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An American National Standard

Standard Specification and Temperature-Electromotive Force (EMF) Tables for Standardized Thermocouples[1]

This standard is issued under the fixed designation E 230; 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.

Note—Paragraph 1.1, and Tables 7, 13, 19, 21, and 46 were editorially corrected and the year date changed on Sept. 23, 2003.

1. Scope

1.1 This specification contains reference tables (Tables 8–23)8–25) that give temperature-electromotive force (emf) relationships for Types B, E, J, K, N, R, S, T, and TC thermocouples.[2] These are the thermocouple types most commonly used in industry.

1.2 Also included are lists of standard and special tolerances on initial values of emf versus temperature for thermocouples (Table 1), thermocouple extension wires (Table 2), and compensating extension wires for thermocouples (Table 3).

1.3 Tables 4–5, included herein, give data on insulation color coding for thermocouple and thermocouple extension wires as customarily used in the United States.

1.4 Recommendations regarding upper temperature limits for the thermocouple types referred to in 1.1 are given in Table 6.

1.5Tables 24–43 give temperature-emf data for single-leg thermoelements referenced to platinum (NIST Pt 67). The tables include values for Types BP, BN, JP, JN, KP (same as EP), KN, NP, NN, TP, and TN (same as EN).

1.6Tables for Types RP, RN, SP, and SN thermoelements are not included since, nominally, Tables 18–21 represent the thermoelectric properties of Type RP and SP thermoelements referenced to pure platinum.

1.7Polynomial coefficients that may be used for computation of thermocouple emf as a function of temperature are given in Table 7. Coefficients for the emf of each thermocouple pair as well as for the emf of individual thermoelements versus platinum are included.

1.5 Tables 26–45 give temperature-emf data for single-leg thermoelements referenced to platinum (NIST Pt 67). The tables include values for Types BP, BN, JP, JN, KP (same as EP), KN, NP, NN, TP, and TN (same as EN).

1.6 Tables for Types RP, RN, SP, and SN thermoelements are not included since, nominally, Tables 18–21 represent the thermoelectric properties of Type RP and SP thermoelements referenced to pure platinum. Tables for the individual thermoelements of Type C are not included because materials for Type C thermocouples are normally supplied as matched pairs only.

1.7 Polynomial coefficients that may be used for computation of thermocouple emf as a function of temperature are given in Table 7. Coefficients for the emf of each thermocouple pair as well as for the emf of most individual thermoelements versus platinum are included. Coefficients for type RP and SP thermoelements are not included since they are nominally the same as for the types R and S thermocouples, and coefficients for type RN or SN relative to the nominally similar Pt-67 would be insignificant. Coefficients for the individual thermoelements of type C are not established.

1.8 Coefficients for sets of inverse polynomials are given in Table 44. These may be used for computing a close approximation of temperature (°C) as a function of thermocouple emf. Inverse functions are provided only for thermocouple pairs and are valid only over the emf ranges specified.

1.9 This specification is intended to define the thermoelectric properties of materials that conform to the relationships presented in the tables of this standard and bear the letter designations contained herein. Topics such as ordering information, physical and mechanical properties, workmanship, testing, and marking are not addressed in this specification. The user is referred to specific standards such as Specifications E 235, E 574, E 585, E 608, E 1159, or E 1223, as appropriate, for guidance in these areas.

1.10 The temperature-emf data in this specification are intended for industrial and laboratory use.

2. Referenced Documents

2.1 *ASTM Standards:*

E 235 Specification for Thermocouples, Sheathed, Type K, for Nuclear or for Other High-Reliability Applications[3]

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

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[2] These temperature-emf relationships have been revised as required by the international adoption in 1989 of a revised International Temperature Scale (ITS-90).

[3] *Annual Book of ASTM Standards*, Vol 14.03.

E 574 Specification for Duplex, Base-Metal Thermocouple Wire with Glass Fiber or Silica Fiber Insulation[3]
E 585 Specification for Sheathed Base-Metal Thermocouple Materials[3]
E 608 Specification for Metal-Sheathed Base-Metal Thermocouples[3]
E 1159 Specification for Thermocouple Materials, Platinum-Rhodium Alloys, and Platinum[3]
E 1223 Specification for Type N Thermocouple Wire[3]

2.2 *NIST Monograph:*

NIST Monograph 175 Temperature-Electromotive Force Reference Functions and Tables for the Letter-Designated Thermocouple Types Based on the ITS-90[4]

2.3 *IEC Standard:*

IEC 584–3 First edition, 1989

3. Source of Data

3.1 The data in these tables are based upon the SI volt[5] and the International Temperature Scale of 1990.

~~3.2The temperature-emf data in Tables 8–43 and the corresponding equations in Tables 7 and 44 for all of the thermocouple types have been extracted from NIST Monograph 175.~~

3.2 The temperature-emf data in Tables 8–23 and 26–45, together with the corresponding equations in Tables 7 and 46 for all of the thermocouple types, except type C, have been extracted from NIST Monograph 175. Temperature-emf data in Tables 24–25 and the coefficients for type C in Tables 7 and 46 have been developed from curves fitted to wire manufacturers' data.

NOTE 1—It is beyond the scope of this standard to discuss the origin of these tables, but if further information is desired, the reader should consult the NIST reference noted above.

3.3 These tables give emf values to three decimal places (1 μV) at temperature intervals of one degree. Such tables are satisfactory for most industrial uses but may not be adequate for computer and similar applications. If greater precision is required, the reader should refer to the NIST reference noted above which includes tables giving emf values to four decimal places (0.1 μV) for each type except type C. Equations which permit easy and unique generation of the temperature-emf relationships will be found in Table 7. For convenience, coefficients of inverse polynomials that may be used to compute approximate temperature (°C) as a function of thermocouple emf are given in Table ~~44.~~ 46.

4. Thermocouple Types and Letter Designations

4.1 The letter symbols identifying each reference table are those which are in common use throughout industry and identify the following thermocouple calibrations:

4.1.1 *Type B*—Platinum-30% rhodium (+) versus platinum-6 % rhodium (−).
4.1.2 *Type E*—Nickel-10 % chromium (+) versus copper-45% nickel (constantan) (−).
4.1.3 *Type J*—Iron (+) versus copper-45% nickel (constantan) (−).
4.1.4 *Type K*—Nickel-10 % chromium (+) versus nickel-5 % (aluminum, silicon) (−) (Note 2).

NOTE 2—Silicon, or aluminum and silicon, may be present in combination with other elements.

4.1.5 *Type N*—Nickel-14 % chromium, 1½ % silicon (+) versus nickel-4½ % silicon-1⁄10 % magnesium (−).
4.1.6 *Type R*—Platinum-13 % rhodium (+) versus platinum (−).
4.1.7 *Type S*—Platinum-10 % rhodium (+) versus platinum (−).
4.1.8 *Type T*—Copper (+) versus copper-45% nickel (constantan) (−).
4.1.9 *Type C*—Tungsten-5% Rhenium (+) versus Tungsten-26% Rhenium (−).

4.2 Each letter designation of 4.1 identifies a specific temperature-emf relationship (Tables 8–23) and may be applied to any thermocouple conforming thereto within stated tolerances on initial values of emf versus temperature, regardless of its composition.

4.3 The thermoelement identifying symbols in Tables ~~24~~26 to ~~43~~45 use the suffix letters P and N to denote, respectively, the positive and negative thermoelement of a given thermocouple type.

4.4 Tables ~~24~~26 to ~~43~~45 identify specific temperature-emf relationships of individual thermoelements with respect to platinum (NIST Pt-67). Although tolerances on initial values of emf versus temperature, in most cases, are not established for individual thermoelements with respect to platinum, the appropriate letter designation may be applied to any thermoelement which, when combined with its mating thermoelement, will form a thermocouple conforming to the corresponding table within the stated tolerances.

4.5 An overall suffix letter "X" (for example KX, TX, EPX, JNX) denotes an "extension grade" material whose thermoelectric properties will match those of the corresponding thermocouple type within the stated extension grade tolerances over a limited temperature span. Most base metal extension wires have the same nominal composition as the thermocouple wires with which they are intended to be used, whereas the *compensating* extension wires for noble metal or refractory metal thermocouple types (S, R,

[4] Available from National Institute of Standards and Technology, U.S. Department of Commerce, Gaithersburg, MD 20899.
[5] Discussed in NIST Technical Note 1263, Guidelines for Implementing the New Representations of the Volt and Ohm Effective January 1, 1990.

B, or ~~B)~~C) are usually of a different, more economical composition whose relative thermoelectric properties as a pair nonetheless closely approximate those of the ~~precious~~noble metal or refractory metal thermocouples with which they are to be used.

5. Tolerances on Initial Values of EMF versus Temperature

5.1 Thermocouples and matched thermocouple wire pairs are normally supplied to the tolerances on initial values of emf versus temperature listed in Table 1.

5.1.1 Tolerances on initial values of emf versus temperature for single-leg thermoelements referenced to platinum have been established only for Types KP and KN. These are supplied, by common practice, to a tolerance equivalent to one half the millivolt tolerance of the Type K thermocouple.

5.1.2 For all other thermocouple types, tolerances on initial values of emf versus temperature for single thermoelements, when required, should be established by agreement between the consumer and the producer.

5.1.3 In reference Tables ~~32, 33, 42,~~34, 35, 44, and ~~43,~~45, the thermoelements are identified by two thermoelement symbols indicating their applicability to two thermocouple types. This indicates that the temperature-electromotive force relationship of the table is typical of the referenced thermoelements over the temperature range given in Table 1 for the corresponding thermocouple type. It should not be assumed, however, that thermoelements used with one thermocouple type are interchangeable with those of the other, or that they have the same millivolt tolerances for the initial values of emf versus temperature.

5.2 Thermocouple extension wires and compensating extension wires are supplied to the tolerances on initial values of emf versus temperature shown in Tables 2–3.

5.2.1 The initial tolerances of extension grade materials and compensating extension materials apply over a more limited span of temperature than the corresponding thermocouple grade materials. Applicable temperature ranges, consistent with typical usage, are given in Tables 2–3.

6. Color Coding

6.1 Color codes for insulation on thermocouple grade materials, along with corresponding thermocouple and thermoelement letter designations, are given in Table 4.

6.2 Extension wires for thermocouples are distinguished by having an identifying color in the outer jacket as shown in Table 5, where letter designations for the extension thermoelements and pairs are also presented.

6.3 Information in Tables 4–5 is based on customary United States practice.

NOTE 3—Other insulation color coding conventions may be found in use elsewhere in the world.

7. List of Tables

7.1 Following is a list of the tables included in this standard:

7.1.1 *General Tables*:

Table Number	Title
1	Tolerances on Initial Values of Emf versus Temperature for Thermocouples
2	Tolerances on Initial Values of Emf versus Temperature for Extension Wires
3	Tolerances on Initial Values of Emf versus Temperature for Compensating Extension Wires
4	United States Color Codes for Single and Duplex Insulated Thermocouple Wires
5	United States Color Codes for Single and Duplex Insulated Extension Wires
6	Suggested Upper Temperature Limits for Protected Thermocouples
7	Polynomial Coefficients for Generating Thermocouple EMF as a Function of Temperature

7.1.2 *EMF versus Temperature Tables for Thermocouples*:

Table Number	Thermocouple Type	Temperature Range[A]
8	B	0 to 1820°C
9	B	32 to 3308°F
10	E	−270 to 1000°C
11	E	−454 to 1832°F
12	J	−210 to 1200°C
13	J	−346 to 2192°F
14	K	−270 to 1372°C
15	K	−454 to 2500°F
16	N	−270 to 1300°C

Table Number	Thermocouple Type	Temperature Range[A]
17	N	–454 to 2372°F
18	R	–50 to 1768°C
19	R	–58 to 3214°F
20	S	–50 to 1768°C
21	S	–58 to 3214°F
22	T	–270 to 400°C
23	T	–454 to 752°F
24	C	0 to 2315°C
25	C	32 to 4200°F

7.1.3 *EMF versus Temperature Tables for Thermoelements*:

Table Number	Thermocouple Type	Thermoele-ment Type	Temperature Range[A]
~~24~~	~~B~~	~~BP~~	~~0 to 1768°C~~
26	B	BP	0 to 1768°C
~~25~~	~~B~~	~~BP~~	~~32 to 3214°F~~
27	B	BP	32 to 3214°F
~~26~~	~~B~~	~~BN~~	~~0 to 1768°C~~
28	B	BN	0 to 1768°C
~~27~~	~~B~~	~~BN~~	~~32 to 3214°F~~
29	B	BN	32 to 3214°F
~~28~~	~~J~~	~~JP~~	~~–210 to 760°C~~
30	J	JP	–210 to 760°C
~~29~~	~~J~~	~~JP~~	~~–346 to 1400°F~~
31	J	JP	–346 to 1400°F
~~30~~	~~J~~	~~JN~~	~~–210 to 760°C~~
32	J	JN	–210 to 760°C
~~31~~	~~J~~	~~JN~~	~~–346 to 1400°F~~
33	J	JN	–346 to 1400°F
~~32~~	~~K or E~~	~~KP or EP~~	~~–270 to 1372°C~~
34	K or E	KP or EP	–270 to 1372°C
~~33~~	~~K or E~~	~~KP or EP~~	~~–454 to 2500°F~~
35	K or E	KP or EP	–454 to 2500°F
~~34~~	~~K~~	~~KN~~	~~–270 to 1372°C~~
36	K	KN	–270 to 1372°C
~~35~~	~~K~~	~~KN~~	~~–454 to 2500°F~~
37	K	KN	–454 to 2500°F
~~36~~	~~N~~	~~NP~~	~~–200 to 1300°C~~
38	N	NP	–200 to 1300°C
~~37~~	~~N~~	~~NP~~	~~–328 to 2372°F~~
39	N	NP	–328 to 2372°F
~~38~~	~~N~~	~~NN~~	~~–200 to 1300°C~~
40	N	NN	–200 to 1300°C
~~39~~	~~N~~	~~NN~~	~~–328 to 2372°F~~
41	N	NN	–328 to 2372°F
~~40~~	~~T~~	~~TP~~	~~–270 to 400°C~~
42	T	TP	–270 to 400°C
~~41~~	~~T~~	~~TP~~	~~–454 to 752°F~~
43	T	TP	–454 to 752°F
~~42~~	~~T or E~~	~~TN or EN~~	~~–270 to 1000°C~~
44	T or E	TN or EN	–270 to 1000°C
~~43~~	~~T or E~~	~~TN or EN~~	~~–454 to 1832°F~~
45	T or E	TN or EN	–454 to 1832°F

[A] These temperature ranges represent the range of published temperature versus emf data for the thermocouple and thermoelement types listed. Refer to Table 6 for recommended maximum upper use temperature limits for a specific thermocouple wire size and type.

7.1.4 *Supplementary Table*:

Table Number	Title
~~44~~	~~Coefficients of Inverse Polynomials for Computation of Approximate Temperature as a Function of Thermocouple EMF~~
46	Coefficients of Inverse Polynomials for Computation of Approximate Temperature as a Function of Thermocouple EMF

8. Keywords

8.1 emf computation; compensating extension wire; inverse polynomial; polynomial coefficient; reference tables; thermocouple; thermocouple extension wire; thermoelement; upper temperature limit

APPENDIX

(Nonmandatory Information)

X1. IEC COLOR CODE SYSTEM

X1.1 General

X1.1.1 The data presented in Tables 4–5 of this specification show the color coding required by this specification. Those colors are well established in the United States and have been in use as the national standard there for many years.

X1.1.2 In other parts of the world, there are alternative color code systems, either now in use, or in process of being implemented.

X1.1.3 One such color code system is that established by the IEC. The IEC color code system is outlined here for reference. Table X1.1 shows the IEC standard colors for thermocouple cables, extension cables, and compensating cables.

TABLE 1 Tolerances on Initial Values of Emf vs. Temperature for Thermocouples

NOTE 1—Tolerances in this table apply to new essentially homogeneous thermocouple wire, normally in the size range 0.25 to 3 mm in diameter (No. 30 to No. 8 Awg) and used at temperatures not exceeding the recommended limits of Table 6. If used at higher temperatures these tolerances may not apply.

NOTE 2—At a given temperature that is expressed in °C, the tolerance expressed in °F is 1.8 times larger than the tolerance expressed in °C. Note that wherever applicable, percentage-based tolerances must be computed from temperatures that are expressed in °C.

NOTE 3—**Caution:** Users should be aware that certain characteristics of thermocouple materials, including the emf versus temperature relationship may change with time in use; consequently, test results and performance obtained at time of manufacture may not necessarily apply throughout an extended period of use. Tolerances given in this table apply only to new wire as delivered to the user *and do not allow for changes in characteristics with use*. The magnitude of such changes will depend on such factors as wire size, temperature, time of exposure, and environment. It should be further noted that due to possible changes in homogeneity, attempting to recalibrate *used* thermocouples is likely to yield irrelevant results, and is not recommended. However, it may be appropriate to compare used thermocouples *in-situ* with new or known good ones to ascertain their suitability for further service under the conditions of the comparison.

Thermo-couple Type	Temperature Range		Tolerances-Reference Junction 0°C (32°F)			
			Standard Tolerances		Special Tolerances	
	°C	°F	°C (whichever is greater)	°F	°C (whichever is greater)	°F
T	0 to 370	32 to 700	±1 or ±0.75 %	Note 2	±0.5 or 0.4 %	Note 2
J	0 to 760	32 to 1400	±2.2 or ±0.75 %		±1.1 or 0.4 %	
E	0 to 870	32 to 1600	±1.7 or ±0.5 %		±1 or ±0.4 %	
K or N	0 to 1260	32 to 2300	±2.2 or ±0.75 %		±1.1 or ±0.4 %	
R or S	0 to 1480	32 to 2700	±1.5 or ±0.25 %		±0.6 or ±0.1 %	
B	870 to 1700	1600 to 3100	±0.5 %		±0.25 %	
C	0 to 2315	32 to 4200	±4.4 or 1 %	Note 2		
T[A]	–200 to 0	–328 to 32	±1 or ±1.5 %		[B]	
E[A]	–200 to 0	–328 to 32	±1.7 or ±1 %		[B]	
K[A]	–200 to 0	–328 to 32	±2.2 or ±2 %		[B]	

[A] Thermocouples and thermocouple materials are normally supplied to meet the tolerances specified in the table for temperatures above 0 °C. The same materials, however, may not fall within the tolerances given for temperatures below °C in the second section of the table. If materials are required to meet the tolerances stated for temperatures below 0 °C the purchase order must so state. Selection of materials usually will be required.

[B] Special tolerances for temperatures below 0 °C are difficult to justify due to limited available information. However, the following values for Types E and T thermocouples are suggested as a guide for discussion between purchaser and supplier:

Type E – 200 to 0 °C ± 1 °C or ± 0.5 % (whichever is greater)

Type T – 200 to 0 °C ± 0.5 °C or ± 0.8 % (whichever is greater)

Initial values of tolerance for Type J thermocouples at temperatures below 0 °C and special tolerances for Type K thermocouples below 0 °C are not given due to the characteristics of the materials.

TABLE 2 Tolerances on Initial Values of Emf vs. Temperature for Extension Wires

NOTE 1—Tolerances in this table represent the maximum error contribution allowable from new and essentially homogeneous thermocouple extension wire when exposed to the full temperature range given in the table below. Extension grade materials are not intended for use outside the temperature range shown.

NOTE 2—Thermocouple extension wire makes a contribution to the total thermoelectric signal that is dependent upon the temperature difference between the extreme ends of the extension wire length. The actual magnitude of any error introduced into a measuring circuit by homogeneous and correctly connected extension wires is equal to the algebraic difference of the deviations at its two end temperatures, as determined for that extension wire pair.

Thermocouple Type	Temperature Range		Tolerances—Reference Junction 0°C (32°F)			
			Standard Tolerances		Special Tolerances	
	°C	(°F)	°C	(°F)	°C	(°F)
TX	–60 to 100	(–75 to 200)	±1.0	(±1.8)	±0.5	(±0.9)
JX	0 to 200	(32 to 400)	±2.2	(±4.0)	±1.1	(±2.0)
EX	0 to 200	(32 to 400)	±1.7	(±3.0)	±1.0	(±1.8)
KX	0 to 200	(32 to 400)	±2.2	(±4.0)	±1.1	(±2.0)
NX	0 to 200	(32 to 400)	±2.2	(±4.0)	±1.1	(±2.0)

TABLE 3 Tolerances on Initial Values of Emf vs. Temperature for Compensating Extension Wires

NOTE 1—Tolerances in this table apply to new and essentially homogeneous thermocouple compensating extension wire when used at temperatures within the range given in the table below.

NOTE 2—Thermocouple compensating extension wire makes a contribution to the total thermoelectric signal that is dependent upon the temperature difference between the extreme ends of the compensating extension wire length.

Thermocouple Type	Temperature Range		Tolerances—Reference Junction 0°C (32°F)		
			Standard Tolerances		Special Tolerances
	°C	(°F)	°C	(°F)	
SX	0 to 200	(32 to 400)	±5	(±9)	A
RX	0 to 200	(32 to 400)	±5	(±9)	A
BX[B]	0 to 200	(32 to 400)	±4.2	(±7.6)	A
B[C]	0 to 100	(32 to 200)	±3.7	(±6.7)	...
CX	0 to 200	(32 to 400)	Initial Calibration Tolerance ±0.110 mV		...

[A] Special tolerance grade compensating extension wires are not available.
[B] Proprietary alloy compensating extension wire is available for use over a wide temperature range.
[C] Special compensating extension wires are not necessary with Type B over the limited temperature range 0 to 50 °C (32 to 125 °F), where the use of non-compensated (copper/copper) conductors introduces no significant error. For a somewhat larger temperature gradient of 0 to 100 °C (32 to 210 °F) across the extension portion of the circuit, the use of non-compensated (copper/copper) extension wires may result in small errors, the magnitude of which will not exceed the tolerance values given in the table above for measurements above 1000 °C (1800 °F).

TABLE 4 United States Color Codes for Single and Duplex Insulated Thermocouple Wire

NOTE 1—Data in this table represents customary practice in the United States of America. Different color code conventions may be found in use in other parts of the world.

NOTE 2—For some types of insulations, colors may appear as a stripe or trace strand. High temperature braided insulation is not normally color coded.

NOTE 3—The noble metal thermocouples are not normally supplied with colored insulations. However, if they were so furnished, the color codes for the corresponding single wire extensions would apply, with a brown overall jacket, where applicable.

Thermocouple Type	Thermoelement Designation	Individual Conductor Color	Overall Jacket Color
T			Brown
	TP (+)	Blue	
	TN (–)	Red	
J			Brown
	JP (+)	White	
	JN (–)	Red	
E			Brown
	EP (+)	Purple	
	EN (–)	Red	
K			Brown
	KP (+)	Yellow	
	KN (–)	Red	
N			Brown
	NP (+)	Orange	
	NN (–)	Red	

TABLE 5 United States Color Codes for Single and Duplex Insulated Extension Wire

NOTE 1—Data in this table represents customary practice in the United States of America. Different color code conventions may be found in use in other parts of the world.

NOTE 2—For some types of insulations, colors may appear as a stripe or trace strand. High temperature braided insulations are normally supplied without color code.

Thermocouple Type	Thermoelement Designation	Individual Conductor Color	Overall Jacket Color
TX			Blue
	TPX (+)	Blue	
	TNX (–)	Red, or Red/Blue Trace	
JX			Black
	JPX (+)	White	
	JNX (–)	Red, or Red/Black Trace	
EX			Purple
	EPX (+)	Purple	
	ENX (–)	Red, or Red/Purple Trace	
KX			Yellow
	KPX (+)	Yellow	
	KNX (–)	Red, or Red/Yellow Trace	
NX			Orange
	NPX (+)	Orange	
	NNX (–)	Red, or Red/Orange Trace	
RX or SX^A			Green
	RPX/SPX (+)	Black	
	RNX/SNX (–)	Red, or Red/Black Trace	
BX^B			Gray
	BPX (+)	Gray	
	BNX (–)	Red, or Red/Gray Trace	
CX			Red
–	CPX (+)	Green	
–	CNX (–)	Red	

^A Type R and S thermocouples utilize the same extension alloys.

^B Color code shown is applicable to constructions incorporating proprietary Type B compensating extension alloy wires. When uncompensated (copper/copper) extension materials are used with Type B thermocouples, the extension wire insulation is not normally color coded.

TABLE 6 Suggested Upper Temperature Limits for Protected Thermocouples

NOTE 1—This table gives the recommended upper temperature limits for the various thermocouples and wire sizes. These limits apply to protected thermocouples, that is, thermocouples in conventional closed-end protecting tubes. They do not apply to sheathed thermocouples having compacted mineral oxide insulation.

NOTE 2—The temperature limits given here are intended only as a guide to the user and should not be taken as absolute values nor as guarantees of satisfactory life or performance. These types and sizes are sometimes used at temperatures above the given limits, but usually at the expense of stability or life or both. In other instances, it may be necessary to reduce the above limits in order to achieve adequate service. ASTM MNL-12[A] and other literature sources should be consulted for additional applications information.

	Upper Temperature limit for Various Wire Sizes (Awg), °C (°F)					
Thermo-couple Type	No. 8 Gage (3.25 mm [0.128 in.])	No. 14 Gage (1.63 mm [0.064 in.])	No. 20 Gage (0.81 mm [0.032 in.])	No. 24 Gage (0.51 mm [0.020 in.])	No. 28 Gage (0.33 mm [0.013 in.])	No. 30 Gage (0.25 mm [0.010 in.])
T		370 (700)	260 (500)	200 (400)	200 (400)	150 (300)
J	760 (1400)	590 (1100)	480 (900)	370 (700)	370 (700)	320 (600)
E	870 (1600)	650 (1200)	540 (1000)	430 (800)	430 (800)	370 (700)
K and N	1260 (2300)	1090 (2000)	980 (1800)	870 (1600)	870 (1600)	760 (1400)
R and S				1480 (2700)		
B				1700 (3100)		
C[B]				2315 (4200)[C]		

[A] *Manual on the Use of Thermocouples in Temperature Measurement*, ASTM MNL-12, 1993.
[B] Type C thermoelements cannot operate in presence of oxygen; therefore, protection for these thermocouples must provide an inert or non-oxidizing environment.
[C] No. 24 Gage thermoelements are common for this thermocouple type, but other sizes are possible and, with adequate protection, are generally useable over the same temperature range.

TABLE 7 Polynomial Coefficients for Generating Thermocouple EMF as a Function of Temperature

~~Note—The following table contains sets of polynomial coefficients used to compute emfs for the various types of thermocouples and for their individual thermoelements paired with Pt-67, when reference junctions are at °C.~~

Note 1—The following table contains sets of polynomial coefficients used to compute emfs for the various types of thermocouples and for their individual thermoelements paired with Pt-67, when reference junctions are at °C.

~~Note—The coefficients given are for an expression of the form: $E = c_0 + c_1t + c_2t^2 + c_3t^3... + c_nt^n$. In this expression, E is in millivolts, t is in °C, and c_0, c_1, c_2... c_n are the coefficients given in the following table. For the Type K thermocouple and the Type KN thermoelement, coefficients b_0 and b_1 for an exponential term containing *e*, the natural logarithm base, also appear in the table. This term is of the form: $b_0e^{b_1(t-126.9686)^2}$ and, where given, it is to be evaluated and added to the polynomial result.~~

Note 2—The coefficients given are for an expression of the form: $E = c_0 + c_1t + c_2t^2 + c_3t^3... + c_nt^n$. In this expression, E is in millivolts, t is in °C, and c_0, c_1, c_2... c_n are the coefficients given in the following table. For the Type K thermocouple and the Type KN thermoelement, coefficients b_0 and b_1 for an exponential term containing *e*, the natural logarithm base, also appear in the table. This term is of the form: $b_0e^{b_1(t-126.9686)^2}$ and, where given, it is to be evaluated and added to the polynomial result.

~~Note—If emf values on another temperature scale are desired, first convert the desired temperature to its equivalent in °C, then evaluate the appropriate polynomial from the table below using the °C equivalent temperature~~

Note 3—If emf values on another temperature scale are desired, first convert the desired temperature to its equivalent in °C, then evaluate the appropriate polynomial from the table below using the °C equivalent temperature

TYPE B Thermocouple

Temperature Range		0 °C to 630.615 °C	630.615 °C to 1820 °C
c_0	=	0.0	-3.893 816 862 1 ....
c_1	=	-2.465 081 834 6 x 10^{-4}	2.857 174 747 0 x 10^{-2}
c_2	=	5.904 042 117 1 x 10^{-6}	-8.488 510 478 5 x 10^{-5}
c_3	=	-1.325 793 163 6 x 10^{-9}	1.578 528 016 4 x 10^{-7}
c_4	=	1.566 829 190 1 x 10^{-12}	-1.683 534 486 4 x 10^{-10}
c_5	=	-1.694 452 924 0 x 10^{-15}	1.110 979 401 3 x 10^{-13}
c_6	=	6.299 034 709 4 x 10^{-19}	-4.451 543 103 3 x 10^{-17}
c_7	=	....	9.897 564 082 1 x 10^{-21}
c_8	=	....	-9.379 133 028 9 x 10^{-25}

TYPE E Thermocouple

Temperature Range		-270 °C to 0 °C	0 °C to 1000 °C
c_0	=	0.0	0.0
c_1	=	5.866 550 870 8 x 10^{-2}	5.866 550 871 0 x 10^{-2}
c_2	=	4.541 097 712 4 x 10^{-5}	4.503 227 558 2 x 10^{-5}
c_3	=	-7.799 804 868 6 x 10^{-7}	2.890 840 721 2 x 10^{-8}
c_4	=	-2.580 016 084 3 x 10^{-8}	-3.305 689 665 2 x 10^{-10}
c_5	=	-5.945 258 305 7 x 10^{-10}	6.502 440 327 0 x 10^{-13}
c_6	=	-9.321 405 866 7 x 10^{-12}	-1.919 749 550 4 x 10^{-16}
c_7	=	-1.028 760 553 4 x 10^{-13}	-1.253 660 049 7 x 10^{-18}
c_8	=	-8.037 012 362 1 x 10^{-16}	2.148 921 756 9 x 10^{-21}
c_9	=	-4.397 949 739 1 x 10^{-18}	-1.438 804 178 2 x 10^{-24}
c_{10}	=	-1.641 477 635 5 x 10^{-20}	3.596 089 948 1 x 10^{-28}
c_{11}	=	-3.967 361 951 6 x 10^{-23}	....
c_{12}	=	-5.582 732 872 1 x 10^{-26}	....
c_{13}	=	-3.465 784 201 3 x 10^{-29}	....

TYPE J Thermocouple

Temperature Range		-210 °C to 760 °C	760 °C to 1200 °C
c_0	=	0.0	2.964 562 568 1 x 10^{2}
c_1	=	5.038 118 781 5 x 10^{-2}	-1.497 612 778 6 ....
c_2	=	3.047 583 693 0 x 10^{-5}	3.178 710 392 4 x 10^{-3}
c_3	=	-8.568 106 572 0 x 10^{-8}	-3.184 768 670 1 x 10^{-6}
c_4	=	1.322 819 529 5 x 10^{-10}	1.572 081 900 4 x 10^{-9}
c_5	=	-1.705 295 833 7 x 10^{-13}	-3.069 136 905 6 x 10^{-13}
c_6	=	2.094 809 069 7 x 10^{-16}	....
c_7	=	-1.253 839 533 6 x 10^{-19}	....
c_8	=	1.563 172 569 7 x 10^{-23}	....

TABLE 7 Polynomial Coefficients for Generating Thermocouple EMF as a Function of Temperature *Continued*

TYPE K Thermocouple

Temperature Range		-270 °C to 0 °C	0 °C to 1372 °C
	c_0 =	0.0	-1.760 041 368 6 x 10^{-2}
	c_1 =	3.945 012 802 5 x 10^{-2}	3.892 120 497 5 x 10^{-2}
	c_2 =	2.362 237 359 8 x 10^{-5}	1.855 877 003 2 x 10^{-5}
	c_3 =	-3.285 890 678 4 x 10^{-7}	-9.945 759 287 4 x 10^{-8}
	c_4 =	-4.990 482 877 7 x 10^{-9}	3.184 094 571 9 x 10^{-10}
	c_5 =	-6.750 905 917 3 x 10^{-11}	-5.607 284 488 9 x 10^{-13}
	c_6 =	-5.741 032 742 8 x 10^{-13}	5.607 505 905 9 x 10^{-16}
	c_7 =	-3.108 887 289 4 x 10^{-15}	-3.202 072 000 3 x 10^{-19}
	c_8 =	-1.045 160 936 5 x 10^{-17}	9.715 114 715 2 x 10^{-23}
	c_9 =	-1.988 926 687 8 x 10^{-20}	-1.210 472 127 5 x 10^{-26}
	c_{10} =	-1.632 269 748 6 x 10^{-23}	....
Exponential Coefficients See NOTE 2	b_0 =	....	1.185 976 x 10^{-1}
	b_1 =	....	-1.183 432 x 10^{-4}

TYPE N Thermocouple

Temperature Range		-270 °C to 0 °C	0 °C to 1300 °C
	c_0 =	0.0	0.0
	c_1 =	2.615 910 596 2 x 10^{-2}	2.592 939 460 1 x 10^{-2}
	c_2 =	1.095 748 422 8 x 10^{-5}	1.571 014 188 0 x 10^{-5}
	c_3 =	-9.384 111 155 4 x 10^{-8}	4.382 562 723 7 x 10^{-8}
	c_4 =	-4.641 203 975 9 x 10^{-11}	-2.526 116 979 4 x 10^{-10}
	c_5 =	-2.630 335 771 6 x 10^{-12}	6.431 181 933 9 x 10^{-13}
	c_6 =	-2.265 343 800 3 x 10^{-14}	-1.006 347 151 9 x 10^{-15}
	c_7 =	-7.608 930 079 1 x 10^{-17}	9.974 533 899 2 x 10^{-19}
	c_8 =	-9.341 966 783 5 x 10^{-20}	-6.086 324 560 7 x 10^{-22}
	c_9 =	....	2.084 922 933 9 x 10^{-25}
	c_{10} =	....	-3.068 219 615 1 x 10^{-29}

TYPE R Thermocouple

Temperature Range		-50 °C to 1064.18 °C	1064.18 °C to 1664.5 °C	1664.5 °C to 1768.1 °C
	c_0 =	0.0	2.951 579 253 16	1.522 321 182 09 x 10^{2}
	c_1 =	5.289 617 297 65 x 10^{-3}	-2.520 612 513 32 x 10^{-3}	-2.688 198 885 45 x 10^{-1}
	c_2 =	1.391 665 897 82 x 10^{-5}	1.595 645 018 65 x 10^{-5}	1.712 802 804 71 x 10^{-4}
	c_3 =	-2.388 556 930 17 x 10^{-8}	-7.640 859 475 76 x 10^{-9}	-3.458 957 064 53 x 10^{-8}
	c_4 =	3.569 160 010 63 x 10^{-11}	2.053 052 910 24 x 10^{-12}	-9.346 339 710 46 x 10^{-15}
	c_5 =	-4.623 476 662 98 x 10^{-14}	-2.933 596 681 73 x 10^{-16}	....
	c_6 =	5.007 774 410 34 x 10^{-17}	....	....
	c_7 =	-3.731 058 861 91 x 10^{-20}	....	....
	c_8 =	1.577 164 823 67 x 10^{-23}	....	....
	c_9 =	-2.810 386 252 51 x 10^{-27}	....	....

TABLE 7 Polynomial Coefficients for Generating Thermocouple EMF as a Function of Temperature *Continued*

TYPE S Thermocouple

Temperature Range	-50 °C to 1064.18 °C	1064.18 °C to 1664.5 °C	1664.5 °C to 1768.1 °C
c_0 =	0.0	1.329 004 440 85	1.466 282 326 36 x 10^{2}
c_1 =	5.403 133 086 31 x 10^{-3}	3.345 093 113 44 x 10^{-3}	-2.584 305 167 52 x 10^{-1}
c_2 =	1.259 342 897 40 x 10^{-5}	6.548 051 928 18 x 10^{-6}	1.636 935 746 41 x 10^{-4}
c_3 =	-2.324 779 686 89 x 10^{-8}	-1.648 562 592 09 x 10^{-9}	-3.304 390 469 87 x 10^{-8}
c_4 =	3.220 288 230 36 x 10^{-11}	1.299 896 051 74 x 10^{-14}	-9.432 236 906 12 x 10^{-15}
c_5 =	-3.314 651 963 89 x 10^{-14}	....	....
c_6 =	2.557 442 517 86 x 10^{-17}	....	....
c_7 =	-1.250 688 713 93 x 10^{-20}	....	....
c_8 =	2.714 431 761 45 x 10^{-24}	....	....

TYPE T Thermocouple

Temperature Range	-270 °C to 0 °C	0 °C to 400 °C
c_0 =	0.0	0.0
c_1 =	3.874 810 636 4 x 10^{-2}	3.874 810 636 4 x 10^{-2}
c_2 =	4.419 443 434 7 x 10^{-5}	3.329 222 788 0 x 10^{-5}
c_3 =	1.184 432 310 5 x 10^{-7}	2.061 824 340 4 x 10^{-7}
c_4 =	2.003 297 355 4 x 10^{-8}	-2.188 225 684 6 x 10^{-9}
c_5 =	9.013 801 955 9 x 10^{-10}	1.099 688 092 8 x 10^{-11}
c_6 =	2.265 115 659 3 x 10^{-11}	-3.081 575 877 2 x 10^{-14}
c_7 =	3.607 115 420 5 x 10^{-13}	4.547 913 529 0 x 10^{-17}
c_8 =	3.849 393 988 3 x 10^{-15}	-2.751 290 167 3 x 10^{-20}
c_9 =	2.821 352 192 5 x 10^{-17}	....
c_{10} =	1.425 159 477 9 x 10^{-19}	....
c_{11} =	4.876 866 228 6 x 10^{-22}	....
c_{12} =	1.079 553 927 0 x 10^{-24}	....
c_{13} =	1.394 502 706 2 x 10^{-27}	....
c_{14} =	7.979 515 392 7 x 10^{-31}	....

TYPE C Coefficients

t = 0°C to 2315°C	
0°C to 630.615°C	630.615°C to 2315°C
c_0 = 0.0000000	4.0528823 X 10^{-1}
c_1 = 1.3406032 X 10^{-2}	1.1509355 X 10^{-2}
c_2 = 1.1924992 X 10^{-5}	1.5696453 X 10^{-5}
c_3 =−7.9806354 X 10^{-9}	−1.3704412 X 10^{-8}
c_4 =−5.0787515 X 10^{-12}	5.2290873 X 10^{-12}
c_5 = 1.3164197 X 10^{-14}	−9.2082758 X 10^{-16}
c_6 =−7.9197332 X 10^{-18}	4.5245112 X 10^{-20}

TYPE BP Thermoelement vs. Platinum (NIST Pt-67)

Temperature Range	0 °C to 630.615 °C	630.615 °C to 1768.1 °C
c_0 =	0.0	-7.968 043 228 2 ....
c_1 =	4.822 787 568 7 x 10^{-3}	6.394 111 021 3 x 10^{-2}
c_2 =	1.565 116 570 9 x 10^{-5}	-1.710 242 141 0 x 10^{-4}
c_3 =	-2.223 379 788 2 x 10^{-8}	3.055 578 252 7 x 10^{-7}
c_4 =	2.833 324 407 4 x 10^{-11}	-3.210 574 449 2 x 10^{-10}
c_5 =	-2.025 894 044 7 x 10^{-14}	2.090 910 279 4 x 10^{-13}
c_6 =	6.148 870 509 6 x 10^{-18}	-8.233 582 542 6 x 10^{-17}
c_7 =	....	1.782 284 151 5 x 10^{-20}
c_8 =	....	-1.618 707 418 7 x 10^{-24}

TABLE 7 Polynomial Coefficients for Generating Thermocouple EMF as a Function of Temperature *Continued*

TYPE BN Thermoelement vs. Platinum (NIST Pt-67)

Temperature Range		0 °C to 630.615 °C	630.615 °C to 1768.1°C
c_0	=	0.0	-4.074 226 366 2 ....
c_1	=	5.069 295 752 2 x 10^{-3}	3.536 936 274 3 x 10^{-2}
c_2	=	9.747 123 592 0 x 10^{-6}	-8.613 910 931 5 x 10^{-5}
c_3	=	-2.090 800 471 8 x 10^{-8}	1.477 050 236 2 x 10^{-7}
c_4	=	2.676 641 488 3 x 10^{-11}	-1.527 039 962 9 x 10^{-10}
c_5	=	-1.856 448 752 3 x 10^{-14}	9.799 308 780 5 x 10^{-14}
c_6	=	5.518 967 038 6 x 10^{-18}	-3.782 039 439 3 x 10^{-17}
c_7	=	....	7.925 277 432 8 x 10^{-21}
c_8	=	....	-6.807 941 157 8 x 10^{-25}

TYPE JP Thermoelement vs. Platinum (NIST Pt-67)

Temperature Range		-210 °C to 760 °C
c_0	=	0.0
c_1	=	1.791 354 855 9 x 10^{-2}
c_2	=	4.677 466 335 8 x 10^{-6}
c_3	=	-7.122 599 299 1 x 10^{-8}
c_4	=	1.335 212 501 6 x 10^{-10}
c_5	=	-1.500 896 263 9 x 10^{-13}
c_6	=	1.551 431 962 5 x 10^{-16}
c_7	=	-7.950 357 212 5 x 10^{-20}
c_8	=	2.429 790 391 0 x 10^{-24}

Platinum (NIST Pt-67) vs. **TYPE JN** Thermoelement

Temperature Range		-210 °C to 760 °C
c_0	=	0.0
c_1	=	3.246 763 925 6 x 10^{-2}
c_2	=	2.579 837 059 4 x 10^{-5}
c_3	=	-1.445 507 273 0 x 10^{-8}
c_4	=	-1.239 297 209 3 x 10^{-12}
c_5	=	-2.043 995 698 0 x 10^{-14}
c_6	=	5.433 771 071 8 x 10^{-17}
c_7	=	-4.588 038 123 5 x 10^{-20}
c_8	=	1.320 193 530 6 x 10^{-23}

TYPE KP or EP Thermoelement vs. Platinum (NIST Pt-67)

Temperature Range		-270 °C to 0 °C	0 °C to 1372 °C
c_0	=	0.0	0.0
c_1	=	2.581 195 057 4 x 10^{-2}	2.581 195 057 3 x 10^{-2}
c_2	=	2.299 008 894 3 x 10^{-5}	2.683 139 535 5 x 10^{-5}
c_3	=	-6.157 475 446 0 x 10^{-7}	-3.867 519 441 2 x 10^{-8}
c_4	=	-2.327 184 376 5 x 10^{-8}	3.030 555 323 4 x 10^{-11}
c_5	=	-5.457 033 359 6 x 10^{-10}	-1.028 040 353 3 x 10^{-14}
c_6	=	-7.845 394 226 4 x 10^{-12}	-3.448 171 733 0 x 10^{-17}
c_7	=	-7.251 284 060 8 x 10^{-14}	8.251 289 448 0 x 10^{-20}
c_8	=	-4.356 917 479 1 x 10^{-16}	-7.889 338 217 7 x 10^{-23}
c_9	=	-1.664 752 760 6 x 10^{-18}	3.569 925 312 6 x 10^{-26}
c_{10}	=	-3.737 720 750 1 x 10^{-21}	-6.331 536 065 9 x 10^{-30}
c_{11}	=	-3.774 144 269 5 x 10^{-24}	....
c_{12}	=	1.002 535 559 0 x 10^{-27}	....
c_{13}	=	3.893 531 072 5 x 10^{-30}	....

TABLE 7 Polynomial Coefficients for Generating Thermocouple EMF as a Function of Temperature *Continued*

Platinum (NIST Pt-67) vs. **TYPE KN** Thermoelement			
Temperature Range		−270 °C to 0 °C	0 °C to 1372 °C
	c_0 =	0.0	$-1.760\ 041\ 368\ 6 \times 10^{-2}$
	c_1 =	$1.363\ 817\ 745\ 2 \times 10^{-2}$	$1.310\ 925\ 440\ 3 \times 10^{-2}$
	c_2 =	$6.322\ 846\ 542\ 6 \times 10^{-7}$	$-8.272\ 625\ 323\ 0 \times 10^{-6}$
	c_3 =	$2.871\ 584\ 767\ 6 \times 10^{-7}$	$-6.078\ 239\ 846\ 2 \times 10^{-8}$
	c_4 =	$1.828\ 136\ 088\ 7 \times 10^{-8}$	$2.881\ 039\ 039\ 6 \times 10^{-10}$
	c_5 =	$4.781\ 942\ 767\ 9 \times 10^{-10}$	$-5.504\ 480\ 453\ 6 \times 10^{-13}$
	c_6 =	$7.271\ 290\ 952\ 1 \times 10^{-12}$	$5.952\ 323\ 079\ 2 \times 10^{-16}$
	c_7 =	$6.940\ 395\ 331\ 9 \times 10^{-14}$	$-4.027\ 200\ 945\ 1 \times 10^{-19}$
	c_8 =	$4.252\ 401\ 385\ 5 \times 10^{-16}$	$1.760\ 445\ 293\ 3 \times 10^{-22}$
	c_9 =	$1.644\ 863\ 493\ 8 \times 10^{-18}$	$-4.780\ 397\ 440\ 1 \times 10^{-26}$
	c_{10} =	$3.721\ 398\ 052\ 6 \times 10^{-21}$	$6.331\ 536\ 065\ 9 \times 10^{-30}$
	c_{11} =	$3.774\ 144\ 269\ 5 \times 10^{-24}$	....
	c_{12} =	$-1.002\ 535\ 559\ 0 \times 10^{-27}$	....
	c_{13} =	$-3.893\ 531\ 072\ 5 \times 10^{-30}$	....
Exponential Coefficients See NOTE 2	b_0 =	....	$1.185\ 976 \times 10^{-1}$
	b_1 =	....	$-1.183\ 432 \times 10^{-4}$

TYPE NP Thermoelement vs. Platinum (NIST Pt-67)			
Temperature Range		−200 °C to 0 °C	0 °C to 1300 °C
	c_0 =	0.0	0.0
	c_1 =	$1.541\ 798\ 843\ 0 \times 10^{-2}$	$1.544\ 538\ 594\ 7 \times 10^{-2}$
	c_2 =	$2.570\ 738\ 245\ 7 \times 10^{-5}$	$2.672\ 234\ 128\ 9 \times 10^{-5}$
	c_3 =	$-9.018\ 782\ 577\ 1 \times 10^{-8}$	$-2.559\ 531\ 305\ 2 \times 10^{-8}$
	c_4 =	$-5.365\ 479\ 300\ 5 \times 10^{-10}$	$-3.302\ 809\ 741\ 4 \times 10^{-11}$
	c_5 =	$-3.352\ 621\ 597\ 6 \times 10^{-12}$	$2.007\ 532\ 297\ 1 \times 10^{-13}$
	c_6 =	$-7.272\ 344\ 767\ 0 \times 10^{-15}$	$-4.270\ 815\ 423\ 0 \times 10^{-16}$
	c_7 =	....	$5.181\ 347\ 352\ 2 \times 10^{-19}$
	c_8 =	....	$-3.688\ 712\ 493\ 1 \times 10^{-22}$
	c_9 =	....	$1.426\ 873\ 470\ 8 \times 10^{-25}$
	c_{10} =	....	$-2.312\ 130\ 215\ 4 \times 10^{-29}$

Platinum (NIST Pt-67) vs. **TYPE NN** Thermoelement			
Temperature Range		−200 °C to 0 °C	0 °C to 1300 °C
	c_0 =	0.0	0.0
	c_1 =	$1.074\ 111\ 753\ 2 \times 10^{-2}$	$1.048\ 400\ 865\ 5 \times 10^{-2}$
	c_2 =	$-1.474\ 989\ 822\ 9 \times 10^{-5}$	$-1.101\ 219\ 940\ 9 \times 10^{-5}$
	c_3 =	$-3.653\ 285\ 783\ 2 \times 10^{-9}$	$6.942\ 094\ 028\ 9 \times 10^{-8}$
	c_4 =	$4.901\ 358\ 902\ 9 \times 10^{-10}$	$-2.195\ 836\ 005\ 3 \times 10^{-10}$
	c_5 =	$7.222\ 858\ 260\ 4 \times 10^{-13}$	$4.423\ 649\ 636\ 8 \times 10^{-13}$
	c_6 =	$-1.538\ 109\ 323\ 6 \times 10^{-14}$	$-5.792\ 656\ 096\ 4 \times 10^{-16}$
	c_7 =	$-7.608\ 930\ 079\ 1 \times 10^{-17}$	$4.793\ 186\ 547\ 0 \times 10^{-19}$
	c_8 =	$-9.341\ 966\ 783\ 5 \times 10^{-20}$	$-2.397\ 612\ 067\ 6 \times 10^{-22}$
	c_9 =	....	$6.580\ 494\ 631\ 8 \times 10^{-26}$
	c_{10} =	....	$-7.560\ 893\ 996\ 5 \times 10^{-30}$

TABLE 7 Polynomial Coefficients for Generating Thermocouple EMF as a Function of Temperature *Continued*

TYPE TP Thermoelement vs. Platinum (NIST Pt-67)

Temperature Range	−270 °C to 0 °C	0 °C to 400 °C
c_0 =	0.0	0.0
c_1 =	$5.894\ 548\ 229\ 7 \times 10^{-3}$	$5.894\ 548\ 226\ 5 \times 10^{-3}$
c_2 =	$2.177\ 354\ 616\ 7 \times 10^{-5}$	$1.509\ 134\ 765\ 2 \times 10^{-5}$
c_3 =	$2.826\ 761\ 733\ 1 \times 10^{-7}$	$1.385\ 988\ 324\ 2 \times 10^{-7}$
c_4 =	$2.256\ 129\ 063\ 2 \times 10^{-8}$	$-1.827\ 351\ 164\ 9 \times 10^{-9}$
c_5 =	$9.502\ 026\ 902\ 0 \times 10^{-10}$	$1.033\ 635\ 649\ 1 \times 10^{-11}$
c_6 =	$2.412\ 716\ 823\ 3 \times 10^{-11}$	$-3.065\ 826\ 553\ 4 \times 10^{-14}$
c_7 =	$3.910\ 747\ 567\ 8 \times 10^{-13}$	$4.681\ 530\ 823\ 5 \times 10^{-17}$
c_8 =	$4.217\ 403\ 476\ 6 \times 10^{-15}$	$-2.974\ 071\ 681\ 2 \times 10^{-20}$
c_9 =	$3.094\ 671\ 890\ 4 \times 10^{-17}$	$1.474\ 503\ 431\ 3 \times 10^{-24}$
c_{10} =	$1.551\ 930\ 033\ 9 \times 10^{-19}$	$-3.659\ 405\ 308\ 7 \times 10^{-28}$
c_{11} =	$5.235\ 860\ 981\ 1 \times 10^{-22}$	....
c_{12} =	$1.136\ 383\ 791\ 3 \times 10^{-24}$	....
c_{13} =	$1.433\ 054\ 079\ 2 \times 10^{-27}$	....
c_{14} =	$7.979\ 515\ 392\ 7 \times 10^{-31}$	....

Platinum (NIST Pt-67) vs. **TYPE TN or EN** Thermoelement

Temperature Range	−270 °C to 0 °C	0 °C to 1000 °C
c_0 =	0.0	0.0
c_1 =	$3.285\ 355\ 813\ 4 \times 10^{-2}$	$3.285\ 355\ 813\ 8 \times 10^{-2}$
c_2 =	$2.242\ 088\ 818\ 1 \times 10^{-5}$	$1.820\ 088\ 022\ 7 \times 10^{-5}$
c_3 =	$-1.642\ 329\ 422\ 6 \times 10^{-7}$	$6.758\ 360\ 162\ 4 \times 10^{-8}$
c_4 =	$-2.528\ 317\ 078\ 0 \times 10^{-9}$	$-3.608\ 745\ 197\ 5 \times 10^{-10}$
c_5 =	$-4.882\ 249\ 460\ 9 \times 10^{-11}$	$6.605\ 244\ 362\ 3 \times 10^{-13}$
c_6 =	$-1.476\ 011\ 640\ 4 \times 10^{-12}$	$-1.574\ 932\ 377\ 1 \times 10^{-16}$
c_7 =	$-3.036\ 321\ 473\ 1 \times 10^{-14}$	$-1.336\ 172\ 944\ 2 \times 10^{-18}$
c_8 =	$-3.680\ 094\ 883\ 0 \times 10^{-16}$	$2.227\ 815\ 139\ 1 \times 10^{-21}$
c_9 =	$-2.733\ 196\ 978\ 5 \times 10^{-18}$	$-1.474\ 503\ 431\ 3 \times 10^{-24}$
c_{10} =	$-1.267\ 705\ 560\ 5 \times 10^{-20}$	$3.659\ 405\ 308\ 7 \times 10^{-28}$
c_{11} =	$-3.589\ 947\ 524\ 7 \times 10^{-23}$	....
c_{12} =	$-5.682\ 986\ 428\ 0 \times 10^{-26}$	....
c_{13} =	$-3.855\ 137\ 308\ 5 \times 10^{-29}$	....