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THE NICROSIL VERSUS NISIL THERMOCOUPLE: Properties and Thermoelectric Reference Data

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THE NICROSIL VERSUS NISIL THERMOCOUPLE: Properties and Thermoelectric Reference Data

Noel A. Burley,* Robert L. Powell, George W. Burns, and Margaret G. Scroger

This monograph deals with the formulation and development of the new highly stable nickel-base thermocouple alloys *Nicrosil* (Ni–14.2Cr–1.4Si) and *Nisil* (Ni–4.4Si–0.1Mg) under the leadership of the Materials Research Laboratories (MRL) of the Australian Government Department of Defence, and their standardization by the National Bureau of Standards (NBS) of the U.S. Department of Commerce.

In the formulation of the new alloys, the main method was to use basic thermodynamic data to predict the conditions of solute concentration, temperature and oxygen pressure under which certain discrete oxide layers could form on the surface as highly efficacious passivating films. This work was the culmination of extensive research in which thermoelectric instability in existing nickel-base thermocouple alloys was correlated with their physical, chemical and metallurgical properties (section 2).

The basic thermoelectric properties of Nicrosil and Nisil more recently have been the subject of a joint research project between NBS and MRL. The aim of this project, which was conducted under the terms of an Arrangement under the U.S./Australia Agreement relating to Scientific and Technical Co-operation, was to establish a body of standard reference data on the thermoelectric and other properties of the new thermocouple alloys which could be recognized by various standards authorities around the world.

Descriptions of the prototype materials and experimental methods used in the joint research are given in sections 3 and 4, while the mathematical methods used to analyse the experimental results are described in section 5. The principal thermoelectric reference data for Nicrosil and Nisil, comprising tabular values of thermoelectric voltages, Seebeck coefficients and derivatives versus temperature, are given in section 7, while other material characteristics, in particular their highly stable thermoelectric properties, are summarized in section 6.

Key words: Calibration drift; chemical analyses; nickel-base alloys; nickel-chromium alloys; nickel-silicon alloys; oxidation; temperature; thermal electromotive force; thermocouples; thermocouple reference tables; thermoelements; thermometry.

1. Introduction

1.1 Thermoelectric Instability and Material Inhomogeneity

Ideally, a metallic thermocouple will comprise thermoelements which are homogeneous. In this case, which is hypothetical, the thermoelectromotive force output, or thermal emf, is a function only of the finite difference in the temperature of the thermojunctions. and it is dependent upon certain homogeneous characteristics of the individual thermoelements, principally solution composition and metallurgical state. It is thus possible to define thermoelectric properties of homogeneous metals in terms of a single parameter, T, temperature. For example, Mott and Jones [1936][1] have defined the reversible heat given up by a metallic conductor of unit cross-section, when an electric current j flows through a temperature gradient $\delta T/\delta x$ along the conductor, as

$$-\mu j \frac{\delta T}{\delta x} \text{ per unit volume in unit time.}$$

The coefficient 'μ' defined in this way is known as the Thomson coefficient. The Thomson coefficient is used in simply defining a quantity, S, the absolute thermoelectric power of a homogeneous metal, as

$$S = \int_0^T \frac{\mu}{T} dT.$$

In reality, chemical, physical and metallurgical inhomogeneities are invariably generated in both the manufacture and subsequent usage of thermoalloys and, as a consequence, the thermal emf of a practical thermocouple is also a function of temperature distribution along the individual thermoelements. Mathematical treatments of the interaction of temperature-dependent inhomogeneities with longitudinal temperature gradients are not simple [see Fenton, 1969]. The 'inhomogeneity component' of the total thermal emf, which is sometimes called the 'spurious thermal emf', is a prime cause of uncertainty in thermoelectric thermometry. Not only can the spurious emf vary indeterminately with short-term temporal variations in the longitudinal temperature distribution, but it can also change in a gradual and insidious way as long-term environmental interactions produce cumulative changes in material composition.

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[1] References cited are listed on page 100.

Thus it can be said that in the use of existing base-metal thermocouples, or in the development of new more stable varieties, inhomogeneities of various kinds must be obviated at all costs. This is easier said than done as the causes of inhomogeneity are many and varied. For example, compositional inhomogeneities include those caused by the local segregation of component or impurity elements in alloy manufacture, the absorption of materials from the environment by solution or by chemical combination, the loss of constituents by selective evaporation or chemical interaction, and the solution of elements produced by nuclear transmutation. Again, inhomogeneous metallurgical states can be caused by such phenomena as the thermal relief of residual internal stresses due to mechanical working, as well as structural ordering and recrystallization. Further, the effects of various physical phenomena such as magnetic fields and nuclear radiation cannot be ignored.

Of the base-metal thermocouples commonly used for temperature measurements up to about 1000 °C, the nickel-base alloy varieties presently designated 'Type K' [2] by the American National Standards Institute [ANSI, 1964] are the most versatile. Indeed, their use at the higher end of the temperature range is almost universal because they possess the best combination of such desirable properties as calibration accuracy and stability, oxidation resistance, high thermal emf, and reasonable cost. Type K alloys have been in widespread use for pyrometric measurement and control in scientific and industrial applications for well over half a century. Their thermoelectric stability in air at elevated temperatures has, over the years, been carefully studied by a number of workers, notably Dahl [1941], Hughes and Burley [1962], Potts and McElroy [1962], Starr and Wang [1963], Burley and Ackland [1967], Fenton [1969], and Burley [1969, 1970, 1972]. In complementary summary, their work provides cumulative evidence that the accuracy of thermocouples of Type K materials can be significantly impaired by two characteristic types of change which can occur in their temperature/thermoelectromotive force characteristics, namely

(i) a gradual and generally cumulative drift in thermal emf on long exposure at high temperatures: and

(ii) a short-term change in thermal emf on heating in the temperature range ca. 250 to 550 °C.

Burley [1969, 1972] has demonstrated that the long-term emf drifts are caused by the development of compositional inhomogeneities as reactive solutes are depleted chiefly by oxidation, in particular by internal oxidation. Fenton [1969] and Burley [1970] independently have adduced much circumstantial evidence in support of a hypothesis that the short-term emf changes are due to short-range ordering in the Ni–Cr atomic structure of the Type KP thermoelement.

1.2 Case for and Development of a New Base-Metal Thermocouple System

For some considerable time a justifiable case has existed for the development of a new base-metal thermocouple system having enhanced environmental, structural, and hence thermoelectrical stabilities. In science and industry, for example, temperature measurements above 1000 °C, especially in the range 1000 to 1300 °C, have become increasingly commonplace in recent times. On the other hand, informed but disinterested opinion [e.g. Bedford, 1964] has it that, for reliable and continuous thermocouple measurements of temperature above 1000 °C, one is restricted to the use of noble metals and alloys composed of them [see also Powell et al., 1974]. Again, for example, in the range of temperatures (250 to 550 °C) where the short-term structure-dependent drifts in the thermal emf of Type K thermocouples reach maximum magnitudes, tolerances on specified process temperatures in technological applications tend toward their most critical values. If the calibration stability, upper operating temperatures, and useful lives of base-metal thermocouple alloys could be significantly increased, considerable advantages would accrue. Not only would there be engendered a higher level of confidence in temperature measurement and control associated with various critical applications such as are found, for instance, in the aerospace, nuclear, and semi-conductor industries, but considerable scope would exist for cost reduction in industry in general, particularly where the maintenance, inspection, and calibration of thermocouple-actuated pyrometric installations are concerned.

It has been shown [Burley, 1972] that the long-term thermoelectric stability of nickel-base thermocouple alloys can in fact be significantly enhanced, particularly at temperatures above 1100 °C, by increasing alloy solute levels above those required to cause a transition from internal to external modes of oxidation, and by selecting solutes which preferentially oxidize to form impervious diffusion-barrier films. Furthermore, the short-term emf changes can virtually be eliminated by the choice of higher solute levels at which this structure-dependent effect is not evident. Based upon these considerations, and following an extensive program of research at the Defence Standards Laboratories of the Australian Government Department of Supply (now the Materials Research Laboratories of the Australian Government Department of Defence) in cooperation with major manufacturers of base-metal thermocouple alloys both in the U.S.A. and in Europe, two new nickel-base alloys for thermocouples have been developed. These alloys, at present called Nicrosil (Ni–14.2% Cr–1.4% Si) and Nisil (Ni–4.4% Si–0.1% Mg) are shown [Burley, 1972: and this Monograph] to be more resistant to

[2] The compositions of typical examples of various Type K alloys at present available are given in Table 1.1.1. Alloy compositions quoted in this Monograph are expressed as percentages by weight, unless specifically noted as atomic percent (ao).

Table 1.1.1 *Typical compositions of various Type K alloys presently available [after Burley, 1972]*

Alloy	Composition, wt.—%[a]									Variety
	Cr	Mn	Al	Si	Co	Nb	Fe	Ni	Traces of Other Elements	
Positive (Type KP)	9.2_0	T	ST	0.2_5	P		T	bal	Mg, Mo, Zn, Sn	Conventional (Lower Si)
	9.3_4	T	T	0.2_6	0.2_0	ST	T	bal	Mg, Mo, Cu, Ca	
	9.3_5	T	FT	0.4_5	0.1_5	ST	ST	bal	Mg, Cu, Ca, Zr	Conventional (Higher Si)
	9.3_1	T	FT	0.4_6	ST		0.1_7	bal	Mg, Mo, Cu, Ca, Zr	
	9.3_1	ST	FT	0.3_5	ST	0.2_2	0.3_5	bal	Mg, Mo, Cu, Ca, Zr	Special Conventional (Nb bearing)
Negative (Type KN)	ST	2.8_7	1.9_6	1.1_5	0.4_9		T	bal	Mg, Cu, Ti, Pb	Conventional
	T	2.7_8	1.8_0	1.0_2	P		T	bal	Mg, Cu, Zn, Pb	
	ST	1.6_7	1.2_5	1.5_6	0.7_2		T	bal	Mg, Mo, Cu, Ca, Pb	Modified Conventional (Mn and Al decreased) Si and Co increased)
	ST	0.3_7	T	2.3_9	0.3_1		ST	bal	Mg, Cu, Ca, Pb	
	ST	ST	FT	2.5_0	1.0_0		0.2_3	bal	(Cu-2.2_2) Mg, Ca	Special Conventional (Mn and Al eliminated, Si and Co increased)
	ST	FT	0.1_3	2.5_8	ST		ST	bal	Mg, Ba, Cu, Ca, Pb	Special Conventional (Mn and Co eliminated, Al reduced, Si increased)

[a] The numerals refer to chemical analysis and the symbols to spectrographic analysis as follows: P = 0.1–0.5%; ST = 0.05–0.1%; T = 0.01–0.05%; FT < 0.01%.

air oxidation, to be usable at higher maximum temperatures, to be substantially freer of the effects of structural ordering and, as a consequence, to have much higher thermoelectromotive force stability than existing nickel-base thermocouple alloys.

1.3 Thermoelectric Reference Data for Nicrosil/Nisil: Joint NBS-DSL Research Program

Subsequent to the research and development work on Nicrosil and Nisil by the Defence Standards Laboratories, and to the presentation of a paper on the subject [Burley, 1972] to the Fifth Temperature Symposium held in Washington, D.C., in June, 1971, a collaborative research program between the Defence Standards Laboratories of the Australian Department of Supply and the National Bureau of Standards of the U.S. Department of Commerce was instigated. The purpose of this arrangement was to facilitate intensive studies of the thermoelectric and certain other properties of the new alloys, in particular the dependence of the thermoelectromotive force characteristics upon temperature and other factors such as solute concentration and structural state. The aim of the joint project, which was bilaterally sponsored by the Australian Department of Science and the U.S. National Science Foundation under the auspices of the U.S./Australia Agreement for Scientific and Technological Co-operation (1968), was to make possible the formulation of reference data on the thermoelectric and other properties of the new alloys which could be recognized by various standards authorities around the world. The venue for the experimental program concerned with temperatures from ambient up to 1300 °C was the Heat Division of the Institute for Basic Standards, National Bureau of Standards, Gaithersburg, Maryland, whilst the sub-ambient temperature work down to 4 K was carried out at the Cryogenics Division of the Institute, Boulder, Colorado. The results of the experimental program are largely embodied in the later sections of this Monograph, whose authors were the principal scientific collaborators in the joint project.

Various manufacturers of base-metal thermocouple alloys around the world played important roles in both the developmental and standardization phases of the Nicrosil/Nisil project, in particular, the Wilbur B. Driver Company made a significant contribution to the formulation of the negative alloy, Nisil (ref. section 2.2.3). Experimental and prototype alloys have been supplied at various times by—

Driver-Harris Company, Harrison, New Jersey
Hoskins Manufacturing Company, Detroit, Michigan
Wilbur B. Driver Company, Newark, New Jersey
British Driver-Harris Company, Stockport, Cheshire
Bulten-Kanthal A.B., Hallstahammar, Sweden

All these companies produced prototype alloys to rigid chemical specifications for the standardization phase of the project. These alloys, which were supplied in wire form, invariably were of excellent quality so that the data that emerged from the experimental program were of a most consistent nature.

Also of note is the significant interest in the project displayed by the American Society for Testing and Materials (ASTM) through its Committee E20 on Temperature Measurement. The E20 Sub-Committee concerned with Newer Thermocouple Materials has kept the development of Nicrosil and Nisil continually under review since 1971, both in its formal bi-annual meetings and through informal discussions with the scientists collaborating in the project.

2. Development of Nicrosil and Nisil Thermocouple Alloys

2.1 The Environmental, Structural and Physical Instabilities of Existing Nickel-Base Thermocouple Alloys

As mentioned in section 1, existing nickel-base thermocouple alloys of Type K possess the best combination of essential properties of all the standard base-metal thermocouple alloys. They do, nevertheless, have certain significant shortcomings related to environmental, structural, and physical instabilities that cause thermoelectric instability. The more important of these effects[3] are described in some detail in the following sub-sections.

2.1.1 Oxidation

While existing nickel-base thermocouple alloys are prone to react deleteriously with a number of normal environmental substances, the chief deteriorative process whereby compositional inhomogeneities are produced is high-temperature air oxidation. Burley [1972] has described the general characteristics of the air oxidation of both the positive and negative conventional Type KP and KN alloys. These processes can be summarized briefly as follows—

On prolonged exposure in air at temperatures in the region of 800 to 1000 °C, several oxide layers of differing morphology are formed. This behavior is characterized in both alloys by the production of:

(i) an outer scale layer of nickelous oxide, NiO, which also appears in one or more of the intermediate layers, the innermost of which may be saturated with various solute ions and is porous. It forms principally at the scale/air interface as a result of the outward diffusion of nickel ions (Ni^{2+}) through vacancies in the defective cation sub-lattice of NiO;

(ii) an internally oxidized zone in which precipitates of oxides of the solute elements appear distributed in a solute-depleted alloy matrix. These precipitates are to some extent concentrated at the grain boundaries. This process arises from the dissolution of atomic oxygen at the metal/scale interface. In the positive alloy the internal oxide precipitates are predominantly Cr_2O_3, while in the negative alloy they are predominantly MnO_2 and Al_2O_3; and

(iii) ternary oxides of the spinel type AB_2O_4 which appear in the inner layers of the scale as the result of solid-state reactions between internal oxide precipitates and the NiO of the external scale. This occurs as the inner porous zone of the external scale advances inwards to take the place of the alloy matrix consumed in scale formation. In the Type KP alloy the spinel is $NiCr_2O_4$, while in the Type KN alloy it is predominantly $NiAl_2O_4$. In addition, small quantities of other complex spinel-type oxides of the several components of the Type KN alloy, e.g., $MnAl_2O_4$, $MnCo_2O_4$, as well as Ni_2SiO_4, form in the inner scales.

The existence of these zones of oxidation is clearly evidenced in figure 6.2.1. The most devastating of these three closely related oxidation processes, in producing compositional inhomogeneities in the underlying alloy, is internal oxidation. A more detailed examination of this process, in particular to show how it leads to thermal emf drift in Type K thermocouple alloys, is worthwhile.

The phenomenon of internal oxidation occurs in the oxidation of dilute solid-solution alloys composed of a base metal such as silver, copper, nickel or iron, and a small amount of one or more of less noble alloying elements such as indium, beryllium, chromium, manganese, silicon, aluminum, or zirconium. When such an alloy is exposed to an oxidizing atmosphere at high temperatures, particles of alloying element oxide are observed to precipitate at an advancing reaction front in a matrix of the base metal immediately below the external surface or an external scale. The conventional nickel-base thermocouple alloys of Type K are typical examples of such alloys, four of the solute elements mentioned above being major constituents.

Rapp [1965] has given an extensive review of the kinetics, microstructures and mechanisms of high-temperature internal oxidation in binary alloys. During the isothermal and isobaric oxidation of a binary alloy, the following criteria are considered necessary for the occurrence of internal oxidation—

(a) the free energy of formation (per mole of oxygen) for the solute metal oxide in the bulk alloy must be more negative than the cor-

[3] When selecting for discussion the more important deteriorative effects that occur in the 'normal' use of Type K thermocouples, consideration was given to the restrictions placed on their use by ASTM [1974]. They should not be used in sulfurous, reducing, or alternately reducing and oxidizing atmospheres unless suitably protected with protecting tubes. They should not be used in vacuum (at high temperatures) for extended times because the chromium in the positive thermoelement vaporizes out of solution and alters the calibration. They should also not be used in atmospheres that promote the well known "green-rot" type of corrosion in chromium-bearing alloys (those with low, but not negligible, oxygen content).

responding energy of formation of the lowest oxide of the base metal;

(b) the free energy for the reaction of dissolved oxygen with solute to form the solute metal oxide in the solvent lattice must be negative;

(c) the pure solvent metal must exhibit a significant solubility and diffusivity for atomic oxygen in its lattice at the temperature of oxidation, if the required activity of dissolved oxygen at the reaction front is to be achieved;

(d) the solute metal content of the bulk alloy must be lower than that required to cause a transition from internal to external oxidation; and

(e) at the onset of oxidation any surface film, naturally or artificially produced, must not prevent the dissolution of oxygen in the base metal.

An examination of available data on free energies, diffusivities, etc. relevant to the conventional nickel-base thermocouple alloys confirms that in their case the above criteria are all met. Thermoelements made from these alloys will thus be prone to deterioration by internal oxidation during normal usage, and will hence exhibit a corresponding degree of thermal emf drift.

In the oxidation of binary alloys, Rapp and coworkers [e.g. Rapp, 1965; Rapp et al, 1966] have derived equations describing the kinetics for the simultaneous formation of an internal oxidation zone and an external scale. These equations predict the presence of substantial concentration gradients for both diffusing species, oxygen and solute metal, in the vicinity of the internal reaction front. From these it can be inferred that there will be substantial depletion of solutes, not only in the base-metal beneath the inner margin of the internally oxidized zone as components of the alloy diffuse outwards to the internal reaction front, but also within the internally oxidized zone itself. In relation to the former, Burley [1969] has quantitatively estimated the degree of solute depletion beneath the internally oxidized zone in Type K alloys using a coupled electron microprobe/computer technique. Typical concentration profiles of, for example, chromium in an oxidizing Type KP alloy are shown in figure 2.1.1.1. In relation to the latter, Rapp [1965] has calculated that for all dilute binary nickel-chromium alloys with mole fractions of chromium in the bulk alloy < 0.1 the concentration of chromium remaining in solution at the interface of the internally oxidized zone and the external scale should be approximately 1 in 10^8, regardless of initial alloy content.

Some examples of the nature and magnitudes of thermal emf drifts caused by the depletion of solutes in oxidizing Type K thermocouple alloys are given in figures 2.1.1.2 and 2.1.1.3.

2.1.2 Atomic Ordering

Little appears to be known about the basic cause of the anomalous thermal emf drifts of a short-term

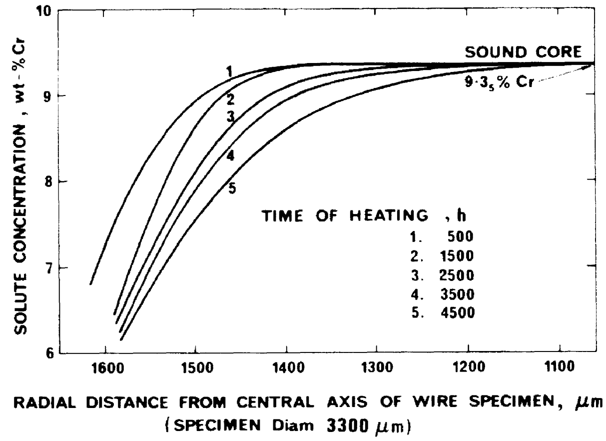

FIGURE 2.1.1.1 *Concentration profiles of chromium in the zone of solute depletion in a conventional Type KP thermoelement after heating in air at 950 °C for the indicated times.*

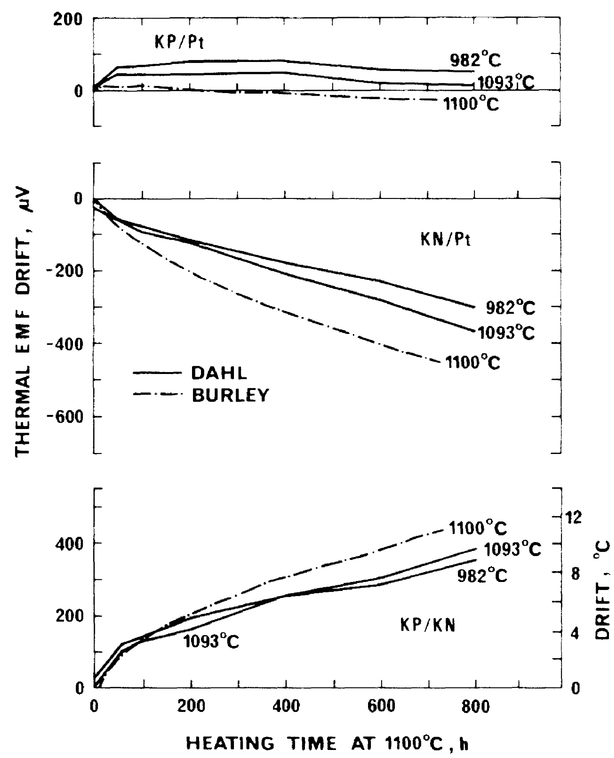

FIGURE 2.1.1.2 *Thermal emf drifts in conventional Type K thermocouples and in their* AWG 8 *thermoelements versus platinum on isothermal exposure in air at 1100 °C.*
Drift magnitudes are measured at the test-temperatures shown [after Dahl, 1941; and Burley, 1972].

reversible nature, referred to in section 1.1, which occur in Type K alloys when heated in the temperature range ca. 250 to 550 °C. These emf changes, whose magnitude is dependent upon previous thermal history, and upon the time and the temperature of heating in this temperature range, can substantially increase the emf output of Type K thermocouples. On initial heat-

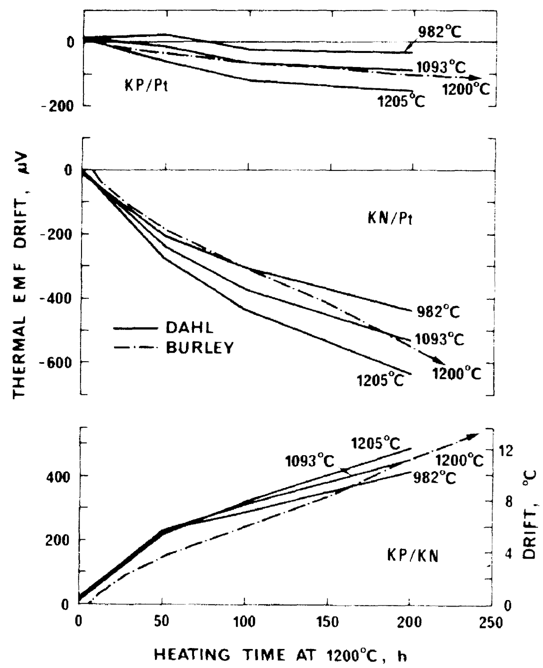

FIGURE 2.1.1.3 *Thermal emf drifts as in figure 2.1.1.2, but after exposure at 1200 °C.*

ing, 'as-received' Type K thermocouples commonly increase their thermal emf outputs by the equivalent of up to 3 °C: this increase is due almost entirely to a change in the emf of the Type KP thermoelement (see figure 2.1.2.1). Fenton [1969], for example, has observed an increase of about 0.6 $\mu V\ °C^{-1}$ in the thermoelectric power of a Type KP thermoelement as a result of heating for 30 days at 340 °C (see figure 2.1.2.2). This increase corresponds to a change in the thermocouple output equivalent to about 5 °C.

The alpha Ni–Cr alloys, which include the Type KP thermocouple alloys, are known to show anomalous deviations in physical and mechanical properties from those expected of a 'simple' solid solution. The weight of evidence seems to favor short-range ordering as the most likely common cause of these anomalous behaviors. Nordheim and Grant [1954], for instance, found that in the temperature range ca. 280 to 430 °C the electrical resistivity of Ni–10Cr increases toward an equilibrium value which is independent of thermal history. They contend that the absence of superstructure lines in their patterns of x-ray diffraction analysis and also the dependence of the magnitude of the effect upon temperature both support a theory of short-range order. Their conclusion is supported by Dehlinger [1962] who showed on theoretical grounds that the development of short-range order can cause a small increase in the resistivity of solid solutions. The development of long-range order in an alloy, on the other hand, is usually accompanied by a resistivity decrease [Schüle and Colella, 1969]. Again, Stansbury et al [1966] have shown that an anomalous increase of about 6 to 10 percent in specific heat occurs in Ni–10Cr and Ni–20Cr in the range 500 to 600 °C. They conclude that since the peak in the anomaly occurs at the same temperature for alloys of different chromium contents, short-range order is the cause. In long-range order, the temperature of the peak in the specific heat curve should decrease with a decrease in chromium content. The short-term cyclic anomalies in the thermal emf of Type KP alloys are consistent in nature and thermal dependence with the anomalies in electrical resistivity and specific heat in Ni–10Cr. It seems reasonable, therefore, to attribute these emf anomalies as well to short-range ordering.

Nordheim's and Grant's results [1954] can also be used to deduce the time-temperature dependences of the emf changes in Type KP alloys which are related to short-range order. Specifically, it is possible to obtain estimates of the times taken by Ni–10Cr to reach equilibrium resistivity values, at any temperature in the range 280 to 500 °C, after water-quenching from 980 °C. This is done by cross-plotting Nordheim's and Grant's results for Ni–11Cr, which are summarized in figure 2.1.2.3, to produce figure 2.1.2.4 which shows time-to-equilibrium resistivity as a function of the temperature for Ni–11Cr. Assuming that the equilibrium resistivity values relate to an equilibrium structural state of a particular degree of short-range order, figure 2.1.2.4 can also be used to estimate the times required for the thermal emfs of Type KP thermoelements to reach a stable value related to the same degree of short-range order. Values so derived are con-

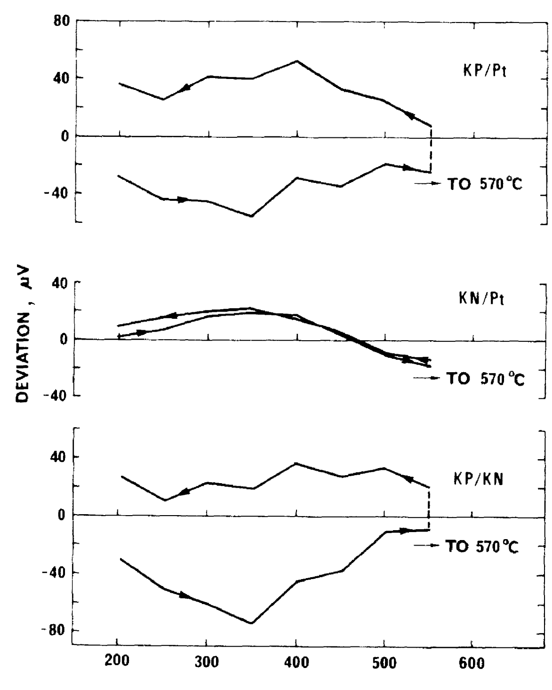

FIGURE 2.1.2.1 *Thermal emf deviations from standard tables for a typical conventional Type K thermocouple and for its AWG 8 thermoelements versus platinum, as measured during initial heating to 570 °C and during subsequent cooling to room temperature [after Burley, 1970].*

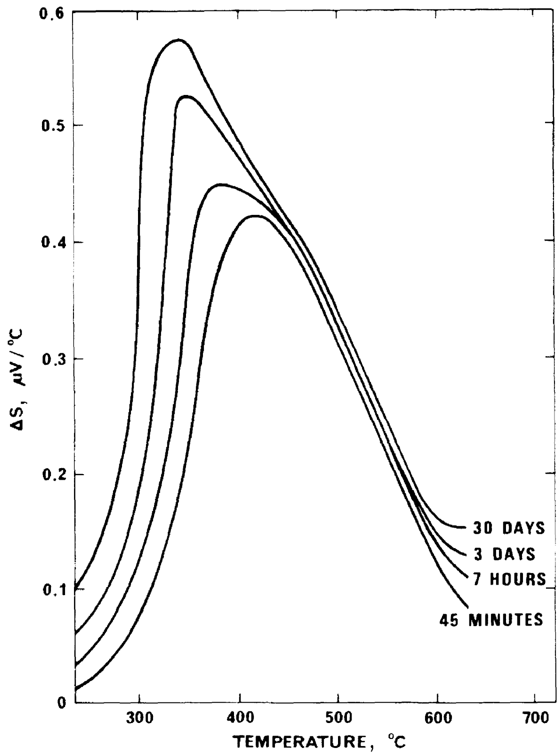

FIGURE 2.1.2.2 *Changes in the thermoelectric power* (ΔS) *of a typical Type KP thermoelement versus platinum on initial heating, as a function of the aging temperature for the indicated times* [*after Fenton, 1969*].

sistent with the results of Fenton [1969], as summarized in figure 2.1.2.2, who measured corresponding changes in Type KP thermoelements directly.

The significance of these observations to the practical use of Type K thermocouples is worth examining. It can be seen that when a Type KP (Ni–9½Cr) thermoelement is heated so that any part of its length attains temperatures up to about 500 °C, it will experience time-temperature-dependent changes in thermal emf output whose net magnitude is a function of inhomogeneous change in the degree of short-range order existent in the 'initial' structure prior to heating. From figures 2.1.2.3 and 2.1.2.4, it may be inferred that the atomic structural changes which produce the resistivity and thermal emf changes in Type KP alloys are virtually time-independent in the temperature range 450 to 575 °C. The 'initial' degree of short-range order will thus be critically dependent upon the rate of cooling from some higher temperature through this virtually time-independent range. The maximum possible emf change will relate to a structural change from a disordered state to some temperature-dependent maximum degree of short-range order. The time required to establish this maximum order will depend only upon the aging temperature. In practice, a Type KP thermoelement operating in a temperature gradient could achieve a quasi-stable emf output in the first few hours, but additional insidious drifts in emf could occur over much longer periods due to the low rates of ordering characteristic of the lower temperatures in the gradient. Furthermore, if the relationship between the temperature gradient and the resultant ordering inhomogeneities was subsequently altered, for example by a change in the temperature or in the depth of immersion of the thermoelement, relative differences in emf output of a cyclic nature, up to the equivalent of about 3 °C, could result.

The exact nature of the atomic ordering processes alluded to in this section is yet to be determined. To this end a joint research program has been set up between the Materials Research Laboratories of the Australian Government Department of Defence and the Research Establishment of the Australian Atomic Energy Commission. Neutron diffraction techniques are being applied to polycrystalline samples of Type KP and Nicrosil-type alloys, and to their single-crystal counterparts of both naturally abundant and mono-isotopic composition, in an effort to elucidate the problem. The possibility that the short-range order in question is of magnetic origin is being investigated.

2.1.3 Magnetic Effects

The conventional negative thermoelement of the Type K thermocouple, the Ni–Mn–Al–Si–Co alloy known as KN of which examples are given in table 1.1.1, has a magnetic transformation which occurs at about 170 °C [Powell et al, 1974]. The actual transformation temperature, in the range 150 to 200 °C, depends upon composition. Since the composition of conventional Type KN thermoelements varies significantly from batch to batch, so does the transformation temperature. The magnetic transformation causes a measurable change in the Seebeck coefficient within about 200 °C of the transformation temperature. This perturbation in Seebeck coefficient was taken into account, however, in the recent revision of the NBS reference tables for Type K thermocouples [Powell et al, 1974], so that uncertainty in temperature measurement from this cause is minimized.

Of greater concern in the use of Type K thermocouples, therefore, is the limitation imposed by the effects produced when these devices are used in the presence of unavoidable magnetic fields. Little seems to be known about the basic influence of magnetic fields on the output thermovoltages of conventional Type K thermocouples, but the phenomenon cannot be ignored on that account. According to Loscoe and Mette [1962], for example, considerable errors in thermocouple measurements can occur in magnetic fields, and it is possible for the extraneous thermovoltages produced by the field to exceed those due to substantial differences in the temperatures of the thermojunctions.

Loscoe and Mette demonstrated that the extraneous 'thermomagnetovoltages' produced in the individual thermoelements, when they were exposed to temperature gradients in a magnetic field, were of two different kinds. The first is independent of the direction of the field while the other is dependent on field direc-

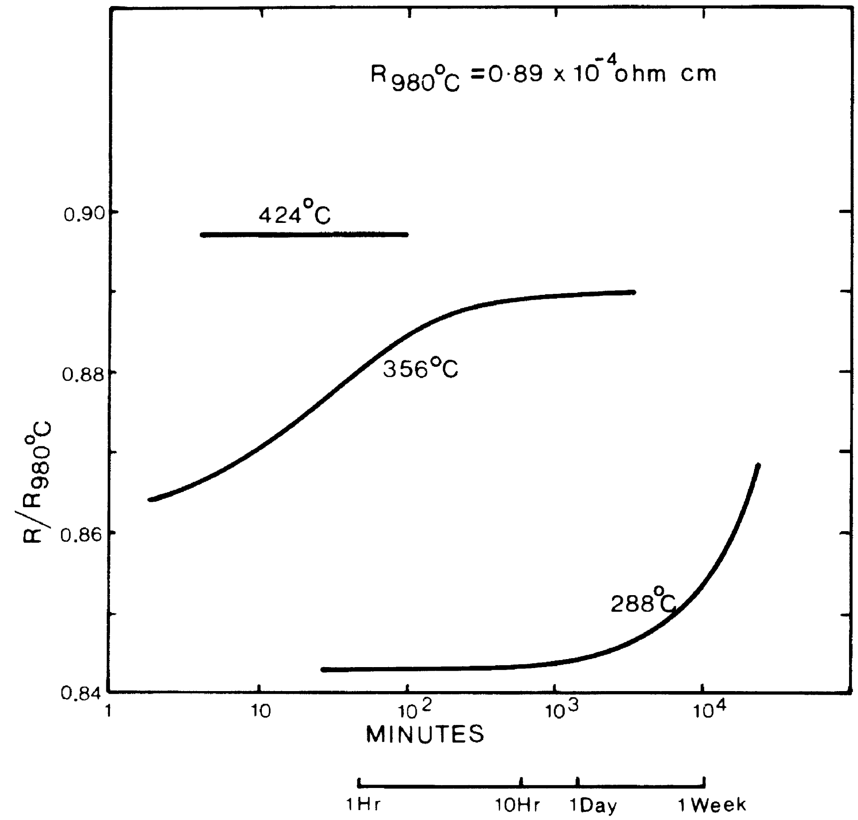

FIGURE 2.1.2.3 *Changes in electric resistivity of* Ni–10.9Cr *during isothermal aging at the indicated temperatures after water-quenching from 980 °C [after Nordheim and Grant, 1954].*

tion. In the first effect, a thermoelement in which a longitudinal temperature gradient exists exhibits an extraneous voltage component when exposed to a magnetic field. It is equivalent to a thermal emf generated in the same temperature gradient by a thermocouple comprising two identical thermoelements, one magnetized and the other not. The thermal emf is then equal to $S(a,a_m)\Delta T$ where $S(a,a_m)$ is the thermoelectric power between the magnetized and unmagnetized materials and ΔT is the temperature difference between the hottest and coldest points in the thermocouple in the magnetic field. In the second effect, with a magnetic field perpendicular to a diametral temperature gradient, a voltage appears at the ends of the thermoelement. This is equivalent to a Nernst effect with the magneto voltage equal to $B(\Delta T/\Delta y)Hb$, where B is the Nernst coefficient, $\Delta T/\Delta y$ is the transverse temperature gradient in a wire sample of diameter b, and H is the magnetic field strength.

In spite of its potentially large size, the first effect may be of little concern if it is possible to reverse the magnetic field: then the effect is eliminated provided the field strength is constant in either direction. On the other hand, the second effect is very difficult to eliminate because it reverses with the field. It can be minimized, however, by an appropriate choice of materials, namely those for which the ratio of their Nernst coefficient to their heat conductivity is small. Unfortunately, this implies a considerable limitation upon the use of Type K thermocouple materials in magnetic fields since, of the common base-metal thermoelements, the small-ratio condition appears to be least fulfilled by the Type KN alloys.

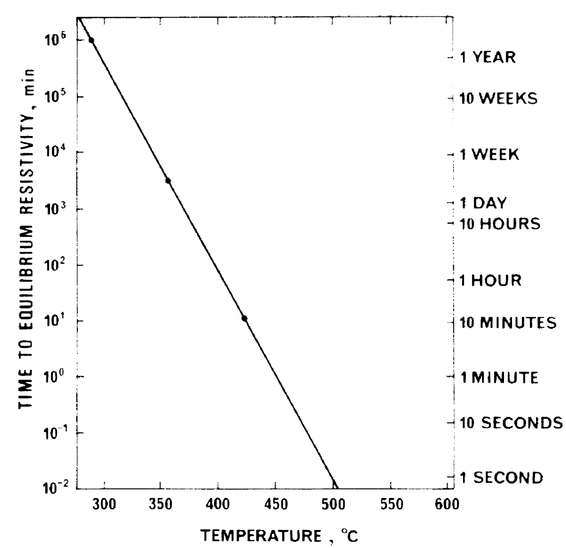

FIGURE 2.1.2.4 *Time-temperature dependence of equilibrium resistivity values in* Ni–10.9Cr *during isothermal aging after water-quenching from 980 °C [after Nordheim and Grant, 1954; and Burley, 1972].*

2.1.4 Nuclear Irradiation

Type K thermocouples are used extensively in nuclear reactors in applications where irradiation by neutrons is possible. The effects of neutron irradiation on thermocouple alloys have been studied in different ways by various workers. Browning and Miller [1962], for instance, have calculated radiation induced changes in composition (transmutations) in Type K thermocouple alloys, for irradiations in a thermal neutron flux of 1×10^{14} n cm^{-2} s^{-1}, for periods up to 20 years. Their results are summarized in figure 2.1.4.1, from which it can be inferred that the Type KP alloys apparently are stable in a neutron environment as neither nickel nor chromium undergoes significant radioactive decay. On the other hand the Type KN alloys appear to be inherently less stable in that they experience significant increases in their iron and copper contents, and decreases in their cobalt and manganese contents.

Since it is possible that the neutron flux will vary over the length of the thermocouple cable in an operating reactor, neutron-induced transmutations may produce chemical inhomogeneity, particularly in the negative thermoelement. The extent to which such compositional inhomogeneities cause cumulative calibration changes in Type K thermocouples in nuclear environments will depend on the nature of the temperature gradients in which they occur. Various workers [e.g. Kelley et al, 1962; Markina et al, 1971] have made quantitative observations of integral changes in the thermal emf of Type K thermocouples, which they ascribe to neutron-induced transmutations. Such changes in emf appear to reach several hundred microvolts.

Transmutations are only one of the possible effects of nuclear irradiation upon materials. There are also various solid-state effects [Billington, 1958] which could be expected to produce changes in materials which do not undergo transmutation. Markina et al [1971] have observed, for example, instantaneous variations in the thermal emf of Type K thermocouples upon neutron irradiation, which they ascribe to variations in electronic state of the materials at the moment of irradiation. These latter phenomena seem little understood and it is disconcerting that Markina et al have demonstrated that such effects can cause thermal emf changes in Type K thermocouples several times larger than those due to transmutations.

2.2 Formulation of the Nicrosil and Nisil Thermocouple Alloys

This section describes the conceptual and theoretical rationale for the formulations of Nicrosil and Nisil thermocouple alloys whose compositions are—

Nicrosil (positive) : Ni–14.2Cr–1.4Si
Nisil (negative) : Ni–4.4Si–0.1Mg

2.2.1 General

In the formulation of materials for a new base-metal thermocouple system which is required to show

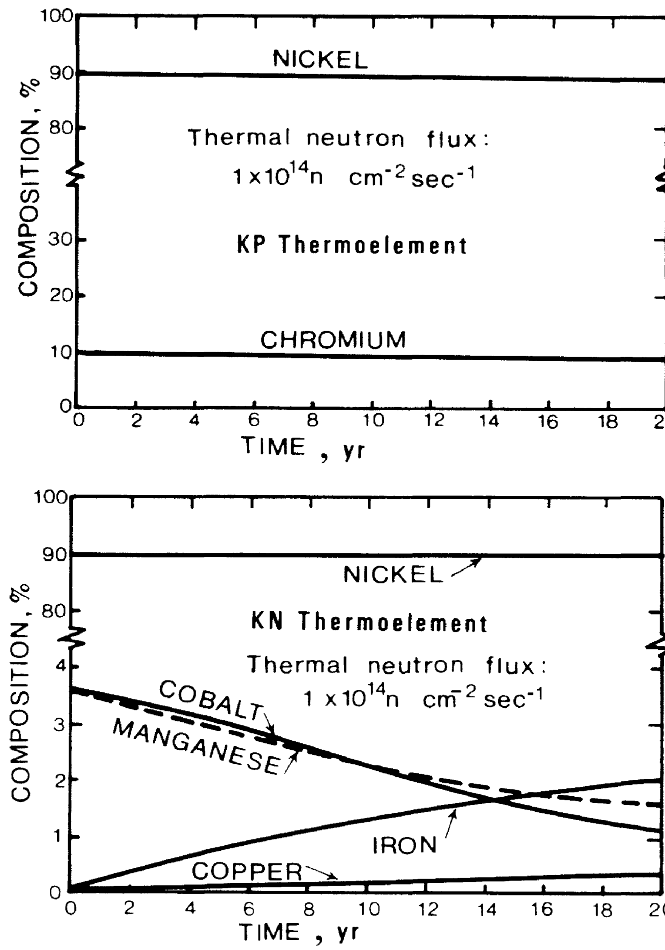

FIGURE 2.1.4.1 *Calculated composition changes in Type KP and KN thermoelements caused by neutron-induced transmutations [after Browning and Miller, 1962].*

markedly enhanced thermoelectric stability in air, particularly at high temperatures, there are sound reasons for retaining nickel as the base metal for both the positive and negative alloys, and chromium and silicon as the major solutes.

Nickel and nickel-chromium alloys, in addition to their economic and metallurgical advantages, have most desirable thermoelectric properties. The addition of a Group VI transitional element such as chromium causes the absolute thermoelectric power of nickel, which is negative, to move strongly in the positive direction. In the case of chromium large positive emf maxima are reached in the compositional range of most interest. From the thermoelectric standpoint, therefore, certain of the alpha nickel-chromium alloys are inherently suitable as positive thermoelements. Furthermore, the ability of silicon to form stable, continuous, and impermeable oxide layers at the metal/scale interface in oxidizing nickel-chromium alloys is of considerable significance to their environmental and thermoelectrical stability. In such circumstances silicon alters the oxygen kinetics in such a way that the oxidation processes described in section 2.1.1 are retarded. The mechanisms involved do not appear to be completely understood, but scales in such alloys are observed to contain silica in the form of alpha cristobalite [Gil'dengorn and Rogel'berg, 1964; Lowell, 1973] with the main concentration occurring at the metal/scale interface. It seems likely that such films act to greatly hinder the diffusion mechanisms essential to the formation of the various oxide layers in nickel-chromium and, in particular, to inhibit internal oxidation.

2.2.2 Nicrosil

Whilst there are sound reasons for retaining both chromium and silicon as the major solute elements in a preferred nickel-base positive thermoelement, there are equally sound reasons for asserting that the concentrations (ca. 9½Cr, ½Si) of these elements in conventional Type KP thermoelements are by no means optimum. As shown in section 2.1, the environmental and structural instabilities of the conventional Type KP alloys are related primarily to their compositional characteristics. In what way, then, should the solute levels of chromium and silicon be changed?

At the outset it is important to note that, as shown by Burley [1970], the differences between thermal emf outputs corresponding to atomically ordered and disordered states in Ni–10Cr are of opposite algebraic sign to those in Ni–20Cr. An increase in the chromium content from 10 to 20 percent reverses the direction of emf change due to short-range ordering from positive to negative. Burley concluded that in this compositional range there is a 'neutral' alloy which is thermoelectrically stable from the atomic ordering point of view. He has further demonstrated [Burley, 1972], as shown in figure 2.2.2.1, that while the exact composition is temperature dependent this neutral alloy contains about 15½ percent chromium in binary solid solution. It is fortuitous that an increase in chromium content to, say, 15 percent would also significantly enhance the oxidation resistance of the alloy.

Recent studies of the composition dependence of the parabolic rate constants in the oxidation of Ni–Cr [e.g. Giggins and Pettit, 1969] have shown that in the temperature range 800 to 1100 °C the addition of chromium to nickel up to about two percent increases the rate constant, that this rate remains substantially the same with further chromium additions up to about ten percent, but that with additions beyond ten percent the rate is substantially reduced. These results are summarized in figure 2.2.2.2. Reference to the nickel-rich zone of the 1000 °C isothermal section of the Ni–Cr–O equilibrium diagram [Croll and Wallwork, 1969] suggests that about 10 percent chromium is the transition composition at which the spinel $NiCr_2O_4$ gives way to Cr_2O_3 as the stable oxide in Ni–Cr alloys. In alloys of 15 percent chromium, the tendency at these temperatures for Cr_2O_3 to form as a continuous passivating layer at the metal/scale interface, instead of as an internal oxide precipitate as in the lower-chromium alloys, has been proposed [Wood and Hodgkiess, 1966] as the major reason for their increased oxidation resistance. Since, as a rule, high-

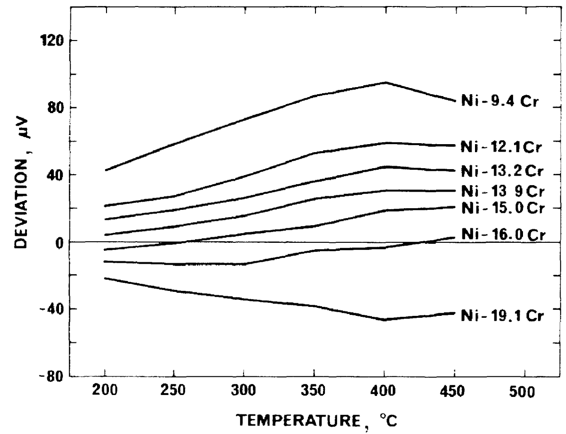

FIGURE 2.2.2.1 *Changes in the thermal emf's of several* Ni–Cr *alloys in the alpha range 9 to 20*Cr *during a heating (to 450 °C) and cooling cycle following water-quenching from 1050 °C.*

The changes are deviations in the emf's versus platinum on cooling from the values measured during heating [after Burley, 1972].

temperature parabolic oxidation signifies that a thermal diffusion process is rate-determining, the effectiveness of the Cr_2O_3 layer is presumably due to the low rate at which cations diffuse through a low concentration of chromium vacancies in the defective cation sublattice of this oxide, which is nearly stoichiometric.

In the conventional positive alloy the main cause of solute depletion and hence of thermal emf drift during oxidation in the temperature range 800 to 1000 °C is internal precipitation of Cr_2O_3 particles. It is therefore most desirable that an improved positive thermoelement should have a bulk chromium content that exceeds the critical value at which the transition from internal precipitate to external film type oxide formation occurs. It is not a simple matter, however, to determine theoretically the compositional range of chromium in Ni–Cr over which this temperature-dependent transition phenomenon occurs [Burley, 1972], and it is thus necessary to rely on empirically determined evidence. Giggins and Pettit [1969], for example, have shown that at temperatures between about 1050 and 1250 °C in 0.1 atm (10 kPa) pressure of oxygen, internal oxidation of chromium in Ni–Cr is not observed when the mole fraction of chromium exceeds about 0.15 (approximately 13 percent chromium). It is thus reasonable to suggest that the optimum chromium content of the preferred positive alloy should be that at which short-range order initiated thermal emf variations are not observed (approximately 14 percent chromium, as is seen below). For such an alloy, not only is the parabolic rate constant for oxidation significantly less than for the 10 percent chromium alloy in the temperature range of interest but also the rate at which the healing layer of Cr_2O_3 forms at the metal/scale interface increases markedly with increasing temperature [Wood and Hodgkiess, 1966].

There are several aspects of the oxidation mechanisms in Ni–14Cr, however, which require further

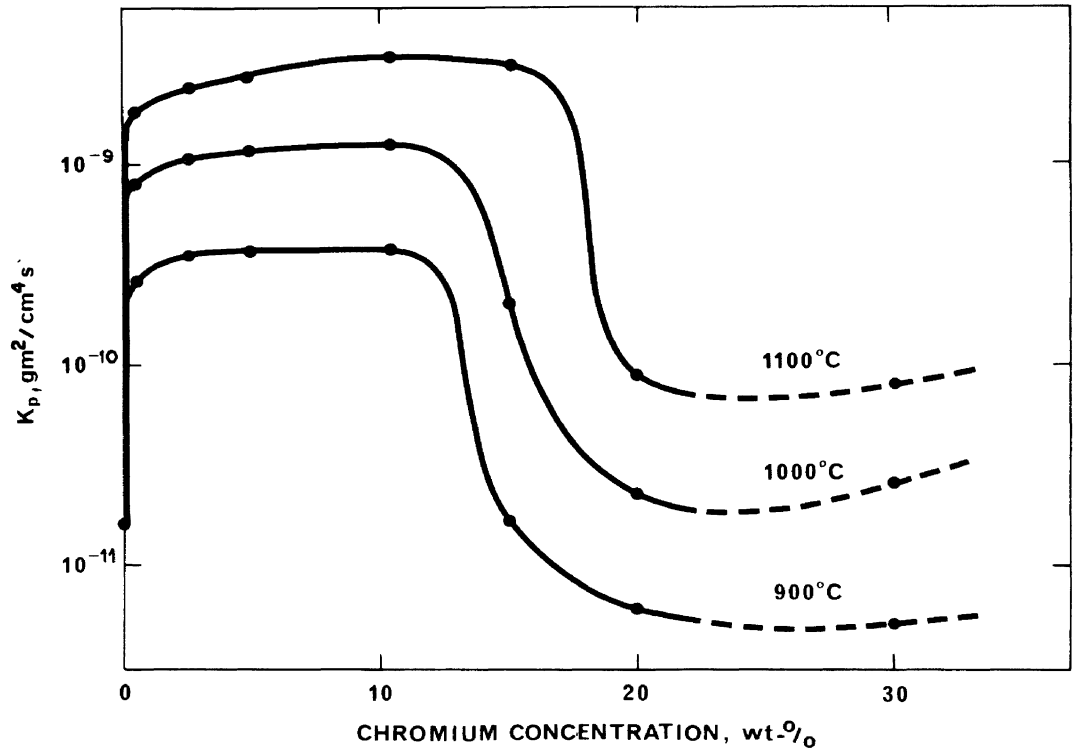

FIGURE 2.2.2.2 *Composition dependence of the parabolic rate constant* (K_p) *in the oxidation, in 10 kPa* O_2, *of alpha* Ni–Cr *alloys at 900, 1000, 1100 °C* [*after Giggins and Pettit, 1969*].

consideration. First, as the chromium concentration at the solute-depleting metal/scale interface falls during protracted heating at 1000 to 1200 °C, the tendency for Cr_2O_3 to form as a non-protective internal precipitate rather than as a protective external film will be increased. Secondly, when Cr_2O_3 is heated above about 1000 °C it tends to oxidize to CrO_3 [Kim and Belton, 1974], which is volatile at such temperatures. The evaporation of the higher oxide from any exposed regions of the healing oxide layer will tend to produce paralinear kinetics, and hence continuous chromium depletion and thermal emf drift. Thirdly, while the Cr_2O_3 film will inhibit outward cation diffusion to the extent that this process becomes the rate-limiting step in the oxidation process, the film could still thicken slowly by oxygen reactions at the metal/film interface. A second oxidation inhibiting mechanism is thus considered to be essential if the preferred positive alloy is to show maximum stability. The formation of a continuous silica film at the metal/scale interface, which occurs in oxidizing Ni–Cr alloys when a small quantity of silicon is present, appears to be such a mechanism. Since the solubility of most elements in SiO_2 is virtually nil, there will be very small chemical potential gradients across the film and hence very small driving forces for the diffusion of oxidation reactants such as nickel and chromium through it. Provided the SiO_2 film were to remain continuous this very low rate of diffusion could be the oxidation rate-controlling factor rather than the diffusion of chromium ions in Cr_2O_3.

Standard free energy data for the formation of the various oxides produced by a Ni–Cr–Si alloy at high temperatures suggest that SiO_2 will tend to form preferentially because it is the oxide with the largest negative free energy value. This factor alone, however, does not guarantee the formation of a complete healing layer of SiO_2; the composition of the bulk alloy must also be taken into account in determining whether this thermodynamically favoured oxide will eventually form a complete external layer or will merely appear as an internal precipitate. The presently available Type KP alloys have silicon contents which do not exceed about a half percent. There is strong evidence to suggest that this amount is significantly less than that required to produce a SiO_2 film of optimum diffusion inhibiting propensity.

Unpublished work [Burley, 1975] on the high-temperature air oxidation of various of the Type KP alloys of table 1.1.1 shows that, even though the differences in the silicon contents of these alloys are small (a range of from 1/4 to 1/2 percent), the degree of chromium depletion in the metal beneath the scale is less in the higher silicon alloys than in the lower. Even so, chromium depletion and hence thermal emf drift in the 1/2 percent silicon alloys is substantial. Data on the effects of silicon in excess of 1/2 percent upon the oxidation characteristics of nickel-base alloys containing 10 percent chromium is meagre, but at least one study [Gil'dengorn and Rogel'berg, 1964], in which the influence of up to five percent silicon upon the growth kinetics of oxides formed on such alloys was investigated, is relevant. With oxidation in air in the range 1000 to 1200 °C, silicon additions reduce the oxidation rate of Ni–10Cr by an order or more, the drop being most marked after the addition of about 1 percent. The maximum effect appeared to be achieved at about 1½ to 2 percent. Of considerable significance to the present work is the result that in alloys containing 1 percent silicon or more an increase in isothermal aging temperature up to 1200 °C had negligible effect in increasing the oxidation rate. As shown later, in section 6.3.3, in Ni–Cr–Si alloys containing 14 to 15 percent chromium, maximum thermal emf stability in air at temperatures up to 1250 °C appears to result when the alloys contain about 1.4 percent silicon.

It seems reasonable to assume that the inner-layer diffusion barrier of SiO_2 in an oxidizing Ni–15Cr–1½Si alloy will be both persistent and tenacious. Although the rate at which silicon diffuses through nickel is such that high temperatures or long times, or both, would be required to replenish the SiO_2 component of the oxide layer, the diffusion coefficient exhibits the usual exponential temperature dependence in the range 1000 to 1200 °C, and the healing rate should increase significantly with increasing temperatures in this range. Furthermore if the diffusivity of oxygen in silica is low, as suggested in the next section, the concentration of oxygen at the metal/scale interface will fall markedly as the diffusion barrier film thickens. The film could thus be strengthened by secondary solid-state reactions which favour the Cr reduction of NiO and $NiCr_2O_4$, and also the Si reduction of Cr_2O_3.

It is not to be assumed that a Ni–Cr–1.4Si alloy will show minimal thermal emf variations due to atomic ordering at a chromium solute level of 15½ percent, the level at which these effects are minimal in the Ni–Cr binary alloy (see sect. 2.2.2). Burley [1974], in investigating the effects of silicon on the ordering phenomenon in these alloys, found that minimal structure-related emf variations occurred in Ni–Cr–1.4Si alloys when the chromium content reached 14 percent (ref. section 6.4).

The optimum formulation of Nicrosil thus appears to be Ni–14.2Cr–1.4Si.

2.2.3 Nisil

As discussed earlier in section 2.1.1, air oxidation of the conventional negative Type KN thermoelement (Ni–3Mn–2Al–1Si–½Co) causes substantial depletion of the reactive solutes manganese and aluminum in the vicinity of the internal oxidation reaction front. That this process produces substantial thermal emf drift is not surprising when one considers the shape of the curves (figure 2.2.3.1) relating the emf output of these alloys with their manganese and aluminum contents. Since the conventional negative alloy originally was developed primarily for sulfurous atmospheres, it can be argued that the readily oxidizable elements manganese and aluminum can be deleted from the formulation of a preferred negative alloy for use at high temperatures in air. Since cobalt is not required

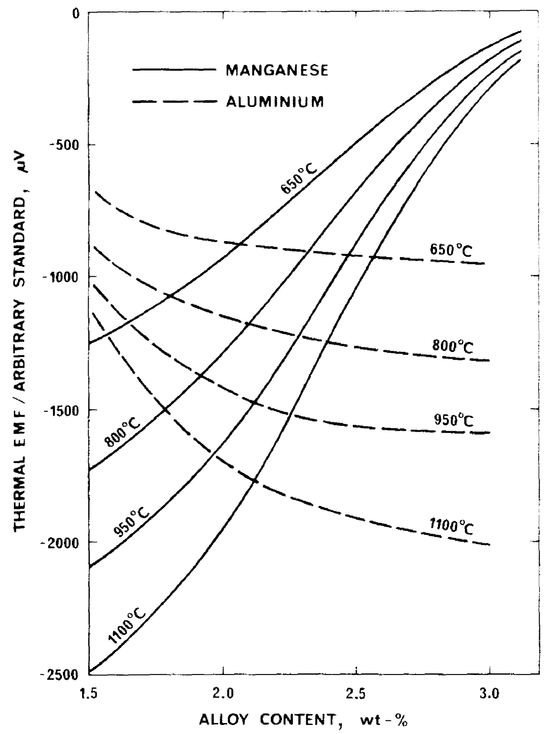

FIGURE 2.2.3.1 *Effects of manganese and aluminum in a conventional Type KN alloy on the deviation of thermal emf's from an arbitrary standard [after Starr and Wang, 1963].*

as an emf-modifying element, the formulation of such a preferred alloy can be developed from first principles. The virtue of nickel as the base for such an alloy has been established in earlier discussion, and there are several strong reasons for retaining silicon as the major solute.

The absolute thermoelectric power (S) characteristics of Ni–Si are quite different from those of Ni–Cr. While silicon moves the S of nickel in the positive direction as does chromium, the magnitude of the effect is relatively small. For example, the addition of 3.8 percent Si changes the S of nickel from -37 to -32 $\mu V\ ^\circ C^{-1}$ at 1094 °C whereas a similar addition of Cr would move the S of nickel to about $-17\ \mu V\ ^\circ C^{-1}$ at this temperature [Wang et al, 1966]. A Ni–4Si alloy would therefore have the essential characteristic of being strongly thermonegative to Niscrosil.

The discussion in section 2.2.2 proposes that silicon can suppress solute depletion and consequent thermal emf drift in oxidizing Ni–Cr–Si alloys by forming a stable, continuous, and impermeable film of its oxide alpha-cristobalite, SiO_2, at the metal/scale interface. There is evidence [Potts and McElroy, 1962; Gil'dengorn and Rogel'berg, 1964] which suggests that silicon can perform a similar role in binary Ni–Si alloys. Prior to the development of Nisil, however, there were no published data on the stability of the temperature-thermoelectromotive force characteristics of Ni–Si in air at temperatures above 1000 °C. For silicon to have optimum stabilizing effect in Ni–Si its oxide would have to form as a continuous and impermeable layer, exclusively on the surface of the metal, which would persist indefinitely at high temperatures not only under isothermal conditions in air but also under conditions of very low oxygen pressure or rapid thermal cycling, or both.

On the assumption that a compact, pore-free oxide scale is formed, the theoretical critical concentration of binary solute (B) above which its oxide is formed exclusively on the surface is given by Wagner [1959, 1965] as—

$$N_B = \frac{V}{Z_B M_o} \cdot (\pi k_p / D)^{1/2}$$

where V is the molar volume of the alloy,
Z_B is the valence of the B atoms,
M_o is the atomic weight of oxygen,
k_p is the parabolic rate constant for exclusive formation of B oxide, and
D is the diffusion coefficient of B in the alloy.

In this equation, the values of V and Z_B are constant for a given alloy, so the value of the fraction $V/Z_B M_o$ is readily determined. Since it is known that the diffusion coefficient (D) of silicon in nickel exhibits the usual temperature dependence, values of D at various temperatures can be calculated from the relationship—

$$D = D_o \exp[-Q/RT]$$

where D_o is the frequency factor,
Q is the activation energy,
R is the gas constant, and
T is the thermodynamic temperature.

Using values of $D_o = 1.5$ cm^2 s^{-1} and $Q = 61.7$ kcal g-atom^{-1} [Swalin, 1957], or 258.2 kJ mol^{-1},[4] as parameters for the diffusion of silicon in nickel, and R = 1.987 cal mol^{-1} deg^{-1}, or 8.314 J mol^{-1} K^{-1}, the values of D(1100 °C) = 2.25×10^{-10} cm^2 s^{-1}, or 22.5×10^{-15} m^2 s^{-1}, and D(1200 °C) = 10.5×10^{-10} cm^2 s^{-1}, or 105×10^{-15} m^2 s^{-1} are obtained from the above equation. Data on oxidation rates in binary Ni–Si alloys are meagre but the relevant values that have been obtained [Gil'dengorn and Rogel'berg, 1964] appear to be reliable. These values are as follows:

k_p(Ni–3.6Si) = 1.2×10^{-10} g^2 cm^{-4} s^{-1} at 1100 °C (or 12×10^{-9} kg^2 m^{-4} s^{-1}), and 5.4×10^{-10} g^2 cm^{-4} s^{-1} at 1200 °C (or 54×10^{-9} kg^2 m^{-4} s^{-1}):

k_p(Ni–4.7Si) = 1.2×10^{-11} g^2 cm^{-4} s^{-1} at 1100 °C (or 1.2×10^{-9} kg^2 m^{-4} s^{-1}), and 6.2×10^{-11} g^2 cm^{-4} s^{-1} at 1200 °C (or 6.2×10^{-9} kg^2 m^{-4} s^{-1}).

Since the value of k_p to be used in the above equation for determining N_B is the value corresponding to the alloy whose mole fraction of silicon is equal to N_B, it is convenient to use an iterative method of solution with interpolated values of k_p. Such a method yields the values N_B(1100 °C) = 0.089 (4.2$_0$Si) and N_B(1200 °C) = 0.090(4.2$_5$Si). These theoretical values of the minimum solute concentration required to give exclusive SiO_2 surface film formation in oxidizing alpha Ni–Si are consistent with the results of a fairly recent investigation [Wolf, 1965] in which the depth of internal oxide penetration in these alloys was measured as a function of silicon content. After heating for 200 hours in air at 980 °C, for example, the depth of penetration was found to be inversely proportional to solute content, the amount of internal precipitate being negligible when the concentration reached 4.0 percent silicon.

The degree to which a silica film on the surface of a Ni–Si alloy would inhibit diffusion is difficult to assess. Results of studies of oxygen transport in silica show large divergences in both diffusivities and activation energies, and the nature of oxygen defects in silica does not appear to be well understood. It can be reasoned from basic principles, however, that silica is highly impermeable to both oxygen and nickel. From Wagner theory the parabolic rate constant for oxidation is seen to be proportional to the electrical conductivity of an oxide which forms a continuous layer in which diffusion processes are rate-controlling. Hence the diffusion rates in SiO_2 should be much lower than in NiO, since the electrical conductivities of these oxides are 10^{-6} and 10^{-2} Ω^{-1} cm^{-1}, respectively. Thus a complete layer of SiO_2 on the surface of a Ni–Si alloy should greatly inhibit oxidation, and in particular it should prevent the silicon concentration at the metal/oxide interface from falling below the value critical to selective oxidation.

The long-term persistence of the silica surface film will be vital and this will be governed by a number of factors, in particular its volatility, reactivity, and spalling characteristics, which are considered in the following.

First, the formation of volatile silicon oxide molecules should not be a serious hindrance to the retention of silica as a protective diffusion barrier. Kellogg's [1966] treatment of relevant thermodynamic data has facilitated graphical representations describing the dependence of vapor pressure of a compound on the non-metal activity. Figure 2.2.3.2, which is derived from these treatments, shows the dependences on oxygen activity of the partial pressures of the volatile species Si(g) and SiO(g) over the condensed phases Si(s) and SiO_2(s) at 1225 °C. The four lines of the diagram were derived from the four vapor-forming reactions—

$$Si(s) + \tfrac{1}{2}O_2 \rightarrow SiO(g)$$
$$Si(s) \rightarrow Si(g)$$
$$SiO_2 \rightarrow SiO(g) + \tfrac{1}{2}O_2$$
$$SiO_2 \rightarrow Si(g) + O_2$$

The slopes of the lines in figure 2.2.3.2, $d \log P_{SiO}/d \log P_{O_2}$ and $d \log P_{Si}/d \log P_{O_2}$, are derived by dif-

[4] For some quantities quoted in this Monograph, preferred equivalents in terms of Système International d'Unités (SI Units) are also given.

ferentiating the logarithms of the equilibrium constants of the above vaporization equations. It can be seen from figure 2.2.3.2 that a SiO_2 scale at 1225 °C would exhibit negligible vapor losses in air and that SiO volatilization would be appreciable only in highly reducing gases.

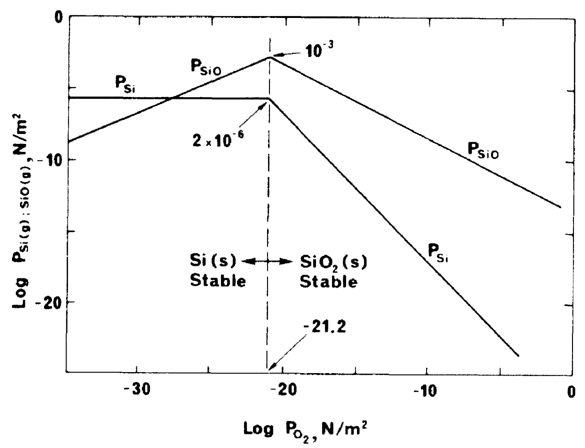

FIGURE 2.2.3.2 *Oxygen activity dependences of the partial pressures of the volatile species* Si(g) *and* SiO(g) *over the condensed phases* Si(s) and SiO_2(s) *at 1225 °C [after Kellogg, 1966; the value for* P_{SiO} *at* Si–SiO_2 *co-existence is after Schäfer and Hörnle, 1950].*

Secondly, the reactivity of SiO_2 with nickel in the alloy to form Ni_2SiO_4 should likewise present little problem. The silicon content at which a binary Ni–Si alloy is in thermodynamic equilibrium with a mixture of Ni_2SiO_4 and SiO_2 can be calculated from the equation—

$$Ni_2SiO_4(s) + Si(alloy) = 2SiO_2(s) + 2Ni(alloy).$$

The equilibrium constant is—

$$RT \log_n K = RT \log_n a_{Ni}^2/a_{Si} = -\Delta G°,$$

where $\Delta G° = -87{,}660$ cal (1000 °C) [Saegusa, 1969]. Thus for $a_{Ni}=1$, $a_{Si}=1.1\times10^{-15}$, and SiO_2 will be more stable at the scale/metal interface when the silicon content exceeds this very low value.

Thirdly, the adhesion of the SiO_2 scale to the substrate in alpha Ni–Si is impossible to predict, but recent experience with thermoalloys of this type shows the mechanical persistence of its protective scale to be extremely good [Burley et al, 1975]. There is, furthermore, evidence [Gil'dengorn and Rogel'berg, 1964; Lowell, 1973] that adhesion increases with increasing temperatures and exposure times.

A compact and continuous scale-layer of silica on the surface of alpha Ni–Si is not assumed to be a perfect diffusion barrier, hence small quantities of oxygen may dissolve in the solid solution substrate at high temperatures. It would be desirable, therefore, to incorporate in the preferred negative thermoalloy a small amount of a highly reactive solute metal which would preferentially getter any such oxygen in forming its own oxide. In particular, this would suppress any tendency for silicon to oxidize internally and perhaps reduce any NiO which might form concurrently with SiO_2 in the early stages of oxidation. Magnesium has been found, at a concentration of 0.1 percent, to be a most suitable element for this role [Starr and Wang; 1967, 1976]. Standard free energy data suggest that its oxide will form preferentially to those of nickel and silicon, while the fact that its diffusion rate in nickel is considerably higher than that of silicon should ensure its replenishment at the metal/scale interface. This is not to suggest that the explanations given above for the proven beneficial effect of magnesium in alpha Ni–Si alloys are adequate. Numerous hypotheses have been advanced to explain how such trace additions affect the oxidation kinetics and scale adhesion in refractory alloys. The particular mechanisms by which magnesium improves the high-temperature oxidation resistance of alpha Ni–Si alloys is the subject of current research at the Australian Defence Materials Research Laboratories.

It can thus be deduced that the silicon content of a preferred binary Ni–Si negative thermoalloy should be between about 4¼ percent, which is the level of transition in these alloys from an internal to an external mode of oxidation in air at about 1200 °C, and 5 percent, which is the limit of binary solid solubility of silicon in nickel at room temperature. As will be shown later in section 6.1, there are sound thermoelectric reasons for a choice of 4.4 percent silicon in this range. In addition to achieving greatly improved thermal emf stability due to the enhanced oxidation resistance of Ni–4½Si–0.1Mg, the elimination of manganese, cobalt, and iron, present as alloying elements in the various conventional Type KN materials, from the preferred negative thermoalloy should also lead to improved stability in nuclear environments, since no neutron-induced transmutations of these elements can occur.

The optimum formulation of Nisil thus appears to be Ni–4.4Si–0.1Mg.

2.2.4 Thermal Passivation

In developing the formulations of Nicrosil and Nisil, in sections 2.2.2 and 2.2.3 above, basic thermodynamic data were used to relate the conditions of solute content, temperature and oxygen pressure under which certain discrete and continuous oxide layers could form exclusively on the alloy surface to produce highly effective diffusion barriers. Using such factors as the standard free energies of formation and the growth rates of the various oxides involved, the alloy inter-diffusion coefficients, and the solubility and diffusivity of atomic oxygen in the alloys, it was predicted that in the case of Nicrosil the barrier would comprise two predominant layers, namely a Cr_2O_3 film superimposed upon an insulating SiO_2 film located at the metal/scale interface, while in Nisil the barrier would consist of a single surface layer of SiO_2. That these diffusion-barrier oxide layers form as predicted, that they are highly efficient oxidation inhibitors and that, as a consequence, Nicrosil and Nisil show much enhanced environmental and thermoelectric stabilities, up to about 1300 °C in air, is established later in this Monograph.

It has been observed [Burley and Jones, 1975], however, that of the very small thermal emf drifts which do occur in Nicrosil/Nisil thermocouples at high temperatures in air, the greater part takes place in the very early stages of exposure and is due principally to the Nicrosil thermoelement. This suggests that once the oxide films on Nicrosil are established they greatly inhibit solute diffusion, but that in the early stages their formation can be relatively slow and may also be characterized by some departure from the theoretically predicted conditions of steady-state oxide growth.

Recent studies of transient or initial oxidation [Wood and Chattopadhyay, 1970] in certain binary nickel-base alloys, in one atm (100 kPa) oxygen at 600 °C, have shown that with Ni-Cr, Ni–Al, and Ni–Si, significant amounts of NiO are produced before the predicted steady-state healing layer of the particular less noble metal oxide is formed at the scale base. In the case of Ni–Cr, NiO was always the major oxide formed in the early stages of oxidation of Ni–5.6 and –11.1 ao Cr, with increasing amounts of $NiCr_2O_4$ forming as oxidation proceeded. The Cr_2O_3 healing layer did appear, however, fairly soon after exposure. The amount of Cr_2O_3 forming increased with chromium content and was detectable as early as 2 to 5 min with Ni–22.0 ao Cr. It is thus apparent that the high diffusion-inhibiting propensity of the Cr_2O_3 and SiO_2 films forming as steady-state passivating layers on Nicrosil could be deleteriously affected by the coformation of NiO and $NiCr_2O_4$ at the transient oxidation stage. This could account for the small initial thermal emf drift observed in this alloy.

It seems likely, however, that the transient formation of unwanted oxides, not only on Nicrosil but also on Nisil, could be suppressed by an initial thermal-treatment involving certain controlled conditions of temperature and of oxygen pressure which were favorable to the exclusive formation of Cr_2O_3 or SiO_2, or both. The theoretical basis of this proposition is outlined in the following.

If Ni–Cr–Si is heated in an abundant supply of air, the three components of the alloy will oxidize at different rates which are dependent initially upon the differences in the standard free energies of formation of their respective oxides. If, however, the oxygen potential of the reacting gas is progressively lowered, say by reducing its total pressure or by changing its composition, the selective oxidation of chromium with respect to nickel, and of silicon with respect to both chromium and nickel, is enhanced. This means that the oxidation of nickel can be suppressed while that of chromium and silicon continues, next the oxidation of nickel and chromium can be suppressed while that of silicon continues, and finally the oxidation of all three alloy components can be suppressed. Such a lowering of the oxygen pressure will also lead, successively, to the dissociation of any NiO, $NiCr_2O_4$, Cr_2O_3, and SiO_2 already formed. Figure 2.2.4.1, which has

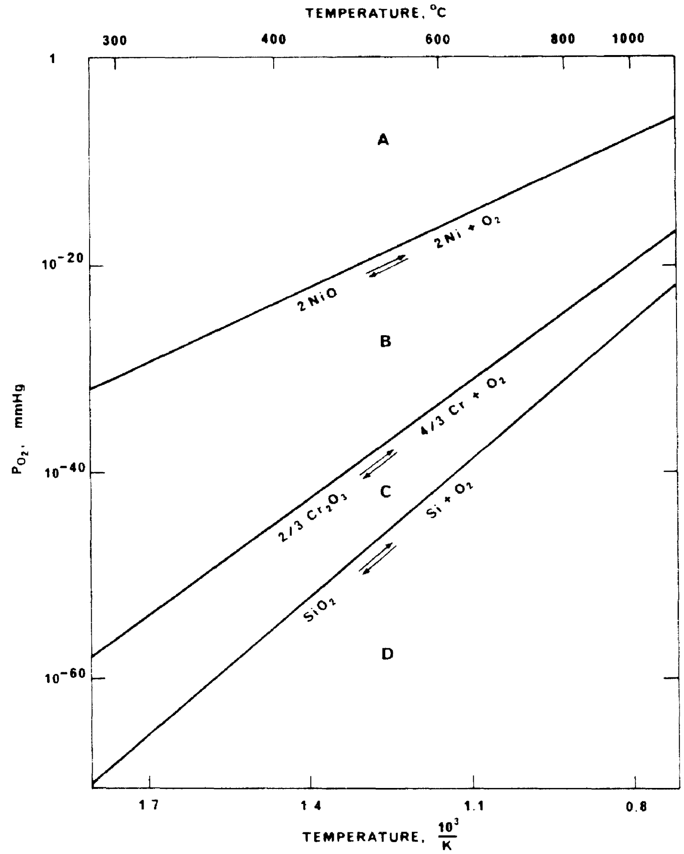

FIGURE 2.2.4.1 *Reaction equilibrium: relation between* P_{O_2} *and temperature (1 mmHg=133.3 Pa). For areas A to D, see text [after Burley, 1972b].*

been calculated from heats of decomposition and entropy data, shows the partial pressure of oxygen in equilibrium with the relevant oxides of nickel, chromium and silicon, at temperatures up to about 1000 °C. If the partial pressure of oxygen and the temperature are such that conditions correspond to the area marked A, the atmosphere will be oxidizing to all three reactions. If, however, the condition lies around B it will be seen that the oxygen partial pressure has fallen below the equilibrium pressure for the reaction—

$$2NiO \rightleftharpoons 2Ni + O_2$$

and thus the equilibrium

$$K = C[Ni] \times P_{O_2}/C[NiO]$$

is disturbed by a lowering of P_{O_2} and a decrease in C [NiO] will occur to restore the equilibrium, i.e. the reaction will go to the right and no oxidation of nickel will occur. The oxygen partial pressure is, however, greater than the equilibrium value for the reactions—

$$\tfrac{2}{3}Cr_2O_3 \rightleftharpoons \tfrac{4}{3}Cr + O_2, \text{ and}$$

$$SiO_2 \rightleftharpoons Si + O_2,$$

both of which will accordingly go to the left and the oxidation of chromium and silicon only will take place. When the condition lies around C both the nickel and chromium reactions will go to the right and the exclusive oxidation of silicon will take place. When the condition lies around D all three reactions will go to the right and the surface will remain bright. From figure 2.2.4.1, it will further be seen that at any given partial pressure, increasing the temperature brings the condition closer to the equilibrium state and thus tends toward the suppression of one reaction and the enhancement of the selective effect.

Thus, in theory, the deleterious effects of the initial formation of NiO and $NiCr_2O_4$ in the transient oxidation of Ni–Cr–Si and Ni–Si can be eliminated by preliminary thermal-treatments at controlled temperatures and pressures in which the exclusive formation of Cr_2O_3 or SiO_2, or both, would occur. This could involve lowering the oxygen pressure to around D in figure 2.2.4.1, at some suitable temperature, and raising it again to around C or B, as appropriate. To achieve the very low oxygen pressure implied would require the use of special atmospheres.

The concept of thermal passivation, particularly as it relates to Nicrosil and Nisil, has been the subject of research at the Australian Defence Materials Research Laboratories since early 1972.

2.3 Tests on Developed Alloys

Subsequent to the work involved in the theoretical formulation of Nicrosil and Nisil which is summarized in section 2.2, prototype samples of the new alloys were obtained from various of the world's leading manufacturers of base-metal thermocouple alloys (refer section 1.3). These samples were subjected to rigorous and exhaustive tests of various kinds, the purpose of which was to gather a body of qualitative and quantitative data on the thermoelectric, metallurgical and physical properties of these alloys. This process would not only test the validity of the predictions made for their greatly enhanced thermoelectric stability, but would also establish the relevant property characteristics of these materials for future reference, in particular for the purposes of standardization.

Predominant among these tests, which were carried out mainly at the Australian Defence Materials Research Laboratories, and also at the U.S. National Bureau of Standards and the Australian National Measurement Laboratory, were those aimed at establishing the degrees of environmental, structural and thermoelectrical stability exhibited by Nicrosil and Nisil. The results of these tests, which are summarized in section 6, show that the new alloys are, in fact, much more resistant to air oxidation, usable at higher maximum temperatures, and substantially freer of the effects of structural ordering than existing alloys of Type K. As a consequence, Nicrosil and Nisil are possessed of much higher thermoelectromotive force stability than any existing base-metal thermocouple alloys.

2.4 Recommended Thermocouple System

In section 2.2 a new thermocouple system is implied which comprises the new nickel-base thermoalloys Nicrosil and Nisil. The compositions of these alloys, whose prototype names are derived from the first syllables of their respective major component elements are

Nicrosil (positive) : Ni–14.2Cr–1.4Si, and
Nisil (negative) : Ni–4.4Si–0.1Mg;

these formulations are quoted as percentages by weight.

In determining compositional tolerance limits about the solute levels quoted above it is necessary to take into account a number of factors, some of which are conflicting. For example, from the standpoint of the manufacturer it is desirable to work to compositional tolerances which are as wide as practicable. There is an obligation on the part of the manufacturer, however, to produce materials whose thermal emf outputs lie within specified tolerance limits, and this imposes compositional bounds because of the sensitivity of the thermal emfs of the alloys to variations in solute content. It would seem desirable that the emf tolerances on Nicrosil/Nisil imposed in manufacture should be the same as, or close to, those specified for Type K thermocouples by the American National Standards Institute, the American Society for Testing and Materials, and the Instrument Society of America. These tolerances are the thermal emf equivalents of ±2¼ °C, or ±¾ percent of the temperature, whichever is the greater (ASTM, 1974).

The sensitivity of the thermal emf's of Nicrosil and Nisil to variations in solute concentration are set out below. The figures in column 3 are emf's versus Pt–67 at 1000 °C.

Alloy	Component	Emf Sensitivity (mV per 0.1 wt. – %)	Reference
Nicrosil	Cr	−0.085	section 6.1.2
	Si	−0.242	section 6.1.2
Nisil	Si	+0.010	section 6.1.3
	Mg	+0.106	Starr and Wang [1976]
	Fe	+0.220	Wang [1976]
	Cr	ca. +0.900	Burley [1975]

From these data it can be seen that the thermal emf of Nicrosil is much more sensitive to variations in its silicon content than it is to variations in its chromium content. Nisil, on the other hand, is virtually insensitive to variations in its silicon content, but is most sensitive to variations in its iron.

Tolerance limits for chromium (in Nicrosil), silicon, magnesium and iron can be estimated from the thermal emf-composition relationships summarized above. In the case of carbon and chromium in Nisil, other factors must be taken into account. Carbon was found to exert a considerable influence upon the linearity of the temperature-emf characteristics in Nisil, while its emf is extremely sensitive to chromium in trace quantities. It is therefore necessary to set the lowest practicable limit on the presence of these elements in the negative alloy.

The thermal emfs of the prototype alloys, particularly the Nisils, were found to be very sensitive to iron. Since the iron content of the prototype alloys differed by up to 0.13 wt.−% over the range (0.04 to 0.17) wt.−% (see table 3.1.2), it was decided to set the iron level at 0.1 wt.−%, even though this implied the need for some manufacturers to add iron to their melts in order to supplement the initial 'impurity' levels of this element.

With such factors in mind, it is suggested that the compositional tolerances for the main alloying constituents of Nicrosil and Nisil should be as follows (percentages by weight)—

Nicrosil		Nisil
14.2±0.15	Cr	0.02 max
1.4±0.05	Si	4.4±0.2
0.1±0.03	Fe	0.1±0.03
0.03 max	C	0.03 max
	Mg	0.1±0.05

3. Prototype Materials and Test Specimens

3.1 Acquisition of Prototype Materials for Thermoelectric Reference Data

Prototype alloy melt batches of Nicrosil and Nisil were acquired from each of the base-metal thermocouple alloy manufacturers mentioned in section 1.3, specifically for establishing the thermoelectric reference data. It was specified that the alloys should be manufactured in accordance with close compositional tolerance limits for the main alloying constituents, similar to those given in section 2.4. In this Monograph the thermocouple alloy manufacturers are individually identified by the letters A, B, C, D and E, which were assigned in a quite arbitrary and random way. The number of melt batches obtained from each of these manufacturers is given in table 3.1.1. Altogether, 15 melt batches of Nicrosil and 16 melt batches of Nisil were procured. Samples of each alloy, in the form of both 1.63 and 0.32 (or 0.25) mm diameter wires (AWG 14 and 28 (or 30), respectively) were drawn down and supplied by the particular manufacturer from each melt batch. All the prototype materials were received at NBS by January, 1974.

The chemical compositions of the individual prototype alloy melt batches are given in table 3.1.2. The elemental analyses were performed by the Metals Analysis Group of MRL using specimens taken from near the mid-point of the coils of 1.63 mm diameter wire. The concentrations of all the elements listed, except carbon, were estimated by conventional wet-way methods after preliminary spectrographic analysis. The carbon values were determined by a combustion-conductimetric method. The specimens were also examined by x-ray fluorescence spectroscopy. All the manufacturers furnished compositional data for their alloys, and the agreement with the MRL data presented in table 3.1.2 is generally very good. Table 3.1.2 shows that the majority of the prototype alloy melt batches were in compliance with the specified compositional tolerances referred to above.

TABLE 3.1.1 *Number of prototype alloy melt batches acquired from various manufacturers*

Manufacturer	Number of melt batches	
	Nicrosil	Nisil
A	2	2
B	2	1
C	4	6
D	3	4
E	4	3

Tables 3.1.2 also gives values of the thermal emfs of the prototype alloy melt batches against Pt–67 at 1000 °C. These data were obtained during preliminary tests. The samples for these tests, and for the final calibration tests in the high temperature range, were also taken from near the mid-point of the coils of 1.63 mm diameter wire, adjacent to the samples for chemical analysis. They were electrically annealed in air for one hour, the Nicrosils at 950 °C and the Nisils at 850 °C, prior to testing at 100 °C intervals from 100 to 1100 °C using the calibration methods and equipment described in section 4.2.

Finally, table 3.1.2 shows the laboratory identification numbers and the manufacturers' melt numbers assigned to the prototype alloys, and indicates the final calibrations performed on them. The methods used in the various temperature ranges for the final calibrations are summarized in section 4.

3.2 Experimental Alloys for Other Property Data

In addition to supplying the prototype alloy melt batches for establishing the thermoelectric reference data, various of the manufacturers mentioned in section 1.3, and one other producer, fabricated groups of alloys in suitable wire form for use in studies (see section 6) of certain physical, chemical, and metallurgical properties of the new thermoalloys. Some of the prototype alloy samples were also used in the section 6 studies. The groups of alloys specially prepared for this work are described in the following.

First, a group of six binary alpha Ni–Si alloys of very high purity, having silicon contents ranging up to five percent, were obtained from the Development and Research Department of the International Nickel Company, Birmingham, U.K. These were used to study the effect of silicon upon the thermal emf of the alpha Ni–Si alloys in general and Nisil in particular. Details of these alloys, including chemical compositions, NBS–MRL identification numbers, and manufacturer numbers, are given in table 3.2.1.

Secondly, a group of eight pure ternary Ni–Cr–Si alloys, having chromium contents spanning a range of values near the 14.2 percent level of Nicrosil and silicon contents fixed at about the Nicrosil level of

Table 3.1.2 *Compositions and calibrations of prototype alloy melt batches.*

Alloy	Manufacturer	NBS-MRL Identification number	Manufacturer's melt number	Chemical Composition [a]					Calibrations performed			EMF against Pt-67 at 1000 °C[b] (mV)
				Cr	Si	Fe	C	Mg	High temperature range (100 to 1300 °C)	Overlap temperature range (−75 to 450 °C)	Cryogenic temperature range (−269 to 7 °C)	
Nicrosil	A	150	BR1/3	14.01	1.58	0.09	0.030		Yes	No	Yes	25.987
	A	151	BR1/4	14.08	1.39	.09	.029		No	No	No	26.440
	B	160	96140	13.92	1.54	.05	.13		No	No	No	26.700
	B	161	96141	13.92	1.52	.04	.14		No	No	No	26.696
	C	170	73007	14.34	1.51	.05	.042		Yes	Yes	Yes	25.961
	C	171	73008	14.34	1.51	.04	.045		Yes	No	Yes	26.030
	C	172	73009	14.34	1.51	.04	.055		No	No	No	26.047
	C	173	73010	14.31	1.50	.05	.050		Yes	Yes	No	26.116
	D	180	3095	14.21	1.46	.10	.006		Yes	Yes	Yes	26.112
	D	181	3096	14.25	1.48	.05	.009		Yes	Yes	Yes	26.976
	D	182	3097	14.19	1.41	.05	.004		Yes	No	Yes	26.040
	E	190	52272/1	14.27	1.44	.09	.014		Yes	No	Yes	26.101
	E	191	52272/2	14.24	1.47	.11	.016		Yes	Yes	Yes	26.050
	E	192	52272/4	14.27	1.47	.09	.026		No	No	No	26.144
	E	193	52272/3	14.18	1.46	.09	.015		Yes	Yes	Yes	26.124
Nisil	A	200	BR2/3		4.18	.04	.008	0.10	No	No	No	−10.671
	A	201	BR2/4		4.36	.04	.006	.11	Yes	No	Yes	−10.660
	B	210	96461		4.24	.14	.019	.04	Yes	Yes	Yes	−10.165
	C	220	73019		4.46	.04	.030	.11	Yes	No	Yes	−10.381
	C	221	73020		4.58	.01	.020	.09	Yes	Yes	No	−10.332
	C	222	73021		[c] 4.23		[c] .12	[c] .09	No	No	No	−10.099
	C	223	73022		[c] 4.23		[c] .12	[c] .09	No	No	No	−10.102
	C	224	73023		4.38	.04	.003	.08	Yes	Yes	Yes	−10.543
	C	225	73024		4.54	.04	.005	.07	No	No	No	−10.520
	D	230	3155		4.22	.17	.006	.09	No	No	No	−9.263
	D	231	3157		4.25	.06	.007	.10	Yes	Yes	Yes	−10.213
	D	232	3168		4.20	.08	.004	.11	Yes	Yes	Yes	−10.134
	D	233	3255		4.17	.07	.008	.07	No	No	No	−9.772
	E	240	52272/5		4.18	.09	.002	.21	Yes	Yes	Yes	−10.213
	E	241	52272/6		4.19	.04	.005	.21	Yes	No	Yes	−10.511
	E	242	52272/7		4.22	.04	.006	.22	Yes	Yes	Yes	−10.532

[a] Balance is nickel; all alloy compositions are expressed as percentages by weight. Some specimens showed traces of Co, Mn and/or Zn.

[b] Values are based on reference junctions at 0 °C and were obtained during preliminary tests on 1.63 mm diameter test specimens that were annealed for one hour in air by electric resistance heating, the Nicrosils at 950 °C and the Nisils at 850 °C.

[c] Data furnished by manufacturer.

TABLE 3.2.1 *Compositions of alpha* Ni–Si *alloys*

Alloy (nominal)	NBS–MRL Identification number	Manufacturer's melt number	Chemical composition [a]				
			Si	Fe	Mg	Cr	C
Ni–0Si	33	Pure nickel	0.001	0.012	<0.005	<0.01	0.022
Ni–1Si	6	MESL	1.06	.04	<0.001	<0.01	.001
Ni–2Si	7	MESJ	2.00	.04	<0.001	<0.01	.001
Ni–3Si	8	MESK	3.00	.05	<0.001	<0.01	.001
Ni–4Si	9	MESM	4.03	.06	<0.001	<0.01	.001
Ni–5Si	10	MESO	5.08	.08	<0.001	<0.01	.001

[a] Percentage by weight; balance is nickel.

TABLE 3.2.2 *Compositions of the* Ni–Cr–1½Si *alloys*

Alloy (nominal)	NBS–MRL Identification number	Manufacturer's melt number	Chemical composition [a]				
			Cr	Si	Fe	Mg	C
Ni–12Cr–1½Si	96	73026	12.04	1.44	0.04	0.02	0.013
Ni–12½Cr–1½Si	97	73027	12.50	1.44	.04	.02	.016
Ni–13Cr–1½Si	98	73028	12.98	1.45	.03	.01	.016
Ni–13½Cr–1½Si	99	73029	13.60	1.47	.10	.02	.021
Ni–15¼Cr–1½Si	92	71005	15.37	1.47	.06	.03	[b] .06
Ni–15¾Cr–1½Si	93	71006	15.79	1.49	.06	.03	[b] .06
Ni–16¼Cr–1½Si	94	71016	16.26	1.49	.05	.03	[b] .06
Ni–16¾Cr–1½Si	95	71017	16.88	1.50	.05	.02	[b] .06

[a] Percentage by weight; balance is nickel.
[b] From manufacturer's data.

TABLE 3.2.3 *Compositions of the* Ni–14¼Cr–Si *alloys*

Alloy (nominal)	NBS–MRL Identification number	Manufacturer's melt number	Chemical composition [a]				
			Cr	Si	Fe	Mg	C
Ni–14¼Cr–½Si	55	3126	14.16	0.61	0.05	0.09	0.012
Ni–14¼Cr–1Si	56	3127	14.25	1.09	.04	.08	.012
Ni–14¼Cr–2Si	57	3128	14.21	2.08	.07	.07	.007
Ni–14¼Cr–2½Si	58	3129	14.28	2.60	.08	.08	.007
Ni–14¼Cr–3Si	59	3130	14.26	3.04	.06	.07	.008

[a] Percentage by weight; balance is nickel.

1.4 percent, were fabricated by manufacturer C. These were used to study the effect of chromium upon the thermal emf of Nicrosil. Details of these alloys are given in table 3.2.2.

Thirdly, a group of five pure ternary Ni–Cr–Si alloys, having silicon contents spanning a range of values near the 1.4 percent level of Nicrosil and chromium contents fixed at about the Nicrosil level of 14.2 percent, were fabricated by manufacturer D. These were used to study the effect of silicon upon the thermal emf of Nicrosil. Details of these alloys are given in table 3.2.3.

All chemical analyses referred to in this section were carried out by the Metals Analysis Group of MRL.

3.3 Alloy Samples Selected for Establishment of Thermoelectric Reference Data

The selection of a final small group of alloy samples of Nicrosil and Nisil for intensive and critical final calibration leading to the establishment of the thermoelectric reference data proceeded in several successive steps.

On receipt of the various prototype alloy batches from their respective manufacturers, each one was calibrated over the range 100 to 1100 °C (as described in section 3.1) to obtain preliminary data on their individual temperature versus thermal emf characteristics. Using these calibration data, from which values at 1000 °C are quoted in table 3.1.2, and the compositional data presented in the same table, a selection of nine individual batches of Nicrosil and nine batches of Nisil was chosen from the original 31 batches for further calibration. In this first reduction the principal criteria which were taken into account in eliminating various of the original alloy batches from further consideration were that—

(i) deviations in elemental solute levels from the nominal compositions quoted in section 2.2 should be minimal,

(ii) deviations in thermal emfs from the mean values of the preliminary calibrations should be minimal, and

(iii) at least one batch of Nicrosil and one of Nisil from each manufacturer should be included.

Using optimum selection techniques based on these criteria, the following alloy batches were nominated for further calibration studies—

Nicrosils				Nisils				
150	170	180	190	201	210	220	231	240
	171	181	191			224	232	241
		182	193					242

Samples from these batches were then calibrated in the high-temperature range 100 to 1300 °C using techniques described in section 4.2, also in the cryogenic range −269 to 7 °C using techniques described in section 4.4, and the majority of them (as detailed in table 3.1.2) in an overlap range −75 to 450 °C using techniques described in section 4.3. It is to be noted that all calibration data obtained relevant to batches 150 and 151 suggest that these batches were almost certainly incorrectly labelled in reverse by their manufacturer. It would seem reasonable, therefore, to read 151 for 150 where the latter alloy is referred to subsequently in this Monograph.

Alloys 173 and 221 were also calibrated in the high-temperature range, but the data were not used in the final analysis.

It was this body of calibration data, utilized in the reduction, analysis, and fitting techniques described in section 5, which led to the production of the thermoelectric reference data for Nicrosil and Nisil presented in section 7.

Principal reliance was placed in the final data analysis on three batches of Nicrosil (171, 182 and 191) and on three batches of Nisil (224, 231 and 240). Nicrosil 191 and Nisil 240 were selected for the generation of the final functions and tables. The rationale of this choice is developed in section 7.1.

4. Experimental Methods for Establishment of Thermoelectric Reference Data

4.1 General

Detailed calibrations were carried out in the range −269 °C to 1300 °C using calibration equipment located in laboratories of NBS at Boulder, Colorado and Gaithersburg, Maryland. Calibrations of the smaller diameter wires were made in the range −269 °C to 7 °C in the Cryogenics Division at Boulder. In the Heat Division at Gaithersburg, the larger diameter wires were calibrated in the high temperature range 100 °C to 1300 °C; in addition, calibrations of the smaller diameter wires were made in an overlapping temperature range −75 °C to 450 °C. The calibration methods employed for these three temperature ranges are summarized in the following subsections. This phase of the project was undertaken during the period July, 1973 through August, 1974 and the experimental work at Gaithersburg was done, for the most part, prior to that at Boulder.

4.2 High Temperature Range (100 to 1300 °C)

In this range the thermal emf's of 1.63 mm diameter Nicrosil and Nisil wire samples were measured at 50 °C intervals against platinum reference-wires whose values of thermal emf were known relative to Pt–67. Standard Pt–10%Rh/Pt thermocouples were used to determine the temperature of the measuring junctions of the test wires, and the platinum thermoelement of the thermocouples served as the reference wire. Testing was done in laboratory tube furnaces. The nickel-chromium tube furnace described in NBS Circular 590 [Roeser and Lonberger, 1958] was used between 100 and 1000 °C and a furnace with a tubular silicon carbide heater [Burns and Gallagher, 1966] was used between 800 and 1300 °C.

A number of the nickel-base alloy wires, usually six, were tested at the same time. Before any test-thermocouples were made up, the wire samples were electrically annealed in air for a half hour, the Nicrosils at 850 °C and the Nisils at 800 °C. They were first assembled in multi-bore sintered alumina tubing and welded together with an oxygen-gas torch to form a common junction. The measuring junction of a standard thermocouple was then welded to the common junction with an electric spot welder. So as to minimize contamination of the standard thermocouple during these tests, it was protected by a double-bore alumina insulating tube and an outer silica glass tube to within a few millimeters of the measuring junction, and the ends of the tubes were sealed to the thermocouple by a small amount of borosilicate glass. The test-wires and standard thermocouple were inserted directly into the nickel-chromium tube furnace, but in the higher temperature furnace they were protected by a closed-end recrystallized alumina tube that was positioned inside the silicon carbide heater so as not to be in contact with it. The temperature was regulated by manually controlling the power to the furnaces with adjustable transformers. The thermal emf of the standard thermocouple and that of the nickel-base alloy wires versus the platinum reference wire were measured simultaneously by the two-potentiometer method [Roeser and Lonberger, 1958]. All calibration runs were taken with increasing temperature and the reference junctions of the test-wires and standard thermocouple were maintained at 0 °C in ice baths.

As indicated in table 3.1.2, twenty of the prototype alloy melt batches were tested by this method, ten of Nicrosil and ten of Nisil. Altogether, corresponding values of emf and temperature were obtained for 18 Nicrosil wires and 20 Nisil wires. With a few exceptions, two samples of wire were used from each melt batch.

For the tests described in this section, the emf measurements were made with calibrated K-3 type potentiometers. The K-3 potentiometers were calibrated in our laboratory (NBS) by intercomparison with a calibrated six-dial laboratory potentiometer having a resolution of 0.01 μV and a limit of error not exceeding ±(0.002% of voltage measured + 0.1 μV). A history of such calibrations indicated that voltages could be measured with these K-3 potentiometers with an uncertainty of not more than ±(0.005% of voltage measured + 0.3 μV) between 0 and 16 mV and ±(0.005% of voltage measured + 2 μV) between 16 and 40 mV.

The Pt-10%Rh/Pt thermocouples employed in these tests were calibrated in our laboratory by the fixed point method [Roeser and Lonberger, 1958], at the outset of the project, and met the requirements of the IPTS-68 for standard thermocouples [CIPM, 1976]. They were tested at the freezing points of zinc, antimony, silver, and gold where the calibrating temperatures were realized in metal freezing-point cells that were essentially the same in design as those described by Evans and Wood [1971]. Corresponding values of emf and temperature for the standard thermocouples in the range 630.74 °C to the gold point (1064.43 °C) were obtained according to the IPTS-68 [CIPM, 1969]. Values outside of this range were interpolated or extrapolated by using the new international reference table for the Pt-10%Rh/Pt thermocouple [Bedford et al., 1972] in conjunction with a deviation curve constructed from the calibration data. Above the gold point, the deviation curve was linearly extrapolated , while below 630.74 °C, it was represented by a quadratic equation fitted to the deviations at the zinc point and at 630.74 °C and constrained to produce 0 μV at 0 °C. The uncertainties in the values are estimated not to exceed 0.3 °C in the range 0 to 1064 °C and then increase to not more than 1.5 °C at 1300 °C. The standard thermocouples were checked periodically for changes in their calibrations by intercomparing them with other, less frequently used, Pt-10%Rh/Pt thermocouples. These checks were performed in the same furnaces, at the same immersions, with the same measuring instruments, and by the same general measurement techniques as those used for testing the nickel-base alloy wires.

4.3 Overlap Temperature Range (−75 to 450 °C)

The thermal emfs of 0.32 (or 0.25) mm diameter Nicrosil and Nisil wires versus platinum reference-wires, whose values of thermal emf were known relative to Pt-67, were measured at 25 °C intervals from −75 to 100 °C and then at 50 °C intervals from 100 to 450 °C. For these measurements, a standard platinum resistance thermometer (SPRT) was used to determine the temperatures of the measuring junctions. A cryostat (below 0 °C), together with a series of stirred liquid baths (above 0 °C), provided the uniform temperature media for this purpose. A stirred water bath was used from 25 to 75 °C. Two different oil baths were used above 75 °C: one between 100 and 200 °C and the second between 200 and 300 °C. Above 300 °C, a stirred molten-tin bath was used. The tin bath has eleven 9 mm i.d. thermometer wells of cold rolled steel equally spaced on a 6.5 cm diameter circle. The salient features of these calibration baths are described in NBS Monograph 150 [Wise, 1976].

The wire samples used in both this temperature range and the cryogenic temperature range were taken from the inside ends of 20-meter lengths of annealed wire which had been removed from the start and finish of the wires on the spools furnished by the various manufacturers.

Prior to the tests in this range, the wire samples were annealed in air for a half hour at 650 °C. For testing, three of the nickel-base alloy wires were assembled with a platinum reference-wire in a four-bore alumina insulating tube. A common measuring junction was formed between the wires by using the welding procedures described in the previous section. The insulated wires were then placed in a closed-end Pyrex glass protecting tube of 6 mm o.d. and 4 mm i.d. Up to four such wire assemblies were tested at a time. In the water, oil, and molten-tin baths, the wire assemblies and the SPRT were immersed about 40 cm below the surface of the bath liquid. The wire assemblies were positioned so that their measuring junctions were at about the same depth as the mid-point of the thermometer resistor. The distance between any assembly and the SPRT was less than 6 cm. In the cryostat, the wire assemblies and the SPRT were equally spaced on a 3 cm diameter circle and were immersed about 25 cm in the bath liquid. The temperature uniformity in each bath was checked by probing the working area with three SPRT's. These checks indicated that under the conditions of test, the measuring junctions of the wires and the thermometer resistor could be expected to be at the same temperature to within about 10 mK in the cryostat, the water bath, and the oil bath used to 200 °C; to within 30 mK in the oil bath used above 200 °C; and to within 75 mK in the tin bath.

The calibration points were taken in order of increasing temperature during these tests, and the reference junctions of the wires were maintained at 0 °C in ice baths. The resistance of the SPRT was determined at the triple point of water [Riddle et al., 1973] both before and after use in each of the calibration baths. G-2 type Mueller bridges, which were calibrated in our laboratory by the method described in Appendix H of NBS Monograph 126 [Riddle et al., 1973], were used to measure all SPRT resistances. The values of thermal emf were measured with a six-dial laboratory potentiometer that had a resolution of 0.01 μV and a limit of error of not more than ± (0.002% of voltage measured + 0.1 μV).

The SPRT's used in this work were calibrated by the NBS Resistance Thermometer Calibration Laboratory. The uncertainties of the calibrations of the SPRT's are estimated not to exceed 3 mK in the range −75 to 400 °C. The calibration methods employed, as well as the equipment and the measurement uncertainties, are discussed in detail in NBS Monograph 126 [Riddle et al., 1973].

By the method described in this section, corresponding values of emf and temperature were obtained for 14 Nicrosil wires and 16 Nisil wires. At least two samples of wire were tested from each of thirteen melt batches denoted in table 3.1.2.

4.4 Cryogenic Range (−269 to 7 °C)

The apparatus was essentially the same as that used earlier for cryogenic calibrations [Sparks et al., 1972]: the main modifications were in the external wiring and instrumentation. The apparatus has been described in detail previously, so that the discussion below is a modified review.

A schematic diagram of the cryostat used to determine the thermal voltage for temperatures between 4 and 280 K (−269 to 7 °C) is shown in figure 4.3.1. The principal parts are labelled UPPER CHAMBER and LOWER CHAMBER. The two chambers are connected by a thermal stand-off tube which serves as a wire duct and allows gas transfer from the lower to the upper chambers. During operation the lower chamber contains the cryogenic liquid. The cryogen serves as the reference junction bath for the thermocouples, provides a source of refrigeration for the upper chamber, and serves as a heat sink for all wires that are in the upper chamber. The upper chamber contains a heavy (~ 10 kg) copper block. The measuring junctions of the thermocouples are thermally anchored to this block. A stable temperature gradient is established between the reference junctions and the measuring junctions by balancing the refrigerator power from the boiling reference cryogen with the power supplied to a heater coil wound on the copper block.

The upper and lower cryostats are completely contained in a vacuum chamber. The vacuum chamber is, in turn, totally immersed in liquid nitrogen. In addition to the vacuum insulation and liquid nitrogen shield, radiation shields have been wrapped on the upper and lower chambers and on the inner surface of the vacuum chamber. The radiation shields consist of layers of aluminum foil separated by balsa wood strips. The insulating vacuum is maintained at approximately 700 μPa by a 20 L/s diffusion pump. All vacuum seals are made using a low melting point solder in the flange and trough arrangement. The outer vacuum chamber seal is effective at ~76 K, while the seals on the two inner cryostats are used down to 4 K. Seals of this sort require no heavy flange and are made

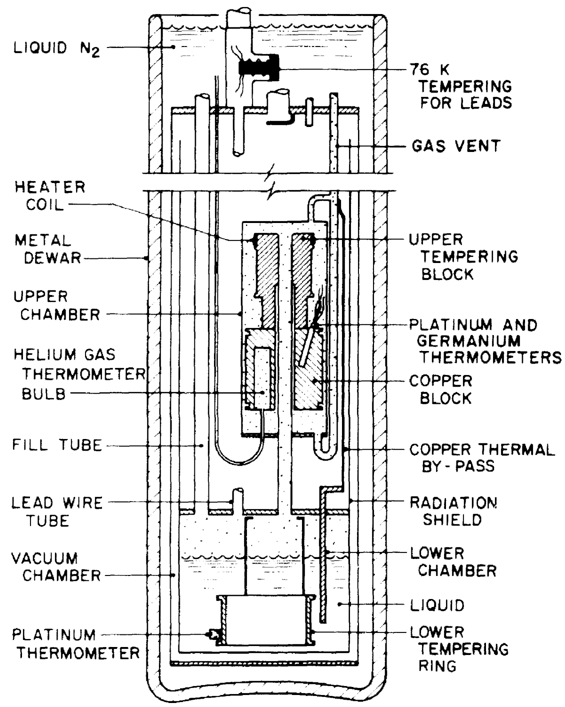

FIGURE 4.3.1 *Schematic diagram of cryogenic thermocouple calibration apparatus.*

at low enough temperatures that there is little danger of overheating nearby primary thermometers.

It is imperative that the upper chamber be isothermal: temperature fluctuations of the measuring junctions of the thermocouples have to be minimized, since approximately twenty minutes is required to make the necessary measurements at each temperature gradient. Energy flow into the upper chamber is controlled as follows:

(i) All wires coming into the system are first brought to 76 K by thermal attachment to the liquid nitrogen shield. They are then thermally anchored in the reference liquid before going into the upper chamber.

(ii) The gas vent line for the inner chambers is in the proximity of the upper chamber. Since the vent line is in contact with the liquid nitrogen shield, it could be warm relative to the temperature of the upper chamber. A heavy copper thermal bypass was installed to transfer any excess energy to the reference liquid in the lower chamber without coming near the upper chamber.

(iii) Radiative heat transfer to the copper block is essentially eliminated by placing a concentric thermal shield between the block and the walls of the upper cryostat. The temperature of the shield is regulated by supplying current to a heater coil on the upper chamber walls. The temperature difference between the block and shield was never greater than 0.05 K while taking the data reported in this Monograph.

The temperatures of the measuring junction block and of the thermal shield surrounding the block are controlled automatically. The controllers used are solid-state devices designed specifically for low power (10 W maximum), high stability applications. For the block heater, either a platinum or germanium resistance thermometer is used as a sensor. A bucking voltage corresponding to the desired thermometer resistance is set on a potentiometer: the controller senses the misbalance between the potentiometer setting and the thermometer voltage and supplies power to the block heater until a null situation is achieved. The temperature drift of the block during a one hour run is nominally between 3 and 5 mK. A separate power supply is used for the shield heater: its control sensor is a four-junction differential thermopile installed between the block and the shield.

The pressure above the reference cryogen is manostatically controlled when using liquid nitrogen. Pressure control is such that the temperature drift of the reference liquid is less than 3 mK/h, as determined from readings of a calibrated platinum resistance thermometer in the reference liquid. This temperature stability corresponds to less than 65 Pa pressure drift during the one hour runs. When liquid helium is used as the reference liquid, the system is opened to atmospheric pressure and the temperature is determined by reading the barometric pressure. The maximum pressure variations observed during a single testing period of one hour are usually less than 120 Pa, which corresponds to a temperature change of 1.4 mK in the liquid helium reference bath.

Two types of resistance thermometer are used to determine the temperature of the measuring junctions of the thermocouples. Capsule type platinum resistance thermometers are used between 20 and 280 K: germanium resistance thermometers are used below 20 K. For this research, one thermometer of each type was calibrated at NBS, Gaithersburg. The ice-point resistance, R_0, for the platinum thermometer was subsequently monitored by measurement at the triple point of water. The remaining thermometers are used as sensors for the heater control system. The thermal resistance between the thermometers and the block is reduced by wrapping each thermometer with layers of 25 μm thick aluminum foil and then removing one layer of foil at a time until a snug fit is obtained between the thermometers and the thermometer wells.

The room temperature segments of the copper wires which connect the measurement system to the voltage sensing devices enter the system through a wax seal. The temperature of these wires is subsequently reduced to liquid nitrogen temperature by wrapping them on an 11 mm diameter copper rod which is in intimate contact with the liquid nitrogen shield. The wires are then drawn into the reference liquid in the lower chamber. Approximately one meter of each wire is wrapped on the copper cylinder below the reference cryogen level in the lower chamber. This is done to ensure that the wires are at the temperature of the reference cryogen before being taken into the upper chamber. The wires are then taken into the upper chamber via the thermal stand-off tube connecting the chambers. Approximately one meter of each wire is wrapped on the upper tempering block, which is made of copper. Each of the 21 thermocouple test wires installed in the apparatus for a calibration run is similarly anchored to the copper block in the upper chamber and to the copper cylinder in the reference liquid in the lower chamber. All of the test wires are brought together to form a common measuring junction that is thermally tied to the copper block, but is electrically isolated from it. The thermocouple reference junctions, which are made by soldering the copper extension wires to the test wires, are electrically insulated from one another and are in good thermal contact with the reference liquid. It is important to note that thermal gradients across the junctions (both measuring and reference) are minimized by carefully bringing all wires to the same temperature as far back from the junctions as possible.

As mentioned above, the wires were thermally anchored over a length of about one meter. A thermal analysis indicated that this length is more than should be necessary even under more unfavorable temperature conditions. However, since our thermocouple test wires had various diameters, thermal conductivities, and insulations, we used a conservatively calculated length.

For these experiments, the potentiometer and resistance bridge used previously was replaced by a '5½' digit electronic multimeter. It worked extremely well, being both more convenient and much more rapid than the previous setup. After calibration, and taking care when changing ranges to not overload the input, it was more accurate, by a very slight amount, than the thermoelectric system itself. Its precision was slightly less than 0.1 μV, sufficient for these measurements.

5. Mathematical Methods and Data Analysis

5.1 Graph Theory Representation

Our method of data acquisition at cryogenic temperatures was designed to take advantage of the large amount of partially redundant information available. The common junction allows many different combinations to be measured. Concepts derived by analogy from the connectivity of paths in graph theory are used to determine optimum experimental procedures. As a simple illustration of how graph theory is applied, consider the situation where one is to intercompare some property of two different objects where two other intermediate objects are also available. Graphically this situation can be represented as in figure 5.1.1. In this figure, the objects are represented by the vertices and the comparison of some property between objects is represented by the connecting lines. For example, the comparison 'd' might represent the difference in weight between objects A and D. In applying graph theory to thermoelectric measurements, the vertices represent the thermocouple test wires and the connecting lines represent the thermal voltages generated by a given temperature gradient. The thermoelectric voltage between A and C in figure 5.1.1 would be determined by (1) measuring c, that is, a direct measurement of the desired voltage, (2) measuring the thermal voltages a and b and combining these data algebraically, and (3) measuring the thermal voltages d and e and similarly combining these data. The algebraic combination of $a+b$ and $d+e$ yield two independent determinations of the desired voltage, equivalent to c. The final determination of the voltage $(A-C)$ is given by

$$e_{\text{calc}} = (A-C) = [2c + (a+b) + (d+e)]/4.$$

The measurement c is given a weight of 2, since it involves only one experimental determination, whereas the other two measurement paths both require two readings. The estimate of the standard deviation for $(A-C)$ is given by

$$S^2 = \{2(e_{\text{calc}} - c)^2 + [e_{\text{calc}} - (a+b)]^2 + [e_{\text{calc}} - (e+d)]^2\}/3.$$

The advantages of taking data in this way are that measuring instrument errors are randomized, any subconscious operator prejudice is eliminated, and spurious voltages in the lead wires are randomized. Since the magnitudes of a, b, c, d, and e usually vary considerably, the readings or the dial settings of the measuring instrument would also be considerably different. Thus, any dial errors which exist are randomized by this method. These random errors would then appear as scatter in the data and would be accounted for in the variance calculated from the above equation.

Since the potentiometer dial or multimeter readings vary a great deal and the order of readings may be random, the chance for subconscious operator prejudice is minimized. In order to influence the readings in a systematic way, the operator would have to algebraically combine very different numbers which are not necessarily taken in adjacent readings. This is not done subconsciously, even on the simple four object system being considered here. On the other hand, if multiple readings are taken of the same quantity, there is a strong tendency to produce data which are biased in a systematic way.

Spurious voltages in the extension wires are also randomized by using the graph theory method. Consider a three wire system such as that which would result if the D wire were eliminated from figure 5.1.1. Assume the number we actually want is $(B-C)$. This is the thermoelectric voltage generated by the thermocouple made from materials B and C when a thermal gradient, $\Delta T = T_1 - T_2$, exists. The number which is actually measured is b which includes the spurious voltages generated in the extension wires to both B and C. If the spurious voltages δ_{Bi} and δ_{Ci} are zero or are at least known, then the true value of $(B-C)$ may be determined. The voltages δ_{Bi} and δ_{Ci} can be determined by an isothermal test where $T_1 = T_2$. When $T_1 = T_2$, $(B-C) = 0$ and $b = (B-C) + \delta_{Bi} + \delta_{Ci} = \delta_{Bi} + \delta_{Ci}$. However, this determination of the spurious voltages is valid only when the thermal gradients in the system are the same as when the isothermal test was made. In many experimental situations this approach to the spurious voltage problem is not practical. The only other solution is to randomize these voltages so that they appear as scatter in the experimental data and are therefore included in the estimate of the variance, S^2. The graph theory approach does allow these voltages to be randomized. Suppose, for instance, that we wish to determine $(B-C)$ in figure 5.1.1. The voltages a, b, and c would then be measured.

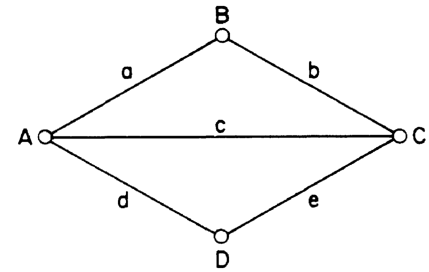

FIGURE 5.1.1 *Four-object measurement graph.*

$$a = (B-A) + \delta_{A1} + \delta_{B1}$$
$$b = (B-C) + \delta_{B2} + \delta_{C1}$$
$$c = (A-C) + \delta_{A2} + \delta_{C2}$$
$$b_{\text{calc}} = [b + \tfrac{1}{2}(a+c)]/3/2 = \frac{2b+a+c}{3}$$
$$b_{\text{calc}} = \frac{[2(B-C) + (B-A) + (A-C)]}{3} + \frac{\delta_{A1} + \delta_{A2} + \delta_{B1} + 2\delta_{B2} + 2\delta_{C1} + \delta_{C2}}{3}$$

If the spurious conditions are stable, i.e., the measurements are made rapidly enough to ensure that the system gradients haven't changed,

then $\delta_A = \delta_{A1} = \delta_{A2}$, $\delta_B = \delta_{B1} = \delta_{B2}$, and $\delta_C = \delta_{C1} = \delta_{C2}$

and $$b_{\text{calc}} = \frac{[2(B-C) + (B-A) + (A-C)]}{3} + \tfrac{2}{3}\delta_A + \delta_B + \delta_C.$$

If the more common procedure of multiple readings of b were used, b would be measured, say, 3 times:

$$b_1 = (B-C)_1 + \delta_B + \delta_C,$$
$$b_2 = (B-C)_2 + \delta_{B1} + \delta_{C1},$$
$$b_3 = (B-C)_3 + \delta_{B2} + \delta_{C2}, \text{ and}$$
$$b_{\text{calc}} = \frac{[(B-C)_1 + (B-C)_2 + (B-C)_3]}{3} + \frac{\delta_B + \delta_C + \delta_{B1} + \delta_{C1} + \delta_{B2} + \delta_{C2}}{3}.$$

Again, assume stable spurious conditions for the time required to determine b three times. Then $\delta_B = \delta_{B1} = \delta_{B2}$, $\delta_C = \delta_{C1} = \delta_{C2}$, and $b_{\text{calc}} = \overline{(B-C)}_{1,2,3} + \delta_B + \delta_C$.

The tendency to randomize dial errors and to eliminate operator prejudice is illustrated by comparing b_{calc} from the graph theory method and from the multiple readings method. More dials are probably changed in determining $(B-C)$, $(B-A)$, and $(A-C)$ than are changed in determining $(B-C)$ three times. The subconscious operator prejudice is reduced by having to combine the two readings $(B-A)$ and $(A-C)$ to get the independent determination of $(B-C)$.

The third and perhaps the most important advantage of the graph theory approach to the measurement of thermocouple outputs is the randomization of spurious voltages in the extension wires. These errors would not be accounted for, i.e., they would be systematic, if the multiple reading approach is utilized. This is shown in the calculation of the estimate of variance for the two methods:

Graph theory:

$$b_{calc}=\frac{[2(B-C)+(B-A)+(A-C)]}{3}+\frac{\delta_{A1}+\delta_{A2}+\delta_{B1}+2\delta_{B2}+2\delta_{C1}+\delta_{C2}}{3}$$

$$S^2{}_{b_{calc}}=\{2(b_{calc}-b)^2+[b_{calc}-(a+c)]^2\}/2;$$

now assume that the only cause of variation is the spurious voltages

$$S^2{}_{b_{calc}}=1/3(\delta_{A'}+\delta_{B'}-\delta_{C'})^2$$

where $\delta_{A'}\equiv\delta_{A1}+\delta_{A2}$,

$\delta_{B'}\equiv\delta_{B1}-\delta_{B2}$, and

$\delta_{C'}\equiv\delta_{C1}-\delta_{C2}$.

If spurious conditions are constant, $\delta_{B'}=0$, $\delta_{C'}=0$ and $S^2{}_{b_{calc}}=1/3(\delta_{A'})^2$.

Multiple measurements:

$$b_{calc}=\frac{[(B-C)_1+(B-C)_2+(B-C)_3]}{3}+\frac{\delta_B+\delta_C+\delta_{B1}+\delta_{C1}+\delta_{B2}+\delta_{C2}}{3};$$

$$S^2{}_{b_{calc}}=\{(b_{calc}-b_1)^2+(b_{calc}-b_2)^2+(b_{calc}-b_3)^2\}/2$$

again assuming all scatter is due to spurious voltages, i.e.,

$(B-C)_1=(B-C)_2=(B-C)_3$, then

$$18\ S^2{}_{b_{calc}}=[-2(\delta_B+\delta_C)+\delta_{B1}+\delta_{C1}+\delta_{B2}+\delta_{C2}]^2+[-2(\delta_{B1}+\delta_{C1})+\delta_B+\delta_C+\delta_{B2}+\delta_{C2}]^2+[-2(\delta_{B2}+\delta_{C2})+\delta_B+\delta_C+\delta_{B1}+\delta_{C1}]^2.$$

Now if the spurious conditions are constant $\delta_B=\delta_{B1}=\delta_{B2}$, $\delta_C=\delta_{C1}=\delta_{C2}$, and $S^2{}_{b_{calc}}=0$.

The spurious voltages do not appear in the estimate of the standard deviation when the multiple measurement method is used. They are present but unaccounted for until some estimate of systematic error is introduced.

The graph used to represent the measurements made on the present thermocouple materials is given in figure 5.1.2. The terminology discussed earlier in this section applies to this figure, i.e., materials are represented by the vertices and thermovoltage measurements are represented by lines.

The high temperature data were obtained in the more conventional manner of experimental data design. The lack of graph circuit redundancy was rectified by making measurements on adjacent wires and by carrying out a carefully planned set of statistical imprecision experiments as described below.

Many sources of error can contribute to the inaccuracies in high-temperature calibration of thermocouples. Some general ones include:

- operator memory or bias,
- instrumental imprecision and inaccuracy,
- temporal changes—time of day, week, or time since beginning of experiment, etc.

Other specific sources of errors for these experiments include:

- short range inhomogeneities in alloys,
- temperature gradients in furnace test zones, and
- variations between different furnaces.

Each of the above sources of error was separately tested.

The three general sources were found to be insignificant, or immeasurably small for these tests, about 0.1 to 0.2 μV or less. The three specific sources of error were analyzed at three different temperatures, 425 °C, 825 °C (for both furnaces), and 1225 °C. The latter two sources, though significant (up to 1 μV for some specimens), were overwhelmed by the main source of error, inhomogeneities in the alloys. The voltage variations caused by those inhomogeneities were found to be strongly temperature dependent, with values ranging from about 1 μV near room temperature to almost 5 μV near 1200 °C. These values, though high with respect to the system inaccuracies, are low compared to the thermoelectric instabilities of most

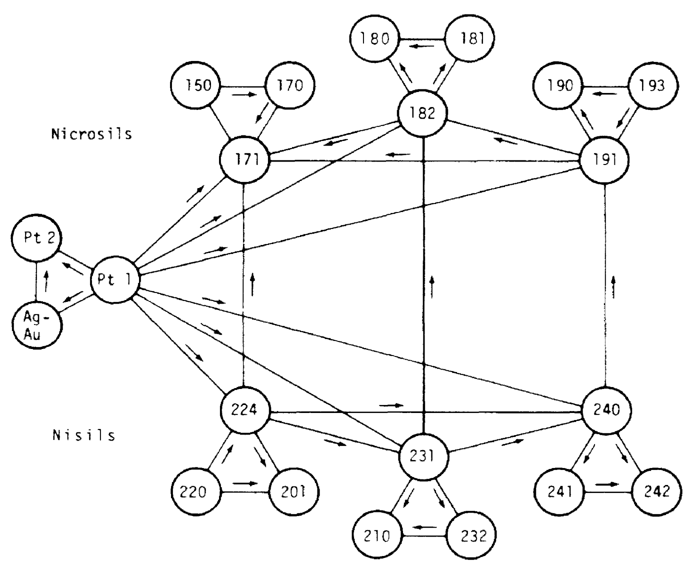

FIGURE 5.1.2 *Measurement graph network for Nicrosil-Nisil thermocouple calibrations.*

thermocouples operated at high temperatures. As discussed in section 7, the experimental data were weighted statistically in order to reflect the wide variations in imprecision.

5.2 Data Analysis

Two major steps were needed to transform the experimental data from their original form into their final form. The first operation involved making minor adjustments to the data and forming the desired thermocouple combinations using graph theory considerations. The second step consisted of finding the best analytical representation of the adjusted data and calculating statistical quantities.

The first operation on the data was to apply potentiometer or multimeter dial corrections to all voltage and resistance data.

A calibrated germanium resistance thermometer was used to determine measuring junction temperatures in the range from 4 K to 20 K. The thermometer current was determined by measuring the voltage across a standard resistor which was in series with the thermometer. Corrected voltages from the thermometer and from the standard resistor were used to determine the resistance of the thermometer. A power series representation of $T=f(R)$ for our thermometer was used to determine the temperature. The germanium thermometer had been calibrated by members of the Cryogenic Physics Section in NBS–Washington.

For each calibration run, the time sequence of primary temperature determinations and thermocouple readings was known. Using this information, it was possible to estimate the variable and reference temperatures which actually existed at the time the individual thermocouple voltages were measured. However, in order to take advantage of the graph theory approach to data acquisition, it was necessary that all combinations have the same reference junction temperature and have the same measuring junction temperature. Linear interpolation in the E_i versus T_i data for each thermocouple combination was used to adjust the measuring junction temperature of each thermocouple to the average of the values which were taken for each temperature gradient.

The data obtained at the upper cryogenic and higher temperatures were easier to analyze for temperatures. The cryogenic data above 20 K utilized calibrated platinum resistance thermometers; while the data above 0 °C utilized calibrated platinum-rhodium versus platinum thermocouples.

After these corrections and adjustments had been made, the data represented the thermoelectric voltages of the desired thermocouple combinations with identical reference junction temperatures and identical measuring junction temperatures. For the cryogenic data, graph theory manipulations were then performed with these data to obtain multiple indirect determinations of a given thermal voltage. The general procedure for calculation of thermal voltages is similar to that given in the previous discussion of graph theory. For the high temperature data, graph theory methods were not possible because of the lack of connecting measurement links. Statistical redundancy was obtained by averaging the results on adjacent wires.

The next major step in the data analysis for the high temperature data was to fit the experimental data in order to provide a continuous $E=f(T)$ relationship for each thermocouple combination. The method used to represent the data is a modified Gram-Schmidt approximation. The calculated values for the voltages of each thermocouple combination were approximated by a series of orthonormal polynomials in the L_2 norm (least squares), that is,

$$E(T) = \sum_{n=1}^{L} A_n F_n(T)$$

where

- $E(T)$ = thermocouple voltage;
- T = temperature of the thermocouple measuring junction:
- L = the highest order fit—an order high enough to represent the data with no loss of precision, but not so high as to introduce mathematical oscillations;
- A_n = constants to be determined by the fitting approximations; and
- $F_n(T)$ = orthonormal polynomials, orthonormal on the data points over the range of variation of the independent variable, T.

The orthonormal polynomials are taken to be the truncated power series

$$F_n(T) = \sum_{j=1}^{n} C_{nj} T^j$$

where the C_{nj} are determined from the orthonormality conditions at the measured temperatures. It should be stressed that the F_n are determined by the values of the independent variable T only. The $F_n(T)$ are therefore the same for all thermocouple combinations which are based on the same set of temperatures.

A common problem in the numerical analysis of data fitting by polynomials is selection of the proper order—an order high enough to represent the data with no loss of precision, but not so high as to introduce mathematical oscillations. This problem is well solved by the method of fitting with orthonormal polynomials. The absolute values of the coefficients A_n decrease with increasing n as long as they are larger than the noise level. However, when the noise level is reached the coefficients are random valued. An inspection of a graph of $|A_n|$ versus number of terms (n) shows the noise level and the probable maximum value of n that is significant. In figure 5.2.1 $|A_n|$ versus n is shown for Nicrosil thermoelement 191X. Incidentally that particular graph is for a cryogenic set of data, but typical high temperature graphs had the same appearance. It is clearly seen that, for that set of data, the sixth and higher order terms were

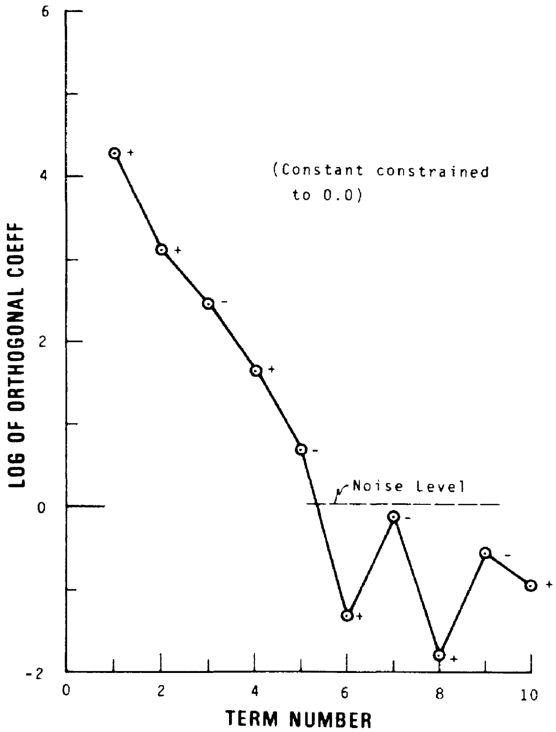

FIGURE 5.2.1 *Convergence of orthogonal coefficients for function fit to measured emf-temperature values for Nicrosil 191X versus platinum,* Pt–67.

random in magnitude, whereas the first five terms decreased rapidly in magnitude. All such representations of well-taken data had that same appearance.

Because of the widely varying reference junction temperatures, the cryogenic data were much more complex to analyze. The method used was based on the following transformation of experimental values. If one assumes that the absolute thermoelectric power S can be represented as

$$S = \sum_{i=1}^{N} A_i T^{i-1}$$

then the total voltage observed between two temperatures will be

$$\Delta E = \int_{T_1}^{T_2} S dT = \sum_{i=1}^{N} A_i \frac{(T_2{}^i - T_1{}^i)}{i}.$$

The cryogenic experimental data were ΔE, T_1, and T_2 for each run. The basis set for computing a least squares fit was

$$\frac{T_2{}^i - T_1{}^i}{i}$$

rather than T^i as it was for high temperature (and most other) data. After that transformation the data analysis for cryogenic temperatures followed the same lines as it did for the high temperature data.

Another advantage of the orthonormal polynomial representation is that the function may be simplified by lowering the order of the fit without having to determine new A_n.

As a convenience to users who wish to use the highest order—and therefore highest precision—fit for a particular thermocouple combination, the orthonormal polynomials and coefficients have been combined to give simple power series coefficients. The power series method of generating the standard data is more straightforward to program for a computer, since it involves only one summation. Using the power series coefficient, the $E = f(T)$ relationships are given by

$$E = \sum_{j=0}^{L} B_j T^j.$$

It should be stressed that the full array of coefficients must be used in the power series method, whereas in the orthogonal representation each order is independent.

6. Material Characteristics

In the joint NBS–MRL research program, in addition to the establishment of thermoelectric reference data in the form of temperature versus thermal emf relationships for Nicrosil/Nisil, various studies of quantitative aspects of certain of their physical, chemical and metallurgical properties were also deemed necessary. Selected for study were those properties which are of most practical significance to the manufacturer and the user. The results of these studies are presented in the following.

6.1 Solute Sensitivity

6.1.1 General

It has been shown [Wang et al, 1966] that the absolute thermoelectric power, S, of binary alloys of nickel is dependent upon the $(s+d)$ electron concentration of the alloy. If the addition of a transition solute atom causes an increase in electron concentration when compared to the matrix nickel, the S of the alloy becomes more negative than that of nickel. On the other hand, if the addition of the transition solute atom causes a decrease in electron concentration, the S of the alloy becomes more positive than that of nickel.

In the case of the Group VI transition elements, which include chromium, the addition of any one of these elements to nickel causes the S to change in the positive direction. The positive maxima of S in such alloys occur at a common electron concentration of about 9.6 $(s+d)$ electrons per atom, the exact value being dependent upon temperature. In the specific case of chromium, a typical value for S_{max} for Ni–Cr is $+15$ μV °C^{-1} at 800 °C. This value occurs when the electron concentration is 9.66 $(s+d)$ electrons per atom which corresponds to an atomic percentage of chromium of 12.0 and a weight percentage of 10.6.

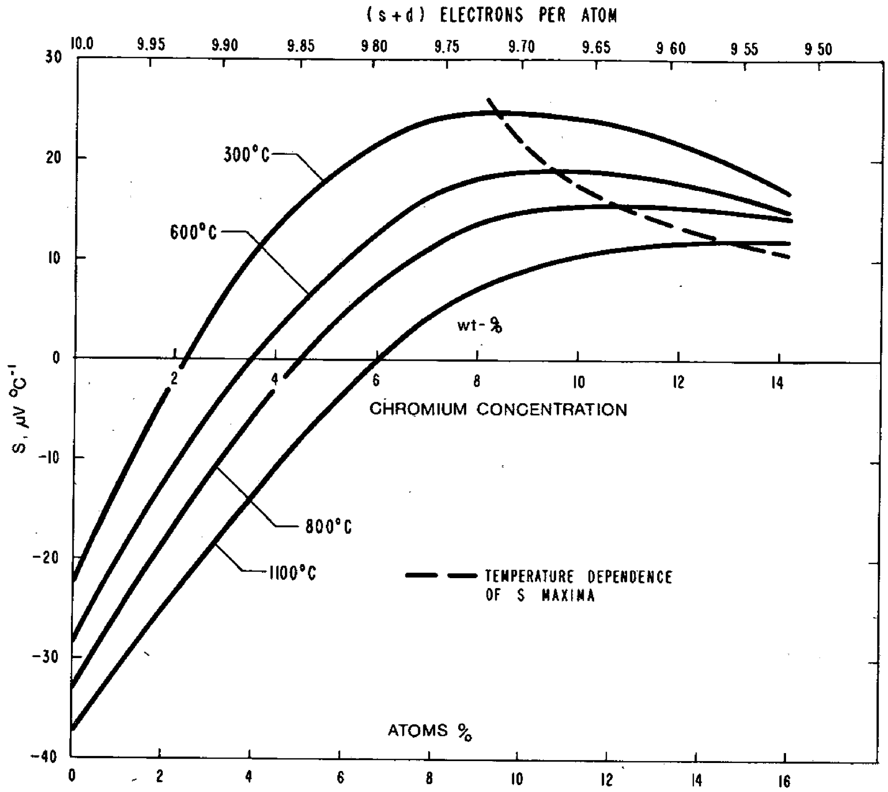

FIGURE 6.1.1.1 *Absolute thermoelectric power* (S) *of binary nickel-chromium alloys* [*after Wang et al, 1966*].

Thus, when the $(s+d)$ electron concentration in Ni–Cr increases above a value of about 9.6 electrons per atom, S will change in a negative direction. At a chromium concentration corresponding to the composition of Nicrosil (14.2 wt. – %) it would be expected that the S of Nicrosil, which in addition contains 1.4 percent Si, would be inversely proportional to chromium content. These relationships are summarized in figure 6.1.1.1.

The S characteristics of Ni–Si are quite different from those of Ni–Cr. The first addition of silicon to nickel drives the S of nickel positive, but the effect is much less than that of chromium. The relative effects of chromium and silicon on the S of nickel are shown in figure 6.1.1.2. The addition of 1.4 percent Si to the binary Ni–14¼Cr alloy to form Nicrosil would be expected to drive the S of the binary alloy negative again. The more complex effect of silicon with increasing binary concentration, as in Nisil, can perhaps be attributed to the Curie transformation in Ni–Si.

The effects of both chromium and silicon upon the thermoelectric properties of Nicrosil, and of silicon upon those of Nisil, have been determined in the present project. The principal results of these studies are presented in the following.

6.1.2 Nicrosil

From section 6.1.1 it can be seen that the thermoelectromotive force of Nicrosil is inversely proportional to its chromium content. The sensitivity of the thermal emf of Nicrosil to variation in its chromium content was investigated by determining the emf's of Ni–Cr–1½Si alloys of various chromium contents versus Pt–67 in the temperature range 600 to 1300 °C. The compositions of the alloys used are listed in table 3.2.2. The calibration techniques used in these tests were the same as those used in the establishment of the thermoelectric reference data in the high temperature range (ref. section 4.2). It will be seen that the alloys of table 3.2.2 comprise two groups. Alloys 92 to 95, inclusive, have chromium contents greater than the 14.2 wt. – % of Nicrosil, while alloys 96 to 99, inclusive, have chromium contents less than 14.2 percent. The salient results of the measurements on both these groups of alloys are expressed graphically in figure 6.1.2.1.

Using experimental data upon which figure 6.1.2.1 is based, it is possible to estimate the dependence of the thermal emf of Nicrosil upon its chromium content. To a first approximation this can be done, with reference to alloys 92 and 93, by expressing the mean change in thermal emf per 0.1 percent Cr as—

$$[(E_{93}-E_{92})_t/(Cr_{93}-Cr_{92})]\times 10^{-1}\text{mV},$$

where $E_{92,93}$ are the thermal emf's in mV of alloys 92 and 93 versus Pt–67 at temperature t, and

$Cr_{92,93}$ are the chromium contents in wt. – % of alloys 92 and 93.

From this expression, the following values are derived—

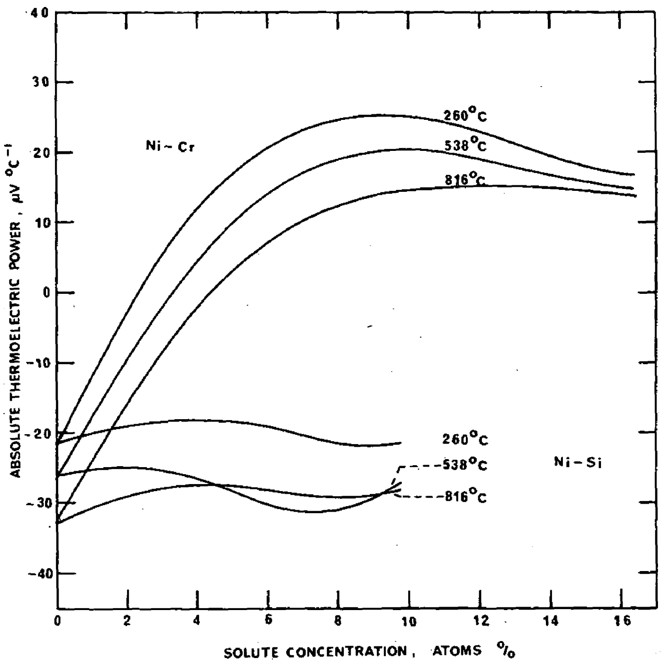

FIGURE 6.1.1.2 *Absolute thermoelectric power* (S) *of binary alloys of nickel with chromium and silicon* [*after Wang et al, 1966*].

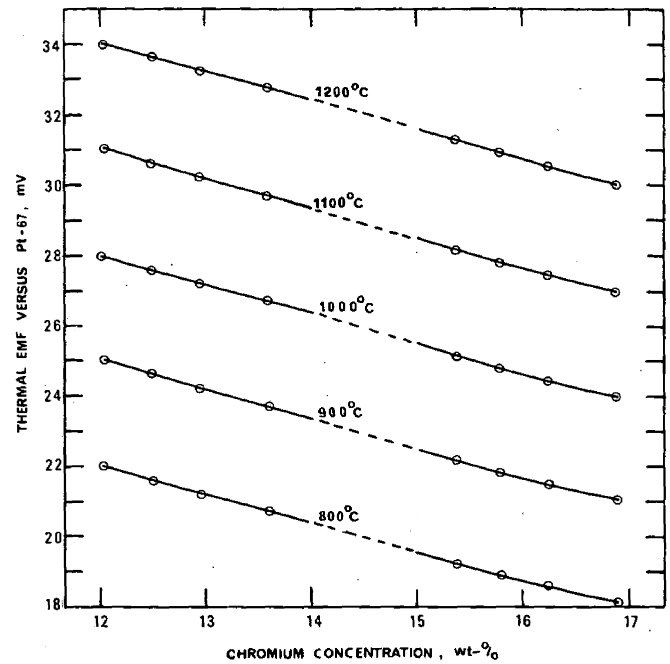

FIGURE 6.1.2.1 *Thermal emf's of* Ni–Cr–1½Si *alloys* (*ref. table 3.2.2*) *of different* Cr *contents versus platinum,* Pt–67.

700 °C	−0.075 mV/+0.1 percent Cr
800	−0.080
900	−0.086
1000	−0.088
1100	−0.089
1200	−0.088
1300	−0.084

For a second approximation, reference can also be made to the alloys 98 and 99. By a similar process further values are derived as follows—

800 °C	−0.080 mV/+0.1 percent Cr
900	−0.082
1000	−0.082
1100	−0.079
1200	−0.076

By averaging the two sets of values given above, which cover a range of 13 to 15.8 percent Cr, a further set of values are obtained which can be regarded as the change in thermal emf of the Nicrosil alloy versus Pt–67 corresponding to a variation of 0.1 percent in its chromium content with its silicon content fixed at 1.47 percent.

800 °C	−0.080 mV/+0.1 percent Cr
900	−0.084
1000	−0.085
1100	−0.084
1200	−0.082

The sensitivity of the thermal emf of Nicrosil to variations in its silicon content were investigated by determining the emf's of Ni–14¼Cr–Si alloys of various silicon contents versus Pt–67 in the temperature range 800 to 1200 °C. The compositions of the alloys used are listed in table 3.2.3. The same calibration techniques were used as are mentioned above. The results are expressed graphically in figure 6.1.2.2.

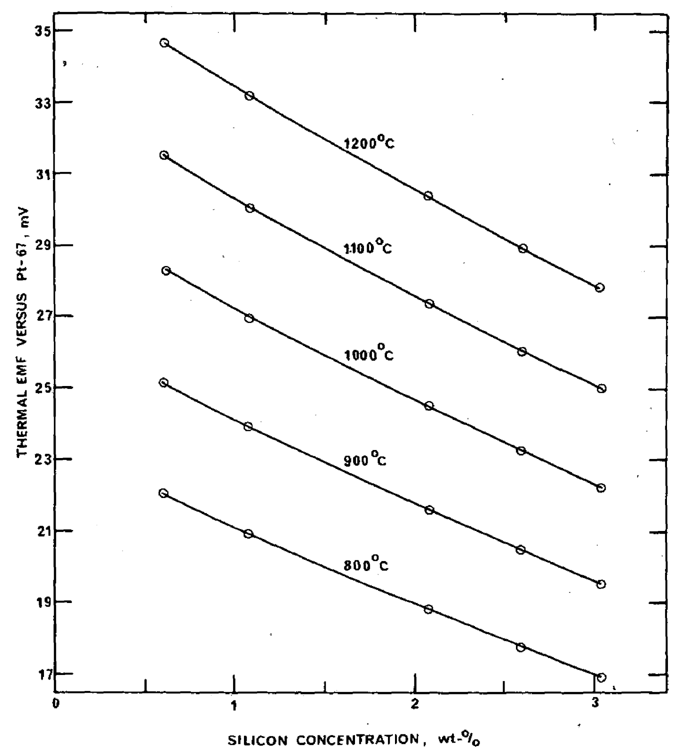

FIGURE 6.1.2.2 *Thermal emf's of* Ni–14¼Cr–Si *alloys* (*ref. table 3.2.3*) *of different* Si *contents versus platinum,* Pt–67.

Using the experimental data upon which figure 6.1.2.2 is based, it is possible to estimate the dependence of the thermal emf of Nicrosil upon its silicon content. This is done by reference to alloys 56 and 57. The change in the emf of Nicrosil per 0.1 percent silicon is given by—

$$[(E_{57}-E_{56})_t/(Si_{57}-Si_{56})]\times 10^{-1} \text{ mV}$$

where $E_{56,57}$ in mV are the thermal emf's of alloys 56 and 57 versus Pt–67 at temperature t, and

$Si_{56,57}$ are the silicon contents in wt.−% of alloys 56 and 57.

From this expression, the following values for the change in the thermal emf of the Nicrosil alloy versus Pt–67, corresponding to a variation of 0.1 percent in its silicon content with its chromium content fixed at 14.23 percent, are derived—

800 °C	−0.203 mV/+0.1 percent Si
900	−0.223
1000	−0.242
1100	−0.259
1200	−0.274

6.1.3 Nisil

The sensitivity of the thermal emf of Nisil to variation in its silicon content was investigated by determining the thermal emf's of the Ni–Si alloys listed in table 3.2.1 versus Pt–67 in the range 400 to 1200 °C. The same calibration techniques were used as are mentioned above. The results of these studies are expressed graphically in figure 6.1.3.1.

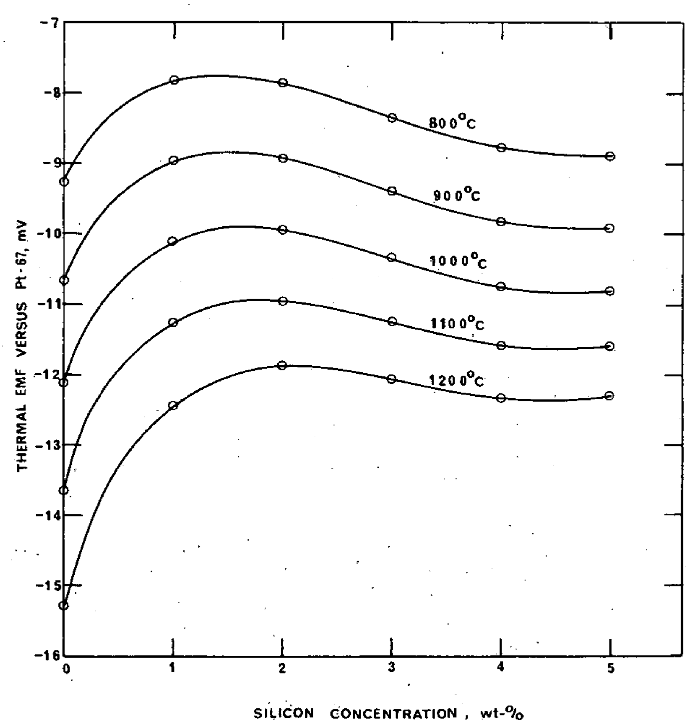

FIGURE 6.1.3.1 *Thermal emf's of alpha* Ni–Si *alloys (ref. table 3.2.1) versus platinum,* Pt–67.

The curves of figure 6.1.3.1 show a series of maxima near a value of 1½ percent Si and a series of minima near a value of 4½ percent Si. For compositions near these values, which appear to be somewhat temperature dependent, the thermal emf's of Ni–Si alloys are relatively insensitive to variations in silicon content. As was proposed in section 2.2.3, the preferred silicon content of Nisil lies between 4¼ percent, which is the level of transition in these alloys from an internal to an external mode of oxidation in air at about 1200 °C, and 5 percent, which is the limit of binary solid solubility of silicon in nickel at room temperature. It is clear from figure 6.1.3.1 that the specific silicon content of Nisil should be 4.4 percent, the mean value of the minima referred to above.

6.2 Oxidation Resistance

It is not proposed in this Monograph to present a qualitative description of the mechanisms and microstructures which characterize the oxidation behaviors of Nicrosil and Nisil. The intention in section 6 is to deal only in quantitative terms with those properties chosen for discussion.

Nevertheless, since the aim in the formulation of the new thermoelements was to develop a thermocouple system which would show greatly enhanced oxidation resistance in air at high temperatures, sufficient evidence is presented here to establish that this aim has been most satisfactorily achieved.

In section 2.1.1 the general characteristics of the air oxidation of both the positive and negative conventional Type K thermcouple alloys are described. In summary, this process results in the formation of—

(i) an outer scale layer of nickelous oxide, NiO,
(ii) an internally oxidized zone in which precipitates of oxides of the solute elements appear in a solute depleted alloy matrix, and
(iii) ternary oxides of the spinel type AB_2O_4 which result from solid-state reactions between the NiO and the internal oxides and which appear in the inner layers of the external scale.

These structures are illustrated in figure 6.2.1.

In section 1.2 it is proposed that the air oxidation resistance of nickel-base thermocouple alloys can be significantly enhanced, particularly at temperatures above 1100 °C, by increasing alloy solute levels above those required to cause a transition from internal to external modes of oxidation, and by selecting solutes which preferentially oxidize to form impervious diffusion-barrier films. It was further suggested that the application of these proposals in the formulation of Nicrosil and Nisil would produce alloys in which the oxidation mechanisms summarized above would be substantially retarded and in which internal oxidation would not occur at all. Figure 6.2.1 shows that Nicrosil and Nisil are thermocouple alloys of such a kind, and that their oxidation resistance is markedly superior to that of the existing Type K thermocouple alloys.

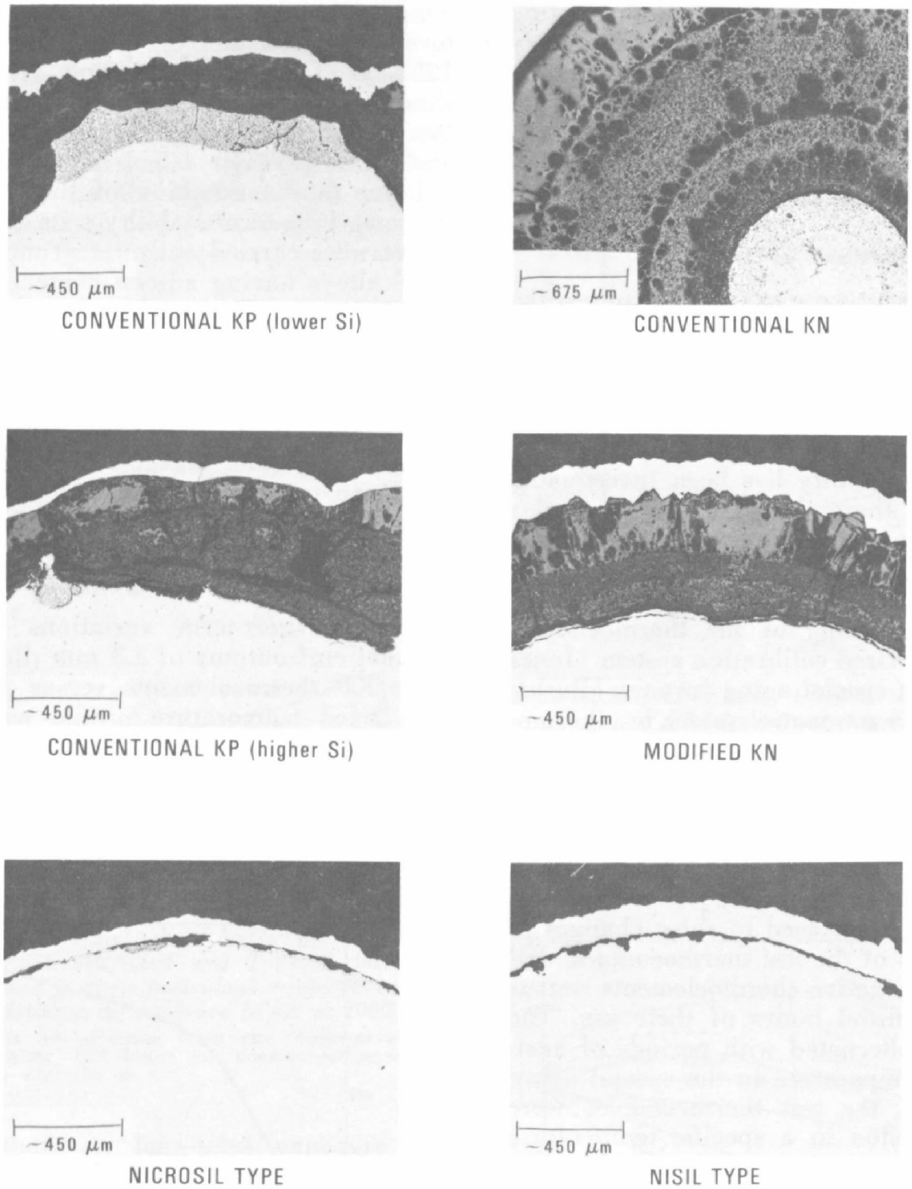

FIGURE 6.2.1 *Oxide structures in conventional and modified conventional Type K thermocouple alloys (ref. table 1.1.1) and in Nicrosil and Nisil type alloys.*

The structures result from constant-temperature exposure in air for 800 hours at 1200 °C. The outer white annular zone is a layer of electrodeposited copper [Burley and Dale, 1962] which is applied to support the fragile oxides.

From figure 6.2.1 it can be seen that the internal and external oxide layers which form in the commercial Type K alloys are, in fact, virtually absent from Nicrosil and Nisil. Of particular note is that, for this group of alloys, the least oxide occurs in Nisil at 1200 °C, a temperature at which the conventional Type KN alloy was oxidized right through after about 700 hours. Studies using a coupled electron-probe/computer technique [Burley, 1969] have shown that solute depletion in Nisil, even after very long times of exposure at 1200 °C, is negligible, while depletions in Nicrosil are considerably less than in the conventional positive alloys.

Studies of oxidation mechanisms and kinetics in Nicrosil and Nisil, and of the effects of thermal passivation treatments (ref. section 2.2.4.) on these behaviors, are continuing at MRL.

6.3 Thermoelectromotive Force Stability Related to Oxidation Resistance

6.3.1 General

In the optimization of the formulations of Nicrosil and Nisil (ref. section 2.2), a main aim was to design positive and negative thermoelements which would be more resistant to air oxidation, and hence show much higher long-term thermal emf stabilities, than existing nickel-base thermocouple alloys. Exhaustive laboratory tests have now been carried out to show whether this aim has been realized. These tests were carried out mainly at the Australian Defence Materials Research Laboratories (MRL), and also at the Australian National Measurement Laboratory (NML).

6.3.2 Methods of Test

Two types of experiment were carried out to test the thermal emf stability of Nicrosil and Nisil thermoelements related to their oxidation resistance in air. The initial calibration stability has been determined at NML [Burley and Jones, 1975] by successive calibration runs on prototype samples (ref. section 3.1). The long-term thermal emf stability has been investigated at MRL by measuring thermal emf drifts in similar samples on long exposure in air at constant temperatures up to 1250 °C.

The investigation of the thermoelectric changes occurring during initial heating of the thermocouples utilized a rapid computerized calibration system [Jones and Egan, 1975], and a special aging furnace [Burley and Jones, 1975]. In this automatic system, test thermocouples are compared with a standard noble-metal thermocouple in a programmed furnace [Jones and Egan, 1975] whose temperature is raised to the test temperature and lowered to ambient at rates which allow the thermocouple measuring junctions to remain above 700 °C for only two hours. Successive calibrations in this equipment were used to show changes in the thermal emf outputs of the test thermocouples, and of their positive and negative thermoelements versus platinum, during the initial hours of their use. The calibration runs were alternated with periods of heating at a selected test temperature in the special aging furnace. During aging, the test thermocouples were located at fixed immersion in a specific temperature profile or were totally immersed for isothermal heating. Identical heating of all the elements of the test assemblies, comprising Nicrosil/Nisil and Type K thermocouple wires supplied by Manufacturer A (ref. section 3.1), was ensured by welding their measuring junctions into a common bead into which was peened the measuring junction of a standard noble-metal thermocouple.

The investigation of the long-term drifts in the thermal emf's of Nicrosil and Nisil involved prolonged exposure of 3.3 mm diameter test thermocouples in air at constant high temperatures in a special furnace [Burley and Jones, 1975] in which temperature profiles were readily controlled. The test assemblies comprised prototype Nicrosil/Nisil, Type K, and standard noble-metal reference thermocouples. These assemblies were similar to those used in the initial calibration stability investigation described above, except that the base metal alloys were obtained from a number of different manufacturers. The thermal emf's of all the thermocouples, and of their positive and negative thermoelements versus platinum, were measured initially and at various times during the prolonged high temperature exposure. Two principal aging temperatures are considered here, namely 1000 °C and 1250 °C. The emf measuring systems for both the short-term and long-term tests, and the uncertainty of the measurements involved, are discussed by Burley and Jones [1975].

Prior to the adoption of the final formulation of Nicrosil, long-term stability tests of the type described above were carried out on a group of seven 'Nicrosil-type' alloys having silicon contents ranging from 0.6 to 3.6 percent. The results of the tests on these alloys, which were specially fabricated for the purpose by Manufacturer B (ref. section 3.1), were used to estimate the optimum silicon content of Nicrosil.

In these tests, the Type K thermocouples were found to be quite unstable at 1250 °C, so results for them are presented at an upper test temperature of 1200 °C.

6.3.3 Nicrosil versus Platinum

Typical short-term variations with time in the thermal emf outputs of 3.3 mm diameter Nicrosil and Type KP thermoelements versus platinum, on aging in a fixed temperature profile with a maximum of 1250 °C, are summarized graphically in figure 6.3.3.1. It can be seen that the initial emf drift of Type KP thermoelements in this test was about 5 times greater than that of Nicrosil.

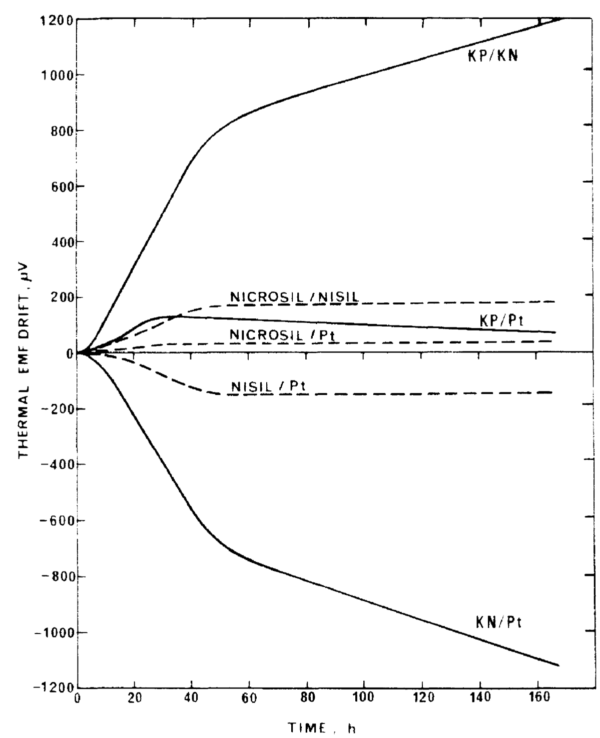

FIGURE 6.3.3.1 *Short-term changes in the thermal emf outputs of 3.3 mm diameter Nicrosil/Nisil and Type K thermocouples and of their individual thermoelements versus platinum on exposure in air at 1250 °C [after Burley and Jones, 1975].*

Typical long-term drifts in the thermal emf outputs of Nicrosil and Type KP thermoelements versus platinum on long exposure in air are presented graphically in figure 6.3.3.2 (1000 °C) and in figure 6.3.3.3 (1200 °C and 1250 °C). The results are given in terms of deviations of thermal emf's from 'original' values as functions of time at the particular temperature. The 'original' value is taken as the thermal emf output after 100 hours of heating so as to effectively separate long-term emf drifts from short-term calibration changes.

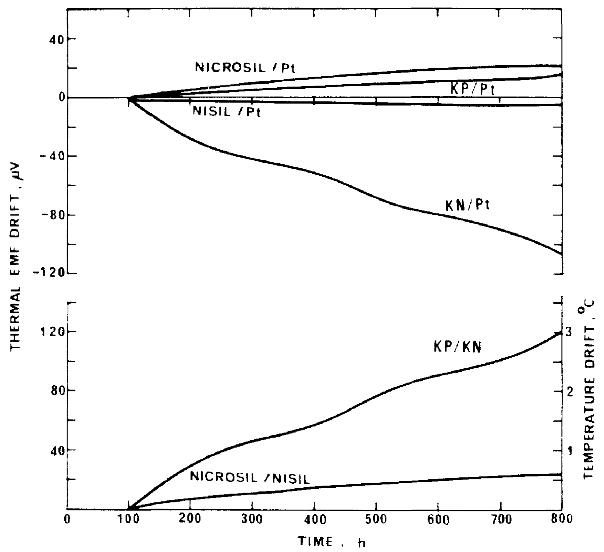

FIGURE 6.3.3.2 *Long-term thermal emf drifts in 3.3 mm diameter Nicrosil/Nisil and Type K thermocouples and in their individual thermoelements versus platinum on exposure in air at 1000 °C.* The drifts are changes from emf output values existent after 100 hours of constant-temperature (1000 °C) exposure in air.

It can be seen that, on long-term exposure at 1000 °C in these tests, Type KP and Nicrosil showed little difference in emf stability, but at the higher temperatures Nicrosil (at 1250 °C) was about 20 times more stable than Type KP (at 1200 °C).

The results for the 'modified Nicrosil' alloys containing different amounts of silicon are expressed graphically in figure 6.3.3.4. The dotted curve, which is the mean of the results for the 1.09 and 1.66 percent Si curves, represents virtually ideal isothermal behavior. The maximum positive deviation for this hypothetical case, about 30 μV, occurs after 750 hours of exposure, and the deviation returns to zero after 1600 hours. This curve corresponds to a silicon content of 1.4 percent, which can thus be considered optimum for Nicrosil. The excellent stability of a series of experimental Nicrosil alloys (pre-prototype) containing 1.4 percent silicon is shown in figure 6.3.3.5.

6.3.4 Nisil versus Platinum

The short-term variations with time in the thermal emf outputs of the 3.3 mm diameter Nisil and Type KN

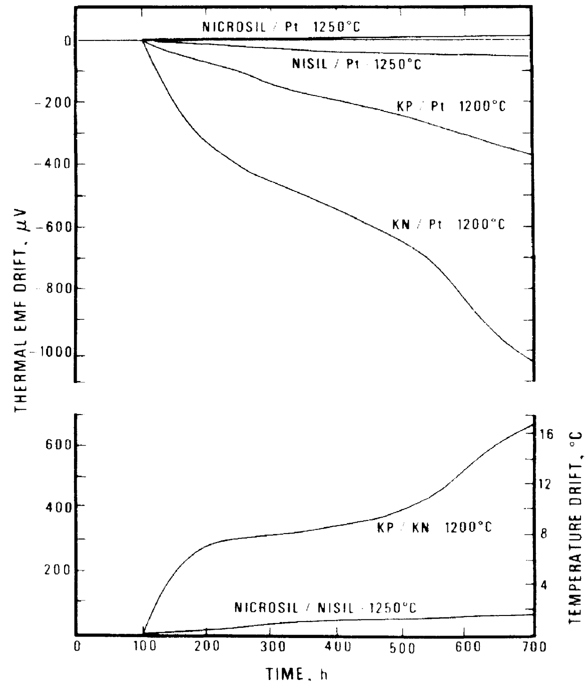

FIGURE 6.3.3.3 *Long-term thermal emf drifts as in figure 6.3.3.2, but on exposure at 1200 °C (Type K) and 1250 °C (Nicrosil/Nisil).*

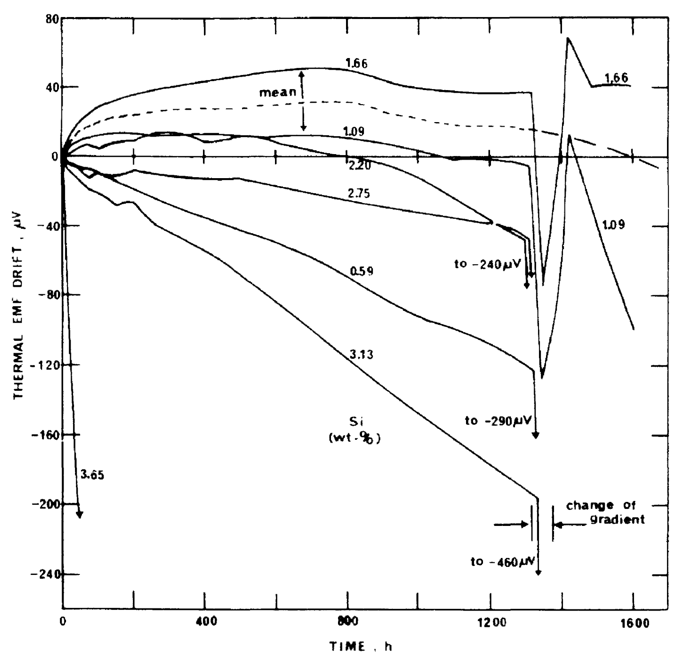

FIGURE 6.3.3.4 *Long-term thermal emf drifts in 2 mm diameter wires of Ni–16Cr–Si alloys of various silicon contents versus platinum on exposure in air at 1250 °C.* The change of gradient is a temporary change to a much steeper temperature profile from the smooth parabolic profile which obtained throughout the 1600-hour test. The significance of the mean curve is described in the text.

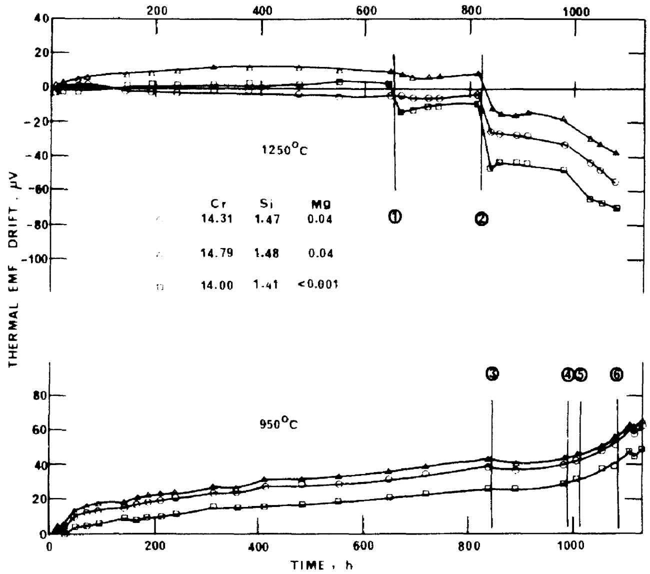

FIGURE 6.3.3.5 *Long-term thermal emf drifts in 3.3 mm diameter experimental Nicrosil-type thermoelements of indicated composition versus platinum on exposure in air at 950 °C and 1250 °C.*

The number annotations refer to short-term temperature excursions from the test-temperature as follows—

(1) to 1000 °C	(2) to 800 °C
(3) to 850 °C	(4) to 600 °C
(5) to 400 °C	(6) to ambient

thermoelements versus platinum at 1250 °C are summarized graphically in figure 6.3.3.1. It can be seen that, at the conclusion of the test, Type KN had drifted about 8 times more than Nisil.

Typical long-term drifts in the thermal emf's of the Nisil and Type KN thermoelements versus platinum are presented graphically in figures 6.3.3.2 (1000 °C) and 6.3.3.3 (1200 °C and 1250 °C). In these tests Nisil was about 25 times more stable than Type KN at 1000 °C, whereas Nisil at 1250 °C was about 20 times more stable than Type KN at 1200 °C.

6.3.5 Nicrosil versus Nisil

The short-term variations and long-term drifts in the thermal emf outputs of the Nicrosil/Nisil and Type K thermocouples are also presented in figures 6.3.3.1, 6.3.3.2 and 6.3.3.3.

It will be seen that the initial calibration stability of the Nicrosil/Nisil thermocouples in these tests was about 7 times greater than that of the Type K thermocouples.

It will be seen that, on long-term exposure at 1000 °C in these tests, Nicrosil versus Nisil thermocouples were about 5 times as stable as Type K thermocouples. A typical deviation of the Nicrosil/Nisil system at 700 hours was about +25 μV (≅0.6 °C) whereas that of the Type K thermocouples was about +120 μV (≅3 °C). While both the Nicrosil and Nisil thermoelements were stable at 1000 °C, the relative instability of the Type K thermocouples was predominantly due to substantial emf drift in their negative thermoelements.

On exposure at 1250 °C, the emf outputs of the Type K thermocouples in these tests were quite unstable, drifting continuously at the rate of about 2 μV per hour. On the other hand, at 1250 °C the deviation of the Nicrosil/Nisil thermocouples at 700 hours was about +60 μV (≅1.5 °C). By way of further contrast at 1200 °C the emf of the Type K thermocouples had drifted by about +650 μV (≅16 °C) at 700 hours. It is also to be noted that, whereas the positive thermoelements of the Type K thermocouples drifted by more than −350 μV at 1200 °C, the Nicrosil elements at 1250 °C were virtually inert and showed negligible emf changes. Were it not for the fact that the emf drifts in the individual thermoelements of the Type K thermocouples were in the same direction, the net thermocouple drifts would have been even greater, e.g. at 700 hours of exposure at 1200 °C, a −360 μV drift in Type KP and a −1020 μV drift in Type KN resulted in a net +660 μV drift in the combination.

It is also to be noted that the thermoelectric stability of Nicrosil/Nisil thermocouples on long exposure in air at 1250 °C compares favorably with that of noble-metal thermocouples of Type R exposed under the same conditions [Burley and Jones, 1975].

6.4 Thermoelectromotive Force Stability Related to Atomic Ordering

6.4.1 General

In section 2.1.2 the discussion embodies circumstantial evidence which exists to support a hypothesis that the short-term variations in the thermal emf of Type K thermocouples, which occur in the temperature range ca. 250 to 550 °C, are due to short-range ordering in their Type KP thermoelements.

In the optimization of the formulation of Nicrosil, in section 2.2.2., a complementary aim was to select a solute level of chromium at which thermal emf variations related to atomic ordering were minimal. It was concluded that, in the case of binary alloys of nickel and chromium, this level was about 15½ percent, but when silicon (1.4%) was added to the binary alloy to form Nicrosil, minimal structure related emf variations occurred when the chromium concentration was about 14 percent.

Experiments aimed at determining the susceptibility of Nicrosil to emf instability related to atomic ordering were carried out at NBS during the joint project. The salient results of these tests are presented in this section.

6.4.2 Methods of Test

First, a series of tests was carried out to determine the characteristic magnitudes of the short-term order-related variations in the thermal emf of Nicrosil. Alloy wire samples (1.63 mm diam., 14 AWG) of Nicrosil, and also of Type KP for direct and simultaneous comparison, were made up into test assemblies incorporating noble-metal standard thermocouples, similar to those described in section 4.2 for use in the establishment of the thermoelectric reference data. The Nicrosil samples were of prototype alloys supplied by manufacturers A and D (ref. section 3.1). The Type KP alloy, which was a commercial sample selected at random from recently procured stocks of the product of manufacturer A, had virtually the same composition as that of the high-silicon conventional type positive alloy listed in table 1.1.1.

Several samples of each alloy, each of which had different thermal histories, were calibrated in the range 200 to 500 °C using the calibration methods described in section 4.2. The four different thermal histories involved were:

(A) 'As-received': The samples were cut from rolls of wire as-received from the manufacturer: their thermal history was thus related to a manufacturing production heat-treatment which was a brief anneal at high temperature—

(i) "about 30 seconds at 1080 °C" in the case of manufacturer A.
(ii) "a few seconds at 950 °C" in the case of manufacturer D.

Since both of these anneals were followed by a fairly rapid cool to room temperature, some degree of atomic order would have been produced in the Type KP samples. This degree of order would increase on subsequent heating during calibration to some higher time-temperature-dependent degree, and the thermal emf of the Type KP samples would increase correspondingly as a consequence.

(B) 'Metastable': As-received samples were annealed in air for six hours at 1050 °C, and then were drastically water-quenched. It was assumed that the high-temperature anneal would produce a state of quasi-random disorder. The extremely rapid cooling produced by the drastic water-quench ought therefore to retain a metastable quasi-disordered structure in both Nicrosil and Type KP alloys. Subsequent reheating of these samples during calibration would produce large changes in the degree of order in the Type KP alloys and correspondingly large changes in thermal emf.

(C) 'Stabilized by slow-cool': As-received samples were annealed at 1050 °C as in (B), but were very slowly cooled to room temperature in the annealing furnace. While such samples would also develop a quasi-disordered structure during the high temperature anneal, on slow cooling the Type KP samples would assume some temperature-dependent high degree of atomic order as they passed through the virtually time-independent ordering range 575 to 450 °C (referred to in section 2.1.2).

(D) 'Stabilized by aging': As-received samples were annealed and water-quenched as in (B), but were then isothermally aged in air at 480 °C for one hour. As implied in section 2.1.2, this aging treatment generates about the maximum degree of short-range order attainable in alloys of Type KP in a relatively short period of time. It can further be inferred that, even though relatively large increases in thermal emf would occur in the Type KP samples during the aging period, any further variations in emf during subsequent heatings would be quite small provided the aging temperature was not significantly exceeded. This would appear to be the most stable state for Type KP alloys.

In addition to the tests on the thermally-treated samples of Type KP and Nicrosil, a further series of tests was carried out to determine the sensitivity of order-related thermal emf variations in Nicrosil to variations in the solute concentration of its major alloying component, chromium. This was done by calibrating, in the manner described above, the range of Ni–Cr–1½Si alloys of various chromium contents which are listed in table 3.2.2, plus the Nicrosil prototype No. 180 which has a Si content close to the average of the alloys in the table. Samples of each of these alloys were thermally treated by a procedure of the type (B) described above, i.e. a high-temperature anneal and water-quench, in this case at 1000 °C for three hours. This procedure ensured that any short-range order which might develop in these alloys on subsequent heating during calibration, and thus any corresponding variation from initial thermal emf values, would initiate from a ground state of quasi-disorder.

6.4.3 Results of Tests

The results of the calibration of samples of thermal history (A), i.e. the 'as-received' samples, are given in figure 6.4.3.1 in terms of the deviation of the calibration values obtained during the cooling portion of the calibration cycle from those obtained during the heating portion. It can be seen that, in comparison with Type KP_A, in which order-related changes in emf output up to about 70 μV occurred, $Nicrosil_A$ was stable within 6 μV and $Nicrosil_D$ was stable within 10 μV during the calibration cycle to 550 °C.

The results of the calibration of samples of thermal history (B), i.e. the high-temperature anneal and water-quench, are also given in figure 6.4.3.1. It can be seen that when the quasi-disordered (quenched) samples were heated in a calibration cycle to 550 °C, the consequent development of a high degree of time-temperature-dependent order in Type KP_A produced changes in emf output up to about 60 μV. On the other hand, identical treatment produced changes in $Nicrosil_D$ not exceeding 10 μV.

While the type (B) thermal treatment is of little practical significance, in that operating thermocouples are almost never water-quenched, it is of considerable scientific relevance in that it facilitates a determination of the magnitudes of the changes in the thermal emf outputs of Type KP thermoelements corresponding to the development of maximal degrees of short-range order from the quasi-disordered state. It is of considerable significance that, in these tests, such emf changes were of the same order of magnitude as those occurring during the calibration of the as-received samples, a practical procedure of considerable importance.

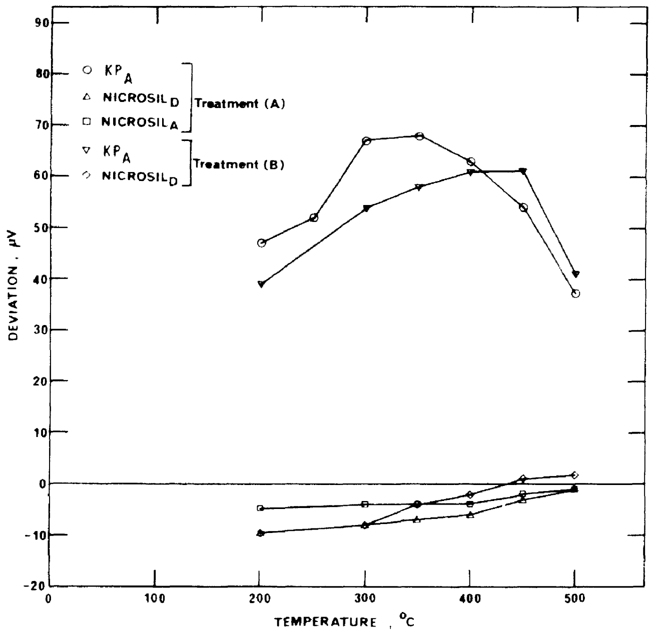

FIGURE 6.4.3.1 *Changes in the calibrations of Type KP and Nicrosil thermoelements versus platinum,* Pt–67, *of thermal histories (A) and (B) (see text), in terms of deviations of the calibration values obtained during the cooling portion of the calibration cycle from those obtained during the heating portion.*
The samples were held at 500 °C (KP_A) and 550 °C (Nicrosils) for one hour before cooling them to room temperature.

The results of the calibration of samples of thermal history (C), i.e. high-temperature anneal and very slow cool, are not summarized in graphical form, nor are those for thermal history (D), i.e. the isothermal aging. This is because these treatments allow the development of maximal degrees of short-range order in thermoalloys of Type KP and, since there is little further change in this state of ordering during subsequent heating to 550 °C, the initial calibration remained reasonably stable. For example, the emf differences between the heating and cooling portions of the calibration cycle for the Type KP_A thermoelements did not exceed 5 μV: corresponding differences for Nicrosil thermoelements did not exceed 1 μV. Similar results accrued when the aging treatments were carried out in the temperature profile (maximum value 480 °C) of the calibrating furnace.

It is to be noted that the stability of Type KP thermoelements 'stabilized' by the slow cooling or by aging treatments described above will persist only until such thermoelements are again heated above about 600 °C. When this occurs, further thermal emf variations will accompany subsequent disorder-order reactions as the Type KP alloys are thermally cycled above and below this temperature. On the other hand, all the experimental evidence presented in this section shows that none of the thermal treatments applied produces any appreciable changes in the emf output of Nicrosil when calibrated in the temperature range of interest. This very high degree of structure-related emf stability, furthermore, is not reduced by subsequent thermal cycling above 600 °C. It is concluded, therefore, that Nicrosil is virtually immune from the instabilities of calibration of the kind related to atomic ordering which so plague the Type KP thermoelements.

The results of the experiment to determine the sensitivity of order-related emf variations in Nicrosil to variations in its chromium content are summarized graphically in figure 6.4.3.2. Since the magnitude of emf shift due to ordering is a function not only of chromium solute level but also of temperature and time of calibration, there are a number of different values of shift for each chromium level. The data of figure 6.4.3.2 therefore are shown in the form of an envelope of values with upper and lower bounds defining the maximum and minimum shifts observed for each chromium level. From this graph it can be seen that the optimum chromium content of Nicrosil should be about 14 wt.-%.

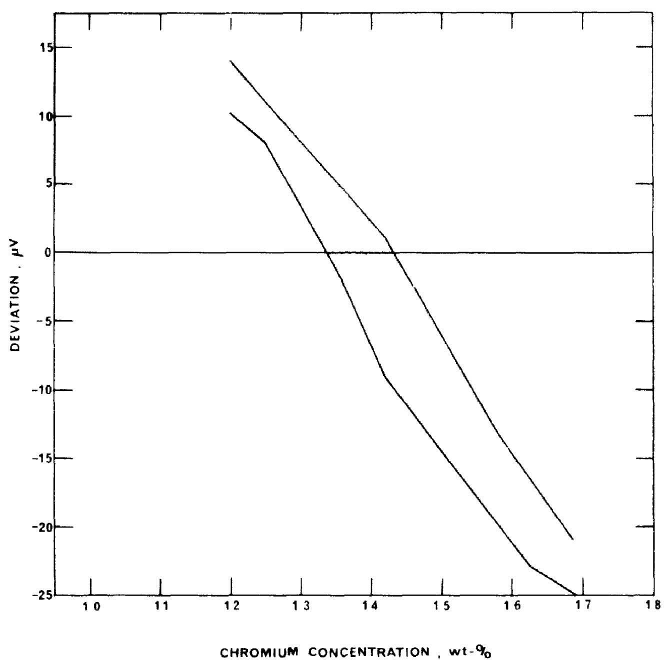

FIGURE 6.4.3.2 *Changes in the calibrations of Nicrosil-type thermoelements of different chromium contents versus platinum,* Pt–67, *(ref. table 3.2.2) as in figure 6.4.3.1.*
The significance of the envelop of values is described in the text.

A similar experiment, using the alloys listed in table 3.2.3 was carried out to estimate the sensitivity of the order-related emf changes in Nicrosil to variations in its silicon content. It was concluded that the sensitivity of such emf changes to variation in silicon content was virtually the same as that for chromium.

6.5 Thermoelectromotive Force Stability Related to Plastic Deformation and Annealing

6.5.1 General

The thermoelectric properties of metallic materials are affected by plastic deformation. Of considerable practical significance is the deformation produced by the mechanical working of thermoalloys during manufacture, and the change in thermal emf output which this process causes. Of equal significance are the effects on thermal emf produced during subsequent heating by such phenomena as recovery, ordering, recrystallization and grain growth in the crystal structure of the alloy.

Practically all base-metal thermocouple wires are annealed at high temperature as a final stage of manufacture. Such heat-treatments, some examples of which are given in section 6.4.2, are generally considered to stabilize thermal emf's and, according to the ASTM [1974], it is seldom found advisable to anneal wires further before testing and use. Potts and McElroy [1962], however, found that commercial nickel-base thermocouple wires, in the as-received state, were residually cold-worked to the extent of 2 to 5 percent and that, as a consequence, errors of measurement up to one percent could occur. They further found that a major part of this emf shift could be removed by thermal treatments aimed at bringing about recovery and recrystallization, which they state occur in nickel-base thermoalloys in the ranges 250 to 450 °C and 500 to 750 °C, respectively.

No definitive studies of the complex effects of deformation and annealing upon the thermoelectric properties of Nicrosil and Nisil were possible in the time available for the joint NBS–MRL project, but sufficient testing was done to gain preliminary knowledge of the sensitivity of the thermal emf's of the new alloys to these effects.

6.5.2 Methods of Test

Two different kinds of experiment were carried out using 1.63 mm (14 AWG) and 0.32 mm (28 AWG) diameter wire samples of prototype alloys from manufacturers A and D, respectively. In the first experiment, several 'as-received' (ref. section 6.4.2) wire samples were strained in tension by different amounts by stretching them in the Tinius-Olsen tensile testing machine located in the Mechanical Properties Section of the Metallurgy Division, NBS Gaithersburg. The strained samples were then calibrated in the range 50 to 450 °C using the calibration techniques described in section 4.2. This was done to determine what effect the tensile plastic deformation had upon the thermal emf's of the wire samples. In the second experiment similar samples were strained in the above manner by elongating them 10 percent (0.32 mm diam. Nicrosil), 15 percent (0.32 mm diam. Nisil), 20 percent (1.63 mm diam. Nicrosil), and 25 percent (1.63 mm diam. Nisil). Each strained sample was then isothermally annealed in air for 30 minutes. The temperatures at which the various samples were annealed ranged from 150 to 950 °C. After they were annealed, the samples were calibrated in the range 50 to 500 °C by the techniques described in section 4.2 to determine what effect high-temperature annealing had upon thermal emf's corresponding to the 'as-strained' condition.

6.5.3 Results of Tests

The results of the low temperature calibration of the 1.63 mm diam. 'as-received' samples of both Nicrosil and Nisil, strained by various amounts, are summarized in figure 6.5.3.1. In these tests, the thermal emf of Nicrosil decreased proportionally with strain and temperature up to test maxima of 20 percent and 450 °C, respectively, where the change was -56 μV. Up to this temperature there was no change from this proportionality, indicating that no significant metallurgical recovery had taken place. With Nisil, on the other hand, 20 percent strain produced a maximum increase in emf of only 17 μV at 150 °C, above which temperatures the emf decreased again indicating a quite low-temperature recovery process. Very similar effects were observed in the case of the finer wires of 0.32 mm diameter.

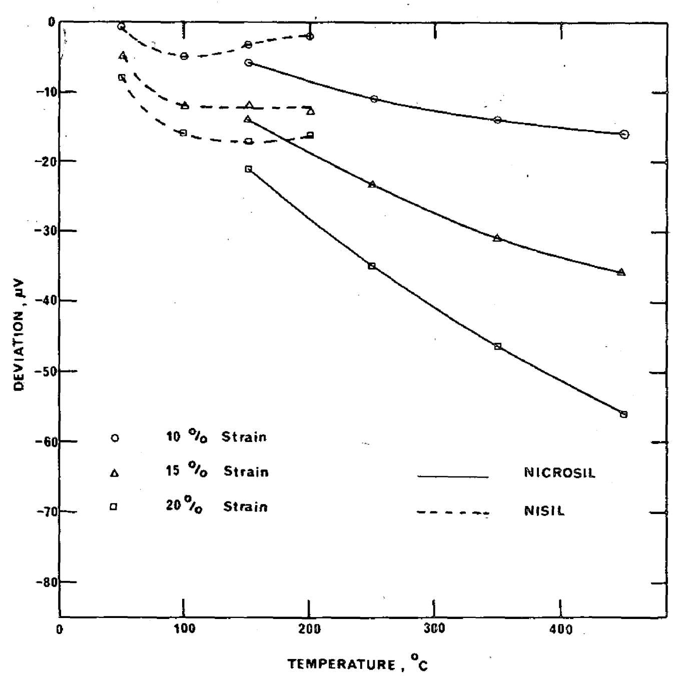

FIGURE 6.5.3.1 *Changes in the calibrations of (1.63 mm diam.) Nicrosil and Nisil thermoelements versus platinum,* Pt–67, *due to tensional plastic deformation.*

The results of the calibration of the strained and annealed samples are given in figures 6.5.3.2 (Nicrosil) and 6.5.3.3 (Nisil). It is to be noted that these graphs are expressed in a different mode from most of those in previous figures. In figures 6.5.3.2 and 6.5.3.3 the abscissas are annealing temperatures, not cali-

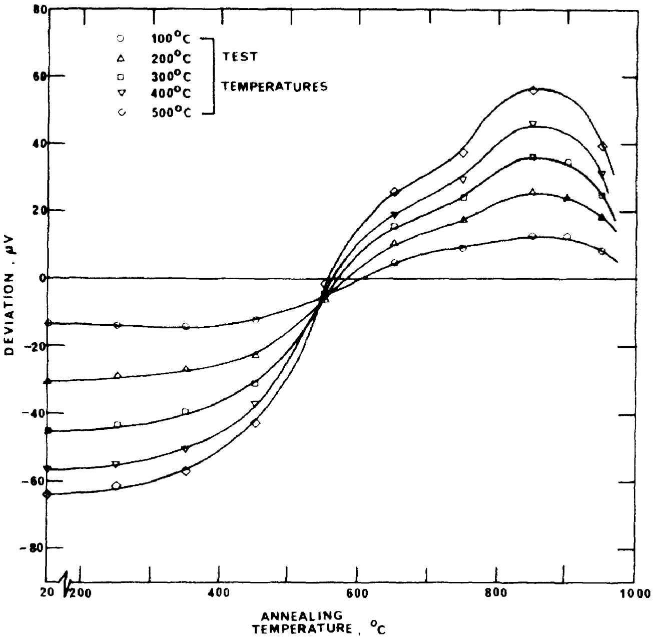

FIGURE 6.5.3.2 *Changes in the calibrations of (1.63 mm diam.) Nicrosil thermoelements versus platinum, Pt–67, due to annealing for 30 minutes in air at various temperatures between 150 and 950 °C after tensional plastic deformation to 20 percent strain.*

The values at 20 °C on the abscissa represent the changes in thermal emf on straining from 'as-received values.'

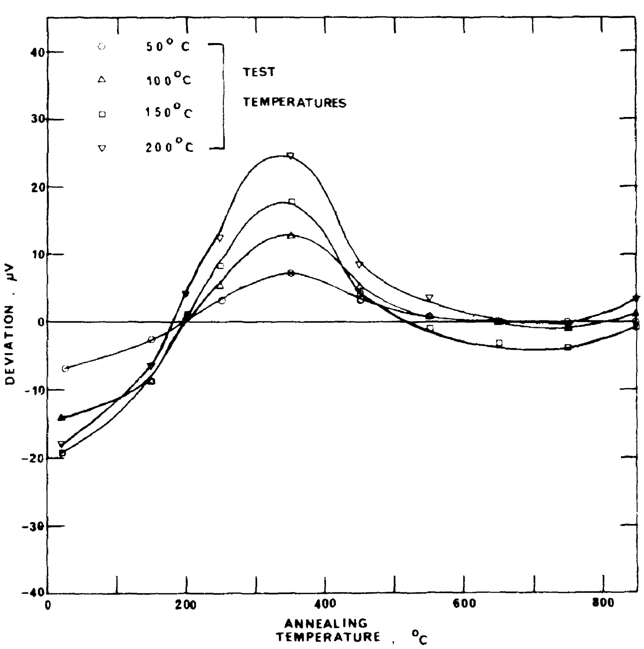

FIGURE 6.5.3.3 *Changes in the calibrations of Nisil thermoelements, as in figure 6.5.3.2, but after 25 percent strain.*

bration temperatures which are represented by the different curves. It will be seen that when Nicrosil was annealed at about 550 °C, its thermal emf's returned to 'as-received' values, namely those which obtained, before straining 20 percent produced decreases up to 63 μV. It seems that the maxima in emf deviations after annealing at 850 °C correspond to the recrystallization phenomenon in Nicrosil. Similar conclusions, with different corresponding temperatures, can be drawn for Nisil. Similar conclusions for both alloys can also be drawn from the results of the tests on the 0.32 mm diam. wires.

6.6 Other Physical Properties

In addition to the various thermoelectric properties of Nicrosil and Nisil quantitatively investigated during the joint NBS–MRL project, several other physical property measurements on these alloys have been made independently by other authorities. Of particular interest are those which have been made at Oak Ridge National Laboratory (ORNL), Tennessee, USA. Moore and associates of the Metals and Ceramics Division and the Instrumentation and Controls Division at ORNL have presented the results of their measurements of thermal conductivity, electrical resistivity, and mean coefficient of thermal expansion, on two alloys near the nominal compositions of Nicrosil and Nisil, to the 14th International Thermal Conductivity Conference (Moore et al, 1975). Their results, together with some of the associated discussion, are summarized in this section. All properties are differentiated, as between the Nicrosil- and Nisil-type alloys, with the symbols (+) and (−), respectively.

6.6.1 Thermal Expansion (α)

All the ORNL experimental data for α are within ± 3 percent of—

$$\alpha(+) = (9.44 + 0.00633T + \frac{815}{T}) \times 10^{-6} \ (\mathrm{K}^{-1})$$

$$400 < T < 1100 \ \mathrm{K, and}$$

$$\alpha(-) = (12.2 + 0.0034T) \times 10^{-6} \ (\mathrm{K}^{-1})$$

$$400 < T < 1100 \ \mathrm{K.}$$

Both α(+) and α(−) are about 15 percent below α of Type 304 stainless steel [Touloukian, 1967a], facts which Moore et al attribute as the cause of reduced mechanical compatibility between Nicrosil/Nisil conductors and stainless steel sheathing in mineral-insulated integrally-sheathed thermocouple cable. As a way of overcoming this problem, they advocate the use of sheathing materials with α values near α(+) and α(−). The authors of this Monograph suggest that Nicrosil and/or Nisil themselves might prove to be adequate sheathing alloys for such cables.

6.6.2 Electrical Resistivity (ρ)

The ORNL experimental values of ρ(+) and ρ(−), corrected for thermal expansion, are shown in figure 6.6.2.1 as well as those for pure nickel. Since the

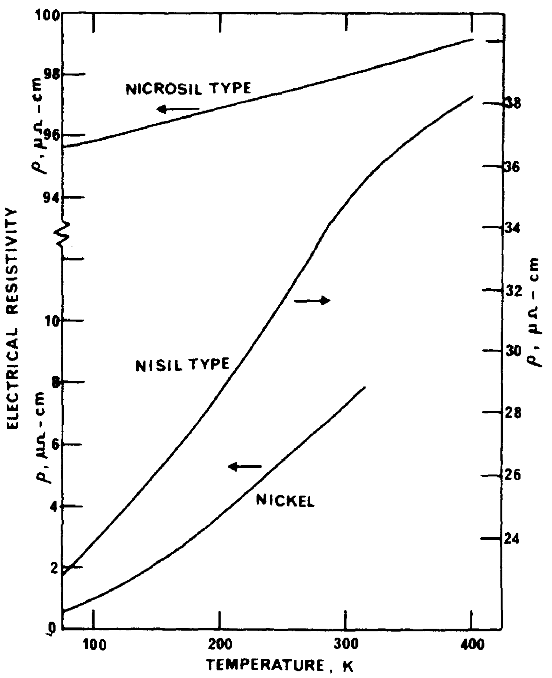

FIGURE 6.6.2.1 *Electrical resistivity of Nicrosil- and Nisil-type alloys compared with pure nickel [after Moore et al, 1975].*
Note scale changes.

values of $\rho(+)$, $\rho(-)$ and $\rho(\mathrm{Ni})$ differ appreciably, the scale of figure 6.6.2.1 is different for each material. The electrical resistivity, $\rho(+)$, of Nicrosil increases smoothly with increasing temperature, T, from 80 to 400 K and all data are within ± 0.05 percent of

$$\rho(+) = 94.79 + 0.010732T$$

The electrical resistivity of Nisil is a factor of three or four below that of Nicrosil but the slope $d\rho(-)/dT$ is greater than $d\rho(+)/dT$.

It is to be noted that the electrical resistivity of a ferromagnetic, antiferromagnetic, or paramagnetic metal is due to scattering of conduction electrons by several mechanisms. The localized spin model would give

$$\rho(T) = \rho_i + \rho_p(T) + \rho_s(T)$$

where ρ_i, $\rho_p(T)$, and $\rho_s(T)$ are due to electron scattering by impurities, lattice vibrations, and disordered spins, respectively. Nicrosil is paramagnetic and, qualitatively, its resistivity can be interpreted as that of a paramagnetic metal where ρ_s is approximately constant and where there is a large ρ_i due mostly to the high chromium content ($14\frac{1}{4}\%$). On the localized spin model, ρ_s and ρ_i of Nicrosil should be constant over the measurement range 80 to 400 K since there are no transformations over this range.

The electrical resistivity-temperature dependence of Nisil is similar to that of nickel (ref. figure 6.6.2.1) except that the Curie temperature, T_c, is lowered from about 630 K for nickel to about 290 K for Nisil by the addition of silicon (to $4\frac{1}{2}\%$). From 80 K to about 290 K, $\rho(-)$ increases rapidly with increasing temperature as the aligned electron spins are thermally disordered. Above T_c the slope of $\rho(-)$ is lower and nearly constant at about 0.035 $\mu\Omega$ cm K^{-1}, which is close to the slope of 0.036 $\mu\Omega$ cm K^{-1} for paramagnetic Ni [Touloukian, 1967b].

6.6.3 Thermal Conductivity (λ)

The ORNL experimental data for thermal conductivity of Nicrosil and Nisil are presented graphically in figure 6.6.3.1. This figure shows that $\lambda(+)$ is low but relatively uniform from 80 to 400 K, whereas $\lambda(-)$ is much higher and has a distinct break near 300 K, very near the T_c for Nisil.

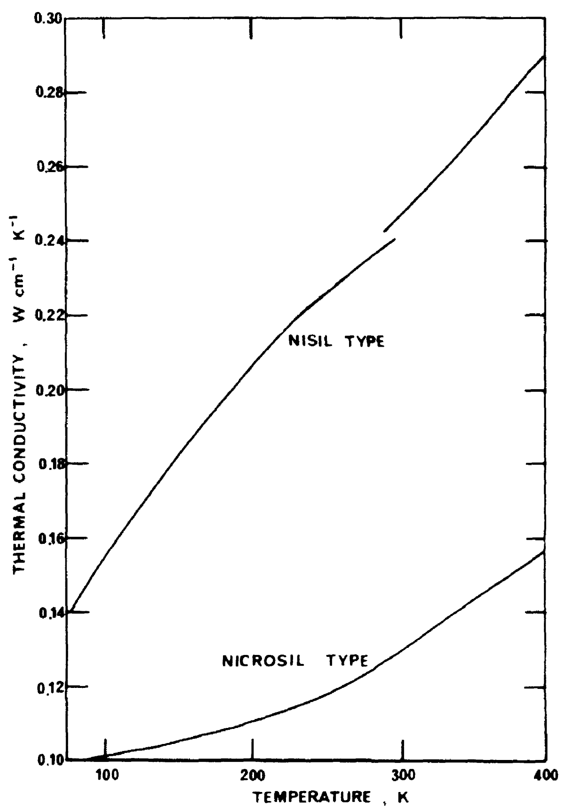

FIGURE 6.6.3.1 *Thermal conductivity of Nicrosil- and Nisil-type alloys from 80 to 400 K [after Moore et al, 1975].*

6.7 Size Dependence and Inhomogeneity

For reasons discussed in section 2, and which largely devolve around a small degree of solute depletion in Nicrosil and Nisil on the formation of passive oxide films, the surface layers of wires of these alloys will differ slightly in composition from that of the bulk. Furthermore, there will be a greater concentration of structural imperfections near the surface layers as a result of non-uniform plastic deformation during manufacture. For both these reasons the ratio of disturbed (inhomogeneous) sub-surface volume to bulk volume will be greater in the smaller diameter wires than in the larger. As a consequence, the two wires of different diameter used in the joint project were expected to show different thermoelectric properties. These differences are exemplified for the Nicrosil and Nisil wires in figures 6.7.1 and 6.7.2. The values plotted in these figures were obtained by making direct intercomparisons between *AWG 28* thermoelements and *AWG 14* thermoelements, rather than by calculating them from the less precise calibration data for the thermoelements versus platinum. Similar differences are observed for all base-metal thermocouple wires.

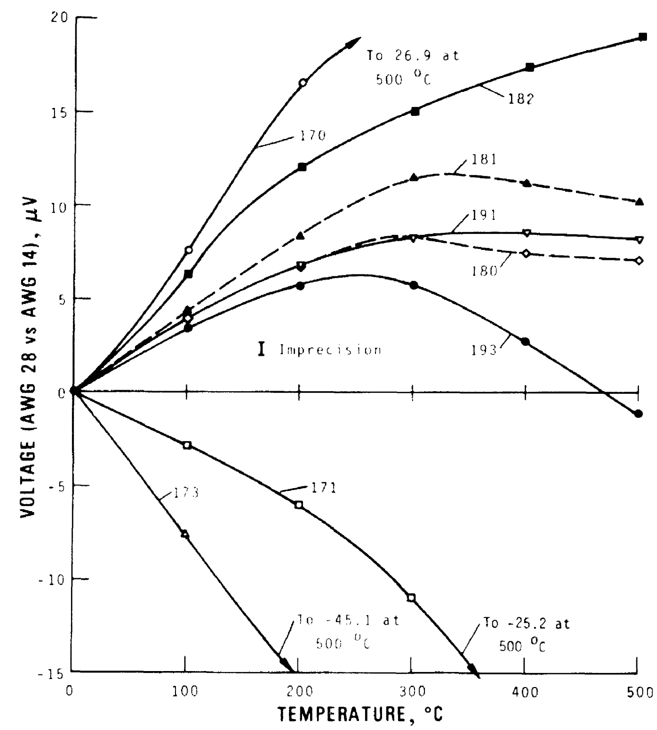

FIGURE 6.7.1 *Effect of size differences for Nicrosil thermoelements.*

It is well known that commercial thermocouple alloys normally have slightly different compositions and imperfections in different lengths from a given coil or spool when received from the manufacturer, and that wires from different melt batches, coils or spools may differ much more. These differences also are represented by different thermoelectric voltages. For the Nicrosil and Nisil prototype alloys, many of these deviations are shown graphically in section 7.2.

7. Nicrosil versus Nisil Reference Data

Section 7 is organized as follows: The procedures for selecting and analyzing the experimental data are outlined in section 7.1. The resultant deviations between different specimens are given in the section following that. The heart of the reference data is incorporated in section 7.3, 7.4 and 7.5 for Nicrosil versus Nisil thermocouples, for Nicrosil thermoelements versus platinum, Pt–67, and for platinum. Pt–67, versus Nisil thermoelements, respectively.

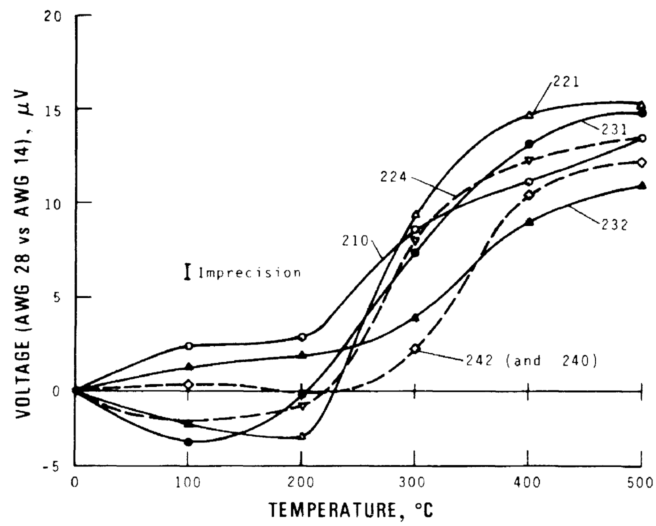

FIGURE 6.7.2 *Effect of size differences for Nisil thermoelements.*

7.1 Data Selection and Analysis

The fitting functions for Nicrosil versus Nisil thermocouples (and for each thermoelement versus platinum) are based on four main sets of experimental data, two each for the *AWG 28* and *AWG 14* wires. For the smaller, *AWG 28*, wire there were cryogenic data between −269 and 7 °C generated in NBS Boulder and overlap data between −75 and 450 °C generated in NBS Gaithersburg. All the data on *AWG 14* wires were obtained in Gaithersburg. As described in section 4, two different furnace systems were used, one from 0 to 1000 °C, the other from 800 to 1300 °C. For both size wires, and for both wide temperature ranges, there were data, overlapping in temperatures, from two different apparatuses. Fortunately, therefore, there were data available for both high- and low-temperature calibrations for material produced at the same time by the same manufacturer. This is quite unlike our previous standardization program that was reported in NBS Monograph 125. The real voltage differences caused by different mechanical and thermal treatments and by different ratios of surface area to volume could be clearly observed. Those differences are undoubtedly present, but not reported for all base-metal thermocouple systems. All temperatures[5] were

[5] Below 20 K, temperatures were actually measured on the National Bureau of Standards acoustical temperature scale, NBS P 2–20 (1965), described by Plumb and Cataland [1965 a,b; 1966]. However, the difference between this temperature scale and the IPTS–68 in the range of overlap (13.81 to 20 K) is substantially less than the experimental imprecision in the measured thermocouple data.
In this Monograph the symbol *T* is used to denote all temperatures. Values of temperature on the IPTS–68 are expressed in either kelvins (symbol K) or degrees Celsius (symbol °C). In a few instances the symbol *T* also is used to denote thermodynamic temperature. The distinction is either explicitly stated or evident from context. The symbolism customarily used to distinguish between

TABLE 7.1.1 *Characteristics of principal alloys chosen for final analysis*

Identification number		Chemical composition [a]					EMF against Pt–67 at 1000 °C [b]	
Element		Cr	Si	Fe	C	Mg	(μV)	
		14.2	1.4	0.1	0.03 max		26040	←Nominal value
				Deviation from nominal value				
NICROSIL	171	+0.14	+0.11	−0.06	+0.015	—	−25	
	182	−0.01	+0.01	−0.05	−0.026	—	−10	
	191	+0.04	+0.07	+0.01	−0.014	—	− 8	
		0.03 max	4.4	0.1	0.03 max	0.1	−10208	←Nominal value
				Deviation from nominal value				
NISIL	224	—	−0.02	−0.06	−0.027	−0.02	−330	
	231	—	−0.15	−0.04	−0.023	0.00	− 3	
	240	—	−0.22	−0.01	−0.028	+0.11	− 6	

[a] Percentages by weight; balance is nickel.
[b] Values are based on reference junctions at 0 °C.

based on the International Practical Temperature Scale of 1968, IPTS–68 [CIPM, 1969].

Extensive preliminary tests were carried out in Gaithersburg on selections of *AWG 14* wire before any of the *AWG 28* wire cryogenic experiments or final analyses were begun. Those prototype materials and selection tests are described in section 3.

The methods of data analysis are theoretically quite straightforward. However, as with any large experiment with data originating from several different apparatus, there were considerable practical difficulties. There were many trial-and-error preliminary analyses and several false leads. In particular the magnetic transformation in Nisil caused significant problems in fitting (as it did in Type KN reported in Monograph 125). Though these problems required considerable manpower and computer time to resolve, and are at the core of practical data analysis, they will not be described. Only the final, simple path to the reference functions and tables will be outlined below.

As a result of the preliminary high temperature and overlap tests, size *AWG 28* wires from three manufacturers were chosen to be critical for the final cryogenic analysis. They had been laboratory number-coded as 171, 182, and 191 for Nicrosil and 224, 231, and 240 for Nisil. This choice was based on close adherence to the criteria for selection laid down in section 3.3 and on a consensus of manufacturers' opinions in relation to optimum concentrations of minor solutes such as iron and carbon. A summary of the essential chemical and electrical characteristics of these alloys is given in table 7.1.1. Secondary wires were also chosen, in an order of preference based on the above selection criteria, for testing: 150, 170, 180, 181, 190, and 193 for Nicrosil and 201, 210, 220, 232, 241, and 242 for Nisil. Two platinum, Pt–67, wires and one reference material, Ag–Au alloy, were also used in the cryogenic calibration. The values of the thermal emf of the platinum reference wires used were known relative to Pt–67. The resultant graph of network measurements is shown in figure 5.1.2.

Each of the main three Nicrosil versus platinum, three platinum versus Nisil, and the nine Nicrosil versus Nisil sets of data were fit independently. Because they are double valued (negative Seebeck coefficients and reversal in signs of the thermoelectric voltage) below −200 °C, the data for the two separate types of thermoelements could not be fit below −200 °C. The resultant Nicrosil versus Nisil data, however are single valued and they could be fit down to −270 °C (actually −269 °C).

Each set of processed data could have been reported separately (that is, Nicrosil versus Nisil and the two thermoelements versus platinum), but that would have led to slight differences and inconsistencies between the sums of the thermoelements and the resultant thermocouple. Instead, it was decided to process three sets independently, select two of them as fundamental, and obtain the third by subtraction. The cryogenic data were fit first and then the overlap data were fit later, with the constraint that the thermoelectric voltages and Seebeck coefficients for the two regions of *AWG 28* wire had to match at the join, 0 °C.

Several combinations of wires from different manufacturers behaved very smoothly, had low standard deviations, and had average typical values. Therefore, somewhat arbitrarily, *AWG 28* Nicrosil 191 and Nisil 240 were selected as the optimum prototype for generating the final *AWG 28* functions and tables. Data for the thermocouple *AWG 28* Nicrosil 191 versus Nisil 240 were ultimately fit with an eighth degree equation in the cryogenic region (−270 to 0 °C). The standard deviation was 0.15 μV. Data for the thermoelement *AWG 28* Nicrosil versus platinum were also fit with an eighth degree equation: but the standard deviation was somewhat lower, 0.12 μV. Reference functions for the platinum versus *AWG 28* Nisil thermoelement were obtained by subtraction. The

thermodynamic temperature, Celsius temperature, International Practical Kelvin Temperature, and International Practical Celsius Temperature is given in the text of the IPTS–68 [CIPM, 1976]. Values of Fahrenheit temperature (t_F), which appear in the appendixes of this Monograph, are related to International Practical Celsius Temperatures (t_{68}) by

$$t_F = (9/5 t_{68} + 32) \ {}^\circ F,$$

where degree Fahrenheit, symbol °F, is the unit of Fahrenheit temperature.

equation was eighth degree, of course; the standard deviation would be about 0.19 μV.

Overlap data were available for *AWG 28* wire between −75 and 450 °C. For each prototype alloy, there were data on two or more samples, at least one from each end of the spool of wire. The same batch numbers were used for fitting for the overlap region as were used for the cryogenic one, i.e., Nicrosil 191 and Nisil 240. For each of these batches, there were data on three samples, a pair of adjacent samples from one end of the spool of wire and a third sample from the other end. Because the measured values for the three samples were so little different, they were averaged together to obtain a single typical result before fitting the data. The fits to the averaged values were constrained at the join, 0 °C, so that the generated functions would smoothly match the more accurate cryogenic data near 0 °C. The upper extreme of temperature for the fits was set at 400 °C, due to excessive deviations found in the values at 450 °C. The reference function obtained for *AWG 28* Nicrosil versus platinum, Pt–67, in the range from 0 to 400 °C was fifth degree: the standard deviation, 0.53 μV. The function obtained for platinum, Pt–67, versus *AWG 28* Nisil was seventh degree: the standard deviation, 0.26 μV. The experimental techniques in the overlap range were different from those used at cryogenic temperatures: the wires were separately tested against platinum standards; there were no Nicrosil versus Nisil combinations experimentally measured. Therefore, the reference function for the *AWG 28* Nicrosil versus Nisil thermocouple was obtained by addition of the functions for the two thermoelements. The function was seventh degree and the calculated standard deviation was 0.59 μV.

The wires selected for the high temperature standard reference values came from the same lot as the smaller wires used for the low temperature standards. This is no accident: both sets of wires were selected on the basis of their regular behavior at both high and low temperatures and their closeness of parameters near room temperature. As with the *AWG 28* overlap data, there were results on several adjacent wires as thermoelements, but no results on the thermocouple combinations. Functions on Nicrosil 191 were combined with those on Nisil 240 to obtain the overall thermocouple function.

The fitting function for *AWG 14* Nicrosil versus platinum, Pt–67, for the 0 to 1300 °C range was determined to be sixth degree with a standard deviation of 3.4 μV. For *AWG 14* Nisil it was ninth degree with a smaller standard deviation, 1.0 μV. The function for the *AWG 14* Nicrosil versus Nisil thermocouple was determined by the addition of the functions for the two thermoelements. It was ninth degree and had a calculated standard deviation of 3.5 μV. For all of the functions the main contributions to the overall error came from the high temperature data. This arises from the fact that small shifts in the emf output of both alloys occur on initial heating to elevated temperatures [Burley and Jones, 1975]. For that reason a weighting function of $1+T/400$ was used in the analyses.

The small shifts in emf output indicate that the initial heating produces minor thermoelectric inhomogeneities in the thermoelements. Consequently, when the thermoelements are tested in furnaces that have different temperature gradients, slightly different values of emf are obtained. The differences in emf found for Nicrosil and Nisil samples, due to testing in the two furnaces used in this investigation, can clearly be seen in the next section by comparing the deviation plots for the 0 to 1000 °C range with those for the 800 to 1300 °C range.

The functions and tabular values for *AWG 28* and *AWG 14* Nicrosil versus Nisil thermocouples are presented in section 7.3, those for Nicrosil thermoelements in section 7.4, and those for Nisil thermoelements in section 7.5.

7.2 Experimental Deviations

The deviations of the actual experimental values from the table values (or fitted functions) are presented in this section. As mentioned in section 4, *AWG 28* samples for final calibration were taken from near the start and the finish of each of the spools of wire. In the figures presented in this section, the letters X and Y that follow the batch identification numbers denote the sample location, X for start and Y for finish. In a few cases, two adjacent samples from an end of the spool of wire were tested and these samples are further identified by the letters a and b (e.g., Xa and Xb). The *AWG 14* samples for final calibration were also taken from widely separated locations on each coil of wire and the letters D, R, and S designate samples from different locations. Again, the letters a and b denote adjacent samples when more than one sample from a given location was tested.

For only one temperature range, the cryogenic range, were total values separately obtained so that the thermocouple combination could be checked against the total functional values. The experimental values for the deviations of *AWG 28* thermocouples are given in figure 7.2.1. It can be seen that two sets of materials, *from different manufacturers*, give virtually identical results. Though this result may be fortuitous, such close agreement has never been observed by NBS before in any of its thermocouple research on other materials. In fact, the agreement of the two sets of values is better than that for the two reference grade platinum wires that were used as standards. The third set of wires shows a significant deviation, though it is no worse than that regularly observed for other commercial thermocouple materials.

Deviations for *AWG 28* Nicrosil thermoelements are given in figures 7.2.2 and 7.2.3 for the cryogenic range and in figures 7.2.4, 7.2.5, and 7.2.6 for the overlap range. Deviations for *AWG 14* Nicrosil thermoelements are given in figures 7.2.7, 7.2.8, and 7.2.9 for the 0 to 1000 °C range and in figures 7.2.10, 7.2.11, and 7.2.12 for the 800 to 1300 °C range.

Similarly for the Nisil thermoelements, deviations for *AWG 28* thermoelements are given in figures 7.2.13 and 7.2.14 for the cryogenic range and in figures

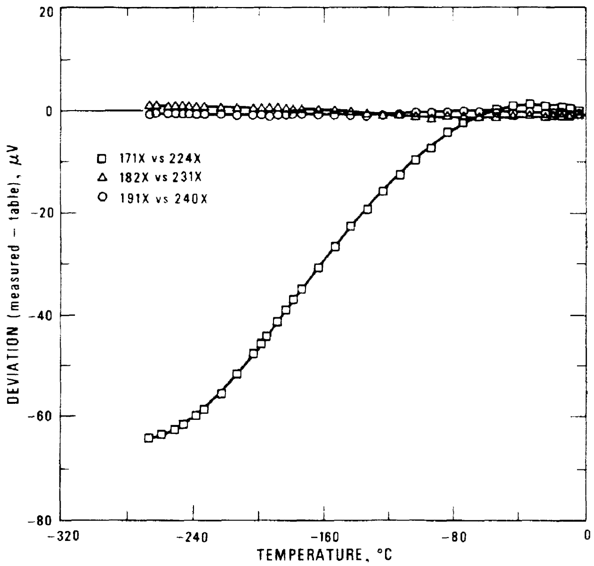

FIGURE 7.2.1 *Deviations of measured values of thermal emf's from table values given in this Monograph.*
The data shown are for various *AWG 28* Nicrosil versus Nisil thermocouples in the cryogenic temperature range.

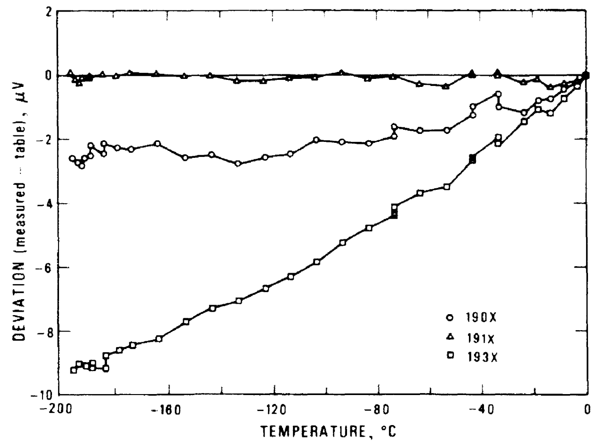

FIGURE 7.2.3 *Deviations of measured values of thermal emfs from table values given in this Monograph.*
The data shown are for various *AWG 28* Nicrosil thermoelements versus platinum, Pt–67, in the cryogenic temperature range.

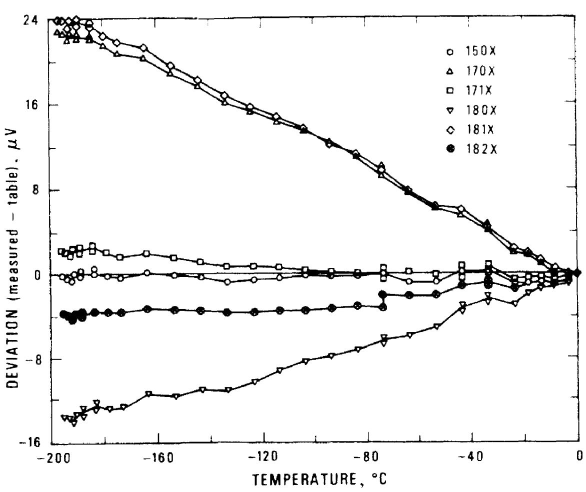

FIGURE 7.2.2 *Deviations of measured values of thermal emfs from table values given in this Monograph.*
The data shown are for various *AWG 28* Nicrosil thermoelements versus platinum, Pt–67, in the cryogenic temperature range.

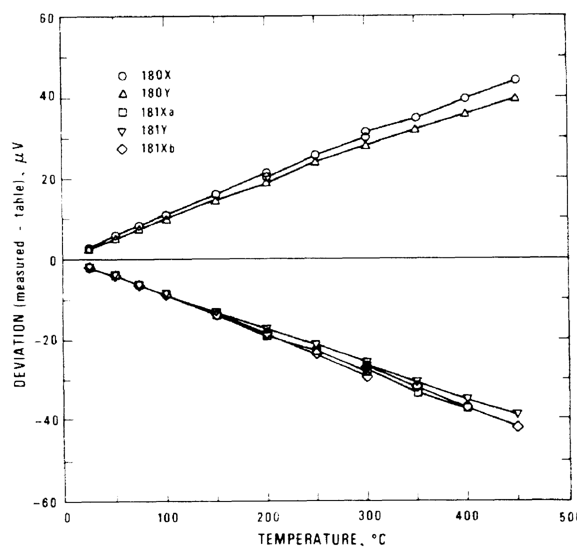

FIGURE 7.2.4 *Deviations of measured values of thermal emfs from table values given in this Monograph.*
The data shown are for various *AWG 28* Nicrosil thermoelements versus platinum, Pt–67, in the overlap temperature range.

7.2.15, 7.2.16, and 7.2.17 for the overlap range. For the larger *AWG 14* thermoelements, deviations are given in figures 7.2.18, 7.2.19, 7.2.20, and 7.2.21 for the 0 to 1000 °C range and in figures 7.2.22, 7.2.23, 7.2.24, and 7.2.25 for the 800 to 1300 °C range.

By comparing these deviations with those reported in NBS Monograph 125 for other base-metal thermocouples, it can be seen that, in general, the deviations for Nicrosil versus Nisil thermocouples are smaller and much smoother than they are for other base-metal thermocouple systems. This smoothness should lead to improved calibration accuracy in practical thermometry.

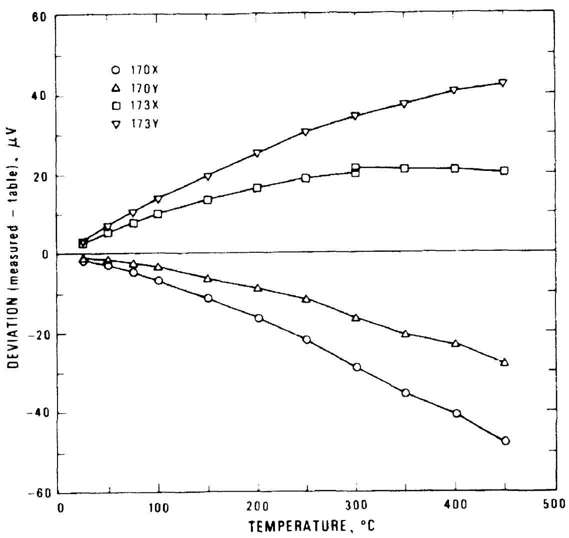

FIGURE 7.2.5 *Deviations of measured values of thermal emf's from table values given in this Monograph.*

The data shown are for various *AWG 28* Nicrosil thermoelements versus platinum, Pt-67, in the overlap temperature range.

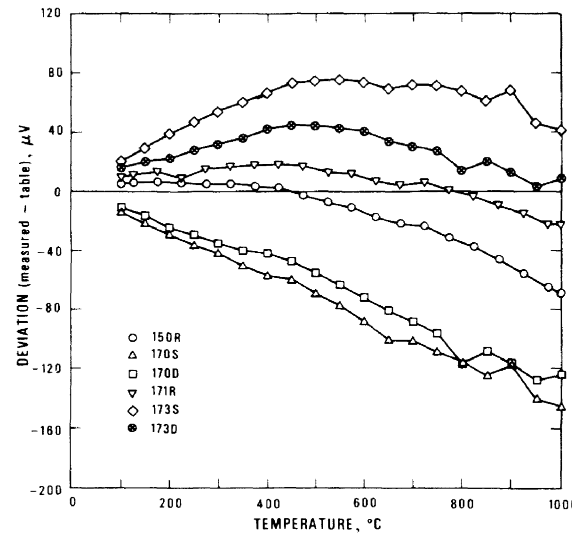

FIGURE 7.2.7 *Deviations of measured values of thermal emf's from table values given in this Monograph.*

The data shown are for various *AWG 14* Nicrosil thermoelements versus platinum, Pt-67, in the 0 to 1000 °C range.

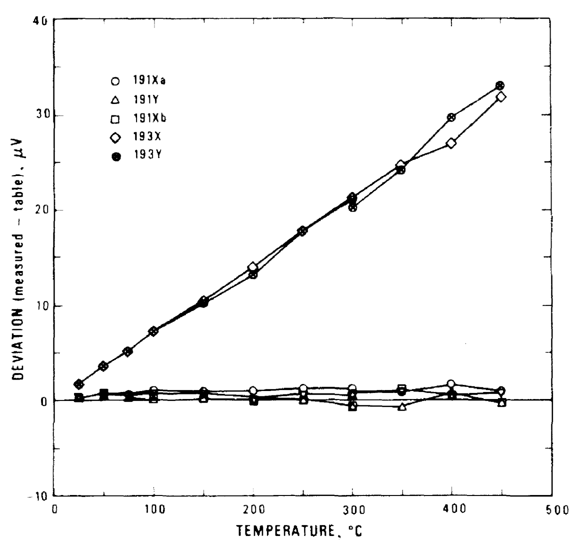

FIGURE 7.2.6 *Deviations of measured values of thermal emf's from table values given in this Monograph.*

The data shown are for various *AWG 28* Nicrosil thermoelements versus platinum, Pt-67, in the overlap temperature range.

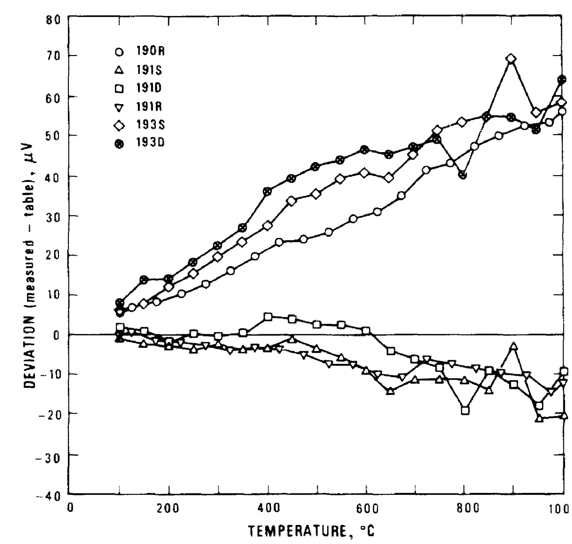

FIGURE 7.2.8 *Deviations of measured values of thermal emf's from table values given in this Monograph.*

The data shown are for various *AWG 14* Nicrosil thermoelements versus platinum, Pt-67, in the 0 to 1000 °C range.

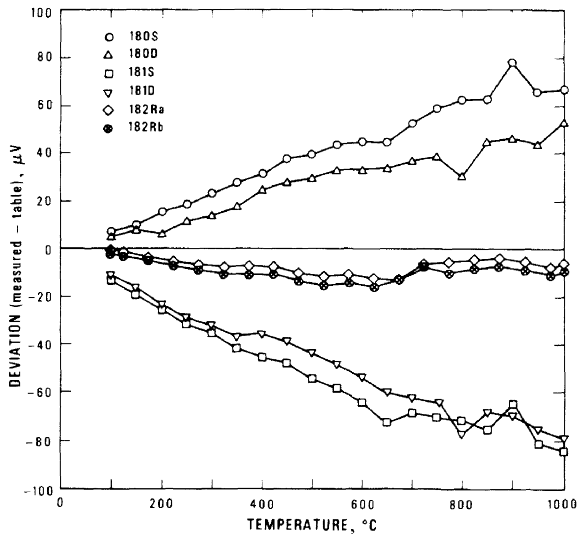

FIGURE 7.2.9 *Deviations of measured values of thermal emfs from table values given in this Monograph.*
The data shown are for various *AWG 14* Nicrosil thermoelements versus platinum, Pt–67, in the 0 to 1000 °C range.

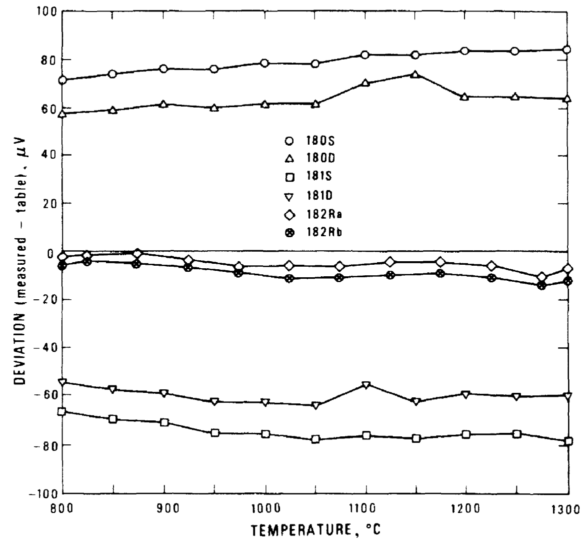

FIGURE 7.2.11 *Deviations of measured values of thermal emfs from table values given in this Monograph.*
The data shown are for various *AWG 14* Nicrosil thermoelements versus platinum, Pt–67, in the 800 to 1300 °C range.

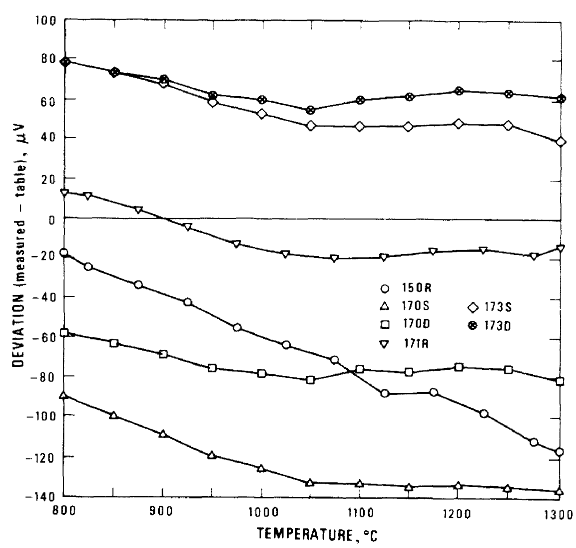

FIGURE 7.2.10 *Deviations of measured values of thermal emfs from table values given in this Monograph.*
The data shown are for various *AWG 14* Nicrosil thermoelements versus platinum, Pt–67, in the 800 to 1300 °C range.

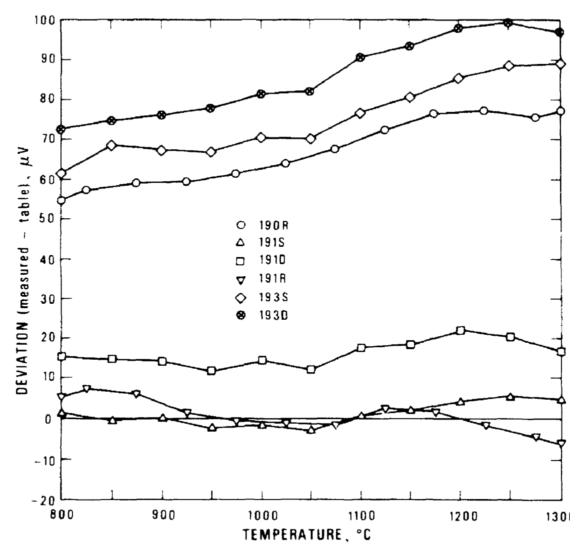

FIGURE 7.2.12 *Deviations of measured values of thermal emfs from table values given in this Monograph.*
The data shown are for various *AWG 14* Nicrosil thermoelements versus platinum, Pt–67, in the 800 to 1300 °C range.

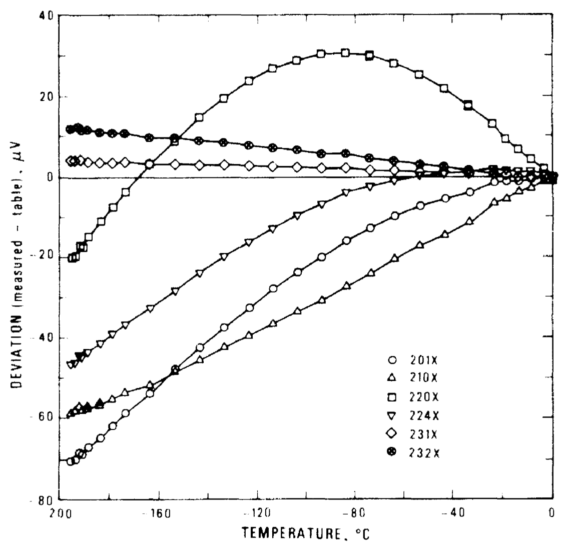

FIGURE 7.2.13 *Deviations of measured values of thermal emf's from table values given in this Monograph.*
The data shown are for platinum, Pt-67, versus various *AWG 28* Nisil thermoelements in the cryogenic temperature range.

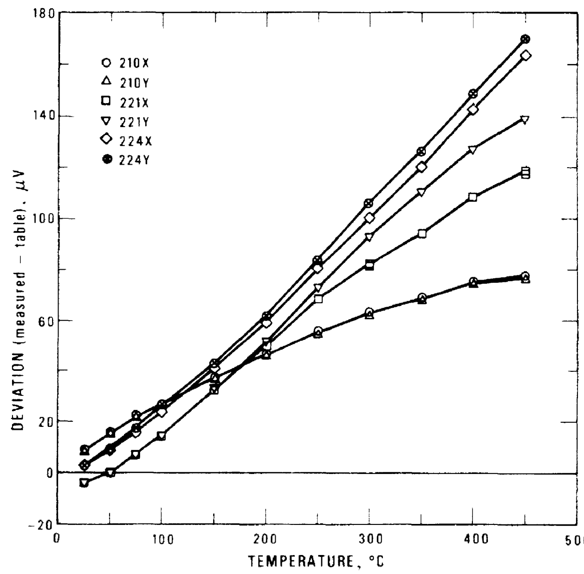

FIGURE 7.2.15 *Deviations of measured values of thermal emf's from table values given in this Monograph.*
The data shown are for platinum, Pt-67, versus various *AWG 28* Nisil thermoelements in the overlap temperature range.

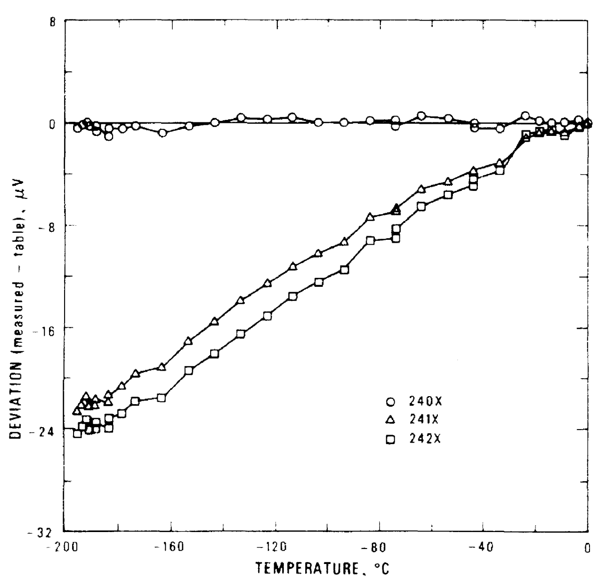

FIGURE 7.2.14 *Deviations of measured values of thermal emf's from table values given in this Monograph.*
The data shown are for platinum, Pt-67, versus various *AWG 28* Nisil thermoelements in the cryogenic temperature range.

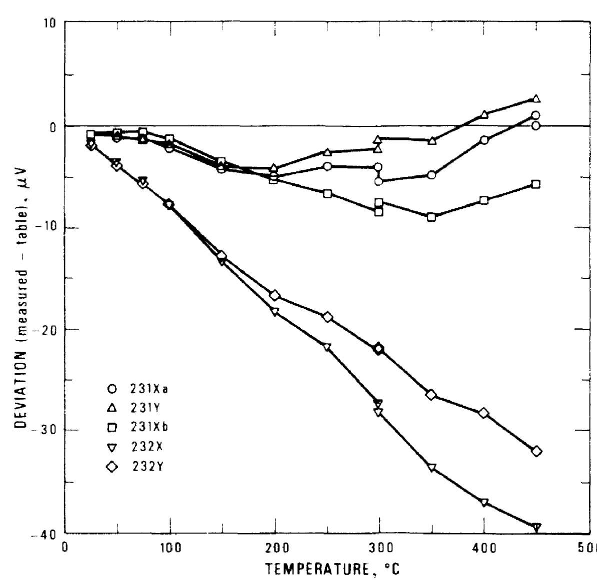

FIGURE 7.2.16 *Deviations of measured values of thermal emf's from table values given in this Monograph.*
The data shown are for platinum, Pt-67, versus various *AWG 28* Nisil thermoelements in the overlap temperature range.

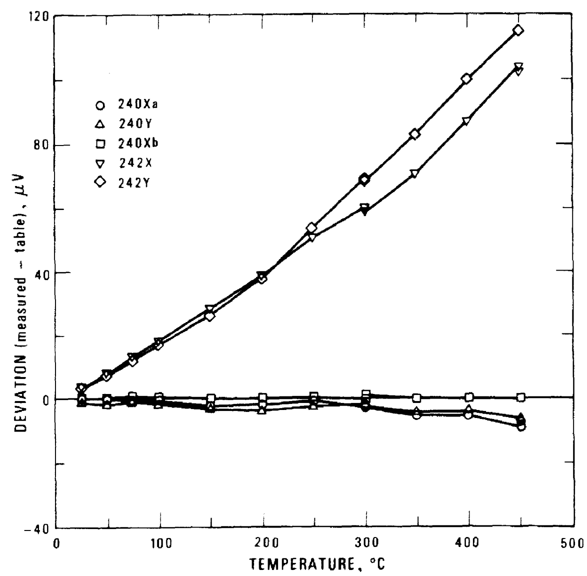

FIGURE 7.2.17 *Deviations of measured values of thermal emf's from table values given in this Monograph.*
The data shown are for platinum, Pt-67, versus various *AWG 28* Nisil thermoelements in the overlap temperature range.

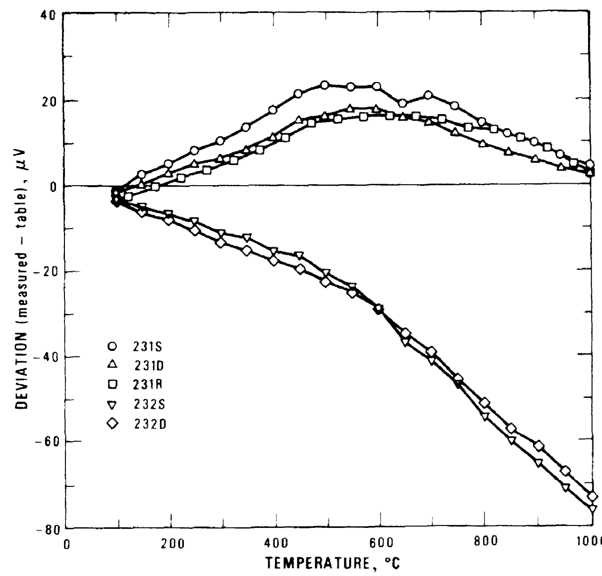

FIGURE 7.2.19 *Deviations of measured values of themal emf's from table values given in this Monograph.*
The data shown are for platinum, Pt-67, versus various *AWG 14* Nisil thermoelements in the 0 to 1000 °C range.

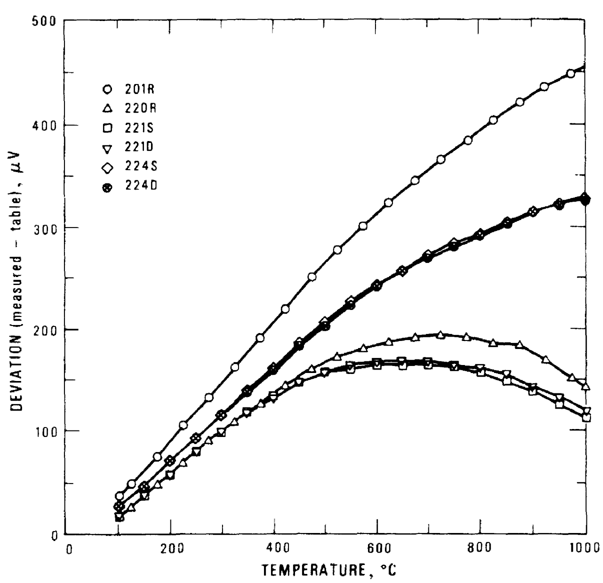

FIGURE 7.2.18 *Deviations of measured values of thermal emf's from table values given in this Monograph.*
The data shown are for platinum, Pt-67, versus various *AWG 14* Nisil thermoelements in the 0 to 1000 °C range.

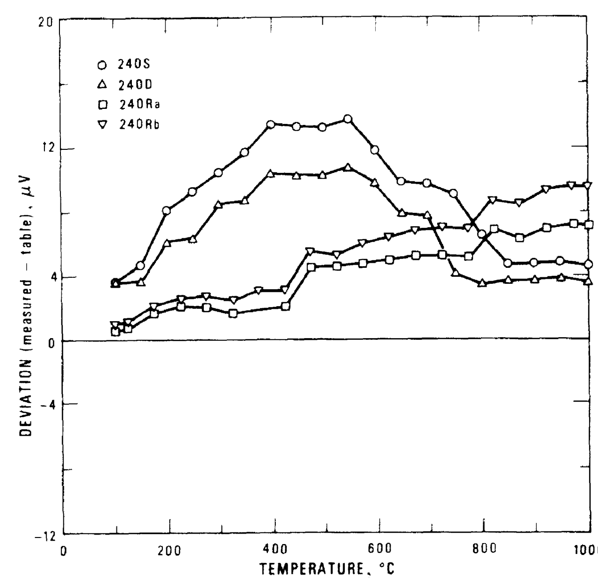

FIGURE 7.2.20 *Deviations of measured values of thermal emf's from table values given in this Monograph.*
The data shown are for platinum, Pt-67, versus various *AWG 14* Nisil thermoelements in the 0 to 1000 °C range.

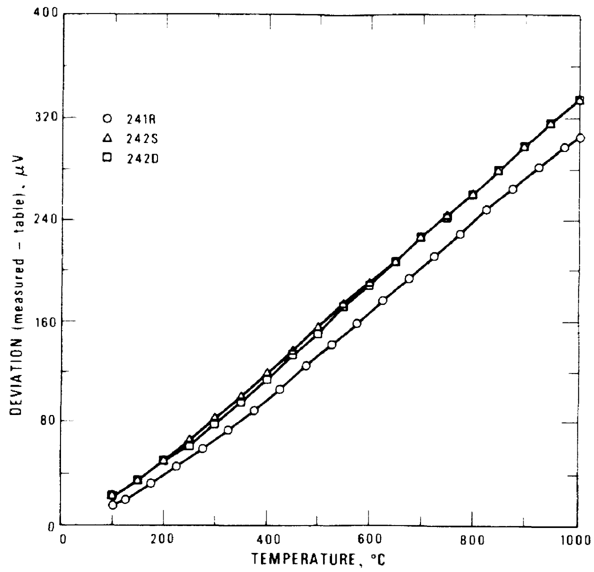

FIGURE 7.2.21 *Deviations of measured values of thermal emf's from table values given in this Monograph.*

The data shown are for platinum, Pt–67, versus various *AWG 14* Nisil thermoelements in the 0 to 1000 °C range.

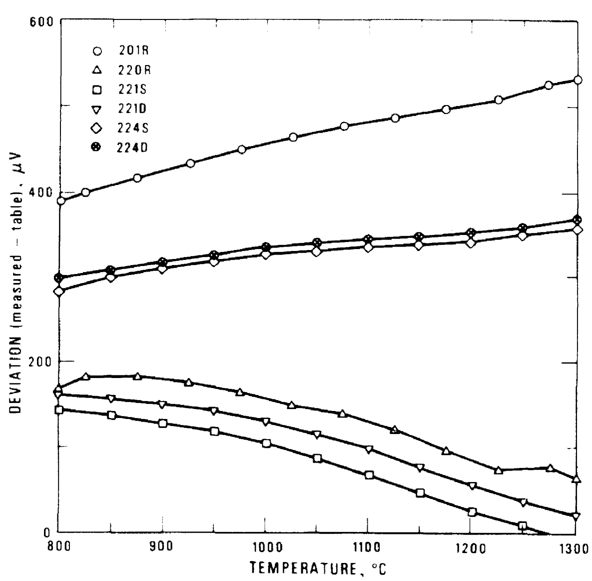

FIGURE 7.2.22 *Deviations of measured values of thermal emf's from table values given in this Monograph.*

The data shown are for platinum, Pt–67, versus various *AWG 14* Nisil thermoelements in the 800 to 1300 °C range.

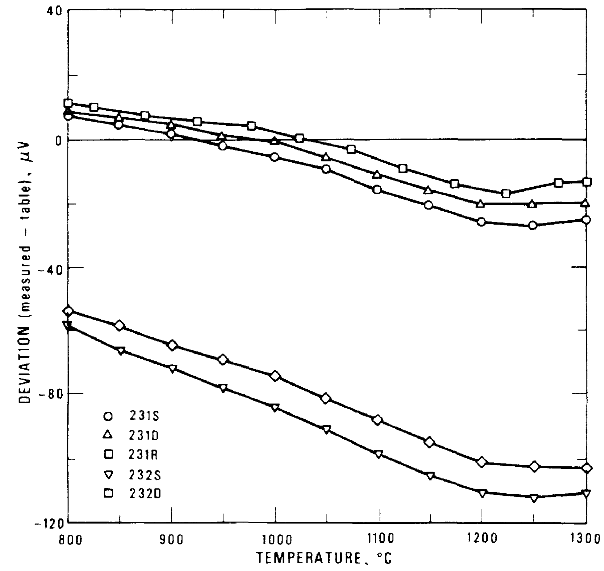

FIGURE 7.2.23 *Deviations of measured values of thermal emf's from table values given in this Monograph.*

The data shown are for platinum, Pt–67, versus various *AWG 14* Nisil thermoelements in the 800 to 1300 °C range.

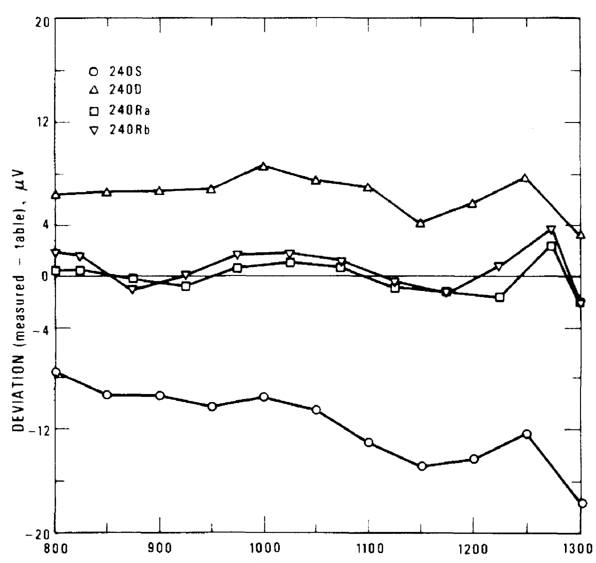

FIGURE 7.2.24 *Deviations of measured values of thermal emf's from table values given in this Monograph.*

The data shown are for platinum, Pt–67, versus various *AWG 14* Nisil thermoelements in the 800 to 1300 °C range.

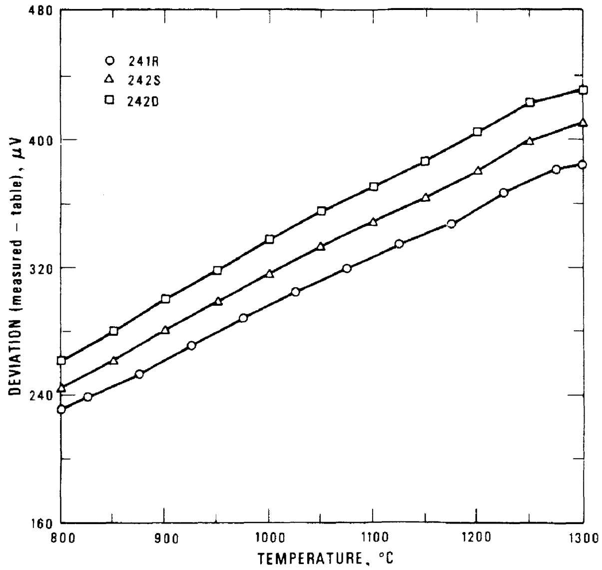

FIGURE 7.2.25 *Deviations of measured values of thermal emf's from table values given in this Monograph.* The data shown are for platinum, Pt–67, versus various *AWG 14* Nisil thermoelements in the 800 to 1300 °C range.

7.3 Reference Functions and Tables for the Thermocouple Combination, Nicrosil versus Nisil

The data for the thermocouple combination are divided into two ranges, depending on the wire size. The smaller wire *AWG 28*, has values tabulated from −270 to 0 °C (with an extended range up to 400 °C). The larger wire, *AWG 14*, has values tabulated from 0 to 1300 °C. The functions and tabular values for the two sizes of wire are not quite identical in the temperature range where they overlap (0 to 400 °C). Those differences are shown in the following tables where the wire gage is specified along with the temperatures and thermoelectric values. At the join, 0 °C, of the cryogenic data and the high temperature data, the voltages are identical; the Seebeck coefficients (the first temperature derivatives of the thermal voltage) differ by 1 percent. The difference is a real representation of the effect of wire diameter (and of the ratio of surface area to volume) for the materials, particularly Nisil. This difference, though not well documented for other materials, is a fundamental characteristic of commercially prepared base-metal thermocouple materials. The values of the coefficients for the fine wire (cryogenic) are higher. Actual differences between the voltages of specially prepared test wires of different sizes are discussed in section 6.7.

The coefficients for the eighth degree expansion for the thermoelectric voltage of *AWG 28* Nicrosil versus Nisil thermocouples between −270 and 0 °C are given in table 7.3.1. The coefficients for the seventh degree expansion for *AWG 28* wire between 0 and 400 °C, an extended range, are also given in table 7.3.1. The equivalent coefficients for the ninth degree expansion for the thermoelectric voltage of *AWG 14* Nicrosil versus Nisil thermocouples between 0 and 1300 °C are given in table 7.3.2. The errors caused by using reduced-bit arithmetic for calculating values of those functions are given in tables 7.3.8 and 7.3.9 for the *AWG 28* and *AWG 14* thermocouples, respectively.

TABLE 7.3.1 *Power series expansion for the thermoelectric voltage of* AWG 28 *Nicrosil versus Nisil thermocouples in the cryogenic and extended temperature ranges.*

Wire gage	Temperature range	Degree	Coefficients	Term
AWG 28	−270 to 0 °C	8	$+2.6153540164\times10^{1}$	T
			$+1.0933114132\times10^{-2}$	T^2
			$-9.3917128470\times10^{-5}$	T^3
			$-5.3592739285\times10^{-8}$	T^4
			$-2.7406835184\times10^{-9}$	T^5
			$-2.3370710645\times10^{-11}$	T^6
			$-7.8250681060\times10^{-14}$	T^7
			$-9.5885491371\times10^{-17}$	T^8
AWG 28	0 to 400 °C	7	$+2.6153540164\times10^{1}$	T
			$+9.3169626960\times10^{-3}$	T^2
			$+1.3507720863\times10^{-4}$	T^3
			$-8.5131026625\times10^{-7}$	T^4
			$+2.5853558632\times10^{-9}$	T^5
			$-3.9887895408\times10^{-12}$	T^6
			$+2.4633802582\times10^{-15}$	T^7

TABLE 7.3.2 *Power series expansion for the thermoelectric voltage of* AWG 14 *Nicrosil versus Nisil thermocouples in the high temperature range.*

Wire gage	Temperature range	Degree	Coefficients	Term
AWG 14	0 to 1300 °C	9	$+2.5897798582\times10^{1}$	T
			$+1.6656127713\times10^{-2}$	T^2
			$+3.1234962101\times10^{-5}$	T^3
			$-1.7248130773\times10^{-7}$	T^4
			$+3.6526665920\times10^{-10}$	T^5
			$-4.4390833504\times10^{-13}$	T^6
			$+3.1553382729\times10^{-16}$	T^7
			$-1.2150879468\times10^{-19}$	T^8
			$+1.9557197559\times10^{-23}$	T^9

The primary reference values for *AWG 28* Nicrosil versus Nisil thermocouples in the temperature range from −270 to 0 °C are given in table 7.3.3. Values for the same gage wire in the extended temperature range from 0 to 400 °C are given in table 7.3.4. Values for the larger, *AWG 14*, wire for temperatures from 0 to 1300 °C are given in table 7.3.5. Near the ends of long calibration ranges, mathematical fitting functions become more variable and subject to error. This is especially true for their higher derivatives. Therefore the second derivatives of the thermal voltages are not tabulated above 1260 °C. Values for the smaller *AWG 28* wire at selected thermometric fixed points are given in table 7.3.6, and for the larger *AWG 14* wire, in table 7.3.7.

Graphs of the thermoelectric voltage, its first derivative (Seebeck coefficient), and second derivative are given in figures 7.3.1, 7.3.2, and 7.3.3, respectively, for *AWG 28* wire between −270 and 400 °C; and in figures 7.3.4, 7.3.5, and 7.3.6 for *AWG 14* wire between 0 and 1300 °C.

It should be stressed that because of the small, but nevertheless significant, size effect ***Nicrosil versus Nisil thermocouples that conform closely to the high temperature tabular values may not conform closely at low temperatures (below 0 °C) and vice versa.*** If Nicrosil versus Nisil thermocouples are to be used for accurate measurements both above and below 0 °C, then the material must be calibrated in the full temperature range, both above and below 0 °C. Special selection of material will often be required.

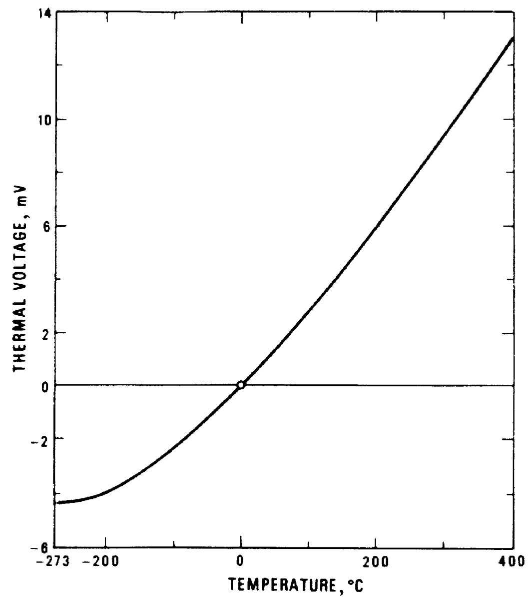

FIGURE 7.3.1. *Thermoelectric voltage for* AWG 28 *Nicrosil versus Nisil thermocouples.*

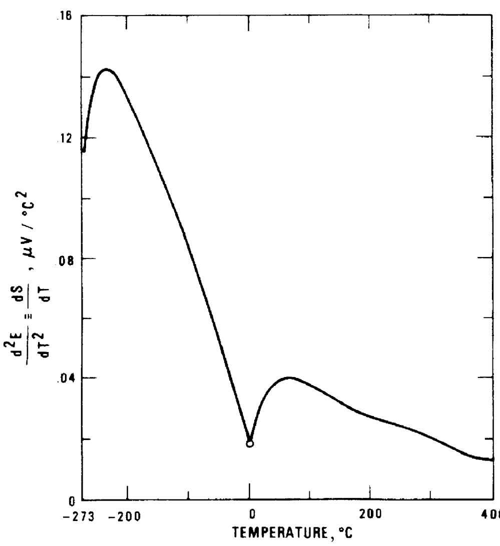

FIGURE 7.3.3 *Derivative of Seebeck coefficient for* AWG 28 *Nicrosil versus Nisil thermocouples.*

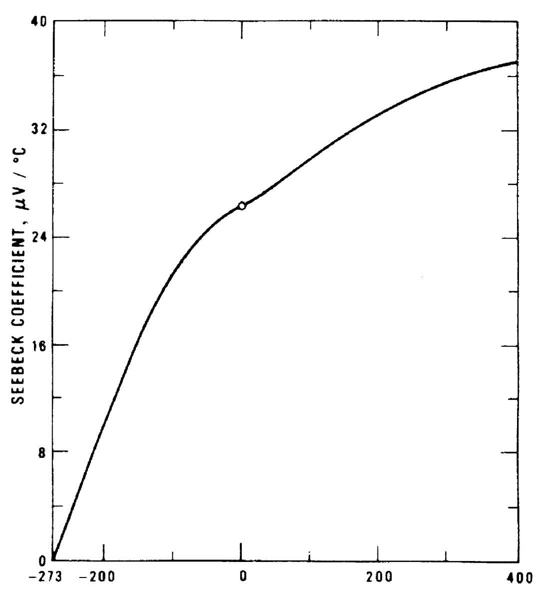

FIGURE 7.3.2 *Seebeck coefficient for* AWG 28 *Nicrosil versus Nisil thermocouples.*

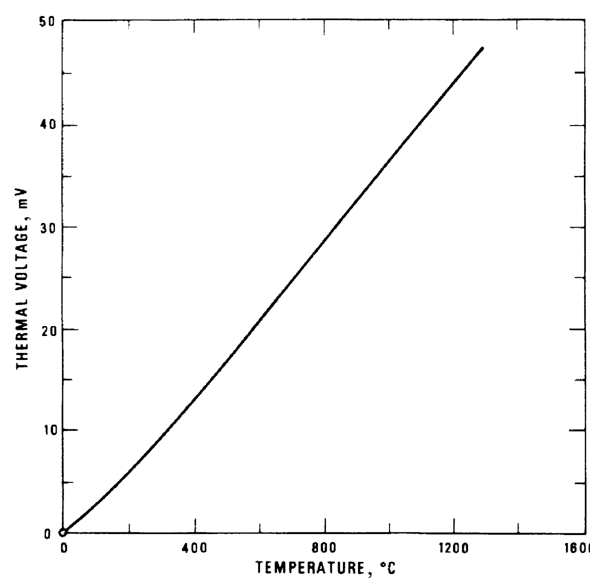

FIGURE 7.3.4 *Thermoelectric voltage for* AWG 14 *Nicrosil versus Nisil thermocouples.*

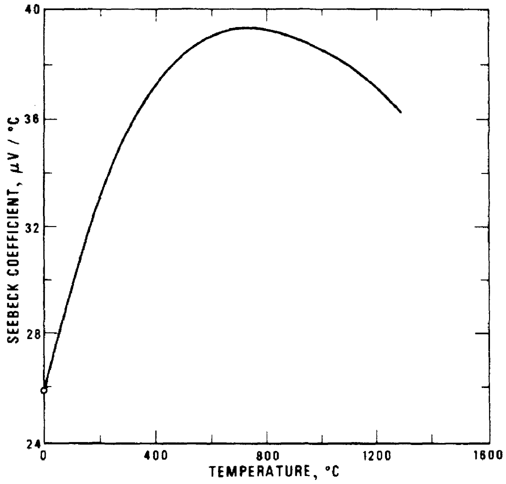

FIGURE 7.3.5 *Seebeck coefficient for* AWG 14 *Nicrosil versus Nisil thermocouples.*

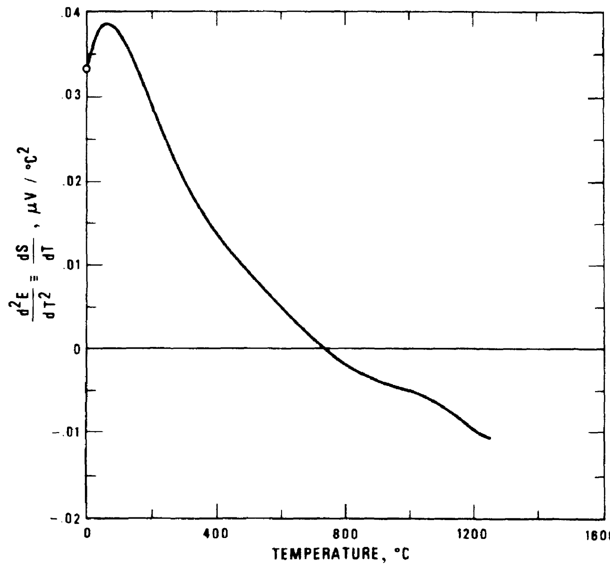

FIGURE 7.3.6 *Derivative of Seebeck coefficient for* AWG 14 *Nicrosil versus Nisil thermocouples.*

TABLE 7.3.3 AWG 28 *Nicrosil versus Nisil thermocouples—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. Cryogenic temperature range, —270 to 0 °C.*

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
-270	-4345.18	0.339	115.50	-240	-4277.03	4.335	142.45	-210	-4082.95	8.577	137.64
-269	-4344.78	0.455	117.35	-239	-4272.62	4.478	142.61	-209	-4074.30	8.715	137.27
-268	-4344.27	0.573	119.12	-238	-4268.07	4.621	142.74	-208	-4065.52	8.852	136.88
-267	-4343.63	0.693	120.80	-237	-4263.38	4.763	142.84	-207	-4056.60	8.988	136.49
-266	-4342.88	0.815	122.40	-236	-4258.54	4.906	142.91	-206	-4047.54	9.125	136.09
-265	-4342.00	0.938	123.93	-235	-4253.57	5.049	142.95	-205	-4038.35	9.261	135.69
-264	-4341.00	1.063	125.38	-234	-4248.45	5.192	142.96	-204	-4029.02	9.396	135.28
-263	-4339.88	1.189	126.75	-233	-4243.18	5.335	142.95	-203	-4019.56	9.531	134.87
-262	-4338.63	1.316	128.05	-232	-4237.77	5.478	142.92	-202	-4009.96	9.666	134.45
-261	-4337.24	1.445	129.28	-231	-4232.23	5.621	142.86	-201	-4000.23	9.800	134.02
-260	-4335.73	1.575	130.45	-230	-4226.53	5.764	142.78	-200	-3990.36	9.934	133.59
-259	-4334.09	1.706	131.55	-229	-4220.70	5.907	142.67	-199	-3980.36	10.067	133.16
-258	-4332.32	1.838	132.59	-228	-4214.72	6.049	142.55	-198	-3970.23	10.200	132.72
-257	-4330.42	1.971	133.56	-227	-4208.60	6.192	142.40	-197	-3959.96	10.333	132.28
-256	-4328.38	2.105	134.48	-226	-4202.34	6.334	142.24	-196	-3949.56	10.465	131.84
-255	-4326.21	2.240	135.33	-225	-4195.93	6.476	142.06	-195	-3939.03	10.596	131.40
-254	-4323.90	2.376	136.14	-224	-4189.38	6.618	141.86	-194	-3928.37	10.728	130.95
-253	-4321.46	2.512	136.88	-223	-4182.70	6.760	141.64	-193	-3917.57	10.858	130.50
-252	-4318.88	2.649	137.58	-222	-4175.87	6.901	141.41	-192	-3906.65	10.989	130.05
-251	-4316.16	2.787	138.23	-221	-4168.89	7.043	141.16	-191	-3895.60	11.118	129.59
-250	-4313.30	2.926	138.82	-220	-4161.78	7.184	140.90	-190	-3884.41	11.248	129.13
-249	-4310.31	3.065	139.37	-219	-4154.53	7.324	140.63	-189	-3873.10	11.377	128.68
-248	-4307.17	3.204	139.88	-218	-4147.13	7.465	140.34	-188	-3861.66	11.505	128.22
-247	-4303.90	3.345	140.34	-217	-4139.60	7.605	140.04	-187	-3850.09	11.633	127.76
-246	-4300.48	3.485	140.75	-216	-4131.92	7.745	139.73	-186	-3838.40	11.761	127.29
-245	-4296.93	3.626	141.13	-215	-4124.11	7.884	139.40	-185	-3826.57	11.888	126.83
-244	-4293.23	3.767	141.47	-214	-4116.15	8.024	139.07	-184	-3814.62	12.014	126.37
-243	-4289.39	3.909	141.77	-213	-4108.06	8.163	138.73	-183	-3802.54	12.140	125.90
-242	-4285.41	4.051	142.03	-212	-4099.83	8.301	138.38	-182	-3790.34	12.266	125.44
-241	-4281.29	4.193	142.26	-211	-4091.46	8.439	138.01	-181	-3778.01	12.391	124.97
-240	-4277.03	4.335	142.45	-210	-4082.95	8.577	137.64	-180	-3765.56	12.516	124.50

TABLE 7.3.3 AWG 28 *Nicrosil versus Nisil thermocouples—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. Cryogenic temperature range, —270 to* 0 °C—Continued

T °C	E µV	S µV/°C	dS/dT nV/°C²	T °C	E µV	S µV/°C	dS/dT nV/°C²	T °C	E µV	S µV/°C	dS/dT nV/°C²
-180	-3765.56	12.516	124.50	-120	-2807.48	19.130	95.31	-60	-1509.02	23.782	58.42
-179	-3752.98	12.640	124.04	-119	-2788.31	19.225	94.77	-59	-1485.21	23.840	57.76
-178	-3740.28	12.764	123.57	-118	-2769.03	19.319	94.23	-58	-1461.34	23.897	57.10
-177	-3727.45	12.887	123.10	-117	-2749.67	19.413	93.68	-57	-1437.41	23.954	56.44
-176	-3714.50	13.010	122.63	-116	-2730.21	19.507	93.14	-56	-1413.43	24.010	55.78
-175	-3701.43	13.133	122.17	-115	-2710.66	19.600	92.59	-55	-1389.39	24.065	55.12
-174	-3688.24	13.255	121.70	-114	-2691.01	19.692	92.03	-54	-1365.30	24.120	54.47
-173	-3674.92	13.376	121.23	-113	-2671.27	19.784	91.48	-53	-1341.15	24.174	53.81
-172	-3661.49	13.497	120.76	-112	-2651.44	19.875	90.92	-52	-1316.95	24.228	53.15
-171	-3647.93	13.618	120.29	-111	-2631.52	19.965	90.36	-51	-1292.70	24.281	52.50
-170	-3634.25	13.738	119.82	-110	-2611.51	20.056	89.79	-50	-1268.39	24.333	51.85
-169	-3620.45	13.857	119.35	-109	-2591.41	20.145	89.23	-49	-1244.03	24.384	51.19
-168	-3606.54	13.976	118.88	-108	-2571.22	20.234	88.65	-48	-1219.62	24.435	50.54
-167	-3592.50	14.095	118.42	-107	-2550.94	20.322	88.08	-47	-1195.16	24.485	49.90
-166	-3578.35	14.213	117.95	-106	-2530.58	20.410	87.50	-46	-1170.65	24.535	49.25
-165	-3564.07	14.331	117.48	-105	-2510.12	20.497	86.93	-45	-1146.09	24.584	48.60
-164	-3549.68	14.448	117.01	-104	-2489.58	20.584	86.34	-44	-1121.48	24.632	47.96
-163	-3535.18	14.565	116.54	-103	-2468.96	20.670	85.76	-43	-1096.83	24.680	47.32
-162	-3520.55	14.681	116.07	-102	-2448.24	20.755	85.17	-42	-1072.12	24.727	46.68
-161	-3505.82	14.797	115.59	-101	-2427.45	20.840	84.58	-41	-1047.37	24.773	46.04
-160	-3490.96	14.912	115.12	-100	-2406.56	20.925	83.98	-40	-1022.58	24.819	45.41
-159	-3475.99	15.027	114.65	-99	-2385.60	21.008	83.39	-39	-997.74	24.864	44.77
-158	-3460.91	15.142	114.18	-98	-2364.55	21.091	82.79	-38	-972.85	24.909	44.14
-157	-3445.71	15.256	113.71	-97	-2343.41	21.174	82.18	-37	-947.92	24.952	43.51
-156	-3430.40	15.369	113.23	-96	-2322.20	21.256	81.58	-36	-922.95	24.996	42.89
-155	-3414.97	15.482	112.76	-95	-2300.90	21.337	80.97	-35	-897.93	25.038	42.26
-154	-3399.43	15.595	112.29	-94	-2279.52	21.418	80.36	-34	-872.87	25.080	41.64
-153	-3383.78	15.707	111.81	-93	-2258.07	21.498	79.74	-33	-847.77	25.121	41.02
-152	-3368.02	15.818	111.34	-92	-2236.53	21.577	79.13	-32	-822.63	25.162	40.41
-151	-3352.14	15.929	110.86	-91	-2214.91	21.656	78.51	-31	-797.44	25.202	39.79
-150	-3336.16	16.040	110.38	-90	-2193.22	21.734	77.88	-30	-772.22	25.242	39.18
-149	-3320.06	16.150	109.90	-89	-2171.44	21.812	77.26	-29	-746.96	25.281	38.57
-148	-3303.86	16.260	109.43	-88	-2149.59	21.889	76.63	-28	-721.66	25.319	37.97
-147	-3287.54	16.369	108.94	-87	-2127.67	21.965	76.00	-27	-696.32	25.357	37.36
-146	-3271.12	16.478	108.46	-86	-2105.66	22.041	75.37	-26	-670.95	25.394	36.76
-145	-3254.59	16.586	107.98	-85	-2083.59	22.116	74.74	-25	-645.54	25.430	36.17
-144	-3237.95	16.694	107.50	-84	-2061.43	22.190	74.10	-24	-620.09	25.466	35.57
-143	-3221.20	16.801	107.01	-83	-2039.21	22.264	73.46	-23	-594.61	25.501	34.98
-142	-3204.35	16.908	106.52	-82	-2016.91	22.337	72.82	-22	-569.09	25.536	34.39
-141	-3187.39	17.014	106.03	-81	-1994.53	22.410	72.18	-21	-543.53	25.570	33.80
-140	-3170.32	17.120	105.54	-80	-1972.09	22.481	71.54	-20	-517.95	25.603	33.22
-139	-3153.15	17.225	105.05	-79	-1949.57	22.553	70.89	-19	-492.33	25.636	32.63
-138	-3135.87	17.330	104.56	-78	-1926.98	22.623	70.25	-18	-466.67	25.669	32.05
-137	-3118.49	17.434	104.06	-77	-1904.32	22.693	69.60	-17	-440.99	25.700	31.48
-136	-3101.00	17.538	103.57	-76	-1881.60	22.762	68.95	-16	-415.27	25.732	30.90
-135	-3083.41	17.641	103.07	-75	-1858.80	22.831	68.30	-15	-389.53	25.762	30.33
-134	-3065.72	17.744	102.57	-74	-1835.93	22.899	67.64	-14	-363.75	25.792	29.75
-133	-3047.92	17.846	102.06	-73	-1813.00	22.966	66.99	-13	-337.94	25.822	29.18
-132	-3030.03	17.948	101.56	-72	-1790.00	23.033	66.33	-12	-312.11	25.851	28.62
-131	-3012.03	18.050	101.05	-71	-1766.93	23.099	65.68	-11	-286.24	25.879	28.05
-130	-2993.93	18.150	100.54	-70	-1743.80	23.164	65.02	-10	-260.35	25.907	27.49
-129	-2975.73	18.251	100.03	-69	-1720.61	23.229	64.36	-9	-234.43	25.934	26.92
-128	-2957.43	18.350	99.51	-68	-1697.34	23.293	63.70	-8	-208.48	25.961	26.36
-127	-2939.03	18.450	99.00	-67	-1674.02	23.356	63.04	-7	-182.51	25.987	25.80
-126	-2920.53	18.548	98.48	-66	-1650.63	23.419	62.38	-6	-156.51	26.012	25.24
-125	-2901.93	18.647	97.95	-65	-1627.18	23.481	61.72	-5	-130.48	26.037	24.67
-124	-2883.23	18.744	97.43	-64	-1603.67	23.543	61.06	-4	-104.43	26.062	24.11
-123	-2864.44	18.841	96.90	-63	-1580.10	23.603	60.40	-3	-78.36	26.085	23.55
-122	-2845.55	18.938	96.37	-62	-1556.46	23.663	59.74	-2	-52.26	26.109	22.99
-121	-2826.57	19.034	95.84	-61	-1532.77	23.723	59.08	-1	-26.14	26.131	22.43
-120	-2807.48	19.130	95.31	-60	-1509.02	23.782	58.42	0	0.00	26.154	21.87

TABLE 7.3.4 AWG 28 *Nicrosil versus Nisil thermocouples—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. Extended temperature range, 0 to 400 °C.*

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
0	0.00	26.154	18.63	60	1622.73	28.145	40.18	120	3382.78	30.477	35.89
1	26.16	26.173	19.43	61	1650.89	28.185	40.23	121	3413.27	30.513	35.77
2	52.35	26.192	20.21	62	1679.10	28.225	40.26	122	3443.80	30.549	35.64
3	78.55	26.213	20.97	63	1707.34	28.265	40.29	123	3474.37	30.584	35.51
4	104.77	26.234	21.72	64	1735.63	28.306	40.32	124	3504.97	30.620	35.38
5	131.02	26.256	22.44	65	1763.95	28.346	40.34	125	3535.61	30.655	35.25
6	157.28	26.279	23.14	66	1792.32	28.386	40.35	126	3566.28	30.690	35.13
7	183.58	26.303	23.82	67	1820.73	28.427	40.36	127	3596.99	30.725	35.00
8	209.89	26.327	24.49	68	1849.17	28.467	40.36	128	3627.73	30.760	34.87
9	236.23	26.352	25.14	69	1877.66	28.507	40.35	129	3658.51	30.795	34.74
10	262.59	26.377	25.77	70	1906.19	28.548	40.35	130	3689.32	30.830	34.61
11	288.98	26.403	26.38	71	1934.76	28.588	40.33	131	3720.17	30.864	34.49
12	315.40	26.430	26.98	72	1963.36	28.628	40.31	132	3751.05	30.899	34.36
13	341.84	26.457	27.55	73	1992.01	28.669	40.29	133	3781.97	30.933	34.23
14	368.31	26.485	28.12	74	2020.70	28.709	40.26	134	3812.92	30.967	34.10
15	394.81	26.513	28.66	75	2049.43	28.749	40.23	135	3843.90	31.001	33.98
16	421.34	26.542	29.19	76	2078.20	28.789	40.19	136	3874.92	31.035	33.85
17	447.90	26.572	29.70	77	2107.01	28.830	40.15	137	3905.97	31.069	33.72
18	474.49	26.602	30.20	78	2135.86	28.870	40.10	138	3937.06	31.103	33.60
19	501.10	26.632	30.68	79	2164.75	28.910	40.06	139	3968.18	31.136	33.47
20	527.75	26.663	31.15	80	2193.68	28.950	40.00	140	3999.33	31.169	33.35
21	554.43	26.694	31.60	81	2222.65	28.990	39.94	141	4030.52	31.203	33.23
22	581.14	26.726	32.04	82	2251.66	29.030	39.88	142	4061.74	31.236	33.10
23	607.88	26.759	32.47	83	2280.71	29.070	39.82	143	4092.99	31.269	32.98
24	634.66	26.791	32.88	84	2309.80	29.109	39.75	144	4124.27	31.302	32.86
25	661.46	26.824	33.27	85	2338.93	29.149	39.68	145	4155.59	31.335	32.74
26	688.30	26.858	33.66	86	2368.10	29.189	39.61	146	4186.94	31.367	32.61
27	715.18	26.892	34.02	87	2397.30	29.228	39.53	147	4218.33	31.400	32.49
28	742.09	26.926	34.38	88	2426.55	29.268	39.45	148	4249.74	31.432	32.37
29	769.03	26.960	34.72	89	2455.84	29.307	39.37	149	4281.19	31.465	32.26
30	796.01	26.995	35.06	90	2485.17	29.347	39.28	150	4312.67	31.497	32.14
31	823.02	27.030	35.37	91	2514.53	29.386	39.19	151	4344.18	31.529	32.02
32	850.07	27.066	35.68	92	2543.94	29.425	39.10	152	4375.73	31.561	31.90
33	877.15	27.102	35.97	93	2573.38	29.464	39.01	153	4407.31	31.593	31.79
34	904.27	27.138	36.26	94	2602.87	29.503	38.92	154	4438.92	31.624	31.67
35	931.43	27.174	36.53	95	2632.39	29.542	38.82	155	4470.56	31.656	31.56
36	958.62	27.211	36.79	96	2661.95	29.581	38.72	156	4502.23	31.688	31.45
37	985.85	27.248	37.04	97	2691.55	29.619	38.62	157	4533.93	31.719	31.33
38	1013.12	27.285	37.28	98	2721.19	29.658	38.51	158	4565.67	31.750	31.22
39	1040.42	27.322	37.50	99	2750.87	29.696	38.41	159	4597.43	31.781	31.11
40	1067.76	27.360	37.72	100	2780.58	29.735	38.30	160	4629.23	31.812	31.00
41	1095.14	27.398	37.93	101	2810.33	29.773	38.19	161	4661.06	31.843	30.90
42	1122.56	27.436	38.12	102	2840.13	29.811	38.08	162	4692.92	31.874	30.79
43	1150.01	27.474	38.31	103	2869.96	29.849	37.97	163	4724.80	31.905	30.68
44	1177.51	27.513	38.49	104	2899.82	29.887	37.85	164	4756.73	31.936	30.58
45	1205.04	27.551	38.66	105	2929.73	29.925	37.74	165	4788.68	31.966	30.47
46	1232.61	27.590	38.82	106	2959.67	29.962	37.62	166	4820.66	31.997	30.37
47	1260.22	27.629	38.97	107	2989.66	30.000	37.50	167	4852.67	32.027	30.26
48	1287.87	27.668	39.11	108	3019.67	30.037	37.38	168	4884.71	32.057	30.16
49	1315.55	27.707	39.24	109	3049.73	30.075	37.26	169	4916.78	32.087	30.06
50	1343.28	27.746	39.37	110	3079.82	30.112	37.14	170	4948.89	32.117	29.96
51	1371.05	27.786	39.48	111	3109.95	30.149	37.02	171	4981.02	32.147	29.86
52	1398.85	27.825	39.59	112	3140.12	30.186	36.90	172	5013.18	32.177	29.76
53	1426.70	27.865	39.69	113	3170.33	30.223	36.78	173	5045.37	32.207	29.67
54	1454.58	27.905	39.78	114	3200.57	30.260	36.65	174	5077.59	32.236	29.57
55	1482.51	27.944	39.87	115	3230.84	30.296	36.53	175	5109.84	32.266	29.48
56	1510.47	27.984	39.94	116	3261.16	30.333	36.40	176	5142.12	32.295	29.38
57	1538.48	28.024	40.01	117	3291.51	30.369	36.27	177	5174.43	32.325	29.29
58	1566.52	28.064	40.08	118	3321.90	30.405	36.15	178	5206.77	32.354	29.20
59	1594.60	28.104	40.13	119	3352.32	30.441	36.02	179	5239.14	32.383	29.11
60	1622.73	28.145	40.18	120	3382.78	30.477	35.89	180	5271.54	32.412	29.02

TABLE 7.3.4 AWG 28 *Nicrosil versus Nisil thermocouples—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. Extended temperature range, 0 to 400 °C*—Continued

T °C	E µV	S µV/°C	dS/dT nV/°C²	T °C	E µV	S µV/°C	dS/dT nV/°C²	T °C	E µV	S µV/°C	dS/dT nV/°C²
180	5271.54	32.412	29.02	240	7265.71	34.019	24.89	300	9349.39	35.394	20.59
181	5303.97	32.441	28.93	241	7299.74	34.044	24.83	301	9384.79	35.415	20.49
182	5336.42	32.470	28.84	242	7333.79	34.069	24.77	302	9420.22	35.435	20.40
183	5368.91	32.499	28.75	243	7367.88	34.094	24.71	303	9455.66	35.455	20.31
184	5401.42	32.527	28.66	244	7401.98	34.119	24.65	304	9491.13	35.476	20.21
185	5433.96	32.556	28.58	245	7436.11	34.143	24.59	305	9526.61	35.496	20.12
186	5466.53	32.585	28.49	246	7470.27	34.168	24.53	306	9562.12	35.516	20.02
187	5499.13	32.613	28.41	247	7504.45	34.192	24.47	307	9597.65	35.536	19.93
188	5531.76	32.641	28.33	248	7538.65	34.217	24.41	308	9633.19	35.556	19.83
189	5564.41	32.670	28.25	249	7572.88	34.241	24.35	309	9668.76	35.576	19.73
190	5597.10	32.698	28.16	250	7607.13	34.265	24.29	310	9704.34	35.595	19.64
191	5629.81	32.726	28.08	251	7641.41	34.290	24.23	311	9739.95	35.615	19.54
192	5662.55	32.754	28.01	252	7675.71	34.314	24.17	312	9775.57	35.634	19.44
193	5695.32	32.782	27.93	253	7710.04	34.338	24.11	313	9811.22	35.654	19.34
194	5728.11	32.810	27.85	254	7744.39	34.362	24.05	314	9846.88	35.673	19.24
195	5760.94	32.838	27.77	255	7778.76	34.386	23.98	315	9882.56	35.692	19.14
196	5793.79	32.865	27.70	256	7813.16	34.410	23.92	316	9918.26	35.711	19.04
197	5826.67	32.893	27.62	257	7847.58	34.434	23.86	317	9953.98	35.730	18.94
198	5859.57	32.921	27.55	258	7882.03	34.458	23.80	318	9989.72	35.749	18.83
199	5892.51	32.948	27.47	259	7916.50	34.482	23.73	319	10025.48	35.768	18.73
200	5925.47	32.976	27.40	260	7950.99	34.505	23.67	320	10061.26	35.787	18.63
201	5958.46	33.003	27.33	261	7985.51	34.529	23.60	321	10097.06	35.805	18.52
202	5991.48	33.030	27.26	262	8020.05	34.552	23.54	322	10132.87	35.824	18.42
203	6024.52	33.058	27.19	263	8054.61	34.576	23.47	323	10168.70	35.842	18.32
204	6057.59	33.085	27.12	264	8089.20	34.599	23.41	324	10204.55	35.860	18.21
205	6090.69	33.112	27.05	265	8123.81	34.623	23.34	325	10240.42	35.878	18.11
206	6123.81	33.139	26.98	266	8158.45	34.646	23.27	326	10276.31	35.896	18.00
207	6156.97	33.166	26.91	267	8193.11	34.669	23.21	327	10312.22	35.914	17.90
208	6190.15	33.193	26.84	268	8227.79	34.692	23.14	328	10348.14	35.932	17.79
209	6223.35	33.219	26.78	269	8262.49	34.716	23.07	329	10384.08	35.950	17.68
210	6256.58	33.246	26.71	270	8297.22	34.739	23.00	330	10420.04	35.968	17.58
211	6289.84	33.273	26.64	271	8331.97	34.762	22.93	331	10456.02	35.985	17.47
212	6323.13	33.299	26.58	272	8366.74	34.784	22.86	332	10492.01	36.003	17.37
213	6356.44	33.326	26.51	273	8401.54	34.807	22.79	333	10528.02	36.020	17.26
214	6389.78	33.352	26.45	274	8436.36	34.830	22.71	334	10564.05	36.037	17.16
215	6423.15	33.379	26.39	275	8471.20	34.853	22.64	335	10600.10	36.054	17.05
216	6456.54	33.405	26.32	276	8506.06	34.875	22.57	336	10636.16	36.071	16.94
217	6489.96	33.431	26.26	277	8540.95	34.898	22.49	337	10672.24	36.088	16.84
218	6523.40	33.458	26.20	278	8575.86	34.920	22.42	338	10708.33	36.105	16.73
219	6556.87	33.484	26.13	279	8610.79	34.943	22.34	339	10744.45	36.122	16.63
220	6590.37	33.510	26.07	280	8645.74	34.965	22.27	340	10780.58	36.138	16.53
221	6623.89	33.536	26.01	281	8680.72	34.987	22.19	341	10816.72	36.155	16.42
222	6657.44	33.562	25.95	282	8715.72	35.009	22.11	342	10852.89	36.171	16.32
223	6691.02	33.588	25.89	283	8750.74	35.031	22.03	343	10889.07	36.187	16.21
224	6724.62	33.614	25.83	284	8785.78	35.053	21.96	344	10925.26	36.203	16.11
225	6758.25	33.640	25.77	285	8820.84	35.075	21.88	345	10961.47	36.219	16.01
226	6791.90	33.665	25.71	286	8855.93	35.097	21.79	346	10997.70	36.235	15.91
227	6825.58	33.691	25.65	287	8891.04	35.119	21.71	347	11033.94	36.251	15.81
228	6859.28	33.717	25.59	288	8926.17	35.141	21.63	348	11070.20	36.267	15.71
229	6893.01	33.742	25.53	289	8961.32	35.162	21.55	349	11106.48	36.283	15.61
230	6926.76	33.768	25.47	290	8996.49	35.184	21.46	350	11142.77	36.298	15.51
231	6960.54	33.793	25.41	291	9031.69	35.205	21.38	351	11179.07	36.314	15.41
232	6994.35	33.819	25.36	292	9066.90	35.226	21.30	352	11215.40	36.329	15.32
233	7028.18	33.844	25.30	293	9102.14	35.248	21.21	353	11251.73	36.344	15.22
234	7062.04	33.869	25.24	294	9137.40	35.269	21.12	354	11288.08	36.360	15.13
235	7095.92	33.894	25.18	295	9172.68	35.290	21.04	355	11324.45	36.375	15.04
236	7129.83	33.919	25.12	296	9207.98	35.311	20.95	356	11360.83	36.390	14.95
237	7163.76	33.945	25.06	297	9243.30	35.332	20.86	357	11397.23	36.405	14.86
238	7197.72	33.970	25.00	298	9278.64	35.353	20.77	358	11433.64	36.419	14.77
239	7231.70	33.995	24.94	299	9314.00	35.373	20.68	359	11470.07	36.434	14.68
240	7265.71	34.019	24.89	300	9349.39	35.394	20.59	360	11506.51	36.449	14.59

TABLE 7.3.4 AWG 28 *Nicrosil versus Nisil thermocouples—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. Extended temperature range, 0 to 400 °C*—Continued

T °C	E µV	S µV/°C	dS/dT nV/°C²	T °C	E µV	S µV/°C	dS/dT nV/°C²	T °C	E µV	S µV/°C	dS/dT nV/°C²
360	11506.51	36.449	14.59	375	12054.84	36.659	13.57	390	12606.23	36.859	13.25
361	11542.97	36.463	14.51	376	12091.51	36.673	13.52	391	12643.10	36.872	13.26
362	11579.44	36.478	14.43	377	12128.19	36.686	13.48	392	12679.98	36.886	13.28
363	11615.92	36.492	14.35	378	12164.88	36.700	13.44	393	12716.87	36.899	13.30
364	11652.42	36.506	14.27	379	12201.58	36.713	13.40	394	12753.78	36.912	13.33
365	11688.93	36.521	14.20	380	12238.30	36.727	13.36	395	12790.70	36.926	13.36
366	11725.46	36.535	14.12	381	12275.04	36.740	13.33	396	12827.63	36.939	13.40
367	11762.00	36.549	14.05	382	12311.78	36.753	13.31	397	12864.57	36.953	13.45
368	11798.56	36.563	13.98	383	12348.54	36.767	13.29	398	12901.53	36.966	13.50
369	11835.13	36.577	13.91	384	12385.32	36.780	13.27	399	12938.51	36.980	13.56
370	11871.71	36.591	13.85	385	12422.10	36.793	13.25	400	12975.49	36.993	13.62
371	11908.31	36.605	13.79	386	12458.90	36.806	13.24				
372	11944.92	36.618	13.73	387	12495.72	36.820	13.24				
373	11981.55	36.632	13.67	388	12532.54	36.833	13.23				
374	12018.19	36.646	13.62	389	12569.38	36.846	13.24				
375	12054.84	36.659	13.57	390	12606.23	36.859	13.25				

TABLE 7.3.5 AWG 14 *Nicrosil versus Nisil thermocouples—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. High temperature range, 0 to 1300 °C.*

T °C	E µV	S µV/°C	dS/dT nV/°C²	T °C	E µV	S µV/°C	dS/dT nV/°C²	T °C	E µV	S µV/°C	dS/dT nV/°C²
0	0.0	25.898	33.31	60	1618.6	28.107	38.52	120	3373.7	30.371	36.17
1	25.9	25.931	33.50	61	1646.7	28.145	38.53	121	3404.1	30.407	36.10
2	51.9	25.965	33.68	62	1674.9	28.184	38.53	122	3434.5	30.443	36.02
3	77.8	25.999	33.86	63	1703.1	28.222	38.53	123	3464.9	30.479	35.95
4	103.9	26.033	34.03	64	1731.3	28.261	38.53	124	3495.4	30.515	35.87
5	129.9	26.067	34.20	65	1759.6	28.299	38.53	125	3526.0	30.551	35.79
6	156.0	26.101	34.36	66	1787.9	28.338	38.53	126	3556.5	30.587	35.72
7	182.1	26.135	34.53	67	1816.3	28.376	38.52	127	3587.1	30.622	35.64
8	208.3	26.170	34.68	68	1844.7	28.415	38.52	128	3617.8	30.658	35.56
9	234.5	26.205	34.84	69	1873.1	28.453	38.51	129	3648.5	30.694	35.48
10	260.7	26.240	34.99	70	1901.6	28.492	38.50	130	3679.2	30.729	35.40
11	286.9	26.275	35.13	71	1930.1	28.530	38.48	131	3709.9	30.764	35.32
12	313.2	26.310	35.28	72	1958.7	28.569	38.47	132	3740.7	30.800	35.24
13	339.6	26.345	35.41	73	1987.2	28.607	38.45	133	3771.5	30.835	35.16
14	365.9	26.381	35.55	74	2015.9	28.646	38.44	134	3802.4	30.870	35.08
15	392.3	26.416	35.68	75	2044.5	28.684	38.42	135	3833.3	30.905	35.00
16	418.7	26.452	35.81	76	2073.2	28.722	38.40	136	3864.2	30.940	34.91
17	445.2	26.488	35.93	77	2102.0	28.761	38.37	137	3895.1	30.975	34.83
18	471.7	26.524	36.06	78	2130.8	28.799	38.35	138	3926.1	31.010	34.74
19	498.3	26.560	36.17	79	2159.6	28.838	38.32	139	3957.2	31.044	34.66
20	524.8	26.596	36.29	80	2188.4	28.876	38.30	140	3988.2	31.079	34.57
21	551.5	26.633	36.40	81	2217.3	28.914	38.27	141	4019.3	31.113	34.49
22	578.1	26.669	36.51	82	2246.3	28.952	38.24	142	4050.4	31.148	34.40
23	604.8	26.706	36.61	83	2275.2	28.991	38.20	143	4081.6	31.182	34.32
24	631.5	26.742	36.71	84	2304.2	29.029	38.17	144	4112.8	31.217	34.23
25	658.3	26.779	36.81	85	2333.3	29.067	38.14	145	4144.0	31.251	34.14
26	685.1	26.816	36.91	86	2362.4	29.105	38.10	146	4175.3	31.285	34.05
27	711.9	26.853	37.00	87	2391.5	29.143	38.06	147	4206.6	31.319	33.97
28	738.8	26.890	37.09	88	2420.7	29.181	38.02	148	4237.9	31.353	33.88
29	765.7	26.927	37.18	89	2449.9	29.219	37.98	149	4269.3	31.387	33.79
30	792.6	26.964	37.26	90	2479.1	29.257	37.94	150	4300.7	31.420	33.70
31	819.6	27.002	37.34	91	2508.4	29.295	37.90	151	4332.2	31.454	33.61
32	846.6	27.039	37.42	92	2537.7	29.333	37.85	152	4363.6	31.488	33.52
33	873.7	27.076	37.49	93	2567.0	29.371	37.81	153	4395.1	31.521	33.43
34	900.8	27.114	37.56	94	2596.4	29.409	37.76	154	4426.7	31.554	33.34
35	927.9	27.152	37.63	95	2625.9	29.446	37.71	155	4458.2	31.588	33.25
36	955.1	27.189	37.70	96	2655.3	29.484	37.66	156	4489.8	31.621	33.15
37	982.3	27.227	37.76	97	2684.8	29.522	37.61	157	4521.5	31.654	33.06
38	1009.5	27.265	37.82	98	2714.4	29.559	37.56	158	4553.2	31.687	32.97
39	1036.8	27.303	37.88	99	2744.0	29.597	37.51	159	4584.9	31.720	32.88
40	1064.2	27.340	37.93	100	2773.6	29.634	37.45	160	4616.6	31.753	32.79
41	1091.5	27.378	37.98	101	2803.2	29.672	37.40	161	4648.4	31.786	32.69
42	1118.9	27.416	38.03	102	2832.9	29.709	37.34	162	4680.2	31.818	32.60
43	1146.3	27.454	38.08	103	2862.6	29.746	37.29	163	4712.0	31.851	32.51
44	1173.8	27.493	38.13	104	2892.4	29.784	37.23	164	4743.9	31.883	32.41
45	1201.3	27.531	38.17	105	2922.2	29.821	37.17	165	4775.8	31.916	32.32
46	1228.9	27.569	38.21	106	2952.0	29.858	37.11	166	4807.7	31.948	32.23
47	1256.5	27.607	38.24	107	2981.9	29.895	37.05	167	4839.7	31.980	32.13
48	1284.1	27.645	38.28	108	3011.8	29.932	36.99	168	4871.7	32.012	32.04
49	1311.8	27.684	38.31	109	3041.8	29.969	36.92	169	4903.7	32.044	31.94
50	1339.5	27.722	38.34	110	3071.8	30.006	36.86	170	4935.7	32.076	31.85
51	1367.2	27.760	38.37	111	3101.8	30.043	36.79	171	4967.8	32.108	31.75
52	1395.0	27.799	38.40	112	3131.9	30.079	36.73	172	5000.0	32.140	31.66
53	1422.8	27.837	38.42	113	3162.0	30.116	36.66	173	5032.1	32.171	31.56
54	1450.7	27.876	38.44	114	3192.1	30.153	36.59	174	5064.3	32.203	31.47
55	1478.6	27.914	38.46	115	3222.3	30.189	36.52	175	5096.5	32.234	31.37
56	1506.5	27.953	38.48	116	3252.5	30.226	36.45	176	5128.8	32.265	31.28
57	1534.5	27.991	38.49	117	3282.7	30.262	36.38	177	5161.1	32.297	31.18
58	1562.5	28.030	38.50	118	3313.0	30.299	36.31	178	5193.4	32.328	31.08
59	1590.5	28.068	38.51	119	3343.3	30.335	36.24	179	5225.7	32.359	30.99
60	1618.6	28.107	38.52	120	3373.7	30.371	36.17	180	5258.1	32.390	30.89

Table 7.3.5 AWG 14 *Nicrosil versus Nisil thermocouples—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. High temperature range, 0 to 1300 °C* —Continued

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
180	5258.1	32.390	30.89	240	7253.6	34.071	25.19	300	9340.0	35.427	20.18
181	5290.5	32.421	30.80	241	7287.7	34.096	25.10	301	9375.5	35.447	20.11
182	5322.9	32.451	30.70	242	7321.8	34.121	25.01	302	9410.9	35.467	20.03
183	5355.4	32.482	30.60	243	7355.9	34.146	24.92	303	9446.4	35.487	19.96
184	5387.9	32.512	30.51	244	7390.1	34.171	24.83	304	9481.9	35.507	19.88
185	5420.4	32.543	30.41	245	7424.3	34.195	24.74	305	9517.4	35.527	19.81
186	5453.0	32.573	30.31	246	7458.5	34.220	24.65	306	9553.0	35.547	19.73
187	5485.6	32.604	30.22	247	7492.7	34.245	24.56	307	9588.5	35.567	19.66
188	5518.2	32.634	30.12	248	7527.0	34.269	24.47	308	9624.1	35.586	19.58
189	5550.8	32.664	30.02	249	7561.3	34.294	24.38	309	9659.7	35.606	19.51
190	5583.5	32.694	29.93	250	7595.6	34.318	24.30	310	9695.3	35.625	19.44
191	5616.2	32.724	29.83	251	7629.9	34.342	24.21	311	9730.9	35.645	19.37
192	5649.0	32.753	29.73	252	7664.2	34.366	24.12	312	9766.6	35.664	19.29
193	5681.7	32.783	29.64	253	7698.6	34.391	24.03	313	9802.3	35.683	19.22
194	5714.5	32.813	29.54	254	7733.0	34.414	23.94	314	9838.0	35.702	19.15
195	5747.4	32.842	29.44	255	7767.4	34.438	23.86	315	9873.7	35.722	19.08
196	5780.2	32.872	29.35	256	7801.9	34.462	23.77	316	9909.4	35.741	19.01
197	5813.1	32.901	29.25	257	7836.4	34.486	23.68	317	9945.2	35.760	18.94
198	5846.0	32.930	29.15	258	7870.9	34.510	23.59	318	9980.9	35.778	18.86
199	5879.0	32.959	29.06	259	7905.4	34.533	23.51	319	10016.7	35.797	18.79
200	5911.9	32.988	28.96	260	7939.9	34.557	23.42	320	10052.5	35.816	18.72
201	5944.9	33.017	28.87	261	7974.5	34.580	23.33	321	10088.4	35.835	18.65
202	5978.0	33.046	28.77	262	8009.1	34.603	23.25	322	10124.2	35.853	18.58
203	6011.0	33.075	28.67	263	8043.7	34.626	23.16	323	10160.1	35.872	18.51
204	6044.1	33.103	28.58	264	8078.4	34.650	23.08	324	10195.9	35.890	18.44
205	6077.2	33.132	28.48	265	8113.0	34.673	22.99	325	10231.8	35.909	18.38
206	6110.4	33.160	28.38	266	8147.7	34.696	22.91	326	10267.8	35.927	18.31
207	6143.5	33.189	28.29	267	8182.4	34.718	22.82	327	10303.7	35.945	18.24
208	6176.8	33.217	28.19	268	8217.1	34.741	22.74	328	10339.6	35.964	18.17
209	6210.0	33.245	28.10	269	8251.9	34.764	22.65	329	10375.6	35.982	18.10
210	6243.2	33.273	28.00	270	8286.7	34.787	22.57	330	10411.6	36.000	18.03
211	6276.5	33.301	27.90	271	8321.5	34.809	22.49	331	10447.6	36.018	17.97
212	6309.8	33.329	27.81	272	8356.3	34.831	22.40	332	10483.6	36.036	17.90
213	6343.2	33.357	27.71	273	8391.1	34.854	22.32	333	10519.7	36.054	17.83
214	6376.6	33.384	27.62	274	8426.0	34.876	22.24	334	10555.8	36.071	17.77
215	6410.0	33.412	27.52	275	8460.9	34.898	22.16	335	10591.8	36.089	17.70
216	6443.4	33.439	27.43	276	8495.8	34.920	22.07	336	10627.9	36.107	17.63
217	6476.8	33.467	27.33	277	8530.7	34.942	21.99	337	10664.0	36.124	17.57
218	6510.3	33.494	27.24	278	8565.7	34.964	21.91	338	10700.2	36.142	17.50
219	6543.8	33.521	27.14	279	8600.6	34.986	21.83	339	10736.3	36.159	17.44
220	6577.4	33.548	27.05	280	8635.6	35.008	21.75	340	10772.5	36.177	17.37
221	6610.9	33.575	26.96	281	8670.7	35.030	21.67	341	10808.7	36.194	17.31
222	6644.5	33.602	26.86	282	8705.7	35.051	21.59	342	10844.9	36.211	17.24
223	6678.1	33.629	26.77	283	8740.8	35.073	21.50	343	10881.1	36.229	17.18
224	6711.8	33.656	26.67	284	8775.8	35.094	21.42	344	10917.3	36.246	17.11
225	6745.4	33.682	26.58	285	8811.0	35.116	21.35	345	10953.6	36.263	17.05
226	6779.1	33.709	26.49	286	8846.1	35.137	21.27	346	10989.9	36.280	16.99
227	6812.9	33.735	26.39	287	8881.2	35.158	21.19	347	11026.2	36.297	16.92
228	6846.6	33.762	26.30	288	8916.4	35.179	21.11	348	11062.5	36.314	16.86
229	6880.4	33.788	26.21	289	8951.6	35.201	21.03	349	11098.8	36.331	16.80
230	6914.2	33.814	26.11	290	8986.8	35.222	20.95	350	11135.1	36.347	16.73
231	6948.0	33.840	26.02	291	9022.0	35.242	20.87	351	11171.5	36.364	16.67
232	6981.9	33.866	25.93	292	9057.3	35.263	20.79	352	11207.9	36.381	16.61
233	7015.7	33.892	25.83	293	9092.6	35.284	20.72	353	11244.2	36.397	16.55
234	7049.6	33.918	25.74	294	9127.8	35.305	20.64	354	11280.6	36.414	16.49
235	7083.6	33.943	25.65	295	9163.2	35.325	20.56	355	11317.1	36.430	16.42
236	7117.5	33.969	25.56	296	9198.5	35.346	20.49	356	11353.5	36.447	16.36
237	7151.5	33.995	25.47	297	9233.9	35.366	20.41	357	11390.0	36.463	16.30
238	7185.5	34.020	25.38	298	9269.2	35.387	20.33	358	11426.4	36.479	16.24
239	7219.5	34.045	25.28	299	9304.6	35.407	20.26	359	11462.9	36.495	16.18
240	7253.6	34.071	25.19	300	9340.0	35.427	20.18	360	11499.4	36.512	16.12

TABLE 7.3.5 AWG 14 *Nicrosil versus Nisil thermocouples—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. High temperature range, 0 to 1300 °C* —Continued

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
360	11499.4	36.512	16.12	420	13717.1	37.378	12.85	480	15981.2	38.064	10.09
361	11535.9	36.528	16.06	421	13754.5	37.390	12.81	481	16019.2	38.074	10.05
362	11572.5	36.544	16.00	422	13791.9	37.403	12.76	482	16057.3	38.084	10.00
363	11609.0	36.560	15.94	423	13829.3	37.416	12.71	483	16095.4	38.094	9.96
364	11645.6	36.576	15.88	424	13866.7	37.429	12.66	484	16133.5	38.104	9.92
365	11682.2	36.591	15.82	425	13904.1	37.441	12.61	485	16171.6	38.114	9.87
366	11718.8	36.607	15.76	426	13941.6	37.454	12.56	486	16209.7	38.124	9.83
367	11755.4	36.623	15.70	427	13979.0	37.466	12.51	487	16247.8	38.134	9.79
368	11792.0	36.639	15.64	428	14016.5	37.479	12.46	488	16286.0	38.143	9.74
369	11828.7	36.654	15.59	429	14054.0	37.491	12.42	489	16324.1	38.153	9.70
370	11865.3	36.670	15.53	430	14091.5	37.504	12.37	490	16362.3	38.163	9.66
371	11902.0	36.685	15.47	431	14129.0	37.516	12.32	491	16400.5	38.172	9.61
372	11938.7	36.701	15.41	432	14166.5	37.528	12.27	492	16438.6	38.182	9.57
373	11975.4	36.716	15.35	433	14204.1	37.541	12.22	493	16476.8	38.192	9.53
374	12012.1	36.731	15.30	434	14241.6	37.553	12.18	494	16515.0	38.201	9.49
375	12048.9	36.747	15.24	435	14279.2	37.565	12.13	495	16553.2	38.211	9.44
376	12085.6	36.762	15.18	436	14316.7	37.577	12.08	496	16591.4	38.220	9.40
377	12122.4	36.777	15.13	437	14354.3	37.589	12.03	497	16629.7	38.229	9.36
378	12159.2	36.792	15.07	438	14391.9	37.601	11.99	498	16667.9	38.239	9.32
379	12196.0	36.807	15.01	439	14429.5	37.613	11.94	499	16706.1	38.248	9.27
380	12232.8	36.822	14.96	440	14467.1	37.625	11.89	500	16744.4	38.257	9.23
381	12269.6	36.837	14.90	441	14504.8	37.637	11.85	501	16782.7	38.266	9.19
382	12306.5	36.852	14.85	442	14542.4	37.649	11.80	502	16820.9	38.276	9.15
383	12343.3	36.867	14.79	443	14580.1	37.660	11.75	503	16859.2	38.285	9.10
384	12380.2	36.882	14.73	444	14617.7	37.672	11.71	504	16897.5	38.294	9.06
385	12417.1	36.896	14.68	445	14655.4	37.684	11.66	505	16935.8	38.303	9.02
386	12454.0	36.911	14.62	446	14693.1	37.695	11.61	506	16974.1	38.312	8.98
387	12490.9	36.926	14.57	447	14730.8	37.707	11.57	507	17012.4	38.321	8.93
388	12527.9	36.940	14.51	448	14768.5	37.719	11.52	508	17050.7	38.330	8.89
389	12564.8	36.955	14.46	449	14806.2	37.730	11.47	509	17089.1	38.339	8.85
390	12601.8	36.969	14.41	450	14844.0	37.742	11.43	510	17127.4	38.347	8.81
391	12638.7	36.983	14.35	451	14881.7	37.753	11.38	511	17165.8	38.356	8.77
392	12675.7	36.998	14.30	452	14919.5	37.764	11.34	512	17204.1	38.365	8.72
393	12712.7	37.012	14.24	453	14957.2	37.776	11.29	513	17242.5	38.374	8.68
394	12749.8	37.026	14.19	454	14995.0	37.787	11.25	514	17280.9	38.382	8.64
395	12786.8	37.040	14.14	455	15032.8	37.798	11.20	515	17319.3	38.391	8.60
396	12823.8	37.054	14.08	456	15070.6	37.809	11.15	516	17357.7	38.400	8.56
397	12860.9	37.069	14.03	457	15108.4	37.820	11.11	517	17396.1	38.408	8.52
398	12898.0	37.083	13.98	458	15146.3	37.831	11.06	518	17434.5	38.417	8.47
399	12935.1	37.096	13.92	459	15184.1	37.843	11.02	519	17472.9	38.425	8.43
400	12972.2	37.110	13.87	460	15221.9	37.854	10.97	520	17511.3	38.433	8.39
401	13009.3	37.124	13.82	461	15259.8	37.864	10.93	521	17549.8	38.442	8.35
402	13046.4	37.138	13.77	462	15297.7	37.875	10.88	522	17588.2	38.450	8.31
403	13083.6	37.152	13.72	463	15335.6	37.886	10.84	523	17626.7	38.458	8.27
404	13120.7	37.165	13.66	464	15373.4	37.897	10.79	524	17665.1	38.467	8.22
405	13157.9	37.179	13.61	465	15411.4	37.908	10.75	525	17703.6	38.475	8.18
406	13195.1	37.193	13.56	466	15449.3	37.919	10.71	526	17742.1	38.483	8.14
407	13232.3	37.206	13.51	467	15487.2	37.929	10.66	527	17780.6	38.491	8.10
408	13269.5	37.220	13.46	468	15525.1	37.940	10.62	528	17819.1	38.499	8.06
409	13306.7	37.233	13.41	469	15563.1	37.950	10.57	529	17857.6	38.507	8.02
410	13344.0	37.246	13.36	470	15601.0	37.961	10.53	530	17896.1	38.515	7.97
411	13381.2	37.260	13.31	471	15639.0	37.972	10.48	531	17934.6	38.523	7.93
412	13418.5	37.273	13.25	472	15677.0	37.982	10.44	532	17973.1	38.531	7.89
413	13455.8	37.286	13.20	473	15715.0	37.992	10.40	533	18011.7	38.539	7.85
414	13493.0	37.300	13.15	474	15753.0	38.003	10.35	534	18050.2	38.547	7.81
415	13530.4	37.313	13.10	475	15791.0	38.013	10.31	535	18088.8	38.555	7.77
416	13567.7	37.326	13.05	476	15829.0	38.023	10.26	536	18127.3	38.562	7.73
417	13605.0	37.339	13.00	477	15867.0	38.034	10.22	537	18165.9	38.570	7.69
418	13642.3	37.352	12.95	478	15905.0	38.044	10.18	538	18204.5	38.578	7.64
419	13679.7	37.365	12.90	479	15943.1	38.054	10.13	539	18243.0	38.585	7.60
420	13717.1	37.378	12.85	480	15981.2	38.064	10.09	540	18281.6	38.593	7.56

TABLE 7.3.5 AWG 14 *Nicrosil versus Nisil thermocouples—thermoelectric voltages,* E(T)*, Seebeck coefficients,* S(T)*, and first derivatives of the Seebeck coefficients,* dS/dT*, reference junctions at 0 °C. High temperature range, 0 to 1300 °C* —Continued

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
540	18281.6	38.593	7.56	600	20609.3	38.973	5.13	660	22955.6	39.210	2.79
541	18320.2	38.601	7.52	601	20648.3	38.979	5.09	661	22994.8	39.213	2.75
542	18358.8	38.608	7.48	602	20687.3	38.984	5.05	662	23034.0	39.216	2.71
543	18397.4	38.615	7.44	603	20726.3	38.989	5.01	663	23073.2	39.219	2.68
544	18436.1	38.623	7.40	604	20765.3	38.994	4.97	664	23112.4	39.221	2.64
545	18474.7	38.630	7.36	605	20804.3	38.999	4.93	665	23151.7	39.224	2.60
546	18513.3	38.638	7.32	606	20843.3	39.004	4.89	666	23190.9	39.227	2.56
547	18552.0	38.645	7.28	607	20882.3	39.008	4.85	667	23230.1	39.229	2.53
548	18590.6	38.652	7.23	608	20921.3	39.013	4.81	668	23269.3	39.232	2.49
549	18629.3	38.659	7.19	609	20960.3	39.018	4.77	669	23308.6	39.234	2.45
550	18667.9	38.667	7.15	610	20999.3	39.023	4.73	670	23347.8	39.236	2.41
551	18706.6	38.674	7.11	611	21038.4	39.027	4.69	671	23387.0	39.239	2.38
552	18745.3	38.681	7.07	612	21077.4	39.032	4.65	672	23426.3	39.241	2.34
553	18784.0	38.688	7.03	613	21116.4	39.037	4.61	673	23465.5	39.244	2.30
554	18822.6	38.695	6.99	614	21155.5	39.041	4.57	674	23504.8	39.246	2.27
555	18861.3	38.702	6.95	615	21194.5	39.046	4.54	675	23544.0	39.248	2.23
556	18900.1	38.709	6.91	616	21233.6	39.050	4.50	676	23583.3	39.250	2.19
557	18938.8	38.716	6.87	617	21272.6	39.055	4.46	677	23622.5	39.252	2.15
558	18977.5	38.722	6.83	618	21311.7	39.059	4.42	678	23661.8	39.255	2.12
559	19016.2	38.729	6.78	619	21350.7	39.064	4.38	679	23701.0	39.257	2.08
560	19054.9	38.736	6.74	620	21389.8	39.068	4.34	680	23740.3	39.259	2.04
561	19093.7	38.743	6.70	621	21428.9	39.072	4.30	681	23779.5	39.261	2.01
562	19132.4	38.749	6.66	622	21467.9	39.077	4.26	682	23818.8	39.263	1.97
563	19171.2	38.756	6.62	623	21507.0	39.081	4.22	683	23858.1	39.265	1.93
564	19209.9	38.763	6.58	624	21546.1	39.085	4.18	684	23897.3	39.267	1.90
565	19248.7	38.769	6.54	625	21585.2	39.089	4.14	685	23936.6	39.269	1.86
566	19287.5	38.776	6.50	626	21624.3	39.093	4.10	686	23975.9	39.270	1.83
567	19326.3	38.782	6.46	627	21663.4	39.098	4.06	687	24015.1	39.272	1.79
568	19365.0	38.789	6.42	628	21702.5	39.102	4.02	688	24054.4	39.274	1.75
569	19403.8	38.795	6.38	629	21741.6	39.106	3.98	689	24093.7	39.276	1.72
570	19442.6	38.801	6.34	630	21780.7	39.110	3.95	690	24133.0	39.277	1.68
571	19481.4	38.808	6.30	631	21819.8	39.113	3.91	691	24172.2	39.279	1.64
572	19520.2	38.814	6.26	632	21858.9	39.117	3.87	692	24211.5	39.281	1.61
573	19559.1	38.820	6.22	633	21898.0	39.121	3.83	693	24250.8	39.282	1.57
574	19597.9	38.826	6.18	634	21937.1	39.125	3.79	694	24290.1	39.284	1.54
575	19636.7	38.833	6.14	635	21976.3	39.129	3.75	695	24329.4	39.285	1.50
576	19675.6	38.839	6.10	636	22015.4	39.132	3.71	696	24368.7	39.287	1.47
577	19714.4	38.845	6.06	637	22054.5	39.136	3.67	697	24407.9	39.288	1.43
578	19753.2	38.851	6.01	638	22093.7	39.140	3.63	698	24447.2	39.290	1.39
579	19792.1	38.857	5.97	639	22132.8	39.143	3.59	699	24486.5	39.291	1.36
580	19831.0	38.863	5.93	640	22172.0	39.147	3.56	700	24525.8	39.292	1.32
581	19869.8	38.869	5.89	641	22211.1	39.151	3.52	701	24565.1	39.294	1.29
582	19908.7	38.875	5.85	642	22250.3	39.154	3.48	702	24604.4	39.295	1.25
583	19947.6	38.880	5.81	643	22289.4	39.158	3.44	703	24643.7	39.296	1.22
584	19986.5	38.886	5.77	644	22328.6	39.161	3.40	704	24683.0	39.297	1.18
585	20025.3	38.892	5.73	645	22367.7	39.164	3.36	705	24722.3	39.299	1.15
586	20064.2	38.898	5.69	646	22406.9	39.168	3.32	706	24761.6	39.300	1.11
587	20103.1	38.903	5.65	647	22446.1	39.171	3.29	707	24800.9	39.301	1.08
588	20142.0	38.909	5.61	648	22485.3	39.174	3.25	708	24840.2	39.302	1.04
589	20181.0	38.915	5.57	649	22524.4	39.177	3.21	709	24879.5	39.303	1.01
590	20219.9	38.920	5.53	650	22563.6	39.181	3.17	710	24918.8	39.304	0.97
591	20258.8	38.926	5.49	651	22602.8	39.184	3.13	711	24958.1	39.305	0.94
592	20297.7	38.931	5.45	652	22642.0	39.187	3.09	712	24997.4	39.306	0.91
593	20336.7	38.937	5.41	653	22681.2	39.190	3.06	713	25036.7	39.307	0.87
594	20375.6	38.942	5.37	654	22720.4	39.193	3.02	714	25076.0	39.308	0.84
595	20414.5	38.947	5.33	655	22759.5	39.196	2.98	715	25115.3	39.308	0.80
596	20453.5	38.953	5.29	656	22798.7	39.199	2.94	716	25154.6	39.309	0.77
597	20492.4	38.958	5.25	657	22837.9	39.202	2.90	717	25194.0	39.310	0.73
598	20531.4	38.963	5.21	658	22877.1	39.205	2.87	718	25233.3	39.311	0.70
599	20570.4	38.968	5.17	659	22916.4	39.208	2.83	719	25272.6	39.311	0.67
600	20609.3	38.973	5.13	660	22955.6	39.210	2.79	720	25311.9	39.312	0.63

TABLE 7.3.5 AWG 14 *Nicrosil versus Nisil thermocouples—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. High temperature range, 0 to 1300 °C* —Continued

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
720	25311.9	39.312	0.63	780	27670.6	39.293	-1.21	840	30025.1	39.175	-2.64
721	25351.2	39.313	0.60	781	27709.9	39.292	-1.23	841	30064.2	39.173	-2.66
722	25390.5	39.313	0.57	782	27749.2	39.290	-1.26	842	30103.4	39.170	-2.68
723	25429.8	39.314	0.53	783	27788.5	39.289	-1.29	843	30142.6	39.167	-2.70
724	25469.1	39.314	0.50	784	27827.7	39.288	-1.32	844	30181.7	39.165	-2.72
725	25508.5	39.315	0.47	785	27867.0	39.286	-1.34	845	30220.9	39.162	-2.74
726	25547.8	39.315	0.43	786	27906.3	39.285	-1.37	846	30260.1	39.159	-2.76
727	25587.1	39.316	0.40	787	27945.6	39.284	-1.40	847	30299.2	39.156	-2.78
728	25626.4	39.316	0.37	788	27984.9	39.282	-1.42	848	30338.4	39.154	-2.80
729	25665.7	39.316	0.33	789	28024.2	39.281	-1.45	849	30377.5	39.151	-2.81
730	25705.0	39.317	0.30	790	28063.4	39.279	-1.47	850	30416.7	39.148	-2.83
731	25744.3	39.317	0.27	791	28102.7	39.278	-1.50	851	30455.8	39.145	-2.85
732	25783.7	39.317	0.24	792	28142.0	39.276	-1.53	852	30495.0	39.142	-2.87
733	25823.0	39.317	0.20	793	28181.3	39.275	-1.55	853	30534.1	39.139	-2.89
734	25862.3	39.318	0.17	794	28220.5	39.273	-1.58	854	30573.2	39.137	-2.91
735	25901.6	39.318	0.14	795	28259.8	39.272	-1.60	855	30612.4	39.134	-2.93
736	25940.9	39.318	0.11	796	28299.1	39.270	-1.63	856	30651.5	39.131	-2.95
737	25980.3	39.318	0.07	797	28338.4	39.268	-1.66	857	30690.6	39.128	-2.96
738	26019.6	39.318	0.04	798	28377.6	39.267	-1.68	858	30729.8	39.125	-2.98
739	26058.9	39.318	0.01	799	28416.9	39.265	-1.71	859	30768.9	39.122	-3.00
740	26098.2	39.318	-0.02	800	28456.2	39.263	-1.73	860	30808.0	39.119	-3.02
741	26137.5	39.318	-0.05	801	28495.4	39.262	-1.76	861	30847.1	39.116	-3.04
742	26176.8	39.318	-0.08	802	28534.7	39.260	-1.78	862	30886.2	39.113	-3.06
743	26216.2	39.318	-0.12	803	28573.9	39.258	-1.81	863	30925.4	39.110	-3.07
744	26255.5	39.318	-0.15	804	28613.2	39.256	-1.83	864	30964.5	39.107	-3.09
745	26294.8	39.317	-0.18	805	28652.5	39.254	-1.85	865	31003.6	39.103	-3.11
746	26334.1	39.317	-0.21	806	28691.7	39.253	-1.88	866	31042.7	39.100	-3.13
747	26373.4	39.317	-0.24	807	28731.0	39.251	-1.90	867	31081.8	39.097	-3.14
748	26412.7	39.317	-0.27	808	28770.2	39.249	-1.93	868	31120.9	39.094	-3.16
749	26452.1	39.317	-0.30	809	28809.5	39.247	-1.95	869	31160.0	39.091	-3.18
750	26491.4	39.316	-0.33	810	28848.7	39.245	-1.98	870	31199.0	39.088	-3.19
751	26530.7	39.316	-0.36	811	28887.9	39.243	-2.00	871	31238.1	39.084	-3.21
752	26570.0	39.315	-0.40	812	28927.2	39.241	-2.02	872	31277.2	39.081	-3.23
753	26609.3	39.315	-0.43	813	28966.4	39.239	-2.05	873	31316.3	39.078	-3.25
754	26648.6	39.315	-0.46	814	29005.7	39.237	-2.07	874	31355.4	39.075	-3.26
755	26688.0	39.314	-0.49	815	29044.9	39.235	-2.09	875	31394.4	39.071	-3.28
756	26727.3	39.314	-0.52	816	29084.1	39.233	-2.12	876	31433.5	39.068	-3.29
757	26766.6	39.313	-0.55	817	29123.4	39.230	-2.14	877	31472.6	39.065	-3.31
758	26805.9	39.313	-0.58	818	29162.6	39.228	-2.16	878	31511.6	39.062	-3.33
759	26845.2	39.312	-0.61	819	29201.8	39.226	-2.19	879	31550.7	39.058	-3.34
760	26884.5	39.311	-0.64	820	29241.0	39.224	-2.21	880	31589.8	39.055	-3.36
761	26923.8	39.311	-0.67	821	29280.3	39.222	-2.23	881	31628.8	39.052	-3.38
762	26963.1	39.310	-0.69	822	29319.5	39.219	-2.25	882	31667.9	39.048	-3.39
763	27002.4	39.309	-0.72	823	29358.7	39.217	-2.28	883	31706.9	39.045	-3.41
764	27041.8	39.309	-0.75	824	29397.9	39.215	-2.30	884	31745.9	39.041	-3.42
765	27081.1	39.308	-0.78	825	29437.1	39.213	-2.32	885	31785.0	39.038	-3.44
766	27120.4	39.307	-0.81	826	29476.4	39.210	-2.34	886	31824.0	39.034	-3.45
767	27159.7	39.306	-0.84	827	29515.6	39.208	-2.36	887	31863.1	39.031	-3.47
768	27199.0	39.305	-0.87	828	29554.8	39.206	-2.38	888	31902.1	39.028	-3.49
769	27238.3	39.304	-0.90	829	29594.0	39.203	-2.41	889	31941.1	39.024	-3.50
770	27277.6	39.304	-0.93	830	29633.2	39.201	-2.43	890	31980.1	39.021	-3.52
771	27316.9	39.303	-0.96	831	29672.4	39.198	-2.45	891	32019.2	39.017	-3.53
772	27356.2	39.302	-0.98	832	29711.6	39.196	-2.47	892	32058.2	39.013	-3.55
773	27395.5	39.301	-1.01	833	29750.8	39.193	-2.49	893	32097.2	39.010	-3.56
774	27434.8	39.300	-1.04	834	29790.0	39.191	-2.51	894	32136.2	39.006	-3.58
775	27474.1	39.299	-1.07	835	29829.1	39.188	-2.53	895	32175.2	39.003	-3.59
776	27513.4	39.297	-1.10	836	29868.3	39.186	-2.55	896	32214.2	38.999	-3.60
777	27552.7	39.296	-1.12	837	29907.5	39.183	-2.58	897	32253.2	38.996	-3.62
778	27592.0	39.295	-1.15	838	29946.7	39.181	-2.60	898	32292.2	38.992	-3.63
779	27631.3	39.294	-1.18	839	29985.9	39.178	-2.62	899	32331.2	38.988	-3.65
780	27670.6	39.293	-1.21	840	30025.1	39.175	-2.64	900	32370.2	38.985	-3.66

TABLE 7.3.5 AWG 14 *Nicrosil versus Nisil thermocouples—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. High temperature range, 0 to 1300 °C* —Continued

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
900	32370.2	38.985	-3.66	960	34702.2	38.741	-4.43	1020	37018.2	38.453	-5.20
901	32409.1	38.981	-3.68	961	34740.9	38.737	-4.44	1021	37056.7	38.448	-5.22
902	32448.1	38.977	-3.69	962	34779.6	38.732	-4.45	1022	37095.1	38.443	-5.23
903	32487.1	38.974	-3.71	963	34818.4	38.728	-4.47	1023	37133.6	38.437	-5.25
904	32526.1	38.970	-3.72	964	34857.1	38.723	-4.48	1024	37172.0	38.432	-5.26
905	32565.0	38.966	-3.73	965	34895.8	38.719	-4.49	1025	37210.4	38.427	-5.28
906	32604.0	38.962	-3.75	966	34934.5	38.714	-4.50	1026	37248.8	38.422	-5.29
907	32643.0	38.959	-3.76	967	34973.2	38.710	-4.51	1027	37287.3	38.416	-5.31
908	32681.9	38.955	-3.78	968	35011.9	38.705	-4.53	1028	37325.7	38.411	-5.32
909	32720.9	38.951	-3.79	969	35050.7	38.701	-4.54	1029	37364.1	38.406	-5.34
910	32759.8	38.947	-3.80	970	35089.4	38.696	-4.55	1030	37402.5	38.400	-5.35
911	32798.8	38.943	-3.82	971	35128.0	38.692	-4.56	1031	37440.9	38.395	-5.37
912	32837.7	38.940	-3.83	972	35166.7	38.687	-4.57	1032	37479.3	38.390	-5.38
913	32876.6	38.936	-3.84	973	35205.4	38.683	-4.59	1033	37517.7	38.384	-5.40
914	32915.6	38.932	-3.86	974	35244.1	38.678	-4.60	1034	37556.0	38.379	-5.42
915	32954.5	38.928	-3.87	975	35282.8	38.673	-4.61	1035	37594.4	38.373	-5.43
916	32993.4	38.924	-3.88	976	35321.4	38.669	-4.62	1036	37632.8	38.368	-5.45
917	33032.4	38.920	-3.90	977	35360.1	38.664	-4.63	1037	37671.2	38.362	-5.46
918	33071.3	38.916	-3.91	978	35398.8	38.659	-4.65	1038	37709.5	38.357	-5.48
919	33110.2	38.913	-3.92	979	35437.4	38.655	-4.66	1039	37747.9	38.351	-5.50
920	33149.1	38.909	-3.94	980	35476.1	38.650	-4.67	1040	37786.2	38.346	-5.51
921	33188.0	38.905	-3.95	981	35514.7	38.645	-4.68	1041	37824.6	38.340	-5.53
922	33226.9	38.901	-3.96	982	35553.4	38.641	-4.70	1042	37862.9	38.335	-5.55
923	33265.8	38.897	-3.98	983	35592.0	38.636	-4.71	1043	37901.2	38.329	-5.56
924	33304.7	38.893	-3.99	984	35630.6	38.631	-4.72	1044	37939.6	38.324	-5.58
925	33343.6	38.889	-4.00	985	35669.3	38.627	-4.73	1045	37977.9	38.318	-5.60
926	33382.5	38.885	-4.01	986	35707.9	38.622	-4.74	1046	38016.2	38.313	-5.62
927	33421.4	38.881	-4.03	987	35746.5	38.617	-4.76	1047	38054.5	38.307	-5.63
928	33460.2	38.877	-4.04	988	35785.1	38.612	-4.77	1048	38092.8	38.301	-5.65
929	33499.1	38.873	-4.05	989	35823.7	38.608	-4.78	1049	38131.1	38.296	-5.67
930	33538.0	38.869	-4.06	990	35862.3	38.603	-4.80	1050	38169.4	38.290	-5.69
931	33576.9	38.865	-4.08	991	35900.9	38.598	-4.81	1051	38207.7	38.284	-5.70
932	33615.7	38.860	-4.09	992	35939.5	38.593	-4.82	1052	38246.0	38.279	-5.72
933	33654.6	38.856	-4.10	993	35978.1	38.588	-4.83	1053	38284.2	38.273	-5.74
934	33693.4	38.852	-4.11	994	36016.7	38.584	-4.85	1054	38322.5	38.267	-5.76
935	33732.3	38.848	-4.13	995	36055.3	38.579	-4.86	1055	38360.8	38.261	-5.78
936	33771.1	38.844	-4.14	996	36093.9	38.574	-4.87	1056	38399.0	38.255	-5.80
937	33810.0	38.840	-4.15	997	36132.5	38.569	-4.88	1057	38437.3	38.250	-5.81
938	33848.8	38.836	-4.16	998	36171.0	38.564	-4.90	1058	38475.5	38.244	-5.83
939	33887.6	38.831	-4.18	999	36209.6	38.559	-4.91	1059	38513.8	38.238	-5.85
940	33926.5	38.827	-4.19	1000	36248.1	38.554	-4.92	1060	38552.0	38.232	-5.87
941	33965.3	38.823	-4.20	1001	36286.7	38.549	-4.94	1061	38590.2	38.226	-5.89
942	34004.1	38.819	-4.21	1002	36325.2	38.544	-4.95	1062	38628.5	38.220	-5.91
943	34042.9	38.815	-4.22	1003	36363.8	38.539	-4.96	1063	38666.7	38.214	-5.93
944	34081.7	38.810	-4.24	1004	36402.3	38.534	-4.98	1064	38704.9	38.209	-5.95
945	34120.6	38.806	-4.25	1005	36440.8	38.529	-4.99	1065	38743.1	38.203	-5.97
946	34159.4	38.802	-4.26	1006	36479.4	38.524	-5.00	1066	38781.3	38.197	-5.99
947	34198.2	38.798	-4.27	1007	36517.9	38.519	-5.02	1067	38819.5	38.191	-6.01
948	34237.0	38.793	-4.29	1008	36556.4	38.514	-5.03	1068	38857.7	38.185	-6.03
949	34275.7	38.789	-4.30	1009	36594.9	38.509	-5.05	1069	38895.9	38.179	-6.05
950	34314.5	38.785	-4.31	1010	36633.4	38.504	-5.06	1070	38934.0	38.172	-6.07
951	34353.3	38.780	-4.32	1011	36671.9	38.499	-5.07	1071	38972.2	38.166	-6.09
952	34392.1	38.776	-4.33	1012	36710.4	38.494	-5.09	1072	39010.4	38.160	-6.11
953	34430.9	38.772	-4.35	1013	36748.9	38.489	-5.10	1073	39048.5	38.154	-6.13
954	34469.6	38.767	-4.36	1014	36787.4	38.484	-5.11	1074	39086.7	38.148	-6.15
955	34508.4	38.763	-4.37	1015	36825.9	38.479	-5.13	1075	39124.8	38.142	-6.17
956	34547.2	38.759	-4.38	1016	36864.4	38.474	-5.14	1076	39163.0	38.136	-6.19
957	34585.9	38.754	-4.39	1017	36902.8	38.469	-5.16	1077	39201.1	38.129	-6.22
958	34624.7	38.750	-4.41	1018	36941.3	38.463	-5.17	1078	39239.2	38.123	-6.24
959	34663.4	38.746	-4.42	1019	36979.8	38.458	-5.19	1079	39277.3	38.117	-6.26
960	34702.2	38.741	-4.43	1020	37018.2	38.453	-5.20	1080	39315.5	38.111	-6.28

TABLE 7.3.5 AWG 14 *Nicrosil versus Nisil thermocouples—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. High temperature range, 0 to 1300 °C* —Continued

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
1080	39315.5	38.111	-6.28	1140	41589.9	37.690	-7.83	1200	43836.1	37.166	-9.61
1081	39353.6	38.104	-6.30	1141	41627.6	37.682	-7.86	1201	43873.3	37.156	-9.63
1082	39391.7	38.098	-6.32	1142	41665.3	37.674	-7.89	1202	43910.4	37.146	-9.66
1083	39429.8	38.092	-6.35	1143	41703.0	37.666	-7.92	1203	43947.6	37.137	-9.69
1084	39467.8	38.085	-6.37	1144	41740.6	37.658	-7.95	1204	43984.7	37.127	-9.71
1085	39505.9	38.079	-6.39	1145	41778.3	37.650	-7.98	1205	44021.8	37.117	-9.74
1086	39544.0	38.073	-6.41	1146	41815.9	37.642	-8.01	1206	44058.9	37.108	-9.76
1087	39582.1	38.066	-6.44	1147	41853.6	37.634	-8.04	1207	44096.0	37.098	-9.79
1088	39620.1	38.060	-6.46	1148	41891.2	37.626	-8.07	1208	44133.1	37.088	-9.82
1089	39658.2	38.053	-6.48	1149	41928.8	37.618	-8.10	1209	44170.2	37.078	-9.84
1090	39696.2	38.047	-6.51	1150	41966.4	37.610	-8.13	1210	44207.3	37.068	-9.86
1091	39734.3	38.040	-6.53	1151	42004.0	37.602	-8.16	1211	44244.4	37.058	-9.89
1092	39772.3	38.034	-6.55	1152	42041.6	37.593	-8.19	1212	44281.4	37.049	-9.91
1093	39810.4	38.027	-6.58	1153	42079.2	37.585	-8.22	1213	44318.5	37.039	-9.94
1094	39848.4	38.021	-6.60	1154	42116.8	37.577	-8.25	1214	44355.5	37.029	-9.96
1095	39886.4	38.014	-6.62	1155	42154.4	37.569	-8.28	1215	44392.5	37.019	-9.98
1096	39924.4	38.007	-6.65	1156	42191.9	37.560	-8.31	1216	44429.5	37.009	-10.01
1097	39962.4	38.001	-6.67	1157	42229.5	37.552	-8.34	1217	44466.5	36.999	-10.03
1098	40000.4	37.994	-6.70	1158	42267.0	37.544	-8.37	1218	44503.5	36.989	-10.05
1099	40038.4	37.987	-6.72	1159	42304.6	37.535	-8.40	1219	44540.5	36.979	-10.07
1100	40076.4	37.981	-6.75	1160	42342.1	37.527	-8.43	1220	44577.5	36.969	-10.09
1101	40114.4	37.974	-6.77	1161	42379.6	37.519	-8.46	1221	44614.4	36.958	-10.11
1102	40152.3	37.967	-6.80	1162	42417.1	37.510	-8.49	1222	44651.4	36.948	-10.13
1103	40190.3	37.960	-6.82	1163	42454.7	37.502	-8.52	1223	44688.3	36.938	-10.16
1104	40228.2	37.953	-6.85	1164	42492.2	37.493	-8.55	1224	44725.3	36.928	-10.17
1105	40266.2	37.947	-6.87	1165	42529.6	37.484	-8.58	1225	44762.2	36.918	-10.19
1106	40304.1	37.940	-6.90	1166	42567.1	37.476	-8.61	1226	44799.1	36.908	-10.21
1107	40342.1	37.933	-6.92	1167	42604.6	37.467	-8.64	1227	44836.0	36.897	-10.23
1108	40380.0	37.926	-6.95	1168	42642.1	37.459	-8.67	1228	44872.9	36.887	-10.25
1109	40417.9	37.919	-6.97	1169	42679.5	37.450	-8.70	1229	44909.8	36.877	-10.27
1110	40455.8	37.912	-7.00	1170	42717.0	37.441	-8.74	1230	44946.7	36.867	-10.28
1111	40493.8	37.905	-7.03	1171	42754.4	37.432	-8.77	1231	44983.5	36.856	-10.30
1112	40531.7	37.898	-7.05	1172	42791.8	37.424	-8.80	1232	45020.4	36.846	-10.32
1113	40569.5	37.891	-7.08	1173	42829.2	37.415	-8.83	1233	45057.2	36.836	-10.33
1114	40607.4	37.884	-7.10	1174	42866.6	37.406	-8.86	1234	45094.0	36.825	-10.35
1115	40645.3	37.877	-7.13	1175	42904.1	37.397	-8.89	1235	45130.9	36.815	-10.36
1116	40683.2	37.869	-7.16	1176	42941.4	37.388	-8.92	1236	45167.7	36.805	-10.38
1117	40721.1	37.862	-7.19	1177	42978.8	37.379	-8.95	1237	45204.5	36.794	-10.39
1118	40758.9	37.855	-7.21	1178	43016.2	37.370	-8.98	1238	45241.3	36.784	-10.40
1119	40796.8	37.848	-7.24	1179	43053.6	37.361	-9.01	1239	45278.0	36.773	-10.41
1120	40834.6	37.841	-7.27	1180	43090.9	37.352	-9.04	1240	45314.8	36.763	-10.43
1121	40872.4	37.833	-7.29	1181	43128.3	37.343	-9.07	1241	45351.6	36.753	-10.44
1122	40910.3	37.826	-7.32	1182	43165.6	37.334	-9.10	1242	45388.3	36.742	-10.45
1123	40948.1	37.819	-7.35	1183	43202.9	37.325	-9.12	1243	45425.1	36.732	-10.46
1124	40985.9	37.811	-7.38	1184	43240.3	37.316	-9.15	1244	45461.8	36.721	-10.47
1125	41023.7	37.804	-7.40	1185	43277.6	37.307	-9.18	1245	45498.5	36.711	-10.48
1126	41061.5	37.796	-7.43	1186	43314.9	37.298	-9.21	1246	45535.2	36.700	-10.48
1127	41099.3	37.789	-7.46	1187	43352.2	37.288	-9.24	1247	45571.9	36.690	-10.49
1128	41137.1	37.781	-7.49	1188	43389.5	37.279	-9.27	1248	45608.6	36.679	-10.50
1129	41174.9	37.774	-7.52	1189	43426.7	37.270	-9.30	1249	45645.3	36.669	-10.50
1130	41212.6	37.766	-7.54	1190	43464.0	37.260	-9.33	1250	45681.9	36.658	-10.51
1131	41250.4	37.759	-7.57	1191	43501.2	37.251	-9.36	1251	45718.6	36.648	-10.51
1132	41288.2	37.751	-7.60	1192	43538.5	37.242	-9.39	1252	45755.2	36.637	-10.52
1133	41325.9	37.744	-7.63	1193	43575.7	37.232	-9.41	1253	45791.8	36.627	-10.52
1134	41363.6	37.736	-7.66	1194	43613.0	37.223	-9.44	1254	45828.5	36.616	-10.52
1135	41401.4	37.728	-7.69	1195	43650.2	37.213	-9.47	1255	45865.1	36.606	-10.52
1136	41439.1	37.721	-7.72	1196	43687.4	37.204	-9.50	1256	45901.7	36.595	-10.52
1137	41476.8	37.713	-7.75	1197	43724.6	37.194	-9.53	1257	45938.3	36.585	-10.52
1138	41514.5	37.705	-7.78	1198	43761.8	37.185	-9.55	1258	45974.8	36.574	-10.52
1139	41552.2	37.697	-7.80	1199	43799.0	37.175	-9.58	1259	46011.4	36.564	-10.52
1140	41589.9	37.690	-7.83	1200	43836.1	37.166	-9.61	1260	46048.0	36.553	-10.52

TABLE 7.3.5 AWG 14 *Nicrosil versus Nisil thermocouples—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. High temperature range, 0 to 1300 °C* —Continued

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
1260	46048.0	36.553		1275	46595.1	36.396		1290	47139.9	36.244	
1261	46084.5	36.543		1276	46631.5	36.386		1291	47176.1	36.234	
1262	46121.1	36.532		1277	46667.9	36.376		1292	47212.3	36.224	
1263	46157.6	36.522		1278	46704.2	36.365		1293	47248.6	36.214	
1264	46194.1	36.511		1279	46740.6	36.355		1294	47284.8	36.204	
1265	46230.6	36.501		1280	46776.9	36.345		1295	47321.0	36.194	
1266	46267.1	36.490		1281	46813.3	36.334		1296	47357.2	36.185	
1267	46303.6	36.480		1282	46849.6	36.324		1297	47393.3	36.175	
1268	46340.1	36.469		1283	46885.9	36.314		1298	47429.5	36.165	
1269	46376.5	36.459		1284	46922.2	36.304		1299	47465.7	36.156	
1270	46413.0	36.448		1285	46958.5	36.294		1300	47501.8	36.146	
1271	46449.4	36.438		1286	46994.8	36.284					
1272	46485.9	36.427		1287	47031.1	36.274					
1273	46522.3	36.417		1288	47067.4	36.264					
1274	46558.7	36.407		1289	47103.6	36.254					
1275	46595.1	36.396		1290	47139.9	36.244					

TABLE 7.3.6 *Thermoelectric values at the fixed points for* AWG 28 *Nicrosil versus Nisil thermocouples in the cryogenic and extended temperature ranges.*

Temperature range	Fixed point	Temp.[a] °C.	*E* μV	*S* μV/°C	*dS/dT* nV/°C²
−270 to 0 °C	Helium NBP	−268.935	−4344.75	0.463	117.47
	Hydrogen TP	−259.340	−4334.67	1.661	131.18
	Hydrogen NBP	−252.870	−4321.13	2.530	136.98
	Neon TP	−248.589	−4309.04	3.122	139.58
	Neon NBP	−246.048	−4300.65	3.478	140.73
	Oxygen TP	−218.789	−4152.98	7.354	140.57
	Nitrogen TP	−210.004	−4082.98	8.577	137.65
	Nitrogen NBP	−195.806	−3947.53	10.490	131.76
	Oxygen NBP	−182.962	−3802.08	12.145	125.88
	Carbon Dioxide SP	−78.476	−1937.74	22.590	70.55
	Mercury FP	−38.836	−993.66	24.871	44.67
	Ice point[b]	0.000	0.00	26.154	21.87
0 to 400 °C	Ether TP	26.87	711.68	26.887	33.98
	Water BP	100.000	2780.58	29.735	38.30
	Benzoic Acid TP	122.37	3455.11	30.562	35.59
	Indium FP	156.634	4522.32	31.708	31.38
	Tin FP	231.968	6993.27	33.818	25.36
	Bismuth FP	271.442	8347.33	34.772	22.90
	Cadmium FP	321.108	10100.92	35.807	18.51
	Lead FP	327.502	10330.25	35.923	17.84
	Mercury BP	356.66	11384.85	36.399	14.89

[a] Values of temperature are from the published text of the IPTS-68 amended edition of 1975 [CIPM, 1976], except for Helium NBP.
[b] Junction point of different functions.

TABLE 7.3.7 *Thermoelectric values at the fixed points for AWG 14 Nicrosil versus Nisil thermocouples in the high temperature range.*

Temperature range	Fixed point	Temp.[a] °C	E μV	S μV/°C	dS/dT nV/°C²
	Ice point	0.000	0.00	25.898	33.31
0 to 1300 °C	Ether TP	26.87	708.42	26.848	36.99
	Water BP	100.000	2773.57	29.634	37.45
	Benzoic Acid TP	122.37	3445.74	30.457	35.99
	Indium FP	156.634	4509.90	31.642	33.10
	Tin FP	231.968	6980.78	33.865	25.93
	Bismuth FP	271.442	8336.85	34.819	22.45
	Cadmium FP	321.108	10092.22	35.837	18.65
	Lead FP	327.502	10321.74	35.955	18.20
	Mercury BP	356.66	11377.57	36.457	16.32
	Zinc FP	419.580	13701.38	37.372	12.88
	Sulphur BP	444.674	14643.12	37.680	11.67
	Cu-Al FP	548.26	18600.66	38.654	7.22
	Antimony FP	630.755	21810.21	39.112	3.92
	Aluminum FP	660.46	22973.60	39.212	2.77
	Silver FP	961.93	34776.92	38.733	−4.45
	Gold FP	1064.43	38721.32	38.206	−5.96
	Copper FP	1084.88	39501.36	38.080	−6.39

[a] Values of temperature are from the published text of the IPTS–68 amended edition of 1975 [CIPM, 1976].

TABLE 7.3.8 *Estimated maximum errors that occur when using reduced-bit arithmetic for the power series expansion for the thermoelectric voltage of* AWG 28 *Nicrosil versus Nisil thermocouples.*

Temperature range	Degree	Estimated maximum error in microvolts				
		12 Bit	16 Bit	24 Bit	27 Bit	36 Bit
−270 to 0 °C	8	1.3	0.1	<0.01	<0.01	<0.01
0 to 200 °C	7	0.9	0.1	<0.01	<0.01	<0.01
200 to 400 °C	7	[a]	1.3	<0.01	<0.01	<0.01

[a] A high order polynomial with a low-bit machine causes extreme error.

TABLE 7.3.9 *Estimated maximum errors that occur when using reduced-bit arithmetic for the power series expansion for the thermoelectric voltage of* AWG 14 *Nicrosil versus Nisil thermocouples.*

Temperature range	Degree	Estimated maximum error in microvolts				
		12 Bit	16 Bit	24 Bit	27 Bit	36 Bit
0 to 200 °C	9	1.5	0.1	<0.01	<0.01	<0.01
200 to 400 °C	9	5.2	0.5	<0.01	<0.01	<0.01
400 to 600 °C	9	[a]	2.3	<0.01	<0.01	<0.01
600 to 800 °C	9	[a]	8.7	0.01	<0.01	<0.01
800 to 1000 °C	9	[a]	[a]	0.05	<0.01	<0.01
1000 to 1200 °C	9	[a]	[a]	0.2	0.01	<0.01
1200 to 1300 °C	9	[a]	[a]	0.3	0.02	<0.01

[a] A high order polynomial with a low-bit machine causes extreme error.

7.4 Reference Functions and Tables for the Positive Thermoelement Nicrosil versus Platinum, Pt-67

As explained earlier, fine and heavy gage Nicrosil wires have slightly different effective overall compositions and therefore have slightly different thermoelectric properties. For that reason the expansion coefficients and the tabular values for the two sizes of wire are not quite identical in the temperature ranges where they overlap. Those differences are reflected in the accompanying tables where the wire gage is specified along with the temperatures and thermoelectric values. At the join, 0 °C, of the cryogenic data (fine wire—*AWG 28*) and the high temperature data (heavy wire—*AWG 14*) the voltages are identical, by definition; and the Seebeck coefficients differ by only 0.12 percent. The values of the coefficients for fine wire (cryogenic) are slightly higher. Actual differences between the voltages for different sizes are discussed in the previous chapter, section 6.7.

The coefficients for the eighth degree expansion for the thermoelectric voltage of *AWG 28* Nicrosil thermoelements versus platinum, Pt–67, between −200 and 0 °C are given in table 7.4.1. The coefficients for the fifth degree expansion for *AWG 28* wire between 0 and 400 °C, an extended range, are also given in table 7.4.1. The equivalent coefficients for the sixth degree expansion for the thermoelectric voltage of *AWG 14* Nicrosil thermoelements versus platinum, Pt–67, between 0 and 1300 °C are given in table 7.4.2. The errors caused by using reduced-bit arithmetic for calculating values of those functions are given in tables 7.4.8 and 7.4.9 for *AWG 28* and *AWG 14* thermoelements, respectively.

The primary reference values for *AWG 28* Nicrosil thermoelements versus platinum, Pt–67, in the temperature range from −200 to 0 °C are given in table 7.4.3. Values for the same gage wire in the extended temperature range from 0 to 400 °C are given in table 7.4.4. Values for the larger, *AWG 14*, wire for temperatures from 0 to 1300 °C are given in table 7.4.5. Near the ends of long calibration ranges, mathematical fitting functions become more variable and subject to error. This is especially true for their higher derivatives. Therefore the second derivatives of the thermal voltages are not tabulated above 1260 °C. Values for the smaller *AWG 28* wire at selected thermometric fixed points are given in table 7.4.6: and for the larger *AWG 14* wire, in table 7.4.7.

Graphs of the thermoelectric voltage, its first derivative (Seebeck coefficient), and second derivative are given in figures 7.4.1, 7.4.2 and 7.4.3 respectively for *AWG 28* wire between −200 and 400 °C; and in figures 7.4.4, 7.4.5, and 7.4.6 for *AWG 14* wire between 0 and 1300 °C.

It should be stressed that b· ause of the small, but significant, size effect ***Nicrosi· 'hermoelement material that conforms closely › the high temperature tabular values may noı conform closely at low temperatures (below 0 °C) and vice versa.*** If Nicrosil thermoelements are to be used for accurate measurements both above and below 0 °C, then the material must be calibrated in the full temperature range, both above and below 0 °C. Special selection of material will often be required.

TABLE 7.4.1 *Power series expansion for the thermoelectric voltage of* AWG 28 *for Nicrosil thermoelements versus platinum,* Pt–67, *in the cryogenic and extended temperature ranges.*

Wire gage	Temperature range	Degree	Coefficients	Term
AWG 28	−200 to 0 °C	8	$+1.5439801101\times10^{1}$	T
			$+2.7740484890\times10^{-2}$	T^2
			$-3.4049445417\times10^{-5}$	T^3
			$+1.1939020268\times10^{-7}$	T^4
			$-4.0789319444\times10^{-10}$	T^5
			$-1.0328196551\times10^{-12}$	T^6
			$-6.3786260843\times10^{-14}$	T^7
			$-1.3906860189\times10^{-16}$	T^8
AWG 28	0 to 400 °C	5	$+1.5439801101\times10^{1}$	T
			$+2.7740484890\times10^{-2}$	T^2
			$-3.7799095566\times10^{-5}$	T^3
			$+3.4845935715\times10^{-8}$	T^4
			$-1.6404244459\times10^{-11}$	T^5

TABLE 7.4.2 *Power series expansion for the thermoelectric voltage of* AWG 14 *Nicrosil thermoelements versus platinum,* Pt–67, *in the high temperature range.*

Wire gage	Temperature range	Degree	Coefficients	Term
AWG 14	0 to 1300 °C	6	$+1.5420916112\times10^{1}$	T
			$+2.7473103889\times10^{-2}$	T^2
			$-3.5459786407\times10^{-5}$	T^3
			$+2.9024574608\times10^{-8}$	T^4
			$-1.2598547166\times10^{-11}$	T^5
			$+2.1794779288\times10^{-15}$	T^6

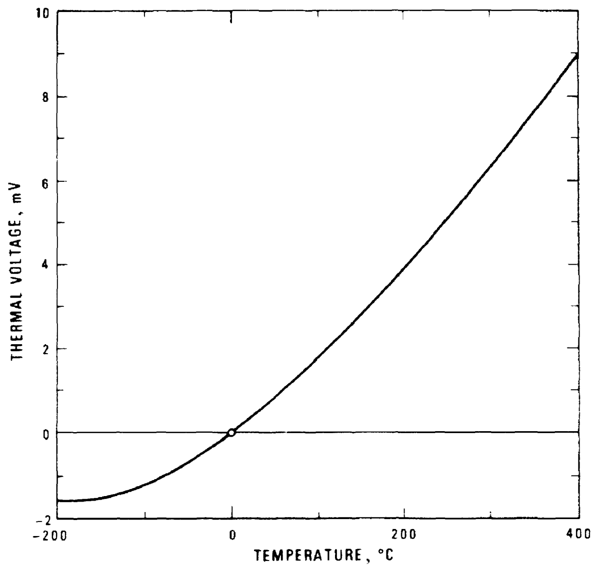

Figure 7.4.1 *Thermoelectric voltage for* AWG 28 *Nicrosil thermoelements versus platinum,* Pt–67.

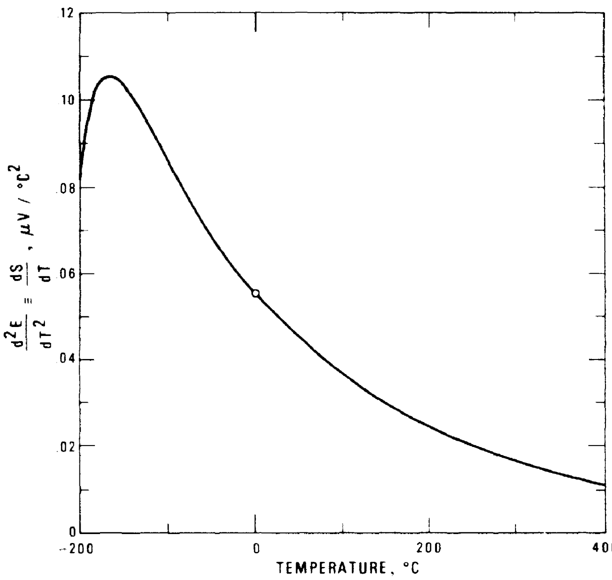

Figure 7.4.2 *Seebeck coefficient for* AWG 28 *Nicrosil thermoelements versus platinum,* Pt–67.

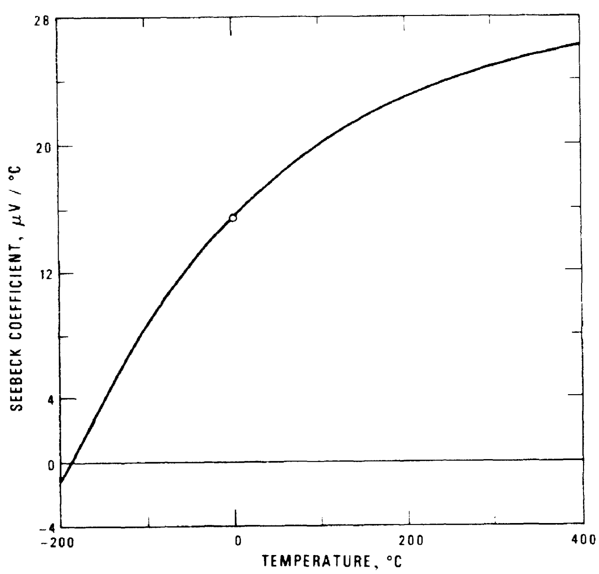

Figure 7.4.3 *Derivative of Seebeck coefficient for* AWG 28 *Nicrosil thermoelements versus platinum,* Pt–67.

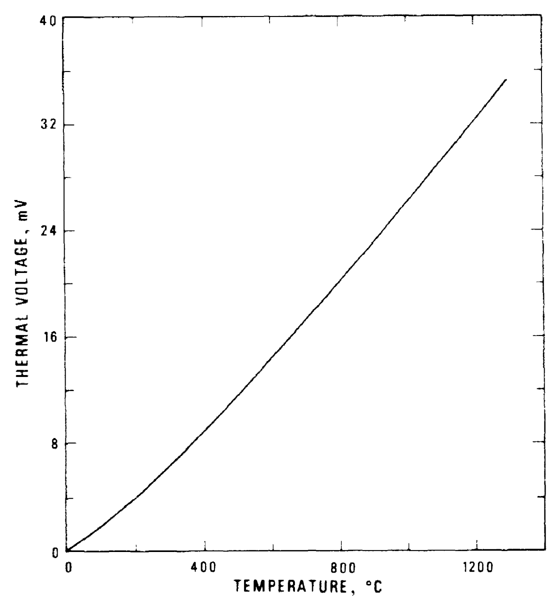

Figure 7.4.4 *Thermoelectric voltage for* AWG 14 *Nicrosil thermoelements versus platinum,* Pt–67.

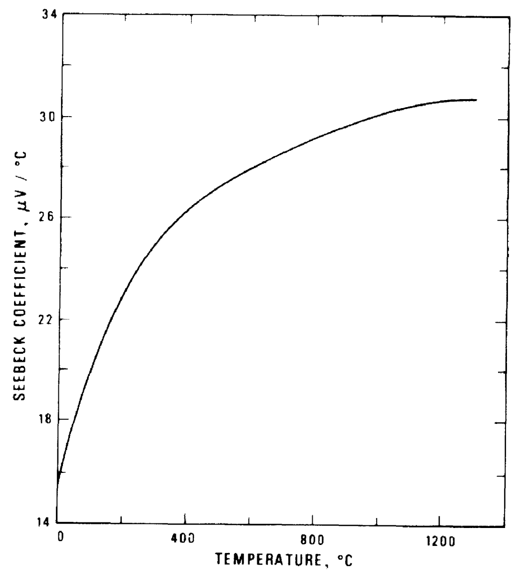

FIGURE 7.4.5 *Seebeck coefficient for* AWG 14 *Nicrosil thermoelements versus platinum,* Pt–67.

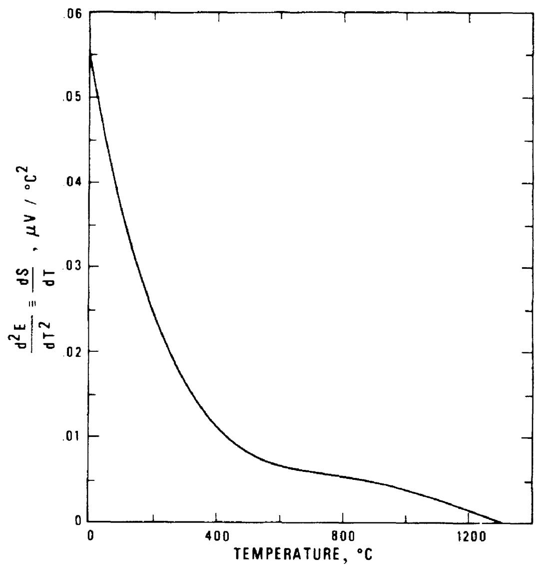

FIGURE 7.4.6 *Derivative of Seebeck coefficient for* AWG 14 *Nicrosil thermoelements versus platinum,* Pt–67.

TABLE 7.4.3 AWG 28 *Nicrosil thermoelements versus platinum*, Pt–67,—*thermoelectric voltages*, E(T), *Seebeck coefficients*, S(T), *and first derivatives of the Seebeck coefficients*, dS/dT, *reference junctions at 0 °C. Cryogenic temperature range, —200 to 0 °C.*

T °C	E µV	S µV/°C	dS/dT nV/°C²	T °C	E µV	S µV/°C	dS/dT nV/°C²	T °C	E µV	S µV/°C	dS/dT nV/°C²
				-200	-1584.95	-1.331	82.02	-190	-1593.92	-0.440	95.14
				-199	-1586.24	-1.249	83.66	-189	-1594.31	-0.344	96.10
				-198	-1587.45	-1.164	85.22	-188	-1594.60	-0.248	96.99
				-197	-1588.57	-1.078	86.71	-187	-1594.80	-0.150	97.83
				-196	-1589.60	-0.991	88.12	-186	-1594.90	-0.052	98.62
				-195	-1590.55	-0.902	89.45	-185	-1594.91	0.047	99.36
				-194	-1591.41	-0.812	90.72	-184	-1594.81	0.147	100.04
				-193	-1592.17	-0.721	91.92	-183	-1594.61	0.247	100.68
				-192	-1592.85	-0.628	93.06	-182	-1594.32	0.348	101.27
				-191	-1593.43	-0.534	94.13	-181	-1593.92	0.450	101.82
-200	-1584.95	-1.331	82.02	-190	-1593.92	-0.440	95.14	-180	-1593.42	0.552	102.32

TABLE 7.4.3 AWG 28 *Nicrosil thermoelements versus platinum,* Pt–67,—*thermoelectric voltages,* E(T), *Seebeck coefficients.* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. Cryogenic temperature range, —200 to 0 °C*—Continued

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
-180	-1593.42	0.552	102.32	-120	-1373.53	6.670	93.88	-60	-817.63	11.644	72.36
-179	-1592.81	0.654	102.79	-119	-1366.82	6.764	93.51	-59	-805.95	11.716	72.03
-178	-1592.11	0.757	103.21	-118	-1360.00	6.857	93.13	-58	-794.20	11.788	71.70
-177	-1591.30	0.861	103.59	-117	-1353.10	6.950	92.76	-57	-782.37	11.860	71.37
-176	-1590.39	0.964	103.94	-116	-1346.10	7.043	92.38	-56	-770.48	11.931	71.04
-175	-1589.37	1.069	104.25	-115	-1339.02	7.135	92.01	-55	-758.51	12.002	70.71
-174	-1588.25	1.173	104.53	-114	-1331.83	7.227	91.63	-54	-746.47	12.072	70.38
-173	-1587.02	1.278	104.77	-113	-1324.56	7.318	91.26	-53	-734.37	12.143	70.05
-172	-1585.69	1.382	104.98	-112	-1317.20	7.409	90.88	-52	-722.19	12.212	69.72
-171	-1584.26	1.488	105.16	-111	-1309.74	7.500	90.51	-51	-709.94	12.282	69.40
-170	-1582.72	1.593	105.31	-110	-1302.20	7.590	90.13	-50	-697.63	12.351	69.08
-169	-1581.07	1.698	105.44	-109	-1294.56	7.680	89.76	-49	-685.24	12.420	68.75
-168	-1579.32	1.804	105.53	-108	-1286.84	7.770	89.38	-48	-672.79	12.489	68.43
-167	-1577.47	1.909	105.60	-107	-1279.02	7.859	89.01	-47	-660.26	12.557	68.11
-166	-1575.50	2.015	105.65	-106	-1271.12	7.948	88.64	-46	-647.67	12.625	67.79
-165	-1573.44	2.120	105.67	-105	-1263.13	8.036	88.26	-45	-635.01	12.693	67.48
-164	-1571.26	2.226	105.67	-104	-1255.05	8.125	87.89	-44	-622.29	12.760	67.16
-163	-1568.98	2.332	105.65	-103	-1246.88	8.212	87.52	-43	-609.49	12.827	66.85
-162	-1566.60	2.437	105.60	-102	-1238.62	8.300	87.15	-42	-596.63	12.894	66.54
-161	-1564.11	2.543	105.54	-101	-1230.28	8.387	86.78	-41	-583.71	12.960	66.23
-160	-1561.51	2.648	105.46	-100	-1221.85	8.473	86.41	-40	-570.71	13.026	65.92
-159	-1558.81	2.754	105.36	-99	-1213.33	8.559	86.05	-39	-557.65	13.092	65.61
-158	-1556.01	2.859	105.24	-98	-1204.73	8.645	85.68	-38	-544.53	13.157	65.30
-157	-1553.09	2.964	105.10	-97	-1196.04	8.731	85.31	-37	-531.34	13.222	65.00
-156	-1550.08	3.069	104.95	-96	-1187.27	8.816	84.95	-36	-518.09	13.287	64.70
-155	-1546.96	3.174	104.79	-95	-1178.41	8.901	84.58	-35	-504.77	13.352	64.40
-154	-1543.73	3.279	104.61	-94	-1169.47	8.985	84.22	-34	-491.38	13.416	64.10
-153	-1540.40	3.383	104.42	-93	-1160.44	9.069	83.85	-33	-477.93	13.480	63.80
-152	-1536.96	3.488	104.21	-92	-1151.33	9.153	83.49	-32	-464.42	13.544	63.51
-151	-1533.42	3.592	103.99	-91	-1142.13	9.236	83.13	-31	-450.85	13.607	63.22
-150	-1529.78	3.696	103.76	-90	-1132.86	9.319	82.77	-30	-437.21	13.670	62.93
-149	-1526.03	3.799	103.52	-89	-1123.50	9.402	82.41	-29	-423.51	13.733	62.64
-148	-1522.18	3.903	103.27	-88	-1114.05	9.484	82.05	-28	-409.74	13.795	62.36
-147	-1518.23	4.006	103.01	-87	-1104.53	9.566	81.70	-27	-395.92	13.858	62.07
-146	-1514.17	4.109	102.74	-86	-1094.92	9.647	81.34	-26	-382.03	13.920	61.79
-145	-1510.01	4.211	102.47	-85	-1085.23	9.728	80.98	-25	-368.08	13.981	61.51
-144	-1505.74	4.314	102.18	-84	-1075.47	9.809	80.63	-24	-354.06	14.043	61.24
-143	-1501.38	4.416	101.89	-83	-1065.62	9.890	80.27	-23	-339.99	14.104	60.97
-142	-1496.91	4.518	101.59	-82	-1055.69	9.970	79.92	-22	-325.86	14.164	60.70
-141	-1492.34	4.619	101.28	-81	-1045.68	10.049	79.57	-21	-311.66	14.225	60.43
-140	-1487.68	4.720	100.96	-80	-1035.59	10.129	79.22	-20	-297.41	14.285	60.16
-139	-1482.90	4.821	100.64	-79	-1025.42	10.208	78.87	-19	-283.09	14.345	59.90
-138	-1478.03	4.921	100.32	-78	-1015.17	10.287	78.52	-18	-268.72	14.405	59.64
-137	-1473.06	5.022	99.99	-77	-1004.85	10.365	78.17	-17	-254.28	14.465	59.39
-136	-1467.99	5.121	99.65	-76	-994.44	10.443	77.82	-16	-239.79	14.524	59.13
-135	-1462.82	5.221	99.31	-75	-983.96	10.521	77.47	-15	-225.23	14.583	58.88
-134	-1457.55	5.320	98.97	-74	-973.40	10.598	77.12	-14	-210.62	14.642	58.63
-133	-1452.18	5.419	98.62	-73	-962.77	10.675	76.78	-13	-195.95	14.700	58.39
-132	-1446.71	5.517	98.27	-72	-952.05	10.751	76.43	-12	-181.22	14.758	58.15
-131	-1441.15	5.615	97.92	-71	-941.26	10.828	76.09	-11	-166.43	14.816	57.91
-130	-1435.48	5.713	97.56	-70	-930.40	10.904	75.75	-10	-151.59	14.874	57.67
-129	-1429.72	5.810	97.20	-69	-919.46	10.979	75.40	-9	-136.69	14.932	57.44
-128	-1423.86	5.907	96.84	-68	-908.44	11.054	75.06	-8	-121.73	14.989	57.21
-127	-1417.90	6.004	96.47	-67	-897.35	11.129	74.72	-7	-106.71	15.046	56.98
-126	-1411.85	6.100	96.11	-66	-886.18	11.204	74.38	-6	-91.63	15.103	56.76
-125	-1405.70	6.196	95.74	-65	-874.94	11.278	74.04	-5	-76.50	15.160	56.54
-124	-1399.46	6.292	95.37	-64	-863.62	11.352	73.71	-4	-61.31	15.216	56.32
-123	-1393.12	6.387	95.00	-63	-852.23	11.425	73.37	-3	-46.07	15.272	56.11
-122	-1386.69	6.482	94.63	-62	-840.77	11.499	73.03	-2	-30.77	15.328	55.90
-121	-1380.16	6.576	94.26	-61	-829.24	11.572	72.70	-1	-15.41	15.384	55.69
-120	-1373.53	6.670	93.88	-60	-817.63	11.644	72.36	0	0.00	15.440	55.48

TABLE 7.4.4 AWG 28 *Nicrosil thermoelements versus platinum,* Pt–67—*thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. Extended temperature range, 0 to 400 °C.*

T °C	E µV	S µV/°C	dS/dT nV/°C²	T °C	E µV	S µV/°C	dS/dT nV/°C²	T °C	E µV	S µV/°C	dS/dT nV/°C²
0	0.00	15.440	55.48	60	1018.53	18.389	43.31	120	2193.74	20.688	33.72
1	15.47	15.495	55.25	61	1036.94	18.433	43.13	121	2214.45	20.722	33.58
2	30.99	15.550	55.03	62	1055.39	18.476	42.95	122	2235.18	20.756	33.44
3	46.57	15.605	54.80	63	1073.89	18.519	42.77	123	2255.96	20.789	33.30
4	62.20	15.660	54.58	64	1092.43	18.561	42.59	124	2276.76	20.822	33.16
5	77.89	15.714	54.36	65	1111.01	18.604	42.42	125	2297.60	20.855	33.02
6	93.63	15.769	54.14	66	1129.64	18.646	42.24	126	2318.47	20.888	32.89
7	109.43	15.823	53.91	67	1148.31	18.688	42.06	127	2339.38	20.921	32.75
8	125.27	15.876	53.69	68	1167.01	18.730	41.89	128	2360.31	20.954	32.61
9	141.18	15.930	53.47	69	1185.77	18.772	41.72	129	2381.28	20.986	32.48
10	157.13	15.983	53.25	70	1204.56	18.814	41.54	130	2402.29	21.019	32.34
11	173.14	16.037	53.04	71	1223.39	18.855	41.37	131	2423.32	21.051	32.21
12	189.21	16.089	52.82	72	1242.27	18.896	41.20	132	2444.39	21.083	32.08
13	205.32	16.142	52.60	73	1261.19	18.938	41.03	133	2465.49	21.115	31.94
14	221.49	16.195	52.39	74	1280.14	18.978	40.86	134	2486.62	21.147	31.81
15	237.71	16.247	52.17	75	1299.14	19.019	40.69	135	2507.78	21.179	31.68
16	253.99	16.299	51.96	76	1318.18	19.060	40.52	136	2528.98	21.210	31.55
17	270.31	16.351	51.74	77	1337.26	19.100	40.35	137	2550.20	21.242	31.41
18	286.69	16.403	51.53	78	1356.38	19.141	40.18	138	2571.46	21.273	31.28
19	303.12	16.454	51.32	79	1375.54	19.181	40.01	139	2592.75	21.304	31.15
20	319.60	16.505	51.11	80	1394.74	19.221	39.85	140	2614.07	21.336	31.03
21	336.13	16.556	50.90	81	1413.98	19.260	39.68	141	2635.42	21.366	30.90
22	352.71	16.607	50.69	82	1433.26	19.300	39.51	142	2656.80	21.397	30.77
23	369.34	16.658	50.48	83	1452.58	19.339	39.35	143	2678.21	21.428	30.64
24	386.02	16.708	50.27	84	1471.94	19.379	39.19	144	2699.66	21.459	30.51
25	402.76	16.758	50.07	85	1491.34	19.418	39.02	145	2721.13	21.489	30.39
26	419.54	16.808	49.86	86	1510.78	19.457	38.86	146	2742.64	21.519	30.26
27	436.37	16.858	49.66	87	1530.25	19.495	38.70	147	2764.17	21.550	30.14
28	453.25	16.907	49.45	88	1549.77	19.534	38.54	148	2785.74	21.580	30.01
29	470.19	16.957	49.25	89	1569.32	19.573	38.38	149	2807.33	21.610	29.89
30	487.17	17.006	49.04	90	1588.91	19.611	38.22	150	2828.95	21.639	29.76
31	504.20	17.055	48.84	91	1608.54	19.649	38.06	151	2850.61	21.669	29.64
32	521.28	17.104	48.64	92	1628.21	19.687	37.90	152	2872.29	21.699	29.52
33	538.41	17.152	48.44	93	1647.92	19.725	37.74	153	2894.01	21.728	29.39
34	555.58	17.200	48.24	94	1667.66	19.762	37.58	154	2915.75	21.757	29.27
35	572.81	17.249	48.04	95	1687.44	19.800	37.43	155	2937.52	21.787	29.15
36	590.08	17.297	47.84	96	1707.26	19.837	37.27	156	2959.32	21.816	29.03
37	607.40	17.344	47.65	97	1727.12	19.874	37.12	157	2981.15	21.845	28.91
38	624.77	17.392	47.45	98	1747.01	19.911	36.96	158	3003.01	21.874	28.79
39	642.18	17.439	47.25	99	1766.94	19.948	36.81	159	3024.90	21.902	28.67
40	659.65	17.486	47.06	100	1786.91	19.985	36.65	160	3046.82	21.931	28.55
41	677.16	17.533	46.86	101	1806.91	20.022	36.50	161	3068.76	21.959	28.44
42	694.71	17.580	46.67	102	1826.95	20.058	36.35	162	3090.73	21.988	28.32
43	712.32	17.627	46.48	103	1847.03	20.094	36.20	163	3112.74	22.016	28.20
44	729.96	17.673	46.28	104	1867.14	20.131	36.05	164	3134.77	22.044	28.09
45	747.66	17.719	46.09	105	1887.29	20.166	35.90	165	3156.83	22.072	27.97
46	765.40	17.765	45.90	106	1907.47	20.202	35.75	166	3178.91	22.100	27.85
47	783.19	17.811	45.71	107	1927.69	20.238	35.60	167	3201.03	22.128	27.74
48	801.03	17.857	45.52	108	1947.95	20.274	35.45	168	3223.17	22.156	27.63
49	818.90	17.902	45.33	109	1968.24	20.309	35.30	169	3245.34	22.183	27.51
50	836.83	17.947	45.15	110	1988.56	20.344	35.16	170	3267.53	22.211	27.40
51	854.80	17.992	44.96	111	2008.93	20.379	35.01	171	3289.76	22.238	27.29
52	872.81	18.037	44.77	112	2029.32	20.414	34.86	172	3312.01	22.265	27.17
53	890.87	18.082	44.59	113	2049.75	20.449	34.72	173	3334.29	22.292	27.06
54	908.98	18.126	44.40	114	2070.22	20.484	34.57	174	3356.59	22.319	26.95
55	927.13	18.171	44.22	115	2090.72	20.518	34.43	175	3378.93	22.346	26.84
56	945.32	18.215	44.03	116	2111.26	20.552	34.29	176	3401.29	22.373	26.73
57	963.56	18.259	43.85	117	2131.83	20.587	34.14	177	3423.67	22.400	26.62
58	981.84	18.302	43.67	118	2152.43	20.621	34.00	178	3446.09	22.426	26.51
59	1000.16	18.346	43.49	119	2173.07	20.655	33.86	179	3468.53	22.453	26.40
60	1018.53	18.389	43.31	120	2193.74	20.688	33.72	180	3490.99	22.479	26.29

Table 7.4.4 AWG 28 *Nicrosil thermoelements versus platinum,* Pt-67—*thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. Extended temperature range, 0 to 400 °C*—Continued

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
180	3490.99	22.479	26.29	240	4883.42	23.878	20.60	300	6350.40	24.977	16.22
181	3513.48	22.505	26.18	241	4907.31	23.899	20.52	301	6375.38	24.994	16.15
182	3536.00	22.531	26.08	242	4931.22	23.919	20.44	302	6400.39	25.010	16.09
183	3558.55	22.557	25.97	243	4955.14	23.940	20.35	303	6425.40	25.026	16.03
184	3581.12	22.583	25.86	244	4979.09	23.960	20.27	304	6450.44	25.042	15.96
185	3603.71	22.609	25.76	245	5003.06	23.980	20.19	305	6475.49	25.058	15.90
186	3626.34	22.635	25.65	246	5027.06	24.000	20.11	306	6500.55	25.073	15.84
187	3648.98	22.661	25.55	247	5051.07	24.020	20.03	307	6525.63	25.089	15.77
188	3671.66	22.686	25.44	248	5075.10	24.040	19.95	308	6550.73	25.105	15.71
189	3694.36	22.711	25.34	249	5099.15	24.060	19.87	309	6575.84	25.121	15.65
190	3717.08	22.737	25.23	250	5123.22	24.080	19.79	310	6600.97	25.136	15.59
191	3739.83	22.762	25.13	251	5147.31	24.100	19.71	311	6626.12	25.152	15.52
192	3762.60	22.787	25.03	252	5171.42	24.120	19.63	312	6651.28	25.167	15.46
193	3785.40	22.812	24.93	253	5195.55	24.139	19.55	313	6676.45	25.183	15.40
194	3808.23	22.837	24.82	254	5219.70	24.159	19.48	314	6701.64	25.198	15.34
195	3831.08	22.862	24.72	255	5243.86	24.178	19.40	315	6726.85	25.213	15.28
196	3853.95	22.886	24.62	256	5268.05	24.198	19.32	316	6752.07	25.229	15.22
197	3876.85	22.911	24.52	257	5292.26	24.217	19.24	317	6777.30	25.244	15.16
198	3899.77	22.935	24.42	258	5316.48	24.236	19.17	318	6802.56	25.259	15.10
199	3922.72	22.960	24.32	259	5340.73	24.255	19.09	319	6827.82	25.274	15.03
200	3945.69	22.984	24.22	260	5365.00	24.274	19.01	320	6853.10	25.289	14.97
201	3968.69	23.008	24.12	261	5389.28	24.293	18.94	321	6878.40	25.304	14.91
202	3991.71	23.032	24.03	262	5413.58	24.312	18.86	322	6903.71	25.319	14.86
203	4014.75	23.056	23.93	263	5437.90	24.331	18.79	323	6929.04	25.334	14.80
204	4037.82	23.080	23.83	264	5462.24	24.350	18.71	324	6954.38	25.349	14.74
205	4060.91	23.104	23.73	265	5486.60	24.368	18.64	325	6979.74	25.363	14.68
206	4084.03	23.128	23.64	266	5510.98	24.387	18.57	326	7005.11	25.378	14.62
207	4107.17	23.151	23.54	267	5535.38	24.405	18.49	327	7030.49	25.392	14.56
208	4130.32	23.175	23.45	268	5559.79	24.424	18.42	328	7055.89	25.407	14.50
209	4153.52	23.198	23.35	269	5584.22	24.442	18.34	329	7081.31	25.421	14.44
210	4176.73	23.221	23.26	270	5608.68	24.461	18.27	330	7106.73	25.436	14.39
211	4199.96	23.245	23.16	271	5633.15	24.479	18.20	331	7132.18	25.450	14.33
212	4223.21	23.268	23.07	272	5657.63	24.497	18.13	332	7157.63	25.465	14.27
213	4246.49	23.291	22.97	273	5682.14	24.515	18.06	333	7183.11	25.479	14.21
214	4269.80	23.314	22.88	274	5706.66	24.533	17.98	334	7208.59	25.493	14.15
215	4293.12	23.336	22.79	275	5731.21	24.551	17.91	335	7234.09	25.507	14.10
216	4316.47	23.359	22.70	276	5755.77	24.569	17.84	336	7259.61	25.521	14.04
217	4339.84	23.382	22.60	277	5780.34	24.587	17.77	337	7285.13	25.535	13.98
218	4363.23	23.404	22.51	278	5804.94	24.604	17.70	338	7310.68	25.549	13.93
219	4386.65	23.427	22.42	279	5829.55	24.622	17.63	339	7336.23	25.563	13.87
220	4410.09	23.449	22.33	280	5854.18	24.640	17.56	340	7361.80	25.577	13.81
221	4433.55	23.471	22.24	281	5878.83	24.657	17.49	341	7387.39	25.591	13.76
222	4457.03	23.494	22.15	282	5903.50	24.675	17.42	342	7412.98	25.604	13.70
223	4480.53	23.516	22.06	283	5928.18	24.692	17.35	343	7438.59	25.618	13.65
224	4504.06	23.538	21.97	284	5952.88	24.709	17.28	344	7464.22	25.632	13.59
225	4527.61	23.560	21.88	285	5977.60	24.727	17.21	345	7489.86	25.645	13.53
226	4551.18	23.582	21.80	286	6002.33	24.744	17.15	346	7515.51	25.659	13.48
227	4574.77	23.603	21.71	287	6027.09	24.761	17.08	347	7541.18	25.672	13.42
228	4598.39	23.625	21.62	288	6051.86	24.778	17.01	348	7566.85	25.686	13.37
229	4622.02	23.647	21.53	289	6076.64	24.795	16.94	349	7592.55	25.699	13.31
230	4645.68	23.668	21.45	290	6101.45	24.812	16.88	350	7618.25	25.712	13.26
231	4669.36	23.689	21.36	291	6126.27	24.829	16.81	351	7643.97	25.725	13.21
232	4693.06	23.711	21.27	292	6151.10	24.845	16.74	352	7669.70	25.739	13.15
233	4716.78	23.732	21.19	293	6175.96	24.862	16.68	353	7695.45	25.752	13.10
234	4740.52	23.753	21.10	294	6200.83	24.879	16.61	354	7721.21	25.765	13.04
235	4764.29	23.774	21.02	295	6225.72	24.895	16.54	355	7746.98	25.778	12.99
236	4788.07	23.795	20.93	296	6250.62	24.912	16.48	356	7772.76	25.791	12.93
237	4811.88	23.816	20.85	297	6275.54	24.928	16.41	357	7798.56	25.804	12.88
238	4835.70	23.837	20.77	298	6300.48	24.945	16.35	358	7824.37	25.817	12.83
239	4859.55	23.858	20.68	299	6325.43	24.961	16.28	359	7850.19	25.829	12.77
240	4883.42	23.878	20.60	300	6350.40	24.977	16.22	360	7876.03	25.842	12.72

TABLE 7.4.4 AWG 28 *Nicrosil thermoelements versus platinum,* Pt–67—*thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. Extended temperature range, 0 to 400 °C*—Continued

T °C	E µV	S µV/°C	dS/dT nV/°C²	T °C	E µV	S µV/°C	dS/dT nV/°C²	T °C	E µV	S µV/°C	dS/dT nV/°C²
360	7876.03	25.842	12.72	375	8265.06	26.027	11.93	390	8656.78	26.200	11.17
361	7901.88	25.855	12.67	376	8291.09	26.039	11.88	391	8682.99	26.211	11.12
362	7927.74	25.867	12.61	377	8317.14	26.051	11.83	392	8709.20	26.222	11.07
363	7953.61	25.880	12.56	378	8343.20	26.063	11.78	393	8735.43	26.234	11.02
364	7979.50	25.893	12.51	379	8369.26	26.074	11.73	394	8761.67	26.245	10.97
365	8005.40	25.905	12.46	380	8395.34	26.086	11.68	395	8787.92	26.255	10.92
366	8031.31	25.917	12.40	381	8421.44	26.098	11.63	396	8814.18	26.266	10.87
367	8057.23	25.930	12.35	382	8447.54	26.109	11.58	397	8840.45	26.277	10.82
368	8083.17	25.942	12.30	383	8473.65	26.121	11.52	398	8866.73	26.288	10.77
369	8109.12	25.954	12.25	384	8499.78	26.132	11.47	399	8893.03	26.299	10.72
370	8135.08	25.967	12.19	385	8525.92	26.144	11.42	400	8919.33	26.309	10.67
371	8161.05	25.979	12.14	386	8552.07	26.155	11.37				
372	8187.03	25.991	12.09	387	8578.23	26.167	11.32				
373	8213.03	26.003	12.04	388	8604.40	26.178	11.27				
374	8239.04	26.015	11.99	389	8630.59	26.189	11.22				
375	8265.06	26.027	11.93	390	8656.78	26.200	11.17				

TABLE 7.4.5 AWG 14 *Nicrosil thermoelements versus platinum,* Pt–67—*thermoelectric voltages,* E(T), *Seebeck coefficients.* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. High temperature range, 0 to 1300 °C.*

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
0	0.0	15.421	54.95	60	1016.9	18.359	43.38	120	2190.6	20.670	34.01
1	15.4	15.476	54.73	61	1035.2	18.402	43.21	121	2211.2	20.704	33.87
2	31.0	15.530	54.52	62	1053.7	18.445	43.03	122	2232.0	20.738	33.73
3	46.5	15.585	54.31	63	1072.1	18.488	42.86	123	2252.7	20.772	33.59
4	62.1	15.639	54.10	64	1090.6	18.531	42.69	124	2273.5	20.805	33.45
5	77.8	15.693	53.89	65	1109.2	18.574	42.52	125	2294.3	20.839	33.32
6	93.5	15.747	53.68	66	1127.8	18.616	42.35	126	2315.2	20.872	33.18
7	109.3	15.800	53.47	67	1146.4	18.658	42.18	127	2336.1	20.905	33.04
8	125.1	15.854	53.27	68	1165.1	18.701	42.01	128	2357.0	20.938	32.91
9	141.0	15.907	53.06	69	1183.8	18.742	41.84	129	2378.0	20.971	32.77
10	156.9	15.960	52.85	70	1202.6	18.784	41.67	130	2398.9	21.004	32.64
11	172.9	16.013	52.65	71	1221.4	18.826	41.51	131	2420.0	21.036	32.50
12	188.9	16.065	52.44	72	1240.2	18.867	41.34	132	2441.0	21.069	32.37
13	205.0	16.117	52.24	73	1259.1	18.908	41.17	133	2462.1	21.101	32.24
14	221.2	16.170	52.04	74	1278.1	18.950	41.01	134	2483.2	21.133	32.11
15	237.4	16.222	51.83	75	1297.0	18.991	40.84	135	2504.4	21.165	31.97
16	253.6	16.273	51.63	76	1316.0	19.031	40.68	136	2525.5	21.197	31.84
17	269.9	16.325	51.43	77	1335.1	19.072	40.52	137	2546.8	21.229	31.71
18	286.3	16.376	51.23	78	1354.2	19.112	40.35	138	2568.0	21.261	31.58
19	302.7	16.427	51.03	79	1373.3	19.153	40.19	139	2589.3	21.292	31.45
20	319.1	16.478	50.83	80	1392.5	19.193	40.03	140	2610.6	21.323	31.32
21	335.6	16.529	50.63	81	1411.7	19.233	39.87	141	2631.9	21.355	31.19
22	352.2	16.579	50.43	82	1431.0	19.272	39.71	142	2653.3	21.386	31.06
23	368.8	16.630	50.23	83	1450.3	19.312	39.55	143	2674.7	21.417	30.93
24	385.4	16.680	50.04	84	1469.6	19.352	39.39	144	2696.1	21.448	30.81
25	402.2	16.730	49.84	85	1489.0	19.391	39.23	145	2717.6	21.478	30.68
26	418.9	16.780	49.65	86	1508.4	19.430	39.07	146	2739.1	21.509	30.55
27	435.7	16.829	49.45	87	1527.8	19.469	38.91	147	2760.6	21.540	30.43
28	452.6	16.879	49.26	88	1547.3	19.508	38.75	148	2782.2	21.570	30.30
29	469.5	16.928	49.06	89	1566.8	19.546	38.60	149	2803.8	21.600	30.18
30	486.4	16.977	48.87	90	1586.4	19.585	38.44	150	2825.4	21.630	30.05
31	503.4	17.025	48.68	91	1606.0	19.623	38.28	151	2847.0	21.660	29.93
32	520.5	17.074	48.49	92	1625.6	19.662	38.13	152	2868.7	21.690	29.80
33	537.6	17.122	48.30	93	1645.3	19.700	37.97	153	2890.4	21.720	29.68
34	554.7	17.171	48.11	94	1665.0	19.737	37.82	154	2912.1	21.749	29.56
35	571.9	17.219	47.92	95	1684.8	19.775	37.67	155	2933.9	21.779	29.44
36	589.2	17.266	47.73	96	1704.6	19.813	37.51	156	2955.7	21.808	29.31
37	606.4	17.314	47.54	97	1724.4	19.850	37.36	157	2977.5	21.838	29.19
38	623.8	17.362	47.35	98	1744.3	19.888	37.21	158	2999.4	21.867	29.07
39	641.2	17.409	47.16	99	1764.2	19.925	37.06	159	3021.2	21.896	28.95
40	658.6	17.456	46.98	100	1784.1	19.962	36.91	160	3043.2	21.925	28.83
41	676.1	17.503	46.79	101	1804.1	19.999	36.76	161	3065.1	21.953	28.71
42	693.6	17.549	46.61	102	1824.1	20.035	36.61	162	3087.1	21.982	28.59
43	711.2	17.596	46.42	103	1844.2	20.072	36.46	163	3109.1	22.011	28.48
44	728.8	17.642	46.24	104	1864.3	20.108	36.31	164	3131.1	22.039	28.36
45	746.5	17.688	46.05	105	1884.4	20.144	36.16	165	3153.1	22.067	28.24
46	764.2	17.734	45.87	106	1904.6	20.180	36.02	166	3175.2	22.095	28.12
47	781.9	17.780	45.69	107	1924.8	20.216	35.87	167	3197.3	22.124	28.01
48	799.7	17.826	45.51	108	1945.0	20.252	35.72	168	3219.5	22.151	27.89
49	817.6	17.871	45.33	109	1965.3	20.288	35.58	169	3241.6	22.179	27.77
50	835.5	17.916	45.15	110	1985.6	20.323	35.43	170	3263.8	22.207	27.66
51	853.4	17.961	44.97	111	2005.9	20.359	35.29	171	3286.0	22.235	27.54
52	871.4	18.006	44.79	112	2026.3	20.394	35.14	172	3308.3	22.262	27.43
53	889.4	18.051	44.61	113	2046.7	20.429	35.00	173	3330.6	22.290	27.32
54	907.5	18.096	44.43	114	2067.2	20.464	34.86	174	3352.9	22.317	27.20
55	925.6	18.140	44.26	115	2087.6	20.499	34.71	175	3375.2	22.344	27.09
56	943.8	18.184	44.08	116	2108.2	20.533	34.57	176	3397.6	22.371	26.98
57	962.0	18.228	43.90	117	2128.7	20.568	34.43	177	3419.9	22.398	26.87
58	980.2	18.272	43.73	118	2149.3	20.602	34.29	178	3442.4	22.425	26.76
59	998.5	18.316	43.55	119	2169.9	20.636	34.15	179	3464.8	22.451	26.64
60	1016.9	18.359	43.38	120	2190.6	20.670	34.01	180	3487.3	22.478	26.53

Table 7.4.5 AWG 14 *Nicrosil thermoelements versus platinum,* Pt–67—*thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. High temperature range, 0 to 1300 °C*—Continued

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
180	3487.3	22.478	26.53	240	4880.0	23.887	20.68	300	6347.5	24.987	16.19
181	3509.7	22.504	26.42	241	4903.9	23.908	20.59	301	6372.5	25.003	16.13
182	3532.3	22.531	26.31	242	4927.8	23.928	20.51	302	6397.5	25.019	16.06
183	3554.8	22.557	26.20	243	4951.7	23.949	20.42	303	6422.5	25.035	16.00
184	3577.4	22.583	26.10	244	4975.7	23.969	20.34	304	6447.6	25.051	15.94
185	3600.0	22.609	25.99	245	4999.6	23.989	20.26	305	6472.6	25.067	15.87
186	3622.6	22.635	25.88	246	5023.6	24.009	20.17	306	6497.7	25.083	15.81
187	3645.2	22.661	25.77	247	5047.7	24.030	20.09	307	6522.8	25.099	15.75
188	3667.9	22.687	25.67	248	5071.7	24.050	20.01	308	6547.9	25.114	15.68
189	3690.6	22.712	25.56	249	5095.8	24.070	19.93	309	6573.0	25.130	15.62
190	3713.3	22.738	25.45	250	5119.8	24.089	19.84	310	6598.2	25.146	15.56
191	3736.1	22.763	25.35	251	5143.9	24.109	19.76	311	6623.3	25.161	15.50
192	3758.9	22.789	25.24	252	5168.1	24.129	19.68	312	6648.5	25.177	15.44
193	3781.7	22.814	25.14	253	5192.2	24.149	19.60	313	6673.7	25.192	15.38
194	3804.5	22.839	25.03	254	5216.4	24.168	19.52	314	6698.9	25.207	15.32
195	3827.3	22.864	24.93	255	5240.5	24.188	19.44	315	6724.1	25.223	15.25
196	3850.2	22.889	24.82	256	5264.7	24.207	19.36	316	6749.3	25.238	15.19
197	3873.1	22.913	24.72	257	5289.0	24.226	19.28	317	6774.6	25.253	15.14
198	3896.1	22.938	24.62	258	5313.2	24.246	19.20	318	6799.8	25.268	15.08
199	3919.0	22.963	24.52	259	5337.4	24.265	19.12	319	6825.1	25.283	15.02
200	3942.0	22.987	24.42	260	5361.7	24.284	19.04	320	6850.4	25.298	14.96
201	3965.0	23.012	24.31	261	5386.0	24.303	18.97	321	6875.7	25.313	14.90
202	3988.0	23.036	24.21	262	5410.3	24.322	18.89	322	6901.0	25.328	14.84
203	4011.0	23.060	24.11	263	5434.7	24.341	18.81	323	6926.4	25.343	14.78
204	4034.1	23.084	24.01	264	5459.0	24.359	18.73	324	6951.7	25.357	14.73
205	4057.2	23.108	23.91	265	5483.4	24.378	18.66	325	6977.1	25.372	14.67
206	4080.3	23.132	23.81	266	5507.8	24.397	18.58	326	7002.5	25.387	14.61
207	4103.5	23.156	23.71	267	5532.2	24.415	18.51	327	7027.9	25.401	14.55
208	4126.6	23.179	23.62	268	5556.6	24.434	18.43	328	7053.3	25.416	14.50
209	4149.8	23.203	23.52	269	5581.0	24.452	18.35	329	7078.7	25.430	14.44
210	4173.1	23.226	23.42	270	5605.5	24.470	18.28	330	7104.1	25.445	14.39
211	4196.3	23.250	23.32	271	5630.0	24.489	18.21	331	7129.6	25.459	14.33
212	4219.6	23.273	23.23	272	5654.5	24.507	18.13	332	7155.0	25.473	14.27
213	4242.8	23.296	23.13	273	5679.0	24.525	18.06	333	7180.5	25.488	14.22
214	4266.1	23.319	23.03	274	5703.5	24.543	17.98	334	7206.0	25.502	14.16
215	4289.5	23.342	22.94	275	5728.1	24.561	17.91	335	7231.5	25.516	14.11
216	4312.8	23.365	22.84	276	5752.6	24.579	17.84	336	7257.0	25.530	14.06
217	4336.2	23.388	22.75	277	5777.2	24.597	17.77	337	7282.6	25.544	14.00
218	4359.6	23.411	22.65	278	5801.8	24.614	17.69	338	7308.1	25.558	13.95
219	4383.0	23.433	22.56	279	5826.5	24.632	17.62	339	7333.7	25.572	13.89
220	4406.5	23.456	22.47	280	5851.1	24.650	17.55	340	7359.3	25.586	13.84
221	4429.9	23.478	22.37	281	5875.8	24.667	17.48	341	7384.9	25.600	13.79
222	4453.4	23.500	22.28	282	5900.4	24.685	17.41	342	7410.5	25.613	13.74
223	4476.9	23.523	22.19	283	5925.1	24.702	17.34	343	7436.1	25.627	13.68
224	4500.5	23.545	22.10	284	5949.8	24.719	17.27	344	7461.7	25.641	13.63
225	4524.0	23.567	22.01	285	5974.6	24.736	17.20	345	7487.4	25.654	13.58
226	4547.6	23.589	21.91	286	5999.3	24.754	17.13	346	7513.0	25.668	13.53
227	4571.2	23.611	21.82	287	6024.1	24.771	17.06	347	7538.7	25.682	13.48
228	4594.8	23.632	21.73	288	6048.9	24.788	16.99	348	7564.4	25.695	13.43
229	4618.5	23.654	21.64	289	6073.7	24.805	16.92	349	7590.1	25.708	13.38
230	4642.1	23.676	21.55	290	6098.5	24.822	16.85	350	7615.8	25.722	13.32
231	4665.8	23.697	21.46	291	6123.3	24.838	16.79	351	7641.6	25.735	13.27
232	4689.5	23.719	21.38	292	6148.1	24.855	16.72	352	7667.3	25.748	13.22
233	4713.3	23.740	21.29	293	6173.0	24.872	16.65	353	7693.0	25.761	13.17
234	4737.0	23.761	21.20	294	6197.9	24.888	16.59	354	7718.8	25.775	13.13
235	4760.8	23.782	21.11	295	6222.8	24.905	16.52	355	7744.6	25.788	13.08
236	4784.6	23.804	21.02	296	6247.7	24.922	16.45	356	7770.4	25.801	13.03
237	4808.4	23.824	20.94	297	6272.6	24.938	16.39	357	7796.2	25.814	12.98
238	4832.2	23.845	20.85	298	6297.6	24.954	16.32	358	7822.0	25.827	12.93
239	4856.1	23.866	20.77	299	6322.5	24.971	16.26	359	7847.9	25.840	12.88
240	4880.0	23.887	20.68	300	6347.5	24.987	16.19	360	7873.7	25.853	12.83

Table 7.4.5 AWG 14 *Nicrosil thermoelements versus platinum,* Pt-67—*thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. High temperature range, 0 to 1300 °C*—Continued

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
360	7873.7	25.853	12.83	420	9446.4	26.545	10.39	480	11056.7	27.114	8.67
361	7899.6	25.865	12.79	421	9472.9	26.556	10.36	481	11083.8	27.123	8.65
362	7925.4	25.878	12.74	422	9499.5	26.566	10.33	482	11110.9	27.131	8.63
363	7951.3	25.891	12.69	423	9526.0	26.576	10.29	483	11138.0	27.140	8.60
364	7977.2	25.903	12.65	424	9552.6	26.587	10.26	484	11165.2	27.149	8.58
365	8003.1	25.916	12.60	425	9579.2	26.597	10.23	485	11192.3	27.157	8.56
366	8029.0	25.929	12.55	426	9605.8	26.607	10.19	486	11219.5	27.166	8.53
367	8055.0	25.941	12.51	427	9632.4	26.617	10.16	487	11246.7	27.174	8.51
368	8080.9	25.954	12.46	428	9659.1	26.627	10.13	488	11273.8	27.183	8.49
369	8106.9	25.966	12.41	429	9685.7	26.637	10.09	489	11301.0	27.191	8.47
370	8132.9	25.979	12.37	430	9712.3	26.648	10.06	490	11328.2	27.200	8.45
371	8158.8	25.991	12.32	431	9739.0	26.658	10.03	491	11355.4	27.208	8.42
372	8184.8	26.003	12.28	432	9765.6	26.668	10.00	492	11382.6	27.217	8.40
373	8210.8	26.015	12.23	433	9792.3	26.678	9.97	493	11409.9	27.225	8.38
374	8236.9	26.028	12.19	434	9819.0	26.688	9.93	494	11437.1	27.233	8.36
375	8262.9	26.040	12.15	435	9845.7	26.697	9.90	495	11464.3	27.242	8.34
376	8289.0	26.052	12.10	436	9872.4	26.707	9.87	496	11491.6	27.250	8.31
377	8315.0	26.064	12.06	437	9899.1	26.717	9.84	497	11518.8	27.258	8.29
378	8341.1	26.076	12.02	438	9925.8	26.727	9.81	498	11546.1	27.267	8.27
379	8367.2	26.088	11.97	439	9952.6	26.737	9.78	499	11573.4	27.275	8.25
380	8393.3	26.100	11.93	440	9979.3	26.747	9.75	500	11600.6	27.283	8.23
381	8419.4	26.112	11.89	441	10006.1	26.756	9.72	501	11627.9	27.291	8.21
382	8445.5	26.124	11.84	442	10032.8	26.766	9.69	502	11655.2	27.299	8.19
383	8471.6	26.136	11.80	443	10059.6	26.776	9.66	503	11682.5	27.308	8.17
384	8497.7	26.147	11.76	444	10086.4	26.785	9.63	504	11709.8	27.316	8.15
385	8523.9	26.159	11.72	445	10113.2	26.795	9.60	505	11737.2	27.324	8.13
386	8550.1	26.171	11.68	446	10140.0	26.805	9.57	506	11764.5	27.332	8.11
387	8576.2	26.182	11.63	447	10166.8	26.814	9.54	507	11791.8	27.340	8.09
388	8602.4	26.194	11.59	448	10193.6	26.824	9.51	508	11819.2	27.348	8.07
389	8628.6	26.206	11.55	449	10220.4	26.833	9.48	509	11846.5	27.356	8.05
390	8654.8	26.217	11.51	450	10247.3	26.843	9.45	510	11873.9	27.364	8.03
391	8681.1	26.229	11.47	451	10274.1	26.852	9.43	511	11901.3	27.372	8.01
392	8707.3	26.240	11.43	452	10301.0	26.861	9.40	512	11928.6	27.380	7.99
393	8733.5	26.252	11.39	453	10327.8	26.871	9.37	513	11956.0	27.388	7.97
394	8759.8	26.263	11.35	454	10354.7	26.880	9.34	514	11983.4	27.396	7.95
395	8786.1	26.274	11.31	455	10381.6	26.889	9.31	515	12010.8	27.404	7.93
396	8812.4	26.286	11.27	456	10408.5	26.899	9.29	516	12038.2	27.412	7.92
397	8838.6	26.297	11.23	457	10435.4	26.908	9.26	517	12065.6	27.420	7.90
398	8864.9	26.308	11.19	458	10462.3	26.917	9.23	518	12093.1	27.428	7.88
399	8891.3	26.319	11.16	459	10489.2	26.927	9.21	519	12120.5	27.436	7.86
400	8917.6	26.330	11.12	460	10516.1	26.936	9.18	520	12147.9	27.444	7.84
401	8943.9	26.341	11.08	461	10543.1	26.945	9.15	521	12175.4	27.452	7.82
402	8970.3	26.352	11.04	462	10570.0	26.954	9.12	522	12202.8	27.459	7.81
403	8996.6	26.363	11.00	463	10597.0	26.963	9.10	523	12230.3	27.467	7.79
404	9023.0	26.374	10.97	464	10624.0	26.972	9.07	524	12257.8	27.475	7.77
405	9049.4	26.385	10.93	465	10650.9	26.981	9.05	525	12285.2	27.483	7.75
406	9075.8	26.396	10.89	466	10677.9	26.990	9.02	526	12312.7	27.490	7.74
407	9102.2	26.407	10.85	467	10704.9	26.999	8.99	527	12340.2	27.498	7.72
408	9128.6	26.418	10.82	468	10731.9	27.008	8.97	528	12367.7	27.506	7.70
409	9155.0	26.429	10.78	469	10758.9	27.017	8.94	529	12395.2	27.514	7.68
410	9181.4	26.440	10.75	470	10786.0	27.026	8.92	530	12422.8	27.521	7.67
411	9207.9	26.450	10.71	471	10813.0	27.035	8.89	531	12450.3	27.529	7.65
412	9234.3	26.461	10.67	472	10840.0	27.044	8.87	532	12477.8	27.537	7.63
413	9260.8	26.472	10.64	473	10867.1	27.053	8.84	533	12505.4	27.544	7.62
414	9287.3	26.482	10.60	474	10894.1	27.062	8.82	534	12532.9	27.552	7.60
415	9313.8	26.493	10.57	475	10921.2	27.070	8.79	535	12560.5	27.559	7.58
416	9340.3	26.503	10.53	476	10948.3	27.079	8.77	536	12588.0	27.567	7.57
417	9366.8	26.514	10.50	477	10975.4	27.088	8.75	537	12615.6	27.575	7.55
418	9393.3	26.524	10.46	478	11002.4	27.097	8.72	538	12643.2	27.582	7.53
419	9419.8	26.535	10.43	479	11029.5	27.105	8.70	539	12670.8	27.590	7.52
420	9446.4	26.545	10.39	480	11056.7	27.114	8.67	540	12698.3	27.597	7.50

TABLE 7.4.5 AWG 14 *Nicrosil thermoelements versus platinum*, Pt–67—*thermoelectric voltages*, E(T), *Seebeck coefficients*, S(T), *and first derivatives of the Seebeck coefficients*, dS/dT, *reference junctions at 0 °C. High temperature range, 0 to 1300 °C*—Continued

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
540	12698.3	27.597	7.50	600	14367.2	28.022	6.73	660	16060.3	28.409	6.21
541	12725.9	27.605	7.49	601	14395.2	28.029	6.71	661	16088.7	28.416	6.20
542	12753.6	27.612	7.47	602	14423.2	28.036	6.70	662	16117.1	28.422	6.19
543	12781.2	27.620	7.46	603	14451.3	28.042	6.69	663	16145.5	28.428	6.19
544	12808.8	27.627	7.44	604	14479.3	28.049	6.68	664	16174.0	28.434	6.18
545	12836.4	27.634	7.42	605	14507.4	28.056	6.67	665	16202.4	28.440	6.17
546	12864.1	27.642	7.41	606	14535.4	28.062	6.66	666	16230.8	28.446	6.17
547	12891.7	27.649	7.39	607	14563.5	28.069	6.65	667	16259.3	28.453	6.16
548	12919.4	27.657	7.38	608	14591.6	28.076	6.64	668	16287.7	28.459	6.15
549	12947.0	27.664	7.36	609	14619.6	28.082	6.63	669	16316.2	28.465	6.15
550	12974.7	27.671	7.35	610	14647.7	28.089	6.62	670	16344.7	28.471	6.14
551	13002.4	27.679	7.33	611	14675.8	28.096	6.61	671	16373.1	28.477	6.13
552	13030.0	27.686	7.32	612	14703.9	28.102	6.60	672	16401.6	28.483	6.13
553	13057.7	27.693	7.31	613	14732.0	28.109	6.60	673	16430.1	28.489	6.12
554	13085.4	27.701	7.29	614	14760.1	28.115	6.59	674	16458.6	28.496	6.11
555	13113.1	27.708	7.28	615	14788.2	28.122	6.58	675	16487.1	28.502	6.11
556	13140.8	27.715	7.26	616	14816.4	28.129	6.57	676	16515.6	28.508	6.10
557	13168.6	27.722	7.25	617	14844.5	28.135	6.56	677	16544.1	28.514	6.09
558	13196.3	27.730	7.23	618	14872.6	28.142	6.55	678	16572.6	28.520	6.09
559	13224.0	27.737	7.22	619	14900.8	28.148	6.54	679	16601.2	28.526	6.08
560	13251.8	27.744	7.21	620	14928.9	28.155	6.53	680	16629.7	28.532	6.07
561	13279.5	27.751	7.19	621	14957.1	28.161	6.52	681	16658.2	28.538	6.07
562	13307.3	27.758	7.18	622	14985.3	28.168	6.51	682	16686.8	28.544	6.06
563	13335.0	27.766	7.17	623	15013.4	28.174	6.50	683	16715.3	28.550	6.06
564	13362.8	27.773	7.15	624	15041.6	28.181	6.49	684	16743.9	28.556	6.05
565	13390.6	27.780	7.14	625	15069.8	28.187	6.49	685	16772.4	28.562	6.04
566	13418.4	27.787	7.13	626	15098.0	28.194	6.48	686	16801.0	28.568	6.04
567	13446.2	27.794	7.11	627	15126.2	28.200	6.47	687	16829.6	28.574	6.03
568	13474.0	27.801	7.10	628	15154.4	28.207	6.46	688	16858.1	28.581	6.02
569	13501.8	27.808	7.09	629	15182.6	28.213	6.45	689	16886.7	28.587	6.02
570	13529.6	27.816	7.07	630	15210.8	28.220	6.44	690	16915.3	28.593	6.01
571	13557.4	27.823	7.06	631	15239.0	28.226	6.43	691	16943.9	28.599	6.01
572	13585.2	27.830	7.05	632	15267.3	28.233	6.42	692	16972.5	28.605	6.00
573	13613.0	27.837	7.04	633	15295.5	28.239	6.42	693	17001.1	28.611	5.99
574	13640.9	27.844	7.02	634	15323.7	28.245	6.41	694	17029.7	28.617	5.99
575	13668.7	27.851	7.01	635	15352.0	28.252	6.40	695	17058.3	28.623	5.98
576	13696.6	27.858	7.00	636	15380.2	28.258	6.39	696	17087.0	28.629	5.98
577	13724.4	27.865	6.99	637	15408.5	28.265	6.38	697	17115.6	28.634	5.97
578	13752.3	27.872	6.97	638	15436.8	28.271	6.38	698	17144.2	28.640	5.96
579	13780.2	27.879	6.96	639	15465.0	28.277	6.37	699	17172.9	28.646	5.96
580	13808.1	27.886	6.95	640	15493.3	28.284	6.36	700	17201.5	28.652	5.95
581	13836.0	27.893	6.94	641	15521.6	28.290	6.35	701	17230.2	28.658	5.95
582	13863.9	27.899	6.93	642	15549.9	28.296	6.34	702	17258.8	28.664	5.94
583	13891.8	27.906	6.91	643	15578.2	28.303	6.34	703	17287.5	28.670	5.93
584	13919.7	27.913	6.90	644	15606.5	28.309	6.33	704	17316.2	28.676	5.93
585	13947.6	27.920	6.89	645	15634.8	28.315	6.32	705	17344.9	28.682	5.92
586	13975.5	27.927	6.88	646	15663.1	28.322	6.31	706	17373.6	28.688	5.92
587	14003.4	27.934	6.87	647	15691.5	28.328	6.30	707	17402.2	28.694	5.91
588	14031.4	27.941	6.86	648	15719.8	28.334	6.30	708	17430.9	28.700	5.91
589	14059.3	27.948	6.84	649	15748.1	28.341	6.29	709	17459.6	28.706	5.90
590	14087.3	27.955	6.83	650	15776.5	28.347	6.28	710	17488.4	28.712	5.90
591	14115.2	27.961	6.82	651	15804.8	28.353	6.27	711	17517.1	28.717	5.89
592	14143.2	27.968	6.81	652	15833.2	28.359	6.27	712	17545.8	28.723	5.88
593	14171.2	27.975	6.80	653	15861.6	28.366	6.26	713	17574.5	28.729	5.88
594	14199.1	27.982	6.79	654	15889.9	28.372	6.25	714	17603.2	28.735	5.87
595	14227.1	27.989	6.78	655	15918.3	28.378	6.24	715	17632.0	28.741	5.87
596	14255.1	27.995	6.77	656	15946.7	28.384	6.24	716	17660.7	28.747	5.86
597	14283.1	28.002	6.76	657	15975.1	28.391	6.23	717	17689.5	28.753	5.86
598	14311.1	28.009	6.75	658	16003.5	28.397	6.22	718	17718.2	28.759	5.85
599	14339.1	28.016	6.74	659	16031.9	28.403	6.22	719	17747.0	28.764	5.85
600	14367.2	28.022	6.73	660	16060.3	28.409	6.21	720	17775.8	28.770	5.84

TABLE 7.4.5 AWG 14 *Nicrosil thermoelements versus platinum*, Pt–67—*thermoelectric voltages*, E(T), *Seebeck coefficients*, S(T), *and first derivatives of the Seebeck coefficients*, dS/dT, *reference junctions at 0 °C. High temperature range, 0 to 1300 °C*—Continued

T °C	E µV	S µV/°C	dS/dT nV/°C²	T °C	E µV	S µV/°C	dS/dT nV/°C²	T °C	E µV	S µV/°C	dS/dT nV/°C²
720	17775.8	28.770	5.84	780	19512.3	29.111	5.53	840	21268.7	29.433	5.19
721	17804.5	28.776	5.83	781	19541.4	29.117	5.52	841	21298.2	29.438	5.19
722	17833.3	28.782	5.83	782	19570.5	29.122	5.52	842	21327.6	29.443	5.18
723	17862.1	28.788	5.82	783	19599.7	29.128	5.51	843	21357.0	29.449	5.18
724	17890.9	28.794	5.82	784	19628.8	29.133	5.50	844	21386.5	29.454	5.17
725	17919.7	28.799	5.81	785	19657.9	29.139	5.50	845	21416.0	29.459	5.16
726	17948.5	28.805	5.81	786	19687.1	29.144	5.49	846	21445.4	29.464	5.16
727	17977.3	28.811	5.80	787	19716.2	29.150	5.49	847	21474.9	29.469	5.15
728	18006.1	28.817	5.80	788	19745.4	29.155	5.48	848	21504.4	29.474	5.15
729	18034.9	28.823	5.79	789	19774.5	29.161	5.48	849	21533.8	29.480	5.14
730	18063.8	28.828	5.79	790	19803.7	29.166	5.47	850	21563.3	29.485	5.13
731	18092.6	28.834	5.78	791	19832.9	29.172	5.47	851	21592.8	29.490	5.13
732	18121.4	28.840	5.78	792	19862.0	29.177	5.46	852	21622.3	29.495	5.12
733	18150.3	28.846	5.77	793	19891.2	29.183	5.46	853	21651.8	29.500	5.12
734	18179.1	28.851	5.76	794	19920.4	29.188	5.45	854	21681.3	29.505	5.11
735	18208.0	28.857	5.76	795	19949.6	29.193	5.45	855	21710.8	29.510	5.10
736	18236.8	28.863	5.75	796	19978.8	29.199	5.44	856	21740.3	29.515	5.10
737	18265.7	28.869	5.75	797	20008.0	29.204	5.44	857	21769.8	29.520	5.09
738	18294.6	28.875	5.74	798	20037.2	29.210	5.43	858	21799.4	29.526	5.08
739	18323.4	28.880	5.74	799	20066.4	29.215	5.43	859	21828.9	29.531	5.08
740	18352.3	28.886	5.73	800	20095.6	29.221	5.42	860	21858.4	29.536	5.07
741	18381.2	28.892	5.73	801	20124.8	29.226	5.41	861	21888.0	29.541	5.06
742	18410.1	28.897	5.72	802	20154.1	29.231	5.41	862	21917.5	29.546	5.06
743	18439.0	28.903	5.72	803	20183.3	29.237	5.40	863	21947.0	29.551	5.05
744	18467.9	28.909	5.71	804	20212.5	29.242	5.40	864	21976.6	29.556	5.04
745	18496.8	28.915	5.71	805	20241.8	29.248	5.39	865	22006.2	29.561	5.04
746	18525.7	28.920	5.70	806	20271.0	29.253	5.39	866	22035.7	29.566	5.03
747	18554.7	28.926	5.70	807	20300.3	29.258	5.38	867	22065.3	29.571	5.03
748	18583.6	28.932	5.69	808	20329.6	29.264	5.38	868	22094.9	29.576	5.02
749	18612.5	28.937	5.69	809	20358.8	29.269	5.37	869	22124.4	29.581	5.01
750	18641.5	28.943	5.68	810	20388.1	29.275	5.37	870	22154.0	29.586	5.01
751	18670.4	28.949	5.68	811	20417.4	29.280	5.36	871	22183.6	29.591	5.00
752	18699.4	28.954	5.67	812	20446.7	29.285	5.36	872	22213.2	29.596	4.99
753	18728.3	28.960	5.67	813	20475.9	29.291	5.35	873	22242.8	29.601	4.99
754	18757.3	28.966	5.66	814	20505.2	29.296	5.34	874	22272.4	29.606	4.98
755	18786.3	28.971	5.65	815	20534.5	29.301	5.34	875	22302.0	29.611	4.97
756	18815.2	28.977	5.65	816	20563.8	29.307	5.33	876	22331.6	29.616	4.97
757	18844.2	28.983	5.64	817	20593.1	29.312	5.33	877	22361.2	29.621	4.96
758	18873.2	28.988	5.64	818	20622.5	29.317	5.32	878	22390.9	29.626	4.95
759	18902.2	28.994	5.63	819	20651.8	29.323	5.32	879	22420.5	29.631	4.94
760	18931.2	29.000	5.63	820	20681.1	29.328	5.31	880	22450.1	29.636	4.94
761	18960.2	29.005	5.62	821	20710.4	29.333	5.30	881	22479.8	29.641	4.93
762	18989.2	29.011	5.62	822	20739.8	29.339	5.30	882	22509.4	29.646	4.92
763	19018.2	29.016	5.61	823	20769.1	29.344	5.29	883	22539.1	29.651	4.92
764	19047.2	29.022	5.61	824	20798.5	29.349	5.29	884	22568.7	29.655	4.91
765	19076.3	29.028	5.60	825	20827.8	29.354	5.28	885	22598.4	29.660	4.90
766	19105.3	29.033	5.60	826	20857.2	29.360	5.28	886	22628.0	29.665	4.90
767	19134.3	29.039	5.59	827	20886.5	29.365	5.27	887	22657.7	29.670	4.89
768	19163.4	29.044	5.59	828	20915.9	29.370	5.26	888	22687.4	29.675	4.88
769	19192.4	29.050	5.58	829	20945.3	29.376	5.26	889	22717.1	29.680	4.87
770	19221.5	29.056	5.58	830	20974.7	29.381	5.25	890	22746.7	29.685	4.87
771	19250.5	29.061	5.57	831	21004.0	29.386	5.25	891	22776.4	29.690	4.86
772	19279.6	29.067	5.57	832	21033.4	29.391	5.24	892	22806.1	29.695	4.85
773	19308.7	29.072	5.56	833	21062.8	29.396	5.24	893	22835.8	29.699	4.85
774	19337.7	29.078	5.56	834	21092.2	29.402	5.23	894	22865.5	29.704	4.84
775	19366.8	29.083	5.55	835	21121.6	29.407	5.22	895	22895.2	29.709	4.83
776	19395.9	29.089	5.55	836	21151.0	29.412	5.22	896	22924.9	29.714	4.82
777	19425.0	29.095	5.54	837	21180.4	29.417	5.21	897	22954.6	29.719	4.82
778	19454.1	29.100	5.54	838	21209.9	29.423	5.21	898	22984.4	29.724	4.81
779	19483.2	29.106	5.53	839	21239.3	29.428	5.20	899	23014.1	29.728	4.80
780	19512.3	29.111	5.53	840	21268.7	29.433	5.19	900	23043.8	29.733	4.79

TABLE 7.4.5 AWG 14 *Nicrosil thermoelements versus platinum,* Pt-67—*thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients.* dS/dT, *reference junctions at 0 °C. High temperature range, 0 to 1300 °C*—Continued

T °C	E μV	S μV/°C	dS/dT nV/°C^2	T °C	E μV	S μV/°C	dS/dT nV/°C^2	T °C	E μV	S μV/°C	dS/dT nV/°C^2
900	23043.8	29.733	4.79	960	24836.2	30.006	4.29	1020	26643.9	30.246	3.68
901	23073.6	29.738	4.79	961	24866.2	30.011	4.28	1021	26674.2	30.250	3.67
902	23103.3	29.743	4.78	962	24896.2	30.015	4.27	1022	26704.4	30.253	3.66
903	23133.0	29.747	4.77	963	24926.2	30.019	4.26	1023	26734.7	30.257	3.65
904	23162.8	29.752	4.76	964	24956.2	30.023	4.26	1024	26764.9	30.261	3.63
905	23192.6	29.757	4.76	965	24986.2	30.028	4.25	1025	26795.2	30.264	3.62
906	23222.3	29.762	4.75	966	25016.3	30.032	4.24	1026	26825.4	30.268	3.61
907	23252.1	29.766	4.74	967	25046.3	30.036	4.23	1027	26855.7	30.271	3.60
908	23281.8	29.771	4.73	968	25076.3	30.040	4.22	1028	26886.0	30.275	3.59
909	23311.6	29.776	4.73	969	25106.4	30.045	4.21	1029	26916.3	30.279	3.58
910	23341.4	29.781	4.72	970	25136.4	30.049	4.20	1030	26946.5	30.282	3.57
911	23371.2	29.785	4.71	971	25166.5	30.053	4.19	1031	26976.8	30.286	3.55
912	23401.0	29.790	4.70	972	25196.5	30.057	4.18	1032	27007.1	30.289	3.54
913	23430.8	29.795	4.69	973	25226.6	30.061	4.17	1033	27037.4	30.293	3.53
914	23460.6	29.799	4.69	974	25256.7	30.065	4.16	1034	27067.7	30.296	3.52
915	23490.4	29.804	4.68	975	25286.7	30.070	4.15	1035	27098.0	30.300	3.51
916	23520.2	29.809	4.67	976	25316.8	30.074	4.14	1036	27128.3	30.303	3.50
917	23550.0	29.814	4.66	977	25346.9	30.078	4.13	1037	27158.6	30.307	3.49
918	23579.8	29.818	4.66	978	25377.0	30.082	4.12	1038	27188.9	30.310	3.47
919	23609.6	29.823	4.65	979	25407.0	30.086	4.11	1039	27219.2	30.314	3.46
920	23639.4	29.827	4.64	980	25437.1	30.090	4.10	1040	27249.5	30.317	3.45
921	23669.3	29.832	4.63	981	25467.2	30.094	4.09	1041	27279.9	30.321	3.44
922	23699.1	29.837	4.62	982	25497.3	30.098	4.08	1042	27310.2	30.324	3.43
923	23728.9	29.841	4.61	983	25527.4	30.102	4.07	1043	27340.5	30.328	3.42
924	23758.8	29.846	4.61	984	25557.5	30.107	4.06	1044	27370.8	30.331	3.40
925	23788.6	29.851	4.60	985	25587.6	30.111	4.05	1045	27401.2	30.334	3.39
926	23818.5	29.855	4.59	986	25617.7	30.115	4.04	1046	27431.5	30.338	3.38
927	23848.3	29.860	4.58	987	25647.9	30.119	4.03	1047	27461.9	30.341	3.37
928	23878.2	29.864	4.57	988	25678.0	30.123	4.02	1048	27492.2	30.344	3.36
929	23908.1	29.869	4.57	989	25708.1	30.127	4.01	1049	27522.5	30.348	3.34
930	23937.9	29.873	4.56	990	25738.2	30.131	4.00	1050	27552.9	30.351	3.33
931	23967.8	29.878	4.55	991	25768.4	30.135	3.99	1051	27583.2	30.355	3.32
932	23997.7	29.883	4.54	992	25798.5	30.139	3.98	1052	27613.6	30.358	3.31
933	24027.6	29.887	4.53	993	25828.6	30.143	3.97	1053	27644.0	30.361	3.30
934	24057.5	29.892	4.52	994	25858.8	30.147	3.96	1054	27674.3	30.364	3.28
935	24087.4	29.896	4.52	995	25888.9	30.151	3.95	1055	27704.7	30.368	3.27
936	24117.3	29.901	4.51	996	25919.1	30.155	3.94	1056	27735.1	30.371	3.26
937	24147.2	29.905	4.50	997	25949.2	30.158	3.93	1057	27765.4	30.374	3.25
938	24177.1	29.910	4.49	998	25979.4	30.162	3.92	1058	27795.8	30.377	3.24
939	24207.0	29.914	4.48	999	26009.6	30.166	3.91	1059	27826.2	30.381	3.22
940	24236.9	29.919	4.47	1000	26039.7	30.170	3.90	1060	27856.6	30.384	3.21
941	24266.8	29.923	4.46	1001	26069.9	30.174	3.89	1061	27887.0	30.387	3.20
942	24296.7	29.928	4.45	1002	26100.1	30.178	3.87	1062	27917.3	30.390	3.19
943	24326.7	29.932	4.45	1003	26130.3	30.182	3.86	1063	27947.7	30.393	3.17
944	24356.6	29.936	4.44	1004	26160.5	30.186	3.85	1064	27978.1	30.397	3.16
945	24386.6	29.941	4.43	1005	26190.6	30.190	3.84	1065	28008.5	30.400	3.15
946	24416.5	29.945	4.42	1006	26220.8	30.193	3.83	1066	28038.9	30.403	3.14
947	24446.4	29.950	4.41	1007	26251.0	30.197	3.82	1067	28069.3	30.406	3.12
948	24476.4	29.954	4.40	1008	26281.2	30.201	3.81	1068	28099.7	30.409	3.11
949	24506.3	29.958	4.39	1009	26311.4	30.205	3.80	1069	28130.2	30.412	3.10
950	24536.3	29.963	4.38	1010	26341.6	30.209	3.79	1070	28160.6	30.415	3.09
951	24566.3	29.967	4.37	1011	26371.8	30.212	3.78	1071	28191.0	30.418	3.08
952	24596.2	29.972	4.37	1012	26402.1	30.216	3.77	1072	28221.4	30.422	3.06
953	24626.2	29.976	4.36	1013	26432.3	30.220	3.76	1073	28251.8	30.425	3.05
954	24656.2	29.980	4.35	1014	26462.5	30.224	3.75	1074	28282.3	30.428	3.04
955	24686.2	29.985	4.34	1015	26492.7	30.227	3.73	1075	28312.7	30.431	3.02
956	24716.2	29.989	4.33	1016	26523.0	30.231	3.72	1076	28343.1	30.434	3.01
957	24746.2	29.993	4.32	1017	26553.2	30.235	3.71	1077	28373.5	30.437	3.00
958	24776.2	29.998	4.31	1018	26583.4	30.239	3.70	1078	28404.0	30.440	2.99
959	24806.2	30.002	4.30	1019	26613.7	30.242	3.69	1079	28434.4	30.443	2.97
960	24836.2	30.006	4.29	1020	26643.9	30.246	3.68	1080	28464.9	30.446	2.96

TABLE 7.4.5 AWG 14 *Nicrosil thermoelements versus platinum,* Pt–67—*thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. High temperature range, 0 to 1300 °C*—Continued

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
1080	28464.9	30.446	2.96	1140	30296.5	30.600	2.17	1200	32135.9	30.706	1.36
1081	28495.3	30.449	2.95	1141	30327.1	30.602	2.16	1201	32166.6	30.707	1.34
1082	28525.8	30.452	2.94	1142	30357.7	30.604	2.14	1202	32197.3	30.708	1.33
1083	28556.2	30.454	2.92	1143	30388.3	30.606	2.13	1203	32228.0	30.710	1.32
1084	28586.7	30.457	2.91	1144	30418.9	30.608	2.12	1204	32258.7	30.711	1.30
1085	28617.1	30.460	2.90	1145	30449.5	30.611	2.10	1205	32289.4	30.712	1.29
1086	28647.6	30.463	2.89	1146	30480.1	30.613	2.09	1206	32320.1	30.714	1.28
1087	28678.1	30.466	2.87	1147	30510.7	30.615	2.08	1207	32350.9	30.715	1.26
1088	28708.5	30.469	2.86	1148	30541.3	30.617	2.06	1208	32381.6	30.716	1.25
1089	28739.0	30.472	2.85	1149	30572.0	30.619	2.05	1209	32412.3	30.717	1.24
1090	28769.5	30.475	2.83	1150	30602.6	30.621	2.03	1210	32443.0	30.719	1.22
1091	28799.9	30.477	2.82	1151	30633.2	30.623	2.02	1211	32473.7	30.720	1.21
1092	28830.4	30.480	2.81	1152	30663.8	30.625	2.01	1212	32504.4	30.721	1.20
1093	28860.9	30.483	2.80	1153	30694.5	30.627	1.99	1213	32535.2	30.722	1.18
1094	28891.4	30.486	2.78	1154	30725.1	30.629	1.98	1214	32565.9	30.723	1.17
1095	28921.9	30.489	2.77	1155	30755.7	30.631	1.97	1215	32596.6	30.724	1.16
1096	28952.4	30.491	2.76	1156	30786.3	30.633	1.95	1216	32627.3	30.726	1.14
1097	28982.9	30.494	2.74	1157	30817.0	30.635	1.94	1217	32658.1	30.727	1.13
1098	29013.4	30.497	2.73	1158	30847.6	30.637	1.93	1218	32688.8	30.728	1.12
1099	29043.9	30.500	2.72	1159	30878.2	30.639	1.91	1219	32719.5	30.729	1.10
1100	29074.4	30.502	2.70	1160	30908.9	30.641	1.90	1220	32750.3	30.730	1.09
1101	29104.9	30.505	2.69	1161	30939.5	30.642	1.89	1221	32781.0	30.731	1.08
1102	29135.4	30.508	2.68	1162	30970.2	30.644	1.87	1222	32811.7	30.732	1.06
1103	29165.9	30.510	2.67	1163	31000.8	30.646	1.86	1223	32842.4	30.733	1.05
1104	29196.4	30.513	2.65	1164	31031.5	30.648	1.84	1224	32873.2	30.734	1.04
1105	29226.9	30.516	2.64	1165	31062.1	30.650	1.83	1225	32903.9	30.735	1.02
1106	29257.4	30.518	2.63	1166	31092.8	30.652	1.82	1226	32934.7	30.736	1.01
1107	29287.9	30.521	2.61	1167	31123.4	30.654	1.80	1227	32965.4	30.737	1.00
1108	29318.5	30.524	2.60	1168	31154.1	30.655	1.79	1228	32996.1	30.738	0.99
1109	29349.0	30.526	2.59	1169	31184.7	30.657	1.78	1229	33026.9	30.739	0.97
1110	29379.5	30.529	2.57	1170	31215.4	30.659	1.76	1230	33057.6	30.740	0.96
1111	29410.0	30.531	2.56	1171	31246.0	30.661	1.75	1231	33088.3	30.741	0.95
1112	29440.6	30.534	2.55	1172	31276.7	30.662	1.74	1232	33119.1	30.742	0.93
1113	29471.1	30.536	2.53	1173	31307.4	30.664	1.72	1233	33149.8	30.743	0.92
1114	29501.7	30.539	2.52	1174	31338.0	30.666	1.71	1234	33180.6	30.744	0.91
1115	29532.2	30.541	2.51	1175	31368.7	30.668	1.69	1235	33211.3	30.745	0.90
1116	29562.7	30.544	2.49	1176	31399.4	30.669	1.68	1236	33242.1	30.746	0.88
1117	29593.3	30.546	2.48	1177	31430.0	30.671	1.67	1237	33272.8	30.747	0.87
1118	29623.8	30.549	2.47	1178	31460.7	30.673	1.65	1238	33303.6	30.748	0.86
1119	29654.4	30.551	2.45	1179	31491.4	30.674	1.64	1239	33334.3	30.748	0.84
1120	29684.9	30.554	2.44	1180	31522.1	30.676	1.63	1240	33365.1	30.749	0.83
1121	29715.5	30.556	2.43	1181	31552.7	30.677	1.61	1241	33395.8	30.750	0.82
1122	29746.0	30.559	2.41	1182	31583.4	30.679	1.60	1242	33426.6	30.751	0.81
1123	29776.6	30.561	2.40	1183	31614.1	30.681	1.59	1243	33457.3	30.752	0.79
1124	29807.2	30.563	2.39	1184	31644.8	30.682	1.57	1244	33488.1	30.753	0.78
1125	29837.7	30.566	2.37	1185	31675.5	30.684	1.56	1245	33518.8	30.753	0.77
1126	29868.3	30.568	2.36	1186	31706.1	30.685	1.54	1246	33549.6	30.754	0.76
1127	29898.9	30.571	2.35	1187	31736.8	30.687	1.53	1247	33580.3	30.755	0.74
1128	29929.4	30.573	2.33	1188	31767.5	30.688	1.52	1248	33611.1	30.756	0.73
1129	29960.0	30.575	2.32	1189	31798.2	30.690	1.50	1249	33641.8	30.756	0.72
1130	29990.6	30.578	2.31	1190	31828.9	30.691	1.49	1250	33672.6	30.757	0.71
1131	30021.2	30.580	2.29	1191	31859.6	30.693	1.48	1251	33703.3	30.758	0.70
1132	30051.7	30.582	2.28	1192	31890.3	30.694	1.46	1252	33734.1	30.758	0.68
1133	30082.3	30.584	2.27	1193	31921.0	30.696	1.45	1253	33764.9	30.759	0.67
1134	30112.9	30.587	2.25	1194	31951.7	30.697	1.44	1254	33795.6	30.760	0.66
1135	30143.5	30.589	2.24	1195	31982.4	30.699	1.42	1255	33826.4	30.760	0.65
1136	30174.1	30.591	2.22	1196	32013.1	30.700	1.41	1256	33857.1	30.761	0.63
1137	30204.7	30.593	2.21	1197	32043.8	30.702	1.40	1257	33887.9	30.762	0.62
1138	30235.3	30.596	2.20	1198	32074.5	30.703	1.38	1258	33918.7	30.762	0.61
1139	30265.9	30.598	2.18	1199	32105.2	30.704	1.37	1259	33949.4	30.763	0.60
1140	30296.5	30.600	2.17	1200	32135.9	30.706	1.36	1260	33980.2	30.763	0.59

TABLE 7.4.5 AWG 14 *Nicrosil thermoelements versus platinum,* Pt–67—*thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. High temperature range, 0 to 1300 °C*—Continued

T °C	E µV	S µV/°C	dS/dT nV/°C²	T °C	E µV	S µV/°C	dS/dT nV/°C²	T °C	E µV	S µV/°C	dS/dT nV/°C²
1260	33980.2	30.763		1275	34441.7	30.771		1290	34903.3	30.776	
1261	34011.0	30.764		1276	34472.5	30.771		1291	34934.1	30.776	
1262	34041.7	30.765		1277	34503.2	30.772		1292	34964.9	30.776	
1263	34072.5	30.765		1278	34534.0	30.772		1293	34995.6	30.777	
1264	34103.2	30.766		1279	34564.8	30.772		1294	35026.4	30.777	
1265	34134.0	30.766		1280	34595.6	30.773		1295	35057.2	30.777	
1266	34164.8	30.767		1281	34626.3	30.773		1296	35088.0	30.777	
1267	34195.5	30.767		1282	34657.1	30.774		1297	35118.7	30.777	
1268	34226.3	30.768		1283	34687.9	30.774		1298	35149.5	30.777	
1269	34257.1	30.768		1284	34718.7	30.774		1299	35180.3	30.778	
1270	34287.9	30.769		1285	34749.4	30.774		1300	35211.1	30.778	
1271	34318.6	30.769		1286	34780.2	30.775					
1272	34349.4	30.770		1287	34811.0	30.775					
1273	34380.2	30.770		1288	34841.8	30.775					
1274	34410.9	30.771		1289	34872.5	30.776					
1275	34441.7	30.771		1290	34903.3	30.776					

TABLE 7.4.6 *Thermoelectric values at the fixed points for* AWG 28 *Nicrosil thermoelements versus platinum,* Pt–67, *in the cryogenic and extended temperature ranges.*

Temperature range	Fixed point	Temp.[a] °C	*E* µV	*S* µV/°C	dS/dT nV/°C²
−200 to 0 °C	Nitrogen NBP	−195.806	−1589.79	−0.974	88.38
	Oxygen NBP	−182.962	−1594.60	0.251	100.70
	Carbon Dioxide SP	−78.476	−1020.06	10.249	78.68
	Mercury FP	−38.836	−555.51	13.103	65.56
	Ice point[b]	0.000	0.00	15.440	55.48
0 to 400 °C	Ether TP	26.87	434.18	16.851	49.68
	Water BP	100.000	1786.91	19.985	36.65
	Benzoic Acid TP	122.37	2242.87	20.768	33.39
	Indium FP	156.634	2973.16	21.834	28.96
	Tin FP	231.968	4692.30	23.710	21.28
	Bismuth FP	271.442	5643.97	24.487	18.17
	Cadmium FP	321.108	6881.13	25.306	14.91
	Lead FP	327.502	7043.24	25.400	14.53
	Mecury BP	356.66	7789.79	25.799	12.90

[a] Values of temperature are from the published text of the IPTS–68 amended edition of 1975 [CIPM, 1976].
[b] Junction point of different functions.

TABLE 7.4.7 *Thermoelectric values at the fixed points for* AWG 14 *Nicrosil thermoelements versus platinum,* P–67, *in the high temperature range.*

Temperature range	Fixed point	Temp.[a] °C	*E* µV	*S* µV/°C	*dS/dT* nV/°C²
	Ice point	0.000	0.00	15.421	54.95
0 to 1300 °C	Ether TP	26.87	433.52	16.823	49.48
	Water BP	100.000	1784.14	19.962	36.91
	Benzoic Acid TP	122.37	2239.64	20.751	33.68
	Indium FP	156.634	2969.52	21.827	29.24
	Tin FP	231.968	4688.77	23.718	21.38
	Bismuth FP	271.442	5640.80	24.497	18.17
	Cadmium FP	321.108	6878.44	25.315	14.89
	Lead FP	327.502	7040.61	25.409	14.53
	Mercury BP	356.66	7787.42	25.809	13.00
	Zinc FP	419.580	9435.22	26.541	10.41
	Sulphur BP	444.674	10104.42	26.792	9.61
	Cu-Al FP	548.26	12926.55	27.659	7.38
	Antimony FP	630.755	15232.12	28.225	6.44
	Aluminum FP	660.46	16073.33	28.412	6.21
	Silver FP	961.93	24894.08	30.015	4.27
	Gold FP	1064.43	27991.20	30.398	3.56
	Copper FP	1084.88	28613.48	30.460	2.90

[a] Values of temperature are from the published text of the IPTS–68 amended edition of 1975 [CIPM, 1976].

TABLE 7.4.8 *Estimated maximum errors that occur when using reduced-bit arithmetic for the power series expansion for the thermoelectric voltage of* AWG 28 *Nicrosil thermoelements versus platinum,* Pt–67.

Temperature range	Degree	Estimated maximum error in microvolts				
		12 Bit	16 Bit	24 Bit	27 Bit	36 Bit
−200 to 0 °C	8	0.4	0.08	<0.01	<0.01	<0.01
0 to 200 °C	5	1.0	0.04	<0.01	<0.01	<0.01
200 to 400 °C	5	2.4	0.1	<0.01	<0.01	<0.01

TABLE 7.4.9 *Estimated maximum errors that occur when using reduced-bit arithmetic for the power series expansion for the thermoelectric voltage of* AWG 14 *Nicrosil thermoelements versus platinum,* Pt–67.

Temperature range	Degree	Estimated maximum error in microvolts				
		12 Bit	16 Bit	24 Bit	27 Bit	36 Bit
0 to 200 °C	6	0.4	0.02	<0.01	<0.01	<0.01
200 to 400 °C	6	0.4	0.05	<0.01	<0.01	<0.01
400 to 600 °C	6	2	0.3	<0.01	<0.01	<0.01
600 to 800 °C	6	5	1	<0.01	<0.01	<0.01
800 to 1000 °C	6	9	2	<0.01	<0.01	<0.01
1000 to 1200 °C	6	11	3	0.02	<0.01	<0.01
1200 to 1300 °C	6	11	4	0.02	<0.01	<0.01

7.5 Reference Functions and Tables for Platinum, Pt-67, versus the Negative Thermoelement Nisil

Nisil wires of different gages, like Nicrosil, also have slightly different effective compositions and thermoelectric properties. Again, the expansion coefficients and tabular values for the two sizes of wire are not quite identical in the temperature ranges where they overlap. As noted in section 6.7, the voltage differences are not as large as they are for Nicrosil, especially below 200 °C.

The numerical analysis is complicated, however, by a rapid change in thermoelectric properties caused by a magnetic transformation near room temperature. The high temperature data are based primarily on Nisil in the paramagnetic state, the low temperature data on Nisil in the ferromagnetic state. Rather than add a complicated transformation term to the two sets of equations, a small difference in the Seebeck coefficients given by them was permitted in the short temperature range, 0 to 37 °C, where the Nisil wire will be in a weakly ferromagnetic state. The differences are significant for precise thermometry and are therefore reflected in the following tables where the wire gage is specified along with the temperatures and thermoelectric values. At the join, 0 °C, of the cryogenic data (fine wire–*AWG 28*) and the high temperature data (heavy wire–*AWG 14*) the voltages are identical, by definition, but the Seebeck coefficients differ by 2 percent. Actual differences between the voltages for different sizes were discussed in section 6.7.

The coefficients for the eighth degree expansion for the thermoelectric voltage of platinum, Pt–67, versus *AWG 28* Nisil thermoelements between −200 and 0 °C are given in table 7.5.1. The coefficients for the seventh degree expansion for *AWG 28* wire between 0 and 400 °C, an extended range, are also given in table 7.5.1. The equivalent coefficients for the ninth degree expansion for the thermoelectric voltage of platinum, Pt–67, versus *AWG 14* Nisil thermoelements are given in table 7.5.2. The errors caused by using reduced-bit arithmetic for calculating values of those functions are given in tables 7.5.8 and 7.5.9 for *AWG 28* and *AWG 14* thermoelements, respectively.

The primary reference values for platinum, Pt–67, versus *AWG 28* Nisil thermoelements in the temperature range from −200 to 0 °C are given in table 7.5.3. Values for the same gage wire in the extended temperature range from 0 to 400 °C are given in table 7.5.4. Values for the larger, *AWG 14*, wire for temperatures from 0 to 1300 °C are given in table 7.5.5. Near the ends of long calibration ranges, mathematical fitting functions become more variable and subject to error. This is especially true for their higher derivatives. Therefore the second derivatives of the thermal voltages are not tabulated above 1260 °C. Values for the smaller, *AWG 28* wire at selected thermometric fixed points are given in table 7.5.6, and for the larger, *AWG 14* wire, in table 7.5.7.

Graphs of the thermoelectric voltage, its first derivative (Seebeck coefficient), and second derivative are given in figures 7.5.1, 7.5.2, and 7.5.3, respectively for *AWG 28* wire between −200 and 400 °C; and in figures 7.5.4, 7.5.5, and 7.5.6 for *AWG 14* wire between 0 and 1300 °C.

It should be stressed that because of the small, but significant, size effect ***Nisil thermoelement material that conforms closely to the high temperature tabular values may not conform closely at low temperatures (below 0 °C) and vice versa.*** If Nisil thermoelements are to be used both above and below 0 °C, then the material must be calibrated in the full temperature range, both above and below 0 °C. Special selection of material will often be required.

TABLE 7.5.1 *Power series expansion for the thermoelectric voltage of platinum,* Pt–67, *versus* AWG 28 *Nisil thermoelements in the cryogenic and extended temperature ranges.*

Wire gage	Temperature range	Degree	Coefficients	Term
AWG 28	−200 to 0 °C	8	$+1.0713739063\times10^{1}$	T
			$-1.6807370758\times10^{-2}$	T^2
			$-5.9867683053\times10^{-5}$	T^3
			$-1.7298294197\times10^{-7}$	T^4
			$-2.3327903240\times10^{-9}$	T^5
			$-1.3042514094\times10^{-11}$	T^6
			$-1.4464420217\times10^{-14}$	T^7
			$+4.3183110519\times10^{-17}$	T^8
AWG 28	0 to 400 °C	7	$+1.0713739063\times10^{1}$	T
			$-1.8423522194\times10^{-2}$	T^2
			$+1.7287630420\times10^{-4}$	T^3
			$-8.8615620197\times10^{-7}$	T^4
			$+2.6017601076\times10^{-9}$	T^5
			$-3.9887895408\times10^{-12}$	T^6
			$+2.4633802582\times10^{-15}$	T^7

TABLE 7.5.2 *Power series expansion for the thermoelectric voltage of platinum,* Pt–67, *versus* AWG 14 *Nisil thermoelements in the high temperature range.*

Wire gage	Temperature range	Degree	Coefficients	Term
AWG 14	0 to 1300 °C	9	$+1.0476882470\times10^{1}$	T
			$-1.0816976176\times10^{-2}$	T^2
			$+6.6694748508\times10^{-5}$	T^3
			$-2.0150588234\times10^{-7}$	T^4
			$+3.7786520637\times10^{-10}$	T^5
			$-4.4608781297\times10^{-13}$	T^6
			$+3.1553382729\times10^{-16}$	T^7
			$-1.2150879468\times10^{-19}$	T^8
			$+1.9557197559\times10^{-23}$	T^9

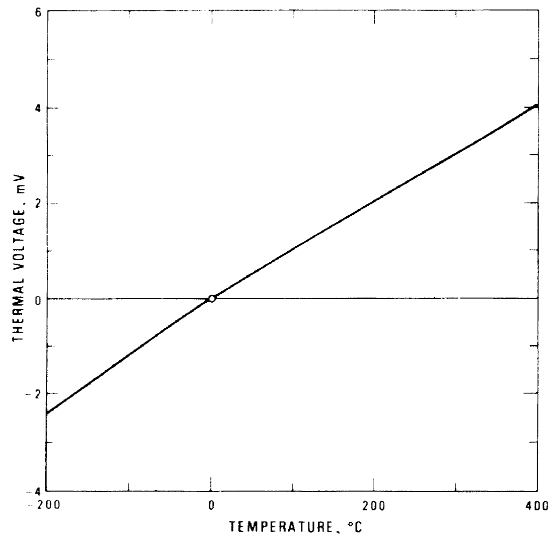

FIGURE 7.5.1 *Thermoelectric voltage for platinum,* Pt–67, *versus* AWG 28 *Nisil thermoelements.*

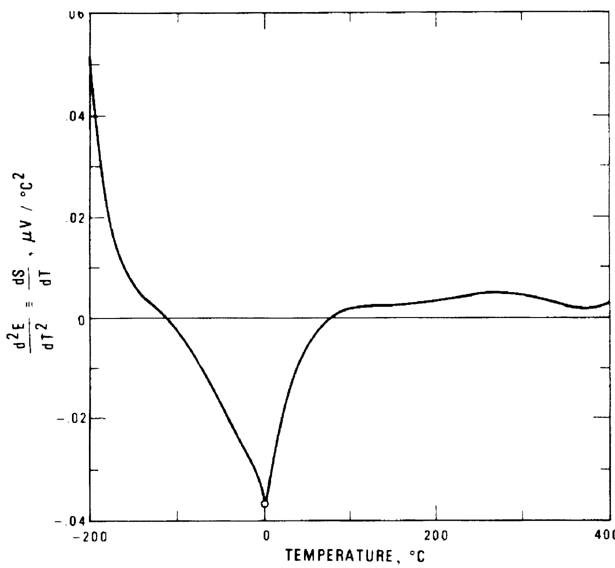

FIGURE 7.5.3 *Derivative of Seebeck coefficient for platinum,* Pt–67, *versus* AWG 28 *Nisil thermoelements.*

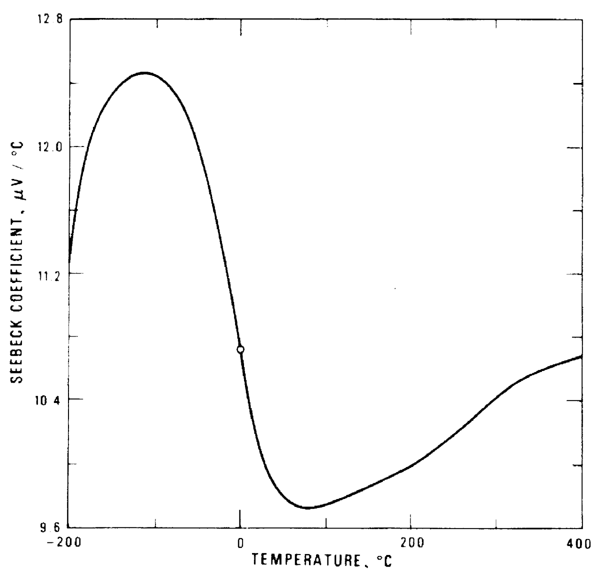

FIGURE 7.5.2 *Seebeck coefficient for platinum,* Pt–67, *versus* AWG 28 *Nisil thermoelements.*

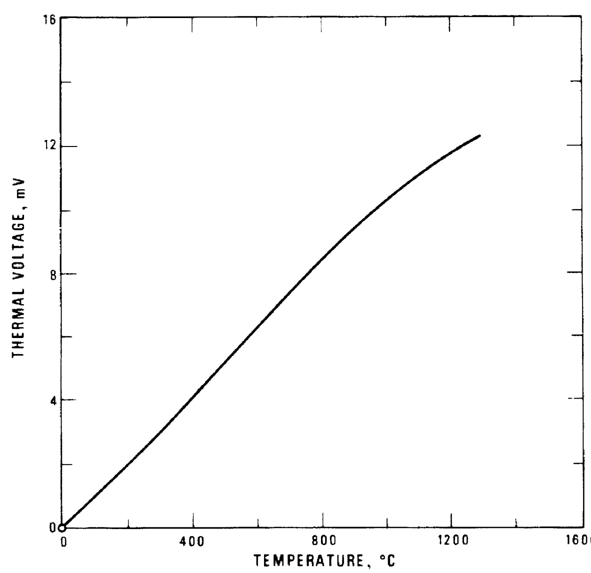

FIGURE 7.5.4 *Thermoelectric voltage for platinum,* Pt–67, *versus* AWG 14 *Nisil thermoelements.*

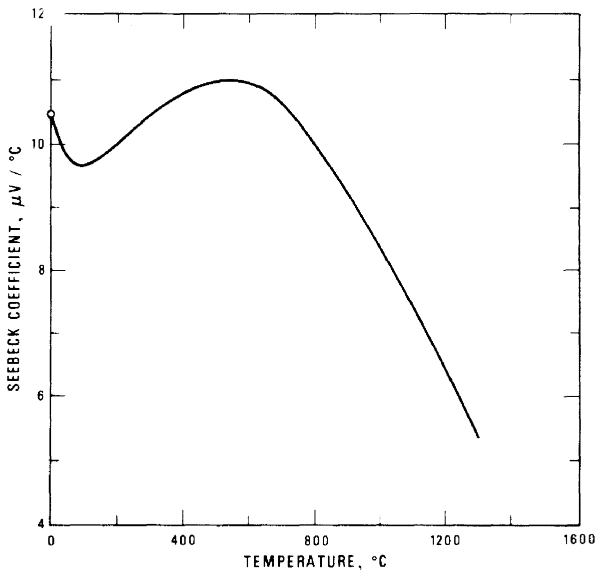

FIGURE 7.5.5 *Seebeck coefficient for platinum,* Pt–67, *versus* AWG 14 *Nisil thermoelements.*

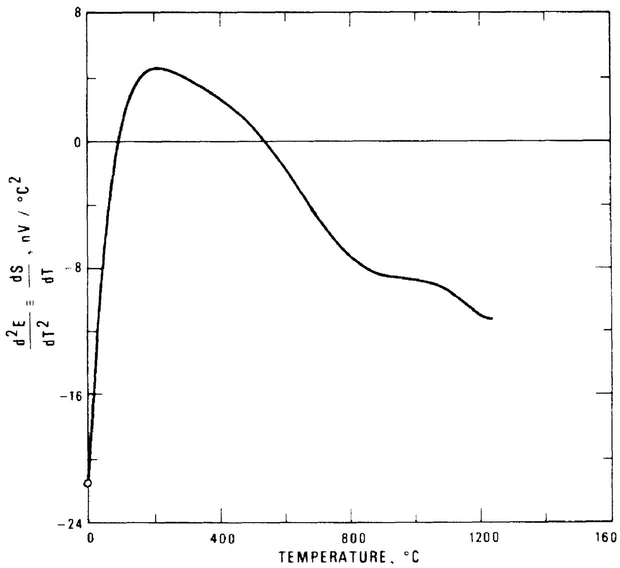

FIGURE 7.5.6 *Derivative of Seebeck coefficient for platinum,* Pt–67, *versus* AWG 14 *Nisil thermoelements.*

TABLE 7.5.3 *Platinum, Pt–67, versus* AWG 28 *Nisil thermoelements—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. Extended temperature range, −200 to 0 °C.*

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
				-200	-2405.41	11.265	51.57	-190	-2290.50	11.688	33.99
				-199	-2394.12	11.316	49.50	-189	-2278.79	11.721	32.58
				-198	-2382.78	11.364	47.50	-188	-2267.06	11.753	31.22
				-197	-2371.39	11.411	45.58	-187	-2255.29	11.783	29.92
				-196	-2359.96	11.456	43.73	-186	-2243.49	11.813	28.67
				-195	-2348.48	11.498	41.94	-185	-2231.66	11.841	27.47
				-194	-2336.96	11.539	40.23	-184	-2219.81	11.868	26.32
				-193	-2325.40	11.579	38.57	-183	-2207.93	11.893	25.22
				-192	-2313.80	11.617	36.99	-182	-2196.02	11.918	24.16
				-191	-2302.17	11.653	35.46	-181	-2184.09	11.942	23.15
-200	-2405.41	11.265	51.57	-190	-2290.50	11.688	33.99	-180	-2172.14	11.964	22.18

TABLE 7.5.3 *Platinum, Pt–67, versus* AWG 28 *Nisil thermoelements—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck Coefficients,* dS/dT, *reference junctions at 0 °C. Cryogenic temperature range, —200 to 0* °C.—Continued

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
-180	-2172.14	11.964	22.18	-120	-1433.95	12.459	1.42	-60	-691.39	12.138	-13.94
-179	-2160.17	11.986	21.25	-119	-1421.49	12.461	1.26	-59	-679.26	12.123	-14.27
-178	-2148.17	12.007	20.36	-118	-1409.03	12.462	1.09	-58	-667.14	12.109	-14.60
-177	-2136.15	12.027	19.51	-117	-1396.57	12.463	0.92	-57	-655.04	12.094	-14.93
-176	-2124.12	12.046	18.70	-116	-1384.10	12.464	0.75	-56	-642.95	12.079	-15.25
-175	-2112.06	12.064	17.92	-115	-1371.64	12.464	0.58	-55	-630.88	12.064	-15.58
-174	-2099.99	12.082	17.17	-114	-1359.18	12.465	0.40	-54	-618.83	12.048	-15.91
-173	-2087.90	12.099	16.46	-113	-1346.71	12.465	0.22	-53	-606.79	12.032	-16.24
-172	-2075.79	12.115	15.78	-112	-1334.24	12.465	0.04	-52	-594.76	12.015	-16.57
-171	-2063.67	12.130	15.13	-111	-1321.78	12.465	-0.15	-51	-582.76	11.999	-16.90
-170	-2051.53	12.145	14.51	-110	-1309.31	12.465	-0.34	-50	-570.76	11.982	-17.23
-169	-2039.38	12.159	13.92	-109	-1296.85	12.465	-0.53	-49	-558.79	11.964	-17.56
-168	-2027.21	12.173	13.35	-108	-1284.39	12.464	-0.73	-48	-546.84	11.947	-17.89
-167	-2015.03	12.186	12.81	-107	-1271.92	12.463	-0.93	-47	-534.90	11.928	-18.22
-166	-2002.84	12.198	12.30	-106	-1259.46	12.462	-1.13	-46	-522.98	11.910	-18.55
-165	-1990.64	12.210	11.81	-105	-1247.00	12.461	-1.34	-45	-511.08	11.891	-18.87
-164	-1978.42	12.222	11.34	-104	-1234.54	12.459	-1.55	-44	-499.20	11.872	-19.20
-163	-1966.19	12.233	10.89	-103	-1222.08	12.458	-1.76	-43	-487.33	11.853	-19.53
-162	-1953.95	12.244	10.46	-102	-1209.62	12.456	-1.98	-42	-475.49	11.833	-19.86
-161	-1941.71	12.254	10.06	-101	-1197.17	12.454	-2.20	-41	-463.67	11.813	-20.18
-160	-1929.45	12.264	9.67	-100	-1184.71	12.451	-2.43	-40	-451.86	11.793	-20.51
-159	-1917.18	12.273	9.30	-99	-1172.26	12.449	-2.66	-39	-440.08	11.772	-20.84
-158	-1904.90	12.283	8.94	-98	-1159.82	12.446	-2.89	-38	-428.32	11.751	-21.16
-157	-1892.61	12.291	8.60	-97	-1147.37	12.443	-3.13	-37	-416.58	11.730	-21.49
-156	-1880.32	12.300	8.28	-96	-1134.93	12.440	-3.37	-36	-404.86	11.708	-21.81
-155	-1868.01	12.308	7.97	-95	-1122.49	12.436	-3.61	-35	-393.16	11.686	-22.14
-154	-1855.70	12.316	7.68	-94	-1110.06	12.433	-3.86	-34	-381.49	11.664	-22.46
-153	-1843.38	12.323	7.40	-93	-1097.63	12.429	-4.11	-33	-369.84	11.641	-22.78
-152	-1831.06	12.330	7.13	-92	-1085.20	12.424	-4.37	-32	-358.21	11.618	-23.10
-151	-1818.72	12.337	6.87	-91	-1072.78	12.420	-4.63	-31	-346.60	11.595	-23.43
-150	-1806.38	12.344	6.62	-90	-1060.36	12.415	-4.89	-30	-335.01	11.572	-23.75
-149	-1794.03	12.351	6.38	-89	-1047.95	12.410	-5.15	-29	-323.46	11.548	-24.07
-148	-1781.68	12.357	6.15	-88	-1035.54	12.405	-5.42	-28	-311.92	11.523	-24.39
-147	-1769.32	12.363	5.93	-87	-1023.14	12.399	-5.69	-27	-300.41	11.499	-24.71
-146	-1756.95	12.369	5.72	-86	-1010.74	12.393	-5.97	-26	-288.92	11.474	-25.03
-145	-1744.58	12.374	5.51	-85	-998.35	12.387	-6.24	-25	-277.46	11.449	-25.35
-144	-1732.20	12.380	5.32	-84	-985.97	12.381	-6.53	-24	-266.02	11.423	-25.67
-143	-1719.82	12.385	5.12	-83	-973.59	12.374	-6.81	-23	-254.61	11.398	-25.99
-142	-1707.43	12.390	4.94	-82	-961.22	12.367	-7.10	-22	-243.23	11.371	-26.31
-141	-1695.04	12.395	4.76	-81	-948.85	12.360	-7.39	-21	-231.87	11.345	-26.63
-140	-1682.64	12.400	4.58	-80	-936.50	12.353	-7.68	-20	-220.54	11.318	-26.95
-139	-1670.24	12.404	4.41	-79	-924.15	12.345	-7.97	-19	-209.24	11.291	-27.27
-138	-1657.84	12.408	4.24	-78	-911.81	12.337	-8.27	-18	-197.96	11.264	-27.59
-137	-1645.43	12.413	4.08	-77	-899.48	12.328	-8.57	-17	-186.71	11.236	-27.91
-136	-1633.01	12.417	3.91	-76	-887.15	12.320	-8.87	-16	-175.49	11.208	-28.23
-135	-1620.59	12.420	3.75	-75	-874.84	12.311	-9.18	-15	-164.29	11.179	-28.56
-134	-1608.17	12.424	3.60	-74	-862.53	12.301	-9.48	-14	-153.13	11.151	-28.88
-133	-1595.74	12.428	3.44	-73	-850.24	12.292	-9.79	-13	-141.99	11.122	-29.20
-132	-1583.32	12.431	3.29	-72	-837.95	12.282	-10.10	-12	-130.88	11.092	-29.53
-131	-1570.88	12.434	3.13	-71	-825.67	12.271	-10.41	-11	-119.81	11.063	-29.86
-130	-1558.45	12.437	2.98	-70	-813.41	12.261	-10.73	-10	-108.76	11.033	-30.19
-129	-1546.01	12.440	2.83	-69	-801.15	12.250	-11.04	-9	-97.74	11.002	-30.52
-128	-1533.57	12.443	2.68	-68	-788.91	12.239	-11.36	-8	-86.76	10.971	-30.85
-127	-1521.12	12.446	2.52	-67	-776.67	12.227	-11.68	-7	-75.80	10.940	-31.19
-126	-1508.68	12.448	2.37	-66	-764.45	12.215	-12.00	-6	-64.87	10.909	-31.52
-125	-1496.23	12.450	2.21	-65	-752.24	12.203	-12.32	-5	-53.98	10.877	-31.87
-124	-1483.78	12.452	2.06	-64	-740.05	12.191	-12.64	-4	-43.12	10.845	-32.21
-123	-1471.32	12.454	1.90	-63	-727.86	12.178	-12.97	-3	-32.29	10.813	-32.55
-122	-1458.87	12.456	1.74	-62	-715.69	12.165	-13.29	-2	-21.49	10.780	-32.90
-121	-1446.41	12.458	1.58	-61	-703.53	12.151	-13.62	-1	-10.73	10.747	-33.26
-120	-1433.95	12.459	1.42	-60	-691.39	12.138	-13.94	0	0.00	10.714	-33.61

TABLE 7.5.4 *Platinum, Pt–67, versus* AWG 28 *Nisil thermoelements—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference functions at 0 °C. Extended temperature range, 0 to 400 °C.*

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
0	0.00	10.714	-36.85	60	604.20	9.755	-3.12	120	1189.04	9.789	2.17
1	10.70	10.677	-35.82	61	613.95	9.752	-2.90	121	1198.83	9.791	2.19
2	21.36	10.642	-34.81	62	623.70	9.749	-2.69	122	1208.62	9.793	2.20
3	31.98	10.608	-33.83	63	633.45	9.747	-2.48	123	1218.42	9.795	2.21
4	42.57	10.574	-32.86	64	643.20	9.744	-2.27	124	1228.21	9.798	2.22
5	53.13	10.542	-31.92	65	652.94	9.742	-2.08	125	1238.01	9.800	2.23
6	63.66	10.511	-31.00	66	662.68	9.740	-1.89	126	1247.81	9.802	2.24
7	74.15	10.480	-30.09	67	672.42	9.738	-1.71	127	1257.61	9.804	2.25
8	84.62	10.450	-29.20	68	682.16	9.737	-1.53	128	1267.42	9.806	2.26
9	95.05	10.422	-28.34	69	691.90	9.735	-1.36	129	1277.23	9.809	2.26
10	105.46	10.394	-27.49	70	701.63	9.734	-1.20	130	1287.04	9.811	2.27
11	115.84	10.367	-26.66	71	711.36	9.733	-1.04	131	1296.85	9.813	2.28
12	126.19	10.340	-25.84	72	721.10	9.732	-0.88	132	1306.66	9.816	2.28
13	136.52	10.315	-25.05	73	730.83	9.731	-0.74	133	1316.48	9.818	2.29
14	146.82	10.290	-24.27	74	740.56	9.731	-0.59	134	1326.30	9.820	2.29
15	157.10	10.266	-23.51	75	750.29	9.730	-0.46	135	1336.12	9.822	2.30
16	167.36	10.243	-22.77	76	760.02	9.730	-0.32	136	1345.94	9.825	2.30
17	177.59	10.221	-22.04	77	769.75	9.729	-0.20	137	1355.77	9.827	2.31
18	187.80	10.199	-21.33	78	779.48	9.729	-0.07	138	1365.60	9.829	2.31
19	197.99	10.178	-20.64	79	789.21	9.729	0.04	139	1375.43	9.832	2.32
20	208.15	10.158	-19.96	80	798.94	9.729	0.16	140	1385.26	9.834	2.32
21	218.30	10.138	-19.30	81	808.67	9.730	0.27	141	1395.10	9.836	2.33
22	228.43	10.119	-18.65	82	818.39	9.730	0.37	142	1404.93	9.839	2.33
23	238.54	10.101	-18.02	83	828.12	9.730	0.47	143	1414.77	9.841	2.34
24	248.63	10.083	-17.40	84	837.86	9.731	0.57	144	1424.62	9.843	2.34
25	258.71	10.066	-16.79	85	847.59	9.731	0.66	145	1434.46	9.846	2.35
26	268.77	10.050	-16.21	86	857.32	9.732	0.75	146	1444.31	9.848	2.35
27	278.81	10.034	-15.63	87	867.05	9.733	0.83	147	1454.16	9.850	2.36
28	288.83	10.018	-15.07	88	876.78	9.734	0.91	148	1464.01	9.853	2.36
29	298.84	10.004	-14.52	89	886.52	9.735	0.99	149	1473.86	9.855	2.37
30	308.84	9.989	-13.99	90	896.25	9.736	1.07	150	1483.72	9.857	2.38
31	318.82	9.976	-13.47	91	905.99	9.737	1.14	151	1493.58	9.860	2.38
32	328.79	9.962	-12.96	92	915.73	9.738	1.20	152	1503.44	9.862	2.39
33	338.75	9.950	-12.47	93	925.47	9.739	1.27	153	1513.30	9.865	2.39
34	348.69	9.937	-11.98	94	935.21	9.741	1.33	154	1523.17	9.867	2.40
35	358.62	9.926	-11.51	95	944.95	9.742	1.39	155	1533.03	9.869	2.41
36	368.54	9.914	-11.05	96	954.69	9.743	1.45	156	1542.91	9.872	2.42
37	378.45	9.904	-10.61	97	964.43	9.745	1.50	157	1552.78	9.874	2.42
38	388.35	9.893	-10.17	98	974.18	9.746	1.55	158	1562.65	9.877	2.43
39	398.24	9.883	-9.75	99	983.93	9.748	1.60	159	1572.53	9.879	2.44
40	408.12	9.874	-9.34	100	993.67	9.749	1.64	160	1582.41	9.882	2.45
41	417.99	9.865	-8.93	101	1003.42	9.751	1.69	161	1592.29	9.884	2.46
42	427.85	9.856	-8.54	102	1013.18	9.753	1.73	162	1602.18	9.886	2.47
43	437.70	9.848	-8.16	103	1022.93	9.755	1.77	163	1612.07	9.889	2.48
44	447.54	9.840	-7.79	104	1032.69	9.756	1.80	164	1621.96	9.891	2.49
45	457.38	9.832	-7.43	105	1042.44	9.758	1.84	165	1631.85	9.894	2.50
46	467.21	9.825	-7.08	106	1052.20	9.760	1.87	166	1641.75	9.896	2.51
47	477.03	9.818	-6.74	107	1061.96	9.762	1.90	167	1651.64	9.899	2.52
48	486.84	9.811	-6.41	108	1071.73	9.764	1.93	168	1661.54	9.901	2.54
49	496.65	9.805	-6.09	109	1081.49	9.766	1.96	169	1671.45	9.904	2.55
50	506.45	9.799	-5.78	110	1091.26	9.768	1.99	170	1681.35	9.907	2.56
51	516.25	9.793	-5.48	111	1101.03	9.770	2.01	171	1691.26	9.909	2.58
52	526.04	9.788	-5.18	112	1110.80	9.772	2.03	172	1701.17	9.912	2.59
53	535.82	9.783	-4.90	113	1120.57	9.774	2.06	173	1711.08	9.914	2.61
54	545.60	9.778	-4.62	114	1130.35	9.776	2.08	174	1721.00	9.917	2.62
55	555.38	9.774	-4.35	115	1140.12	9.778	2.10	175	1730.92	9.920	2.64
56	565.15	9.770	-4.09	116	1149.90	9.780	2.11	176	1740.84	9.922	2.65
57	574.92	9.766	-3.84	117	1159.68	9.782	2.13	177	1750.76	9.925	2.67
58	584.68	9.762	-3.59	118	1169.47	9.784	2.15	178	1760.69	9.928	2.69
59	594.44	9.758	-3.35	119	1179.25	9.787	2.16	179	1770.62	9.930	2.70
60	604.20	9.755	-3.12	120	1189.04	9.789	2.17	180	1780.55	9.933	2.72

TABLE 7.5.4 *Platinum, Pt–67, versus* AWG 28 *Nisil thermoelements—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *refeernce junctions at 0 °C. Extended temperature range, 0 to 400 °C*—Continued

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
180	1780.55	9.933	2.72	240	2382.29	10.141	4.29	300	2998.99	10.417	4.37
181	1790.48	9.936	2.74	241	2392.43	10.146	4.31	301	3009.41	10.421	4.34
182	1800.42	9.938	2.76	242	2402.58	10.150	4.33	302	3019.83	10.425	4.31
183	1810.36	9.941	2.78	243	2412.73	10.154	4.36	303	3030.26	10.430	4.28
184	1820.30	9.944	2.80	244	2422.89	10.159	4.38	304	3040.69	10.434	4.25
185	1830.25	9.947	2.82	245	2433.05	10.163	4.40	305	3051.13	10.438	4.22
186	1840.20	9.950	2.84	246	2443.21	10.167	4.42	306	3061.57	10.442	4.19
187	1850.15	9.952	2.86	247	2453.38	10.172	4.44	307	3072.01	10.447	4.16
188	1860.10	9.955	2.88	248	2463.56	10.176	4.46	308	3082.46	10.451	4.12
189	1870.06	9.958	2.91	249	2473.73	10.181	4.48	309	3092.91	10.455	4.09
190	1880.02	9.961	2.93	250	2483.92	10.185	4.50	310	3103.37	10.459	4.05
191	1889.98	9.964	2.95	251	2494.11	10.190	4.52	311	3113.83	10.463	4.02
192	1899.95	9.967	2.98	252	2504.30	10.194	4.54	312	3124.30	10.467	3.98
193	1909.91	9.970	3.00	253	2514.49	10.199	4.55	313	3134.77	10.471	3.94
194	1919.89	9.973	3.02	254	2524.69	10.203	4.57	314	3145.24	10.475	3.90
195	1929.86	9.976	3.05	255	2534.90	10.208	4.59	315	3155.72	10.479	3.86
196	1939.84	9.979	3.07	256	2545.11	10.213	4.60	316	3166.20	10.483	3.82
197	1949.82	9.982	3.10	257	2555.33	10.217	4.62	317	3176.68	10.486	3.78
198	1959.80	9.985	3.12	258	2565.55	10.222	4.63	318	3187.17	10.490	3.74
199	1969.79	9.989	3.15	259	2575.77	10.226	4.64	319	3197.66	10.494	3.70
200	1979.78	9.992	3.18	260	2586.00	10.231	4.65	320	3208.16	10.497	3.65
201	1989.77	9.995	3.20	261	2596.23	10.236	4.66	321	3218.66	10.501	3.61
202	1999.77	9.998	3.23	262	2606.47	10.240	4.67	322	3229.16	10.505	3.56
203	2009.77	10.001	3.26	263	2616.71	10.245	4.68	323	3239.67	10.508	3.52
204	2019.77	10.005	3.28	264	2626.96	10.250	4.69	324	3250.18	10.512	3.47
205	2029.78	10.008	3.31	265	2637.21	10.254	4.70	325	3260.69	10.515	3.43
206	2039.79	10.011	3.34	266	2647.47	10.259	4.71	326	3271.21	10.519	3.38
207	2049.80	10.015	3.37	267	2657.73	10.264	4.71	327	3281.73	10.522	3.34
208	2059.82	10.018	3.40	268	2668.00	10.269	4.72	328	3292.25	10.525	3.29
209	2069.84	10.021	3.42	269	2678.27	10.273	4.72	329	3302.78	10.529	3.24
210	2079.86	10.025	3.45	270	2688.54	10.278	4.73	330	3313.31	10.532	3.19
211	2089.89	10.028	3.48	271	2698.82	10.283	4.73	331	3323.84	10.535	3.15
212	2099.92	10.032	3.51	272	2709.11	10.287	4.73	332	3334.38	10.538	3.10
213	2109.95	10.035	3.54	273	2719.40	10.292	4.73	333	3344.92	10.541	3.05
214	2119.99	10.039	3.57	274	2729.69	10.297	4.73	334	3355.46	10.544	3.00
215	2130.03	10.042	3.60	275	2739.99	10.302	4.73	335	3366.00	10.547	2.95
216	2140.07	10.046	3.63	276	2750.30	10.306	4.73	336	3376.55	10.550	2.90
217	2150.12	10.050	3.66	277	2760.60	10.311	4.72	337	3387.10	10.553	2.86
218	2160.17	10.053	3.68	278	2770.92	10.316	4.72	338	3397.66	10.556	2.81
219	2170.23	10.057	3.71	279	2781.24	10.321	4.71	339	3408.22	10.559	2.76
220	2180.29	10.061	3.74	280	2791.56	10.325	4.71	340	3418.78	10.561	2.71
221	2190.35	10.065	3.77	281	2801.89	10.330	4.70	341	3429.34	10.564	2.66
222	2200.41	10.068	3.80	282	2812.22	10.335	4.69	342	3439.90	10.567	2.62
223	2210.48	10.072	3.83	283	2822.56	10.339	4.68	343	3450.47	10.569	2.57
224	2220.56	10.076	3.86	284	2832.90	10.344	4.67	344	3461.04	10.572	2.52
225	2230.64	10.080	3.89	285	2843.24	10.349	4.66	345	3471.61	10.574	2.48
226	2240.72	10.084	3.91	286	2853.60	10.353	4.65	346	3482.19	10.577	2.43
227	2250.80	10.088	3.94	287	2863.95	10.358	4.64	347	3492.77	10.579	2.38
228	2260.89	10.092	3.97	288	2874.31	10.363	4.62	348	3503.35	10.581	2.34
229	2270.99	10.096	4.00	289	2884.68	10.367	4.61	349	3513.93	10.584	2.29
230	2281.09	10.100	4.03	290	2895.05	10.372	4.59	350	3524.52	10.586	2.25
231	2291.19	10.104	4.05	291	2905.42	10.376	4.57	351	3535.10	10.588	2.21
232	2301.29	10.108	4.08	292	2915.80	10.381	4.55	352	3545.69	10.590	2.17
233	2311.40	10.112	4.11	293	2926.18	10.386	4.53	353	3556.28	10.593	2.13
234	2321.52	10.116	4.13	294	2936.57	10.390	4.51	354	3566.88	10.595	2.09
235	2331.63	10.120	4.16	295	2946.96	10.395	4.49	355	3577.47	10.597	2.05
236	2341.76	10.124	4.19	296	2957.36	10.399	4.47	356	3588.07	10.599	2.01
237	2351.88	10.128	4.21	297	2967.76	10.403	4.45	357	3598.67	10.601	1.97
238	2362.01	10.133	4.24	298	2978.17	10.408	4.42	358	3609.27	10.603	1.94
239	2372.15	10.137	4.26	299	2988.58	10.412	4.40	359	3619.88	10.605	1.91
240	2382.29	10.141	4.29	300	2998.99	10.417	4.37	360	3630.48	10.607	1.87

TABLE 7.5.4 *Platinum, Pt–67, versus* AWG 28 *Nisil thermoelements—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference functions at 0 °C. Extended temperature range, 0 to 400 °C*—Continued

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
360	3630.48	10.607	1.87	375	3789.78	10.632	1.63	390	3949.45	10.659	2.08
361	3641.09	10.608	1.84	376	3800.41	10.634	1.64	391	3960.11	10.661	2.14
362	3651.70	10.610	1.82	377	3811.05	10.636	1.65	392	3970.78	10.663	2.21
363	3662.31	10.612	1.79	378	3821.68	10.637	1.66	393	3981.44	10.666	2.28
364	3672.92	10.614	1.76	379	3832.32	10.639	1.67	394	3992.11	10.668	2.36
365	3683.54	10.616	1.74	380	3842.96	10.641	1.69	395	4002.78	10.670	2.44
366	3694.15	10.617	1.72	381	3853.60	10.642	1.71	396	4013.45	10.673	2.53
367	3704.77	10.619	1.70	382	3864.24	10.644	1.73	397	4024.12	10.675	2.63
368	3715.39	10.621	1.68	383	3874.89	10.646	1.76	398	4034.80	10.678	2.73
369	3726.01	10.622	1.67	384	3885.54	10.647	1.79	399	4045.48	10.681	2.84
370	3736.64	10.624	1.66	385	3896.18	10.649	1.83	400	4056.16	10.684	2.95
371	3747.26	10.626	1.65	386	3906.83	10.651	1.87				
372	3757.89	10.627	1.64	387	3917.49	10.653	1.91				
373	3768.52	10.629	1.63	388	3928.14	10.655	1.96				
374	3779.15	10.631	1.63	389	3938.80	10.657	2.02				
375	3789.78	10.632	1.63	390	3949.45	10.659	2.08				

TABLE 7.5.5 *Platinum, Pt–67. versus* AWG 14 *Nisil thermoelements—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. High temperature range, 0 to 1300 °C.*

T °C	E μV	S μV/°C	dS/dT nV/°C^2	T °C	E μV	S μV/°C	dS/dT nV/°C^2	T °C	E μV	S μV/°C	dS/dT nV/°C^2
0	0.0	10.477	-21.63	60	601.7	9.748	-4.86	120	1183.1	9.701	2.16
1	10.5	10.455	-21.24	61	611.5	9.743	-4.68	121	1192.8	9.703	2.23
2	20.9	10.434	-20.84	62	621.2	9.738	-4.50	122	1202.5	9.705	2.29
3	31.3	10.414	-20.46	63	631.0	9.734	-4.33	123	1212.2	9.707	2.35
4	41.7	10.393	-20.07	64	640.7	9.730	-4.16	124	1221.9	9.710	2.42
5	52.1	10.374	-19.69	65	650.4	9.725	-3.99	125	1231.6	9.712	2.48
6	62.5	10.354	-19.32	66	660.1	9.722	-3.82	126	1241.3	9.715	2.54
7	72.8	10.335	-18.95	67	669.9	9.718	-3.66	127	1251.1	9.717	2.60
8	83.2	10.316	-18.58	68	679.6	9.714	-3.49	128	1260.8	9.720	2.65
9	93.5	10.298	-18.22	69	689.3	9.711	-3.34	129	1270.5	9.723	2.71
10	103.8	10.280	-17.87	70	699.0	9.708	-3.18	130	1280.2	9.725	2.76
11	114.0	10.262	-17.51	71	708.7	9.704	-3.02	131	1290.0	9.728	2.82
12	124.3	10.245	-17.17	72	718.4	9.702	-2.87	132	1299.7	9.731	2.87
13	134.5	10.228	-16.82	73	728.1	9.699	-2.72	133	1309.4	9.734	2.92
14	144.7	10.211	-16.49	74	737.8	9.696	-2.57	134	1319.2	9.737	2.97
15	154.9	10.195	-16.15	75	747.5	9.694	-2.43	135	1328.9	9.740	3.02
16	165.1	10.179	-15.82	76	757.2	9.691	-2.28	136	1338.6	9.743	3.07
17	175.3	10.163	-15.49	77	766.9	9.689	-2.14	137	1348.4	9.746	3.12
18	185.4	10.148	-15.17	78	776.6	9.687	-2.00	138	1358.1	9.749	3.16
19	195.6	10.133	-14.85	79	786.3	9.685	-1.87	139	1367.9	9.752	3.21
20	205.7	10.118	-14.54	80	795.9	9.683	-1.73	140	1377.6	9.756	3.25
21	215.8	10.104	-14.23	81	805.6	9.682	-1.60	141	1387.4	9.759	3.30
22	225.9	10.090	-13.92	82	815.3	9.680	-1.47	142	1397.1	9.762	3.34
23	236.0	10.076	-13.62	83	825.0	9.679	-1.34	143	1406.9	9.765	3.38
24	246.1	10.062	-13.32	84	834.7	9.677	-1.22	144	1416.7	9.769	3.42
25	256.1	10.049	-13.03	85	844.3	9.676	-1.09	145	1426.4	9.772	3.46
26	266.2	10.036	-12.74	86	854.0	9.675	-0.97	146	1436.2	9.776	3.50
27	276.2	10.024	-12.45	87	863.7	9.674	-0.85	147	1446.0	9.779	3.54
28	286.2	10.011	-12.17	88	873.4	9.673	-0.73	148	1455.8	9.783	3.58
29	296.2	9.999	-11.89	89	883.0	9.673	-0.61	149	1465.6	9.786	3.61
30	306.2	9.988	-11.61	90	892.7	9.672	-0.50	150	1475.4	9.790	3.65
31	316.2	9.976	-11.34	91	902.4	9.672	-0.39	151	1485.1	9.794	3.68
32	326.2	9.965	-11.07	92	912.1	9.671	-0.28	152	1494.9	9.797	3.71
33	336.1	9.954	-10.81	93	921.7	9.671	-0.17	153	1504.7	9.801	3.75
34	346.1	9.943	-10.54	94	931.4	9.671	-0.06	154	1514.5	9.805	3.78
35	356.0	9.933	-10.29	95	941.1	9.671	0.05	155	1524.4	9.809	3.81
36	365.9	9.923	-10.03	96	950.7	9.671	0.15	156	1534.2	9.813	3.84
37	375.9	9.913	-9.78	97	960.4	9.671	0.25	157	1544.0	9.816	3.87
38	385.8	9.903	-9.53	98	970.1	9.672	0.35	158	1553.8	9.820	3.90
39	395.7	9.894	-9.29	99	979.8	9.672	0.45	159	1563.6	9.824	3.93
40	405.6	9.885	-9.05	100	989.4	9.673	0.55	160	1573.4	9.828	3.95
41	415.4	9.876	-8.81	101	999.1	9.673	0.64	161	1583.3	9.832	3.98
42	425.3	9.867	-8.57	102	1008.8	9.674	0.74	162	1593.1	9.836	4.01
43	435.2	9.859	-8.34	103	1018.4	9.675	0.83	163	1602.9	9.840	4.03
44	445.0	9.850	-8.11	104	1028.1	9.676	0.92	164	1612.8	9.844	4.06
45	454.9	9.842	-7.89	105	1037.8	9.676	1.01	165	1622.6	9.848	4.08
46	464.7	9.835	-7.66	106	1047.5	9.678	1.09	166	1632.5	9.852	4.10
47	474.5	9.827	-7.45	107	1057.2	9.679	1.18	167	1642.3	9.856	4.12
48	484.4	9.820	-7.23	108	1066.8	9.680	1.26	168	1652.2	9.861	4.15
49	494.2	9.813	-7.02	109	1076.5	9.681	1.35	169	1662.1	9.865	4.17
50	504.0	9.806	-6.81	110	1086.2	9.683	1.43	170	1671.9	9.869	4.19
51	513.8	9.799	-6.60	111	1095.9	9.684	1.51	171	1681.8	9.873	4.21
52	523.6	9.792	-6.39	112	1105.6	9.686	1.58	172	1691.7	9.877	4.23
53	533.4	9.786	-6.19	113	1115.2	9.687	1.66	173	1701.6	9.882	4.24
54	543.2	9.780	-5.99	114	1124.9	9.689	1.74	174	1711.4	9.886	4.26
55	552.9	9.774	-5.80	115	1134.6	9.691	1.81	175	1721.3	9.890	4.28
56	562.7	9.768	-5.60	116	1144.3	9.693	1.88	176	1731.2	9.894	4.30
57	572.5	9.763	-5.41	117	1154.0	9.694	1.95	177	1741.1	9.899	4.31
58	582.2	9.758	-5.23	118	1163.7	9.696	2.02	178	1751.0	9.903	4.33
59	592.0	9.753	-5.04	119	1173.4	9.699	2.09	179	1760.9	9.907	4.34
60	601.7	9.748	-4.86	120	1183.1	9.701	2.16	180	1770.8	9.912	4.36

TABLE 7.5.5 *Platinum, Pt–67, versus* AWG 14 *Nisil thermoelements—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. High temperature range, 0 to 1300 °C*—Continued

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
180	1770.8	9.912	4.36	240	2373.7	10.184	4.51	300	2992.5	10.440	3.99
181	1780.7	9.916	4.37	241	2383.8	10.188	4.51	301	3003.0	10.444	3.98
182	1790.7	9.920	4.39	242	2394.0	10.193	4.50	302	3013.4	10.448	3.97
183	1800.6	9.925	4.40	243	2404.2	10.197	4.50	303	3023.9	10.452	3.96
184	1810.5	9.929	4.41	244	2414.4	10.202	4.49	304	3034.3	10.456	3.95
185	1820.4	9.934	4.42	245	2424.6	10.206	4.49	305	3044.8	10.460	3.93
186	1830.4	9.938	4.43	246	2434.8	10.211	4.48	306	3055.2	10.464	3.92
187	1840.3	9.943	4.44	247	2445.0	10.215	4.47	307	3065.7	10.468	3.91
188	1850.3	9.947	4.46	248	2455.3	10.220	4.47	308	3076.2	10.472	3.90
189	1860.2	9.951	4.47	249	2465.5	10.224	4.46	309	3086.7	10.476	3.89
190	1870.2	9.956	4.47	250	2475.7	10.229	4.45	310	3097.1	10.480	3.88
191	1880.1	9.960	4.48	251	2485.9	10.233	4.45	311	3107.6	10.484	3.87
192	1890.1	9.965	4.49	252	2496.2	10.237	4.44	312	3118.1	10.487	3.86
193	1900.1	9.969	4.50	253	2506.4	10.242	4.43	313	3128.6	10.491	3.85
194	1910.0	9.974	4.51	254	2516.7	10.246	4.42	314	3139.1	10.495	3.83
195	1920.0	9.978	4.52	255	2526.9	10.251	4.42	315	3149.6	10.499	3.82
196	1930.0	9.983	4.52	256	2537.2	10.255	4.41	316	3160.1	10.503	3.81
197	1940.0	9.987	4.53	257	2547.4	10.260	4.40	317	3170.6	10.507	3.80
198	1950.0	9.992	4.54	258	2557.7	10.264	4.39	318	3181.1	10.510	3.79
199	1960.0	9.997	4.54	259	2567.9	10.268	4.38	319	3191.6	10.514	3.78
200	1970.0	10.001	4.55	260	2578.2	10.273	4.38	320	3202.1	10.518	3.77
201	1980.0	10.006	4.55	261	2588.5	10.277	4.37	321	3212.6	10.522	3.75
202	1990.0	10.010	4.56	262	2598.8	10.281	4.36	322	3223.2	10.525	3.74
203	2000.0	10.015	4.56	263	2609.1	10.286	4.35	323	3233.7	10.529	3.73
204	2010.0	10.019	4.56	264	2619.3	10.290	4.34	324	3244.2	10.533	3.72
205	2020.0	10.024	4.57	265	2629.6	10.294	4.33	325	3254.8	10.537	3.71
206	2030.0	10.028	4.57	266	2639.9	10.299	4.33	326	3265.3	10.540	3.70
207	2040.1	10.033	4.57	267	2650.2	10.303	4.32	327	3275.8	10.544	3.68
208	2050.1	10.038	4.58	268	2660.5	10.307	4.31	328	3286.4	10.548	3.67
209	2060.1	10.042	4.58	269	2670.8	10.312	4.30	329	3296.9	10.551	3.66
210	2070.2	10.047	4.58	270	2681.2	10.316	4.29	330	3307.5	10.555	3.65
211	2080.2	10.051	4.58	271	2691.5	10.320	4.28	331	3318.0	10.559	3.64
212	2090.3	10.056	4.58	272	2701.8	10.325	4.27	332	3328.6	10.562	3.63
213	2100.4	10.060	4.58	273	2712.1	10.329	4.26	333	3339.2	10.566	3.61
214	2110.4	10.065	4.58	274	2722.5	10.333	4.25	334	3349.7	10.569	3.60
215	2120.5	10.070	4.58	275	2732.8	10.337	4.24	335	3360.3	10.573	3.59
216	2130.6	10.074	4.58	276	2743.1	10.342	4.23	336	3370.9	10.577	3.58
217	2140.6	10.079	4.58	277	2753.5	10.346	4.23	337	3381.5	10.580	3.57
218	2150.7	10.083	4.58	278	2763.8	10.350	4.22	338	3392.0	10.584	3.55
219	2160.8	10.088	4.58	279	2774.2	10.354	4.21	339	3402.6	10.587	3.54
220	2170.9	10.093	4.58	280	2784.5	10.358	4.20	340	3413.2	10.591	3.53
221	2181.0	10.097	4.58	281	2794.9	10.363	4.19	341	3423.8	10.594	3.52
222	2191.1	10.102	4.58	282	2805.3	10.367	4.18	342	3434.4	10.598	3.51
223	2201.2	10.106	4.58	283	2815.6	10.371	4.17	343	3445.0	10.601	3.49
224	2211.3	10.111	4.58	284	2826.0	10.375	4.16	344	3455.6	10.605	3.48
225	2221.4	10.115	4.57	285	2836.4	10.379	4.15	345	3466.2	10.608	3.47
226	2231.5	10.120	4.57	286	2846.8	10.383	4.14	346	3476.8	10.612	3.46
227	2241.6	10.125	4.57	287	2857.1	10.388	4.13	347	3487.4	10.615	3.45
228	2251.8	10.129	4.57	288	2867.5	10.392	4.12	348	3498.1	10.619	3.43
229	2261.9	10.134	4.56	289	2877.9	10.396	4.11	349	3508.7	10.622	3.42
230	2272.0	10.138	4.56	290	2888.3	10.400	4.10	350	3519.3	10.626	3.41
231	2282.2	10.143	4.56	291	2898.7	10.404	4.08	351	3529.9	10.629	3.40
232	2292.3	10.147	4.55	292	2909.1	10.408	4.07	352	3540.6	10.632	3.38
233	2302.5	10.152	4.55	293	2919.5	10.412	4.06	353	3551.2	10.636	3.37
234	2312.6	10.157	4.54	294	2930.0	10.416	4.05	354	3561.8	10.639	3.36
235	2322.8	10.161	4.54	295	2940.4	10.420	4.04	355	3572.5	10.642	3.35
236	2333.0	10.166	4.53	296	2950.8	10.424	4.03	356	3583.1	10.646	3.34
237	2343.1	10.170	4.53	297	2961.2	10.428	4.02	357	3593.8	10.649	3.32
238	2353.3	10.175	4.52	298	2971.7	10.432	4.01	358	3604.4	10.652	3.31
239	2363.5	10.179	4.52	299	2982.1	10.436	4.00	359	3615.1	10.656	3.30
240	2373.7	10.184	4.51	300	2992.5	10.440	3.99	360	3625.7	10.659	3.29

TABLE 7.5.5 *Platinum, Pt–67, versus* AWG 14 *Nisil thermoelements—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. High temperature range, 0 to 1300 °C*—Continued

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
360	3625.7	10.659	3.29	420	4270.7	10.832	2.46	480	4924.5	10.950	1.42
361	3636.4	10.662	3.27	421	4281.5	10.835	2.45	481	4935.4	10.951	1.40
362	3647.1	10.666	3.26	422	4292.4	10.837	2.43	482	4946.4	10.953	1.38
363	3657.7	10.669	3.25	423	4303.2	10.840	2.42	483	4957.4	10.954	1.36
364	3668.4	10.672	3.23	424	4314.1	10.842	2.40	484	4968.3	10.955	1.34
365	3679.1	10.675	3.22	425	4324.9	10.844	2.38	485	4979.3	10.957	1.31
366	3689.7	10.679	3.21	426	4335.8	10.847	2.37	486	4990.2	10.958	1.29
367	3700.4	10.682	3.20	427	4346.6	10.849	2.35	487	5001.2	10.959	1.27
368	3711.1	10.685	3.18	428	4357.4	10.851	2.34	488	5012.1	10.961	1.25
369	3721.8	10.688	3.17	429	4368.3	10.854	2.32	489	5023.1	10.962	1.23
370	3732.5	10.691	3.16	430	4379.2	10.856	2.31	490	5034.1	10.963	1.21
371	3743.2	10.694	3.15	431	4390.0	10.858	2.29	491	5045.0	10.964	1.19
372	3753.9	10.698	3.13	432	4400.9	10.861	2.27	492	5056.0	10.966	1.17
373	3764.6	10.701	3.12	433	4411.7	10.863	2.26	493	5067.0	10.967	1.15
374	3775.3	10.704	3.11	434	4422.6	10.865	2.24	494	5077.9	10.968	1.13
375	3786.0	10.707	3.09	435	4433.5	10.867	2.23	495	5088.9	10.969	1.11
376	3796.7	10.710	3.08	436	4444.3	10.870	2.21	496	5099.9	10.970	1.09
377	3807.4	10.713	3.07	437	4455.2	10.872	2.19	497	5110.8	10.971	1.06
378	3818.1	10.716	3.05	438	4466.1	10.874	2.18	498	5121.8	10.972	1.04
379	3828.8	10.719	3.04	439	4477.0	10.876	2.16	499	5132.8	10.973	1.02
380	3839.5	10.722	3.03	440	4487.8	10.878	2.14	500	5143.8	10.974	1.00
381	3850.3	10.725	3.01	441	4498.7	10.881	2.13	501	5154.7	10.975	0.98
382	3861.0	10.728	3.00	442	4509.6	10.883	2.11	502	5165.7	10.976	0.96
383	3871.7	10.731	2.99	443	4520.5	10.885	2.09	503	5176.7	10.977	0.93
384	3882.5	10.734	2.97	444	4531.4	10.887	2.08	504	5187.7	10.978	0.91
385	3893.2	10.737	2.96	445	4542.2	10.889	2.06	505	5198.6	10.979	0.89
386	3903.9	10.740	2.95	446	4553.1	10.891	2.04	506	5209.6	10.980	0.87
387	3914.7	10.743	2.93	447	4564.0	10.893	2.03	507	5220.6	10.981	0.85
388	3925.4	10.746	2.92	448	4574.9	10.895	2.01	508	5231.6	10.982	0.82
389	3936.2	10.749	2.91	449	4585.8	10.897	1.99	509	5242.6	10.982	0.80
390	3946.9	10.752	2.89	450	4596.7	10.899	1.97	510	5253.5	10.983	0.78
391	3957.7	10.755	2.88	451	4607.6	10.901	1.96	511	5264.5	10.984	0.76
392	3968.4	10.758	2.87	452	4618.5	10.903	1.94	512	5275.5	10.985	0.73
393	3979.2	10.760	2.85	453	4629.4	10.905	1.92	513	5286.5	10.985	0.71
394	3989.9	10.763	2.84	454	4640.3	10.907	1.90	514	5297.5	10.986	0.69
395	4000.7	10.766	2.82	455	4651.2	10.909	1.89	515	5308.5	10.987	0.66
396	4011.5	10.769	2.81	456	4662.1	10.910	1.87	516	5319.5	10.987	0.64
397	4022.3	10.772	2.80	457	4673.1	10.912	1.85	517	5330.4	10.988	0.62
398	4033.0	10.775	2.78	458	4684.0	10.914	1.83	518	5341.4	10.989	0.59
399	4043.8	10.777	2.77	459	4694.9	10.916	1.81	519	5352.4	10.989	0.57
400	4054.6	10.780	2.75	460	4705.8	10.918	1.80	520	5363.4	10.990	0.55
401	4065.4	10.783	2.74	461	4716.7	10.920	1.78	521	5374.4	10.990	0.52
402	4076.1	10.786	2.73	462	4727.6	10.921	1.76	522	5385.4	10.991	0.50
403	4086.9	10.788	2.71	463	4738.6	10.923	1.74	523	5396.4	10.991	0.48
404	4097.7	10.791	2.70	464	4749.5	10.925	1.72	524	5407.4	10.992	0.45
405	4108.5	10.794	2.68	465	4760.4	10.927	1.70	525	5418.4	10.992	0.43
406	4119.3	10.796	2.67	466	4771.3	10.928	1.69	526	5429.4	10.993	0.41
407	4130.1	10.799	2.65	467	4782.3	10.930	1.67	527	5440.3	10.993	0.38
408	4140.9	10.802	2.64	468	4793.2	10.932	1.65	528	5451.3	10.993	0.36
409	4151.7	10.804	2.63	469	4804.1	10.933	1.63	529	5462.3	10.994	0.33
410	4162.5	10.807	2.61	470	4815.1	10.935	1.61	530	5473.3	10.994	0.31
411	4173.3	10.810	2.60	471	4826.0	10.936	1.59	531	5484.3	10.994	0.28
412	4184.1	10.812	2.58	472	4836.9	10.938	1.57	532	5495.3	10.995	0.26
413	4194.9	10.815	2.57	473	4847.9	10.940	1.55	533	5506.3	10.995	0.23
414	4205.8	10.817	2.55	474	4858.8	10.941	1.53	534	5517.3	10.995	0.21
415	4216.6	10.820	2.54	475	4869.8	10.943	1.51	535	5528.3	10.995	0.19
416	4227.4	10.822	2.52	476	4880.7	10.944	1.49	536	5539.3	10.995	0.16
417	4238.2	10.825	2.51	477	4891.7	10.946	1.47	537	5550.3	10.996	0.14
418	4249.1	10.827	2.49	478	4902.6	10.947	1.46	538	5561.3	10.996	0.11
419	4259.9	10.830	2.48	479	4913.5	10.949	1.44	539	5572.3	10.996	0.08
420	4270.7	10.832	2.46	480	4924.5	10.950	1.42	540	5583.3	10.996	0.06

TABLE 7.5.5 *Platinum, Pt–67, versus* AWG 14 *Nisil thermoelements—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. High temperature range, 0 to 1300 °C*—Continued

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
540	5583.3	10.996	0.06	600	6242.2	10.951	-1.59	660	6895.3	10.801	-3.42
541	5594.3	10.996	0.03	601	6253.1	10.950	-1.62	661	6906.1	10.798	-3.45
542	5605.3	10.996	0.01	602	6264.1	10.948	-1.65	662	6916.9	10.794	-3.48
543	5616.3	10.996	-0.02	603	6275.0	10.946	-1.68	663	6927.7	10.791	-3.51
544	5627.3	10.996	-0.04	604	6286.0	10.945	-1.71	664	6938.5	10.787	-3.54
545	5638.3	10.996	-0.07	605	6296.9	10.943	-1.74	665	6949.3	10.784	-3.57
546	5649.3	10.996	-0.09	606	6307.9	10.941	-1.77	666	6960.0	10.780	-3.60
547	5660.2	10.996	-0.12	607	6318.8	10.939	-1.80	667	6970.8	10.776	-3.63
548	5671.2	10.996	-0.15	608	6329.7	10.937	-1.83	668	6981.6	10.773	-3.66
549	5682.2	10.995	-0.17	609	6340.7	10.936	-1.86	669	6992.4	10.769	-3.69
550	5693.2	10.995	-0.20	610	6351.6	10.934	-1.89	670	7003.1	10.765	-3.73
551	5704.2	10.995	-0.22	611	6362.5	10.932	-1.92	671	7013.9	10.762	-3.76
552	5715.2	10.995	-0.25	612	6373.5	10.930	-1.95	672	7024.7	10.758	-3.79
553	5726.2	10.994	-0.28	613	6384.4	10.928	-1.98	673	7035.4	10.754	-3.82
554	5737.2	10.994	-0.30	614	6395.3	10.926	-2.01	674	7046.2	10.750	-3.85
555	5748.2	10.994	-0.33	615	6406.3	10.924	-2.04	675	7056.9	10.746	-3.88
556	5759.2	10.994	-0.36	616	6417.2	10.922	-2.07	676	7067.7	10.743	-3.91
557	5770.2	10.993	-0.38	617	6428.1	10.920	-2.10	677	7078.4	10.739	-3.94
558	5781.2	10.993	-0.41	618	6439.0	10.918	-2.13	678	7089.1	10.735	-3.97
559	5792.2	10.992	-0.44	619	6449.9	10.915	-2.16	679	7099.9	10.731	-4.00
560	5803.2	10.992	-0.46	620	6460.8	10.913	-2.19	680	7110.6	10.727	-4.03
561	5814.2	10.991	-0.49	621	6471.8	10.911	-2.22	681	7121.3	10.723	-4.06
562	5825.2	10.991	-0.52	622	6482.7	10.909	-2.25	682	7132.0	10.719	-4.09
563	5836.1	10.990	-0.54	623	6493.6	10.907	-2.28	683	7142.8	10.714	-4.12
564	5847.1	10.990	-0.57	624	6504.5	10.904	-2.31	684	7153.5	10.710	-4.15
565	5858.1	10.989	-0.60	625	6515.4	10.902	-2.34	685	7164.2	10.706	-4.18
566	5869.1	10.989	-0.63	626	6526.3	10.900	-2.37	686	7174.9	10.702	-4.21
567	5880.1	10.988	-0.65	627	6537.2	10.897	-2.40	687	7185.6	10.698	-4.24
568	5891.1	10.987	-0.68	628	6548.1	10.895	-2.44	688	7196.3	10.693	-4.27
569	5902.1	10.987	-0.71	629	6559.0	10.892	-2.47	689	7207.0	10.689	-4.30
570	5913.1	10.986	-0.74	630	6569.9	10.890	-2.50	690	7217.7	10.685	-4.33
571	5924.1	10.985	-0.76	631	6580.8	10.887	-2.53	691	7228.3	10.680	-4.36
572	5935.0	10.984	-0.79	632	6591.6	10.885	-2.56	692	7239.0	10.676	-4.39
573	5946.0	10.984	-0.82	633	6602.5	10.882	-2.59	693	7249.7	10.672	-4.42
574	5957.0	10.983	-0.85	634	6613.4	10.880	-2.62	694	7260.4	10.667	-4.45
575	5968.0	10.982	-0.87	635	6624.3	10.877	-2.65	695	7271.0	10.663	-4.48
576	5979.0	10.981	-0.90	636	6635.2	10.874	-2.68	696	7281.7	10.658	-4.51
577	5989.9	10.980	-0.93	637	6646.0	10.872	-2.71	697	7292.3	10.654	-4.54
578	6000.9	10.979	-0.96	638	6656.9	10.869	-2.74	698	7303.0	10.649	-4.57
579	6011.9	10.978	-0.99	639	6667.8	10.866	-2.77	699	7313.6	10.645	-4.60
580	6022.9	10.977	-1.02	640	6678.6	10.863	-2.80	700	7324.3	10.640	-4.63
581	6033.9	10.976	-1.04	641	6689.5	10.861	-2.83	701	7334.9	10.635	-4.66
582	6044.8	10.975	-1.07	642	6700.4	10.858	-2.86	702	7345.6	10.631	-4.69
583	6055.8	10.974	-1.10	643	6711.2	10.855	-2.90	703	7356.2	10.626	-4.72
584	6066.8	10.973	-1.13	644	6722.1	10.852	-2.93	704	7366.8	10.621	-4.75
585	6077.8	10.972	-1.16	645	6732.9	10.849	-2.96	705	7377.4	10.617	-4.78
586	6088.7	10.971	-1.19	646	6743.8	10.846	-2.99	706	7388.0	10.612	-4.80
587	6099.7	10.969	-1.22	647	6754.6	10.843	-3.02	707	7398.7	10.607	-4.83
588	6110.7	10.968	-1.24	648	6765.5	10.840	-3.05	708	7409.3	10.602	-4.86
589	6121.6	10.967	-1.27	649	6776.3	10.837	-3.08	709	7419.9	10.597	-4.89
590	6132.6	10.966	-1.30	650	6787.1	10.834	-3.11	710	7430.5	10.592	-4.92
591	6143.6	10.964	-1.33	651	6798.0	10.831	-3.14	711	7441.0	10.587	-4.95
592	6154.5	10.963	-1.36	652	6808.8	10.828	-3.17	712	7451.6	10.582	-4.98
593	6165.5	10.962	-1.39	653	6819.6	10.824	-3.20	713	7462.2	10.577	-5.01
594	6176.5	10.960	-1.42	654	6830.4	10.821	-3.23	714	7472.8	10.572	-5.04
595	6187.4	10.959	-1.45	655	6841.3	10.818	-3.26	715	7483.4	10.567	-5.06
596	6198.4	10.957	-1.48	656	6852.1	10.815	-3.30	716	7493.9	10.562	-5.09
597	6209.3	10.956	-1.51	657	6862.9	10.811	-3.33	717	7504.5	10.557	-5.12
598	6220.3	10.954	-1.54	658	6873.7	10.808	-3.36	718	7515.0	10.552	-5.15
599	6231.2	10.953	-1.56	659	6884.5	10.805	-3.39	719	7525.6	10.547	-5.18
600	6242.2	10.951	-1.59	660	6895.3	10.801	-3.42	720	7536.1	10.542	-5.21

TABLE 7.5.5 *Platinum, Pt–67, versus* AWG 14 *Nisil thermoelements—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. High temperature range, 0 to 1300 °C*—Continued

T °C	E μV	S μV/°C	dS/dT nV/°C^2	T °C	E μV	S μV/°C	dS/dT nV/°C^2	T °C	E μV	S μV/°C	dS/dT nV/°C^2
720	7536.1	10.542	-5.21	780	8158.3	10.182	-6.73	840	8756.3	9.742	-7.83
721	7546.7	10.536	-5.23	781	8168.5	10.175	-6.75	841	8766.1	9.735	-7.85
722	7557.2	10.531	-5.26	782	8178.6	10.168	-6.78	842	8775.8	9.727	-7.86
723	7567.7	10.526	-5.29	783	8188.8	10.161	-6.80	843	8785.5	9.719	-7.87
724	7578.2	10.521	-5.32	784	8199.0	10.155	-6.82	844	8795.2	9.711	-7.89
725	7588.8	10.515	-5.35	785	8209.1	10.148	-6.84	845	8804.9	9.703	-7.90
726	7599.3	10.510	-5.37	786	8219.2	10.141	-6.86	846	8814.6	9.695	-7.91
727	7609.8	10.505	-5.40	787	8229.4	10.134	-6.88	847	8824.3	9.687	-7.93
728	7620.3	10.499	-5.43	788	8239.5	10.127	-6.91	848	8834.0	9.679	-7.94
729	7630.8	10.494	-5.46	789	8249.6	10.120	-6.93	849	8843.7	9.671	-7.95
730	7641.3	10.488	-5.48	790	8259.8	10.113	-6.95	850	8853.4	9.663	-7.97
731	7651.8	10.483	-5.51	791	8269.9	10.106	-6.97	851	8863.0	9.655	-7.98
732	7662.2	10.477	-5.54	792	8280.0	10.099	-6.99	852	8872.7	9.647	-7.99
733	7672.7	10.472	-5.57	793	8290.1	10.092	-7.01	853	8882.3	9.639	-8.01
734	7683.2	10.466	-5.59	794	8300.2	10.085	-7.03	854	8892.0	9.631	-8.02
735	7693.6	10.460	-5.62	795	8310.2	10.078	-7.05	855	8901.6	9.623	-8.03
736	7704.1	10.455	-5.65	796	8320.3	10.071	-7.07	856	8911.2	9.615	-8.04
737	7714.6	10.449	-5.67	797	8330.4	10.064	-7.09	857	8920.8	9.607	-8.05
738	7725.0	10.443	-5.70	798	8340.4	10.057	-7.11	858	8930.4	9.599	-8.07
739	7735.4	10.438	-5.73	799	8350.5	10.050	-7.13	859	8940.0	9.591	-8.08
740	7745.9	10.432	-5.75	800	8360.5	10.043	-7.15	860	8949.6	9.583	-8.09
741	7756.3	10.426	-5.78	801	8370.6	10.036	-7.17	861	8959.2	9.575	-8.10
742	7766.7	10.420	-5.81	802	8380.6	10.028	-7.19	862	8968.7	9.567	-8.11
743	7777.1	10.415	-5.83	803	8390.6	10.021	-7.21	863	8978.3	9.559	-8.12
744	7787.6	10.409	-5.86	804	8400.7	10.014	-7.23	864	8987.9	9.551	-8.14
745	7798.0	10.403	-5.89	805	8410.7	10.007	-7.25	865	8997.4	9.542	-8.15
746	7808.4	10.397	-5.91	806	8420.7	9.999	-7.27	866	9006.9	9.534	-8.16
747	7818.8	10.391	-5.94	807	8430.7	9.992	-7.29	867	9016.5	9.526	-8.17
748	7829.1	10.385	-5.96	808	8440.7	9.985	-7.30	868	9026.0	9.518	-8.18
749	7839.5	10.379	-5.99	809	8450.6	9.978	-7.32	869	9035.5	9.510	-8.19
750	7849.9	10.373	-6.01	810	8460.6	9.970	-7.34	870	9045.0	9.502	-8.20
751	7860.3	10.367	-6.04	811	8470.6	9.963	-7.36	871	9054.5	9.493	-8.21
752	7870.6	10.361	-6.07	812	8480.5	9.956	-7.38	872	9064.0	9.485	-8.22
753	7881.0	10.355	-6.09	813	8490.5	9.948	-7.40	873	9073.5	9.477	-8.23
754	7891.3	10.349	-6.12	814	8500.4	9.941	-7.41	874	9083.0	9.469	-8.24
755	7901.7	10.343	-6.14	815	8510.4	9.933	-7.43	875	9092.4	9.460	-8.25
756	7912.0	10.337	-6.17	816	8520.3	9.926	-7.45	876	9101.9	9.452	-8.26
757	7922.4	10.330	-6.19	817	8530.2	9.918	-7.47	877	9111.3	9.444	-8.27
758	7932.7	10.324	-6.22	818	8540.1	9.911	-7.48	878	9120.8	9.436	-8.28
759	7943.0	10.318	-6.24	819	8550.0	9.903	-7.50	879	9130.2	9.427	-8.29
760	7953.3	10.312	-6.27	820	8559.9	9.896	-7.52	880	9139.6	9.419	-8.30
761	7963.6	10.305	-6.29	821	8569.8	9.888	-7.54	881	9149.0	9.411	-8.31
762	7973.9	10.299	-6.31	822	8579.7	9.881	-7.55	882	9158.4	9.403	-8.32
763	7984.2	10.293	-6.34	823	8589.6	9.873	-7.57	883	9167.8	9.394	-8.32
764	7994.5	10.286	-6.36	824	8599.5	9.866	-7.59	884	9177.2	9.386	-8.33
765	8004.8	10.280	-6.39	825	8609.3	9.858	-7.60	885	9186.6	9.378	-8.34
766	8015.1	10.274	-6.41	826	8619.2	9.851	-7.62	886	9196.0	9.369	-8.35
767	8025.4	10.267	-6.43	827	8629.0	9.843	-7.63	887	9205.4	9.361	-8.36
768	8035.6	10.261	-6.46	828	8638.9	9.835	-7.65	888	9214.7	9.352	-8.37
769	8045.9	10.254	-6.48	829	8648.7	9.828	-7.67	889	9224.1	9.344	-8.37
770	8056.1	10.248	-6.50	830	8658.5	9.820	-7.68	890	9233.4	9.336	-8.38
771	8066.4	10.241	-6.53	831	8668.3	9.812	-7.70	891	9242.7	9.327	-8.39
772	8076.6	10.235	-6.55	832	8678.1	9.805	-7.71	892	9252.1	9.319	-8.40
773	8086.8	10.228	-6.57	833	8687.9	9.797	-7.73	893	9261.4	9.311	-8.41
774	8097.1	10.222	-6.60	834	8697.7	9.789	-7.74	894	9270.7	9.302	-8.41
775	8107.3	10.215	-6.62	835	8707.5	9.781	-7.76	895	9280.0	9.294	-8.42
776	8117.5	10.208	-6.64	836	8717.3	9.774	-7.77	896	9289.3	9.285	-8.43
777	8127.7	10.202	-6.67	837	8727.1	9.766	-7.79	897	9298.5	9.277	-8.44
778	8137.9	10.195	-6.69	838	8736.8	9.758	-7.80	898	9307.8	9.268	-8.44
779	8148.1	10.188	-6.71	839	8746.6	9.750	-7.82	899	9317.1	9.260	-8.45
780	8158.3	10.182	-6.73	840	8756.3	9.742	-7.83	900	9326.3	9.252	-8.46

TABLE 7.5.5 *Platinum, Pt–67, versus* AWG 14 *Nisil thermoelements—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. High temperature range, 0 to 1300 °C*—Continued

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
900	9326.3	9.252	-8.46	960	9866.0	8.735	-8.72	1020	10374.3	8.207	-8.88
901	9335.6	9.243	-8.46	961	9874.7	8.726	-8.72	1021	10382.5	8.198	-8.88
902	9344.8	9.235	-8.47	962	9883.5	8.717	-8.73	1022	10390.7	8.189	-8.89
903	9354.1	9.226	-8.48	963	9892.2	8.709	-8.73	1023	10398.9	8.180	-8.89
904	9363.3	9.218	-8.48	964	9900.9	8.700	-8.73	1024	10407.1	8.171	-8.89
905	9372.5	9.209	-8.49	965	9909.6	8.691	-8.74	1025	10415.2	8.163	-8.90
906	9381.7	9.201	-8.50	966	9918.3	8.682	-8.74	1026	10423.4	8.154	-8.90
907	9390.9	9.192	-8.50	967	9926.9	8.674	-8.74	1027	10431.5	8.145	-8.91
908	9400.1	9.184	-8.51	968	9935.6	8.665	-8.74	1028	10439.7	8.136	-8.91
909	9409.3	9.175	-8.51	969	9944.3	8.656	-8.75	1029	10447.8	8.127	-8.91
910	9418.4	9.167	-8.52	970	9952.9	8.648	-8.75	1030	10455.9	8.118	-8.92
911	9427.6	9.158	-8.53	971	9961.6	8.639	-8.75	1031	10464.0	8.109	-8.92
912	9436.7	9.150	-8.53	972	9970.2	8.630	-8.75	1032	10472.2	8.100	-8.93
913	9445.9	9.141	-8.54	973	9978.8	8.621	-8.75	1033	10480.2	8.091	-8.93
914	9455.0	9.132	-8.54	974	9987.4	8.612	-8.76	1034	10488.3	8.082	-8.94
915	9464.2	9.124	-8.55	975	9996.0	8.604	-8.76	1035	10496.4	8.073	-8.94
916	9473.3	9.115	-8.55	976	10004.6	8.595	-8.76	1036	10504.5	8.064	-8.94
917	9482.4	9.107	-8.56	977	10013.2	8.586	-8.76	1037	10512.5	8.056	-8.95
918	9491.5	9.098	-8.57	978	10021.8	8.577	-8.77	1038	10520.6	8.047	-8.95
919	9500.6	9.090	-8.57	979	10030.4	8.569	-8.77	1039	10528.6	8.038	-8.96
920	9509.7	9.081	-8.58	980	10039.0	8.560	-8.77	1040	10536.7	8.029	-8.96
921	9518.7	9.073	-8.58	981	10047.5	8.551	-8.77	1041	10544.7	8.020	-8.97
922	9527.8	9.064	-8.59	982	10056.1	8.542	-8.78	1042	10552.7	8.011	-8.97
923	9536.9	9.055	-8.59	983	10064.6	8.534	-8.78	1043	10560.7	8.002	-8.98
924	9545.9	9.047	-8.59	984	10073.1	8.525	-8.78	1044	10568.7	7.993	-8.98
925	9555.0	9.038	-8.60	985	10081.6	8.516	-8.78	1045	10576.7	7.984	-8.99
926	9564.0	9.030	-8.60	986	10090.2	8.507	-8.79	1046	10584.7	7.975	-9.00
927	9573.0	9.021	-8.61	987	10098.7	8.498	-8.79	1047	10592.6	7.966	-9.00
928	9582.0	9.012	-8.61	988	10107.2	8.490	-8.79	1048	10600.6	7.957	-9.01
929	9591.0	9.004	-8.62	989	10115.6	8.481	-8.79	1049	10608.6	7.948	-9.01
930	9600.0	8.995	-8.62	990	10124.1	8.472	-8.79	1050	10616.5	7.939	-9.02
931	9609.0	8.987	-8.63	991	10132.6	8.463	-8.80	1051	10624.4	7.930	-9.02
932	9618.0	8.978	-8.63	992	10141.0	8.454	-8.80	1052	10632.4	7.921	-9.03
933	9627.0	8.969	-8.63	993	10149.5	8.446	-8.80	1053	10640.3	7.912	-9.04
934	9636.0	8.961	-8.64	994	10157.9	8.437	-8.80	1054	10648.2	7.903	-9.04
935	9644.9	8.952	-8.64	995	10166.4	8.428	-8.81	1055	10656.1	7.894	-9.05
936	9653.9	8.943	-8.65	996	10174.8	8.419	-8.81	1056	10664.0	7.885	-9.06
937	9662.8	8.935	-8.65	997	10183.2	8.410	-8.81	1057	10671.9	7.875	-9.06
938	9671.7	8.926	-8.65	998	10191.6	8.402	-8.81	1058	10679.7	7.866	-9.07
939	9680.7	8.917	-8.66	999	10200.0	8.393	-8.82	1059	10687.6	7.857	-9.08
940	9689.6	8.909	-8.66	1000	10208.4	8.384	-8.82	1060	10695.4	7.848	-9.08
941	9698.5	8.900	-8.66	1001	10216.8	8.375	-8.82	1061	10703.3	7.839	-9.09
942	9707.4	8.891	-8.67	1002	10225.1	8.366	-8.83	1062	10711.1	7.830	-9.10
943	9716.3	8.883	-8.67	1003	10233.5	8.358	-8.83	1063	10718.9	7.821	-9.10
944	9725.1	8.874	-8.67	1004	10241.9	8.349	-8.83	1064	10726.8	7.812	-9.11
945	9734.0	8.865	-8.68	1005	10250.2	8.340	-8.83	1065	10734.6	7.803	-9.12
946	9742.9	8.857	-8.68	1006	10258.5	8.331	-8.84	1066	10742.4	7.794	-9.13
947	9751.7	8.848	-8.68	1007	10266.9	8.322	-8.84	1067	10750.2	7.785	-9.13
948	9760.6	8.839	-8.69	1008	10275.2	8.313	-8.84	1068	10757.9	7.775	-9.14
949	9769.4	8.831	-8.69	1009	10283.5	8.305	-8.84	1069	10765.7	7.766	-9.15
950	9778.2	8.822	-8.69	1010	10291.8	8.296	-8.85	1070	10773.5	7.757	-9.16
951	9787.0	8.813	-8.70	1011	10300.1	8.287	-8.85	1071	10781.2	7.748	-9.16
952	9795.8	8.805	-8.70	1012	10308.4	8.278	-8.85	1072	10789.0	7.739	-9.17
953	9804.6	8.796	-8.70	1013	10316.6	8.269	-8.86	1073	10796.7	7.730	-9.18
954	9813.4	8.787	-8.71	1014	10324.9	8.260	-8.86	1074	10804.4	7.720	-9.19
955	9822.2	8.778	-8.71	1015	10333.2	8.251	-8.86	1075	10812.1	7.711	-9.20
956	9831.0	8.770	-8.71	1016	10341.4	8.243	-8.87	1076	10819.8	7.702	-9.21
957	9839.8	8.761	-8.71	1017	10349.6	8.234	-8.87	1077	10827.5	7.693	-9.22
958	9848.5	8.752	-8.72	1018	10357.9	8.225	-8.87	1078	10835.2	7.684	-9.22
959	9857.3	8.744	-8.72	1019	10366.1	8.216	-8.88	1079	10842.9	7.674	-9.23
960	9866.0	8.735	-8.72	1020	10374.3	8.207	-8.88	1080	10850.6	7.665	-9.24

TABLE 7.5.5 *Platinum, Pt–67, versus* AWG 14 *Nisil thermoelements—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. High temperature range, 0 to 1300 °C*—Continued

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
1080	10850.6	7.665	-9.24	1140	11293.5	7.090	-10.00	1200	11700.2	6.460	-10.96
1081	10858.2	7.656	-9.25	1141	11300.5	7.080	-10.02	1201	11706.7	6.449	-10.98
1082	10865.9	7.647	-9.26	1142	11307.6	7.070	-10.04	1202	11713.1	6.438	-10.99
1083	10873.5	7.637	-9.27	1143	11314.7	7.060	-10.05	1203	11719.6	6.427	-11.00
1084	10881.2	7.628	-9.28	1144	11321.7	7.050	-10.07	1204	11726.0	6.416	-11.01
1085	10888.8	7.619	-9.29	1145	11328.8	7.039	-10.08	1205	11732.4	6.405	-11.03
1086	10896.4	7.609	-9.30	1146	11335.8	7.029	-10.10	1206	11738.8	6.394	-11.04
1087	10904.0	7.600	-9.31	1147	11342.8	7.019	-10.12	1207	11745.2	6.383	-11.05
1088	10911.6	7.591	-9.32	1148	11349.8	7.009	-10.13	1208	11751.6	6.372	-11.06
1089	10919.2	7.582	-9.33	1149	11356.9	6.999	-10.15	1209	11757.9	6.361	-11.08
1090	10926.8	7.572	-9.34	1150	11363.8	6.989	-10.17	1210	11764.3	6.350	-11.09
1091	10934.3	7.563	-9.35	1151	11370.8	6.979	-10.18	1211	11770.6	6.339	-11.10
1092	10941.9	7.553	-9.36	1152	11377.8	6.968	-10.20	1212	11777.0	6.328	-11.11
1093	10949.4	7.544	-9.37	1153	11384.8	6.958	-10.21	1213	11783.3	6.317	-11.12
1094	10957.0	7.535	-9.38	1154	11391.7	6.948	-10.23	1214	11789.6	6.305	-11.13
1095	10964.5	7.525	-9.39	1155	11398.7	6.938	-10.25	1215	11795.9	6.294	-11.14
1096	10972.0	7.516	-9.41	1156	11405.6	6.928	-10.26	1216	11802.2	6.283	-11.15
1097	10979.5	7.507	-9.42	1157	11412.5	6.917	-10.28	1217	11808.5	6.272	-11.16
1098	10987.0	7.497	-9.43	1158	11419.4	6.907	-10.30	1218	11814.7	6.261	-11.17
1099	10994.5	7.488	-9.44	1159	11426.3	6.897	-10.31	1219	11821.0	6.250	-11.18
1100	11002.0	7.478	-9.45	1160	11433.2	6.886	-10.33	1220	11827.2	6.238	-11.18
1101	11009.5	7.469	-9.46	1161	11440.1	6.876	-10.35	1221	11833.5	6.227	-11.19
1102	11017.0	7.459	-9.47	1162	11447.0	6.866	-10.36	1222	11839.7	6.216	-11.20
1103	11024.4	7.450	-9.49	1163	11453.8	6.855	-10.38	1223	11845.9	6.205	-11.21
1104	11031.9	7.440	-9.50	1164	11460.7	6.845	-10.40	1224	11852.1	6.194	-11.21
1105	11039.3	7.431	-9.51	1165	11467.5	6.835	-10.41	1225	11858.3	6.182	-11.22
1106	11046.7	7.421	-9.52	1166	11474.4	6.824	-10.43	1226	11864.5	6.171	-11.22
1107	11054.1	7.412	-9.53	1167	11481.2	6.814	-10.45	1227	11870.6	6.160	-11.23
1108	11061.5	7.402	-9.55	1168	11488.0	6.803	-10.46	1228	11876.8	6.149	-11.24
1109	11068.9	7.393	-9.56	1169	11494.8	6.793	-10.48	1229	11882.9	6.138	-11.24
1110	11076.3	7.383	-9.57	1170	11501.6	6.782	-10.50	1230	11889.1	6.126	-11.24
1111	11083.7	7.374	-9.59	1171	11508.3	6.772	-10.51	1231	11895.2	6.115	-11.25
1112	11091.1	7.364	-9.60	1172	11515.1	6.761	-10.53	1232	11901.3	6.104	-11.25
1113	11098.4	7.354	-9.61	1173	11521.9	6.751	-10.55	1233	11907.4	6.093	-11.25
1114	11105.8	7.345	-9.62	1174	11528.6	6.740	-10.56	1234	11913.5	6.081	-11.26
1115	11113.1	7.335	-9.64	1175	11535.3	6.730	-10.58	1235	11919.5	6.070	-11.26
1116	11120.5	7.325	-9.65	1176	11542.1	6.719	-10.60	1236	11925.6	6.059	-11.26
1117	11127.8	7.316	-9.67	1177	11548.8	6.708	-10.61	1237	11931.7	6.048	-11.26
1118	11135.1	7.306	-9.68	1178	11555.5	6.698	-10.63	1238	11937.7	6.036	-11.26
1119	11142.4	7.296	-9.69	1179	11562.2	6.687	-10.65	1239	11943.7	6.025	-11.26
1120	11149.7	7.287	-9.71	1180	11568.9	6.676	-10.66	1240	11949.8	6.014	-11.26
1121	11157.0	7.277	-9.72	1181	11575.5	6.666	-10.68	1241	11955.8	6.002	-11.26
1122	11164.2	7.267	-9.73	1182	11582.2	6.655	-10.69	1242	11961.8	5.991	-11.26
1123	11171.5	7.258	-9.75	1183	11588.8	6.644	-10.71	1243	11967.7	5.980	-11.25
1124	11178.7	7.248	-9.76	1184	11595.5	6.634	-10.73	1244	11973.7	5.969	-11.25
1125	11186.0	7.238	-9.78	1185	11602.1	6.623	-10.74	1245	11979.7	5.957	-11.25
1126	11193.2	7.228	-9.79	1186	11608.7	6.612	-10.76	1246	11985.6	5.946	-11.24
1127	11200.4	7.218	-9.81	1187	11615.3	6.601	-10.77	1247	11991.6	5.935	-11.24
1128	11207.7	7.209	-9.82	1188	11621.9	6.591	-10.79	1248	11997.5	5.924	-11.23
1129	11214.9	7.199	-9.84	1189	11628.5	6.580	-10.80	1249	12003.4	5.913	-11.22
1130	11222.1	7.189	-9.85	1190	11635.1	6.569	-10.82	1250	12009.3	5.901	-11.22
1131	11229.2	7.179	-9.87	1191	11641.7	6.558	-10.83	1251	12015.2	5.890	-11.21
1132	11236.4	7.169	-9.88	1192	11648.2	6.547	-10.85	1252	12021.1	5.879	-11.20
1133	11243.6	7.159	-9.90	1193	11654.8	6.536	-10.86	1253	12027.0	5.868	-11.19
1134	11250.7	7.149	-9.91	1194	11661.3	6.526	-10.88	1254	12032.8	5.857	-11.18
1135	11257.9	7.140	-9.93	1195	11667.8	6.515	-10.89	1255	12038.7	5.845	-11.17
1136	11265.0	7.130	-9.94	1196	11674.3	6.504	-10.91	1256	12044.5	5.834	-11.16
1137	11272.1	7.120	-9.96	1197	11680.8	6.493	-10.92	1257	12050.4	5.823	-11.14
1138	11279.3	7.110	-9.97	1198	11687.3	6.482	-10.94	1258	12056.2	5.812	-11.13
1139	11286.4	7.100	-9.99	1199	11693.8	6.471	-10.95	1259	12062.0	5.801	-11.12
1140	11293.5	7.090	-10.00	1200	11700.2	6.460	-10.96	1260	12067.8	5.790	-11.10

TABLE 7.5.5 *Platinum, Pt–67, versus* AWG 14 *Nisil thermoelements—thermoelectric voltages,* E(T), *Seebeck coefficients,* S(T), *and first derivatives of the Seebeck coefficients,* dS/dT, *reference junctions at 0 °C. High temperature range, 0 to 1300 °C*—Continued

T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²	T °C	E μV	S μV/°C	dS/dT nV/°C²
1260	12067.8	5.790		1275	12153.4	5.625		1290	12236.6	5.468	
1261	12073.6	5.779		1276	12159.0	5.615		1291	12242.0	5.458	
1262	12079.3	5.767		1277	12164.6	5.604		1292	12247.5	5.447	
1263	12085.1	5.756		1278	12170.2	5.593		1293	12252.9	5.437	
1264	12090.9	5.745		1279	12175.8	5.582		1294	12258.4	5.427	
1265	12096.6	5.734		1280	12181.4	5.572		1295	12263.8	5.417	
1266	12102.3	5.723		1281	12186.9	5.561		1296	12269.2	5.408	
1267	12108.0	5.712		1282	12192.5	5.551		1297	12274.6	5.398	
1268	12113.7	5.701		1283	12198.1	5.540		1298	12280.0	5.388	
1269	12119.4	5.690		1284	12203.6	5.530		1299	12285.4	5.378	
1270	12125.1	5.680		1285	12209.1	5.519		1300	12290.8	5.368	
1271	12130.8	5.669		1286	12214.6	5.509					
1272	12136.5	5.658		1287	12220.1	5.499					
1273	12142.1	5.647		1288	12225.6	5.488					
1274	12147.8	5.636		1289	12231.1	5.478					
1275	12153.4	5.625		1290	12236.6	5.468					

TABLE 7.5.6 *Thermoelectric values at the fixed points for platinum,* Pt–67, *versus* AWG 28 *Nisil thermoelements in the cryogenic and extended temperature ranges.*

Temperature range	Fixed point	Temp.[a] °C	*E* μV	*S* μV/°C	*dS/dT* nV/°C²
−200 to 0 °C	Nitrogen NBP	−195.806	−2357.73	11.464	43.38
	Oxygen NBP	−182.962	−2207.48	11.894	25.18
	Carbon Dioxide SP	−78.476	−917.68	12.341	−8.13
	Mercury FP	−38.836	−438.15	11.769	−20.89
	Ice point[b]	0.000	0.00	10.714	−33.61
0 to 400 °C	Ether TP	26.87	277.50	10.036	−15.70
	Water BP	100.000	993.67	9.749	1.64
	Benzoic Acid TP	122.37	1212.24	9.794	2.20
	Indium FP	156.634	1549.16	9.873	2.42
	Tin FP	231.968	2300.97	10.108	4.08
	Bismuth FP	271.442	2703.37	10.285	4.73
	Cadmium FP	321.108	3219.79	10.502	3.60
	Lead FP	327.502	3287.01	10.524	3.31
	Mercury BP	356.66	3595.07	10.600	1.99

[a] Values of temperature are from the published text of the IPTS-68 amended edition of 1975 [CIPM, 1976].
[b] Junction point of different functions.

TABLE 7.5.7 *Thermoelectric values at the fixed points for platinum,* Pt–67, *versus* AWG 14 *Nisil thermoelements in the high temperature range.*

Temperature range	Fixed point	Temp.[a] °C	E μV	S μV/°C	dS/dT nV/°C²
0 to 1300 °C	Ice Point	0.000	0.00	10.477	−21.63
	Ether TP	26.87	274.90	10.025	−12.49
	Water BP	100.000	989.43	9.673	0.55
	Benzoic Acid TP	122.37	1206.10	9.706	2.31
	Indium FP	156.634	1540.38	9.815	3.86
	Tin FP	231.968	2292.00	10.147	4.55
	Bismuth FP	271.442	2696.04	10.322	4.28
	Cadmium FP	321.108	3213.78	10.522	3.75
	Lead FP	327.502	3281.13	10.546	3.68
	Mercury BP	356.66	3590.14	10.648	3.33
	Zinc FP	419.580	4266.16	10.831	2.47
	Sulphur BP	444.674	4538.70	10.888	2.06
	Cu–Al FP	548.26	5674.10	10.996	−0.15
	Antimony FP	630.755	6578.09	10.888	−2.52
	Aluminum FP	660.46	6900.27	10.800	−3.43
	Silver FP	961.93	9882.85	8.718	−8.73
	Gold FP	1064.43	10730.12	7.808	−9.11
	Copper FP	1084.88	10887.88	7.620	−9.29

[a] Values of temperature are from the published text of the I PTS–68 amended edition of 1975 [CIPM, 1976].

TABLE 7.5.8 *Estimated maximum errors that occur when using reduced-bit arithmetic for the power series expansion for the thermoelectric voltage of platinum,* Pt–67, *versus* AWG 28 *Nisil thermoelements*

Temperature range	Degree	Estimated maximum error in microvolts				
		12 Bit	16 Bit	24 Bit	27 Bit	36 Bit
−200 to 0 °C	8	0.7	0.09	<0.01	<0.01	<0.01
0 to 200 °C	7	1.0	0.04	<0.01	<0.01	<0.01
200 to 400 °C	7	[a]	0.6	<0.01	<0.01	<0.01

[a] A high order polynomial with a low-bit machine causes extreme error.

TABLE 7.5.9 *Estimated maximum errors that occur when using reduced-bit arithmetic for the power series expansion for the thermoelectric voltage of platinum,* Pt–67, *versus* AWG 14 *Nisil thermoelements.*

Temperature range	Degree	Estimated maximum error in microvolts				
		12 Bit	16 Bit	24 Bit	27 Bit	36 Bit
0 to 200 °C	9	0.7	0.02	<0.01	<0.01	<0.01
200 to 400 °C	9	0.8	0.06	<0.01	<0.01	<0.01
400 to 600 °C	9	5	0.2	<0.01	<0.01	<0.01
600 to 800 °C	9	[a]	0.2	0.03	<0.01	<0.01
800 to 1000 °C	9	[a]	1	0.1	<0.01	<0.01
1000 to 1200 °C	9	[a]	9	0.4	0.02	<0.01
1200 to 1300 °C	9	[a]	[a]	0.6	0.03	<0.01

[a] A high order polynomial with a low-bit machine causes extreme error.

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10. Appendixes

Appendix A. Supplementary Functional Approximations for Nicrosil versus Nisil Thermocouples

For many applications, such as those using on-lin controllers, minicomputers, desk calculators, etc., functional approximations are valuable for saving computing time or memory storage. A selection of approximations for different temperature ranges are included in this appendix. Sets of overlapping approximations are also tabulated. As before, the values for *AWG 28* and *AWG 14* wires are tabulated separately.

For the overlapping approximation equations, the approximations have been calculated to fit the primary data with an error spread that is less than 0.05 percent of the absolute temperature. If a data point is more than about 3 °C from the extreme value of any range, then the error is less than 0.02 percent. The temperature ranges for each fit overlap each other by about 10 percent of the absolute temperature. The temperature ranges have been made as wide as possible consistent with the above criteria.

It is difficult to make good low order approximations to the curves where the sensitivity, dE/dT, is small or varying rapidly. Therefore quadratic approximations are not given for two of the selected temperature ranges below 0 °C.

TABLE A1. AWG 28 *Nicrosil versus Nisil thermocouples—quadratic, cubic, and quartic approximations to the temperature data as a function of voltage in selected temperature ranges. The expansion is of the form* $T=A_1E+A_2E^2+A_3E^3+A_4E^4$, *where* T *is in degrees Celsius and* E *is in microvolts.*

Temperature range (°C)	A_1 Argument	Exp.	A_2 Argument	Exp.	A_3 Argument	Exp.	A_4 Argument	Exp.	Error range (°C)
I. Quadratic equations									
−200 to 0	3.143455	−2	−4.375508	−6	--	--	--	--	−5 to 4
0 to 50	3.833763	−2	−8.255147	−7	--	--	--	--	<0.01
0 to 400	3.645264	−2	−4.480891	−7	--	--	--	--	−2 to 3
II. Cubic equations									
−200 to 0	4.262622	−2	4.276051	−6	1.520918	−9	--	--	−1.5 to 1.3
−200 to 400	4.074915	−2	−1.503463	−6	5.816619	−11	--	--	−10 to 8
0 to 50	3.826460	−2	−6.512970	−7	−9.331708	−11	--	--	<0.01
0 to 400	3.812049	−2	−8.711717	−7	2.396423	−11	--	--	−0.3 to 0.3
III. Quartic equations									
−200 to 0	3.523634	−2	−6.080743	−6	−2.748231	−9	−5.396201	−13	−0.4 to 0.7
−200 to 400	3.920032	−2	−1.650547	−6	1.469131	−10	−5.394067	−15	−7 to 6
0 to 50	3.823891	−2	−5.403608	−7	−2.328326	−10	5.340190	−14	<0.01
0 to 400	3.857711	−2	−1.080822	−6	5.182122	−11	−1.122986	−15	−0.06 to 0.05

TABLE A2. AWG 28 *Nicrosil versus Nisil thermocouples—quadratic, cubic, and quartic approximations to the voltage data as a function of temperature for variable reference junctiion corrections. The expansion is of the form* $E = A_1T + A_2T^2 + A_3T^3 + A_4T^4$, *where* T *is in degrees Celsius and* E *is in microvolts.*

Temperature range (°C)	A_1 Argument	Exp.	A_2 Argument	Exp.	A_3 Argument	Exp.	A_4 Argument	Exp.	Error range (μV)
I. Quadratic equation 0 to 50	2.606406	1	1.589325	−2	--	--	--	--	−0.3 to 0.4
II. Cubic Equation 0 to 50	2.613796	1	1.116942	−2	6.789227	−5	--	--	−0.03 to 0.04
III. Quartic equation 0 to 50	2.615230	1	9.510055	−3	1.238615	−4	−5.749568	−7	<0.01

TABLE A3. AWG 28 *Nicrosil versus Nisil thermocouples—overlapping cubic approximations to the temperature data as a function of voltage. The expansion is of the form* $T = A_0 + A_1E + A_2E^2 + A_3E^3$, *where* T *is in kelvin and* E *is in microvolts. Over most of each range the temperature error is less than 0.02 percent.*

Range from 70 to 110 K (−203 to −163 °C)
The coefficients (argument and exponent) are

1.72602467 +3	Constant
1.26848043 +0	*E*
3.49442124 −4	E^2
3.39220068 −8	E^3

Range from 98 to 162 K (−175 to −111 °C)
The coefficients are

3.75946549 +2	Constant
1.48775894 −1	*E*
3.98017292 −5	E^2
5.37110795 −9	E^3

Range from 146 to 246 K (−127 to −27 °C)
The coefficients are

2.74210569 +2	Constant
4.08919110 −2	*E*
1.54189597 −6	E^2
8.32439718 −10	E^3

Range from 222 to 394 K (−51 to 121°C)
The coefficients are

2.73192235 +2	Constant
3.83120481 −2	*E*
−8.54180147 −7	E^2
2.60298671 −12	E^3

Range from 358 to 673 K (85 to 400°C)
The coefficients are

2.75649120 +2	Constant
3.68894533 −2	*E*
−6.99142610 −7	E^2
1.67755019 −11	E^3

TABLE A4. AWG 28 *Nicrosil versus Nisil thermocouples—overlapping quartic approximations to the temperature data as a function of voltage. The expansion is of the form* $T = A_0 + A_1E + A_2E^2 + A_3E^3 + A_4E^4$, *where* T *is in kelvins and* E *is in microvolts. Over most of each range, the temperature error is less than 0.02 percent.*

Range from 70 to 86 K (−203 to −187 °C)
The coefficients (argument and exponent) are

−2.33597900 +4	Constant
−2.47706024 +1	*E*
−9.78542830 −3	E^2
−1.71909958 −6	E^3
−1.13695184 −10	E^4

Range from 78 to 154 K (−195 to −119 °C)
The coefficients are

−3.30022140 +2	Constant
−7.38038652 −1	*E*
−3.76381509 −4	E^2
−8.11117201 −8	E^3
−6.71418860 −12	E^4

Range from 138 to 290 K (−135 to 17 °C)
The coefficients are

2.73177142 +2	Constant
3.82354887 −2	*E*
−8.77780173 −7	E^2
−1.00379382 −10	E^3
−1.29079177 −13	E^4

Range from 262 to 673 K (−11 to 400 °C)
The coefficients are

2.73158004 +2	Constant
3.85720309 −2	*E*
−1.08073298 −6	E^2
5.19720128 −11	E^3
−1.13424988 −15	E^4

TABLE A5. AWG 14 *Nicrosil versus Nisil thermocouples—quadratic, cubic, and quartic approximations to the temperature data as a function of voltage in selected temperature ranges. The expansion is of the form* $T=A_1E+A_2E^2+A_3E^3+A_4E^4$, *where* T *is in degrees Celsius and* E *is in microvolts.*

Temperature range (°C)	A_1 Argument	Exp.	A_2 Argument	Exp.	A_3 Argument	Exp.	A_4 Argument	Exp.	Error range (°C)
I. Quadratic equation									
0 to 50	3.860831	−2	−9.570146	−7	--	--	--	--	<0.01
0 to 400	3.656723	−2	−4.566896	−7	--	--	--	--	−1.7 to 2.5
450 to 1000	3.141413	−2	−1.105032	−7	--	--	--	--	−5 to 8
850 to 1000	2.873831	−2	−3.054420	−8	--	--	--	--	−3 to 4
1000 to 1300	2.820624	−2	−1.847854	−8	--	--	--	--	−1 to 2
II. Cubic equation									
0 to 50	3.861843	−2	−9.812299	−7	1.300932	−11	--	--	<0.01
0 to 400	3.825962	−2	−8.862736	−7	2.434387	−11	--	--	−0.3 to 0.3
450 to 1000	3.445072	−2	−3.482337	−7	4.397892	−12	--	--	−0.6 to 1.0
850 to 1000	3.240401	−2	−2.192067	−7	2.382986	−12	--	--	−0.1 to 0.1
1000 to 1300	3.226729	−2	−2.126340	−7	2.304693	−12	--	--	−0.01 to 0.01
III. Quartic equation									
0 to 50	3.861153	−2	−9.513633	−7	−2.466762	−11	1.446443	−14	<0.01
0 to 400	3.868881	−2	−1.083431	−6	5.055108	−11	−1.056823	−15	−0.02 to 0.02
450 to 1000	3.593932	−2	−5.313789	−7	1.158359	−11	−9.053322	−17	−0.1 to 0.1
850 to 1000	3.308804	−2	−2.726068	−7	3.756099	−12	−1.163691	−17	−0.05 to 0.04
1000 to 1300	3.184042	−2	−1.819054	−7	1.570465	−12	5.823682	−18	<0.01

TABLE A6. AWG 14 *Nicrosil versus Nisil thermocouples—quadratic, cubic, and quartic approximations to the voltage data as a function of temperature for variable reference junction corrections. The expansion is of the form* $E=A_1T+A_2T^2+A_3T^3+A_4T^4$, *where* T *is in degrees Celsius and* E *is in microvolts.*

Temperature range (°C)	A_1 Argument	Exp.	A_2 Argument	Exp.	A_3 Argument	Exp.	A_4 Argument	Exp.	Error range (μV)
I. Quadratic equation									
0 to 50	2.587482	1	1.826214	−2	--	--	--	--	−0.09 to 0.1
II. Cubic equation									
0 to 50	2.589489	1	1.697919	−2	1.843898	−5	--	--	−0.04 to 0.06
III. Quartic equation									
0 to 50	2.589943	1	1.645332	−2	3.617621	−5	−1.822097	−7	−0.03 to 0.05

TABLE A7. AWG 14 *Nicrosil versus Nisil thermocouples—overlapping quadratic approximations to the temperature data as a function of voltage. The expansion is of the form* $T = A_0 + A_1E + A_2E^2$, *where* T *is in kelvins and* E *is in microvolts. Over most of each range the temperature error is less than 0.02 percent.*

Range from 273 to 394 K (0 to 91 °C)
The coefficients (argument and exponent) are

2.73195897 +2	Constant
3.84234905 −2	*E*
−8.56002843 −7	E^2

Range from 358 to 510 K (85 to 237 °C)
The coefficients are

2.76356401 +2	Constant
3.63148831 −2	*E*
−5.09733325 −7	E^2

Range from 462 to 658 K (189 to 385 °C)
The coefficients are

2.87166063 +2	Constant
3.29364427 −2	*E*
−2.47604989 −7	E^2

Range from 598 to 886 K (325 to 613 °C)
The coefficients are

3.06929499 +2	Constant
2.94999352 −2	*E*
−9.86158543 −8	E^2

Range from 802 to 1182 K (529 to 909 °C)
The coefficients are

3.42522337 +2	Constant
2.58934339 −2	*E*
−7.44508115 −9	E^2

Range from 1074 to 1573 K (801 to 1300 °C)
The coefficients are

4.02432540 +2	Constant
2.20306185 −2	*E*
5.47686632 −8	E^2

TABLE A8. AWG 14 *Nicrosil versus Nisil thermocouples—overlapping cubic approximations to the temperature data as a function of voltage. The expansion is of the form* $T = A_0 + A_1E + A_2E^2 + A_3E^3$, *where* T *is in kelvins and* E *is in microvolts. Over most of each range the temperature error is less than 0.02 percent.*

Range from 273 to 474 K (0 to 201 °C)
The coefficients (argument and exponent) are

2.73147117 +2	Constant
3.86594460 −2	*E*
−1.04623626 −6	E^2
3.88528636 −11	E^3

Range from 430 to 802 K (157 to 529 °C)
The coefficients are

2.80700025 +2	Constant
3.51607022 −2	*E*
−4.97641434 −7	E^2
9.20465614 −12	E^3

Range from 726 to 1573 K (453 to 1300 °C)
The coefficients are

3.14791658 +2	Constant
2.92239025 −2	*E*
−1.39229018 −7	E^2
1.71985311 −12	E^3

TABLE A9. AWG 14 *Nicrosil versus Nisil thermocouples—overlapping quartic approximations to the temperature data as a function of voltage. The expansion is of the form* $T = A_0 + A_1E + A_2E^2 + A_3E^3 + A_4E^4$, *where* T *is in kelvins and* E *is in microvolts. Over most of each range the temperature error is less than 0.02 percent.*

Range from 273 to 638 K (0 to 365 °C)
The coefficients (argument and exponent) are

2.73134350 +2	Constant
3.87205729 −2	*E*
−1.09710024 −6	E^2
5.25218480 −11	E^3
−1.14636136 −15	E^4

Range from 578 to 1573 K (305 to 1300 °C)
The coefficients are

2.94724845 +2	Constant
3.21321378 −2	*E*
−2.89538382 −2	E^2
5.02114728 −12	E^3
−2.61445196 −17	E^4

Appendix B. Supplementary Reference Tables for Nicrosil versus Nisil Thermocouples: Temperature (°C) and (°F) as a Function of Thermoelectric Voltage

The full precision coefficients given in the main text are used to generate the voltage as a function of temperature data given in section 7. The tables in this appendix give the reverse dependence—temperature as a function of voltage. Table B1 presents the data in degrees Celsius for *AWG 28* wire; and table B2, for *AWG 14* wire. Table B3 presents the data in degrees Fahrenheit for *AWG 28* wire; and table B4, for *AWG 14* wire.

The temperature as a function of voltage data given in the following tables were obtained by iteration in the primary equations for voltage as a function of temperature.

TABLE B1. AWG 28 *Nicrosil versus Nisil thermocouples—temperature (°C) as a function of thermoelectric voltage, reference junctions at 0 °C.*

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
	TEMPERATURES IN DEGREES C (IPTS 1968)											
-4.30	-245.86	-248.90	-252.43	-256.79	-263.10							-4.30
-4.20	-225.63	-227.23	-228.88	-230.61	-232.41	-234.30	-236.30	-238.42	-240.69	-243.16	-245.86	-4.20
-4.10	-212.02	-213.24	-214.48	-215.75	-217.05	-218.39	-219.75	-221.16	-222.60	-224.09	-225.63	-4.10
-4.00	-200.98	-202.00	-203.05	-204.10	-205.18	-206.27	-207.38	-208.51	-209.66	-210.83	-212.02	-4.00
-3.90	-191.40	-192.31	-193.22	-194.15	-195.09	-196.04	-197.00	-197.98	-198.96	-199.96	-200.98	-3.90
-3.80	-182.79	-183.62	-184.45	-185.29	-186.14	-186.99	-187.86	-188.73	-189.61	-190.50	-191.40	-3.80
-3.70	-174.89	-175.65	-176.42	-177.20	-177.98	-178.76	-179.56	-180.36	-181.16	-181.97	-182.79	-3.70
-3.60	-167.53	-168.25	-168.97	-169.69	-170.42	-171.15	-171.89	-172.63	-173.38	-174.13	-174.89	-3.60
-3.50	-160.61	-161.28	-161.96	-162.65	-163.33	-164.02	-164.72	-165.41	-166.12	-166.82	-167.53	-3.50
-3.40	-154.04	-154.68	-155.33	-155.97	-156.63	-157.28	-157.94	-158.60	-159.27	-159.94	-160.61	-3.40
-3.30	-147.76	-148.38	-149.00	-149.62	-150.24	-150.87	-151.49	-152.13	-152.76	-153.40	-154.04	-3.30
-3.20	-141.74	-142.33	-142.93	-143.52	-144.12	-144.72	-145.33	-145.93	-146.54	-147.15	-147.76	-3.20
-3.10	-135.94	-136.51	-137.09	-137.66	-138.24	-138.82	-139.40	-139.98	-140.57	-141.15	-141.74	-3.10
-3.00	-130.33	-130.89	-131.44	-132.00	-132.56	-133.12	-133.68	-134.24	-134.81	-135.37	-135.94	-3.00
-2.90	-124.90	-125.43	-125.97	-126.51	-127.05	-127.60	-128.14	-128.69	-129.23	-129.78	-130.33	-2.90
-2.80	-119.61	-120.13	-120.66	-121.18	-121.71	-122.23	-122.76	-123.30	-123.83	-124.36	-124.90	-2.80
-2.70	-114.46	-114.97	-115.48	-115.99	-116.50	-117.02	-117.53	-118.05	-118.57	-119.09	-119.61	-2.70
-2.60	-109.43	-109.92	-110.42	-110.92	-111.43	-111.93	-112.43	-112.94	-113.44	-113.95	-114.46	-2.60
-2.50	-104.51	-104.99	-105.48	-105.97	-106.46	-106.95	-107.45	-107.94	-108.43	-108.93	-109.43	-2.50
-2.40	-99.69	-100.16	-100.64	-101.12	-101.60	-102.08	-102.57	-103.05	-103.53	-104.02	-104.51	-2.40
-2.30	-94.96	-95.43	-95.90	-96.37	-96.84	-97.31	-97.78	-98.26	-98.73	-99.21	-99.69	-2.30
-2.20	-90.31	-90.77	-91.24	-91.70	-92.16	-92.63	-93.09	-93.56	-94.02	-94.49	-94.96	-2.20
-2.10	-85.74	-86.20	-86.65	-87.11	-87.56	-88.02	-88.48	-88.93	-89.39	-89.85	-90.31	-2.10
-2.00	-81.24	-81.69	-82.14	-82.59	-83.04	-83.49	-83.94	-84.39	-84.84	-85.29	-85.74	-2.00
-1.90	-76.81	-77.25	-77.69	-78.13	-78.58	-79.02	-79.46	-79.91	-80.35	-80.80	-81.24	-1.90
-1.80	-72.43	-72.87	-73.30	-73.74	-74.18	-74.61	-75.05	-75.49	-75.93	-76.37	-76.81	-1.80
-1.70	-68.11	-68.54	-68.97	-69.40	-69.84	-70.27	-70.70	-71.13	-71.57	-72.00	-72.43	-1.70
-1.60	-63.84	-64.27	-64.69	-65.12	-65.55	-65.97	-66.40	-66.83	-67.26	-67.68	-68.11	-1.60
-1.50	-59.62	-60.04	-60.46	-60.88	-61.30	-61.73	-62.15	-62.57	-63.00	-63.42	-63.84	-1.50
-1.40	-55.44	-55.86	-56.27	-56.69	-57.11	-57.53	-57.94	-58.36	-58.78	-59.20	-59.62	-1.40
-1.30	-51.30	-51.71	-52.13	-52.54	-52.95	-53.37	-53.78	-54.19	-54.61	-55.03	-55.44	-1.30
-1.20	-47.20	-47.61	-48.02	-48.42	-48.83	-49.24	-49.66	-50.07	-50.48	-50.89	-51.30	-1.20
-1.10	-43.13	-43.53	-43.94	-44.35	-44.75	-45.16	-45.57	-45.97	-46.38	-46.79	-47.20	-1.10
-1.00	-39.09	-39.49	-39.90	-40.30	-40.70	-41.11	-41.51	-41.91	-42.32	-42.72	-43.13	-1.00
-0.90	-35.08	-35.48	-35.88	-36.28	-36.68	-37.08	-37.48	-37.89	-38.29	-38.69	-39.09	-0.90
-0.80	-31.10	-31.50	-31.90	-32.29	-32.69	-33.09	-33.49	-33.89	-34.28	-34.68	-35.08	-0.80
-0.70	-27.14	-27.54	-27.93	-28.33	-28.72	-29.12	-29.52	-29.91	-30.31	-30.70	-31.10	-0.70
-0.60	-23.21	-23.60	-24.00	-24.39	-24.78	-25.18	-25.57	-25.96	-26.36	-26.75	-27.14	-0.60
-0.50	-19.30	-19.69	-20.08	-20.47	-20.86	-21.25	-21.64	-22.04	-22.43	-22.82	-23.21	-0.50
-0.40	-15.41	-15.80	-16.18	-16.57	-16.96	-17.35	-17.74	-18.13	-18.52	-18.91	-19.30	-0.40
-0.30	-11.53	-11.92	-12.31	-12.69	-13.08	-13.47	-13.85	-14.24	-14.63	-15.02	-15.41	-0.30
-0.20	-7.67	-8.06	-8.44	-8.83	-9.21	-9.60	-9.99	-10.37	-10.76	-11.15	-11.53	-0.20
-0.10	-3.83	-4.21	-4.60	-4.98	-5.37	-5.75	-6.13	-6.52	-6.90	-7.29	-7.67	-0.10
0.00	0.00	-0.38	-0.76	-1.15	-1.53	-1.91	-2.30	-2.68	-3.06	-3.45	-3.83	0.00
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

Table B1. AWG 28 *Nicrosil versus Nisil thermocouples—temperature (°C) as a function of thermoelectric voltage, reference junctions at 0 °C*—Continued

TEMPERATURES IN DEGREES C (IPTS 1968)

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
0.00	0.00	0.38	0.76	1.15	1.53	1.91	2.29	2.67	3.06	3.44	3.82	0.00
0.10	3.82	4.20	4.58	4.96	5.34	5.72	6.10	6.48	6.86	7.24	7.62	0.10
0.20	7.62	8.00	8.38	8.76	9.14	9.52	9.90	10.28	10.66	11.04	11.42	0.20
0.30	11.42	11.80	12.17	12.55	12.93	13.31	13.69	14.06	14.44	14.82	15.20	0.30
0.40	15.20	15.57	15.95	16.33	16.70	17.08	17.46	17.83	18.21	18.58	18.96	0.40
0.50	18.96	19.33	19.71	20.08	20.46	20.83	21.21	21.58	21.96	22.33	22.71	0.50
0.60	22.71	23.08	23.45	23.83	24.20	24.57	24.95	25.32	25.69	26.06	26.44	0.60
0.70	26.44	26.81	27.18	27.55	27.92	28.29	28.66	29.04	29.41	29.78	30.15	0.70
0.80	30.15	30.52	30.89	31.26	31.63	32.00	32.37	32.74	33.11	33.47	33.84	0.80
0.90	33.84	34.21	34.58	34.95	35.32	35.68	36.05	36.42	36.79	37.15	37.52	0.90
1.00	37.52	37.89	38.25	38.62	38.98	39.35	39.72	40.08	40.45	40.81	41.18	1.00
1.10	41.18	41.54	41.91	42.27	42.64	43.00	43.36	43.73	44.09	44.45	44.82	1.10
1.20	44.82	45.18	45.54	45.91	46.27	46.63	46.99	47.35	47.72	48.08	48.44	1.20
1.30	48.44	48.80	49.16	49.52	49.88	50.24	50.60	50.96	51.32	51.68	52.04	1.30
1.40	52.04	52.40	52.76	53.12	53.48	53.84	54.19	54.55	54.91	55.27	55.63	1.40
1.50	55.63	55.98	56.34	56.70	57.05	57.41	57.77	58.12	58.48	58.84	59.19	1.50
1.60	59.19	59.55	59.90	60.26	60.61	60.97	61.32	61.68	62.03	62.39	62.74	1.60
1.70	62.74	63.09	63.45	63.80	64.15	64.51	64.86	65.21	65.57	65.92	66.27	1.70
1.80	66.27	66.62	66.97	67.33	67.68	68.03	68.38	68.73	69.08	69.43	69.78	1.80
1.90	69.78	70.13	70.48	70.83	71.18	71.53	71.88	72.23	72.58	72.93	73.28	1.90
2.00	73.28	73.63	73.98	74.32	74.67	75.02	75.37	75.72	76.06	76.41	76.76	2.00
2.10	76.76	77.10	77.45	77.80	78.14	78.49	78.84	79.18	79.53	79.87	80.22	2.10
2.20	80.22	80.56	80.91	81.25	81.60	81.94	82.29	82.63	82.98	83.32	83.66	2.20
2.30	83.66	84.01	84.35	84.69	85.04	85.38	85.72	86.07	86.41	86.75	87.09	2.30
2.40	87.09	87.43	87.78	88.12	88.46	88.80	89.14	89.48	89.82	90.16	90.51	2.40
2.50	90.51	90.85	91.19	91.53	91.87	92.21	92.55	92.89	93.22	93.56	93.90	2.50
2.60	93.90	94.24	94.58	94.92	95.26	95.60	95.93	96.27	96.61	96.95	97.29	2.60
2.70	97.29	97.62	97.96	98.30	98.63	98.97	99.31	99.64	99.98	100.32	100.65	2.70
2.80	100.65	100.99	101.32	101.66	102.00	102.33	102.67	103.00	103.34	103.67	104.01	2.80
2.90	104.01	104.34	104.67	105.01	105.34	105.68	106.01	106.34	106.68	107.01	107.34	2.90
3.00	107.34	107.68	108.01	108.34	108.68	109.01	109.34	109.67	110.01	110.34	110.67	3.00
3.10	110.67	111.00	111.33	111.66	112.00	112.33	112.66	112.99	113.32	113.65	113.98	3.10
3.20	113.98	114.31	114.64	114.97	115.30	115.63	115.96	116.29	116.62	116.95	117.28	3.20
3.30	117.28	117.61	117.94	118.27	118.60	118.92	119.25	119.58	119.91	120.24	120.56	3.30
3.40	120.56	120.89	121.22	121.55	121.88	122.20	122.53	122.86	123.18	123.51	123.84	3.40
3.50	123.84	124.16	124.49	124.82	125.14	125.47	125.80	126.12	126.45	126.77	127.10	3.50
3.60	127.10	127.42	127.75	128.07	128.40	128.72	129.05	129.37	129.70	130.02	130.35	3.60
3.70	130.35	130.67	130.99	131.32	131.64	131.97	132.29	132.61	132.94	133.26	133.58	3.70
3.80	133.58	133.91	134.23	134.55	134.87	135.20	135.52	135.84	136.16	136.49	136.81	3.80
3.90	136.81	137.13	137.45	137.77	138.09	138.42	138.74	139.06	139.38	139.70	140.02	3.90
4.00	140.02	140.34	140.66	140.98	141.30	141.62	141.94	142.26	142.58	142.90	143.22	4.00
4.10	143.22	143.54	143.86	144.18	144.50	144.82	145.14	145.46	145.78	146.10	146.42	4.10
4.20	146.42	146.73	147.05	147.37	147.69	148.01	148.33	148.64	148.96	149.28	149.60	4.20
4.30	149.60	149.92	150.23	150.55	150.87	151.18	151.50	151.82	152.14	152.45	152.77	4.30
4.40	152.77	153.09	153.40	153.72	154.03	154.35	154.67	154.98	155.30	155.61	155.93	4.40
4.50	155.93	156.25	156.56	156.88	157.19	157.51	157.82	158.14	158.45	158.77	159.08	4.50
4.60	159.08	159.40	159.71	160.02	160.34	160.65	160.97	161.28	161.59	161.91	162.22	4.60
4.70	162.22	162.54	162.85	163.16	163.48	163.79	164.10	164.42	164.73	165.04	165.35	4.70
4.80	165.35	165.67	165.98	166.29	166.60	166.92	167.23	167.54	167.85	168.16	168.48	4.80
4.90	168.48	168.79	169.10	169.41	169.72	170.03	170.35	170.66	170.97	171.28	171.59	4.90
5.00	171.59	171.90	172.21	172.52	172.83	173.14	173.45	173.76	174.07	174.38	174.69	5.00
5.10	174.69	175.00	175.31	175.62	175.93	176.24	176.55	176.86	177.17	177.48	177.79	5.10
5.20	177.79	178.10	178.41	178.72	179.03	179.34	179.64	179.95	180.26	180.57	180.88	5.20
5.30	180.88	181.19	181.49	181.80	182.11	182.42	182.73	183.03	183.34	183.65	183.96	5.30
5.40	183.96	184.26	184.57	184.88	185.19	185.49	185.80	186.11	186.41	186.72	187.03	5.40
5.50	187.03	187.33	187.64	187.95	188.25	188.56	188.86	189.17	189.48	189.78	190.09	5.50
5.60	190.09	190.39	190.70	191.01	191.31	191.62	191.92	192.23	192.53	192.84	193.14	5.60
5.70	193.14	193.45	193.75	194.06	194.36	194.67	194.97	195.28	195.58	195.88	196.19	5.70
5.80	196.19	196.49	196.80	197.10	197.41	197.71	198.01	198.32	198.62	198.92	199.23	5.80
5.90	199.23	199.53	199.83	200.14	200.44	200.74	201.05	201.35	201.65	201.96	202.26	5.90
6.00	202.26	202.56	202.86	203.17	203.47	203.77	204.07	204.38	204.68	204.98	205.28	6.00
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

Table B1. AWG 28 *Nicrosil versus Nisil thermocouples—temperature (°C) as a function of thermoelectric voltage, reference junctions at 0 °C*—Continued

TEMPERATURES IN DEGREES C (IPTS 1968)

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
6.00	202.26	202.56	202.86	203.17	203.47	203.77	204.07	204.38	204.68	204.98	205.28	6.00
6.10	205.28	205.58	205.88	206.19	206.49	206.79	207.09	207.39	207.69	208.00	208.30	6.10
6.20	208.30	208.60	208.90	209.20	209.50	209.80	210.10	210.40	210.70	211.00	211.31	6.20
6.30	211.31	211.61	211.91	212.21	212.51	212.81	213.11	213.41	213.71	214.01	214.31	6.30
6.40	214.31	214.61	214.91	215.21	215.50	215.80	216.10	216.40	216.70	217.00	217.30	6.40
6.50	217.30	217.60	217.90	218.20	218.50	218.79	219.09	219.39	219.69	219.99	220.29	6.50
6.60	220.29	220.59	220.88	221.18	221.48	221.78	222.08	222.37	222.67	222.97	223.27	6.60
6.70	223.27	223.57	223.86	224.16	224.46	224.75	225.05	225.35	225.65	225.94	226.24	6.70
6.80	226.24	226.54	226.83	227.13	227.43	227.72	228.02	228.32	228.61	228.91	229.21	6.80
6.90	229.21	229.50	229.80	230.10	230.39	230.69	230.98	231.28	231.58	231.87	232.17	6.90
7.00	232.17	232.46	232.76	233.05	233.35	233.64	233.94	234.24	234.53	234.83	235.12	7.00
7.10	235.12	235.42	235.71	236.01	236.30	236.59	236.89	237.18	237.48	237.77	238.07	7.10
7.20	238.07	238.36	238.66	238.95	239.24	239.54	239.83	240.13	240.42	240.71	241.01	7.20
7.30	241.01	241.30	241.60	241.89	242.18	242.48	242.77	243.06	243.36	243.65	243.94	7.30
7.40	243.94	244.23	244.53	244.82	245.11	245.41	245.70	245.99	246.28	246.58	246.87	7.40
7.50	246.87	247.16	247.45	247.75	248.04	248.33	248.62	248.92	249.21	249.50	249.79	7.50
7.60	249.79	250.08	250.38	250.67	250.96	251.25	251.54	251.83	252.12	252.42	252.71	7.60
7.70	252.71	253.00	253.29	253.58	253.87	254.16	254.45	254.75	255.04	255.33	255.62	7.70
7.80	255.62	255.91	256.20	256.49	256.78	257.07	257.36	257.65	257.94	258.23	258.52	7.80
7.90	258.52	258.81	259.10	259.39	259.68	259.97	260.26	260.55	260.84	261.13	261.42	7.90
8.00	261.42	261.71	262.00	262.29	262.58	262.87	263.16	263.44	263.73	264.02	264.31	8.00
8.10	264.31	264.60	264.89	265.18	265.47	265.76	266.04	266.33	266.62	266.91	267.20	8.10
8.20	267.20	267.49	267.78	268.06	268.35	268.64	268.93	269.22	269.50	269.79	270.08	8.20
8.30	270.08	270.37	270.66	270.94	271.23	271.52	271.81	272.09	272.38	272.67	272.96	8.30
8.40	272.96	273.24	273.53	273.82	274.10	274.39	274.68	274.97	275.25	275.54	275.83	8.40
8.50	275.83	276.11	276.40	276.69	276.97	277.26	277.55	277.83	278.12	278.40	278.69	8.50
8.60	278.69	278.98	279.26	279.55	279.84	280.12	280.41	280.69	280.98	281.27	281.55	8.60
8.70	281.55	281.84	282.12	282.41	282.69	282.98	283.26	283.55	283.84	284.12	284.41	8.70
8.80	284.41	284.69	284.98	285.26	285.55	285.83	286.12	286.40	286.69	286.97	287.26	8.80
8.90	287.26	287.54	287.82	288.11	288.39	288.68	288.96	289.25	289.53	289.82	290.10	8.90
9.00	290.10	290.38	290.67	290.95	291.24	291.52	291.80	292.09	292.37	292.66	292.94	9.00
9.10	292.94	293.22	293.51	293.79	294.07	294.36	294.64	294.92	295.21	295.49	295.77	9.10
9.20	295.77	296.06	296.34	296.62	296.91	297.19	297.47	297.76	298.04	298.32	298.60	9.20
9.30	298.60	298.89	299.17	299.45	299.73	300.02	300.30	300.58	300.86	301.15	301.43	9.30
9.40	301.43	301.71	301.99	302.23	302.56	302.84	303.12	303.40	303.69	303.97	304.25	9.40
9.50	304.25	304.53	304.81	305.10	305.38	305.66	305.94	306.22	306.50	306.78	307.07	9.50
9.60	307.07	307.35	307.63	307.91	308.19	308.47	308.75	309.03	309.32	309.60	309.88	9.60
9.70	309.88	310.16	310.44	310.72	311.00	311.28	311.56	311.84	312.12	312.40	312.69	9.70
9.80	312.69	312.97	313.25	313.53	313.81	314.09	314.37	314.65	314.93	315.21	315.49	9.80
9.90	315.49	315.77	316.05	316.33	316.61	316.89	317.17	317.45	317.73	318.01	318.29	9.90
10.00	318.29	318.57	318.85	319.13	319.41	319.69	319.96	320.24	320.52	320.80	321.08	10.00
10.10	321.08	321.36	321.64	321.92	322.20	322.48	322.76	323.04	323.32	323.59	323.87	10.10
10.20	323.87	324.15	324.43	324.71	324.99	325.27	325.55	325.82	326.10	326.38	326.66	10.20
10.30	326.66	326.94	327.22	327.50	327.77	328.05	328.33	328.61	328.89	329.16	329.44	10.30
10.40	329.44	329.72	330.00	330.28	330.55	330.83	331.11	331.39	331.67	331.94	332.22	10.40
10.50	332.22	332.50	332.78	333.05	333.33	333.61	333.89	334.17	334.44	334.72	335.00	10.50
10.60	335.00	335.27	335.55	335.83	336.11	336.38	336.66	336.94	337.22	337.49	337.77	10.60
10.70	337.77	338.05	338.32	338.60	338.88	339.15	339.43	339.71	339.98	340.26	340.54	10.70
10.80	340.54	340.81	341.09	341.37	341.64	341.92	342.20	342.47	342.75	343.03	343.30	10.80
10.90	343.30	343.58	343.85	344.13	344.41	344.68	344.96	345.24	345.51	345.79	346.06	10.90
11.00	346.06	346.34	346.62	346.89	347.17	347.44	347.72	347.99	348.27	348.55	348.82	11.00
11.10	348.82	349.10	349.37	349.65	349.92	350.20	350.47	350.75	351.03	351.30	351.58	11.10
11.20	351.58	351.85	352.13	352.40	352.68	352.95	353.23	353.50	353.78	354.05	354.33	11.20
11.30	354.33	354.60	354.88	355.15	355.43	355.70	355.98	356.25	356.53	356.80	357.08	11.30
11.40	357.08	357.35	357.63	357.90	358.17	358.45	358.72	359.00	359.27	359.55	359.82	11.40
11.50	359.82	360.10	360.37	360.64	360.92	361.19	361.47	361.74	362.02	362.29	362.56	11.50
11.60	362.56	362.84	363.11	363.39	363.66	363.93	364.21	364.48	364.76	365.03	365.30	11.60
11.70	365.30	365.58	365.85	366.12	366.40	366.67	366.95	367.22	367.49	367.77	368.04	11.70
11.80	368.04	368.31	368.59	368.86	369.13	369.41	369.68	369.95	370.23	370.50	370.77	11.80
11.90	370.77	371.05	371.32	371.59	371.87	372.14	372.41	372.68	372.96	373.23	373.50	11.90
12.00	373.50	373.78	374.05	374.32	374.60	374.87	375.14	375.41	375.69	375.96	376.23	12.00
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

TABLE B1. AWG 28 *Nicrosil versus Nisil thermocouples—temperature (°C) as a function of thermoelectric voltage, reference junctions at 0 °C*—Continued

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
						TEMPERATURES IN DEGREES C (IPTS 1968)						
12.00	373.50	373.78	374.05	374.32	374.60	374.87	375.14	375.41	375.69	375.96	376.23	12.00
12.10	376.23	376.50	376.78	377.05	377.32	377.59	377.87	378.14	378.41	378.68	378.96	12.10
12.20	378.96	379.23	379.50	379.77	380.05	380.32	380.59	380.86	381.14	381.41	381.68	12.20
12.30	381.68	381.95	382.22	382.50	382.77	383.04	383.31	383.58	383.86	384.13	384.40	12.30
12.40	384.40	384.67	384.94	385.21	385.49	385.76	386.03	386.30	386.57	386.84	387.12	12.40
12.50	387.12	387.39	387.66	387.93	388.20	388.47	388.75	389.02	389.29	389.56	389.83	12.50
12.60	389.83	390.10	390.37	390.64	390.92	391.19	391.46	391.73	392.00	392.27	392.54	12.60
12.70	392.54	392.81	393.08	393.36	393.63	393.90	394.17	394.44	394.71	394.98	395.25	12.70
12.80	395.25	395.52	395.79	396.06	396.33	396.61	396.88	397.15	397.42	397.69	397.96	12.80
12.90	397.96	398.23	398.50	398.77	399.04	399.31	399.58	399.85				12.90
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

Table B2. AWG 14 *Nicrosil versus Nisil thermocouples—temperature (°C) as a function of thermoelectric voltage, reference junctions at 0 °C.*

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
					TEMPERATURES IN DEGREES C (IPTS 1968)							
0.00	0.00	0.39	0.77	1.16	1.54	1.93	2.31	2.70	3.08	3.47	3.85	0.00
0.10	3.85	4.24	4.62	5.00	5.39	5.77	6.15	6.54	6.92	7.30	7.68	0.10
0.20	7.68	8.07	8.45	8.83	9.21	9.59	9.97	10.36	10.74	11.12	11.50	0.20
0.30	11.50	11.88	12.26	12.64	13.02	13.40	13.78	14.15	14.53	14.91	15.29	0.30
0.40	15.29	15.67	16.05	16.43	16.80	17.18	17.56	17.94	18.31	18.69	19.07	0.40
0.50	19.07	19.44	19.82	20.19	20.57	20.95	21.32	21.70	22.07	22.45	22.82	0.50
0.60	22.82	23.19	23.57	23.94	24.32	24.69	25.06	25.44	25.81	26.18	26.56	0.60
0.70	26.56	26.93	27.30	27.67	28.05	28.42	28.79	29.16	29.53	29.90	30.27	0.70
0.80	30.27	30.64	31.01	31.38	31.75	32.12	32.49	32.86	33.23	33.60	33.97	0.80
0.90	33.97	34.34	34.71	35.08	35.44	35.81	36.18	36.55	36.92	37.28	37.65	0.90
1.00	37.65	38.02	38.38	38.75	39.12	39.48	39.85	40.21	40.58	40.94	41.31	1.00
1.10	41.31	41.67	42.04	42.40	42.77	43.13	43.50	43.86	44.22	44.59	44.95	1.10
1.20	44.95	45.31	45.68	46.04	46.40	46.77	47.13	47.49	47.85	48.21	48.58	1.20
1.30	48.58	48.94	49.30	49.66	50.02	50.38	50.74	51.10	51.46	51.82	52.18	1.30
1.40	52.18	52.54	52.90	53.26	53.62	53.98	54.34	54.69	55.05	55.41	55.77	1.40
1.50	55.77	56.13	56.48	56.84	57.20	57.55	57.91	58.27	58.63	58.98	59.34	1.50
1.60	59.34	59.69	60.05	60.41	60.76	61.12	61.47	61.83	62.18	62.54	62.89	1.60
1.70	62.89	63.24	63.60	63.95	64.31	64.66	65.01	65.37	65.72	66.07	66.43	1.70
1.80	66.43	66.78	67.13	67.48	67.83	68.19	68.54	68.89	69.24	69.59	69.94	1.80
1.90	69.94	70.29	70.65	71.00	71.35	71.70	72.05	72.40	72.75	73.10	73.45	1.90
2.00	73.45	73.79	74.14	74.49	74.84	75.19	75.54	75.89	76.24	76.58	76.93	2.00
2.10	76.93	77.28	77.63	77.97	78.32	78.67	79.01	79.36	79.71	80.05	80.40	2.10
2.20	80.40	80.75	81.09	81.44	81.78	82.13	82.47	82.82	83.16	83.51	83.85	2.20
2.30	83.85	84.20	84.54	84.89	85.23	85.57	85.92	86.26	86.61	86.95	87.29	2.30
2.40	87.29	87.63	87.98	88.32	88.66	89.00	89.35	89.69	90.03	90.37	90.71	2.40
2.50	90.71	91.06	91.40	91.74	92.08	92.42	92.76	93.10	93.44	93.78	94.12	2.50
2.60	94.12	94.46	94.80	95.14	95.48	95.82	96.16	96.50	96.84	97.18	97.51	2.60
2.70	97.51	97.85	98.19	98.53	98.87	99.20	99.54	99.88	100.22	100.55	100.89	2.70
2.80	100.89	101.23	101.57	101.90	102.24	102.58	102.91	103.25	103.58	103.92	104.26	2.80
2.90	104.26	104.59	104.93	105.26	105.60	105.93	106.27	106.60	106.94	107.27	107.60	2.90
3.00	107.60	107.94	108.27	108.61	108.94	109.27	109.61	109.94	110.27	110.61	110.94	3.00
3.10	110.94	111.27	111.61	111.94	112.27	112.60	112.94	113.27	113.60	113.93	114.26	3.10
3.20	114.26	114.59	114.93	115.26	115.59	115.92	116.25	116.58	116.91	117.24	117.57	3.20
3.30	117.57	117.90	118.23	118.56	118.89	119.22	119.55	119.88	120.21	120.54	120.87	3.30
3.40	120.87	121.20	121.52	121.85	122.18	122.51	122.84	123.17	123.49	123.82	124.15	3.40
3.50	124.15	124.48	124.80	125.13	125.46	125.79	126.11	126.44	126.77	127.09	127.42	3.50
3.60	127.42	127.75	128.07	128.40	128.72	129.05	129.38	129.70	130.03	130.35	130.68	3.60
3.70	130.68	131.00	131.33	131.65	131.98	132.30	132.63	132.95	133.28	133.60	133.92	3.70
3.80	133.92	134.25	134.57	134.89	135.22	135.54	135.86	136.19	136.51	136.83	137.16	3.80
3.90	137.16	137.48	137.80	138.12	138.45	138.77	139.09	139.41	139.74	140.06	140.38	3.90
4.00	140.38	140.70	141.02	141.34	141.66	141.99	142.31	142.63	142.95	143.27	143.59	4.00
4.10	143.59	143.91	144.23	144.55	144.87	145.19	145.51	145.83	146.15	146.47	146.79	4.10
4.20	146.79	147.11	147.43	147.75	148.07	148.38	148.70	149.02	149.34	149.66	149.98	4.20
4.30	149.98	150.30	150.61	150.93	151.25	151.57	151.88	152.20	152.52	152.84	153.15	4.30
4.40	153.15	153.47	153.79	154.11	154.42	154.74	155.06	155.37	155.69	156.00	156.32	4.40
4.50	156.32	156.64	156.95	157.27	157.58	157.90	158.22	158.53	158.85	159.16	159.48	4.50
4.60	159.48	159.79	160.11	160.42	160.74	161.05	161.37	161.68	161.99	162.31	162.62	4.60
4.70	162.62	162.94	163.25	163.56	163.88	164.19	164.51	164.82	165.13	165.45	165.76	4.70
4.80	165.76	166.07	166.38	166.70	167.01	167.32	167.64	167.95	168.26	168.57	168.88	4.80
4.90	168.88	169.20	169.51	169.82	170.13	170.44	170.76	171.07	171.38	171.69	172.00	4.90
5.00	172.00	172.31	172.62	172.93	173.24	173.56	173.87	174.18	174.49	174.80	175.11	5.00
5.10	175.11	175.42	175.73	176.04	176.35	176.66	176.97	177.28	177.59	177.90	178.21	5.10
5.20	178.21	178.51	178.82	179.13	179.44	179.75	180.06	180.37	180.68	180.98	181.29	5.20
5.30	181.29	181.60	181.91	182.22	182.53	182.83	183.14	183.45	183.76	184.06	184.37	5.30
5.40	184.37	184.68	184.99	185.29	185.60	185.91	186.22	186.52	186.83	187.14	187.44	5.40
5.50	187.44	187.75	188.06	188.36	188.67	188.97	189.28	189.59	189.89	190.20	190.50	5.50
5.60	190.50	190.81	191.12	191.42	191.73	192.03	192.34	192.64	192.95	193.25	193.56	5.60
5.70	193.56	193.86	194.17	194.47	194.78	195.08	195.39	195.69	195.99	196.30	196.60	5.70
5.80	196.60	196.91	197.21	197.51	197.82	198.12	198.42	198.73	199.03	199.34	199.64	5.80
5.90	199.64	199.94	200.24	200.55	200.85	201.15	201.46	201.76	202.06	202.36	202.67	5.90
6.00	202.67	202.97	203.27	203.57	203.88	204.18	204.48	204.78	205.08	205.39	205.69	6.00
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

TABLE B2. AWG 14 *Nicrosil versus Nisil thermocouples—temperature (°C) as a function of thermoelectric voltage, reference junctions at 0 °C*—Continued

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
					TEMPERATURES IN DEGREES C (IPTS 1968)							
6.00	202.67	202.97	203.27	203.57	203.88	204.18	204.48	204.78	205.08	205.39	205.69	6.00
6.10	205.69	205.99	206.29	206.59	206.89	207.19	207.50	207.80	208.10	208.40	208.70	6.10
6.20	208.70	209.00	209.30	209.60	209.90	210.20	210.50	210.80	211.10	211.40	211.70	6.20
6.30	211.70	212.00	212.30	212.60	212.90	213.20	213.50	213.80	214.10	214.40	214.70	6.30
6.40	214.70	215.00	215.30	215.60	215.90	216.20	216.50	216.80	217.09	217.39	217.69	6.40
6.50	217.69	217.99	218.29	218.59	218.89	219.18	219.48	219.78	220.08	220.38	220.67	6.50
6.60	220.67	220.97	221.27	221.57	221.87	222.16	222.46	222.76	223.06	223.35	223.65	6.60
6.70	223.65	223.95	224.24	224.54	224.84	225.14	225.43	225.73	226.03	226.32	226.62	6.70
6.80	226.62	226.92	227.21	227.51	227.80	228.10	228.40	228.69	228.99	229.28	229.58	6.80
6.90	229.58	229.88	230.17	230.47	230.76	231.06	231.35	231.65	231.95	232.24	232.54	6.90
7.00	232.54	232.83	233.13	233.42	233.72	234.01	234.31	234.60	234.89	235.19	235.48	7.00
7.10	235.48	235.78	236.07	236.37	236.66	236.96	237.25	237.54	237.84	238.13	238.43	7.10
7.20	238.43	238.72	239.01	239.31	239.60	239.89	240.19	240.48	240.77	241.07	241.36	7.20
7.30	241.36	241.65	241.95	242.24	242.53	242.83	243.12	243.41	243.70	244.00	244.29	7.30
7.40	244.29	244.58	244.88	245.17	245.46	245.75	246.04	246.34	246.63	246.92	247.21	7.40
7.50	247.21	247.50	247.80	248.09	248.38	248.67	248.96	249.26	249.55	249.84	250.13	7.50
7.60	250.13	250.42	250.71	251.00	251.29	251.59	251.88	252.17	252.46	252.75	253.04	7.60
7.70	253.04	253.33	253.62	253.91	254.20	254.49	254.78	255.07	255.36	255.65	255.94	7.70
7.80	255.94	256.24	256.53	256.82	257.11	257.40	257.68	257.97	258.26	258.55	258.84	7.80
7.90	258.84	259.13	259.42	259.71	260.00	260.29	260.58	260.87	261.16	261.45	261.74	7.90
8.00	261.74	262.03	262.32	262.60	262.89	263.18	263.47	263.76	264.05	264.34	264.62	8.00
8.10	264.62	264.91	265.20	265.49	265.78	266.07	266.35	266.64	266.93	267.22	267.51	8.10
8.20	267.51	267.79	268.08	268.37	268.66	268.95	269.23	269.52	269.81	270.10	270.38	8.20
8.30	270.38	270.67	270.96	271.25	271.53	271.82	272.11	272.39	272.68	272.97	273.25	8.30
8.40	273.25	273.54	273.83	274.12	274.40	274.69	274.97	275.26	275.55	275.83	276.12	8.40
8.50	276.12	276.41	276.69	276.98	277.27	277.55	277.84	278.12	278.41	278.70	278.98	8.50
8.60	278.98	279.27	279.55	279.84	280.12	280.41	280.70	280.98	281.27	281.55	281.84	8.60
8.70	281.84	282.12	282.41	282.69	282.98	283.26	283.55	283.83	284.12	284.40	284.69	8.70
8.80	284.69	284.97	285.26	285.54	285.83	286.11	286.40	286.68	286.97	287.25	287.53	8.80
8.90	287.53	287.82	288.10	288.39	288.67	288.95	289.24	289.52	289.81	290.09	290.37	8.90
9.00	290.37	290.66	290.94	291.23	291.51	291.79	292.08	292.36	292.64	292.93	293.21	9.00
9.10	293.21	293.49	293.78	294.06	294.34	294.63	294.91	295.19	295.48	295.76	296.04	9.10
9.20	296.04	296.33	296.61	296.89	297.17	297.46	297.74	298.02	298.30	298.59	298.87	9.20
9.30	298.87	299.15	299.43	299.72	300.00	300.28	300.56	300.85	301.13	301.41	301.69	9.30
9.40	301.69	301.97	302.26	302.54	302.82	303.10	303.38	303.66	303.95	304.23	304.51	9.40
9.50	304.51	304.79	305.07	305.35	305.64	305.92	306.20	306.48	306.76	307.04	307.32	9.50
9.60	307.32	307.60	307.88	308.17	308.45	308.73	309.01	309.29	309.57	309.85	310.13	9.60
9.70	310.13	310.41	310.69	310.97	311.25	311.53	311.81	312.10	312.38	312.66	312.94	9.70
9.80	312.94	313.22	313.50	313.78	314.06	314.34	314.62	314.90	315.18	315.46	315.74	9.80
9.90	315.74	316.02	316.30	316.58	316.86	317.14	317.41	317.69	317.97	318.25	318.53	9.90
10.00	318.53	318.81	319.09	319.37	319.65	319.93	320.21	320.49	320.77	321.05	321.33	10.00
10.10	321.33	321.60	321.88	322.16	322.44	322.72	323.00	323.28	323.56	323.83	324.11	10.10
10.20	324.11	324.39	324.67	324.95	325.23	325.51	325.78	326.06	326.34	326.62	326.90	10.20
10.30	326.90	327.18	327.45	327.73	328.01	328.29	328.57	328.84	329.12	329.40	329.68	10.30
10.40	329.68	329.96	330.23	330.51	330.79	331.07	331.34	331.62	331.90	332.18	332.45	10.40
10.50	332.45	332.73	333.01	333.29	333.56	333.84	334.12	334.39	334.67	334.95	335.23	10.50
10.60	335.23	335.50	335.78	336.06	336.33	336.61	336.89	337.16	337.44	337.72	338.00	10.60
10.70	338.00	338.27	338.55	338.82	339.10	339.38	339.65	339.93	340.21	340.48	340.76	10.70
10.80	340.76	341.04	341.31	341.59	341.87	342.14	342.42	342.69	342.97	343.25	343.52	10.80
10.90	343.52	343.80	344.07	344.35	344.62	344.90	345.18	345.45	345.73	346.00	346.28	10.90
11.00	346.28	346.55	346.83	347.11	347.38	347.66	347.93	348.21	348.48	348.76	349.03	11.00
11.10	349.03	349.31	349.58	349.86	350.13	350.41	350.68	350.96	351.23	351.51	351.78	11.10
11.20	351.78	352.06	352.33	352.61	352.88	353.16	353.43	353.71	353.98	354.26	354.53	11.20
11.30	354.53	354.81	355.08	355.35	355.63	355.90	356.18	356.45	356.73	357.00	357.28	11.30
11.40	357.28	357.55	357.82	358.10	358.37	358.65	358.92	359.19	359.47	359.74	360.02	11.40
11.50	360.02	360.29	360.56	360.84	361.11	361.38	361.66	361.93	362.21	362.48	362.75	11.50
11.60	362.75	363.03	363.30	363.57	363.85	364.12	364.39	364.67	364.94	365.21	365.49	11.60
11.70	365.49	365.76	366.03	366.31	366.58	366.85	367.13	367.40	367.67	367.94	368.22	11.70
11.80	368.22	368.49	368.76	369.04	369.31	369.58	369.85	370.13	370.40	370.67	370.95	11.80
11.90	370.95	371.22	371.49	371.76	372.04	372.31	372.58	372.85	373.12	373.40	373.67	11.90
12.00	373.67	373.94	374.21	374.49	374.76	375.03	375.30	375.57	375.85	376.12	376.39	12.00
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

TABLE B2. AWG 14 *Nicrosil versus Nisil thermocouples—temperature (°C) as a function of thermoelectric voltage, reference junctions at 0 °C*—Continued

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
	TEMPERATURES IN DEGREES C (IPTS 1968)											
12.00	373.67	373.94	374.21	374.49	374.76	375.03	375.30	375.57	375.85	376.12	376.39	12.00
12.10	376.39	376.66	376.93	377.21	377.48	377.75	378.02	378.29	378.57	378.84	379.11	12.10
12.20	379.11	379.38	379.65	379.92	380.20	380.47	380.74	381.01	381.28	381.55	381.82	12.20
12.30	381.82	382.10	382.37	382.64	382.91	383.18	383.45	383.72	383.99	384.27	384.54	12.30
12.40	384.54	384.81	385.08	385.35	385.62	385.89	386.16	386.43	386.70	386.98	387.25	12.40
12.50	387.25	387.52	387.79	388.06	388.33	388.60	388.87	389.14	389.41	389.68	389.95	12.50
12.60	389.95	390.22	390.49	390.76	391.03	391.30	391.57	391.85	392.12	392.39	392.66	12.60
12.70	392.66	392.93	393.20	393.47	393.74	394.01	394.28	394.55	394.82	395.09	395.36	12.70
12.80	395.36	395.63	395.90	396.17	396.44	396.71	396.98	397.25	397.52	397.79	398.05	12.80
12.90	398.05	398.32	398.59	398.86	399.13	399.40	399.67	399.94	400.21	400.48	400.75	12.90
13.00	400.75	401.02	401.29	401.56	401.83	402.10	402.37	402.64	402.90	403.17	403.44	13.00
13.10	403.44	403.71	403.98	404.25	404.52	404.79	405.06	405.33	405.59	405.86	406.13	13.10
13.20	406.13	406.40	406.67	406.94	407.21	407.48	407.75	408.01	408.28	408.55	408.82	13.20
13.30	408.82	409.09	409.36	409.63	409.89	410.16	410.43	410.70	410.97	411.24	411.50	13.30
13.40	411.50	411.77	412.04	412.31	412.58	412.85	413.11	413.38	413.65	413.92	414.19	13.40
13.50	414.19	414.45	414.72	414.99	415.26	415.53	415.79	416.06	416.33	416.60	416.87	13.50
13.60	416.87	417.13	417.40	417.67	417.94	418.20	418.47	418.74	419.01	419.28	419.54	13.60
13.70	419.54	419.81	420.08	420.35	420.61	420.88	421.15	421.42	421.68	421.95	422.22	13.70
13.80	422.22	422.49	422.75	423.02	423.29	423.55	423.82	424.09	424.36	424.62	424.89	13.80
13.90	424.89	425.16	425.42	425.69	425.96	426.23	426.49	426.76	427.03	427.29	427.56	13.90
14.00	427.56	427.83	428.09	428.36	428.63	428.89	429.16	429.43	429.69	429.96	430.23	14.00
14.10	430.23	430.49	430.76	431.03	431.29	431.56	431.83	432.09	432.36	432.63	432.89	14.10
14.20	432.89	433.16	433.42	433.69	433.96	434.22	434.49	434.76	435.02	435.29	435.55	14.20
14.30	435.55	435.82	436.09	436.35	436.62	436.89	437.15	437.42	437.68	437.95	438.22	14.30
14.40	438.22	438.48	438.75	439.01	439.28	439.54	439.81	440.08	440.34	440.61	440.87	14.40
14.50	440.87	441.14	441.40	441.67	441.94	442.20	442.47	442.73	443.00	443.26	443.53	14.50
14.60	443.53	443.79	444.06	444.33	444.59	444.86	445.12	445.39	445.65	445.92	446.18	14.60
14.70	446.18	446.45	446.71	446.98	447.24	447.51	447.77	448.04	448.30	448.57	448.83	14.70
14.80	448.83	449.10	449.36	449.63	449.89	450.16	450.42	450.69	450.95	451.22	451.48	14.80
14.90	451.48	451.75	452.01	452.28	452.54	452.81	453.07	453.34	453.60	453.87	454.13	14.90
15.00	454.13	454.40	454.66	454.93	455.19	455.45	455.72	455.98	456.25	456.51	456.78	15.00
15.10	456.78	457.04	457.31	457.57	457.83	458.10	458.36	458.63	458.89	459.16	459.42	15.10
15.20	459.42	459.68	459.95	460.21	460.48	460.74	461.01	461.27	461.53	461.80	462.06	15.20
15.30	462.06	462.33	462.59	462.85	463.12	463.38	463.65	463.91	464.17	464.44	464.70	15.30
15.40	464.70	464.96	465.23	465.49	465.76	466.02	466.28	466.55	466.81	467.07	467.34	15.40
15.50	467.34	467.60	467.86	468.13	468.39	468.66	468.92	469.18	469.45	469.71	469.97	15.50
15.60	469.97	470.24	470.50	470.76	471.03	471.29	471.55	471.82	472.08	472.34	472.61	15.60
15.70	472.61	472.87	473.13	473.40	473.66	473.92	474.19	474.45	474.71	474.97	475.24	15.70
15.80	475.24	475.50	475.76	476.03	476.29	476.55	476.82	477.08	477.34	477.60	477.87	15.80
15.90	477.87	478.13	478.39	478.66	478.92	479.18	479.44	479.71	479.97	480.23	480.50	15.90
16.00	480.50	480.76	481.02	481.28	481.55	481.81	482.07	482.33	482.60	482.86	483.12	16.00
16.10	483.12	483.38	483.65	483.91	484.17	484.43	484.70	484.96	485.22	485.48	485.75	16.10
16.20	485.75	486.01	486.27	486.53	486.79	487.06	487.32	487.58	487.84	488.11	488.37	16.20
16.30	488.37	488.63	488.89	489.15	489.42	489.68	489.94	490.20	490.46	490.73	490.99	16.30
16.40	490.99	491.25	491.51	491.77	492.04	492.30	492.56	492.82	493.08	493.34	493.61	16.40
16.50	493.61	493.87	494.13	494.39	494.65	494.92	495.18	495.44	495.70	495.96	496.22	16.50
16.60	496.22	496.49	496.75	497.01	497.27	497.53	497.79	498.05	498.32	498.58	498.84	16.60
16.70	498.84	499.10	499.36	499.62	499.89	500.15	500.41	500.67	500.93	501.19	501.45	16.70
16.80	501.45	501.71	501.98	502.24	502.50	502.76	503.02	503.28	503.54	503.80	504.07	16.80
16.90	504.07	504.33	504.59	504.85	505.11	505.37	505.63	505.89	506.15	506.41	506.68	16.90
17.00	506.68	506.94	507.20	507.46	507.72	507.98	508.24	508.50	508.76	509.02	509.28	17.00
17.10	509.28	509.55	509.81	510.07	510.33	510.59	510.85	511.11	511.37	511.63	511.89	17.10
17.20	511.89	512.15	512.41	512.67	512.93	513.20	513.46	513.72	513.98	514.24	514.50	17.20
17.30	514.50	514.76	515.02	515.28	515.54	515.80	516.06	516.32	516.58	516.84	517.10	17.30
17.40	517.10	517.36	517.62	517.88	518.14	518.40	518.66	518.92	519.18	519.44	519.71	17.40
17.50	519.71	519.97	520.23	520.49	520.75	521.01	521.27	521.53	521.79	522.05	522.31	17.50
17.60	522.31	522.57	522.83	523.09	523.35	523.61	523.87	524.13	524.39	524.65	524.91	17.60
17.70	524.91	525.17	525.43	525.69	525.95	526.21	526.47	526.73	526.99	527.24	527.50	17.70
17.80	527.50	527.76	528.02	528.28	528.54	528.80	529.06	529.32	529.58	529.84	530.10	17.80
17.90	530.10	530.36	530.62	530.88	531.14	531.40	531.66	531.92	532.18	532.44	532.70	17.90
18.00	532.70	532.96	533.22	533.48	533.74	533.99	534.25	534.51	534.77	535.03	535.29	18.00
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

TABLE B2. AWG 14 *Nicrosil versus Nisil thermocouples—temperature (°C) as a function of thermoelectric voltage, reference junctions at 0 °C*—Continued

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
	TEMPERATURES IN DEGREES C (IPTS 1968)											
18.00	532.70	532.96	533.22	533.48	533.74	533.99	534.25	534.51	534.77	535.03	535.29	18.00
18.10	535.29	535.55	535.81	536.07	536.33	536.59	536.85	537.11	537.37	537.63	537.88	18.10
18.20	537.88	538.14	538.40	538.66	538.92	539.18	539.44	539.70	539.96	540.22	540.48	18.20
18.30	540.48	540.74	540.99	541.25	541.51	541.77	542.03	542.29	542.55	542.81	543.07	18.30
18.40	543.07	543.33	543.58	543.84	544.10	544.36	544.62	544.88	545.14	545.40	545.66	18.40
18.50	545.66	545.91	546.17	546.43	546.69	546.95	547.21	547.47	547.73	547.98	548.24	18.50
18.60	548.24	548.50	548.76	549.02	549.28	549.54	549.80	550.05	550.31	550.57	550.83	18.60
18.70	550.83	551.09	551.35	551.61	551.86	552.12	552.38	552.64	552.90	553.16	553.41	18.70
18.80	553.41	553.67	553.93	554.19	554.45	554.71	554.97	555.22	555.48	555.74	556.00	18.80
18.90	556.00	556.26	556.52	556.77	557.03	557.29	557.55	557.81	558.06	558.32	558.58	18.90
19.00	558.58	558.84	559.10	559.36	559.61	559.87	560.13	560.39	560.65	560.90	561.16	19.00
19.10	561.16	561.42	561.68	561.94	562.20	562.45	562.71	562.97	563.23	563.49	563.74	19.10
19.20	563.74	564.00	564.26	564.52	564.78	565.03	565.29	565.55	565.81	566.07	566.32	19.20
19.30	566.32	566.58	566.84	567.10	567.35	567.61	567.87	568.13	568.39	568.64	568.90	19.30
19.40	568.90	569.16	569.42	569.67	569.93	570.19	570.45	570.71	570.96	571.22	571.48	19.40
19.50	571.48	571.74	571.99	572.25	572.51	572.77	573.02	573.28	573.54	573.80	574.05	19.50
19.60	574.05	574.31	574.57	574.83	575.08	575.34	575.60	575.86	576.11	576.37	576.63	19.60
19.70	576.63	576.89	577.14	577.40	577.66	577.92	578.17	578.43	578.69	578.95	579.20	19.70
19.80	579.20	579.46	579.72	579.98	580.23	580.49	580.75	581.00	581.26	581.52	581.78	19.80
19.90	581.78	582.03	582.29	582.55	582.81	583.06	583.32	583.58	583.83	584.09	584.35	19.90
20.00	584.35	584.61	584.86	585.12	585.38	585.63	585.89	586.15	586.41	586.66	586.92	20.00
20.10	586.92	587.18	587.43	587.69	587.95	588.20	588.46	588.72	588.98	589.23	589.49	20.10
20.20	589.49	589.75	590.00	590.26	590.52	590.77	591.03	591.29	591.54	591.80	592.06	20.20
20.30	592.06	592.32	592.57	592.83	593.09	593.34	593.60	593.86	594.11	594.37	594.63	20.30
20.40	594.63	594.88	595.14	595.40	595.65	595.91	596.17	596.42	596.68	596.94	597.19	20.40
20.50	597.19	597.45	597.71	597.96	598.22	598.48	598.73	598.99	599.25	599.50	599.76	20.50
20.60	599.76	600.02	600.27	600.53	600.79	601.04	601.30	601.56	601.81	602.07	602.33	20.60
20.70	602.33	602.58	602.84	603.10	603.35	603.61	603.86	604.12	604.38	604.63	604.89	20.70
20.80	604.89	605.15	605.40	605.66	605.92	606.17	606.43	606.69	606.94	607.20	607.45	20.80
20.90	607.45	607.71	607.97	608.22	608.48	608.74	608.99	609.25	609.50	609.76	610.02	20.90
21.00	610.02	610.27	610.53	610.79	611.04	611.30	611.55	611.81	612.07	612.32	612.58	21.00
21.10	612.58	612.84	613.09	613.35	613.60	613.86	614.12	614.37	614.63	614.88	615.14	21.10
21.20	615.14	615.40	615.65	615.91	616.17	616.42	616.68	616.93	617.19	617.45	617.70	21.20
21.30	617.70	617.96	618.21	618.47	618.73	618.98	619.24	619.49	619.75	620.01	620.26	21.30
21.40	620.26	620.52	620.77	621.03	621.29	621.54	621.80	622.05	622.31	622.56	622.82	21.40
21.50	622.82	623.08	623.33	623.59	623.84	624.10	624.36	624.61	624.87	625.12	625.38	21.50
21.60	625.38	625.63	625.89	626.15	626.40	626.66	626.91	627.17	627.43	627.68	627.94	21.60
21.70	627.94	628.19	628.45	628.70	628.96	629.22	629.47	629.73	629.98	630.24	630.49	21.70
21.80	630.49	630.75	631.01	631.26	631.52	631.77	632.03	632.28	632.54	632.79	633.05	21.80
21.90	633.05	633.31	633.56	633.82	634.07	634.33	634.58	634.84	635.10	635.35	635.61	21.90
22.00	635.61	635.86	636.12	636.37	636.63	636.88	637.14	637.40	637.65	637.91	638.16	22.00
22.10	638.16	638.42	638.67	638.93	639.18	639.44	639.69	639.95	640.21	640.46	640.72	22.10
22.20	640.72	640.97	641.23	641.48	641.74	641.99	642.25	642.50	642.76	643.01	643.27	22.20
22.30	643.27	643.53	643.78	644.04	644.29	644.55	644.80	645.06	645.31	645.57	645.82	22.30
22.40	645.82	646.08	646.33	646.59	646.84	647.10	647.36	647.61	647.87	648.12	648.38	22.40
22.50	648.38	648.63	648.89	649.14	649.40	649.65	649.91	650.16	650.42	650.67	650.93	22.50
22.60	650.93	651.18	651.44	651.69	651.95	652.20	652.46	652.72	652.97	653.23	653.48	22.60
22.70	653.48	653.74	653.99	654.25	654.50	654.76	655.01	655.27	655.52	655.78	656.03	22.70
22.80	656.03	656.29	656.54	656.80	657.05	657.31	657.56	657.82	658.07	658.33	658.58	22.80
22.90	658.58	658.84	659.09	659.35	659.60	659.86	660.11	660.37	660.62	660.88	661.13	22.90
23.00	661.13	661.39	661.64	661.90	662.15	662.41	662.66	662.92	663.17	663.43	663.68	23.00
23.10	663.68	663.94	664.19	664.45	664.70	664.96	665.21	665.47	665.72	665.98	666.23	23.10
23.20	666.23	666.49	666.74	667.00	667.25	667.51	667.76	668.02	668.27	668.53	668.78	23.20
23.30	668.78	669.04	669.29	669.55	669.80	670.06	670.31	670.57	670.82	671.08	671.33	23.30
23.40	671.33	671.59	671.84	672.09	672.35	672.60	672.86	673.11	673.37	673.62	673.88	23.40
23.50	673.88	674.13	674.39	674.64	674.90	675.15	675.41	675.66	675.92	676.17	676.43	23.50
23.60	676.43	676.68	676.94	677.19	677.45	677.70	677.95	678.21	678.46	678.72	678.97	23.60
23.70	678.97	679.23	679.48	679.74	679.99	680.25	680.50	680.76	681.01	681.27	681.52	23.70
23.80	681.52	681.78	682.03	682.29	682.54	682.79	683.05	683.30	683.56	683.81	684.07	23.80
23.90	684.07	684.32	684.58	684.83	685.09	685.34	685.60	685.85	686.11	686.36	686.61	23.90
24.00	686.61	686.87	687.12	687.38	687.63	687.89	688.14	688.40	688.65	688.91	689.16	24.00
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

TABLE B2. AWG 14 *Nicrosil versus Nisil thermocouples—temperature (°C) as a function of thermoelectric voltage, reference junctions at 0 °C*—Continued

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
					TEMPERATURES IN DEGREES C (IPTS 1968)							
24.00	686.61	686.87	687.12	687.38	687.63	687.89	688.14	688.40	688.65	688.91	689.16	24.00
24.10	689.16	689.42	689.67	689.92	690.18	690.43	690.69	690.94	691.20	691.45	691.71	24.10
24.20	691.71	691.96	692.22	692.47	692.72	692.98	693.23	693.49	693.74	694.00	694.25	24.20
24.30	694.25	694.51	694.76	695.02	695.27	695.53	695.78	696.03	696.29	696.54	696.80	24.30
24.40	696.80	697.05	697.31	697.56	697.82	698.07	698.32	698.58	698.83	699.09	699.34	24.40
24.50	699.34	699.60	699.85	700.11	700.36	700.62	700.87	701.12	701.38	701.63	701.89	24.50
24.60	701.89	702.14	702.40	702.65	702.91	703.16	703.41	703.67	703.92	704.18	704.43	24.60
24.70	704.43	704.69	704.94	705.20	705.45	705.70	705.96	706.21	706.47	706.72	706.98	24.70
24.80	706.98	707.23	707.49	707.74	707.99	708.25	708.50	708.76	709.01	709.27	709.52	24.80
24.90	709.52	709.78	710.03	710.28	710.54	710.79	711.05	711.30	711.56	711.81	712.07	24.90
25.00	712.07	712.32	712.57	712.83	713.08	713.34	713.59	713.85	714.10	714.36	714.61	25.00
25.10	714.61	714.86	715.12	715.37	715.63	715.88	716.14	716.39	716.65	716.90	717.15	25.10
25.20	717.15	717.41	717.66	717.92	718.17	718.43	718.68	718.93	719.19	719.44	719.70	25.20
25.30	719.70	719.95	720.21	720.46	720.72	720.97	721.22	721.48	721.73	721.99	722.24	25.30
25.40	722.24	722.50	722.75	723.00	723.26	723.51	723.77	724.02	724.28	724.53	724.79	25.40
25.50	724.79	725.04	725.29	725.55	725.80	726.06	726.31	726.57	726.82	727.07	727.33	25.50
25.60	727.33	727.58	727.84	728.09	728.35	728.60	728.85	729.11	729.36	729.62	729.87	25.60
25.70	729.87	730.13	730.38	730.64	730.89	731.14	731.40	731.65	731.91	732.16	732.42	25.70
25.80	732.42	732.67	732.92	733.18	733.43	733.69	733.94	734.20	734.45	734.70	734.96	25.80
25.90	734.96	735.21	735.47	735.72	735.98	736.23	736.48	736.74	736.99	737.25	737.50	25.90
26.00	737.50	737.76	738.01	738.27	738.52	738.77	739.03	739.28	739.54	739.79	740.05	26.00
26.10	740.05	740.30	740.55	740.81	741.06	741.32	741.57	741.83	742.08	742.33	742.59	26.10
26.20	742.59	742.84	743.10	743.35	743.61	743.86	744.12	744.37	744.62	744.88	745.13	26.20
26.30	745.13	745.39	745.64	745.90	746.15	746.40	746.66	746.91	747.17	747.42	747.68	26.30
26.40	747.68	747.93	748.18	748.44	748.69	748.95	749.20	749.46	749.71	749.96	750.22	26.40
26.50	750.22	750.47	750.73	750.98	751.24	751.49	751.75	752.00	752.25	752.51	752.76	26.50
26.60	752.76	753.02	753.27	753.53	753.78	754.03	754.29	754.54	754.80	755.05	755.31	26.60
26.70	755.31	755.56	755.82	756.07	756.32	756.58	756.83	757.09	757.34	757.60	757.85	26.70
26.80	757.85	758.10	758.36	758.61	758.87	759.12	759.38	759.63	759.89	760.14	760.39	26.80
26.90	760.39	760.65	760.90	761.16	761.41	761.67	761.92	762.17	762.43	762.68	762.94	26.90
27.00	762.94	763.19	763.45	763.70	763.96	764.21	764.46	764.72	764.97	765.23	765.48	27.00
27.10	765.48	765.74	765.99	766.24	766.50	766.75	767.01	767.26	767.52	767.77	768.03	27.10
27.20	768.03	768.28	768.53	768.79	769.04	769.30	769.55	769.81	770.06	770.32	770.57	27.20
27.30	770.57	770.82	771.08	771.33	771.59	771.84	772.10	772.35	772.61	772.86	773.11	27.30
27.40	773.11	773.37	773.62	773.88	774.13	774.39	774.64	774.90	775.15	775.40	775.66	27.40
27.50	775.66	775.91	776.17	776.42	776.68	776.93	777.19	777.44	777.69	777.95	778.20	27.50
27.60	778.20	778.46	778.71	778.97	779.22	779.48	779.73	779.99	780.24	780.49	780.75	27.60
27.70	780.75	781.00	781.26	781.51	781.77	782.02	782.28	782.53	782.78	783.04	783.29	27.70
27.80	783.29	783.55	783.80	784.06	784.31	784.57	784.82	785.08	785.33	785.58	785.84	27.80
27.90	785.84	786.09	786.35	786.60	786.86	787.11	787.37	787.62	787.88	788.13	788.38	27.90
28.00	788.38	788.64	788.89	789.15	789.40	789.66	789.91	790.17	790.42	790.68	790.93	28.00
28.10	790.93	791.19	791.44	791.69	791.95	792.20	792.46	792.71	792.97	793.22	793.48	28.10
28.20	793.48	793.73	793.99	794.24	794.50	794.75	795.00	795.26	795.51	795.77	796.02	28.20
28.30	796.02	796.28	796.53	796.79	797.04	797.30	797.55	797.81	798.06	798.32	798.57	28.30
28.40	798.57	798.82	799.08	799.33	799.59	799.84	800.10	800.35	800.61	800.86	801.12	28.40
28.50	801.12	801.37	801.63	801.88	802.14	802.39	802.64	802.90	803.15	803.41	803.66	28.50
28.60	803.66	803.92	804.17	804.43	804.68	804.94	805.19	805.45	805.70	805.96	806.21	28.60
28.70	806.21	806.47	806.72	806.98	807.23	807.49	807.74	807.99	808.25	808.50	808.76	28.70
28.80	808.76	809.01	809.27	809.52	809.78	810.03	810.29	810.54	810.80	811.05	811.31	28.80
28.90	811.31	811.56	811.82	812.07	812.33	812.58	812.84	813.09	813.35	813.60	813.86	28.90
29.00	813.86	814.11	814.37	814.62	814.88	815.13	815.38	815.64	815.89	816.15	816.40	29.00
29.10	816.40	816.66	816.91	817.17	817.42	817.68	817.93	818.19	818.44	818.70	818.95	29.10
29.20	818.95	819.21	819.46	819.72	819.97	820.23	820.48	820.74	820.99	821.25	821.50	29.20
29.30	821.50	821.76	822.01	822.27	822.52	822.78	823.03	823.29	823.54	823.80	824.05	29.30
29.40	824.05	824.31	824.56	824.82	825.07	825.33	825.58	825.84	826.09	826.35	826.60	29.40
29.50	826.60	826.86	827.11	827.37	827.62	827.88	828.13	928.39	828.64	828.90	829.15	29.50
29.60	829.15	829.41	829.66	829.92	830.17	830.43	830.68	830.94	831.19	831.45	831.70	29.60
29.70	831.70	831.96	832.22	832.47	832.73	832.98	833.24	833.49	833.75	834.00	834.26	29.70
29.80	834.26	834.51	834.77	835.02	835.28	835.53	835.79	836.04	836.30	836.55	836.81	29.80
29.90	836.81	837.06	837.32	837.57	837.83	838.08	838.34	838.59	838.85	839.11	839.36	29.90
30.00	839.36	839.62	839.87	840.13	840.38	840.64	840.89	841.15	841.40	841.66	841.91	30.00
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

TABLE B2. AWG 14 *Nicrosil versus Nisil thermocouples—temperature (°C) as a function of thermoelectric voltage, reference junctions at 0 °C*—Continued

TEMPERATURES IN DEGREES C (IPTS 1968)

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
30.00	839.36	839.62	839.87	840.13	840.38	840.64	840.89	841.15	841.40	841.66	841.91	30.00
30.10	841.91	842.17	842.42	842.68	842.93	843.19	843.45	843.70	843.96	844.21	844.47	30.10
30.20	844.47	844.72	844.98	845.23	845.49	845.74	846.00	846.25	846.51	846.76	847.02	30.20
30.30	847.02	847.28	847.53	847.79	848.04	848.30	848.55	848.81	849.06	849.32	849.57	30.30
30.40	849.57	849.83	850.08	850.34	850.60	850.85	851.11	851.36	851.62	851.87	852.13	30.40
30.50	852.13	852.38	852.64	852.90	853.15	853.41	853.66	853.92	854.17	854.43	854.68	30.50
30.60	854.68	854.94	855.19	855.45	855.71	855.96	856.22	856.47	856.73	856.98	857.24	30.60
30.70	857.24	857.49	857.75	858.01	858.26	858.52	858.77	859.03	859.28	859.54	859.80	30.70
30.80	859.80	860.05	860.31	860.56	860.82	861.07	861.33	861.58	861.84	862.10	862.35	30.80
30.90	862.35	862.61	862.86	863.12	863.37	863.63	863.89	864.14	864.40	864.65	864.91	30.90
31.00	864.91	865.16	865.42	865.68	865.93	866.19	866.44	866.70	866.95	867.21	867.47	31.00
31.10	867.47	867.72	867.98	868.23	868.49	868.75	869.00	869.26	869.51	869.77	870.02	31.10
31.20	870.02	870.28	870.54	870.79	871.05	871.30	871.56	871.82	872.07	872.33	872.58	31.20
31.30	872.58	872.84	873.09	873.35	873.61	873.86	874.12	874.37	874.63	874.89	875.14	31.30
31.40	875.14	875.40	875.65	875.91	876.17	876.42	876.68	876.93	877.19	877.45	877.70	31.40
31.50	877.70	877.96	878.21	878.47	878.73	878.98	879.24	879.49	879.75	880.01	880.26	31.50
31.60	880.26	880.52	880.77	881.03	881.29	881.54	881.80	882.05	882.31	882.57	882.82	31.60
31.70	882.82	883.08	883.34	883.59	883.85	884.10	884.36	884.62	884.87	885.13	885.38	31.70
31.80	885.38	885.64	885.90	886.15	886.41	886.67	886.92	887.18	887.43	887.69	887.95	31.80
31.90	887.95	888.20	888.46	888.72	888.97	889.23	889.48	889.74	890.00	890.25	890.51	31.90
32.00	890.51	890.77	891.02	891.28	891.53	891.79	892.05	892.30	892.56	892.82	893.07	32.00
32.10	893.07	893.33	893.58	893.84	894.10	894.35	894.61	894.87	895.12	895.38	895.64	32.10
32.20	895.64	895.89	896.15	896.41	896.66	896.92	897.17	897.43	897.69	897.94	898.20	32.20
32.30	898.20	898.46	898.71	898.97	899.23	899.48	899.74	900.00	900.25	900.51	900.77	32.30
32.40	900.77	901.02	901.28	901.54	901.79	902.05	902.30	902.56	902.82	903.07	903.33	32.40
32.50	903.33	903.59	903.84	904.10	904.36	904.61	904.87	905.13	905.38	905.64	905.90	32.50
32.60	905.90	906.15	906.41	906.67	906.92	907.18	907.44	907.69	907.95	908.21	908.46	32.60
32.70	908.46	908.72	908.98	909.23	909.49	909.75	910.00	910.26	910.52	910.77	911.03	32.70
32.80	911.03	911.29	911.55	911.80	912.06	912.32	912.57	912.83	913.09	913.34	913.60	32.80
32.90	913.60	913.86	914.11	914.37	914.63	914.88	915.14	915.40	915.65	915.91	916.17	32.90
33.00	916.17	916.43	916.68	916.94	917.20	917.45	917.71	917.97	918.22	918.48	918.74	33.00
33.10	918.74	919.00	919.25	919.51	919.77	920.02	920.28	920.54	920.79	921.05	921.31	33.10
33.20	921.31	921.57	921.82	922.08	922.34	922.59	922.85	923.11	923.36	923.62	923.88	33.20
33.30	923.88	924.14	924.39	924.65	924.91	925.16	925.42	925.68	925.94	926.19	926.45	33.30
33.40	926.45	926.71	926.96	927.22	927.48	927.74	927.99	928.25	928.51	928.77	929.02	33.40
33.50	929.02	929.28	929.54	929.79	930.05	930.31	930.57	930.82	931.08	931.34	931.60	33.50
33.60	931.60	931.85	932.11	932.37	932.62	932.88	933.14	933.40	933.65	933.91	934.17	33.60
33.70	934.17	934.43	934.68	934.94	935.20	935.46	935.71	935.97	936.23	936.49	936.74	33.70
33.80	936.74	937.00	937.26	937.52	937.77	938.03	938.29	938.55	938.80	939.06	939.32	33.80
33.90	939.32	939.58	939.83	940.09	940.35	940.61	940.86	941.12	941.38	941.64	941.89	33.90
34.00	941.89	942.15	942.41	942.67	942.92	943.18	943.44	943.70	943.96	944.21	944.47	34.00
34.10	944.47	944.73	944.99	945.24	945.50	945.76	946.02	946.27	946.53	946.79	947.05	34.10
34.20	947.05	947.31	947.56	947.82	948.08	948.34	948.59	948.85	949.11	949.37	949.63	34.20
34.30	949.63	949.88	950.14	950.40	950.66	950.91	951.17	951.43	951.69	951.95	952.20	34.30
34.40	952.20	952.46	952.72	952.98	953.24	953.49	953.75	954.01	954.27	954.53	954.78	34.40
34.50	954.78	955.04	955.30	955.56	955.82	956.07	956.33	956.59	956.85	957.11	957.36	34.50
34.60	957.36	957.62	957.88	958.14	958.40	958.65	958.91	959.17	959.43	959.69	959.94	34.60
34.70	959.94	960.20	960.46	960.72	960.98	961.23	961.49	961.75	962.01	962.27	962.53	34.70
34.80	962.53	962.78	963.04	963.30	963.56	963.82	964.08	964.33	964.59	964.85	965.11	34.80
34.90	965.11	965.37	965.62	965.88	966.14	966.40	966.66	966.92	967.17	967.43	967.69	34.90
35.00	967.69	967.95	968.21	968.47	968.72	968.98	969.24	969.50	969.76	970.02	970.28	35.00
35.10	970.28	970.53	970.79	971.05	971.31	971.57	971.83	972.08	972.34	972.60	972.86	35.10
35.20	972.86	973.12	973.38	973.64	973.89	974.15	974.41	974.67	974.93	975.19	975.45	35.20
35.30	975.45	975.70	975.96	976.22	976.48	976.74	977.00	977.26	977.51	977.77	978.03	35.30
35.40	978.03	978.29	978.55	978.81	979.07	979.33	979.58	979.84	980.10	980.36	980.62	35.40
35.50	980.62	980.88	981.14	981.40	981.65	981.91	982.17	982.43	982.69	982.95	983.21	35.50
35.60	983.21	983.47	983.72	983.98	984.24	984.50	984.76	985.02	985.28	985.54	985.80	35.60
35.70	985.80	986.05	986.31	986.57	986.83	987.09	987.35	987.61	987.87	988.13	988.39	35.70
35.80	988.39	988.64	988.90	989.16	989.42	989.68	989.94	990.20	990.46	990.72	990.98	35.80
35.90	990.98	991.23	991.49	991.75	992.01	992.27	992.53	992.79	993.05	993.31	993.57	35.90
36.00	993.57	993.83	994.08	994.34	994.60	994.86	995.12	995.38	995.64	995.90	996.16	36.00
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

Table B2. AWG 14 *Nicrosil versus Nisil thermocouples—temperature (°C) as a function of thermoelectric voltage, reference junctions at 0 °C*—Continued

TEMPERATURES IN DEGREES C (IPTS 1968)

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
36.00	993.57	993.83	994.08	994.34	994.60	994.86	995.12	995.38	995.64	995.90	996.16	36.00
36.10	996.16	996.42	996.68	996.94	997.20	997.46	997.71	997.97	998.23	998.49	998.75	36.10
36.20	998.75	999.01	999.27	999.53	999.79	1000.05	1000.31	1000.57	1000.83	1001.09	1001.35	36.20
36.30	1001.35	1001.60	1001.86	1002.12	1002.38	1002.64	1002.90	1003.16	1003.42	1003.68	1003.94	36.30
36.40	1003.94	1004.20	1004.46	1004.72	1004.98	1005.24	1005.50	1005.76	1006.02	1006.28	1006.54	36.40
36.50	1006.54	1006.80	1007.05	1007.31	1007.57	1007.83	1008.09	1008.35	1008.61	1008.87	1009.13	36.50
36.60	1009.13	1009.39	1009.65	1009.91	1010.17	1010.43	1010.69	1010.95	1011.21	1011.47	1011.73	36.60
36.70	1011.73	1011.99	1012.25	1012.51	1012.77	1013.03	1013.29	1013.55	1013.81	1014.07	1014.33	36.70
36.80	1014.33	1014.59	1014.85	1015.11	1015.37	1015.63	1015.89	1016.15	1016.41	1016.67	1016.93	36.80
36.90	1016.93	1017.19	1017.45	1017.71	1017.97	1018.23	1018.49	1018.75	1019.01	1019.27	1019.53	36.90
37.00	1019.53	1019.79	1020.05	1020.31	1020.57	1020.83	1021.09	1021.35	1021.61	1021.87	1022.13	37.00
37.10	1022.13	1022.39	1022.65	1022.91	1023.17	1023.43	1023.69	1023.95	1024.21	1024.47	1024.73	37.10
37.20	1024.73	1024.99	1025.25	1025.51	1025.77	1026.03	1026.29	1026.55	1026.81	1027.07	1027.33	37.20
37.30	1027.33	1027.59	1027.85	1028.11	1028.37	1028.63	1028.89	1029.15	1029.41	1029.67	1029.94	37.30
37.40	1029.94	1030.20	1030.46	1030.72	1030.98	1031.24	1031.50	1031.76	1032.02	1032.28	1032.54	37.40
37.50	1032.54	1032.80	1033.06	1033.32	1033.58	1033.84	1034.10	1034.36	1034.62	1034.88	1035.15	37.50
37.60	1035.15	1035.41	1035.67	1035.93	1036.19	1036.45	1036.71	1036.97	1037.23	1037.49	1037.75	37.60
37.70	1037.75	1038.01	1038.27	1038.53	1038.79	1039.06	1039.32	1039.58	1039.84	1040.10	1040.36	37.70
37.80	1040.36	1040.62	1040.88	1041.14	1041.40	1041.66	1041.92	1042.19	1042.45	1042.71	1042.97	37.80
37.90	1042.97	1043.23	1043.49	1043.75	1044.01	1044.27	1044.53	1044.79	1045.06	1045.32	1045.58	37.90
38.00	1045.58	1045.84	1046.10	1046.36	1046.62	1046.88	1047.14	1047.40	1047.67	1047.93	1048.19	38.00
38.10	1048.19	1048.45	1048.71	1048.97	1049.23	1049.49	1049.75	1050.02	1050.28	1050.54	1050.80	38.10
38.20	1050.80	1051.06	1051.32	1051.58	1051.84	1052.11	1052.37	1052.63	1052.89	1053.15	1053.41	38.20
38.30	1053.41	1053.67	1053.93	1054.20	1054.46	1054.72	1054.98	1055.24	1055.50	1055.76	1056.03	38.30
38.40	1056.03	1056.29	1056.55	1056.81	1057.07	1057.33	1057.59	1057.86	1058.12	1058.38	1058.64	38.40
38.50	1058.64	1058.90	1059.16	1059.42	1059.69	1059.95	1060.21	1060.47	1060.73	1060.99	1061.26	38.50
38.60	1061.26	1061.52	1061.78	1062.04	1062.30	1062.56	1062.83	1063.09	1063.35	1063.61	1063.87	38.60
38.70	1063.87	1064.13	1064.40	1064.66	1064.92	1065.18	1065.44	1065.70	1065.97	1066.23	1066.49	38.70
38.80	1066.49	1066.75	1067.01	1067.28	1067.54	1067.80	1068.06	1068.32	1068.58	1068.85	1069.11	38.80
38.90	1069.11	1069.37	1069.63	1069.89	1070.16	1070.42	1070.68	1070.94	1071.20	1071.47	1071.73	38.90
39.00	1071.73	1071.99	1072.25	1072.51	1072.78	1073.04	1073.30	1073.56	1073.83	1074.09	1074.35	39.00
39.10	1074.35	1074.61	1074.87	1075.14	1075.40	1075.66	1075.92	1076.18	1076.45	1076.71	1076.97	39.10
39.20	1076.97	1077.23	1077.50	1077.76	1078.02	1078.28	1078.55	1078.81	1079.07	1079.33	1079.59	39.20
39.30	1079.59	1079.86	1080.12	1080.38	1080.64	1080.91	1081.17	1081.43	1081.69	1081.96	1082.22	39.30
39.40	1082.22	1082.48	1082.74	1083.01	1083.27	1083.53	1083.79	1084.06	1084.32	1084.58	1084.84	39.40
39.50	1084.84	1085.11	1085.37	1085.63	1085.89	1086.16	1086.42	1086.68	1086.95	1087.21	1087.47	39.50
39.60	1087.47	1087.73	1088.00	1088.26	1088.52	1088.78	1089.05	1089.31	1089.57	1089.84	1090.10	39.60
39.70	1090.10	1090.36	1090.62	1090.89	1091.15	1091.41	1091.68	1091.94	1092.20	1092.46	1092.73	39.70
39.80	1092.73	1092.99	1093.25	1093.52	1093.78	1094.04	1094.31	1094.57	1094.83	1095.09	1095.36	39.80
39.90	1095.36	1095.62	1095.88	1096.15	1096.41	1096.67	1096.94	1097.20	1097.46	1097.73	1097.99	39.90
40.00	1097.99	1098.25	1098.52	1098.78	1099.04	1099.31	1099.57	1099.83	1100.10	1100.36	1100.62	40.00
40.10	1100.62	1100.89	1101.15	1101.41	1101.68	1101.94	1102.20	1102.47	1102.73	1102.99	1103.26	40.10
40.20	1103.26	1103.52	1103.78	1104.05	1104.31	1104.57	1104.84	1105.10	1105.36	1105.63	1105.89	40.20
40.30	1105.89	1106.15	1106.42	1106.68	1106.95	1107.21	1107.47	1107.74	1108.00	1108.26	1108.53	40.30
40.40	1108.53	1108.79	1109.05	1109.32	1109.58	1109.85	1110.11	1110.37	1110.64	1110.90	1111.16	40.40
40.50	1111.16	1111.43	1111.69	1111.96	1112.22	1112.48	1112.75	1113.01	1113.28	1113.54	1113.80	40.50
40.60	1113.80	1114.07	1114.33	1114.60	1114.86	1115.12	1115.39	1115.65	1115.92	1116.18	1116.44	40.60
40.70	1116.44	1116.71	1116.97	1117.24	1117.50	1117.76	1118.03	1118.29	1118.56	1118.82	1119.09	40.70
40.80	1119.09	1119.35	1119.61	1119.88	1120.14	1120.41	1120.67	1120.94	1121.20	1121.46	1121.73	40.80
40.90	1121.73	1121.99	1122.26	1122.52	1122.79	1123.05	1123.31	1123.58	1123.84	1124.11	1124.37	40.90
41.00	1124.37	1124.64	1124.90	1125.17	1125.43	1125.70	1125.96	1126.22	1126.49	1126.75	1127.02	41.00
41.10	1127.02	1127.28	1127.55	1127.81	1128.08	1128.34	1128.61	1128.87	1129.14	1129.40	1129.67	41.10
41.20	1129.67	1129.93	1130.19	1130.46	1130.72	1130.99	1131.25	1131.52	1131.78	1132.05	1132.31	41.20
41.30	1132.31	1132.58	1132.84	1133.11	1133.37	1133.64	1133.90	1134.17	1134.43	1134.70	1134.96	41.30
41.40	1134.96	1135.23	1135.49	1135.76	1136.02	1136.29	1136.55	1136.82	1137.08	1137.35	1137.61	41.40
41.50	1137.61	1137.88	1138.15	1138.41	1138.68	1138.94	1139.21	1139.47	1139.74	1140.00	1140.27	41.50
41.60	1140.27	1140.53	1140.80	1141.06	1141.33	1141.59	1141.86	1142.13	1142.39	1142.66	1142.92	41.60
41.70	1142.92	1143.19	1143.45	1143.72	1143.98	1144.25	1144.51	1144.78	1145.05	1145.31	1145.58	41.70
41.80	1145.58	1145.84	1146.11	1146.37	1146.64	1146.91	1147.17	1147.44	1147.70	1147.97	1148.23	41.80
41.90	1148.23	1148.50	1148.77	1149.03	1149.30	1149.56	1149.83	1150.10	1150.36	1150.63	1150.89	41.90
42.00	1150.89	1151.16	1151.42	1151.69	1151.96	1152.22	1152.49	1152.75	1153.02	1153.29	1153.55	42.00
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

Table B2. AWG 14 *Nicrosil versus Nisil thermocouples—temperature (°C) as a function of thermoelectric voltage, reference junctions at 0 °C*—Continued

TEMPERATURES IN DEGREES C (IPTS 1968)

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
42.00	1150.89	1151.16	1151.42	1151.69	1151.96	1152.22	1152.49	1152.75	1153.02	1153.29	1153.55	42.00
42.10	1153.55	1153.82	1154.09	1154.35	1154.62	1154.88	1155.15	1155.42	1155.68	1155.95	1156.21	42.10
42.20	1156.21	1156.48	1156.75	1157.01	1157.28	1157.55	1157.81	1158.08	1158.35	1158.61	1158.88	42.20
42.30	1158.88	1159.14	1159.41	1159.68	1159.94	1160.21	1160.48	1160.74	1161.01	1161.28	1161.54	42.30
42.40	1161.54	1161.81	1162.08	1162.34	1162.61	1162.88	1163.14	1163.41	1163.68	1163.94	1164.21	42.40
42.50	1164.21	1164.48	1164.74	1165.01	1165.28	1165.54	1165.81	1166.08	1166.34	1166.61	1166.88	42.50
42.60	1166.88	1167.14	1167.41	1167.68	1167.95	1168.21	1168.48	1168.75	1169.01	1169.28	1169.55	42.60
42.70	1169.55	1169.81	1170.08	1170.35	1170.62	1170.88	1171.15	1171.42	1171.68	1171.95	1172.22	42.70
42.80	1172.22	1172.49	1172.75	1173.02	1173.29	1173.55	1173.82	1174.09	1174.36	1174.62	1174.89	42.80
42.90	1174.89	1175.16	1175.43	1175.69	1175.96	1176.23	1176.50	1176.76	1177.03	1177.30	1177.57	42.90
43.00	1177.57	1177.83	1178.10	1178.37	1178.64	1178.90	1179.17	1179.44	1179.71	1179.98	1180.24	43.00
43.10	1180.24	1180.51	1180.78	1181.05	1181.31	1181.58	1181.85	1182.12	1182.39	1182.65	1182.92	43.10
43.20	1182.92	1183.19	1183.46	1183.73	1183.99	1184.26	1184.53	1184.80	1185.07	1185.33	1185.60	43.20
43.30	1185.60	1185.87	1186.14	1186.41	1186.67	1186.94	1187.21	1187.48	1187.75	1188.01	1188.28	43.30
43.40	1188.28	1188.55	1188.82	1189.09	1189.36	1189.62	1189.89	1190.16	1190.43	1190.70	1190.97	43.40
43.50	1190.97	1191.23	1191.50	1191.77	1192.04	1192.31	1192.58	1192.85	1193.11	1193.38	1193.65	43.50
43.60	1193.65	1193.92	1194.19	1194.46	1194.73	1195.00	1195.26	1195.53	1195.80	1196.07	1196.34	43.60
43.70	1196.34	1196.61	1196.88	1197.15	1197.41	1197.68	1197.95	1198.22	1198.49	1198.76	1199.03	43.70
43.80	1199.03	1199.30	1199.57	1199.84	1200.10	1200.37	1200.64	1200.91	1201.18	1201.45	1201.72	43.80
43.90	1201.72	1201.99	1202.26	1202.53	1202.80	1203.07	1203.33	1203.60	1203.87	1204.14	1204.41	43.90
44.00	1204.41	1204.68	1204.95	1205.22	1205.49	1205.76	1206.03	1206.30	1206.57	1206.84	1207.11	44.00
44.10	1207.11	1207.38	1207.65	1207.92	1208.18	1208.45	1208.72	1208.99	1209.26	1209.53	1209.80	44.10
44.20	1209.80	1210.07	1210.34	1210.61	1210.88	1211.15	1211.42	1211.69	1211.96	1212.23	1212.50	44.20
44.30	1212.50	1212.77	1213.04	1213.31	1213.58	1213.85	1214.12	1214.39	1214.66	1214.93	1215.20	44.30
44.40	1215.20	1215.47	1215.74	1216.01	1216.28	1216.55	1216.82	1217.09	1217.36	1217.63	1217.90	44.40
44.50	1217.90	1218.18	1218.45	1218.72	1218.99	1219.26	1219.53	1219.80	1220.07	1220.34	1220.61	44.50
44.60	1220.61	1220.88	1221.15	1221.42	1221.69	1221.96	1222.23	1222.50	1222.77	1223.04	1223.32	44.60
44.70	1223.32	1223.59	1223.86	1224.13	1224.40	1224.67	1224.94	1225.21	1225.48	1225.75	1226.02	44.70
44.80	1226.02	1226.30	1226.57	1226.84	1227.11	1227.38	1227.65	1227.92	1228.19	1228.46	1228.73	44.80
44.90	1228.73	1229.01	1229.28	1229.55	1229.82	1230.09	1230.36	1230.63	1230.90	1231.18	1231.45	44.90
45.00	1231.45	1231.72	1231.99	1232.26	1232.53	1232.80	1233.08	1233.35	1233.62	1233.89	1234.16	45.00
45.10	1234.16	1234.43	1234.70	1234.98	1235.25	1235.52	1235.79	1236.06	1236.33	1236.61	1236.88	45.10
45.20	1236.88	1237.15	1237.42	1237.69	1237.97	1238.24	1238.51	1238.78	1239.05	1239.33	1239.60	45.20
45.30	1239.60	1239.87	1240.14	1240.41	1240.69	1240.96	1241.23	1241.50	1241.77	1242.05	1242.32	45.30
45.40	1242.32	1242.59	1242.86	1243.13	1243.41	1243.68	1243.95	1244.22	1244.50	1244.77	1245.04	45.40
45.50	1245.04	1245.31	1245.59	1245.86	1246.13	1246.40	1246.68	1246.95	1247.22	1247.49	1247.77	45.50
45.60	1247.77	1248.04	1248.31	1248.58	1248.86	1249.13	1249.40	1249.67	1249.95	1250.22	1250.49	45.60
45.70	1250.49	1250.77	1251.04	1251.31	1251.58	1251.86	1252.13	1252.40	1252.68	1252.95	1253.22	45.70
45.80	1253.22	1253.50	1253.77	1254.04	1254.32	1254.59	1254.86	1255.13	1255.41	1255.68	1255.95	45.80
45.90	1255.95	1256.23	1256.50	1256.77	1257.05	1257.32	1257.59	1257.87	1258.14	1258.41	1258.69	45.90
46.00	1258.69	1258.96	1259.23	1259.51	1259.78	1260.06	1260.33	1260.60	1260.88	1261.15	1261.42	46.00
46.10	1261.42	1261.70	1261.97	1262.24	1262.52	1262.79	1263.07	1263.34	1263.61	1263.89	1264.16	46.10
46.20	1264.16	1264.44	1264.71	1264.98	1265.26	1265.53	1265.81	1266.08	1266.35	1266.63	1266.90	46.20
46.30	1266.90	1267.18	1267.45	1267.72	1268.00	1268.27	1268.55	1268.82	1269.10	1269.37	1269.64	46.30
46.40	1269.64	1269.92	1270.19	1270.47	1270.74	1271.02	1271.29	1271.56	1271.84	1272.11	1272.39	46.40
46.50	1272.39	1272.66	1272.94	1273.21	1273.49	1273.76	1274.04	1274.31	1274.59	1274.86	1275.13	46.50
46.60	1275.13	1275.41	1275.68	1275.96	1276.23	1276.51	1276.78	1277.06	1277.33	1277.61	1277.88	46.60
46.70	1277.88	1278.16	1278.43	1278.71	1278.98	1279.26	1279.53	1279.81	1280.08	1280.36	1280.63	46.70
46.80	1280.63	1280.91	1281.18	1281.46	1281.74	1282.01	1282.29	1282.56	1282.84	1283.11	1283.39	46.80
46.90	1283.39	1283.66	1283.94	1284.21	1284.49	1284.76	1285.04	1285.32	1285.59	1285.87	1286.14	46.90
47.00	1286.14	1286.42	1286.69	1286.97	1287.25	1287.52	1287.80	1288.07	1288.35	1288.62	1288.90	47.00
47.10	1288.90	1289.18	1289.45	1289.73	1290.00	1290.28	1290.56	1290.83	1291.11	1291.38	1291.66	47.10
47.20	1291.66	1291.94	1292.21	1292.49	1292.76	1293.04	1293.32	1293.59	1293.87	1294.14	1294.42	47.20
47.30	1294.42	1294.70	1294.97	1295.25	1295.53	1295.80	1296.08	1296.35	1296.63	1296.91	1297.18	47.30
47.40	1297.18	1297.46	1297.74	1298.01	1298.29	1298.57	1298.84	1299.12	1299.40	1299.67	1299.95	47.40
47.50	1299.95											47.50
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

TABLE B3. AWG 28 *Nicrosil versus Nisil thermocouples—temperature (°F) as a function of thermoelectric voltage, reference junctions at 32 °F.*

TEMPERATURES IN DEGREES F

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
-4.30	-410.55	-416.02	-422.37	-430.22	-441.59							-4.30
-4.20	-374.14	-377.01	-379.99	-383.09	-386.34	-389.74	-393.34	-397.16	-401.25	-405.68	-410.55	-4.20
-4.10	-349.64	-351.83	-354.07	-356.35	-358.70	-361.09	-363.56	-366.08	-368.69	-371.37	-374.14	-4.10
-4.00	-329.76	-331.61	-333.48	-335.39	-337.32	-339.29	-341.28	-343.31	-345.38	-347.49	-349.64	-4.00
-3.90	-312.51	-314.15	-315.80	-317.47	-319.16	-320.88	-322.61	-324.36	-326.14	-327.93	-329.76	-3.90
-3.80	-297.02	-298.51	-300.01	-301.52	-303.05	-304.59	-306.14	-307.71	-309.30	-310.90	-312.51	-3.80
-3.70	-282.80	-284.18	-285.56	-286.96	-288.36	-289.78	-291.20	-292.64	-294.09	-295.55	-297.02	-3.70
-3.60	-269.56	-270.85	-272.14	-273.44	-274.75	-276.07	-277.40	-278.74	-280.08	-281.44	-282.80	-3.60
-3.50	-257.09	-258.31	-259.53	-260.76	-262.00	-263.24	-264.49	-265.75	-267.01	-268.28	-269.56	-3.50
-3.40	-245.27	-246.42	-247.59	-248.75	-249.93	-251.11	-252.29	-253.48	-254.68	-255.88	-257.09	-3.40
-3.30	-233.97	-235.08	-236.19	-237.31	-238.43	-239.56	-240.69	-241.83	-242.97	-244.11	-245.27	-3.30
-3.20	-223.14	-224.20	-225.27	-226.34	-227.42	-228.50	-229.59	-230.68	-231.77	-232.87	-233.97	-3.20
-3.10	-212.70	-213.72	-214.76	-215.79	-216.83	-217.87	-218.92	-219.97	-221.02	-222.08	-223.14	-3.10
-3.00	-202.60	-203.60	-204.60	-205.60	-206.60	-207.61	-208.62	-209.63	-210.65	-211.67	-212.70	-3.00
-2.90	-192.81	-193.78	-194.75	-195.72	-196.69	-197.67	-198.65	-199.64	-200.62	-201.61	-202.60	-2.90
-2.80	-183.30	-184.24	-185.18	-186.12	-187.07	-188.02	-188.98	-189.93	-190.89	-191.85	-192.81	-2.80
-2.70	-174.02	-174.94	-175.86	-176.78	-177.70	-178.63	-179.56	-180.49	-181.42	-182.36	-183.30	-2.70
-2.60	-164.97	-165.86	-166.76	-167.66	-168.57	-169.47	-170.38	-171.28	-172.19	-173.11	-174.02	-2.60
-2.50	-156.11	-156.99	-157.87	-158.75	-159.63	-160.52	-161.40	-162.29	-163.18	-164.07	-164.97	-2.50
-2.40	-147.44	-148.30	-149.16	-150.02	-150.89	-151.75	-152.62	-153.49	-154.36	-155.24	-156.11	-2.40
-2.30	-138.92	-139.77	-140.61	-141.46	-142.31	-143.16	-144.01	-144.87	-145.72	-146.58	-147.44	-2.30
-2.20	-130.56	-131.39	-132.22	-133.06	-133.89	-134.73	-135.56	-136.40	-137.24	-138.08	-138.92	-2.20
-2.10	-122.34	-123.15	-123.97	-124.79	-125.61	-126.43	-127.26	-128.08	-128.91	-129.73	-130.56	-2.10
-2.00	-114.24	-115.04	-115.85	-116.66	-117.46	-118.27	-119.08	-119.90	-120.71	-121.52	-122.34	-2.00
-1.90	-106.26	-107.05	-107.84	-108.64	-109.44	-110.23	-111.03	-111.83	-112.63	-113.44	-114.24	-1.90
-1.80	-98.38	-99.16	-99.95	-100.73	-101.52	-102.31	-103.09	-103.88	-104.67	-105.47	-106.26	-1.80
-1.70	-90.61	-91.38	-92.15	-92.93	-93.70	-94.48	-95.26	-96.04	-96.82	-97.60	-98.38	-1.70
-1.60	-82.92	-83.68	-84.45	-85.22	-85.98	-86.75	-87.52	-88.29	-89.06	-89.83	-90.61	-1.60
-1.50	-75.32	-76.07	-76.83	-77.59	-78.35	-79.11	-79.87	-80.63	-81.39	-82.16	-82.92	-1.50
-1.40	-67.79	-68.54	-69.29	-70.04	-70.79	-71.55	-72.30	-73.05	-73.81	-74.56	-75.32	-1.40
-1.30	-60.34	-61.08	-61.83	-62.57	-63.31	-64.06	-64.80	-65.55	-66.30	-67.05	-67.79	-1.30
-1.20	-52.96	-53.69	-54.43	-55.16	-55.90	-56.64	-57.38	-58.12	-58.86	-59.60	-60.34	-1.20
-1.10	-45.63	-46.36	-47.09	-47.82	-48.55	-49.29	-50.02	-50.75	-51.49	-52.22	-52.96	-1.10
-1.00	-38.36	-39.09	-39.81	-40.54	-41.26	-41.99	-42.72	-43.45	-44.17	-44.90	-45.63	-1.00
-0.90	-31.15	-31.87	-32.59	-33.31	-34.03	-34.75	-35.47	-36.19	-36.92	-37.64	-38.36	-0.90
-0.80	-23.98	-24.70	-25.41	-26.13	-26.84	-27.56	-28.28	-28.99	-29.71	-30.43	-31.15	-0.80
-0.70	-16.86	-17.57	-18.28	-18.99	-19.70	-20.42	-21.13	-21.84	-22.55	-23.27	-23.98	-0.70
-0.60	-9.78	-10.49	-11.19	-11.90	-12.61	-13.32	-14.02	-14.73	-15.44	-16.15	-16.86	-0.60
-0.50	-2.74	-3.44	-4.14	-4.85	-5.55	-6.26	-6.96	-7.66	-8.37	-9.07	-9.78	-0.50
-0.40	4.27	3.57	2.87	2.17	1.47	0.77	0.07	-0.63	-1.33	-2.04	-2.74	-0.40
-0.30	11.24	10.55	9.85	9.15	8.46	7.76	7.06	6.36	5.67	4.97	4.27	-0.30
-0.20	18.19	17.49	16.80	16.11	15.41	14.72	14.02	13.33	12.63	11.94	11.24	-0.20
-0.10	25.11	24.42	23.72	23.03	22.34	21.65	20.96	20.27	19.57	18.88	18.19	-0.10
0.00	32.00	31.31	30.62	29.93	29.25	28.56	27.87	27.18	26.49	25.80	25.11	0.00
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

TABLE B3. AWG 28 *Nicrosil versus Nisil thermocouples—temperature (°F) as a function of thermoelectric voltage, reference junctions at 32 °F*—Continued

TEMPERATURES IN DEGREES F

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
0.00	32.00	32.69	33.38	34.06	34.75	35.44	36.13	36.81	37.50	38.19	38.87	0.00
0.10	38.87	39.56	40.24	40.93	41.62	42.30	42.99	43.67	44.36	45.04	45.72	0.10
0.20	45.72	46.41	47.09	47.77	48.46	49.14	49.82	50.51	51.19	51.87	52.55	0.20
0.30	52.55	53.23	53.91	54.59	55.27	55.95	56.63	57.31	57.99	58.67	59.35	0.30
0.40	59.35	60.03	60.71	61.39	62.06	62.74	63.42	64.10	64.77	65.45	66.13	0.40
0.50	66.13	66.80	67.48	68.15	68.83	69.50	70.18	70.85	71.52	72.20	72.87	0.50
0.60	72.87	73.54	74.21	74.89	75.56	76.23	76.90	77.57	78.24	78.91	79.58	0.60
0.70	79.58	80.25	80.92	81.59	82.26	82.93	83.60	84.26	84.93	85.60	86.27	0.70
0.80	86.27	86.93	87.60	88.26	88.93	89.60	90.26	90.92	91.59	92.25	92.92	0.80
0.90	92.92	93.58	94.24	94.91	95.57	96.23	96.89	97.55	98.21	98.87	99.53	0.90
1.00	99.53	100.19	100.85	101.51	102.17	102.83	103.49	104.15	104.80	105.46	106.12	1.00
1.10	106.12	106.78	107.43	108.09	108.74	109.40	110.05	110.71	111.36	112.02	112.67	1.10
1.20	112.67	113.32	113.98	114.63	115.28	115.93	116.59	117.24	117.89	118.54	119.19	1.20
1.30	119.19	119.84	120.49	121.14	121.79	122.44	123.08	123.73	124.38	125.03	125.67	1.30
1.40	125.67	126.32	126.97	127.61	128.26	128.90	129.55	130.19	130.84	131.48	132.13	1.40
1.50	132.13	132.77	133.41	134.06	134.70	135.34	135.98	136.62	137.26	137.91	138.55	1.50
1.60	138.55	139.19	139.83	140.46	141.10	141.74	142.38	143.02	143.66	144.30	144.93	1.60
1.70	144.93	145.57	146.21	146.84	147.48	148.11	148.75	149.38	150.02	150.65	151.29	1.70
1.80	151.29	151.92	152.55	153.19	153.82	154.45	155.08	155.72	156.35	156.98	157.61	1.80
1.90	157.61	158.24	158.87	159.50	160.13	160.76	161.39	162.02	162.65	163.27	163.90	1.90
2.00	163.90	164.53	165.16	165.78	166.41	167.04	167.66	168.29	168.91	169.54	170.16	2.00
2.10	170.16	170.79	171.41	172.03	172.66	173.28	173.90	174.53	175.15	175.77	176.39	2.10
2.20	176.39	177.01	177.64	178.26	178.88	179.50	180.12	180.74	181.36	181.98	182.59	2.20
2.30	182.59	183.21	183.83	184.45	185.07	185.68	186.30	186.92	187.53	188.15	188.77	2.30
2.40	188.77	189.38	190.00	190.61	191.23	191.84	192.46	193.07	193.68	194.30	194.91	2.40
2.50	194.91	195.52	196.13	196.75	197.36	197.97	198.58	199.19	199.80	200.41	201.03	2.50
2.60	201.03	201.64	202.24	202.85	203.46	204.07	204.68	205.29	205.90	206.51	207.11	2.60
2.70	207.11	207.72	208.33	208.93	209.54	210.15	210.75	211.36	211.96	212.57	213.18	2.70
2.80	213.18	213.78	214.38	214.99	215.59	216.20	216.80	217.40	218.01	218.61	219.21	2.80
2.90	219.21	219.81	220.41	221.02	221.62	222.22	222.82	223.42	224.02	224.62	225.22	2.90
3.00	225.22	225.82	226.42	227.02	227.62	228.22	228.81	229.41	230.01	230.61	231.21	3.00
3.10	231.21	231.80	232.40	233.00	233.59	234.19	234.78	235.38	235.98	236.57	237.17	3.10
3.20	237.17	237.76	238.36	238.95	239.54	240.14	240.73	241.32	241.92	242.51	243.10	3.20
3.30	243.10	243.70	244.29	244.88	245.47	246.06	246.65	247.25	247.84	248.43	249.02	3.30
3.40	249.02	249.61	250.20	250.79	251.38	251.96	252.55	253.14	253.73	254.32	254.91	3.40
3.50	254.91	255.50	256.08	256.67	257.26	257.84	258.43	259.02	259.60	260.19	260.78	3.50
3.60	260.78	261.36	261.95	262.53	263.12	263.70	264.29	264.87	265.46	266.04	266.62	3.60
3.70	266.62	267.21	267.79	268.37	268.96	269.54	270.12	270.70	271.29	271.87	272.45	3.70
3.80	272.45	273.03	273.61	274.19	274.77	275.35	275.93	276.51	277.09	277.67	278.25	3.80
3.90	278.25	278.83	279.41	279.99	280.57	281.15	281.73	282.31	282.88	283.46	284.04	3.90
4.00	284.04	284.62	285.19	285.77	286.35	286.92	287.50	288.08	288.65	289.23	289.80	4.00
4.10	289.80	290.38	290.95	291.53	292.10	292.68	293.25	293.83	294.40	294.98	295.55	4.10
4.20	295.55	296.12	296.70	297.27	297.84	298.41	298.99	299.56	300.13	300.70	301.28	4.20
4.30	301.28	301.85	302.42	302.99	303.56	304.13	304.70	305.27	305.84	306.41	306.98	4.30
4.40	306.98	307.55	308.12	308.69	309.26	309.83	310.40	310.97	311.54	312.11	312.67	4.40
4.50	312.67	313.24	313.81	314.38	314.94	315.51	316.08	316.65	317.21	317.78	318.35	4.50
4.60	318.35	318.91	319.48	320.04	320.61	321.17	321.74	322.31	322.87	323.44	324.00	4.60
4.70	324.00	324.56	325.13	325.69	326.26	326.82	327.38	327.95	328.51	329.07	329.64	4.70
4.80	329.64	330.20	330.76	331.33	331.89	332.45	333.01	333.57	334.14	334.70	335.26	4.80
4.90	335.26	335.82	336.38	336.94	337.50	338.06	338.62	339.18	339.74	340.30	340.86	4.90
5.00	340.86	341.42	341.98	342.54	343.10	343.66	344.22	344.78	345.33	345.89	346.45	5.00
5.10	346.45	347.01	347.57	348.12	348.68	349.24	349.80	350.35	350.91	351.47	352.02	5.10
5.20	352.02	352.58	353.14	353.69	354.25	354.80	355.36	355.91	356.47	357.02	357.58	5.20
5.30	357.58	358.13	358.69	359.24	359.80	360.35	360.91	361.46	362.01	362.57	363.12	5.30
5.40	363.12	363.67	364.23	364.78	365.33	365.89	366.44	366.99	367.54	368.10	368.65	5.40
5.50	368.65	369.20	369.75	370.30	370.85	371.41	371.96	372.51	373.06	373.61	374.16	5.50
5.60	374.16	374.71	375.26	375.81	376.36	376.91	377.46	378.01	378.56	379.11	379.66	5.60
5.70	379.66	380.21	380.75	381.30	381.85	382.40	382.95	383.50	384.04	384.59	385.14	5.70
5.80	385.14	385.69	386.24	386.78	387.33	387.88	388.42	388.97	389.52	390.06	390.61	5.80
5.90	390.61	391.16	391.70	392.25	392.79	393.34	393.88	394.43	394.97	395.52	396.06	5.90
6.00	396.06	396.61	397.15	397.70	398.24	398.79	399.33	399.88	400.42	400.96	401.51	6.00
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

Table B3. AWG 28 *Nicrosil versus Nisil thermocouples—temperature (°F) as a function of thermoelectric voltage, reference junctions at 32 °F*—Continued

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
						TEMPERATURES IN DEGREES F						
6.00	396.06	396.61	397.15	397.70	398.24	398.79	399.33	399.88	400.42	400.96	401.51	6.00
6.10	401.51	402.05	402.59	403.14	403.68	404.22	404.76	405.31	405.85	406.39	406.93	6.10
6.20	406.93	407.48	408.02	408.56	409.10	409.64	410.18	410.73	411.27	411.81	412.35	6.20
6.30	412.35	412.89	413.43	413.97	414.51	415.05	415.59	416.13	416.67	417.21	417.75	6.30
6.40	417.75	418.29	418.83	419.37	419.91	420.45	420.99	421.53	422.06	422.60	423.14	6.40
6.50	423.14	423.68	424.22	424.75	425.29	425.83	426.37	426.91	427.44	427.98	428.52	6.50
6.60	428.52	429.05	429.59	430.13	430.66	431.20	431.74	432.27	432.81	433.35	433.88	6.60
6.70	433.88	434.42	434.95	435.49	436.02	436.56	437.09	437.63	438.16	438.70	439.23	6.70
6.80	439.23	439.77	440.30	440.84	441.37	441.90	442.44	442.97	443.51	444.04	444.57	6.80
6.90	444.57	445.11	445.64	446.17	446.71	447.24	447.77	448.30	448.84	449.37	449.90	6.90
7.00	449.90	450.43	450.96	451.50	452.03	452.56	453.09	453.62	454.15	454.69	455.22	7.00
7.10	455.22	455.75	456.28	456.81	457.34	457.87	458.40	458.93	459.46	459.99	460.52	7.10
7.20	460.52	461.05	461.58	462.11	462.64	463.17	463.70	464.23	464.76	465.29	465.81	7.20
7.30	465.81	466.34	466.87	467.40	467.93	468.46	468.98	469.51	470.04	470.57	471.10	7.30
7.40	471.10	471.62	472.15	472.68	473.20	473.73	474.26	474.79	475.31	475.84	476.37	7.40
7.50	476.37	476.89	477.42	477.94	478.47	479.00	479.52	480.05	480.57	481.10	481.63	7.50
7.60	481.63	482.15	482.68	483.20	483.73	484.25	484.78	485.30	485.82	486.35	486.87	7.60
7.70	486.87	487.40	487.92	488.45	488.97	489.49	490.02	490.54	491.06	491.59	492.11	7.70
7.80	492.11	492.63	493.16	493.68	494.20	494.73	495.25	495.77	496.29	496.82	497.34	7.80
7.90	497.34	497.86	498.38	498.90	499.43	499.95	500.47	500.99	501.51	502.03	502.56	7.90
8.00	502.56	503.08	503.60	504.12	504.64	505.16	505.68	506.20	506.72	507.24	507.76	8.00
8.10	507.76	508.28	508.80	509.32	509.84	510.36	510.88	511.40	511.92	512.44	512.96	8.10
8.20	512.96	513.48	514.00	514.51	515.03	515.55	516.07	516.59	517.11	517.63	518.14	8.20
8.30	518.14	518.66	519.18	519.70	520.22	520.73	521.25	521.77	522.29	522.80	523.32	8.30
8.40	523.32	523.84	524.35	524.87	525.39	525.91	526.42	526.94	527.45	527.97	528.49	8.40
8.50	528.49	529.00	529.52	530.04	530.55	531.07	531.58	532.10	532.61	533.13	533.64	8.50
8.60	533.64	534.16	534.67	535.19	535.70	536.22	536.73	537.25	537.76	538.28	538.79	8.60
8.70	538.79	539.31	539.82	540.33	540.85	541.36	541.88	542.39	542.90	543.42	543.93	8.70
8.80	543.93	544.44	544.96	545.47	545.98	546.50	547.01	547.52	548.03	548.55	549.06	8.80
8.90	549.06	549.57	550.08	550.60	551.11	551.62	552.13	552.64	553.16	553.67	554.18	8.90
9.00	554.18	554.69	555.20	555.71	556.23	556.74	557.25	557.76	558.27	558.78	559.29	9.00
9.10	559.29	559.80	560.31	560.82	561.33	561.84	562.35	562.86	563.37	563.88	564.39	9.10
9.20	564.39	564.90	565.41	565.92	566.43	566.94	567.45	567.96	568.47	568.98	569.49	9.20
9.30	569.49	570.00	570.51	571.01	571.52	572.03	572.54	573.05	573.56	574.06	574.57	9.30
9.40	574.57	575.08	575.59	576.10	576.60	577.11	577.62	578.13	578.64	579.14	579.65	9.40
9.50	579.65	580.16	580.66	581.17	581.68	582.19	582.69	583.20	583.71	584.21	584.72	9.50
9.60	584.72	585.23	585.73	586.24	586.74	587.25	587.76	588.26	588.77	589.27	589.78	9.60
9.70	589.78	590.29	590.79	591.30	591.80	592.31	592.81	593.32	593.82	594.33	594.83	9.70
9.80	594.83	595.34	595.84	596.35	596.85	597.36	597.86	598.37	598.87	599.38	599.88	9.80
9.90	599.88	600.38	600.89	601.39	601.90	602.40	602.90	603.41	603.91	604.41	604.92	9.90
10.00	604.92	605.42	605.92	606.43	606.93	607.43	607.94	608.44	608.94	609.45	609.95	10.00
10.10	609.95	610.45	610.95	611.46	611.96	612.46	612.96	613.47	613.97	614.47	614.97	10.10
10.20	614.97	615.47	615.98	616.48	616.98	617.48	617.98	618.48	618.98	619.49	619.99	10.20
10.30	619.99	620.49	620.99	621.49	621.99	622.49	622.99	623.49	624.00	624.50	625.00	10.30
10.40	625.00	625.50	626.00	626.50	627.00	627.50	628.00	628.50	629.00	629.50	630.00	10.40
10.50	630.00	630.50	631.00	631.50	632.00	632.50	633.00	633.50	634.00	634.50	635.00	10.50
10.60	635.00	635.49	635.99	636.49	636.99	637.49	637.99	638.49	638.99	639.49	639.98	10.60
10.70	639.98	640.48	640.98	641.48	641.98	642.48	642.97	643.47	643.97	644.47	644.97	10.70
10.80	644.97	645.47	645.96	646.46	646.96	647.46	647.95	648.45	648.95	649.45	649.94	10.80
10.90	649.94	650.44	650.94	651.44	651.93	652.43	652.93	653.42	653.92	654.42	654.91	10.90
11.00	654.91	655.41	655.91	656.40	656.90	657.40	657.89	658.39	658.89	659.38	659.88	11.00
11.10	659.88	660.37	660.87	661.37	661.86	662.36	662.85	663.35	663.85	664.34	664.84	11.10
11.20	664.84	665.33	665.83	666.32	666.82	667.31	667.81	668.30	668.80	669.29	669.79	11.20
11.30	669.79	670.28	670.78	671.27	671.77	672.26	672.76	673.25	673.75	674.24	674.74	11.30
11.40	674.74	675.23	675.73	676.22	676.71	677.21	677.70	678.20	678.69	679.18	679.68	11.40
11.50	679.68	680.17	680.67	681.16	681.65	682.15	682.64	683.13	683.63	684.12	684.61	11.50
11.60	684.61	685.11	685.60	686.09	686.59	687.08	687.57	688.07	688.56	689.05	689.55	11.60
11.70	689.55	690.04	690.53	691.02	691.52	692.01	692.50	692.99	693.49	693.98	694.47	11.70
11.80	694.47	694.96	695.46	695.95	696.44	696.93	697.42	697.92	698.41	698.90	699.39	11.80
11.90	699.39	699.88	700.37	700.87	701.36	701.85	702.34	702.83	703.32	703.82	704.31	11.90
12.00	704.31	704.80	705.29	705.78	706.27	706.76	707.25	707.74	708.24	708.73	709.22	12.00
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

TABLE B3. AWG 28 *Nicrosil versus Nisil thermocouples—temperature (°F) as a function of thermoelectric voltage, reference junctions at 32 °F*—Continued

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
					TEMPERATURES IN DEGREES F							
0.00	32.00	32.69	33.38	34.06	34.75	35.44	36.13	36.81	37.50	38.19	38.87	0.00
0.10	38.87	39.56	40.24	40.93	41.62	42.30	42.99	43.67	44.36	45.04	45.72	0.10
0.20	45.72	46.41	47.09	47.77	48.46	49.14	49.82	50.51	51.19	51.87	52.55	0.20
0.30	52.55	53.23	53.91	54.59	55.27	55.95	56.63	57.31	57.99	58.67	59.35	0.30
0.40	59.35	60.03	60.71	61.39	62.06	62.74	63.42	64.10	64.77	65.45	66.13	0.40
0.50	66.13	66.80	67.48	68.15	68.83	69.50	70.18	70.85	71.52	72.20	72.87	0.50
0.60	72.87	73.54	74.21	74.89	75.56	76.23	76.90	77.57	78.24	78.91	79.58	0.60
0.70	79.58	80.25	80.92	81.59	82.26	82.93	83.60	84.26	84.93	85.60	86.27	0.70
0.80	86.27	86.93	87.60	88.26	88.93	89.60	90.26	90.92	91.59	92.25	92.92	0.80
0.90	92.92	93.58	94.24	94.91	95.57	96.23	96.89	97.55	98.21	98.87	99.53	0.90
1.00	99.53	100.19	100.85	101.51	102.17	102.83	103.49	104.15	104.80	105.46	106.12	1.00
1.10	106.12	106.78	107.43	108.09	108.74	109.40	110.05	110.71	111.36	112.02	112.67	1.10
1.20	112.67	113.32	113.98	114.63	115.28	115.93	116.59	117.24	117.89	118.54	119.19	1.20
1.30	119.19	119.84	120.49	121.14	121.79	122.44	123.08	123.73	124.38	125.03	125.67	1.30
1.40	125.67	126.32	126.97	127.61	128.26	128.90	129.55	130.19	130.84	131.48	132.13	1.40
1.50	132.13	132.77	133.41	134.06	134.70	135.34	135.98	136.62	137.26	137.91	138.55	1.50
1.60	138.55	139.19	139.83	140.46	141.10	141.74	142.38	143.02	143.66	144.30	144.93	1.60
1.70	144.93	145.57	146.21	146.84	147.48	148.11	148.75	149.38	150.02	150.65	151.29	1.70
1.80	151.29	151.92	152.55	153.19	153.82	154.45	155.08	155.72	156.35	156.98	157.61	1.80
1.90	157.61	158.24	158.87	159.50	160.13	160.76	161.39	162.02	162.65	163.27	163.90	1.90
2.00	163.90	164.53	165.16	165.78	166.41	167.04	167.66	168.29	168.91	169.54	170.16	2.00
2.10	170.16	170.79	171.41	172.03	172.66	173.28	173.90	174.53	175.15	175.77	176.39	2.10
2.20	176.39	177.01	177.64	178.26	178.88	179.50	180.12	180.74	181.36	181.98	182.59	2.20
2.30	182.59	183.21	183.83	184.45	185.07	185.68	186.30	186.92	187.53	188.15	188.77	2.30
2.40	188.77	189.38	190.00	190.61	191.23	191.84	192.46	193.07	193.68	194.30	194.91	2.40
2.50	194.91	195.52	196.13	196.75	197.36	197.97	198.58	199.19	199.80	200.41	201.03	2.50
2.60	201.03	201.64	202.24	202.85	203.46	204.07	204.68	205.29	205.90	206.51	207.11	2.60
2.70	207.11	207.72	208.33	208.93	209.54	210.15	210.75	211.36	211.96	212.57	213.18	2.70
2.80	213.18	213.78	214.38	214.99	215.59	216.20	216.80	217.40	218.01	218.61	219.21	2.80
2.90	219.21	219.81	220.41	221.02	221.62	222.22	222.82	223.42	224.02	224.62	225.22	2.90
3.00	225.22	225.82	226.42	227.02	227.62	228.22	228.81	229.41	230.01	230.61	231.21	3.00
3.10	231.21	231.80	232.40	233.00	233.59	234.19	234.78	235.38	235.98	236.57	237.17	3.10
3.20	237.17	237.76	238.36	238.95	239.54	240.14	240.73	241.32	241.92	242.51	243.10	3.20
3.30	243.10	243.70	244.29	244.88	245.47	246.06	246.65	247.25	247.84	248.43	249.02	3.30
3.40	249.02	249.61	250.20	250.79	251.38	251.96	252.55	253.14	253.73	254.32	254.91	3.40
3.50	254.91	255.50	256.08	256.67	257.26	257.84	258.43	259.02	259.60	260.19	260.78	3.50
3.60	260.78	261.36	261.95	262.53	263.12	263.70	264.29	264.87	265.46	266.04	266.62	3.60
3.70	266.62	267.21	267.79	268.37	268.96	269.54	270.12	270.70	271.29	271.87	272.45	3.70
3.80	272.45	273.03	273.61	274.19	274.77	275.35	275.93	276.51	277.09	277.67	278.25	3.80
3.90	278.25	278.83	279.41	279.99	280.57	281.15	281.73	282.31	282.88	283.46	284.04	3.90
4.00	284.04	284.62	285.19	285.77	286.35	286.92	287.50	288.08	288.65	289.23	289.80	4.00
4.10	289.80	290.38	290.95	291.53	292.10	292.68	293.25	293.83	294.40	294.98	295.55	4.10
4.20	295.55	296.12	296.70	297.27	297.84	298.41	298.99	299.56	300.13	300.70	301.28	4.20
4.30	301.28	301.85	302.42	302.99	303.56	304.13	304.70	305.27	305.84	306.41	306.98	4.30
4.40	306.98	307.55	308.12	308.69	309.26	309.83	310.40	310.97	311.54	312.11	312.67	4.40
4.50	312.67	313.24	313.81	314.38	314.94	315.51	316.08	316.65	317.21	317.78	318.35	4.50
4.60	318.35	318.91	319.48	320.04	320.61	321.17	321.74	322.31	322.87	323.44	324.00	4.60
4.70	324.00	324.56	325.13	325.69	326.26	326.82	327.38	327.95	328.51	329.07	329.64	4.70
4.80	329.64	330.20	330.76	331.33	331.89	332.45	333.01	333.57	334.14	334.70	335.26	4.80
4.90	335.26	335.82	336.38	336.94	337.50	338.06	338.62	339.18	339.74	340.30	340.86	4.90
5.00	340.86	341.42	341.98	342.54	343.10	343.66	344.22	344.78	345.33	345.89	346.45	5.00
5.10	346.45	347.01	347.57	348.12	348.68	349.24	349.80	350.35	350.91	351.47	352.02	5.10
5.20	352.02	352.58	353.14	353.69	354.25	354.80	355.36	355.91	356.47	357.02	357.58	5.20
5.30	357.58	358.13	358.69	359.24	359.80	360.35	360.91	361.46	362.01	362.57	363.12	5.30
5.40	363.12	363.67	364.23	364.78	365.33	365.89	366.44	366.99	367.54	368.10	368.65	5.40
5.50	368.65	369.20	369.75	370.30	370.85	371.41	371.96	372.51	373.06	373.61	374.16	5.50
5.60	374.16	374.71	375.26	375.81	376.36	376.91	377.46	378.01	378.56	379.11	379.66	5.60
5.70	379.66	380.21	380.75	381.30	381.85	382.40	382.95	383.50	384.04	384.59	385.14	5.70
5.80	385.14	385.69	386.24	386.78	387.33	387.88	388.42	388.97	389.52	390.06	390.61	5.80
5.90	390.61	391.16	391.70	392.25	392.79	393.34	393.88	394.43	394.97	395.52	396.06	5.90
6.00	396.06	396.61	397.15	397.70	398.24	398.79	399.33	399.88	400.42	400.96	401.51	6.00
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

TABLE B3. AWG 28 *Nicrosil versus Nisil thermocouples—temperature (°F) as a function of thermoelectric voltage, reference junctions at 32 °F*—Continued

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
	TEMPERATURES IN DEGREES F											
6.00	396.06	396.61	397.15	397.70	398.24	398.79	399.33	399.88	400.42	400.96	401.51	6.00
6.10	401.51	402.05	402.59	403.14	403.68	404.22	404.76	405.31	405.85	406.39	406.93	6.10
6.20	406.93	407.48	408.02	408.56	409.10	409.64	410.18	410.73	411.27	411.81	412.35	6.20
6.30	412.35	412.89	413.43	413.97	414.51	415.05	415.59	416.13	416.67	417.21	417.75	6.30
6.40	417.75	418.29	418.83	419.37	419.91	420.45	420.99	421.53	422.06	422.60	423.14	6.40
6.50	423.14	423.68	424.22	424.75	425.29	425.83	426.37	426.91	427.44	427.98	428.52	6.50
6.60	428.52	429.05	429.59	430.13	430.66	431.20	431.74	432.27	432.81	433.35	433.88	6.60
6.70	433.88	434.42	434.95	435.49	436.02	436.56	437.09	437.63	438.16	438.70	439.23	6.70
6.80	439.23	439.77	440.30	440.84	441.37	441.90	442.44	442.97	443.51	444.04	444.57	6.80
6.90	444.57	445.11	445.64	446.17	446.71	447.24	447.77	448.30	448.84	449.37	449.90	6.90
7.00	449.90	450.43	450.96	451.50	452.03	452.56	453.09	453.62	454.15	454.69	455.22	7.00
7.10	455.22	455.75	456.28	456.81	457.34	457.87	458.40	458.93	459.46	459.99	460.52	7.10
7.20	460.52	461.05	461.58	462.11	462.64	463.17	463.70	464.23	464.76	465.29	465.81	7.20
7.30	465.81	466.34	466.87	467.40	467.93	468.46	468.98	469.51	470.04	470.57	471.10	7.30
7.40	471.10	471.62	472.15	472.68	473.20	473.73	474.26	474.79	475.31	475.84	476.37	7.40
7.50	476.37	476.89	477.42	477.94	478.47	479.00	479.52	480.05	480.57	481.10	481.63	7.50
7.60	481.63	482.15	482.68	483.20	483.73	484.25	484.78	485.30	485.82	486.35	486.87	7.60
7.70	486.87	487.40	487.92	488.45	488.97	489.49	490.02	490.54	491.06	491.59	492.11	7.70
7.80	492.11	492.63	493.16	493.68	494.20	494.73	495.25	495.77	496.29	496.82	497.34	7.80
7.90	497.34	497.86	498.38	498.90	499.43	499.95	500.47	500.99	501.51	502.03	502.56	7.90
8.00	502.56	503.08	503.60	504.12	504.64	505.16	505.68	506.20	506.72	507.24	507.76	8.00
8.10	507.76	508.28	508.80	509.32	509.84	510.36	510.88	511.40	511.92	512.44	512.96	8.10
8.20	512.96	513.48	514.00	514.51	515.03	515.55	516.07	516.59	517.11	517.63	518.14	8.20
8.30	518.14	518.66	519.18	519.70	520.22	520.73	521.25	521.77	522.29	522.80	523.32	8.30
8.40	523.32	523.84	524.35	524.87	525.39	525.91	526.42	526.94	527.45	527.97	528.49	8.40
8.50	528.49	529.00	529.52	530.04	530.55	531.07	531.58	532.10	532.61	533.13	533.64	8.50
8.60	533.64	534.16	534.67	535.19	535.70	536.22	536.73	537.25	537.76	538.28	538.79	8.60
8.70	538.79	539.31	539.82	540.33	540.85	541.36	541.88	542.39	542.90	543.42	543.93	8.70
8.80	543.93	544.44	544.96	545.47	545.98	546.50	547.01	547.52	548.03	548.55	549.06	8.80
8.90	549.06	549.57	550.08	550.60	551.11	551.62	552.13	552.64	553.16	553.67	554.18	8.90
9.00	554.18	554.69	555.20	555.71	556.23	556.74	557.25	557.76	558.27	558.78	559.29	9.00
9.10	559.29	559.80	560.31	560.82	561.33	561.84	562.35	562.86	563.37	563.88	564.39	9.10
9.20	564.39	564.90	565.41	565.92	566.43	566.94	567.45	567.96	568.47	568.98	569.49	9.20
9.30	569.49	570.00	570.51	571.01	571.52	572.03	572.54	573.05	573.56	574.06	574.57	9.30
9.40	574.57	575.08	575.59	576.10	576.60	577.11	577.62	578.13	578.64	579.14	579.65	9.40
9.50	579.65	580.16	580.66	581.17	581.68	582.19	582.69	583.20	583.71	584.21	584.72	9.50
9.60	584.72	585.23	585.73	586.24	586.74	587.25	587.76	588.26	588.77	589.27	589.78	9.60
9.70	589.78	590.29	590.79	591.30	591.80	592.31	592.81	593.32	593.82	594.33	594.83	9.70
9.80	594.83	595.34	595.84	596.35	596.85	597.36	597.86	598.37	598.87	599.38	599.88	9.80
9.90	599.88	600.38	600.89	601.39	601.90	602.40	602.90	603.41	603.91	604.41	604.92	9.90
10.00	604.92	605.42	605.92	606.43	606.93	607.43	607.94	608.44	608.94	609.45	609.95	10.00
10.10	609.95	610.45	610.95	611.46	611.96	612.46	612.96	613.47	613.97	614.47	614.97	10.10
10.20	614.97	615.47	615.98	616.48	616.98	617.48	617.98	618.48	618.98	619.49	619.99	10.20
10.30	619.99	620.49	620.99	621.49	621.99	622.49	622.99	623.49	624.00	624.50	625.00	10.30
10.40	625.00	625.50	626.00	626.50	627.00	627.50	628.00	628.50	629.00	629.50	630.00	10.40
10.50	630.00	630.50	631.00	631.50	632.00	632.50	633.00	633.50	634.00	634.50	635.00	10.50
10.60	635.00	635.49	635.99	636.49	636.99	637.49	637.99	638.49	638.99	639.49	639.98	10.60
10.70	639.98	640.48	640.98	641.48	641.98	642.48	642.97	643.47	643.97	644.47	644.97	10.70
10.80	644.97	645.47	645.96	646.46	646.96	647.46	647.95	648.45	648.95	649.45	649.94	10.80
10.90	649.94	650.44	650.94	651.44	651.93	652.43	652.93	653.42	653.92	654.42	654.91	10.90
11.00	654.91	655.41	655.91	656.40	656.90	657.40	657.89	658.39	658.89	659.38	659.88	11.00
11.10	659.88	660.37	660.87	661.37	661.86	662.36	662.85	663.35	663.85	664.34	664.84	11.10
11.20	664.84	665.33	665.83	666.32	666.82	667.31	667.81	668.30	668.80	669.29	669.79	11.20
11.30	669.79	670.28	670.78	671.27	671.77	672.26	672.76	673.25	673.75	674.24	674.74	11.30
11.40	674.74	675.23	675.73	676.22	676.71	677.21	677.70	678.20	678.69	679.18	679.68	11.40
11.50	679.68	680.17	680.67	681.16	681.65	682.15	682.64	683.13	683.63	684.12	684.61	11.50
11.60	684.61	685.11	685.60	686.09	686.59	687.08	687.57	688.07	688.56	689.05	689.55	11.60
11.70	689.55	690.04	690.53	691.02	691.52	692.01	692.50	692.99	693.49	693.98	694.47	11.70
11.80	694.47	694.96	695.46	695.95	696.44	696.93	697.42	697.92	698.41	698.90	699.39	11.80
11.90	699.39	699.88	700.37	700.87	701.36	701.85	702.34	702.83	703.32	703.82	704.31	11.90
12.00	704.31	704.80	705.29	705.78	706.27	706.76	707.25	707.74	708.24	708.73	709.22	12.00
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

Table B3. AWG 28 *Nicrosil versus Nisil thermocouples—temperature (°F) as a function of thermoelectric voltage, reference junctions at 32 °F*—Continued

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
						TEMPERATURES IN DEGREES F						
12.00	704.31	704.80	705.29	705.78	706.27	706.76	707.25	707.74	708.24	708.73	709.22	12.00
12.10	709.22	709.71	710.20	710.69	711.18	711.67	712.16	712.65	713.14	713.63	714.12	12.10
12.20	714.12	714.61	715.10	715.59	716.08	716.57	717.06	717.55	718.04	718.53	719.02	12.20
12.30	719.02	719.51	720.00	720.49	720.98	721.47	721.96	722.45	722.94	723.43	723.92	12.30
12.40	723.92	724.41	724.90	725.39	725.88	726.36	726.85	727.34	727.83	728.32	728.81	12.40
12.50	728.81	729.30	729.79	730.28	730.76	731.25	731.74	732.23	732.72	733.21	733.70	12.50
12.60	733.70	734.18	734.67	735.16	735.65	736.14	736.62	737.11	737.60	738.09	738.58	12.60
12.70	738.58	739.06	739.55	740.04	740.53	741.02	741.50	741.99	742.48	742.97	743.45	12.70
12.80	743.45	743.94	744.43	744.92	745.40	745.89	746.38	746.86	747.35	747.84	748.33	12.80
12.90	748.33	748.81	749.30	749.79	750.27	750.76	751.25	751.73				12.90
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

Table B4. AWG 14 *Nicrosil versus Nisil thermocouples—temperature (°F) as a function of thermoelectric voltage, reference junctions at 32 °F.*

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
						TEMPERATURES IN DEGREES F						
0.00	32.00	32.69	33.39	34.08	34.78	35.47	36.16	36.86	37.55	38.24	38.93	0.00
0.10	38.93	39.62	40.32	41.01	41.70	42.39	43.08	43.77	44.45	45.14	45.83	0.10
0.20	45.83	46.52	47.21	47.89	48.58	49.27	49.95	50.64	51.33	52.01	52.70	0.20
0.30	52.70	53.38	54.06	54.75	55.43	56.11	56.80	57.48	58.16	58.84	59.52	0.30
0.40	59.52	60.20	60.89	61.57	62.25	62.93	63.60	64.28	64.96	65.64	66.32	0.40
0.50	66.32	67.00	67.67	68.35	69.03	69.70	70.38	71.05	71.73	72.40	73.08	0.50
0.60	73.08	73.75	74.42	75.10	75.77	76.44	77.12	77.79	78.46	79.13	79.80	0.60
0.70	79.80	80.47	81.14	81.81	82.48	83.15	83.82	84.49	85.16	85.82	86.49	0.70
0.80	86.49	87.16	87.83	88.49	89.16	89.82	90.49	91.15	91.82	92.48	93.15	0.80
0.90	93.15	93.81	94.47	95.14	95.80	96.46	97.12	97.79	98.45	99.11	99.77	0.90
1.00	99.77	100.43	101.09	101.75	102.41	103.07	103.73	104.38	105.04	105.70	106.36	1.00
1.10	106.36	107.01	107.67	108.33	108.98	109.64	110.29	110.95	111.60	112.26	112.91	1.10
1.20	112.91	113.57	114.22	114.87	115.53	116.18	116.83	117.48	118.13	118.78	119.44	1.20
1.30	119.44	120.09	120.74	121.39	122.03	122.68	123.33	123.98	124.63	125.28	125.92	1.30
1.40	125.92	126.57	127.22	127.87	128.51	129.16	129.80	130.45	131.09	131.74	132.38	1.40
1.50	132.38	133.03	133.67	134.31	134.96	135.60	136.24	136.88	137.53	138.17	138.81	1.50
1.60	138.81	139.45	140.09	140.73	141.37	142.01	142.65	143.29	143.93	144.56	145.20	1.60
1.70	145.20	145.84	146.48	147.11	147.75	148.39	149.02	149.66	150.30	150.93	151.57	1.70
1.80	151.57	152.20	152.83	153.47	154.10	154.74	155.37	156.00	156.63	157.27	157.90	1.80
1.90	157.90	158.53	159.16	159.79	160.42	161.05	161.68	162.31	162.94	163.57	164.20	1.90
2.00	164.20	164.83	165.46	166.09	166.72	167.34	167.97	168.60	169.22	169.85	170.48	2.00
2.10	170.48	171.10	171.73	172.35	172.98	173.60	174.23	174.85	175.47	176.10	176.72	2.10
2.20	176.72	177.34	177.97	178.59	179.21	179.83	180.45	181.07	181.70	182.32	182.94	2.20
2.30	182.94	183.56	184.18	184.80	185.42	186.03	186.65	187.27	187.89	188.51	189.12	2.30
2.40	189.12	189.74	190.36	190.98	191.59	192.21	192.82	193.44	194.06	194.67	195.28	2.40
2.50	195.28	195.90	196.51	197.13	197.74	198.35	198.97	199.58	200.19	200.81	201.42	2.50
2.60	201.42	202.03	202.64	203.25	203.86	204.47	205.09	205.70	206.31	206.92	207.52	2.60
2.70	207.52	208.13	208.74	209.35	209.96	210.57	211.18	211.78	212.39	213.00	213.60	2.70
2.80	213.60	214.21	214.82	215.42	216.03	216.64	217.24	217.85	218.45	219.05	219.66	2.80
2.90	219.66	220.26	220.87	221.47	222.07	222.68	223.28	223.88	224.48	225.09	225.69	2.90
3.00	225.69	226.29	226.89	227.49	228.09	228.69	229.29	229.89	230.49	231.09	231.69	3.00
3.10	231.69	232.29	232.89	233.49	234.09	234.69	235.28	235.88	236.48	237.08	237.67	3.10
3.20	237.67	238.27	238.87	239.46	240.06	240.65	241.25	241.84	242.44	243.03	243.63	3.20
3.30	243.63	244.22	244.82	245.41	246.00	246.60	247.19	247.78	248.38	248.97	249.56	3.30
3.40	249.56	250.15	250.74	251.34	251.93	252.52	253.11	253.70	254.29	254.88	255.47	3.40
3.50	255.47	256.06	256.65	257.24	257.83	258.42	259.00	259.59	260.18	260.77	261.36	3.50
3.60	261.36	261.94	262.53	263.12	263.70	264.29	264.88	265.46	266.05	266.63	267.22	3.60
3.70	267.22	267.80	268.39	268.97	269.56	270.14	270.73	271.31	271.90	272.48	273.06	3.70
3.80	273.06	273.64	274.23	274.81	275.39	275.97	276.56	277.14	277.72	278.30	278.88	3.80
3.90	278.88	279.46	280.04	280.62	281.20	281.79	282.36	282.94	283.52	284.10	284.68	3.90
4.00	284.68	285.26	285.84	286.42	287.00	287.57	288.15	288.73	289.31	289.88	290.46	4.00
4.10	290.46	291.04	291.61	292.19	292.77	293.34	293.92	294.49	295.07	295.64	296.22	4.10
4.20	296.22	296.79	297.37	297.94	298.52	299.09	299.67	300.24	300.81	301.39	301.96	4.20
4.30	301.96	302.53	303.10	303.68	304.25	304.82	305.39	305.96	306.54	307.11	307.68	4.30
4.40	307.68	308.25	308.82	309.39	309.96	310.53	311.10	311.67	312.24	312.81	313.38	4.40
4.50	313.38	313.95	314.52	315.08	315.65	316.22	316.79	317.36	317.92	318.49	319.06	4.50
4.60	319.06	319.63	320.19	320.76	321.33	321.89	322.46	323.02	323.59	324.16	324.72	4.60
4.70	324.72	325.29	325.85	326.42	326.98	327.55	328.11	328.67	329.24	329.80	330.37	4.70
4.80	330.37	330.93	331.49	332.06	332.62	333.18	333.74	334.31	334.87	335.43	335.99	4.80
4.90	335.99	336.55	337.12	337.68	338.24	338.80	339.36	339.92	340.48	341.04	341.60	4.90
5.00	341.60	342.16	342.72	343.28	343.84	344.40	344.96	345.52	346.08	346.64	347.19	5.00
5.10	347.19	347.75	348.31	348.87	349.43	349.98	350.54	351.10	351.66	352.21	352.77	5.10
5.20	352.77	353.33	353.88	354.44	354.99	355.55	356.11	356.66	357.22	357.77	358.33	5.20
5.30	358.33	358.88	359.44	359.99	360.55	361.10	361.66	362.21	362.76	363.32	363.87	5.30
5.40	363.87	364.42	364.98	365.53	366.08	366.64	367.19	367.74	368.29	368.84	369.40	5.40
5.50	369.40	369.95	370.50	371.05	371.60	372.15	372.71	373.26	373.81	374.36	374.91	5.50
5.60	374.91	375.46	376.01	376.56	377.11	377.66	378.21	378.76	379.31	379.85	380.40	5.60
5.70	380.40	380.95	381.50	382.05	382.60	383.15	383.69	384.24	384.79	385.34	385.88	5.70
5.80	385.88	386.43	386.98	387.52	388.07	388.62	389.16	389.71	390.26	390.80	391.35	5.80
5.90	391.35	391.89	392.44	392.99	393.53	394.08	394.62	395.17	395.71	396.26	396.80	5.90
6.00	396.80	397.34	397.89	398.43	398.98	399.52	400.06	400.61	401.15	401.69	402.24	6.00
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

Table B4. AWG 14 *Nicrosil versus Nisil thermocouples—temperature (°F) as a function of thermoelectric voltage, reference junctions at 32 °F*—Continued

TEMPERATURES IN DEGREES F

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
6.00	396.80	397.34	397.89	398.43	398.98	399.52	400.06	400.61	401.15	401.69	402.24	6.00
6.10	402.24	402.78	403.32	403.87	404.41	404.95	405.49	406.03	406.58	407.12	407.66	6.10
6.20	407.66	408.20	408.74	409.28	409.82	410.37	410.91	411.45	411.99	412.53	413.07	6.20
6.30	413.07	413.61	414.15	414.69	415.23	415.77	416.31	416.85	417.39	417.92	418.46	6.30
6.40	418.46	419.00	419.54	420.08	420.62	421.16	421.69	422.23	422.77	423.31	423.85	6.40
6.50	423.85	424.38	424.92	425.46	425.99	426.53	427.07	427.61	428.14	428.68	429.21	6.50
6.60	429.21	429.75	430.29	430.82	431.36	431.89	432.43	432.97	433.50	434.04	434.57	6.60
6.70	434.57	435.11	435.64	436.18	436.71	437.24	437.78	438.31	438.85	439.38	439.91	6.70
6.80	439.91	440.45	440.98	441.51	442.05	442.58	443.11	443.65	444.18	444.71	445.25	6.80
6.90	445.25	445.78	446.31	446.84	447.37	447.91	448.44	448.97	449.50	450.03	450.56	6.90
7.00	450.56	451.10	451.63	452.16	452.69	453.22	453.75	454.28	454.81	455.34	455.87	7.00
7.10	455.87	456.40	456.93	457.46	457.99	458.52	459.05	459.58	460.11	460.64	461.17	7.10
7.20	461.17	461.70	462.22	462.75	463.28	463.81	464.34	464.87	465.39	465.92	466.45	7.20
7.30	466.45	466.98	467.51	468.03	468.56	469.09	469.61	470.14	470.67	471.20	471.72	7.30
7.40	471.72	472.25	472.78	473.30	473.83	474.35	474.88	475.41	475.93	476.46	476.98	7.40
7.50	476.98	477.51	478.03	478.56	479.08	479.61	480.13	480.66	481.18	481.71	482.23	7.50
7.60	482.23	482.76	483.28	483.81	484.33	484.85	485.38	485.90	486.43	486.95	487.47	7.60
7.70	487.47	488.00	488.52	489.04	489.56	490.09	490.61	491.13	491.66	492.18	492.70	7.70
7.80	492.70	493.22	493.75	494.27	494.79	495.31	495.83	496.35	496.88	497.40	497.92	7.80
7.90	497.92	498.44	498.96	499.48	500.00	500.52	501.04	501.57	502.09	502.61	503.13	7.90
8.00	503.13	503.65	504.17	504.69	505.21	505.73	506.25	506.77	507.29	507.81	508.32	8.00
8.10	508.32	508.84	509.36	509.88	510.40	510.92	511.44	511.96	512.48	512.99	513.51	8.10
8.20	513.51	514.03	514.55	515.07	515.58	516.10	516.62	517.14	517.66	518.17	518.69	8.20
8.30	518.69	519.21	519.72	520.24	520.76	521.28	521.79	522.31	522.83	523.34	523.86	8.30
8.40	523.86	524.37	524.89	525.41	525.92	526.44	526.95	527.47	527.99	528.50	529.02	8.40
8.50	529.02	529.53	530.05	530.56	531.08	531.59	532.11	532.62	533.14	533.65	534.17	8.50
8.60	534.17	534.68	535.20	535.71	536.22	536.74	537.25	537.77	538.28	538.79	539.31	8.60
8.70	539.31	539.82	540.33	540.85	541.36	541.87	542.39	542.90	543.41	543.93	544.44	8.70
8.80	544.44	544.95	545.46	545.98	546.49	547.00	547.51	548.03	548.54	549.05	549.56	8.80
8.90	549.56	550.07	550.58	551.10	551.61	552.12	552.63	553.14	553.65	554.16	554.67	8.90
9.00	554.67	555.19	555.70	556.21	556.72	557.23	557.74	558.25	558.76	559.27	559.78	9.00
9.10	559.78	560.29	560.80	561.31	561.82	562.33	562.84	563.35	563.86	564.37	564.88	9.10
9.20	564.88	565.39	565.89	566.40	566.91	567.42	567.93	568.44	568.95	569.46	569.96	9.20
9.30	569.96	570.47	570.98	571.49	572.00	572.51	573.01	573.52	574.03	574.54	575.04	9.30
9.40	575.04	575.55	576.06	576.57	577.07	577.58	578.09	578.60	579.10	579.61	580.12	9.40
9.50	580.12	580.62	581.13	581.64	582.14	582.65	583.16	583.66	584.17	584.67	585.18	9.50
9.60	585.18	585.69	586.19	586.70	587.20	587.71	588.22	588.72	589.23	589.73	590.24	9.60
9.70	590.24	590.74	591.25	591.75	592.26	592.76	593.27	593.77	594.28	594.78	595.29	9.70
9.80	595.29	595.79	596.29	596.80	597.30	597.81	598.31	598.81	599.32	599.82	600.33	9.80
9.90	600.33	600.83	601.33	601.84	602.34	602.84	603.35	603.85	604.35	604.86	605.36	9.90
10.00	605.36	605.86	606.36	606.87	607.37	607.87	608.38	608.88	609.38	609.88	610.39	10.00
10.10	610.39	610.89	611.39	611.89	612.39	612.90	613.40	613.90	614.40	614.90	615.40	10.10
10.20	615.40	615.91	616.41	616.91	617.41	617.91	618.41	618.91	619.41	619.91	620.42	10.20
10.30	620.42	620.92	621.42	621.92	622.42	622.92	623.42	623.92	624.42	624.92	625.42	10.30
10.40	625.42	625.92	626.42	626.92	627.42	627.92	628.42	628.92	629.42	629.92	630.42	10.40
10.50	630.42	630.92	631.42	631.91	632.41	632.91	633.41	633.91	634.41	634.91	635.41	10.50
10.60	635.41	635.91	636.40	636.90	637.40	637.90	638.40	638.90	639.39	639.89	640.39	10.60
10.70	640.39	640.89	641.39	641.88	642.38	642.88	643.38	643.88	644.37	644.87	645.37	10.70
10.80	645.37	645.87	646.36	646.86	647.36	647.85	648.35	648.85	649.34	649.84	650.34	10.80
10.90	650.34	650.84	651.33	651.83	652.32	652.82	653.32	653.81	654.31	654.81	655.30	10.90
11.00	655.30	655.80	656.29	656.79	657.29	657.78	658.28	658.77	659.27	659.76	660.26	11.00
11.10	660.26	660.76	661.25	661.75	662.24	662.74	663.23	663.73	664.22	664.72	665.21	11.10
11.20	665.21	665.71	666.20	666.70	667.19	667.68	668.18	668.67	669.17	669.66	670.16	11.20
11.30	670.16	670.65	671.14	671.64	672.13	672.63	673.12	673.61	674.11	674.60	675.10	11.30
11.40	675.10	675.59	676.08	676.58	677.07	677.56	678.06	678.55	679.04	679.54	680.03	11.40
11.50	680.03	680.52	681.01	681.51	682.00	682.49	682.99	683.48	683.97	684.46	684.96	11.50
11.60	684.96	685.45	685.94	686.43	686.92	687.42	687.91	688.40	688.89	689.38	689.88	11.60
11.70	689.88	690.37	690.86	691.35	691.84	692.33	692.83	693.32	693.81	694.30	694.79	11.70
11.80	694.79	695.28	695.77	696.27	696.76	697.25	697.74	698.23	698.72	699.21	699.70	11.80
11.90	699.70	700.19	700.68	701.17	701.66	702.15	702.64	703.13	703.62	704.11	704.61	11.90
12.00	704.61	705.10	705.59	706.08	706.57	707.05	707.54	708.03	708.52	709.01	709.50	12.00
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

TABLE B4. AWG 14 *Nicrosil versus Nisil thermocouples—temperature (°F) as a function of thermoelectric voltage, reference junctions at 32 °F*—Continued

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
						TEMPERATURES IN DEGREES F						
12.00	704.61	705.10	705.59	706.08	706.57	707.05	707.54	708.03	708.52	709.01	709.50	12.00
12.10	709.50	709.99	710.48	710.97	711.46	711.95	712.44	712.93	713.42	713.91	714.40	12.10
12.20	714.40	714.89	715.37	715.86	716.35	716.84	717.33	717.82	718.31	718.80	719.28	12.20
12.30	719.28	719.77	720.26	720.75	721.24	721.73	722.21	722.70	723.19	723.68	724.17	12.30
12.40	724.17	724.65	725.14	725.63	726.12	726.60	727.09	727.58	728.07	728.56	729.04	12.40
12.50	729.04	729.53	730.02	730.50	730.99	731.48	731.97	732.45	732.94	733.43	733.91	12.50
12.60	733.91	734.40	734.89	735.37	735.86	736.35	736.83	737.32	737.81	738.29	738.78	12.60
12.70	738.78	739.27	739.75	740.24	740.73	741.21	741.70	742.18	742.67	743.16	743.64	12.70
12.80	743.64	744.13	744.61	745.10	745.59	746.07	746.56	747.04	747.53	748.01	748.50	12.80
12.90	748.50	748.98	749.47	749.95	750.44	750.92	751.41	751.90	752.38	752.87	753.35	12.90
13.00	753.35	753.83	754.32	754.80	755.29	755.77	756.26	756.74	757.23	757.71	758.20	13.00
13.10	758.20	758.68	759.17	759.65	760.13	760.62	761.10	761.59	762.07	762.55	763.04	13.10
13.20	763.04	763.52	764.01	764.49	764.97	765.46	765.94	766.42	766.91	767.39	767.88	13.20
13.30	767.88	768.36	768.84	769.33	769.81	770.29	770.78	771.26	771.74	772.22	772.71	13.30
13.40	772.71	773.19	773.67	774.16	774.64	775.12	775.61	776.09	776.57	777.05	777.54	13.40
13.50	777.54	778.02	778.50	778.98	779.47	779.95	780.43	780.91	781.39	781.88	782.36	13.50
13.60	782.36	782.84	783.32	783.80	784.29	784.77	785.25	785.73	786.21	786.70	787.18	13.60
13.70	787.18	787.66	788.14	788.62	789.10	789.59	790.07	790.55	791.03	791.51	791.99	13.70
13.80	791.99	792.47	792.95	793.44	793.92	794.40	794.88	795.36	795.84	796.32	796.80	13.80
13.90	796.80	797.28	797.76	798.24	798.72	799.21	799.69	800.17	800.65	801.13	801.61	13.90
14.00	801.61	802.09	802.57	803.05	803.53	804.01	804.49	804.97	805.45	805.93	806.41	14.00
14.10	806.41	806.89	807.37	807.85	808.33	808.81	809.29	809.77	810.25	810.73	811.21	14.10
14.20	811.21	811.69	812.16	812.64	813.12	813.60	814.08	814.56	815.04	815.52	816.00	14.20
14.30	816.00	816.48	816.96	817.44	817.91	818.39	818.87	819.35	819.83	820.31	820.79	14.30
14.40	820.79	821.27	821.74	822.22	822.70	823.18	823.66	824.14	824.62	825.09	825.57	14.40
14.50	825.57	826.05	826.53	827.01	827.48	827.96	828.44	828.92	829.40	829.88	830.35	14.50
14.60	830.35	830.83	831.31	831.79	832.26	832.74	833.22	833.70	834.17	834.65	835.13	14.60
14.70	835.13	835.61	836.08	836.56	837.04	837.52	837.99	838.47	838.95	839.43	839.90	14.70
14.80	839.90	840.38	840.86	841.33	841.81	842.29	842.76	843.24	843.72	844.19	844.67	14.80
14.90	844.67	845.15	845.63	846.10	846.58	847.05	847.53	848.01	848.48	848.96	849.44	14.90
15.00	849.44	849.91	850.39	850.87	851.34	851.82	852.29	852.77	853.25	853.72	854.20	15.00
15.10	854.20	854.67	855.15	855.63	856.10	856.58	857.05	857.53	858.00	858.48	858.96	15.10
15.20	858.96	859.43	859.91	860.38	860.86	861.33	861.81	862.28	862.76	863.24	863.71	15.20
15.30	863.71	864.19	864.66	865.14	865.61	866.09	866.56	867.04	867.51	867.99	868.46	15.30
15.40	868.46	868.94	869.41	869.89	870.36	870.83	871.31	871.78	872.26	872.73	873.21	15.40
15.50	873.21	873.68	874.16	874.63	875.11	875.58	876.05	876.53	877.00	877.48	877.95	15.50
15.60	877.95	878.43	878.90	879.37	879.85	880.32	880.80	881.27	881.74	882.22	882.69	15.60
15.70	882.69	883.17	883.64	884.11	884.59	885.06	885.53	886.01	886.48	886.95	887.43	15.70
15.80	887.43	887.90	888.37	888.85	889.32	889.80	890.27	890.74	891.21	891.69	892.16	15.80
15.90	892.16	892.63	893.11	893.58	894.05	894.53	895.00	895.47	895.95	896.42	896.89	15.90
16.00	896.89	897.36	897.84	898.31	898.78	899.25	899.73	900.20	900.67	901.15	901.62	16.00
16.10	901.62	902.09	902.56	903.04	903.51	903.98	904.45	904.92	905.40	905.87	906.34	16.10
16.20	906.34	906.81	907.29	907.76	908.23	908.70	909.17	909.65	910.12	910.59	911.06	16.20
16.30	911.06	911.53	912.00	912.48	912.95	913.42	913.89	914.36	914.84	915.31	915.78	16.30
16.40	915.78	916.25	916.72	917.19	917.66	918.14	918.61	919.08	919.55	920.02	920.49	16.40
16.50	920.49	920.96	921.43	921.91	922.38	922.85	923.32	923.79	924.26	924.73	925.20	16.50
16.60	925.20	925.67	926.14	926.62	927.09	927.56	928.03	928.50	928.97	929.44	929.91	16.60
16.70	929.91	930.38	930.85	931.32	931.79	932.26	932.73	933.20	933.67	934.15	934.62	16.70
16.80	934.62	935.09	935.56	936.03	936.50	936.97	937.44	937.91	938.38	938.85	939.32	16.80
16.90	939.32	939.79	940.26	940.73	941.20	941.67	942.14	942.61	943.08	943.55	944.02	16.90
17.00	944.02	944.49	944.96	945.43	945.90	946.36	946.83	947.30	947.77	948.24	948.71	17.00
17.10	948.71	949.18	949.65	950.12	950.59	951.06	951.53	952.00	952.47	952.94	953.41	17.10
17.20	953.41	953.88	954.34	954.81	955.28	955.75	956.22	956.69	957.16	957.63	958.10	17.20
17.30	958.10	958.57	959.03	959.50	959.97	960.44	960.91	961.38	961.85	962.32	962.78	17.30
17.40	962.78	963.25	963.72	964.19	964.66	965.13	965.60	966.06	966.53	967.00	967.47	17.40
17.50	967.47	967.94	968.41	968.87	969.34	969.81	970.28	970.75	971.22	971.68	972.15	17.50
17.60	972.15	972.62	973.09	973.56	974.02	974.49	974.96	975.43	975.90	976.36	976.83	17.60
17.70	976.83	977.30	977.77	978.23	978.70	979.17	979.64	980.11	980.57	981.04	981.51	17.70
17.80	981.51	981.98	982.44	982.91	983.38	983.85	984.31	984.78	985.25	985.72	986.18	17.80
17.90	986.18	986.65	987.12	987.59	988.05	988.52	988.99	989.45	989.92	990.39	990.86	17.90
18.00	990.86	991.32	991.79	992.25	992.72	993.19	993.66	994.12	994.59	995.06	995.52	18.00
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

Table B4. AWG 14 *Nicrosil versus Nisil thermocouples—temperature (°F) as a function of thermoelectric voltage, reference junctions at 32 °F*—Continued

TEMPERATURES IN DEGREES F

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
18.00	990.86	991.32	991.79	992.26	992.72	993.19	993.66	994.12	994.59	995.06	995.52	18.00
18.10	995.52	995.99	996.46	996.93	997.39	997.86	998.33	998.79	999.26	999.73	1000.19	18.10
18.20	1000.19	1000.66	1001.13	1001.59	1002.06	1002.52	1002.99	1003.46	1003.92	1004.39	1004.86	18.20
18.30	1004.86	1005.32	1005.79	1006.26	1006.72	1007.19	1007.65	1008.12	1008.59	1009.05	1009.52	18.30
18.40	1009.52	1009.99	1010.45	1010.92	1011.38	1011.85	1012.32	1012.78	1013.25	1013.71	1014.18	18.40
18.50	1014.18	1014.65	1015.11	1015.58	1016.04	1016.51	1016.97	1017.44	1017.91	1018.37	1018.84	18.50
18.60	1018.84	1019.30	1019.77	1020.23	1020.70	1021.17	1021.63	1022.10	1022.56	1023.03	1023.49	18.60
18.70	1023.49	1023.96	1024.42	1024.89	1025.35	1025.82	1026.29	1026.75	1027.22	1027.68	1028.15	18.70
18.80	1028.15	1028.61	1029.08	1029.54	1030.01	1030.47	1030.94	1031.40	1031.87	1032.33	1032.80	18.80
18.90	1032.80	1033.26	1033.73	1034.19	1034.66	1035.12	1035.59	1036.05	1036.52	1036.98	1037.45	18.90
19.00	1037.45	1037.91	1038.38	1038.84	1039.31	1039.77	1040.24	1040.70	1041.16	1041.63	1042.09	19.00
19.10	1042.09	1042.56	1043.02	1043.49	1043.95	1044.42	1044.88	1045.35	1045.81	1046.27	1046.74	19.10
19.20	1046.74	1047.20	1047.67	1048.13	1048.60	1049.06	1049.52	1049.99	1050.45	1050.92	1051.38	19.20
19.30	1051.38	1051.85	1052.31	1052.77	1053.24	1053.70	1054.17	1054.63	1055.09	1055.56	1056.02	19.30
19.40	1056.02	1056.49	1056.95	1057.41	1057.88	1058.34	1058.81	1059.27	1059.73	1060.20	1060.66	19.40
19.50	1060.66	1061.12	1061.59	1062.05	1062.52	1062.98	1063.44	1063.91	1064.37	1064.83	1065.30	19.50
19.60	1065.30	1065.76	1066.23	1066.69	1067.15	1067.62	1068.08	1068.54	1069.01	1069.47	1069.93	19.60
19.70	1069.93	1070.40	1070.86	1071.32	1071.79	1072.25	1072.71	1073.18	1073.64	1074.10	1074.57	19.70
19.80	1074.57	1075.03	1075.49	1075.96	1076.42	1076.88	1077.35	1077.81	1078.27	1078.73	1079.20	19.80
19.90	1079.20	1079.66	1080.12	1080.59	1081.05	1081.51	1081.98	1082.44	1082.90	1083.36	1083.83	19.90
20.00	1083.83	1084.29	1084.75	1085.22	1085.68	1086.14	1086.60	1087.07	1087.53	1087.99	1088.45	20.00
20.10	1088.45	1088.92	1089.38	1089.84	1090.31	1090.77	1091.23	1091.69	1092.16	1092.62	1093.08	20.10
20.20	1093.08	1093.54	1094.01	1094.47	1094.93	1095.39	1095.86	1096.32	1096.78	1097.24	1097.71	20.20
20.30	1097.71	1098.17	1098.63	1099.09	1099.55	1100.02	1100.48	1100.94	1101.40	1101.87	1102.33	20.30
20.40	1102.33	1102.79	1103.25	1103.71	1104.18	1104.64	1105.10	1105.56	1106.02	1106.49	1106.95	20.40
20.50	1106.95	1107.41	1107.87	1108.33	1108.80	1109.26	1109.72	1110.18	1110.64	1111.11	1111.57	20.50
20.60	1111.57	1112.03	1112.49	1112.95	1113.42	1113.88	1114.34	1114.80	1115.26	1115.72	1116.19	20.60
20.70	1116.19	1116.65	1117.11	1117.57	1118.03	1118.49	1118.96	1119.42	1119.88	1120.34	1120.80	20.70
20.80	1120.80	1121.26	1121.73	1122.19	1122.65	1123.11	1123.57	1124.03	1124.49	1124.96	1125.42	20.80
20.90	1125.42	1125.88	1126.34	1126.80	1127.26	1127.72	1128.19	1128.65	1129.11	1129.57	1130.03	20.90
21.00	1130.03	1130.49	1130.95	1131.41	1131.88	1132.34	1132.80	1133.26	1133.72	1134.18	1134.64	21.00
21.10	1134.64	1135.10	1135.57	1136.03	1136.49	1136.95	1137.41	1137.87	1138.33	1138.79	1139.25	21.10
21.20	1139.25	1139.71	1140.18	1140.64	1141.10	1141.56	1142.02	1142.48	1142.94	1143.40	1143.86	21.20
21.30	1143.86	1144.32	1144.78	1145.25	1145.71	1146.17	1146.63	1147.09	1147.55	1148.01	1148.47	21.30
21.40	1148.47	1148.93	1149.39	1149.85	1150.31	1150.77	1151.23	1151.70	1152.16	1152.62	1153.08	21.40
21.50	1153.08	1153.54	1154.00	1154.46	1154.92	1155.38	1155.84	1156.30	1156.76	1157.22	1157.68	21.50
21.60	1157.68	1158.14	1158.60	1159.06	1159.52	1159.98	1160.44	1160.91	1161.37	1161.83	1162.29	21.60
21.70	1162.29	1162.75	1163.21	1163.67	1164.13	1164.59	1165.05	1165.51	1165.97	1166.43	1166.89	21.70
21.80	1166.89	1167.35	1167.81	1168.27	1168.73	1169.19	1169.65	1170.11	1170.57	1171.03	1171.49	21.80
21.90	1171.49	1171.95	1172.41	1172.87	1173.33	1173.79	1174.25	1174.71	1175.17	1175.63	1176.09	21.90
22.00	1176.09	1176.55	1177.01	1177.47	1177.93	1178.39	1178.85	1179.31	1179.77	1180.23	1180.69	22.00
22.10	1180.69	1181.15	1181.61	1182.07	1182.53	1182.99	1183.45	1183.91	1184.37	1184.83	1185.29	22.10
22.20	1185.29	1185.75	1186.21	1186.67	1187.13	1187.59	1188.05	1188.51	1188.97	1189.43	1189.89	22.20
22.30	1189.89	1190.35	1190.81	1191.27	1191.72	1192.18	1192.64	1193.10	1193.56	1194.02	1194.48	22.30
22.40	1194.48	1194.94	1195.40	1195.86	1196.32	1196.78	1197.24	1197.70	1198.16	1198.62	1199.08	22.40
22.50	1199.08	1199.54	1200.00	1200.46	1200.92	1201.37	1201.83	1202.29	1202.75	1203.21	1203.67	22.50
22.60	1203.67	1204.13	1204.59	1205.05	1205.51	1205.97	1206.43	1206.89	1207.35	1207.81	1208.27	22.60
22.70	1208.27	1208.72	1209.18	1209.64	1210.10	1210.56	1211.02	1211.48	1211.94	1212.40	1212.86	22.70
22.80	1212.86	1213.32	1213.78	1214.24	1214.69	1215.15	1215.61	1216.07	1216.53	1216.99	1217.45	22.80
22.90	1217.45	1217.91	1218.37	1218.83	1219.29	1219.74	1220.20	1220.66	1221.12	1221.58	1222.04	22.90
23.00	1222.04	1222.50	1222.96	1223.42	1223.88	1224.33	1224.79	1225.25	1225.71	1226.17	1226.63	23.00
23.10	1226.63	1227.09	1227.55	1228.01	1228.47	1228.92	1229.38	1229.84	1230.30	1230.76	1231.22	23.10
23.20	1231.22	1231.68	1232.14	1232.60	1233.05	1233.51	1233.97	1234.43	1234.89	1235.35	1235.81	23.20
23.30	1235.81	1236.27	1236.72	1237.18	1237.64	1238.10	1238.56	1239.02	1239.48	1239.94	1240.39	23.30
23.40	1240.39	1240.85	1241.31	1241.77	1242.23	1242.69	1243.15	1243.61	1244.06	1244.52	1244.98	23.40
23.50	1244.98	1245.44	1245.90	1246.36	1246.82	1247.27	1247.73	1248.19	1248.65	1249.11	1249.57	23.50
23.60	1249.57	1250.03	1250.48	1250.94	1251.40	1251.86	1252.32	1252.78	1253.24	1253.69	1254.15	23.60
23.70	1254.15	1254.61	1255.07	1255.53	1255.99	1256.45	1256.90	1257.36	1257.82	1258.28	1258.74	23.70
23.80	1258.74	1259.20	1259.65	1260.11	1260.57	1261.03	1261.49	1261.95	1262.41	1262.86	1263.32	23.80
23.90	1263.32	1263.78	1264.24	1264.70	1265.16	1265.61	1266.07	1266.53	1266.99	1267.45	1267.91	23.90
24.00	1267.91	1268.36	1268.82	1269.28	1269.74	1270.20	1270.66	1271.11	1271.57	1272.03	1272.49	24.00
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

Table B4. AWG 14 *Nicrosil versus Nisil thermocouples—temperature (°F) as a function of thermoelectric voltage, reference junctions at 32 °F*—Continued

TEMPERATURES IN DEGREES F

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
24.00	1267.91	1268.36	1268.82	1269.28	1269.74	1270.20	1270.66	1271.11	1271.57	1272.03	1272.49	24.00
24.10	1272.49	1272.95	1273.41	1273.86	1274.32	1274.78	1275.24	1275.70	1276.16	1276.61	1277.07	24.10
24.20	1277.07	1277.53	1277.99	1278.45	1278.90	1279.36	1279.82	1280.28	1280.74	1281.20	1281.65	24.20
24.30	1281.65	1282.11	1282.57	1283.03	1283.49	1283.95	1284.40	1284.86	1285.32	1285.78	1286.24	24.30
24.40	1286.24	1286.69	1287.15	1287.61	1288.07	1288.53	1288.98	1289.44	1289.90	1290.36	1290.82	24.40
24.50	1290.82	1291.28	1291.73	1292.19	1292.65	1293.11	1293.57	1294.02	1294.48	1294.94	1295.40	24.50
24.60	1295.40	1295.86	1296.31	1296.77	1297.23	1297.69	1298.15	1298.60	1299.06	1299.52	1299.98	24.60
24.70	1299.98	1300.44	1300.89	1301.35	1301.81	1302.27	1302.73	1303.18	1303.64	1304.10	1304.56	24.70
24.80	1304.56	1305.02	1305.48	1305.93	1306.39	1306.85	1307.31	1307.76	1308.22	1308.68	1309.14	24.80
24.90	1309.14	1309.60	1310.05	1310.51	1310.97	1311.43	1311.89	1312.34	1312.80	1313.26	1313.72	24.90
25.00	1313.72	1314.18	1314.63	1315.09	1315.55	1316.01	1316.47	1316.92	1317.38	1317.84	1318.30	25.00
25.10	1318.30	1318.76	1319.21	1319.67	1320.13	1320.59	1321.05	1321.50	1321.96	1322.42	1322.88	25.10
25.20	1322.88	1323.33	1323.79	1324.25	1324.71	1325.17	1325.62	1326.08	1326.54	1327.00	1327.46	25.20
25.30	1327.46	1327.91	1328.37	1328.83	1329.29	1329.75	1330.20	1330.66	1331.12	1331.58	1332.03	25.30
25.40	1332.03	1332.49	1332.95	1333.41	1333.87	1334.32	1334.78	1335.24	1335.70	1336.16	1336.61	25.40
25.50	1336.61	1337.07	1337.53	1337.99	1338.44	1338.90	1339.36	1339.82	1340.28	1340.73	1341.19	25.50
25.60	1341.19	1341.65	1342.11	1342.56	1343.02	1343.48	1343.94	1344.40	1344.85	1345.31	1345.77	25.60
25.70	1345.77	1346.23	1346.69	1347.14	1347.60	1348.06	1348.52	1348.97	1349.43	1349.89	1350.35	25.70
25.80	1350.35	1350.81	1351.26	1351.72	1352.18	1352.64	1353.09	1353.55	1354.01	1354.47	1354.93	25.80
25.90	1354.93	1355.38	1355.84	1356.30	1356.76	1357.22	1357.67	1358.13	1358.59	1359.05	1359.50	25.90
26.00	1359.50	1359.96	1360.42	1360.83	1361.34	1361.79	1362.25	1362.71	1363.17	1363.62	1364.08	26.00
26.10	1364.08	1364.54	1365.00	1365.46	1365.91	1366.37	1366.83	1367.29	1367.74	1368.20	1368.66	26.10
26.20	1368.66	1369.12	1369.58	1370.03	1370.49	1370.95	1371.41	1371.86	1372.32	1372.78	1373.24	26.20
26.30	1373.24	1373.70	1374.15	1374.61	1375.07	1375.53	1375.99	1376.44	1376.90	1377.36	1377.82	26.30
26.40	1377.82	1378.27	1378.73	1379.19	1379.65	1380.11	1380.56	1381.02	1381.48	1381.94	1382.39	26.40
26.50	1382.39	1382.85	1383.31	1383.77	1384.23	1384.68	1385.14	1385.60	1386.06	1386.52	1386.97	26.50
26.60	1386.97	1387.43	1387.89	1388.35	1388.80	1389.26	1389.72	1390.18	1390.64	1391.09	1391.55	26.60
26.70	1391.55	1392.01	1392.47	1392.93	1393.38	1393.84	1394.30	1394.76	1395.21	1395.67	1396.13	26.70
26.80	1396.13	1396.59	1397.05	1397.50	1397.96	1398.42	1398.88	1399.34	1399.79	1400.25	1400.71	26.80
26.90	1400.71	1401.17	1401.62	1402.08	1402.54	1403.00	1403.46	1403.91	1404.37	1404.83	1405.29	26.90
27.00	1405.29	1405.75	1406.20	1406.66	1407.12	1407.58	1408.04	1408.49	1408.95	1409.41	1409.87	27.00
27.10	1409.87	1410.32	1410.78	1411.24	1411.70	1412.16	1412.61	1413.07	1413.53	1413.99	1414.45	27.10
27.20	1414.45	1414.90	1415.36	1415.82	1416.28	1416.74	1417.19	1417.65	1418.11	1418.57	1419.03	27.20
27.30	1419.03	1419.48	1419.94	1420.40	1420.86	1421.32	1421.77	1422.23	1422.69	1423.15	1423.61	27.30
27.40	1423.61	1424.06	1424.52	1424.98	1425.44	1425.90	1426.35	1426.81	1427.27	1427.73	1428.19	27.40
27.50	1428.19	1428.64	1429.10	1429.56	1430.02	1430.48	1430.93	1431.39	1431.85	1432.31	1432.77	27.50
27.60	1432.77	1433.22	1433.68	1434.14	1434.60	1435.06	1435.52	1435.97	1436.43	1436.89	1437.35	27.60
27.70	1437.35	1437.81	1438.26	1438.72	1439.18	1439.64	1440.10	1440.55	1441.01	1441.47	1441.93	27.70
27.80	1441.93	1442.39	1442.85	1443.30	1443.76	1444.22	1444.68	1445.14	1445.59	1446.05	1446.51	27.80
27.90	1446.51	1446.97	1447.43	1447.89	1448.34	1448.80	1449.26	1449.72	1450.18	1450.63	1451.09	27.90
28.00	1451.09	1451.55	1452.01	1452.47	1452.93	1453.38	1453.84	1454.30	1454.76	1455.22	1455.68	28.00
28.10	1455.68	1456.13	1456.59	1457.05	1457.51	1457.97	1458.42	1458.88	1459.34	1459.80	1460.26	28.10
28.20	1460.26	1460.72	1461.17	1461.63	1462.09	1462.55	1463.01	1463.47	1463.92	1464.38	1464.84	28.20
28.30	1464.84	1465.30	1465.76	1466.22	1466.68	1467.13	1467.59	1468.05	1468.51	1468.97	1469.43	28.30
28.40	1469.43	1469.88	1470.34	1470.80	1471.26	1471.72	1472.18	1472.63	1473.09	1473.55	1474.01	28.40
28.50	1474.01	1474.47	1474.93	1475.39	1475.84	1476.30	1476.76	1477.22	1477.68	1478.14	1478.59	28.50
28.60	1478.59	1479.05	1479.51	1479.97	1480.43	1480.89	1481.35	1481.80	1482.26	1482.72	1483.18	28.60
28.70	1483.18	1483.64	1484.10	1484.56	1485.01	1485.47	1485.93	1486.39	1486.85	1487.31	1487.77	28.70
28.80	1487.77	1488.22	1488.68	1489.14	1489.60	1490.06	1490.52	1490.98	1491.44	1491.89	1492.35	28.80
28.90	1492.35	1492.81	1493.27	1493.73	1494.19	1494.65	1495.11	1495.56	1496.02	1496.48	1496.94	28.90
29.00	1496.94	1497.40	1497.86	1498.32	1498.78	1499.23	1499.69	1500.15	1500.61	1501.07	1501.53	29.00
29.10	1501.53	1501.99	1502.45	1502.90	1503.36	1503.82	1504.28	1504.74	1505.20	1505.66	1506.12	29.10
29.20	1506.12	1506.58	1507.03	1507.49	1507.95	1508.41	1508.87	1509.33	1509.79	1510.25	1510.71	29.20
29.30	1510.71	1511.16	1511.62	1512.03	1512.54	1513.00	1513.46	1513.92	1514.38	1514.84	1515.30	29.30
29.40	1515.30	1515.75	1516.21	1516.67	1517.13	1517.59	1518.05	1518.51	1518.97	1519.43	1519.89	29.40
29.50	1519.89	1520.34	1520.80	1521.26	1521.72	1522.18	1522.64	1523.10	1523.56	1524.02	1524.48	29.50
29.60	1524.48	1524.94	1525.40	1525.85	1526.31	1526.77	1527.23	1527.69	1528.15	1528.61	1529.07	29.60
29.70	1529.07	1529.53	1529.99	1530.45	1530.91	1531.36	1531.82	1532.28	1532.74	1533.20	1533.66	29.70
29.80	1533.66	1534.12	1534.58	1535.04	1535.50	1535.96	1536.42	1536.88	1537.34	1537.80	1538.25	29.80
29.90	1538.25	1538.71	1539.17	1539.63	1540.09	1540.55	1541.01	1541.47	1541.93	1542.39	1542.85	29.90
30.00	1542.85	1543.31	1543.77	1544.23	1544.69	1545.15	1545.61	1546.07	1546.52	1546.98	1547.44	30.00
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

Table B4. AWG 14 *Nicrosil versus Nisil thermocouples—temperature (°F) as a function of thermoelectric voltage, reference junctions at 32 °F*—Continued

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
					TEMPERATURES IN DEGREES F							
30.00	1542.85	1543.31	1543.77	1544.23	1544.69	1545.15	1545.61	1546.07	1546.52	1546.98	1547.44	30.00
30.10	1547.44	1547.90	1548.36	1548.82	1549.28	1549.74	1550.20	1550.66	1551.12	1551.58	1552.04	30.10
30.20	1552.04	1552.50	1552.96	1553.42	1553.88	1554.34	1554.80	1555.26	1555.72	1556.18	1556.64	30.20
30.30	1556.64	1557.10	1557.56	1558.02	1558.47	1558.93	1559.39	1559.85	1560.31	1560.77	1561.23	30.30
30.40	1561.23	1561.69	1562.15	1562.61	1563.07	1563.53	1563.99	1564.45	1564.91	1565.37	1565.83	30.40
30.50	1565.83	1566.29	1566.75	1567.21	1567.67	1568.13	1568.59	1569.05	1569.51	1569.97	1570.43	30.50
30.60	1570.43	1570.89	1571.35	1571.81	1572.27	1572.73	1573.19	1573.65	1574.11	1574.57	1575.03	30.60
30.70	1575.03	1575.49	1575.95	1576.41	1576.87	1577.33	1577.79	1578.25	1578.71	1579.17	1579.63	30.70
30.80	1579.63	1580.09	1580.55	1581.01	1581.47	1581.93	1582.39	1582.85	1583.31	1583.77	1584.23	30.80
30.90	1584.23	1584.69	1585.15	1585.61	1586.07	1586.53	1586.99	1587.45	1587.92	1588.38	1588.84	30.90
31.00	1588.84	1589.30	1589.76	1590.22	1590.68	1591.14	1591.60	1592.06	1592.52	1592.98	1593.44	31.00
31.10	1593.44	1593.90	1594.36	1594.82	1595.28	1595.74	1596.20	1596.66	1597.12	1597.58	1598.04	31.10
31.20	1598.04	1598.50	1598.97	1599.43	1599.89	1600.35	1600.81	1601.27	1601.73	1602.19	1602.65	31.20
31.30	1602.65	1603.11	1603.57	1604.03	1604.49	1604.95	1605.41	1605.87	1606.33	1606.80	1607.26	31.30
31.40	1607.26	1607.72	1608.18	1608.64	1609.10	1609.56	1610.02	1610.48	1610.94	1611.40	1611.86	31.40
31.50	1611.86	1612.32	1612.79	1613.25	1613.71	1614.17	1614.63	1615.09	1615.55	1616.01	1616.47	31.50
31.60	1616.47	1616.93	1617.39	1617.85	1618.32	1618.78	1619.24	1619.70	1620.16	1620.62	1621.08	31.60
31.70	1621.08	1621.54	1622.00	1622.46	1622.93	1623.39	1623.85	1624.31	1624.77	1625.23	1625.69	31.70
31.80	1625.69	1626.15	1626.61	1627.08	1627.54	1628.00	1628.46	1628.92	1629.38	1629.84	1630.30	31.80
31.90	1630.30	1630.76	1631.23	1631.69	1632.15	1632.61	1633.07	1633.53	1633.99	1634.46	1634.92	31.90
32.00	1634.92	1635.38	1635.84	1636.30	1636.76	1637.22	1637.68	1638.15	1638.61	1639.07	1639.53	32.00
32.10	1639.53	1639.99	1640.45	1640.91	1641.38	1641.84	1642.30	1642.76	1643.22	1643.68	1644.14	32.10
32.20	1644.14	1644.61	1645.07	1645.53	1645.99	1646.45	1646.91	1647.38	1647.84	1648.30	1648.76	32.20
32.30	1648.76	1649.22	1649.68	1650.15	1650.61	1651.07	1651.53	1651.99	1652.45	1652.92	1653.38	32.30
32.40	1653.38	1653.84	1654.30	1654.76	1655.22	1655.69	1656.15	1656.61	1657.07	1657.53	1658.00	32.40
32.50	1658.00	1658.46	1658.92	1659.38	1659.84	1660.31	1660.77	1661.23	1661.69	1662.15	1662.62	32.50
32.60	1662.62	1663.08	1663.54	1664.00	1664.46	1664.93	1665.39	1665.85	1666.31	1666.77	1667.24	32.60
32.70	1667.24	1667.70	1668.16	1668.62	1669.08	1669.55	1670.01	1670.47	1670.93	1671.39	1671.86	32.70
32.80	1671.86	1672.32	1672.78	1673.24	1673.71	1674.17	1674.63	1675.09	1675.55	1676.02	1676.48	32.80
32.90	1676.48	1676.94	1677.40	1677.87	1678.33	1678.79	1679.25	1679.72	1680.18	1680.64	1681.10	32.90
33.00	1681.10	1681.57	1682.03	1682.49	1682.95	1683.42	1683.88	1684.34	1684.80	1685.27	1685.73	33.00
33.10	1685.73	1686.19	1686.65	1687.12	1687.58	1688.04	1688.50	1688.97	1689.43	1689.89	1690.35	33.10
33.20	1690.35	1690.82	1691.28	1691.74	1692.21	1692.67	1693.13	1693.59	1694.06	1694.52	1694.98	33.20
33.30	1694.98	1695.45	1695.91	1696.37	1696.83	1697.30	1697.76	1698.22	1698.69	1699.15	1699.61	33.30
33.40	1699.61	1700.07	1700.54	1701.00	1701.46	1701.93	1702.39	1702.85	1703.31	1703.78	1704.24	33.40
33.50	1704.24	1704.70	1705.17	1705.63	1706.09	1706.56	1707.02	1707.48	1707.95	1708.41	1708.87	33.50
33.60	1708.87	1709.34	1709.80	1710.26	1710.72	1711.19	1711.65	1712.11	1712.58	1713.04	1713.50	33.60
33.70	1713.50	1713.97	1714.43	1714.89	1715.36	1715.82	1716.28	1716.75	1717.21	1717.67	1718.14	33.70
33.80	1718.14	1718.60	1719.06	1719.53	1719.99	1720.46	1720.92	1721.38	1721.85	1722.31	1722.77	33.80
33.90	1722.77	1723.24	1723.70	1724.16	1724.63	1725.09	1725.55	1726.02	1726.48	1726.95	1727.41	33.90
34.00	1727.41	1727.87	1728.34	1728.80	1729.26	1729.73	1730.19	1730.66	1731.12	1731.58	1732.05	34.00
34.10	1732.05	1732.51	1732.97	1733.44	1733.90	1734.37	1734.83	1735.29	1735.76	1736.22	1736.69	34.10
34.20	1736.69	1737.15	1737.61	1738.08	1738.54	1739.01	1739.47	1739.93	1740.40	1740.86	1741.33	34.20
34.30	1741.33	1741.79	1742.25	1742.72	1743.18	1743.65	1744.11	1744.57	1745.04	1745.50	1745.97	34.30
34.40	1745.97	1746.43	1746.90	1747.36	1747.82	1748.29	1748.75	1749.22	1749.68	1750.15	1750.61	34.40
34.50	1750.61	1751.07	1751.54	1752.00	1752.47	1752.93	1753.40	1753.86	1754.33	1754.79	1755.25	34.50
34.60	1755.25	1755.72	1756.18	1756.65	1757.11	1757.58	1758.04	1758.51	1758.97	1759.43	1759.90	34.60
34.70	1759.90	1760.36	1760.83	1761.29	1761.76	1762.22	1762.69	1763.15	1763.62	1764.08	1764.55	34.70
34.80	1764.55	1765.01	1765.48	1765.94	1766.41	1766.87	1767.34	1767.80	1768.26	1768.73	1769.19	34.80
34.90	1769.19	1769.66	1770.12	1770.59	1771.05	1771.52	1771.98	1772.45	1772.91	1773.38	1773.84	34.90
35.00	1773.84	1774.31	1774.77	1775.24	1775.70	1776.17	1776.63	1777.10	1777.57	1778.03	1778.50	35.00
35.10	1778.50	1778.96	1779.43	1779.89	1780.36	1780.82	1781.29	1781.75	1782.22	1782.68	1783.15	35.10
35.20	1783.15	1783.61	1784.08	1784.54	1785.01	1785.47	1785.94	1786.41	1786.87	1787.34	1787.80	35.20
35.30	1787.80	1788.27	1788.73	1789.20	1789.66	1790.13	1790.59	1791.06	1791.53	1791.99	1792.46	35.30
35.40	1792.46	1792.92	1793.39	1793.85	1794.32	1794.79	1795.25	1795.72	1796.18	1796.65	1797.11	35.40
35.50	1797.11	1797.58	1798.05	1798.51	1798.98	1799.44	1799.91	1800.37	1800.84	1801.31	1801.77	35.50
35.60	1801.77	1802.24	1802.70	1803.17	1803.64	1804.10	1804.57	1805.03	1805.50	1805.97	1806.43	35.60
35.70	1806.43	1806.90	1807.36	1807.83	1808.30	1808.76	1809.23	1809.69	1810.16	1810.63	1811.09	35.70
35.80	1811.09	1811.56	1812.03	1812.49	1812.96	1813.42	1813.89	1814.36	1814.82	1815.29	1815.76	35.80
35.90	1815.76	1816.22	1816.69	1817.15	1817.62	1818.09	1818.55	1819.02	1819.49	1819.95	1820.42	35.90
36.00	1820.42	1820.89	1821.35	1821.82	1822.29	1822.75	1823.22	1823.69	1824.15	1824.62	1825.09	36.00
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

Table B4. AWG 14 *Nicrosil versus Nisil thermocouples—temperature (°F) as a function of thermoelectric voltage, reference junctions at 32 °F*—Continued

TEMPERATURES IN DEGREES F

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
36.00	1820.42	1820.89	1821.35	1821.82	1822.29	1822.75	1823.22	1823.69	1824.15	1824.62	1825.09	36.00
36.10	1825.09	1825.55	1826.02	1826.49	1826.95	1827.42	1827.89	1828.35	1828.82	1829.29	1829.75	36.10
36.20	1829.75	1830.22	1830.69	1831.15	1831.62	1832.09	1832.55	1833.02	1833.49	1833.95	1834.42	36.20
36.30	1834.42	1834.89	1835.36	1835.82	1836.29	1836.76	1837.22	1837.69	1838.16	1838.62	1839.09	36.30
36.40	1839.09	1839.56	1840.03	1840.49	1840.96	1841.43	1841.89	1842.36	1842.83	1843.30	1843.76	36.40
36.50	1843.76	1844.23	1844.70	1845.17	1845.63	1846.10	1846.57	1847.04	1847.50	1847.97	1848.44	36.50
36.60	1848.44	1848.90	1849.37	1849.84	1850.31	1850.77	1851.24	1851.71	1852.18	1852.64	1853.11	36.60
36.70	1853.11	1853.58	1854.05	1854.52	1854.98	1855.45	1855.92	1856.39	1856.85	1857.32	1857.79	36.70
36.80	1857.79	1858.26	1858.72	1859.19	1859.66	1860.13	1860.60	1861.06	1861.53	1862.00	1862.47	36.80
36.90	1862.47	1862.94	1863.40	1863.87	1864.34	1864.81	1865.28	1865.74	1866.21	1866.68	1867.15	36.90
37.00	1867.15	1867.62	1868.08	1868.55	1869.02	1869.49	1869.96	1870.42	1870.89	1871.36	1871.83	37.00
37.10	1871.83	1872.30	1872.77	1873.23	1873.70	1874.17	1874.64	1875.11	1875.58	1876.04	1876.51	37.10
37.20	1876.51	1876.98	1877.45	1877.92	1878.39	1878.85	1879.32	1879.79	1880.26	1880.73	1881.20	37.20
37.30	1881.20	1881.67	1882.13	1882.60	1883.07	1883.54	1884.01	1884.48	1884.95	1885.41	1885.88	37.30
37.40	1885.88	1886.35	1886.82	1887.29	1887.76	1888.23	1888.70	1889.17	1889.63	1890.10	1890.57	37.40
37.50	1890.57	1891.04	1891.51	1891.98	1892.45	1892.92	1893.39	1893.85	1894.32	1894.79	1895.26	37.50
37.60	1895.26	1895.73	1896.20	1896.67	1897.14	1897.61	1898.08	1898.55	1899.02	1899.48	1899.95	37.60
37.70	1899.95	1900.42	1900.89	1901.36	1901.83	1902.30	1902.77	1903.24	1903.71	1904.18	1904.65	37.70
37.80	1904.65	1905.12	1905.59	1906.06	1906.52	1906.99	1907.46	1907.93	1908.40	1908.87	1909.34	37.80
37.90	1909.34	1909.81	1910.28	1910.75	1911.22	1911.69	1912.16	1912.63	1913.10	1913.57	1914.04	37.90
38.00	1914.04	1914.51	1914.98	1915.45	1915.92	1916.39	1916.86	1917.33	1917.80	1918.27	1918.74	38.00
38.10	1918.74	1919.21	1919.68	1920.15	1920.62	1921.09	1921.56	1922.03	1922.50	1922.97	1923.44	38.10
38.20	1923.44	1923.91	1924.38	1924.85	1925.32	1925.79	1926.26	1926.73	1927.20	1927.67	1928.14	38.20
38.30	1928.14	1928.61	1929.08	1929.55	1930.02	1930.49	1930.96	1931.43	1931.90	1932.37	1932.85	38.30
38.40	1932.85	1933.32	1933.79	1934.26	1934.73	1935.20	1935.67	1936.14	1936.61	1937.08	1937.55	38.40
38.50	1937.55	1938.02	1938.49	1938.96	1939.43	1939.91	1940.38	1940.85	1941.32	1941.79	1942.26	38.50
38.60	1942.26	1942.73	1943.20	1943.67	1944.14	1944.61	1945.09	1945.56	1946.03	1946.50	1946.97	38.60
38.70	1946.97	1947.44	1947.91	1948.38	1948.85	1949.33	1949.80	1950.27	1950.74	1951.21	1951.68	38.70
38.80	1951.68	1952.15	1952.62	1953.10	1953.57	1954.04	1954.51	1954.98	1955.45	1955.92	1956.40	38.80
38.90	1956.40	1956.87	1957.34	1957.81	1958.28	1958.75	1959.22	1959.70	1960.17	1960.64	1961.11	38.90
39.00	1961.11	1961.58	1962.05	1962.53	1963.00	1963.47	1963.94	1964.41	1964.89	1965.36	1965.83	39.00
39.10	1965.83	1966.30	1966.77	1967.24	1967.72	1968.19	1968.66	1969.13	1969.60	1970.08	1970.55	39.10
39.20	1970.55	1971.02	1971.49	1971.96	1972.44	1972.91	1973.38	1973.85	1974.33	1974.80	1975.27	39.20
39.30	1975.27	1975.74	1976.21	1976.69	1977.16	1977.63	1978.10	1978.58	1979.05	1979.52	1979.99	39.30
39.40	1979.99	1980.47	1980.94	1981.41	1981.88	1982.36	1982.83	1983.30	1983.77	1984.25	1984.72	39.40
39.50	1984.72	1985.19	1985.67	1986.14	1986.61	1987.08	1987.56	1988.03	1988.50	1988.97	1989.45	39.50
39.60	1989.45	1989.92	1990.39	1990.87	1991.34	1991.81	1992.29	1992.76	1993.23	1993.70	1994.18	39.60
39.70	1994.18	1994.65	1995.12	1995.60	1996.07	1996.54	1997.02	1997.49	1997.96	1998.44	1998.91	39.70
39.80	1998.91	1999.38	1999.86	2000.33	2000.80	2001.28	2001.75	2002.22	2002.70	2003.17	2003.64	39.80
39.90	2003.64	2004.12	2004.59	2005.07	2005.54	2006.01	2006.49	2006.96	2007.43	2007.91	2008.38	39.90
40.00	2008.38	2008.85	2009.33	2009.80	2010.28	2010.75	2011.22	2011.70	2012.17	2012.65	2013.12	40.00
40.10	2013.12	2013.59	2014.07	2014.54	2015.02	2015.49	2015.96	2016.44	2016.91	2017.39	2017.86	40.10
40.20	2017.86	2018.33	2018.81	2019.28	2019.76	2020.23	2020.71	2021.18	2021.65	2022.13	2022.60	40.20
40.30	2022.60	2023.08	2023.55	2024.03	2024.50	2024.98	2025.45	2025.93	2026.40	2026.87	2027.35	40.30
40.40	2027.35	2027.82	2028.30	2028.77	2029.25	2029.72	2030.20	2030.67	2031.15	2031.62	2032.10	40.40
40.50	2032.10	2032.57	2033.05	2033.52	2034.00	2034.47	2034.95	2035.42	2035.90	2036.37	2036.85	40.50
40.60	2036.85	2037.32	2037.80	2038.27	2038.75	2039.22	2039.70	2040.17	2040.65	2041.12	2041.60	40.60
40.70	2041.60	2042.07	2042.55	2043.03	2043.50	2043.98	2044.45	2044.93	2045.40	2045.88	2046.35	40.70
40.80	2046.35	2046.83	2047.31	2047.78	2048.26	2048.73	2049.21	2049.68	2050.16	2050.64	2051.11	40.80
40.90	2051.11	2051.59	2052.06	2052.54	2053.01	2053.49	2053.97	2054.44	2054.92	2055.39	2055.87	40.90
41.00	2055.87	2056.35	2056.82	2057.30	2057.78	2058.25	2058.73	2059.20	2059.68	2060.16	2060.63	41.00
41.10	2060.63	2061.11	2061.59	2062.06	2062.54	2063.01	2063.49	2063.97	2064.44	2064.92	2065.40	41.10
41.20	2065.40	2065.87	2066.35	2066.83	2067.30	2067.78	2068.26	2068.73	2069.21	2069.69	2070.16	41.20
41.30	2070.16	2070.64	2071.12	2071.60	2072.07	2072.55	2073.03	2073.50	2073.98	2074.46	2074.93	41.30
41.40	2074.93	2075.41	2075.89	2076.37	2076.84	2077.32	2077.80	2078.27	2078.75	2079.23	2079.71	41.40
41.50	2079.71	2080.18	2080.66	2081.14	2081.62	2082.09	2082.57	2083.05	2083.53	2084.00	2084.48	41.50
41.60	2084.48	2084.96	2085.44	2085.91	2086.39	2086.87	2087.35	2087.83	2088.30	2088.78	2089.26	41.60
41.70	2089.26	2089.74	2090.21	2090.69	2091.17	2091.65	2092.13	2092.60	2093.08	2093.56	2094.04	41.70
41.80	2094.04	2094.52	2094.99	2095.47	2095.95	2096.43	2096.91	2097.39	2097.86	2098.34	2098.82	41.80
41.90	2098.82	2099.30	2099.78	2100.26	2100.74	2101.21	2101.69	2102.17	2102.65	2103.13	2103.61	41.90
42.00	2103.61	2104.09	2104.56	2105.04	2105.52	2106.00	2106.48	2106.96	2107.44	2107.92	2108.40	42.00
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

Table B4. AWG 14 *Nicrosil versus Nisil thermocouples—temperature (°F) as a function of thermoelectric voltage, reference junctions at 32 °F*—Continued

mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
42.00	2103.61	2104.09	2104.56	2105.04	2105.52	2106.00	2106.48	2106.96	2107.44	2107.92	2108.40	42.00
42.10	2108.40	2108.87	2109.35	2109.83	2110.31	2110.79	2111.27	2111.75	2112.23	2112.71	2113.19	42.10
42.20	2113.19	2113.67	2114.14	2114.62	2115.10	2115.58	2116.06	2116.54	2117.02	2117.50	2117.98	42.20
42.30	2117.98	2118.46	2118.94	2119.42	2119.90	2120.38	2120.86	2121.34	2121.82	2122.30	2122.78	42.30
42.40	2122.78	2123.26	2123.74	2124.22	2124.70	2125.18	2125.66	2126.14	2126.62	2127.10	2127.58	42.40
42.50	2127.58	2128.06	2128.54	2129.02	2129.50	2129.98	2130.46	2130.94	2131.42	2131.90	2132.38	42.50
42.60	2132.38	2132.86	2133.34	2133.82	2134.30	2134.78	2135.26	2135.74	2136.22	2136.70	2137.18	42.60
42.70	2137.18	2137.67	2138.15	2138.63	2139.11	2139.59	2140.07	2140.55	2141.03	2141.51	2141.99	42.70
42.80	2141.99	2142.47	2142.96	2143.44	2143.92	2144.40	2144.88	2145.36	2145.84	2146.32	2146.81	42.80
42.90	2146.81	2147.29	2147.77	2148.25	2148.73	2149.21	2149.69	2150.17	2150.66	2151.14	2151.62	42.90
43.00	2151.62	2152.10	2152.58	2153.06	2153.55	2154.03	2154.51	2154.99	2155.47	2155.96	2156.44	43.00
43.10	2156.44	2156.92	2157.40	2157.88	2158.37	2158.85	2159.33	2159.81	2160.29	2160.78	2161.26	43.10
43.20	2161.26	2161.74	2162.22	2162.71	2163.19	2163.67	2164.15	2164.63	2165.12	2165.60	2166.08	43.20
43.30	2166.08	2166.56	2167.05	2167.53	2168.01	2168.50	2168.98	2169.46	2169.94	2170.43	2170.91	43.30
43.40	2170.91	2171.39	2171.88	2172.36	2172.84	2173.32	2173.81	2174.29	2174.77	2175.26	2175.74	43.40
43.50	2175.74	2176.22	2176.71	2177.19	2177.67	2178.16	2178.64	2179.12	2179.61	2180.09	2180.57	43.50
43.60	2180.57	2181.06	2181.54	2182.02	2182.51	2182.99	2183.48	2183.96	2184.44	2184.93	2185.41	43.60
43.70	2185.41	2185.89	2186.38	2186.86	2187.35	2187.83	2188.31	2188.80	2189.28	2189.77	2190.25	43.70
43.80	2190.25	2190.73	2191.22	2191.70	2192.19	2192.67	2193.16	2193.64	2194.13	2194.61	2195.09	43.80
43.90	2195.09	2195.58	2196.06	2196.55	2197.03	2197.52	2198.00	2198.49	2198.97	2199.46	2199.94	43.90
44.00	2199.94	2200.43	2200.91	2201.40	2201.88	2202.37	2202.85	2203.34	2203.82	2204.31	2204.79	44.00
44.10	2204.79	2205.28	2205.76	2206.25	2206.73	2207.22	2207.70	2208.19	2208.67	2209.16	2209.65	44.10
44.20	2209.65	2210.13	2210.62	2211.10	2211.59	2212.07	2212.56	2213.05	2213.53	2214.02	2214.50	44.20
44.30	2214.50	2214.99	2215.47	2215.96	2216.45	2216.93	2217.42	2217.91	2218.39	2218.88	2219.36	44.30
44.40	2219.36	2219.85	2220.34	2220.82	2221.31	2221.80	2222.28	2222.77	2223.26	2223.74	2224.23	44.40
44.50	2224.23	2224.72	2225.20	2225.69	2226.18	2226.66	2227.15	2227.64	2228.12	2228.61	2229.10	44.50
44.60	2229.10	2229.58	2230.07	2230.56	2231.04	2231.53	2232.02	2232.51	2232.99	2233.48	2233.97	44.60
44.70	2233.97	2234.46	2234.94	2235.43	2235.92	2236.41	2236.89	2237.38	2237.87	2238.36	2238.84	44.70
44.80	2238.84	2239.33	2239.82	2240.31	2240.79	2241.28	2241.77	2242.26	2242.75	2243.23	2243.72	44.80
44.90	2243.72	2244.21	2244.70	2245.19	2245.67	2246.16	2246.65	2247.14	2247.63	2248.12	2248.60	44.90
45.00	2248.60	2249.09	2249.58	2250.07	2250.56	2251.05	2251.54	2252.02	2252.51	2253.00	2253.49	45.00
45.10	2253.49	2253.98	2254.47	2254.96	2255.45	2255.94	2256.42	2256.91	2257.40	2257.89	2258.38	45.10
45.20	2258.38	2258.87	2259.36	2259.85	2260.34	2260.83	2261.32	2261.81	2262.30	2262.79	2263.27	45.20
45.30	2263.27	2263.76	2264.25	2264.74	2265.23	2265.72	2266.21	2266.70	2267.19	2267.68	2268.17	45.30
45.40	2268.17	2268.66	2269.15	2269.64	2270.13	2270.62	2271.11	2271.60	2272.09	2272.58	2273.07	45.40
45.50	2273.07	2273.56	2274.05	2274.54	2275.04	2275.53	2276.02	2276.51	2277.00	2277.49	2277.98	45.50
45.60	2277.98	2278.47	2278.96	2279.45	2279.94	2280.43	2280.92	2281.41	2281.91	2282.40	2282.89	45.60
45.70	2282.89	2283.38	2283.87	2284.36	2284.85	2285.34	2285.84	2286.33	2286.82	2287.31	2287.80	45.70
45.80	2287.80	2288.29	2288.78	2289.28	2289.77	2290.26	2290.75	2291.24	2291.73	2292.23	2292.72	45.80
45.90	2292.72	2293.21	2293.70	2294.19	2294.69	2295.18	2295.67	2296.16	2296.65	2297.15	2297.64	45.90
46.00	2297.64	2298.13	2298.62	2299.11	2299.61	2300.10	2300.59	2301.08	2301.58	2302.07	2302.56	46.00
46.10	2302.56	2303.06	2303.55	2304.04	2304.53	2305.03	2305.52	2306.01	2306.50	2307.00	2307.49	46.10
46.20	2307.49	2307.98	2308.48	2308.97	2309.46	2309.96	2310.45	2310.94	2311.44	2311.93	2312.42	46.20
46.30	2312.42	2312.92	2313.41	2313.90	2314.40	2314.89	2315.38	2315.88	2316.37	2316.87	2317.36	46.30
46.40	2317.36	2317.85	2318.35	2318.84	2319.33	2319.83	2320.32	2320.82	2321.31	2321.80	2322.30	46.40
46.50	2322.30	2322.79	2323.29	2323.78	2324.28	2324.77	2325.26	2325.76	2326.25	2326.75	2327.24	46.50
46.60	2327.24	2327.74	2328.23	2328.73	2329.22	2329.72	2330.21	2330.71	2331.20	2331.70	2332.19	46.60
46.70	2332.19	2332.69	2333.18	2333.68	2334.17	2334.67	2335.16	2335.66	2336.15	2336.65	2337.14	46.70
46.80	2337.14	2337.64	2338.13	2338.63	2339.12	2339.62	2340.11	2340.61	2341.11	2341.60	2342.10	46.80
46.90	2342.10	2342.59	2343.09	2343.58	2344.08	2344.58	2345.07	2345.57	2346.06	2346.56	2347.06	46.90
47.00	2347.06	2347.55	2348.05	2348.55	2349.04	2349.54	2350.03	2350.53	2351.03	2351.52	2352.02	47.00
47.10	2352.02	2352.52	2353.01	2353.51	2354.01	2354.50	2355.00	2355.50	2355.99	2356.49	2356.99	47.10
47.20	2356.99	2357.48	2357.98	2358.48	2358.97	2359.47	2359.97	2360.47	2360.96	2361.46	2361.96	47.20
47.30	2361.96	2362.45	2362.95	2363.45	2363.95	2364.44	2364.94	2365.44	2365.94	2366.43	2366.93	47.30
47.40	2366.93	2367.43	2367.93	2368.42	2368.92	2369.42	2369.92	2370.42	2370.91	2371.41	2371.91	47.40
47.50	2371.91											47.50
mV	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV

TEMPERATURES IN DEGREES F

Appendix C. Abbreviated Tables for Nicrosil versus Nisil Thermocouples, for Nicrosil Thermoelements versus Platinum, Pt–67, and for Platinum, Pt–67, versus Nisil Thermoelements

The primary tables and functions presented in section 7 are more precise than is often necessary. The tables in this appendix present the same data in different formats to satisfy special needs. Table C1 gives the voltage as a function of temperature, T, in degrees Celsius, with the voltage expressed in millivolts rather than microvolts (without columns for the Seebeck coefficient and its derivative), for *AWG 28* thermocouples. Table C2 gives the equilavent for *AWG 14* thermocouples. Tables C3, C4, C5, C6, C7, and C8 give similar data with the temperature given in degrees Fahrenheit. Tables C3 and C4 are for the thermocouple combination; tables C5 and C6 are for the Nicrosil thermoelement versus platinum, Pt–67; and tables C7 and C8 are for platinum, Pt–67, versus the Nisil thermoelement.

TABLE C1. AWG 28 *Nicrosil versus Nisil thermocouples—thermoelectric voltage as a function of temperature (°C), reference junctions at 0 °C. Abbreviated table.*

THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS

°C	0	1	2	3	4	5	6	7	8	9	10	°C
-270	-4.3452											-270
-260	-4.3357	-4.3372	-4.3386	-4.3399	-4.3410	-4.3420	-4.3429	-4.3436	-4.3443	-4.3448	-4.3452	-260
-250	-4.3133	-4.3162	-4.3189	-4.3215	-4.3239	-4.3262	-4.3284	-4.3304	-4.3323	-4.3341	-4.3357	-250
-240	-4.2770	-4.2813	-4.2854	-4.2894	-4.2932	-4.2969	-4.3005	-4.3039	-4.3072	-4.3103	-4.3133	-240
-230	-4.2265	-4.2322	-4.2378	-4.2432	-4.2484	-4.2536	-4.2585	-4.2634	-4.2681	-4.2726	-4.2770	-230
-220	-4.1618	-4.1689	-4.1759	-4.1827	-4.1894	-4.1959	-4.2023	-4.2086	-4.2147	-4.2207	-4.2265	-220
-210	-4.0829	-4.0915	-4.0998	-4.1081	-4.1162	-4.1241	-4.1319	-4.1396	-4.1471	-4.1545	-4.1618	-210
-200	-3.9904	-4.0002	-4.0100	-4.0196	-4.0290	-4.0384	-4.0475	-4.0566	-4.0655	-4.0743	-4.0829	-200
-190	-3.8844	-3.8956	-3.9067	-3.9176	-3.9284	-3.9390	-3.9496	-3.9600	-3.9702	-3.9804	-3.9904	-190
-180	-3.7656	-3.7780	-3.7903	-3.8025	-3.8146	-3.8266	-3.8384	-3.8501	-3.8617	-3.8731	-3.8844	-180
-170	-3.6343	-3.6479	-3.6615	-3.6749	-3.6882	-3.7014	-3.7145	-3.7275	-3.7403	-3.7530	-3.7656	-170
-160	-3.4910	-3.5058	-3.5206	-3.5352	-3.5497	-3.5641	-3.5783	-3.5925	-3.6065	-3.6205	-3.6343	-160
-150	-3.3362	-3.3521	-3.3680	-3.3838	-3.3994	-3.4150	-3.4304	-3.4457	-3.4609	-3.4760	-3.4910	-150
-140	-3.1703	-3.1874	-3.2043	-3.2212	-3.2379	-3.2546	-3.2711	-3.2875	-3.3039	-3.3201	-3.3362	-140
-130	-2.9939	-3.0120	-3.0300	-3.0479	-3.0657	-3.0834	-3.1010	-3.1185	-3.1359	-3.1531	-3.1703	-130
-120	-2.8075	-2.8266	-2.8456	-2.8644	-2.8832	-2.9019	-2.9205	-2.9390	-2.9574	-2.9757	-2.9939	-120
-110	-2.6115	-2.6315	-2.6514	-2.6713	-2.6910	-2.7107	-2.7302	-2.7497	-2.7690	-2.7883	-2.8075	-110
-100	-2.4066	-2.4274	-2.4482	-2.4690	-2.4896	-2.5101	-2.5306	-2.5509	-2.5712	-2.5914	-2.6115	-100
-90	-2.1932	-2.2149	-2.2365	-2.2581	-2.2795	-2.3009	-2.3222	-2.3434	-2.3645	-2.3856	-2.4066	-90
-80	-1.9721	-1.9945	-2.0169	-2.0392	-2.0614	-2.0836	-2.1057	-2.1277	-2.1496	-2.1714	-2.1932	-80
-70	-1.7438	-1.7669	-1.7900	-1.8130	-1.8359	-1.8588	-1.8816	-1.9043	-1.9270	-1.9496	-1.9721	-70
-60	-1.5090	-1.5328	-1.5565	-1.5801	-1.6037	-1.6272	-1.6506	-1.6740	-1.6973	-1.7206	-1.7438	-60
-50	-1.2684	-1.2927	-1.3170	-1.3412	-1.3653	-1.3894	-1.4134	-1.4374	-1.4613	-1.4852	-1.5090	-50
-40	-1.0226	-1.0474	-1.0721	-1.0968	-1.1215	-1.1461	-1.1707	-1.1952	-1.2196	-1.2440	-1.2684	-40
-30	-0.7722	-0.7974	-0.8226	-0.8478	-0.8729	-0.8979	-0.9229	-0.9479	-0.9729	-0.9977	-1.0226	-30
-20	-0.5179	-0.5435	-0.5691	-0.5946	-0.6201	-0.6455	-0.6709	-0.6963	-0.7217	-0.7470	-0.7722	-20
-10	-0.2603	-0.2862	-0.3121	-0.3379	-0.3637	-0.3895	-0.4153	-0.4410	-0.4667	-0.4923	-0.5179	-10
0	0.0000											0
°C	0	1	2	3	4	5	6	7	8	9	10	°C

TABLE C1. AWG 28 *Nicrosil versus Nisil thermocouples—thermoelectric voltage as a function of temperature (°C), reference junctions at 0 °C*—Continued

°C	0	1	2	3	4	5	6	7	8	9	10	°C
						THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS						
0	0.0000	0.0262	0.0523	0.0785	0.1048	0.1310	0.1573	0.1836	0.2099	0.2362	0.2626	0
10	0.2626	0.2890	0.3154	0.3418	0.3683	0.3948	0.4213	0.4479	0.4745	0.5011	0.5278	10
20	0.5278	0.5544	0.5811	0.6079	0.6347	0.6615	0.6883	0.7152	0.7421	0.7690	0.7960	20
30	0.7960	0.8230	0.8501	0.8772	0.9043	0.9314	0.9586	0.9859	1.0131	1.0404	1.0678	30
40	1.0678	1.0951	1.1226	1.1500	1.1775	1.2050	1.2326	1.2602	1.2879	1.3156	1.3433	40
50	1.3433	1.3710	1.3989	1.4267	1.4546	1.4825	1.5105	1.5385	1.5665	1.5946	1.6227	50
60	1.6227	1.6509	1.6791	1.7073	1.7356	1.7640	1.7923	1.8207	1.8492	1.8777	1.9062	60
70	1.9062	1.9348	1.9634	1.9920	2.0207	2.0494	2.0782	2.1070	2.1359	2.1647	2.1937	70
80	2.1937	2.2226	2.2517	2.2807	2.3098	2.3389	2.3681	2.3973	2.4266	2.4558	2.4852	80
90	2.4852	2.5145	2.5439	2.5734	2.6029	2.6324	2.6620	2.6915	2.7212	2.7509	2.7806	90
100	2.7806	2.8103	2.8401	2.8700	2.8998	2.9297	2.9597	2.9897	3.0197	3.0497	3.0798	100
110	3.0798	3.1100	3.1401	3.1703	3.2006	3.2308	3.2612	3.2915	3.3219	3.3523	3.3828	110
120	3.3828	3.4133	3.4438	3.4744	3.5050	3.5356	3.5663	3.5970	3.6277	3.6585	3.6893	120
130	3.6893	3.7202	3.7511	3.7820	3.8129	3.8439	3.8749	3.9060	3.9371	3.9682	3.9993	130
140	3.9993	4.0305	4.0617	4.0930	4.1243	4.1556	4.1869	4.2183	4.2497	4.2812	4.3127	140
150	4.3127	4.3442	4.3757	4.4073	4.4389	4.4706	4.5022	4.5339	4.5657	4.5974	4.6292	150
160	4.6292	4.6611	4.6929	4.7248	4.7567	4.7887	4.8207	4.8527	4.8847	4.9168	4.9489	160
170	4.9489	4.9810	5.0132	5.0454	5.0776	5.1098	5.1421	5.1744	5.2068	5.2391	5.2715	170
180	5.2715	5.3040	5.3364	5.3689	5.4014	5.4340	5.4665	5.4991	5.5318	5.5644	5.5971	180
190	5.5971	5.6298	5.6625	5.6953	5.7281	5.7609	5.7938	5.8267	5.8596	5.8925	5.9255	190
200	5.9255	5.9585	5.9915	6.0245	6.0576	6.0907	6.1238	6.1570	6.1901	6.2234	6.2566	200
210	6.2566	6.2898	6.3231	6.3564	6.3898	6.4231	6.4565	6.4900	6.5234	6.5569	6.5904	210
220	6.5904	6.6239	6.6574	6.6910	6.7246	6.7582	6.7919	6.8256	6.8593	6.8930	6.9268	220
230	6.9268	6.9605	6.9944	7.0282	7.0620	7.0959	7.1298	7.1638	7.1977	7.2317	7.2657	230
240	7.2657	7.2997	7.3338	7.3679	7.4020	7.4361	7.4703	7.5044	7.5387	7.5729	7.6071	240
250	7.6071	7.6414	7.6757	7.7100	7.7444	7.7788	7.8132	7.8476	7.8820	7.9165	7.9510	250
260	7.9510	7.9855	8.0201	8.0546	8.0892	8.1238	8.1584	8.1931	8.2278	8.2625	8.2972	260
270	8.2972	8.3320	8.3667	8.4015	8.4364	8.4712	8.5061	8.5409	8.5759	8.6108	8.6457	270
280	8.6457	8.6807	8.7157	8.7507	8.7858	8.8208	8.8559	8.8910	8.9262	8.9613	8.9965	280
290	8.9965	9.0317	9.0669	9.1021	9.1374	9.1727	9.2080	9.2433	9.2786	9.3140	9.3494	290
300	9.3494	9.3848	9.4202	9.4557	9.4911	9.5266	9.5621	9.5976	9.6332	9.6688	9.7043	300
310	9.7043	9.7399	9.7756	9.8112	9.8469	9.8826	9.9183	9.9540	9.9897	10.0255	10.0613	310
320	10.0613	10.0971	10.1329	10.1687	10.2046	10.2404	10.2763	10.3122	10.3481	10.3841	10.4200	320
330	10.4200	10.4560	10.4920	10.5280	10.5641	10.6001	10.6362	10.6722	10.7083	10.7444	10.7806	330
340	10.7806	10.8167	10.8529	10.8891	10.9253	10.9615	10.9977	11.0339	11.0702	11.1065	11.1428	340
350	11.1428	11.1791	11.2154	11.2517	11.2881	11.3245	11.3608	11.3972	11.4336	11.4701	11.5065	350
360	11.5065	11.5430	11.5794	11.6159	11.6524	11.6889	11.7255	11.7620	11.7986	11.8351	11.8717	360
370	11.8717	11.9083	11.9449	11.9815	12.0182	12.0548	12.0915	12.1282	12.1649	12.2016	12.2383	370
380	12.2383	12.2750	12.3118	12.3485	12.3853	12.4221	12.4589	12.4957	12.5325	12.5694	12.6062	380
390	12.6062	12.6431	12.6800	12.7169	12.7538	12.7907	12.8276	12.8646	12.9015	12.9385	12.9755	390
400	12.9755											400
°C	0	1	2	3	4	5	6	7	8	9	10	°C

Table C2. AWG 14 *Nicrosil versus Nisil thermocouples—thermoelectric voltage as a function of temperature (°C), reference junctions at 0 °C. Abbreviated table.*

THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS

°C	0	1	2	3	4	5	6	7	8	9	10	°C
0	0.0000	0.0259	0.0519	0.0778	0.1039	0.1299	0.1560	0.1821	0.2083	0.2345	0.2607	0
10	0.2607	0.2869	0.3132	0.3396	0.3659	0.3923	0.4187	0.4452	0.4717	0.4983	0.5248	10
20	0.5248	0.5515	0.5781	0.6048	0.6315	0.6583	0.6851	0.7119	0.7388	0.7657	0.7926	20
30	0.7926	0.8196	0.8466	0.8737	0.9008	0.9279	0.9551	0.9823	1.0095	1.0368	1.0642	30
40	1.0642	1.0915	1.1189	1.1463	1.1738	1.2013	1.2289	1.2565	1.2841	1.3118	1.3395	40
50	1.3395	1.3672	1.3950	1.4228	1.4507	1.4786	1.5065	1.5345	1.5625	1.5905	1.6186	50
60	1.6186	1.6467	1.6749	1.7031	1.7313	1.7596	1.7879	1.8163	1.8447	1.8731	1.9016	60
70	1.9016	1.9301	1.9587	1.9872	2.0159	2.0445	2.0732	2.1020	2.1308	2.1596	2.1884	70
80	2.1884	2.2173	2.2463	2.2752	2.3042	2.3333	2.3624	2.3915	2.4207	2.4499	2.4791	80
90	2.4791	2.5084	2.5377	2.5670	2.5964	2.6259	2.6553	2.6848	2.7144	2.7440	2.7736	90
100	2.7736	2.8032	2.8329	2.8626	2.8924	2.9222	2.9520	2.9819	3.0118	3.0418	3.0718	100
110	3.0718	3.1018	3.1319	3.1620	3.1921	3.2223	3.2525	3.2827	3.3130	3.3433	3.3737	110
120	3.3737	3.4041	3.4345	3.4649	3.4954	3.5260	3.5565	3.5871	3.6178	3.6485	3.6792	120
130	3.6792	3.7099	3.7407	3.7715	3.8024	3.8333	3.8642	3.8951	3.9261	3.9572	3.9882	130
140	3.9882	4.0193	4.0504	4.0816	4.1128	4.1440	4.1753	4.2066	4.2379	4.2693	4.3007	140
150	4.3007	4.3322	4.3636	4.3951	4.4267	4.4582	4.4898	4.5215	4.5532	4.5849	4.6166	150
160	4.6166	4.6484	4.6802	4.7120	4.7439	4.7758	4.8077	4.8397	4.8717	4.9037	4.9357	160
170	4.9357	4.9678	5.0000	5.0321	5.0643	5.0965	5.1288	5.1611	5.1934	5.2257	5.2581	170
180	5.2581	5.2905	5.3229	5.3554	5.3879	5.4204	5.4530	5.4856	5.5182	5.5508	5.5835	180
190	5.5835	5.6162	5.6490	5.6817	5.7145	5.7474	5.7802	5.8131	5.8460	5.8790	5.9119	190
200	5.9119	5.9449	5.9780	6.0110	6.0441	6.0772	6.1104	6.1435	6.1768	6.2100	6.2432	200
210	6.2432	6.2765	6.3098	6.3432	6.3766	6.4100	6.4434	6.4768	6.5103	6.5438	6.5774	210
220	6.5774	6.6109	6.6445	6.6781	6.7118	6.7454	6.7791	6.8129	6.8466	6.8804	6.9142	220
230	6.9142	6.9480	6.9819	7.0157	7.0496	7.0836	7.1175	7.1515	7.1855	7.2195	7.2536	230
240	7.2536	7.2877	7.3218	7.3559	7.3901	7.4243	7.4585	7.4927	7.5270	7.5613	7.5956	240
250	7.5956	7.6299	7.6642	7.6986	7.7330	7.7674	7.8019	7.8364	7.8709	7.9054	7.9399	250
260	7.9399	7.9745	8.0091	8.0437	8.0784	8.1130	8.1477	8.1824	8.2171	8.2519	8.2867	260
270	8.2867	8.3215	8.3563	8.3911	8.4260	8.4609	8.4958	8.5307	8.5657	8.6006	8.6356	270
280	8.6356	8.6707	8.7057	8.7408	8.7758	8.8110	8.8461	8.8812	8.9164	8.9516	8.9868	280
290	8.9868	9.0220	9.0573	9.0926	9.1278	9.1632	9.1985	9.2339	9.2692	9.3046	9.3400	290
300	9.3400	9.3755	9.4109	9.4464	9.4819	9.5174	9.5530	9.5885	9.6241	9.6597	9.6953	300
310	9.6953	9.7309	9.7666	9.8023	9.8380	9.8737	9.9094	9.9452	9.9809	10.0167	10.0525	310
320	10.0525	10.0884	10.1242	10.1601	10.1959	10.2318	10.2678	10.3037	10.3396	10.3756	10.4116	320
330	10.4116	10.4476	10.4836	10.5197	10.5558	10.5918	10.6279	10.6640	10.7002	10.7363	10.7725	330
340	10.7725	10.8087	10.8449	10.3811	10.9173	10.9536	10.9899	11.0262	11.0625	11.0988	11.1351	340
350	11.1351	11.1715	11.2079	11.2442	11.2806	11.3171	11.3535	11.3900	11.4264	11.4629	11.4994	350
360	11.4994	11.5359	11.5725	11.6090	11.6456	11.6822	11.7188	11.7554	11.7920	11.8287	11.8653	360
370	11.8653	11.9020	11.9387	11.9754	12.0121	12.0489	12.0856	12.1224	12.1592	12.1960	12.2328	370
380	12.2328	12.2696	12.3065	12.3433	12.3802	12.4171	12.4540	12.4909	12.5279	12.5648	12.6018	380
390	12.6018	12.6387	12.6757	12.7127	12.7498	12.7868	12.8238	12.8609	12.8980	12.9351	12.9722	390
400	12.9722	13.0093	13.0464	13.0836	13.1207	13.1579	13.1951	13.2323	13.2695	13.3067	13.3440	400
410	13.3440	13.3812	13.4185	13.4558	13.4930	13.5304	13.5677	13.6050	13.6423	13.6797	13.7171	410
420	13.7171	13.7545	13.7919	13.8293	13.8667	13.9041	13.9416	13.9790	14.0165	14.0540	14.0915	420
430	14.0915	14.1290	14.1665	14.2041	14.2416	14.2792	14.3167	14.3543	14.3919	14.4295	14.4671	430
440	14.4671	14.5048	14.5424	14.5801	14.6177	14.6554	14.6931	14.7308	14.7685	14.8062	14.8440	440
450	14.8440	14.8817	14.9195	14.9572	14.9950	15.0328	15.0706	15.1084	15.1463	15.1841	15.2219	450
460	15.2219	15.2598	15.2977	15.3356	15.3734	15.4114	15.4493	15.4872	15.5251	15.5631	15.6010	460
470	15.6010	15.6390	15.6770	15.7150	15.7530	15.7910	15.8290	15.8670	15.9050	15.9431	15.9812	470
480	15.9812	16.0192	16.0573	16.0954	16.1335	16.1716	16.2097	16.2478	16.2860	16.3241	16.3623	480
490	16.3623	16.4005	16.4386	16.4768	16.5150	16.5532	16.5914	16.6297	16.6679	16.7061	16.7444	490
500	16.7444	16.7827	16.8209	16.3592	16.8975	16.9358	16.9741	17.0124	17.0507	17.0891	17.1274	500
510	17.1274	17.1658	17.2041	17.2425	17.2809	17.3193	17.3577	17.3961	17.4345	17.4729	17.5113	510
520	17.5113	17.5498	17.5882	17.6267	17.6651	17.7036	17.7421	17.7806	17.8191	17.8576	17.8961	520
530	17.8961	17.9346	17.9731	18.0117	18.0502	18.0888	18.1273	18.1659	18.2045	18.2430	18.2816	530
540	18.2816	18.3202	18.3588	18.3974	18.4361	18.4747	18.5133	18.5520	18.5906	18.6293	18.6679	540
550	18.6679	18.7066	18.7453	18.7840	18.8226	18.8613	18.9001	18.9388	18.9775	19.0162	19.0549	550
560	19.0549	19.0937	19.1324	19.1712	19.2099	19.2487	19.2875	19.3263	19.3650	19.4038	19.4426	560
570	19.4426	19.4814	19.5202	19.5591	19.5979	19.6367	19.6756	19.7144	19.7532	19.7921	19.8310	570
580	19.8310	19.8698	19.9087	19.9476	19.9865	20.0253	20.0642	20.1031	20.1420	20.1810	20.2199	580
590	20.2199	20.2588	20.2977	20.3367	20.3756	20.4145	20.4535	20.4924	20.5314	20.5704	20.6093	590
600	20.6093	20.6483	20.6873	20.7263	20.7653	20.8043	20.8433	20.8823	20.9213	20.9603	20.9993	600
°C	0	1	2	3	4	5	6	7	8	9	10	°C

TABLE C2. AWG 14 *Nicrosil versus Nisil thermocouples—thermoelectric voltage as a function of temperature (°C), reference junctions at 0 °C*—Continued

°C	0	1	2	3	4	5	6	7	8	9	10	°C
					THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS							
600	20.6093	20.6483	20.6873	20.7263	20.7653	20.8043	20.8433	20.8823	20.9213	20.9603	20.9993	600
610	20.9993	21.0384	21.0774	21.1164	21.1555	21.1945	21.2336	21.2726	21.3117	21.3507	21.3898	610
620	21.3898	21.4289	21.4679	21.5070	21.5461	21.5852	21.6243	21.6634	21.7025	21.7416	21.7807	620
630	21.7807	21.8198	21.8589	21.8980	21.9371	21.9763	22.0154	22.0545	22.0937	22.1328	22.1720	630
640	22.1720	22.2111	22.2503	22.2894	22.3286	22.3677	22.4069	22.4461	22.4853	22.5244	22.5636	640
650	22.5636	22.6028	22.6420	22.6812	22.7204	22.7595	22.7987	22.8379	22.8771	22.9164	22.9556	650
660	22.9556	22.9948	23.0340	23.0732	23.1124	23.1517	23.1909	23.2301	23.2693	23.3086	23.3478	660
670	23.3478	23.3870	23.4263	23.4655	23.5048	23.5440	23.5833	23.6225	23.6618	23.7010	23.7403	670
680	23.7403	23.7795	23.8188	23.8581	23.8973	23.9366	23.9759	24.0151	24.0544	24.0937	24.1330	680
690	24.1330	24.1722	24.2115	24.2508	24.2901	24.3294	24.3687	24.4079	24.4472	24.4865	24.5258	690
700	24.5258	24.5651	24.6044	24.6437	24.6830	24.7223	24.7616	24.8009	24.8402	24.8795	24.9188	700
710	24.9188	24.9581	24.9974	25.0367	25.0760	25.1153	25.1546	25.1940	25.2333	25.2726	25.3119	710
720	25.3119	25.3512	25.3905	25.4298	25.4691	25.5085	25.5478	25.5871	25.6264	25.6657	25.7050	720
730	25.7050	25.7443	25.7837	25.8230	25.8623	25.9016	25.9409	25.9803	26.0196	26.0589	26.0982	730
740	26.0982	26.1375	26.1768	26.2162	26.2555	26.2948	26.3341	26.3734	26.4127	26.4521	26.4914	740
750	26.4914	26.5307	26.5700	26.6093	26.6486	26.6880	26.7273	26.7666	26.8059	26.8452	26.8845	750
760	26.8845	26.9238	26.9631	27.0024	27.0418	27.0911	27.1204	27.1597	27.1990	27.2383	27.2776	760
770	27.2776	27.3169	27.3562	27.3955	27.4348	27.4741	27.5134	27.5527	27.5920	27.6313	27.6706	770
780	27.6706	27.7099	27.7492	27.7885	27.8277	27.8670	27.9063	27.9456	27.9849	28.0242	28.0634	780
790	28.0634	28.1027	28.1420	28.1813	28.2205	28.2598	28.2991	28.3384	28.3776	28.4169	28.4562	790
800	28.4562	28.4954	28.5347	28.5739	28.6132	28.6525	28.6917	28.7310	28.7702	28.8095	28.8487	800
810	28.8487	28.8879	28.9272	28.9664	29.0057	29.0449	29.0841	29.1234	29.1626	29.2018	29.2410	810
820	29.2410	29.2803	29.3195	29.3587	29.3979	29.4371	29.4764	29.5156	29.5548	29.5940	29.6332	820
830	29.6332	29.6724	29.7116	29.7508	29.7900	29.8291	29.8683	29.9075	29.9467	29.9859	30.0251	830
840	30.0251	30.0642	30.1034	30.1426	30.1817	30.2209	30.2601	30.2992	30.3384	30.3775	30.4167	840
850	30.4167	30.4558	30.4950	30.5341	30.5732	30.6124	30.6515	30.6906	30.7298	30.7689	30.8080	850
860	30.8080	30.8471	30.8862	30.9254	30.9645	31.0036	31.0427	31.0818	31.1209	31.1600	31.1990	860
870	31.1990	31.2381	31.2772	31.3163	31.3554	31.3944	31.4335	31.4726	31.5116	31.5507	31.5898	870
880	31.5898	31.6288	31.6679	31.7069	31.7459	31.7850	31.8240	31.8631	31.9021	31.9411	31.9801	880
890	31.9801	32.0192	32.0582	32.0972	32.1362	32.1752	32.2142	32.2532	32.2922	32.3312	32.3702	890
900	32.3702	32.4091	32.4481	32.4871	32.5261	32.5650	32.6040	32.6430	32.6819	32.7209	32.7598	900
910	32.7598	32.7988	32.8377	32.8766	32.9156	32.9545	32.9934	33.0324	33.0713	33.1102	33.1491	910
920	33.1491	33.1880	33.2269	33.2658	33.3047	33.3436	33.3825	33.4214	33.4602	33.4991	33.5380	920
930	33.5380	33.5769	33.6157	33.6546	33.6934	33.7323	33.7711	33.8100	33.8488	33.8876	33.9265	930
940	33.9265	33.9653	34.0041	34.0429	34.0817	34.1206	34.1594	34.1982	34.2370	34.2757	34.3145	940
950	34.3145	34.3533	34.3921	34.4309	34.4696	34.5084	34.5472	34.5859	34.6247	34.6634	34.7022	950
960	34.7022	34.7409	34.7796	34.8184	34.8571	34.8958	34.9345	34.9732	35.0119	35.0507	35.0894	960
970	35.0894	35.1280	35.1667	35.2054	35.2441	35.2828	35.3214	35.3601	35.3988	35.4374	35.4761	970
980	35.4761	35.5147	35.5534	35.5920	35.6306	35.6693	35.7079	35.7465	35.7851	35.8237	35.8623	980
990	35.8623	35.9009	35.9395	35.9781	36.0167	36.0553	36.0939	36.1325	36.1710	36.2096	36.2481	990
1,000	36.2481	36.2867	36.3252	36.3638	36.4023	36.4408	36.4794	36.5179	36.5564	36.5949	36.6334	1,000
1,010	36.6334	36.6719	36.7104	36.7489	36.7874	36.8259	36.8644	36.9028	36.9413	36.9798	37.0182	1,010
1,020	37.0182	37.0567	37.0951	37.1336	37.1720	37.2104	37.2488	37.2873	37.3257	37.3641	37.4025	1,020
1,030	37.4025	37.4409	37.4793	37.5177	37.5560	37.5944	37.6328	37.6712	37.7095	37.7479	37.7862	1,030
1,040	37.7862	37.8246	37.8629	37.9012	37.9396	37.9779	38.0162	38.0545	38.0928	38.1311	38.1694	1,040
1,050	38.1694	38.2077	38.2460	38.2842	38.3225	38.3608	38.3990	38.4373	38.4755	38.5138	38.5520	1,050
1,060	38.5520	38.5902	38.6285	38.6667	38.7049	38.7431	38.7813	38.8195	38.8577	38.8959	38.9340	1,060
1,070	38.9340	38.9722	39.0104	39.0485	39.0867	39.1248	39.1630	39.2011	39.2392	39.2773	39.3155	1,070
1,080	39.3155	39.3536	39.3917	39.4298	39.4678	39.5059	39.5440	39.5821	39.6201	39.6582	39.6962	1,080
1,090	39.6962	39.7343	39.7723	39.8104	39.8484	39.8964	39.9244	39.9624	40.0004	40.0384	40.0764	1,090
1,100	40.0764	40.1144	40.1523	40.1903	40.2282	40.2662	40.3041	40.3421	40.3800	40.4179	40.4558	1,100
1,110	40.4558	40.4938	40.5317	40.5695	40.6074	40.6453	40.6832	40.7211	40.7589	40.7968	40.8346	1,110
1,120	40.8346	40.8724	40.9103	40.9481	40.9859	41.0237	41.0615	41.0993	41.1371	41.1749	41.2126	1,120
1,130	41.2126	41.2504	41.2882	41.3259	41.3636	41.4014	41.4391	41.4768	41.5145	41.5522	41.5899	1,130
1,140	41.5899	41.6276	41.6653	41.7030	41.7406	41.7783	41.8159	41.8536	41.8912	41.9288	41.9664	1,140
1,150	41.9664	42.0040	42.0416	42.0792	42.1168	42.1544	42.1919	42.2295	42.2670	42.3046	42.3421	1,150
1,160	42.3421	42.3796	42.4171	42.4547	42.4922	42.5296	42.5671	42.6046	42.6421	42.6795	42.7170	1,160
1,170	42.7170	42.7544	42.7918	42.8292	42.8666	42.9041	42.9414	42.9788	43.0162	43.0536	43.0909	1,170
1,180	43.0909	43.1283	43.1656	43.2029	43.2403	43.2776	43.3149	43.3522	43.3895	43.4267	43.4640	1,180
1,190	43.4640	43.5012	43.5385	43.5757	43.6130	43.6502	43.6874	43.7246	43.7618	43.7990	43.8361	1,190
1,200	43.8361	43.8733	43.9104	43.9476	43.9847	44.0218	44.0589	44.0960	44.1331	44.1702	44.2073	1,200
°C	0	1	2	3	4	5	6	7	8	9	10	°C

Table C2. AWG 14 *Nicrosil versus Nisil thermocouples—thermoelectric voltage as a function of temperature (°C), reference junctions at 0 °C*—Continued

C	0	1	2	3	4	5	6	7	8	9	10	C
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS											
1,200	43.8361	43.8733	43.9104	43.9476	43.9847	44.0218	44.0589	44.0960	44.1331	44.1702	44.2073	1,200
1,210	44.2073	44.2444	44.2814	44.3185	44.3555	44.3925	44.4295	44.4665	44.5035	44.5405	44.5775	1,210
1,220	44.5775	44.6144	44.6514	44.6883	44.7253	44.7622	44.7991	44.8360	44.8729	44.9098	44.9467	1,220
1,230	44.9467	44.9835	45.0204	45.0572	45.0940	45.1309	45.1677	45.2045	45.2413	45.2780	45.3148	1,230
1,240	45.3148	45.3516	45.3883	45.4251	45.4618	45.4985	45.5352	45.5719	45.6086	45.6453	45.6819	1,240
1,250	45.6819	45.7186	45.7552	45.7918	45.8285	45.8651	45.9017	45.9383	45.9748	46.0114	46.0480	1,250
1,260	46.0480	46.0845	46.1211	46.1576	46.1941	46.2306	46.2671	46.3036	46.3401	46.3765	46.4130	1,260
1,270	46.4130	46.4494	46.4859	46.5223	46.5587	46.5951	46.6315	46.6679	46.7042	46.7406	46.7769	1,270
1,280	46.7769	46.8133	46.8496	46.8859	46.9222	46.9585	46.9948	47.0311	47.0674	47.1036	47.1399	1,280
1,290	47.1399	47.1761	47.2123	47.2486	47.2848	47.3210	47.3572	47.3933	47.4295	47.4657	47.5018	1,290
1,300	47.5018											1,300
C	0	1	2	3	4	5	6	7	8	9	10	C

TABLE C3. AWG 28 *Nicrosil versus Nisil thermocouples—thermoelectric voltage as a function of temperature (°F), reference junctions at 32 °F. Abbreviated table.*

°F	0	1	2	3	4	5	6	7	8	9	10	°F
						THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS						
-450	-4.3441											-450
-440	-4.3389	-4.3396	-4.3403	-4.3409	-4.3415	-4.3420	-4.3425	-4.3430	-4.3434	-4.3438	-4.3441	-440
-430	-4.3298	-4.3309	-4.3319	-4.3329	-4.3339	-4.3348	-4.3357	-4.3366	-4.3374	-4.3382	-4.3389	-430
-420	-4.3165	-4.3180	-4.3195	-4.3209	-4.3223	-4.3236	-4.3249	-4.3262	-4.3274	-4.3286	-4.3298	-420
-410	-4.2989	-4.3009	-4.3028	-4.3046	-4.3065	-4.3082	-4.3100	-4.3117	-4.3133	-4.3149	-4.3165	-410
-400	-4.2770	-4.2794	-4.2818	-4.2841	-4.2863	-4.2885	-4.2907	-4.2928	-4.2949	-4.2969	-4.2989	-400
-390	-4.2507	-4.2536	-4.2563	-4.2591	-4.2618	-4.2644	-4.2670	-4.2696	-4.2721	-4.2746	-4.2770	-390
-380	-4.2200	-4.2233	-4.2265	-4.2297	-4.2328	-4.2359	-4.2390	-4.2420	-4.2450	-4.2479	-4.2507	-380
-370	-4.1849	-4.1886	-4.1923	-4.1959	-4.1995	-4.2030	-4.2065	-4.2100	-4.2134	-4.2167	-4.2200	-370
-360	-4.1455	-4.1496	-4.1537	-4.1578	-4.1618	-4.1657	-4.1697	-4.1736	-4.1774	-4.1812	-4.1849	-360
-350	-4.1017	-4.1062	-4.1108	-4.1153	-4.1197	-4.1241	-4.1285	-4.1328	-4.1371	-4.1413	-4.1455	-350
-340	-4.0536	-4.0586	-4.0635	-4.0685	-4.0733	-4.0782	-4.0829	-4.0877	-4.0924	-4.0971	-4.1017	-340
-330	-4.0013	-4.0067	-4.0121	-4.0174	-4.0227	-4.0280	-4.0332	-4.0384	-4.0435	-4.0486	-4.0536	-330
-320	-3.9449	-3.9507	-3.9565	-3.9623	-3.9680	-3.9736	-3.9792	-3.9848	-3.9904	-3.9959	-4.0013	-320
-310	-3.8844	-3.8906	-3.8968	-3.9030	-3.9091	-3.9152	-3.9212	-3.9272	-3.9331	-3.9390	-3.9449	-310
-300	-3.8199	-3.8266	-3.8332	-3.8397	-3.8462	-3.8527	-3.8591	-3.8655	-3.8718	-3.8781	-3.8844	-300
-290	-3.7516	-3.7586	-3.7656	-3.7725	-3.7794	-3.7862	-3.7931	-3.7998	-3.8066	-3.8133	-3.8199	-290
-280	-3.6794	-3.6868	-3.6941	-3.7014	-3.7087	-3.7159	-3.7231	-3.7303	-3.7374	-3.7445	-3.7516	-280
-270	-3.6034	-3.6112	-3.6189	-3.6266	-3.6343	-3.6419	-3.6494	-3.6570	-3.6645	-3.6719	-3.6794	-270
-260	-3.5238	-3.5319	-3.5400	-3.5481	-3.5561	-3.5641	-3.5720	-3.5799	-3.5878	-3.5956	-3.6034	-260
-250	-3.4406	-3.4491	-3.4575	-3.4659	-3.4743	-3.4827	-3.4910	-3.4992	-3.5075	-3.5157	-3.5238	-250
-240	-3.3539	-3.3627	-3.3715	-3.3803	-3.3890	-3.3977	-3.4064	-3.4150	-3.4236	-3.4321	-3.4406	-240
-230	-3.2638	-3.2730	-3.2821	-3.2912	-3.3002	-3.3093	-3.3183	-3.3272	-3.3362	-3.3451	-3.3539	-230
-220	-3.1703	-3.1798	-3.1893	-3.1987	-3.2081	-3.2175	-3.2268	-3.2361	-3.2454	-3.2546	-3.2638	-220
-210	-3.0736	-3.0834	-3.0932	-3.1030	-3.1127	-3.1224	-3.1320	-3.1416	-3.1512	-3.1608	-3.1703	-210
-200	-2.9737	-2.9838	-2.9939	-3.0040	-3.0140	-3.0240	-3.0340	-3.0440	-3.0539	-3.0637	-3.0736	-200
-190	-2.8707	-2.8812	-2.8916	-2.9019	-2.9123	-2.9226	-2.9329	-2.9431	-2.9533	-2.9635	-2.9737	-190
-180	-2.7647	-2.7755	-2.7862	-2.7968	-2.8075	-2.8181	-2.8287	-2.8392	-2.8498	-2.8603	-2.8707	-180
-170	-2.6559	-2.6669	-2.6779	-2.6888	-2.6998	-2.7107	-2.7215	-2.7324	-2.7432	-2.7540	-2.7647	-170
-160	-2.5442	-2.5555	-2.5667	-2.5780	-2.5892	-2.6004	-2.6115	-2.6226	-2.6337	-2.6448	-2.6559	-160
-150	-2.4298	-2.4413	-2.4529	-2.4644	-2.4758	-2.4873	-2.4987	-2.5101	-2.5215	-2.5328	-2.5442	-150
-140	-2.3127	-2.3246	-2.3364	-2.3481	-2.3599	-2.3716	-2.3833	-2.3949	-2.4066	-2.4182	-2.4298	-140
-130	-2.1932	-2.2053	-2.2173	-2.2293	-2.2413	-2.2533	-2.2652	-2.2771	-2.2890	-2.3009	-2.3127	-130
-120	-2.0713	-2.0836	-2.0959	-2.1081	-2.1203	-2.1325	-2.1447	-2.1569	-2.1690	-2.1811	-2.1932	-120
-110	-1.9471	-1.9596	-1.9721	-1.9846	-1.9970	-2.0095	-2.0219	-2.0343	-2.0466	-2.0590	-2.0713	-110
-100	-1.8207	-1.8334	-1.8461	-1.8588	-1.8715	-1.8841	-1.8968	-1.9094	-1.9220	-1.9345	-1.9471	-100
-90	-1.6922	-1.7051	-1.7180	-1.7309	-1.7438	-1.7567	-1.7695	-1.7823	-1.7951	-1.8079	-1.8207	-90
-80	-1.5617	-1.5749	-1.5880	-1.6011	-1.6141	-1.6272	-1.6402	-1.6532	-1.6662	-1.6792	-1.6922	-80
-70	-1.4294	-1.4427	-1.4560	-1.4693	-1.4826	-1.4958	-1.5090	-1.5222	-1.5354	-1.5486	-1.5617	-70
-60	-1.2954	-1.3089	-1.3223	-1.3358	-1.3492	-1.3626	-1.3760	-1.3894	-1.4028	-1.4161	-1.4294	-60
-50	-1.1597	-1.1734	-1.1870	-1.2006	-1.2142	-1.2278	-1.2413	-1.2549	-1.2684	-1.2819	-1.2954	-50
-40	-1.0226	-1.0364	-1.0501	-1.0639	-1.0776	-1.0913	-1.1051	-1.1187	-1.1324	-1.1461	-1.1597	-40
-30	-0.8840	-0.8979	-0.9118	-0.9257	-0.9396	-0.9535	-0.9673	-0.9812	-0.9950	-1.0088	-1.0226	-30
-20	-0.7442	-0.7582	-0.7722	-0.7862	-0.8002	-0.8142	-0.8282	-0.8422	-0.8561	-0.8701	-0.8840	-20
-10	-0.6031	-0.6173	-0.6314	-0.6455	-0.6597	-0.6738	-0.6879	-0.7020	-0.7160	-0.7301	-0.7442	-10
- 0	-0.4610	-0.4752	-0.4895	-0.5037	-0.5179	-0.5322	-0.5464	-0.5606	-0.5748	-0.5889	-0.6031	- 0
+ 0	-0.4610	-0.4467	-0.4324	-0.4181	-0.4038	-0.3895	-0.3752	-0.3609	-0.3465	-0.3322	-0.3179	+ 0
10	-0.3179	-0.3035	-0.2891	-0.2747	-0.2603	-0.2460	-0.2315	-0.2171	-0.2027	-0.1883	-0.1738	10
20	-0.1738	-0.1594	-0.1449	-0.1305	-0.1160	-0.1015	-0.0871	-0.0726	-0.0581	-0.0436	-0.0290	20
30	-0.0290	-0.0145	0.0000									30
°F	0	1	2	3	4	5	6	7	8	9	10	°F

TABLE C3. AWG 28 *Nicrosil versus Nisil thermocouples—thermoelectric voltage as a function of temperature (°F), reference junctions at 32 °F*—Continued

°F	0	1	2	3	4	5	6	7	8	9	10	°F
					THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS							
30			0.0000	0.0145	0.0291	0.0436	0.0582	0.0727	0.0873	0.1019	0.1164	30
40	0.1164	0.1310	0.1456	0.1602	0.1748	0.1894	0.2040	0.2187	0.2333	0.2479	0.2626	40
50	0.2626	0.2773	0.2919	0.3066	0.3213	0.3360	0.3507	0.3654	0.3801	0.3948	0.4095	50
60	0.4095	0.4243	0.4390	0.4538	0.4686	0.4834	0.4981	0.5129	0.5278	0.5426	0.5574	60
70	0.5574	0.5722	0.5871	0.6019	0.6168	0.6317	0.6466	0.6615	0.6764	0.6913	0.7062	70
80	0.7062	0.7212	0.7361	0.7511	0.7660	0.7810	0.7960	0.8110	0.8260	0.8410	0.8561	80
90	0.8561	0.8711	0.8862	0.9013	0.9163	0.9314	0.9465	0.9616	0.9768	0.9919	1.0071	90
100	1.0071	1.0222	1.0374	1.0526	1.0678	1.0830	1.0982	1.1134	1.1287	1.1439	1.1592	100
110	1.1592	1.1745	1.1897	1.2050	1.2204	1.2357	1.2510	1.2664	1.2817	1.2971	1.3125	110
120	1.3125	1.3279	1.3433	1.3587	1.3741	1.3896	1.4050	1.4205	1.4360	1.4515	1.4670	120
130	1.4670	1.4825	1.4980	1.5136	1.5291	1.5447	1.5603	1.5759	1.5915	1.6071	1.6227	130
140	1.6227	1.6384	1.6540	1.6697	1.6854	1.7011	1.7168	1.7325	1.7482	1.7640	1.7797	140
150	1.7797	1.7955	1.8113	1.8270	1.8428	1.8587	1.8745	1.8903	1.9062	1.9221	1.9379	150
160	1.9379	1.9538	1.9697	1.9856	2.0016	2.0175	2.0335	2.0494	2.0654	2.0814	2.0974	160
170	2.0974	2.1134	2.1294	2.1455	2.1615	2.1776	2.1937	2.2098	2.2259	2.2420	2.2581	170
180	2.2581	2.2742	2.2904	2.3066	2.3227	2.3389	2.3551	2.3713	2.3876	2.4038	2.4200	180
190	2.4200	2.4363	2.4526	2.4689	2.4852	2.5015	2.5178	2.5341	2.5505	2.5668	2.5832	190
200	2.5832	2.5996	2.6160	2.6324	2.6488	2.6652	2.6817	2.6981	2.7146	2.7311	2.7476	200
210	2.7476	2.7641	2.7806	2.7971	2.8136	2.8302	2.8468	2.8633	2.8799	2.8965	2.9131	210
220	2.9131	2.9297	2.9464	2.9630	2.9797	2.9963	3.0130	3.0297	3.0464	3.0631	3.0798	220
230	3.0798	3.0966	3.1133	3.1301	3.1468	3.1636	3.1804	3.1972	3.2140	3.2308	3.2477	230
240	3.2477	3.2645	3.2814	3.2983	3.3151	3.3320	3.3489	3.3659	3.3828	3.3997	3.4167	240
250	3.4167	3.4336	3.4506	3.4676	3.4846	3.5016	3.5186	3.5356	3.5526	3.5697	3.5868	250
260	3.5868	3.6038	3.6209	3.6380	3.6551	3.6722	3.6893	3.7065	3.7236	3.7408	3.7579	260
270	3.7579	3.7751	3.7923	3.8095	3.8267	3.8439	3.8611	3.8784	3.8956	3.9129	3.9301	270
280	3.9301	3.9474	3.9647	3.9820	3.9993	4.0167	4.0340	4.0513	4.0687	4.0860	4.1034	280
290	4.1034	4.1208	4.1382	4.1556	4.1730	4.1904	4.2079	4.2253	4.2428	4.2602	4.2777	290
300	4.2777	4.2952	4.3127	4.3302	4.3477	4.3652	4.3827	4.4003	4.4178	4.4354	4.4530	300
310	4.4530	4.4706	4.4881	4.5057	4.5234	4.5410	4.5586	4.5763	4.5939	4.6116	4.6292	310
320	4.6292	4.6469	4.6646	4.6823	4.7000	4.7177	4.7354	4.7532	4.7709	4.7887	4.8064	320
330	4.8064	4.8242	4.8420	4.8598	4.8776	4.8954	4.9132	4.9310	4.9489	4.9667	4.9846	330
340	4.9846	5.0025	5.0203	5.0382	5.0561	5.0740	5.0919	5.1098	5.1278	5.1457	5.1637	340
350	5.1637	5.1816	5.1996	5.2176	5.2355	5.2535	5.2715	5.2896	5.3076	5.3256	5.3436	350
360	5.3436	5.3617	5.3797	5.3978	5.4159	5.4340	5.4521	5.4702	5.4883	5.5064	5.5245	360
370	5.5245	5.5426	5.5608	5.5789	5.5971	5.6153	5.6334	5.6516	5.6698	5.6880	5.7062	370
380	5.7062	5.7245	5.7427	5.7609	5.7792	5.7974	5.8157	5.8340	5.8523	5.8705	5.8888	380
390	5.8888	5.9072	5.9255	5.9438	5.9621	5.9805	5.9988	6.0172	6.0355	6.0539	6.0723	390
400	6.0723	6.0907	6.1091	6.1275	6.1459	6.1643	6.1828	6.2012	6.2197	6.2381	6.2566	400
410	6.2566	6.2751	6.2935	6.3120	6.3305	6.3490	6.3676	6.3861	6.4046	6.4231	6.4417	410
420	6.4417	6.4603	6.4788	6.4974	6.5160	6.5346	6.5532	6.5718	6.5904	6.6090	6.6276	420
430	6.6276	6.6463	6.6649	6.6836	6.7022	6.7209	6.7396	6.7582	6.7769	6.7956	6.8143	430
440	6.8143	6.8331	6.8518	6.8705	6.8893	6.9080	6.9268	6.9455	6.9643	6.9831	7.0019	440
450	7.0019	7.0207	7.0395	7.0583	7.0771	7.0959	7.1148	7.1336	7.1524	7.1713	7.1902	450
460	7.1902	7.2090	7.2279	7.2468	7.2657	7.2846	7.3035	7.3224	7.3414	7.3603	7.3792	460
470	7.3792	7.3982	7.4171	7.4361	7.4551	7.4741	7.4931	7.5120	7.5310	7.5501	7.5691	470
480	7.5691	7.5881	7.6071	7.6262	7.6452	7.6643	7.6833	7.7024	7.7215	7.7406	7.7597	480
490	7.7597	7.7788	7.7979	7.8170	7.8361	7.8552	7.8744	7.8935	7.9127	7.9318	7.9510	490
500	7.9510	7.9702	7.9893	8.0085	8.0277	8.0469	8.0661	8.0854	8.1046	8.1238	8.1431	500
510	8.1431	8.1623	8.1816	8.2008	8.2201	8.2394	8.2586	8.2779	8.2972	8.3165	8.3358	510
520	8.3358	8.3551	8.3745	8.3938	8.4131	8.4325	8.4518	8.4712	8.4906	8.5099	8.5293	520
530	8.5293	8.5487	8.5681	8.5875	8.6069	8.6263	8.6457	8.6652	8.6846	8.7040	8.7235	530
540	8.7235	8.7430	8.7624	8.7819	8.8014	8.8208	8.8403	8.8598	8.8793	8.8988	8.9184	540
550	8.9184	8.9379	8.9574	8.9769	8.9965	9.0160	9.0356	9.0552	9.0747	9.0943	9.1139	550
560	9.1139	9.1335	9.1531	9.1727	9.1923	9.2119	9.2315	9.2512	9.2708	9.2904	9.3101	560
570	9.3101	9.3297	9.3494	9.3691	9.3887	9.4084	9.4281	9.4478	9.4675	9.4872	9.5069	570
580	9.5069	9.5266	9.5463	9.5661	9.5858	9.6055	9.6253	9.6450	9.6648	9.6846	9.7043	580
590	9.7043	9.7241	9.7439	9.7637	9.7835	9.8033	9.8231	9.8429	9.8627	9.8826	9.9024	590
600	9.9024	9.9222	9.9421	9.9619	9.9818	10.0016	10.0215	10.0414	10.0613	10.0811	10.1010	600
°F	0	1	2	3	4	5	6	7	8	9	10	°F

TABLE C3. AWG 28 *Nicrosil versus Nisil thermocouples—thermoelectric voltage as a function of temperature (°F), reference junctions at 32 °F*—Continued

°F	0	1	2	3	4	5	6	7	8	9	10	°F
						THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS						
600	9.9024	9.9222	9.9421	9.9619	9.9818	10.0016	10.0215	10.0414	10.0613	10.0811	10.1010	600
610	10.1010	10.1209	10.1408	10.1607	10.1807	10.2006	10.2205	10.2404	10.2604	10.2803	10.3002	610
620	10.3002	10.3202	10.3402	10.3601	10.3801	10.4001	10.4200	10.4400	10.4600	10.4800	10.5000	620
630	10.5000	10.5200	10.5400	10.5600	10.5801	10.6001	10.6201	10.6402	10.6602	10.6803	10.7003	630
640	10.7003	10.7204	10.7404	10.7605	10.7806	10.8007	10.8207	10.8408	10.8609	10.8810	10.9011	640
650	10.9011	10.9212	10.9414	10.9615	10.9816	11.0017	11.0219	11.0420	11.0621	11.0823	11.1024	650
660	11.1024	11.1226	11.1428	11.1629	11.1831	11.2033	11.2235	11.2437	11.2638	11.2840	11.3042	660
670	11.3042	11.3245	11.3447	11.3649	11.3851	11.4053	11.4255	11.4458	11.4660	11.4863	11.5065	670
680	11.5065	11.5268	11.5470	11.5673	11.5875	11.6078	11.6281	11.6484	11.6686	11.6889	11.7092	680
690	11.7092	11.7295	11.7498	11.7701	11.7904	11.8107	11.8311	11.8514	11.8717	11.8920	11.9124	690
700	11.9124	11.9327	11.9531	11.9734	11.9938	12.0141	12.0345	12.0548	12.0752	12.0956	12.1160	700
710	12.1160	12.1363	12.1567	12.1771	12.1975	12.2179	12.2383	12.2587	12.2791	12.2995	12.3200	710
720	12.3200	12.3404	12.3608	12.3812	12.4017	12.4221	12.4425	12.4630	12.4834	12.5039	12.5244	720
730	12.5244	12.5448	12.5653	12.5858	12.6062	12.6267	12.6472	12.6677	12.6882	12.7087	12.7292	730
740	12.7292	12.7497	12.7702	12.7907	12.8112	12.8317	12.8523	12.8728	12.8933	12.9139	12.9344	740
750	12.9344	12.9549	12.9755									750
°F	0	1	2	3	4	5	6	7	8	9	10	°F

Table C4. AWG 14 *Nicrosil versus Nisil thermocouples—thermoelectric voltage as a function of temperature (°F), reference junctions at 32 °F. Abbreviated table.*

°F	0	1	2	3	4	5	6	7	8	9	10	°F
					THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS							
30			0.0000	0.0144	0.0288	0.0432	0.0576	0.0721	0.0865	0.1010	0.1154	30
40	0.1154	0.1299	0.1444	0.1589	0.1734	0.1879	0.2024	0.2170	0.2315	0.2461	0.2607	40
50	0.2607	0.2753	0.2898	0.3045	0.3191	0.3337	0.3483	0.3630	0.3776	0.3923	0.4070	50
60	0.4070	0.4217	0.4364	0.4511	0.4658	0.4806	0.4953	0.5101	0.5248	0.5396	0.5544	60
70	0.5544	0.5692	0.5840	0.5989	0.6137	0.6285	0.6434	0.6583	0.6732	0.6881	0.7030	70
80	0.7030	0.7179	0.7328	0.7477	0.7627	0.7777	0.7926	0.8076	0.8226	0.8376	0.8526	80
90	0.8526	0.8677	0.8827	0.8978	0.9128	0.9279	0.9430	0.9581	0.9732	0.9884	1.0035	90
100	1.0035	1.0186	1.0338	1.0490	1.0642	1.0793	1.0946	1.1098	1.1250	1.1402	1.1555	100
110	1.1555	1.1708	1.1860	1.2013	1.2166	1.2319	1.2473	1.2626	1.2780	1.2933	1.3087	110
120	1.3087	1.3241	1.3395	1.3549	1.3703	1.3857	1.4012	1.4166	1.4321	1.4476	1.4631	120
130	1.4631	1.4786	1.4941	1.5096	1.5251	1.5407	1.5562	1.5718	1.5874	1.6030	1.6186	130
140	1.6186	1.6342	1.6499	1.6655	1.6812	1.6968	1.7125	1.7282	1.7439	1.7596	1.7753	140
150	1.7753	1.7911	1.8068	1.8226	1.8384	1.8542	1.8700	1.8858	1.9016	1.9174	1.9333	150
160	1.9333	1.9491	1.9650	1.9809	1.9968	2.0127	2.0286	2.0445	2.0605	2.0764	2.0924	160
170	2.0924	2.1084	2.1244	2.1404	2.1564	2.1724	2.1884	2.2045	2.2205	2.2366	2.2527	170
180	2.2527	2.2688	2.2849	2.3010	2.3172	2.3333	2.3494	2.3656	2.3818	2.3980	2.4142	180
190	2.4142	2.4304	2.4466	2.4629	2.4791	2.4954	2.5116	2.5279	2.5442	2.5605	2.5768	190
200	2.5768	2.5932	2.6095	2.6259	2.6422	2.6586	2.6750	2.6914	2.7078	2.7242	2.7407	200
210	2.7407	2.7571	2.7736	2.7900	2.8065	2.8230	2.8395	2.8560	2.8726	2.8891	2.9056	210
220	2.9056	2.9222	2.9388	2.9554	2.9720	2.9886	3.0052	3.0218	3.0385	3.0551	3.0718	220
230	3.0718	3.0884	3.1051	3.1218	3.1385	3.1553	3.1720	3.1887	3.2055	3.2223	3.2390	230
240	3.2390	3.2558	3.2726	3.2894	3.3063	3.3231	3.3399	3.3568	3.3737	3.3905	3.4074	240
250	3.4074	3.4243	3.4412	3.4582	3.4751	3.4920	3.5090	3.5260	3.5429	3.5599	3.5769	250
260	3.5769	3.5939	3.6110	3.6280	3.6450	3.6621	3.6792	3.6962	3.7133	3.7304	3.7475	260
270	3.7475	3.7647	3.7818	3.7989	3.8161	3.8333	3.8504	3.8676	3.8848	3.9020	3.9192	270
280	3.9192	3.9365	3.9537	3.9710	3.9882	4.0055	4.0228	4.0401	4.0574	4.0747	4.0920	280
290	4.0920	4.1093	4.1267	4.1440	4.1614	4.1788	4.1962	4.2136	4.2310	4.2484	4.2658	290
300	4.2658	4.2833	4.3007	4.3182	4.3357	4.3531	4.3706	4.3881	4.4056	4.4232	4.4407	300
310	4.4407	4.4582	4.4758	4.4934	4.5109	4.5285	4.5461	4.5637	4.5813	4.5990	4.6166	310
320	4.6166	4.6342	4.6519	4.6696	4.6872	4.7049	4.7226	4.7403	4.7580	4.7758	4.7935	320
330	4.7935	4.8112	4.8290	4.8468	4.8645	4.8823	4.9001	4.9179	4.9357	4.9536	4.9714	330
340	4.9714	4.9893	5.0071	5.0250	5.0428	5.0607	5.0786	5.0965	5.1144	5.1324	5.1503	340
350	5.1503	5.1682	5.1862	5.2041	5.2221	5.2401	5.2581	5.2761	5.2941	5.3121	5.3301	350
360	5.3301	5.3482	5.3662	5.3843	5.4023	5.4204	5.4385	5.4566	5.4747	5.4928	5.5109	360
370	5.5109	5.5291	5.5472	5.5654	5.5835	5.6017	5.6199	5.6380	5.6562	5.6744	5.6927	370
380	5.6927	5.7109	5.7291	5.7474	5.7656	5.7839	5.8021	5.8204	5.8387	5.8570	5.8753	380
390	5.8753	5.8936	5.9119	5.9303	5.9486	5.9669	5.9853	6.0037	6.0220	6.0404	6.0588	390
400	6.0588	6.0772	6.0956	6.1141	6.1325	6.1509	6.1694	6.1878	6.2063	6.2248	6.2432	400
410	6.2432	6.2617	6.2802	6.2987	6.3173	6.3358	6.3543	6.3728	6.3914	6.4100	6.4285	410
420	6.4285	6.4471	6.4657	6.4843	6.5029	6.5215	6.5401	6.5587	6.5774	6.5960	6.6146	420
430	6.6146	6.6333	6.6520	6.6707	6.6893	6.7080	6.7267	6.7454	6.7642	6.7829	6.8016	430
440	6.8016	6.8203	6.8391	6.8579	6.8766	6.8954	6.9142	6.9330	6.9518	6.9706	6.9894	440
450	6.9894	7.0082	7.0270	7.0459	7.0647	7.0836	7.1024	7.1213	7.1402	7.1591	7.1780	450
460	7.1780	7.1969	7.2158	7.2347	7.2536	7.2725	7.2915	7.3104	7.3294	7.3483	7.3673	460
470	7.3673	7.3863	7.4053	7.4243	7.4433	7.4623	7.4813	7.5003	7.5194	7.5384	7.5574	470
480	7.5574	7.5765	7.5956	7.6146	7.6337	7.6528	7.6719	7.6910	7.7101	7.7292	7.7483	480
490	7.7483	7.7674	7.7866	7.8057	7.8249	7.8440	7.8632	7.8824	7.9016	7.9207	7.9399	490
500	7.9399	7.9591	7.9783	7.9976	8.0168	8.0360	8.0553	8.0745	8.0938	8.1130	8.1323	500
510	8.1323	8.1516	8.1708	8.1901	8.2094	8.2287	8.2480	8.2673	8.2867	8.3060	8.3253	510
520	8.3253	8.3447	8.3640	8.3834	8.4027	8.4221	8.4415	8.4609	8.4803	8.4997	8.5191	520
530	8.5191	8.5385	8.5579	8.5773	8.5968	8.6162	8.6356	8.6551	8.6746	8.6940	8.7135	530
540	8.7135	8.7330	8.7525	8.7719	8.7914	8.8110	8.8305	8.8500	8.8695	8.8890	8.9086	540
550	8.9086	8.9281	8.9477	8.9672	8.9868	9.0064	9.0259	9.0455	9.0651	9.0847	9.1043	550
560	9.1043	9.1239	9.1435	9.1632	9.1828	9.2024	9.2221	9.2417	9.2614	9.2810	9.3007	560
570	9.3007	9.3204	9.3400	9.3597	9.3794	9.3991	9.4188	9.4385	9.4582	9.4780	9.4977	570
580	9.4977	9.5174	9.5372	9.5569	9.5767	9.5964	9.6162	9.6360	9.6557	9.6755	9.6953	580
590	9.6953	9.7151	9.7349	9.7547	9.7745	9.7943	9.8142	9.8340	9.8538	9.8737	9.8935	590
600	9.8935	9.9134	9.9332	9.9531	9.9730	9.9929	10.0127	10.0326	10.0525	10.0724	10.0923	600
°F	0	1	2	3	4	5	6	7	8	9	10	°F

Table C4. AWG 14 *Nicrosil versus Nisil thermocouples—thermoelectric voltage as a function of temperature (°F), reference junctions at 32 °F*—Continued

THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS

°F	0	1	2	3	4	5	6	7	8	9	10	°F
600	9.8935	9.9134	9.9332	9.9531	9.9730	9.9929	10.0127	10.0326	10.0525	10.0724	10.0923	600
610	10.0923	10.1122	10.1322	10.1521	10.1720	10.1920	10.2119	10.2318	10.2518	10.2717	10.2917	610
620	10.2917	10.3117	10.3317	10.3516	10.3716	10.3916	10.4116	10.4316	10.4516	10.4716	10.4917	620
630	10.4917	10.5117	10.5317	10.5517	10.5718	10.5918	10.6119	10.6319	10.6520	10.6721	10.6921	630
640	10.6921	10.7122	10.7323	10.7524	10.7725	10.7926	10.8127	10.8328	10.8529	10.8731	10.8932	640
650	10.8932	10.9133	10.9335	10.9536	10.9737	10.9939	11.0141	11.0342	11.0544	11.0746	11.0947	650
660	11.0947	11.1149	11.1351	11.1553	11.1755	11.1957	11.2159	11.2362	11.2564	11.2766	11.2968	660
670	11.2968	11.3171	11.3373	11.3576	11.3778	11.3981	11.4183	11.4386	11.4589	11.4791	11.4994	670
680	11.4994	11.5197	11.5400	11.5603	11.5806	11.6009	11.6212	11.6415	11.6619	11.6822	11.7025	680
690	11.7025	11.7229	11.7432	11.7635	11.7839	11.8042	11.8246	11.8450	11.8653	11.8857	11.9061	690
700	11.9061	11.9265	11.9469	11.9673	11.9877	12.0081	12.0285	12.0489	12.0693	12.0897	12.1101	700
710	12.1101	12.1306	12.1510	12.1715	12.1919	12.2123	12.2328	12.2533	12.2737	12.2942	12.3147	710
720	12.3147	12.3351	12.3556	12.3761	12.3966	12.4171	12.4376	12.4581	12.4786	12.4991	12.5196	720
730	12.5196	12.5402	12.5607	12.5812	12.6018	12.6223	12.6428	12.6634	12.6840	12.7045	12.7251	730
740	12.7251	12.7456	12.7662	12.7868	12.8074	12.8280	12.8485	12.8691	12.8897	12.9103	12.9309	740
750	12.9309	12.9515	12.9722	12.9928	13.0134	13.0340	13.0547	13.0753	13.0959	13.1166	13.1372	750
760	13.1372	13.1579	13.1785	13.1992	13.2199	13.2405	13.2612	13.2819	13.3026	13.3233	13.3440	760
770	13.3440	13.3646	13.3853	13.4060	13.4268	13.4475	13.4682	13.4889	13.5096	13.5304	13.5511	770
780	13.5511	13.5718	13.5926	13.6133	13.6340	13.6548	13.6756	13.6963	13.7171	13.7378	13.7586	780
790	13.7586	13.7794	13.8002	13.8210	13.8417	13.8625	13.8833	13.9041	13.9249	13.9457	13.9665	790
800	13.9665	13.9874	14.0082	14.0290	14.0498	14.0707	14.0915	14.1123	14.1332	14.1540	14.1749	800
810	14.1749	14.1957	14.2166	14.2374	14.2583	14.2792	14.3000	14.3209	14.3418	14.3627	14.3836	810
820	14.3836	14.4044	14.4253	14.4462	14.4671	14.4880	14.5089	14.5299	14.5508	14.5717	14.5926	820
830	14.5926	14.6135	14.6345	14.6554	14.6763	14.6973	14.7182	14.7392	14.7601	14.7811	14.8020	830
840	14.8020	14.8230	14.8440	14.8649	14.8859	14.9069	14.9279	14.9489	14.9698	14.9908	15.0118	840
850	15.0118	15.0328	15.0538	15.0748	15.0958	15.1168	15.1379	15.1589	15.1799	15.2009	15.2219	850
860	15.2219	15.2430	15.2640	15.2851	15.3061	15.3271	15.3482	15.3692	15.3903	15.4114	15.4324	860
870	15.4324	15.4535	15.4745	15.4956	15.5167	15.5378	15.5589	15.5799	15.6010	15.6221	15.6432	870
880	15.6432	15.6643	15.6854	15.7065	15.7276	15.7487	15.7698	15.7910	15.8121	15.8332	15.8543	880
890	15.8543	15.8755	15.8966	15.9177	15.9389	15.9600	15.9812	16.0023	16.0235	16.0446	16.0658	890
900	16.0658	16.0869	16.1081	16.1293	16.1504	16.1716	16.1928	16.2140	16.2351	16.2563	16.2775	900
910	16.2775	16.2987	16.3199	16.3411	16.3623	16.3835	16.4047	16.4259	16.4471	16.4683	16.4896	910
920	16.4896	16.5108	16.5320	16.5532	16.5745	16.5957	16.6169	16.6382	16.6594	16.6806	16.7019	920
930	16.7019	16.7231	16.7444	16.7657	16.7869	16.8082	16.8294	16.8507	16.8720	16.8932	16.9145	930
940	16.9145	16.9358	16.9571	16.9784	16.9996	17.0209	17.0422	17.0635	17.0848	17.1061	17.1274	940
950	17.1274	17.1487	17.1700	17.1913	17.2127	17.2340	17.2553	17.2766	17.2979	17.3193	17.3406	950
960	17.3406	17.3619	17.3833	17.4046	17.4259	17.4473	17.4686	17.4900	17.5113	17.5327	17.5540	960
970	17.5540	17.5754	17.5968	17.6181	17.6395	17.6609	17.6822	17.7036	17.7250	17.7464	17.7677	970
980	17.7677	17.7891	17.8105	17.8319	17.8533	17.8747	17.8961	17.9175	17.9389	17.9603	17.9817	980
990	17.9817	18.0031	18.0245	18.0459	18.0673	18.0888	18.1102	18.1316	18.1530	18.1745	18.1959	990
1,000	18.1959	18.2173	18.2387	18.2602	18.2816	18.3031	18.3245	18.3460	18.3674	18.3889	18.4103	1,000
1,010	18.4103	18.4318	18.4532	18.4747	18.4961	18.5176	18.5391	18.5605	18.5820	18.6035	18.6250	1,010
1,020	18.6250	18.6464	18.6679	18.6894	18.7109	18.7324	18.7539	18.7754	18.7969	18.8183	18.8398	1,020
1,030	18.8398	18.8613	18.8828	18.9044	18.9259	18.9474	18.9689	18.9904	19.0119	19.0334	19.0549	1,030
1,040	19.0549	19.0765	19.0980	19.1195	19.1410	19.1626	19.1841	19.2056	19.2272	19.2487	19.2702	1,040
1,050	19.2702	19.2918	19.3133	19.3349	19.3564	19.3780	19.3995	19.4211	19.4426	19.4642	19.4857	1,050
1,060	19.4857	19.5073	19.5289	19.5504	19.5720	19.5936	19.6151	19.6367	19.6583	19.6799	19.7014	1,060
1,070	19.7014	19.7230	19.7446	19.7662	19.7878	19.8094	19.8310	19.8525	19.8741	19.8957	19.9173	1,070
1,080	19.9173	19.9389	19.9605	19.9821	20.0037	20.0253	20.0470	20.0686	20.0902	20.1118	20.1334	1,080
1,090	20.1334	20.1550	20.1766	20.1983	20.2199	20.2415	20.2631	20.2847	20.3064	20.3280	20.3496	1,090
1,100	20.3496	20.3713	20.3929	20.4145	20.4362	20.4578	20.4795	20.5011	20.5228	20.5444	20.5660	1,100
1,110	20.5660	20.5877	20.6093	20.6310	20.6527	20.6743	20.6960	20.7176	20.7393	20.7609	20.7826	1,110
1,120	20.7826	20.8043	20.8259	20.8476	20.8693	20.8910	20.9126	20.9343	20.9560	20.9777	20.9993	1,120
1,130	20.9993	21.0210	21.0427	21.0644	21.0861	21.1077	21.1294	21.1511	21.1728	21.1945	21.2162	1,130
1,140	21.2162	21.2379	21.2596	21.2813	21.3030	21.3247	21.3464	21.3681	21.3898	21.4115	21.4332	1,140
1,150	21.4332	21.4549	21.4766	21.4983	21.5200	21.5418	21.5635	21.5852	21.6069	21.6286	21.6503	1,150
1,160	21.6503	21.6721	21.6938	21.7155	21.7372	21.7590	21.7807	21.8024	21.8241	21.8459	21.8676	1,160
1,170	21.8676	21.8893	21.9111	21.9328	21.9545	21.9763	21.9980	22.0198	22.0415	22.0632	22.0850	1,170
1,180	22.0850	22.1067	22.1285	22.1502	22.1720	22.1937	22.2155	22.2372	22.2590	22.2807	22.3025	1,180
1,190	22.3025	22.3242	22.3460	22.3677	22.3895	22.4113	22.4330	22.4548	22.4765	22.4983	22.5201	1,190
1,200	22.5201	22.5418	22.5636	22.5854	22.6071	22.6289	22.6507	22.6725	22.6942	22.7160	22.7378	1,200
°F	0	1	2	3	4	5	6	7	8	9	10	°F

TABLE C4. AWG 14 *Nicrosil versus Nisil thermocouples—thermoelectric voltage as a function of temperature (°F), reference junctions at 32 °F*—Continued

THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS

°F	0	1	2	3	4	5	6	7	8	9	10	°F
1,200	22.5201	22.5418	22.5636	22.5854	22.6071	22.6289	22.6507	22.6725	22.6942	22.7160	22.7378	1,200
1,210	22.7378	22.7595	22.7813	22.8031	22.8249	22.8467	22.8684	22.8902	22.9120	22.9338	22.9556	1,210
1,220	22.9556	22.9773	22.9991	23.0209	23.0427	23.0645	23.0863	23.1081	23.1299	23.1517	23.1734	1,220
1,230	23.1734	23.1952	23.2170	23.2388	23.2606	23.2824	23.3042	23.3260	23.3478	23.3696	23.3914	1,230
1,240	23.3914	23.4132	23.4350	23.4568	23.4786	23.5004	23.5222	23.5440	23.5658	23.5876	23.6094	1,240
1,250	23.6094	23.6312	23.6530	23.6749	23.6967	23.7185	23.7403	23.7621	23.7839	23.8057	23.8275	1,250
1,260	23.8275	23.8493	23.8712	23.8930	23.9148	23.9366	23.9584	23.9802	24.0021	24.0239	24.0457	1,260
1,270	24.0457	24.0675	24.0893	24.1111	24.1330	24.1548	24.1766	24.1984	24.2203	24.2421	24.2639	1,270
1,280	24.2639	24.2857	24.3075	24.3294	24.3512	24.3730	24.3949	24.4167	24.4385	24.4603	24.4822	1,280
1,290	24.4822	24.5040	24.5258	24.5476	24.5695	24.5913	24.6131	24.6350	24.6568	24.6786	24.7005	1,290
1,300	24.7005	24.7223	24.7441	24.7660	24.7878	24.8096	24.8315	24.8533	24.8751	24.8970	24.9188	1,300
1,310	24.9188	24.9406	24.9625	24.9843	25.0061	25.0280	25.0498	25.0717	25.0935	25.1153	25.1372	1,310
1,320	25.1372	25.1590	25.1808	25.2027	25.2245	25.2464	25.2682	25.2900	25.3119	25.3337	25.3556	1,320
1,330	25.3556	25.3774	25.3992	25.4211	25.4429	25.4648	25.4866	25.5085	25.5303	25.5521	25.5740	1,330
1,340	25.5740	25.5958	25.6177	25.6395	25.6613	25.6832	25.7050	25.7269	25.7487	25.7706	25.7924	1,340
1,350	25.7924	25.8142	25.8361	25.8579	25.8798	25.9016	25.9235	25.9453	25.9671	25.9890	26.0108	1,350
1,360	26.0108	26.0327	26.0545	26.0764	26.0982	26.1200	26.1419	26.1637	26.1856	26.2074	26.2293	1,360
1,370	26.2293	26.2511	26.2730	26.2948	26.3166	26.3385	26.3603	26.3822	26.4040	26.4259	26.4477	1,370
1,380	26.4477	26.4695	26.4914	26.5132	26.5351	26.5569	26.5787	26.6006	26.6224	26.6443	26.6661	1,380
1,390	26.6661	26.6880	26.7098	26.7316	26.7535	26.7753	26.7972	26.8190	26.8408	26.8627	26.8845	1,390
1,400	26.8845	26.9064	26.9282	26.9500	26.9719	26.9937	27.0156	27.0374	27.0592	27.0811	27.1029	1,400
1,410	27.1029	27.1247	27.1466	27.1684	27.1903	27.2121	27.2339	27.2558	27.2776	27.2994	27.3213	1,410
1,420	27.3213	27.3431	27.3649	27.3868	27.4086	27.4304	27.4523	27.4741	27.4959	27.5178	27.5396	1,420
1,430	27.5396	27.5614	27.5833	27.6051	27.6269	27.6488	27.6706	27.6924	27.7142	27.7361	27.7579	1,430
1,440	27.7579	27.7797	27.8015	27.8234	27.8452	27.8670	27.8889	27.9107	27.9325	27.9543	27.9762	1,440
1,450	27.9762	27.9980	28.0198	28.0416	28.0634	28.0853	28.1071	28.1289	28.1507	28.1725	28.1944	1,450
1,460	28.1944	28.2162	28.2380	28.2598	28.2816	28.3035	28.3253	28.3471	28.3689	28.3907	28.4125	1,460
1,470	28.4125	28.4343	28.4562	28.4780	28.4998	28.5216	28.5434	28.5652	28.5870	28.6088	28.6306	1,470
1,480	28.6306	28.6525	28.6743	28.6961	28.7179	28.7397	28.7615	28.7833	28.8051	28.8269	28.8487	1,480
1,490	28.8487	28.8705	28.8923	28.9141	28.9359	28.9577	28.9795	29.0013	29.0231	29.0449	29.0667	1,490
1,500	29.0667	29.0885	29.1103	29.1321	29.1539	29.1757	29.1975	29.2193	29.2410	29.2628	29.2846	1,500
1,510	29.2846	29.3064	29.3282	29.3500	29.3718	29.3936	29.4154	29.4371	29.4589	29.4807	29.5025	1,510
1,520	29.5025	29.5243	29.5461	29.5678	29.5896	29.6114	29.6332	29.6550	29.6767	29.6985	29.7203	1,520
1,530	29.7203	29.7421	29.7638	29.7856	29.8074	29.8291	29.8509	29.8727	29.8945	29.9162	29.9380	1,530
1,540	29.9380	29.9598	29.9815	30.0033	30.0251	30.0468	30.0686	30.0903	30.1121	30.1339	30.1556	1,540
1,550	30.1556	30.1774	30.1991	30.2209	30.2427	30.2644	30.2862	30.3079	30.3297	30.3514	30.3732	1,550
1,560	30.3732	30.3949	30.4167	30.4384	30.4602	30.4819	30.5037	30.5254	30.5472	30.5689	30.5906	1,560
1,570	30.5906	30.6124	30.6341	30.6559	30.6776	30.6993	30.7211	30.7428	30.7645	30.7863	30.8080	1,570
1,580	30.8080	30.8297	30.8515	30.8732	30.8949	30.9167	30.9384	30.9601	30.9818	31.0036	31.0253	1,580
1,590	31.0253	31.0470	31.0687	31.0905	31.1122	31.1339	31.1556	31.1773	31.1990	31.2208	31.2425	1,590
1,600	31.2425	31.2642	31.2859	31.3076	31.3293	31.3510	31.3727	31.3944	31.4161	31.4379	31.4596	1,600
1,610	31.4596	31.4813	31.5030	31.5247	31.5464	31.5681	31.5898	31.6115	31.6331	31.6548	31.6765	1,610
1,620	31.6765	31.6982	31.7199	31.7416	31.7633	31.7850	31.8067	31.8284	31.8500	31.8717	31.8934	1,620
1,630	31.8934	31.9151	31.9368	31.9585	31.9801	32.0018	32.0235	32.0452	32.0668	32.0885	32.1102	1,630
1,640	32.1102	32.1319	32.1535	32.1752	32.1969	32.2185	32.2402	32.2619	32.2835	32.3052	32.3268	1,640
1,650	32.3268	32.3485	32.3702	32.3918	32.4135	32.4351	32.4568	32.4784	32.5001	32.5217	32.5434	1,650
1,660	32.5434	32.5650	32.5867	32.6083	32.6300	32.6516	32.6733	32.6949	32.7165	32.7382	32.7598	1,660
1,670	32.7598	32.7815	32.8031	32.8247	32.8464	32.8680	32.8896	32.9113	32.9329	32.9545	32.9761	1,670
1,680	32.9761	32.9978	33.0194	33.0410	33.0626	33.0843	33.1059	33.1275	33.1491	33.1707	33.1923	1,680
1,690	33.1923	33.2139	33.2356	33.2572	33.2788	33.3004	33.3220	33.3436	33.3652	33.3868	33.4084	1,690
1,700	33.4084	33.4300	33.4516	33.4732	33.4948	33.5164	33.5380	33.5596	33.5812	33.6028	33.6244	1,700
1,710	33.6244	33.6459	33.6675	33.6891	33.7107	33.7323	33.7539	33.7754	33.7970	33.8186	33.8402	1,710
1,720	33.8402	33.8618	33.8833	33.9049	33.9265	33.9480	33.9696	33.9912	34.0127	34.0343	34.0559	1,720
1,730	34.0559	34.0774	34.0990	34.1206	34.1421	34.1637	34.1852	34.2068	34.2283	34.2499	34.2714	1,730
1,740	34.2714	34.2930	34.3145	34.3361	34.3576	34.3792	34.4007	34.4223	34.4438	34.4653	34.4869	1,740
1,750	34.4869	34.5084	34.5299	34.5515	34.5730	34.5945	34.6161	34.6376	34.6591	34.6806	34.7022	1,750
1,760	34.7022	34.7237	34.7452	34.7667	34.7882	34.8098	34.8313	34.8528	34.8743	34.8958	34.9173	1,760
1,770	34.9173	34.9388	34.9603	34.9818	35.0033	35.0249	35.0464	35.0679	35.0894	35.1108	35.1323	1,770
1,780	35.1323	35.1538	35.1753	35.1968	35.2183	35.2398	35.2613	35.2828	35.3043	35.3257	35.3472	1,780
1,790	35.3472	35.3687	35.3902	35.4117	35.4331	35.4546	35.4761	35.4976	35.5190	35.5405	35.5620	1,790
1,800	35.5620	35.5834	35.6049	35.6264	35.6478	35.6693	35.6907	35.7122	35.7336	35.7551	35.7766	1,800
°F	0	1	2	3	4	5	6	7	8	9	10	°F

TABLE C4. AWG 14 *Nicrosil versus Nisil thermocouples—thermoelectric voltage as a function of temperature (°F), reference junctions at 32 °F*—Continued

°F	0	1	2	3	4	5	6	7	8	9	10	°F
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS											
1,800	35.5620	35.5834	35.6049	35.6264	35.6478	35.6693	35.6907	35.7122	35.7336	35.7551	35.7766	1,800
1,810	35.7766	35.7980	35.8195	35.8409	35.8623	35.8838	35.9052	35.9267	35.9481	35.9696	35.9910	1,810
1,820	35.9910	36.0124	36.0339	36.0553	36.0767	36.0982	36.1196	36.1410	36.1624	36.1839	36.2053	1,820
1,830	36.2053	36.2267	36.2481	36.2696	36.2910	36.3124	36.3338	36.3552	36.3766	36.3980	36.4194	1,830
1,840	36.4194	36.4408	36.4622	36.4837	36.5051	36.5265	36.5479	36.5692	36.5906	36.6120	36.6334	1,840
1,850	36.6334	36.6548	36.6762	36.6976	36.7190	36.7404	36.7617	36.7831	36.8045	36.8259	36.8473	1,850
1,860	36.8473	36.8686	36.8900	36.9114	36.9328	36.9541	36.9755	36.9969	37.0182	37.0396	37.0609	1,860
1,870	37.0609	37.0823	37.1037	37.1250	37.1464	37.1677	37.1891	37.2104	37.2318	37.2531	37.2745	1,870
1,880	37.2745	37.2958	37.3171	37.3385	37.3598	37.3811	37.4025	37.4238	37.4451	37.4665	37.4878	1,880
1,890	37.4878	37.5091	37.5305	37.5518	37.5731	37.5944	37.6157	37.6371	37.6584	37.6797	37.7010	1,890
1,900	37.7010	37.7223	37.7436	37.7649	37.7862	37.8075	37.8288	37.8501	37.8714	37.8927	37.9140	1,900
1,910	37.9140	37.9353	37.9566	37.9779	37.9992	38.0204	38.0417	38.0630	38.0843	38.1056	38.1268	1,910
1,920	38.1268	38.1481	38.1694	38.1907	38.2119	38.2332	38.2545	38.2757	38.2970	38.3183	38.3395	1,920
1,930	38.3395	38.3608	38.3820	38.4033	38.4245	38.4458	38.4670	38.4883	38.5095	38.5308	38.5520	1,930
1,940	38.5520	38.5732	38.5945	38.6157	38.6370	38.6582	38.6794	38.7006	38.7219	38.7431	38.7643	1,940
1,950	38.7643	38.7855	38.8068	38.8280	38.8492	38.8704	38.8916	38.9128	38.9340	38.9552	38.9764	1,950
1,960	38.9764	38.9976	39.0188	39.0400	39.0612	39.0824	39.1036	39.1248	39.1460	39.1672	39.1884	1,960
1,970	39.1884	39.2096	39.2307	39.2519	39.2731	39.2943	39.3155	39.3366	39.3578	39.3790	39.4001	1,970
1,980	39.4001	39.4213	39.4425	39.4636	39.4848	39.5059	39.5271	39.5482	39.5694	39.5905	39.6117	1,980
1,990	39.6117	39.6328	39.6540	39.6751	39.6962	39.7174	39.7385	39.7596	39.7808	39.8019	39.8230	1,990
2,000	39.8230	39.8442	39.8653	39.8864	39.9075	39.9286	39.9497	39.9709	39.9920	40.0131	40.0342	2,000
2,010	40.0342	40.0553	40.0764	40.0975	40.1186	40.1397	40.1608	40.1819	40.2029	40.2240	40.2451	2,010
2,020	40.2451	40.2662	40.2873	40.3084	40.3294	40.3505	40.3716	40.3926	40.4137	40.4348	40.4558	2,020
2,030	40.4558	40.4769	40.4980	40.5190	40.5401	40.5611	40.5822	40.6032	40.6243	40.6453	40.6664	2,030
2,040	40.6664	40.6874	40.7084	40.7295	40.7505	40.7715	40.7926	40.8136	40.8346	40.8556	40.8766	2,040
2,050	40.8766	40.8977	40.9187	40.9397	40.9607	40.9817	41.0027	41.0237	41.0447	41.0657	41.0867	2,050
2,060	41.0867	41.1077	41.1287	41.1497	41.1707	41.1917	41.2126	41.2336	41.2546	41.2756	41.2966	2,060
2,070	41.2966	41.3175	41.3385	41.3595	41.3804	41.4014	41.4223	41.4433	41.4643	41.4852	41.5062	2,070
2,080	41.5062	41.5271	41.5480	41.5690	41.5899	41.6109	41.6318	41.6527	41.6737	41.6946	41.7155	2,080
2,090	41.7155	41.7364	41.7574	41.7783	41.7992	41.8201	41.8410	41.8619	41.8828	41.9037	41.9246	2,090
2,100	41.9246	41.9455	41.9664	41.9873	42.0082	42.0291	42.0500	42.0709	42.0917	42.1126	42.1335	2,100
2,110	42.1335	42.1544	42.1752	42.1961	42.2170	42.2378	42.2587	42.2796	42.3004	42.3213	42.3421	2,110
2,120	42.3421	42.3630	42.3838	42.4046	42.4255	42.4463	42.4672	42.4880	42.5088	42.5296	42.5505	2,120
2,130	42.5505	42.5713	42.5921	42.6129	42.6337	42.6545	42.6753	42.6962	42.7170	42.7378	42.7586	2,130
2,140	42.7586	42.7793	42.8001	42.8209	42.8417	42.8625	42.8833	42.9041	42.9248	42.9456	42.9664	2,140
2,150	42.9664	42.9871	43.0079	43.0287	43.0494	43.0702	43.0909	43.1117	43.1324	43.1532	43.1739	2,150
2,160	43.1739	43.1946	43.2154	43.2361	43.2568	43.2776	43.2983	43.3190	43.3397	43.3605	43.3812	2,160
2,170	43.3812	43.4019	43.4226	43.4433	43.4640	43.4847	43.5054	43.5261	43.5468	43.5675	43.5881	2,170
2,180	43.5881	43.6088	43.6295	43.6502	43.6708	43.6915	43.7122	43.7328	43.7535	43.7742	43.7948	2,180
2,190	43.7948	43.8155	43.8361	43.8568	43.8774	43.8981	43.9187	43.9393	43.9600	43.9806	44.0012	2,190
2,200	44.0012	44.0218	44.0425	44.0631	44.0837	44.1043	44.1249	44.1455	44.1661	44.1867	44.2073	2,200
2,210	44.2073	44.2279	44.2485	44.2691	44.2896	44.3102	44.3308	44.3514	44.3719	44.3925	44.4131	2,210
2,220	44.4131	44.4336	44.4542	44.4748	44.4953	44.5159	44.5364	44.5569	44.5775	44.5980	44.6186	2,220
2,230	44.6186	44.6391	44.6596	44.6801	44.7007	44.7212	44.7417	44.7622	44.7827	44.8032	44.8237	2,230
2,240	44.8237	44.8442	44.8647	44.8852	44.9057	44.9262	44.9467	44.9671	44.9876	45.0081	45.0286	2,240
2,250	45.0286	45.0490	45.0695	45.0900	45.1104	45.1309	45.1513	45.1718	45.1922	45.2126	45.2331	2,250
2,260	45.2331	45.2535	45.2740	45.2944	45.3148	45.3352	45.3557	45.3761	45.3965	45.4169	45.4373	2,260
2,270	45.4373	45.4577	45.4781	45.4985	45.5189	45.5393	45.5597	45.5800	45.6004	45.6208	45.6412	2,270
2,280	45.6412	45.6615	45.6819	45.7023	45.7226	45.7430	45.7634	45.7837	45.8041	45.8244	45.8447	2,280
2,290	45.8447	45.8651	45.8854	45.9057	45.9261	45.9464	45.9667	45.9870	46.0074	46.0277	46.0480	2,290
2,300	46.0480	46.0683	46.0886	46.1089	46.1292	46.1495	46.1698	46.1900	46.2103	46.2306	46.2509	2,300
2,310	46.2509	46.2712	46.2914	46.3117	46.3320	46.3522	46.3725	46.3927	46.4130	46.4332	46.4535	2,310
2,320	46.4535	46.4737	46.4940	46.5142	46.5344	46.5546	46.5749	46.5951	46.6153	46.6355	46.6557	2,320
2,330	46.6557	46.6759	46.6962	46.7164	46.7366	46.7568	46.7769	46.7971	46.8173	46.8375	46.8577	2,330
2,340	46.8577	46.8779	46.8980	46.9182	46.9384	46.9585	46.9787	46.9989	47.0190	47.0392	47.0593	2,340
2,350	47.0593	47.0795	47.0996	47.1197	47.1399	47.1600	47.1801	47.2003	47.2204	47.2405	47.2606	2,350
2,360	47.2606	47.2808	47.3009	47.3210	47.3411	47.3612	47.3813	47.4014	47.4215	47.4416	47.4617	2,360
2,370	47.4617	47.4817	47.5018									2,370
°F	0	1	2	3	4	5	6	7	8	9	10	°F

TABLE C5. AWG 28 *Nicrosil thermoelements versus platinum,* Pt–67—*thermoelectric voltage as a function of temperature (°F), reference junctions at 32 °F. Abbreviated table.*

THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS

°F	0	1	2	3	4	5	6	7	8	9	10	°F
-320	-1.5900	-1.5895	-1.5889	-1.5883	-1.5877	-1.5871	-1.5864	-1.5857	-1.5850			-320
-310	-1.5939	-1.5937	-1.5934	-1.5931	-1.5927	-1.5923	-1.5919	-1.5915	-1.5910	-1.5906	-1.5900	-310
-300	-1.5949	-1.5949	-1.5949	-1.5949	-1.5948	-1.5948	-1.5947	-1.5945	-1.5943	-1.5941	-1.5939	-300
-290	-1.5927	-1.5931	-1.5934	-1.5937	-1.5940	-1.5942	-1.5944	-1.5946	-1.5947	-1.5948	-1.5949	-290
-280	-1.5874	-1.5881	-1.5888	-1.5894	-1.5899	-1.5905	-1.5910	-1.5915	-1.5919	-1.5924	-1.5927	-280
-270	-1.5789	-1.5799	-1.5809	-1.5818	-1.5827	-1.5836	-1.5844	-1.5852	-1.5860	-1.5867	-1.5874	-270
-260	-1.5671	-1.5685	-1.5698	-1.5710	-1.5722	-1.5734	-1.5746	-1.5757	-1.5768	-1.5779	-1.5789	-260
-250	-1.5521	-1.5538	-1.5554	-1.5570	-1.5585	-1.5600	-1.5615	-1.5630	-1.5644	-1.5658	-1.5671	-250
-240	-1.5338	-1.5358	-1.5377	-1.5396	-1.5415	-1.5434	-1.5452	-1.5470	-1.5487	-1.5504	-1.5521	-240
-230	-1.5123	-1.5146	-1.5169	-1.5191	-1.5213	-1.5235	-1.5256	-1.5277	-1.5298	-1.5318	-1.5338	-230
-220	-1.4877	-1.4903	-1.4929	-1.4954	-1.4979	-1.5004	-1.5028	-1.5053	-1.5077	-1.5100	-1.5123	-220
-210	-1.4599	-1.4628	-1.4657	-1.4686	-1.4714	-1.4742	-1.4769	-1.4797	-1.4824	-1.4850	-1.4877	-210
-200	-1.4291	-1.4323	-1.4355	-1.4386	-1.4418	-1.4449	-1.4479	-1.4510	-1.4540	-1.4570	-1.4599	-200
-190	-1.3952	-1.3988	-1.4022	-1.4057	-1.4091	-1.4125	-1.4159	-1.4192	-1.4225	-1.4258	-1.4291	-190
-180	-1.3585	-1.3623	-1.3661	-1.3698	-1.3735	-1.3772	-1.3809	-1.3845	-1.3881	-1.3917	-1.3952	-180
-170	-1.3188	-1.3229	-1.3270	-1.3310	-1.3350	-1.3390	-1.3430	-1.3469	-1.3508	-1.3546	-1.3585	-170
-160	-1.2764	-1.2808	-1.2851	-1.2894	-1.2937	-1.2980	-1.3022	-1.3064	-1.3106	-1.3147	-1.3188	-160
-150	-1.2312	-1.2358	-1.2405	-1.2450	-1.2496	-1.2541	-1.2586	-1.2631	-1.2676	-1.2720	-1.2764	-150
-140	-1.1833	-1.1882	-1.1931	-1.1980	-1.2028	-1.2076	-1.2124	-1.2171	-1.2218	-1.2265	-1.2312	-140
-130	-1.1329	-1.1380	-1.1432	-1.1483	-1.1534	-1.1584	-1.1635	-1.1685	-1.1735	-1.1784	-1.1833	-130
-120	-1.0798	-1.0852	-1.0906	-1.0960	-1.1013	-1.1067	-1.1119	-1.1172	-1.1225	-1.1277	-1.1329	-120
-110	-1.0243	-1.0299	-1.0356	-1.0412	-1.0468	-1.0524	-1.0579	-1.0634	-1.0689	-1.0744	-1.0798	-110
-100	-0.9663	-0.9722	-0.9781	-0.9840	-0.9898	-0.9956	-1.0014	-1.0071	-1.0129	-1.0186	-1.0243	-100
-90	-0.9060	-0.9121	-0.9182	-0.9243	-0.9304	-0.9364	-0.9425	-0.9485	-0.9544	-0.9604	-0.9663	-90
-80	-0.8433	-0.8497	-0.8560	-0.8624	-0.8687	-0.8749	-0.8812	-0.8874	-0.8936	-0.8998	-0.9060	-80
-70	-0.7784	-0.7850	-0.7916	-0.7981	-0.8046	-0.8111	-0.8176	-0.8241	-0.8305	-0.8369	-0.8433	-70
-60	-0.7113	-0.7181	-0.7249	-0.7317	-0.7384	-0.7451	-0.7518	-0.7585	-0.7652	-0.7718	-0.7784	-60
-50	-0.6421	-0.6491	-0.6561	-0.6631	-0.6700	-0.6769	-0.6839	-0.6908	-0.6976	-0.7045	-0.7113	-50
-40	-0.5707	-0.5779	-0.5851	-0.5923	-0.5995	-0.6066	-0.6138	-0.6209	-0.6280	-0.6350	-0.6421	-40
-30	-0.4973	-0.5048	-0.5122	-0.5196	-0.5269	-0.5343	-0.5416	-0.5489	-0.5562	-0.5635	-0.5707	-30
-20	-0.4220	-0.4296	-0.4372	-0.4448	-0.4524	-0.4599	-0.4674	-0.4749	-0.4824	-0.4899	-0.4973	-20
-10	-0.3447	-0.3525	-0.3603	-0.3681	-0.3758	-0.3836	-0.3913	-0.3990	-0.4067	-0.4143	-0.4220	-10
- 0	-0.2655	-0.2735	-0.2815	-0.2895	-0.2974	-0.3053	-0.3132	-0.3211	-0.3290	-0.3369	-0.3447	- 0
+ 0	-0.2655	-0.2575	-0.2495	-0.2414	-0.2333	-0.2252	-0.2171	-0.2090	-0.2008	-0.1927	-0.1845	+ 0
10	-0.1845	-0.1763	-0.1681	-0.1598	-0.1516	-0.1433	-0.1350	-0.1267	-0.1184	-0.1100	-0.1017	10
20	-0.1017	-0.0933	-0.0849	-0.0765	-0.0681	-0.0596	-0.0512	-0.0427	-0.0342	-0.0257	-0.0171	20
30	-0.0171	-0.0086	0.0000									30
°F	0	1	2	3	4	5	6	7	8	9	10	°F

TABLE C5. AWG 28 *Nicrosil thermoelements versus platinum*, Pt–67—*thermoelectric voltage as a function of temperature (°F), reference junctions at 32 °F*—Continued

°F	0	1	2	3	4	5	6	7	8	9	10	°F
					THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS							
30			0.0000	0.0086	0.0172	0.0258	0.0344	0.0431	0.0518	0.0605	0.0692	30
40	0.0692	0.0779	0.0866	0.0954	0.1042	0.1129	0.1217	0.1306	0.1394	0.1483	0.1571	40
50	0.1571	0.1660	0.1749	0.1838	0.1928	0.2017	0.2107	0.2197	0.2287	0.2377	0.2467	50
60	0.2467	0.2558	0.2649	0.2739	0.2830	0.2922	0.3013	0.3104	0.3196	0.3288	0.3380	60
70	0.3380	0.3472	0.3564	0.3656	0.3749	0.3842	0.3935	0.4028	0.4121	0.4214	0.4308	70
80	0.4308	0.4401	0.4495	0.4589	0.4683	0.4777	0.4872	0.4966	0.5061	0.5156	0.5251	80
90	0.5251	0.5346	0.5441	0.5537	0.5632	0.5728	0.5824	0.5920	0.6016	0.6113	0.6209	90
100	0.6209	0.6306	0.6402	0.6499	0.6596	0.6694	0.6791	0.6889	0.6986	0.7084	0.7182	100
110	0.7182	0.7280	0.7378	0.7477	0.7575	0.7674	0.7773	0.7872	0.7971	0.8070	0.8169	110
120	0.8169	0.8269	0.8368	0.8468	0.8568	0.8668	0.8768	0.8869	0.8969	0.9070	0.9170	120
130	0.9170	0.9271	0.9372	0.9473	0.9575	0.9676	0.9778	0.9879	0.9981	1.0083	1.0185	130
140	1.0185	1.0288	1.0390	1.0492	1.0595	1.0698	1.0801	1.0904	1.1007	1.1110	1.1214	140
150	1.1214	1.1317	1.1421	1.1525	1.1629	1.1733	1.1837	1.1941	1.2046	1.2150	1.2255	150
160	1.2255	1.2360	1.2465	1.2570	1.2675	1.2780	1.2886	1.2991	1.3097	1.3203	1.3309	160
170	1.3309	1.3415	1.3521	1.3628	1.3734	1.3841	1.3947	1.4054	1.4161	1.4268	1.4376	170
180	1.4376	1.4483	1.4590	1.4698	1.4806	1.4913	1.5021	1.5129	1.5238	1.5346	1.5454	180
190	1.5454	1.5563	1.5671	1.5780	1.5889	1.5998	1.6107	1.6217	1.6326	1.6435	1.6545	190
200	1.6545	1.6655	1.6764	1.6874	1.6984	1.7095	1.7205	1.7315	1.7426	1.7536	1.7647	200
210	1.7647	1.7758	1.7869	1.7980	1.8091	1.8203	1.8314	1.8426	1.8537	1.8649	1.8761	210
220	1.8761	1.8873	1.8985	1.9097	1.9209	1.9322	1.9434	1.9547	1.9660	1.9773	1.9886	220
230	1.9886	1.9999	2.0112	2.0225	2.0339	2.0452	2.0566	2.0679	2.0793	2.0907	2.1021	230
240	2.1021	2.1135	2.1250	2.1364	2.1478	2.1593	2.1708	2.1823	2.1937	2.2052	2.2167	240
250	2.2167	2.2283	2.2398	2.2513	2.2629	2.2744	2.2860	2.2976	2.3092	2.3208	2.3324	250
260	2.3324	2.3440	2.3557	2.3673	2.3790	2.3906	2.4023	2.4140	2.4257	2.4374	2.4491	260
270	2.4491	2.4608	2.4725	2.4843	2.4960	2.5078	2.5196	2.5313	2.5431	2.5549	2.5667	270
280	2.5667	2.5786	2.5904	2.6022	2.6141	2.6259	2.6378	2.6497	2.6616	2.6735	2.6854	280
290	2.6854	2.6973	2.7092	2.7211	2.7331	2.7450	2.7570	2.7690	2.7809	2.7929	2.8049	290
300	2.8049	2.8169	2.8290	2.8410	2.8530	2.8651	2.8771	2.8892	2.9013	2.9133	2.9254	300
310	2.9254	2.9375	2.9496	2.9617	2.9739	2.9860	2.9982	3.0103	3.0225	3.0346	3.0468	310
320	3.0468	3.0590	3.0712	3.0834	3.0956	3.1078	3.1201	3.1323	3.1446	3.1568	3.1691	320
330	3.1691	3.1814	3.1937	3.2059	3.2182	3.2306	3.2429	3.2552	3.2675	3.2799	3.2922	330
340	3.2922	3.3046	3.3170	3.3293	3.3417	3.3541	3.3665	3.3789	3.3913	3.4038	3.4162	340
350	3.4162	3.4287	3.4411	3.4536	3.4660	3.4785	3.4910	3.5035	3.5160	3.5285	3.5410	350
360	3.5410	3.5535	3.5661	3.5786	3.5912	3.6037	3.6163	3.6289	3.6414	3.6540	3.6666	360
370	3.6666	3.6792	3.6918	3.7045	3.7171	3.7297	3.7424	3.7550	3.7677	3.7803	3.7930	370
380	3.7930	3.8057	3.8184	3.8311	3.8438	3.8565	3.8692	3.8819	3.8947	3.9074	3.9202	380
390	3.9202	3.9329	3.9457	3.9585	3.9712	3.9840	3.9968	4.0096	4.0224	4.0353	4.0481	390
400	4.0481	4.0609	4.0738	4.0866	4.0995	4.1123	4.1252	4.1381	4.1509	4.1638	4.1767	400
410	4.1767	4.1896	4.2025	4.2155	4.2284	4.2413	4.2543	4.2672	4.2802	4.2931	4.3061	410
420	4.3061	4.3191	4.3320	4.3450	4.3580	4.3710	4.3840	4.3971	4.4101	4.4231	4.4362	420
430	4.4362	4.4492	4.4622	4.4753	4.4884	4.5014	4.5145	4.5276	4.5407	4.5538	4.5669	430
440	4.5669	4.5800	4.5931	4.6063	4.6194	4.6325	4.6457	4.6588	4.6720	4.6852	4.6983	440
450	4.6983	4.7115	4.7247	4.7379	4.7511	4.7643	4.7775	4.7907	4.8039	4.8172	4.8304	450
460	4.8304	4.8436	4.8569	4.8702	4.8834	4.8967	4.9100	4.9232	4.9365	4.9498	4.9631	460
470	4.9631	4.9764	4.9897	5.0031	5.0164	5.0297	5.0431	5.0564	5.0698	5.0831	5.0965	470
480	5.0965	5.1098	5.1232	5.1366	5.1500	5.1634	5.1768	5.1902	5.2036	5.2170	5.2304	480
490	5.2304	5.2439	5.2573	5.2707	5.2842	5.2976	5.3111	5.3246	5.3380	5.3515	5.3650	490
500	5.3650	5.3785	5.3920	5.4055	5.4190	5.4325	5.4460	5.4595	5.4731	5.4866	5.5001	500
510	5.5001	5.5137	5.5272	5.5408	5.5544	5.5679	5.5815	5.5951	5.6087	5.6223	5.6359	510
520	5.6359	5.6495	5.6631	5.6767	5.6903	5.7039	5.7176	5.7312	5.7448	5.7585	5.7721	520
530	5.7721	5.7858	5.7995	5.8131	5.8268	5.8405	5.8542	5.8679	5.8816	5.8953	5.9090	530
540	5.9090	5.9227	5.9364	5.9501	5.9639	5.9776	5.9913	6.0051	6.0188	6.0326	6.0464	540
550	6.0464	6.0601	6.0739	6.0877	6.1014	6.1152	6.1290	6.1428	6.1566	6.1704	6.1842	550
560	6.1842	6.1981	6.2119	6.2257	6.2395	6.2534	6.2672	6.2811	6.2949	6.3088	6.3227	560
570	6.3227	6.3365	6.3504	6.3643	6.3782	6.3920	6.4059	6.4198	6.4337	6.4477	6.4616	570
580	6.4616	6.4755	6.4894	6.5033	6.5173	6.5312	6.5452	6.5591	6.5731	6.5870	6.6010	580
590	6.6010	6.6149	6.6289	6.6429	6.6569	6.6709	6.6848	6.6988	6.7128	6.7268	6.7409	590
600	6.7409	6.7549	6.7689	6.7829	6.7969	6.8110	6.8250	6.8391	6.8531	6.8672	6.8812	600
°F	0	1	2	3	4	5	6	7	8	9	10	°F

Table C5. AWG 28 *Nicrosil thermoelements versus platinum,* Pt–67—*thermoelectric voltage as a function of temperature (°F), reference junctions at 32 °F*—Continued

°F	0	1	2	3	4	5	6	7	8	9	10	°F
					THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS							
600	6.7409	6.7549	6.7689	6.7829	6.7969	6.8110	6.8250	6.8391	6.8531	6.8672	6.8812	600
610	6.8812	6.8953	6.9093	6.9234	6.9375	6.9516	6.9656	6.9797	6.9938	7.0079	7.0220	610
620	7.0220	7.0361	7.0502	7.0644	7.0785	7.0926	7.1067	7.1209	7.1350	7.1491	7.1633	620
630	7.1633	7.1774	7.1916	7.2058	7.2199	7.2341	7.2483	7.2624	7.2766	7.2908	7.3050	630
640	7.3050	7.3192	7.3334	7.3476	7.3618	7.3760	7.3902	7.4044	7.4187	7.4329	7.4471	640
650	7.4471	7.4614	7.4756	7.4899	7.5041	7.5184	7.5326	7.5469	7.5611	7.5754	7.5897	650
660	7.5897	7.6040	7.6183	7.6325	7.6468	7.6611	7.6754	7.6897	7.7040	7.7183	7.7327	660
670	7.7327	7.7470	7.7613	7.7756	7.7900	7.8043	7.8186	7.8330	7.8473	7.8617	7.8760	670
680	7.8760	7.8904	7.9047	7.9191	7.9335	7.9479	7.9622	7.9766	7.9910	8.0054	8.0198	680
690	8.0198	8.0342	8.0486	8.0630	8.0774	8.0918	8.1062	8.1207	8.1351	8.1495	8.1639	690
700	8.1639	8.1784	8.1928	8.2073	8.2217	8.2361	8.2506	8.2651	8.2795	8.2940	8.3085	700
710	8.3085	8.3229	8.3374	8.3519	8.3664	8.3809	8.3953	8.4098	8.4243	8.4388	8.4533	710
720	8.4533	8.4679	8.4824	8.4969	8.5114	8.5259	8.5404	8.5550	8.5695	8.5840	8.5986	720
730	8.5986	8.6131	8.6277	8.6422	8.6568	8.6713	8.6859	8.7005	8.7150	8.7296	8.7442	730
740	8.7442	8.7588	8.7733	8.7879	8.8025	8.8171	8.8317	8.8463	8.8609	8.8755	8.8901	740
750	8.8901	8.9047	8.9193									750
°F	0	1	2	3	4	5	6	7	8	9	10	°F

TABLE C6. AWG 14 *Nicrosil thermoelements versus platinum,* Pt–67—*thermoelectric voltage as a function of temperature (°F), reference junctions at 32 °F. Abbreviated table.*

THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS

°F	0	1	2	3	4	5	6	7	8	9	10	°F
30			0.0000	0.0086	0.0172	0.0258	0.0344	0.0430	0.0517	0.0604	0.0691	30
40	0.0691	0.0778	0.0865	0.0953	0.1040	0.1128	0.1216	0.1304	0.1392	0.1481	0.1569	40
50	0.1569	0.1658	0.1747	0.1836	0.1925	0.2015	0.2104	0.2194	0.2284	0.2374	0.2464	50
60	0.2464	0.2554	0.2645	0.2736	0.2826	0.2917	0.3009	0.3100	0.3191	0.3283	0.3375	60
70	0.3375	0.3467	0.3559	0.3651	0.3743	0.3836	0.3929	0.4022	0.4115	0.4208	0.4301	70
80	0.4301	0.4395	0.4488	0.4582	0.4676	0.4770	0.4864	0.4959	0.5053	0.5148	0.5243	80
90	0.5243	0.5338	0.5433	0.5528	0.5624	0.5719	0.5815	0.5911	0.6007	0.6103	0.6199	90
100	0.6199	0.6296	0.6392	0.6489	0.6586	0.6683	0.6780	0.6878	0.6975	0.7073	0.7170	100
110	0.7170	0.7268	0.7366	0.7465	0.7563	0.7661	0.7760	0.7859	0.7958	0.8057	0.8156	110
120	0.8156	0.8255	0.8355	0.8454	0.8554	0.8654	0.8754	0.8854	0.8954	0.9055	0.9155	120
130	0.9155	0.9256	0.9357	0.9458	0.9559	0.9660	0.9762	0.9863	0.9965	1.0067	1.0169	130
140	1.0169	1.0271	1.0373	1.0475	1.0578	1.0680	1.0783	1.0886	1.0989	1.1092	1.1195	140
150	1.1195	1.1299	1.1402	1.1506	1.1610	1.1713	1.1817	1.1922	1.2026	1.2130	1.2235	150
160	1.2235	1.2340	1.2444	1.2549	1.2654	1.2760	1.2865	1.2970	1.3076	1.3182	1.3287	160
170	1.3287	1.3393	1.3499	1.3606	1.3712	1.3818	1.3925	1.4032	1.4138	1.4245	1.4352	170
180	1.4352	1.4460	1.4567	1.4674	1.4782	1.4890	1.4997	1.5105	1.5213	1.5321	1.5430	180
190	1.5430	1.5538	1.5647	1.5755	1.5864	1.5973	1.6082	1.6191	1.6300	1.6409	1.6519	190
200	1.6519	1.6628	1.6738	1.6848	1.6958	1.7068	1.7178	1.7288	1.7399	1.7509	1.7620	200
210	1.7620	1.7731	1.7841	1.7952	1.8063	1.8175	1.8286	1.8397	1.8509	1.8620	1.8732	210
220	1.8732	1.8844	1.8956	1.9068	1.9180	1.9293	1.9405	1.9518	1.9630	1.9743	1.9856	220
230	1.9856	1.9969	2.0082	2.0195	2.0308	2.0422	2.0535	2.0649	2.0763	2.0876	2.0990	230
240	2.0990	2.1104	2.1218	2.1333	2.1447	2.1562	2.1676	2.1791	2.1906	2.2020	2.2135	240
250	2.2135	2.2251	2.2366	2.2481	2.2596	2.2712	2.2828	2.2943	2.3059	2.3175	2.3291	250
260	2.3291	2.3407	2.3523	2.3640	2.3756	2.3873	2.3989	2.4106	2.4223	2.4340	2.4457	260
270	2.4457	2.4574	2.4691	2.4809	2.4926	2.5044	2.5161	2.5279	2.5397	2.5515	2.5633	270
280	2.5633	2.5751	2.5869	2.5987	2.6106	2.6224	2.6343	2.6462	2.6581	2.6699	2.6818	280
290	2.6818	2.6937	2.7057	2.7176	2.7295	2.7415	2.7534	2.7654	2.7774	2.7894	2.8014	290
300	2.8014	2.8134	2.8254	2.8374	2.8494	2.8615	2.8735	2.8856	2.8976	2.9097	2.9218	300
310	2.9218	2.9339	2.9460	2.9581	2.9702	2.9824	2.9945	3.0067	3.0188	3.0310	3.0432	310
320	3.0432	3.0553	3.0675	3.0797	3.0919	3.1042	3.1164	3.1286	3.1409	3.1531	3.1654	320
330	3.1654	3.1777	3.1900	3.2022	3.2145	3.2268	3.2392	3.2515	3.2638	3.2762	3.2885	330
340	3.2885	3.3009	3.3132	3.3256	3.3380	3.3504	3.3628	3.3752	3.3876	3.4000	3.4125	340
350	3.4125	3.4249	3.4374	3.4498	3.4623	3.4748	3.4873	3.4997	3.5122	3.5248	3.5373	350
360	3.5373	3.5498	3.5623	3.5749	3.5874	3.6000	3.6125	3.6251	3.6377	3.6503	3.6629	360
370	3.6629	3.6755	3.6881	3.7007	3.7133	3.7260	3.7386	3.7513	3.7639	3.7766	3.7893	370
380	3.7893	3.8020	3.8146	3.8273	3.8401	3.8528	3.8655	3.8782	3.8910	3.9037	3.9165	380
390	3.9165	3.9292	3.9420	3.9548	3.9675	3.9803	3.9931	4.0059	4.0187	4.0316	4.0444	390
400	4.0444	4.0572	4.0701	4.0829	4.0958	4.1086	4.1215	4.1344	4.1473	4.1602	4.1731	400
410	4.1731	4.1860	4.1989	4.2118	4.2247	4.2377	4.2506	4.2636	4.2765	4.2895	4.3024	410
420	4.3024	4.3154	4.3284	4.3414	4.3544	4.3674	4.3804	4.3934	4.4065	4.4195	4.4325	420
430	4.4325	4.4456	4.4586	4.4717	4.4848	4.4979	4.5109	4.5240	4.5371	4.5502	4.5633	430
440	4.5633	4.5765	4.5896	4.6027	4.6158	4.6290	4.6421	4.6553	4.6685	4.6816	4.6948	440
450	4.6948	4.7080	4.7212	4.7344	4.7476	4.7608	4.7740	4.7872	4.8004	4.8137	4.8269	450
460	4.8269	4.8402	4.8534	4.8667	4.8800	4.8932	4.9065	4.9198	4.9331	4.9464	4.9597	460
470	4.9597	4.9730	4.9863	4.9996	5.0130	5.0263	5.0397	5.0530	5.0664	5.0797	5.0931	470
480	5.0931	5.1065	5.1198	5.1332	5.1466	5.1600	5.1734	5.1868	5.2003	5.2137	5.2271	480
490	5.2271	5.2405	5.2540	5.2674	5.2809	5.2943	5.3078	5.3213	5.3347	5.3482	5.3617	490
500	5.3617	5.3752	5.3887	5.4022	5.4157	5.4292	5.4428	5.4563	5.4698	5.4834	5.4969	500
510	5.4969	5.5105	5.5240	5.5376	5.5512	5.5647	5.5783	5.5919	5.6055	5.6191	5.6327	510
520	5.6327	5.6463	5.6599	5.6735	5.6872	5.7008	5.7144	5.7281	5.7417	5.7554	5.7690	520
530	5.7690	5.7827	5.7964	5.8100	5.8237	5.8374	5.8511	5.8648	5.8785	5.8922	5.9059	530
540	5.9059	5.9196	5.9334	5.9471	5.9608	5.9746	5.9883	6.0021	6.0158	6.0296	6.0433	540
550	6.0433	6.0571	6.0709	6.0847	6.0985	6.1123	6.1261	6.1399	6.1537	6.1675	6.1813	550
560	6.1813	6.1951	6.2089	6.2228	6.2366	6.2505	6.2643	6.2782	6.2920	6.3059	6.3198	560
570	6.3198	6.3336	6.3475	6.3614	6.3753	6.3892	6.4031	6.4170	6.4309	6.4448	6.4587	570
580	6.4587	6.4726	6.4866	6.5005	6.5144	6.5284	6.5423	6.5563	6.5703	6.5842	6.5982	580
590	6.5982	6.6122	6.6261	6.6401	6.6541	6.6681	6.6821	6.6961	6.7101	6.7241	6.7381	590
600	6.7381	6.7521	6.7662	6.7802	6.7942	6.8083	6.8223	6.8364	6.8504	6.8645	6.8785	600
°F	0	1	2	3	4	5	6	7	8	9	10	°F

TABLE C6. AWG 14 *Nicrosil thermoelements versus platinum,* Pt–67—*thermoelectric voltage as a function of temperature (°F), reference junctions at 32 °F*—Continued

°F	0	1	2	3	4	5	6	7	8	9	10	°F
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS											
600	6.7381	6.7521	6.7662	6.7802	6.7942	6.8083	6.8223	6.8364	6.8504	6.8645	6.8785	600
610	6.8785	6.8926	6.9067	6.9207	6.9348	6.9489	6.9630	6.9771	6.9912	7.0053	7.0194	610
620	7.0194	7.0335	7.0476	7.0617	7.0759	7.0900	7.1041	7.1183	7.1324	7.1466	7.1607	620
630	7.1607	7.1749	7.1890	7.2032	7.2174	7.2315	7.2457	7.2599	7.2741	7.2883	7.3025	630
640	7.3025	7.3167	7.3309	7.3451	7.3593	7.3735	7.3877	7.4019	7.4162	7.4304	7.4446	640
650	7.4446	7.4589	7.4731	7.4874	7.5016	7.5159	7.5302	7.5444	7.5587	7.5730	7.5873	650
660	7.5873	7.6015	7.6158	7.6301	7.6444	7.6587	7.6730	7.6873	7.7016	7.7160	7.7303	660
670	7.7303	7.7446	7.7589	7.7733	7.7876	7.8019	7.8163	7.8306	7.8450	7.8593	7.8737	670
680	7.8737	7.8881	7.9024	7.9168	7.9312	7.9456	7.9599	7.9743	7.9887	8.0031	8.0175	680
690	8.0175	8.0319	8.0463	8.0607	8.0752	8.0896	8.1040	8.1184	8.1329	8.1473	8.1617	690
700	8.1617	8.1762	8.1906	8.2051	8.2195	8.2340	8.2484	8.2629	8.2774	8.2918	8.3063	700
710	8.3063	8.3208	8.3353	8.3498	8.3643	8.3788	8.3933	8.4078	8.4223	8.4368	8.4513	710
720	8.4513	8.4658	8.4803	8.4948	8.5094	8.5239	8.5384	8.5530	8.5675	8.5821	8.5966	720
730	8.5966	8.6112	8.6257	8.6403	8.6548	8.6694	8.6840	8.6986	8.7131	8.7277	8.7423	730
740	8.7423	8.7569	8.7715	8.7861	8.8007	8.8153	8.8299	8.8445	8.8591	8.8737	8.8883	740
750	8.8883	8.9030	8.9176	8.9322	8.9468	8.9615	8.9761	8.9908	9.0054	9.0201	9.0347	750
760	9.0347	9.0494	9.0640	9.0787	9.0934	9.1080	9.1227	9.1374	9.1521	9.1667	9.1814	760
770	9.1814	9.1961	9.2108	9.2255	9.2402	9.2549	9.2696	9.2843	9.2991	9.3138	9.3285	770
780	9.3285	9.3432	9.3579	9.3727	9.3874	9.4021	9.4169	9.4316	9.4464	9.4611	9.4759	780
790	9.4759	9.4906	9.5054	9.5201	9.5349	9.5497	9.5644	9.5792	9.5940	9.6088	9.6236	790
800	9.6236	9.6383	9.6531	9.6679	9.6827	9.6975	9.7123	9.7271	9.7419	9.7568	9.7716	800
810	9.7716	9.7864	9.8012	9.8160	9.8309	9.8457	9.8605	9.8754	9.8902	9.9050	9.9199	810
820	9.9199	9.9347	9.9496	9.9644	9.9793	9.9942	10.0090	10.0239	10.0388	10.0536	10.0685	820
830	10.0685	10.0834	10.0983	10.1132	10.1280	10.1429	10.1578	10.1727	10.1876	10.2025	10.2174	830
840	10.2174	10.2323	10.2473	10.2622	10.2771	10.2920	10.3069	10.3218	10.3368	10.3517	10.3666	840
850	10.3666	10.3816	10.3965	10.4115	10.4264	10.4414	10.4563	10.4713	10.4862	10.5012	10.5161	850
860	10.5161	10.5311	10.5461	10.5611	10.5760	10.5910	10.6060	10.6210	10.6359	10.6509	10.6659	860
870	10.6659	10.6809	10.6959	10.7109	10.7259	10.7409	10.7559	10.7709	10.7860	10.8010	10.8160	870
880	10.8160	10.8310	10.8460	10.8611	10.8761	10.8911	10.9062	10.9212	10.9362	10.9513	10.9663	880
890	10.9663	10.9814	10.9964	11.0115	11.0265	11.0416	11.0567	11.0717	11.0868	11.1019	11.1169	890
900	11.1169	11.1320	11.1471	11.1622	11.1773	11.1923	11.2074	11.2225	11.2376	11.2527	11.2678	900
910	11.2678	11.2829	11.2980	11.3131	11.3282	11.3433	11.3585	11.3736	11.3887	11.4038	11.4189	910
920	11.4189	11.4341	11.4492	11.4643	11.4795	11.4946	11.5097	11.5249	11.5400	11.5552	11.5703	920
930	11.5703	11.5855	11.6006	11.6158	11.6310	11.6461	11.6613	11.6765	11.6916	11.7068	11.7220	930
940	11.7220	11.7372	11.7523	11.7675	11.7827	11.7979	11.8131	11.8283	11.8435	11.8587	11.8739	940
950	11.8739	11.8891	11.9043	11.9195	11.9347	11.9499	11.9651	11.9804	11.9956	12.0108	12.0260	950
960	12.0260	12.0413	12.0565	12.0717	12.0870	12.1022	12.1174	12.1327	12.1479	12.1632	12.1784	960
970	12.1784	12.1937	12.2089	12.2242	12.2394	12.2547	12.2700	12.2852	12.3005	12.3158	12.3311	970
980	12.3311	12.3463	12.3616	12.3769	12.3922	12.4075	12.4228	12.4380	12.4533	12.4686	12.4839	980
990	12.4839	12.4992	12.5145	12.5298	12.5451	12.5605	12.5758	12.5911	12.6064	12.6217	12.6370	990
1,000	12.6370	12.6524	12.6677	12.6830	12.6983	12.7137	12.7290	12.7444	12.7597	12.7750	12.7904	1,000
1,010	12.7904	12.8057	12.8211	12.8364	12.8518	12.8671	12.8825	12.8979	12.9132	12.9286	12.9439	1,010
1,020	12.9439	12.9593	12.9747	12.9901	13.0054	13.0208	13.0362	13.0516	13.0670	13.0824	13.0977	1,020
1,030	13.0977	13.1131	13.1285	13.1439	13.1593	13.1747	13.1901	13.2055	13.2209	13.2364	13.2518	1,030
1,040	13.2518	13.2672	13.2826	13.2980	13.3134	13.3289	13.3443	13.3597	13.3751	13.3906	13.4060	1,040
1,050	13.4060	13.4214	13.4369	13.4523	13.4678	13.4832	13.4987	13.5141	13.5296	13.5450	13.5605	1,050
1,060	13.5605	13.5759	13.5914	13.6069	13.6223	13.6378	13.6533	13.6687	13.6842	13.6997	13.7152	1,060
1,070	13.7152	13.7306	13.7461	13.7616	13.7771	13.7926	13.8081	13.8236	13.8391	13.8546	13.8701	1,070
1,080	13.8701	13.8856	13.9011	13.9166	13.9321	13.9476	13.9631	13.9786	13.9941	14.0097	14.0252	1,080
1,090	14.0252	14.0407	14.0562	14.0717	14.0873	14.1028	14.1183	14.1339	14.1494	14.1650	14.1805	1,090
1,100	14.1805	14.1960	14.2116	14.2271	14.2427	14.2582	14.2738	14.2893	14.3049	14.3205	14.3360	1,100
1,110	14.3360	14.3516	14.3672	14.3827	14.3983	14.4139	14.4294	14.4450	14.4606	14.4762	14.4918	1,110
1,120	14.4918	14.5074	14.5229	14.5385	14.5541	14.5697	14.5853	14.6009	14.6165	14.6321	14.6477	1,120
1,130	14.6477	14.6633	14.6789	14.6945	14.7102	14.7258	14.7414	14.7570	14.7726	14.7882	14.8039	1,130
1,140	14.8039	14.8195	14.8351	14.8508	14.8664	14.8820	14.8977	14.9133	14.9289	14.9446	14.9602	1,140
1,150	14.9602	14.9759	14.9915	15.0072	15.0228	15.0385	15.0541	15.0698	15.0855	15.1011	15.1168	1,150
1,160	15.1168	15.1324	15.1481	15.1638	15.1795	15.1951	15.2108	15.2265	15.2422	15.2579	15.2735	1,160
1,170	15.2735	15.2892	15.3049	15.3206	15.3363	15.3520	15.3677	15.3834	15.3991	15.4148	15.4305	1,170
1,180	15.4305	15.4462	15.4619	15.4776	15.4933	15.5090	15.5248	15.5405	15.5562	15.5719	15.5876	1,180
1,190	15.5876	15.6034	15.6191	15.6348	15.6506	15.6663	15.6820	15.6978	15.7135	15.7292	15.7450	1,190
1,200	15.7450	15.7607	15.7765	15.7922	15.8080	15.8237	15.8395	15.8552	15.8710	15.8868	15.9025	1,200
°F	0	1	2	3	4	5	6	7	8	9	10	°F

Table C6. AWG 14 *Nicrosil thermoelements versus platinum,* Pt–67—*thermoelectric voltage as a function of temperature (°F), reference junctions at 32 °F*—Continued

°F	0	1	2	3	4	5	6	7	8	9	10	°F
					THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS							
1,200	15.7450	15.7607	15.7765	15.7922	15.8080	15.8237	15.8395	15.8552	15.8710	15.8868	15.9025	1,200
1,210	15.9025	15.9183	15.9341	15.9498	15.9656	15.9814	15.9971	16.0129	16.0287	16.0445	16.0603	1,210
1,220	16.0603	16.0760	16.0918	16.1076	16.1234	16.1392	16.1550	16.1708	16.1866	16.2024	16.2182	1,220
1,230	16.2182	16.2340	16.2498	16.2656	16.2814	16.2972	16.3130	16.3288	16.3447	16.3605	16.3763	1,230
1,240	16.3763	16.3921	16.4080	16.4238	16.4396	16.4554	16.4713	16.4871	16.5029	16.5188	16.5346	1,240
1,250	16.5346	16.5505	16.5663	16.5821	16.5980	16.6138	16.6297	16.6455	16.6614	16.6772	16.6931	1,250
1,260	16.6931	16.7090	16.7248	16.7407	16.7566	16.7724	16.7883	16.8042	16.8200	16.8359	16.8518	1,260
1,270	16.8518	16.8677	16.8835	16.8994	16.9153	16.9312	16.9471	16.9630	16.9789	16.9948	17.0106	1,270
1,280	17.0106	17.0265	17.0424	17.0583	17.0742	17.0902	17.1061	17.1220	17.1379	17.1538	17.1697	1,280
1,290	17.1697	17.1856	17.2015	17.2175	17.2334	17.2493	17.2652	17.2811	17.2971	17.3130	17.3289	1,290
1,300	17.3289	17.3449	17.3608	17.3767	17.3927	17.4086	17.4246	17.4405	17.4565	17.4724	17.4884	1,300
1,310	17.4884	17.5043	17.5203	17.5362	17.5522	17.5681	17.5841	17.6001	17.6160	17.6320	17.6480	1,310
1,320	17.6480	17.6639	17.6799	17.6959	17.7118	17.7278	17.7438	17.7598	17.7758	17.7917	17.8077	1,320
1,330	17.8077	17.8237	17.8397	17.8557	17.8717	17.8877	17.9037	17.9197	17.9357	17.9517	17.9677	1,330
1,340	17.9677	17.9837	17.9997	18.0157	18.0317	18.0477	18.0638	18.0798	18.0958	18.1118	18.1278	1,340
1,350	18.1278	18.1439	18.1599	18.1759	18.1919	18.2080	18.2240	18.2400	18.2561	18.2721	18.2882	1,350
1,360	18.2882	18.3042	18.3202	18.3363	18.3523	18.3684	18.3844	18.4005	18.4165	18.4326	18.4486	1,360
1,370	18.4486	18.4647	18.4808	18.4968	18.5129	18.5290	18.5450	18.5611	18.5772	18.5932	18.6093	1,370
1,380	18.6093	18.6254	18.6415	18.6576	18.6736	18.6897	18.7058	18.7219	18.7380	18.7541	18.7702	1,380
1,390	18.7702	18.7863	18.8024	18.8185	18.8346	18.8507	18.8668	18.8829	18.8990	18.9151	18.9312	1,390
1,400	18.9312	18.9473	18.9634	18.9795	18.9956	19.0118	19.0279	19.0440	19.0601	19.0763	19.0924	1,400
1,410	19.0924	19.1085	19.1246	19.1408	19.1569	19.1730	19.1892	19.2053	19.2215	19.2376	19.2538	1,410
1,420	19.2538	19.2699	19.2860	19.3022	19.3183	19.3345	19.3507	19.3668	19.3830	19.3991	19.4153	1,420
1,430	19.4153	19.4315	19.4476	19.4638	19.4800	19.4961	19.5123	19.5285	19.5446	19.5608	19.5770	1,430
1,440	19.5770	19.5932	19.6094	19.6256	19.6417	19.6579	19.6741	19.6903	19.7065	19.7227	19.7389	1,440
1,450	19.7389	19.7551	19.7713	19.7875	19.8037	19.8199	19.8361	19.8523	19.8685	19.8847	19.9009	1,450
1,460	19.9009	19.9172	19.9334	19.9496	19.9658	19.9820	19.9982	20.0145	20.0307	20.0469	20.0632	1,460
1,470	20.0632	20.0794	20.0956	20.1119	20.1281	20.1443	20.1606	20.1768	20.1931	20.2093	20.2255	1,470
1,480	20.2255	20.2418	20.2580	20.2743	20.2905	20.3068	20.3231	20.3393	20.3556	20.3718	20.3881	1,480
1,490	20.3881	20.4044	20.4206	20.4369	20.4532	20.4694	20.4857	20.5020	20.5183	20.5345	20.5508	1,490
1,500	20.5508	20.5671	20.5834	20.5997	20.6159	20.6322	20.6485	20.6648	20.6811	20.6974	20.7137	1,500
1,510	20.7137	20.7300	20.7463	20.7626	20.7789	20.7952	20.8115	20.8278	20.8441	20.8604	20.8767	1,510
1,520	20.8767	20.8931	20.9094	20.9257	20.9420	20.9583	20.9747	20.9910	21.0073	21.0236	21.0400	1,520
1,530	21.0400	21.0563	21.0726	21.0890	21.1053	21.1216	21.1380	21.1543	21.1706	21.1870	21.2033	1,530
1,540	21.2033	21.2197	21.2360	21.2524	21.2687	21.2851	21.3014	21.3178	21.3341	21.3505	21.3669	1,540
1,550	21.3669	21.3832	21.3996	21.4160	21.4323	21.4487	21.4651	21.4814	21.4978	21.5142	21.5306	1,550
1,560	21.5306	21.5469	21.5633	21.5797	21.5961	21.6125	21.6288	21.6452	21.6616	21.6780	21.6944	1,560
1,570	21.6944	21.7108	21.7272	21.7436	21.7600	21.7764	21.7928	21.8092	21.8256	21.8420	21.8584	1,570
1,580	21.8584	21.8748	21.8912	21.9076	21.9241	21.9405	21.9569	21.9733	21.9897	22.0062	22.0226	1,580
1,590	22.0226	22.0390	22.0554	22.0719	22.0883	22.1047	22.1212	22.1376	22.1540	22.1705	22.1869	1,590
1,600	22.1869	22.2033	22.2198	22.2362	22.2527	22.2691	22.2856	22.3020	22.3185	22.3349	22.3514	1,600
1,610	22.3514	22.3678	22.3843	22.4007	22.4172	22.4337	22.4501	22.4666	22.4831	22.4995	22.5160	1,610
1,620	22.5160	22.5325	22.5489	22.5654	22.5819	22.5984	22.6149	22.6313	22.6478	22.6643	22.6808	1,620
1,630	22.6808	22.6973	22.7138	22.7302	22.7467	22.7632	22.7797	22.7962	22.8127	22.8292	22.8457	1,630
1,640	22.8457	22.8622	22.8787	22.8952	22.9117	22.9282	22.9447	22.9613	22.9778	22.9943	23.0108	1,640
1,650	23.0108	23.0273	23.0438	23.0603	23.0769	23.0934	23.1099	23.1264	23.1430	23.1595	23.1760	1,650
1,660	23.1760	23.1926	23.2091	23.2256	23.2422	23.2587	23.2752	23.2918	23.3083	23.3249	23.3414	1,660
1,670	23.3414	23.3579	23.3745	23.3910	23.4076	23.4241	23.4407	23.4572	23.4738	23.4904	23.5069	1,670
1,680	23.5069	23.5235	23.5400	23.5566	23.5732	23.5897	23.6063	23.6229	23.6394	23.6560	23.6726	1,680
1,690	23.6726	23.6892	23.7057	23.7223	23.7389	23.7555	23.7720	23.7886	23.8052	23.8218	23.8384	1,690
1,700	23.8384	23.8550	23.8716	23.8882	23.9048	23.9213	23.9379	23.9545	23.9711	23.9877	24.0043	1,700
1,710	24.0043	24.0209	24.0375	24.0542	24.0708	24.0874	24.1040	24.1206	24.1372	24.1538	24.1704	1,710
1,720	24.1704	24.1870	24.2037	24.2203	24.2369	24.2535	24.2701	24.2868	24.3034	24.3200	24.3367	1,720
1,730	24.3367	24.3533	24.3699	24.3866	24.4032	24.4198	24.4365	24.4531	24.4697	24.4864	24.5030	1,730
1,740	24.5030	24.5197	24.5363	24.5530	24.5696	24.5863	24.6029	24.6196	24.6362	24.6529	24.6695	1,740
1,750	24.6695	24.6862	24.7028	24.7195	24.7362	24.7528	24.7695	24.7862	24.8028	24.8195	24.8362	1,750
1,760	24.8362	24.8528	24.8695	24.8862	24.9028	24.9195	24.9362	24.9529	24.9696	24.9862	25.0029	1,760
1,770	25.0029	25.0196	25.0363	25.0530	25.0697	25.0864	25.1030	25.1197	25.1364	25.1531	25.1698	1,770
1,780	25.1698	25.1865	25.2032	25.2199	25.2366	25.2533	25.2700	25.2867	25.3034	25.3201	25.3369	1,780
1,790	25.3369	25.3536	25.3703	25.3870	25.4037	25.4204	25.4371	25.4538	25.4706	25.4873	25.5040	1,790
1,800	25.5040	25.5207	25.5375	25.5542	25.5709	25.5876	25.6044	25.6211	25.6378	25.6546	25.6713	1,800
°F	0	1	2	3	4	5	6	7	8	9	10	°F

Table C6. AWG 14 *Nicrosil thermoelements versus platinum,* Pt–67—*thermoelectric voltage as a function of temperature (°F), reference junctions at 32 °F*—Continued

THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS

°F	0	1	2	3	4	5	6	7	8	9	10	°F
1,800	25.5040	25.5207	25.5375	25.5542	25.5709	25.5876	25.6044	25.6211	25.6378	25.6546	25.6713	1,800
1,810	25.6713	25.6880	25.7048	25.7215	25.7382	25.7550	25.7717	25.7885	25.8052	25.8219	25.8387	1,810
1,820	25.8387	25.8554	25.8722	25.8889	25.9057	25.9224	25.9392	25.9559	25.9727	25.9895	26.0062	1,820
1,830	26.0062	26.0230	26.0397	26.0565	26.0733	26.0900	26.1068	26.1236	26.1403	26.1571	26.1739	1,830
1,840	26.1739	26.1906	26.2074	26.2242	26.2410	26.2577	26.2745	26.2913	26.3081	26.3249	26.3416	1,840
1,850	26.3416	26.3584	26.3752	26.3920	26.4088	26.4256	26.4424	26.4591	26.4759	26.4927	26.5095	1,850
1,860	26.5095	26.5263	26.5431	26.5599	26.5767	26.5935	26.6103	26.6271	26.6439	26.6607	26.6775	1,860
1,870	26.6775	26.6943	26.7111	26.7279	26.7447	26.7616	26.7784	26.7952	26.8120	26.8288	26.8456	1,870
1,880	26.8456	26.8624	26.8793	26.8961	26.9129	26.9297	26.9465	26.9634	26.9802	26.9970	27.0139	1,880
1,890	27.0139	27.0307	27.0475	27.0643	27.0812	27.0980	27.1148	27.1317	27.1485	27.1653	27.1822	1,890
1,900	27.1822	27.1990	27.2159	27.2327	27.2495	27.2664	27.2832	27.3001	27.3169	27.3338	27.3506	1,900
1,910	27.3506	27.3675	27.3843	27.4012	27.4180	27.4349	27.4517	27.4686	27.4855	27.5023	27.5192	1,910
1,920	27.5192	27.5360	27.5529	27.5698	27.5866	27.6035	27.6203	27.6372	27.6541	27.6709	27.6878	1,920
1,930	27.6878	27.7047	27.7216	27.7384	27.7553	27.7722	27.7891	27.8059	27.8228	27.8397	27.8566	1,930
1,940	27.8566	27.8734	27.8903	27.9072	27.9241	27.9410	27.9579	27.9748	27.9916	28.0085	28.0254	1,940
1,950	28.0254	28.0423	28.0592	28.0761	28.0930	28.1099	28.1268	28.1437	28.1606	28.1775	28.1944	1,950
1,960	28.1944	28.2113	28.2282	28.2451	28.2620	28.2789	28.2958	28.3127	28.3296	28.3465	28.3634	1,960
1,970	28.3634	28.3803	28.3972	28.4141	28.4310	28.4480	28.4649	28.4818	28.4987	28.5156	28.5325	1,970
1,980	28.5325	28.5495	28.5664	28.5833	28.6002	28.6171	28.6341	28.6510	28.6679	28.6848	28.7018	1,980
1,990	28.7018	28.7187	28.7356	28.7525	28.7695	28.7864	28.8033	28.8203	28.8372	28.8541	28.8711	1,990
2,000	28.8711	28.8880	28.9049	28.9219	28.9388	28.9558	28.9727	28.9896	29.0066	29.0235	29.0405	2,000
2,010	29.0405	29.0574	29.0744	29.0913	29.1083	29.1252	29.1421	29.1591	29.1760	29.1930	29.2100	2,010
2,020	29.2100	29.2269	29.2439	29.2608	29.2778	29.2947	29.3117	29.3286	29.3456	29.3626	29.3795	2,020
2,030	29.3795	29.3965	29.4134	29.4304	29.4474	29.4643	29.4813	29.4983	29.5152	29.5322	29.5492	2,030
2,040	29.5492	29.5661	29.5831	29.6001	29.6170	29.6340	29.6510	29.6680	29.6849	29.7019	29.7189	2,040
2,050	29.7189	29.7359	29.7528	29.7698	29.7868	29.8038	29.8207	29.8377	29.8547	29.8717	29.8887	2,050
2,060	29.8887	29.9057	29.9226	29.9396	29.9566	29.9736	29.9906	30.0076	30.0246	30.0416	30.0585	2,060
2,070	30.0585	30.0755	30.0925	30.1095	30.1265	30.1435	30.1605	30.1775	30.1945	30.2115	30.2285	2,070
2,080	30.2285	30.2455	30.2625	30.2795	30.2965	30.3135	30.3305	30.3475	30.3645	30.3815	30.3985	2,080
2,090	30.3985	30.4155	30.4325	30.4495	30.4665	30.4835	30.5005	30.5175	30.5345	30.5515	30.5686	2,090
2,100	30.5686	30.5856	30.6026	30.6196	30.6366	30.6536	30.6706	30.6876	30.7047	30.7217	30.7387	2,100
2,110	30.7387	30.7557	30.7727	30.7897	30.8068	30.8238	30.8408	30.8578	30.8748	30.8919	30.9089	2,110
2,120	30.9089	30.9259	30.9429	30.9600	30.9770	30.9940	31.0110	31.0281	31.0451	31.0621	31.0791	2,120
2,130	31.0791	31.0962	31.1132	31.1302	31.1473	31.1643	31.1813	31.1984	31.2154	31.2324	31.2495	2,130
2,140	31.2495	31.2665	31.2835	31.3006	31.3176	31.3346	31.3517	31.3687	31.3857	31.4028	31.4198	2,140
2,150	31.4198	31.4369	31.4539	31.4709	31.4880	31.5050	31.5221	31.5391	31.5561	31.5732	31.5902	2,150
2,160	31.5902	31.6073	31.6243	31.6414	31.6584	31.6755	31.6925	31.7096	31.7266	31.7437	31.7607	2,160
2,170	31.7607	31.7777	31.7948	31.8118	31.8289	31.8459	31.8630	31.8801	31.8971	31.9142	31.9312	2,170
2,180	31.9312	31.9483	31.9653	31.9824	31.9994	32.0165	32.0335	32.0506	32.0677	32.0847	32.1018	2,180
2,190	32.1018	32.1188	32.1359	32.1529	32.1700	32.1871	32.2041	32.2212	32.2382	32.2553	32.2724	2,190
2,200	32.2724	32.2894	32.3065	32.3236	32.3406	32.3577	32.3747	32.3918	32.4089	32.4259	32.4430	2,200
2,210	32.4430	32.4601	32.4771	32.4942	32.5113	32.5283	32.5454	32.5625	32.5795	32.5966	32.6137	2,210
2,220	32.6137	32.6308	32.6478	32.6649	32.6820	32.6990	32.7161	32.7332	32.7503	32.7673	32.7844	2,220
2,230	32.7844	32.8015	32.8185	32.8356	32.8527	32.8698	32.8868	32.9039	32.9210	32.9381	32.9551	2,230
2,240	32.9551	32.9722	32.9893	33.0064	33.0234	33.0405	33.0576	33.0747	33.0918	33.1088	33.1259	2,240
2,250	33.1259	33.1430	33.1601	33.1772	33.1942	33.2113	33.2284	33.2455	33.2626	33.2796	33.2967	2,250
2,260	33.2967	33.3138	33.3309	33.3480	33.3651	33.3821	33.3992	33.4163	33.4334	33.4505	33.4676	2,260
2,270	33.4676	33.4846	33.5017	33.5188	33.5359	33.5530	33.5701	33.5872	33.6042	33.6213	33.6384	2,270
2,280	33.6384	33.6555	33.6726	33.6897	33.7068	33.7238	33.7409	33.7580	33.7751	33.7922	33.8093	2,280
2,290	33.8093	33.8264	33.8435	33.8606	33.8776	33.8947	33.9118	33.9289	33.9460	33.9631	33.9802	2,290
2,300	33.9802	33.9973	34.0144	34.0315	34.0486	34.0656	34.0827	34.0998	34.1169	34.1340	34.1511	2,300
2,310	34.1511	34.1682	34.1853	34.2024	34.2195	34.2366	34.2537	34.2708	34.2879	34.3049	34.3220	2,310
2,320	34.3220	34.3391	34.3562	34.3733	34.3904	34.4075	34.4246	34.4417	34.4588	34.4759	34.4930	2,320
2,330	34.4930	34.5101	34.5272	34.5443	34.5614	34.5785	34.5956	34.6127	34.6298	34.6468	34.6639	2,330
2,340	34.6639	34.6810	34.6981	34.7152	34.7323	34.7494	34.7665	34.7836	34.8007	34.8178	34.8349	2,340
2,350	34.8349	34.8520	34.8691	34.8862	34.9033	34.9204	34.9375	34.9546	34.9717	34.9888	35.0059	2,350
2,360	35.0059	35.0230	35.0401	35.0572	35.0743	35.0914	35.1085	35.1256	35.1427	35.1598	35.1769	2,360
2,370	35.1769	35.1940	35.2111									2,370
°F	0	1	2	3	4	5	6	7	8	9	10	°F

Table C7. *Platinum,* Pt–67, *versus* AWG 28 *Nisil thermoelements—thermoelectric voltage as a function of temperature (°F), reference junctions at 32 °F. Abbreviated table.*

°F	0	1	2	3	4	5	6	7	8	9	10	°F
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS											
-320	-2.3549	-2.3612	-2.3676	-2.3739	-2.3803	-2.3866	-2.3929	-2.3991	-2.4054			-320
-310	-2.2905	-2.2970	-2.3035	-2.3099	-2.3164	-2.3228	-2.3293	-2.3357	-2.3421	-2.3485	-2.3549	-310
-300	-2.2251	-2.2317	-2.2382	-2.2448	-2.2514	-2.2579	-2.2644	-2.2710	-2.2775	-2.2840	-2.2905	-300
-290	-2.1588	-2.1655	-2.1721	-2.1788	-2.1854	-2.1920	-2.1987	-2.2053	-2.2119	-2.2185	-2.2251	-290
-280	-2.0919	-2.0986	-2.1054	-2.1121	-2.1188	-2.1255	-2.1321	-2.1388	-2.1455	-2.1522	-2.1588	-280
-270	-2.0245	-2.0313	-2.0380	-2.0448	-2.0515	-2.0583	-2.0650	-2.0718	-2.0785	-2.0852	-2.0919	-270
-260	-1.9567	-1.9635	-1.9703	-1.9771	-1.9839	-1.9906	-1.9974	-2.0042	-2.0110	-2.0177	-2.0245	-260
-250	-1.8885	-1.8953	-1.9022	-1.9090	-1.9158	-1.9226	-1.9294	-1.9363	-1.9431	-1.9499	-1.9567	-250
-240	-1.8201	-1.8269	-1.8338	-1.8406	-1.8475	-1.8543	-1.8612	-1.8680	-1.8749	-1.8817	-1.8885	-240
-230	-1.7515	-1.7583	-1.7652	-1.7721	-1.7789	-1.7858	-1.7927	-1.7995	-1.8064	-1.8132	-1.8201	-230
-220	-1.6826	-1.6895	-1.6964	-1.7033	-1.7102	-1.7171	-1.7240	-1.7308	-1.7377	-1.7446	-1.7515	-220
-210	-1.6137	-1.6206	-1.6275	-1.6344	-1.6413	-1.6482	-1.6551	-1.6620	-1.6689	-1.6758	-1.6826	-210
-200	-1.5446	-1.5515	-1.5584	-1.5654	-1.5723	-1.5792	-1.5861	-1.5930	-1.5999	-1.6068	-1.6137	-200
-190	-1.4755	-1.4824	-1.4893	-1.4962	-1.5031	-1.5101	-1.5170	-1.5239	-1.5308	-1.5377	-1.5446	-190
-180	-1.4063	-1.4132	-1.4201	-1.4270	-1.4340	-1.4409	-1.4478	-1.4547	-1.4616	-1.4686	-1.4755	-180
-170	-1.3370	-1.3439	-1.3509	-1.3578	-1.3647	-1.3716	-1.3786	-1.3855	-1.3924	-1.3993	-1.4063	-170
-160	-1.2678	-1.2747	-1.2816	-1.2885	-1.2955	-1.3024	-1.3093	-1.3162	-1.3232	-1.3301	-1.3370	-160
-150	-1.1986	-1.2055	-1.2124	-1.2193	-1.2262	-1.2332	-1.2401	-1.2470	-1.2539	-1.2608	-1.2678	-150
-140	-1.1294	-1.1363	-1.1432	-1.1501	-1.1571	-1.1640	-1.1709	-1.1778	-1.1847	-1.1916	-1.1986	-140
-130	-1.0604	-1.0673	-1.0742	-1.0811	-1.0880	-1.0949	-1.1018	-1.1087	-1.1156	-1.1225	-1.1294	-130
-120	-0.9915	-0.9984	-1.0052	-1.0121	-1.0190	-1.0259	-1.0328	-1.0397	-1.0466	-1.0535	-1.0604	-120
-110	-0.9228	-0.9296	-0.9365	-0.9434	-0.9502	-0.9571	-0.9640	-0.9708	-0.9777	-0.9846	-0.9915	-110
-100	-0.8543	-0.8612	-0.8680	-0.8748	-0.8817	-0.8885	-0.8954	-0.9022	-0.9091	-0.9159	-0.9228	-100
-90	-0.7862	-0.7930	-0.7998	-0.8066	-0.8134	-0.8202	-0.8270	-0.8339	-0.8407	-0.8475	-0.8543	-90
-80	-0.7184	-0.7252	-0.7319	-0.7387	-0.7455	-0.7522	-0.7590	-0.7658	-0.7726	-0.7794	-0.7862	-80
-70	-0.6510	-0.6577	-0.6645	-0.6712	-0.6779	-0.6846	-0.6914	-0.6981	-0.7049	-0.7116	-0.7184	-70
-60	-0.5841	-0.5908	-0.5974	-0.6041	-0.6108	-0.6175	-0.6242	-0.6309	-0.6376	-0.6443	-0.6510	-60
-50	-0.5177	-0.5243	-0.5309	-0.5376	-0.5442	-0.5508	-0.5575	-0.5641	-0.5708	-0.5774	-0.5841	-50
-40	-0.4519	-0.4584	-0.4650	-0.4715	-0.4781	-0.4847	-0.4913	-0.4979	-0.5045	-0.5111	-0.5177	-40
-30	-0.3867	-0.3932	-0.3997	-0.4062	-0.4127	-0.4192	-0.4257	-0.4322	-0.4388	-0.4453	-0.4519	-30
-20	-0.3222	-0.3286	-0.3350	-0.3414	-0.3479	-0.3543	-0.3608	-0.3672	-0.3737	-0.3802	-0.3867	-20
-10	-0.2584	-0.2648	-0.2711	-0.2775	-0.2838	-0.2902	-0.2966	-0.3030	-0.3094	-0.3158	-0.3222	-10
- 0	-0.1955	-0.2017	-0.2080	-0.2143	-0.2205	-0.2268	-0.2331	-0.2394	-0.2458	-0.2521	-0.2584	- 0
+ 0	-0.1955	-0.1892	-0.1830	-0.1767	-0.1705	-0.1643	-0.1581	-0.1519	-0.1457	-0.1395	-0.1334	+ 0
10	-0.1334	-0.1272	-0.1210	-0.1149	-0.1088	-0.1026	-0.0965	-0.0904	-0.0843	-0.0782	-0.0722	10
20	-0.0722	-0.0661	-0.0600	-0.0540	-0.0479	-0.0419	-0.0359	-0.0299	-0.0239	-0.0179	-0.0119	20
30	-0.0119	-0.0060	0.0000									30
°F	0	1	2	3	4	5	6	7	8	9	10	°F

Table C7. *Platinum, Pt–67, versus* AWG 28 *Nisil thermoelements—thermoelectric voltage as a function of temperature (°F), reference junctions at 32 °F*—Continued

°F	0	1	2	3	4	5	6	7	8	9	10	°F
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS											
30			0.0000	0.0059	0.0119	0.0178	0.0237	0.0296	0.0355	0.0414	0.0473	30
40	0.0473	0.0531	0.0590	0.0648	0.0707	0.0765	0.0823	0.0881	0.0939	0.0997	0.1055	40
50	0.1055	0.1112	0.1170	0.1227	0.1285	0.1342	0.1400	0.1457	0.1514	0.1571	0.1628	50
60	0.1628	0.1685	0.1742	0.1799	0.1855	0.1912	0.1969	0.2025	0.2082	0.2138	0.2194	60
70	0.2194	0.2251	0.2307	0.2363	0.2419	0.2475	0.2531	0.2587	0.2643	0.2699	0.2755	70
80	0.2755	0.2810	0.2866	0.2922	0.2977	0.3033	0.3088	0.3144	0.3199	0.3255	0.3310	80
90	0.3310	0.3365	0.3421	0.3476	0.3531	0.3586	0.3641	0.3696	0.3752	0.3807	0.3862	90
100	0.3862	0.3916	0.3971	0.4026	0.4081	0.4136	0.4191	0.4246	0.4300	0.4355	0.4410	100
110	0.4410	0.4464	0.4519	0.4574	0.4628	0.4683	0.4738	0.4792	0.4847	0.4901	0.4956	110
120	0.4956	0.5010	0.5065	0.5119	0.5173	0.5228	0.5282	0.5337	0.5391	0.5445	0.5500	120
130	0.5500	0.5554	0.5608	0.5662	0.5717	0.5771	0.5825	0.5879	0.5934	0.5988	0.6042	130
140	0.6042	0.6096	0.6150	0.6205	0.6259	0.6313	0.6367	0.6421	0.6475	0.6529	0.6584	140
150	0.6584	0.6638	0.6692	0.6746	0.6800	0.6854	0.6908	0.6962	0.7016	0.7070	0.7124	150
160	0.7124	0.7179	0.7233	0.7287	0.7341	0.7395	0.7449	0.7503	0.7557	0.7611	0.7665	160
170	0.7665	0.7719	0.7773	0.7827	0.7881	0.7935	0.7989	0.8043	0.8097	0.8152	0.8206	170
180	0.8206	0.8260	0.8314	0.8368	0.8422	0.8476	0.8530	0.8584	0.8638	0.8692	0.8746	180
190	0.8746	0.8800	0.8854	0.8908	0.8963	0.9017	0.9071	0.9125	0.9179	0.9233	0.9287	190
200	0.9287	0.9341	0.9395	0.9449	0.9504	0.9558	0.9612	0.9666	0.9720	0.9774	0.9828	200
210	0.9828	0.9883	0.9937	0.9991	1.0045	1.0099	1.0153	1.0208	1.0262	1.0316	1.0370	210
220	1.0370	1.0424	1.0479	1.0533	1.0587	1.0641	1.0696	1.0750	1.0804	1.0858	1.0913	220
230	1.0913	1.0967	1.1021	1.1075	1.1130	1.1184	1.1238	1.1293	1.1347	1.1401	1.1456	230
240	1.1456	1.1510	1.1564	1.1619	1.1673	1.1727	1.1782	1.1836	1.1890	1.1945	1.1999	240
250	1.1999	1.2054	1.2108	1.2162	1.2217	1.2271	1.2326	1.2380	1.2435	1.2489	1.2543	250
260	1.2543	1.2598	1.2652	1.2707	1.2761	1.2816	1.2870	1.2925	1.2979	1.3034	1.3088	260
270	1.3088	1.3143	1.3198	1.3252	1.3307	1.3361	1.3416	1.3470	1.3525	1.3580	1.3634	270
280	1.3634	1.3689	1.3743	1.3798	1.3853	1.3907	1.3962	1.4017	1.4071	1.4126	1.4181	280
290	1.4181	1.4235	1.4290	1.4345	1.4399	1.4454	1.4509	1.4563	1.4618	1.4673	1.4728	290
300	1.4728	1.4782	1.4837	1.4892	1.4947	1.5002	1.5056	1.5111	1.5166	1.5221	1.5276	300
310	1.5276	1.5330	1.5385	1.5440	1.5495	1.5550	1.5605	1.5659	1.5714	1.5769	1.5824	310
320	1.5824	1.5879	1.5934	1.5989	1.6044	1.6099	1.6154	1.6209	1.6264	1.6319	1.6373	320
330	1.6373	1.6428	1.6483	1.6538	1.6593	1.6648	1.6703	1.6758	1.6814	1.6869	1.6924	330
340	1.6924	1.6979	1.7034	1.7089	1.7144	1.7199	1.7254	1.7309	1.7364	1.7419	1.7475	340
350	1.7475	1.7530	1.7585	1.7640	1.7695	1.7750	1.7805	1.7861	1.7916	1.7971	1.8026	350
360	1.8026	1.8082	1.8137	1.8192	1.8247	1.8302	1.8358	1.8413	1.8468	1.8524	1.8579	360
370	1.8579	1.8634	1.8690	1.8745	1.8800	1.8856	1.8911	1.8966	1.9022	1.9077	1.9132	370
380	1.9132	1.9188	1.9243	1.9299	1.9354	1.9409	1.9465	1.9520	1.9576	1.9631	1.9687	380
390	1.9687	1.9742	1.9798	1.9853	1.9909	1.9964	2.0020	2.0075	2.0131	2.0187	2.0242	390
400	2.0242	2.0298	2.0353	2.0409	2.0465	2.0520	2.0576	2.0632	2.0687	2.0743	2.0799	400
410	2.0799	2.0854	2.0910	2.0966	2.1021	2.1077	2.1133	2.1189	2.1244	2.1300	2.1356	410
420	2.1356	2.1412	2.1468	2.1524	2.1579	2.1635	2.1691	2.1747	2.1803	2.1859	2.1915	420
430	2.1915	2.1971	2.2027	2.2082	2.2138	2.2194	2.2250	2.2306	2.2362	2.2418	2.2474	430
440	2.2474	2.2530	2.2587	2.2643	2.2699	2.2755	2.2811	2.2867	2.2923	2.2979	2.3035	440
450	2.3035	2.3092	2.3148	2.3204	2.3260	2.3316	2.3373	2.3429	2.3485	2.3541	2.3598	450
460	2.3598	2.3654	2.3710	2.3767	2.3823	2.3879	2.3936	2.3992	2.4048	2.4105	2.4161	460
470	2.4161	2.4218	2.4274	2.4330	2.4387	2.4443	2.4500	2.4556	2.4613	2.4669	2.4726	470
480	2.4726	2.4783	2.4839	2.4896	2.4952	2.5009	2.5066	2.5122	2.5179	2.5236	2.5292	480
490	2.5292	2.5349	2.5406	2.5462	2.5519	2.5576	2.5633	2.5690	2.5746	2.5803	2.5860	490
500	2.5860	2.5917	2.5974	2.6031	2.6087	2.6144	2.6201	2.6258	2.6315	2.6372	2.6429	500
510	2.6429	2.6486	2.6543	2.6600	2.6657	2.6714	2.6771	2.6828	2.6885	2.6943	2.7000	510
520	2.7000	2.7057	2.7114	2.7171	2.7228	2.7285	2.7343	2.7400	2.7457	2.7514	2.7572	520
530	2.7572	2.7629	2.7686	2.7744	2.7801	2.7858	2.7916	2.7973	2.8030	2.8088	2.8145	530
540	2.8145	2.8203	2.8260	2.8317	2.8375	2.8432	2.8490	2.8547	2.8605	2.8663	2.8720	540
550	2.8720	2.8778	2.8835	2.8893	2.8950	2.9008	2.9066	2.9123	2.9181	2.9239	2.9296	550
560	2.9296	2.9354	2.9412	2.9470	2.9527	2.9585	2.9643	2.9701	2.9759	2.9816	2.9874	560
570	2.9874	2.9932	2.9990	3.0048	3.0106	3.0164	3.0221	3.0279	3.0337	3.0395	3.0453	570
580	3.0453	3.0511	3.0569	3.0627	3.0685	3.0743	3.0801	3.0859	3.0918	3.0976	3.1034	580
590	3.1034	3.1092	3.1150	3.1208	3.1266	3.1324	3.1383	3.1441	3.1499	3.1557	3.1615	590
600	3.1615	3.1674	3.1732	3.1790	3.1848	3.1907	3.1965	3.2023	3.2082	3.2140	3.2198	600
°F	0	1	2	3	4	5	6	7	8	9	10	°F

Table C7. *Platinum,* Pt–67, *versus* AWG 28 *Nisil thermoelements—thermoelectric voltage as a function of temperature (°F), reference junctions at 32 °F*—Continued

°F	0	1	2	3	4	5	6	7	8	9	10	°F
					THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS							
600	3.1615	3.1674	3.1732	3.1790	3.1848	3.1907	3.1965	3.2023	3.2082	3.2140	3.2198	600
610	3.2198	3.2257	3.2315	3.2373	3.2432	3.2490	3.2548	3.2607	3.2665	3.2724	3.2782	610
620	3.2782	3.2841	3.2899	3.2958	3.3016	3.3075	3.3133	3.3192	3.3250	3.3309	3.3367	620
630	3.3367	3.3426	3.3484	3.3543	3.3601	3.3660	3.3719	3.3777	3.3836	3.3894	3.3953	630
640	3.3953	3.4012	3.4070	3.4129	3.4188	3.4246	3.4305	3.4364	3.4423	3.4481	3.4540	640
650	3.4540	3.4599	3.4657	3.4716	3.4775	3.4834	3.4892	3.4951	3.5010	3.5069	3.5128	650
660	3.5128	3.5186	3.5245	3.5304	3.5363	3.5422	3.5480	3.5539	3.5598	3.5657	3.5716	660
670	3.5716	3.5775	3.5834	3.5892	3.5951	3.6010	3.6069	3.6128	3.6187	3.6246	3.6305	670
680	3.6305	3.6364	3.6423	3.6482	3.6541	3.6600	3.6658	3.6717	3.6776	3.6835	3.6894	680
690	3.6894	3.6953	3.7012	3.7071	3.7130	3.7189	3.7248	3.7307	3.7366	3.7425	3.7484	690
700	3.7484	3.7543	3.7603	3.7662	3.7721	3.7780	3.7839	3.7898	3.7957	3.8016	3.8075	700
710	3.8075	3.8134	3.8193	3.8252	3.8311	3.8370	3.8430	3.8489	3.8548	3.8607	3.8666	710
720	3.8666	3.8725	3.8784	3.8844	3.8903	3.8962	3.9021	3.9080	3.9139	3.9199	3.9258	720
730	3.9258	3.9317	3.9376	3.9435	3.9495	3.9554	3.9613	3.9672	3.9731	3.9791	3.9850	730
740	3.9850	3.9909	3.9968	4.0028	4.0087	4.0146	4.0206	4.0265	4.0324	4.0384	4.0443	740
750	4.0443	4.0502	4.0562									750
°F	0	1	2	3	4	5	6	7	8	9	10	°F

Table C8. *Platinum, Pt–67, versus* AWG 14 *Nisil thermoelements—thermoelectric voltage as a function of temperature (°F), reference junctions at 32 °F. Abbreviated table.*

°F	0	1	2	3	4	5	6	7	8	9	10	°F
					THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS							
30			0.0000	0.0058	0.0116	0.0174	0.0232	0.0290	0.0348	0.0406	0.0464	30
40	0.0464	0.0521	0.0579	0.0636	0.0694	0.0751	0.0809	0.0865	0.0923	0.0980	0.1038	40
50	0.1038	0.1095	0.1152	0.1209	0.1266	0.1322	0.1379	0.1436	0.1493	0.1549	0.1606	50
60	0.1606	0.1663	0.1719	0.1776	0.1832	0.1888	0.1945	0.2001	0.2057	0.2113	0.2169	60
70	0.2169	0.2226	0.2282	0.2338	0.2394	0.2450	0.2505	0.2561	0.2617	0.2673	0.2729	70
80	0.2729	0.2784	0.2840	0.2896	0.2951	0.3007	0.3062	0.3118	0.3173	0.3228	0.3284	80
90	0.3284	0.3339	0.3394	0.3450	0.3505	0.3560	0.3615	0.3670	0.3726	0.3781	0.3836	90
100	0.3836	0.3891	0.3946	0.4001	0.4056	0.4110	0.4165	0.4220	0.4275	0.4330	0.4385	100
110	0.4385	0.4439	0.4494	0.4549	0.4603	0.4658	0.4713	0.4767	0.4822	0.4876	0.4931	110
120	0.4931	0.4985	0.5040	0.5094	0.5149	0.5203	0.5258	0.5312	0.5366	0.5421	0.5475	120
130	0.5475	0.5529	0.5584	0.5638	0.5692	0.5746	0.5801	0.5855	0.5909	0.5963	0.6017	130
140	0.6017	0.6072	0.6126	0.6180	0.6234	0.6288	0.6342	0.6396	0.6450	0.6504	0.6558	140
150	0.6558	0.6612	0.6666	0.6720	0.6774	0.6828	0.6882	0.6936	0.6990	0.7044	0.7098	150
160	0.7098	0.7152	0.7206	0.7260	0.7313	0.7367	0.7421	0.7475	0.7529	0.7583	0.7637	160
170	0.7637	0.7690	0.7744	0.7798	0.7852	0.7906	0.7959	0.8013	0.8067	0.8121	0.8175	170
180	0.8175	0.8228	0.8282	0.8336	0.8390	0.8443	0.8497	0.8551	0.8605	0.8658	0.8712	180
190	0.8712	0.8766	0.8820	0.8873	0.8927	0.8981	0.9035	0.9088	0.9142	0.9196	0.9249	190
200	0.9249	0.9303	0.9357	0.9411	0.9464	0.9518	0.9572	0.9626	0.9679	0.9733	0.9787	200
210	0.9787	0.9841	0.9894	0.9948	1.0002	1.0055	1.0109	1.0163	1.0217	1.0270	1.0324	210
220	1.0324	1.0378	1.0432	1.0485	1.0539	1.0593	1.0647	1.0701	1.0754	1.0808	1.0862	220
230	1.0862	1.0916	1.0970	1.1023	1.1077	1.1131	1.1185	1.1239	1.1292	1.1346	1.1400	230
240	1.1400	1.1454	1.1508	1.1562	1.1616	1.1669	1.1723	1.1777	1.1831	1.1885	1.1939	240
250	1.1939	1.1993	1.2047	1.2101	1.2155	1.2208	1.2262	1.2316	1.2370	1.2424	1.2478	250
260	1.2478	1.2532	1.2586	1.2640	1.2694	1.2748	1.2802	1.2856	1.2910	1.2964	1.3018	260
270	1.3018	1.3073	1.3127	1.3181	1.3235	1.3289	1.3343	1.3397	1.3451	1.3505	1.3560	270
280	1.3560	1.3614	1.3668	1.3722	1.3776	1.3830	1.3885	1.3939	1.3993	1.4047	1.4102	280
290	1.4102	1.4156	1.4210	1.4264	1.4319	1.4373	1.4427	1.4482	1.4536	1.4590	1.4645	290
300	1.4645	1.4699	1.4754	1.4808	1.4862	1.4917	1.4971	1.5026	1.5080	1.5135	1.5189	300
310	1.5189	1.5244	1.5298	1.5353	1.5407	1.5462	1.5516	1.5571	1.5625	1.5680	1.5734	310
320	1.5734	1.5789	1.5844	1.5898	1.5953	1.6008	1.6062	1.6117	1.6172	1.6226	1.6281	320
330	1.6281	1.6336	1.6391	1.6445	1.6500	1.6555	1.6610	1.6664	1.6719	1.6774	1.6829	330
340	1.6829	1.6884	1.6939	1.6994	1.7048	1.7103	1.7158	1.7213	1.7268	1.7323	1.7378	340
350	1.7378	1.7433	1.7488	1.7543	1.7598	1.7653	1.7708	1.7763	1.7818	1.7874	1.7929	350
360	1.7929	1.7984	1.8039	1.8094	1.8149	1.8204	1.8260	1.8315	1.8370	1.8425	1.8481	360
370	1.8481	1.8536	1.8591	1.8646	1.8702	1.8757	1.8812	1.8868	1.8923	1.8978	1.9034	370
380	1.9034	1.9089	1.9145	1.9200	1.9255	1.9311	1.9366	1.9422	1.9477	1.9533	1.9588	380
390	1.9588	1.9644	1.9700	1.9755	1.9811	1.9866	1.9922	1.9977	2.0033	2.0089	2.0144	390
400	2.0144	2.0200	2.0256	2.0312	2.0367	2.0423	2.0479	2.0535	2.0590	2.0646	2.0702	400
410	2.0702	2.0758	2.0814	2.0869	2.0925	2.0981	2.1037	2.1093	2.1149	2.1205	2.1261	410
420	2.1261	2.1317	2.1373	2.1429	2.1485	2.1541	2.1597	2.1653	2.1709	2.1765	2.1821	420
430	2.1821	2.1877	2.1933	2.1989	2.2046	2.2102	2.2158	2.2214	2.2270	2.2326	2.2383	430
440	2.2383	2.2439	2.2495	2.2552	2.2608	2.2664	2.2720	2.2777	2.2833	2.2889	2.2946	440
450	2.2946	2.3002	2.3059	2.3115	2.3171	2.3228	2.3284	2.3341	2.3397	2.3454	2.3510	450
460	2.3510	2.3567	2.3623	2.3680	2.3737	2.3793	2.3850	2.3906	2.3963	2.4020	2.4076	460
470	2.4076	2.4133	2.4190	2.4246	2.4303	2.4360	2.4416	2.4473	2.4530	2.4587	2.4644	470
480	2.4644	2.4700	2.4757	2.4814	2.4871	2.4928	2.4985	2.5041	2.5098	2.5155	2.5212	480
490	2.5212	2.5269	2.5326	2.5383	2.5440	2.5497	2.5554	2.5611	2.5668	2.5725	2.5782	490
500	2.5782	2.5839	2.5896	2.5953	2.6011	2.6068	2.6125	2.6182	2.6239	2.6296	2.6354	500
510	2.6354	2.6411	2.6468	2.6525	2.6582	2.6640	2.6697	2.6754	2.6812	2.6869	2.6926	510
520	2.6926	2.6984	2.7041	2.7098	2.7156	2.7213	2.7271	2.7328	2.7385	2.7443	2.7500	520
530	2.7500	2.7558	2.7615	2.7673	2.7730	2.7788	2.7845	2.7903	2.7960	2.8018	2.8076	530
540	2.8076	2.8133	2.8191	2.8249	2.8306	2.8364	2.8421	2.8479	2.8537	2.8595	2.8652	540
550	2.8652	2.8710	2.8768	2.3826	2.8883	2.8941	2.8999	2.9057	2.9115	2.9172	2.9230	550
560	2.9230	2.9288	2.9346	2.9404	2.9462	2.9520	2.9578	2.9635	2.9693	2.9751	2.9809	560
570	2.9809	2.9867	2.9925	2.9983	3.0041	3.0099	3.0157	3.0215	3.0274	3.0332	3.0390	570
580	3.0390	3.0448	3.0506	3.0564	3.0622	3.0680	3.0739	3.0797	3.0855	3.0913	3.0971	580
590	3.0971	3.1030	3.1088	3.1146	3.1204	3.1263	3.1321	3.1379	3.1437	3.1496	3.1554	590
600	3.1554	3.1612	3.1671	3.1729	3.1788	3.1846	3.1904	3.1963	3.2021	3.2080	3.2138	600
°F	0	1	2	3	4	5	6	7	8	9	10	°F

Table C8. *Platinum, Pt–67, versus* AWG 14 *Nisil thermoelements—thermoelectric voltage as a function of temperature (°F), reference junctions at 32 °F*—Continued

°F	0	1	2	3	4	5	6	7	8	9	10	°F
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS											
600	3.1554	3.1612	3.1671	3.1729	3.1788	3.1846	3.1904	3.1963	3.2021	3.2080	3.2138	600
610	3.2138	3.2197	3.2255	3.2314	3.2372	3.2431	3.2489	3.2548	3.2606	3.2665	3.2723	610
620	3.2723	3.2782	3.2840	3.2899	3.2958	3.3016	3.3075	3.3134	3.3192	3.3251	3.3310	620
630	3.3310	3.3368	3.3427	3.3486	3.3544	3.3603	3.3662	3.3721	3.3779	3.3838	3.3897	630
640	3.3897	3.3956	3.4015	3.4073	3.4132	3.4191	3.4250	3.4309	3.4368	3.4427	3.4485	640
650	3.4485	3.4544	3.4603	3.4662	3.4721	3.4780	3.4839	3.4898	3.4957	3.5016	3.5075	650
660	3.5075	3.5134	3.5193	3.5252	3.5311	3.5370	3.5429	3.5488	3.5547	3.5606	3.5666	660
670	3.5666	3.5725	3.5784	3.5843	3.5902	3.5961	3.6020	3.6080	3.6139	3.6198	3.6257	670
680	3.6257	3.6316	3.6376	3.6435	3.6494	3.6553	3.6613	3.6672	3.6731	3.6791	3.6850	680
690	3.6850	3.6909	3.6969	3.7028	3.7087	3.7147	3.7206	3.7265	3.7325	3.7384	3.7444	690
700	3.7444	3.7503	3.7562	3.7622	3.7681	3.7741	3.7800	3.7860	3.7919	3.7979	3.8038	700
710	3.8038	3.8098	3.8157	3.8217	3.8276	3.8336	3.8395	3.8455	3.8515	3.8574	3.8634	710
720	3.8634	3.8693	3.8753	3.8813	3.8872	3.8932	3.8992	3.9051	3.9111	3.9171	3.9230	720
730	3.9230	3.9290	3.9350	3.9409	3.9469	3.9529	3.9589	3.9648	3.9708	3.9768	3.9828	730
740	3.9828	3.9888	3.9947	4.0007	4.0067	4.0127	4.0187	4.0246	4.0306	4.0366	4.0426	740
750	4.0426	4.0486	4.0546	4.0606	4.0666	4.0726	4.0785	4.0845	4.0905	4.0965	4.1025	750
760	4.1025	4.1085	4.1145	4.1205	4.1265	4.1325	4.1385	4.1445	4.1505	4.1565	4.1625	760
770	4.1625	4.1685	4.1745	4.1805	4.1865	4.1925	4.1986	4.2046	4.2106	4.2166	4.2226	770
780	4.2226	4.2286	4.2346	4.2406	4.2466	4.2527	4.2587	4.2647	4.2707	4.2767	4.2828	780
790	4.2828	4.2888	4.2948	4.3008	4.3068	4.3129	4.3189	4.3249	4.3309	4.3370	4.3430	790
800	4.3430	4.3490	4.3550	4.3611	4.3671	4.3731	4.3792	4.3852	4.3912	4.3973	4.4033	800
810	4.4033	4.4093	4.4154	4.4214	4.4274	4.4335	4.4395	4.4455	4.4516	4.4576	4.4637	810
820	4.4637	4.4697	4.4757	4.4818	4.4878	4.4939	4.4999	4.5060	4.5120	4.5181	4.5241	820
830	4.5241	4.5302	4.5362	4.5422	4.5483	4.5543	4.5604	4.5665	4.5725	4.5786	4.5846	830
840	4.5846	4.5907	4.5967	4.6028	4.6088	4.6149	4.6209	4.6270	4.6331	4.6391	4.6452	840
850	4.6452	4.6512	4.6573	4.6634	4.6694	4.6755	4.6815	4.6876	4.6937	4.6997	4.7058	850
860	4.7058	4.7119	4.7179	4.7240	4.7301	4.7361	4.7422	4.7483	4.7543	4.7604	4.7665	860
870	4.7665	4.7726	4.7786	4.7847	4.7908	4.7968	4.8029	4.8090	4.8151	4.8211	4.8272	870
880	4.8272	4.8333	4.8394	4.8454	4.8515	4.8576	4.8637	4.8698	4.8758	4.8819	4.8880	880
890	4.8880	4.8941	4.9002	4.9062	4.9123	4.9184	4.9245	4.9306	4.9367	4.9427	4.9488	890
900	4.9488	4.9549	4.9610	4.9671	4.9732	4.9793	4.9853	4.9914	4.9975	5.0036	5.0097	900
910	5.0097	5.0158	5.0219	5.0280	5.0341	5.0402	5.0462	5.0523	5.0584	5.0645	5.0706	910
920	5.0706	5.0767	5.0828	5.0889	5.0950	5.1011	5.1072	5.1133	5.1194	5.1255	5.1316	920
930	5.1316	5.1377	5.1438	5.1498	5.1559	5.1620	5.1681	5.1742	5.1803	5.1864	5.1925	930
940	5.1925	5.1986	5.2047	5.2108	5.2169	5.2230	5.2291	5.2352	5.2413	5.2474	5.2535	940
950	5.2535	5.2596	5.2657	5.2718	5.2779	5.2841	5.2902	5.2963	5.3024	5.3085	5.3146	950
960	5.3146	5.3207	5.3268	5.3329	5.3390	5.3451	5.3512	5.3573	5.3634	5.3695	5.3756	960
970	5.3756	5.3817	5.3878	5.3939	5.4000	5.4061	5.4123	5.4184	5.4245	5.4306	5.4367	970
980	5.4367	5.4428	5.4489	5.4550	5.4611	5.4672	5.4733	5.4794	5.4855	5.4917	5.4978	980
990	5.4978	5.5039	5.5100	5.5161	5.5222	5.5283	5.5344	5.5405	5.5466	5.5527	5.5588	990
1,000	5.5588	5.5650	5.5711	5.5772	5.5833	5.5894	5.5955	5.6016	5.6077	5.6138	5.6199	1,000
1,010	5.6199	5.6260	5.6321	5.6383	5.6444	5.6505	5.6566	5.6627	5.6688	5.6749	5.6810	1,010
1,020	5.6810	5.6871	5.6932	5.6993	5.7055	5.7116	5.7177	5.7238	5.7299	5.7360	5.7421	1,020
1,030	5.7421	5.7482	5.7543	5.7604	5.7665	5.7726	5.7787	5.7849	5.7910	5.7971	5.8032	1,030
1,040	5.8032	5.8093	5.8154	5.8215	5.8276	5.8337	5.8398	5.8459	5.8520	5.8581	5.8642	1,040
1,050	5.8642	5.8703	5.8764	5.8825	5.8886	5.8948	5.9009	5.9070	5.9131	5.9192	5.9253	1,050
1,060	5.9253	5.9314	5.9375	5.9436	5.9497	5.9558	5.9619	5.9680	5.9741	5.9802	5.9863	1,060
1,070	5.9863	5.9924	5.9985	6.0046	6.0107	6.0168	6.0229	6.0290	6.0351	6.0412	6.0473	1,070
1,080	6.0473	6.0534	6.0595	6.0656	6.0717	6.0778	6.0839	6.0899	6.0960	6.1021	6.1082	1,080
1,090	6.1082	6.1143	6.1204	6.1265	6.1326	6.1387	6.1448	6.1509	6.1570	6.1631	6.1691	1,090
1,100	6.1691	6.1752	6.1813	6.1874	6.1935	6.1996	6.2057	6.2118	6.2178	6.2239	6.2300	1,100
1,110	6.2300	6.2361	6.2422	6.2483	6.2544	6.2604	6.2665	6.2726	6.2787	6.2848	6.2908	1,110
1,120	6.2908	6.2969	6.3030	6.3091	6.3152	6.3212	6.3273	6.3334	6.3395	6.3455	6.3516	1,120
1,130	6.3516	6.3577	6.3638	6.3698	6.3759	6.3820	6.3880	6.3941	6.4002	6.4063	6.4123	1,130
1,140	6.4123	6.4184	6.4245	6.4305	6.4366	6.4427	6.4487	6.4548	6.4608	6.4669	6.4730	1,140
1,150	6.4730	6.4790	6.4851	6.4912	6.4972	6.5033	6.5093	6.5154	6.5214	6.5275	6.5336	1,150
1,160	6.5336	6.5396	6.5457	6.5517	6.5578	6.5638	6.5699	6.5759	6.5820	6.5880	6.5941	1,160
1,170	6.5941	6.6001	6.6062	6.6122	6.6182	6.6243	6.6303	6.6364	6.6424	6.6484	6.6545	1,170
1,180	6.6545	6.6605	6.6666	6.6726	6.6786	6.6847	6.6907	6.6967	6.7028	6.7088	6.7148	1,180
1,190	6.7148	6.7209	6.7269	6.7329	6.7389	6.7450	6.7510	6.7570	6.7630	6.7691	6.7751	1,190
1,200	6.7751	6.7811	6.7871	6.7931	6.7992	6.8052	6.8112	6.8172	6.8232	6.8292	6.8352	1,200
°F	0	1	2	3	4	5	6	7	8	9	10	°F

TABLE C8. *Platinum,* Pt–67, *versus* AWG 14 *Nisil thermoelements—thermoelectric voltage as a function of temperature (°F), reference junctions at 32 °F*—Continued

°F	0	1	2	3	4	5	6	7	8	9	10	°F
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS											
1,200	6.7751	6.7811	6.7871	6.7931	6.7992	6.8052	6.8112	6.8172	6.8232	6.8292	6.8352	1,200
1,210	6.8352	6.8413	6.8473	6.8533	6.8593	6.8653	6.8713	6.8773	6.8833	6.8893	6.8953	1,210
1,220	6.8953	6.9013	6.9073	6.9133	6.9193	6.9253	6.9313	6.9373	6.9433	6.9493	6.9553	1,220
1,230	6.9553	6.9612	6.9672	6.9732	6.9792	6.9852	6.9912	6.9972	7.0031	7.0091	7.0151	1,230
1,240	7.0151	7.0211	7.0271	7.0330	7.0390	7.0450	7.0509	7.0569	7.0629	7.0689	7.0748	1,240
1,250	7.0748	7.0808	7.0868	7.0927	7.0987	7.1046	7.1106	7.1166	7.1225	7.1285	7.1344	1,250
1,260	7.1344	7.1404	7.1463	7.1523	7.1582	7.1642	7.1701	7.1761	7.1820	7.1880	7.1939	1,260
1,270	7.1939	7.1998	7.2058	7.2117	7.2177	7.2236	7.2295	7.2355	7.2414	7.2473	7.2533	1,270
1,280	7.2533	7.2592	7.2651	7.2710	7.2770	7.2829	7.2888	7.2947	7.3006	7.3065	7.3125	1,280
1,290	7.3125	7.3184	7.3243	7.3302	7.3361	7.3420	7.3479	7.3538	7.3597	7.3656	7.3715	1,290
1,300	7.3715	7.3774	7.3833	7.3892	7.3951	7.4010	7.4069	7.4128	7.4187	7.4246	7.4305	1,300
1,310	7.4305	7.4363	7.4422	7.4481	7.4540	7.4599	7.4657	7.4716	7.4775	7.4834	7.4892	1,310
1,320	7.4892	7.4951	7.5010	7.5068	7.5127	7.5185	7.5244	7.5303	7.5361	7.5420	7.5478	1,320
1,330	7.5478	7.5537	7.5595	7.5654	7.5712	7.5771	7.5829	7.5888	7.5946	7.6004	7.6063	1,330
1,340	7.6063	7.6121	7.6180	7.6238	7.6296	7.6354	7.6413	7.6471	7.6529	7.6587	7.6646	1,340
1,350	7.6646	7.6704	7.6762	7.6820	7.6878	7.6936	7.6995	7.7053	7.7111	7.7169	7.7227	1,350
1,360	7.7227	7.7285	7.7343	7.7401	7.7459	7.7517	7.7575	7.7633	7.7690	7.7748	7.7806	1,360
1,370	7.7806	7.7864	7.7922	7.7980	7.8037	7.8095	7.8153	7.8211	7.8268	7.8326	7.8384	1,370
1,380	7.8384	7.8441	7.8499	7.8557	7.8614	7.8672	7.8729	7.8787	7.8844	7.8902	7.8959	1,380
1,390	7.8959	7.9017	7.9074	7.9132	7.9189	7.9247	7.9304	7.9361	7.9419	7.9476	7.9533	1,390
1,400	7.9533	7.9591	7.9648	7.9705	7.9762	7.9820	7.9877	7.9934	7.9991	8.0048	8.0105	1,400
1,410	8.0105	8.0162	8.0219	8.0276	8.0333	8.0390	8.0447	8.0504	8.0561	8.0618	8.0675	1,410
1,420	8.0675	8.0732	8.0789	8.0846	8.0903	8.0959	8.1016	8.1073	8.1130	8.1186	8.1243	1,420
1,430	8.1243	8.1300	8.1356	8.1413	8.1470	8.1526	8.1583	8.1639	8.1696	8.1752	8.1809	1,430
1,440	8.1809	8.1865	8.1922	8.1978	8.2035	8.2091	8.2147	8.2204	8.2260	8.2316	8.2373	1,440
1,450	8.2373	8.2429	8.2485	8.2541	8.2598	8.2654	8.2710	8.2766	8.2822	8.2878	8.2934	1,450
1,460	8.2934	8.2990	8.3046	8.3102	8.3158	8.3214	8.3270	8.3326	8.3382	8.3438	8.3494	1,460
1,470	8.3494	8.3550	8.3605	8.3661	8.3717	8.3773	8.3828	8.3884	8.3940	8.3995	8.4051	1,470
1,480	8.4051	8.4107	8.4162	8.4218	8.4273	8.4329	8.4384	8.4440	8.4495	8.4551	8.4606	1,480
1,490	8.4606	8.4661	8.4717	8.4772	8.4827	8.4883	8.4938	8.4993	8.5048	8.5104	8.5159	1,490
1,500	8.5159	8.5214	8.5269	8.5324	8.5379	8.5434	8.5489	8.5544	8.5599	8.5654	8.5709	1,500
1,510	8.5709	8.5764	8.5819	8.5874	8.5929	8.5984	8.6038	8.6093	8.6148	8.6203	8.6257	1,510
1,520	8.6257	8.6312	8.6367	8.6421	8.6476	8.6531	8.6585	8.6640	8.6694	8.6749	8.6803	1,520
1,530	8.6803	8.6858	8.6912	8.6967	8.7021	8.7075	8.7130	8.7184	8.7238	8.7292	8.7347	1,530
1,540	8.7347	8.7401	8.7455	8.7509	8.7563	8.7617	8.7672	8.7726	8.7780	8.7834	8.7888	1,540
1,550	8.7888	8.7942	8.7996	8.8049	8.8103	8.8157	8.8211	8.8265	8.8319	8.8372	8.8426	1,550
1,560	8.8426	8.8480	8.8534	8.8587	8.8641	8.8695	8.8748	8.8802	8.8855	8.8909	8.8962	1,560
1,570	8.8962	8.9016	8.9069	8.9123	8.9176	8.9229	8.9283	8.9336	8.9389	8.9443	8.9496	1,570
1,580	8.9496	8.9549	8.9602	8.9656	8.9709	8.9762	8.9815	8.9868	8.9921	8.9974	9.0027	1,580
1,590	9.0027	9.0080	9.0133	9.0186	9.0239	9.0292	9.0345	9.0397	9.0450	9.0503	9.0556	1,590
1,600	9.0556	9.0608	9.0661	9.0714	9.0766	9.0819	9.0872	9.0924	9.0977	9.1029	9.1082	1,600
1,610	9.1082	9.1134	9.1187	9.1239	9.1292	9.1344	9.1396	9.1449	9.1501	9.1553	9.1605	1,610
1,620	9.1605	9.1658	9.1710	9.1762	9.1814	9.1866	9.1918	9.1970	9.2022	9.2074	9.2126	1,620
1,630	9.2126	9.2178	9.2230	9.2282	9.2334	9.2386	9.2438	9.2489	9.2541	9.2593	9.2645	1,630
1,640	9.2645	9.2696	9.2748	9.2800	9.2851	9.2903	9.2955	9.3006	9.3058	9.3109	9.3161	1,640
1,650	9.3161	9.3212	9.3263	9.3315	9.3366	9.3417	9.3469	9.3520	9.3571	9.3623	9.3674	1,650
1,660	9.3674	9.3725	9.3776	9.3827	9.3878	9.3929	9.3980	9.4031	9.4082	9.4133	9.4184	1,660
1,670	9.4184	9.4235	9.4286	9.4337	9.4388	9.4439	9.4489	9.4540	9.4591	9.4642	9.4692	1,670
1,680	9.4692	9.4743	9.4793	9.4844	9.4895	9.4945	9.4996	9.5046	9.5097	9.5147	9.5198	1,680
1,690	9.5198	9.5248	9.5298	9.5349	9.5399	9.5449	9.5499	9.5550	9.5600	9.5650	9.5700	1,690
1,700	9.5700	9.5750	9.5800	9.5850	9.5900	9.5950	9.6000	9.6050	9.6100	9.6150	9.6200	1,700
1,710	9.6200	9.6250	9.6300	9.6350	9.6399	9.6449	9.6499	9.6549	9.6598	9.6648	9.6697	1,710
1,720	9.6697	9.6747	9.6797	9.6846	9.6896	9.6945	9.6995	9.7044	9.7093	9.7143	9.7192	1,720
1,730	9.7192	9.7241	9.7291	9.7340	9.7389	9.7438	9.7488	9.7537	9.7586	9.7635	9.7684	1,730
1,740	9.7684	9.7733	9.7782	9.7831	9.7880	9.7929	9.7978	9.8027	9.8076	9.8125	9.8173	1,740
1,750	9.8173	9.8222	9.8271	9.8320	9.8368	9.8417	9.8466	9.8514	9.8563	9.8612	9.8660	1,750
1,760	9.8660	9.8709	9.8757	9.8806	9.8854	9.8902	9.8951	9.8999	9.9047	9.9096	9.9144	1,760
1,770	9.9144	9.9192	9.9240	9.9289	9.9337	9.9385	9.9433	9.9481	9.9529	9.9577	9.9625	1,770
1,780	9.9625	9.9673	9.9721	9.9769	9.9817	9.9865	9.9913	9.9960	10.0008	10.0056	10.0104	1,780
1,790	10.0104	10.0151	10.0199	10.0247	10.0294	10.0342	10.0390	10.0437	10.0485	10.0532	10.0580	1,790
1,800	10.0580	10.0627	10.0674	10.0722	10.0769	10.0816	10.0864	10.0911	10.0958	10.1005	10.1053	1,800
°F	0	1	2	3	4	5	6	7	8	9	10	°F

TABLE C8. *Platinum,* Pt–67, *versus* AWG 14 *Nisil thermoelements—thermoelectric voltage as a function of temperature (°F), reference junctions at 32 °F*—Continued

THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS

°F	0	1	2	3	4	5	6	7	8	9	10	°F
1,800	10.0580	10.0627	10.0674	10.0722	10.0769	10.0816	10.0864	10.0911	10.0958	10.1005	10.1053	1,800
1,810	10.1053	10.1100	10.1147	10.1194	10.1241	10.1288	10.1335	10.1382	10.1429	10.1476	10.1523	1,810
1,820	10.1523	10.1570	10.1617	10.1664	10.1710	10.1757	10.1804	10.1851	10.1897	10.1944	10.1991	1,820
1,830	10.1991	10.2037	10.2084	10.2131	10.2177	10.2224	10.2270	10.2317	10.2363	10.2409	10.2456	1,830
1,840	10.2456	10.2502	10.2548	10.2595	10.2641	10.2687	10.2733	10.2780	10.2826	10.2872	10.2918	1,840
1,850	10.2918	10.2964	10.3010	10.3056	10.3102	10.3148	10.3194	10.3240	10.3286	10.3332	10.3377	1,850
1,860	10.3377	10.3423	10.3469	10.3515	10.3560	10.3606	10.3652	10.3697	10.3743	10.3789	10.3834	1,860
1,870	10.3834	10.3880	10.3925	10.3971	10.4016	10.4062	10.4107	10.4152	10.4198	10.4243	10.4288	1,870
1,880	10.4288	10.4333	10.4379	10.4424	10.4469	10.4514	10.4559	10.4604	10.4649	10.4695	10.4740	1,880
1,890	10.4740	10.4785	10.4829	10.4874	10.4919	10.4964	10.5009	10.5054	10.5099	10.5143	10.5188	1,890
1,900	10.5188	10.5233	10.5277	10.5322	10.5367	10.5411	10.5456	10.5500	10.5545	10.5589	10.5634	1,900
1,910	10.5634	10.5678	10.5723	10.5767	10.5811	10.5856	10.5900	10.5944	10.5988	10.6033	10.6077	1,910
1,920	10.6077	10.6121	10.6165	10.6209	10.6253	10.6297	10.6341	10.6385	10.6429	10.6473	10.6517	1,920
1,930	10.6517	10.6561	10.6605	10.6649	10.6692	10.6736	10.6780	10.6823	10.6867	10.6911	10.6954	1,930
1,940	10.6954	10.6998	10.7042	10.7085	10.7129	10.7172	10.7216	10.7259	10.7302	10.7346	10.7389	1,940
1,950	10.7389	10.7432	10.7476	10.7519	10.7562	10.7605	10.7648	10.7692	10.7735	10.7778	10.7821	1,950
1,960	10.7821	10.7864	10.7907	10.7950	10.7993	10.8036	10.8079	10.8121	10.8164	10.8207	10.8250	1,960
1,970	10.8250	10.8293	10.8335	10.8378	10.8421	10.8463	10.8506	10.8548	10.8591	10.8633	10.8676	1,970
1,980	10.8676	10.8718	10.8761	10.8803	10.8846	10.8888	10.8930	10.8972	10.9015	10.9057	10.9099	1,980
1,990	10.9099	10.9141	10.9183	10.9226	10.9268	10.9310	10.9352	10.9394	10.9436	10.9478	10.9520	1,990
2,000	10.9520	10.9561	10.9603	10.9645	10.9687	10.9729	10.9770	10.9812	10.9854	10.9895	10.9937	2,000
2,010	10.9937	10.9979	11.0020	11.0062	11.0103	11.0145	11.0186	11.0228	11.0269	11.0310	11.0352	2,010
2,020	11.0352	11.0393	11.0434	11.0475	11.0517	11.0558	11.0599	11.0640	11.0681	11.0722	11.0763	2,020
2,030	11.0763	11.0804	11.0845	11.0886	11.0927	11.0968	11.1009	11.1050	11.1090	11.1131	11.1172	2,030
2,040	11.1172	11.1213	11.1253	11.1294	11.1335	11.1375	11.1416	11.1456	11.1497	11.1537	11.1578	2,040
2,050	11.1578	11.1618	11.1658	11.1699	11.1739	11.1779	11.1820	11.1860	11.1900	11.1940	11.1980	2,050
2,060	11.1980	11.2021	11.2061	11.2101	11.2141	11.2181	11.2221	11.2261	11.2300	11.2340	11.2380	2,060
2,070	11.2380	11.2420	11.2460	11.2499	11.2539	11.2579	11.2618	11.2658	11.2698	11.2737	11.2777	2,070
2,080	11.2777	11.2816	11.2856	11.2895	11.2935	11.2974	11.3013	11.3053	11.3092	11.3131	11.3170	2,080
2,090	11.3170	11.3209	11.3249	11.3288	11.3327	11.3366	11.3405	11.3444	11.3483	11.3522	11.3561	2,090
2,100	11.3561	11.3600	11.3638	11.3677	11.3716	11.3755	11.3794	11.3832	11.3871	11.3909	11.3948	2,100
2,110	11.3948	11.3987	11.4025	11.4064	11.4102	11.4141	11.4179	11.4217	11.4256	11.4294	11.4332	2,110
2,120	11.4332	11.4370	11.4409	11.4447	11.4485	11.4523	11.4561	11.4599	11.4637	11.4675	11.4713	2,120
2,130	11.4713	11.4751	11.4789	11.4827	11.4865	11.4903	11.4940	11.4978	11.5016	11.5053	11.5091	2,130
2,140	11.5091	11.5129	11.5166	11.5204	11.5241	11.5279	11.5316	11.5353	11.5391	11.5428	11.5465	2,140
2,150	11.5465	11.5503	11.5540	11.5577	11.5614	11.5652	11.5689	11.5726	11.5763	11.5800	11.5837	2,150
2,160	11.5837	11.5874	11.5911	11.5947	11.5984	11.6021	11.6058	11.6095	11.6131	11.6168	11.6205	2,160
2,170	11.6205	11.6241	11.6278	11.6314	11.6351	11.6387	11.6424	11.6460	11.6497	11.6533	11.6569	2,170
2,180	11.6569	11.6606	11.6642	11.6678	11.6714	11.6750	11.6786	11.6823	11.6859	11.6895	11.6931	2,180
2,190	11.6931	11.6966	11.7002	11.7038	11.7074	11.7110	11.7146	11.7181	11.7217	11.7253	11.7288	2,190
2,200	11.7288	11.7324	11.7360	11.7395	11.7431	11.7466	11.7502	11.7537	11.7572	11.7608	11.7643	2,200
2,210	11.7643	11.7678	11.7713	11.7749	11.7784	11.7819	11.7854	11.7889	11.7924	11.7959	11.7994	2,210
2,220	11.7994	11.8029	11.8064	11.8099	11.8133	11.8168	11.8203	11.8238	11.8272	11.8307	11.8342	2,220
2,230	11.8342	11.8376	11.8411	11.8445	11.8480	11.8514	11.8548	11.8583	11.8617	11.8651	11.8686	2,230
2,240	11.8686	11.8720	11.8754	11.8788	11.8822	11.8857	11.8891	11.8925	11.8959	11.8993	11.9026	2,240
2,250	11.9026	11.9060	11.9094	11.9128	11.9162	11.9195	11.9229	11.9263	11.9296	11.9330	11.9364	2,250
2,260	11.9364	11.9397	11.9431	11.9464	11.9498	11.9531	11.9564	11.9598	11.9631	11.9664	11.9697	2,260
2,270	11.9697	11.9731	11.9764	11.9797	11.9830	11.9863	11.9896	11.9929	11.9962	11.9995	12.0028	2,270
2,280	12.0028	12.0061	12.0093	12.0126	12.0159	12.0192	12.0224	12.0257	12.0289	12.0322	12.0354	2,280
2,290	12.0354	12.0387	12.0419	12.0452	12.0484	12.0517	12.0549	12.0581	12.0613	12.0646	12.0678	2,290
2,300	12.0678	12.0710	12.0742	12.0774	12.0806	12.0838	12.0870	12.0902	12.0934	12.0966	12.0998	2,300
2,310	12.0998	12.1030	12.1061	12.1093	12.1125	12.1156	12.1188	12.1220	12.1251	12.1283	12.1314	2,310
2,320	12.1314	12.1346	12.1377	12.1409	12.1440	12.1471	12.1503	12.1534	12.1565	12.1596	12.1628	2,320
2,330	12.1628	12.1659	12.1690	12.1721	12.1752	12.1783	12.1814	12.1845	12.1876	12.1907	12.1937	2,330
2,340	12.1937	12.1968	12.1999	12.2030	12.2060	12.2091	12.2122	12.2152	12.2183	12.2214	12.2244	2,340
2,350	12.2244	12.2275	12.2305	12.2335	12.2366	12.2396	12.2426	12.2457	12.2487	12.2517	12.2547	2,350
2,360	12.2547	12.2578	12.2608	12.2638	12.2668	12.2698	12.2728	12.2758	12.2788	12.2818	12.2848	2,360
2,370	12.2848	12.2878	12.2908									2,370
°F	0	1	2	3	4	5	6	7	8	9	10	°F

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16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

This monograph deals with the formulation and development of the new highly stable nickel-base thermocouple alloys *Nicrosil* (Ni-14.2Cr-1.4Si) and *Nisil* (Ni-4.4Si-0.1Mg) under the leadership of the Materials Research Laboratories (MRL) of the Australian Government Department of Defence, and their standardization by the National Bureau of Standards (NBS) of the U.S. Department of Commerce.

In the formulation of the new alloys, the main method was to use basic thermodynamic data to predict the conditions of solute concentration, temperature and oxygen pressure under which certain discrete oxide layers could form on the surface as highly efficacious passivating films. This work was the culmination of extensive research in which thermoelectric instability in existing nickel-base thermocouple alloys was correlated with their physical, chemical and metallurgical properties (section 2). The basic thermoelectric properties of Nicrosil and Nisil more recently have been the subject of a joint research project between NBS and MRL. The aim of this project, which was conducted under the terms of an Arrangement under the U.S./Australia Agreement relating to Scientific and Technical Co-operation, was to establish a body of standard reference data on the thermoelectric and other properties of the new thermocouple alloys which could be recognized by various standards authorities around the world.

Cont.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)* Calibration drift; chemical analyses; nickel-base alloys; nickel-chromium alloys; nickel-silicon alloys; oxidation; temperature; thermal electromotive force; thermocouples; thermocouple reference tables; thermoelements; thermometry.

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Descriptions of the prototype materials and experimental methods used in the joint research are given in sections 3 and 4, while the mathematical methods used to analyze the experimental results are described in section 5. The principal thermoelectric reference data for Nicrosil and Nisil, comprising tabular values of thermoelectric voltages, Seebeck coefficients and derivatives versus temperature, are given in section 7, while other material characteristics, in particular their highly stable thermoelectric properties, are summarized in section 6.

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