

Eastern desert ware : traces of the inhabitants of the eastern desert in Egypt and Sudan during the 4th-6th centuries CE Barnard, H.

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APPENDIX ELEVEN Open Fire Temperature Measurements

Temperatures are usually recorded with alcohol or mercury thermometers, with thermistors or resistance temperature detectors (platinum resistance thermometers), or with a thermocouple. Alcohol and mercury thermometers are based on the fact that the volume of a liquid changes with its temperature. Such thermometers are suitable for most household and laboratory uses and accurately display temperatures between the freezing and boiling points of methanol, ethanol or mercury (Table 17-1).

	°F	°C				
Methanol (CH ₃ OH)						
freezing	-143	-97				
boiling	148	65				
Ethanol (C ₂ H	₅OH)					
freezing	-174	-114				
boiling	173	78				
Mercury (Hg)						
freezing	-38	-39				
boiling	674	357				

Table 17-1: Freezing and boiling temperatures of liquids commonly used in thermometers.

Themistors and resistance temperature detectors (RTDs) are based on the fact that the electrical resistance of metals depend on their temperature. Such thermometers require a small current to operate and an Ohmmeter to measure the electrical resistance in the system. Specific configurations have been developed for different applications and, in the form of digital thermometers, thermistors and RTDs have replaced most other temperature measuring devices. Given the large range and the high maximum reached, the temperatures required to fire pottery, in a kiln or in an open fire, are best measured with a thermocouple (Figure 17-1).

A thermocouple is based on the observation by Thomas Johann Seebeck (Tallinn, 9 April 1770-Berlin, 10 December 1831) that a circuit of two different metal wires produces a small, continuous electric current. The voltage of this current, known as the Seebeck voltage, depends on the metals used as well as on the temperature of the joints. If one of the joints is kept at a fixed, known temperature (for instance at 0°C or 32°F in melting ice), or is kept constant by an 'electronic ice point reference', the voltage in the system depends on the temperature of the second joint, which can now be used as a probe (Figure 17-2). It has to be kept in mind that the connection of the leads to the voltmeter, where different metals are connected, results in another thermocouple. If very accurate measurements are needed these connections should be placed in an 'isothermal block'. A large number of different thermocouples, comprising different combinations of metals, are commercially available. A K-type thermocouple, which consists of an alumel (nickel-aluminium alloy) and a chromel (nickelchromium alloy) lead, is a general purpose thermocouple that is suitable to record the temperatures in an open wood fire, as well as in most pottery kilns. The correlation between the temperature of the probe and the current in the system (Figure 17-1) is given in Table 17-3 and Figure 17-3.

Two temperature scales are currently most frequently used (Tables 17-2 and 17-4), one developed by Daniel Gabriel Fahrenheit (Gdansk, 24 May 1686-The Hague, 16 September 1736) and another by Anders Celsius (Uppsala, 27 November 1701-25 April 1744). Fahrenheit identified the temperature of melting ice as 32°F and that of the human body as 96°F. His scale won great popularity because of the quality of the (mercury) thermometers (outfitted with his scale) that he produced. Celsius, on the other hand, was concerned with the universality of the units used in the sciences. He identified the temperature of boiling water as 0°C and that of melting ice as 100°C. How these figures were reversed remains unclear, although it has been suggested that this was done by Carolus Linnaeus (Carl von Linné) in 1745. The Celsius scale was chosen as the basis for the Kelvin scale (K = $^{\circ}C + 273.15$), named after William Thomson, Baron Kelvin that places 0 K (without a °-sign) at 'absolute zero' (-273.15°C or -459.67°F), which is one of the seven base units of the International System of Units (SI).

°F	°C
-40	-40
0	-18
32	0
61	16
82	28
100	38
212	100
1000	538
1832	1000
°F = (°C x 1.8) + 32	°C = (°F – 32) x 0.56

Table 17-2: Correlation of °F and °C (cf. Table 17-4).

Appendix XI: Temperature Measurements

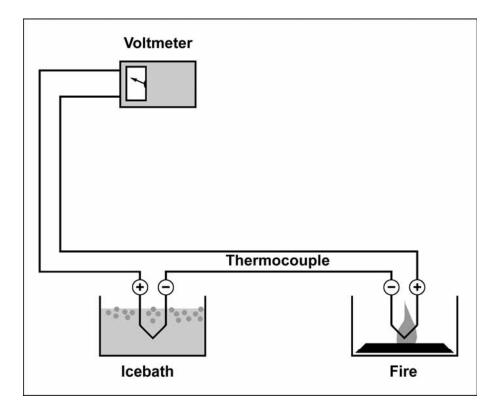


Figure 17-1: Theoretical lay-out of a thermocouple set to measure large temperature differences (cf. Figures 17-2 and 17-3).

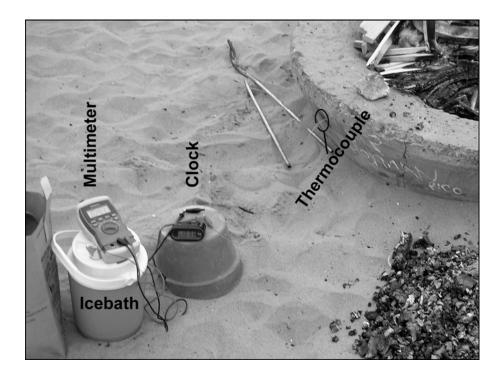


Figure 17-2: A K-type thermocouple employed to record the temperature of an open wood fire (cf. Figures 17-1 and 17-4).

Eastern Desert Ware

mV	°F	°C]	mV	°F	°C
0	32	0		20	905	485
1	77	25		21	948	509
2	122	50		22	990	532
3	165	74		23	1033	556
4	208	98		24	1074	579
5	252	122		25	1117	603
6	297	147		26	1159	626
7	342	172		27	1202	650
8	387	197		28	1245	674
9	432	222		29	1287	697
10	477	247		30	1330	721
11	520	271		31	1373	745
12	563	295		32	1416	769
13	608	320		33	1461	794
14	649	343		34	1504	818
15	693	367		35	1549	843
16	736	391		36	1593	867
17	779	415		37	1638	892
18	820	438		38	1683	917
19	864	462		39	1729	943
20	905	485		40	1774	968

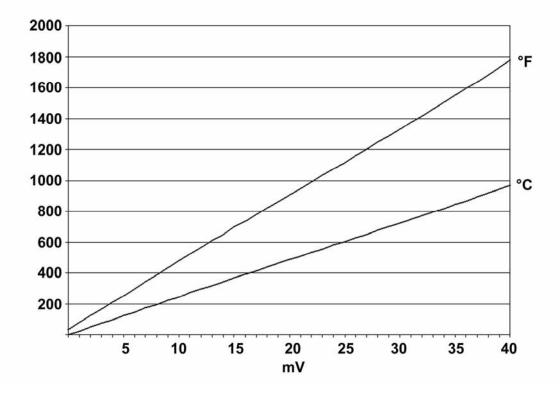


Table 17-3 and Figure 17-3: Correlation between the temperature and the voltage in a K-type thermocouple.

Appendix XI: Temperature Measurements

°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
0		100		200		300		400	
5	41	105	221	205	401	305	581	405	761
10	50	110	230	210	410	310	590	410	770
15	59	115	239	215	419	315	599	415	779
20	68	120	248	220	428	320	608	420	788
25	77	125	257	225	437	325	617	425	797
30	86	130	266	230	446	330	626	430	806
35	95	135	275	235	455	335	635	435	815
40	104	140	284	240	464	340	644	440	824
45	113	145	293	245	473	345	653	445	833
50	122	150	302	250	482	350	662	450	842
55	131	155	311	255	491	355	671	455	851
60	140	160	320	260	500	360	680	460	860
65	149	165	329	265	509	365	689	465	869
70	158	170	338	270	518	370	698	470	878
75	167	175	347	275	527	375	707	475	887
80	176	180	356	280	536	380	716	480	896
85	185	185	365	285	545	385	725	485	905
90	194	190	374	290	554	390	734	490	914
95	203	195	383	295	563	395	743	495	923
100	212	200	392	300	572	400	752	500	932
°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
°C 500	°F	°C 600	°F	°C 700	°F	°C 800	°F	°C 900	°F
	° F 941		° F 1121		° F 1301		° F 1481		° F 1661
500		600		700		800		900	
500 505	941	600 605	1121	700 705	1301	800 805	1481	900 905	1661
500 505 510	941 950	600 605 610	1121 1130	700 705 710	1301 1310	800 805 810	1481 1490	900 905 910	1661 1670
500 505 510 515	941 950 959	600 605 610 615	1121 1130 1139	700 705 710 715	1301 1310 1319	800 805 810 815	1481 1490 1499	900 905 910 915	1661 1670 1679
500 505 510 515 520	941 950 959 968	600 605 610 615 620	1121 1130 1139 1148	700 705 710 715 720	1301 1310 1319 1328	800 805 810 815 820	1481 1490 1499 1508	900 905 910 915 920	1661 1670 1679 1688
500 505 510 515 520 525	941 950 959 968 977	600 605 610 615 620 625	1121 1130 1139 1148 1157	700 705 710 715 720 725	1301 1310 1319 1328 1337	800 805 810 815 820 825	1481 1490 1499 1508 1517	900 905 910 915 920 925	1661 1670 1679 1688 1697
500 505 510 515 520 525 530 535 535	941 950 959 968 977 986 995 1004	600 605 610 615 620 625 630 635 640	1121 1130 1139 1148 1157 1166 1175 1184	700 705 710 715 720 725 730 735 740	1301 1310 1319 1328 1337 1346 1355 1364	800 805 810 815 820 825 830	1481 1490 1499 1508 1517 1526 1535 1544	900 905 910 915 920 925 930 935 940	1661 1670 1679 1688 1697 1706
500 505 510 515 520 525 530 535 540 545	941 950 959 968 977 986 995 1004 1013	600 605 610 615 620 625 630 635 640 645	1121 1130 1139 1148 1157 1166 1175 1184 1193	700 705 710 715 720 725 730 735 740 745	1301 1310 1319 1328 1337 1346 1355 1364 1373	800 805 810 815 820 825 830 835 840 845	1481 1490 1499 1508 1517 1526 1535 1544 1553	900 905 910 915 920 925 930 935 940 945	1661 1670 1679 1688 1697 1706 1715 1724 1733
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500 505 510 515 520 525 530 535 540 545 550 555	941 950 959 968 977 986 995 1004 1013 1022 1031	600 605 610 625 620 625 630 635 640 645 650 655	1121 1130 1139 1148 1157 1166 1175 1184 1193 1202 1211	700 705 710 715 720 725 730 735 740 745 750 755	1301 1310 1319 1328 1337 1346 1355 1364 1373 1382 1391	800 805 810 815 820 825 830 835 840 845 850 855	1481 1490 1499 1508 1517 1526 1535 1544 1553 1562 1571	900 905 910 925 920 935 930 935 940 945 950 955	1661 1679 1688 1697 1706 1715 1724 1733 1742 1751
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Table 17-4: Conversion table from 0 - 1000°C into °F (cf. Table 17-2).

Eastern Desert Ware

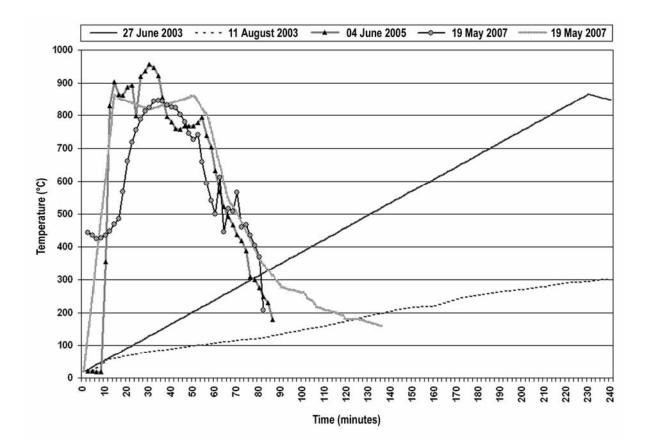


Figure 17-4: Temperature curves in an open wood fire (4 June 2005 and 19 May 2007, cf. Figure 17-2) compared to the temperature of the soil below a continuous wood fire (11 August 2003) and inside an electric pottery kiln, with kiln sitter 012, until just after it shuts off (27 June 2003).