

# ITS-90 Thermocouple Direct & Inverse Polynomials

Direct Polynomials provide the thermoelectric voltage ( $\mu\text{V}$ ) from a known temperature ( $^{\circ}\text{C}$ ); Inverse Polynomials provide the temperature ( $^{\circ}\text{C}$ ) from a known thermoelectric voltage ( $\mu\text{V}$ ).

**Type J Thermocouples** - coefficients,  $c_i$ , of reference equations giving the thermoelectric voltage,  $E$ , as a function of temperature  $t_{90}$ , for the indicated temperature ranges. The equations are of the form:

$$E = \sum_{i=0}^n c_i (t_{90})^i$$

where  $E$  is in microvolts and  $t_{90}$  is in degrees Celsius.

Temperature Range:	-210 to 760°C	760 to 1,200°C
$C_0 =$	0.000 000 000 0 ....	2.964 562 568 1 x 10 <sup>5</sup>
$C_1 =$	5.038 118 781 5 x 10 <sup>1</sup>	-1.497 612 778 6 x 10 <sup>3</sup>
$C_2 =$	3.047 583 693 0 x 10 <sup>-2</sup>	3.178 710 392 4
$C_3 =$	-8.568 106 572 0 x 10 <sup>-5</sup>	-3.184 768 670 1 x 10 <sup>-3</sup>
$C_4 =$	1.322 819 529 5 x 10 <sup>-7</sup>	1.572 081 900 4 x 10 <sup>-6</sup>
$C_5 =$	-1.705 295 833 7 x 10 <sup>-10</sup>	-3.069 136 905 6 x 10 <sup>-10</sup>
$C_6 =$	2.094 809 069 7 x 10 <sup>-13</sup>	
$C_7 =$	-1.253 839 533 6 x 10 <sup>-16</sup>	
$C_8 =$	1.563 172 569 7 x 10 <sup>-20</sup>	

**Type K Thermocouples** - coefficients  $\alpha_0$ ,  $\alpha_1$  and  $\alpha_i$ , of reference equations giving the thermoelectric voltage,  $E$ , as a function of temperature,  $t_{90}$  for the indicated temperature ranges. The equation below 0°C is of the form:

$$E = \sum_{i=0}^n c_i (t_{90})^i$$

the equation above 0°C is of the form:

$$E = \sum_{i=0}^n c_i (t_{90})^i + \alpha_0 e^{\alpha_1 (t_{90} - 126.9686)^2}$$

where  $e$  is the natural logarithm constant,  $E$  is in microvolts and  $t_{90}$  is in degrees Celsius.

Temperature Range:	Coefficients
-270 to 0°C	$C_0 =$ 0.000 000 000 0 ....
	$C_1 =$ 3.945 012 802 5 x 10 <sup>1</sup>
	$C_2 =$ 2.362 237 359 8 x 10 <sup>-2</sup>
	$C_3 =$ -3.285 890 678 4 x 10 <sup>-4</sup>
	$C_4 =$ -4.990 482 877 7 x 10 <sup>-6</sup>
	$C_5 =$ -6.750 905 917 3 x 10 <sup>-8</sup>
	$C_6 =$ -5.741 032 742 8 x 10 <sup>-10</sup>
	$C_7 =$ -3.108 887 289 4 x 10 <sup>-12</sup>
	$C_8 =$ -1.045 160 936 5 x 10 <sup>-14</sup>
	$C_9 =$ -1.988 926 687 8 x 10 <sup>-17</sup>
	$C_{10} =$ -1.632 269 748 6 x 10 <sup>-20</sup>
0 to 1372°C	$C_0 =$ -1.760 041 368 6 x 10 <sup>1</sup>
	$C_1 =$ 3.892 120 497 5 x 10 <sup>1</sup>
	$C_2 =$ 1.855 877 003 2 x 10 <sup>-2</sup>
	$C_3 =$ -9.945 759 287 4 x 10 <sup>-5</sup>
	$C_4 =$ 3.184 094 571 9 x 10 <sup>-7</sup>
	$C_5 =$ -5.607 284 488 9 x 10 <sup>-10</sup>
	$C_6 =$ 5.607 505 905 9 x 10 <sup>-13</sup>
	$C_7 =$ -3.202 072 000 3 x 10 <sup>-16</sup>
	$C_8 =$ 9.715 114 715 2 x 10 <sup>-20</sup>
	$C_9 =$ -1.210 472 127 5 x 10 <sup>-23</sup>
	$\alpha_0 =$ 1.185 976 x 10 <sup>2</sup>
$\alpha_1 =$ -1.183 432 x 10 <sup>-4</sup>	

**Type J Thermocouples** - coefficients of approximate inverse functions giving temperature,  $t_{90}$ , as a function of the thermoelectric voltage,  $E$ , in selected temperature and voltage ranges. The functions are of the form:

$$t_{90} = c_0 + c_1 E + c_2 E^2 + \dots + c_i E^i$$

where  $E$  is in microvolts and  $t_{90}$  is in degrees Celsius.

Temperature Range:	-210 to 0°C	0 to 760°C	760 to 1,200°C
<b>Voltage Range:</b>	-8,095 to 0 $\mu\text{V}$	0 to 42,919 $\mu\text{V}$	42,919 to 69,553 $\mu\text{V}$
$C_0 =$	0.000 000 0 ....	0.000 000 ....	-3.113 581 87 x 10 <sup>3</sup>
$C_1 =$	1.952 826 8 x 10 <sup>-2</sup>	1.978 425 x 10 <sup>-2</sup>	3.005 436 84 x 10 <sup>-1</sup>
$C_2 =$	-1.228 618 5 x 10 <sup>-6</sup>	-2.001 204 x 10 <sup>-7</sup>	-9.947 732 30 x 10 <sup>-6</sup>
$C_3 =$	-1.075 217 8 x 10 <sup>-9</sup>	1.036 969 x 10 <sup>-11</sup>	1.702 766 30 x 10 <sup>-10</sup>
$C_4 =$	-5.908 693 3 x 10 <sup>-13</sup>	-2.549 687 x 10 <sup>-16</sup>	-1.430 334 68 x 10 <sup>-15</sup>
$C_5 =$	-1.725 671 3 x 10 <sup>-16</sup>	3.585 153 x 10 <sup>-21</sup>	4.738 860 84 x 10 <sup>-21</sup>
$C_6 =$	-2.813 151 3 x 10 <sup>-20</sup>	-5.344 285 x 10 <sup>-26</sup>	
$C_7 =$	-2.396 337 0 x 10 <sup>-24</sup>	5.099 890 x 10 <sup>-31</sup>	
$C_8 =$	-8.382 332 1 x 10 <sup>-29</sup>		
<b>Error Range:</b>	0.03 to -0.05°C	0.04 to -0.04°C	0.03 to -0.04°C

**Type K Thermocouples** - coefficients of approximate inverse functions giving temperature,  $t_{90}$ , as a function of the thermoelectric voltage,  $E$ , in selected temperature and voltage ranges. The functions are of the form:

$$t_{90} = c_0 + c_1 E + c_2 E^2 + c_i E^i$$

where  $E$  is in microvolts and  $t_{90}$  is in degrees Celsius.

Temperature Range:	-200 to 0°C	0 to 500°C	500 to 1,372°C
<b>Voltage Range:</b>	-5891 to 0 $\mu\text{V}$	0 to 20,644 $\mu\text{V}$	20,644 to 54,886 $\mu\text{V}$
$C_0 =$	0.000 000 0 ....	0.000 000 ....	-1.318 058 x 10 <sup>2</sup>
$C_1 =$	2.517 346 2 x 10 <sup>-2</sup>	2.508 355 x 10 <sup>-2</sup>	4.830 222 x 10 <sup>-2</sup>
$C_2 =$	-1.166 287 8 x 10 <sup>-6</sup>	7.860 106 x 10 <sup>-8</sup>	-1.646 031 x 10 <sup>-6</sup>
$C_3 =$	-1.083 363 8 x 10 <sup>-9</sup>	-2.503 131 x 10 <sup>-10</sup>	5.464 731 x 10 <sup>-11</sup>
$C_4 =$	-8.977 354 0 x 10 <sup>-13</sup>	8.315 270 x 10 <sup>-14</sup>	-9.650 715 x 10 <sup>-16</sup>
$C_5 =$	-3.734 237 7 x 10 <sup>-16</sup>	-1.228 034 x 10 <sup>-17</sup>	8.802 193 x 10 <sup>-21</sup>
$C_6 =$	-8.663 264 3 x 10 <sup>-20</sup>	9.804 036 x 10 <sup>-22</sup>	-3.110 810 x 10 <sup>-26</sup>
$C_7 =$	-1.045 059 8 x 10 <sup>-23</sup>	-4.413 030 x 10 <sup>-26</sup>	
$C_8 =$	-5.192 057 7 x 10 <sup>-28</sup>	1.057 734 x 10 <sup>-30</sup>	
$C_9 =$		-1.052 755 x 10 <sup>-35</sup>	
<b>Error Range:</b>	0.04°C to -0.02°C	0.04°C to -0.05°C	0.06°C to -0.05°C

# ITS-90 Thermocouple Direct & Inverse Polynomials Cont'd

**Type T Thermocouples** - coefficients,  $c_i$ , of reference equations giving the thermoelectric voltage,  $E$ , as a function of temperature,  $t_{90}$ , for the indicated temperature ranges. The equations are of the form:

$$E = \sum_{i=0}^n c_i (t_{90})^i$$

where  $E$  is in microvolts and  $t_{90}$  is in degrees Celsius.

Temperature Range:	-270 to 0°C	0 to 400°C
$C_0 =$	0.000 000 000 0....	0.000 000 000 0....
$C_1 =$	3.874 810 636 4 x 10 <sup>1</sup>	3.874 810 636 4 x 10 <sup>1</sup>
$C_2 =$	4.419 443 434 7 x 10 <sup>-2</sup>	3.329 222 788 0 x 10 <sup>-2</sup>
$C_3 =$	1.184 432 310 5 x 10 <sup>-4</sup>	2.061 824 340 4 x 10 <sup>-4</sup>
$C_4 =$	2.003 297 355 4 x 10 <sup>-5</sup>	-2.188 225 684 6 x 10 <sup>-6</sup>
$C_5 =$	9.013 801 955 9 x 10 <sup>-7</sup>	1.099 688 092 8 x 10 <sup>-8</sup>
$C_6 =$	2.265 115 659 3 x 10 <sup>-8</sup>	-3.081 575 877 2 x 10 <sup>-11</sup>
$C_7 =$	3.607 115 420 5 x 10 <sup>-10</sup>	4.547 913 529 0 x 10 <sup>-14</sup>
$C_8 =$	3.849 393 988 3 x 10 <sup>-12</sup>	-2.751 290 167 3 x 10 <sup>-17</sup>
$C_9 =$	2.821 352 192 5 x 10 <sup>-14</sup>	
$C_{10} =$	1.425 159 477 9 x 10 <sup>-16</sup>	
$C_{11} =$	4.876 866 228 6 x 10 <sup>-19</sup>	
$C_{12} =$	1.079 553 927 0 x 10 <sup>-21</sup>	
$C_{13} =$	1.394 502 706 2 x 10 <sup>-24</sup>	
$C_{14} =$	7.979 515 392 7 x 10 <sup>-28</sup>	

**Type T Thermocouples** - coefficients of approximate inverse functions giving temperature,  $t_{90}$ , as a function of the thermoelectric voltage,  $E$ , in selected temperature and voltage ranges. The functions are of the form:

$$t_{90} = c_0 + c_1 E + c_2 E^2 + \dots c_i E^i$$

where  $E$  is in microvolts and  $t_{90}$  is in degrees Celsius.

Temperature Range:	-200 to 0°C	0 to 400°C
<b>Voltage Range:</b>	<b>-5,603 to 0 μV</b>	<b>0 to 20,872 μV</b>
$C_0 =$	0.000 000 0....	0.000 000 0....
$C_1 =$	2.594 919 2 x 10 <sup>-2</sup>	2.592 800 x 10 <sup>-2</sup>
$C_2 =$	-2.131 696 7 x 10 <sup>-7</sup>	-7.602 961 x 10 <sup>-7</sup>
$C_3 =$	7.901 869 2 x 10 <sup>-10</sup>	4.637 791 x 10 <sup>-11</sup>
$C_4 =$	4.252 777 7 x 10 <sup>-13</sup>	-2.165 394 x 10 <sup>-15</sup>
$C_5 =$	1.330 447 3 x 10 <sup>-16</sup>	6.048 144 x 10 <sup>-20</sup>
$C_6 =$	2.024 144 6 x 10 <sup>-20</sup>	-7.293 422 x 10 <sup>-25</sup>
$C_7 =$	1.266 817 1 x 10 <sup>-24</sup>	
<b>Error Range:</b>	<b>0.04 to -0.02°C</b>	<b>0.03 to -0.03°C</b>

**Type E Thermocouples** - coefficients,  $c_i$ , of reference equations giving the thermoelectric voltage,  $E$ , as a function of temperature,  $t_{90}$ , for the indicated temperature ranges. The equations are of the form:

$$E = \sum_{i=0}^n c_i (t_{90})^i$$

where  $E$  is in microvolts and  $t_{90}$  is in degrees Celsius.

Temperature Range:	-270 to 0°C	0 to 400°C
$C_0 =$	0.000 000 000 0 ....	0.000 000 000 0 ....
$C_1 =$	5.866 550 870 8 x 10 <sup>1</sup>	5.866 550 871 0 x 10 <sup>1</sup>
$C_2 =$	4.541 097 712 4 x 10 <sup>-2</sup>	4.503 227 558 2 x 10 <sup>-2</sup>
$C_3 =$	-7.799 804 868 6 x 10 <sup>-4</sup>	2.890 840 721 2 x 10 <sup>-5</sup>
$C_4 =$	-2.580 016 084 3 x 10 <sup>-5</sup>	-3.305 689 665 2 x 10 <sup>-7</sup>
$C_5 =$	-5.945 258 305 7 x 10 <sup>-7</sup>	6.502 440 327 0 x 10 <sup>-10</sup>
$C_6 =$	-9.321 405 866 7 x 10 <sup>-9</sup>	-1.919 749 550 4 x 10 <sup>-13</sup>
$C_7 =$	-1.028 760 553 4 x 10 <sup>-10</sup>	-1.253 660 049 7 x 10 <sup>-15</sup>
$C_8 =$	-8.037 012 362 1 x 10 <sup>-13</sup>	2.148 921 756 9 x 10 <sup>-18</sup>
$C_9 =$	-4.397 949 739 1 x 10 <sup>-15</sup>	-1.438 804 178 2 x 10 <sup>-21</sup>
$C_{10} =$	-1.641 477 635 5 x 10 <sup>-17</sup>	3.596 089 948 1 x 10 <sup>-25</sup>
$C_{11} =$	-3.967 361 951 6 x 10 <sup>-20</sup>	
$C_{12} =$	-5.582 732 872 1 x 10 <sup>-23</sup>	
$C_{13} =$	-3.465 784 201 3 x 10 <sup>-26</sup>	

**Type E Thermocouples** - coefficients of approximate inverse functions giving temperature,  $t_{90}$ , as a function of the thermoelectric voltage,  $E$ , in selected temperature and voltage ranges. The functions are of the form:

$$t_{90} = c_0 + c_1 E + c_2 E^2 + \dots c_i E^i$$

where  $E$  is in microvolts and  $t_{90}$  is in degrees Celsius.

Temperature Range:	-200 to 0°C	0 to 1,000°C
<b>Voltage Range:</b>	<b>-8,825 to 0 μV</b>	<b>0 to 76,373 μV</b>
$C_0 =$	0.000 000 0 ....	0.000 000 0 ....
$C_1 =$	1.697 728 8 x 10 <sup>-2</sup>	1.705 703 5 x 10 <sup>-2</sup>
$C_2 =$	-4.351 497 0 x 10 <sup>-7</sup>	-2.330 175 9 x 10 <sup>-7</sup>
$C_3 =$	-1.585 969 7 x 10 <sup>-10</sup>	6.543 558 5 x 10 <sup>-12</sup>
$C_4 =$	-9.250 287 1 x 10 <sup>-14</sup>	-7.356 274 9 x 10 <sup>-17</sup>
$C_5 =$	-2.608 431 4 x 10 <sup>-17</sup>	-1.789 600 1 x 10 <sup>-21</sup>
$C_6 =$	-4.136 019 9 x 10 <sup>-21</sup>	8.403 616 5 x 10 <sup>-26</sup>
$C_7 =$	-3.403 403 0 x 10 <sup>-25</sup>	-1.373 587 9 x 10 <sup>-30</sup>
$C_8 =$	-1.156 489 0 x 10 <sup>-29</sup>	1.062 982 3 x 10 <sup>-35</sup>
$C_9 =$		-3.244 708 7 x 10 <sup>-41</sup>
<b>Error Range:</b>	<b>0.03 to -0.01°C</b>	<b>0.02 to -0.02°C</b>

**Type N Thermocouples** - coefficients,  $c_i$ , of reference equations giving the thermoelectric voltage,  $E$ , as a function of temperature,  $t_{90}$ , for the indicated temperature ranges. The equations are of the form:

$$E = \sum_{i=0}^n c_i (t_{90})^i$$

where  $E$  is in microvolts and  $t_{90}$  is in degrees Celsius.

Temperature Range:	-270 to 0°C	0 to 1,300°C
$C_0 =$	0.000 000 000 0....	0.000 000 000 0....
$C_1 =$	2.615 910 596 2 x 10 <sup>1</sup>	2.592 939 460 1 x 10 <sup>1</sup>
$C_2 =$	1.095 748 422 8 x 10 <sup>-2</sup>	1.571 014 188 0 x 10 <sup>-2</sup>
$C_3 =$	-9.384 111 155 4 x 10 <sup>-5</sup>	4.382 562 723 7 x 10 <sup>-5</sup>
$C_4 =$	-4.641 203 975 9 x 10 <sup>-8</sup>	-2.526 116 979 4 x 10 <sup>-7</sup>
$C_5 =$	-2.630 335 771 6 x 10 <sup>-9</sup>	6.431 181 933 9 x 10 <sup>-10</sup>
$C_6 =$	-2.265 343 800 3 x 10 <sup>-11</sup>	-1.006 347 151 9 x 10 <sup>-12</sup>
$C_7 =$	-7.608 930 079 1 x 10 <sup>-14</sup>	9.974 533 899 2 x 10 <sup>-16</sup>
$C_8 =$	-9.341 966 783 5 x 10 <sup>-17</sup>	-6.086 324 560 7 x 10 <sup>-19</sup>
$C_9 =$		2.084 922 933 9 x 10 <sup>-22</sup>
$C_{10} =$		-3.068 219 615 1 x 10 <sup>-26</sup>

**Type N Thermocouples** - coefficients of approximate inverse functions giving temperature,  $t_{90}$ , as a function of the thermoelectric voltage,  $E$ , in selected temperature and voltage ranges. The functions are of the form:

$$t_{90} = c_0 + c_1 E + c_2 E^2 + \dots + c_i E^i$$

where  $E$  is in microvolts and  $t_{90}$  is in degrees Celsius.

Temperature Range:	-200 to 0°C	0 to 600°C	600 to 1,300°C	0 to 1,300°C
<b>Voltage Range:</b>	-3,990 to 0 μV	0 to 20,613 μV	20,613 to 47,513 μV	0 to 47,513 μV
$C_0 =$	0.000 000 0 ....	0.000 00 ....	1.972 485 x 10 <sup>1</sup>	0.000 000 0 ....
$C_1 =$	3.843 684 7 x 10 <sup>-2</sup>	3.868 96 x 10 <sup>-2</sup>	3.300 943 x 10 <sup>-2</sup>	3.878 327 7 x 10 <sup>-2</sup>
$C_2 =$	1.101 048 5 x 10 <sup>-6</sup>	-1.082 67 x 10 <sup>-6</sup>	-3.915 159 x 10 <sup>-7</sup>	-1.161 234 4 x 10 <sup>-6</sup>
$C_3 =$	5.222 931 2 x 10 <sup>-9</sup>	4.702 05 x 10 <sup>-11</sup>	9.855 391 x 10 <sup>-12</sup>	6.952 565 5 x 10 <sup>-11</sup>
$C_4 =$	7.206 052 5 x 10 <sup>-12</sup>	-2.121 69 x 10 <sup>-18</sup>	-1.274 371 x 10 <sup>-16</sup>	-3.009 007 7 x 10 <sup>-15</sup>
$C_5 =$	5.848 858 6 x 10 <sup>-15</sup>	-1.172 72 x 10 <sup>-19</sup>	7.767 022 x 10 <sup>-22</sup>	8.831 158 4 x 10 <sup>-20</sup>
$C_6 =$	2.775 491 6 x 10 <sup>-18</sup>	5.392 80 x 10 <sup>-24</sup>		-1.621 383 9 x 10 <sup>-24</sup>
$C_7 =$	7.707 516 6 x 10 <sup>-22</sup>	-7.981 56 x 10 <sup>-29</sup>		1.669 336 2 x 10 <sup>-29</sup>
$C_8 =$	1.158 266 5 x 10 <sup>-25</sup>			-7.311 754 0 x 10 <sup>-35</sup>
$C_9 =$	7.313 886 8 x 10 <sup>-30</sup>			
<b>Error Range:</b>	0.03 to -0.02°C	0.03 to -0.02°C	0.02 to -0.04°C	0.06 to -0.06°C

**Type B Thermocouples** - coefficients,  $c_i$ , of reference equations giving the thermoelectric voltage,  $E$ , as a function of temperature,  $t_{90}$ , for the indicated temperature ranges. The equations are of the form:

$$E = \sum_{i=0}^n c_i (t_{90})^i$$

where  $E$  is in microvolts and  $t_{90}$  is in degrees Celsius.

Temperature Range:	0 to 630.615°C	630.615 to 1,820°C
$C_0 =$	0.000 000 000 0 ....	-3.893 816 862 1 x 10 <sup>3</sup>
$C_1 =$	-2.465 081 834 6 x 10 <sup>-1</sup>	2.857 174 747 0 x 10 <sup>1</sup>
$C_2 =$	5.904 042 117 1 x 10 <sup>-3</sup>	-8.488 510 478 5 x 10 <sup>-2</sup>
$C_3 =$	-1.325 793 163 6 x 10 <sup>-6</sup>	1.578 528 016 4 x 10 <sup>-4</sup>
$C_4 =$	1.566 829 190 1 x 10 <sup>-9</sup>	-1.683 534 486 4 x 10 <sup>-7</sup>
$C_5 =$	-1.694 452 924 0 x 10 <sup>-12</sup>	1.110 979 401 3 x 10 <sup>-10</sup>
$C_6 =$	6.229 034 709 4 x 10 <sup>-16</sup>	-4.451 543 103 3 x 10 <sup>-14</sup>
$C_7 =$		9.897 564 082 1 x 10 <sup>-18</sup>
$C_8 =$		-9.379 133 028 9 x 10 <sup>-22</sup>

**Type B Thermocouples** - coefficients of approximate inverse functions giving temperature,  $t_{90}$ , as a function of the thermoelectric voltage,  $E$ , in selected temperature and voltage ranges. The functions are of the form:

$$t_{90} = c_0 + c_1 E + c_2 E^2 + \dots + c_i E^i$$

where  $E$  is in microvolts and  $t_{90}$  is in degrees Celsius.

Temperature Range:	250 to 700°C	700 to 1,820°C
<b>Voltage Range:</b>	291 to 2,431 μV	2,431 to 13,820 μV
$C_0 =$	9.842 332 1 x 10 <sup>1</sup>	2.131 507 1 x 10 <sup>2</sup>
$C_1 =$	6.997 150 0 x 10 <sup>-1</sup>	2.851 050 4 x 10 <sup>-1</sup>
$C_2 =$	-8.476 530 4 x 10 <sup>-4</sup>	-5.274 288 7 x 10 <sup>-5</sup>
$C_3 =$	1.005 264 4 x 10 <sup>-6</sup>	9.916 080 4 x 10 <sup>-9</sup>
$C_4 =$	-8.334 595 2 x 10 <sup>-10</sup>	-1.296 530 3 x 10 <sup>-12</sup>
$C_5 =$	4.550 854 2 x 10 <sup>-13</sup>	1.119 587 0 x 10 <sup>-16</sup>
$C_6 =$	-1.552 303 7 x 10 <sup>-16</sup>	-6.062 519 9 x 10 <sup>-21</sup>
$C_7 =$	2.988 675 0 x 10 <sup>-20</sup>	1.866 169 6 x 10 <sup>-25</sup>
$C_8 =$	-2.474 286 0 x 10 <sup>-24</sup>	-2.487 858 5 x 10 <sup>-30</sup>
<b>Error Range:</b>	0.03 to -0.02°C	0.02 to -0.01°C

# ITS-90 Thermocouple Direct & Inverse Polynomials Cont'd

## Type R Thermocouples -

coefficients,  $c_i$ , of reference equations giving the thermoelectric voltage,  $E$ , as a function of temperature,  $t_{90}$ , for the indicated temperature ranges. The equations are of the for:

$$E = \sum_{i=0}^n c_i (t_{90})^i$$

where  $E$  is in microvolts and  $t_{90}$  is in degrees Celsius.

Temperature Range:	-50 to 1,064.18°C	1,064.18 to 1,664.5°C	1,664.5 to 1,768.1°C
$C_0 =$	0.000 000 000 0 ....	2.951 579 253 16 x 10 <sup>3</sup>	1.522 321 182 09 x 10 <sup>5</sup>
$C_1 =$	5.289 617 297 65 ....	-2.520 612 513 32 ....	-2.688 198 885 45 x 10 <sup>2</sup>
$C_2 =$	1.391 665 897 82 x 10 <sup>-2</sup>	1.595 645 018 65 x 10 <sup>-2</sup>	1.712 802 804 71 x 10 <sup>-1</sup>
$C_3 =$	-2.388 556 930 17 x 10 <sup>-5</sup>	-7.640 859 475 76 x 10 <sup>-6</sup>	-3.458 957 064 53 x 10 <sup>-5</sup>
$C_4 =$	3.569 160 010 63 x 10 <sup>-8</sup>	2.053 052 910 24 x 10 <sup>-9</sup>	-9.346 339 710 46 x 10 <sup>-12</sup>
$C_5 =$	-4.623 476 662 98 x 10 <sup>-11</sup>	-2.933 596 681 73 x 10 <sup>-13</sup>	
$C_6 =$	5.007 774 410 34 x 10 <sup>-14</sup>		
$C_7 =$	-3.731 058 861 91 x 10 <sup>-17</sup>		
$C_8 =$	1.577 164 823 67 x 10 <sup>-20</sup>		
$C_9 =$	-2.810 386 252 51 x 10 <sup>-24</sup>		

## Type R Thermocouples -

coefficients of approximate inverse functions giving temperature,  $t_{90}$ , as a function of the thermoelectric voltage,  $E$ , in selected temperature and voltage ranges. The functions are of the form:

$$t_{90} = c_0 + c_1 E + c_2 E^2 + \dots + c_i E^i$$

where  $E$  is in microvolts and  $t_{90}$  is in degrees Celsius.

Temperature Range:	-50°C to 250°C	250 to 1,200°C	1,064 to 1,664.5°C	1,664.5 to 1,768.1°C
<b>Voltage Range:</b>	-226 to 1,923 μV	1,923 to 13,228 μV	11,361 to 19,739 μV	19,739 to 21,103 μV
$C_0 =$	0.000 000 0 ....	1.334 584 505 x 10 <sup>1</sup>	-8.199 599 416 x 10 <sup>1</sup>	3.406 177 836 x 10 <sup>4</sup>
$C_1 =$	1.889 138 0 x 10 <sup>-1</sup>	1.472 644 573 x 10 <sup>-1</sup>	1.553 962 042 x 10 <sup>-1</sup>	-7.023 729 171 ....
$C_2 =$	-9.383 529 0 x 10 <sup>-5</sup>	-1.844 024 844 x 10 <sup>-5</sup>	-8.342 197 663 x 10 <sup>-6</sup>	5.582 903 813 x 10 <sup>-4</sup>
$C_3 =$	1.306 861 9 x 10 <sup>-7</sup>	4.031 129 x 726 10 <sup>-9</sup>	4.279 433 549 x 10 <sup>-10</sup>	-1.952 394 635 x 10 <sup>-8</sup>
$C_4 =$	-2.270 358 0 x 10 <sup>-10</sup>	-6.249 428 360 x 10 <sup>-13</sup>	-1.191 577 910 x 10 <sup>-14</sup>	2.560 740 231 x 10 <sup>-13</sup>
$C_5 =$	3.514 565 9 x 10 <sup>-13</sup>	6.468 412 046 x 10 <sup>-17</sup>	1.492 290 091 x 10 <sup>-19</sup>	
$C_6 =$	-3.895 390 0 x 10 <sup>-16</sup>	-4.458 750 426 x 10 <sup>-21</sup>		
$C_7 =$	2.823.947 1 x 10 <sup>-19</sup>	1.994 710 146 x 10 <sup>-25</sup>		
$C_8 =$	-1.260 728 1 x 10 <sup>-22</sup>	-5.313 401 790 x 10 <sup>-30</sup>		
$C_9 =$	3.135 361 1 x 10 <sup>-26</sup>	6.481 976 217 x 10 <sup>-35</sup>		
$C_{10} =$	-3.318 776 9 x 10 <sup>-30</sup>			
<b>Error Range:</b>	0.02 to -0.02°C	0.005 to -0.005°C	0.001 to -0.0005°C	0.002 to -0.001°C

## Type S Thermocouples -

coefficients,  $c_i$ , of reference equations giving the thermoelectric voltage,  $E$ , as a function of temperature,  $t_{90}$ , for the indicated temperature ranges. The equations are of the for:

$$E = \sum_{i=0}^n c_i (t_{90})^i$$

where  $E$  is in microvolts and  $t_{90}$  is in degrees Celsius.

Temperature Range:	-50 to 1,064.18°C	1,064.18 to 1,664.5°C	1,664.5 to 1,768.1°C
$C_0 =$	0.000 000 000 0 ....	1.329 004 450 85 x 10 <sup>3</sup>	1.466 282 326 36 x 10 <sup>5</sup>
$C_1 =$	5.403 133 086 31....	3.345 093 113 44 ....	-2.584 305 167 52 x 10 <sup>2</sup>
$C_2 =$	1.259 342 897 40 x 10 <sup>-2</sup>	6.548 051 928 18 x 10 <sup>-3</sup>	1.636 935 746 41 x 10 <sup>-1</sup>
$C_3 =$	-2.324 779 686 89 x 10 <sup>-5</sup>	-1.648 562 592 09 x 10 <sup>-6</sup>	-3.304 390 469 87 x 10 <sup>-5</sup>
$C_4 =$	3.220 288 230 36 x 10 <sup>-8</sup>	1.299 896 051 74 x 10 <sup>-11</sup>	-9.432 236 906 12 x 10 <sup>-12</sup>
$C_5 =$	-3.314 651 963 89 x 10 <sup>-11</sup>		
$C_6 =$	2.557 442 517 86 x 10 <sup>-14</sup>		
$C_7 =$	-1.250 688 713 93 x 10 <sup>-17</sup>		
$C_8 =$	2.714 431 761 45 x 10 <sup>-21</sup>		

## Type S Thermocouples -

coefficients of approximate inverse functions giving temperature,  $t_{90}$ , as a function of the thermoelectric voltage,  $E$ , in selected temperature and voltage ranges. The functions are of the form:

$$t_{90} = c_0 + c_1 E + c_2 E^2 + \dots + c_i E^i$$

where  $E$  is in microvolts and  $t_{90}$  is in degrees Celsius.

Temperature Range:	-50 to 250°C	250 to 1,200°C	1,064 to 1,664.5°C	1,664.5 to 1,768.1°C
<b>Voltage Range:</b>	-235 to 1,874 μV	1,874 to 11,950 μV	10,332 to 17,536 μV	17,536 to 18,693 μV
$C_0 =$	0.000 000 0 ....	1.291 507 177 x 10 <sup>1</sup>	-8.087 801 117 x 10 <sup>1</sup>	5.333 875 126 x 10 <sup>4</sup>
$C_1 =$	1.849 494 60 x 10 <sup>-1</sup>	1.466 298 863 x 10 <sup>-1</sup>	1.621 573 104 x 10 <sup>-1</sup>	-1.235 892 298 x 10 <sup>1</sup>
$C_2 =$	-8.005 040 62 x 10 <sup>-5</sup>	-1.534 713 402 x 10 <sup>-5</sup>	-8.536 869 453 x 10 <sup>-6</sup>	1.092 657 613 x 10 <sup>-3</sup>
$C_3 =$	1.022 374 30 x 10 <sup>-7</sup>	3.145 945 973 x 10 <sup>-9</sup>	4.719 686 976 x 10 <sup>-10</sup>	-4.265 693 686 x 10 <sup>-8</sup>
$C_4 =$	-1.522 485 92 x 10 <sup>-10</sup>	-4.163 257 839 x 10 <sup>-13</sup>	-1.441 693 666 x 10 <sup>-14</sup>	6.247 205 420 x 10 <sup>-13</sup>
$C_5 =$	1.888 213 43 x 10 <sup>-13</sup>	3.187 963 771 x 10 <sup>-17</sup>	2.081 618 890 x 10 <sup>-19</sup>	
$C_6 =$	-1.590 859 41 x 10 <sup>-16</sup>	-1.291 637 500 x 10 <sup>-21</sup>		
$C_7 =$	8.230 278 80 x 10 <sup>-20</sup>	2.183 475 087 x 10 <sup>-26</sup>		
$C_8 =$	-2.341 819 44 x 10 <sup>-23</sup>	-1.447 379 511 x 10 <sup>-31</sup>		
$C_9 =$	2.797 862 60 x 10 <sup>-27</sup>	8.211 272 125 x 10 <sup>-36</sup>		
<b>Error Range:</b>	0.02 to -0.02°C	0.01 to -0.01°C	0.0002 to -0.0002°C	0.002 to -0.002°C