



Standard Guide for Use of Thermocouples in Creep and Stress-Rupture Testing to 1800°F (1000°C) in Air¹

This standard is issued under the fixed designation E 633; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

This guide provides basic information, options, and guidelines to enable the user to apply thermocouples, temperature measurement, and control equipment with sufficient accuracy to satisfy the temperature requirements for creep and stress-rupture testing of materials.

1. Scope

1.1 This guide covers the use of ANSI/ISA thermocouple Types K, N, R, and S for creep and stress-rupture testing at temperatures up to 1800°F (1000°C) in air at one atmosphere of pressure. It does not cover the use of sheathed thermocouples.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

- E 139 Practice for Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials²
- E 207 Method of Thermal EMF Test of Single Thermoelement Materials by Comparison with a Secondary Standard of Similar EMF-Temperature Properties³
- E 220 Test Method for Calibration of Thermocouples by Comparison Techniques³
- E 230 Specification and Temperature-Electromotive Force (EMF) Tables for Standardized Thermocouples³
- E 292 Practice for Conducting Time-For-Rupture Notch Tension Tests of Materials²
- E 344 Terminology Relating to Thermometry and Hydrometry³
- E 574 Specification for Duplex Base Metal Thermocouple

Wire with Glass Fiber or Silica Fiber Insulation³

E 1129/E 1129M Specification for Thermocouple Connectors³

E 1684 Specification for Miniature Thermocouple Connectors³

3. Terminology

3.1 *Definitions*—Unless otherwise indicated, the definitions given in Terminology E 344 shall apply.

4. Classification

4.1 The following thermocouple types are identified in Tables E 230:

4.1.1 *Type K*—Nickel—10 % chromium (+) versus nickel—5 % (aluminum, silicon) (–),

4.1.2 *Type N*—Nickel—14 % chromium, 1.5 % silicon (+) versus nickel—4.5 % silicon—0.1 % magnesium (–),

4.1.3 *Type R*—Platinum—13 % rhodium (+) versus platinum (–),

4.1.4 *Type S*—Platinum—10 % rhodium (+) versus platinum (–).

5. Summary of Guide

5.1 This guide will help the user to conduct a creep or stress-rupture test with the highest degree of temperature precision available. It provides information on the proper application of thermocouples that are used to measure and control the temperature of the test specimen. It also points out sources of error and suggests methods to eliminate them.

6. Significance and Use

6.1 This guide presents techniques on the use of thermocouples and associated equipment for measuring temperature in creep and stress-rupture testing in air at temperatures up to 1800°F (1000°C).

6.2 Since creep and stress-rupture properties are highly sensitive to temperature, users should make every effort practicable to make accurate temperature measurements and

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² *Annual Book of ASTM Standards*, Vol 03.01.

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

provide stable control of the test temperature. The goal of this guide is to provide users with good pyrometric practice and techniques for precise temperature control for creep and stress-rupture testing.

6.3 Techniques are given in this guide for maintaining a stable temperature throughout the period of test.

6.4 If the techniques of this guide are followed, the difference between “indicated”⁴ temperature and “true”⁵ temperature will be reduced to the lowest practical level.

7. Apparatus

7.1 Instrumentation may be individual instruments, a data acquisition system (multipoint recorders or digital type), a computer-based control system, or a combination of these devices. (**Warning**—Since each thermocouple is “grounded” by contacting the specimen, it is necessary that the instrumentation treat each thermocouple as isolated or “floating” from all other thermocouples. Neither leg should be connected to a common ground at the instrumentation end of the system. Also, equipment having a high common mode rejection ratio is necessary because of the proximity of strong electromagnetic fields from the heating elements of the furnace.)

7.2 *Temperature Measurement Instrumentation*—The measurement system should be able to resolve the thermocouple signal to $\pm 0.1^\circ\text{F}$ (0.05°C). The temperature indication should have no more than $\pm 1.0^\circ\text{F}$ (0.5°C) uncertainty for the purposes of this test. In addition, where specific corrections for the calibration of individual thermocouples or a thermocouple lot is required, the capability of the instrumentation system to accommodate these data shall be considered.

7.2.1 Reference Junction Compensation:

7.2.1.1 Thermocouples are usually calibrated to a 32°F (0°C) reference temperature. Unless an ice point reference is used, some means must be provided to compensate for the temperature where the thermoelectric circuit connects to the instrument (refer to MNL-12 on Reference Junctions⁶).

7.2.1.2 Reference junction compensation is usually performed within the instrumentation itself. Most devices or electronic data acquisition systems measure the temperature where the thermoelements connect to the input terminals and introduce a compensating emf to simulate the ice point.

7.2.1.3 The input connections shall be isothermal and shielded from sudden changes of temperature.

7.2.2 *Recalibration*—The accuracy of the temperature measurement equipment may be affected by component aging, environment, handling, or wear. Therefore, a periodic recalibration of the measuring instrumentation with a checking instrument is necessary. The checking instrument should be of higher accuracy than the measurement system, and to ensure conformity to national standards, it should be calibrated with a known primary test standard, traceable to the National Institute of Standards and Technology.

7.3 *Temperature Control Equipment Requirements*—A temperature controller or temperature control system should be

selected on the basis of stability (variations of $\pm 1^\circ\text{F}$ (0.5°C) or less), and accuracy (uncertainty of $\pm 1.5^\circ\text{F}$ (0.7°C) or less). Generally, a control system with proportional band, automatic reset, and slow approach to final set point features should be used. When employing an automatic feedback control system, the tuning constants or control algorithm shall be optimized, not only to maintain the test specimen at the set point without excessive deviations, but to eliminate or limit the amount of overshoot upon initial heating.

NOTE 1—The same precautions regarding reference junction compensation in the control device apply as in 7.2.1.

7.3.1 *Configuration*—The control configuration may take one of several forms:

7.3.1.1 The center thermocouple is connected to a control loop that strives to maintain the temperature of the center of the reduced section at set point. The upper and lower thermocouples are used to measure the temperatures at the ends of the reduced section. Means shall be provided to adjust the heating power above and below the center to equalize the temperatures.

7.3.1.2 The bottom and top thermocouples may be connected to control loops that regulate the power to the upper and lower heaters independently. Thus, the end temperatures are maintained automatically. The center thermocouple is used only as a monitor.

7.3.2 *Control System Recalibration and Reliability*—The control system should be subjected to routine recalibration, as circumstances and type of equipment dictate. The checking procedure should include calibration of the controller and a sensitivity check. A calibration circuit, as shown in Appendix X1, should be employed.

7.4 *Heating Equipment*—Furnaces should be appropriately sized or adjusted relative to the workload and heat losses to provide a zone of uniform temperature across the specimen. Because creep and stress-rupture testing is usually done at constant temperature and with an unchanging furnace load, the main requirement is a well-insulated furnace, capable of achieving the desired temperatures. The top and bottom openings should be closed to limit convection losses, but the furnace should not be sealed airtight.

8. Hazards

8.1 The duration of a creep test ranges from a few hours to several hundred hours at elevated temperatures, at least partially unattended by operators. Such tests are normally ended before test specimen failure. Stress-rupture tests may operate at higher stresses, higher temperatures, and for shorter times than creep tests, but they normally continue until the specimen has achieved its required life or has failed.

8.2 The stability of the emf of the thermocouples and the rapid response of the control system to any changes of temperature over the period of the test are crucial to maintain the specimen within the allowable temperature band.

8.3 *Thermocouple Requirements*—The requirements for thermocouples used for measurement are somewhat different from thermocouples used for control purposes (especially with automatic feedback control systems). Of course, both requirements may be met with one set of thermocouples that is judiciously chosen and placed.

⁴ As defined in Practices E 139 and E 292.

⁵ As defined in Practice E 139.

⁶ Manual on the Use of Thermocouples in Temperature Measurement, ASTM MNL-12.

8.3.1 *Measurement*—Thermocouples used for measurement are designed to represent the temperature of the specimen along its reduced section.⁵ Since only two or three thermocouples are used, they shall be located at places on the specimen that represent the average temperature of their respective sections. This can be determined by a test program, where more than the usual number of thermocouples are mounted along the reduced section to establish the temperature profile.

8.3.2 *Control*—Thermocouples used for control are designed and placed to be sensitive to changes of or impending changes to the temperature of the specimen. Control thermocouple wire should be as thin as possible. However, the wire should not be so thin that oxidation or strain would cause emf errors or failure during the test period.

NOTE 2—Locating a control thermocouple next to the heater as a means to limit fluctuations of temperature is not advisable. A controller with a wide proportional band and automatic reset is capable of compensating for the thermal lag of most furnace designs.

9. Thermocouples

9.1 *Basic Information*—Information on basic thermocouple characteristics and performance is available from ASTM publications such as MNL-12.⁶ Stability of the emf over the period of test is the most crucial requirement for a control thermocouple, whereas accuracy of the measurement thermocouple is paramount for successful correlation of test results.

9.1.1 Factors affecting thermocouple selection are: atmosphere, temperature of exposure, duration of testing, and response time. These factors should be considered to determine type (K, N, R, or S), wire size, insulation, and installation methods.

9.2 *Precautions*—The emf output of a thermocouple is affected by inhomogeneities in the region of a temperature gradient. Inhomogeneities are produced by cold work, contamination, or metallurgical changes produced by temperature itself. Therefore, thermocouples should be handled carefully without unnecessary stretching, bending, or twisting the wires. Bending around small radii should be avoided entirely, especially where the wires may lie in a temperature gradient. Where necessary, a minimum amount of bending may be performed carefully around bend radii at least 20 times the diameter of the wire.

9.3 *Types K and N Thermocouples:*

9.3.1 *Suitability*—Types K and N thermocouples are useful for creep and rupture testing because they provide a relatively high emf and are relatively stable over the low and middle temperatures of the testing range.

9.3.2 *Limitations*—Conventional Type K, and to a lesser extent, Type N thermocouples undergo emf drift as the result of metallurgical changes during use. Therefore, that portion of wire that has been exposed to temperatures above 500°F (260°C) or 1600°F (870°C) for Types K and N thermocouples, respectively, should be discarded after one use.

9.3.3 *Assessment*—Type K or N thermocouples should be reused only after their suitability for a particular test program is proven by a body of test data. Stability tests are advised, using Type R or S thermocouples as references.

9.4 *Types R and S Thermocouples:*

TABLE 1 Thermocouple and Extension Wire Tolerances and Calibration Uncertainties

Thermocouples, °F				
Type	Temperature Range	Tolerance Standard ^A	Special	Typical Calibration Uncertainty ^B
K, N	32 to 2000	4 or 0.75 %	2 or 0.4 %	1.8 to 2.2
S, R	32 to 2000	2.7 or 0.25 %	1 or 0.1 %	1.1 to 1.2
Extension Wire, °F ^C				
KX, NX	32 to 400	4	^D	0.5 to 2
RX, SX	32 to 400	9	^D	2 to 4
Thermocouples, °C				
Type	Temperature Range	Tolerance Standard ^A	Special	Calibration Uncertainty ^B
K, N	0 to 1100	2.2 or 0.75 %	1.1 or 0.4 %	1 to 1.2
R, S	0 to 1100	1.5 or 0.25 %	0.6 or 0.1 %	0.6 to 0.7
Extension Wire, °C ^C				
KX, NX	0 to + 200	2	^D	0.3 to 1
RX, SX	0 to + 200	5	^D	1 to 2

^A Tolerances and uncertainties are plus or minus the indicated values expressed in degrees Fahrenheit or degrees Celsius or as a percentage of the value of the measured temperature, whichever is greater (see Tables 1, 2, and 3 in Specification E 230).

^B Calibration uncertainty in an actual test depends on number of test points, media, and reference standard used during the calibration (see Test Method E 220).

^C Worst case, where the temperature of the transition point differs from the instrument's reference junction by 360°F (200°C).

^D No special tolerance limits have been established, but materials with tolerances closer than the standard limits may be available.

9.4.1 *Suitability*—Types R and S are highly resistant to oxidation and are therefore stable for these tests at the higher temperatures of the range. They provide the highest reproducibility and repeatability of the several thermocouple types but are initially more costly. Because they do not deteriorate during normal use, it is possible to reuse them. When Types R and S wires are no longer suitable for service, they still retain a significant portion of their initial cost in salvage value.

9.4.2 *Limitations*—The limiting factor for reuse of Type R or S thermocouples is error introduced by strain or contamination. Wires of Types R and S are mechanically weaker than Types K and N, so they must be adequately supported to avoid straining them. Sufficient slack should be provided so that the wires do not strain or tear when the specimen elongates. Contamination of the wire⁷ may be caused by oils, grease, or other chemicals, and from metallic vapors from the test specimen during heating.

9.4.3 *Assessment*—A Type R or S thermocouple should not be used indefinitely. One way to determine the end of its useful life is to place a new thermocouple from the same lot beside the old one and compare outputs. Replace the older thermocouple when the change exceeds the uncertainty indicated on Table 1. Special precaution is advised to avoid errors arising from the use of compensating extension wires. See Table 1.

9.5 *Stability*—Studies have been made to determine emf stability with time of the thermocouple types covered by this guide. Results of those investigations show that the Types R and S thermocouples may be expected to have greater stability

⁷ "Creep and Rupture Test Pyrometry," Charles R. Wilks, ASTM Special Technical Publication No. 178—Panel Discussion on Pyrometric Practices, Presented at the 58th Annual Meeting, June 30, 1955.

TABLE 2 Relative Stability of Thermocouples

Thermocouple Type		
R or S	N	K
Most stable	Intermediate	Least stable

under favorable conditions than either Type K or N. Other work indicates Type N is more stable than Type K.⁸ Relative stabilities are summarized in Table 2.

9.6 Calibration:

9.6.1 *Method*—Calibration of thermocouples should be done on representative lot samples with Test Method E 220. Recalibration of used thermocouples that may contain inhomogeneities is not recommended unless it can be performed in place and under actual conditions of use.

9.6.2 *Thermocouple and Extension Wire Tolerance Grades*—Thermocouples are commercially available in two tolerance grades, as given in Specification E 230. In lieu of ordering special or better tolerances, it is advisable that the calibration of a specific lot of wire be determined. This should be done by actual calibration of representative samples to determine the specific emf temperature relation of each wire lot. An estimate of the uncertainties contributed by wire selection and testing is included in Table 1. Extension wire Types KX and NX are commercially available in two tolerances, but only the standard tolerances of Specification E 230 are stated here. Compensating extension wires for Types R and S are available in several tolerances but only the standard tolerances of Specification E 230 for Types RX and SX are included here.

9.6.2.1 The values of thermocouple tolerances given here represent initial values, applicable only to new thermocouple material in the as-manufactured condition. The emf of a thermocouple during use may change.

9.6.2.2 The stability of special emf tolerance wire is not necessarily greater than standard emf tolerance wire. Special emf tolerance is attained by mating selected pairs of the two wires. Emf stability is an inherent characteristic of the thermocouple alloys relative to the environment in which they are used.

9.6.2.3 Because of an expected emf shift after initial heating to high temperature and the development of inhomogeneities in the wire, it is not recommended that individual Type K or Type N thermocouples be calibrated and subsequently used to make critical temperature measurements. It is preferable to calibrate representative thermocouples from sections of each spool of wire instead and make the measurements with unheated thermocouples made from those spools.

9.6.3 *Other Tolerances and Compensations*—Requesting tighter tolerances than special grade from the thermocouple provider is possible but not advisable. It may incur higher costs and difficulties with availability. A more practical approach would be to calibrate samples from the lot, and apply corrections (manually or automatically) to the instrumentation to match the emf-temperature curve of the lot over the range of test.

9.7 Insulation:

9.7.1 Any degradation or decomposition of the electrical insulation between the thermocouple wires can introduce errors in the indicated temperature. Pre-insulated wire is acceptable if it is used within the temperature constraints given in Specification E 574. The basic kinds of materials for this use are fiberglass, fibrous silica, or fibrous ceramic. Impregnants should be avoided, since they may contaminate the thermocouple or test specimen. (**Warning**—Silica or insulations containing boron are not suitable for use with platinum or its alloys at high temperatures.)

9.7.2 *Ceramic Sleeves and Beads*—Hard-fired unglazed ceramic insulators are preferred to insulate the thermocouple at the higher temperatures. Mullite (alumina + silica) insulators may be used with either Type K or Type N thermoelements. Type R and S thermoelements require high purity insulators (96 % minimum alumina).

9.7.3 *Reuse of Insulators*—Insulators may become soiled or contaminated by careless or inappropriate storage or handling. Because soiled or contaminated insulators can produce conduction, only clean insulators (new or used) should be used for this work.

9.8 Thermocouple Junction Fabrication:

9.8.1 *Wire Preparation*—Cut the thermoelement wires to length. Strip the wires with tools that do not nick the surface. Avoid excessive stretching and cold working the wire. Discard ends damaged by gripping. Wear latex, plastic, or clean cloth gloves to avoid contaminating the wires with dirty hands.

9.8.2 *Welded Junctions*—The diameter of the weld bead should not exceed four times the diameter of a single thermoelement wire.

9.8.2.1 Fusion of Types K and N by the tungsten-inert-gas (TIG) process is preferred. Processes based on electric arc or other non-contact fusion principles as well as electric resistance welding may be used. A clean, sound weld junction shall be produced. Fluxes, filler materials, or mercury processes should not be used.

9.8.2.2 For Type R or S junctions, an oxygen-gas torch with an excess-oxygen flame is suitable, however, this process is not recommended for Types K or N materials.

9.8.3 *Mechanical Junctions*—Compression fittings are acceptable, provided their durability for the intended use is demonstrated. When using compression-type junctions, it is convenient to insert the thermoelement ends into the fitting from opposite directions so that each end extends sufficiently beyond it. This facilitates attaching the thermocouple to the specimen using the thermocouple wires themselves (see 9.10.4).

9.9 *Installation of Thermocouples*—Locate the measurement thermocouples as indicated by the profile test (see 8.3.1). Exact location of the control thermocouples will depend upon the specimen configuration and the heating system.

9.10 Attachment of Thermocouples:

9.10.1 *Precautions*—Attach the thermocouples to the specimen in such a way that the thermocouple measuring junction will attain thermal equilibrium with the test specimen at the attachment point. This should be done without affecting the specimen in any way. In general, the thermocouple shall be

⁸ "The Nicrosil versus Nisil Thermocouple: Properties and Thermoelectric Reference Data," NBS Monograph 161, April 1978, U.S. Dept. of Commerce, NIST, Gaithersburg, MD. Also see RR:E20-1001, available from ASTM.

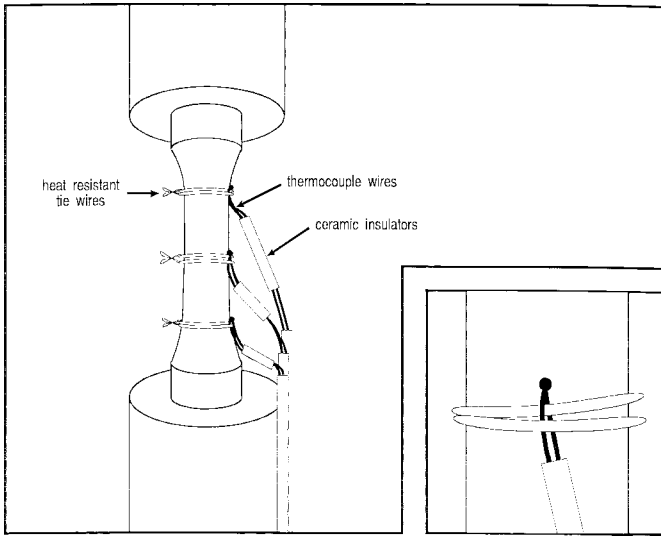


FIG. 1 Installation with Welded Junctions (Inset: Attachment Detail)

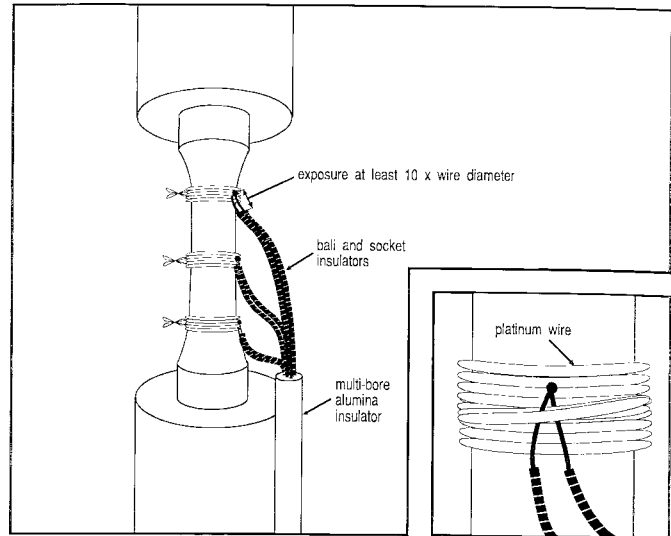


FIG. 2 Installation of Type R or S Thermocouples (Inset: Attachment Detail)

held tightly against the specimen with as good a thermal contact as possible.

9.10.2 One way to check attachment is to prepare two thermocouples that are cut adjacent from the same spool of wires. Spot weld the ends of one thermocouple to the surface, or bury its junction in a tight-fitting hole close to the junction of the attached thermocouple in an expendable sample. Compare readings of the two at operating temperatures.

9.10.3 *Welded Junctions*—The measuring junction shall be held against the specimen by wrapping a length of heat-resistant alloy wire of approximately the same diameter directly across the wires immediately behind the junction and around the specimen, as illustrated in Fig. 1. To minimize contamination of Type R or S thermocouples, employ the technique shown in Fig. 2.

NOTE 3—By wrapping a conductor across the thermoelements, the weld bead becomes shorted. This is not necessarily poor practice; it merely shifts the measuring junction from the weld bead to the points of conduction. Also, the third conductor will not affect the emf, if the path between the positive and negative legs is isothermal. In that case, the resultant emf will be that of the thermocouple wires, and it will be unaffected by the third metal.

9.10.4 *Compression Junctions*—Attach crimped-type compression junctions by wrapping the free ends of the thermocouple wires around the specimen from opposite directions as illustrated in Fig. 3. A crimped flat on the fitting should seat against the specimen to promote good thermal contact with it.

9.10.5 *Alternate Attachments*—Other forms of thermocouple junctions or different methods of attachment may be used. Their suitability for a given test program should be demonstrated by experience or test. Any such substitute techniques shall satisfy the fundamental requirements outlined in 9.10.1.

9.11 *Thermocouple Wire Support*—Thermocouple wires and insulators should be attached to the specimen and grips to adequately support the assembly until it reaches the outside of the furnace. Sufficient slack of the wires should be provided so that any specimen elongation will carry the thermocouple

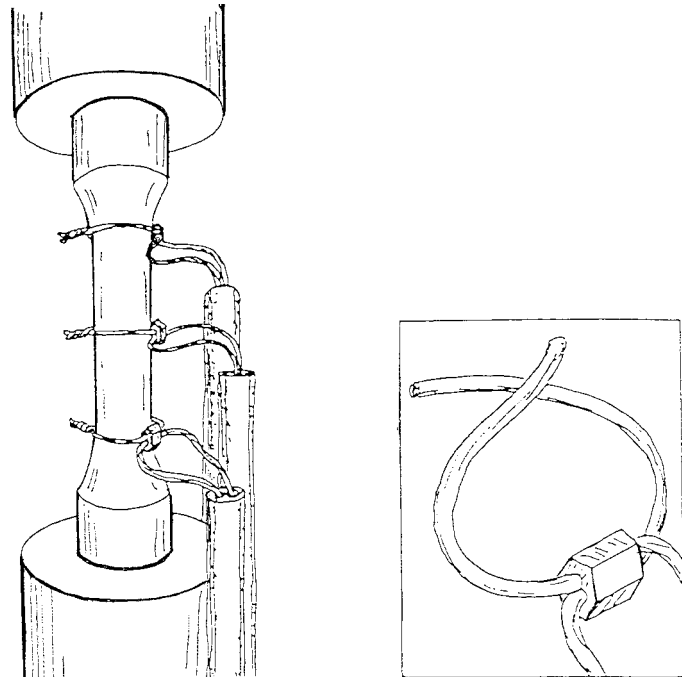


FIG. 3 Installation with Compression Junctions (Inset: Compression Junction Detail)

junction along with it. To avoid shorting wires covered with fiber insulation, use ceramic insulators where tie wires are wrapped.

9.12 *Extension Wire:*

9.12.1 In most installations, it is convenient to use extension wires, or compensating extension wires (conductors of a different composition from the thermocouple materials, but of equivalent emf) to extend to the instrument. There is a possibility of error due to the slight mismatch in thermoelectric properties between the thermocouple and extension portions of the circuit (see Table 1). The magnitude of this error can be minimized by maintaining the temperature of the transition point (that is, where the thermocouple wires and the extension

TABLE 3 Uncertainty of Temperature Measurement^A in Stress-Rupture Testing (for example, 1200°F or 650°C in 24 h)

		in degrees Fahrenheit					
Thermocouple Type: Error Source	R or S		N		K		
	Min	Max	Min	Max	Min	Max	
Calibration ^B	1.0	1.3	1.8	2.2	1.8	2.2	
Uniformity ^C	0.1	0.5	0.2	2.0	0.2	2.0	
Stability ^D	0.1	0.2	0.0	+1	+2	+5	
Extensions ^E	0.2	0.4	0.1	0.2	0.1	0.2	
Connectors ^F	0.1	0.2	0.05	0.1	0.05	0.1	
Instrument ^G	0.1	1.0	0.1	1.0	0.1	1.0	
Uncertainty ^H	1.0	1.8	1.8	+1 ± 3.1	+2 ± 1.8	+5 ± 3.1	

		in degrees Celsius					
Thermocouple Type: Error Source	R or S		N		K		
	Min	Max	Min	Max	Min	Max	
Calibration ^B	0.6	0.7	1.0	1.2	1.0	1.2	
Uniformity ^C	0.05	0.25	0.1	1.0	0.1	1.0	
Stability ^D	0.05	0.1	0	+0.5	+1	+2.6	
Extensions ^E	0.1	0.2	0.05	0.1	0.05	0.1	
Connectors ^F	0.05	0.1	0.025	0.05	0.025	0.05	
Instrument ^G	0.05	0.5	0.05	0.5	0.05	0.5	
Uncertainty ^H	0.6	0.9	1.0	+0.5 ± 1.6	+1 ± 1.0	+2.6 ± 1.6	

^A Measurement System only.
^B Uncertainty of the thermocouple. Refer to Table 1.
^C Depending on lot size, estimated.
^D Drift of the thermocouple, estimated, awg 20 wire, at 1000 to 1800°F (530 to 980°C), after 24 h.
^E For a 10 to 20°F (5 to 10°C) difference between transition point and reference junction.
^F For a 5 to 10°F (3 to 5°C) difference across the terminal.
^G Refer to 7.1.
^H Unidirectional drift, if any, plus the square root of the sum of the squares of the uncertainties.

wires meet) as close to the temperature of the reference junction (where the extension wire is connected to the instrument) as practicable. For Type RX or SX extension wire in particular, the temperature difference between these two points must be minimal to realize the inherent accuracy of the thermocouple. For a complete analysis of possible errors, refer to MNL-12 on Thermocouple Materials, Extension Wire.⁶

9.12.1.1 To determine the error contributed by the extension wire, replace the thermocouple at the transition point with an emf source of known output (for example, a calibrated thermocouple simulator), and read it at the instrument connection with a precise indicator (see Appendix X1).

9.12.2 Thermoelectric circuit wiring should be protected from electromagnetic fields that may induce spurious voltages into the system. Wherever possible, the insulated conductors should be twisted (transposed along their length) and protected with an overall shield. The shield should be grounded (one end only) or the thermoelectric wires should be run in a metal conduit, separate from power wiring.

9.13 Connections:

9.13.1 Where thermocouple wires are joined to extension wires, care must be taken so that spurious emfs are not introduced because of dissimilar metals in the presence of temperature gradients (see to MNL-12, Extension Wires and Circuit Connections⁶).

9.13.2 If terminal blocks must be used, the conductors shall be specifically designed for the type of thermocouple employed.

9.13.3 If connectors are used, the conductors shall be specifically designed for the type of thermocouple employed.

NOTE 4—Connectors should be certified as meeting the criteria in 9.13. Otherwise, they must be tested according to Specification E 1129/ E 1129M or Specification E 1684.

10. Precision and Bias of Temperature Measurement

10.1 Temperature Measurement—An estimate of the expected uncertainty, considering all sources of error, is given in Table 3.

10.2 Test Results—Precision and bias of creep/rupture test results may be established by acquiring standard bars available from ASTM.⁹ This will evaluate not only the temperature control of the test but other important factors that shall be closely controlled, including: specimen dimensions, surface preparation, specimen position in the furnace, nonuniformity of the temperature distribution across the test specimen, loading, and specimen alignment.

11. Keywords

11.1 compensation; creep test; instrumentation; insulation; stress-rupture test; temperature; thermocouples; tolerance

⁹ A creep-rupture specimen bank has been established by the Test Methods Panel of the ASTM-ASME Joint Committee on the Effect of Temperature on the Properties of Metals.

X1. INSTRUMENTATION CALIBRATION PROCEDURE

CALIBRATION CIRCUIT

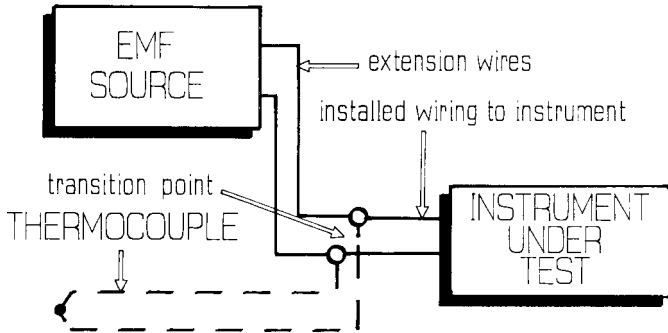


FIG. X1.1 Calibration Circuit

X1.1 *Apparatus*—The accuracy of the measurement or control instrumentation, including the extension wiring (if used) in a creep or rupture test installation should be checked with Fig. X1.1.

X1.2 *Procedure:*

X1.2.1 Obtain a calibrated emf source, such as a commercial “temperature calibrator,” which is set in units of temperature and is provided with internal reference temperature compensation for the type of thermocouple being used.

X1.2.2 In place of the thermocouple, connect the emf source to the transition point with extension wire that has been calibrated (or minimize the temperature difference between the emf source and the transition point).

X1.2.3 Compare the reading of the instrument under test to the setting of the emf source to determine the magnitude of adjustment or correction required.

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