllium (Fe-22.6)	2219	1215
Beryllium-Nickel (Ni-95)	2102	1150
Beryllium-Silicon (Si-64)	1994	1090
Carbon-Iron (Fe-22.6)	2107	1153
Carbon-Molybdenum	4001	2205
Carbon-Nickel (C-2.5)	2421	1327
Chromium-Carbon (C-3.6)	2793	1534
Chromium-Cobalt (Co-59)	2489	1365
Chromium- Molybdenum (Mo-21)	3308	1820
Chromium-Nickel (Ni-46)	2453	1345
Chromium-Tantalum (Ta-34)	3200	1760
Chromium-Titanium (Ti-53)	2570	1410
Chromium-Zirconium (Zr-86)	2430	1332
Cobalt-Carbon (C-2.6)	2498	1320
Cobalt-Molybdenum (Mo-39)	2435	1335
Cobalt-Tantalum (Ta-21)	2336	1280
Cobalt-Tin (Sn-34)	2034	1112
Cobalt-Titanium (Ti-73)	1868	1020
Cobalt-Vanadium (V-38)	2278	1248
Cobalt-Tungsten (W-45)	2680	1471
Copper-Magnesium(Mg-66)	909	487

MELTING POINTS		
Eutectics		
ALLOY (Element-Wt. %)	MELTING POINT °F	MELTING POINT °C
Copper-Silicon	1476	802
Copper-Titanium (Ti-12)	1607	875
Iron-Carbon (C-4.2)	2107	1153
Iron-Molybdenum (Mo-37)	2640	1449
Iron-Niobium (Nb-19)	2503	1373
Iron-Silicon (Si-20 &Si-53)	2197	1203
Iron-Tin (Sn-49)	2066	1130
Iron-Tantalum(Ta-20))	2606	1430
Iron-Titanium (Ti-67)	1985	1085
Magnesium-Nickel (Mg-24)	946	508
Magnesium-Silicon (Si-1.34)	1180	638
Magnesium-Tin (Sn-98)	399	204
Magnesium-Zinc (Zn-53)	644	340
Manganese-Titanium (Ti-59)	2156	1180
Molybdenum-Nickel (56-Mo)	2388	1309
Molybdenum-Silicon (Si-94)	2577	1414
Nickel-Carbon (C-0.6)	2421	1327
Nickel-Niobium (Nb-23)	2347	1286
Nickel-Silicon (Si-29)	1767	964
Nickel-Tantalum (Ta-63)	2462	1350
Nickel-Tin (Sn-33)	2066	1130
Nickel-Titanium ((Ti-73)	1728	942
Nickel-Vanadium (V-47)	2196	1202
Silicon-Tantalum (Ta-5)	2543	1395
Silicon-Zinc (Zn-99.98)	787	419
Silver-Aluminum (Al-26.5)	1053	567
Silver-Beryllium (Be-0.03)	1616	880
Silver-Calcium (Ca-60)	878	470
Silver-Copper (Cu-28)	1434	779
Silver-Magnesium (Mg-51.4)	882	472
Silver-Tin(Sn-96.5)	430	221
Tantalum-Carbon (C-2)	5149	2843
Tungsten-Carbon (W-1.3)	4919	2715

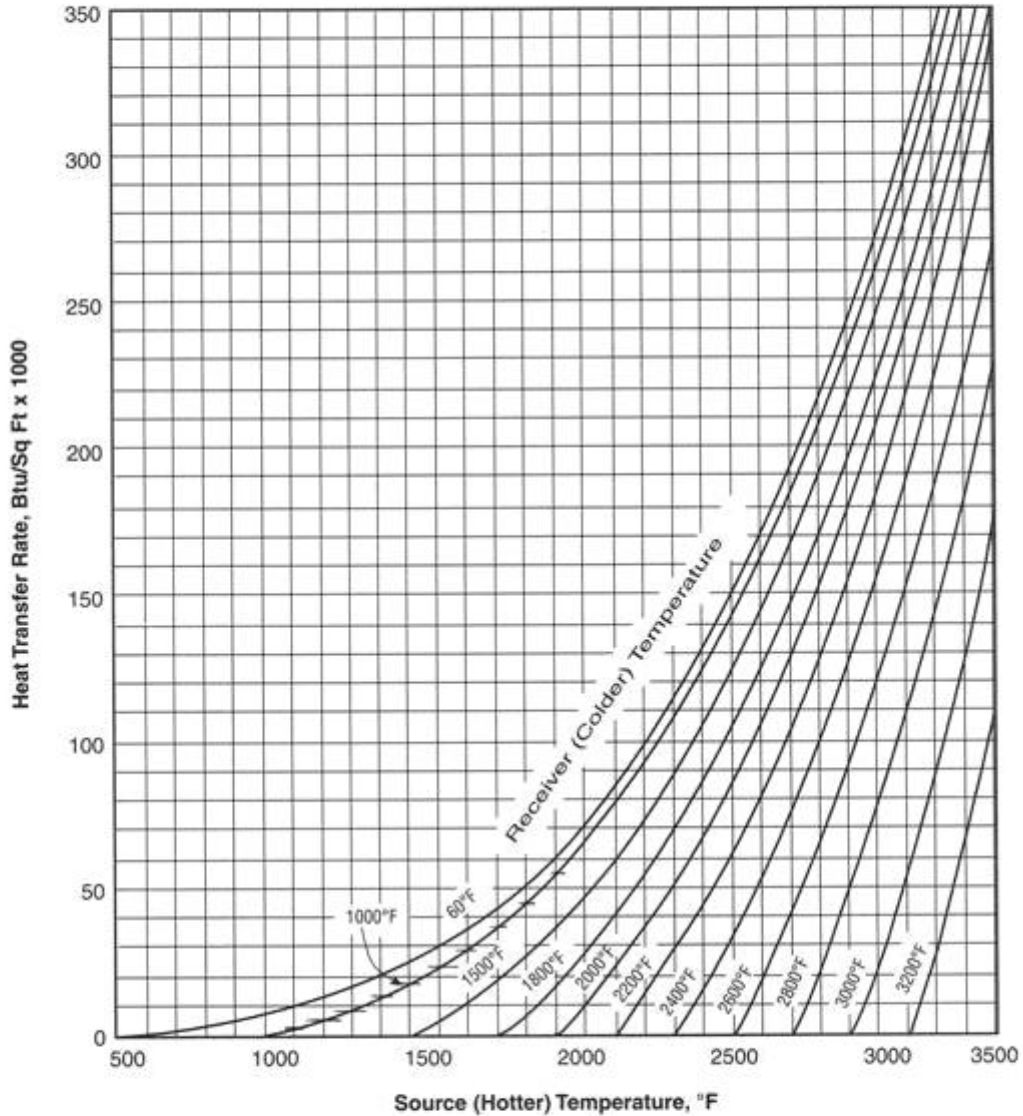
ONSET TEMPERATURE FOR ADVERSE REACTIONS BETWEEN GRAPHITE OR OXIDES AND FURNACE COMPONENTS		
Surface to Surface Contact	Temperature °F	Temperature °C
Al₂O₃-C	<2912	<1600
Al₂O₃-Mo	3452	1900
Al₂O₃-Ta	3452	1900
Al₂O₃-W	3452	1900
BeO-C	4172	2300
BeO-Mo	3452	1900
BeO-MgO	3272	1800
BeO-W	3632	2000
C-Mo	2192	1200*
C-Ta	1832	1000*
C-W	2730	1499*
BeO-ZrO₂	3452	1900
MgO-C	3272	1800
MgO-Mo	2912	1600
MgO-Ta	3272	1800
MgO-W	3632	2000**
MgO-ZrO₂	3632	2000
ZrO₂-C	2912	1600
ZrO₂-Mo	3992	2200
ZrO₂-W	2912	1600

- *Strong Carbide Formation at higher temperatures.
 - ** Strong Magnesia evaporation

MELTING POINTS OF CERTAIN SIMPLE AND COMPLEX REFRACTORY OXIDES			
Compound	Chemical Formula	Melting Point	
		°F	°C
Alumina	Al ₂ O ₃	3762	2072
Aluminum Silicate (mullite)	3Al ₂ O ₃ ·2SiO ₂	3326	1830*
Aluminum Titanate	Al ₂ O ₃ ·TiO ₂	3371	1855
Aluminum Titanate	Al ₂ O ₃ ·2TiO ₂	3443	1895
Barium Aluminate	BaO·Al ₂ O ₃	3632	2000
Barium Aluminate	BaO·6Al ₂ O ₃	3380	1860
Barium Orthosilicate	BaO·SiO ₂	3191	1755
Barium Zirconate	BaO·ZrO ₂	4892	2700
Beryllium Oxide	BeO	4649	2565
Chromic Oxide	Cr ₂ O ₃	4109	2265
Iron (II) Oxide	FeO	2510	1377
Iron (III) Oxide	Fe ₂ O ₃	2851	1566
Iron (IV) Oxide	Fe ₃ O ₄	2901	1594
Magnesium Aluminate	MgO·Al ₂ O ₃	3875	2135
Magnesium Ferrite	MgO·Fe ₂ O ₃	3200	1760
Magnesium Oxide	MgO	5156	2852
Manganese Oxide	Mn ₃ O ₄	2849	1565
Niobium Pentoxide	Nb ₂ O ₅	2716	1491
Nickel Oxide	NiO	3603	1984
Silicon Dioxide	SiO ₂	3133	1723
Tantalum Pentoxide	Ta ₂ O ₅	3402	1872
Titanium Dioxide	TiO ₂	3344	1840
Vanadium Oxide	V ₂ O ₃	3578	1970
Zinc Aluminate	ZnO·Al ₂ O ₃	3542	1950
Zinc Oxide	ZnO	3576	1969
Zirconium Oxide	ZrO ₂	4825	2663
Zirconium Oxide (stabilized)	ZrO ₂ (stabilized)	4500	2482
Zinc Zirconium Silicate	ZnO·ZrO ₂ ·SiO ₂	3772	2078
Tungsten Oxide	WO ₃	2683	1473

BLACK BODY RADIATION

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These curves are plotted from the relationship

$$Q = \frac{AK(T_1^4 - T_2^4)}{\frac{1}{P_1} + \frac{1}{P_2} - 1}$$

where P_1 & P_2 equal 1, that is, the heat source and receiver both have emissivities of 1.0, and they are arranged so there is no barrier to heat transfer between them.

EMISSIVITY OF COMMON MATERIALS			
MATERIAL	TEMPERATURE °F	TEMPERATURE °C	EMISSIVITY NUMBER
Blackbody	75	24	1.0
Black Paint, CuO	75	24	0.96
Carbon, Lamp Black	75	24	0.96
Soot , acetylene	75	24	0.97
Cement	32-392	0-200	0.96
White ceramic, Al ₂ O ₃	75	24	0.90
Carbon, unoxidized	75	24	0.81
Water	100	38	0.67

EMMISSIVITY OF SELECT METALS			
MATERIAL	TEMPERATURE °F	TEMPERATURE °C	EMISSIVITY NUMBER
Aluminum unoxidized	75	24	0.02
Aluminum oxidized	390	199	0.11
Aluminum heavily oxidized	200	93	0.20
Brass unoxidized	77	25	0.035
Brass oxidized	392	200	0.61
Bronze polished	122	50	0.10
Chromium unoxidized	212	100	0.08
Chromium oxidized	600	316	0.08
Copper cuprous oxide	100	38	0.87
Copper heavily oxidized, black	100	38	0.78
Copper polished	100	38	0.03
Copper Dow Metal	100	38	0.15
GOLD polished or unoxidized	212	100	0.02
Iconel X	75	24	0.19
Iconel B	75	24	0.21
Iron cast unoxidized	392	200	0.21
Iron cast oxidized	392	200	0.64
Iron cast heavily oxidized	100	38	0.95
Iron unoxidized	212	100	0.05
Iron oxidized	212	100	0.74
Iron heavily oxidized (rust)	77	25	0.65
Iron (Wrought)	77	25	0.94
Lead oxidized	100	38	0.43
Magnesium	100	38	0.07

EMMISSIVITY OF SELECT METALS

MATERIAL	TEMPERATURE °F	TEMPERATURE °C	EMISSIVITY NUMBER
Mercury	77	25	0.10
Molybdenum	100	38	0.06
Molybdenum	2000	1093	0.18
Monel Ni-Cu	392	200	0.41
Monel Ni-Cu, oxidized	77	25	0.43
Nickel unoxidized	77	25	0.05
Nickel oxidized	100	38	0.31
Niobium unoxidized	1500-2000	816-1093	0.19-0.24
Niobium oxidized	1500	816	0.73
Nichrome wire unoxidized	122	50	0.65
Nichrome wire oxidized	122	50	0.95
Nickel unoxidized	77-932	25-500	0.045-0.12
Nickel oxidized	392	200	0.37
Platinum	100	38	0.05
Platinum Black	100	38	0.93
Silver polished	100	38	0.01
Steel unoxidized	212	100	0.08
Steel oxidized	77	25	0.80
Steel type 301 polished	75	24	0.27
Steel type 303 oxidized	600	316	0.74
Steel type 316	75	24	0.28
Tantalum unoxidized	2732	1500	0.21
Tin unoxidized	77	25	0.04
Titanium C110M	300	149	0.08
Tungsten unoxidized	77	25	0.02
Zinc Bright galvanized	100	38	0.23
Zinc unoxidized	500	260	0.05
Zinc oxidized	500	260	0.11

VAPOR PRESSURE OF THE ELEMENTS (s-sublime)

<i>Element</i>	<i>10⁻⁴ Torr</i>		<i>10⁻³ Torr</i>		<i>10⁻² Torr</i>		<i>10⁻¹ Torr</i>	
	<i>°C</i>	<i>°F</i>	<i>°C</i>	<i>°F</i>	<i>°C</i>	<i>°F</i>	<i>°C</i>	<i>°F</i>
Aluminum	808	1486	889	1632	996	1825	1123	2053
Beryllium	1029	1884	1130	2066	1246	2275	1395	2543
Boron	1140	2084	1239	2262	1355	2471	1489	2712
Cadmium	180	356	220	428	264	507	321	610
Calcium	463	865	528	982	605	1121	700	1292
Carbon	2290	4150	2471	4480	2681	4858	2926	5299
Cerium	1091	1996	1190	2174	1305	2381	1439	2622
Cesium	74	165	110	230	153	307	207	405
Chromium	992	1818	1090	1994	1205	2201	1342	2448
Cobalt	1362	2484	1494	2721	1649	3000	1833	3331
Copper	1035	1895	1141	2086	1273	2323	1432	2610
Gallium	859	1578	965	1769	1093	1999	1248	2278
Germanium	996	1825	1112	2034	1251	2284	1421	2590
Gold	1190	2174	1316	2401	1465	2669	1646	2995
Iron	1195	2183	1310	2390	1447	2637	1602	2916
Lead	548	1018	620	1148	718	1324	832	1508
Magnesium	331	628	380	716	443	829	515	959
Manganese	791	1456	878	1612	980	1796	1020	1868
Mercury			18	64	48	118	82	180
Molybdenum	2098	3809	2295	4163	2533	4591	2880	5216
Neodymium			1192	2177	1342	2448	1537	2799
Nickel	1257	2295	1371	2500	1510	2750	1679	3054
Niobium	2355	4271	2539	4602				
Palladium	1271	2320	1405	2561	1566	2851	1759	3198
Phosphorus			160	320	190	374	225	437
Platinum	1744	3171	1904	3459	2090	3794	2293	4150
Potassium	123	253	161	322	207	405	265	509
Rhenium			2790	5054	3060	5540	3400	6152
Rhodium	1815	3299	1971	3580	2149	3900	2358	4274
Selenium			200	392	235	455	280	536
Silicon	1116	2041	1223	2233	1343	2449	1485	2705
Silver	848	1558	920	1688	1047	1917	1184	2163
Sodium	195	383	238	460	291	556	356	673
Sulfur			66	151	97	207	135	275
Tantalum	2599	4710	2820	5108	3074	5565	3370	6098
Tin	922	1692	1042		1189		1373	
Titanium	1250		1384	2523	1546	2815	1742	3168
Tungsten	2767		3016	5461	3309	5988		
Uranium	1585		1730	3146	1898	3448	2098	3808
Vanadium	1586		1725	3137	1888	3430	2079	3774
Yttrium	1362	2484	1494	2721	1650	3000	1833	3331
Zinc	248	478	292	558	343	649	405	761
Zirconium	1660	3020	1816	3301	2001	3634	2212	4014

VAPOR PRESSURE OF THE ELEMENTS (s-sublimes)

<i>Element</i>	<i>1.0 Torr</i>		<i>10¹ Torr</i>		<i>10² Torr</i>		<i>760 Torr</i>	
	<i>°C</i>	<i>°F</i>	<i>°C</i>	<i>°F</i>	<i>°C</i>	<i>°F</i>	<i>°C</i>	<i>°F</i>
Aluminum	1279	2334	1487	2709	1749	3180	2467	4473
Beryllium	1567	2853	1787	3249	2097	3087	2507	4545
Boron	1648	2998	3030	5486	3460	6260	2527(s)	4581(s)
Cadmium	394	741	484	903	611	1132	765	1409
Calcium	817	1503	983	1801	1207	2205	1487	2709
Carbon	3214	5817	3946	7135	4373	7903	4827	8721
Cerium							3426	6199
Cesium			373	703	513	955	690	1274
Chromium	1504	2739					2222	4031
Cobalt	2056	3732	2380	4316	2720	4928	3097	5607
Copper	1628	2962	1879	3414	2207	4005	2595	4703
Gallium	1443	2629	1541	2806	1784	3243	2427	4400
Germanium	1635	2975	1880	3416	2210	4010	2707	4905
Gold	1867	3393	2154	3909	2521	4570	2966	5371
Iron	1783	3241	2039	3702	2360	4280	2727	4941
Lead	975	1787	1167	2133	1417	2583	1737	3159
Magnesium	605	1121	702	1296	909	1668	1126	2059
Manganese	1251	2284	1505	2741	1792	3257	2097	3807
Mercury	126	259	184	363	216	421	361	682
Molybdenum	3102	5616	3535	6395	4109	7428	4804	8679
Neodymium	1775	3227	2095	3803	2530	4586	3090	5594
Nickel	1884	3423	2007	3645	2364	4287	2837	5139
Niobium							4742	8568
Palladium	2000	3632	2280	4136	2780	5036	3167	5732
Phosphorus	265	509	310	590	370	698	431,	808
Platinum	2582	4680	3146	5695	3714	6717	3827	6921
Potassium	338	640	443	829	581	1078	779	1434
Rhenium	3810	6890					5630	10166
Rhodium	2607	4725	2880	5216	3392	6138	3877	7011
Selenium	350	662	430	806	550	1022	685	1265
Silicon	1670	3038	1888	3430	2083	3781	2477	4491
Silver	1353	2467	1575	2867	1865	3389	2212	4013
Sodium	437	819	548	1018	696	1285	914	1677
Sulfur	183	361	246	475	333	631	444	831
Tantalum	3740	6764					6027	10881
Tin	1609		1703		1968		2727	
Titanium	1965	3569	2180	3956	2480	4496	3127	5661
Tungsten							5927	10701
Uranium	2338	4240					3527	6381
Vanadium	2207	4005	2570	4665	2950	5342	3380	6116
Yttrium							3338	6040
Zinc	487	907	593	1099	736	1357	907	1665
Zirconium	2459	4458					3577	6471

Vapor Pressures of Certain Metal Oxides

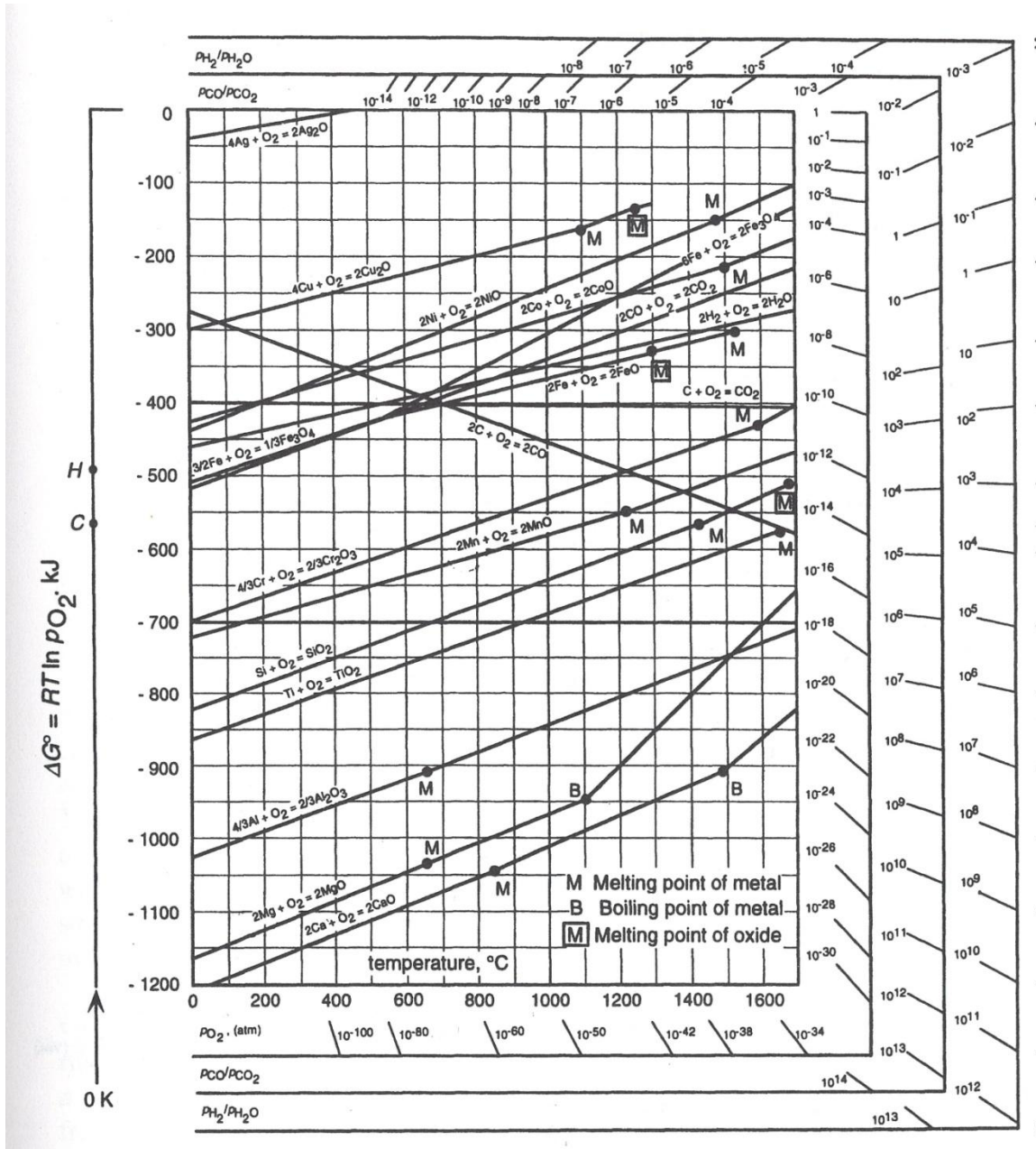
Compound	Formula	10 ⁻⁵ Torr (0.01 micron)		10 ⁻⁴ Torr (0.1 microns)		10 ⁻³ Torr (1.0 micron)		10 ⁻² Torr (10 microns)		10 ⁻¹ Torr (100 microns)		760 Torr 760,000 microns	
		°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
Aluminum Oxide	Al ₂ O ₃			1880	3390	1980	3570	2105	3790	2265	4080	3545	6330
Barium Oxide	BaO			1266	2310	1382	2520	1516	2760			1999	3630
Beryllium Oxide	BeO	1754	3190	1893	3440	2049	3720	2227	4040	2421	4390	4132	7470
Calcium Oxide	CaO	1543	2810	1666	3030	1810	3290	1982	3600	2182	3960	2849	5160
Chromic Oxide	Cr ₂ O ₃	1320	2410	1425	2600	1555	2830	1695	3080	1875	3380	3030	5440
Iron (III) Oxide	Fe ₂ O ₃								1880				
Magnesium Oxide	MgO	1388	2530	1510	2750	1632	2970	1788	3250	1954	3550	3599	6510
Molybdenum Trioxide	MoO ₃					593	1100	627	1160	699	1290	793	1460
Potassium Oxide	K ₂ O	438	820	499	930	577	1070	643	1190	743	1370	1466	2670
Silicon Dioxide	SiO ₂	1366	2490	1482	2700	1604	2920	1738	3160	1893	3440	2232	4050
Sodium Oxide	Na ₂ O	554	1031	627	1160	704	1300	799	1470	916	1680	1277	2330
Titanium Oxide	TiO ₂	1577	2870	1704	3100								
Zirconium Oxide	ZrO ₂	1877	3410	2049	3720	2177	3950	2399	4350	2577	4670	4299	7770

Richardson-Ellingham Diagram

The Richardson-Ellingham Diagram is a graphical representation of the standard Gibbs free energy changes for chemical reactions. It can be used to determine necessary furnace conditions for prevention of unwanted oxidation of metals or the reduction of metal oxides.

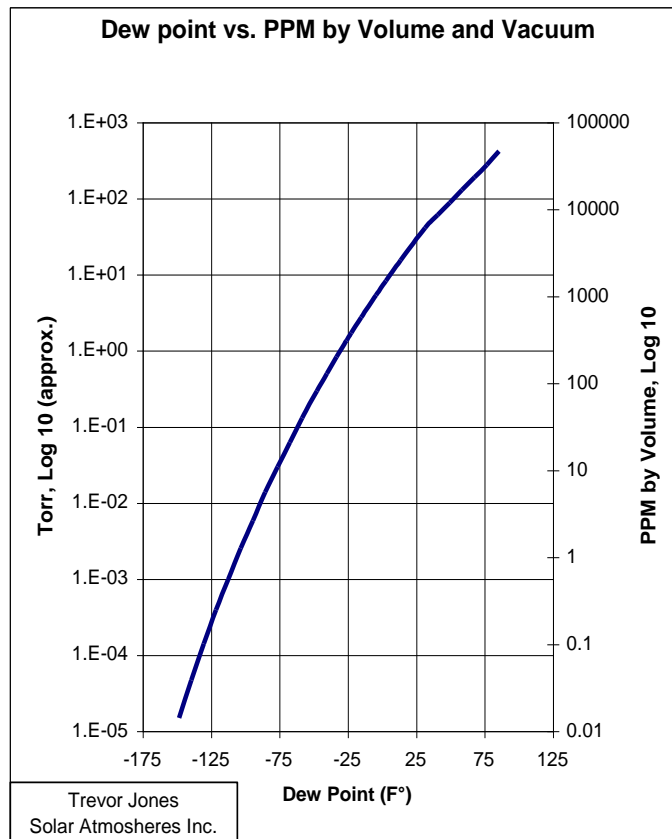
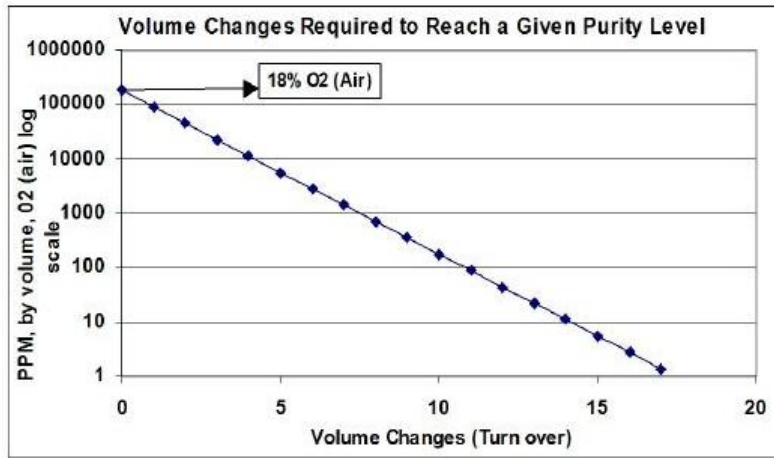
The main uses of this diagram are:

1. Determine the partial pressure of oxygen that is in equilibrium with the metal oxide for a given temperature;
2. Calculate the CO/CO₂ ratio required to reduce an oxide at a given temperature.
3. Determine the ease of oxidation for a given temperature and dew point.
4. Predict the temperatures at which a metal is stable and the temperature that it will readily oxidize.

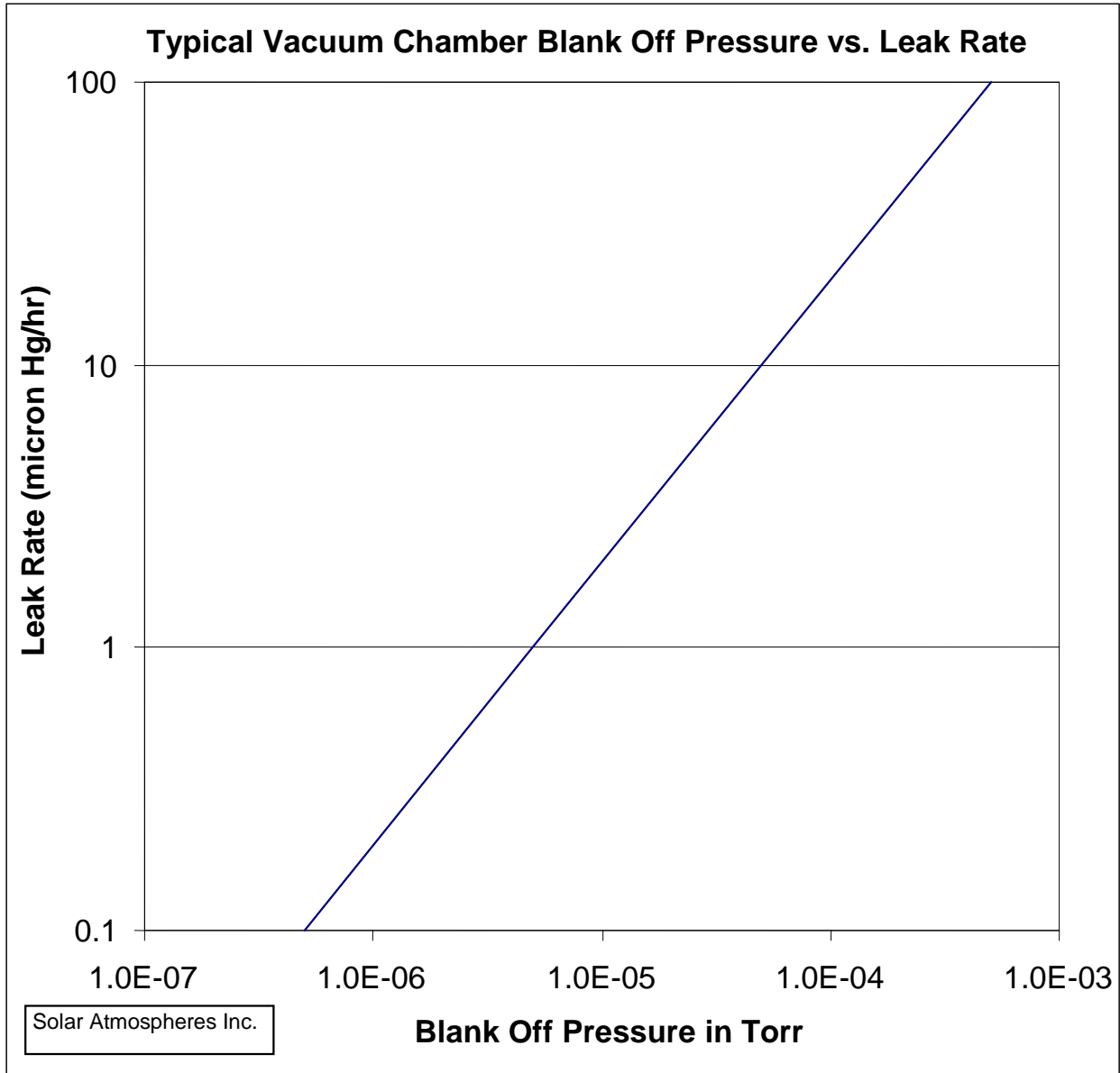


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Gas Purge Chart



Vacuum Furnace Blank Off Pressure vs. Leak Rate



Common English to Metric Conversions

Conversion Factors for Common Units of Length

1 inch = 2.54 centimeters (cm) = 25.4 millimeters (mm)

1 foot = 0.305 meters

1 centimeter = 0.394 inches

1 meter = 39.37 inches = 3.28 feet = 1.094 yards

Conversion Factors for Common Units of Area

1 square inch = 6.45 square centimeters

1 square foot = 0.093 square meter = 930 square centimeters

1 square centimeter = 0.155 square inches

1 square meter = 10.764 square feet = 1550 square inches

Common Conversion Factors for Units of Volume (Solid and Liquid)

1 cubic inch = 16.4 cubic centimeters (cc)

1 cubic inches = 16.4 milliliters (ml)

1 cubic foot = 0.0283 cubic meters

1 cubic foot = 7.48 U.S. gallons

1 U.S. gallon = 3.78 liters

1 cubic foot = 28.3 liters (L)

1 cubic centimeter (cc) = 0.061 cubic inches

1 milliliters (ml) = 0.061 cubic inches

1 cubic meter = 35.314 cubic feet

1 liter = 35.314 cubic feet

Common Conversion Factors for Units of Mass (Weight)

1 pound (avoirdupois) lb. = 453.6 gram

1 ounce = 0.0625 lb. = 28.35 grams

1 gram = 0.0022 pounds = 0.0353 ounces

Common Pressure Conversion Factors

Multiply by ↓ to calculate→	Atmosphere (Atm)	Torr	Pascal	Bar	Micron	Psia (lb/in ²)
Atm	1	760	1.01325X10 ⁵	1.01325	7.6X10 ⁵	14.696
Torr	1.316X10 ⁻³	1	133.322	1.3332X10 ⁻³	1000	1.9337X10 ⁻²
Pascal	9.8692X10 ⁻⁶	7.5006X10 ⁻³	1	1X10 ⁻⁵	7.5006	1.4504X10 ⁻⁴
Bar	9.8692X10 ⁻¹	750.06	1X10 ⁵	1	7.5006X10 ⁵	14.504
Microns	1.31579X10 ⁻⁶	1X10 ⁻³	1.3332X10 ⁻¹	1.3332X10 ⁻⁶	1	1.9337X10 ⁻⁵
Psia Lb/In ²	6.8046X10 ⁻²	51.7151	6894.757	6.8946X10 ⁻²	51715.1	1

To convert from one pressure unit to another use the left column to locate the old unit and multiply by the conversion factor to obtain the value in the new pressure unit.

Example:

To convert Atmospheres to Bar

$$1 \text{ Atm} = 1.01325 \text{ Bar}$$

$$1 \text{ Pascal} = 9.8692 \times 10^{-6} \text{ Atm}$$

Equivalence Table for Pressure/Vacuum Measurements

(Relating Furnace Vacuum Gauge Readings (Inches Hg) to Absolute Pressure Values)

Micron Hg	Millibar (mbar)	Torr (mmHg)	<i>Inches Hg* Vacuum Gauge</i>	Inches Hg Absolute	Psia (lb/in. ² absolute)	Atm
760,000	1013	760	0.0	29.92	14.7	1.000
750,000	1000	750	0.42	29.5	14.5	0.987
735,000	981	735.6	1.02	28.9	14.2	0.968
700,000	934	700	2.32	27.6	13.5	0.921
600,000	800	600	6.32	23.6	11.6	0.789
500,000	667	500	10.22	19.7	9.7	0.658
400,000	533	400	14.22	15.7	7.7	0.526
380,000	507	380	14.92	15.0	7.3	0.500
300,000	400	300	18.12	11.8	5.8	0.395
200,000	267	200	22.07	7.85	3.9	0.264
100,000	133.3	100	25.98	3.94	1.93	0.132
90,000	120	90	26.38	3.54	1.74	0.118
80,000	106.8	80	26.77	3.15	1.55	0.105
70,000	93.4	70	27.16	2.76	1.35	0.0921
60,000	80	60	27.56	2.36	1.16	0.0789
51,700	68.8	51.7	27.89	2.03	1.00	0.068
50,000	66.7	50	27.95	1.97	0.97	0.0658
40,000	53.3	40	28.35	1.57	0.77	0.0526
30,000	40.0	30	28.74	1.18	0.58	0.0395
25,400	33.8	25.4	28.92	1.00	0.4912	0.034
20,000	26.7	20	29.14	0.785	0.39	0.0264
10,000	13.33	10	29.53	0.394	0.193	0.0132
7,600	10.13	7.6	29.62	0.299	0.147	0.01
1,000	1.33	1	29.88	0.03937	0.01934	0.00132
750	1.00	0.75	29.89	0.0295	0.0145	0.000987
100	0.133	0.1	29.916	0.00394	0.00193	0.000132
10	0.0133	0.01	29.9196	0.000394	0.000193	0.0000132
1	0.00133	0.001	29.91996	0.0000394	0.0000193	0.0000013
0.1	0.000133	0.0001	29.919996	0.0000039	0.0000019	0.0000001

**EQUIVALENCE TABLE
FURNACE VACUUM GAUGE READINGS (PSIG OR PSI)
TO ABSOLUTE PRESSURE VALUES**

Bar	Torr	Psig (<i>Furnace gauge</i>)	Psia (lb/in ² absolute)	Atm
1.01325	760.0	0	14.7	1.00
1.082515	811.8	1	15.7	1.0682
1.358315	1018.7	5	19.7	1.3404
1.703065	1277.4	10	24.7	1.6806
2.047815	1535.8	15	29.7	2.0208
2.392565	1794.3	20	34.7	2.36098
3.082065	2311.4	30	44.7	3.04139
3.771565	2828.5	40	54.7	3.72179
4.461065	3345.6	50	64.7	4.40219
5.150565	3862.7	60	74.7	5.08259
5.840065	4379.8	70	84.7	5.76299
6.529565	4896.9	80	94.7	6.44339
7.219065	5414.0	90	104.7	7.12379
7.908565	5931.1	100	114.7	7.80419
14.80357	11102.1	200	214.7	14.6082
18.25207	13690.2	250	264.7	18.0102
21.69857	16273.1	300	314.7	21.4122
28.59357	21444.1	400	414.7	28.2162
35.48857	26615.1	500	514.7	35.0202
42.38357	31786.1	600	614.7	41.8242
49.27857	36957.1	700	714.7	48.6282
56.17357	42128.1	800	814.7	55.4322
63.06857	47299.1	900	914.7	62.2362
69.96357	52470.1	1000	1014.7	69.0402
104.4386	78325.1	1500	1514.7	103.0602
173.3886	130052.9	2500	2514.7	171.1206
207.8636	155910.2	3000	3014.7	205.1447
242.3386	181769.9	3500	3514.7	239.1688

**TEMPERATURE CONVERSION
FAHRENHEIT TO CELSIUS OR KELVIN**

°F	°C	K	°F	°C	K	°F	°C	K
-40	-40	233.2	550	287.8	560.9	1700	926.7	1199.8
-32	-35.6	237.6	600	315.6	588.7	1750	954.4	1227.6
-20	-28.9	244.3	650	343.3	616.5	1800	982.2	1255.4
-10	-23.3	249.8	700	371.1	644.3	1850	1010.0	1283.2
0	-17.8	255.4	750	398.9	672.0	1900	1037.8	1310.9
5	-15	258.2	800	426.7	699.8	1950	1065.6	1338.7
10	-12.2	260.9	850	454.4	727.6	2000	1093.3	1366.5
20	-6.7	266.5	900	482.2	755.4	2050	1121.1	1394.3
32	0	273.2	950	510.0	783.2	2100	1148.9	1422.0
40	4.4	277.6	1000	537.8	810.9	2150	1176.7	1449.8
50	10	283.2	1050	565.6	838.7	2200	1204.4	1477.6
70	21.1	294.3	1100	593.3	866.5	2250	1232.2	1505.4
90	32.2	305.4	1150	621.1	894.3	2300	1260.0	1533.2
100	37.8	310.9	1200	648.9	922.0	2350	1287.8	1560.9
120	48.9	322.0	1250	676.7	949.8	2400	1315.6	1588.7
150	65.6	338.7	1300	704.4	977.6	2450	1343.3	1616.5
212	100	373.2	1350	732.2	1005.4	2500	1371.1	1644.3
250	121.1	394.3	1400	760.0	1033.2	2550	1398.9	1672.0
300	148.9	422.0	1450	787.8	1060.9	2600	1426.7	1699.8
350	176.7	449.8	1500	815.6	1088.7	2650	1454.4	1727.6
400	204.4	477.6	1550	843.3	1116.5	2700	1482.2	1755.4
450	232.2	505.4	1600	871.1	1144.3	2750	1510.0	1783.2
500	260	533.2	1650	898.9	1172.0	2800	1537.8	1810.9

Formulas:

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32)/1.8$$

$$\text{K} = (^{\circ}\text{F} + 459.67)/1.8$$

$$^{\circ}\text{F} = (1.8 * \text{K}) - 459.67$$

$$^{\circ}\text{F} = (1.8 * ^{\circ}\text{C}) + 32$$

$$^{\circ}\text{C} = \text{K} - 273$$

$$\text{K} = ^{\circ}\text{C} + 273$$

POWDERED METALS				
U.S. MESH TO MICRON CONVERSION CHART				
U.S. Mesh	Microns	Millimeters	Inches	Appearance
5	400	4.0	0.1570	
10	2000	2.0	0.0787	
20	841	0.841	0.0331	
28	700	0.700	0.028	Beach Sand
35	500	0.500	0.0197	
40	400	0.400	0.0165	
50	297	0.297	0.0117	
60	250	0.250	0.0098	Fine Sand
70	210	0.210	0.0083	
80	177	0.177	0.0070	
100	149	0.149	0.0059	
120	125	0.125	0.0049	
140	105	0.105	0.0041	
200	74	0.074	0.0029	Cement
325	44	0.044	0.0017	Silt
400	37	0.037	0.0015	Plant pollen

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