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Designation: E 988 – 96

Standard Temperature-Electromotive Force (EMF) Tables for Tungsten-Rhenium Thermocouples[1]

This standard is issued under the fixed designation E 988; 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.

1. Scope

1.1 This standard consists of reference tables that give temperature-electromotive force (emf) relationships for 97 % Tungsten 3 % Rhenium versus 75 % Tungsten 25 % Rhenium and 95 % Tungsten 5 % Rhenium versus 74 % Tungsten 26 % Rhenium thermocouples. These are the refractory metal thermocouple types most commonly used in industry.

1.2 Also included is a list (Table 1) of initial calibration tolerances for the thermocouple types referred to in 1.1, and their respective compensating extension wires (Table 2).

1.3 These data are intended for industrial and laboratory use.

2. Referenced Documents

2.1 *ASTM Standards:*

E 380 Practice for Use of the International System of Units (SI) (the Modernized Metric System)[2]

3. Source of Data

3.1 The data in these tables are based upon the SI volt (see Practice E 380) and the International Temperature Scale of 1990.

3.2 All temperature-electromotive force data in Tables 3-6 have been developed from wire manufacturers' data.

3.3 These tables give emf values to three decimal places (1 µV) for each degree of temperature. Such tables are satisfactory for most industrial uses but may not be adequate for computer and similar applications. If greater precision is required, the reader should refer to the equations in Table 7 which permit further generation of the temperature-emf relationships. In addition, Tables 8 and 9 present polynomial approximations giving temperature as a function of the thermocouple EMF.

4. Identification of Thermocouple Types

4.1 Letter symbols have not been assigned. Identification is made by composition.

4.2 *W3Re/W25Re*—97 % Tungsten 3 % Rhenium (+) versus 75 % Tungsten 25 % Rhenium (−).

4.3 *W5Re/W26Re*—95 % Tungsten 5 % Rhenium (+) versus 74 % Tungsten 26 % Rhenium (−).

5. Initial Calibration Tolerances

5.1 Thermocouples and matched thermocouple wire are supplied to the initial calibration tolerances listed in Table 1.

6. List of Tables

6.1 Following is a list of tables included in this standard:

Table Number	Title
1	Initial Calibration Tolerances and Suggested Temperature Ranges for Thermocouples
2	Initial Calibration Tolerances and Suggested Temperature Ranges for Thermocouple Compensating Extension Wires
3	Temperature versus EMF for W3Re/W25Re from 0 to 2315°C
4	Temperature versus EMF for W3Re/W25Re from 32 to 4200°F
5	Temperature versus EMF for W5Re/W26Re from 0 to 2315°C
6	Temperature versus EMF for W5Re/W26Re from 32 to 4200°F
7	Equations Used to Derive Tables 3-6
8	Polynomial Coefficients for the Computation of Temperatures in °C as a Function of the Thermocouple EMF
9	Polynomial Coefficients for the Computation of Temperatures in °F as a Function of the Thermocouple EMF

7. Keywords

7.1 emf; rhenium; thermocouple; tungsten

[1] These tables are under the jurisdiction of ASTM Committee E-20 on Temperature Measurement and are the direct responsibility of Subcommittee E20.04 on Thermocouples.

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[2] *Annual Book of ASTM Standards,* Vol 14.02.

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TABLE 1 Initial Calibration Tolerances and Suggested Temperature Ranges for Thermocouples[A]

NOTE 1—Initial calibration tolerances in this table apply to new thermocouple wire, normally in the size range 0.125 to 0.5 mm in diameter (No. 36 to 24 Awg) and used at temperatures not exceeding the suggested upper temperatures of Table 1. If used at higher temperatures these initial calibration tolerances may not apply.

NOTE 2—Initial calibration tolerances apply to new wire as delivered to the user and do not allow for calibration drift during use. The magnitude of such changes depends on such factors as wire size, temperature, time of exposure, and environment.

NOTE 3—Where initial calibration tolerances are given in percent, the percentage applies to the temperature being measured when expressed in degrees Fahrenheit. To determine the tolerance in degrees Celsius multiply the tolerance in degrees Fahrenheit by 5/9.

NOTE 4—Tables 1 and 2 also describe suggested upper temperature limits for the thermocouples and extension wires. These limits apply to protected thermocouples, that is, thermocouples in inert or non-oxidizing atmospheres.

Thermocouple Type	Temperature Range	Initial Calibration Tolerances
W3%Re/W25%Re and W5%Re/W26%Re	0 to 426°C 32 to 800°F 426 to 2315°C 800 to 4200°F}	±4.4°C ±8°F ±1 % of actual temperature

[A] CAUTION—Users should be aware that certain characteristics of thermocouple materials including calibration may change in time with use; consequently, test results obtained at time of manufacture may not necessarily apply throughout an extended period of use.

TABLE 2 Initial Calibration Tolerances and Suggested Temperature Ranges for Thermocouple Compensating Extension Wires

Designation	Temperature Range	Initial Calibration Tolerances
For W3%Re/W25%Re		
300P(+) 97.7Ni BAL Cr,Al,Si[A] 300N(−) 96Ni, 4W[A]	0 *to* 330°*C* 32 *to* 625°*F*}	±0.125 mV
203(+) 90Ni, 10Cr[B] 225(−) 98Ni, 2Cr[B]	0 *to* 260°*C* 32 *to* 500°*F*}	±0.110 mV
For W5%Re/W26%Re 405(+) 94.5Ni[B] 2 Mn 1 Si 1.5 AL 426(−) 80 Ni, 20 Cu[B]	0 *to* 871°*C* 32 *to* 1600°*F*}	±0.110 mV

[A] U.S. Patent 3,502,510 assigned to Engelhard Industries.
[B] Designation of Hoskins Mfg.

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TABLE 3 Tungsten-3 % Rhenium versus Tungsten-25 % Rhenium Thermocouples—Thermoelectric Voltage as a Function of Temperature (°C)

EMF in Millivolts — Reference Junctions at 0°C

DEG C	0	1	2	3	4	5	6	7	8	9	10	DEG C
Thermoelectric Voltage in Millivolts												
0	0.000	0.010	0.019	0.029	0.039	0.048	0.058	0.068	0.078	0.088	0.098	**0**
10	0.098	0.108	0.118	0.128	0.138	0.148	0.159	0.169	0.179	0.189	0.200	**10**
20	0.200	0.210	0.221	0.231	0.242	0.252	0.263	0.273	0.284	0.295	0.305	**20**
30	0.305	0.316	0.327	0.338	0.349	0.360	0.371	0.382	0.393	0.404	0.415	**30**
40	0.415	0.426	0.437	0.448	0.460	0.471	0.482	0.494	0.505	0.517	0.528	**40**
50	0.528	0.540	0.551	0.563	0.574	0.586	0.598	0.609	0.621	0.633	0.645	**50**
60	0.645	0.657	0.668	0.680	0.692	0.704	0.716	0.728	0.741	0.753	0.765	**60**
70	0.765	0.777	0.789	0.802	0.814	0.826	0.839	0.851	0.863	0.876	0.888	**70**
80	0.888	0.901	0.914	0.926	0.939	0.951	0.964	0.977	0.990	1.002	1.015	**80**
90	1.015	1.028	1.041	1.054	1.067	1.080	1.093	1.106	1.119	1.132	1.145	**90**
100	1.145	1.158	1.172	1.185	1.198	1.212	1.225	1.238	1.252	1.265	1.278	**100**
110	1.278	1.292	1.305	1.319	1.333	1.346	1.360	1.374	1.387	1.401	1.415	**110**
120	1.415	1.428	1.442	1.456	1.470	1.484	1.498	1.512	1.526	1.540	1.554	**120**
130	1.554	1.568	1.582	1.596	1.610	1.624	1.639	1.653	1.667	1.681	1.696	**130**
140	1.696	1.710	1.725	1.739	1.753	1.768	1.782	1.797	1.811	1.826	1.841	**140**
150	1.841	1.855	1.870	1.884	1.899	1.914	1.929	1.943	1.958	1.973	1.988	**150**
160	1.988	2.003	2.018	2.033	2.048	2.063	2.078	2.093	2.108	2.123	2.138	**160**
170	2.138	2.153	2.168	2.183	2.199	2.214	2.229	2.244	2.260	2.275	2.290	**170**
180	2.290	2.306	2.321	2.337	2.352	2.368	2.383	2.399	2.414	2.430	2.445	**180**
190	2.445	2.461	2.477	2.492	2.508	2.524	2.539	2.555	2.571	2.587	2.603	**190**
200	2.603	2.618	2.634	2.650	2.666	2.682	2.698	2.714	2.730	2.746	2.762	**200**
210	2.762	2.778	2.794	2.810	2.826	2.843	2.859	2.875	2.891	2.907	2.924	**210**
220	2.924	2.940	2.956	2.973	2.989	3.005	3.022	3.038	3.055	3.071	3.088	**220**
230	3.088	3.104	3.121	3.137	3.154	3.170	3.187	3.203	3.220	3.237	3.253	**230**
240	3.253	3.270	3.287	3.303	3.320	3.337	3.354	3.371	3.387	3.404	3.421	**240**
250	3.421	3.438	3.455	3.472	3.489	3.506	3.523	3.540	3.557	3.574	3.591	**250**
260	3.591	3.608	3.625	3.642	3.659	3.676	3.693	3.711	3.728	3.745	3.762	**260**
270	3.762	3.780	3.797	3.814	3.831	3.849	3.866	3.883	3.901	3.918	3.936	**270**
280	3.936	3.953	3.970	3.988	4.005	4.023	4.040	4.058	4.075	4.093	4.111	**280**
290	4.111	4.128	4.146	4.163	4.181	4.199	4.216	4.234	4.252	4.269	4.287	**290**
300	4.287	4.305	4.323	4.340	4.358	4.376	4.394	4.412	4.430	4.447	4.465	**300**
310	4.465	4.483	4.501	4.519	4.537	4.555	4.573	4.591	4.609	4.627	4.645	**310**
320	4.645	4.663	4.681	4.699	4.717	4.735	4.753	4.772	4.790	4.808	4.826	**320**
330	4.826	4.844	4.862	4.881	4.899	4.917	4.935	4.954	4.972	4.990	5.009	**330**
340	5.009	5.027	5.045	5.064	5.082	5.100	5.119	5.137	5.156	5.174	5.192	**340**
350	5.192	5.211	5.229	5.248	5.266	5.285	5.303	5.322	5.340	5.359	5.378	**350**
360	5.378	5.396	5.415	5.433	5.452	5.471	5.489	5.508	5.527	5.545	5.564	**360**
370	5.564	5.583	5.601	5.620	5.639	5.658	5.676	5.695	5.714	5.733	5.752	**370**
380	5.752	5.770	5.789	5.808	5.827	5.846	5.865	5.884	5.902	5.921	5.940	**380**
390	5.940	5.959	5.978	5.997	6.016	6.035	6.054	6.073	6.092	6.111	6.130	**390**
400	6.130	6.149	6.168	6.187	6.206	6.225	6.245	6.264	6.283	6.302	6.321	**400**
410	6.321	6.340	6.359	6.378	6.398	6.417	6.436	6.455	6.474	6.494	6.513	**410**
420	6.513	6.532	6.551	6.571	6.590	6.609	6.628	6.648	6.667	6.686	6.706	**420**
430	6.706	6.725	6.744	6.764	6.783	6.802	6.822	6.841	6.861	6.880	6.899	**430**
440	6.899	6.919	6.938	6.958	6.977	6.997	7.016	7.035	7.055	7.074	7.094	**440**
450	7.094	7.113	7.133	7.152	7.172	7.191	7.211	7.231	7.250	7.270	7.289	**450**
460	7.289	7.309	7.328	7.348	7.368	7.387	7.407	7.427	7.446	7.466	7.485	**460**
470	7.485	7.505	7.525	7.544	7.564	7.584	7.604	7.623	7.643	7.663	7.682	**470**
480	7.682	7.702	7.722	7.742	7.761	7.781	7.801	7.821	7.840	7.860	7.880	**480**
490	7.880	7.900	7.920	7.939	7.959	7.979	7.999	8.019	8.038	8.058	8.078	**490**
500	8.078	8.098	8.118	8.138	8.158	8.178	8.197	8.217	8.237	8.257	8.277	**500**

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TABLE 3 *(continued)*

EMF in Millivolts												Reference Junctions at 0°C
DEG C	0	1	2	3	4	5	6	7	8	9	10	DEG C
Thermoelectric Voltage in Millivolts												
500	8.078	8.098	8.118	8.138	8.158	8.178	8.197	8.217	8.237	8.257	8.277	**500**
510	8.277	8.297	8.317	8.337	8.357	8.377	8.397	8.417	8.437	8.457	8.476	**510**
520	8.476	8.496	8.516	8.536	8.556	8.576	8.596	8.616	8.636	8.656	8.676	**520**
530	8.676	8.696	8.717	8.737	8.757	8.777	8.797	8.817	8.837	8.857	8.877	**530**
540	8.877	8.897	8.917	8.937	8.957	8.977	8.997	9.018	9.038	9.058	9.078	**540**
550	9.078	9.098	9.118	9.138	9.158	9.178	9.199	9.219	9.239	9.259	9.279	**550**
560	9.279	9.299	9.320	9.340	9.360	9.380	9.400	9.420	9.441	9.461	9.481	**560**
570	9.481	9.501	9.521	9.542	9.562	9.582	9.602	9.622	9.643	9.663	9.683	**570**
580	9.683	9.703	9.723	9.744	9.764	9.784	9.804	9.825	9.845	9.865	9.885	**580**
590	9.885	9.906	9.926	9.946	9.966	9.987	10.007	10.027	10.048	10.068	10.088	**590**
600	10.088	10.108	10.129	10.149	10.169	10.190	10.210	10.230	10.250	10.271	10.291	**600**
610	10.291	10.311	10.332	10.352	10.372	10.393	10.413	10.433	10.454	10.474	10.494	**610**
620	10.494	10.515	10.535	10.555	10.576	10.596	10.616	10.637	10.657	10.677	10.698	**620**
630	10.698	10.718	10.738	10.759	10.779	10.799	10.820	10.840	10.860	10.881	10.901	**630**
640	10.901	10.921	10.942	10.962	10.983	11.003	11.023	11.044	11.064	11.084	11.105	**640**
650	11.105	11.125	11.146	11.166	11.186	11.207	11.227	11.247	11.268	11.288	11.309	**650**
660	11.309	11.329	11.349	11.370	11.390	11.410	11.431	11.451	11.472	11.492	11.512	**660**
670	11.512	11.533	11.553	11.574	11.594	11.614	11.635	11.655	11.676	11.696	11.716	**670**
680	11.716	11.737	11.757	11.778	11.798	11.818	11.839	11.859	11.880	11.900	11.921	**680**
690	11.921	11.941	11.961	11.982	12.002	12.023	12.043	12.063	12.084	12.104	12.125	**690**
700	12.125	12.145	12.165	12.186	12.206	12.227	12.247	12.268	12.288	12.308	12.329	**700**
710	12.329	12.349	12.370	12.390	12.410	12.431	12.451	12.472	12.492	12.513	12.533	**710**
720	12.533	12.553	12.574	12.594	12.615	12.635	12.656	12.676	12.696	12.717	12.737	**720**
730	12.737	12.758	12.778	12.799	12.819	12.840	12.860	12.880	12.901	12.921	12.942	**730**
740	12.942	12.962	12.983	13.003	13.023	13.044	13.064	13.085	13.105	13.126	13.146	**740**
750	13.146	13.167	13.187	13.207	13.228	13.248	13.269	13.289	13.310	13.330	13.351	**750**
760	13.351	13.371	13.392	13.412	13.433	13.453	13.473	13.494	13.514	13.535	13.555	**760**
770	13.555	13.576	13.596	13.617	13.637	13.658	13.678	13.699	13.719	13.740	13.760	**770**
780	13.760	13.781	13.801	13.822	13.842	13.863	13.883	13.904	13.924	13.945	13.965	**780**
790	13.965	13.986	14.006	14.027	14.047	14.068	14.088	14.109	14.129	14.150	14.170	**790**
800	14.170	14.191	14.211	14.232	14.252	14.273	14.293	14.314	14.334	14.355	14.375	**800**
810	14.375	14.395	14.416	14.436	14.457	14.477	14.498	14.518	14.539	14.559	14.580	**810**
820	14.580	14.600	14.621	14.641	14.662	14.682	14.703	14.723	14.744	14.764	14.784	**820**
830	14.784	14.805	14.825	14.846	14.866	14.887	14.907	14.928	14.948	14.969	14.989	**830**
840	14.989	15.009	15.030	15.050	15.071	15.091	15.112	15.132	15.152	15.173	15.193	**840**
850	15.193	15.214	15.234	15.255	15.275	15.295	15.316	15.336	15.357	15.377	15.398	**850**
860	15.398	15.418	15.438	15.459	15.479	15.500	15.520	15.540	15.561	15.581	15.602	**860**
870	15.602	15.622	15.642	15.663	15.683	15.703	15.724	15.744	15.765	15.785	15.805	**870**
880	15.805	15.826	15.846	15.866	15.887	15.907	15.928	15.948	15.968	15.989	16.009	**880**
890	16.009	16.029	16.050	16.070	16.090	16.111	16.131	16.151	16.172	16.192	16.212	**890**
900	16.212	16.233	16.253	16.273	16.294	16.314	16.334	16.354	16.375	16.395	16.415	**900**
910	16.415	16.436	16.456	16.476	16.497	16.517	16.537	16.557	16.578	16.598	16.618	**910**
920	16.618	16.638	16.659	16.679	16.699	16.720	16.740	16.760	16.780	16.801	16.821	**920**
930	16.821	16.841	16.861	16.881	16.902	16.922	16.942	16.962	16.983	17.003	17.023	**930**
940	17.023	17.043	17.063	17.084	17.104	17.124	17.144	17.164	17.185	17.205	17.225	**940**
950	17.225	17.245	17.265	17.285	17.306	17.326	17.346	17.366	17.386	17.406	17.427	**950**
960	17.427	17.447	17.467	17.487	17.507	17.527	17.547	17.568	17.588	17.608	17.628	**960**
970	17.628	17.648	17.668	17.688	17.708	17.728	17.748	17.769	17.789	17.809	17.829	**970**
980	17.829	17.849	17.869	17.889	17.909	17.929	17.949	17.969	17.989	18.009	18.029	**980**
990	18.029	18.049	18.069	18.090	18.110	18.130	18.150	18.170	18.190	18.210	18.230	**990**
1000	18.230	18.250	18.270	18.290	18.310	18.330	18.350	18.370	18.390	18.410	18.430	**1000**

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TABLE 3 *(continued)*

EMF in Millivolts — Reference Junctions at 0°C

DEG C	0	1	2	3	4	5	6	7	8	9	10	DEG C
Thermoelectric Voltage in Millivolts												
1000	18.230	18.250	18.270	18.290	18.310	18.330	18.350	18.370	18.390	18.410	18.430	**1000**
1010	18.430	18.450	18.469	18.489	18.509	18.529	18.549	18.569	18.589	18.609	18.629	**1010**
1020	18.629	18.649	18.669	18.689	18.709	18.729	18.749	18.768	18.788	18.808	18.828	**1020**
1030	18.828	18.848	18.868	18.888	18.908	18.928	18.947	18.967	18.987	19.007	19.027	**1030**
1040	19.027	19.047	19.067	19.086	19.106	19.126	19.146	19.166	19.186	19.205	19.225	**1040**
1050	19.225	19.245	19.265	19.285	19.304	19.324	19.344	19.364	19.384	19.403	19.423	**1050**
1060	19.423	19.443	19.463	19.482	19.502	19.522	19.542	19.561	19.581	19.601	19.621	**1060**
1070	19.621	19.640	19.660	19.680	19.700	19.719	19.739	19.759	19.778	19.798	19.818	**1070**
1080	19.818	19.837	19.857	19.877	19.896	19.916	19.936	19.955	19.975	19.995	20.014	**1080**
1090	20.014	20.034	20.054	20.073	20.093	20.113	20.132	20.152	20.171	20.191	20.211	**1090**
1100	20.211	20.230	20.250	20.269	20.289	20.309	20.328	20.348	20.367	20.387	20.406	**1100**
1110	20.406	20.426	20.446	20.465	20.485	20.504	20.524	20.543	20.563	20.582	20.602	**1110**
1120	20.602	20.621	20.641	20.660	20.680	20.699	20.719	20.738	20.758	20.777	20.797	**1120**
1130	20.797	20.816	20.836	20.855	20.875	20.894	20.914	20.933	20.952	20.972	20.991	**1130**
1140	20.991	21.011	21.030	21.050	21.069	21.088	21.108	21.127	21.147	21.166	21.185	**1140**
1150	21.185	21.205	21.224	21.243	21.263	21.282	21.301	21.321	21.340	21.360	21.379	**1150**
1160	21.379	21.398	21.418	21.437	21.456	21.475	21.495	21.514	21.533	21.553	21.572	**1160**
1170	21.572	21.591	21.611	21.630	21.649	21.668	21.688	21.707	21.726	21.745	21.765	**1170**
1180	21.765	21.784	21.803	21.822	21.842	21.861	21.880	21.899	21.918	21.938	21.957	**1180**
1190	21.957	21.976	21.995	22.014	22.034	22.053	22.072	22.091	22.110	22.129	22.149	**1190**
1200	22.149	22.168	22.187	22.206	22.225	22.244	22.263	22.283	22.302	22.321	22.340	**1200**
1210	22.340	22.359	22.378	22.397	22.416	22.435	22.454	22.473	22.493	22.512	22.531	**1210**
1220	22.531	22.550	22.569	22.588	22.607	22.626	22.645	22.664	22.683	22.702	22.721	**1220**
1230	22.721	22.740	22.759	22.778	22.797	22.816	22.835	22.854	22.873	22.892	22.911	**1230**
1240	22.911	22.930	22.949	22.968	22.987	23.006	23.024	23.043	23.062	23.081	23.100	**1240**
1250	23.100	23.119	23.138	23.157	23.176	23.195	23.214	23.232	23.251	23.270	23.289	**1250**
1260	23.289	23.308	23.327	23.346	23.364	23.383	23.402	23.421	23.440	23.459	23.477	**1260**
1270	23.477	23.496	23.515	23.534	23.553	23.571	23.590	23.609	23.628	23.647	23.665	**1270**
1280	23.665	23.684	23.703	23.722	23.740	23.759	23.778	23.797	23.815	23.834	23.853	**1280**
1290	23.853	23.871	23.890	23.909	23.928	23.946	23.965	23.984	24.002	24.021	24.040	**1290**
1300	24.040	24.058	24.077	24.096	24.114	24.133	24.152	24.170	24.189	24.208	24.226	**1300**
1310	24.226	24.245	24.263	24.282	24.301	24.319	24.338	24.356	24.375	24.394	24.412	**1310**
1320	24.412	24.431	24.449	24.468	24.486	24.505	24.523	24.542	24.561	24.579	24.598	**1320**
1330	24.598	24.616	24.635	24.653	24.672	24.690	24.709	24.727	24.746	24.764	24.783	**1330**
1340	24.783	24.801	24.820	24.838	24.856	24.875	24.893	24.912	24.930	24.949	24.967	**1340**
1350	24.967	24.985	25.004	25.022	25.041	25.059	25.078	25.096	25.114	25.133	25.151	**1350**
1360	25.151	25.169	25.188	25.206	25.224	25.243	25.261	25.280	25.298	25.316	25.335	**1360**
1370	25.335	25.353	25.371	25.389	25.408	25.426	25.444	25.463	25.481	25.499	25.517	**1370**
1380	25.517	25.536	25.554	25.572	25.591	25.609	25.627	25.645	25.664	25.682	25.700	**1380**
1390	25.700	25.718	25.736	25.755	25.773	25.791	25.809	25.827	25.846	25.864	25.882	**1390**
1400	25.882	25.900	25.918	25.936	25.955	25.973	25.991	26.009	26.027	26.045	26.063	**1400**
1410	26.063	26.082	26.100	26.118	26.136	26.154	26.172	26.190	26.208	26.226	26.244	**1410**
1420	26.244	26.262	26.281	26.299	26.317	26.335	26.353	26.371	26.389	26.407	26.425	**1420**
1430	26.425	26.443	26.461	26.479	26.497	26.515	26.533	26.551	26.569	26.587	26.605	**1430**
1440	26.605	26.623	26.641	26.659	26.677	26.695	26.712	26.730	26.748	26.766	26.784	**1440**
1450	26.784	26.802	26.820	26.838	26.856	26.874	26.892	26.909	26.927	26.945	26.963	**1450**
1460	26.963	26.981	26.999	27.017	27.035	27.052	27.070	27.088	27.106	27.124	27.141	**1460**
1470	27.141	27.159	27.177	27.195	27.213	27.230	27.248	27.266	27.284	27.302	27.319	**1470**
1480	27.319	27.337	27.355	27.373	27.390	27.408	27.426	27.444	27.461	27.479	27.497	**1480**
1490	27.497	27.514	27.532	27.550	27.567	27.585	27.603	27.621	27.638	27.656	27.673	**1490**
1500	27.673	27.691	27.709	27.726	27.744	27.762	27.779	27.797	27.815	27.832	27.850	**1500**

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TABLE 3 *(continued)*

EMF in Millivolts — Reference Junctions at 0°C

DEG C	0	1	2	3	4	5	6	7	8	9	10	DEG C
Thermoelectric Voltage in Millivolts												
1500	27.673	27.691	27.709	27.726	27.744	27.762	27.779	27.797	27.815	27.832	27.850	**1500**
1510	27.850	27.867	27.885	27.903	27.920	27.938	27.955	27.973	27.990	28.008	28.026	**1510**
1520	28.026	28.043	28.061	28.078	28.096	28.113	28.131	28.148	28.166	28.183	28.201	**1520**
1530	28.201	28.218	28.236	28.253	28.271	28.288	28.306	28.323	28.341	28.358	28.375	**1530**
1540	28.375	28.393	28.410	28.428	28.445	28.463	28.480	28.497	28.515	28.532	28.550	**1540**
1550	28.550	28.567	28.584	28.602	28.619	28.636	28.654	28.671	28.688	28.706	28.723	**1550**
1560	28.723	28.740	28.758	28.775	28.792	28.810	28.827	28.844	28.862	28.879	28.896	**1560**
1570	28.896	28.913	28.931	28.948	28.965	28.982	29.000	29.017	29.034	29.051	29.069	**1570**
1580	29.069	29.086	29.103	29.120	29.137	29.155	29.172	29.189	29.206	29.223	29.241	**1580**
1590	29.241	29.258	29.275	29.292	29.309	29.326	29.343	29.361	29.378	29.395	29.412	**1590**
1600	29.412	29.429	29.446	29.463	29.480	29.497	29.514	29.532	29.549	29.566	29.583	**1600**
1610	29.583	29.600	29.617	29.634	29.651	29.668	29.685	29.702	29.719	29.736	29.753	**1610**
1620	29.753	29.770	29.787	29.804	29.821	29.838	29.855	29.872	29.889	29.906	29.923	**1620**
1630	29.923	29.939	29.956	29.973	29.990	30.007	30.024	30.041	30.058	30.075	30.092	**1630**
1640	30.092	30.108	30.125	30.142	30.159	30.176	30.193	30.210	30.226	30.243	30.260	**1640**
1650	30.260	30.277	30.294	30.311	30.327	30.344	30.361	30.378	30.394	30.411	30.428	**1650**
1660	30.428	30.445	30.461	30.478	30.495	30.512	30.528	30.545	30.562	30.579	30.595	**1660**
1670	30.595	30.612	30.629	30.645	30.662	30.679	30.695	30.712	30.729	30.745	30.762	**1670**
1680	30.762	30.779	30.795	30.812	30.828	30.845	30.862	30.878	30.895	30.911	30.928	**1680**
1690	30.928	30.944	30.961	30.978	30.994	31.011	31.027	31.044	31.060	31.077	31.093	**1690**
1700	31.093	31.110	31.126	31.143	31.159	31.176	31.192	31.209	31.225	31.242	31.258	**1700**
1710	31.258	31.275	31.291	31.307	31.324	31.340	31.357	31.373	31.389	31.406	31.422	**1710**
1720	31.422	31.439	31.455	31.471	31.488	31.504	31.520	31.537	31.553	31.569	31.586	**1720**
1730	31.586	31.602	31.618	31.635	31.651	31.667	31.684	31.700	31.716	31.732	31.749	**1730**
1740	31.749	31.765	31.781	31.797	31.814	31.830	31.846	31.862	31.878	31.895	31.911	**1740**
1750	31.911	31.927	31.943	31.959	31.976	31.992	32.008	32.024	32.040	32.056	32.072	**1750**
1760	32.072	32.088	32.105	32.121	32.137	32.153	32.169	32.185	32.201	32.217	32.233	**1760**
1770	32.233	32.249	32.265	32.281	32.297	32.313	32.329	32.345	32.361	32.377	32.393	**1770**
1780	32.393	32.409	32.425	32.441	32.457	32.473	32.489	32.505	32.521	32.537	32.553	**1780**
1790	32.553	32.569	32.585	32.600	32.616	32.632	32.648	32.664	32.680	32.696	32.712	**1790**
1800	32.712	32.727	32.743	32.759	32.775	32.791	32.806	32.822	32.838	32.854	32.870	**1800**
1810	32.870	32.885	32.901	32.917	32.933	32.948	32.964	32.980	32.995	33.011	33.027	**1810**
1820	33.027	33.042	33.058	33.074	33.090	33.105	33.121	33.136	33.152	33.168	33.183	**1820**
1830	33.183	33.199	33.215	33.230	33.246	33.261	33.277	33.292	33.308	33.324	33.339	**1830**
1840	33.339	33.355	33.370	33.386	33.401	33.417	33.432	33.448	33.463	33.479	33.494	**1840**
1850	33.494	33.510	33.525	33.540	33.556	33.571	33.587	33.602	33.618	33.633	33.648	**1850**
1860	33.648	33.664	33.679	33.694	33.710	33.725	33.741	33.756	33.771	33.786	33.802	**1860**
1870	33.802	33.817	33.832	33.848	33.863	33.878	33.893	33.909	33.924	33.939	33.954	**1870**
1880	33.954	33.970	33.985	34.000	34.015	34.030	34.046	34.061	34.076	34.091	34.106	**1880**
1890	34.106	34.121	34.136	34.152	34.167	34.182	34.197	34.212	34.227	34.242	34.257	**1890**
1900	34.257	34.272	34.287	34.302	34.317	34.332	34.347	34.362	34.377	34.392	34.407	**1900**
1910	34.407	34.422	34.437	34.452	34.467	34.482	34.497	34.512	34.527	34.542	34.556	**1910**
1920	34.556	34.571	34.586	34.601	34.616	34.631	34.646	34.660	34.675	34.690	34.705	**1920**
1930	34.705	34.720	34.734	34.749	34.764	34.779	34.793	34.808	34.823	34.838	34.852	**1930**
1940	34.852	34.867	34.882	34.896	34.911	34.926	34.940	34.955	34.970	34.984	34.999	**1940**
1950	34.999	35.013	35.028	35.043	35.057	35.072	35.086	35.101	35.115	35.130	35.144	**1950**
1960	35.144	35.159	35.173	35.188	35.202	35.217	35.231	35.246	35.260	35.275	35.289	**1960**
1970	35.289	35.303	35.318	35.332	35.347	35.361	35.375	35.390	35.404	35.418	35.433	**1970**
1980	35.433	35.447	35.461	35.476	35.490	35.504	35.518	35.533	35.547	35.561	35.575	**1980**
1990	35.575	35.590	35.604	35.618	35.632	35.646	35.660	35.675	35.689	35.703	35.717	**1990**
2000	35.717	35.731	35.745	35.759	35.773	35.787	35.801	35.816	35.830	35.844	35.858	**2000**

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TABLE 3 *(continued)*

EMF in Millivolts												Reference Junctions at 0°C
DEG C	0	1	2	3	4	5	6	7	8	9	10	DEG C
Thermoelectric Voltage in Millivolts												
2000	35.717	35.731	35.745	35.759	35.773	35.787	35.801	35.816	35.830	35.844	35.858	**2000**
2010	35.858	35.872	35.886	35.900	35.914	35.927	35.941	35.955	35.969	35.983	35.997	**2010**
2020	35.997	36.011	36.025	36.039	36.053	36.067	36.080	36.094	36.108	36.122	36.136	**2020**
2030	36.136	36.149	36.163	36.177	36.191	36.204	36.218	36.232	36.246	36.259	36.273	**2030**
2040	36.273	36.287	36.300	36.314	36.328	36.341	36.355	36.368	36.382	36.396	36.409	**2040**
2050	36.409	36.423	36.436	36.450	36.463	36.477	36.490	36.504	36.517	36.531	36.544	**2050**
2060	36.544	36.558	36.571	36.585	36.598	36.611	36.625	36.638	36.652	36.665	36.678	**2060**
2070	36.678	36.692	36.705	36.718	36.731	36.745	36.758	36.771	36.784	36.798	36.811	**2070**
2080	36.811	36.824	36.837	36.850	36.864	36.877	36.890	36.903	36.916	36.929	36.942	**2080**
2090	36.942	36.955	36.969	36.982	36.995	37.008	37.021	37.034	37.047	37.060	37.073	**2090**
2100	37.073	37.086	37.099	37.111	37.124	37.137	37.150	37.163	37.176	37.189	37.202	**2100**
2110	37.202	37.214	37.227	37.240	37.253	37.266	37.278	37.291	37.304	37.317	37.329	**2110**
2120	37.329	37.342	37.355	37.367	37.380	37.393	37.405	37.418	37.430	37.443	37.456	**2120**
2130	37.456	37.468	37.481	37.493	37.506	37.518	37.531	37.543	37.556	37.568	37.580	**2130**
2140	37.580	37.593	37.605	37.618	37.630	37.642	37.655	37.667	37.679	37.692	37.704	**2140**
2150	37.704	37.716	37.729	37.741	37.753	37.765	37.777	37.790	37.802	37.814	37.826	**2150**
2160	37.826	37.838	37.850	37.862	37.875	37.887	37.899	37.911	37.923	37.935	37.947	**2160**
2170	37.947	37.959	37.971	37.983	37.995	38.006	38.018	38.030	38.042	38.054	38.066	**2170**
2180	38.066	38.078	38.089	38.101	38.113	38.125	38.137	38.148	38.160	38.172	38.183	**2180**
2190	38.183	38.195	38.207	38.218	38.230	38.242	38.253	38.265	38.276	38.288	38.299	**2190**
2200	38.299	38.311	38.323	38.334	38.345	38.357	38.368	38.380	38.391	38.403	38.414	**2200**
2210	38.414	38.425	38.437	38.448	38.459	38.471	38.482	38.493	38.504	38.515	38.527	**2210**
2220	38.527	38.538	38.549	38.560	38.571	38.582	38.594	38.605	38.616	38.627	38.638	**2220**
2230	38.638	38.649	38.660	38.671	38.682	38.693	38.704	38.715	38.725	38.736	38.747	**2230**
2240	38.747	38.758	38.769	38.780	38.790	38.801	38.812	38.823	38.833	38.844	38.855	**2240**
2250	38.855	38.865	38.876	38.887	38.897	38.908	38.918	38.929	38.940	38.950	38.961	**2250**
2260	38.961	38.971	38.982	38.992	39.002	39.013	39.023	39.034	39.044	39.054	39.065	**2260**
2270	39.065	39.075	39.085	39.095	39.106	39.116	39.126	39.136	39.146	39.157	39.167	**2270**
2280	39.167	39.177	39.187	39.197	39.207	39.217	39.227	39.237	39.247	39.257	39.267	**2280**
2290	39.267	39.277	39.287	39.296	39.306	39.316	39.326	39.336	39.345	39.355	39.365	**2290**
2300	39.365	39.375	39.384	39.394	39.404	39.413	39.423	39.432	39.442	39.452	39.461	**2300**
2310	39.461	39.471	39.480	39.490	39.499	39.508						**2310**

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TABLE 4 Tungsten-3 % Rhenium versus Tungsten-25 % Rhenium Thermocouples—Thermoelectric Voltage as a Function of Temperature (°F)

EMF in Millivolts — Reference Junctions at 32°F

DEG F	0	1	2	3	4	5	6	7	8	9	10	DEG F
Thermoelectric Voltage in Millivolts												
30			0.000	0.005	0.011	0.016	0.021	0.027	0.032	0.038	0.043	**30**
40	0.043	0.048	0.054	0.059	0.065	0.070	0.076	0.081	0.087	0.092	0.098	**40**
50	0.098	0.103	0.109	0.115	0.120	0.126	0.131	0.137	0.143	0.148	0.154	**50**
60	0.154	0.160	0.165	0.171	0.177	0.183	0.188	0.194	0.200	0.206	0.211	**60**
70	0.211	0.217	0.223	0.229	0.235	0.240	0.246	0.252	0.258	0.264	0.270	**70**
80	0.270	0.276	0.282	0.288	0.294	0.299	0.305	0.311	0.317	0.323	0.329	**80**
90	0.329	0.335	0.342	0.348	0.354	0.360	0.366	0.372	0.378	0.384	0.390	**90**
100	0.390	0.396	0.403	0.409	0.415	0.421	0.427	0.433	0.440	0.446	0.452	**100**
110	0.452	0.458	0.465	0.471	0.477	0.484	0.490	0.496	0.503	0.509	0.515	**110**
120	0.515	0.522	0.528	0.534	0.541	0.547	0.554	0.560	0.566	0.573	0.579	**120**
130	0.579	0.586	0.592	0.599	0.605	0.612	0.618	0.625	0.632	0.638	0.645	**130**
140	0.645	0.651	0.658	0.664	0.671	0.678	0.684	0.691	0.698	0.704	0.711	**140**
150	0.711	0.718	0.724	0.731	0.738	0.745	0.751	0.758	0.765	0.772	0.778	**150**
160	0.778	0.785	0.792	0.799	0.806	0.812	0.819	0.826	0.833	0.840	0.847	**160**
170	0.847	0.854	0.861	0.868	0.875	0.881	0.888	0.895	0.902	0.909	0.916	**170**
180	0.916	0.923	0.930	0.937	0.944	0.951	0.958	0.966	0.973	0.980	0.987	**180**
190	0.987	0.994	1.001	1.008	1.015	1.022	1.030	1.037	1.044	1.051	1.058	**190**
200	1.058	1.065	1.073	1.080	1.087	1.094	1.102	1.109	1.116	1.123	1.131	**200**
210	1.131	1.138	1.145	1.153	1.160	1.167	1.175	1.182	1.189	1.197	1.204	**210**
220	1.204	1.212	1.219	1.226	1.234	1.241	1.249	1.256	1.264	1.271	1.278	**220**
230	1.278	1.286	1.293	1.301	1.308	1.316	1.324	1.331	1.339	1.346	1.354	**230**
240	1.354	1.361	1.369	1.377	1.384	1.392	1.399	1.407	1.415	1.422	1.430	**240**
250	1.430	1.438	1.445	1.453	1.461	1.468	1.476	1.484	1.492	1.499	1.507	**250**
260	1.507	1.515	1.523	1.530	1.538	1.546	1.554	1.562	1.569	1.577	1.585	**260**
270	1.585	1.593	1.601	1.609	1.617	1.624	1.632	1.640	1.648	1.656	1.664	**270**
280	1.664	1.672	1.680	1.688	1.696	1.704	1.712	1.720	1.728	1.736	1.744	**280**
290	1.744	1.752	1.760	1.768	1.776	1.784	1.792	1.800	1.808	1.816	1.824	**290**
300	1.824	1.832	1.841	1.849	1.857	1.865	1.873	1.881	1.889	1.898	1.906	**300**
310	1.906	1.914	1.922	1.930	1.939	1.947	1.955	1.963	1.971	1.980	1.988	**310**
320	1.988	1.996	2.004	2.013	2.021	2.029	2.038	2.046	2.054	2.063	2.071	**320**
330	2.071	2.079	2.088	2.096	2.104	2.113	2.121	2.130	2.138	2.146	2.155	**330**
340	2.155	2.163	2.172	2.180	2.188	2.197	2.205	2.214	2.222	2.231	2.239	**340**
350	2.239	2.248	2.256	2.265	2.273	2.282	2.290	2.299	2.307	2.316	2.325	**350**
360	2.325	2.333	2.342	2.350	2.359	2.368	2.376	2.385	2.393	2.402	2.411	**360**
370	2.411	2.419	2.428	2.437	2.445	2.454	2.463	2.471	2.480	2.489	2.497	**370**
380	2.497	2.506	2.515	2.524	2.532	2.541	2.550	2.559	2.567	2.576	2.585	**380**
390	2.585	2.594	2.603	2.611	2.620	2.629	2.638	2.647	2.655	2.664	2.673	**390**
400	2.673	2.682	2.691	2.700	2.709	2.718	2.726	2.735	2.744	2.753	2.762	**400**
410	2.762	2.771	2.780	2.789	2.798	2.807	2.816	2.825	2.834	2.843	2.852	**410**
420	2.852	2.861	2.870	2.879	2.888	2.897	2.906	2.915	2.924	2.933	2.942	**420**
430	2.942	2.951	2.960	2.969	2.978	2.987	2.996	3.005	3.014	3.024	3.033	**430**
440	3.033	3.042	3.051	3.060	3.069	3.078	3.088	3.097	3.106	3.115	3.124	**440**
450	3.124	3.133	3.143	3.152	3.161	3.170	3.179	3.189	3.198	3.207	3.216	**450**
460	3.216	3.226	3.235	3.244	3.253	3.263	3.272	3.281	3.290	3.300	3.309	**460**
470	3.309	3.318	3.328	3.337	3.346	3.356	3.365	3.374	3.384	3.393	3.402	**470**
480	3.402	3.412	3.421	3.431	3.440	3.449	3.459	3.468	3.477	3.487	3.496	**480**
490	3.496	3.506	3.515	3.525	3.534	3.543	3.553	3.562	3.572	3.581	3.591	**490**
500	3.591	3.600	3.610	3.619	3.629	3.638	3.648	3.657	3.667	3.676	3.686	**500**

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TABLE 4 *(continued)*

EMF in Millivolts												Reference Junctions at 32°F
DEG F	0	1	2	3	4	5	6	7	8	9	10	DEG F
Thermoelectric Voltage in Millivolts												
500	3.591	3.600	3.610	3.619	3.629	3.638	3.648	3.657	3.667	3.676	3.686	**500**
510	3.686	3.695	3.705	3.714	3.724	3.734	3.743	3.753	3.762	3.772	3.781	**510**
520	3.781	3.791	3.801	3.810	3.820	3.829	3.839	3.849	3.858	3.868	3.878	**520**
530	3.878	3.887	3.897	3.907	3.916	3.926	3.936	3.945	3.955	3.965	3.974	**530**
540	3.974	3.984	3.994	4.003	4.013	4.023	4.033	4.042	4.052	4.062	4.071	**540**
550	4.071	4.081	4.091	4.101	4.111	4.120	4.130	4.140	4.150	4.159	4.169	**550**
560	4.169	4.179	4.189	4.199	4.208	4.218	4.228	4.238	4.248	4.258	4.267	**560**
570	4.267	4.277	4.287	4.297	4.307	4.317	4.327	4.336	4.346	4.356	4.366	**570**
580	4.366	4.376	4.386	4.396	4.406	4.416	4.426	4.435	4.445	4.455	4.465	**580**
590	4.465	4.475	4.485	4.495	4.505	4.515	4.525	4.535	4.545	4.555	4.565	**590**
600	4.565	4.575	4.585	4.595	4.605	4.615	4.625	4.635	4.645	4.655	4.665	**600**
610	4.665	4.675	4.685	4.695	4.705	4.715	4.725	4.735	4.745	4.755	4.766	**610**
620	4.766	4.776	4.786	4.796	4.806	4.816	4.826	4.836	4.846	4.856	4.866	**620**
630	4.866	4.877	4.887	4.897	4.907	4.917	4.927	4.937	4.948	4.958	4.968	**630**
640	4.968	4.978	4.988	4.998	5.009	5.019	5.029	5.039	5.049	5.060	5.070	**640**
650	5.070	5.080	5.090	5.100	5.111	5.121	5.131	5.141	5.151	5.162	5.172	**650**
660	5.172	5.182	5.192	5.203	5.213	5.223	5.233	5.244	5.254	5.264	5.275	**660**
670	5.275	5.285	5.295	5.305	5.316	5.326	5.336	5.347	5.357	5.367	5.378	**670**
680	5.378	5.388	5.398	5.409	5.419	5.429	5.440	5.450	5.460	5.471	5.481	**680**
690	5.481	5.491	5.502	5.512	5.522	5.533	5.543	5.554	5.564	5.574	5.585	**690**
700	5.585	5.595	5.606	5.616	5.626	5.637	5.647	5.658	5.668	5.678	5.689	**700**
710	5.689	5.699	5.710	5.720	5.731	5.741	5.752	5.762	5.772	5.783	5.793	**710**
720	5.793	5.804	5.814	5.825	5.835	5.846	5.856	5.867	5.877	5.888	5.898	**720**
730	5.898	5.909	5.919	5.930	5.940	5.951	5.961	5.972	5.982	5.993	6.003	**730**
740	6.003	6.014	6.025	6.035	6.046	6.056	6.067	6.077	6.088	6.098	6.109	**740**
750	6.109	6.120	6.130	6.141	6.151	6.162	6.172	6.183	6.194	6.204	6.215	**750**
760	6.215	6.225	6.236	6.247	6.257	6.268	6.278	6.289	6.300	6.310	6.321	**760**
770	6.321	6.332	6.342	6.353	6.364	6.374	6.385	6.395	6.406	6.417	6.427	**770**
780	6.427	6.438	6.449	6.459	6.470	6.481	6.491	6.502	6.513	6.524	6.534	**780**
790	6.534	6.545	6.556	6.566	6.577	6.588	6.598	6.609	6.620	6.631	6.641	**790**
800	6.641	6.652	6.663	6.673	6.684	6.695	6.706	6.716	6.727	6.738	6.749	**800**
810	6.749	6.759	6.770	6.781	6.792	6.802	6.813	6.824	6.835	6.845	6.856	**810**
820	6.856	6.867	6.878	6.889	6.899	6.910	6.921	6.932	6.942	6.953	6.964	**820**
830	6.964	6.975	6.986	6.997	7.007	7.018	7.029	7.040	7.051	7.061	7.072	**830**
840	7.072	7.083	7.094	7.105	7.116	7.126	7.137	7.148	7.159	7.170	7.181	**840**
850	7.181	7.191	7.202	7.213	7.224	7.235	7.246	7.257	7.268	7.278	7.289	**850**
860	7.289	7.300	7.311	7.322	7.333	7.344	7.355	7.365	7.376	7.387	7.398	**860**
870	7.398	7.409	7.420	7.431	7.442	7.453	7.464	7.475	7.485	7.496	7.507	**870**
880	7.507	7.518	7.529	7.540	7.551	7.562	7.573	7.584	7.595	7.606	7.617	**880**
890	7.617	7.628	7.639	7.649	7.660	7.671	7.682	7.693	7.704	7.715	7.726	**890**
900	7.726	7.737	7.748	7.759	7.770	7.781	7.792	7.803	7.814	7.825	7.836	**900**
910	7.836	7.847	7.858	7.869	7.880	7.891	7.902	7.913	7.924	7.935	7.946	**910**
920	7.946	7.957	7.968	7.979	7.990	8.001	8.012	8.023	8.034	8.045	8.056	**920**
930	8.056	8.067	8.078	8.089	8.100	8.111	8.122	8.133	8.144	8.155	8.167	**930**
940	8.167	8.178	8.189	8.200	8.211	8.222	8.233	8.244	8.255	8.266	8.277	**940**
950	8.277	8.288	8.299	8.310	8.321	8.332	8.343	8.355	8.366	8.377	8.388	**950**
960	8.388	8.399	8.410	8.421	8.432	8.443	8.454	8.465	8.476	8.488	8.499	**960**
970	8.499	8.510	8.521	8.532	8.543	8.554	8.565	8.576	8.588	8.599	8.610	**970**
980	8.610	8.621	8.632	8.643	8.654	8.665	8.676	8.688	8.699	8.710	8.721	**980**
990	8.721	8.732	8.743	8.754	8.765	8.777	8.788	8.799	8.810	8.821	8.832	**990**
1000	8.832	8.843	8.855	8.866	8.877	8.888	8.899	8.910	8.922	8.933	8.944	**1000**

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TABLE 4 *(continued)*

EMF in Millivolts — Reference Junctions at 32°F

DEG F	0	1	2	3	4	5	6	7	8	9	10	DEG F
Thermoelectric Voltage in Millivolts												
1000	8.832	8.843	8.855	8.866	8.877	8.888	8.899	8.910	8.922	8.933	8.944	**1000**
1010	8.944	8.955	8.966	8.977	8.988	9.000	9.011	9.022	9.033	9.044	9.055	**1010**
1020	9.055	9.067	9.078	9.089	9.100	9.111	9.123	9.134	9.145	9.156	9.167	**1020**
1030	9.167	9.178	9.190	9.201	9.212	9.223	9.234	9.246	9.257	9.268	9.279	**1030**
1040	9.279	9.290	9.302	9.313	9.324	9.335	9.346	9.358	9.369	9.380	9.391	**1040**
1050	9.391	9.402	9.414	9.425	9.436	9.447	9.458	9.470	9.481	9.492	9.503	**1050**
1060	9.503	9.515	9.526	9.537	9.548	9.559	9.571	9.582	9.593	9.604	9.616	**1060**
1070	9.616	9.627	9.638	9.649	9.661	9.672	9.683	9.694	9.705	9.717	9.728	**1070**
1080	9.728	9.739	9.750	9.762	9.773	9.784	9.795	9.807	9.818	9.829	9.840	**1080**
1090	9.840	9.852	9.863	9.874	9.885	9.897	9.908	9.919	9.930	9.942	9.953	**1090**
1100	9.953	9.964	9.975	9.987	9.998	10.009	10.021	10.032	10.043	10.054	10.066	**1100**
1110	10.066	10.077	10.088	10.099	10.111	10.122	10.133	10.144	10.156	10.167	10.178	**1110**
1120	10.178	10.190	10.201	10.212	10.223	10.235	10.246	10.257	10.268	10.280	10.291	**1120**
1130	10.291	10.302	10.314	10.325	10.336	10.347	10.359	10.370	10.381	10.393	10.404	**1130**
1140	10.404	10.415	10.426	10.438	10.449	10.460	10.472	10.483	10.494	10.505	10.517	**1140**
1150	10.517	10.528	10.539	10.551	10.562	10.573	10.585	10.596	10.607	10.618	10.630	**1150**
1160	10.630	10.641	10.652	10.664	10.675	10.686	10.698	10.709	10.720	10.731	10.743	**1160**
1170	10.743	10.754	10.765	10.777	10.788	10.799	10.811	10.822	10.833	10.845	10.856	**1170**
1180	10.856	10.867	10.878	10.890	10.901	10.912	10.924	10.935	10.946	10.958	10.969	**1180**
1190	10.969	10.980	10.992	11.003	11.014	11.026	11.037	11.048	11.059	11.071	11.082	**1190**
1200	11.082	11.093	11.105	11.116	11.127	11.139	11.150	11.161	11.173	11.184	11.195	**1200**
1210	11.195	11.207	11.218	11.229	11.241	11.252	11.263	11.275	11.286	11.297	11.309	**1210**
1220	11.309	11.320	11.331	11.343	11.354	11.365	11.377	11.388	11.399	11.410	11.422	**1220**
1230	11.422	11.433	11.444	11.456	11.467	11.478	11.490	11.501	11.512	11.524	11.535	**1230**
1240	11.535	11.546	11.558	11.569	11.580	11.592	11.603	11.614	11.626	11.637	11.648	**1240**
1250	11.648	11.660	11.671	11.682	11.694	11.705	11.716	11.728	11.739	11.750	11.762	**1250**
1260	11.762	11.773	11.784	11.796	11.807	11.818	11.830	11.841	11.852	11.864	11.875	**1260**
1270	11.875	11.886	11.898	11.909	11.921	11.932	11.943	11.955	11.966	11.977	11.989	**1270**
1280	11.989	12.000	12.011	12.023	12.034	12.045	12.057	12.068	12.079	12.091	12.102	**1280**
1290	12.102	12.113	12.125	12.136	12.147	12.159	12.170	12.181	12.193	12.204	12.215	**1290**
1300	12.215	12.227	12.238	12.249	12.261	12.272	12.283	12.295	12.306	12.317	12.329	**1300**
1310	12.329	12.340	12.351	12.363	12.374	12.386	12.397	12.408	12.420	12.431	12.442	**1310**
1320	12.442	12.454	12.465	12.476	12.488	12.499	12.510	12.522	12.533	12.544	12.556	**1320**
1330	12.556	12.567	12.578	12.590	12.601	12.612	12.624	12.635	12.647	12.658	12.669	**1330**
1340	12.669	12.681	12.692	12.703	12.715	12.726	12.737	12.749	12.760	12.771	12.783	**1340**
1350	12.783	12.794	12.805	12.817	12.828	12.840	12.851	12.862	12.874	12.885	12.896	**1350**
1360	12.896	12.908	12.919	12.930	12.942	12.953	12.964	12.976	12.987	12.998	13.010	**1360**
1370	13.010	13.021	13.033	13.044	13.055	13.067	13.078	13.089	13.101	13.112	13.123	**1370**
1380	13.123	13.135	13.146	13.158	13.169	13.180	13.192	13.203	13.214	13.226	13.237	**1380**
1390	13.237	13.248	13.260	13.271	13.282	13.294	13.305	13.317	13.328	13.339	13.351	**1390**
1400	13.351	13.362	13.373	13.385	13.396	13.408	13.419	13.430	13.442	13.453	13.464	**1400**
1410	13.464	13.476	13.487	13.498	13.510	13.521	13.533	13.544	13.555	13.567	13.578	**1410**
1420	13.578	13.589	13.601	13.612	13.624	13.635	13.646	13.658	13.669	13.681	13.692	**1420**
1430	13.692	13.703	13.715	13.726	13.737	13.749	13.760	13.772	13.783	13.794	13.806	**1430**
1440	13.806	13.817	13.829	13.840	13.851	13.863	13.874	13.885	13.897	13.908	13.920	**1440**
1450	13.920	13.931	13.942	13.954	13.965	13.977	13.988	13.999	14.011	14.022	14.033	**1450**
1460	14.033	14.045	14.056	14.068	14.079	14.090	14.102	14.113	14.125	14.136	14.147	**1460**
1470	14.147	14.159	14.170	14.182	14.193	14.204	14.216	14.227	14.238	14.250	14.261	**1470**
1480	14.261	14.273	14.284	14.295	14.307	14.318	14.329	14.341	14.352	14.364	14.375	**1480**
1490	14.375	14.386	14.398	14.409	14.421	14.432	14.443	14.455	14.466	14.477	14.489	**1490**
1500	14.489	14.500	14.512	14.523	14.534	14.546	14.557	14.568	14.580	14.591	14.603	**1500**

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