ASME B40.200-2008
(Revision of ASME B40.200-2001)

Thermometers, Direct Reading and Remote Reading

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

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Date of Issuance: August 4, 2008

This Standard will be revised when the Society approves the issuance of a new edition. There will be no addenda or written interpretations of the requirements of this Standard issued to this edition.

The American Society of Mechanical Engineers
Three Park Avenue, New York, NY 10016-5990

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FOREWORD

ASME B40 Standard Committee is composed of a balanced cross section of manufacturers of pressure and temperature instruments, users, and interested individuals representing government agencies, testing laboratories, and other standards-producing bodies.

This Standard has been prepared not only to provide performance, configuration, and interchangeability guidelines but also to inform and update the specifier and user regarding product types, application, and use. This Standard is a vehicle by which the Committee can transmit to users the benefits of their combined knowledge and experience regarding the proper and safe use of temperature instruments and accessories.

Use of this advisory standard is a voluntary matter and shall in no way preclude the manufacture or use of products that do not conform. Neither ASME nor the B40 Committee assumes responsibility for the effect of observance or nonobservance of recommendations made herein.

This Standard is a consolidation and revision of the following standards:

(a) B40.3, Bimetallic Actuated Thermometers

(b) B40.4, Filled System Thermometers

(c) B40.8, Liquid-in-Glass Thermometers

(d) B40.9, Thermowells for Thermometers and Elastic Temperature Sensors

This Standard provides terminology and definitions, dimensions, safety, construction and installation issues, test procedures, and general recommendations.

This Standard supersedes SAMA Standard RC-6-10-1963, RC-4-1-1962, and is intended to supersede Military Specifications MIL-I-17244, MIL-T-19646, and MIL-T-24272.

Suggestions for the improvement of this Standard are welcome. They should be addressed to The American Society of Mechanical Engineers, Secretary, B40 Standards Committee, Three Park Avenue, New York, NY 10016-5990.

ASME B40.200 was approved by the American National Standards Institute on May 8, 2008.

ASME B40 COMMITTEE
Standards for Pressure and Temperature Instruments and Accessories

(The following is the roster of the Committee at the time of approval of this Standard.)

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CORRESPONDENCE WITH THE B40 COMMITTEE

General. ASME standards are developed and maintained with the intent to represent the consensus of concerned interests. As such, users of this Standard may interact with the Committee by proposing revisions, and attending Committee meetings. Correspondence should be addressed to:

Secretary, B40 Standards Committee
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Proposing Revisions. Revisions are made periodically to the Standard to incorporate changes that appear necessary or desirable, as demonstrated by the experience gained from the application of the Standard. Approved revisions will be published periodically.

The Committee welcomes proposals for revisions to this Standard. Such proposals should be as specific as possible, citing the paragraph number(s), the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent documentation.

Proposing a Case. Cases may be issued for the purpose of providing alternative rules when justified, to permit early implementation of an approved revision when the need is urgent, or to provide rules not covered by existing provisions. Cases are effective immediately upon ASME approval and shall be posted on the ASME Committee Web page.

Requests for Cases shall provide a Statement of Need and Background Information. The request should identify the Code, the paragraph, figure or table number(s), and be written as a Question and Reply in the same format as existing Cases. Requests for Cases should also indicate the applicable edition(s) of the Code to which the proposed Case applies.

Attending Committee Meetings. The B40 Standards Committee regularly holds meetings, which are open to the public. Persons wishing to attend any meeting should contact the Secretary of the B40 Standards Committee.

ASME B40.3

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Table

Nonmandatory Appendix

BIMETALLIC ACTUATED THERMOMETERS

1 SCOPE

This Standard is confined to analog, dial-type bimetallic actuated thermometers utilizing helical bimetallic elements that mechanically sense temperature and indicate it by means of a pointer moving over a scale.

2 TERMINOLOGY AND DEFINITIONS

accuracy: the conformity of indication to an accepted standard or true value. Accuracy is the difference (error) between the true value and indicated value expressed as a percentage of span. It includes the combined effects of method, observer, apparatus, and environment. Accuracy error includes hysteresis and repeatability errors but not friction error.

accuracy, reference: the accuracy of a thermometer under reference conditions [normal position at 20°C ± 1°C (approximately 68°F ± 2°F) and 29.92 in. Hg (101.32 kPa) barometric pressure].

adjustment, pointer indication: a means of causing a change in indication. The change is approximately equal over the entire scale. Some examples of this type of adjustment are adjustable pointers, rotatable dials, or other similar items. This adjustment, if provided, is generally accessible to the user.

bezel: see *ring*.

bimetallic element: see *element, bimetallic*.

bulb: a term sometimes used to describe the temperature-sensitive portion of the stem (see also *length, sensitive portion*).

bushing: a fitting usually provided with external threads for attachment to a vessel. A bushing does not have a pressure-tight sheath below the external threads.

calibration: the process of causing the thermometer to indicate within specified accuracy limits.

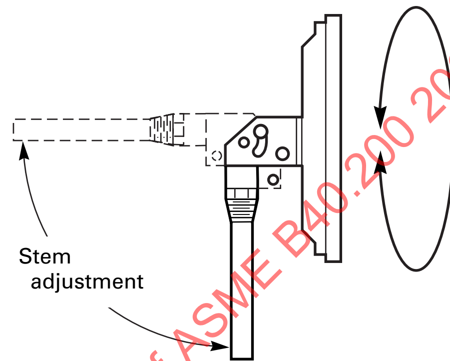
calibration verification: the checking of a thermometer by comparison with a given standard to determine the error at specified points on the scale.

cam ring: see *ring, cam*.

case: the housing or container that supports, protects, and surrounds the internals.

case, hermetically sealed: for purposes of this Standard, a term used to describe a sealed bimetallic thermometer meeting the requirements of the prescribed test (see para. 6.7). Removal of the ring may void the hermetic seal.

Fig. 1 Connection, Adjustable Angle



GENERAL NOTE: This illustration is not intended to show design details.

case, liquid-filled: see *thermometer, liquid-filled*.

case, sealed: a case that is sealed but need not comply with the hermetic seal test as prescribed in this Standard.

case size: see *size, case*.

Celsius: SI unit of temperature measurement (formerly Centigrade), abbreviation °C.

Centigrade: see *Celsius*.

conditions, environmental: the conditions, other than process, that are external to the thermometer including weather, temperature, humidity, salt spray, vibration, corrosive atmosphere, etc., and could affect the thermometer's performance or life.

connection, adjustable angle: one that allows case rotation of 360 deg and stem adjustment of at least 90 deg (see Fig. 1).

connection, back: (90-deg back angle, rear connection) one in which the stem projects from the rear of the case at a 90-deg rear angle to the dial.

connection, bottom: (straight form, lower connection) one in which the stem projects downward from the case, parallel to the dial.

connection, left-side: one in which the stem projects from the left side of the case, parallel to the dial, as viewed from the front.

connection, right-side: one in which the stem projects from the right side of the case, parallel to the dial, as viewed from the front.

connection, top: one in which the stem projects upward from the case, parallel to the dial (see Fig. 2).

connector: the component that joins the stem to the case assembly.

connector, jam nut: a connector using a straight-thread nut and seating part for connecting the thermometer to a bushing, flange, or thermowell.

connector, plain: a connector with no threads.

connector, threaded: a connector with fixed threads, usually tapered.

connector, union: a threaded fitting that is rotatable relative to the case.

correction: the quantity that is algebraically added to an indicated value to obtain the true value. The algebraic sign of correction is the opposite of the sign of the error (see also *error*).

corrosion failure: see *failure, corrosion*.

coupling nut: see *connector, jam nut*.

crystal: see *window*.

dampening: a method used to reduce the effects of shock and vibration, usually the application of a viscous material to the bimetallic element and/or bearing.

dial: the component that contains the scale.

dial, anti-parallax: see *dial, mirror*; *dial, multi-plane*.

dial, dished: see *dial, multi-plane*.

dial, dual-scale: a dial containing two scales with different units of measure, such as °F and °C.

dial, graduations: the individual division marks of a scale.

dial, mirror: a dial with a reflector band for the purpose of reducing parallax error.

dial, multi-plane: a dial with graduations in approximately the same plane as the pointer (to reduce parallax error).

dial, rotatable: a feature that allows rotation of the dial relative to the pointer.

diameter, stem: the outside diameter of the stem.

element, bimetallic: the temperature-responsive component. It is composed of two or more metals mechanically associated in such a way that relative expansion of the metals, caused by temperature change, produces motion.

element, bimetallic helical: a bimetallic element formed in the shape of a helix.

environmental conditions: see *conditions, environmental*.

error: the difference between the true and indicated values of the variable being measured. A positive error denotes that the indicated value is greater than the true value (see also *correction*).

error, friction: the difference between the indicated values before and after the thermometer has been lightly tapped.

error, parallax: reading error induced by visual misalignment.

Fahrenheit: U.S. customary unit of temperature measurement, abbreviation °F.

failure, corrosion: failure caused by environmental or process-corrosive chemical attack.

failure, over-temperature: failure caused by environmental or process exposure to temperatures in excess of rated temperature limit (see para. 6.3).

failure, vibration: failure caused by exposure to vibration (see para. 6.6).

friction error: see *error, friction*.

friction ring: see *ring, friction*.

graduations, dial: see *dial, graduations*.

hermetically sealed: see *case, hermetically sealed*.

jam nut: see *connector, jam nut*.

length, immersion: the distance from the free end of the stem to the point of immersion in the medium. This length must be greater than length, sensitive portion (see para. 3.6.4).

length, insertion: the length from the free end of the stem to, but not including, the external threads or other means of attachment.

length, sensitive portion: the length of that section of the stem enclosing the bimetallic element.

length, stem: the distance from the free end of the stem to the underside of the wrench flat portion on the threaded connector. The stem length of a plain stem thermometer is the distance from the free end of the stem to the connector or, where there is no connector, to the case (see Fig. 3).

lens: see *window*.

liquid-filled case: see *thermometer, liquid-filled*.

mirror dial: see *dial, mirror*.

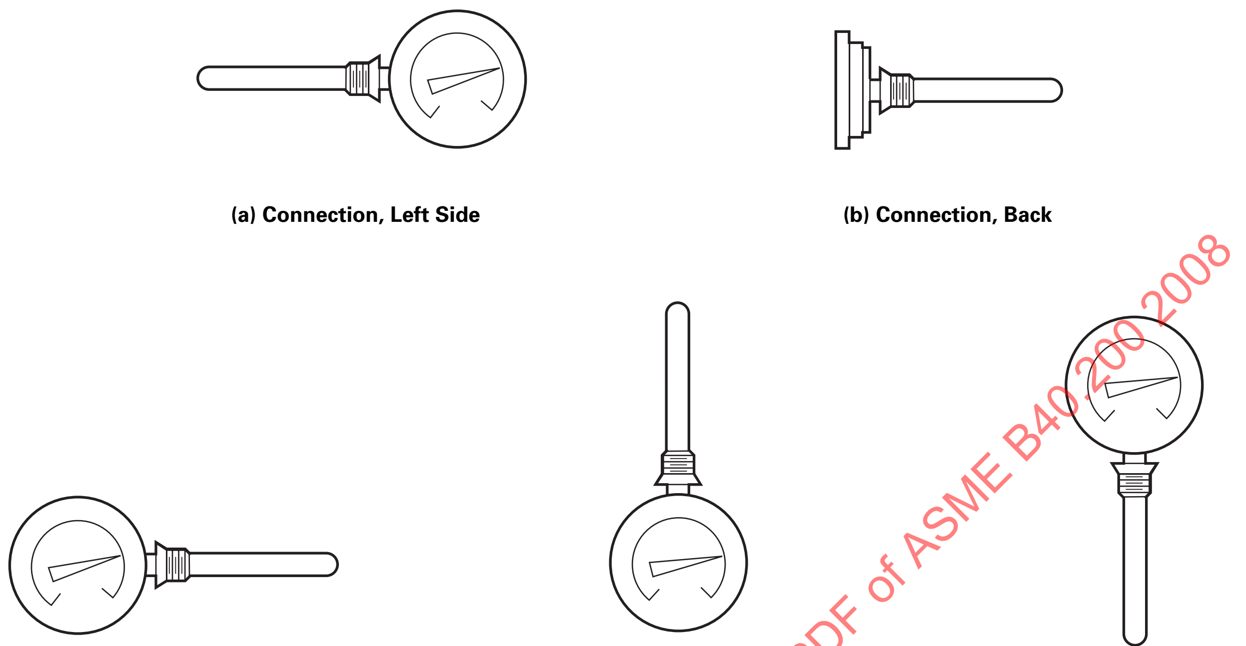
NPT: American National Standard Taper Pipe Thread (ASME B1.20.1).

parallax: see *error, parallax*.

pointer: the component that, in conjunction with the dial, indicates temperature.

pointer, maximum: a component that is moved by the indicating pointer to the maximum temperature indicated and remains at that point until reset. Inclusion of this accessory may affect the thermometer's accuracy.

Fig. 2 Connections, Stem



(a) Connection, Left Side

(b) Connection, Back

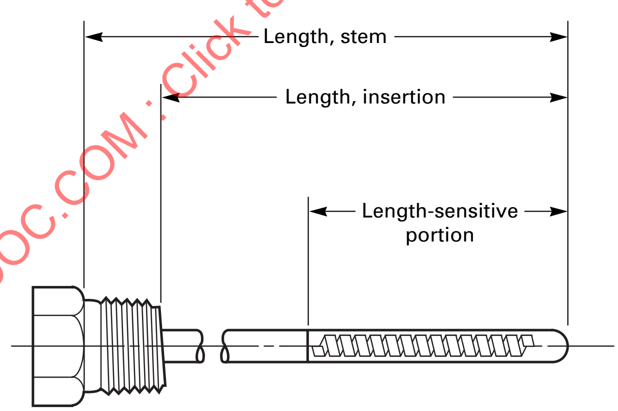
(c) Connection, Right Side

(d) Connection, Top

(e) Connection, Bottom

GENERAL NOTE: These illustrations are not intended to show design details.

Fig. 3 Length, Stem Sections



pointer, minimum: a component that is moved by the indicating pointer to the minimum temperature indicated and remains at that point until reset. Inclusion of this accessory may affect the thermometer's accuracy.

range: the low and high limits of the scale.

readability: the observer's ability to determine the indicated value. Factors that may affect readability include length of scale, graduation configuration and spacing, pointer design and width, parallax, distance between observer and scale, illumination, stability of pointer, pointer and scale colors, and the liquid-level line in the case of a liquid-filled thermometer.

repeatability: the maximum difference between a number of consecutive indications of the same applied temperature under the same operating conditions, approaching the temperature from the same direction, after lightly tapping the thermometer. It is usually expressed as a percentage of span.

reset, external: a means of causing change in indication by rotating the dial relative to the pointer. This change is approximately equal over the entire scale.

response time: time required to indicate a step change in temperature (see para. 3.7).

ring: the component that secures the window to the case. Ring configurations will vary for design and aesthetic reasons.

ring, bayonet: see *ring, cam*.

ring, cam: a ring similar to the threaded ring except that the threads are replaced by a cam arrangement.

ring, crimped: a ring formed to the case at assembly, so as to be nonremovable.

ring, friction: a ring retained by means of an interference or friction fit between it and the case.

ring, slip: a ring similar to the friction ring except that it slips over the case and is secured by screws.

ring, threaded: a ring having threads that match threads on the case.

scale: the markings on the dial consisting of graduations, related numerals, and unit(s) of measure.

sensitive portion: see *length, sensitive portion*.

shaft: the component connecting the free end of the bimetallic element directly or indirectly to the pointer.

SI (Le Systeme International d'Unites): these units are recognized by the CIPM (Comité International des Poids et Mesures).

size, case: the approximate diameter of the dial, in inches.

slip ring: see *ring, slip*.

span: the algebraic difference between the limits of the scale:

(a) The span of a 0°F/100°F thermometer is 100°F.
(b) The span of a 200°C/500°C thermometer is 300°C.
(c) The span of a −40°F/120°F thermometer is 160°F.

staff: see *shaft*.

standard, calibration: a temperature instrument used to determine the accuracy of a thermometer (see ASME PTC 19.3, Temperature Measurement).

stem: the component that extends from the connector and encloses the bimetallic element.

stem length: see *length, stem*.

stem, plain: see *connector, plain*.

stop pin: a component on the dial that limits the motion of the pointer.

swivel nut: see *connector, jam nut*.

threaded ring: see *ring, threaded*.

threaded window: see *window, threaded*.

thermometer, liquid-filled: one that contains a liquid to protect the internals from damage caused by vibration.

thermowell: a pressure-tight receptacle adapted to receive a stem and provided with external threads or other means for pressure-tight attachment to a vessel or system.

traceability: documentation of the existence of a calibration chain between an instrument and the National Institute of Standards and Technology (formerly known as the National Bureau of Standards).

union connector: see *connector, union*.

union, lock nut: a component used to mount a thermometer having a threaded connector so that the dial may be oriented in a predetermined position.

well: see *thermowell*.

window: a transparent component through which the dial is viewed.

window, heat-treated glass: a window of heat-treated (tempered) glass, which, when broken, will form small, granular pieces, usually with no jagged edges.

window, laminated glass: a window with two or more sheets of glass held together by an intervening layer(s) of clear plastic. When cracked or broken, the pieces of glass tend to adhere to the plastic.

window, plain glass: a window of commercial glass.

window, plastic: a window of transparent plastic.

window, threaded: a window generally made of plastic with integral threads that match threads on the case. No separate ring is required.

3 GENERAL RECOMMENDATIONS

3.1 Case (Dial) Sizes

Recommended Case (Dial) Sizes, in.
1
1¾
2
3
5

3.2 Stem Length

3.2.1 Industrial Applications

Recommended Stem Lengths, in.
2½
4
6
9
12
15
18
24

NOTE: Nonstandard stem lengths may be required for special applications. Some ranges may not be available with stem lengths shorter than 4 in. Where applications require a thermowell, stem length and diameter must be compatible with the thermowell.

3.2.2 Laboratory Application. Typical stem length for the laboratory application of bimetallic actuated thermometers is 8 in.

3.2.3 Pocket Thermometer. Typical stem length for pocket bimetallic actuated thermometers is 5 in.

3.3 Stem Diameter

3.3.1 Industrial Applications. For industrial applications, $\frac{1}{4}$-in. O.D. (outside diameter) is normally supplied. For stem lengths over 36 in., $\frac{3}{8}$-in. O.D. or a combination of $\frac{1}{4}$-in. and $\frac{3}{8}$-in. O.D. may be considered.

3.3.2 Laboratory and Pocket Thermometer Applications. For laboratory and pocket thermometer applications, $\frac{9}{64}$-in. O.D. to $\frac{3}{16}$-in. O.D. is normally supplied. Since this item is not used in conjunction with a thermowell, diameter may vary.

3.4 Typical Ranges

3.4.1 Industrial and Commercial Applications

°F	°C
–100/100	–50/50
–40/160	0/100
0/250	0/150
50/400	0/200
50/550	0/300
150/750	0/400
200/1,000	100/550

3.4.2 Laboratory and Pocket Thermometer Applications

°F	°C
–40/160	–50/50
–25/125	0/50
0/220	0/100
50/300	0/150
50/400	0/200
50/550	0/300

NOTE: Other ranges are in common use and acceptable.

3.5 Construction (See Fig. 4)

3.5.1 Case

3.5.1.1 General. Cases may be fabricated from various materials using various manufacturing processes but most commonly are made of stainless steel. Cases may be hermetically sealed to prevent the incursion of undesirable environmental contaminants.

3.5.1.2 Case Closure. Typical closure methods include threading the window directly to the case, retaining the window by a ring, or forming the case over the edge of the window.

3.5.2 Indication Adjustment. Some thermometers are provided with a pointer-adjusting device, which is accessible by removing the window, or with a dial-rotating mechanism, accessible without removing the window. Other thermometers are nonadjustable.

3.5.3 Dials

3.5.3.1 Units. Dials are normally graduated in either Fahrenheit or Celsius, or with two scales, such as Fahrenheit and Celsius. Dual-scale dials are useful where thermometers are used on equipment that may be used internationally or where users plan to convert from one unit of measure to another.

The unit of measure shall be noted on the dial either by the word Fahrenheit or Celsius or the abbreviation "F" or "C." The degree symbol (°) is optional. The value of a subdivision may also be indicated.

3.5.3.2 Graduations. The recommended minimum arc of the scale is 270 deg. Special applications and ranges may require other arcs.

Graduation lines should be radial to the center of rotation of the pointer. Major and intermediate graduation lines should be emphasized. Scale, numeral, and graduation increments should follow the format 1×10^n, 2×10^n, or 5×10^n, where n is a whole positive or negative number or zero.

The smallest graduation increment should not exceed twice the absolute value of the error permitted at midscale.

Numerals should be sufficient to enable the observer to quickly and accurately identify any temperature. They should not obscure or crowd graduations.

3.5.3.3 Anti-Parallax Dial. Some dials are designed so that the plane of the graduated portion is nominally the same as the plane of the pointer; others are provided with a reflector band (mirror dial). These configurations minimize the effect of reading error introduced by visual misalignment.

3.5.4 Pointer. The pointer shall rotate clockwise with increasing temperature. The width of the tip of the pointer should be no greater than approximately twice the width of the minor graduations. The radial distance between the pointer tip and the inner end of the minor graduations should not exceed the width of the tip of the pointer. In the case of a dual-scale dial, the pointer width should be maintained at a minimum so as not to obscure the inner scale. The radial distance between the tip of the pointer and the inner end of the minor graduations of the outer scale should not exceed the width of the tip of the pointer.

3.5.5 Connector

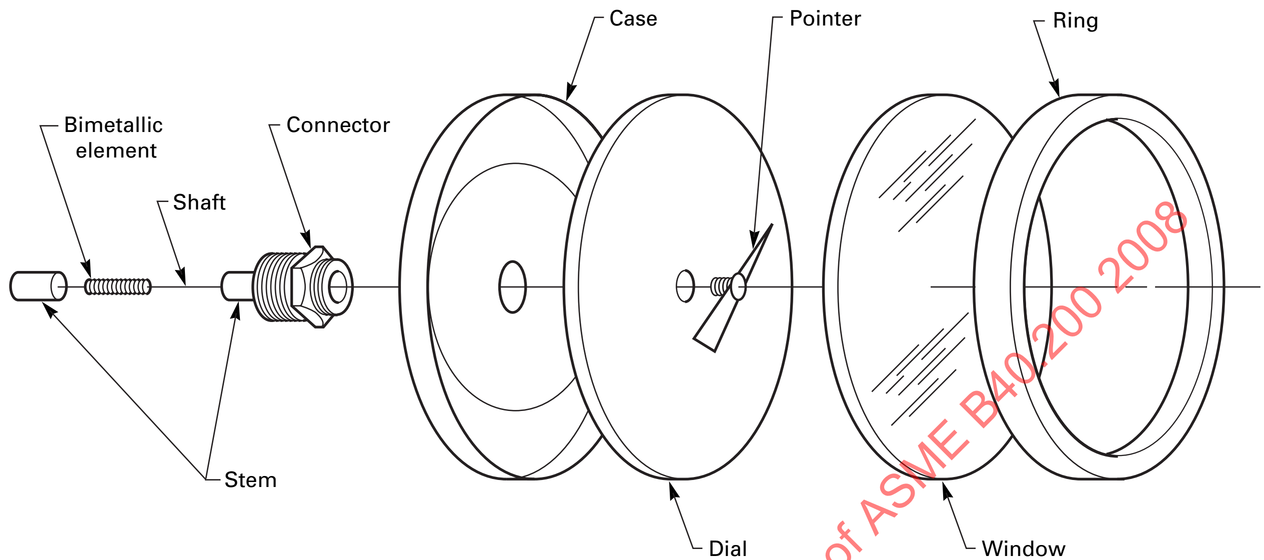
3.5.5.1 Connector Location. The following connector locations are available:

(*a*) adjustable angle
(*b*) back
(*c*) bottom
(*d*) left side
(*e*) right side
(*f*) top

3.5.5.2 Connector Type. The following connector types are available:

(*a*) plain

Fig. 4 Bimetallic Actuated Thermometer — Typical Components



GENERAL NOTE: This illustration is not intended to show design details.

(b) threaded
(c) union
(d) jam nut

Threaded, union, and jam nut connectors are available with various sizes of tapered or straight threads.

3.5.6 Stop Pin. Some thermometers are provided with a stop pin. The purpose of the stop pin is to prevent the pointer from rotating to a graduated portion of the scale when temperatures either above or below the indicated range are applied.

3.5.7 Window

3.5.7.1 Laminated Glass Laminated glass shall comply with ASTM C 1172 Kind LA. This glass offers some protection in all applications. It reduces the possibility of glass particles scattering if there is mechanical damage.

3.5.7.2 Heat-Treated Glass. Heat-treated glass shall comply with ANSI Z26.1. This glass has greater resistance to mechanical damage than plain glass.

3.5.7.3 Plastic. Abrasive environmental and impact conditions, especially excessive temperature and corrosive atmosphere, must be carefully considered to determine the type of plastic best suited for the application.

3.5.7.4 Plain Glass. This window material is commonly used due to its abrasion, chemical, and wear-resistant properties. Careful consideration of its use should be given for hazardous applications.

3.5.8 Stem

3.5.8.1 General. The stem encloses the bimetallic element and is generally made of tubular stainless steel (see paras. 3.2 and 3.3).

3.6 Accuracy

3.6.1 Thermometer accuracy is graded as shown in Fig. 5.

3.6.2 Adjustment of the angle between case and stem of a thermometer with an adjustable angle connection may affect the thermometer's accuracy. This effect should not exceed 0.5% of span.

3.6.3 Exposure of the thermometer to temperatures exceeding the maximum range may affect accuracy. Consult the supplier for temperature limits (see para. 6.3).

3.6.4 Sensitive length will vary with temperature range and manufacturer. Consult the supplier for recommended immersion length, which must be greater than the sensitive length to avoid inaccurate readings. Gas service generally requires a greater immersion length than liquid service.

3.6.5 See section 6 for testing procedures.

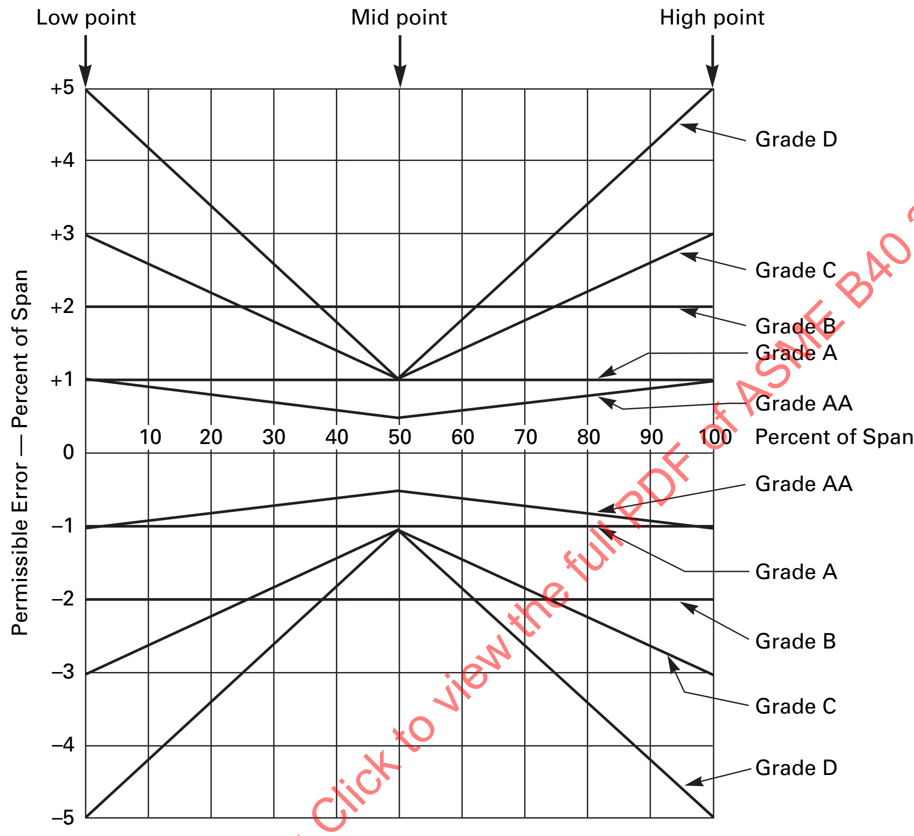
3.7 Response Time

Response time is the time required for a thermometer to respond to a step change in temperature.

Response time varies according to a number of interrelated parameters, including the following:

(a) temperature differential

Fig. 5 Accuracy Grades



EXAMPLES:

(1) Range 0°F/250°F. Grade A
Span = 250 — 0 = 250°F
Accuracy at 20% of span (50°F) = ±1% = ±2.5°F
Accuracy at 50% of span (125°F) = ±1% = ±2.5°F
Accuracy at 100% of span (250°F) = ±1% = ±2.5°F

(2) Range –40°F/160°F. Grade D
Span = 160 — (–40) = 200°F
Accuracy at 20% of span (0°F) = ±3.4% = ±6.8°F
Accuracy at 50% of span (60°F) = ±1% = ±2.0°F
Accuracy at 100% of span (160°F) = ±5% = ±10.0°F

(3) Range 50°F/300°F. Grade AA
Span = 300 — 50 = 250°F
Accuracy at 0% of span (50°F) = ±1% = ±2.5°F
Accuracy at 50% of span (175°F) = ±0.5% = ±1.25°F
Accuracy at 70% of span (225°F) = ±0.7% = ±1.75°F

(b) depth of immersion
(c) heat-transfer capability, including flow effects of process medium
(d) whether or not the instrument is in a thermowell
(e) thickness of the thermowell wall
(f) conductivity of the thermowell material
(g) air gap and/or medium contained within the thermowell to transfer heat from the thermowell to the stem of the thermometer
(h) friction within the thermometer
(i) viscosity, location, amount, and thermal characteristics of dampening medium, if present

The user is encouraged to determine whether or not response time is critical.

4 SAFETY

4.1 Scope

This section of the Standard presents information to guide users, suppliers, and manufacturers towards minimizing the hazards that could result from misuse or misapplication of thermometers. The user should become familiar with all sections of this Standard, as all aspects of safety cannot be covered in this section. Consult the supplier for advice whenever there is uncertainty about the safe application of a thermometer.

4.2 General Discussion

4.2.1 Adequate safety results from intelligent planning and careful selection and installation of a thermometer into a system, the temperature of which is to be measured. The user should inform the supplier of all conditions pertinent to the application and systems environment so that the supplier can recommend the most suitable thermometer/attachments for that application.

4.2.2 Many applications of thermometers, particularly those with plain connectors, involve temperature measurement of unpressurized systems. In general, the principal hazards of using thermometers at ambient pressure are those associated with proximity to the system being measured (e.g., exposure to hot liquids, corrosive material, freezing fluids, etc.).

4.2.3 Safe use of a thermometer with a threaded connector in a system where the stem is not protected by a thermowell requires that factors such as the following be considered:
(a) effect of static pressure and maximum transient pressure on the stem integrity
(b) effect of temperature on material
(c) any corrosive effects on stem materials
(d) flow-induced vibration on the stem
(e) consequences of accidental breaching of the stem

4.2.4 Thermowells permit the use of thermometers at higher pressure than could be safely applied to an unprotected stem. Thermowells facilitate the removal and reinstallation of thermometers without creating a temporary leak and without requiring process shutdown. They protect the stem from excessive temperatures and corrosive attack by the process medium and against structural damage caused by fluid velocity-induced vibration.

To improve response time, the space surrounding the stem within the thermowell may be filled with a heat transfer medium suitable for use at the process temperature.[1] Consult the thermowell supplier for proper selection and application.

4.2.5 Expansion of air or other fluids trapped in a sealed case (sealed by design or otherwise) may cause a blowout failure of the window. When high ambient temperatures are expected, such a blowout possibility should be considered. After a period of time, a nonsealed case may become sealed due to an accumulation of varnish-like atmospheric contamination.

4.3 Safety Recommendations

4.3.1 Pressure and temperature ratings should be determined by the manufacturer, and an unprotected stem should not be used beyond the recommended rating. Installation of any thermometer should be consistent with application codes.

4.3.2 The location of the thermometer should be such that injury to personnel and damage to property is minimized in the event of an accidental breach of stem/thermowell combination.

4.3.3 For liquid-filled thermometers, it has been general practice to use glycerin- or silicone-filling liquids. However, these fluids may not be suitable for all applications. They should be avoided where strong oxidizing agents, including (but not limited to) oxygen, chlorine, nitric acid, and hydrogen peroxide, are involved. In the presence of oxidizing agents, a potential hazard can result from chemical reaction, ignition, or explosion. Completely fluorinated or chlorinated fluids, or both, may be more suitable for such applications.

4.3.4 Liquid-filled thermometers may not be available in all ranges because of the effect of temperature on the fill material. Since a liquid-filled, bimetallic thermometer is completely filled with fluid, including both its stem and case, the fill is exposed to the process temperature. Not only will the fill expand as the temperature increases, raising pressure inside the case, but it may also degrade because of continuous exposure to extreme temperature. Because of the possibility of temperature-induced pressure inside the case, plain glass windows must not be used.

[1] Care should be taken to avoid heat-transfer medium from contacting the connector of the thermometer.

4.4 Reuse of Thermometers

Should it be necessary to reuse a thermometer in another application, accuracy should be checked, surfaces should be thoroughly cleaned, and all requirements of a new installation should be considered.

CAUTION: Failure to thoroughly clean the thermometer could result in an explosive reaction and/or accelerated corrosion of the stem.

5 SELECTION CRITERIA

When selecting a thermometer, section 4 and the following must be considered:

(a) temperature range or the minimum and maximum operating temperatures and unit of measure (see para. 3.4)
(b) accuracy grade required (see para. 3.6)
(c) case size (see para. 3.1)
(d) case, ring, stem, and connector materials
(e) window material
(f) location of connector to provide maximum readability when installed
(g) connector type, threat type, and size
(h) stem length and diameter (see paras. 3.2 and 3.3)
(i) process compatibility
(j) environmental conditions
(k) pointer adjustment or external reset, if required
(l) hermetically sealed case, if required
(m) variations, options, and/or accessories, including
  (1) liquid-filled thermometer
  (2) minimum-indicating pointer
  (3) maximum-indicating pointer
  (4) special dial marking or tagging
  (5) thermowell

6 TEST PROCEDURES

6.1 Scope

This section is intended to provide an outline of the parameters used when evaluating thermometer performance and to suggest evaluation guidelines. These test methods may or may not satisfy the requirements of the intended applications. When it is known that the thermometer will encounter conditions more or less severe than those specified, the tests may be modified to match the application more closely. A functional test in the intended application is generally the best evaluation method.

CAUTION:
(1) The test equipment utilized for the tests in this section often operate at potentially dangerous high or low temperatures. Hazards may exist for skin burn, steam flash and/or explosion, eye injury, and other health hazards.
(2) These tests should be performed ONLY by competent, trained individuals familiar with the test procedures and test equipment.
(3) High-temperature salt baths often contain salts that are not compatible with other salts. Moving a thermometer from one bath to another without cleaning the first bath residue from it can result in an explosion. Similarly, while not explosive, any water carried from a low-temperature bath to a high-temperature bath has the potential to flash into steam. This flashing can throw extremely hot liquid from the high-temperature bath for significant distances. This type of steam/salt bath explosion can cause severe injury.

6.2 Accuracy

6.2.1 Purpose. This test determines the accuracy of the thermometer under test in compliance with para. 3.6.

6.2.2 Procedure

(a) Throughout this test, the bath temperature shall be measured using a calibration standard. The accuracy of the standard should be at least four times that of the thermometer under test. The bath must be properly agitated.

(b) Immerse the stem of the thermometer to be tested to the manufacturer's recommended depth.h must be properly agitated.

(c) Before starting the accuracy test, precycle by immersing the stem at least once in hot and cold baths with temperatures close to the high and low values of the span.

(d) Readings are to be taken, after gently tapping, at approximately 10%, 50%, and 90% of the span, both increasing and decreasing temperatures. Comparison with the calibration standard shall be made at each point.

(e) Readings should be taken before and after gently tapping the thermometer. The difference between the readings at a given temperature is the friction error expressed as a percentage of span.

6.3 Under-/Over-Temperature

6.3.1 Purpose. This test determines the effect of short-term exposure to process temperature either above or below the indicated range limits. Prior to testing liquid-filled thermometers, consult the manufacturer for recommended maximum temperature.

6.3.2 Procedure

(a) Test for accuracy (see para. 6.2).

(b) Raise temperature of stem by approximately 10% of the span over the highest indicated value. Maintain for approximately 5 min (e.g., for range of 50°F/400°F, test temperature would be approximately 435°F).

(c) Repeat accuracy test (see para. 6.2).

(d) The difference between the reading in (c) and (a) above is the effect of over-temperature.

(e) Lower temperature of stem by approximately 10% of the span below the lowest indicated value. Maintain

for approximately 5 min (e.g., for range of 50°F/400°F, test temperature would be approximately 15°F).

(f) Repeat accuracy test (see para. 6.2).

(g) The difference between the readings in (f) and (c) above is the effect of under-temperature.

6.4 Storage

6.4.1 Purpose. This test determines the effect of temperature extremes that may be encountered during storage.

6.4.2 Procedure

(a) Test for accuracy (see para. 6.2).

(b) Place the thermometer in a temperature chamber at the manufacturer's recommended high limit of storage temperature for a period of 24 hr.

(c) Place the thermometer in a temperature chamber at the manufacturer's recommended low limit of storage temperature for a period of 24 hr.

(d) Repeat this 48-hr cycle for a total of two complete tests; allow the thermometer to stabilize at room temperature.t of storage temperature for a period of 24 hr.

(e) Repeat accuracy test (see para. 6.2).

(f) The difference between the two accuracy tests is the effect of storage temperature, expressed as a percentage of span.

6.5 Load

6.5.1 Purpose. This test determines the effect of a specified external load applied to a thermometer supplied with a threaded connector.

6.5.2 Procedure

(a) Test for accuracy (see para. 6.2).

(b) Mount the thermometer using the connector.

(c) Gradually apply a load of 150 lb, as shown in Fig. 6, and maintain for at least 1 min.

(d) Repeat accuracy test (see para. 6.2).

(e) The difference between the two accuracy tests is the effect of the load test, expressed as a percentage of span.

(f) Any obvious damage or severe distortion should be noted.

6.6 Vibration

6.6.1 Purpose. This test determines the effect of 6 hr of exposure to the test described below.

6.6.2 Procedure

(a) Test for accuracy (see para. 6.2).

(b) Each of the tests specified below shall be conducted separately in each of the three mutually perpendicular axes. All tests in one axis shall be completed before proceeding to test in another axis.

(c) The thermometer under test shall be secured to the vibration table in the same manner that it will be secured in service. The mounting device shall be sufficiently rigid to ensure that its motion will be essentially the same as the motion of the table of the vibration machine.

(d) To determine the presence of resonances, the thermometer under test shall be vibrated at frequencies from 5 Hz to 60 Hz at peak-to-peak amplitudes, as per Table 1. The change in frequency shall be made in discrete frequency intervals at approximately 1 Hz and maintained at each frequency for 15 sec. The frequencies and location at which resonances occur shall be noted.

(e) The thermometer shall be tested for a period of 2 hr in each of the mutually perpendicular axes (6 hr in total) at the resonant frequency. If more than one resonant frequency exists, the rest shall be conducted at the highest resonant frequency. If no resonance is observed, the test shall be performed at 60 Hz. The amplitude of vibration shall be in accordance with Table 1.

(f) Repeat accuracy test (see para. 6.2).

(g) The difference between the two accuracy tests is the effect of vibration, expressed as a percentage of span.

6.7 Hermetic Seal

6.7.1 Purpose. This test determines if a sealed case can be described as hermetically sealed as it pertains to a bimetallic actuated thermometer.

6.7.2 Procedure

(a) All tests involve a complete thermometer, without a thermowell.

(b) Fully immerse the thermometer in water with the dial did not more than 6 in. below the surface.

(c) Transfer from one water bath to the next within 30 sec.

(d) Subject the thermometer to the following sequence of temperature changes:

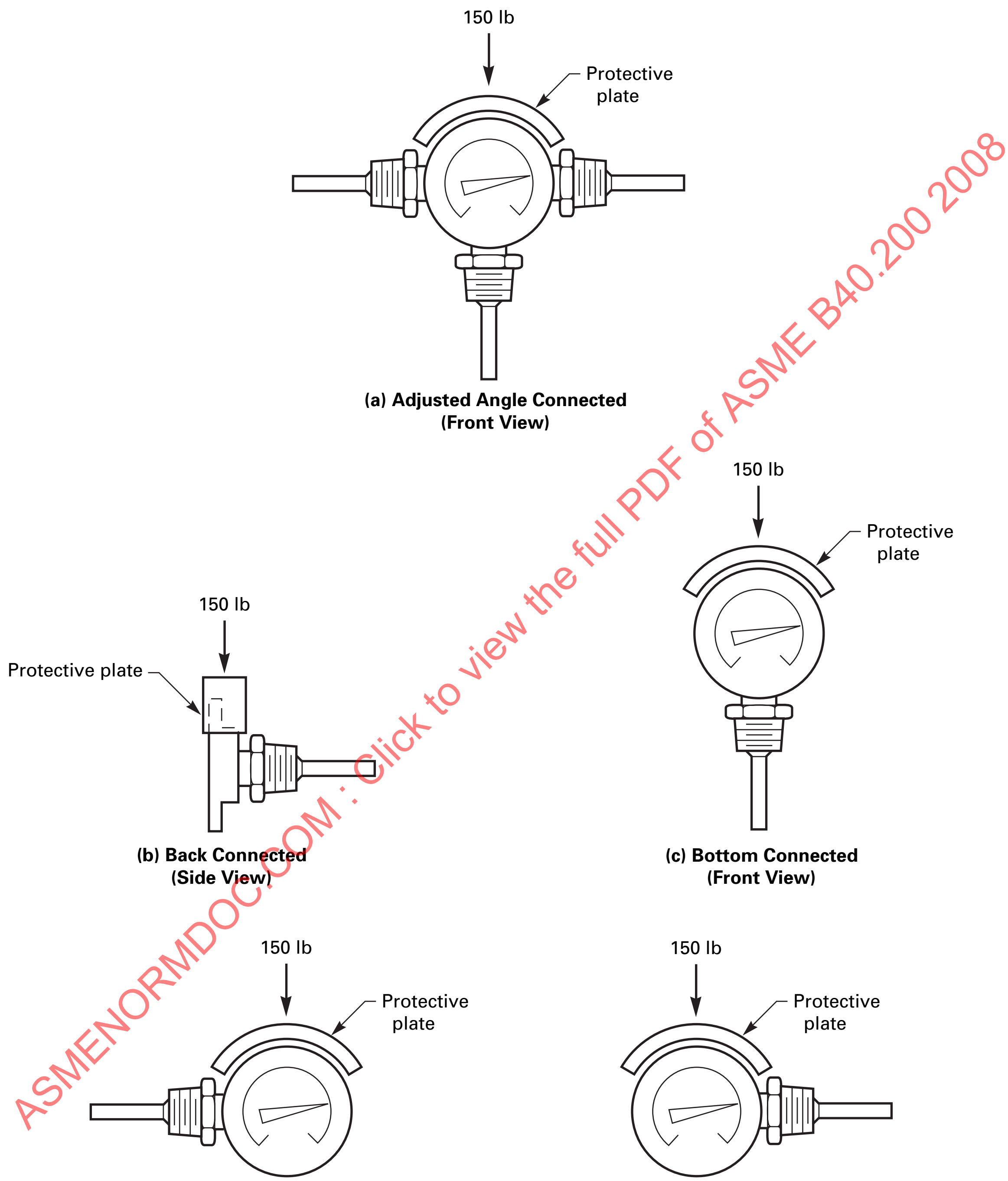
(1) air at 65°F/85°F for a minimum of 2 hr
(2) water at 150°F/160°F for 15 min
(3) water at 40°F/50°F for 15 min
(4) water at 150°F/160°F for 15 min
(5) water at 40°F/50°F for 15 min
(6) air at 35°F/40°F for 1 hr

(e) Examine the thermometer. Evidence of leakage, condensed moisture, or fog within the thermometer at any point during or subsequent to the test procedure indicates that the thermometer does not meet this definition of hermetic seal.

7 REFERENCES

ANSI Z26.1-1990, Safety Code for Glazing Materials for Glazing Motor Vehicles Operating on Land Highways

Fig. 6 Load Test



(a) Adjusted Angle Connected (Front View)

(b) Back Connected (Side View)

(c) Bottom Connected (Front View)

(d) Left-Side Connected (Front View)

(e) Right-Side Connected (Front View)

GENERAL NOTE: Test in each position shown.

Table 1 Vibration Test Amplitudes

Frequency, Hz	Amplitude, in.	Amplitude, mm
5 to 15	0.060 ± 0.012	1.5 ± 0.3
15 to 25	0.040 ± 0.008	1.0 ± 0.2
26 to 33	0.020 ± 0.004	0.5 ± 0.1
34 to 40	0.010 ± 0.002	0.25 ± 0.05
41 to 60	0.005 ± 0.001	0.013 ± 0.025

Publisher: American National Standards Institute (ANSI), 25 West 43rd Street, New York, NY 10036

ASME B1.20.1-1983 (R1992), Pipe Threads, General Purpose (Inch)

ASME PTC 19.3-1974 (R1986), Instruments and Apparatus: Part 3, Temperature Measurement

Publisher: The American Society of Mechanical Engineers (ASME), Three Park Avenue, New York, NY 10016-5990; Order Department: 22 Law Drive, P.O. Box 2300, Fairfield, NJ 07007-2300

ASTM C 1172, Standard Specification for Laminated Architectural Flat Glass

Publisher: ASTM International (ASTM), 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959

NONMANDATORY APPENDIX A
BIMETALLIC ACTUATED THERMOMETERS
(SUPPLEMENTARY INFORMATION)

This Appendix, established for naval shipboard application, shall apply when specified in the contract or purchase order. When there is conflict between the Standard (ASME B40.3) and this Appendix, the requirements of this Appendix shall take precedence for equipment acquired in accordance with this supplement. This document supersedes MIL-I-17244, Indicators, Temperature, Direct Reading, Bimetallic (3-in. and 5-in. dial) for new ship construction.

A-1 SCOPE

This Appendix covers 3-in. and 5-in. dial size, shock resistant, environmentally hardened, bimetallic thermometers. Two configurations, direct reading temperature indicating (ITD) and maximum/minimum temperature indicating (ITM), are specified for shipboard use.

A-2 GENERAL REQUIREMENTS

A-2.1 Case (Dial) Sizes

Thermometers shall utilize dial sizes of either 3 in. or 5 in.

A-2.2 Stem Length

Thermometers shall utilize 2-in., 4-in., and 6-in. stem lengths as shown in Fig. A-1.

A-2.3 Stem Diameter

Thermometers shall utilize 0.375-in. stem diameters, only.

A-2.4 Ranges

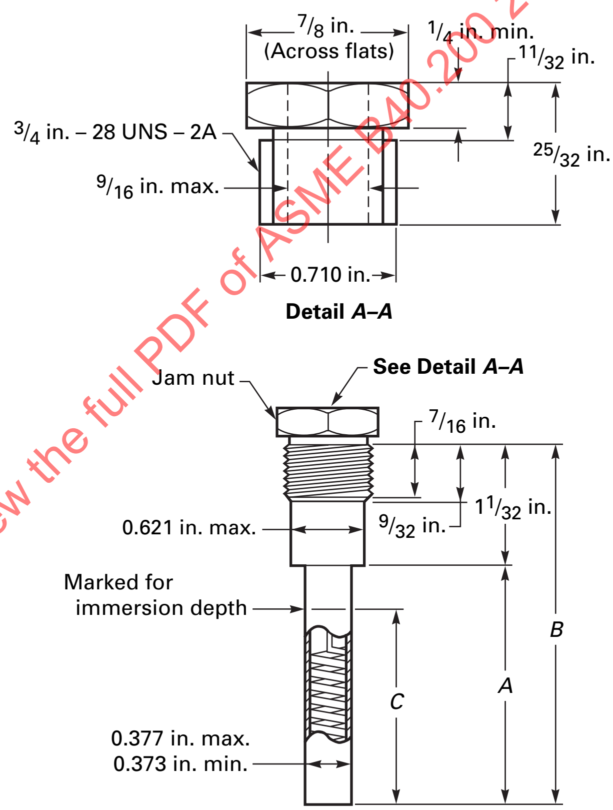
Thermometer ranges shall be selected from Table A-1.

A-2.5 Construction

A-2.5.1 Case. Thermometer cases shall be fabricated from corrosion-resisting steel (CRES) as specified by ASTM A 276, series 300 and shall have a satin or brushed finish.

A-2.5.2 Dial. Thermometer dials shall be fabricated to resist damage from corrosion and temperature. Dials shall have a white or silvered background with black graduations and markings.

Fig. A-1 Connection and Stem Dimensions



A	B, ±1/32	C, ±1/32
2	3 1/32	2
4	5 1/32	2
6	7 1/32	3

GENERAL NOTE: All dimensions are in inches.

A-2.5.2.1 Markings. Dial markings shall include the following:

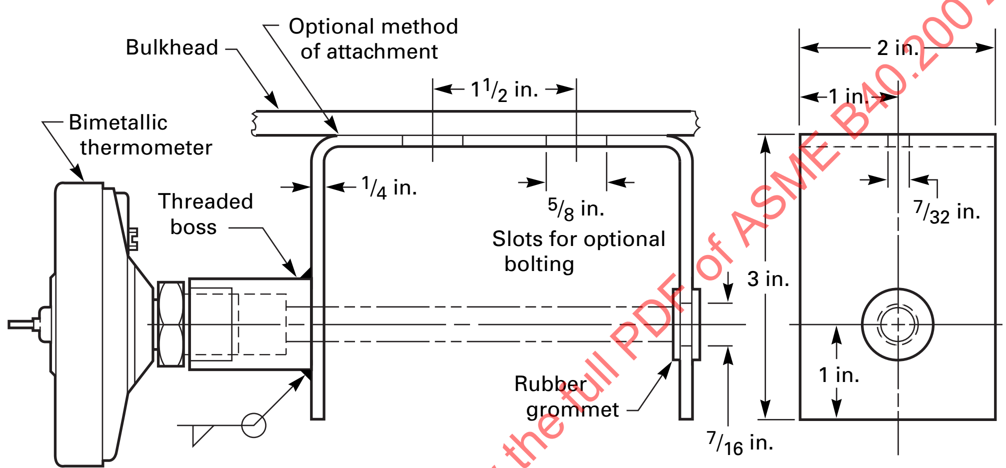
(a) manufacturer's name or trademark
(b) manufacturer's CAGE (Commercial and Government Entity) code
(c) Part Identifying Number (PIN)
(d) National Stock Number (NSN)

A-2.5.3 Window. Windows shall be fabricated from thermoplastic in accordance with ASTM D 788.

Table A-1 Thermometer Ranges

Range of Scale, °F	Accuracy, °F	Min. Number of Degrees Between Graduations	Min. Number of Degrees Between Numbers
−40 to 180	2.2	2	20
20 to 240	2.2	2	20
50 to 550	5.0	5	50
50 to 750	7.0	10	100

Fig. A-2 Thermometer-Mounting Bracket (for ITM Indicator)



A-2.5.4 Gaskets. Gaskets shall be fabricated from fluorocarbon rubber (250°F max.) or nitrile (Buna N) rubber (180°F max.) depending on temperature range of subject thermometer. Gaskets shall be suitable for not less than 210°F on ranges above 240°F.

A-2.5.5 Pointers. Indicating pointers shall be nonreflective black. Index pointers (maximum and minimum indicator only) shall be red.

A-2.5.6 Reset Knob. Reset knobs for maximum and minimum indicators shall be fabricated from CRES. Reset knobs shall be accessible to the operator.

A-2.5.7 Stem. Stems shall be fabricated from CRES. All joints in the stem and connection (see Fig. A-1) shall be welded and leak tight.

A-2.5.8 Jam Nut. Jam nuts shall be fabricated from CRES and shall have ¾–28–UNS threads. Tapered pipe threads are not permitted.

A-2.5.9 Mounting Bracket. A thermometer-mounting bracket may be used to install a thermometer in locations where ambient air temperature readings are required. For example, ITM indicators are intended for installation in ammunition and pyrotechnic magazines/lockers. The mounting bracket shall be in accordance with Fig. A-2.

A-2.6 Thermowells

Thermowells shall be in accordance with ASME B40.9 and its Nonmandatory Appendix A.

A-2.7 Cleaning and Packaging

Unless special cleaning, drying, unit protection, and intermediate packaging are specified, the bimetallic thermometer shall be cleaned, dried, and bagged with boxing in accordance with ASTM D 3951.

A-3 TEST PROCEDURES AND REQUIREMENTS

A-3.1 Responsibility for Inspection

Unless otherwise specified in the contract or purchase order, the manufacturer is responsible for performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the manufacturer may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the purchaser. The purchaser reserves the right to perform any of the inspections set forth in the standard where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

A-3.1.1 Responsibility for Compliance. All items shall meet all requirements of section A-3. The inspection

Table A-2 Inspection Requirements

Tests and Examinations	Qualification Inspection	Conformance Inspection
Accuracy	X	X
Repeatability	X	X
Inclination	X	. . .
Thermal response	X	. . .
Load	X	. . .
Enclosure leakage	X	. . .
Fog	X	. . .
Vibration	X	. . .
Shock	X	. . .

set forth in this specification shall become a part of the manufacturer's overall inspection system or quality program. The absence of any inspection requirements in this specification shall not relieve the manufacturer of the responsibility of ensuring that all products or supplies submitted to the purchaser for acceptance comply with all requirements of the contract. Sampling inspection, as part of the manufacturing operations, is an acceptable practice to ascertain conformance to requirements; however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the purchaser to accept defective material.

A-3.2 Classification of Inspections

A-3.2.1 Qualification Inspection. Qualification inspection shall consist of tests and examinations listed in Table A-2 and shall be performed and passed prior to production. Qualification inspection shall be performed on samples that have been produced with equipment and procedures normally used in production.

A-3.2.1.1 Sample Size. Two thermometers of each classification shall be subjected to the qualification inspection.

A-3.2.2 Conformance Inspection. Conformance inspection shall consist of tests and examinations listed in Table A-2 and shall be performed and passed by each thermometer.

A-3.3 Acceptance Criteria

If any thermometer fails to meet the inspection requirements of Table A-2, no thermometer shall be accepted until the manufacturer has determined the cause of the defect and has taken necessary action to correct or eliminate the defect from each thermometer. The failed test shall be repeated to demonstrate that the corrective action will enable the thermometers to meet the specified requirements. In addition, the results of previous inspections may be deemed invalid, unless the manufacturer can prove to the satisfaction of the purchaser that such test would not be adversely impacted by the corrective action.

A-3.4 Accuracy

Accuracy tests shall be conducted in accordance with para. 6.2 of ASME B40.3. Accuracy shall meet the requirements of Table A-1. Maximum/minimum temperature-indicating (ITM) indicators shall be permitted an additional error for a total of twice the specified accuracy when index pointers are in contact with the indicating pointer.

A-3.4.1 Repeatability. The indicators shall be tested for the initial accuracy three times. The spread of the data at any point shall be within ±½% of the specified accuracy.

A-3.5 Inclination

With the indicator held so as to face the dial and with the pointer in a vertical position, the instrument shall be rotated to place the pointer 60 deg to the left and then 60 deg to the right of vertical. The indicator shall be within ½% of the specified accuracy in both positions. The indicator shall be at ambient condition during this test.

A-3.6 Thermal Response

Test temperature and bath medium shall be in accordance with Table A-3. The response time shall not exceed 15 sec when installed in a thermowell. The indicators shall be stored upright with the stems vertical for ½ hr before the response test.

WARNING: Use extreme caution when performing a thermal response test or another test using hot bath. See CAUTION in para. 6.1 of ASME B40.3.

A-3.6.1 Response Time. A standard cylinder shall be used for this test. The information needed to construct a standard cylinder is provided on Fig. A-3. Connecting wires from the standard cylinder thermocouple shall terminate at an ice bottle, ice point reference junction, or a reference junction-compensated electronic indicator. If an ice bottle or ice point reference junction is used, the extension wires coming from the reference junction shall be connected to an indicator such as a potentiometer or a millivolt recorder. No matter what form of indicator is used, the indicator shall have a response time not less than two times faster than the response time of the temperature rise that the standard cylinder will measure (see Table A-4). Response time measurement shall be conducted using either a stop watch or any method capable of timing to 0.2 sec or better.

A-3.6.2 Temperature Bath. Two temperature baths are used in performing this test. The baths shall be sufficiently large or constructed in such a manner that the temperature bath fluid will not be cooled by greater than 0.5% of the span when either the cylinder or the bimetallic thermometer is immersed. The "hot" bath shall contain a variable speed stirrer and be thoroughly

Table A-3 Thermal Response Test Bath Mediums and Temperatures

Range (Symbol)	Bath Medium	Initial Temperature, °F	T_1 Start Timing, °F	T_2 Stop Timing, °F	Bath Temperature, °F
18	Water	50	80	143	180
24	Water	50	80	143	180
55	Water	50	80	143	180
75	Salt	400	500	626	700

Fig. A-3 Standard Cylinder

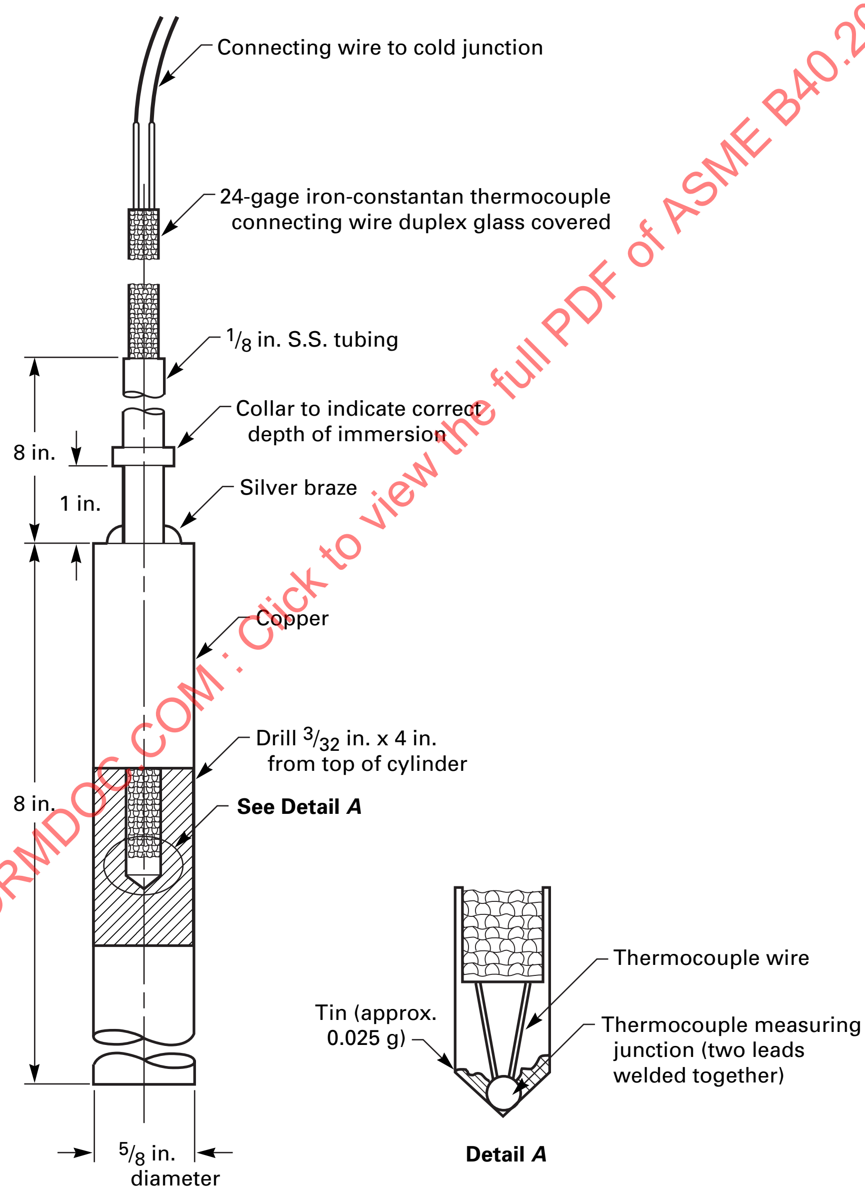


Table A-4 Response Time for Standard Cylinder

Bath Medium	Response Time, sec, ±0.2
Water	6
Salt [Note (1)]	8

NOTE:
(1) Noncorrosive low melting point mixture of nitrates and nitrites of sodium and potassium. The liquid shall be stable at all operating temperatures.

agitated. Two liquid temperature bath fluids are permissible for use with this test and are specified in Table A-3. The temperature range classification designation of the bimetallic thermometer will determine which of these two fluids shall be used. The temperature at which the fluids in the two temperature baths are set are listed in Table A-3. One fluid temperature is referred to as the "cold bath temperature," while the other is referred to as the "hot bath temperature."

A-3.6.2.1 Set Up. The conditions in the hot temperature bath fluid shall be set up such that the standard cylinder response time will be within the limits specified in Table A-4. Hot temperature bath fluid conditions and, thus, the standard cylinder response time will be changed by varying the agitation parameters. The standard cylinder shall be immersed in the temperature bath fluid to the bottom of the standard cylinder collar (see Fig. A-3 for location). The standard cylinder shall always be immersed in the hot temperature bath fluid in the same location and orientation.

A-3.6.3 Determining Response Time. The bulb of the bimetallic thermometer (or standard cylinder) shall be immersed in the hot temperature bath until there is no further indication of temperature rise. The bulb of the thermometer (or standard cylinder) shall then be immersed in the cold temperature bath until there is no further indication of temperature decrease. The bulb of the thermometer (or standard cylinder) shall again be immersed in the hot temperature bath. Timing shall be started when the thermometer (or stand cylinder) indicator reaches temperature T_1 (see Table A-3) and stopped when temperature T_2 is reached. The time it takes the thermometer (or standard cylinder) to indicate the difference between temperatures T_1 and T_2 shall be defined as the response time.

A-3.6.4 Conducting Test. The response time test shall be conducted by taking alternate response time measurements between the standard cylinder and thermometer. Each alternation of the standard cylinder's then the thermometer's response time measurements shall be defined as a trial. At least four trials shall be required in a temperature bath fluid of water and four trials in salt. The standard cylinder response time shall be within the limits of Table A-4 for the trial to be considered valid.

A-3.7 Load

The indicator, while mounted in its thermowell, shall be tested in accordance with para. 6.5 of ASME B40.3. Enclosure leakage test shall be conducted before and after the load test.

A-3.8 Enclosure Leakage

The thermometer case shall be tested for leakage in accordance with para. 6.7 of ASME B40.3. The indicator shall show no signs of leakage.

A-3.9 Fog

After completion of the final cycle of the enclosure leakage test, the indicator shall be placed in a cooling cabinet held at a temperature between 35°F and 40°F. After 1 hr the indicator shall be visually examined to determine that no signs of condensed moisture (fog) are evident inside the enclosure.

A-3.10 Vibration

The vibration test shall consist of two parts, an exploratory test and an endurance test. Indicator stem temperature during all tests shall be 70°F and 85°F. Mounting fixture and orientation shall be as shown in Fig. A-4.

A-3.10.1 Exploratory Vibration. The direct reading temperature indicator (ITD) shall be subjected to a rapid exploratory test from 5 Hz to 500 Hz in 1-Hz increments, each frequency to be held for a minimum of 5 sec. Displacement or vibratory amplitudes for ITD design indicators shall be as specified in Table A-5. The ITM design indicator shall be tested in accordance with MIL-STD-167-1, Type I.

Subsequent to the rapid exploratory scan, the ITD design indicator shall be subjected to a detailed resonance search from 500 Hz to 5 Hz in 5-Hz increments. Displacement shall be as specified in Table A-5. Each 5-Hz incremental frequency shall be maintained for a minimum of 2 min. ITM design indicators shall be tested in accordance with the variable frequency test of MIL-STD-167-1, Type I. Additionally, any frequency where resonance of any part of the indicator was detected during the initial rapid exploratory test shall be subjected to the 2-min detail resonance search for ITD design or 5 min for ITM design.

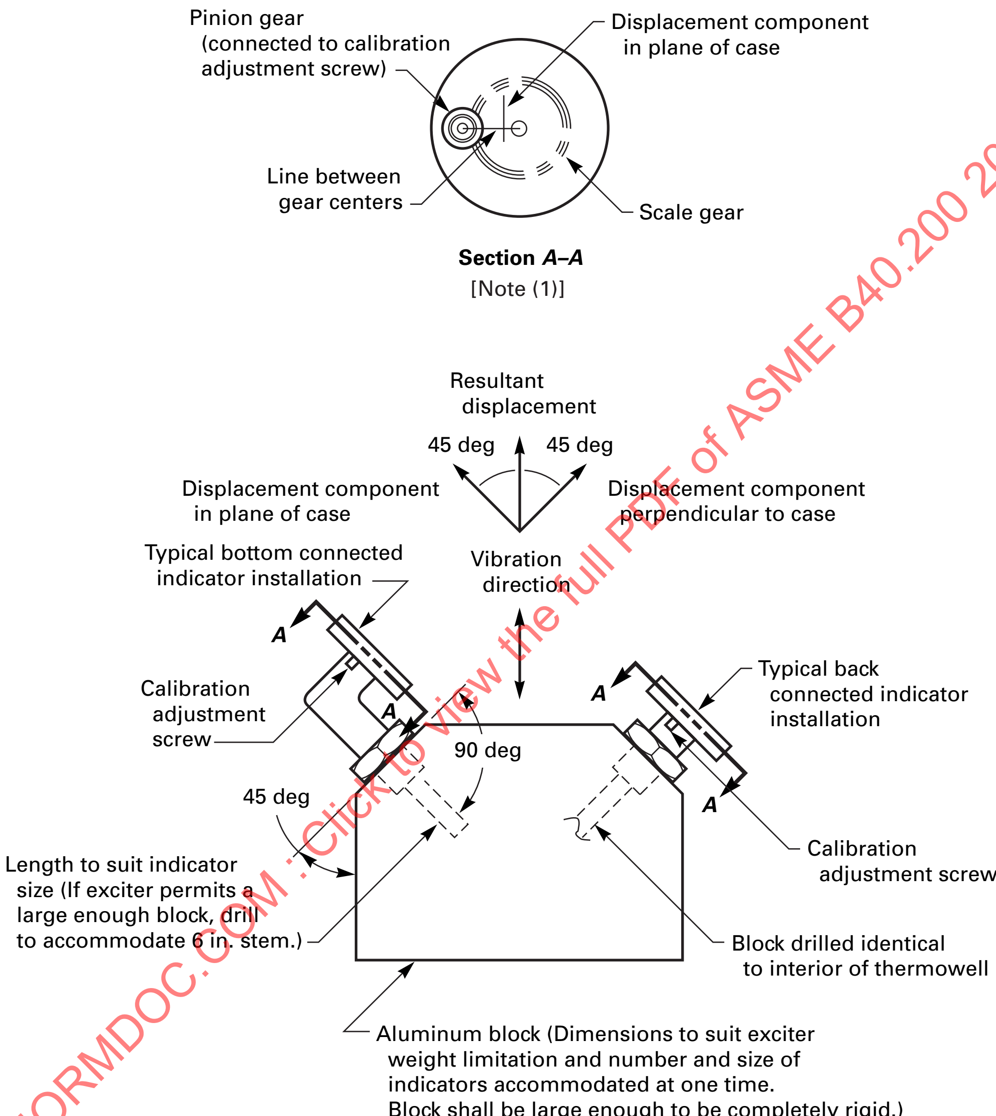
During the exploratory vibration tests, the indicator shall perform within the limits of the following:

(a) Accuracy shall be within the specified requirements before and after the vibration tests.

(b) Pointer oscillation shall not exceed three times the specified accuracy. Center of oscillation shall be within ±1% of the reading obtained under static condition.

(c) Indices of maximum and minimum indicators shall not shift during testing.

Fig. A-4 Mounting Fixture and Orientation for Indicator Vibration Tests



GENERAL NOTES:
(a) Method of fastening block to exciter table is optional but shall not reduce setup rigidity.
(b) Displacement components = 0.707 (input displacement).

NOTE:
(1) Displacement component in plane of case is perpendicular to line connecting gear centers.

Table A-5 Displacement Criteria for ITD Design Indicators

Frequency Range, Hz	Displacement (in., peak to peak)
5 to 20	0.300
21 to 500	22.67 (freq.)$^{-1.5}$

(*d*) A calibration shift placing data outside the data band established by the repeatability test or significant wear on any vital part constitutes failure.

(*e*) Failure also results from any instrument behavior not covered above that could be a serious vibration performance defect.

(*f*) Zero adjustment shall remain functional.

A-3.10.2 Vibration Endurance. The vibration endurance test shall include tests designed to evaluate the vibrational effects on the bimetallic element and the effects of vibration on component wear.

A-3.10.2.1 Bimetallic Element. The endurance test of the bimetallic element shall be run at the resonant frequency producing the most damage potential during the exploratory test. Generally, this is the resonant frequency producing the greatest pointer oscillation. Displacement shall be in accordance with Table A-5 for ITD design indicators or in accordance with the vibratory displacement requirements of the endurance test of MIL-STD-167-1, Type I for the ITM design. The test shall be run for 1 hr for the ITD design, 2 hr for the ITM design, or until the indicator fails to meet the specified performance requirements, whichever comes first. If performance requirements are met during the test, an accuracy verification must be performed.

A-3.10.2.2 Component Wear. The vibration component wear test shall be run at the frequency causing the worst excitation of the indicator case as noted during the exploratory test. Test duration shall be 20 hr or until significant wear or damage is produced, whichever comes first. Displacement shall be in accordance with Table A-5 for the ITD design or in accordance with the vibratory displacement requirements of the endurance test of MIL-STD-167-1, Type I for the ITM design. Accuracy verification must be performed subsequent to this test. In the event that the case does not exhibit a resonant frequency anywhere in the test frequency range, the wear test shall be run at 400 Hz for ITD design or 50 Hz for ITM design. If significant wear occurs in less than 20 hr or pointer behavior does not meet performance requirements during the wear test, the sample fails, and testing shall be terminated. If no significant wear is detected at the completion of the wear test, accuracy and repeatability verification shall be conducted. If these requirements are met, the wear test shall be deemed to be successfully passed.

A-3.11 Shock

A shock test shall be conducted in accordance with grade A, class I, type C requirements for lightweight equipment specified in MIL-S-901. Nine blows shall be applied. The indicator shall be mounted with a 4C fixture, mounting platform No. 2. The bimetallic actuated thermometer shall be mounted 3 in. or more from the side or rear of the platform. The thermometer shall be subjected to an accuracy test after the shock test. The accuracy shall not exceed three times the specified accuracy after all nine blows. An accuracy adjustment shall bring performance within the specified accuracy.

A-4 ORDERING PARAMETERS

A-4.1 Acquisition Requirements

When specifying a thermometer for acquisition, the following shall be provided:

(*a*) title, number, and date of this supplement
(*b*) Part Identifying Number (PIN)
(*c*) special dial marking or tagging
(*d*) mounting bracket, where required
(*e*) when qualification is required

A-4.2 Part Identifying Number (PIN) Parameters

Bimetallic actuated thermometer PINs incorporate the following variables:

(*a*) design
(*b*) size
(*c*) range
(*d*) case form
(*e*) stem length

A-4.2.1 Part Identifying Number (PIN) Format. The PINs are created as follows:

EXAMPLE: B40.3S1-ITD318A2

Specification	Design	Dial Size	Range	Case Form	Stem Length
B40.3S1	ITD	3	18	A	2

A-4.2.2 Design. Thermometer design shall be one of the following:

Symbol	Instrument Design
ITD	Indicator, temperature, direct-reading
ITM	Indicator, temperature, maximum and minimum

A-4.2.3 Dial Size. Thermometer dial size shall be one of the following:

Symbol	Dial Diameter, in.
3	3
5	5

A-4.2.4 Range. Thermometer temperature ranges shall be one of the following:

Symbol	Range, °F
18	−40 to 180
24	20 to 240
55	50 to 550
75	50 to 750

A-4.2.5 Case Form. Thermometer case form shall be one of the following:

Symbol	Forms [Note (1)]
A	Back connected
O	Bottom connected

NOTE:
(1) See Fig. 2 of ASME B40.3.

A-4.2.6 Stem Length. Thermometer stem lengths shall be one of the following:

Symbol	Stem Length, in. [Note (1)]
2	2
4	4
6	6

NOTE:
(1) See Table A-1 of ASME B40.3.

A-4.3 Ammunition and Pyrotechnic Space Temperature Measurement

ITM indicators are intended for ammunition and pyrotechnic magazines/lockers and shall consist of 3-in. dial size, back-angle form, 4-in. stem length, and −40°F to 180°F and 20°F to 240°F ranges.

A-5 REFERENCES

ASME B40.9, Thermowells for Thermometers and Electrical Temperature Indicators

Publisher: The American Society of Mechanical Engineers (ASME), Three Park Avenue, New York, NY 10016-5990; Order Department: 22 Law Drive, P.O. Box 2300, Fairfield, NJ 07007-2300

ASTM A 276, Hot Rolled, Cold Finish Stainless and Heat Resisting Steel Bars

ASTM D 788, Standard Classification System for Poly (-Methyl Methacrylate) (PMMA) Molding and Extrusion Compounds

ASTM D 3951, Standard Practice for Commercial Packaging

Publisher: ASTM International (ASTM), 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959

MIL-STD-167-1, Mechanical Vibrations of Shipboard Equipment (Type I - Environmental and Type II - Internally Excited)

MIL-S-901, Shock Tests, H.I. (High Impact); Shipboard Machinery, Equipment and Systems, Requirements for

Publisher: Department of Defense Single Stock Point Military Specifications and Standards (DODSSP), Defense Automated Printing Service, 700 Robbins Avenue, Building 4/D, Philadephia, PA 19111

ASME B40.4

FILLED SYSTEM THERMOMETERS

1 SCOPE

This Standard is confined to analog, dial-type filled system thermometers, utilizing elastic elements that enable the mechanically converted thermal energy to indicate temperature by means of a pointer moving over a scale.

The purpose of this Standard is to present information that will guide the user in the selection, installation, and use of filled system thermometers.

2 CLASSIFICATION

Filled system thermometers are separated into classifications of fill media as specified in paras. 2.1 through 2.1.4.2. See Table 1 for a summary of the classification discussed below and Table 2 for typical temperature ranges.

2.1 Classifications Defined

2.1.1 Class 1. Liquid actuated, solid filled with a high volumetric expansion organic liquid (not mercury). The elastic element responds to volumetric expansion of liquid in the bulb. Common-fill liquids are hydrocarbons and silicone fluids. Bulb size is dependent on temperature span and fill medium. Liquid-filled systems are sensitive to ambient temperature changes on the elastic element and capillary unless some means of compensation is employed.

2.1.1.1 Class 1A. A Class 1 thermometer with full compensation to correct the effects of ambient temperature changes on the elastic element and entire length of capillary.

2.1.1.2 Class 1B. A Class 1 thermometer with partial compensation to correct the effects of ambient temperature changes on the elastic element and a specified length of capillary.

2.1.2 Class 2. Vapor actuated, partially filled with a volatile liquid and its vapor at equilibrium. Component volume and quantity of liquid are designed so that the liquid-vapor interface occurs in the bulb throughout its rated operating range. The elastic element responds to the vapor pressure generated in the bulb due to its temperature. Vapor fill media have well known and predictable vapor-pressure characteristics. Common fills are hydrocarbons. Because the liquid-vapor interface occurs in the bulb, the primary ambient temperature effect is due to the spring rate change of the elastic element.

Table 1 Classification Summary

Class Fill	Typical Range Limits, °F (°C)	Scale
1, Organic liquid	−100/750 (−70/400)	Linear
2, Vapor	−40/500 (−40/260)	Nonlinear
3, Gas	−320/1,300 (−200/700)	Linear
4, Gas (with adsorbent)	−320/1,300 (−200/700)	Linear

2.1.2.1 Class 2A. A Class 2 thermometer designed for use where the bulb temperature is always above ambient temperature of the indicating head and capillary. Essentially all vapor is in the bulb (see Fig. 1).

2.1.2.2 Class 2B. A Class 2 thermometer designed for use where the bulb temperature is always below ambient temperature of the indicating head and capillary. Essentially all liquid is in the bulb (see Fig. 1).

2.1.2.3 Class 2C. A Class 2 thermometer designed for use where the bulb temperature may be above or below the indicating head and capillary ambient temperature. When the bulb temperature is above ambient, the capillary fill is liquefied and the vapor is in the bulb (Class 2A), and when the bulb temperature is below ambient, the capillary fill is vapor and liquefied in the bulb. When the bulb temperature is the same as ambient, there is a moment of indicator instability as liquefaction and vaporization occur throughout the system (see Fig. 1).

2.1.2.4 Class 2D. A Class 2 thermometer designed for use above, below, or at the indicating head and capillary ambient temperature. The volatile liquid (and interface) is confined to the sensor bulb by the use of a second nonvolatile liquid in the capillary and elastic element (see Fig. 1).

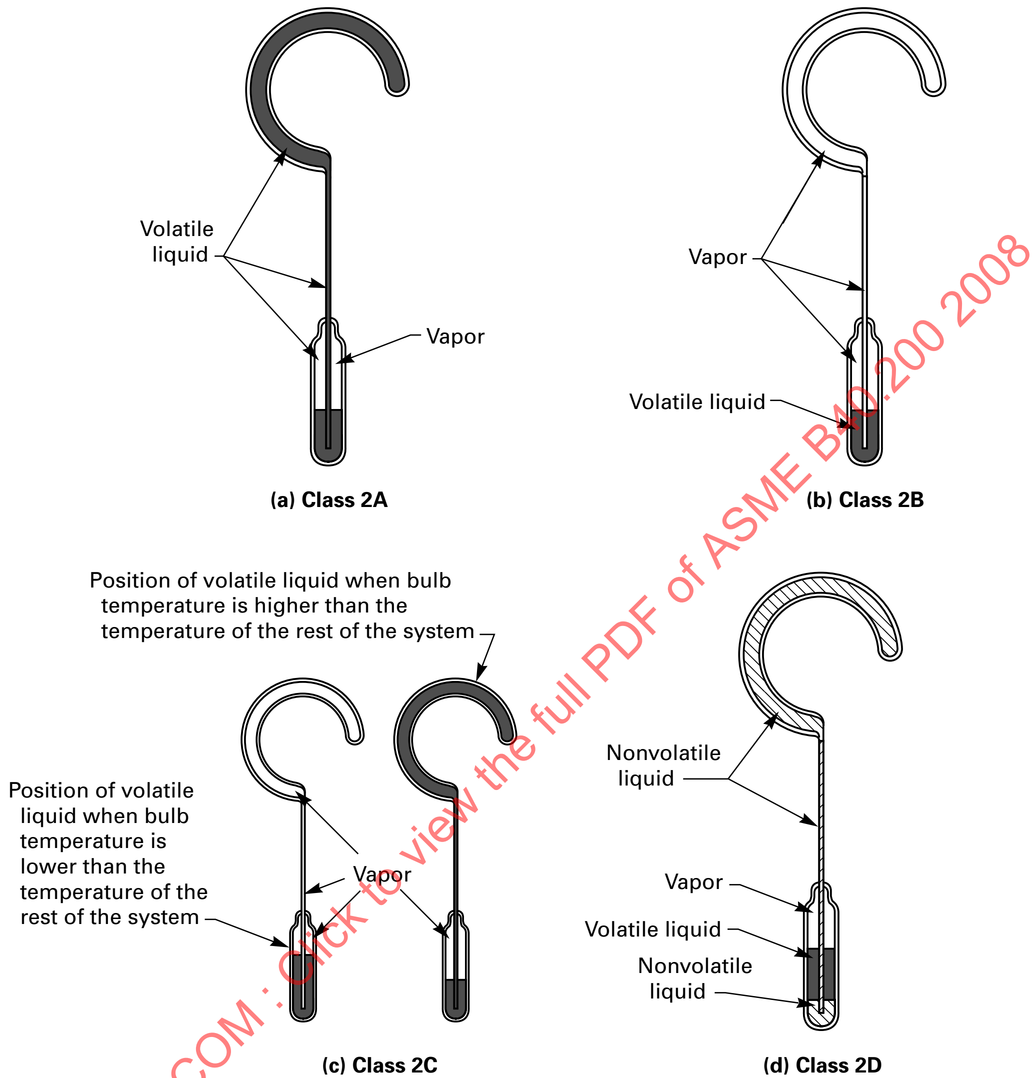
2.1.3 Class 3. Gas actuated with elastic element, capillary and bulb filled with inert gas. Internal pressure

Table 2 Typical Ranges

Range, °F	Class 1 Liquid	Class 2 Vapor	Class 3 to 4 Gas
−320/200	. . .	. . .	X
−120/120	. . .	. . .	X
− 40/60	. . .	X	. . .
− 40/180	. . .	. . .	X
0/100	. . .	X	X
0/120	. . .	. . .	X
0/150	. . .	X	X
0/180	. . .	X	X
0/200	. . .	. . .	X
20/240	X	X	X
0/300	. . .	X	X
50/400	X	X	X
50/550	. . .	X	X
50/750	X	. . .	X
0/1,000	X	. . .	X
200/1,200	. . .	. . .	X
Range, °C			
−200/40	. . .	. . .	X
− 40/15	. . .	X	X
− 20/70	X	X	X
0/100	X	X	X
0/150	X	X	X
0/200	X	X	X
0/300	X	. . .	X
0/400	X	. . .	X
0/500	X	. . .	X
0/600	. . .	. . .	X
200/650	. . .	. . .	X

GENERAL NOTE: Other ranges are available, including dual Fahrenheit and Celsius scales.

Fig. 1 Vapor Pressure Thermal Systems



GENERAL NOTE: This illustration is not intended to show design details.

changes occur as a result of temperature changes anywhere on the system, but since the volume of the bulb is 10 to 20 times that of the elastic element and capillary, the internal pressure is primarily a function of the bulb temperature.

2.1.3.1 Class 3B. A Class 3 thermometer with compensation at the elastic element to partially correct for ambient temperature error.

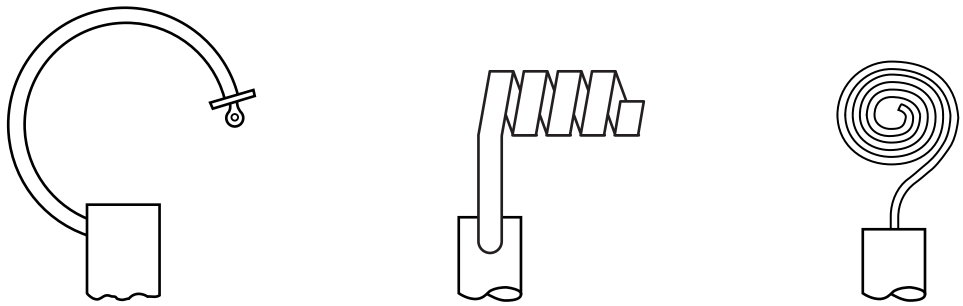
2.1.4 Class 4. Gas-actuated thermometer with an adsorbent (such as activated carbon) in the bulb. The adsorbent amplifies the pressure-temperature relationship providing a pressure change greater than that of an equivalent range Class 3 thermometer. This permits the use of smaller bulbs and narrower temperature spans. Lower operating pressures minimize ambient temperature errors.

2.1.4.1 Class 4A. A Class 4 thermometer with an ultra low-volume elastic element made of NiSpan C®[1] (or equivalent), a small bore capillary, and a small bulb. This construction permits very narrow temperature span (50°F or less) with minimal ambient effect.

2.1.4.2 Class 4B. A Class 4 thermometer with compensation at the elastic element to partially correct for ambient temperature error.

[1] NI-SPAN-C is a registered trademark of the International Nickel Company, Inc.

Fig. 2 Elastic Elements



(a) C-Type Bourdon Tube

(b) Helical Bourdon Tube

(c) Spiral Bourdon Tube

GENERAL NOTE: This illustration is not intended to show design details.

3 TERMINOLOGY AND DEFINITIONS

accuracy: the conformity of indication to an accepted standard or true value. Accuracy is the difference (error) between the true value and the indicated value expressed as a percent of span. It includes the combined effects of method, observer, apparatus, and environment. Accuracy error includes hysteresis and repeatability errors but not friction error.

accuracy, reference: the accuracy of the thermometer under reference conditions [normal position at 20°C ± 1°C (approximately 68°F ± 2°F) and 29.92 in. Hg (101.32 kPa) barometric pressure].

adjustment, pointer indication: a means of causing a change in indication. The change is approximately equal over the entire scale, except for vapor-filled thermometers, which have nonlinear scales. Some examples of this type of adjustment are adjustable pointers, rotatable dials and movements, and other similar items. This adjustment, if provided, is generally accessible to the user.

ambient temperature: see *temperature, ambient.*

armor: a protective covering over the capillary.

averaging bulb: see *bulb, averaging.*

bendable extension: see *extension, bendable.*

bezel: see *ring.*

bourdon tube: a tubular elastic pressure element. May have "C," helical, spiral, or other form (see Fig. 2).

bulb: the sensitive portion of a filled system thermometer (see Fig. 3).

bulb, averaging: a bulb made of a long length of tubing that may be coiled, so as to provide a large area-to-volume ratio. The bulb is installed in a vessel so as to pass through high and low temperature zones, thereby sensing the approximate average temperature of the process fluid.

bulb, elevation error: see *error, bulb elevation.*

bulb, finned: a bulb, a portion of which is provided with external fins.

bulb, flush: a bulb, the sensitive portion of which is inserted through an opening in the wall of a vessel, such as a mechanical mixer, so that the sensitive portion substantially forms a continuation of the inner surface of the vessel.

bulb length: see *length, bulb.*

bulb, plain: a bulb with no means for attachment (see Fig. 4).

bulb, preformed: a bulb that is formed by the manufacturer and not designed to be reformed at installation.

bulb, union connected: a bulb that is provided with a union connector for the purpose of attaching to a bushing, flange, or thermowell on the process vessel. This joint may or may not be pressure tight (see Fig. 4).

bushing: a fitting provided with external and internal threads.

calibration: the process of causing the thermometer to indicate within specified accuracy limits.

calibration verification: the checking of a thermometer by comparison with an accepted standard to determine the error at specified points on the scale.

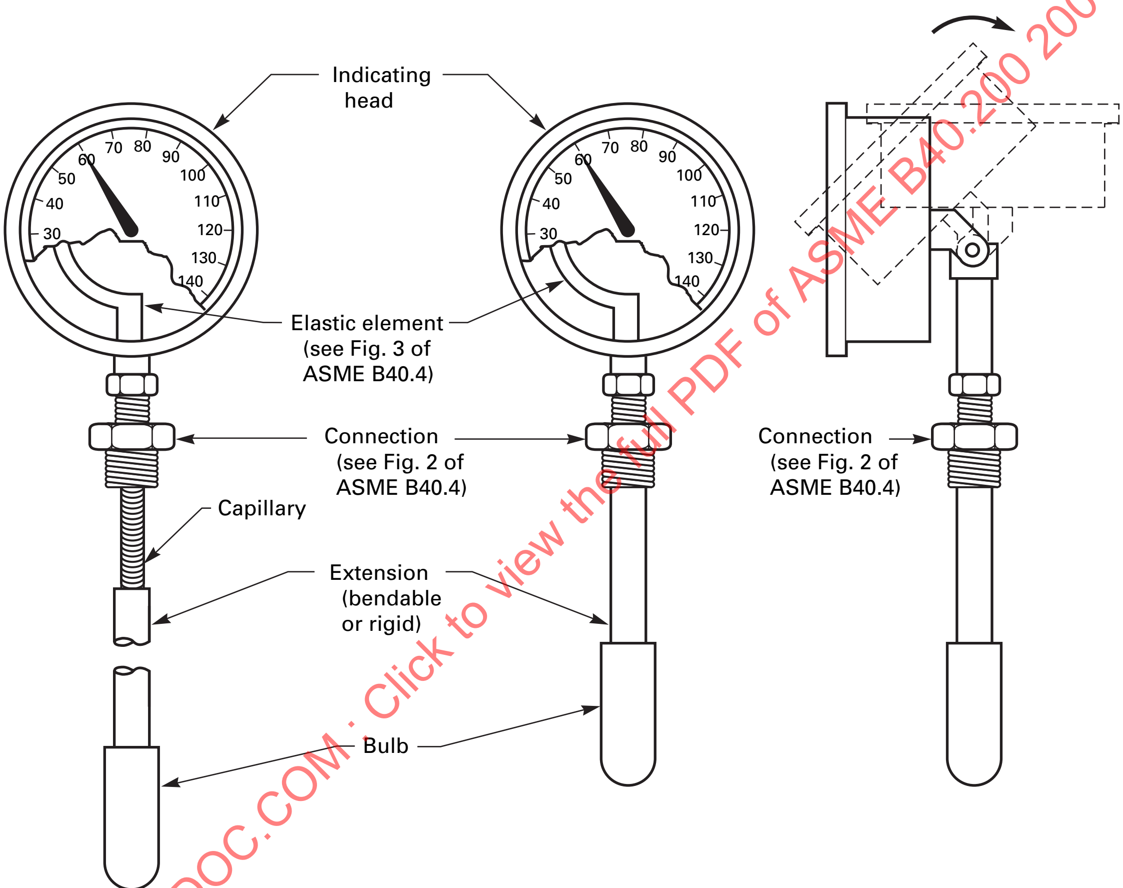
cam ring: see *ring, cam.*

capillary: that portion of the thermal system between the bulb or extension and the indicating head (see Fig. 3).

case: the housing or container that supports, protects, and surrounds the internal parts of the indicating head.

case, liquid filled: a case that is filled with a liquid such as glycerin or silicone fluid to at least 75% of its total

Fig. 3 Thermometer Configurations



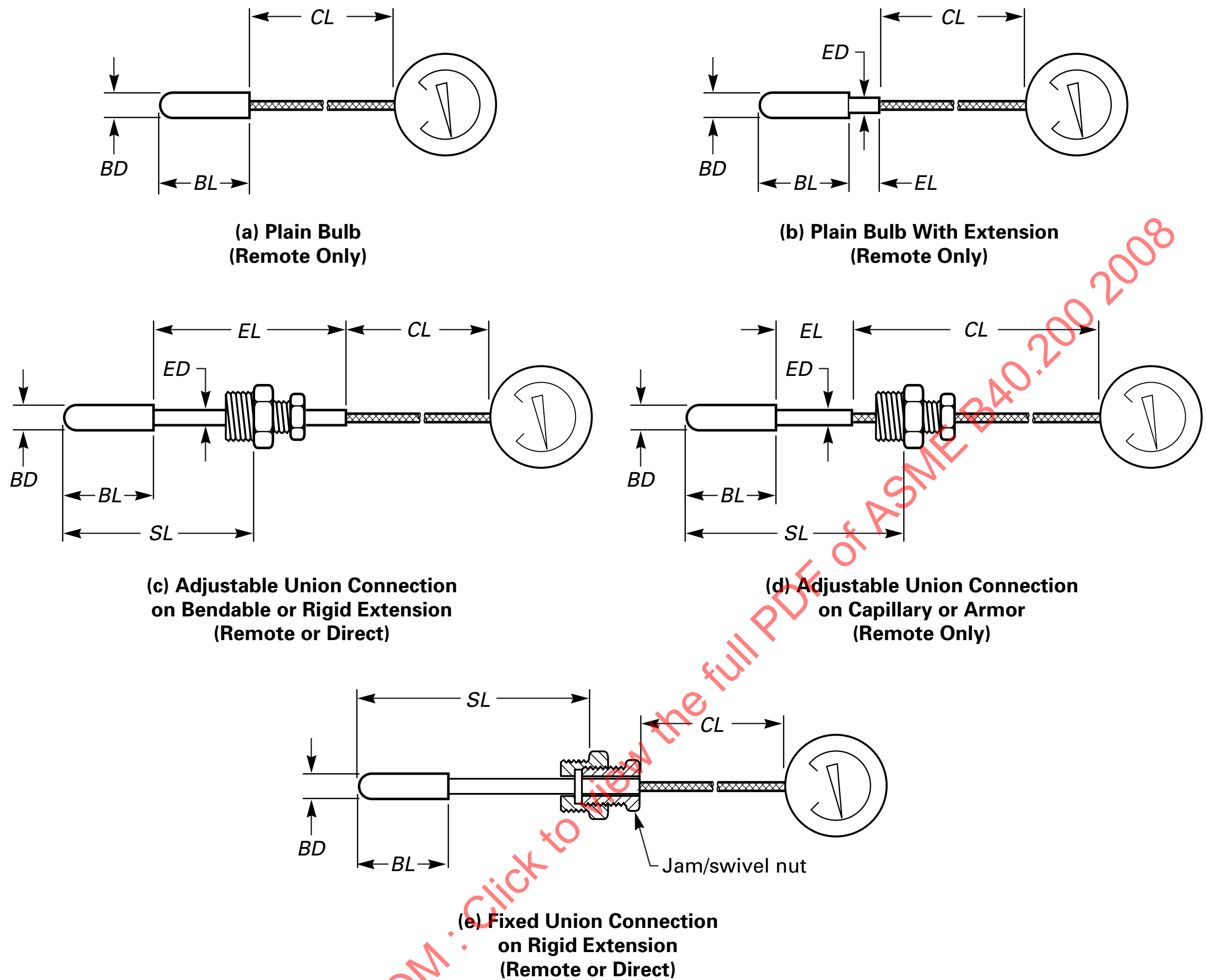
(a) Remote Reading

(b) Direct Reading (Fixed)

(c) Direct Reading (Adjustable)

GENERAL NOTES:
(a) Capillary may or may not be armored.
(b) See Fig. 2 of ASME B40.4 for bulb and connection configurations.
(c) This illustration is not intended to show design details.

Fig. 4 Bulb and Connection Configurations



BD = bulb diameter
BL = bulb length
CL = capillary length
ED = extension diameter may be the same as *BD*
EL = extension (bendable or rigid) length
SL = stem length (insertion length)

GENERAL NOTES:
(a) Capillary may or may not be armored.
(b) This illustration is not intended to show design details.

volume. The purposes of this construction are to protect the internal parts from damage caused by severe vibration, reduce pointer fluctuation, and/or exclude ambient corrosives.

case, open front: a case having no partition between the elastic element and window.

case sealed: a case that is sealed from the environment.

case size: see *size, case*.

case, solid front: a case with a partition between the elastic element and window.

Celsius: SI unit of temperature measurement (formerly Centigrade), abbreviation °C.

centigrade: see *celsius*.

compensation, indicating head: a means to reduce the change in the indicated temperature resulting from the effects of ambient temperature change on the elastic element and the fill within the elastic element.

compensation, full: a means to reduce the change in the indicated temperature resulting from the effects of ambient temperature change on the elastic element and the fill within the elastic element and the capillary.

conditions, environmental: the conditions, other than process, external to the thermometer, including weather, temperature, humidity, salt spray, vibration corrosive atmosphere, etc., which could affect its performance or life.

connecting tubing: see *capillary.*

connection, union, adjustable: a connection located remotely at the bulb end of the capillary. It allows the case and capillary to swivel and also permits bulb insertion adjustment. It is locked with a swivel nut and usually pressure tight. Distance, *SL*, is adjustable (see Fig. 4).

connection, union, fixed: a connection located at the case or remotely at the bulb. It allows capillary and case to swivel but no bulb insertion adjustment. It is locked with a swivel nut and usually pressure tight. Distance, *SL*, is not adjustable (see Fig. 4).

connection, union, sliding: see *connector, union, adjustable.*

correction: the quantity that is algebraically added to an indicated value to obtain the true value. The algebraic sign of the correction is opposite to the sign of the error (see *error*).

corrosion failure: see *failure, corrosion.*

cross-ambient effect: Class 2A, Class 2B, and Class 2C vapor-actuated thermometers will not indicate the process temperature when that temperature is at or near the ambient temperature of the indicating head. Erratic pointer movement is caused by the transfer of the fill medium between the bulb and indicating head.

dial: the component that contains the scale.

dial, anti-parallax: see *dial, dished and dial, multi-plane.*

dial, dished: see *dial, multi-plane.*

dial, dual scale: a dial containing two scales with different units of measure, such as °F and °C.

dial graduations: the division marks of the scale.

dial, multi-plane: a dial with graduations in approximately the same plane as the pointer to reduce parallax error.

dial, size: see *size, case.*

direct reading thermometer: see *thermometer, direct reading.*

elastic element: a component that deflects in response to pressure or volume change (see Fig. 2).

environmental conditions: see *conditions, environmental.*

error: the difference between the true value and the indicated value of the variable being measured. A positive error denotes that the indicated value is greater than the true value (see also *correction*).

error, ambient: the change of temperature indication that results when the indicating head and capillary are at a temperature different from their temperature at calibration.

error, bulb elevation: the error in the indicated temperature that results from installing the bulb in a position above or below the indicating head different from that at which the thermometer was calibrated. This error may be negligible in some classes of thermometers.

error, friction: the difference between indicated values before and after the indicating head has been lightly tapped.

error, head: see *error, bulb elevation.*

error, hysteresis: the difference between increasing temperature and decreasing temperature readings at any point on the scale obtained during a temperature cycle, after friction errors have been eliminated by tapping.

error, immersion: the error due to the bulb not being fully immersed.

error, parallax: reading error induced by visual misalignment.

error, position: the change of temperature indication that results from rotating the indicating head into a position different from that in which it was calibrated (see para. 5.2.6).

extension: a component between the bulb and capillary or indicating head (see Fig. 3).

extension, bendable: an extension that is designed to be bent by the user to permit the bulb to be located in the desired location.

extension, rigid: an extension that is not designed to be bendable by the user.

Fahrenheit: a U.S. Customary unit of temperature measurement, abbreviation °F.

failure, corrosion: thermal system failure resulting from environmental or process corrosive chemical attack.

failure, fatigue: elastic element failure resulting from repeated application of stress (see para. 7.1.2.1).

failure, over-temperature: failure caused by exposure to environmental or process temperature in excess of rated temperature limit.

failure, vibration: failure caused by exposure to vibration.

fatigue failure: see *failure, fatigue.*

fill fluid: the fluid (liquid or gas) in the thermal system that converts temperature (heat energy) to mechanical energy.

fill medium: see *fill fluid.*

fin: a plate or structure attached to the bulb to increase surface area and therefore the rate of heat transfer.

finned bulb: see *bulb, finned.*

flush mounted: see *thermometer, flush mounted.*

friction error: see *error, friction.*

friction ring: see *ring, friction.*

graduation, dial: see *dial, graduations*.

hysteresis error: see *error, hysteresis*.

immersion error: see *error, immersion*.

immersion length: see *length, immersion*.

indicating head: the case, window, elastic element, ring, and other components (see Fig. 3).

insertion length: see *length, stem* (see Fig. 4).

length, bulb, "BL": see Fig. 4.

length, capillary, "CL": the distance from the bulb or extension to the indicating head (see Fig. 4).

length, extension, "EL": see Fig. 4.

length, immersion: the length from the free end of the bulb to the point of immersion in the medium.

length, stem, "SL": see Fig. 4.

lens: see *window*.

mounting: the means by which the indicating head is installed or supported.

mounting, direct: see *thermometer, direct reading.*

mounting, remote: see *thermometer, remote reading*.

mounting, flush: see *thermometer, flush mounted*.

mounting, surface (wall): see *thermometer, surface (wall) mounted.*

movement: the component that converts elastic element motion to rotary pointer motion.

NPT: American Standard Taper Pipe Threads (ASME B1.20.1).

parallax: see *error, parallax*.

plain bulb: see *bulb, plain*.

pointer: the component that, in conjunction with the dial, indicates temperature.

pointer adjustment: see *adjustment, pointer indication.*

pointer, maximum: a component that is moved by the indicating pointer to the maximum temperature indicated and remains at that point until reset. Inclusion of this accessory may affect accuracy.

pointer, minimum: a component that is moved by the indicating pointer to the minimum temperature indicated and remains at that point until reset. Inclusion of this accessory may affect accuracy.

preformed bulb: see *bulb, preformed*.

range: the low and high limits of the scale.

readability: the observer's ability to determine the indicated temperature value. Factors that may affect readability include length of the scale, graduation configuration and spacing, pointer design and width, parallax, distance between observer and scale, illumination, stability of pointer, pointer and scale colors, and the liquid level line in liquid-filled cases.

remote reading thermometer: see *thermometer, remote reading.*

repeatability: the maximum difference between a number of consecutive indications of the same applied temperature under the same operating conditions, approaching the temperature from the same direction, after lightly tapping the indicating head, expressed as a percent of span.

response time: time required indicate a step change in temperature (see para. 5.2.10).

ring: the component that secures the window to the case.

ring, bayonet: see *ring, cam*.

ring, cam: a ring similar to the threaded ring except that the threads are replaced by a cam arrangement.

ring, crimped: a ring formed to the case at assembly so as to be nonremovable.

ring, friction: a ring retained by means of an interference or friction fit between it and the case.

ring, slip: a ring similar to the friction ring except that it has a clearance fit with the case and is secured by screws.

ring, snap: a ring that snaps into a groove in the case.

ring, threaded: a ring having threads that match threads on the case.

scale: markings on the dial consisting of graduations, related numerals, and units(s) of measure.

sealed case: see *case, sealed*.

separable socket: see *thermowell*.

SI (Le Systeme International d'Unites): these units are recognized by the CIPM (Comité International des Poids et Measures).

size, case (dial): the nominal size of a case. The approximate inside diameter of the case, in inches, at the dial.

slip ring: see *ring, slip*.

snap ring: see *ring, snap*.

span: the algebraic difference between the limits of the scale:

(a) The span of a 0°F/100°F thermometer is 100°F.
(b) The span of a 200°C/500°C thermometer is 300°C.
(c) The span of a −40°F/120°F thermometer is 160°F.

standard, calibration: a temperature instrument used to determine the accuracy of a thermometer (see ASME PTC 19.3, Temperature Measurement).

stem length: see *length, stem, "SL."*

stop pin: a component on the dial that limits the motion of the pointer.

surface (wall) mounted: see *thermometer, surface (wall) mounted.*

swivel nut: see *jam nut*.

temperature, ambient: the temperature of the medium surrounding the indicating head and capillary. Temperature at the capillary may be different from the temperature at the indicating head.

temperature compensation: see *compensation, full* and *compensation, indicating head*.

temperature, process: the temperature of the process medium.

temperature, storage: the extremes of temperature (high and low) that the thermometer may be exposed to when stored, transported, or not in use.

thermal system: the portion of a thermometer consisting of the bulb, extension (if provided), capillary, elastic element, and the fill medium.

thermometer, direct reading: a thermometer with the indicating head connected directly to a rigid extension (see Fig. 3).

thermometer, flush mounted: a thermometer provided with supporting means on the indicating head so that it may be set in a panel. When installed, the dial is approximately flush with the panel (see Fig. 5).

thermometer, remote reading: a thermometer with the indicating head connected to the bulb with capillary (see Fig. 3).

thermometer, surface (wall) mounted: a thermometer whose indicating head can be mounted to a wall or flat surface (see Fig. 5).

thermometer, temperature compensated: a thermometer that is compensated to reduce errors during operation at ambient temperatures other than that at which it was calibrated.

thermowell: a pressure-tight receptacle adapted to receive a bulb and provided with external threads or other means for pressure-tight attachment to a vessel or system.

threaded ring: see *ring, threaded*.

traceability, calibration: documentation of the existence of a calibration chain between an instrument and the National Institute of Standards and Technology (formerly the National Bureau of Standards).

true value: the value of the parameter being measured as determined by an accepted calibration standard after all corrections have been made.

union-connected bulb: see *bulb, union connected*.

well: see *thermowell*.

window: a transparent component through which the dial is viewed.

window, heat-treated glass: a window of heat-treated (tempered) glass, that, when broken, will form small, granular pieces, usually with no jagged edges.

window, laminated glass: a window with two or more sheets of glass held together by an intervening layer(s) of clear plastic. When cracked or broken, the pieces of glass tend to adhere to the plastic.

window, plain glass: a window of commercial glass.

window, plastic: a window of transparent plastic.

window, threaded: a window generally made of plastic with integral threads that match threads on the case. No separate ring is required.

4 INSTALLATION

4.1 General

4.1.1 Before installing a thermometer, consideration should be given to ambient temperature, humidity, vibration, shock, and other climatic and ambient conditions of the service application (see Safety, section 6).

4.1.2 The bulb may be installed directly into the medium (see Safety, section 6).

4.1.3 The filled system of the thermometer is a sealed unit and must remain sealed. The capillary should be kept coiled until installation to avoid sharp bends or kinks.

4.1.4 A thermometer can be rendered inaccurate during shipment despite care taken in packaging. To ensure conformance to the accuracy grade to which the thermometer was manufactured, it should be checked before use (see Test Procedures, section 8).

4.2 Installation Procedure

4.2.1 Placement. The bulb should be located and completely immersed at the point that will provide temperature indication that is most representative of the process. Adequate circulation of the medium is necessary for optimum response and accuracy.

4.2.2 Direct Reading Thermometer. Use the wrench flats, when provided, to install the thermometer.

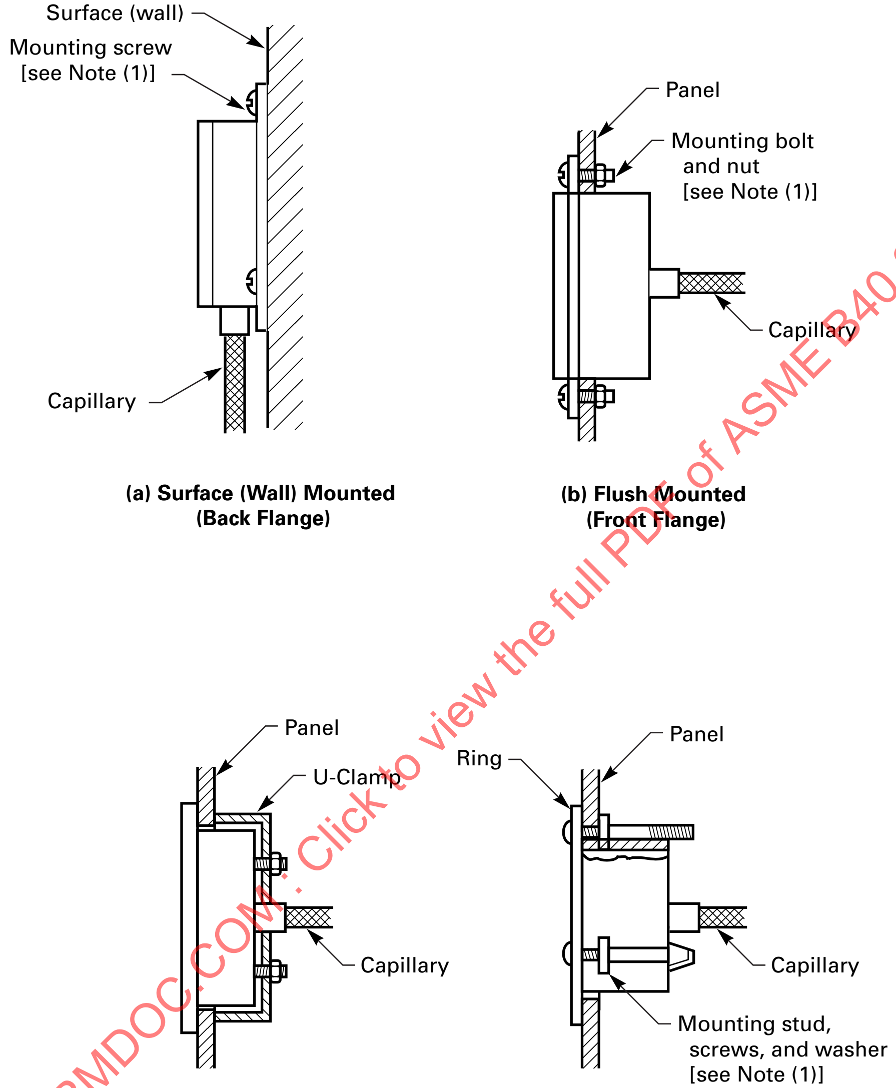
4.2.3 Remote Reading Thermometer. Do not twist, kink, strain, or cut the capillary. After the indicating head has been mounted, uncoil the capillary and place the bulb at its intended location.

After installing the bulb, fasten the capillary to a wall or other support to prevent accidental damage. Position capillary to avoid extreme temperatures. Since the capillary length cannot be altered, any excess should be coiled to a 3-in. minimum radius and supported near the case.

4.3 Vapor Thermometer Bulb Orientation

Some vapor-actuated thermometer bulbs must be installed in a specific orientation. Suppliers may provide marking of the bulb and installation instructions when required.

Fig. 5 Mounting Variations



(a) Surface (Wall) Mounted (Back Flange)

(b) Flush Mounted (Front Flange)

(c) Flush Mounted (U-Clamp)

(d) Flush Mounted (Ring)

GENERAL NOTES:
(a) Capillary may or may not be armored.
(b) Capillary location at case may vary.
(c) This illustration is not intended to show design details.

NOTE:
(1) For mounting dimensions, see para. 7.1.3 of ASME B40.4.

5 ACCURACY (See Para. 8.2)

5.1 Grade

GRADE A ±1.0% of span over entire scale
GRADE B ±2.0% of span over entire scale

NOTE: The above tolerances apply only to approximately the upper ½ of the arc of the scale for Vapor-Actuated Dial Thermometers (Class 2). Consult the supplier for specific accuracy information. Refer to para. 2.1.

5.2 Factors Affecting Accuracy

5.2.1 Bulb Temperature. Exposure of the bulb, either in use or during storage to temperatures below the lower end or above the upper end of the scale.

Because the vapor pressure and temperature relationship is nonlinear, the scale is nonlinear. The spacing between graduations is expanded on increasing temperature, making the indication more readable in the upper part of the scale. The range of a vapor thermometer should be selected so that its operating temperature(s) occur in the upper half of the scale. Typical accuracies for vapor thermometers are

(a) ±15% in first ¼ of span
(b) ±5% in second ¼ of span
(c) ±2% in upper ½ of span

Normally, scales are graduated so that these accuracies represent one scale division. Consult the supplier for temperature limits.

5.2.2 Indicating Head Temperature. Exposure of the indicating head either in use or during storage to temperatures other than normal ambient conditions. Consult the supplier for temperature limits.

5.2.3 Capillary Temperature. Exposing the capillary either in use or during storage to temperatures other than normal ambient conditions.

5.2.4 Bulb Immersion. The bulb should be completely immersed in the medium (see para. 4.2).

5.2.5 Bulb Elevation. Exposure of the bulb to an elevation above or below the indicating head in Liquid-Actuated (Class 1) or Vapor-Actuated (Class 2) thermometers. Consult the supplier for correction factors.

5.2.6 Indicating Head Position. Mounting the indicating head in a position other than that at which it was calibrated. Normal calibration position is dial upright/vertical. Consult the supplier for correction factors (see *error, position*).

5.2.7 Readability. See section 3.

5.2.8 Cross-Ambient Effect. See section 3.

5.2.9 Thermowell. Thermowell should be of proper length to ensure complete immersion of the bulb.

5.2.10 Response Time. Response time is the time required for a thermometer to respond to a step change in temperature. Response time varies according to a number of interrelated parameters, including

(a) temperature differential
(b) heat transfer capability, including flow effects of process medium
(c) whether or not the bulb is in a thermowell
(d) the thickness of the thermowell wall
(e) conductivity of the thermowell material
(f) air gap and/or medium contained within the thermowell to transfer heat from the thermowell to the bulb of the thermometer
(g) friction within the indicating head
(h) viscosity, location, amount, and thermal characteristics of dampening medium, if present
(i) capillary length

The user is encouraged to determine whether or not response time is critical.

6 SAFETY

6.1 Scope

This section of the standard presents information to guide users, suppliers, and manufacturers towards minimizing the hazards that could result from misuse or misapplication of filled system thermometers. The user should become familiar with all sections of this Standard, as all aspects of safety cannot be covered in this section. Consult the supplier for advice whenever there is uncertainty about the safe application of a thermometer.

6.2 General Discussion

The user should inform the supplier of all conditions pertinent to the application and system environment so that the supplier can recommend the most suitable thermometer.

Adequate safety results from intelligent planning and careful selection and installation of a thermometer into the system whose temperature is to be measured. Suppliers' pressure and temperature ratings should not be exceeded. The location of the thermometer should be such that in the event of a failure, injury to personnel and damage to property are minimized.

6.2.1 Many applications involve temperature measurement of unpressurized systems. The principal hazards of using direct reading thermometers in such systems are those associated with proximity to the system being measured (e.g., exposure to hot liquids, corrosive material, freezing fluids, etc.). Consideration should be given to using a remote reading thermometer in such applications.

6.2.2 Safe use of a thermometer in a pressurized system requires that factors such as, but not limited to, the following should be considered:

(a) the effect of static and dynamic pressure on the bulb

(b) the effect of temperature on materials

(c) any corrosive effects on materials

(d) vibration

(e) consequences of a leak in the thermal system resulting in mixing of the fill fluid and the process medium

(f) pressure and temperature rating of union or other types of connections

6.2.3 Thermowells permit the use of thermometers at higher pressure than could be safely applied to an unprotected bulb. Thermowells facilitate the removal and reinstallation of thermometers without creating a temporary leak and without requiring process shutdown. Thermowells protect bulbs from excessive temperatures and corrosive attack by the process medium and against structural damage caused by fluid velocity-induced vibration. The following should be considered:

(a) Choose a thermowell material that is compatible with the process medium at the maximum operating concentrations, temperatures, and flow rates.

(b) Apprise the thermowell supplier of the maximum pressure, flow rate, vibration, and cavitation conditions of the process.

(c) The addition of a thermowell can result in a temperature time lag resulting in an indication error, especially during changing temperature conditions. Temperature time lag may be minimized by the addition of a heat transfer material in the thermowell around the bulb.

(d) When transferring a thermometer bulb from one thermowell to another, make sure the thermowell is properly sized so there is minimum dead-air space between the bulb and well.

6.2.4 Use of a direct-connected thermometer on a process requires consideration of the effect of the heat transfer through the connection to the thermometer head; significant heat gain or loss can result in indication errors. If the thermometer case is sealed, errors can be even larger, or damage may result from build-up of internal pressure. Consult the supplier for recommendations.

6.3 Reuse of Thermometers

Should it be necessary to reuse a thermometer in another application, accuracy should be checked (see para. 8.2). The portion of the thermal system exposed to the process should be cleaned, and all requirements of a new installation should be considered.

7 CONSTRUCTION

7.1 Case

7.1.1 General. Cases may be fabricated from various materials using various manufacturing processes. They may have solid fronts and may or may not employ various case pressure relief means. Specific applications may require design variations with respect to case construction. There should be mutual agreement between user and supplier regarding the applications and design variations.

7.1.2 Types

7.1.2.1 Cases Without Pressure Relief Means. Filled system thermometers present a low possibility of elastic element failure. Closed systems such as these limit the pressure applied to the pressure element reducing the probability of over-pressure being applied. The low number of cycles in temperature measurement versus the design fatigue life of the elastic element makes the probability of fatigue failure low. Cases with pressure relief means are available but not as important as they are in pressure gages.

(a) Solid Front. A case having a partition with minimum opening(s) between the elastic element and window. The partition may be an integral part of the case.

(b) Open Front. A case with no partition between the elastic element and window.

7.1.2.2 Cases With Pressure Relief Means

(a) Solid Front with Pressure Relief Back. A case having a partition with minimum opening(s) between the elastic element and window and having a pressure relieving back device or opening(s). The partition may be an integral part of the case.

(b) Open Front with Pressure Relief Back. A case with a pressure relief device or opening and no partition between the elastic element and window.

7.1.3 Mounting. Where holes or studs are used for flush and surface-mounted thermometers, they shall be sized and located in accordance with Tables 3 and 4.

7.1.4 Size. This Standard defines size as the approximate inside diameter of the case, in inches, at the dial. Other standards, such as the German DIN series, define size as the precise outside diameter of the case. Because of this difference, a B40.4 thermometer and a DIN thermometer may not be interchangeable, even though the nominal sizes are approximately the same at the inside of the case at the dial. The outside diameter of a B40.4 thermometer case may be over 10% larger than a comparable DIN thermometer.

7.2 Dials

Dials are normally graduated in either Fahrenheit or Celsius or with two scales, such as Fahrenheit and Celsius. Dual scales dials are useful where thermometers are employed on equipment that may be used internationally or where users plan to convert from one unit of measure to another.

The unit of measure shall be noted on the dial either by the word Fahrenheit or Celsius, or abbreviation "F"

Table 3 Round Cases

Case Size	Mounting Bolt Circle Diameter		Case Bolt Hole Diameter		Panel Opening Diameter	
	in.	mm	in.	mm	in.	mm
1 1/2	1.91	48.5	0.13	3.4	1.65	41.9
2	2.56	65.0	0.16	4.5	2.19	55.6
2 1/2	3.13	79.5	0.16	4.5	2.81	71.4
3 1/5	4.25	108.0	0.22	5.6	3.81	96.8
4 1/5	5.38	137.0	0.22	5.6	4.94	125.0
6	7.00	178.0	0.28	7.1	6.50	165.0
8 1/5	9.63	245.0	0.28	7.1	9.00	229.0

GENERAL NOTE: Above sizes are identical to ASME B40.1.

Table 4 ISO/ANSI Z17.1-1973 Case Sizes

Case Size	Mounting Bolt Circle Diameter		Case Bolt Hole Diameter		Panel Opening Diameter	
	in.	mm	in.	mm	in.	mm
40	2.01	51	0.14	3.6	1.73	44
50	2.36	60	0.14	3.6	2.13	54
63	2.95	75	0.14	3.6	2.64	67
80	3.74	95	0.19	4.8	3.31	84
100	4.57	116	0.19	4.8	4.09	104
160	7.01	178	0.23	5.8	6.46	164
250	10.63	270	0.23	5.8	10.00	254

GENERAL NOTE: Other sizes may be available.

or "C." The degree symbol (°) is optional. The value of a subdivision may be indicated.

7.2.1 Graduations. The recommended minimum arc of the scale is 270 deg. Special applications and ranges may require other arcs greater or less than 270 deg.

Graduation lines should be radial to the center of rotation of the pointer. Major and intermediate graduation lines should be emphasized. Scale, numeral, and graduation increments should follow the format 1, 2, or 5×10^n, where n is a whole positive or negative number or zero.

The smallest graduation increment should not exceed twice the absolute value of the error permitted at midscale. The exception would be for vapor-actuated (Class 2) thermometers in the lower portion of the scale.

Numerals should be sufficient to enable the observer to quickly and accurately identify any temperature. They should not obscure or crowd graduations.

7.2.2 Anti-Parallax Dials. Dials designed so that the plane of the graduated portion is nominally the same as the plane of the pointer. This configuration minimizes the effect of reading error introduced by visual misalignment.

7.3 Pointer

The pointer shall rotate clockwise with increasing temperature. The width of the tip of the pointer should not be greater than approximately twice the width of the minor graduations. The radial distance between the pointer tip and inner end of the minor graduations should not exceed the width of the tip of the pointer. In the case of a dual scale dial, the pointer width should be maintained at a minimum so as not to obscure the inner scale. The radial distance between the tip of the pointer and inner end of the minor graduations of the outer scale should not exceed the width of the tip of the pointer.

7.4 Stop Pin

Some thermometers are provided with a stop pin. The purpose of the stop is to prevent the pointer from rotating to a graduated portion of the scale when temperatures either above or below the indicated range are applied.

7.5 Window

7.5.1 Laminated Glass. Laminated glass shall comply with ANSI Z26.1. Laminated glass offers some protection in all applications. It reduces the possibility of glass particles scattering if the pressure element ruptures and window failure results.

7.5.2 Heat-Treated Glass. Heat-treated glass shall comply with ANSI Z26.1. Heat-treated glass offers greater resistance to mechanical damage than plain glass.

7.5.3 Plastic. Impact, abrasive environmental conditions, especially temperature and corrosive atmosphere, must be carefully considered to determine the type of plastic best suited for the application.

7.5.4 Plain Glass. This window material is commonly used due to its abrasion, chemical, and wear resistance properties. Careful consideration of its use should be given for hazardous applications.

7.6 Capillary

The capillary is generally made of copper or stainless steel tubing and is often covered with a protective material. It is joined at each end by welding, brazing, or soldering.

7.7 Extension

The extension is generally made of copper or stainless steel tubing and is joined to the capillary and bulb by welding, brazing, or soldering.

7.8 Connections

See Figs. 3 and 4 of ASME B40.4.

7.9 Bulb

The bulb is generally made of copper or stainless steel and may have welded, brazed, or soldered joints. See bulb definitions for various configurations.

8 TEST PROCEDURES

8.1 Scope

This section is intended to provide an outline of the parameters used when evaluating new thermometer performance and to suggest evaluation procedures. These test methods may or may not satisfy the requirement of the intended application. When it is known that the thermometer will encounter conditions more severe or less severe than those specified, the tests may be modified to match more closely the application. A functional test in the intended application is generally the best evaluation method.

CAUTION: The test procedures and equipment utilized for the tests in this section often operate at potentially dangerous high or low temperature. Hazards may exist for skin burn, steam flash, and/or explosion, eye injury, and other health hazards.

These tests should be performed ONLY by competent, trained individuals familiar with test procedures and test equipment.

High-temperature salt baths often contain salts that are not compatible with other salts. Moving a thermometer from one bath to another without cleaning the first bath residue from it can result in an explosion. Similarly, while not explosive, any water carried from a low-temperature bath to a high-temperature bath has the potential to flash into steam. This flashing can throw extremely hot liquid significant distances. This type of steam/salt bath explosion can cause severe injury.

8.2 Accuracy

8.2.1 Purpose. This test determines the accuracy of the thermometer under test in compliance with section 5.

8.2.2 Procedure

(a) Throughout this test, the bath temperature shall be measured using a calibration standard. The accuracy of the standard should be at least four times that of the thermometer under test.

The bath must be properly agitated. An ambient temperature of 23°C (73.4°F) shall be the reference standard for testing all thermometers; test ambient temperature may be 75°F ± 5°F.

(b) Immerse the bulb of the thermometer to be tested to the supplier's recommended depth.

(c) Before starting the accuracy test, precycle by immersing the bulb at least once in hot and cold baths with temperatures close to the high and low values of the span.

(d) Readings are to be taken, after gently tapping, at approximately 10%, 50%, and 90% of the span, both increasing and decreasing temperatures. Comparison with the calibration standard shall be made at each point.

(e) Readings should be taken before and after gently tapping the thermometer. The difference between the readings at a given temperature is the friction error expressed as a percent of span.

8.3 Repeatability

8.3.1 Purpose. This test determines the ability of the thermometer to produce the same results when the accuracy test procedure is repeated.

8.3.2 Procedure

(a) Repeatability can be determined using the data obtained in the two temperature cycles (see para. 8.2.2).

(b) Repeatability is the difference between any two readings taken after tapping at the same temperature, approached from the same direction, in the two temperature cycles, and expressed as a percentage of span. More than two temperature cycles may be desirable.

(c) Repeatability does not include hysteresis or friction error.

8.4 Error, Position

8.4.1 Purpose. This test determines the effect on the accuracy of the thermometer when mounted in a position different from that in which it was calibrated (see para. 5.2.6).

8.4.2 Procedure

(a) Mount the thermometer in an upright and vertical position.

(b) Test for accuracy (see para. 8.2.2).

(c) Place the thermometer in its intended operating position.

(d) Repeat the accuracy test (see para. 8.2.2).

(e) The difference between the two sets of readings is the position error.

8.5 Error, Ambient Temperature

8.5.1 Purpose. This test determines the effectiveness of the provisions made in the thermometer system to compensate for temperature changes around the indicating head and along the capillary. Without compensation or with inadequate compensation, the temperature variations around these elements may have a substantial influence on the indication.

8.5.2 Procedure

(a) The indicating head and capillary shall be subjected to ambient temperatures of 50°F, 100°F, and 135°F.

(b) For each ambient temperature, the bulb shall be tested at three different temperatures. The three bulb temperatures shall be approximately 10%, 50%, and 90% of the span of the thermometer.

(c) Both the indicating head and the capillary shall be held at the required temperatures for not less than 1 hr before taking each reading.

(d) Readings shall be taken at every bulb temperature within each environmental condition (see para. 8.2.2).

(e) The error at any selected bulb temperature can be determined by comparing the pointer indication to the actual temperature at the bulb. The difference between the error at the test environmental conditions and at 23°C is the ambient temperature error.

(f) In instances where the indicating head and capillary may be subjected to significantly different temperatures, additional testing may be necessary. Consult the supplier.

8.6 Under-/Over-Temperature

8.6.1 Purpose. This test determines the effect of short-term exposure to process temperature either above or below indicated range limits. Prior to testing thermometers, consult the supplier for recommended minimum and maximum temperatures.

8.6.2 Procedure

(a) Test for accuracy (see para. 8.2.2).

(b) Raise temperature of bulb by approximately 10% of the span over the highest indicated value. Maintain for approximately 5 min.

EXAMPLE: Range 20°F/240°F

(1) 240°F minus 20°F equals 220°F span.

(2) 10% of 220°F equals 22°F.

(3) 240°F plus 22°F equals 262°F.

(4) Test temperature would be approximately 260°F.

(c) Repeat the accuracy test (see para. 8.2.2).

(d) The difference between the reading in (a) and (c) above is the effect of over-temperature.

(e) Lower temperature of bulb by approximately 10% of the span below the lowest indicated value. Maintain for approximately 5 min.

EXAMPLE: Range 20°F/240°F: Test temperature would be approximately 0°F.

(f) Repeat the accuracy test (see para. 8.2.2).

(g) The difference between the readings in °C and °F is the effect of under-temperature.

8.7 Storage

8.7.1 Purpose. This test determines the effect of temperature extremes that may be encountered during storage.

8.7.2 Procedure

(a) Test for accuracy (see para. 8.2.2).

(b) The thermometer shall be placed in a temperature test chamber at the supplier's recommended high limit of storage temperature for a period of 24 hr.

(c) The thermometer shall be placed in a temperature chamber at the supplier's recommended low limit of storage temperature for a period of 24 hr.

(d) Repeat this 48-hr cycle for a total of two complete tests.

(e) Repeat accuracy test (see para. 8.2.2).

(f) The difference between the two accuracy tests is the effect of storage temperature, expressed as a percentage of span.

8.8 Vibration

8.8.1 Purpose. This test determines the effect of 6 hr of exposure to the test described below.

8.8.2 Procedure

(a) Test for accuracy (see para. 8.2.2).

(b) Each of the tests specified below shall be conducted separately in each of the three mutually perpendicular axes. All tests in one axis shall be completed before proceeding to tests in another axis.

(c) The thermometer under test shall be secured to the vibration table in essentially the same manner as it will be secured in service. The mounting device shall be sufficiently rigid to ensure that its motion will be essentially the same as the motion of the platform of the vibration machine. The bulb temperature should be at approximately the middle of the scale.

(d) To determine the presence of resonance, the thermometer under test shall be vibrated at frequencies from 5 Hz to 60 Hz at peak amplitudes per Table 5. The change in frequency shall be made in discrete frequency

Table 5 Vibration Test Amplitudes

Frequency Range, Hz	Peak-to-Peak Vibration Amplitudes	
	in.	mm
5 to 15	0.060 ± 0.012	1.5 ± 0.3
16 to 25	0.040 ± 0.008	1.0 ± 0.2
26 to 33	0.020 ± 0.004	0.5 ± 0.1
34 to 40	0.010 ± 0.002	0.25 ± 0.05
41 to 60	0.005 ± 0.001	0.013 ± 0.025

intervals of approximately 1 Hz and maintained at each frequency for 15 sec. The frequencies and locations at which resonance occur shall be noted.

(e) The thermometer shall be tested for a period of 2 hr in each of the mutually perpendicular axes (6 hr total) at the resonant frequency. If more than one resonant frequency exists, the test shall be conducted at the highest resonant frequency. If no resonance is observed, the test shall be performed at 60 Hz.

(f) Repeat accuracy test (see para. 8.2.2).

(g) The difference between the two accuracy tests is the effect of vibration expressed as a percent of span.

9 SELECTION CRITERIA

When selecting a thermometer, section 6, Safety, and the following must be considered:

(a) class (see section 2)
(b) temperature range and units of measure
(c) accuracy (see section 5)
(d) case size (see section 7)
(e) case and ring, style and material
(f) window material
(g) process compatibility
(h) environmental conditions
(i) for remote reading
  (1) bulb style and size
  (2) stem length
  (3) extension length (if any)
  (4) capillary length
  (5) connection — plain or threaded, fixed or adjustable
  (6) bulb, extension, and capillary material
  (7) armor style and material
  (8) head elevation (if applicable)
  (9) connection location — back or bottom
  (10) case mounting configuration
(j) for direct reading
  (1) bulb style and size
  (2) stem length and diameter
  (3) extension length (if any)
  (4) bulb and extension material
  (5) connector — plain or threaded, fixed or adjustable
  (6) connector location — back, bottom, top, right, or left
(k) variations, options, and/or accessories
  (1) special dial markings
  (2) pointer — fixed or adjustable
  (3) minimum and/or maximum indicating pointer
  (4) thermowell

10 REFERENCES

ANSI Z26.1-1990, Safety Code for Glazing Materials for Glazing Motor Vehicles Operating on Land Highways
Publisher: American National Standards Institute (ANSI), 25 West 43rd Street, New York, NY 10036

ASME B1.20.1-1983 (R1992), Pipe Threads, General Purpose (Inch)
ASME PTC 19.3-1974 (R1998), Instruments and Apparatus: Part 3, Temperature Measurement
Publisher: The American Society of Mechanical Engineers (ASME), Three Park Avenue, New York, NY 10016-5990; Order Department: 22 Law Drive, P.O. Box 2300, Fairfield, NJ 07007-2300

NONMANDATORY APPENDIX A
FILLED SYSTEM THERMOMETERS
(SUPPLEMENTARY INFORMATION)

This Appendix, established for naval shipboard application, shall apply when specified in the contract or purchase order. When there is conflict between the Standard (ASME B40.4) and this Appendix, the requirements of this Appendix shall take precedence for equipment acquired in accordance with this supplement. This Appendix supersedes MIL-T-19646, Thermometer, Gas Actuated, Remote Reading, for new ship construction.

A-1 SCOPE

This specification Appendix covers shock-resistant, environmentally hardened, gas-actuated, remote reading, filled system thermometers configured to meet the requirements for shipboard use. This Appendix, when combined with ASME B40.4, covers thermometers that utilize an elastic element to measure the pressure within a gas-filled closed system (thermal system) and convert this pressure to an analog temperature indication on a circular dial. Remote reading is accomplished by a sensor consisting of a thermal bulb connected to an analog temperature indicator by a specified length of capillary tubing. The gas actuated thermometer bulb is configured for either direct immersion or insertion into a thermowell.

A-2 GENERAL REQUIREMENTS

A filled system thermometer shall utilize nitrogen or an inert gas.

A-2.1 Size

Thermometers shall utilize sizes of 3½, 4½, and 8½.

A-2.2 Scale

Scales shall cover an arc of not less than 270 deg central angle.

A-2.3 Adjustments

A zero adjustment shall be accomplished by the adjustment of the pointer or the dial.

A-2.4 Line Length

Standard line lengths shall be 15 ft, 30 ft, 45 ft, 60 ft, and 75 ft. Any excess line should be neatly coiled. Any requirement beyond these standard lengths shall be submitted as a deviation.

A-2.5 Cleaning and Packaging

The filled system thermometer (especially the wetted parts) shall be free of loose scale, rust, grit, filings, mercury, calibration liquids, oil, grease, solvents, and other organic materials. Unless special cleaning, drying, unit protection, and intermediate packaging are specified, the filled system thermometer shall be cleaned, dried, and bagged with boxing in accordance with ASTM D 3951.

A-2.6 Construction

A-2.6.1 General. Materials and combinations of materials that liberate gases that combine with the atmosphere to form an acid or corrosive alkali shall not be used. Materials and combinations of materials shall not liberate toxic or corrosive fumes that would be detrimental to the performance of the gas-actuated thermometer or the health of the operator. The materials shall also not liberate gases that will produce an explosive atmosphere.

A-2.6.2 Threads. Threads shall be in accordance with FED-STD-H28. Tapered pipe threads shall not be used.

A-2.6.3 Lubrication. The filled system thermometer shall operate without the need for lubrication of any part after assembly.

A-2.7 Sensors

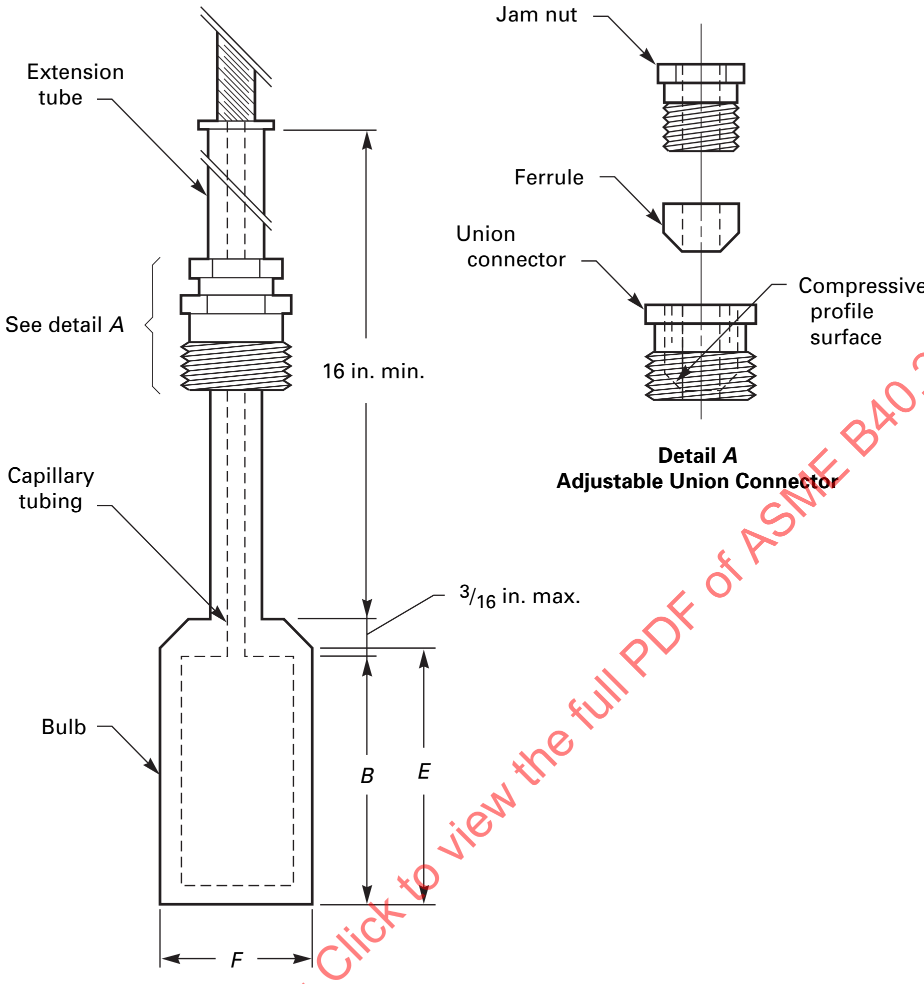
The sensor shall consist of a bulb, an extension tube, and a fitting. Sensors acquired by this supplement are classified by configuration, which is discussed in detail in section A-5. The sensor configuration classification identifies the sensor type, mounting method, and dimensions.

A-2.7.1 Bulbs. Bulbs shall be fabricated from corrosion-resistant steel (CRES). The bulb shall meet dimensional requirements as specified in Fig. A-1.

A-2.7.2 Extension Tube. Extension tubes shall be fabricated from CRES. The extension tubing shall be heavy walled.

A-2.7.3 Connection, Union, Adjustable. Adjustable union connection shall be fabricated from CRES. The adjustable union connection (see Fig. A-1, Detail *A*) shall

Fig. A-1 Class C Sensor Configuration



Sensor Configuration Classification Designation	*F*, ±0.002 (in.)	*B*, Max. (in.)	*E*, Max. (in.)
C1	0.375	1.500	2.000
C2 [Note (1)]	0.375	3.000	3.500

NOTE:
(1) Equivalent to sensor configuration classification designation A1.

consist of a jam nut, ferrule, and union connector and shall be adjustable along the length of the extension tube. Adjustable union connection shall be furnished with each class A and class C sensor.

A-2.7.3.1 Union Connector. The thread of the union connector shall be in accordance with the following table.

Nominal Diameter Bulb, in.	Union Connector Thread Size
3⁄8	3⁄4–28–2A

A-2.8 Capillary Tubing and Spiral Armor

Capillary tubing and spiral armor shall be fabricated from CRES. The capillary tubing shall be protected by the extension tube and spiral armor. The strength of the capillary tubing protection shall ensure that neither the weight of the bulb nor the indicator shall subject the capillary tubing to tensile stress.

A-2.9 Indicator

The indicator shall include the case, dial, window, elastic element, movement, indicating pointer, and red index pointer.

A-2.9.1 Case. Cases shall be fabricated from aluminum, ASTM B 26, ASTM B 85, or CRES, ASTM A 167, or ASTM A 473. Aluminum shall be prepared for protection against corrosion by chromate conversion coatings or anodizing. Aluminum shall then by finished with an air-dry primer and a gray enamel finish coat. Corrosion resisting steel cases shall be prepared for protection against corrosion by providing a 0.001-in. to 0.002-in. surface profile. Case finish shall then contain a finish that shall include air-dry primer and a gray enamel finish coat in accordance with FED-STD-595, color 26307. Cases shall be interchangeable for mounting purposes with the cases shown in Fig. A-2. Dimensions A3, A4, A8, A10, A15, and A17 shall be critical dimensions of the case and shall be in strict accordance with Fig. A-2.

A-2.9.1.1 Case Connection. Unless otherwise specified, the protrusion of the capillary from the case (the case connection) shall be in the lower back connected orientation. The only other alternative orientation permitted shall be in the bottom connected configuration. The location of the case connection shall be in accordance with Fig. A-2.

A-2.9.2 Dials. Dials shall be designed to resist damage from high temperature and corrosion and shall be in accordance with para. 7.2 of ASME B40.4. The dial color shall be yellow background with black graduations and markings.

A-2.9.2.1 Markings. Dial markings shall include the following:

(a) manufacturer's name or trademark
(b) manufacturer's CAGE (Commercial and Government Entity) code
(c) Part Identifying Number (PIN)
(d) National Stock Number (NSN)

A-2.9.3 Window. Windows shall be fabricated from thermoplastic in accordance with ASTM D 788.

A-2.9.4 Pointers. Indicating pointers shall be nonreflective black, and index pointers shall be nonreflective red.

A-2.9.5 Pointer Stop. Filled system thermometers shall incorporate a maximum stop. See para. 7.4 of ASME B40.4 for details.

A-2.9.6 Gaskets and O-Rings. Gaskets and o-rings shall be fabricated from fluorocarbon rubber with a maximum rating of 250°F.

A-2.9.7 Case Mounting. A flush-mounting kit shall be provided with all filled system thermometers. Material shall be CRES.

A-3 INSTALLATION

A-3.1 Mounting

Indicators shall be mounted directly to an instrument panel or bulkhead. Sensors may be mounted directly into brackets, thermowells, or directly immersed in the process fluid. Filled system indicators are designed to operate satisfactorily when installed in such a manner that the capillary tubing and case at no point exceeds a temperature of 160°F. When a filled system indicator is provided with excess capillary tubing, the excess shall be coiled behind the instrument panel and secured.

A-3.2 Thermowells

Where required, thermowells shall be provided in accordance with ASME B40.9, Thermowells for Thermometers and Electrical Temperature Sensors, and its appendix.

A-4 TEST PROCEDURES AND REQUIREMENTS

WARNING: Where two baths are used, the heat transfer medium should be the same in both baths. Some high-temperature salts are not compatible, and the dragging of one liquid to the other can result in an explosion. Similarly, while not explosive, any water carried into a high-temperature bath will flash into steam, thus throwing hot liquid from the bath and endangering personnel and equipment.

A-4.1 Responsibility for Inspection

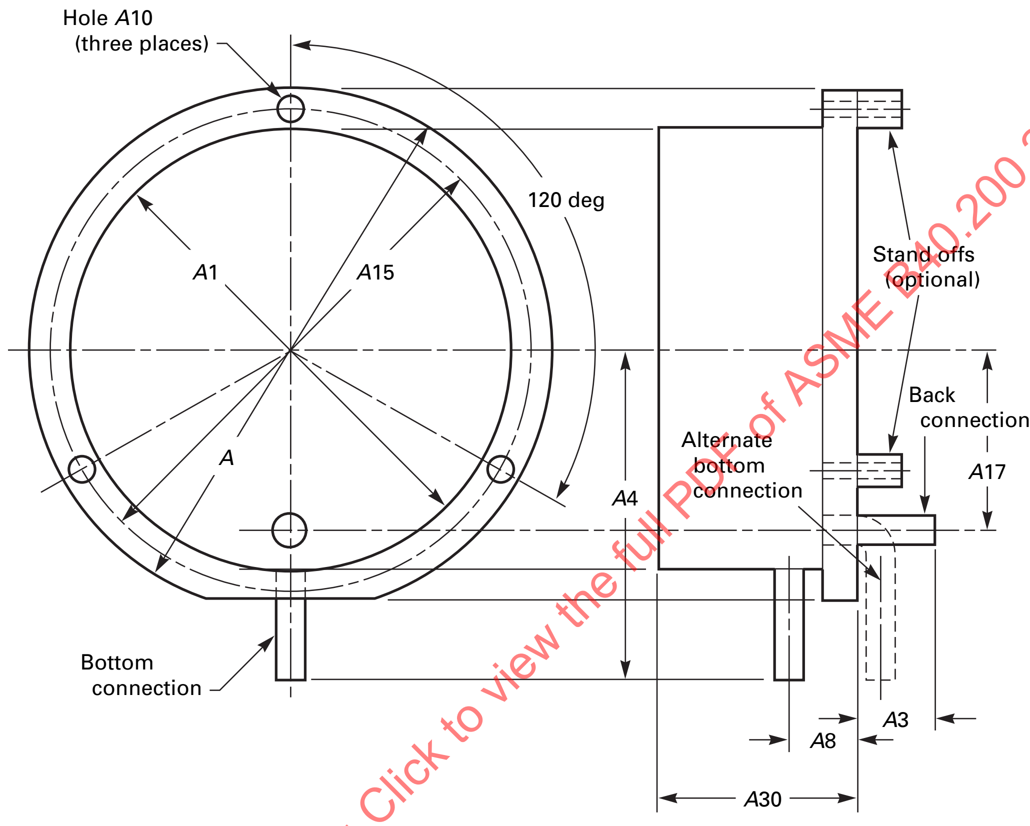
Unless otherwise specified in the contract or purchase order, the manufacturer is responsible for performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the manufacturer may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the purchaser. The purchaser reserves the right to perform any of the inspections set forth in the Standard where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

A-4.1.1 Responsibility for Compliance. All items shall meet all requirements of this section. The inspection set forth in this specification shall become a part of the manufacturer's overall inspection system or quality program. The absence of any inspection requirements in this specification shall not relieve the manufacturer of the responsibility of ensuring that all products or supplies submitted to the purchaser for acceptance comply with all requirements of the contract. Sampling inspection, as part of the manufacturing operations, is an acceptable practice to ascertain conformance to requirements; however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the purchaser to accept defective material.

A-4.2 Classification of Inspections

A-4.2.1 Qualification Inspection. Qualification inspection shall consist of tests and examinations listed in Table A-1 and shall be performed and passed prior

Fig. A-2 Cases for Flush-Mounted Thermometers



(a) Front Elevation **(b) Side View**

GENERAL NOTE: For flush mounting, standard panel hole diameters are: $3^{1}/_{2}$ – $4^{15}/_{32}$ in.; $4^{1}/_{2}$ – $5^{19}/_{32}$ in.; $8^{1}/_{2}$ – $9^{29}/_{32}$ in.

	Dimensions								
Size	*A* (±0.1)	*A1* (+0.000, −0.1)	*A3* (±0.3)	*A4* (±0.3)	*A8* (±0.1)	*A10* (±0.01)	*A15* (±0.015)	*A17* (±0.050)	*A30*
$3\frac{1}{2}$	4.75	3.97	1.2	3.2	1.0	0.22	4.25	1.063	2.50-4
$4\frac{1}{2}$	5.80	5.00	1.2	3.8	1.0	0.22	5.375	1.625	2.50-4
$8\frac{1}{2}$	10.25	8.97	1.2	5.8	1.0	0.28	9.625	3.625	2.50-4

GENERAL NOTE: All dimensions are in inches.

Table A-1 Inspection Requirements

Tests And Examinations	Qualification Inspection	Conformance Inspection
Accuracy	X	X
Repeatability	X	X
Inclination	X	. . .
Compensation	X	. . .
Response time	X	. . .
Salt spray	X	. . .
Over temperature	X	. . .
Vibration	X	. . .
Shock	X	. . .

to production. Qualification inspection shall be performed on samples that have been produced with equipment and procedures normally used in production.

A-4.2.1.1 Sample Size. Two thermometers of each classification shall be subjected to the qualification inspection.

A-4.2.2 Conformance Inspection. Conformance inspection shall consist of tests and examinations listed in Table A-1 and shall be performed and passed by each thermometer.

A-4.3 Acceptance Criteria

If any thermometer fails to meet the inspection requirements of Table A-1, no thermometer shall be accepted until the manufacturer has determined the cause of the defect and has taken necessary action to correct or eliminate the defect from each thermometer. The failed test shall be repeated to demonstrate that the corrective action will enable the thermometers to meet the specified requirements. In addition, the results of previous inspections may be deemed invalid, unless the manufacturer can prove to the satisfaction of the purchaser that such test would not be adversely impacted by the corrective action.

A-4.4 Accuracy

Accuracy tests shall be conducted in accordance with para. 8.2 of ASME B40.4. Accuracy shall be within ±1% of span.

A-4.5 Repeatability

Repeatability tests shall be conducted in accordance with para. 8.3 of ASME B40.4. Repeatability shall be within ±½% of span.

A-4.6 Inclination

The filled system thermometer shall indicate the midspan temperature so that the pointer is in a vertical position. The indicator shall be positioned such that the dial faces the operator. The indicator shall then be inclined 60 deg to the right, left, front, and back. The indicator shall remain at each inclined position for at least 1 min before taking each reading. The inclined pointer position change shall be within ±½% of span.

A-4.7 Compensation

The filled system thermometer shall be placed into one of two categories. The first category (category 1) shall consist of thermometers whose maximum dial indication is not greater than 240°F. The second category (category 2) shall consist of thermometers whose maximum dial indication is greater than 240°F. The thermometers shall be tested under the environmental conditions of Table A-2, whichever is applicable. For each environmental condition, perform an accuracy test. Both the indicator and the capillary shall be held at the required temperature for not less than 1 hr before taking each reading. Accuracy shall be within ±1% of span.

A-4.8 Response Time

A standard cylinder shall be used for this test. The information needed to construct a standard cylinder is provided on Fig. A-3. Connecting wires from the standard cylinder thermocouple shall terminate at an ice bottle, ice point reference junction, or a reference junction compensated electronic indicator. If an ice bottle or ice point reference junction is used, the extension wires coming from the reference junction shall be connected to an indicator such as a potentiometer or a millivolt recorder. No matter what form of indicator is used, the indicator shall have a response time not less than two times faster than the response time of the temperature rise that the standard cylinder will measure (see Table A-3 of B40.3). Response time measurement shall be conducted using either a stop watch or any method capable of timing to 0.2 sec or better and shall be within the requirements of Table A-3.

A-4.8.1 Temperature Bath. Two temperature baths are used in performing this test. The baths shall be sufficiently large or constructed in such a manner that the temperature bath fluid will not be cooled by greater than 0.5% of the span when either the cylinder or the filled system thermometer is immersed. The "hot" bath shall contain a variable speed stirrer. Two liquid temperature bath fluids are permissible for use with this test and are specified in Table A-4. The temperature range classification designation of the filled system thermometer will determine which of these two fluids shall be used. The temperature at which the fluids in the two temperature baths are set are listed in Table A-4. One fluid temperature is referred to as the "cold bath temperature," while the other is referred to as the "hot bath temperature."

A-4.8.1.1 Set Up. The conditions in the hot temperature bath fluid shall be set up such that the standard cylinder response time will be within the limits specified in Table A-3. Hot temperature bath fluid conditions,

Table A-2 Compensation Conditions, Case Assembly, and Capillary Temperatures, Categories 1 and 2

Category 1		Category 2	
Environmental Condition	Capillary/Indicator Temperature, °F	Environmental Condition	Capillary/Indicator Temperature, °F
1	75	1	110
2	50	2	85
3	100	3	135

Fig. A-3 Standard Cylinder

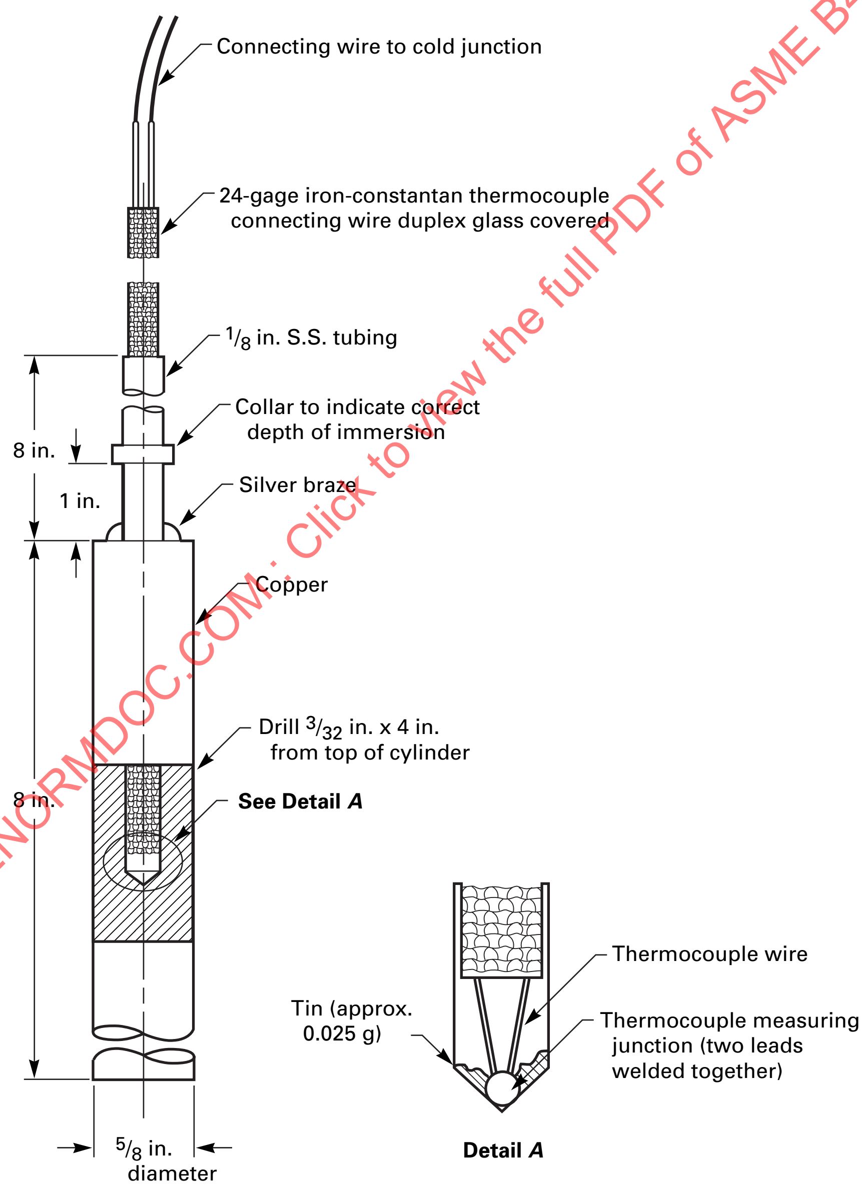


Table A-3 Permissible Response Time

Bath Fluid	Sensor Configuration Classification Designation	Maximum Permissible Response Time, sec
Water	A1, C1, C2	10
Salt	C1, C2	12

Table A-4 Test Temperatures and Bath Mediums

Bath Medium	Cold Bath Temperature, °F	T_1, Start Timing, °F	T_2, Stop Timing, °F	Hot Bath Temperature	Temperature Range Classification Designation
Water	50	80	143	180	18d, 24d, 55d
Salt	400	500	626	700	75d, 12h

and, thus, the standard cylinder response time, will be changed by varying the stirring parameters. The standard cylinder shall be immersed in the temperature bath fluid to the bottom of the standard cylinder collar (see Fig. A-2 for location). The standard cylinder shall always be immersed in the hot temperature bath fluid in the same location and orientation.

A-4.8.1.2 Determining Response Time. The bulb of the filled system thermometer (or standard cylinder) shall be immersed in the hot temperature bath until there is no further indication of temperature rise. The bulb of the thermometer (or standard cylinder) shall then be immersed in the cold temperature bath until there is no further indication of temperature decrease. The bulb of the thermometer (or standard cylinder) shall again be immersed in the hot temperature bath. Timing shall be started when the thermometer (or stand cylinder) indicator reaches temperature T_1 (see Table A-4) and stopped when temperature T_2 is reached. The time it takes the thermometer (or standard cylinder) to indicate the difference between temperatures T_1 and T_2 shall be defined as the response time.

A-4.8.1.3 Conducting Response Time Test. The response time test shall be conducted by taking alternate response time measurements between the standard cylinder and thermometer. Each alternation between the standard cylinder's response and the thermometer's response time measurements shall be defined as a trial. At least four trials shall be required in a temperature bath fluid of water and four trials in salt. The standard cylinder response time shall be within the limits of Table A-3 for the trial to be considered valid.

A-4.9 Salt Spray

The filled system thermometer shall be subjected to the salt spray test in accordance with ASTM B 117. The duration of the test shall be 96 hr. The filled system thermometer shall neither show visible corrosion, improper operation, failure, leakage in the case, nor other damage. At the conclusion of this test, accuracy shall be within ±1% of span.

Table A-5 Over Temperature Bath Temperature

Range, °F	Temperature Range Classification Designation	RequiredBath Temperature, °F
−40 to 180	18d	202 ± 2
20 to 240	24d	308 ± 3
50 to 550	55d	650 ± 5
50 to 750	75d	870 ± 7
400 to 1,200	12h	1,200 ± 10

A-4.10 Over-Temperature

The bulb of the filled system thermometer shall be placed in a hot temperature bath that is maintained at a temperature specified in Table A-5 for 5 min. The bulb shall then be allowed to cool to ambient temperature in air. After the cooling period, an accuracy test shall be performed.

A-4.11 Vibration

The vibration test consists of the exploratory test, the variable frequency test, and the endurance test. These tests shall be conducted in the sequence listed. Each of the three tests shall be conducted in each of the three mutually perpendicular axes. All three tests shall be completed in one axis before performing the tests in another axis. For each of the sensor temperature range classifications submitted, one filled system thermometer indicator shall be secured to the panel in a flush mounting configuration and another indicator in a surface-mounted configuration. The panel shall be rigid to ensure that its motion will be essentially the same as the motion of the platform of the vibration machine. The sensor configuration for each thermometer sensor configuration class shall be mounted in a manner that

Table A-6 Sensor Vibration Mounting

Sensor Configuration Class Designation	Sensor Mounting
A	Bracket bolted to platform, sensor attached to bracket.
C	Fitting screwed into platform, adjustable union connection affixed to fitting.

Table A-7 Vibratory Displacement Criteria

Frequency Range, Hz (Inclusive)	Table Displacement, in. (Peak to Peak)	
	Exploratory Test	Variable Frequency Test
5 to 15	0.020 ± 0.004	0.060 ± 0.012
16 to 25	0.020 ± 0.004	0.040 ± 0.008
26 to 33	0.020 ± 0.004	0.020 ± 0.004
34 to 40	0.005 ± 0.001	0.010 ± 0.002
41 to 60	0.005 ± 0.001	0.005 ± 0.001

will simulate its intended application (see Table A-6). For all tests, the capillary tubing shall be arranged in such a manner as to not exercise restraint or otherwise hinder the movement of the sensor or indicator during the test.

The exploratory test, the variable frequency test, and the endurance test shall be as follows:

(a) exploratory test

(1) Maintain each discrete frequency from 5 Hz to 60 Hz at 1-Hz intervals for not less than 15 sec or a sweep rate that shall not be greater than 4 Hz per min.

(2) Displacements shall be as specified in Table A-7.

(3) Frequencies and locations where resonance occurs during this test shall be determined.

(b) variable frequency test

(1) Maintain each discrete frequency from 5 Hz to 60 Hz at 1-Hz intervals for not less than 5 min.

(2) Displacements shall be as specified in Table A-7.

(3) Frequencies and locations where resonance occurs during this test shall be determined.

(c) endurance test

(1) The filled system thermometer shall be subjected to a 2-hr endurance run at each resonance.

(2) Displacements shall be the variable frequency test values that are specified in Table A-7.

(3) If no resonance is found, a 2-hr endurance run shall be performed at 50 Hz.

After the conclusion of the vibration test, accuracy shall be within ±1% of span. The filled system thermometer shall be visually examined for wear after the vibration test. The red index pointer shall not shift during the vibration test.

A-4.12 Shock

A shock test shall be conducted in accordance with the grade A, class I, type C requirements for lightweight equipment specified in MIL-S-901. Nine blows shall be applied. The capillary tubing shall be arranged in such a manner as neither to exercise restraint nor otherwise hinder the movement of the sensor or indicator during each blow. The filled system thermometer shall be mounted to a 6D fixture. For each filled system thermometer sensor configuration test, one indicator shall be attached in the surface-mounted configuration; the other indicator shall be attached in the flush-mounted configuration. The filled system thermometer shall indicate the ambient temperature and show no evidence of damage. A shift in pointer indication shall be within 4% of span for the set of nine blows. The red index pointer shall not shift. After a zero adjustment, the accuracy shall be within ±4% of span.

A-5 ORDERING PARAMETERS

A-5.1 Acquisition Requirements

When specifying a thermometer for acquisition, the following shall be provided:

(a) title, number, and date of this appendix
(b) Part Identifying Number (PIN)
(c) special marking or tagging
(d) when qualification is required

A-5.2 Part Identifying Number (PIN) Parameters

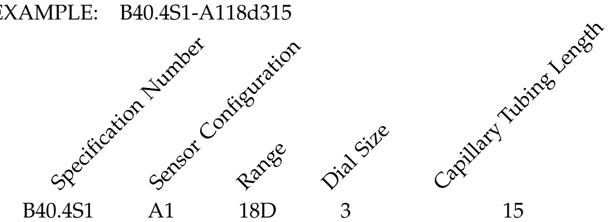
Shipboard filled system thermometers shall utilize the following PIN variables:

(a) sensor configuration
(b) range
(c) dial size
(d) capillary tube length

A-5.3 Part Identifying Number (PIN) Format

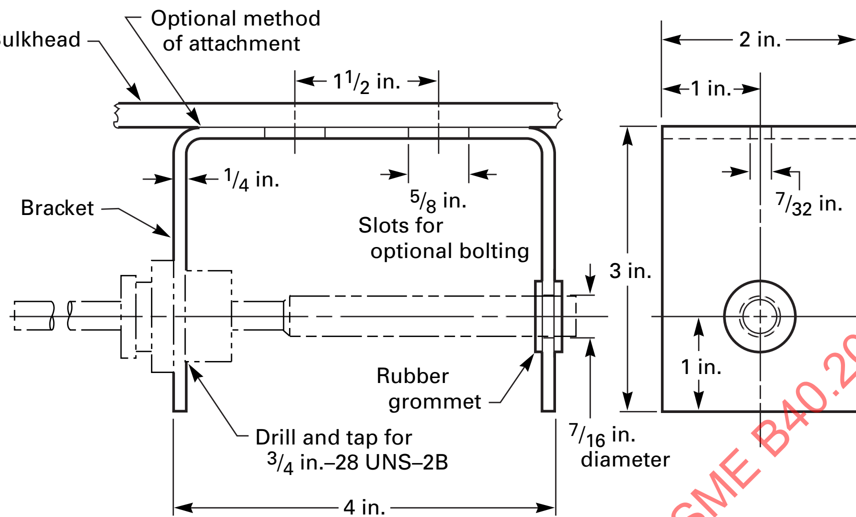
The PINs to be used for items acquired to this supplement are created as follows:

EXAMPLE: B40.4S1-A118d315



A-5.3.1 Sensor Configuration. The sensor configuration shall be designated by two symbols: the first symbol

Fig. A-4 Typical Bracket for Filled System Thermometer



shall designate the class, and the second symbol shall designate the subclass. The class, designated by the letter A or C, identifies the sensor type and mounting method.

A-5.3.1.1 Class A Sensor Configuration. Class A has one configuration and is designated A1. A1 Class A sensor configuration shall be constructed for insertion into a bracket that conforms to Fig. A-4. Class A sensors are intended to be used in applications where the air temperature is being measured at pressures of or near 1 atmosphere. The class A sensor configuration shall meet the dimensional requirements of Fig. A-1, classification designation C2. A bracket that conforms to the requirements of Fig. A-4 shall be supplied with each class A sensor configuration.

A-5.3.1.2 Class C Sensor Configuration. The class C sensor configuration shall be constructed for insertion into a thermowell. This sensor configuration is not intended for applications requiring direct immersion into process fluid or for applications where the sensor becomes part of the process system pressure boundary. The class C sensor configuration shall conform to the requirements on Fig. A-1.

A-5.3.2 Range. Each temperature range is intended for use in the application or process fluid listed below.

(a) −40°F to 180°F range for cold storage (air)
(b) 20°F to 240°F range for water and oil
(c) 50°F to 550°F range for hot water and compressed air
(d) 50°F to 750°F range for saturated steam
(e) 400°F to 1,200°F range for superheated steam

The range shall be designated by a series of symbols specified in Table A-8.

A-5.3.3 Dial Size. Standard dial sizes shall be designated by a series of symbols specified in the following table.

Dial Size	Symbol
3½	3
4½	4
8½	8

A-5.3.4 Capillary Tubing Length. Capillary tubing shall be specified in increments of 15 ft and shall be limited to 75-ft length except for ranges below 240°F when specifically approved by the purchaser.

A-6 REFERENCES

ASME B40.9, Thermowells for Thermometers and Electrical Temperature Sensors

Publisher: The American Society of Mechanical Engineers (ASME), Three Park Avenue, New York, NY 10016-5990, Order Department: 22 Law Drive, P.O. Box 2300, Fairfield, NJ 07007-2300

ASTM A 167, Standard Specification for Stainless and Heat Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

ASTM A 473, Standard Specification for Stainless Steel Forgings

ASTM B 26, Standard Specification for Aluminum-Alloy Sand Castings

ASTM B 85, Standard Specification for Aluminum-Alloy Die Castings

ASTM B 117, Standard Test Method of Salt Spray (Fog) Testing

Table A-8 Temperature Range Classification Designations

Range, °F	Max. Operating Temperature, °F	Dial Minor Division	Dial Numeral Interval	Applicable Class(es)	Temperature Range Classification Designation
−40 to 180	180	2	20	A, C	18d
20 to 240	240	2	20	C	24d
50 to 550	500	5	50	C	55d
50 to 750	700	5	50	C	75d
400 to 1,200	1,100	10	100	C	12h

ASTM D 788, Standard Classification System for Poly (Methyl Methacrylate) (PMMA) Molding and Extrusion Compounds

ASTM D 3951, Standard Practice for Commercial Packaging

Publisher: ASTM International (ASTM), 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959

FED-STD-H28, Screw Thread Standards for Federal Service

FED-STD-595, Colors Used in Government Procurement Commercial

MIL-S-901, Shock Tests, H.I. (High Impact); Shipboard Machinery, Equipment and Systems, Requirements for

Publisher: Department of Defense Single Stock Point for Military Specifications and Standards (DODSSP), Defense Automated Printing Service, 700 Robbins Avenue, Building 4/D, Philadelphia, PA 19111

ASME B40.8

Figures

Table

LIQUID-IN-GLASS THERMOMETERS

1 SCOPE

This Standard is confined to analog, liquid-in-glass industrial-type thermometers for industrial applications that sense process temperature by means of the expansion of the liquid within the glass thermometer bulb. The liquid fill, based on the temperature to be measured, may be mercury or organic liquid. This Standard does not include laboratory-type ASTM thermometers (Specification Designation: ASTM E 1-86).

NOTE: Thermowell Standard ASME B40.9 does not include dimensional information or drawings for the internally tapered thermowell described in this Standard. This internally tapered thermowell has been in continuous use since 1927. The dimensional information listed is to be considered critical to ensure interchangeability within the industry, for both new and existing thermometers.

2 HISTORY

Since 1900, the introduction of the liquid-in-glass thermometer for pipe line, tankage, and other temperature-measuring applications became a reality. In such equipment, if the fitting attaching the thermometer to the equipment is not dimensionally standardized, extreme difficulty in replacing a thermometer is encountered. Over the years, manufacturers have standardized the product. To accommodate the interchangeability, this endeavor has been helped by the introduction of Military, Federal, and Trade Association Standards. Dimensional and other information from the following liquid-in-glass industrial thermometer specifications have been incorporated into this Standard.

(a) F.S.B. No. 472, March 5, 1927, United States Government Master Specification for Thermometers, Industrial. "This specification was officially promulgated by the Federal Specifications Board on March 5, 1927, for the use of the Departments and Independent Establishments of the Government in the purchase of industrial thermometers." (From the title page of the specification.)

(b) GG-T-321, March 31, 1931, superceding U.S.G.M.S. 472a October 1928; Federal Specification, Industrial Thermometers

(c) 18T14(INT), November 1941, Thermometers, Mercurial, Navy Type, 6-in. case, Bureau of Ships

(d) 18T7j, July 1, 1944, superceding 18T7j December 1937, Navy Department Specification; Thermometers, Industrial

(e) MIL-T-656, April 1953, Thermometer, Self-Indicating, 6-in. case

(f) MIL-T-19474, April 1956, Military Specification; Thermometer, Self-Indicating, Liquid-in-Glass, 6 in.

(g) MIL-T-19475, April 1956, Military Specification; Thermometer, Self-Indicating, Liquid-in-Glass, 7-in. and 9-in. case

(h) RC7-1, 1962 SAMA (Scientific Apparatus Makers Association) Standard: Liquid-in-Glass Industrial Thermometers

(i) GG-T-321d, July 1977, Federal Specification, superceding GG-T-321c, dated 1962, Thermometers, Self-Indicating, Liquid-in-Glass for Machinery and Piping Systems

NOTE: All of the above standards have been cancelled. This Standard retains the critical dimensions and terminology of the cancelled standards.

ASME has been granted authorization by SAMA to assume responsibility for the cancelled RC7-1 Standard and replace it with this B40.8 Standard.

3 STYLE

3.1 Industrial

The thermometers described have a nominal case size of 7 in., 9 in., or 12 in. See Fig. 1, illustration (b).

3.2 Compact 6 in.

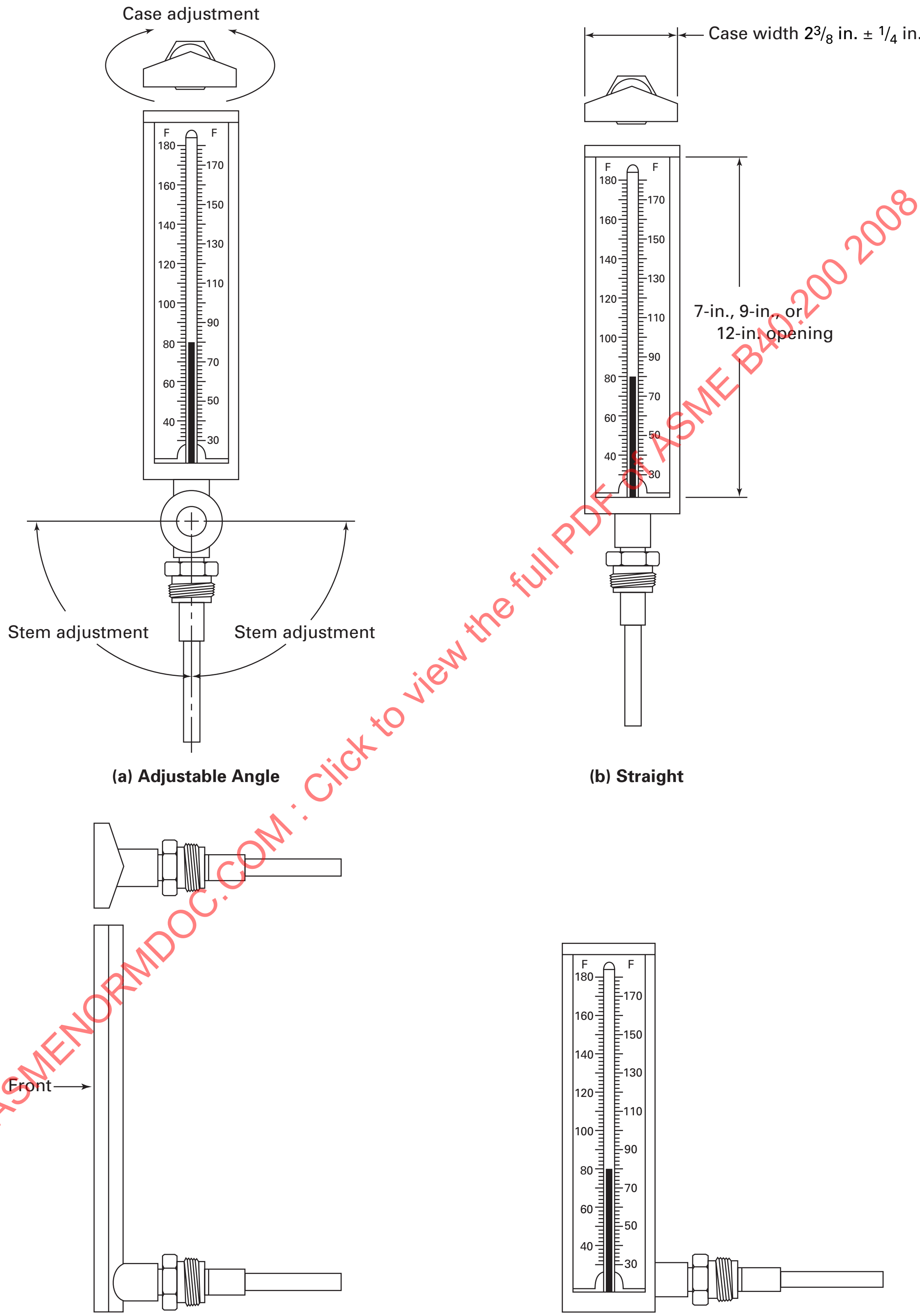
The thermometers described are of a different design and are not interchangeable with Industrial Style of para. 3.1. The primary use for a 6-in. nominal case size thermometer is for small diameter pipe lines, wherein shorter immersion length of thermowells is required, or mounting space for the thermometer is restricted. See Fig. 2, illustrations (a) and (b).

4 TERMINOLOGY AND DEFINITIONS

4.1 Thermometer Tube and Scale

scale, thermometer: a thermometer scale is printed or engraved on metal with the temperature range in readable lines and readable numerals. The scale is secured within the case with the test points on the thermometer tube aligned with the corresponding scale graduation. The height of the liquid column within the glass thermometer tube is then visually translated into temperature. Thermometer scales are graduated in degrees Fahrenheit (°F), degrees Celsius (°C), or degrees Fahrenheit and Celsius (°F/°C). Formulas and abbreviations for conversion of these temperature units are

Fig. 1 Case Form



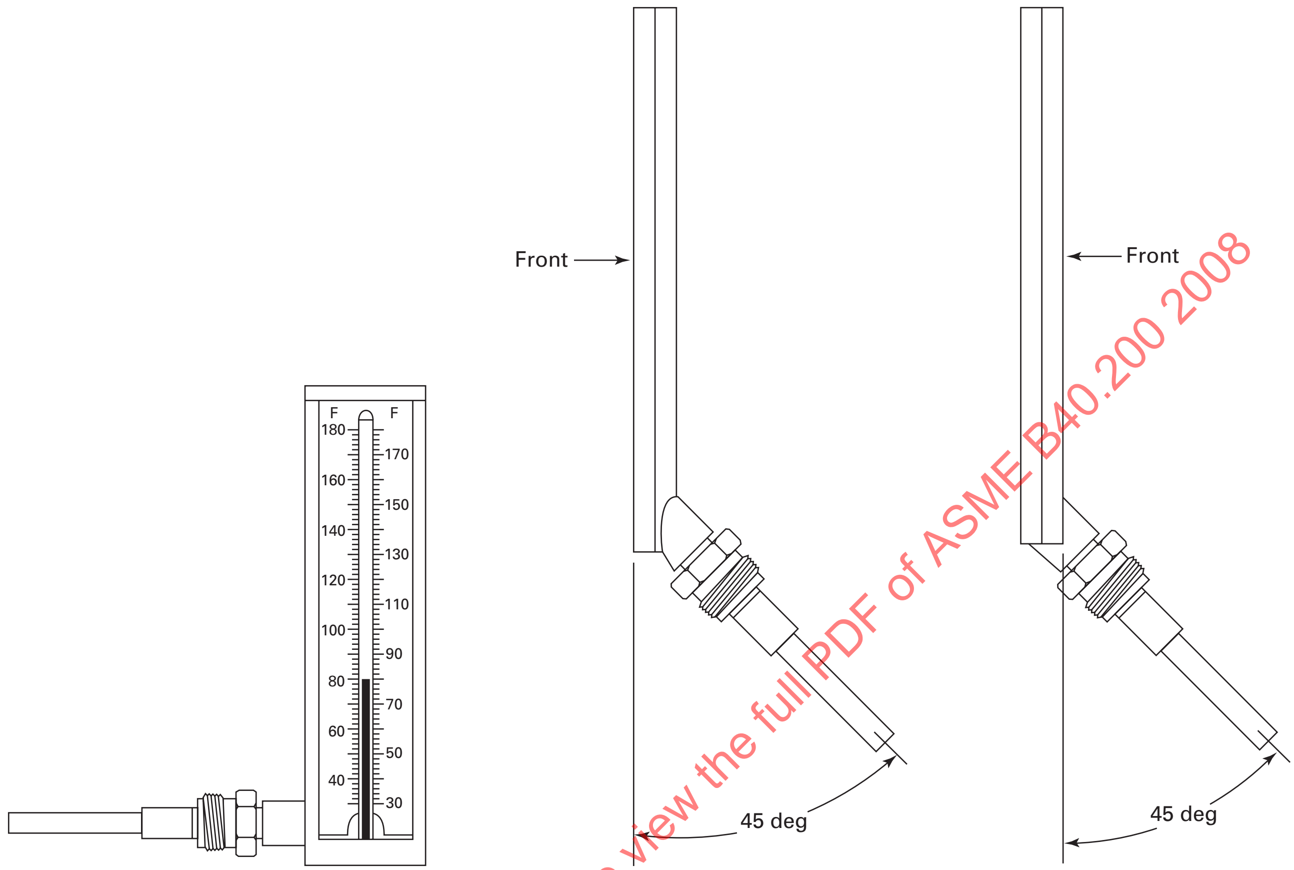
(a) Adjustable Angle

(b) Straight

(c) 90-deg Back Angle

(d) 90-deg Right-Side Angle

Fig. 1 Case Form (Cont'd)

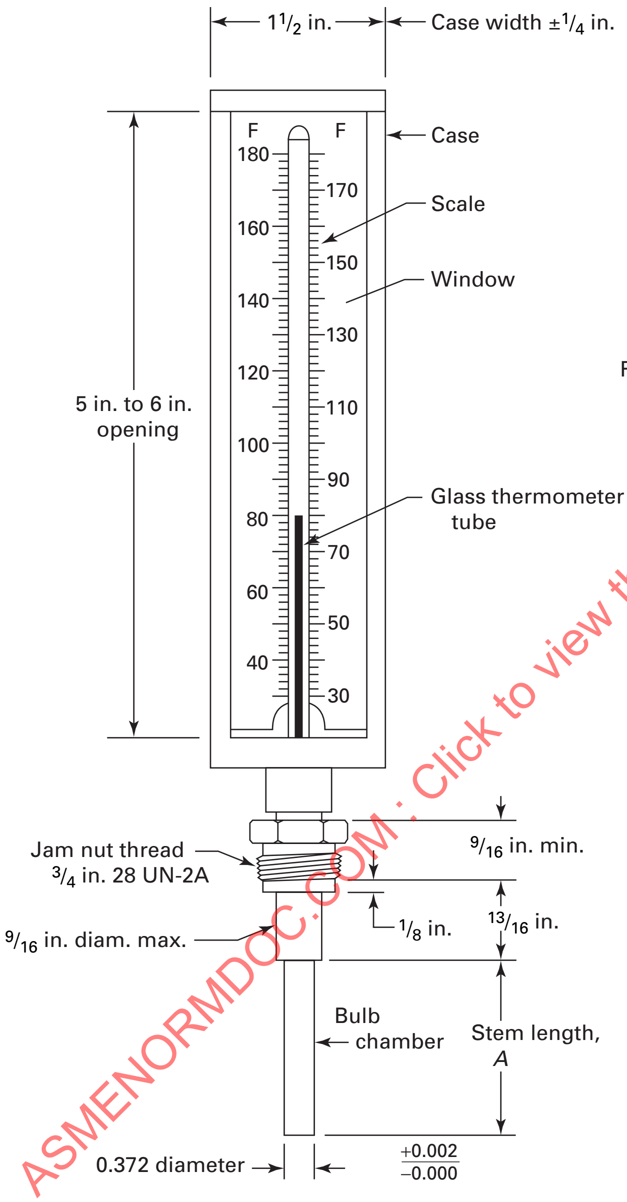


(e) 90-deg Left-Side Angle

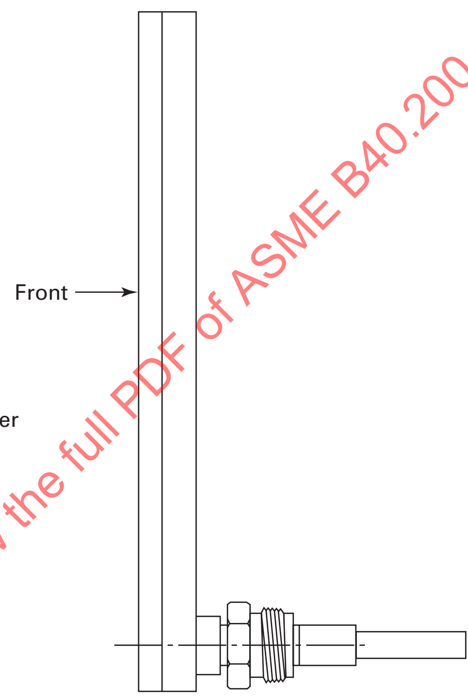
(f) 45-deg Reclined Angle

(g) 45-deg Inclined Angle

Fig. 2 Liquid-in-Glass Compact 6-in. Style Thermometer



(a) Straight Form

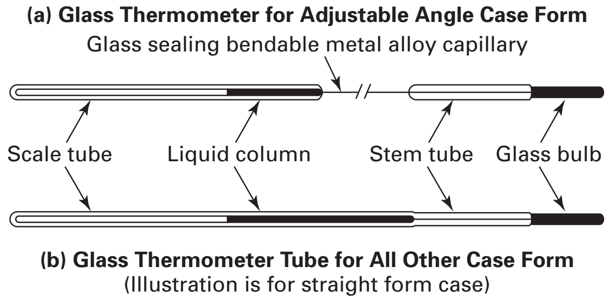


(b) 90-deg, Back-Angle Form

Nominal Stem Length, *A*	Thermowell (See Fig. 13)
2 in.	Standard — short
4 in.	Standard — long

GENERAL NOTE: This illustration is not intended to show design details, except as noted.

Fig. 3 Glass Thermometer Tube Types



GENERAL NOTE: This illustration is not intended to show design details.

Fahrenheit: U.S. Customary unit of temperature measurement. Abbreviation °F.

$$°F = (°C \times 9/5) + 32\ (212°F = 100°C)$$

Celsius: SI unit of temperature measurement (formerly Centigrade). Abbreviation °C.

$$°C = (°F - 32) \times 5/9\ (32°F = 0°C)$$

tube, thermometer: a thermometer tube manufactured of special thermometer glass capillary stem tube fused to a thermometer glass bulb and glass scale capillary tube is a temperature-measuring component containing a liquid fill in which the liquid column is observed as an indication of temperature. For the adjustable type thermometer tube, a capillary of metal alloy is fused between the stem tube and the scale tube. The scale tube may be a magnifying lens for better visibility of the liquid column (see Fig. 3).

4.2 Thermometer Stem

bulb chamber: that portion of the stem length that encloses the temperature-sensitive glass bulb. The space between the glass bulb and inner wall of the bulb chamber is filled with a heat-conducting medium capable of withstanding the temperature range of the thermometer [see Fig. 4, illustrations (a) and (b)].

bulb guard: that portion of a stem enclosing the temperature-sensitive glass bulb. The bulb guard is slotted or perforated to expose the glass bulb to process temperatures and provide fast response to temperature changes [see Fig. 4, illustrations (c) and (d) and Fig. 5].

jam nut: a threaded fitting that is located at the top of the stem assembly. The jam nut freely rotates in its captive connector, and when the thermometer is inserted into a thermowell, bushing, or flange, the thermometer can be positioned for maximum readability before the jam nut is tightened [see Fig. 4, illustration (a)].

sensitive portion: that portion of a stem, bulb chamber, or bulb guard enclosing the temperature-sensitive glass bulb (see Figs. 5 and 6).

stem: a component that extends from the case and encloses the temperature-sensitive portion of the glass thermometer tube within the bulb chamber or guard. The stem can also include the component called the jam nut if the thermometer is to be fitted with a union connection, flange, or thermowell fitting (see Fig. 7).

stem length, compact style: a stem is composed of a sensitive portion (bulb chamber) for lengths of 2 in. and 4 in. and a revolving jam nut for installation into a thermowell [see Fig. 2, illustrations (a) and (b)].

stem length, industrial style: a stem is composed of a sensitive portion (bulb chamber or guard) and an extension for lengths longer than 3½ in. (see Fig. 8). The two commonly used stems are plain and union connected. The union-connected stem has a seating part and revolving jam nut fitting for attachment to a thermowell, bushing, or flange [see Fig. 4, illustrations (a) through (d)].

4.3 Thermometer Case and Form

case, thermometer: a v-shaped housing that accepts the scale portion of the glass thermometer tube and scale and provides a threaded boss to accept the thermometer stem. Provision is also made in the thermometer case to accept the clear window that protects the glass thermometer tube from damage [see Fig. 1, illustrations (a) through (g); Fig. 2, illustrations (a) and (b); and Fig. 7].

form, adjustable angle: one in which the case can be positioned to assume, as a minimum adjustment, all of the case forms listed, with respect to the center line of the stem [see Fig. 1, illustration (a)]. Range limitation for the adjustable angle form may be to a maximum of 750°F or 400°C.

form, case: the case form of the thermometer is determined by the orientation of the thermometer stem with respect to the case front.

form, straight: a straight-form thermometer is one in which the stem projects downward from the bottom of the case in a line parallel to the face of the thermometer [see Fig. 1, illustration (b)].

form, 90-deg back angle: a 90-deg, back-angle form thermometer is one in which the stem projects from the lower rear of the case at a 90-deg rear angle to the scale [see Fig. 1, illustration (c)].

form, 90-deg, right-side angle: a 90-deg, right-side angle form thermometer is one in which the stem projects from the lower right side of the case at a 90-deg angle, parallel to the face of the thermometer, as viewed from the front [see Fig. 1, illustration (d)].

form, 90-deg, left-side angle: a 90-deg, left-side angle form thermometer is one in which the stem projects from the lower left side of the case at a 90-deg angle, parallel to

Fig. 4 Types of Stems

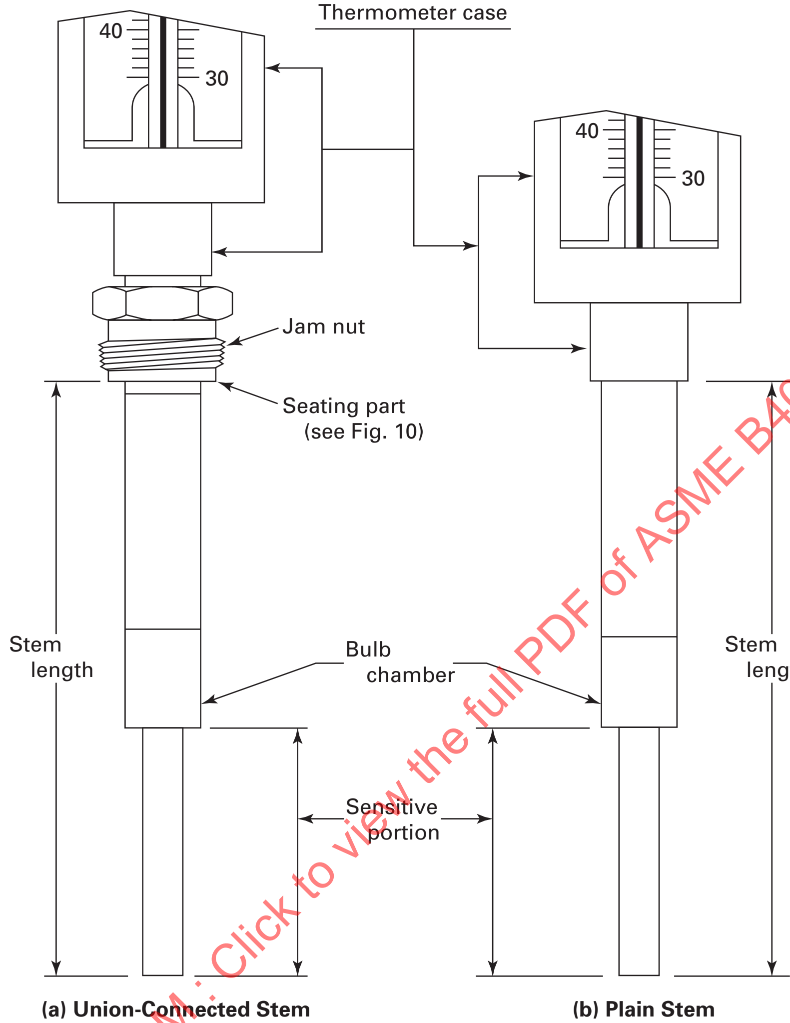
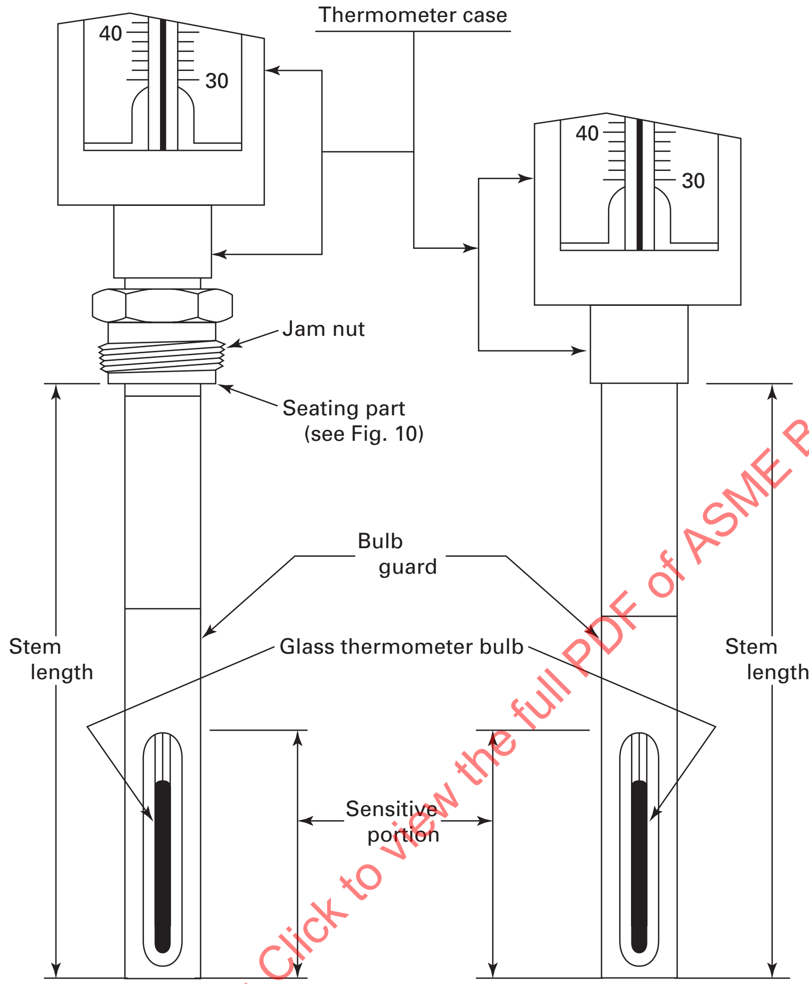


Fig. 4 Types of Stems (Cont'd)

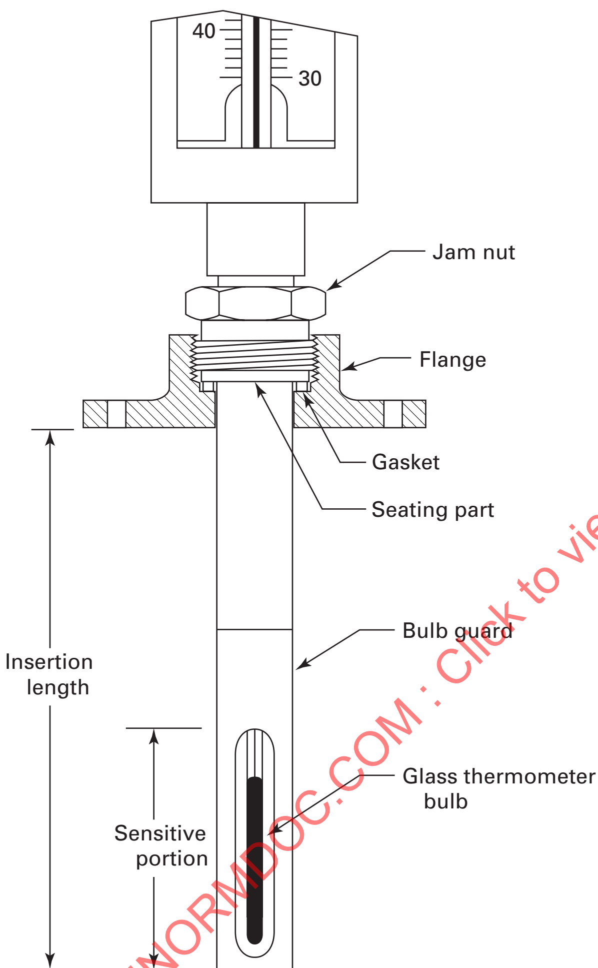


(c) Union-Connected Stem

(d) Plain Stem

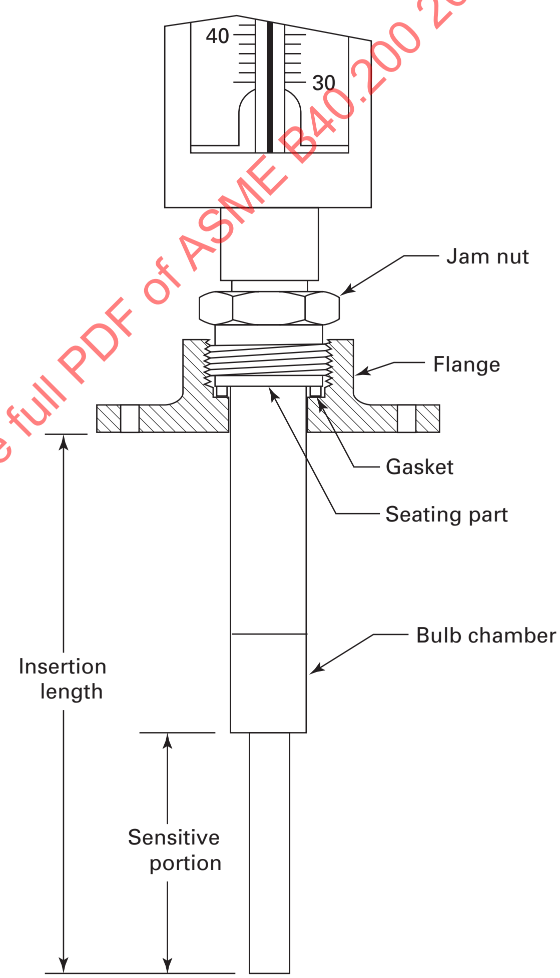
GENERAL NOTE: These illustrations are not intended to show design details.

Fig. 5 Union-Connected, Air-Duct Stem With Flange



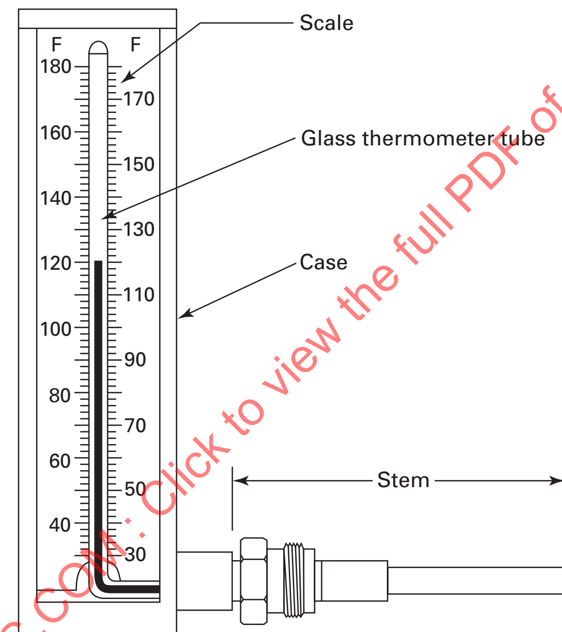
GENERAL NOTE: This illustration is not intended to show design details.

Fig. 6 Union-Connected Stem With Flange



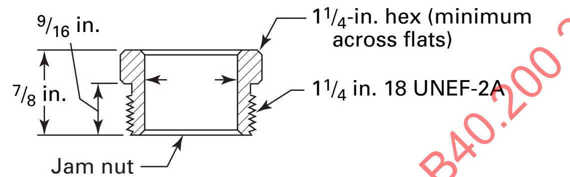
GENERAL NOTE: This illustration is not intended to show design details.

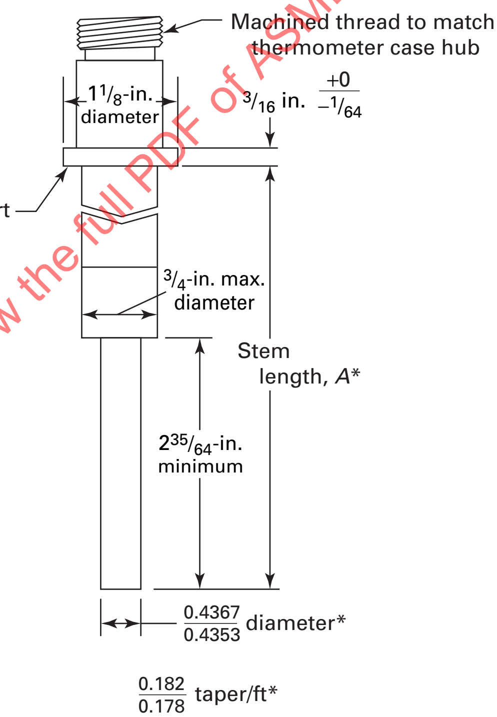
Fig. 7 Liquid-in-Glass Industrial Thermometer



GENERAL NOTE: This illustration is not intended to show design details.

Fig. 8 Union-Connected Stem Dimensions





Nominal Stem Length, in.	Dimension *A*, in.
3 1/2	3 5/8
6	6 1/8
8	8 1/8
9	9 1/8
12	12 1/8
18	18 1/8
24	24 1/8

NOTE: Fractional dimensions ±1/64 in., unless otherwise noted.

GENERAL NOTES:
(a) All dimensions with asterisks (*) are critical for proper fit to thermowells detailed on Fig. 12 and thermowell dimensions as shown in Table 1.
(b) Fractional dimensions ±1/64 in. unless otherwise noted.
(c) All dimensions are in inches.
(d) This illustration is not intended to show design detail, except as noted.

the face of the thermometer, as viewed from the front [see Fig. 1, illustration (e)].

form, 45-deg inclined angle: a 45-deg, inclined-angle form thermometer is one in which the front of the case is tilted forward through an angle of 45 deg with respect to the center line of the stem [see Fig. 1, illustration (g)].

form, 45-deg reclined angle: a 45-deg, reclined-angle form thermometer is one in which the front of the case is tilted backward through an angle of 45 deg with respect to the center line of the stem [see Fig. 1, illustration (f)].

4.4 Fittings and Stems

bushing: a fitting provided with external threads for attachment to a vessel and with internal threads and seating means for mounting the temperature sensing element of the thermometer to the bushing. To effect pressure tightness, a gasket (fiber or otherwise) is inserted between the seating part of the stem and internal face of the bushing [see Fig. 9, illustrations (a) and (b)].

flange: a fitting provided with a flanged surface for attachment to a vessel and with internal threads and seating means for mounting a temperature-sensing element therein. A flange does not have a pressure-tight sheath below the flanged surface (see Figs. 5 and 6).

insertion length, thermowell: that portion of a thermowell that protrudes into the process medium being measured [see Fig. 10, illustrations (a) and (b)].

insertion length, union-connected stem: that portion of a union-connected stem that protrudes into the process medium being measured [see Fig. 9, illustrations (a) and (b)].

lagging extension: that portion of a bushing or thermowell, above the external threads, intended to extend through the lagging (insulation) of a vessel or piping system [see Fig. 9, illustration (a), and Fig. 10, illustration (a)].

plain stem: not provided with a threaded connection or other means of attachment to a vessel or piping system. Installation of a thermometer having this type stem is generally by means of an adjustable clamp or plain bored flange provided with a locking screw [see Fig. 4, illustrations (b) and (d)]. Mounting flange or clamp not shown.

thermowell: a pressure-tight fitting that can be installed to a process network and accepts the thermometer stem. It facilitates the removal and reinstallation of a thermometer without creating a temporary leak and without requiring process shutdown. A thermowell is provided with external threads or other means for pressure-tight attachment to a vessel or piping system [see Fig. 10, illustrations (a) and (b), industrial style, and Fig. 11, compact style].

union-connected stem: using a jam nut and seating part for connecting the thermometer stem to a bushing, thermowell, or flange [see Fig. 4, illustration (a)].

union-connected stem for air-duct applications: the bulb guard, a perforated or slotted metal enclosure at the base of the stem, protects the glass thermometer bulb while providing rapid response to temperature change [see Fig. 4, illustration (c), and Fig. 5]. Stem lengths are the same as shown in Fig. 10.

5 DIMENSIONS — COMPACT STYLE

5.1 Jam Nut

The jam nut thread shall be $\frac{3}{4}$-28 UN-2A. The hexagon size shall be 1 in. [see Fig. 2, illustrations (a) and (b)].

5.2 Stem Chamber Diameter

The stem chamber diameter shall be 0.372 in., +0.002 in./−0.000 in. The stem chamber shall be straight for the full length (see Fig. 2).

5.3 Stem Length

The nominal standard stem length shall be 2-in. standard short and 4-in. standard long (see Fig. 2).

5.4 Thermowells

Thermowells for compact 6-in. thermometers are designed to provide clearance between the stem chamber diameter and bore of the thermowell to ensure ease of insertion of the thermometer stem to the thermowell (see Fig. 11). To improve response time, the space surrounding the stem within the thermowell may be filled with a heat transfer medium suitable for use at the process temperature.

5.5 Thermometer Assembly

Nominal case size is 6 in. [see Fig. 2, illustrations (a) and (b), for nomenclature and nominal size for the assembled compact thermometer].

6 DIMENSIONS — INDUSTRIAL STYLE

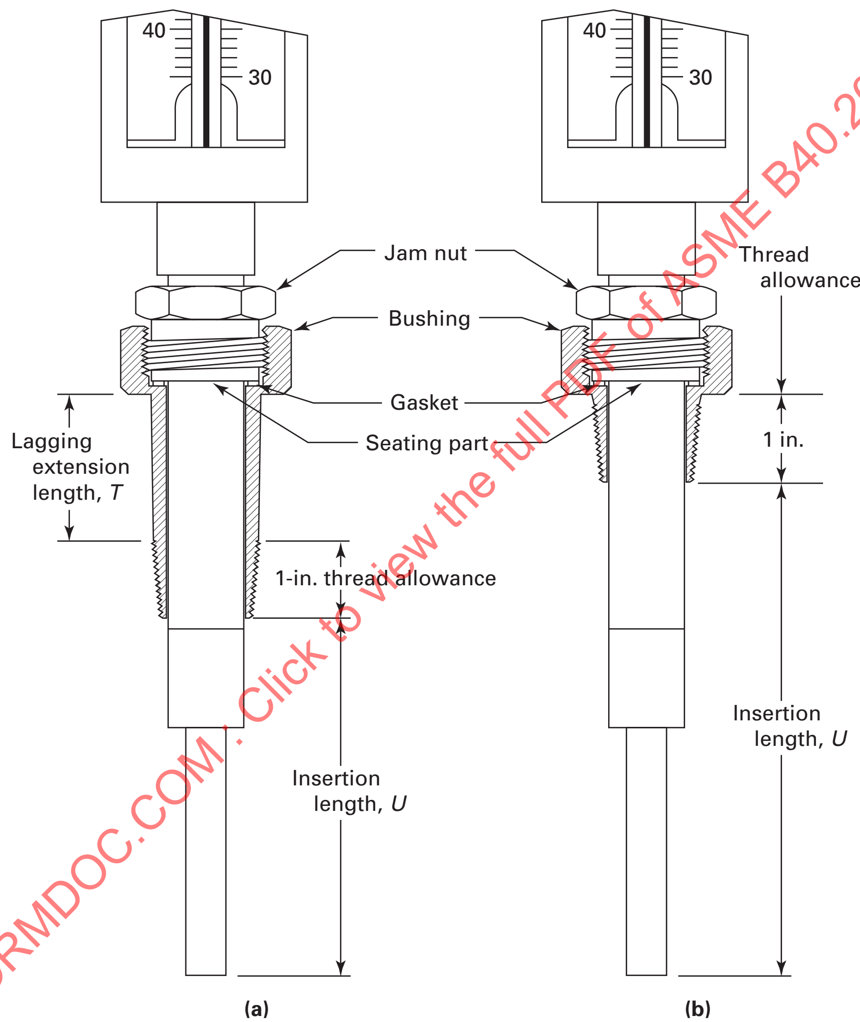
6.1 Jam Nut

The jam nut thread shall be $1\frac{1}{4}$-18 UNEF-2A. The hexagon size shall be $1\frac{1}{4}$ in. minimum across the flats (see Fig. 8).

6.2 Seating Part

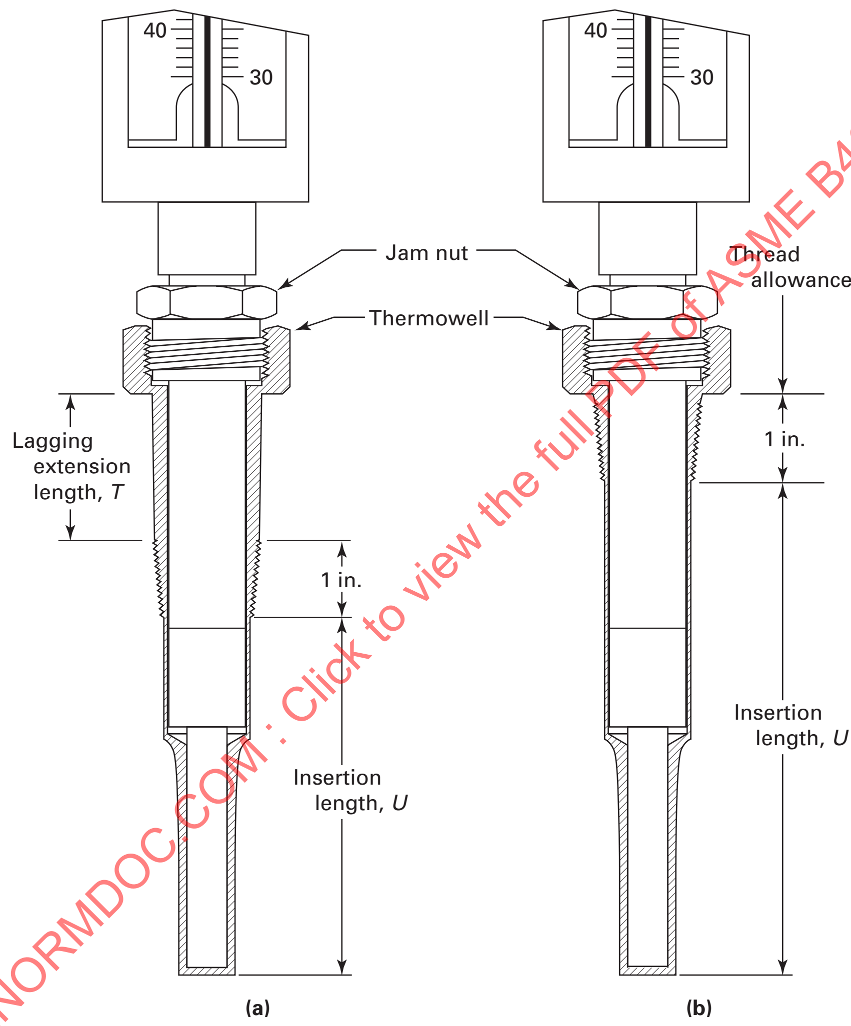
The seating part shall be $1\frac{1}{8}$ in. outside diameter and have a thickness of $\frac{3}{16}$ in., +0 in./−$\frac{1}{64}$ in. (see Fig. 8). The function of the seating part is to provide a flat surface to engage the jam nut face, enabling the thermometer stem to be engaged into a union bushing or a thermowell or flange [see Figs. 5 and 6; Fig. 9, illustrations (a) and (b); and Fig. 10, illustrations (a) and (b)].

Fig. 9 Union-Connected Stem With Bushings



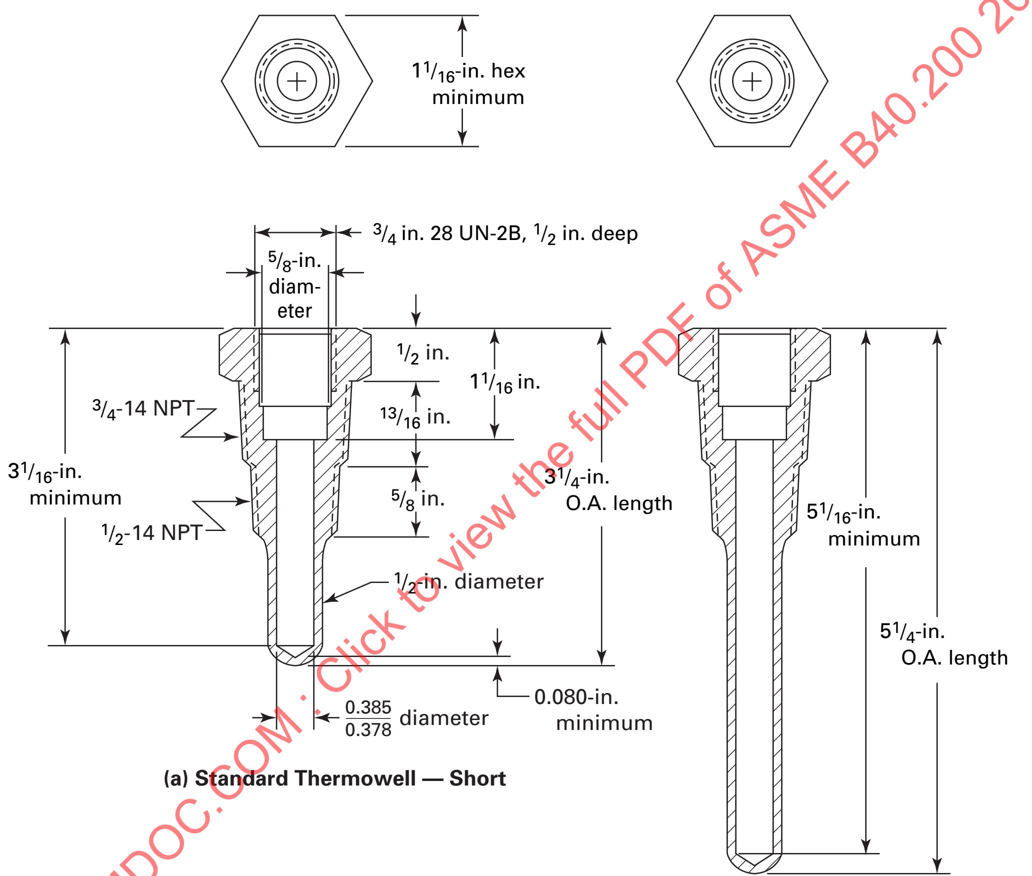
GENERAL NOTES:
(a) See Table 1 for *T* and *U* dimensions.
(b) These illustrations are not intended to show design details.

Fig. 10 Union-Connected Stem With Thermowell



GENERAL NOTES:
(a) See Table 1 for *T* and *U* dimensions.
(b) These illustrations are not intended to show design details.

Fig. 11 Thermowell for 6-in. Compact Style Thermometer



(a) Standard Thermowell — Short

(b) Standard Thermowell — Long

GENERAL NOTES:
(a) Tolerances on fractional dimensions to be ±1/64 in.
(b) All dimension are in inches.
(c) These illustrations are not intended to show design details, except as noted.

6.3 Stem Length

The nominal standard stem lengths shall be $3^1/_2$ in., 6 in., 8 in., 9 in., 12 in., 18 in., and 24 in. (see Fig. 8 for actual stem length dimensions).

6.4 Extension Diameter

The diameter of the stem extension below the seating part on the union-connected stems shall not exceed ¾ in. On plain stems, the extension shall have a maximum outside diameter of 1 in.

6.5 Union-Connected Stem

The union-connected stem shall be in accordance with Fig. 8. When a bulb guard is used, the sensitive portion shall have the same diameter as the extension (see Fig. 5).

6.6 Bushing

Dimensions for bushings are shown in Fig. 12, illustrations (a) and (b).

6.7 Thermowells

Thermowells for industrial thermometers are designed to provide metal-to-metal contact between the tapered portion of the union-connected stem and the tapered portion of the thermowell bore, providing a quick response to temperature changes of the system being measured. Nominal thermowell sizes shall be 3½ in., 6 in., 8 in., 9 in., 12 in., 18 in., and 24 in. [see Fig. 13, illustration (a)]. Where lagging extension is required, this length shall be 2½ in. to 3 in. [see Fig. 13, illustration (b)]. Thermowell style numbers are designed in Table 1.

6.7.1 Thermowell Materials. In general, material selection is governed by temperature, pressure, flow, and corrosive effect of the process medium to be measured. Standard materials commonly offered are brass (ASTM B 16), carbon steel (ASTM C 1018), stainless steel (AISI 304 and AISI 316), and Monel.

6.7.2 Thermowell Construction. Thermowell configurations are manufactured by machining to specified dimensions bar stock materials, castings, or forgings.

7 THERMOMETER FLUID

The fluid shall be organic liquid with an upper limit of 500°F or 288°C.

7.1 Organic Liquid

The organic liquid shall be chemically stable and capable of coloring with lightfast dyes. Colors other than red are acceptable. The dyes shall not fade or precipitate out of the organic liquid with long-term use. No separation of liquid and coloring shall be evident as a result of continuous exposure to temperatures within the scale range.

7.2 Glass Tube and Bulb

The thermometer shall be provided with a glass tube and bulb that has been adequately annealed for long-term indicating accuracy. For the adjustable angle thermometer, a glass-sealing, bendable metal alloy capillary shall be heat sealed between the thermometer glass tube and bulb. The tube shall be a magnifying lens tubing with a white enamel strip at the back. The width shall be not less than ¼ in. (industrial style) and 3⁄16 in. (compact style). The filling above the liquid column shall be nitrogen or other inert gas (see Fig. 3).

8 DESIGN

8.1 Case

The case shall be designed to ensure maximum readability. The window shall be securely fitted into the case or a frame attached to the case so the thermometer tube will be protected from mishandling during installation and use. Cases and frames shall be made of metal or an engineering plastic, able to withstand the operating temperatures encountered after installation.

8.2 Stem

A union-connected stem and plain-stem thermometer shall be protected and sealed by a metal bulb chamber, or bulb guard to prevent breakage of the glass thermometer bulb. The glass thermometer bulb shall extend into this chamber or guard to ensure proper heat transfer from the process being measured to the thermometer tube. The space between the glass thermometer bulb and internal diameter of the bulb chamber shall be filled with a heat-conducting medium to ensure a rapid response to temperature change.

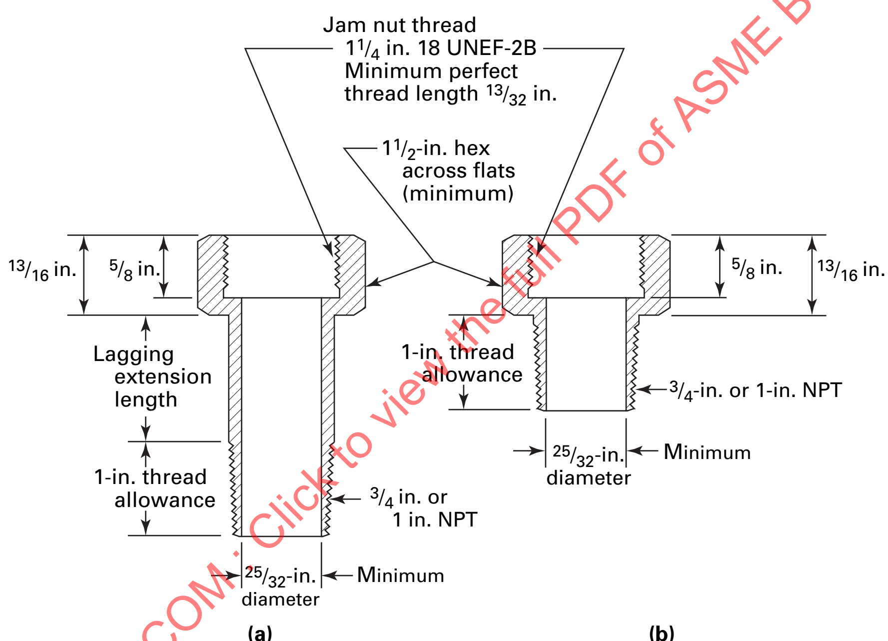
8.3 Scale

The nominal length *L* of the thermometer scale shall be 7 in., 9 in., and 12 in. for the industrial style thermometer and 6 in. for the compact style thermometer and have dimensions in accordance with the following in-text table. Scales shall be metal suitably coated and printed (or engraved) and may be slotted to provide an adjustment of two scale divisions.

L, Nominal, in.	Graduated Length, Minimum, in.	Width, Minimum, in.
6	3½	1
7	5	1⅝
9	7	1⅝
12	10	1⅝

8.3.1 Scale Marking. The scale shall be accurately and correctly graduated up to and including the last subdivision of the scale. The scale markings shall not be extended to temperatures beyond which the thermometer is suited. The units °F or °C, or °F and °C and a legend "ORGANIC LIQUID" may be legibly marked thereon.

Fig. 12 Bushing Dimensions



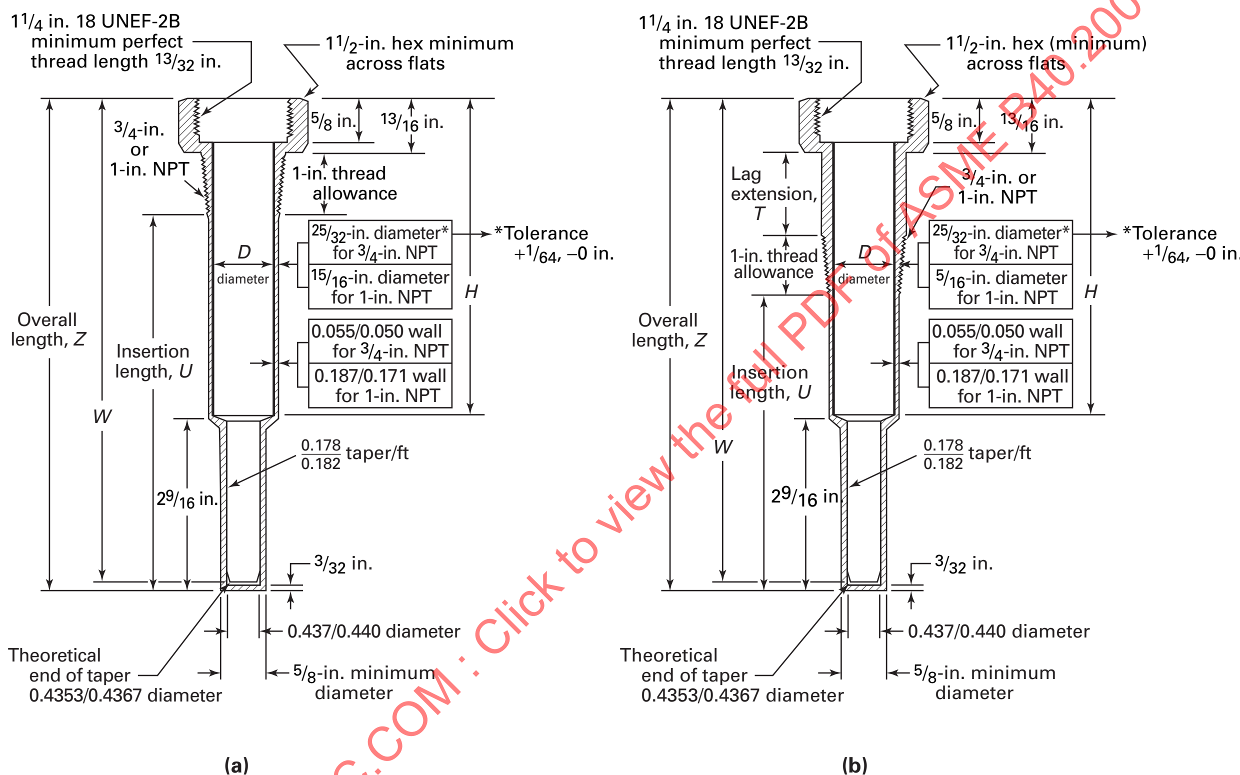
GENERAL NOTES:

(a) Fractional dimensions $\pm\frac{1}{64}$ in. unless otherwise noted.

(b) All dimensions are in inches.

(c) These illustrations are not intended to show design details, except as noted.

Fig. 13 Thermowell Dimensions



GENERAL NOTES:

(a) Fractional dimensions ±1/64 in., unless otherwise noted.

(b) All internal diameters to be concentric within 0.010 T.I.R.

(c) All dimensions are in inches.

(d) Length W is the dimension to the end of internal taper reaming from the top of the thermowell.

(e) Refer to Table 1 for other dimensions.

(f) These illustrations show dimensional details.

Table 1 Thermowell Dimensions, in.

Well Style	Thermometer Stem Length (See Fig. 10)	Insertion Length, *U*	Lagging Extension, *T*	Overall Length, *Z*	Length, *H*	Length, *W* [Note (1)] +0.034 −0.000
$3\frac{1}{2}$	$3\frac{5}{8}$	$2\frac{9}{16}$	0	$4\frac{3}{8}$	$1\frac{43}{64}$	4.125
6	$6\frac{1}{8}$	$5\frac{1}{16}$	0	$6\frac{7}{8}$	$4\frac{11}{64}$	6.625
6 Ext	$6\frac{1}{8}$	$2\frac{9}{16}$	$2\frac{1}{2}$	$6\frac{7}{8}$	$4\frac{11}{64}$	6.625
8	$8\frac{1}{8}$	$7\frac{1}{16}$	0	$8\frac{7}{8}$	$6\frac{11}{64}$	8.625
8 Ext	$8\frac{1}{8}$	$4\frac{9}{16}$	$2\frac{1}{2}$	$8\frac{7}{8}$	$6\frac{11}{64}$	8.625
9	$9\frac{1}{8}$	$9\frac{1}{16}$	0	$9\frac{7}{8}$	$7\frac{11}{64}$	9.625
9 Ext	$9\frac{1}{8}$	$5\frac{1}{16}$	3	$9\frac{7}{8}$	$7\frac{11}{64}$	9.625
12	$12\frac{1}{8}$	$11\frac{1}{16}$	0	$12\frac{7}{8}$	$10\frac{11}{64}$	12.625
12 Ext	$12\frac{1}{8}$	$8\frac{1}{16}$	3	$12\frac{7}{8}$	$10\frac{11}{64}$	12.625
18	$18\frac{1}{8}$	$17\frac{1}{16}$	0	$18\frac{7}{8}$	$16\frac{11}{64}$	18.625
18 Ext	$18\frac{1}{8}$	$14\frac{1}{16}$	3	$18\frac{7}{8}$	$16\frac{11}{64}$	18.625
24	$24\frac{1}{8}$	$23\frac{1}{16}$	0	$24\frac{7}{8}$	$22\frac{11}{64}$	24.625
24 Ext	$24\frac{1}{8}$	$20\frac{1}{16}$	3	$24\frac{7}{8}$	$22\frac{11}{64}$	24.625

GENERAL NOTE: See Fig. 12 for all other dimensional information for thermowells.

NOTE:

(1) Length *W* is the dimension to the end of internal taper reaming from the top of the thermowell.

8.3.1.1 Scale Ranges. The list shows typical scale ranges for the industrial style thermometer and the compact style (6-in. case) thermometer. Other ranges are in common use and acceptable. Combination °F and °C ranges can be placed on a single scale blank. The °F range is usually placed on the left side of the scale, and the °C range is placed on the right side of the scale.

EXAMPLE: 30°F/240°F and 0°C/115°C.

Industrial Style (7-in., 9-in., and 12-in. Case Thermometers)		Compact Style (6-in. Case Thermometers)	
°F	°C	°F	°C
−40/110	−40/45	−40/110	−40/45
30/180	0/80	30/180	0/80
30/240	0/115	30/240	0/115
30/300	0/150	30/300	0/115
50/400	10/200	50/400	10/200
50/550	10/290		
50/750	10/400		
200/950	95/510		
200/1000	95/525		

8.4 Threads

All screw threads shall be in accordance with ASME B1.1, Screw Threads, Inch Unified. All pipe threads on bushings or thermowells shall be in accordance with ASME B1.20.1, Pipe Threads.

8.5 Accuracy

The conformity of indication to an accepted standard or true value. Accuracy is the difference (error) between the true value and the indicated value expressed as a percent of span. It includes the combined effects of method, observer, apparatus, and environment. Accuracy errors include repeatability errors. Where specifications or requirements dictate accuracy of 1% of range span, the following should be considered:

(*a*) heat transfer capability, including flow effects of process medium

(*b*) whether or not the bulb chamber is in a thermowell

(*c*) conductivity of the thermowell material

8.5.1 The entire insertion length shall be immersed in a suitable bath. A calibration standard will be used to measure the temperature of the bath. The bath shall be uniformly agitated. A calibration curve consisting of at least five equally spaced points shall be obtained over the operating range of the instrument to determine the extent of the accuracy of the indication. The bath must be agitated in such a manner as to eliminate lag between the thermometer and standard. For purposes of meeting the accuracy requirement of para. 8.5, the thermometer shall be considered satisfactory if the calibration curve indicates that adjustment of the scale will bring all data within 1% of the range span.

8.6 Over-Temperature

Each thermometer glass tube shall have an expansion chamber, blown into the top of the tube, capable of providing a minimum of 50°F above the top of the scale range.

EXAMPLE: Range 0°F/120°F. Thermometer to be capable of withstanding a temperature of 170°F without damage or breakage.

NOTE: For thermometers with a maximum indicating range above 550°F, no expansion chamber is required.

8.7 Response Time

Response time is the time required for a thermometer to respond to a step change in temperature. Response time varies according to a number of interrelated parameters, including the following:

(a) temperature differential
(b) depth of immersion
(c) heat transfer capability, including flow effects of process medium
(d) whether or not the instrument is in a thermowell
(e) thickness of the thermowell wall
(f) conductivity of the thermowell material
(g) heat transfer speed between thermometer stem (sensitive portion) and thermowell

The user is encouraged to determine whether or not response time is critical.

8.8 Safety

The industrial and compact style thermometers contain mercury, or organic liquid, to indicate temperature. Under current federal guidelines, metallic mercury is considered a hazardous substance. Mercury sealed within the thermometer-indicating tube is harmless. If broken, it must be disposed of in accordance with applicable federal, state, and local laws and regulations. Consult the manufacturer's Material Safety Data Sheet (MSDS) for details. The nominal quantity of mercury within a thermometer is 4.5 g (0.16 oz.). For hazardous components, consult the manufacturer's MSDS sheet.

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