STANDARD ITS-90 THERMOCOUPLE TABLES

The Instrument Society of America (ISA) has assigned standard letter designations to a number of thermocouple types having specified emf-temperature relations. These designations and the approximate metal compositions which meet the required relations, as well as the useful temperature ranges, are given below:

Type B	(Pt + 30% Rh) vs. (Pt + 6% Rh)	0 to 1820°C
Type E	(Ni + 10% Cr) vs. (Cu + 43% Ni)	-270 to 1000°C
Type J	Fe vs. (Cu + 43% Ni)	-210 to 1200°C
Type K	(Ni + 10% Cr) vs. (Ni + 2% Al + 2% Mn + 1% Si)	-270 to 1372°C
Type N	(Ni + 14% Cr + 1.5% Si) vs. (Ni + 4.5% Si + 0. 1% Mg)	-270 to 1300°C
Type R	(Pt + 13% Rh) vs. Pt	-50 to 1768°C
Type S	(Pt + 10% Rh) vs. Pt	-50 to 1768°C
Type T	Cu vs. (Cu + 43% Ni)	-270 to 400°C

The compositions are given in weight percent, and the positive leg is listed first. It should be emphasized that the standard letter designations do not imply a precise composition but rather that the specified emf-temperature relation is satisfied.

The first set of tables below lists, for each thermocouple type, the emf as a function of temperature on the International Temperature Scale of 1990 (ITS-90). The coefficients in the equation used to generate the table are also given. The second set of tables gives the inverse relationships, i.e., the coefficients in the polynomial equation which expresses the temperature as a function of thermocouple emf. The accuracy of these equations is also stated.

Further details and tables at closer intervals may be found in Reference 1.

REFERENCES

1. Burns, G. W., Seroger, M. G., Strouse, G. F., Croarkin, M. C., and Guthrie, W.F., *Temperature-Electromotive Force Reference Functions and Tables for the Letter-Designated Thermocouple Types Based on the ITS-90*, Nat. Inst. Stand. Tech. (U.S.) Monogr. 175, 1993.
2. Schooley, J. F., *Thermometry*, CRC Press, Boca Raton, FL, 1986.

Type B thermocouples: emf-temperature (°C) reference table and equations

Thermocouple emf in Millivolts as a Function of Temperature in Degrees Celsius (ITS-90)

Reference Junctions at 0°C

t/°C	0	10	20	30	40	50	60	70	80	90	100
0	0.000	-0.002	-0.003	-0.002	-0.000	0.002	0.006	0.011	0.017	0.025	0.033
100	0.033	0.043	0.053	0.065	0.078	0.092	0.107	0.123	0.141	0.159	0.178
200	0.178	0.199	0.220	0.243	0.267	0.291	0.317	0.344	0.372	0.401	0.431
300	0.431	0.462	0.494	0.527	0.561	0.596	0.632	0.669	0.707	0.746	0.787
400	0.787	0.828	0.870	0.913	0.957	1.002	1.048	1.095	1.143	1.192	1.242
500	1.242	1.293	1.344	1.397	1.451	1.505	1.561	1.617	1.675	1.733	1.792
600	1.792	1.852	1.913	1.975	2.037	2.101	2.165	2.230	2.296	2.363	2.431
700	2.431	2.499	2.569	2.639	2.710	2.782	2.854	2.928	3.002	3.078	3.154
800	3.154	3.230	3.308	3.386	3.466	3.546	3.626	3.708	3.790	3.873	3.957
900	3.957	4.041	4.127	4.213	4.299	4.387	4.475	4.564	4.653	4.743	4.834
1000	4.834	4.926	5.018	5.111	5.205	5.299	5.394	5.489	5.585	5.682	5.780
1100	5.780	5.878	5.976	6.075	6.175	6.276	6.377	6.478	6.580	6.683	6.786
1200	6.786	6.890	6.995	7.100	7.205	7.311	7.417	7.524	7.632	7.740	7.848
1300	7.848	7.957	8.066	8.176	8.286	8.397	8.508	8.620	8.731	8.844	8.956
1400	8.956	9.069	9.182	9.296	9.410	9.524	9.639	9.753	9.868	9.984	10.099
1500	10.099	10.215	10.331	10.447	10.563	10.679	10.796	10.913	11.029	11.146	11.263
1600	11.263	11.380	11.497	11.614	11.731	11.848	11.965	12.082	12.199	12.316	12.433
1700	12.433	12.549	12.666	12.782	12.898	13.014	13.130	13.246	13.361	13.476	13.591
1800	13.591	13.706	13.820								

Temperature Ranges and Coefficients of Equations Used to Compute the Above Table

The equations are of the form: $E = c_0 + c_1 t + c_2 t^2 + c_3 t^3 + \ldots c_n t^n$, where E is the emf in millivolts, t is the temperature in degrees Celsius (ITS-90), and c_0, c_1, c_2, c_3, etc. are the coefficients. These coefficients are extracted from NIST Monograph 175.

		0°C to 630.615°C	630.615°C to 1820°C
c_0	=	0.000 000 000 0	-3.893 816 862 1
c_1	=	$-2.465\,081\,834\,6 \times 10^{-4}$	$2.857\,174\,747\,0 \times 10^{-2}$
c_2	=	$5.904\,042\,117\,1 \times 10^{-6}$	$-8.488\,510\,478\,5 \times 10^{-5}$
c_3	=	$-1.325\,793\,163\,6 \times 10^{-9}$	$1.578\,528\,016\,4 \times 10^{-7}$
c_4	=	$1.566\,829\,190\,1 \times 10^{-12}$	$-1.683\,534\,486\,4 \times 10^{-10}$
c_5	=	$-1.694\,452\,924\,0 \times 10^{-15}$	$1.110\,979\,401\,3 \times 10^{-13}$
c_6	=	$6.299\,034\,709\,4 \times 10^{-19}$	$-4.451\,543\,103\,3 \times 10^{-17}$
c_7	=	. . . . .	$9.897\,564\,082\,1 \times 10^{-21}$
c_8	=	. . . . .	$-9.379\,133\,028\,9 \times 10^{-25}$

Type E thermocouples: emf-temperature (°C) reference table and equations

Thermocouple emf in Millivolts as a Function of Temperature in Degrees Celsius (ITS-90)

Reference Junctions at 0°C

t/°C	0	-10	-20	-30	-40	-50	-60	-70	-80	-90	-100
-200	-8.825	-9.063	-9.274	-9.455	-9.604	-9.718	-9.797	-9.835			
-100	-5.237	-5.681	-6.107	-6.516	-6.907	-7.279	-7.632	-7.963	-8.273	-8.561	-8.825
0	0.000	-0.582	-1.152	-1.709	-2.255	-2.787	-3.306	-3.811	-4.302	-4.777	-5.237

t/°C	0	10	20	30	40	50	60	70	80	90	100
0	0.000	0.591	1.192	1.801	2.420	3.048	3.685	4.330	4.985	5.648	6.319
100	6.319	6.998	7.685	8.379	9.081	9.789	10.503	11.224	11.951	12.684	13.421
200	13.421	14.164	14.912	15.664	16.420	17.181	17.945	18.713	19.484	20.259	21.036
300	21.036	21.817	22.600	23.386	24.174	24.964	25.757	26.552	27.348	28.146	28.946
400	28.946	29.747	30.550	31.354	32.159	32.965	33.772	34.579	35.387	36.196	37.005
500	37.005	37.815	38.624	39.434	40.243	41.053	41.862	42.671	43.479	44.286	45.093
600	45.093	45.900	46.705	47.509	48.313	49.116	49.917	50.718	51.517	52.315	53.112
700	53.112	53.908	54.703	55.497	56.289	57.080	57.870	58.659	59.446	60.232	61.017
800	61.017	61.801	62.583	63.364	64.144	64.922	65.698	66.473	67.246	68.017	68.787
900	68.787	69.554	70.319	71.082	71.844	72.603	73.360	74.115	74.869	75.621	76.373
1000	76.373										

Temperature Ranges and Coefficients of Equations Used to Compute the Above Table

The equations are of the form: $E = c_0 + c_1 t + c_2 t^2 + c_3 t^3 + \ldots c_n t^n$, where E is the emf in millivolts, t is the temperature in degrees Celsius (ITS-90), and c_0, c_1, c_2, c_3, etc. are the coefficients. These coefficients are extracted from NIST Monograph 175.

	-270°C to 0°C	0°C to 1000°C
c_0 =	0.000 000 000 0	0.000 000 000 0
c_1 =	$5.866\,550\,870\,8 \times 10^{-2}$	$5.866\,550\,871\,0 \times 10^{-2}$
c_2 =	$4.541\,097\,712\,4 \times 10^{-5}$	$4.503\,227\,558\,2 \times 10^{-5}$
c_3 =	$-7.799\,804\,868\,6 \times 10^{-7}$	$2.890\,840\,721\,2 \times 10^{-8}$
c_4 =	$-2.580\,016\,084\,3 \times 10^{-8}$	$-3.305\,689\,665\,2 \times 10^{-10}$
c_5 =	$-5.945\,258\,305\,7 \times 10^{-10}$	$6.502\,440\,327\,0 \times 10^{-13}$
c_6 =	$-9.321\,405\,866\,7 \times 10^{-12}$	$-1.919\,749\,550\,4 \times 10^{-16}$
c_7 =	$-1.028\,760\,553\,4 \times 10^{-13}$	$-1.253\,660\,049\,7 \times 10^{-18}$
c_8 =	$-8.037\,012\,362\,1 \times 10^{-16}$	$2.148\,921\,756\,9 \times 10^{-21}$
c_9 =	$-4.397\,949\,739\,1 \times 10^{-18}$	$-1.438\,804\,178\,2 \times 10^{-24}$
c_{10} =	$-1.641\,477\,635\,5 \times 10^{-20}$	$3.596\,089\,948\,1 \times 10^{-28}$
c_{11} =	$-3.967\,361\,951\,6 \times 10^{-23}$	. . . . .
c_{12} =	$-5.582\,732\,872\,1 \times 10^{-26}$	. . . . .
c_{13} =	$-3.465\,784\,201\,3 \times 10^{-29}$	. . . . .

Type J thermocouples: emf-temperature (°C) reference table and equations

Thermocouple emf in Millivolts as a Function of Temperature in Degrees Celsius (ITS-90)

Reference Junctions at 0°C

t/°C	0	-10	-20	-30	-40	-50	-60	-70	-80	-90	-100
-200	-7.890	-8.095									
-100	-4.633	-5.037	-5.426	-5.801	-6.159	-6.500	-6.821	-7.123	-7.403	-7.659	-7.890
0	0.000	-0.501	-0.995	-1.482	-1.961	-2.431	-2.893	-3.344	-3.786	-4.215	-4.633

t/°C	0	10	20	30	40	50	60	70	80	90	100
0	0.000	0.507	1.019	1.537	2.059	2.585	3.116	3.650	4.187	4.726	5.269
100	5.269	5.814	6.360	6.909	7.459	8.010	8.562	9.115	9.669	10.224	10.779
200	10.779	11.334	11.889	12.445	13.000	13.555	14.110	14.665	15.219	15.773	16.327
300	16.327	16.881	17.434	17.986	18.538	19.090	19.642	20.194	20.745	21.297	21.848
400	21.848	22.400	22.952	23.504	24.057	24.610	25.164	25.720	26.276	26.834	27.393
500	27.393	27.953	28.516	29.080	29.647	30.216	30.788	31.362	31.939	32.519	33.102
600	33.102	33.689	34.279	34.873	35.470	36.071	36.675	37.284	37.896	38.512	39.132
700	39.132	39.755	40.382	41.012	41.645	42.281	42.919	43.559	44.203	44.848	45.494
800	45.494	46.141	46.786	47.431	48.074	48.715	49.353	49.989	50.622	51.251	51.877
900	51.877	52.500	53.119	53.735	54.347	54.956	55.561	56.164	56.763	57.360	57.953
1000	57.953	58.545	59.134	59.721	60.307	60.890	61.473	62.054	62.634	63.214	63.792
1100	63.792	64.370	64.948	65.525	66.102	66.679	67.255	67.831	68.406	68.980	69.553
1200	69.553										

Temperature Ranges and Coefficients of Equations Used to Compute the Above Table

The equations are of the form: $E = c_0 + c_1 t + c_2 t^2 + c_3 t^3 + \ldots c_n t^n$, where E is the emf in millivolts, t is the temperature in degrees Celsius (ITS-90), and c_0, c_1, c_2, c_3, etc. are the coefficients. These coefficients are extracted from NIST Monograph 175.

		-210°C to 760°C	760°C to 1200°C
c_0	=	0.000 000 000 0	$2.964\,562\,568\,1 \times 10^{2}$
c_1	=	$5.038\,118\,781\,5 \times 10^{-2}$	-1.497 612 778 6
c_2	=	$3.047\,583\,693\,0 \times 10^{-5}$	$3.178\,710\,392\,4 \times 10^{-3}$
c_3	=	$-8.568\,106\,572\,0 \times 10^{-8}$	$-3.184\,768\,670\,1 \times 10^{-6}$
c_4	=	$1.322\,819\,529\,5 \times 10^{-10}$	$1.572\,081\,900\,4 \times 10^{-9}$
c_5	=	$-1.705\,295\,833\,7 \times 10^{-13}$	$-3.069\,136\,905\,6 \times 10^{-13}$
c_6	=	$2.094\,809\,069\,7 \times 10^{-16}$	. . . . .
c_7	=	$-1.253\,839\,533\,6 \times 10^{-19}$	. . . . .
c_8	=	$1.563\,172\,569\,7 \times 10^{-23}$	. . . . .

Type K thermocouples: emf-temperature (°C) reference table and equations

Thermocouple emf in Millivolts as a Function of Temperature in Degrees Celsius (ITS-90)

Reference Junctions at 0°C

t/°C	0	-10	-20	-30	-40	-50	-60	-70	-80	-90	-100
-200	-5.891	-6.035	-6.158	-6.262	-6.344	-6.404	-6.441	-6.458			
-100	-3.554	-3.852	-4.138	-4.411	-4.669	-4.913	-5.141	-5.354	-5.550	-5.730	-5.891
0	0.000	-0.392	-0.778	-1.156	-1.527	-1.889	-2.243	-2.587	-2.920	-3.243	-3.554

t/°C	0	10	20	30	40	50	60	70	80	90	100
0	0.000	0.397	0.798	1.203	1.612	2.023	2.436	2.851	3.267	3.682	4.096
100	4.096	4.509	4.920	5.328	5.735	6.138	6.540	6.941	7.340	7.739	8.138
200	8.138	8.539	8.940	9.343	9.747	10.153	10.561	10.971	11.382	11.795	12.209
300	12.209	12.624	13.040	13.457	13.874	14.293	14.713	15.133	15.554	15.975	16.397
400	16.397	16.820	17.243	17.667	18.091	18.516	18.941	19.366	19.792	20.218	20.644
500	20.644	21.071	21.497	21.924	22.350	22.776	23.203	23.629	24.055	24.480	24.905
600	24.905	25.330	25.755	26.179	26.602	27.025	27.447	27.869	28.289	28.710	29.129
700	29.129	29.548	29.965	30.382	30.798	31.213	31.628	32.041	32.453	32.865	33.275
800	33.275	33.685	34.093	34.501	34.908	35.313	35.718	36.121	36.524	36.925	37.326
900	37.326	37.725	38.124	38.522	38.918	39.314	39.708	40.101	40.494	40.885	41.276
1000	41.276	41.665	42.053	42.440	42.826	43.211	43.595	43.978	44.359	44.740	45.119
1100	45.119	45.497	45.873	46.249	46.623	46.995	47.367	47.737	48.105	48.473	48.838
1200	48.838	49.202	49.565	49.926	50.286	50.644	51.000	51.355	51.708	52.060	52.410
1300	52.410	52.759	53.106	53.451	53.795	54.138	54.479	54.819			

Temperature Ranges and Coefficients of Equations Used to Compute the Above Table

The equations are of the form: $E = c_0 + c_1 t + c_2 t^2 + c_3 t^3 + \ldots c_n t^n$, where E is the emf in millivolts, t is the temperature in degrees Celsius (ITS-90), and c_0, c_1, c_2, c_3, etc. are the coefficients. In the 0°C to 1372°C range there is also an exponential term that must be evaluated and added to the equation. The exponential term is of the form: $c_0 \exp[c_1(t\text{-}126.9686)^2]$, where t is the temperature in °C and c_0 and c_1 are the coefficients. These coefficients are extracted from NIST Monograph 175.

		-270°C to 0°C	0°C to 1372°C	0°C to 1372°C (exponential term)
c_0	=	0.000 000 000 0	$-1.760\,041\,368\,6 \times 10^{-2}$	$1.185\,976 \times 10^{-1}$
c_1	=	$3.945\,012\,802\,5 \times 10^{-2}$	$3.892\,120\,497\,5 \times 10^{-2}$	$-1.183\,432 \times 10^{-4}$
c_2	=	$2.362\,237\,359\,8 \times 10^{-5}$	$1.855\,877\,003\,2 \times 10^{-5}$	. . . . .
c_3	=	$-3.285\,890\,678\,4 \times 10^{-7}$	$-9.945\,759\,287\,4 \times 10^{-8}$	. . . . .
c_4	=	$-4.990\,482\,877\,7 \times 10^{-9}$	$3.184\,094\,571\,9 \times 10^{-10}$	. . . . .
c_5	=	$-6.750\,905\,917\,3 \times 10^{-11}$	$-5.607\,284\,488\,9 \times 10^{-13}$	. . . . .
c_6	=	$-5.741\,032\,742\,8 \times 10^{-13}$	$5.607\,505\,905\,9 \times 10^{-16}$	. . . . .
c_7	=	$-3.108\,887\,289\,4 \times 10^{-15}$	$-3.202\,072\,000\,3 \times 10^{-19}$	. . . . .
c_8	=	$-1.045\,160\,936\,5 \times 10^{-17}$	$9.715\,114\,715\,2 \times 10^{-23}$	. . . . .
c_9	=	$-1.988\,926\,687\,8 \times 10^{-20}$	$-1.210\,472\,127\,5 \times 10^{-26}$	. . . . .
c_{10}	=	$-1.632\,269\,748\,6 \times 10^{-23}$	. . . . .	. . . . .

Type N thermocouples: emf-temperature (°C) reference table and equations

Thermocouple emf in Millivolts as a Function of Temperature in Degrees Celsius (ITS-90)

Reference Junctions at 0°C

t/°C	0	-10	-20	-30	-40	-50	-60	-70	-80	-90	-100
-200	-3.990	-4.083	-4.162	-4.226	-4.277	-4.313	-4.336	-4.345			
-100	-2.407	-2.612	-2.808	-2.994	-3.171	-3.336	-3.491	-3.634	-3.766	-3.884	-3.990
0	0.000	-0.260	-0.518	-0.772	-1.023	-1.269	-1.509	-1.744	-1.972	-2.193	-2.407

t/°C	0	10	20	30	40	50	60	70	80	90	100
0	0.000	0.261	0.525	0.793	1.065	1.340	1.619	1.902	2.189	2.480	2.774
100	2.774	3.072	3.374	3.680	3.989	4.302	4.618	4.937	5.259	5.585	5.913
200	5.913	6.245	6.579	6.916	7.255	7.597	7.941	8.288	8.637	8.988	9.341
300	9.341	9.696	10.054	10.413	10.774	11.136	11.501	11.867	12.234	12.603	12.974
400	12.974	13.346	13.719	14.094	14.469	14.846	15.225	15.604	15.984	16.366	16.748
500	16.748	17.131	17.515	17.900	18.286	18.672	19.059	19.447	19.835	20.224	20.613
600	20.613	21.003	21.393	21.784	22.175	22.566	22.958	23.350	23.742	24.134	24.527
700	24.527	24.919	25.312	25.705	26.098	26.491	26.883	27.276	27.669	28.062	28.455
800	28.455	28.847	29.239	29.632	30.024	30.416	30.807	31.199	31.590	31.981	32.371
900	32.371	32.761	33.151	33.541	33.930	34.319	34.707	35.095	35.482	35.869	36.256
1000	36.256	36.641	37.027	37.411	37.795	38.179	38.562	38.944	39.326	39.706	40.087
1100	40.087	40.466	40.845	41.223	41.600	41.976	42.352	42.727	43.101	43.474	43.846
1200	43.846	44.218	44.588	44.958	45.326	45.694	46.060	46.425	46.789	47.152	47.513
1300	47.513										

Temperature Ranges and Coefficients of Equations Used to Compute the Above Table

The equations are of the form: $E = c_0 + c_1 t + c_2 t^2 + c_3 t^3 + \ldots c_n t^n$, where E is the emf in millivolts, t is the temperature in degrees Celsius (ITS-90), and c_0, c_1, c_2, c_3, etc. are the coefficients. These coefficients are extracted from NIST Monograph 175.

		-270°C to 0°C	0°C to 1300°C
c_0	=	0.000 000 000 0	0.000 000 000 0
c_1	=	$2.615\,910\,596\,2 \times 10^{-2}$	$2.592\,939\,460\,1 \times 10^{-2}$
c_2	=	$1.095\,748\,422\,8 \times 10^{-5}$	$1.571\,014\,188\,0 \times 10^{-5}$
c_3	=	$-9.384\,111\,155\,4 \times 10^{-8}$	$4.382\,562\,723\,7 \times 10^{-8}$
c_4	=	$-4.641\,203\,975\,9 \times 10^{-11}$	$-2.526\,116\,979\,4 \times 10^{-10}$
c_5	=	$-2.630\,335\,771\,6 \times 10^{-12}$	$6.431\,181\,933\,9 \times 10^{-13}$
c_6	=	$-2.265\,343\,800\,3 \times 10^{-14}$	$-1.006\,347\,151\,9 \times 10^{-15}$
c_7	=	$-7.608\,930\,079\,1 \times 10^{-17}$	$9.974\,533\,899\,2 \times 10^{-19}$
c_8	=	$-9.341\,966\,783\,5 \times 10^{-20}$	$-6.086\,324\,560\,7 \times 10^{-22}$
c_9	=	. . . . .	$2.084\,922\,933\,9 \times 10^{-25}$
c_{10}	=	. . . . .	$-3.068\,219\,615\,1 \times 10^{-29}$

Type R thermocouples: emf-temperature (°C) reference table and equations

Thermocouple emf in Millivolts as a Function of Temperature in Degrees Celsius (ITS-90)

Reference Junctions at 0°C

t/°C	0	-10	-20	-30	-40	-50	-60	-70	-80	-90	-100
0	0.000	-0.051	-0.100	-0.145	-0.188	-0.226					

t/°C	0	10	20	30	40	50	60	70	80	90	100
0	0.000	0.054	0.111	0.171	0.232	0.296	0.363	0.431	0.501	0.573	0.647
100	0.647	0.723	0.800	0.879	0.959	1.041	1.124	1.208	1.294	1.381	1.469
200	1.469	1.558	1.648	1.739	1.831	1.923	2.017	2.112	2.207	2.304	2.401
300	2.401	2.498	2.597	2.696	2.796	2.896	2.997	3.099	3.201	3.304	3.408
400	3.408	3.512	3.616	3.721	3.827	3.933	4.040	4.147	4.255	4.363	4.471
500	4.471	4.580	4.690	4.800	4.910	5.021	5.133	5.245	5.357	5.470	5.583
600	5.583	5.697	5.812	5.926	6.041	6.157	6.273	6.390	6.507	6.625	6.743
700	6.743	6.861	6.980	7.100	7.220	7.340	7.461	7.583	7.705	7.827	7.950
800	7.950	8.073	8.197	8.321	8.446	8.571	8.697	8.823	8.950	9.077	9.205
900	9.205	9.333	9.461	9.590	9.720	9.850	9.980	10.111	10.242	10.374	10.506
1000	10.506	10.638	10.771	10.905	11.039	11.173	11.307	11.442	11.578	11.714	11.850
1100	11.850	11.986	12.123	12.260	12.397	12.535	12.673	12.812	12.950	13.089	13.228
1200	13.228	13.367	13.507	13.646	13.786	13.926	14.066	14.207	14.347	14.488	14.629
1300	14.629	14.770	14.911	15.052	15.193	15.334	15.475	15.616	15.758	15.899	16.040
1400	16.040	16.181	16.323	16.464	16.605	16.746	16.887	17.028	17.169	17.310	17.451
1500	17.451	17.591	17.732	17.872	18.012	18.152	18.292	18.431	18.571	18.710	18.849
1600	18.849	18.988	19.126	19.264	19.402	19.540	19.677	19.814	19.951	20.087	20.222
1700	20.222	20.356	20.488	20.620	20.749	20.877	21.003				

Temperature Ranges and Coefficients of Equations Used to Compute the Above Table

The equations are of the form: $E = c_0 + c_1 t + c_2 t^2 + c_3 t^3 + \ldots c_n t^n$, where E is the emf in millivolts, t is the temperature in degrees Celsius (ITS-90), and c_0, c_1, c_2, c_3, etc. are the coefficients. These coefficients are extracted from NIST Monograph 175.

		-50°C to 1064.18°C	1064.18°C to 1664.5°C	1664.5°C to 1768.1°C
c_0	=	0.000 000 000 00.	2.951 579 253 16	$1.522\,321\,182\,09 \times 10^{2}$
c_1	=	$5.289\,617\,297\,65 \times 10^{-3}$	$-2.520\,612\,513\,32 \times 10^{-3}$	$-2.688\,198\,885\,45 \times 10^{-1}$
c_2	=	$1.391\,665\,897\,82 \times 10^{-5}$	$1.595\,645\,018\,65 \times 10^{-5}$	$1.712\,802\,804\,71 \times 10^{-4}$
c_3	=	$-2.388\,556\,930\,17 \times 10^{-8}$	$-7.640\,859\,475\,76 \times 10^{-9}$	$-3.458\,957\,064\,53 \times 10^{-8}$
c_4	=	$3.569\,160\,010\,63 \times 10^{-11}$	$2.053\,052\,910\,24 \times 10^{-12}$	$-9.346\,339\,710\,46 \times 10^{-15}$
c_5	=	$-4.623\,476\,662\,98 \times 10^{-14}$	$-2.933\,596\,681\,73 \times 10^{-16}$	. . . . .
c_6	=	$5.007\,774\,410\,34 \times 10^{-17}$	. . . . .	. . . . .
c_7	=	$-3.731\,058\,861\,91 \times 10^{-20}$	. . . . .	. . . . .
c_8	=	$1.577\,164\,823\,67 \times 10^{-23}$	. . . . .	. . . . .
c_9	=	$-2.810\,386\,252\,51 \times 10^{-27}$	. . . . .	. . . . .

Type S thermocouples: emf-temperature (°C) reference table and equations

Thermocouple emf in Millivolts as a Function of Temperature in Degrees Celsius (ITS-90)

Reference Junctions at 0°C

t/°C	0	-10	-20	-30	-40	-50	-60	-70	-80	-90	-100
0	0.000	-0.053	-0.103	-0.150	-0.194	-0.236					

t/°C	0	10	20	30	40	50	60	70	80	90	100
0	0.000	0.055	0.113	0.173	0.235	0.299	0.365	0.433	0.502	0.573	0.646
100	0.646	0.720	0.795	0.872	0.950	1.029	1.110	1.191	1.273	1.357	1.441
200	1.441	1.526	1.612	1.698	1.786	1.874	1.962	2.052	2.141	2.232	2.323
300	2.323	2.415	2.507	2.599	2.692	2.786	2.880	2.974	3.069	3.164	3.259
400	3.259	3.355	3.451	3.548	3.645	3.742	3.840	3.938	4.036	4.134	4.233
500	4.233	4.332	4.432	4.532	4.632	4.732	4.833	4.934	5.035	5.137	5.239
600	5.239	5.341	5.443	5.546	5.649	5.753	5.857	5.961	6.065	6.170	6.275
700	6.275	6.381	6.486	6.593	6.699	6.806	6.913	7.020	7.128	7.236	7.345
800	7.345	7.454	7.563	7.673	7.783	7.893	8.003	8.114	8.226	8.337	8.449
900	8.449	8.562	8.674	8.787	8.900	9.014	9.128	9.242	9.357	9.472	9.587
1000	9.587	9.703	9.819	9.935	10.051	10.168	10.285	10.403	10.520	10.638	10.757
1100	10.757	10.875	10.994	11.113	11.232	11.351	11.471	11.590	11.710	11.830	11.951
1200	11.951	12.071	12.191	12.312	12.433	12.554	12.675	12.796	12.917	13.038	13.159
1300	13.159	13.280	13.402	13.523	13.644	13.766	13.887	14.009	14.130	14.251	14.373
1400	14.373	14.494	14.615	14.736	14.857	14.978	15.099	15.220	15.341	15.461	15.582
1500	15.582	15.702	15.822	15.942	16.062	16.182	16.301	16.420	16.539	16.658	16.777
1600	16.777	16.895	17.013	17.131	17.249	17.366	17.483	17.600	17.717	17.832	17.947
1700	17.947	18.061	18.174	18.285	18.395	18.503	18.609				

Temperature Ranges and Coefficients of Equations Used to Compute the Above Table

The equations are of the form: $E = c_0 + c_1 t + c_2 t^2 + c_3 t^3 + \ldots c_n t^n$, where E is the emf in millivolts, t is the temperature in degrees Celsius (ITS-90), and c_0, c_1, c_2, c_3, etc. are the coefficients. These coefficients are extracted from NIST Monograph 175.

		-50°C to 1064.18°C	1064.18°C to 1664.5°C	1664.5°C to 1768.1°C
c_0	=	0.000 000 000 00	1.329 004 440 85	$1.466\,282\,326\,36 \times 10^{2}$
c_1	=	$5.403\,133\,086\,31 \times 10^{-3}$	$3.345\,093\,113\,44 \times 10^{-3}$	$-2.584\,305\,167\,52 \times 10^{-1}$
c_2	=	$1.259\,342\,897\,40 \times 10^{-5}$	$6.548\,051\,928\,18 \times 10^{-6}$	$1.636\,935\,746\,41 \times 10^{-4}$
c_3	=	$-2.324\,779\,686\,89 \times 10^{-8}$	$-1.648\,562\,592\,09 \times 10^{-9}$	$-3.304\,390\,469\,87 \times 10^{-8}$
c_4	=	$3.220\,288\,230\,36 \times 10^{-11}$	$1.299\,896\,051\,74 \times 10^{-14}$	$-9.432\,236\,906\,12 \times 10^{-15}$
c_5	=	$-3.314\,651\,963\,89 \times 10^{-14}$	. . . . .	. . . . .
c_6	=	$2.557\,442\,517\,86 \times 10^{-17}$	. . . . .	. . . . .
c_7	=	$-1.250\,688\,713\,93 \times 10^{-20}$	. . . . .	. . . . .
c_8	=	$2.714\,431\,761\,45 \times 10^{-24}$	. . . . .	. . . . .

Type T thermocouples: emf-temperature (°C) reference table and equations

Thermocouple emf in Millivolts as a Function of Temperature in Degrees Celsius (ITS-90)

Reference Junctions at 0°C

t/°C	0	-10	-20	-30	-40	-50	-60	-70	-80	-90	-100
-200	-5.603	-5.753	-5.888	-6.007	-6.105	-6.180	-6.232	-6.258			
-100	-3.379	-3.657	-3.923	-4.177	-4.419	-4.648	-4.865	-5.070	-5.261	-5.439	-5.603
0	0.000	-0.383	-0.757	-1.121	-1.475	-1.819	-2.153	-2.476	-2.788	-3.089	-3.379

t/°C	0	10	20	30	40	50	60	70	80	90	100
0	0.000	0.391	0.790	1.196	1.612	2.036	2.468	2.909	3.358	3.814	4.279
100	4.279	4.750	5.228	5.714	6.206	6.704	7.209	7.720	8.237	8.759	9.288
200	9.288	9.822	10.362	10.907	11.458	12.013	12.574	13.139	13.709	14.283	14.862
300	14.862	15.445	16.032	16.624	17.219	17.819	18.422	19.030	19.641	20.255	20.872
400	20.872										

Temperature Ranges and Coefficients of Equations Used to Compute the Above Table

The equations are of the form: $E = c_0 + c_1 t + c_2 t^2 + c_3 t^3 + \ldots c_n t^n$, where E is the emf in millivolts, t is the temperature in degrees Celsius (ITS-90), and c_0, c_1, c_2, c_3, etc. are the coefficients. These coefficients are extracted from NIST Monograph 175.

		-270°C to 0°C	0°C to 400°C
c_0	=	0.000 000 000 0	0.000 000 000 0
c_1	=	$3.874\,810\,636\,4 \times 10^{-2}$	$3.874\,810\,636\,4 \times 10^{-2}$
c_2	=	$4.419\,443\,434\,7 \times 10^{-5}$	$3.329\,222\,788\,0 \times 10^{-5}$
c_3	=	$1.184\,432\,310\,5 \times 10^{-7}$	$2.061\,824\,340\,4 \times 10^{-7}$
c_4	=	$2.003\,297\,355\,4 \times 10^{-8}$	$-2.188\,225\,684\,6 \times 10^{-9}$
c_5	=	$9.013\,801\,955\,9 \times 10^{-10}$	$1.099\,688\,092\,8 \times 10^{-11}$
c_6	=	$2.265\,115\,659\,3 \times 10^{-11}$	$-3.081\,575\,877\,2 \times 10^{-14}$
c_7	=	$3.607\,115\,420\,5 \times 10^{-13}$	$4.547\,913\,529\,0 \times 10^{-17}$
c_8	=	$3.849\,393\,988\,3 \times 10^{-15}$	$-2.751\,290\,167\,3 \times 10^{-20}$
c_9	=	$2.821\,352\,192\,5 \times 10^{-17}$	. . . . .
c_{10}	=	$1.425\,159\,477\,9 \times 10^{-19}$	. . . . .
c_{11}	=	$4.876\,866\,228\,6 \times 10^{-22}$	. . . . .
c_{12}	=	$1.079\,553\,927\,0 \times 10^{-24}$	. . . . .
c_{13}	=	$1.394\,502\,706\,2 \times 10^{-27}$	. . . . .
c_{14}	=	$7.979\,515\,392\,7 \times 10^{-31}$	. . . . .

Type B thermocouples: coefficients (c_i) of polynomials for the computation of temperatures in °C as a function of the thermocouple emf in various temperature and emf ranges

Temperature Range:	250°C to 700°C	700°C to 1820°C
emf Range:	0.291 mV to 2.431 mV	2.431 mV to 13.820 mV
c_0 =	$9.842\,332\,1 \times 10^{1}$	$2.131\,507\,1 \times 10^{2}$
c_1 =	$6.997\,150\,0 \times 10^{2}$	$2.851\,050\,4 \times 10^{2}$
c_2 =	$-8.476\,530\,4 \times 10^{2}$	$-5.274\,288\,7 \times 10^{1}$
c_3 =	$1.005\,264\,4 \times 10^{3}$	9.916 080 4
c_4 =	$-8.334\,595\,2 \times 10^{2}$	-1.296 530 3
c_5 =	$4.550\,854\,2 \times 10^{2}$	$1.119\,587\,0 \times 10^{-1}$
c_6 =	$-1.552\,303\,7 \times 10^{2}$	$-6.062\,519\,9 \times 10^{-3}$
c_7 =	$2.988\,675\,0 \times 10^{1}$	$1.866\,169\,6 \times 10^{-4}$
c_8 =	-2.474 286 0	$-2.487\,858\,5 \times 10^{-6}$

Type E thermocouples: coefficients (c_i) of polynomials for the computation of temperatures in °C as a function of the thermocouple emf in various temperature and emf ranges

Temperature Range:	-200°C to 0°C	0°C to 1000°C
emf Range:	-8.825 mV to 0.0 mV	0.0 mV to 76.373 mV
c_0 =	0.000 000 0	0.000 000 0
c_1 =	$1.697\,728\,8 \times 10^{1}$	$1.705\,703\,5 \times 10^{1}$
c_2 =	$-4.351\,497\,0 \times 10^{-1}$	$-2.330\,175\,9 \times 10^{-1}$
c_3 =	$-1.585\,969\,7 \times 10^{-1}$	$6.543\,558\,5 \times 10^{-3}$
c_4 =	$-9.250\,287\,1 \times 10^{-2}$	$-7.356\,274\,9 \times 10^{-5}$
c_5 =	$-2.608\,431\,4 \times 10^{-2}$	$-1.789\,600\,1 \times 10^{-6}$
c_6 =	$-4.136\,019\,9 \times 10^{-3}$	$8.403\,616\,5 \times 10^{-8}$
c_7 =	$-3.403\,403\,0 \times 10^{-4}$	$-1.373\,587\,9 \times 10^{-9}$
c_8 =	$-1.156\,489\,0 \times 10^{-5}$	$1.062\,982\,3 \times 10^{-11}$
c_9 =	. . . . .	$-3.244\,708\,7 \times 10^{-14}$

Type J thermocouples: coefficients (c_i) of polynomials for the computation of temperatures in ˚C as a function of the thermocouple emf in various temperature and emf ranges

Temperature Range:	-210°C to 0°C	0°C to 760°C	760°C to 1200°C
emf Range:	-8.095 mV to 0.0 mV	0.0 mV to 42.919 mV	42.919 mV to 69.553 mV
c_0 =	0.000 000 0	0.000 000	$-3.113\,581\,87 \times 10^{3}$
c_1 =	$1.952\,826\,8 \times 10^{1}$	$1.978\,425 \times 10^{1}$	$3.005\,436\,84 \times 10^{2}$
c_2 =	-1.228 618 5	$-2.001\,204 \times 10^{-1}$	-9.947 732 30
c_3 =	-1.075 217 8	$1.036\,969 \times 10^{-2}$	$1.702\,766\,30 \times 10^{-1}$
c_4 =	$-5.908\,693\,3 \times 10^{-1}$	$-2.549\,687 \times 10^{-4}$	$-1.430\,334\,68 \times 10^{-3}$
c_5 =	$-1.725\,671\,3 \times 10^{-1}$	$3.585\,153 \times 10^{-6}$	$4.738\,860\,84 \times 10^{-6}$
c_6 =	$-2.813\,151\,3 \times 10^{-2}$	$-5.344\,285 \times 10^{-8}$	. . . . .
c_7 =	$-2.396\,337\,0 \times 10^{-3}$	$5.099\,890 \times 10^{-10}$	. . . . .
c_8 =	$-8.382\,332\,1 \times 10^{-5}$	. . . . .	. . . . .

Type K thermocouples: coefficients (c_i) of polynomials for the computation of temperatures in ˚C as a function of the thermocouple emf in various temperature and emf ranges

Temperature Range:	-200°C to 0°C	0°C to 500°C	500°C to 1372°C
emf Range:	-5.891 mV to 0.0 mV	0.0 mV to 20.644 mV	20.644 mV to 54.886 mV
c_0 =	0.000 000 0	0.000 000 0	$-1.318\,058 \times 10^{2}$
c_1 =	$2.517\,346\,2 \times 10^{1}$	$2.508\,355 \times 10^{1}$	$4.830\,222 \times 10^{1}$
c_2 =	-1.166 287 8	$7.860\,106 \times 10^{-2}$	-1.646 031
c_3 =	-1.083 363 8	$-2.503\,131 \times 10^{-1}$	$5.464\,731 \times 10^{-2}$
c_4 =	$-8.977\,354\,0 \times 10^{-1}$	$8.315\,270 \times 10^{-2}$	$-9.650\,715 \times 10^{-4}$
c_5 =	$-3.734\,237\,7 \times 10^{-1}$	$-1.228\,034 \times 10^{-2}$	$8.802\,193 \times 10^{-6}$
c_6 =	$-8.663\,264\,3 \times 10^{-2}$	$9.804\,036 \times 10^{-4}$	$-3.110\,810 \times 10^{-8}$
c_7 =	$-1.045\,059\,8 \times 10^{-2}$	$-4.413\,030 \times 10^{-5}$	. . . . .
c_8 =	$-5.192\,057\,7 \times 10^{-4}$	$1.057\,734 \times 10^{-6}$	. . . . .
c_9 =	. . . . .	$-1.052\,755 \times 10^{-8}$	. . . . .

Type N thermocouples: coefficients (c_i) of polynomials for the computation of temperatures in °C as a function of the thermocouple emf in various temperature and emf ranges

Temperature Range:	-200°C to 0°C	0°C to 600°C	600°C to 1300°C
emf Range:	-3.990 mV to 0.0 mV	0.0 mV to 20.613 mV	20.613 mV to 47.513 mV
c_0 =	0.000 000 0	0.000 00	$1.972\,485 \times 10^{1}$
c_1 =	$3.843\,684\,7 \times 10^{1}$	$3.868\,96 \times 10^{1}$	$3.300\,943 \times 10^{1}$
c_2 =	1.101 048 5	-1.082 67	$-3.915\,159 \times 10^{-1}$
c_3 =	5.222 931 2	$4.702\,05 \times 10^{-2}$	$9.855\,391 \times 10^{-3}$
c_4 =	7.206 052 5	$-2.121\,69 \times 10^{-6}$	$-1.274\,371 \times 10^{-4}$
c_5 =	5.848 858 6	$-1.172\,72 \times 10^{-4}$	$7.767\,022 \times 10^{-7}$
c_6 =	2.775 491 6	$5.392\,80 \times 10^{-6}$	. . . . .
c_7 =	$7.707\,516\,6 \times 10^{-1}$	$-7.981\,56 \times 10^{-8}$	. . . . .
c_8 =	$1.158\,266\,5 \times 10^{-1}$	. . . . .	. . . . .
c_9 =	$7.313\,886\,8 \times 10^{-3}$	. . . . .	. . . . .

Type R thermocouples: coefficients (c_i) of polynomials for the computation of temperatures in °C as a function of the thermocouple emf in various temperature and emf ranges

Temperature Range:	-50°C to 250°C	250°C to 1200°C	1064°C to 1664.5°C	1664.5°C to 1768.1°C
emf Range:	-0.226 mV to 1.923 mV	1.923 mV to 13.228 mV	11.361 mV to 19.739 mV	19.739 mV to 21.103 mV
c_0 =	0.000 000 0	$1.334\,584\,505 \times 10^{1}$	$-8.199\,599\,416 \times 10^{1}$	$3.406\,177\,836 \times 10^{4}$
c_1 =	$1.889\,138\,0 \times 10^{2}$	$1.472\,644\,573 \times 10^{2}$	$1.553\,962\,042 \times 10^{2}$	$-7.023\,729\,171 \times 10^{3}$
c_2 =	$-9.383\,529\,0 \times 10^{1}$	$-1.844\,024\,844 \times 10^{1}$	-8.342 197 663	$5.582\,903\,813 \times 10^{2}$
c_3 =	$1.306\,861\,9 \times 10^{2}$	4.031 129 726	$4.279\,433\,549 \times 10^{-1}$	$-1.952\,394\,635 \times 10^{1}$
c_4 =	$-2.270\,358\,0 \times 10^{2}$	$-6.249\,428\,360 \times 10^{-1}$	$-1.191\,577\,910 \times 10^{-2}$	$2.560\,740\,231 \times 10^{-1}$
c_5 =	$3.514\,565\,9 \times 10^{2}$	$6.468\,412\,046 \times 10^{-2}$	$1.492\,290\,091 \times 10^{-4}$	. . . . .
c_6 =	$-3.895\,390\,0 \times 10^{2}$	$-4.458\,750\,426 \times 10^{-3}$	. . . . .	. . . . .
c_7 =	$2.823\,947\,1 \times 10^{2}$	$1.994\,710\,149 \times 10^{-4}$	. . . . .	. . . . .
c_8 =	$-1.260\,728\,1 \times 10^{2}$	$-5.313\,401\,790 \times 10^{-6}$	. . . . .	. . . . .
c_9 =	$3.135\,361\,1 \times 10^{1}$	$6.481\,976\,217 \times 10^{-8}$	. . . . .	. . . . .
c_{10} =	-3.318 776 9	. . . . .	. . . . .	. . . . .

Type S thermocouples: coefficients (c_i) of polynomials for the computation of temperatures in °C as a function of the thermocouple emf in various temperature and emf ranges

Temperature Range:	-50°C to 250°C	250°C to 1200°C	1064°C to 1664.5°C	1664.5°C to 1768.1°C
emf Range:	-0.235 mV to 1.874 mV	1.874 mV to 11.950 mV	10.332 mV to 17.536 mV	17.536 mV to 18.693 mV
c_0 =	0.000 000 00	$1.291\,507\,177 \times 10^{1}$	$-8.087\,801\,117 \times 10^{1}$	$5.333\,875\,126 \times 10^{4}$
c_1 =	$1.849\,494\,60 \times 10^{2}$	$1.466\,298\,863 \times 10^{2}$	$1.621\,573\,104 \times 10^{2}$	$-1.235\,892\,298 \times 10^{4}$
c_2 =	$-8.005\,040\,62 \times 10^{1}$	$-1.534\,713\,402 \times 10^{1}$	-8.536 869 453	$1.092\,657\,613 \times 10^{3}$
c_3 =	$1.022\,374\,30 \times 10^{2}$	3.145 945 973	$4.719\,686\,976 \times 10^{-1}$	$-4.265\,693\,686 \times 10^{1}$
c_4 =	$-1.522\,485\,92 \times 10^{2}$	$-4.163\,257\,839 \times 10^{-1}$	$-1.441\,693\,666 \times 10^{-2}$	$6.247\,205\,420 \times 10^{-1}$
c_5 =	$1.888\,213\,43 \times 10^{2}$	$3.187\,963\,771 \times 10^{-2}$	$2.081\,618\,890 \times 10^{-4}$	. . . . .
c_6 =	$-1.590\,859\,41 \times 10^{2}$	$-1.291\,637\,500 \times 10^{-3}$	. . . . .	. . . . .
c_7 =	$8.230\,278\,80 \times 10^{1}$	$2.183\,475\,087 \times 10^{-5}$	. . . . .	. . . . .
c_8 =	$-2.341\,819\,44 \times 10^{1}$	$-1.447\,379\,511 \times 10^{-7}$	. . . . .	. . . . .
c_9 =	2.797 862 60	$8.211\,272\,125 \times 10^{-9}$	. . . . .	. . . . .

Type T thermocouples: coefficients (c_i) of polynomials for the computation of temperatures in °C as a function of the thermocouple emf in various temperature and emf ranges

Temperature Range:	-200°C to 0°C	0°C to 400°C
emf Range:	-5.603 mV to 0.0 mV	0.0 mV to 20.872 mV
c_0 =	0.000 000 0	0.000 000
c_1 =	$2.594\,919\,2 \times 10^{1}$	$2.592\,800 \times 10^{1}$
c_2 =	$-2.131\,696\,7 \times 10^{-1}$	$-7.602\,961 \times 10^{-1}$
c_3 =	$7.901\,869\,2 \times 10^{-1}$	$4.637\,791 \times 10^{-2}$
c_4 =	$4.252\,777\,7 \times 10^{-1}$	$-2.165\,394 \times 10^{-3}$
c_5 =	$1.330\,447\,3 \times 10^{-1}$	$6.048\,144 \times 10^{-5}$
c_6 =	$2.024\,144\,6 \times 10^{-2}$	$-7.293\,422 \times 10^{-7}$
c_7 =	$1.266\,817\,1 \times 10^{-3}$	. . . . .