



Designation: **E1751/E1751M – 09^{ε1} E1751/E1751M – 15**

Standard Guide for Temperature Electromotive Force (emf) Tables for Non- Letter Designated Thermocouple Combinations¹

This standard is issued under the fixed designation E1751/E1751M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

~~^{ε1} NOTE—Units information and designation was corrected editorially in June 2009.~~

1. Scope

1.1 This guide consists of reference tables that give temperature-electromotive force (emf) relationships for special purpose, limited use, thermocouple combinations that do not have a letter designation.

1.2 Extension wire or compensating extension wires are not covered by this guide. ASTM MNL 12² or thermocouple alloy suppliers should be consulted.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

2. Referenced Documents

2.1 *ASTM Standards*:³

E344 Terminology Relating to Thermometry and Hydrometry

E696 Specification for Tungsten-Rhenium Alloy Thermocouple Wire

3. Terminology

3.1 *Definitions*:

3.1.1 For definitions of terms used in this guide see Terminology **E344**.

3.2 *Definitions of Terms Specific to This Standard*:

3.2.1 *matched pairs, n*—a set of positive and negative thermoelements chosen so that a thermocouple fabricated from these thermoelements will match a specified temperature-electromotive force relationship to within a specified tolerance, at the time of first use.

4. Source of Data

4.1 The data in these tables are based on the SI Volt and the International Temperature Scale of 1990.

4.2 All temperature-electromotive force data in **Tables 1-20** have been developed from NIST, NRC, and wire manufacturers' data.

4.3 **Tables 1-16** give emf values in millivolts to three decimal places (1 μV) at $\pm 1^\circ\text{C}$ or $\pm 1^\circ\text{F}$ intervals. **Tables 17-20** give emf values in microvolts to one decimal place (0.1 μV) at $\pm 1^\circ\text{C}$ or $\pm 1^\circ\text{F}$ intervals. If greater precision is required, refer to the equation and coefficients listed for each thermocouple alloy.

5. Significance and Use

5.1 These thermocouple combinations have been developed for specific applications by the wire manufacturer(s). If additional information is required, consult ASTM MNL 12 or one of the following thermocouple manufacturers: Carpenter Technology, Engelhard Corp. Specialty Metals Div., Hoskins Mfg. Co., Johnson Matthey, Sigmund Cohn Corp. the wire manufacturer.

¹ This guide is under the jurisdiction of ASTM Committee **E20** on Temperature Measurement and is the direct responsibility of Subcommittee **E20.04** on Thermocouples. Current edition approved ~~June 1, 2009~~ May 1, 2015. Published ~~December 2009~~ June 2015. Originally approved in 1995. Last previous edition approved in ~~2000~~ 2009 as ~~E 1751 – 00, E1751 E1751M – 09^{ε1}~~ which was withdrawn March 2009 and reinstated in June 2009. DOI: 10.1520/E1751_E1751M-09E01. DOI: 10.1520/E1751_E1751M-15.

² "Manual on the Use of Thermocouples in Temperature Measurement," *ASTM Manual*, 12, ASTM, 1993.

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

6. Thermocouple Types

6.1 Letter symbols have not been assigned. Identification is made by alloy composition with the thermoelectrically positive material listed first.

- 6.1.1 ~~Tungsten-26 %tungsten-26 %~~ tungsten versus ~~tungsten-26 %tungsten-26 %~~ rhenium.
- 6.1.2 ~~Tungsten-3 %Tungsten-3 %~~ tungsten-3 % rhenium versus ~~tungsten-25 %tungsten-25 %~~ tungsten-25 % rhenium.
- 6.1.3 ~~Platinel II.~~⁴
- 6.1.4 ~~KP versus gold-0.07 %gold-0.07 %~~ KP versus ~~gold-0.07 %gold-0.07 %~~ iron.⁵
- 6.1.5 ~~Platinum-5 %Platinum-5 %~~ platinum-5 % molybdenum versus ~~platinum-0.1 %platinum-0.1 %~~ platinum-0.1 % molybdenum.
- 6.1.6 ~~Platinum-40 %Platinum-40 %~~ platinum-40 % rhodium versus ~~platinum-20 %platinum-20 %~~ platinum-20 % rhodium.
- 6.1.7 ~~Nickel-18 %Nickel-18 %~~ nickel-18 % molybdenum versus ~~nickel-0.8 %nickel-0.8 %~~ nickel-0.8 % cobalt.⁶
- 6.1.8 ~~Iridium-40 %Iridium-40 %~~ iridium-40 % rhodium versus iridium.
- 6.1.9 Gold versus platinum.
- 6.1.10 Platinum versus palladium.

7. Tolerances on Initial Values of emf versus Temperature

7.1 Tolerances on initial values of emf versus temperature have not been established for the thermocouples in this guide except for the ~~Tungsten-3 %Tungsten-3 %~~ Tungsten-3 % Rhenium versus ~~Tungsten-25 %Tungsten-25 %~~ Tungsten-25 % Rhenium, and that data can be found in Specification E696. When required, tolerances on initial values of emf versus temperature should be established by agreement between the consumer and the producer. These thermocouple combinations are supplied typically as matched pairs.

8. Table Information

8.1 The following is a list of emf versus temperature tables included in this guide.

Table Number	Thermocouple Type	Temperature Range
Table 1	Tungsten versus Tungsten-26 % Rhenium	0 °C to 2315 °C
Table 1	Tungsten versus Tungsten-26 % Rhenium	0 to 2315 °C
Table 2	Tungsten versus Tungsten-26 % Rhenium	32 °F to 4200 °F
Table 2	Tungsten versus Tungsten-26 % Rhenium	32 to 4200 °F
Table 3	Tungsten-3 % Rhenium versus Tungsten-25 % Rhenium	0 °C to 2315 °C
Table 3	Tungsten-3 % Rhenium versus Tungsten-25 % Rhenium	0 to 2315 °C
Table 4	Tungsten-3 % Rhenium versus Tungsten-25 % Rhenium	32 °F to 4200 °F
Table 4	Tungsten-3 % Rhenium versus Tungsten-25 % Rhenium	32 to 4200 °F
Table 5	Platinel II	0 °C to 1395 °C
Table 5	Platinel II	0 to 1395 °C
Table 6	Platinel II	32 °F to 2543 °F
Table 6	Platinel II	32 to 2543 °F
Table 7	KP versus Gold-0.07 % Iron	-273 °C to 7 °C
Table 7	KP versus Gold-0.07 % Iron	-273 to 7 °C
Table 8	KP versus Gold-0.07 % Iron	-459 °F to 44 °F
Table 8	KP versus Gold-0.07 % Iron	-459 to 44 °F
Table 9	Platinum-5 % Molybdenum versus Platinum-0.1 % Molybdenum	0 °C to 1600 °C
Table 9	Platinum-5 % Molybdenum versus Platinum-0.1 % Molybdenum	0 to 1600 °C
Table 10	Platinum-5 % Molybdenum versus Platinum-0.1 % Molybdenum	32 °F to 2912 °F
Table 10	Platinum-5 % Molybdenum versus Platinum-0.1 % Molybdenum	32 to 2912 °F
Table 11	Platinum-40 % Rhodium versus Platinum-20 % Rhodium	0 °C to 1888 °C
Table 11	Platinum-40 % Rhodium versus Platinum-20 % Rhodium	0 to 1888 °C
Table 12	Platinum-40 % Rhodium versus Platinum-20 % Rhodium	32 °F to 3430 °F
Table 12	Platinum-40 % Rhodium versus Platinum-20 % Rhodium	3 to 3430 °F
Table 13	Nickel-18 % Molybdenum versus Nickel-0.8 % Cobalt	-50 °C to 1410 °C
Table 13	Nickel-18 % Molybdenum versus Nickel-0.8 % Cobalt	-50 to 1410 °C

⁴ Trademark of Engelhard Corp., Specialty Metals Division.

⁵ Alloy compositions are expressed in percentages by mass, except for the ~~gold-0.07 %gold-0.07 %~~ gold-0.07 % iron alloy, which is given in atomic percent.

⁶ ~~Nickel-18 %Nickel-18 %~~ nickel-18 % molybdenum versus nickel 0.8 % cobalt is supplied by Carpenter Technology as 20 alloy and 19 alloy.

Table 14	Nickel-18 % Molybdenum versus Nickel-0.8 % Cobalt	-58 °F to 2570 °F
Table 14	Nickel-18 % Molybdenum versus Nickel-0.8 % Cobalt	-58 to 2570°F
Table 15	Iridium 40 % Rhodium versus Iridium	0 °C to 2110 °C
Table 15	Iridium 40 % Rhodium versus Iridium	0 to 2110°C
Table 16	Iridium 40 % Rhodium versus Iridium	32 °F to 3830 °F
Table 16	Iridium 40 % Rhodium versus Iridium	32 to 3830°F
Table 17	Gold versus Platinum	0 °C to 1000 °C
Table 17	Gold versus Platinum	0 to 1000°C
Table 18	Gold versus Platinum	32 °F to 1832 °F
Table 18	Gold versus Platinum	32 to 1832°F
Table 19	Platinum versus Palladium	0 °C to 1500 °C
Table 19	Platinum versus Palladium	0 to 1500°C
Table 20	Platinum versus Palladium	32 °F to 2732 °F
Table 20	Platinum versus Palladium	32 to 2732°F
Table 21	Polynomial Coefficients for the Computation of Temperatures in °C or °F as a Function of Thermocouple emf	

8.2 Tables 1-20 were derived from equations of the form:

$$E = c_0 + c_1 T + c_2 T^2 + \dots + c_n T^n \tag{1}$$

where:

E = the emf in millivolts (except for Tables 17-20 where E is in microvolts), and

T = the temperature in °C or °F. The coefficients used to calculate each table are given at the end of the table.

8.3 Table 21 gives coefficients of inverse equations that may be used to compute approximate values of temperature (T) in either °C or °F for each thermocouple combination. The inverse equations are of the form:

$$T = b_0 + b_1 E + b_2 E^2 + \dots + b_n E^n \tag{2}$$

except for the gold versus platinum thermocouple in the ranges 209 °C to 1000 °C (408.2 °F to 1832 °F), where the inverse equation is of the form:

$$T = b_0 + \sum_{i=1}^{11} b_i \left(\frac{E - 9645}{7620} \right)^i \tag{3}$$

For these equations, the thermocouple emf (E) is in units of millivolts, except for gold versus platinum and platinum versus palladium thermocouples, for which the emf is in units of microvolts.

8.3.1 Table 21 also gives the temperature range, emf range, and error range of each inverse equation.

9. Keywords

9.1 cobalt; coefficients; gold; iridium; iron; molybdenum; nickel; palladium; platinum; polynomal; rhenium; rhodium; thermocouple; tungsten

TABLE 1 Tungsten versus Tungsten-26 % Rhenium Thermocouples—Thermoelectric Voltage as a Function of Temperature (°C), Reference Junctions at 0 °C

Tungsten versus Tungsten-26 % Rhenium Thermocouples												
Thermoelectric Voltage as a Function of Temperature (°C), Reference Junctions at 0°C												
°C	0	1	2	3	4	5	6	7	8	9	10	°C
Thermoelectric Voltage in Millivolts												
0	0.000	0.001	0.003	0.004	0.005	0.007	0.008	0.010	0.012	0.013	0.015	0
10	0.015	0.017	0.018	0.020	0.022	0.024	0.026	0.028	0.030	0.032	0.034	10
20	0.034	0.036	0.038	0.041	0.043	0.045	0.048	0.050	0.053	0.055	0.058	20
30	0.058	0.060	0.063	0.065	0.068	0.071	0.074	0.076	0.079	0.082	0.085	30
40	0.085	0.088	0.091	0.094	0.097	0.100	0.104	0.107	0.110	0.113	0.117	40
50	0.117	0.120	0.123	0.127	0.130	0.134	0.138	0.141	0.145	0.148	0.152	50
60	0.152	0.156	0.160	0.164	0.168	0.172	0.175	0.179	0.184	0.188	0.192	60
70	0.192	0.196	0.200	0.204	0.209	0.213	0.217	0.222	0.226	0.231	0.235	70
80	0.235	0.240	0.244	0.249	0.254	0.258	0.263	0.268	0.273	0.277	0.282	80
90	0.282	0.287	0.292	0.297	0.302	0.307	0.312	0.318	0.323	0.328	0.333	90
100	0.333	0.339	0.344	0.349	0.355	0.360	0.366	0.371	0.377	0.382	0.388	100
110	0.388	0.394	0.399	0.405	0.411	0.417	0.422	0.428	0.434	0.440	0.446	110
120	0.446	0.452	0.458	0.464	0.471	0.477	0.483	0.489	0.495	0.502	0.508	120
130	0.508	0.514	0.521	0.527	0.534	0.540	0.547	0.553	0.560	0.567	0.573	130

TABLE 1 *Continued*
Tungsten versus Tungsten-26 % Rhenium Thermocouples
Thermoelectric Voltage as a Function of Temperature (°C), Reference Junctions at 0°C

°C	0	1	2	3	4	5	6	7	8	9	10	°C
Thermoelectric Voltage in Millivolts												
140	0.573	0.580	0.587	0.594	0.601	0.607	0.614	0.621	0.628	0.635	0.642	140
150	0.642	0.649	0.656	0.664	0.671	0.678	0.685	0.693	0.700	0.707	0.715	150
160	0.715	0.722	0.729	0.737	0.744	0.752	0.760	0.767	0.775	0.782	0.790	160
170	0.790	0.798	0.806	0.813	0.821	0.829	0.837	0.845	0.853	0.861	0.869	170
180	0.869	0.877	0.885	0.893	0.902	0.910	0.918	0.926	0.935	0.943	0.951	180
190	0.951	0.960	0.968	0.976	0.985	0.993	1.002	1.011	1.019	1.028	1.037	190
200	1.037	1.045	1.054	1.063	1.072	1.080	1.089	1.098	1.107	1.116	1.125	200
210	1.125	1.134	1.143	1.152	1.161	1.170	1.180	1.189	1.198	1.207	1.217	210
220	1.217	1.226	1.235	1.245	1.254	1.264	1.273	1.283	1.292	1.302	1.311	220
230	1.311	1.321	1.331	1.340	1.350	1.360	1.369	1.379	1.389	1.399	1.409	230
240	1.409	1.419	1.429	1.439	1.449	1.459	1.469	1.479	1.489	1.499	1.509	240
250	1.509	1.520	1.530	1.540	1.550	1.561	1.571	1.582	1.592	1.602	1.613	250
260	1.613	1.623	1.634	1.644	1.655	1.666	1.676	1.687	1.698	1.708	1.719	260
270	1.719	1.730	1.741	1.752	1.762	1.773	1.784	1.795	1.806	1.817	1.828	270
280	1.828	1.839	1.850	1.862	1.873	1.884	1.895	1.906	1.918	1.929	1.940	280
290	1.940	1.951	1.963	1.974	1.986	1.997	2.009	2.020	2.032	2.043	2.055	290
300	2.055	2.066	2.078	2.090	2.101	2.113	2.125	2.136	2.148	2.160	2.172	300
310	2.172	2.184	2.196	2.208	2.219	2.231	2.243	2.255	2.267	2.280	2.292	310
320	2.292	2.304	2.316	2.328	2.340	2.353	2.365	2.377	2.389	2.402	2.414	320
330	2.414	2.426	2.439	2.451	2.464	2.476	2.489	2.501	2.514	2.526	2.539	330
340	2.539	2.552	2.564	2.577	2.590	2.602	2.615	2.628	2.641	2.653	2.666	340
350	2.666	2.679	2.692	2.705	2.718	2.731	2.744	2.757	2.770	2.783	2.796	350
360	2.796	2.809	2.822	2.836	2.849	2.862	2.875	2.888	2.902	2.915	2.928	360
370	2.928	2.942	2.955	2.968	2.982	2.995	3.009	3.022	3.036	3.049	3.063	370
380	3.063	3.076	3.090	3.104	3.117	3.131	3.145	3.158	3.172	3.186	3.200	380
390	3.200	3.214	3.227	3.241	3.255	3.269	3.283	3.297	3.311	3.325	3.339	390
400	3.339	3.353	3.367	3.381	3.395	3.409	3.423	3.438	3.452	3.466	3.480	400
410	3.480	3.494	3.509	3.523	3.537	3.552	3.566	3.580	3.595	3.609	3.624	410
420	3.624	3.638	3.653	3.667	3.682	3.696	3.711	3.725	3.740	3.755	3.769	420
430	3.769	3.784	3.799	3.813	3.828	3.843	3.858	3.872	3.887	3.902	3.917	430
440	3.917	3.932	3.947	3.962	3.977	3.992	4.007	4.022	4.037	4.052	4.067	440
450	4.067	4.082	4.097	4.112	4.127	4.142	4.158	4.173	4.188	4.203	4.219	450
460	4.219	4.234	4.249	4.264	4.280	4.295	4.311	4.326	4.341	4.357	4.372	460
470	4.372	4.388	4.403	4.419	4.434	4.450	4.465	4.481	4.497	4.512	4.528	470
480	4.528	4.544	4.559	4.575	4.591	4.606	4.622	4.638	4.654	4.670	4.685	480
490	4.685	4.701	4.717	4.733	4.749	4.765	4.781	4.797	4.813	4.829	4.845	490
500	4.845	4.861	4.877	4.893	4.909	4.925	4.941	4.957	4.974	4.990	5.006	500
510	5.006	5.022	5.038	5.055	5.071	5.087	5.104	5.120	5.136	5.153	5.169	510
520	5.169	5.185	5.202	5.218	5.235	5.251	5.267	5.284	5.300	5.317	5.334	520
530	5.334	5.350	5.367	5.383	5.400	5.416	5.433	5.450	5.466	5.483	5.500	530
540	5.500	5.517	5.533	5.550	5.567	5.584	5.600	5.617	5.634	5.651	5.668	540
550	5.668	5.685	5.702	5.718	5.735	5.752	5.769	5.786	5.803	5.820	5.837	550
560	5.837	5.854	5.871	5.888	5.906	5.923	5.940	5.957	5.974	5.991	6.008	560
570	6.008	6.026	6.043	6.060	6.077	6.095	6.112	6.129	6.146	6.164	6.181	570
580	6.181	6.198	6.216	6.233	6.250	6.268	6.285	6.303	6.320	6.338	6.355	580
590	6.355	6.373	6.390	6.408	6.425	6.443	6.460	6.478	6.495	6.513	6.531	590
600	6.531	6.548	6.566	6.583	6.601	6.619	6.636	6.654	6.672	6.690	6.707	600
610	6.707	6.725	6.743	6.761	6.778	6.796	6.814	6.832	6.850	6.868	6.886	610
620	6.886	6.903	6.921	6.939	6.957	6.975	6.993	7.011	7.029	7.047	7.065	620
630	7.065	7.083	7.101	7.119	7.137	7.155	7.173	7.191	7.210	7.228	7.246	630
640	7.246	7.264	7.282	7.300	7.319	7.337	7.355	7.373	7.391	7.410	7.428	640
650	7.428	7.446	7.465	7.483	7.501	7.519	7.538	7.556	7.575	7.593	7.611	650
660	7.611	7.630	7.648	7.667	7.685	7.703	7.722	7.740	7.759	7.777	7.796	660
670	7.796	7.814	7.833	7.852	7.870	7.889	7.907	7.926	7.944	7.963	7.982	670
680	7.982	8.000	8.019	8.038	8.056	8.075	8.094	8.113	8.131	8.150	8.169	680
690	8.169	8.187	8.206	8.225	8.244	8.263	8.281	8.300	8.319	8.338	8.357	690
700	8.357	8.376	8.395	8.414	8.432	8.451	8.470	8.489	8.508	8.527	8.546	700
710	8.546	8.565	8.584	8.603	8.622	8.641	8.660	8.679	8.698	8.717	8.737	710

TABLE 1 *Continued*
Tungsten versus Tungsten-26 % Rhenium Thermocouples
Thermoelectric Voltage as a Function of Temperature (°C), Reference Junctions at 0°C

°C	0	1	2	3	4	5	6	7	8	9	10	°C
Thermoelectric Voltage in Millivolts												
720	8.737	8.756	8.775	8.794	8.813	8.832	8.851	8.870	8.890	8.909	8.928	720
730	8.928	8.947	8.966	8.986	9.005	9.024	9.043	9.063	9.082	9.101	9.120	730
740	9.120	9.140	9.159	9.178	9.198	9.217	9.236	9.256	9.275	9.295	9.314	740
750	9.314	9.333	9.353	9.372	9.392	9.411	9.430	9.450	9.469	9.489	9.508	750
760	9.508	9.528	9.547	9.567	9.586	9.606	9.625	9.645	9.665	9.684	9.704	760
770	9.704	9.723	9.743	9.763	9.782	9.802	9.821	9.841	9.861	9.880	9.900	770
780	9.900	9.920	9.939	9.959	9.979	9.998	10.018	10.038	10.058	10.077	10.097	780
790	10.097	10.117	10.137	10.156	10.176	10.196	10.216	10.236	10.256	10.275	10.295	790
800	10.295	10.315	10.335	10.355	10.375	10.395	10.414	10.434	10.454	10.474	10.494	800
810	10.494	10.514	10.534	10.554	10.574	10.594	10.614	10.634	10.654	10.674	10.694	810
820	10.694	10.714	10.734	10.754	10.774	10.794	10.814	10.834	10.854	10.874	10.894	820
830	10.894	10.914	10.934	10.954	10.974	10.995	11.015	11.035	11.055	11.075	11.095	830
840	11.095	11.115	11.136	11.156	11.176	11.196	11.216	11.236	11.257	11.277	11.297	840
850	11.297	11.317	11.338	11.358	11.378	11.398	11.419	11.439	11.459	11.479	11.500	850
860	11.500	11.520	11.540	11.561	11.581	11.601	11.622	11.642	11.662	11.683	11.703	860
870	11.703	11.723	11.744	11.764	11.784	11.805	11.825	11.845	11.866	11.886	11.907	870
880	11.907	11.927	11.948	11.968	11.988	12.009	12.029	12.050	12.070	12.091	12.111	880
890	12.111	12.132	12.152	12.173	12.193	12.214	12.234	12.255	12.275	12.296	12.316	890
900	12.316	12.337	12.357	12.378	12.398	12.419	12.439	12.460	12.481	12.501	12.522	900
910	12.522	12.542	12.563	12.583	12.604	12.625	12.645	12.666	12.686	12.707	12.728	910
920	12.728	12.748	12.769	12.790	12.810	12.831	12.852	12.872	12.893	12.914	12.934	920
930	12.934	12.955	12.976	12.996	13.017	13.038	13.058	13.079	13.100	13.121	13.141	930
940	13.141	13.162	13.183	13.204	13.224	13.245	13.266	13.287	13.307	13.328	13.349	940
950	13.349	13.370	13.390	13.411	13.432	13.453	13.474	13.494	13.515	13.536	13.557	950
960	13.557	13.578	13.598	13.619	13.640	13.661	13.682	13.702	13.723	13.744	13.765	960
970	13.765	13.786	13.807	13.828	13.848	13.869	13.890	13.911	13.932	13.953	13.974	970
980	13.974	13.995	14.015	14.036	14.057	14.078	14.099	14.120	14.141	14.162	14.183	980
990	14.183	14.204	14.225	14.245	14.266	14.287	14.308	14.329	14.350	14.371	14.392	990
1000	14.392	14.413	14.434	14.455	14.476	14.497	14.518	14.539	14.560	14.581	14.602	1000
1010	14.602	14.623	14.644	14.665	14.686	14.707	14.728	14.749	14.770	14.791	14.812	1010
1020	14.812	14.833	14.854	14.875	14.896	14.917	14.938	14.959	14.980	15.001	15.022	1020
1030	15.022	15.043	15.064	15.085	15.106	15.127	15.148	15.169	15.190	15.211	15.232	1030
1040	15.232	15.253	15.274	15.295	15.316	15.337	15.359	15.380	15.401	15.422	15.443	1040
1050	15.443	15.464	15.485	15.506	15.527	15.548	15.569	15.590	15.611	15.633	15.654	1050
1060	15.654	15.675	15.696	15.717	15.738	15.759	15.780	15.801	15.822	15.844	15.865	1060
1070	15.865	15.886	15.907	15.928	15.949	15.970	15.991	16.012	16.034	16.055	16.076	1070
1080	16.076	16.097	16.118	16.139	16.160	16.181	16.202	16.224	16.245	16.266	16.287	1080
1090	16.287	16.308	16.329	16.350	16.372	16.393	16.414	16.435	16.456	16.477	16.498	1090
1100	16.498	16.520	16.541	16.562	16.583	16.604	16.625	16.646	16.668	16.689	16.710	1100
1110	16.710	16.731	16.752	16.773	16.794	16.816	16.837	16.858	16.879	16.900	16.921	1110
1120	16.921	16.943	16.964	16.985	17.006	17.027	17.048	17.069	17.091	17.112	17.133	1120
1130	17.133	17.154	17.175	17.196	17.218	17.239	17.260	17.281	17.302	17.323	17.345	1130
1140	17.345	17.366	17.387	17.408	17.429	17.450	17.471	17.493	17.514	17.535	17.556	1140
1150	17.556	17.577	17.598	17.620	17.641	17.662	17.683	17.704	17.725	17.747	17.768	1150
1160	17.768	17.789	17.810	17.831	17.852	17.874	17.895	17.916	17.937	17.958	17.979	1160
1170	17.979	18.000	18.022	18.043	18.064	18.085	18.106	18.127	18.149	18.170	18.191	1170
1180	18.191	18.212	18.233	18.254	18.275	18.297	18.318	18.339	18.360	18.381	18.402	1180
1190	18.402	18.423	18.445	18.466	18.487	18.508	18.529	18.550	18.571	18.593	18.614	1190
1200	18.614	18.635	18.656	18.677	18.698	18.719	18.741	18.762	18.783	18.804	18.825	1200
1210	18.825	18.846	18.867	18.888	18.910	18.931	18.952	18.973	18.994	19.015	19.036	1210
1220	19.036	19.057	19.078	19.100	19.121	19.142	19.163	19.184	19.205	19.226	19.247	1220
1230	19.247	19.268	19.289	19.311	19.332	19.353	19.374	19.395	19.416	19.437	19.458	1230
1240	19.458	19.479	19.500	19.521	19.543	19.564	19.585	19.606	19.627	19.648	19.669	1240
1250	19.669	19.690	19.711	19.732	19.753	19.774	19.795	19.816	19.837	19.858	19.880	1250
1260	19.880	19.901	19.922	19.943	19.964	19.985	20.006	20.027	20.048	20.069	20.090	1260
1270	20.090	20.111	20.132	20.153	20.174	20.195	20.216	20.237	20.258	20.279	20.300	1270
1280	20.300	20.321	20.342	20.363	20.384	20.405	20.426	20.447	20.468	20.489	20.510	1280
1290	20.510	20.531	20.552	20.573	20.594	20.615	20.636	20.657	20.678	20.699	20.720	1290



TABLE 1 Continued
Tungsten versus Tungsten-26 % Rhenium Thermocouples
Thermoelectric Voltage as a Function of Temperature (°C), Reference Junctions at 0°C

Table with columns for temperature in °C (0 to 10) and thermoelectric voltage in millivolts. Rows are labeled with temperatures from 1300 to 1880 °C.



TABLE 1 Continued
Tungsten versus Tungsten-26 % Rhenium Thermocouples
Thermoelectric Voltage as a Function of Temperature (°C), Reference Junctions at 0°C

Table with columns for temperature in °C (0 to 10) and rows for temperature in °C (1890 to 2310). The table contains thermoelectric voltage values in millivolts for various temperatures.

Coefficients and temperature ranges of equations used to compute the above ITS-90 based table for Tungsten versus Tungsten-26% Rhenium thermocouples.

Coefficients and temperature ranges of equations used to compute the above ITS-90 based table for Tungsten versus Tungsten-26% Rhenium thermocouples.

0 °C to 630.615 °C
0 to 630.615 °C

630.615 °C to 2315 °C
630.615 to 2315 °C

Equations for coefficients c0 through c5 for the 0 °C to 630.615 °C range.

Equations for coefficients c0 through c8 for the 630.615 °C to 2315 °C range.

TABLE 2 Tungsten versus Tungsten-26 % Rhenium Thermocouples—Thermoelectric Voltage as a Function of Temperature (°F), Reference Junctions at 32 °F

**Tungsten versus Tungsten-26 % Rhenium Thermocouples
Thermoelectric Voltage as a Function of Temperature (°F), Reference Junctions at 32 °F**

°F	0	1	2	3	4	5	6	7	8	9	10	°F
Thermoelectric Voltage in Millivolts												
30			0.000	0.001	0.001	0.002	0.003	0.004	0.005	0.005	0.006	30
40	0.006	0.007	0.008	0.009	0.009	0.010	0.011	0.012	0.013	0.014	0.015	40
50	0.015	0.016	0.017	0.018	0.019	0.020	0.021	0.022	0.023	0.024	0.025	50
60	0.025	0.026	0.027	0.028	0.030	0.031	0.032	0.033	0.034	0.035	0.037	60
70	0.037	0.038	0.039	0.040	0.041	0.043	0.044	0.045	0.047	0.048	0.049	70
80	0.049	0.051	0.052	0.053	0.055	0.056	0.058	0.059	0.060	0.062	0.063	80
90	0.063	0.065	0.066	0.068	0.069	0.071	0.072	0.074	0.075	0.077	0.079	90
100	0.079	0.080	0.082	0.083	0.085	0.087	0.088	0.090	0.092	0.093	0.095	100
110	0.095	0.097	0.099	0.100	0.102	0.104	0.106	0.107	0.109	0.111	0.113	110
120	0.113	0.115	0.117	0.119	0.120	0.122	0.124	0.126	0.128	0.130	0.132	120
130	0.132	0.134	0.136	0.138	0.140	0.142	0.144	0.146	0.148	0.150	0.152	130
140	0.152	0.154	0.156	0.159	0.161	0.163	0.165	0.167	0.169	0.172	0.174	140
150	0.174	0.176	0.178	0.180	0.183	0.185	0.187	0.189	0.192	0.194	0.196	150
160	0.196	0.199	0.201	0.203	0.206	0.208	0.211	0.213	0.215	0.218	0.220	160
170	0.220	0.223	0.225	0.228	0.230	0.233	0.235	0.238	0.240	0.243	0.245	170
180	0.245	0.248	0.250	0.253	0.256	0.258	0.261	0.264	0.266	0.269	0.272	180
190	0.272	0.274	0.277	0.280	0.282	0.285	0.288	0.291	0.293	0.296	0.299	190
200	0.299	0.302	0.305	0.307	0.310	0.313	0.316	0.319	0.322	0.325	0.327	200
210	0.327	0.330	0.333	0.336	0.339	0.342	0.345	0.348	0.351	0.354	0.357	210
220	0.357	0.360	0.363	0.366	0.369	0.372	0.375	0.379	0.382	0.385	0.388	220
230	0.388	0.391	0.394	0.397	0.401	0.404	0.407	0.410	0.413	0.417	0.420	230
240	0.420	0.423	0.426	0.430	0.433	0.436	0.440	0.443	0.446	0.450	0.453	240
250	0.453	0.456	0.460	0.463	0.466	0.470	0.473	0.477	0.480	0.484	0.487	250
260	0.487	0.491	0.494	0.498	0.501	0.505	0.508	0.512	0.515	0.519	0.522	260
270	0.522	0.526	0.529	0.533	0.537	0.540	0.544	0.548	0.551	0.555	0.559	270
280	0.559	0.562	0.566	0.570	0.573	0.577	0.581	0.585	0.588	0.592	0.596	280
290	0.596	0.600	0.604	0.607	0.611	0.615	0.619	0.623	0.627	0.631	0.634	290
300	0.634	0.638	0.642	0.646	0.650	0.654	0.658	0.662	0.666	0.670	0.674	300
310	0.674	0.678	0.682	0.686	0.690	0.694	0.698	0.702	0.706	0.710	0.715	310
320	0.715	0.719	0.723	0.727	0.731	0.735	0.739	0.744	0.748	0.752	0.756	320
330	0.756	0.760	0.765	0.769	0.773	0.777	0.782	0.786	0.790	0.794	0.799	330
340	0.799	0.803	0.807	0.812	0.816	0.820	0.825	0.829	0.834	0.838	0.842	340
350	0.842	0.847	0.851	0.856	0.860	0.865	0.869	0.874	0.878	0.883	0.887	350
360	0.887	0.892	0.896	0.901	0.905	0.910	0.914	0.919	0.923	0.928	0.933	360
370	0.933	0.937	0.942	0.947	0.951	0.956	0.961	0.965	0.970	0.975	0.979	370
380	0.979	0.984	0.989	0.993	0.998	1.003	1.008	1.013	1.017	1.022	1.027	380
390	1.027	1.032	1.037	1.041	1.046	1.051	1.056	1.061	1.066	1.071	1.076	390
400	1.076	1.080	1.085	1.090	1.095	1.100	1.105	1.110	1.115	1.120	1.125	400
410	1.125	1.130	1.135	1.140	1.145	1.150	1.155	1.160	1.165	1.170	1.176	410
420	1.176	1.181	1.186	1.191	1.196	1.201	1.206	1.211	1.217	1.222	1.227	420
430	1.227	1.232	1.237	1.243	1.248	1.253	1.258	1.264	1.269	1.274	1.279	430
440	1.279	1.285	1.290	1.295	1.301	1.306	1.311	1.317	1.322	1.327	1.333	440
450	1.333	1.338	1.343	1.349	1.354	1.360	1.365	1.371	1.376	1.381	1.387	450
460	1.387	1.392	1.398	1.403	1.409	1.414	1.420	1.425	1.431	1.437	1.442	460
470	1.442	1.448	1.453	1.459	1.464	1.470	1.476	1.481	1.487	1.492	1.498	470
480	1.498	1.504	1.509	1.515	1.521	1.526	1.532	1.538	1.544	1.549	1.555	480
490	1.555	1.561	1.567	1.572	1.578	1.584	1.590	1.595	1.601	1.607	1.613	490
500	1.613	1.619	1.625	1.630	1.636	1.642	1.648	1.654	1.660	1.666	1.672	500
510	1.672	1.677	1.683	1.689	1.695	1.701	1.707	1.713	1.719	1.725	1.731	510
520	1.731	1.737	1.743	1.749	1.755	1.761	1.767	1.773	1.779	1.785	1.792	520
530	1.792	1.798	1.804	1.810	1.816	1.822	1.828	1.834	1.841	1.847	1.853	530
540	1.853	1.859	1.865	1.871	1.878	1.884	1.890	1.896	1.903	1.909	1.915	540
550	1.915	1.921	1.928	1.934	1.940	1.946	1.953	1.959	1.965	1.972	1.978	550
560	1.978	1.984	1.991	1.997	2.003	2.010	2.016	2.023	2.029	2.035	2.042	560

TABLE 2 *Continued*
Tungsten versus Tungsten-26 % Rhenium Thermocouples
Thermoelectric Voltage as a Function of Temperature (°F), Reference Junctions at 32°F

°F	0	1	2	3	4	5	6	7	8	9	10	°F
Thermoelectric Voltage in Millivolts												
570	2.042	2.048	2.055	2.061	2.068	2.074	2.080	2.087	2.093	2.100	2.106	570
580	2.106	2.113	2.119	2.126	2.132	2.139	2.146	2.152	2.159	2.165	2.172	580
590	2.172	2.178	2.185	2.192	2.198	2.205	2.211	2.218	2.225	2.231	2.238	590
600	2.238	2.245	2.251	2.258	2.265	2.272	2.278	2.285	2.292	2.298	2.305	600
610	2.305	2.312	2.319	2.325	2.332	2.339	2.346	2.353	2.359	2.366	2.373	610
620	2.373	2.380	2.387	2.393	2.400	2.407	2.414	2.421	2.428	2.435	2.442	620
630	2.442	2.448	2.455	2.462	2.469	2.476	2.483	2.490	2.497	2.504	2.511	630
640	2.511	2.518	2.525	2.532	2.539	2.546	2.553	2.560	2.567	2.574	2.581	640
650	2.581	2.588	2.595	2.602	2.609	2.616	2.624	2.631	2.638	2.645	2.652	650
660	2.652	2.659	2.666	2.673	2.681	2.688	2.695	2.702	2.709	2.717	2.724	660
670	2.724	2.731	2.738	2.745	2.753	2.760	2.767	2.774	2.782	2.789	2.796	670
680	2.796	2.803	2.811	2.818	2.825	2.833	2.840	2.847	2.855	2.862	2.869	680
690	2.869	2.877	2.884	2.891	2.899	2.906	2.914	2.921	2.928	2.936	2.943	690
700	2.943	2.951	2.958	2.965	2.973	2.980	2.988	2.995	3.003	3.010	3.018	700
710	3.018	3.025	3.033	3.040	3.048	3.055	3.063	3.070	3.078	3.086	3.093	710
720	3.093	3.101	3.108	3.116	3.123	3.131	3.139	3.146	3.154	3.161	3.169	720
730	3.169	3.177	3.184	3.192	3.200	3.207	3.215	3.223	3.230	3.238	3.246	730
740	3.246	3.254	3.261	3.269	3.277	3.284	3.292	3.300	3.308	3.315	3.323	740
750	3.323	3.331	3.339	3.347	3.354	3.362	3.370	3.378	3.386	3.394	3.401	750
760	3.401	3.409	3.417	3.425	3.433	3.441	3.449	3.456	3.464	3.472	3.480	760
770	3.480	3.488	3.496	3.504	3.512	3.520	3.528	3.536	3.544	3.552	3.560	770
780	3.560	3.568	3.576	3.584	3.592	3.600	3.608	3.616	3.624	3.632	3.640	780
790	3.640	3.648	3.656	3.664	3.672	3.680	3.688	3.696	3.704	3.712	3.721	790
800	3.721	3.729	3.737	3.745	3.753	3.761	3.769	3.777	3.786	3.794	3.802	800
810	3.802	3.810	3.818	3.826	3.835	3.843	3.851	3.859	3.868	3.876	3.884	810
820	3.884	3.892	3.900	3.909	3.917	3.925	3.934	3.942	3.950	3.958	3.967	820
830	3.967	3.975	3.983	3.992	4.000	4.008	4.017	4.025	4.033	4.042	4.050	830
840	4.050	4.058	4.067	4.075	4.084	4.092	4.100	4.109	4.117	4.126	4.134	840
850	4.134	4.142	4.151	4.159	4.168	4.176	4.185	4.193	4.202	4.210	4.219	850
860	4.219	4.227	4.236	4.244	4.253	4.261	4.270	4.278	4.287	4.295	4.304	860
870	4.304	4.312	4.321	4.329	4.338	4.346	4.355	4.364	4.372	4.381	4.389	870
880	4.389	4.398	4.407	4.415	4.424	4.433	4.441	4.450	4.458	4.467	4.476	880
890	4.476	4.484	4.493	4.502	4.511	4.519	4.528	4.537	4.545	4.554	4.563	890
900	4.563	4.571	4.580	4.589	4.598	4.606	4.615	4.624	4.633	4.641	4.650	900
910	4.650	4.659	4.668	4.677	4.685	4.694	4.703	4.712	4.721	4.730	4.738	910
920	4.738	4.747	4.756	4.765	4.774	4.783	4.791	4.800	4.809	4.818	4.827	920
930	4.827	4.836	4.845	4.854	4.863	4.872	4.880	4.889	4.898	4.907	4.916	930
940	4.916	4.925	4.934	4.943	4.952	4.961	4.970	4.979	4.988	4.997	5.006	940
950	5.006	5.015	5.024	5.033	5.042	5.051	5.060	5.069	5.078	5.087	5.096	950
960	5.096	5.105	5.114	5.123	5.133	5.142	5.151	5.160	5.169	5.178	5.187	960
970	5.187	5.196	5.205	5.214	5.224	5.233	5.242	5.251	5.260	5.269	5.278	970
980	5.278	5.288	5.297	5.306	5.315	5.324	5.334	5.343	5.352	5.361	5.370	980
990	5.370	5.380	5.389	5.398	5.407	5.416	5.426	5.435	5.444	5.453	5.463	990
1000	5.463	5.472	5.481	5.491	5.500	5.509	5.518	5.528	5.537	5.546	5.556	1000
1010	5.556	5.565	5.574	5.584	5.593	5.602	5.612	5.621	5.630	5.640	5.649	1010
1020	5.649	5.658	5.668	5.677	5.687	5.696	5.705	5.715	5.724	5.734	5.743	1020
1030	5.743	5.752	5.762	5.771	5.781	5.790	5.800	5.809	5.818	5.828	5.837	1030
1040	5.837	5.847	5.856	5.866	5.875	5.885	5.894	5.904	5.913	5.923	5.932	1040
1050	5.932	5.942	5.951	5.961	5.970	5.980	5.989	5.999	6.008	6.018	6.027	1050
1060	6.027	6.037	6.047	6.056	6.066	6.075	6.085	6.095	6.104	6.114	6.123	1060
1070	6.123	6.133	6.143	6.152	6.162	6.171	6.181	6.191	6.200	6.210	6.220	1070
1080	6.220	6.229	6.239	6.249	6.258	6.268	6.278	6.287	6.297	6.307	6.316	1080
1090	6.316	6.326	6.336	6.345	6.355	6.365	6.374	6.384	6.394	6.404	6.413	1090
1100	6.413	6.423	6.433	6.443	6.452	6.462	6.472	6.482	6.491	6.501	6.511	1100
1110	6.511	6.521	6.531	6.540	6.550	6.560	6.570	6.580	6.589	6.599	6.609	1110
1120	6.609	6.619	6.629	6.638	6.648	6.658	6.668	6.678	6.688	6.698	6.707	1120
1130	6.707	6.717	6.727	6.737	6.747	6.757	6.767	6.777	6.786	6.796	6.806	1130

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TABLE 2 *Continued*
Tungsten versus Tungsten-26 % Rhenium Thermocouples
Thermoelectric Voltage as a Function of Temperature (°F), Reference Junctions at 32°F

°F	0	1	2	3	4	5	6	7	8	9	10	°F
Thermoelectric Voltage in Millivolts												
1140	6.806	6.816	6.826	6.836	6.846	6.856	6.866	6.876	6.886	6.896	6.905	1140
1150	6.905	6.915	6.925	6.935	6.945	6.955	6.965	6.975	6.985	6.995	7.005	1150
1160	7.005	7.015	7.025	7.035	7.045	7.055	7.065	7.075	7.085	7.095	7.105	1160
1170	7.105	7.115	7.125	7.135	7.145	7.155	7.165	7.175	7.185	7.196	7.206	1170
1180	7.206	7.216	7.226	7.236	7.246	7.256	7.266	7.276	7.286	7.296	7.306	1180
1190	7.306	7.317	7.327	7.337	7.347	7.357	7.367	7.377	7.387	7.398	7.408	1190
1200	7.408	7.418	7.428	7.438	7.448	7.458	7.469	7.479	7.489	7.499	7.509	1200
1210	7.509	7.519	7.530	7.540	7.550	7.560	7.570	7.581	7.591	7.601	7.611	1210
1220	7.611	7.622	7.632	7.642	7.652	7.662	7.673	7.683	7.693	7.703	7.714	1220
1230	7.714	7.724	7.734	7.745	7.755	7.765	7.775	7.786	7.796	7.806	7.816	1230
1240	7.816	7.827	7.837	7.847	7.858	7.868	7.878	7.889	7.899	7.909	7.920	1240
1250	7.920	7.930	7.940	7.951	7.961	7.971	7.982	7.992	8.002	8.013	8.023	1250
1260	8.023	8.034	8.044	8.054	8.065	8.075	8.085	8.096	8.106	8.117	8.127	1260
1270	8.127	8.137	8.148	8.158	8.169	8.179	8.190	8.200	8.210	8.221	8.231	1270
1280	8.231	8.242	8.252	8.263	8.273	8.284	8.294	8.305	8.315	8.325	8.336	1280
1290	8.336	8.346	8.357	8.367	8.378	8.388	8.399	8.409	8.420	8.430	8.441	1290
1300	8.441	8.451	8.462	8.472	8.483	8.493	8.504	8.515	8.525	8.536	8.546	1300
1310	8.546	8.557	8.567	8.578	8.588	8.599	8.610	8.620	8.631	8.641	8.652	1310
1320	8.652	8.662	8.673	8.684	8.694	8.705	8.715	8.726	8.737	8.747	8.758	1320
1330	8.758	8.768	8.779	8.790	8.800	8.811	8.821	8.832	8.843	8.853	8.864	1330
1340	8.864	8.875	8.885	8.896	8.907	8.917	8.928	8.939	8.949	8.960	8.971	1340
1350	8.971	8.981	8.992	9.003	9.013	9.024	9.035	9.045	9.056	9.067	9.078	1350
1360	9.078	9.088	9.099	9.110	9.120	9.131	9.142	9.153	9.163	9.174	9.185	1360
1370	9.185	9.196	9.206	9.217	9.228	9.239	9.249	9.260	9.271	9.282	9.292	1370
1380	9.292	9.303	9.314	9.325	9.335	9.346	9.357	9.368	9.379	9.389	9.400	1380
1390	9.400	9.411	9.422	9.433	9.443	9.454	9.465	9.476	9.487	9.498	9.508	1390
1400	9.508	9.519	9.530	9.541	9.552	9.563	9.573	9.584	9.595	9.606	9.617	1400
1410	9.617	9.628	9.638	9.649	9.660	9.671	9.682	9.693	9.704	9.715	9.725	1410
1420	9.725	9.736	9.747	9.758	9.769	9.780	9.791	9.802	9.813	9.824	9.834	1420
1430	9.834	9.845	9.856	9.867	9.878	9.889	9.900	9.911	9.922	9.933	9.944	1430
1440	9.944	9.955	9.966	9.977	9.988	9.998	10.009	10.020	10.031	10.042	10.053	1440
1450	10.053	10.064	10.075	10.086	10.097	10.108	10.119	10.130	10.141	10.152	10.163	1450
1460	10.163	10.174	10.185	10.196	10.207	10.218	10.229	10.240	10.251	10.262	10.273	1460
1470	10.273	10.284	10.295	10.306	10.317	10.328	10.339	10.350	10.361	10.372	10.383	1470
1480	10.383	10.395	10.406	10.417	10.428	10.439	10.450	10.461	10.472	10.483	10.494	1480
1490	10.494	10.505	10.516	10.527	10.538	10.549	10.561	10.572	10.583	10.594	10.605	1490
1500	10.605	10.616	10.627	10.638	10.649	10.660	10.671	10.683	10.694	10.705	10.716	1500
1510	10.716	10.727	10.738	10.749	10.760	10.772	10.783	10.794	10.805	10.816	10.827	1510
1520	10.827	10.838	10.850	10.861	10.872	10.883	10.894	10.905	10.916	10.928	10.939	1520
1530	10.939	10.950	10.961	10.972	10.983	10.995	11.006	11.017	11.028	11.039	11.051	1530
1540	11.051	11.062	11.073	11.084	11.095	11.106	11.118	11.129	11.140	11.151	11.162	1540
1550	11.162	11.174	11.185	11.196	11.207	11.219	11.230	11.241	11.252	11.263	11.275	1550
1560	11.275	11.286	11.297	11.308	11.320	11.331	11.342	11.353	11.365	11.376	11.387	1560
1570	11.387	11.398	11.410	11.421	11.432	11.443	11.455	11.466	11.477	11.488	11.500	1570
1580	11.500	11.511	11.522	11.533	11.545	11.556	11.567	11.579	11.590	11.601	11.612	1580
1590	11.612	11.624	11.635	11.646	11.658	11.669	11.680	11.692	11.703	11.714	11.725	1590
1600	11.725	11.737	11.748	11.759	11.771	11.782	11.793	11.805	11.816	11.827	11.839	1600
1610	11.839	11.850	11.861	11.873	11.884	11.895	11.907	11.918	11.929	11.941	11.952	1610
1620	11.952	11.963	11.975	11.986	11.997	12.009	12.020	12.032	12.043	12.054	12.066	1620
1630	12.066	12.077	12.088	12.100	12.111	12.123	12.134	12.145	12.157	12.168	12.179	1630
1640	12.179	12.191	12.202	12.214	12.225	12.236	12.248	12.259	12.271	12.282	12.293	1640
1650	12.293	12.305	12.316	12.328	12.339	12.350	12.362	12.373	12.385	12.396	12.407	1650
1660	12.407	12.419	12.430	12.442	12.453	12.465	12.476	12.487	12.499	12.510	12.522	1660
1670	12.522	12.533	12.545	12.556	12.567	12.579	12.590	12.602	12.613	12.625	12.636	1670
1680	12.636	12.648	12.659	12.670	12.682	12.693	12.705	12.716	12.728	12.739	12.751	1680
1690	12.751	12.762	12.774	12.785	12.797	12.808	12.819	12.831	12.842	12.854	12.865	1690
1700	12.865	12.877	12.888	12.900	12.911	12.923	12.934	12.946	12.957	12.969	12.980	1700
1710	12.980	12.992	13.003	13.015	13.026	13.038	13.049	13.061	13.072	13.084	13.095	1710

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TABLE 2 *Continued*
Tungsten versus Tungsten-26 % Rhenium Thermocouples
Thermoelectric Voltage as a Function of Temperature (°F), Reference Junctions at 32°F

°F	0	1	2	3	4	5	6	7	8	9	10	°F
Thermoelectric Voltage in Millivolts												
1720	13.095	13.107	13.118	13.130	13.141	13.153	13.164	13.176	13.187	13.199	13.210	1720
1730	13.210	13.222	13.234	13.245	13.257	13.268	13.280	13.291	13.303	13.314	13.326	1730
1740	13.326	13.337	13.349	13.360	13.372	13.383	13.395	13.407	13.418	13.430	13.441	1740
1750	13.441	13.453	13.464	13.476	13.487	13.499	13.510	13.522	13.534	13.545	13.557	1750
1760	13.557	13.568	13.580	13.591	13.603	13.615	13.626	13.638	13.649	13.661	13.672	1760
1770	13.672	13.684	13.696	13.707	13.719	13.730	13.742	13.753	13.765	13.777	13.788	1770
1780	13.788	13.800	13.811	13.823	13.835	13.846	13.858	13.869	13.881	13.892	13.904	1780
1790	13.904	13.916	13.927	13.939	13.950	13.962	13.974	13.985	13.997	14.009	14.020	1790
1800	14.020	14.032	14.043	14.055	14.067	14.078	14.090	14.101	14.113	14.125	14.136	1800
1810	14.136	14.148	14.159	14.171	14.183	14.194	14.206	14.218	14.229	14.241	14.252	1810
1820	14.252	14.264	14.276	14.287	14.299	14.311	14.322	14.334	14.345	14.357	14.369	1820
1830	14.369	14.380	14.392	14.404	14.415	14.427	14.439	14.450	14.462	14.474	14.485	1830
1840	14.485	14.497	14.508	14.520	14.532	14.543	14.555	14.567	14.578	14.590	14.602	1840
1850	14.602	14.613	14.625	14.637	14.648	14.660	14.672	14.683	14.695	14.707	14.718	1850
1860	14.718	14.730	14.742	14.753	14.765	14.777	14.788	14.800	14.812	14.823	14.835	1860
1870	14.835	14.847	14.858	14.870	14.882	14.893	14.905	14.917	14.928	14.940	14.952	1870
1880	14.952	14.963	14.975	14.987	14.998	15.010	15.022	15.033	15.045	15.057	15.069	1880
1890	15.069	15.080	15.092	15.104	15.115	15.127	15.139	15.150	15.162	15.174	15.185	1890
1900	15.185	15.197	15.209	15.220	15.232	15.244	15.256	15.267	15.279	15.291	15.302	1900
1910	15.302	15.314	15.326	15.337	15.349	15.361	15.373	15.384	15.396	15.408	15.419	1910
1920	15.419	15.431	15.443	15.455	15.466	15.478	15.490	15.501	15.513	15.525	15.536	1920
1930	15.536	15.548	15.560	15.572	15.583	15.595	15.607	15.618	15.630	15.642	15.654	1930
1940	15.654	15.665	15.677	15.689	15.701	15.712	15.724	15.736	15.747	15.759	15.771	1940
1950	15.771	15.783	15.794	15.806	15.818	15.829	15.841	15.853	15.865	15.876	15.888	1950
1960	15.888	15.900	15.912	15.923	15.935	15.947	15.958	15.970	15.982	15.994	16.005	1960
1970	16.005	16.017	16.029	16.041	16.052	16.064	16.076	16.087	16.099	16.111	16.123	1970
1980	16.123	16.134	16.146	16.158	16.170	16.181	16.193	16.205	16.217	16.228	16.240	1980
1990	16.240	16.252	16.264	16.275	16.287	16.299	16.310	16.322	16.334	16.346	16.357	1990
2000	16.357	16.369	16.381	16.393	16.404	16.416	16.428	16.440	16.451	16.463	16.475	2000
2010	16.475	16.487	16.498	16.510	16.522	16.534	16.545	16.557	16.569	16.581	16.592	2010
2020	16.592	16.604	16.616	16.628	16.639	16.651	16.663	16.675	16.686	16.698	16.710	2020
2030	16.710	16.722	16.733	16.745	16.757	16.769	16.780	16.792	16.804	16.816	16.827	2030
2040	16.827	16.839	16.851	16.863	16.874	16.886	16.898	16.910	16.921	16.933	16.945	2040
2050	16.945	16.957	16.968	16.980	16.992	17.004	17.015	17.027	17.039	17.051	17.062	2050
2060	17.062	17.074	17.086	17.098	17.109	17.121	17.133	17.145	17.156	17.168	17.180	2060
2070	17.180	17.192	17.203	17.215	17.227	17.239	17.250	17.262	17.274	17.286	17.298	2070
2080	17.298	17.309	17.321	17.333	17.345	17.356	17.368	17.380	17.392	17.403	17.415	2080
2090	17.415	17.427	17.439	17.450	17.462	17.474	17.486	17.497	17.509	17.521	17.533	2090
2100	17.533	17.544	17.556	17.568	17.580	17.591	17.603	17.615	17.627	17.638	17.650	2100
2110	17.650	17.662	17.674	17.685	17.697	17.709	17.721	17.732	17.744	17.756	17.768	2110
2120	17.768	17.780	17.791	17.803	17.815	17.827	17.838	17.850	17.862	17.874	17.885	2120
2130	17.885	17.897	17.909	17.921	17.932	17.944	17.956	17.968	17.979	17.991	18.003	2130
2140	18.003	18.015	18.026	18.038	18.050	18.062	18.073	18.085	18.097	18.109	18.120	2140
2150	18.120	18.132	18.144	18.156	18.167	18.179	18.191	18.203	18.214	18.226	18.238	2150
2160	18.238	18.250	18.261	18.273	18.285	18.297	18.308	18.320	18.332	18.344	18.355	2160
2170	18.355	18.367	18.379	18.391	18.402	18.414	18.426	18.438	18.449	18.461	18.473	2170
2180	18.473	18.485	18.496	18.508	18.520	18.532	18.543	18.555	18.567	18.579	18.590	2180
2190	18.590	18.602	18.614	18.625	18.637	18.649	18.661	18.672	18.684	18.696	18.708	2190
2200	18.708	18.719	18.731	18.743	18.755	18.766	18.778	18.790	18.802	18.813	18.825	2200
2210	18.825	18.837	18.849	18.860	18.872	18.884	18.895	18.907	18.919	18.931	18.942	2210
2220	18.942	18.954	18.966	18.978	18.989	19.001	19.013	19.025	19.036	19.048	19.060	2220
2230	19.060	19.071	19.083	19.095	19.107	19.118	19.130	19.142	19.154	19.165	19.177	2230
2240	19.177	19.189	19.200	19.212	19.224	19.236	19.247	19.259	19.271	19.282	19.294	2240
2250	19.294	19.306	19.318	19.329	19.341	19.353	19.364	19.376	19.388	19.400	19.411	2250
2260	19.411	19.423	19.435	19.446	19.458	19.470	19.482	19.493	19.505	19.517	19.528	2260
2270	19.528	19.540	19.552	19.564	19.575	19.587	19.599	19.610	19.622	19.634	19.646	2270
2280	19.646	19.657	19.669	19.681	19.692	19.704	19.716	19.727	19.739	19.751	19.763	2280
2290	19.763	19.774	19.786	19.798	19.809	19.821	19.833	19.844	19.856	19.868	19.880	2290

TABLE 2 *Continued*
Tungsten versus Tungsten-26 % Rhenium Thermocouples
Thermoelectric Voltage as a Function of Temperature (°F), Reference Junctions at 32°F

°F	0	1	2	3	4	5	6	7	8	9	10	°F
Thermoelectric Voltage in Millivolts												
2300	19.880	19.891	19.903	19.915	19.926	19.938	19.950	19.961	19.973	19.985	19.996	2300
2310	19.996	20.008	20.020	20.031	20.043	20.055	20.067	20.078	20.090	20.102	20.113	2310
2320	20.113	20.125	20.137	20.148	20.160	20.172	20.183	20.195	20.207	20.218	20.230	2320
2330	20.230	20.242	20.253	20.265	20.277	20.288	20.300	20.312	20.323	20.335	20.347	2330
2340	20.347	20.358	20.370	20.382	20.393	20.405	20.417	20.428	20.440	20.452	20.463	2340
2350	20.463	20.475	20.487	20.498	20.510	20.522	20.533	20.545	20.557	20.568	20.580	2350
2360	20.580	20.592	20.603	20.615	20.627	20.638	20.650	20.661	20.673	20.685	20.696	2360
2370	20.696	20.708	20.720	20.731	20.743	20.755	20.766	20.778	20.790	20.801	20.813	2370
2380	20.813	20.824	20.836	20.848	20.859	20.871	20.883	20.894	20.906	20.918	20.929	2380
2390	20.929	20.941	20.952	20.964	20.976	20.987	20.999	21.011	21.022	21.034	21.045	2390
2400	21.045	21.057	21.069	21.080	21.092	21.103	21.115	21.127	21.138	21.150	21.162	2400
2410	21.162	21.173	21.185	21.196	21.208	21.220	21.231	21.243	21.254	21.266	21.278	2410
2420	21.278	21.289	21.301	21.312	21.324	21.336	21.347	21.359	21.370	21.382	21.394	2420
2430	21.394	21.405	21.417	21.428	21.440	21.452	21.463	21.475	21.486	21.498	21.509	2430
2440	21.509	21.521	21.533	21.544	21.556	21.567	21.579	21.591	21.602	21.614	21.625	2440
2450	21.625	21.637	21.648	21.660	21.672	21.683	21.695	21.706	21.718	21.729	21.741	2450
2460	21.741	21.753	21.764	21.776	21.787	21.799	21.810	21.822	21.833	21.845	21.857	2460
2470	21.857	21.868	21.880	21.891	21.903	21.914	21.926	21.937	21.949	21.960	21.972	2470
2480	21.972	21.984	21.995	22.007	22.018	22.030	22.041	22.053	22.064	22.076	22.087	2480
2490	22.087	22.099	22.110	22.122	22.134	22.145	22.157	22.168	22.180	22.191	22.203	2490
2500	22.203	22.214	22.226	22.237	22.249	22.260	22.272	22.283	22.295	22.306	22.318	2500
2510	22.318	22.329	22.341	22.352	22.364	22.375	22.387	22.398	22.410	22.421	22.433	2510
2520	22.433	22.444	22.456	22.467	22.479	22.490	22.502	22.513	22.525	22.536	22.548	2520
2530	22.548	22.559	22.571	22.582	22.594	22.605	22.617	22.628	22.640	22.651	22.663	2530
2540	22.663	22.674	22.686	22.697	22.709	22.720	22.731	22.743	22.754	22.766	22.777	2540
2550	22.777	22.789	22.800	22.812	22.823	22.835	22.846	22.858	22.869	22.880	22.892	2550
2560	22.892	22.903	22.915	22.926	22.938	22.949	22.961	22.972	22.983	22.995	23.006	2560
2570	23.006	23.018	23.029	23.041	23.052	23.064	23.075	23.086	23.098	23.109	23.121	2570
2580	23.121	23.132	23.143	23.155	23.166	23.178	23.189	23.201	23.212	23.223	23.235	2580
2590	23.235	23.246	23.258	23.269	23.280	23.292	23.303	23.315	23.326	23.337	23.349	2590
2600	23.349	23.360	23.372	23.383	23.394	23.406	23.417	23.429	23.440	23.451	23.463	2600
2610	23.463	23.474	23.486	23.497	23.508	23.520	23.531	23.542	23.554	23.565	23.577	2610
2620	23.577	23.588	23.599	23.611	23.622	23.633	23.645	23.656	23.668	23.679	23.690	2620
2630	23.690	23.702	23.713	23.724	23.736	23.747	23.758	23.770	23.781	23.792	23.804	2630
2640	23.804	23.815	23.826	23.838	23.849	23.860	23.872	23.883	23.894	23.906	23.917	2640
2650	23.917	23.928	23.940	23.951	23.962	23.974	23.985	23.996	24.008	24.019	24.030	2650
2660	24.030	24.042	24.053	24.064	24.076	24.087	24.098	24.110	24.121	24.132	24.143	2660
2670	24.143	24.155	24.166	24.177	24.189	24.200	24.211	24.222	24.234	24.245	24.256	2670
2680	24.256	24.268	24.279	24.290	24.301	24.313	24.324	24.335	24.347	24.358	24.369	2680
2690	24.369	24.380	24.392	24.403	24.414	24.425	24.437	24.448	24.459	24.470	24.482	2690
2700	24.482	24.493	24.504	24.516	24.527	24.538	24.549	24.560	24.572	24.583	24.594	2700
2710	24.594	24.605	24.617	24.628	24.639	24.650	24.662	24.673	24.684	24.695	24.707	2710
2720	24.707	24.718	24.729	24.740	24.751	24.763	24.774	24.785	24.796	24.807	24.819	2720
2730	24.819	24.830	24.841	24.852	24.863	24.875	24.886	24.897	24.908	24.919	24.931	2730
2740	24.931	24.942	24.953	24.964	24.975	24.987	24.998	25.009	25.020	25.031	25.042	2740
2750	25.042	25.054	25.065	25.076	25.087	25.098	25.109	25.121	25.132	25.143	25.154	2750
2760	25.154	25.165	25.176	25.188	25.199	25.210	25.221	25.232	25.243	25.254	25.266	2760
2770	25.266	25.277	25.288	25.299	25.310	25.321	25.332	25.344	25.355	25.366	25.377	2770
2780	25.377	25.388	25.399	25.410	25.421	25.433	25.444	25.455	25.466	25.477	25.488	2780
2790	25.488	25.499	25.510	25.521	25.532	25.544	25.555	25.566	25.577	25.588	25.599	2790
2800	25.599	25.610	25.621	25.632	25.643	25.654	25.666	25.677	25.688	25.699	25.710	2800
2810	25.710	25.721	25.732	25.743	25.754	25.765	25.776	25.787	25.798	25.809	25.820	2810
2820	25.820	25.832	25.843	25.854	25.865	25.876	25.887	25.898	25.909	25.920	25.931	2820
2830	25.931	25.942	25.953	25.964	25.975	25.986	25.997	26.008	26.019	26.030	26.041	2830
2840	26.041	26.052	26.063	26.074	26.085	26.096	26.107	26.118	26.129	26.140	26.151	2840
2850	26.151	26.162	26.173	26.184	26.195	26.206	26.217	26.228	26.239	26.250	26.261	2850
2860	26.261	26.272	26.283	26.294	26.305	26.316	26.327	26.338	26.349	26.360	26.371	2860
2870	26.371	26.382	26.393	26.404	26.415	26.426	26.437	26.447	26.458	26.469	26.480	2870
2880	26.480	26.491	26.502	26.513	26.524	26.535	26.546	26.557	26.568	26.579	26.590	2880

TABLE 2 *Continued*
Tungsten versus Tungsten-26 % Rhenium Thermocouples
Thermoelectric Voltage as a Function of Temperature (°F), Reference Junctions at 32°F

°F	0	1	2	3	4	5	6	7	8	9	10	°F
Thermoelectric Voltage in Millivolts												
2890	26.590	26.601	26.611	26.622	26.633	26.644	26.655	26.666	26.677	26.688	26.699	2890
2900	26.699	26.710	26.721	26.731	26.742	26.753	26.764	26.775	26.786	26.797	26.808	2900
2910	26.808	26.819	26.829	26.840	26.851	26.862	26.873	26.884	26.895	26.905	26.916	2910
2920	26.916	26.927	26.938	26.949	26.960	26.971	26.982	26.992	27.003	27.014	27.025	2920
2930	27.025	27.036	27.047	27.057	27.068	27.079	27.090	27.101	27.112	27.122	27.133	2930
2940	27.133	27.144	27.155	27.166	27.176	27.187	27.198	27.209	27.220	27.230	27.241	2940
2950	27.241	27.252	27.263	27.274	27.284	27.295	27.306	27.317	27.328	27.338	27.349	2950
2960	27.349	27.360	27.371	27.382	27.392	27.403	27.414	27.425	27.435	27.446	27.457	2960
2970	27.457	27.468	27.478	27.489	27.500	27.511	27.521	27.532	27.543	27.554	27.564	2970
2980	27.564	27.575	27.586	27.597	27.607	27.618	27.629	27.639	27.650	27.661	27.672	2980
2990	27.672	27.682	27.693	27.704	27.714	27.725	27.736	27.747	27.757	27.768	27.779	2990
3000	27.779	27.789	27.800	27.811	27.821	27.832	27.843	27.854	27.864	27.875	27.886	3000
3010	27.886	27.896	27.907	27.918	27.928	27.939	27.950	27.960	27.971	27.982	27.992	3010
3020	27.992	28.003	28.013	28.024	28.035	28.045	28.056	28.067	28.077	28.088	28.099	3020
3030	28.099	28.109	28.120	28.130	28.141	28.152	28.162	28.173	28.184	28.194	28.205	3030
3040	28.205	28.215	28.226	28.237	28.247	28.258	28.268	28.279	28.290	28.300	28.311	3040
3050	28.311	28.321	28.332	28.342	28.353	28.364	28.374	28.385	28.395	28.406	28.416	3050
3060	28.416	28.427	28.438	28.448	28.459	28.469	28.480	28.490	28.501	28.511	28.522	3060
3070	28.522	28.533	28.543	28.554	28.564	28.575	28.585	28.596	28.606	28.617	28.627	3070
3080	28.627	28.638	28.648	28.659	28.669	28.680	28.690	28.701	28.711	28.722	28.732	3080
3090	28.732	28.743	28.753	28.764	28.774	28.785	28.795	28.806	28.816	28.827	28.837	3090
3100	28.837	28.848	28.858	28.869	28.879	28.889	28.900	28.910	28.921	28.931	28.942	3100
3110	28.942	28.952	28.963	28.973	28.983	28.994	29.004	29.015	29.025	29.036	29.046	3110
3120	29.046	29.056	29.067	29.077	29.088	29.098	29.109	29.119	29.129	29.140	29.150	3120
3130	29.150	29.161	29.171	29.181	29.192	29.202	29.213	29.223	29.233	29.244	29.254	3130
3140	29.254	29.264	29.275	29.285	29.296	29.306	29.316	29.327	29.337	29.347	29.358	3140
3150	29.358	29.368	29.378	29.389	29.399	29.409	29.420	29.430	29.440	29.451	29.461	3150
3160	29.461	29.471	29.482	29.492	29.502	29.513	29.523	29.533	29.544	29.554	29.564	3160
3170	29.564	29.575	29.585	29.595	29.605	29.616	29.626	29.636	29.647	29.657	29.667	3170
3180	29.667	29.677	29.688	29.698	29.708	29.718	29.729	29.739	29.749	29.760	29.770	3180
3190	29.770	29.780	29.790	29.801	29.811	29.821	29.831	29.841	29.852	29.862	29.872	3190
3200	29.872	29.882	29.893	29.903	29.913	29.923	29.933	29.944	29.954	29.964	29.974	3200
3210	29.974	29.985	29.995	30.005	30.015	30.025	30.035	30.046	30.056	30.066	30.076	3210
3220	30.076	30.086	30.097	30.107	30.117	30.127	30.137	30.147	30.158	30.168	30.178	3220
3230	30.178	30.188	30.198	30.208	30.218	30.229	30.239	30.249	30.259	30.269	30.279	3230
3240	30.279	30.289	30.299	30.310	30.320	30.330	30.340	30.350	30.360	30.370	30.380	3240
3250	30.380	30.390	30.401	30.411	30.421	30.431	30.441	30.451	30.461	30.471	30.481	3250
3260	30.481	30.491	30.501	30.511	30.521	30.532	30.542	30.552	30.562	30.572	30.582	3260
3270	30.582	30.592	30.602	30.612	30.622	30.632	30.642	30.652	30.662	30.672	30.682	3270
3280	30.682	30.692	30.702	30.712	30.722	30.732	30.742	30.752	30.762	30.772	30.782	3280
3290	30.782	30.792	30.802	30.812	30.822	30.832	30.842	30.852	30.862	30.872	30.882	3290
3300	30.882	30.892	30.902	30.912	30.922	30.932	30.942	30.952	30.962	30.972	30.982	3300
3310	30.982	30.991	31.001	31.011	31.021	31.031	31.041	31.051	31.061	31.071	31.081	3310
3320	31.081	31.091	31.101	31.111	31.120	31.130	31.140	31.150	31.160	31.170	31.180	3320
3330	31.180	31.190	31.200	31.209	31.219	31.229	31.239	31.249	31.259	31.269	31.279	3330
3340	31.279	31.288	31.298	31.308	31.318	31.328	31.338	31.347	31.357	31.367	31.377	3340
3350	31.377	31.387	31.397	31.406	31.416	31.426	31.436	31.446	31.456	31.465	31.475	3350
3360	31.475	31.485	31.495	31.505	31.514	31.524	31.534	31.544	31.553	31.563	31.573	3360
3370	31.573	31.583	31.593	31.602	31.612	31.622	31.632	31.641	31.651	31.661	31.671	3370
3380	31.671	31.680	31.690	31.700	31.710	31.719	31.729	31.739	31.749	31.758	31.768	3380
3390	31.768	31.778	31.787	31.797	31.807	31.817	31.826	31.836	31.846	31.855	31.865	3390
3400	31.865	31.875	31.884	31.894	31.904	31.913	31.923	31.933	31.942	31.952	31.962	3400
3410	31.962	31.971	31.981	31.991	32.000	32.010	32.020	32.029	32.039	32.049	32.058	3410
3420	32.058	32.068	32.078	32.087	32.097	32.106	32.116	32.126	32.135	32.145	32.154	3420
3430	32.154	32.164	32.174	32.183	32.193	32.202	32.212	32.222	32.231	32.241	32.250	3430
3440	32.250	32.260	32.270	32.279	32.289	32.298	32.308	32.317	32.327	32.336	32.346	3440
3450	32.346	32.356	32.365	32.375	32.384	32.394	32.403	32.413	32.422	32.432	32.441	3450
3460	32.441	32.451	32.460	32.470	32.479	32.489	32.498	32.508	32.517	32.527	32.536	3460

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TABLE 2 *Continued*
Tungsten versus Tungsten-26 % Rhenium Thermocouples
Thermoelectric Voltage as a Function of Temperature (°F), Reference Junctions at 32°F

°F	0	1	2	3	4	5	6	7	8	9	10	°F
Thermoelectric Voltage in Millivolts												
3470	32.536	32.546	32.555	32.565	32.574	32.584	32.593	32.603	32.612	32.622	32.631	3470
3480	32.631	32.640	32.650	32.659	32.669	32.678	32.688	32.697	32.707	32.716	32.725	3480
3490	32.725	32.735	32.744	32.754	32.763	32.773	32.782	32.791	32.801	32.810	32.820	3490
3500	32.820	32.829	32.838	32.848	32.857	32.867	32.876	32.885	32.895	32.904	32.913	3500
3510	32.913	32.923	32.932	32.942	32.951	32.960	32.970	32.979	32.988	32.998	33.007	3510
3520	33.007	33.016	33.026	33.035	33.044	33.054	33.063	33.072	33.082	33.091	33.100	3520
3530	33.100	33.109	33.119	33.128	33.137	33.147	33.156	33.165	33.175	33.184	33.193	3530
3540	33.193	33.202	33.212	33.221	33.230	33.239	33.249	33.258	33.267	33.276	33.286	3540
3550	33.286	33.295	33.304	33.313	33.323	33.332	33.341	33.350	33.360	33.369	33.378	3550
3560	33.378	33.387	33.396	33.406	33.415	33.424	33.433	33.442	33.452	33.461	33.470	3560
3570	33.470	33.479	33.488	33.498	33.507	33.516	33.525	33.534	33.543	33.553	33.562	3570
3580	33.562	33.571	33.580	33.589	33.598	33.607	33.617	33.626	33.635	33.644	33.653	3580
3590	33.653	33.662	33.671	33.680	33.690	33.699	33.708	33.717	33.726	33.735	33.744	3590
3600	33.744	33.753	33.762	33.771	33.781	33.790	33.799	33.808	33.817	33.826	33.835	3600
3610	33.835	33.844	33.853	33.862	33.871	33.880	33.889	33.898	33.907	33.916	33.925	3610
3620	33.925	33.934	33.943	33.952	33.961	33.970	33.979	33.988	33.997	34.006	34.015	3620
3630	34.015	34.024	34.033	34.042	34.051	34.060	34.069	34.078	34.087	34.096	34.105	3630
3640	34.105	34.114	34.123	34.132	34.141	34.150	34.159	34.168	34.177	34.186	34.195	3640
3650	34.195	34.204	34.213	34.222	34.230	34.239	34.248	34.257	34.266	34.275	34.284	3650
3660	34.284	34.293	34.302	34.311	34.319	34.328	34.337	34.346	34.355	34.364	34.373	3660
3670	34.373	34.382	34.390	34.399	34.408	34.417	34.426	34.435	34.444	34.452	34.461	3670
3680	34.461	34.470	34.479	34.488	34.497	34.505	34.514	34.523	34.532	34.541	34.549	3680
3690	34.549	34.558	34.567	34.576	34.585	34.593	34.602	34.611	34.620	34.629	34.637	3690
3700	34.637	34.646	34.655	34.664	34.672	34.681	34.690	34.699	34.707	34.716	34.725	3700
3710	34.725	34.734	34.742	34.751	34.760	34.768	34.777	34.786	34.795	34.803	34.812	3710
3720	34.812	34.821	34.829	34.838	34.847	34.855	34.864	34.873	34.881	34.890	34.899	3720
3730	34.899	34.908	34.916	34.925	34.933	34.942	34.951	34.959	34.968	34.977	34.985	3730
3740	34.985	34.994	35.003	35.011	35.020	35.029	35.037	35.046	35.054	35.063	35.072	3740
3750	35.072	35.080	35.089	35.097	35.106	35.115	35.123	35.132	35.140	35.149	35.157	3750
3760	35.157	35.166	35.175	35.183	35.192	35.200	35.209	35.217	35.226	35.234	35.243	3760
3770	35.243	35.251	35.260	35.269	35.277	35.286	35.294	35.303	35.311	35.320	35.328	3770
3780	35.328	35.337	35.345	35.354	35.362	35.371	35.379	35.388	35.396	35.404	35.413	3780
3790	35.413	35.421	35.430	35.438	35.447	35.455	35.464	35.472	35.481	35.489	35.497	3790
3800	35.497	35.506	35.514	35.523	35.531	35.540	35.548	35.556	35.565	35.573	35.582	3800
3810	35.582	35.590	35.598	35.607	35.615	35.623	35.632	35.640	35.649	35.657	35.665	3810
3820	35.665	35.674	35.682	35.690	35.699	35.707	35.715	35.724	35.732	35.740	35.749	3820
3830	35.749	35.757	35.765	35.774	35.782	35.790	35.799	35.807	35.815	35.824	35.832	3830
3840	35.832	35.840	35.848	35.857	35.865	35.873	35.882	35.890	35.898	35.906	35.915	3840
3850	35.915	35.923	35.931	35.939	35.948	35.956	35.964	35.972	35.981	35.989	35.997	3850
3860	35.997	36.005	36.013	36.022	36.030	36.038	36.046	36.054	36.063	36.071	36.079	3860
3870	36.079	36.087	36.095	36.104	36.112	36.120	36.128	36.136	36.144	36.153	36.161	3870
3880	36.161	36.169	36.177	36.185	36.193	36.201	36.210	36.218	36.226	36.234	36.242	3880
3890	36.242	36.250	36.258	36.266	36.275	36.283	36.291	36.299	36.307	36.315	36.323	3890
3900	36.323	36.331	36.339	36.347	36.355	36.363	36.371	36.380	36.388	36.396	36.404	3900
3910	36.404	36.412	36.420	36.428	36.436	36.444	36.452	36.460	36.468	36.476	36.484	3910
3920	36.484	36.492	36.500	36.508	36.516	36.524	36.532	36.540	36.548	36.556	36.564	3920
3930	36.564	36.572	36.580	36.588	36.596	36.604	36.612	36.619	36.627	36.635	36.643	3930
3940	36.643	36.651	36.659	36.667	36.675	36.683	36.691	36.699	36.707	36.715	36.722	3940
3950	36.722	36.730	36.738	36.746	36.754	36.762	36.770	36.778	36.785	36.793	36.801	3950
3960	36.801	36.809	36.817	36.825	36.833	36.840	36.848	36.856	36.864	36.872	36.880	3960
3970	36.880	36.888	36.895	36.903	36.911	36.919	36.926	36.934	36.942	36.950	36.958	3970
3980	36.958	36.965	36.973	36.981	36.989	36.996	37.004	37.012	37.020	37.028	37.035	3980
3990	37.035	37.043	37.051	37.058	37.066	37.074	37.082	37.089	37.097	37.105	37.113	3990
4000	37.113	37.120	37.128	37.136	37.143	37.151	37.159	37.166	37.174	37.182	37.189	4000
4010	37.189	37.197	37.205	37.212	37.220	37.228	37.235	37.243	37.251	37.258	37.266	4010
4020	37.266	37.274	37.281	37.289	37.296	37.304	37.312	37.319	37.327	37.334	37.342	4020
4030	37.342	37.350	37.357	37.365	37.372	37.380	37.388	37.395	37.403	37.410	37.418	4030
4040	37.418	37.425	37.433	37.440	37.448	37.456	37.463	37.471	37.478	37.486	37.493	4040