**Designation: E988 – 96 (Reapproved 2002)**

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

This standard is issued under the fixed designation E988; 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:*[2]

E380 Practice for Use of the International System of Units (SI) (the Modernized Metric System)

## 3. Source of Data

3.1 The data in these tables are based upon the SI volt (see Practice E380) 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 satisfac-

tory 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

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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 | ±4.4°C |
| | 32 to 800°F | ±8°F |
| | 426 to 2315°C | ±1 % of actual |
| | 800 to 4200°F} | 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

Thermoelectric Voltage in Millivolts

| DEG C | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | DEG C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |

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 |

5

## TABLE 3  *(continued)*

EMF in Millivolts
Reference Junctions at 0°C

Thermoelectric Voltage in Millivolts

| DEG C | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | DEG C |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |

**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 |

## 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

Thermoelectric Voltage in Millivolts

| DEG F | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | DEG F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |

## TABLE 4  (continued)

Thermoelectric Voltage in Millivolts

| DEG F | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | DEG F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |

## 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 |

**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 | | | | | | | | | | | |
| 1500 | 14.489 | 14.500 | 14.512 | 14.523 | 14.534 | 14.546 | 14.557 | 14.568 | 14.580 | 14.591 | 14.603 | 1500 |
| 1510 | 14.603 | 14.614 | 14.625 | 14.637 | 14.648 | 14.659 | 14.671 | 14.682 | 14.693 | 14.705 | 14.716 | 1510 |
| 1520 | 14.716 | 14.728 | 14.739 | 14.750 | 14.762 | 14.773 | 14.784 | 14.796 | 14.807 | 14.819 | 14.830 | 1520 |
| 1530 | 14.830 | 14.841 | 14.853 | 14.864 | 14.875 | 14.887 | 14.898 | 14.909 | 14.921 | 14.932 | 14.944 | 1530 |
| 1540 | 14.944 | 14.955 | 14.966 | 14.978 | 14.989 | 15.000 | 15.012 | 15.023 | 15.034 | 15.046 | 15.057 | 1540 |
| 1550 | 15.057 | 15.068 | 15.080 | 15.091 | 15.103 | 15.114 | 15.125 | 15.137 | 15.148 | 15.159 | 15.171 | 1550 |
| 1560 | 15.171 | 15.182 | 15.193 | 15.205 | 15.216 | 15.227 | 15.239 | 15.250 | 15.261 | 15.273 | 15.284 | 1560 |
| 1570 | 15.284 | 15.295 | 15.307 | 15.318 | 15.330 | 15.341 | 15.352 | 15.364 | 15.375 | 15.386 | 15.398 | 1570 |
| 1580 | 15.398 | 15.409 | 15.420 | 15.432 | 15.443 | 15.454 | 15.466 | 15.477 | 15.488 | 15.500 | 15.511 | 1580 |
| 1590 | 15.511 | 15.522 | 15.534 | 15.545 | 15.556 | 15.568 | 15.579 | 15.590 | 15.602 | 15.613 | 15.624 | 1590 |
| 1600 | 15.624 | 15.636 | 15.647 | 15.658 | 15.670 | 15.681 | 15.692 | 15.703 | 15.715 | 15.726 | 15.737 | 1600 |
| 1610 | 15.737 | 15.749 | 15.760 | 15.771 | 15.783 | 15.794 | 15.805 | 15.817 | 15.828 | 15.839 | 15.851 | 1610 |
| 1620 | 15.851 | 15.862 | 15.873 | 15.885 | 15.896 | 15.907 | 15.919 | 15.930 | 15.941 | 15.952 | 15.964 | 1620 |
| 1630 | 15.964 | 15.975 | 15.986 | 15.998 | 16.009 | 16.020 | 16.032 | 16.043 | 16.054 | 16.065 | 16.077 | 1630 |
| 1640 | 16.077 | 16.088 | 16.099 | 16.111 | 16.122 | 16.133 | 16.145 | 16.156 | 16.167 | 16.178 | 16.190 | 1640 |
| 1650 | 16.190 | 16.201 | 16.212 | 16.224 | 16.235 | 16.246 | 16.257 | 16.269 | 16.280 | 16.291 | 16.303 | 1650 |
| 1660 | 16.303 | 16.314 | 16.325 | 16.336 | 16.348 | 16.359 | 16.370 | 16.382 | 16.393 | 16.404 | 16.415 | 1660 |
| 1670 | 16.415 | 16.427 | 16.438 | 16.449 | 16.460 | 16.472 | 16.483 | 16.494 | 16.506 | 16.517 | 16.528 | 1670 |
| 1680 | 16.528 | 16.539 | 16.551 | 16.562 | 16.573 | 16.584 | 16.596 | 16.607 | 16.618 | 16.629 | 16.641 | 1680 |
| 1690 | 16.641 | 16.652 | 16.663 | 16.675 | 16.686 | 16.697 | 16.708 | 16.720 | 16.731 | 16.742 | 16.753 | 1690 |
| 1700 | 16.753 | 16.765 | 16.776 | 16.787 | 16.798 | 16.810 | 16.821 | 16.832 | 16.843 | 16.854 | 16.866 | 1700 |
| 1710 | 16.866 | 16.877 | 16.888 | 16.899 | 16.911 | 16.922 | 16.933 | 16.944 | 16.956 | 16.967 | 16.978 | 1710 |
| 1720 | 16.978 | 16.989 | 17.001 | 17.012 | 17.023 | 17.034 | 17.045 | 17.057 | 17.068 | 17.079 | 17.090 | 1720 |
| 1730 | 17.090 | 17.102 | 17.113 | 17.124 | 17.135 | 17.146 | 17.158 | 17.169 | 17.180 | 17.191 | 17.203 | 1730 |
| 1740 | 17.203 | 17.214 | 17.225 | 17.236 | 17.247 | 17.259 | 17.270 | 17.281 | 17.292 | 17.303 | 17.315 | 1740 |
| 1750 | 17.315 | 17.326 | 17.337 | 17.348 | 17.359 | 17.371 | 17.382 | 17.393 | 17.404 | 17.415 | 17.427 | 1750 |
| 1760 | 17.427 | 17.438 | 17.449 | 17.460 | 17.471 | 17.483 | 17.494 | 17.505 | 17.516 | 17.527 | 17.538 | 1760 |
| 1770 | 17.538 | 17.550 | 17.561 | 17.572 | 17.583 | 17.594 | 17.606 | 17.617 | 17.628 | 17.639 | 17.650 | 1770 |
| 1780 | 17.650 | 17.661 | 17.673 | 17.684 | 17.695 | 17.706 | 17.717 | 17.728 | 17.740 | 17.751 | 17.762 | 1780 |
| 1790 | 17.762 | 17.773 | 17.784 | 17.795 | 17.807 | 17.818 | 17.829 | 17.840 | 17.851 | 17.862 | 17.873 | 1790 |
| 1800 | 17.873 | 17.885 | 17.896 | 17.907 | 17.918 | 17.929 | 17.940 | 17.951 | 17.963 | 17.974 | 17.985 | 1800 |
| 1810 | 17.985 | 17.996 | 18.007 | 18.018 | 18.029 | 18.041 | 18.052 | 18.063 | 18.074 | 18.085 | 18.096 | 1810 |
| 1820 | 18.096 | 18.107 | 18.118 | 18.130 | 18.141 | 18.152 | 18.163 | 18.174 | 18.185 | 18.196 | 18.207 | 1820 |
| 1830 | 18.207 | 18.219 | 18.230 | 18.241 | 18.252 | 18.263 | 18.274 | 18.285 | 18.296 | 18.307 | 18.319 | 1830 |
| 1840 | 18.319 | 18.330 | 18.341 | 18.352 | 18.363 | 18.374 | 18.385 | 18.396 | 18.407 | 18.418 | 18.430 | 1840 |
| 1850 | 18.430 | 18.441 | 18.452 | 18.463 | 18.474 | 18.485 | 18.496 | 18.507 | 18.518 | 18.529 | 18.540 | 1850 |
| 1860 | 18.540 | 18.552 | 18.563 | 18.574 | 18.585 | 18.596 | 18.607 | 18.618 | 18.629 | 18.640 | 18.651 | 1860 |
| 1870 | 18.651 | 18.662 | 18.673 | 18.684 | 18.695 | 18.707 | 18.718 | 18.729 | 18.740 | 18.751 | 18.762 | 1870 |
| 1880 | 18.762 | 18.773 | 18.784 | 18.795 | 18.806 | 18.817 | 18.828 | 18.839 | 18.850 | 18.861 | 18.872 | 1880 |
| 1890 | 18.872 | 18.883 | 18.894 | 18.905 | 18.917 | 18.928 | 18.939 | 18.950 | 18.961 | 18.972 | 18.983 | 1890 |
| 1900 | 18.983 | 18.994 | 19.005 | 19.016 | 19.027 | 19.038 | 19.049 | 19.060 | 19.071 | 19.082 | 19.093 | 1900 |
| 1910 | 19.093 | 19.104 | 19.115 | 19.126 | 19.137 | 19.148 | 19.159 | 19.170 | 19.181 | 19.192 | 19.203 | 1910 |
| 1920 | 19.203 | 19.214 | 19.225 | 19.236 | 19.247 | 19.258 | 19.269 | 19.280 | 19.291 | 19.302 | 19.313 | 1920 |
| 1930 | 19.313 | 19.324 | 19.335 | 19.346 | 19.357 | 19.368 | 19.379 | 19.390 | 19.401 | 19.412 | 19.423 | 1930 |
| 1940 | 19.423 | 19.434 | 19.445 | 19.456 | 19.467 | 19.478 | 19.489 | 19.500 | 19.511 | 19.522 | 19.533 | 1940 |
| 1950 | 19.533 | 19.544 | 19.555 | 19.566 | 19.577 | 19.588 | 19.599 | 19.610 | 19.621 | 19.632 | 19.643 | 1950 |
| 1960 | 19.643 | 19.654 | 19.664 | 19.675 | 19.686 | 19.697 | 19.708 | 19.719 | 19.730 | 19.741 | 19.752 | 1960 |
| 1970 | 19.752 | 19.763 | 19.774 | 19.785 | 19.796 | 19.807 | 19.818 | 19.829 | 19.840 | 19.851 | 19.861 | 1970 |
| 1980 | 19.861 | 19.872 | 19.883 | 19.894 | 19.905 | 19.916 | 19.927 | 19.938 | 19.949 | 19.960 | 19.971 | 1980 |
| 1990 | 19.971 | 19.982 | 19.993 | 20.003 | 20.014 | 20.025 | 20.036 | 20.047 | 20.058 | 20.069 | 20.080 | 1990 |
| 2000 | 20.080 | 20.091 | 20.102 | 20.113 | 20.123 | 20.134 | 20.145 | 20.156 | 20.167 | 20.178 | 20.189 | 2000 |

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